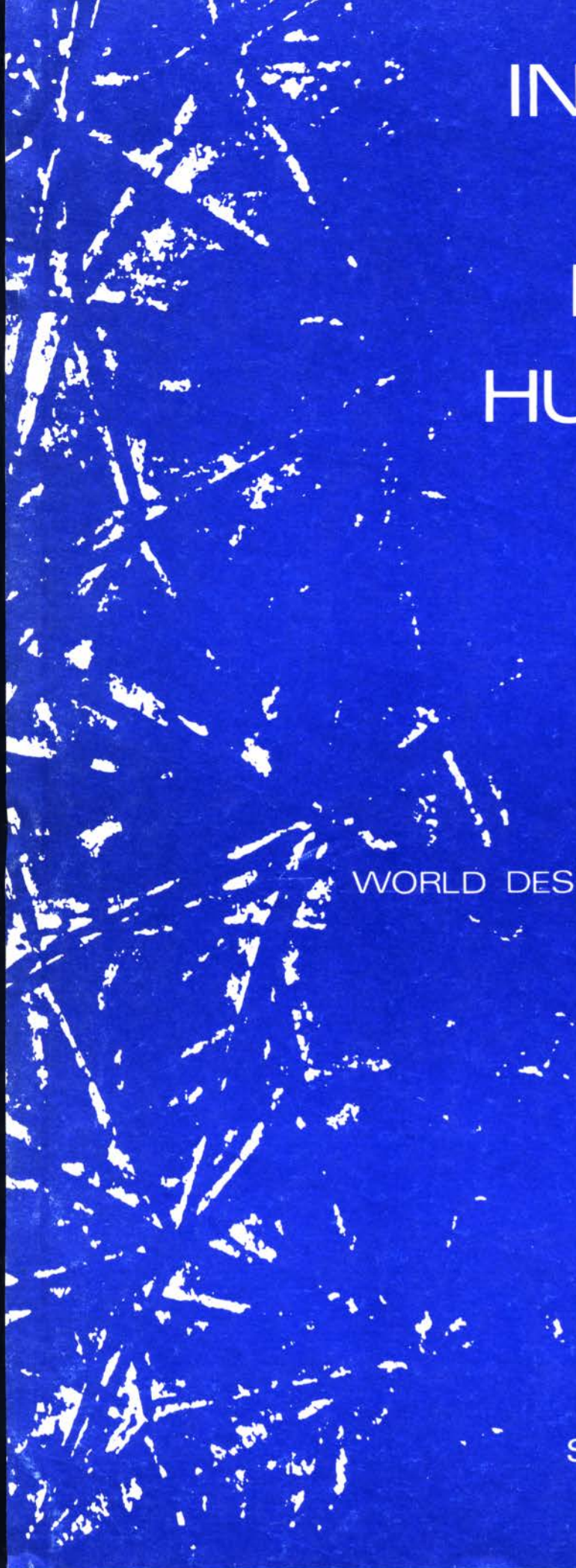

INVENTORY OF WORLD RESOURCES

HUMAN TRENDS AND NEEDS

Fundamentals of Satisfaction of the Needs and Trends by the Resources Through the WORLD GAME-
A Philosophy
B Design Science

DOCUMENT 2

WORLD DESIGN SCIENCE DECADE 1965-1975
PHASE 1

The Design Initiative
by R B Fuller

WORLD RESOURCES INVENTORY

HUMAN TRENDS AND NEEDS

FULLER PROJECTS
SOUTHERN ILLINOIS UNIVERSITY
CARBONDALE, ILLINOIS 62901

Phase 1, (1964) Document 2

THE DESIGN INITIATIVE

Also brief outline of:

Phase 2 - 1965-1967

Phase 3 - 1967-1971

Phase 4 - 1971-1973

Phase 5 - 1973-1975

(Phase I (1963) Document 1 was
'Inventory of World Resources, Human Trends and Needs')

World Resources Inventory
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For not only respectively identifying virus shells, male testes, human cornea, algae and diatoms with my geodesic structures and my discovery of the mathematical coordinate system apparently employed by nature, but also for their courtesy in accrediting my work, visiting and corresponding with me, and for supplying photographs and data.

R. Buckminster Fuller

PREFACE

This document, the second in the 'World Design Science Decade' series, deals specifically with the ways in which the design initiative may be taken, and gives procedural outlines for the conduct of generalized design science exploration.

The first chapter, entitled "World Design Initiative", contains the text and illustrations of R. Buckminster Fuller's address to the International Symposium on Architecture, held in Mexico City in October, 1963, by the International Union of Architects as part of their Seventh Congress. This discourse forms an overall introduction to the world program and furnishes also a selected record of Fuller's personal researches into the various aspects of comprehensive environment control systems.

Following this chapter is the outline of the five design science phases of the ten year world tool redesign program. As a guide to the forward development of the successive stages of the program, this indicates briefly the content area and relationship of each phase. Preparatory work on the expansion and documentation of this outline has already been initiated by this center and will form the next publication in the present series.

The charts and their accompanying texts of the 'Historical Blast Off into the Space Age of Man' are an updating of a series of such socio-economic analyses of scientific and technological trends, first published by Fuller in "Nine Chains to the Moon', in 1938, and revised for 'Fortune' magazine in 1940. The present version was especially prepared for this book and draws upon the latest and most authoritative data available. The time chart of the acquisition of the chemical elements as forming a profile of the Industrial Revolution, which is included in the 'Cumulative Nature of Wealth' represents an extension of such studies in the relative growth of man's scientific and technological capacities. Both of these sections are given here, particularly, as guide material for such extended future analyses to be undertaken by architectural and planning groups participating in the world program.

The 'Universal Requirements of a Dwelling Advantage' was first drawn up by Fuller in 1927, as a scientific control for the development of the Dymaxion House, and has been successively revised and published at intervals since that time. The version used here appeared in "Architectural Design" magazine, England, and was finally revised for inclusion in his "No More Second Hand God", published by Southern Illinois University Press in 1963. This checklist is a comprehensive attempt to list every requirement, and meet most contingencies, likely to occur to man in relation to shelter as his prime environ control system.

John McHale
World Resources Inventory
Carbondale, Illinois

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WORLD DESIGN INITIATIVE

WORLD DESIGN INITIATIVE

Discourse to the 'International Symposium on Architecture' of the Union of International Architects - Mexico, October 10, 1963.

Dr. R. Buckminster Fuller

At the present moment in history, we are witnessing extraordinary changes in the relationships of man with his earth. Nothing could be more impressively evident of the changes than the fact that we are able to hold biennial world congresses, attended by thousands of architects from approximately all the countries on earth. Rarely wealthy, architects nevertheless can afford within their professional means to convene at cities anywhere around the earth. But--only because of the extraordinary changes brought about by the economic efficiencies of industrialization and the latter's world embracing, hypersensitive, dynamic, tool network.

Up to, and including, the lifetime of my father, the average distance over Earth's surface accomplished by human beings in their total life span was less than 30,000 miles. Though I am still alive, and my life span is incomplete, I have already covered 3,000,000 miles. In one generation it has become normal for man to be accomplishing 100 times greater life span distances than all men before us were able to accomplish. This average will be thousand folded in the next generation and millionfolded in the next. Such is the acceleration of the great, new, industrially implemented life pattern. Its ecological-pattern-transforming networks of tools have been invented by men only as a result of progressively externalizing and amplifying their integral, bodily functions and innate faculties. Granted the intellectual discovery of physical principles and inventive initiative of man it is none the less clear that the network of industrialization has been realized only through the a priori existence of the physical resources. However it took Industrial Man, functioning intellectually with invisible scientific logic, to extract the metals from the Stone Age's exclusively superficial use of the raw stones only as dynamic tools or static masonry thus multi-million-folding the resource effectiveness.

All the metals that have been mined by man in all history, together with all the metals that have been recovered thereafter from the original, but progressively obsolete, use forms and put again into recirculation as newly designed and improved tools, together are able to serve only 44% of humanity, under the presently existing patterns of metals and energy employment.

This is to say that the world around industrial network cannot be stretched to serve more than 44% under the present pattern of technical design. This also means that the vast majority of humanity must continue to live under conditions that are far below the standards of those of us who are industrially

advantaged and are able to accomplish the "freedom" of 3,000,000 miles in a lifetime, rather than the 30,000 miles of static, local, to-and-froing. Furthermore the reserves of discovered but as yet unmined metals are not being amplified by new ore field discoveries at the rate at which humanity itself is increasing. The world's total mined and unmined metals per capita are continuously diminishing. Thus far in history war has been the only and ultimate solution of fundamental, ecological needs and resource inadequacies. Wars have seemingly demonstrated Darwin's survival, --only, of the so-called fittest, - the mightiest, fighting "fittest", -- to be valid.

I am convinced by the facts that I have recited that it is impossible for us under the present comprehensive design pattern of world industrialization to make the earth's total metals serve 100% of humanity exclusively through political revolutions, or peaceful reforms and rearrangements of the ways of administering the economic accounting of the commercial and social affairs of man. All we can do politically with the fundamental resource inadequacy is to take from one group and give to another. Competitive enterprise assumes exclusive success.

Summarizing historically, we may say that in the industrialization of the earth we are as yet faced with a condition of not enough of "whatever it takes" for more than a minority to prosper. However, there are, I have discovered, at least two important and popularly unknown alternatives to that of the political initiative which we may consider as a solution of the seemingly worsening resource inadequacy of humanity on earth and its cataclysmic and inescapable implications threatened by the enormous atomic-warhead stockpiles whose use is inferentially inexorable, -save for our two alternatives, one slow and one relatively swift. We are not accustomed to think of architecture as having anything to do with the fundamentals of war or with avoidance of atomic holocaust. When I say that you as architects can eliminate the atomic war threat I am not referring to a bomb shelter program, but to the eliminating of world resource inadequacies through a new design science competence, thereby eliminating the inexorability of recurring world wars and their atomic finale. Yours is an unprecedented historical opportunity of prime, vital service to mankind. Yours is the one quarter of a century (i. e. one human generation) faster and equally effective happy alternative. In contrast to the slow, laissez-faire, bumble-through, alternative to Armageddon, we will call this high speed alternative:- The Architectural Initiative.

To comprehend the validity of the two alternatives to race suicide we must first observe that the 44% who are now being served exclusively by total industrialization, represent a very large number, in contrast to the small number who prospered by industrialization at the beginning of the twentieth century. In 1900 less than 1% of humanity were enjoying the physical advantages

provided by industrial tools and their interacting networks. This condition was changed by the following complex of events. The integration of accelerating technology that came in the last part of the 19th century, brought about a new trial of arms of the world's economic gargantuas in history's first officially recognized total Earth sphere warring for the world's economic and political supremacy. The integration of the new twentieth century science and technology during World War One resulted in entirely unprecedented magnitudes of technical advantage gains accomplished in all the fundamental capabilities of the worlds industrial networks.

As a postwar consequence of the major mobilization of the new industrial equation, brought about through realizations of the long suppressed scientific backlog, accomplished in World War I, the industrial advantage subsequently accruing in the domestic economy, as by-products of the munitions industry, had so increased that by 1919 6% of humanity, instead of the pre-War-One 1%, were enjoying the prevalently "high" standard and ever advancing physical advantages of the industrial network. By 1940 the percentage of the ever increasing world population that had now come to enjoy high standard industrial advantage increased to 20%. As a consequence of the again extraordinary advances of technology in World War II, and in the post World War II cold wars, we have now increased the numbers of those humans who are participating in the industrial network to 44% of the world's total population. (See Chart). C-4-7.

The foregoing are very extraordinary figures because the continually accelerating rates of increase in the number being served with ever higher standards of industrialization has occurred despite the evermore rapid increase in world population, concurrent with a continual decrease in the world metals per capita. The surprise rise in the number enjoying higher standards may only be accounted for by the fact that the increased ability of man and the increase in the number being served is an indirect consequence of our constantly doing more with ever less per given unit of resources, per given function.

Doing constantly more with ever less came from the world of seaborne, or airborne weapons. To persist as a "winner" in the game of world armaments a constantly accelerating evolution must be regeneratively initiated in specific improvements in performances per pounds of physical resources and per hours of scientific and technical expertise invested in a given task in order to be supreme in carrying the greatest hitting power the greatest distances in the shortest time, with ever increasing accuracy of aim and at ever higher degrees of energy efficiency.

The inception of the historical world around magnitude of seaborne and airborne armaments racing, and outright warring, began importantly

with steam driven metal ships, -a century ago. The most powerful ships formed what was called the first line of military defense of each of the would-be "leading" industrial nations.

In conjunction with the foregoing observations we also find that there is a fundamental and technical requirement in the building of ships which is unknown to builders of structures on the dry land. The unique requirement is that the prime structure, -the ship, has to float, i. e. to stay on top of the water. As Archimedes showed, we can only float as much weight as the weight of the water the ship displaces. Therefore, in designing a ship there is a specifically limited amount of weight to invest in each of the ships many and various essential functions. The essential functions are those which must integrate to structurally "best" the great forces of the sea.

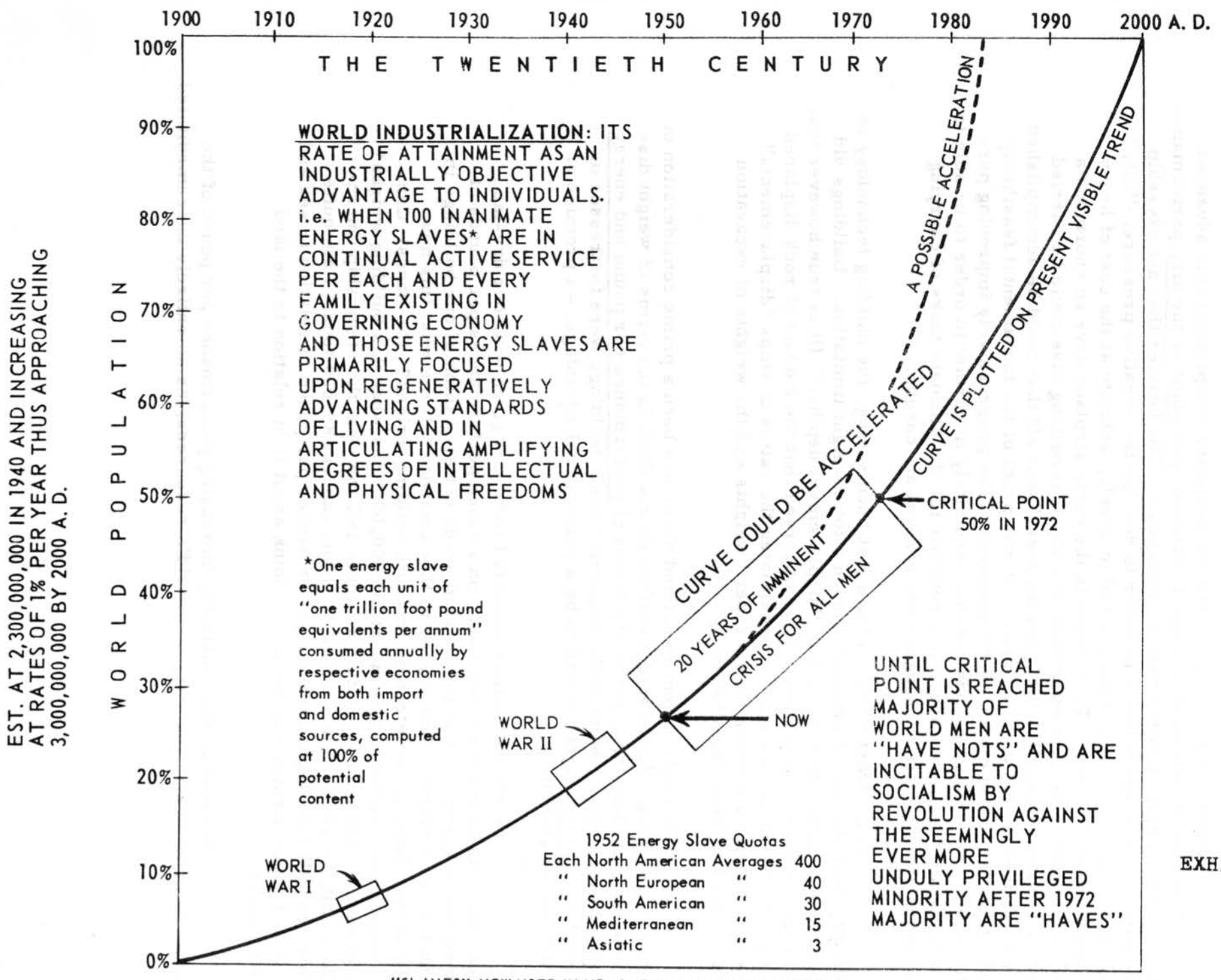
When great seas curl over and crash on the ship's deck, they do so with the force of an avalanche. The ship must best such an avalanche force.

The ship must continually best the flood.

The early sailing ships rather than being devastated by hurricanes exploited the hurricane to drive them through the seas, -they bested the hurricanes.

It was therefore of prior importance to invest certain amounts of the total displacement weight in the structural strength of the ships themselves and in their means of propulsion. It was also necessary to invest a certain amount of displacement weight in the carrying of the fuel, and in the carrying of foods for the crew. It was also desirable to invest in a large amount of cargo space (and therefore of additional weight), to make the trip worthwhile. It was often fundamental to invest in cargo capacity for replenishment and improvement of the home-port's ship-building industry resource, as well as to invest in cargo capacity for munitions and guns to protect the ship. The latter investment became, of progressive necessity, so great that separate escorting ships had to be built as the wealth generated by sea commerce brought the world battling for high seas domination to a point where the gun batteries became greater than those of land fortresses and were floated in fast maneuvering ships, -gun boats, cruisers and battleships.

As men became informed by their high seas storm and battle experiences they built continually improving ships, by continued improvement of the ratios of invested resources of weight and energy and time per given functions of essential ship performance requirements.



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FUNCTION OF NO. AMERICA: TO UP EFFICIENCY AND EXPORT SWELLING SURPLUS

EXHIBIT 3.

When the art, and industry of weaponry competition next advanced to a prime world command strategy fulcrumed upon ships of the air, performance per pound became of even greater importance. The heavier than air sky-ship required directional velocity in order to develop the negative pressure, -"lift," above its wingfoils. The airplane had to develop velocity at the cost of heavy engine and fuel weight. This meant in the early airplane days so enormous a weight of fuel to be carried through the sky that nothing else could be carried but the aviator himself. Just "getting there" was all that could be accomplished by a Lindbergh, but that was great. It was proof of the fundamental feasibility which in time could obviously be improved. The progressively improving performance per aircraft pounds became exquisitely important in order to be able to earn additional weight capacity increments for the ultimate tasks of carrying weapons and later air passengers and general air cargos.

In contrast to what I have just been saying, the building technology on the dry land was never predicated upon a total weight limitation. Buildings did not seem to sink into the earth to "displacement depths." (It is true however that in very recent years engineers have observed that the amount of rock displaced to get firm foundations often approximates the ratios of ships "displacements" as demonstrated between "skyscraper" weights and the weights of excavation removals for those skyscrapers.)

But displacement is not and never has been a prime consideration of dry land building - Architects therefore do not think in the terms of weight displacements of buildings, nor in the terms of performance per pound and energy expenditure ratios. Most of the important early buildings were fortresses or temples. Extra weight seemed to be a protectional advantage, —a promise of long lasting security.

For all the various reasons I have just given you, our dry-land building arts have never been based on ratioed performances per pounds of invested resources. For this reason we do not even think of our buildings in the terms of weight. Can anyone in this audience tell me what this new Zacatenco National Polytechnic Institute building weighs? (No hands) Can anyone in this audience tell me within 100,000 tons what this building weighs? (No hands) Can anybody in this audience tell me what the steamship Queen Elizabeth weighs? I am sure many of you can, yes 85,000 tons. I am quite sure you all have a good idea of performances per pound in relation to sea and air and space structures, but do not think about it in relation to the land structures.

Because of the constantly increasing performance per pound of the sea, air, and space weaponry the world's resources, as an entirely unpremeditated,

inadvertent, by-product event, are now beginning to serve more and more people with higher and higher standards of living, despite the fact that the resources per capita are continually decreasing.

This must all come to you as a surprise, because, as architects, and as people preoccupied with the non-weaponry mechanics and structures of the land, you do not tend to think tactically about performance per pound. However, had it not been for the ships, first of the seas and then of the air and now of outer space, whose technical design developments were financially subsidized in an enormous way, as the prime weapons of the most powerful nations, the world history of man would have been one of swiftly diminishing resources and capabilities leading to few survivors and possibly to early race extinction. However, the inexorably precarious survival of 99% of humanity; and the surprise riches occurring irregularly in remote overseas places; the narrow channeling of world trade routes by natural phenomena resulted in a universal lure to piracy of those sea lanes. Consequently a world weapons race was inspired by piratical ambitions. The pirates invented world around sovereignity patterns of prime-resources-and-harbors. The sovereignities were controlled locally by the pirates organized nation-al "Governments." Through their national "governments" the strongest pirates, competing for world supremacy, subsidized development of the naval land base technology. The competing nation's capital undertakings thereafter became the visible economic generators of history's progressive sea, air and space technology evolution. The top pirates always assumed that they could well afford to go to any part of the earth to get the right resources to fulfill the given functions, provided that those resources promised ever higher and often seemingly supreme performances per pound and effort whereby the rewarding world commerce riches would be handily won and secured. The top pirates' law became the law of the lands they invisibly controlled, by controlling the lines of world supply. Their subservient brigand kings on the land could count upon their master's, -the top pirate's, -line of supply to help them win any seige on the land. Problems between local brigand rulers and their sub strongmen or people themselves were resolved locally as in the Magna Carta, Bill of Rights, etc., but these did not obtain at sea. At sea the ships captain was supreme. And he was governed only by the grand masters of the seas.

As a consequence of all the foregoing facts of history we have today two utterly different levels of technology, the high performance and the low performance. The latter might best be called the indifferent performance arts. The high performance, and historically scarce, weapons producing arts are called, during wartime, the high priority arts. For every priority there must be an anti-priority and the anti-priority has always been applied to the land buildings or so called peaceful home arts. When troops and the best weapons are sent to the front, any kind of cover that keeps the rain off the people producing the metabolic and logistic support at home will do "well enough." This dichotomy between the science based high performance weaponry producing arts and the fortuitous, non-science benefacted, home front arts is responsible in a major way for the development of the great chasm noted by Sir Charles Snow that exists at present between the sciences and the humanities and their respective economic rewards in wage scales, and employment opportunity.

Because the various nations started in isolation from one another, each, driven locally by economic want, has seemed inherently "against" the other, particularly as whipped up and propagandized to feel toward one another by their pirate manipulators of the as yet very recent past. The master world pirates entered the limbo of the past in 1929 and though many of their servants, and servants' training schools as yet believe them alive, the old pirates are dead. The meek have inherited the earth. But the meek, being meek, haven't caught on to the fact that they are their own masters and keep throwing their new inheritance responsibilities over to their politicians who are fundamentally frustrated by utterly inappropriate and complex accounting and control procedures of the old pirate invented sovereignities. As a consequence there has never been an organized mutual effort of total man to make the total resources of the earth provide higher and higher performance, thereby directly purposing that all men on the earth should be rendered physically successful. On the contrary, each nation has been looking out for itself and each man within the nations has been looking out for himself and his family! Therefore the surprising and continual increase in the proportion of world humanity being served at ever higher industrial standards as noted earlier, cannot be attributed in any way, to any consciously organized effort of humanity to make the resources go further. It is in no way attributable to charitable gifts.

Forced to look elsewhere for an explanation, we find that the increase in the world's numbers who are prospering has been brought about, entirely by indirection and inadvertance, as the consequence of man's earlier heavy and prime subsidy of the weapons race evolution.

The high performance technology developed for the production of weapons comes progressively to levels of obsolescence -- for instance the premier type of submarine or airplane finally becomes eclipsed by competition and therefore becomes obsolete. Second grade weapons are worthless. The contractor who has been producing the now obsolete item often finds himself failing to get the next contract for the newer kind of weapon or tool. However, the ex-contractors are tooled-up with the powerful high performance technology - they can produce a great deal with very little - i. e. with high performance per pound. For these obvious reasons the ex-government contractors look around in the domestic market to find ways in which to exploit their super technical ability. The ex-government supplier thus brought the dynamo, originally developed exclusively for the battleship, into the city to light man's streets and the electric lights developed for the battleship came thereafter to replace the candles in our domestic candelabras, but the candelabras were not changed. The domestic economy was never made the comprehensive focus of generalized systems theory and the prime beneficiary of scientific knowledge. The high performance technology items were only progressively substituted for low performance items

within the overall low performance or indifferent performance of the total structural and mechanical scheme of the forever-fortuitous, land borne edifices. Parts became improved without improvement in the total concept of land borne technology. All of our television, our radios, our electronic developments in general, came out of the original weaponry development. We see millions of glistening metallic T. V. antenna sprouting above the roofs of filth festering, bathroomless, fire trap living shacks - the world around. Thus we find ourselves continually advancing in domestic technology, but only as the secondhand gadgetry, by-producted by the cast off segments of the weaponry industry.

Only because of what I in due course named the "livingry" vs. "weaponry" focused world resource studies, which I initiated a third of a century ago and have been conducting ever since, was I able to discover for instance the causal pattern and curve of comprehensive improvement and amplification of world technology which I described to you at the outset of my discourse. That pattern and curve have since been verified by others but it took the weaponry vs. livingry studies to bring them to light. I began to see in the min-nineteen twenties that this patterning of doing more with less in the domestic economy, as a by-product of government subsidized weaponry development, was occurring subjectively. I saw that it might be developed objectively to invalidate the Malthus concept of fundamental inadequacy of the world resources and Darwin's "survival only of the physically fittest." If so then I saw that man could abet this trend by development of design science competence. My insights were in consequence of my training in the U. S. Navy in World War I.

After World War I, I left the Navy and entered the building world where I developed a building technique that had been invented by my architect father-in-law. His invention was useful for building reinforced concrete structures in a novel and patentable manner. I organized five factories for the manufacture of his building components and built 240 of his structures in the Eastern half of the United States between the years 1922 and 1927. After having been in the very advanced technology of the Navy, and its new air arm, its new submarines, new electronics, etc., I became aware of the fact that the home arts, -our so called peaceful arts - the livingry arts, -were milleniums behind the weaponry arts and were only being advanced as a by-product of the high priority weapons race which latter weaponry entirely preoccupied our highest scientific and industrial potential by the supreme authority of our world commerce masters, -the only superficially peaceful progeny of the earlier master world pirates, and their land brigand henchmen. At the opening of the Twentieth Century the masters of world commerce were the inheritors of the world-command weaponry and the latter's evolution supporting tools, ergo the economic masters of world industry.

In 1927, I decided to take the initiative, and without benefit of a patron, to investigate what would happen; what could happen, if world society

or its industrial sectors were to apply the highest technology directly to making man a success on earth, -not waiting for the new technology to first serve the weaponry and a generation later to piecemeal upgrade the domestic arts.

There were no private, corporate or governmental patrons with inherent need and mandate to underwrite my investigation. No government existed anywhere that said, "I will employ you and continually foster your attempt to make all world men successful exclusively through design science competence." No sovereign governments existed which represented more than a small percentage of "all" people. Governments will only patronize defense of the enterprise of their own respective nations' promulgations. No corporations were interested in all men. -- There were, -and are as yet, -no capitalized patrons, even amongst the great foundations, chartered to underwrite such a comprehensive undertaking. I was convinced however, that the proposition was worth investigating, so foresaking the a priori concept of "Earning a Living" I began the investigation in 1927 on my approximately zero capital.

I soon found something that I will now announce to you as holding true, right up to this minute in history -- that is: That no scientist has ever been retained, or hired professionally, to consider the scientific design of the home of man; -to consider objectively the ecological pattern of man; - to design ways of employing the highest scientific potential, towards helping man to be a success on earth; - to implement total man to enjoy total earth; - to enjoy the great antiquities, - each to enjoy the total earth without cost of disadvantage to any other men. No scientist has ever been retained to do such a task. Paradoxically we speak of our times as the age of science.

Many scientists live in houses -- they look at the plumbing, often find that the plumbing isn't working, twiddle the knob and send for the plumber. You know as architects that you do not design the plumbing which you buy. You design the superficial use and arrangement of fixtures which are designed by non-architects, and manufactured by commerce for you. You are free only to choose the coloring of the bathroom tiles and the coloring of the fixtures. But what goes on back of the bathroom tile is not part of the architectural design. Even if you studied "plumbing" and detailed the plumbing pipe layouts, your design would not be followed or even looked at. The layout would be as dictated by the plumbers' scientifically illiterate craft code and frequent whimsy.

The fact is that the plumbing system, and the sewer system, and the aquaduct system, have not been importantly changed for 4, 500 years. Only one improvement in the system was made, 100 years ago, in England. That was the development of the roof vented plumbing stack and water seal in plumbing fixtures, to keep the sewer gases from entering the house.

In contrast to the home arts let us look at the space rocketry world. At the present moment, we have the enormous, major-governments subsidized, weaponry-race into space undertaken by both Russia and the United States. In order to be able to put a man into space - to stay in space, not to make a few orbits - in order to have man in effect, live continuously in outer space for weeks and months and possibly years, we have to solve scientifically the problem of mastering the ecological pattern of the human being and the metabolic pattern of the human being. We have to realize that the energy events that take place metabolically in supporting man ecologically on Earth involve energy transforming functions of trees, worms, water, sunlight, the slowly forming top soil, et al. The delicately balanced pressure and heat of energy exchanges and chemical transformings involve very large ecological domains to complete the cycles of a man-supporting-environment process on earth. We are going to have to compress the total ecological domain of man from approximately a one mile radius process into a ten foot radius process. We are going to have to reduce the total volume of energy transformation patterning several millionfold. In order to be able to send that man off into space, we have to scientifically anticipate and effectively service all his processes and psychological reflex requirements. In order to be able to do that, we are in effect, building a little house, a little space house. We had been used to the word "capsule" which has hidden from man the fact that what science is really working on is a little house; not much room to move around in, no garden of roses outside, but nonetheless, a little house with a six billion dollar mortgage.

In this strange battle of man to anticipate offensive-defensive weaponry battles in the cold warring, the battle to attain the moon, or protracted living upon a platform in space, has brought about a race in capital funding initiatives between Russia and the United States specifically in relation to this little house, amounting to 6 billion dollars. This staggering amount is now appropriated to hire scientists to go to work to design and produce one little sky house, the first scientific human dwelling in history. It must be capable of sustaining man as a metabolic success anywhere in universe. It won't be a very charming little house - it won't be "good architecture" by "traditional" a-la-mode aesthetics - Above all I want you architects at this Seventh World Congress of the I. U. A. to realize that what the space scientists are working on is in fact the design of a house: -- that is architecture-- the scientists are in your business competing with you in the solution of all the problems that a house for regenerative man involves. It involves every one of the fundamental principles ever discovered by man in universe. The scientists are attending to the dwelling problems that you have failed to attend to or have left to someone else to solve.as for instance to the plumbers. When the prototype moon dwelling and its space autonomy mechanics are developed, and it has been satisfactorily test orbited for 100 days, and that house has finally taken man successfully to the moon, or to a space platform, there to dwell for months, then we will have history's first, scientific, semi-autonomous dwelling. In that sky dwelling we will have the energy exchange processes, internal and external to metabolic man's ecology, becoming locally regenerative.

The process and its scientific tooling and instrumentation must become locally regenerative on an extraordinarily satisfactory basis before we shoot man to the moon or into protracted space orbiting. We are not going to pick the finest, healthiest world specimens, the best coordinated human specimens we have and send them off into space, to live in some highly inadequate and swiftly deteriorating condition. All the world will be hooked up by T. V. to observe the details of man's first home life in the sky. The technology will have to be developed superlatively before we shoot man to the moon or sky platform. This means that the problems will be solved on Earth and not in the sky. The mechanics of solution will be produced here on Earth. The establishment of this capability here on Earth also is going to make possible a very different kind of dwelling technology right here on Earth. We will no longer have to have water pipes and sewer systems, mankind will suddenly start mass reproducing the space-house prototype's pipeless, wireless, trackless ability to deploy man around the earth's surface as well as in space. Man will be able to take position anywhere on the face of the earth, as an eagle takes firm, safe poise on his beautiful mountain peak vantage, with man able to readily reach such points by rotoflight and able to survive at such remote, spectacular points at very high living standards, comfort and low cost with swift ability to reconvene in cultural centers, etc.

I know that what I am saying to you, as architects, may at first make you uncomfortable, but I want you to realize that this is what is happening. I am trying to make it clear to you that for the first time in the history of man on Earth, we are actually applying the highest scientific capability to that extra terrestrial space dwelling, underwritten, inadvertently and exclusively, by weaponry supremacy ambitions for celestial control of world fire power. This celestial supremacy involves however an unprecedented weaponry system requirement, that of making man a successfully, semi-autonomous, biological intelligence system, remote from earth, where he will be unable to survive normally by himself, as detached reconnaissance soldiers have been able to do in all previous history. A surprise event thus entered into the age old weaponry system evolution the significance of which has not been as yet publicly nor politically apprehended or comprehended.

It is however uniquely important for us as architects to comprehend that surprise event, and at the earliest possible moment, if architecture is to play an important role in man's future. We must therefore take a quick look at the theory and history of weaponry systems. When man first picked up a heavy stick and used it as a club - "weaponry systems" were invented and were also ultra simple. When man discovered that he could use one kind of stone as a tool to make other kinds of stones into heads for arrows and spears weaponry systems entered their first phase of anticipatory, -vs. fortuitous, -design science complexity and comprehensivity. Gradually, spurred on by ambitions for victory at war and its rich spoils, a few men began to make capital risks of time and resource investments in order to develop tools that promised in due course to make weapons superior to those which could be made with man's bare hands. The investments paid off. Then man

began to make tools that made superior tools that in turn made super weapons. Weaponry systems finally came to embrace the whole complex of tools-to-make-tools-to-make-tools (to high exponential degree) with which in turn finally to make, support, supply, maintain, mount and use the weapons in warfare. Obviously, weaponry systems came to embrace many tools that can and frequently are applied secondarily to peaceful purposes. The whole family of industrial tools thus came into being. Along with weaponry systems there developed a necessity for minimal housing to protect the men who operated the tools and the weapons or fought with the weapons. Unlike the high performance tools-to-make-tools the housing was always kept at a bare survival minimum and was fashioned only of surplus materials unwanted in the high performance structures and mechanics required by the weaponry and the tools-to-make-tools. Tentative, "tents," - barracks, weather "sheds" and latrines were sufficient to implement production, maintenance and forwarding of weaponry to the "front." No scientists were assigned to the housing phase of weaponry systems. We may say that all weaponry up to this moment in history has been designed primarily to kill men with maximum scientific skill.

Here we discover the as yet uncomprehended surprise. Now for the first time in history the space weaponry race has forced the weaponry system directors inadvertently to design a means of housing and servicing men (or women or both) anywhere in universe which means under vastly more difficult conditions than on earth and, because of the superman requirements of the service, at a higher standard of satisfaction of living fundamentals than any men have every known.

Tents won't do in airless space. If you spit in space the spit goes into orbit and you retro-orbit. There is no sewer system in space. There is no gravity to pull matter down the drain. There are no water supply lines, no electric wires, no supermarkets. Because of the completely unearthly conditions within which our men at the new space-front have to operate, science has now been invoked for the first time in history to "enshrine: living man." That is the surprise!

Science has always been a complex of independent and subjective economic slave disciplines, primarily concerned with the harvesting of information, rather than with the practical application of that information. To provide the unearthly sky dwelling for our celestial-fire-power soldiers, science has at last been brought to bear objectively and integratively upon the generalized problem of converting man's combined ecological and metabolic patterning in universe from a random matrix of happenstance interferences, of unknown miles of overall dimension, into a compacted metabolic coordinate system of high certitude of controllability - ergo a local ecological success under approximately

any conditions other than those of falling into the sun or other stars. The sky house man must be made capable of taking position at will, either by interior or remote control, approximately anywhere in the dynamic intercoordination of physical universe. Yet, by virtue of entropy, that is of inherent local loss of energy of all local systems in universe, the sky house may not be perpetually independent and self-regenerative. It is ultimately dependent upon the good will replenishment of that local and remote ecological system by the organized energetic activities of other men acting both as individuals, and as vast teams, coordinated under the predominant will of organizations of men on earth.

In marked contrast to the foregoing super functionalism of the space dwelling machines, in our world of earthian architecture we are prone to over think of the appearance of things. This superficiality seems to be a fundamental characteristic of architecture. As a consequence society in general speaks of architecture, -(without much thought of what it is saying), primarily in terms of the sculptural, modal and monumental aspects of buildings. Despite anything that you architects wish or feel to the contrary, society reflexes, popularly, in respect to buildings, in two distinct ways; one: - How and why do the buildings stand up and work? And: two: - What do they look like, (feel like, smell like and sound like)? The man in the street has been conditioned to assign the first set of problems to the engineers and the second set to the architects, - (but neither, ever, to scientists).

During World War One the conditions governing this popular reflexing began to change (even though the popular reflexing continued unaltered and unabated). The advanced technology went from wire to wireless, from track to trackless and from visible to invisible structural logic. The latter came with the development of the alloys in World War I. Alloying was a great secret development of World War I and became the clue to highest technical advantage in World War II. With the development of metallic alloys, man suddenly became able to do much more structurally with less chemical matter. There are available commercially today aluminum alloys which make it possible for us to consider four test billets of aluminum alloys, each of which is one inch in diameter and twelve inches long. Each of the four examples are available from commercial stocks: The first one will have an, -inferior, -tensile strength of 8,000 pounds to the square inch; the next one will have a tensile strength of 16,000 pounds to the square inch, which is twice as strong as the first; the next one will be twice as strong again, that is 32,000 pounds to the square inch tensile; the next one will be twice as strong again, 64,000 P.S.I. tensile strength, - a fourth power gain over the first sample. These four samples of the aluminum alloy cannot be told one from the other by the best metallurgists when employing only their integral naked senses, - that is by looking at them, smelling them, listening to them or touching them. The strength difference is invisible and can only be discovered by use of instruments.

With the alloying in World War I, the fundamental differentials in structuring capabilities went into the realistic but invisible physical realm. Up to the time of World War I, we thought that the strong structures were those structures which we could see to be obviously massive or muscular, ergo strong; a good thick stone wall provided an obviously very strong building. Men prized "deep reveals."

Since World War I, however, all the advanced technologies of man have departed from the sensorial ranges of the frequency spectrums into the non sensorially tunable ranges of the electro-magnetic and other wave spectra. The invisible ranges begin with the ultra violets, and the infra-reds in the twilight zones adjacent to our sensorial ranges of direct tunability.

At the present moment in history all the nationally funded, advanced, scientific and industrial technology is being conducted in realms of the universe that are invisible to and comprehendingly untouchable by man. I can say to you that 99.9% of everything that is important in our world of high performance technology is now invisible. This invisible world can only be dealt with by the scientifically disciplined mind operating through mathematics and instruments. Only the world of architecture, the world of the home arts, - the low performance, - the so-called peaceful arts, - are as yet preoccupied with the sensorial surfaces of things. That is one reason why the kind of information that I have been giving to you today must come, despite your collateral reading, as somewhat of a surprise, probably a shocking surprise. It is a surprise because this historical rearrangement of values-criteria is in itself both invisible and often times secret and has come upon us without sensorial apprehendibility.

I am going to show you some slides and recount to you experiments that I have been conducting for over a third of a century. I made these experiments in the course of an attempt to test the feasibility of applying the highest capabilities of world developing technology directly to problems of man's environmental controlling and to application of the advantages of highest industrial productivity, distribution, and communications systems, to bring about man's direct and immediate living advantage.

I undertook this experimental exploration because I was, and as yet am, convinced that it is possible now for us to take the design initiative, not waiting for patrons to tell us to go to work and thereby freeing ourselves for the scientific designing of a successful "livingry system" for man in universe. As I pointed out earlier there are no patrons with free capital initiative who are concerned exclusively with world problems. However there was nothing fundamental to stop the Wright brothers from considering the use of all the sky surrounding the Earth and all the technical knowledge accrued to mankind and

all the developed resources of the Earth in their invention and development of the airplane. Their province was inherently transcendental to sovereign nations and political theories and their victory effected all men everywhere. Within ten short years the two Wright brothers did more for mankind, --by bringing men to their collective senses and by bringing men together around the world to witness one another's ways of life and one another's individual integrity, thereby to understand each other, --than all the politicians have been able to do for man in all the milleniums of history.

Employing ourselves, taking the initiative, it is quite possible for us to consider, at least theoretically, and to plan in all important ways the redesigning of the use of the world's total resources in order to employ those resources, --by comprehensive, anticipatory, design science, -in such a manner that 100%, rather than the present minority of 44% of humanity can enjoy higher physical success than any men now or before us have ever known. The problem's feasibility studies which I have conducted for a third of a century make it thoroughly clear that this comprehensive livingry system for man can be accomplished. However, if we wait for it to happen, as a secondary effect of the weaponry race, operating exclusively under prime political initiatives we will have to wait a whole generation longer than will be necessary if we as architects now take the initiative in bringing this about through our consciously organized design science applied directly to the refocusing of science and technology from weaponry to livingry realizations.

I want you to realize that the laissez-faire process and its one generation slower by-products means the accelerating reoccurrence of political crises after political crises all apparently invoked by evoluting nature to force us, through dilemna adopted expediences, to yield compromisingly inch by inch from our inertia of "let well enough alone", thus fortuitously establishing, under each emergency, further increments of technical advances until we have finally, grudgingly and ignorantly, acquired a level of technical efficiency adequate to provide high standard physical living for total man; --which was always subjectively implicit and objectively inevitable because of the presence of intellect in physical universe. Entropy is the name given by the scientists to the inherent loss of energy by machines or local systems of universe in general. The scientists speak of entropy as the "law of increase of the random element." Nature balances positive matter by negative matter. Differentiative and integrative intellect, anti-entropy present in man, operates to coordinate entropy and anti-entropy within the comprehensive inventory of non-simultaneous, complementarity of interrelatedness, of an evolutionarily transforming, physical universe.

The mandates of the world's separately nationalized societies, acting exclusively through their respective national leaders, command the separate leaders to protect only their respective sovereign and unique positions. Even treaties with allies seeking mutual survival protection must be effected by the leaders own initiative and be subject to ratification by the people or the peoples parliamentary representatives. The only spontaneously mandated authority the present political leader has, is to channel the highest technology directly into weaponry systems' production to keep his nation in highest possible hitting-power advantage. Exploitation of any and all domestic needs are claimed by private business to be their inviolable domain which if invaded by government would constitute "socialism," the outworn, now obsolete, but certified vote-getting super scare-crow of the last century's politics. Under present laissez-faire and political vote-getting expediency processes, we will have to wait for the, generation tardy, second-handing of technology into piecemeal domestic improvements.

I have said that what we have here is first a problem of our own personal initiative and secondly a problem of design science. Since 1927 I have myself experimented, as an individual and more or less on behalf of the architectural profession, with taking the design science initiative. In doing so I have learned that I can carry on successfully as an individual, --and quite transcendentally to politics. Only the 1930 depression communists said that in view of 1929's seemingly irreparable crash of capitalism that I could not get on without political support and particularly of their brand. I have proven that I could. No other political parties have questioned my independent initiative. I assure you that you too will be able to carry on successfully — by the use of design science, transcendentally to, and unprotested by, politics and will probably be honored in due course by all political parties. I have been able also to measurably alter some of the relationships of man to his environment, thereby giving man measurably increased advantage over a priori conditions. I can therefore assure you that design science will work even more powerfully through your joint use of it. You will develop synergetic advantages.

As a total consequence I am quite confident that if we, as world architects, take the initiative in communicating with each other, as effectively as we know how, regarding our total resource positions, and regarding our estimates of the world's needs, and the problems to be solved, that we can develop at least a theoretically desirable model of the way in which the physical world may be made to work satisfactorily for all men, a model so attractive and so transcendental to political idiosyncrasies, yet so mutually desirable to the common aspirations and needs that it will be adopted in the course of forward emergencies, by the world, --bringing man to full physical survival success a

generation earlier than by the present inadvertancy timetable. Instead of the present slow progress in fearfully undertaken negative agreements to give up weapons - your model will provide a positive technical advantage adoption vs - power relinquishment. When you have, by your model, taught the world to see its problem and the clearly designed model of its solution - the world, weary of its artificially induced dilemnas, will suddenly vote for your LIVINGRY, forsaking the obsolete KILLINGRY, as the prime, commonwealth regenerating, preoccupation.

I developed a fundamental philosophic concept in 1927 which was that it is possible instead of trying to reform man - to reform the physical patterns, to reform the environment in such a way as to make the physical environment patterning more favorable to the new life being born into it. It seemed possible that the new human generation, born into the streamlined environment, might quickly react by re-employing the newly designed advantages and in so doing might establish a new level of integrity of human response to environmental stimulii whereby society might come to act in creative spontaneity to continually convert the highest knowledge born of the cummulative experience of man toward the direct enhancement of the life processes; instead of, as at present, leaving the prime social initiative for the weaponry exploiters, who derive their mandate only from the negative fears, born of ignorance and the congealing inertia of that ignorant fear.

At the last world congress of the International Union of Architects in London, I was given several opportunities to speak for a total of thirty minutes and I commented and proposed as follows:

> The architectural profession is not a wealthy profession, yet it has an extraordinary altruism and sense of responsibility. It is not a practical matter for architectural offices to invest their time, unpaid, in research and development work. However, the architectural profession controls the curricula of the architectural students in the universities around the world. Wherefor: - The world architects, - through their control of the professional accrediting boards visiting the university architectural schools and ruling on the universities' respective privileges to give architectural diplomas of varying degrees, - have the power through unanimous resolve to command the universities to allow the architectural students to invest a substantial portion of their curricula in conducting a joint, design-science problem with all the other world's architectural students; - undertaking thereby to re-design the use of the world's total resources in such a manner as to make those resources now engaged exclusively in the service of only 40% of humanity adequate to the effective service of 100% of humanity at higher standards of living than any men anywhere have ever known despite a continually decreasing inventory of metals per capita.

You might like some examples of the ways in which that could be done.

In the first place, if you are not familiar with the world of metals, you might not be familiar with the fact that our metals do not go down a one-way street. When I was young, I was brought up with the idea that we could and probably would use up all the world's iron. I was brought up to think that after we finished using something made of iron that the iron went into the trash heap to rust away to dust in the city dumps and could never be used again. The fact is that it came as a surprise, even to world industry, in the nineteen-thirties of this twentieth century, that all of the metals are continually being melted up and recirculated. For instance, out of all the copper mined in all the history of man, only 14% is not at present in an averagely recirculating twenty-two year cycle of use; and the 14% which is not in present recycling use is now in munitions ships lying on the bottom of the ocean. We know where that copper is, and in due course, it will be brought back into use, and within two decades, as much as 98% of all the copper that has been mined by all man will be in continual re-circulation. The recirculation of the entire copper inventory of man, as well as approximately all the other metals, occurs at an average rate of every twenty-two years.

The chief engineer of the American Telephone Company was able to state to me in 1935 that while the telephone company had so much copper in wires and dynamos, etc. the telephone design science was increasing the messages per cross section of wire so rapidly (going for instance from one message to twenty-eight and then to a thousand per given cross section of a copper wire circuit and finally from wire to wireless), that the telephone company is continually increasing its copper scrap inventory out of old and obsolete equipment. He said, therefore, that the telephone company would not have to buy any more copper or take any more copper out of the mines in order to expand the telephone service from serving only the population of the United States, to serving all of humanity, at an equal per capita frequency of high standard communication. The American Telephone Company's chief engineer went on to say that the company's copper resources, either in use or in scrap, were in such constant surplus through improved performance per pound that the company would be continually selling excess copper while expanding its service from a domestic to a world service without, in effect, having to buy any more copper. It would he said, however, be commercially more feasible to buy new wire and sell scrap due to the non matching of the geographical operations of scrapping, bricquetting, smelting and fabrication operations.

Sixty-five per cent of all our steel is now made out of scrap. That is very roughly the ratio of recirculating metal to new mine production metal in all of the metals categories. It is perfectly practical to think about taking the

metals out of obsolete automobiles, taking all the two-ton automobiles off the road, melting them up and making twice as many higher performance one-ton automobiles from the same metal. You may say that you don't want more automobiles -- that: -- the parking problems are too great. In speaking of automobiles I have chosen an industrial tool that you are familiar with. I am not advocating more autos. I am simply considering the feasibility of the principles involved through which we can, by design science, take care of twice as many people in a given function with a given obsolete scrap resource. I have learned by experience that it is possible and feasible for the world of architectural students to undertake an amplification of the functional effectiveness of the world's resources through design science.

I realized a year ago, from my own experience, and from the frustrated attempt on the part of enthusiastic architectural students in various schools around the world to get going with the world redesign, that it is not going to be a practical matter for the world's architectural students to take a world inventory of resources as well as an inventory of all the trend patternings and needs of men in order to learn how to reorganize the designed use of the total resources to highest advantage. Such economic intelligence harvesting is not within the present training or even the extra-curricula experience of architectural students.

On the other hand I have had extensive experience in making such inventories - in 1936 - for the world copper industry, in 1940 for FORTUNE Magazine, and in 1943 for the United States Board of Economic Warfare. Therefore I have undertaken with the help of Southern Illinois University and the assistance of my colleague, John McHale, to prepare for this congress and for the world architectural students, a very complete inventory, not only of the world's resources, but also of the patternings of men's trendings and needs.

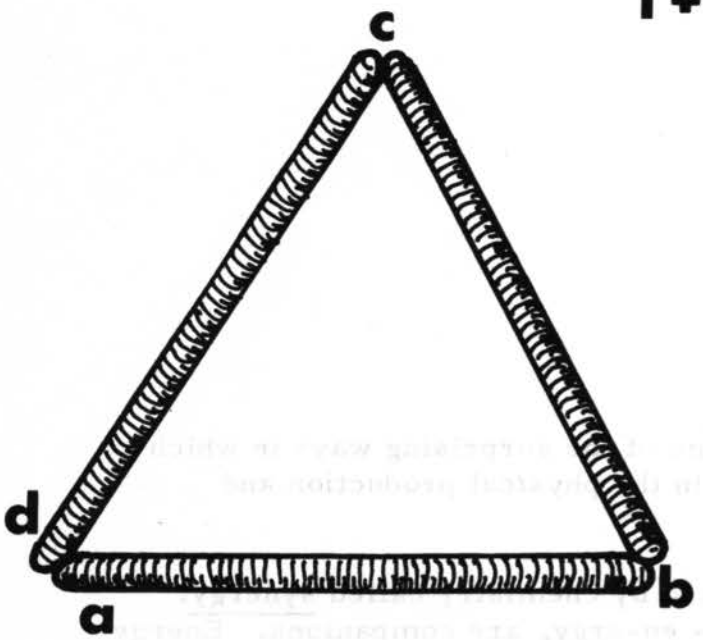
This inventory has been completed and printed in book form. I am quite confident that as of this congress, the world architectural students program can go forward for we are distributing the world inventory books to all the delegates of the countries who are attending this Seventh World Congress of the International Union of Architects. There is a world architectural students' organization similar to the senior professional organization of which we are now members. The world architectural students had a meeting in Barcelona this year and asked me to be their speaker, and as a consequence of so speaking and outlining the world resources redesign program I received their affirmation of their enthusiasm for the task. The resource inventories will be dispatched to the world architectural student organization.

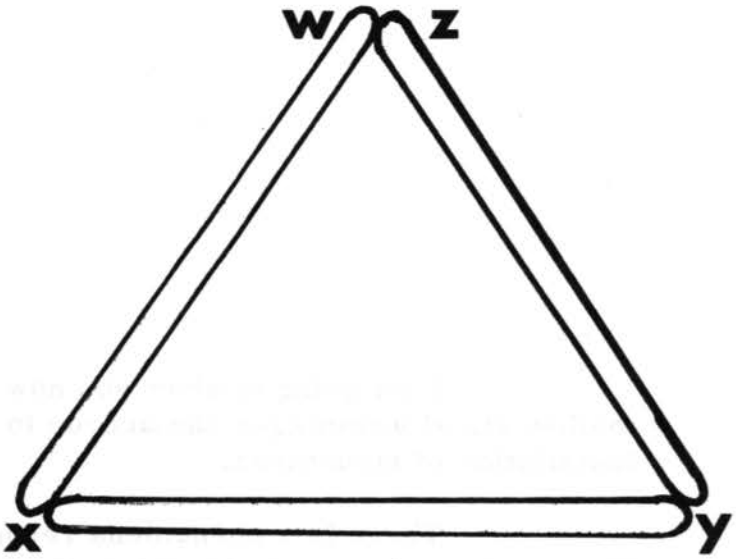
I am going to show you now some of the surprising ways in which mathematical advantages can accrue to us in the physical production and installation of structures.

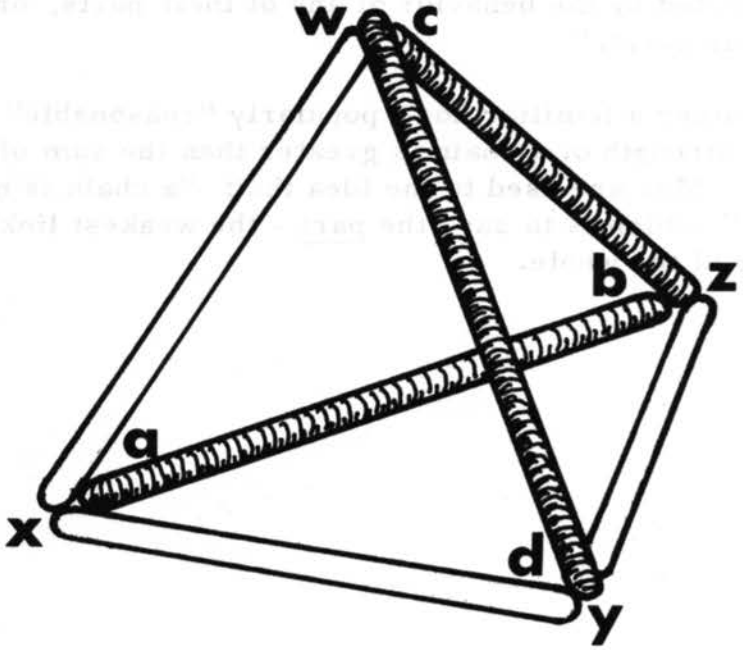
There is a phenomena recognized by chemistry called synergy. The word syn-ergy and the word energy, - en-ergy, are companions. Energy studies are familiar. Energy relates to differentiating-out the separate functions of nature, - studying objects, isolated out of the whole complex of universe; - for instance, studying gravity, without consideration of hydraulics or of plant genetics. But synergy represents the integrated behaviors instead of the differentiated behaviors of nature. The word "synergy" means "behaviors of whole systems unpredicted by the behavior of any of their parts, or the sub-assemblies of their parts."

This is neither a familiar nor a popularly "reasonable" kind of thought i. e. "that the strength of a chain is greater than the sum of the strengths of its separate links." Men are used to the idea that: "a chain is no stronger than its weakest link," which is to say, the part - the weakest link - will prophesy the behavior of the whole.

1+1=2





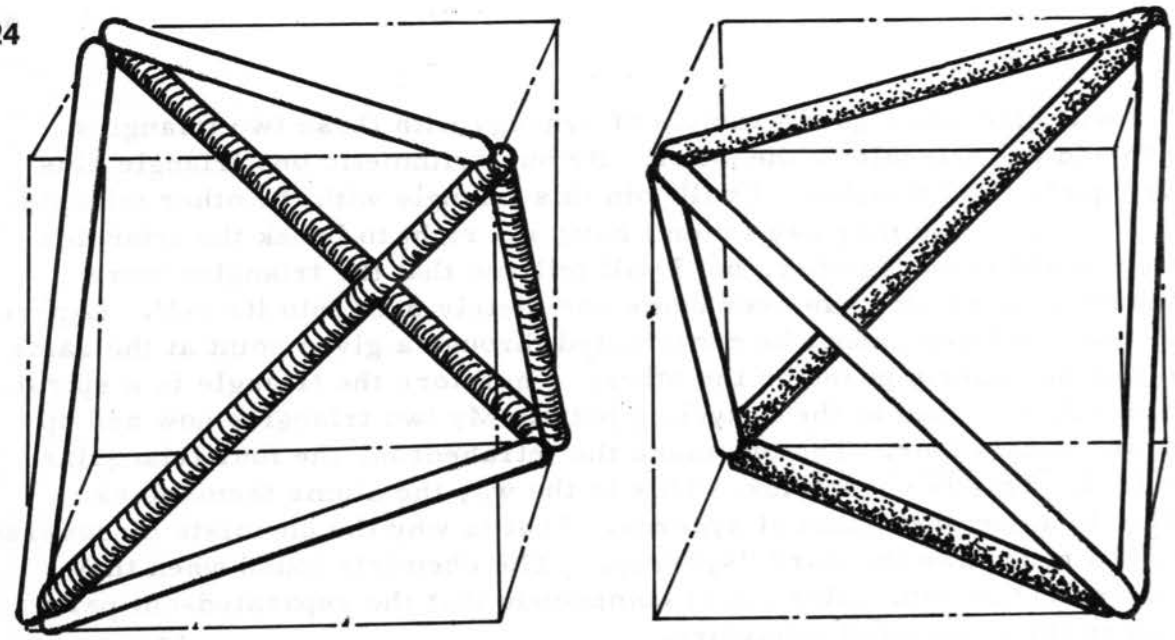


D-1-129

1+1=4

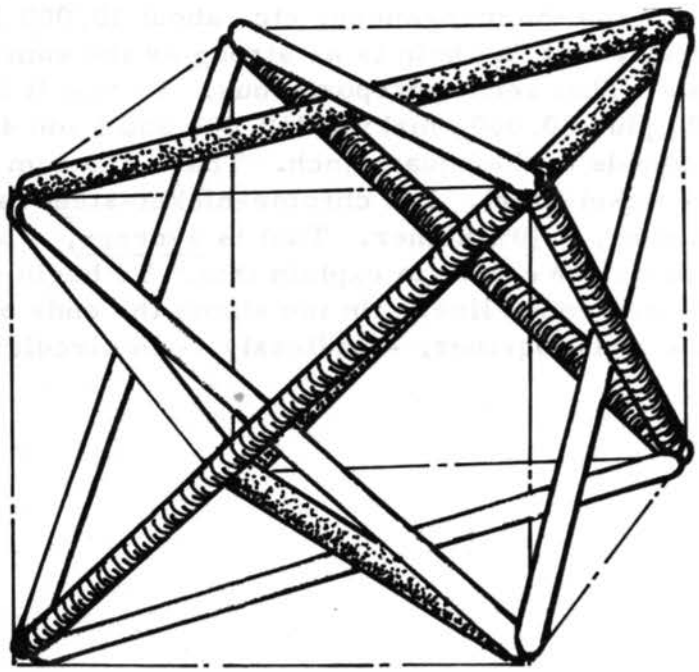
I will give you a good example of synergy with these two triangles. I am going to add one triangle to the other. By our arithmetic one triangle plus one triangle equals two triangles. I will join this triangle with the other triangle. (D-1-129) You may say I didn't have any right to break the triangles open in order to add them together, but I will tell you that the triangles were never closed because no line can ever come completely back into its self. Experiment shows that two lines cannot be constructed through a given point at the same time. One will be superimposed on the other. Therefore the triangle is a spiral -- a very flat spiral, but open at the recycling point. My two triangles now add up as one plus one equals four. The two make the tetrahedron, the four, triangular side, polyhedron. This is not a trick. This is the way the atoms themselves behave. This is a demonstration of synergy. That is why the chemists discovered that they had to recognize the word "synergy." The chemists found when they separated atoms out, or molecules out, of compounds that the separated-out parts never explained the associated behaviors.

Synergy alone explains metals increasing in their strength, as did the aluminum alloys of which I have spoken. A very good example is chrome-nickel-steel. The unprecedented structural stability at super high temperatures of chrome-nickel-steel has made possible the jet engine, - one of the reasons why the earth has swiftly shrunken. The primary constituent metals of chrome-nickel-steel are chromium, nickel and iron. The subsidiary or minor constituents of the chrome-nickel-steel are carbon, manganese, etc. Iron at its highest commercially available tensile strength is 60,000 pounds to the square inch, i.e. (P.S.I.); - the chromium, 70,000 P.S.I.; the nickel, 80,000 P.S.I. The sum of the strength of the carbon and the manganese, etc. about 40,000 P.S.I. I am going to say hypothetically that "a chain is as strong as the sum of the strength of all of its links." That seems preposterous. To test it I add 60,000 to 70,000, making 130,000 plus 80,000, making 210,000 and I add 40,000 more giving a total of 250,000 pounds to the square inch. That's the sum of the strength of all the links of chrome-nickel-steel. But chrome-nickel-steel has a strength of 350,000 - very much higher, - 40% higher. That is synergy, - behavior of a whole unpredicted by its parts. We have to explain this. To begin with, chains in metals do not occur as open ended lines. In the atoms the ends of the chain come around and fasten the ends together, - endlessly -- in circular actions.



(D-1-130)

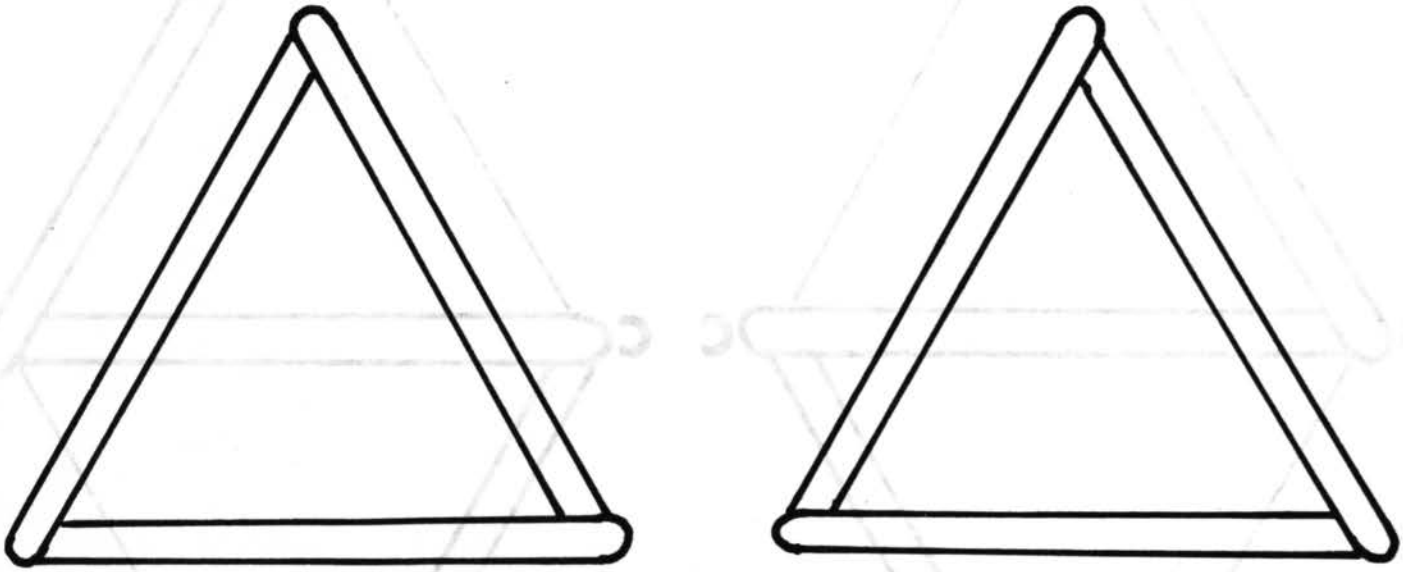
When I break one link of a circular chain continuity, it is still one piece of chain, and because atomic circular chains are dynamic, while I am breaking one link the other is mending itself. Our metal chains are also interweaving, spherically in a number of directions. We find the associated behaviors of various atoms complementing each other, so that we are not just talking about one thing and another one thing, but we are beginning to get something like this tetrahedronal structure that I give you here. (D-1-130) I bring two tetrahedra together that have a common center of gravity. They make a cube. (D-1-131)



(D-1-131)

1 positive tetrahedron
+ 1 negative "
= 1 stable cube

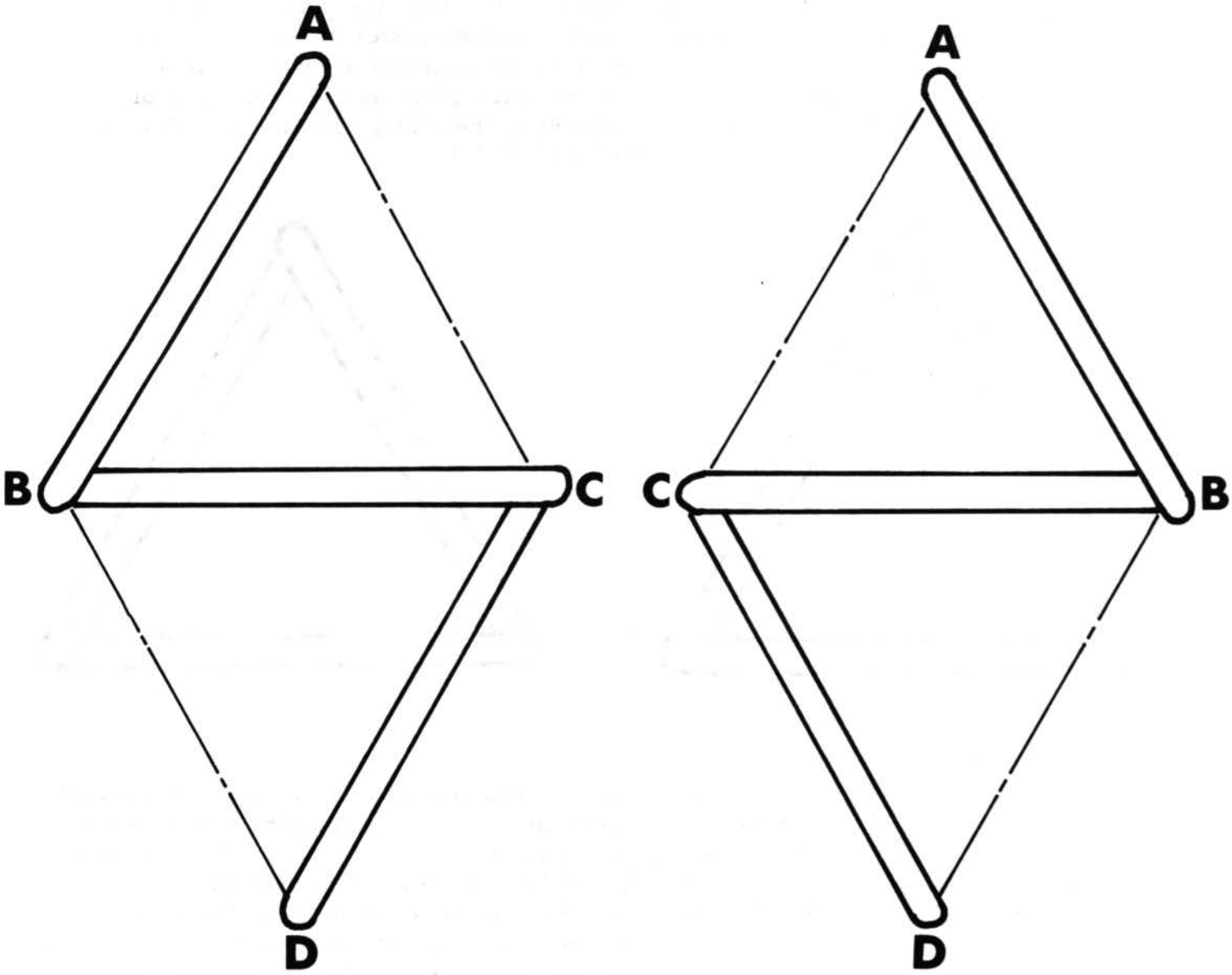
Instead of having four stars and four other separate stars, I now have eight stars symetrically equidistant from the same center and from each other. All the stars are nearer to each other. The stars therefore attract one another, gravitationally in the terms of the second power of their relative proximity, in accordance with Newton. So it is no surprise to suddenly discover that the closer inter-association of the energy stars gives us a four-folding of the tensile strength of our strongest component of the alloy, chrome-nickel-steel of 350,000 P.S.I. in relation to nickel's 80,000 P.S.I.



(D-1-132)

Again I have my two triangles: one red and the other green. (D-1-132) And you see the red one is spiraling like this and the green one spirals in reverse. I am going to take the red and green spiraling triangles apart again. Now we have an open affair. One of the ways in which men have been fooling themselves as I told you earlier is to say that "lines can go through the same point at the same time." We find operationally, physically, that lines cannot go through the same point at the same time - one is superimposed on the other. Therefore we do not have any such thing as a closed triangle in a plane; all triangles are merely spirals, very flat spirals. There are no planes. Triangles are inherently open. Once you realize that triangles are <u>open</u> you are going to find many open positions of the triangle. This kind of triangle position is wide open. Look at it carefully -

it has a diamond shape with two invisible edges. You can imagine a line in here between A and C and you can imagine a line in there between B and D. (D-1-133)



(D-1-133)

Because I have a diamond I have two triangles but they are both unstable because both of them are two sided triangles. What I do is to take this unstable triangle and add it to the other unstable triangle. What happens is that the visible edges of one fill in the invisible edges on the other. We found earlier that the potential of two triangles which really existed in each single open triangle, each of which we had previously thought mistakenly of as only one triangle, combined to make one whole stable tetrahedron, - which in turn disclosed the four stable triangles.

Mathematically, there are very important concepts about this tetrahedron. The tetrahedron is made up of four triangles. The angles of each triangle are inter-stabilized. Each of the separate angles which as such were originally amorphous, - that is unstable, became stable because we went out on the edge of each triangle, - each edge of which is a lever, - to the ends of the levers, and there with minimum effort, we controlled the opposite angles with a push-pull opposite edge vector. The triangle represents the means by which each side stablizes the opposite angle with minimum effort. The triangle is the fundamental function of structure but it takes two functions, - the positive and the negative to make a structure. The tetrahedron is the simplest structure known to man. The triangle exists operationally only as a positive or negative function of a polyhedron. Of all the polygons only triangles are structurally stable. Try a square with rubber joints, it folds up. Try any other rubber jointed polygon - it will fold up - try a rubber jointed triangle, it won't fold up, it is stable. If we want to have a structure, we have to have triangles and to have a structure also requires a minimum of four triangles. A structural system may be symmetrical or asymmetrical, but it always has a withinness and a withoutness. A structure divides the universe into two main parts - all of the universe that is inside and all the rest of the universe which is outside the structural system. We find there are only three types of fundamental omni-triangular, symmetrical structural systems. We can have three triangles around each vertex of a symmetrical structure, this makes a regular tetrahedron; or we can have four triangles around each vertex, - this makes the regular octahedron. Finally we can have five triangles around each vertex which makes the icosahedron. The tetrahedron, octahedron, and icosahedron, are made up respectively of one, two and five pairs of positive-negative function open triangles. We can't have six symmetrical or equilateral triangles around each vertex, because the angles add up to 360°, - thus forming an infinite edgeless plane. The structural system with six equilaterals around each vertex never comes back upon itself. It can have no withinness and without-outness. It cannot be constructed with pairs of positive-negative function open triangles. In order to have a structural system it must return upon itself in all directions. If the system's openings are all triangulated it is structured with minimum effort. There are only three possible omni-symmetrical, omni-triangulated, lease effort structural systems in nature. They are the tetrahedron, octohedron and icosahedron. When their edges are all equal in length, the volumes of these three structures are respectively: one; four; and eighteen and two-thirds (approx.).

In the tetrahedron we get one unit of volume for four identical surfaces. In the octahedron we get two units of volume for four surfaces. In the icosahedron we get approximately 20 (18.63) units of volume for 20 surfaces. If we call four triangles of surface unity then the ratio of faces to volumes contained by the three fundamental and symmetrically stable structures are:

tetrahedron one unit of surface (4 triangles) contains one unit of volume.

octahedron one unit of surface (4 triangles) contains two units of volume.

icosahedron one unit of surface (4 triangles) contains five* units of volume.

* approx.

Of the three fundamental structures the tetrahedron contains the least volume with the most surface and is therefore the strongest structure per unit of volume. Whereas the icosahedron gives the most volume with the least surface and though least strong it is stable and gives the most efficient volume per units of invested structure. That is the reason I decided to develop the triangulated icosahedron as the fundamental, volume controlling devise of man. I decided also to obtain high local strength on the icosahedron by sub-triangulating its twenty basic spherical triangles with locally superimposed tetrahedra, - i.e. an octahedra/tetrahedra truss, - which would take highly concentrated local loads or impacts, with minimum effort, while the surrounding rings of triangles would swiftly distribute, and diminishingly inhibit, the outward waves of stresses from the point of concentrated loading.

There is one more principle I must discuss before showing the slides to you. This principle is one which I call "tensegrity." The word is an invention - it is a contraction of a tensional integrity, a structure the shape of which is guaranteed by the tensional behaviors of the system, and not by the compressional behaviors. Men, in building their buildings on the land, have thought of the bedrock under the land as solid. Today, we know that the bedrock is not solid. It is composed of atoms and the atoms are constellations of energy event concentrations with vast distances between them.

Superficially (and reasoning only in the spectrum ranges directly tunable by his senses) man thought of the land as solid and thought of putting solid stone on the solid land and of piling up the solid stone into a solid mass. Men also dug holes in the solid earth and inserted a solid mast in the hole, tamping the earth in solidly around the solid mast. Thus the solid mast became a continuity of solid earth. The mast became a sort of formalized vertical solid "mountain" as an asymmetric solid. But the wind pushed on the top end of the mast with leverage advantage which tended to either break the mast in two parts or to pry it loose from solid earth. So men ran three or more tension members from the top leverage point at the mast head back down to remote triangular, - or more, - tie down points, around the mast, in the solid earth, to stay the mast against wind bending. Tension thus became a secondary helper but the primary structural logic was the "solid" compression continuity - a solid structural logic -- a compressional integrity.

Tension and compression are complementary functions of structure. Therefore as functions they only co-exist. When pulling a tensional rope its girth contracts in compression. When we load a column in compression its girth tends to expand in tension. When we investigate tension and compression, we find that compression members, as you all know as architects, have very limited lengths in relation to their cross sections. They get too long and too slender and will readily break. Tension members, when you pull them, tend to pull, approximately, (almost but never entirely), straight instead of trying to curve more and more as do too thin compressionally loaded columns. The contraction of the tension members in their girth, when tensionally loaded, brings its atoms closer together which makes it even stronger. There is no limit ratio of cross section to length in tensional members of structural systems. There is a fundamental limit ratio in compression. Therefore when nature has very large tasks to do, such as cohering the solar system or the universe she arranges her structural systems both in the microcosm and macrocosm in the following manner. Nature has compression operating in little remotely positioned islands, as high energy concentrations, such as the earth and other planets, in the macrocosm; or as islanded electrons, or protons or other atomic nuclear components in the microcosm while cohering the whole universal system, both macro and micro, of mutually remote, compressional, and oft non-simultaneous, islands by comprehensive tension; -- compression islands in a non-simultaneous universe of tension. The Universe is a tensegrity.

I saw - when I began this kind of fundamental structural investigation and experiment - that in using the better alloys that man has discovered (as permitted by nature) that as the tensional coherence of the metals increased we

could use longer and longer and thinner and thinner tension members. The question was, could we get vastly strong, long members that had no section at all? I saw that was exactly what nature had done in her gravitational cohering relationship of the earth and the moon with a 320,000 mile tension "member" of zero diameter. Twice daily we may witness this moon earth tension as it gravitationally lifts moonward billions of tons of the watery ocean film of earth in what we call tides. "Tides" means "tension," (as we tie a string-i.e. make a tension connection.) I saw that, in the tides and gravity, nature had accomplished a truly invisible, formless, structural, tensional coherence. The question was, could man begin to approximate the magnificent efficiencies and economies of these macro-micro tensional integrities of nature? And I discovered it was possible for man to do so. So the first pictures I am going to show you, relate to structures, tensegrity and synergy.

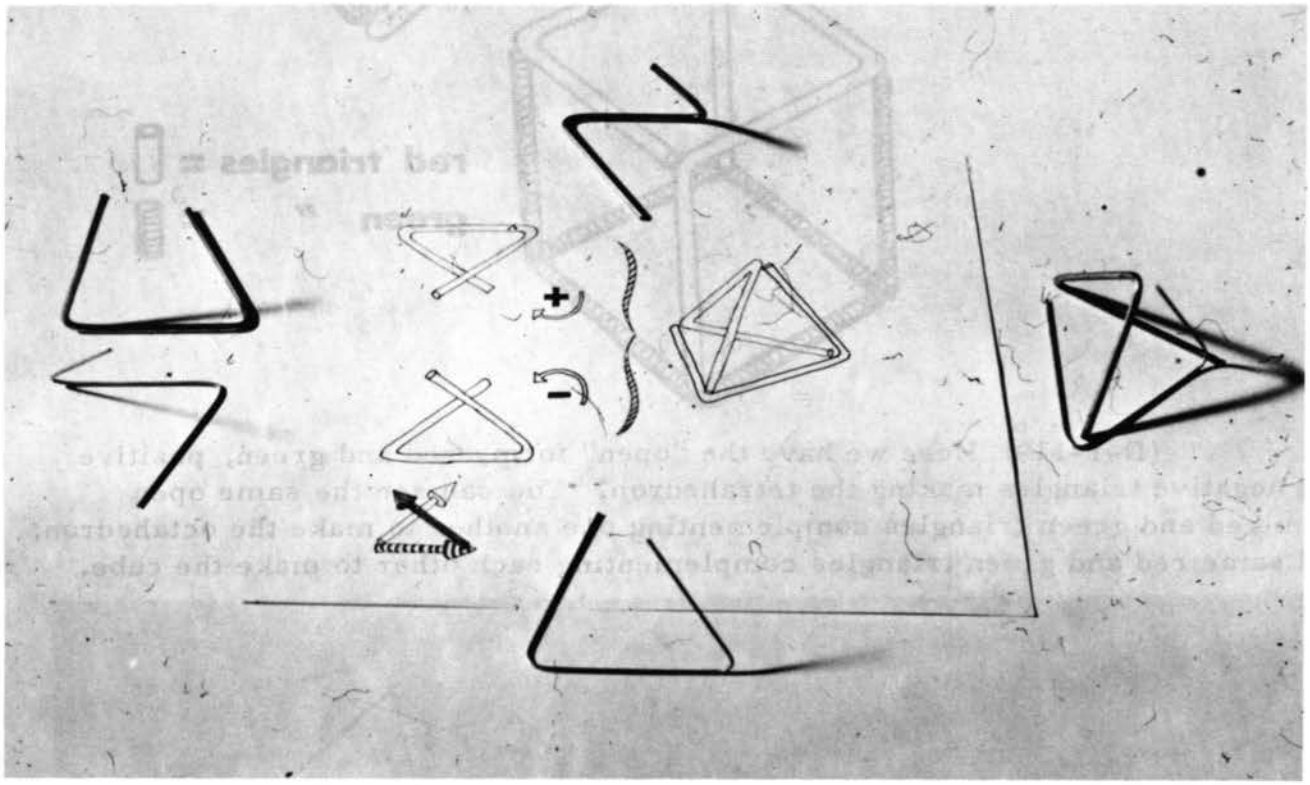
I made up my mind tonight to try to talk to you about what seems to me to be fundamental and not just to show superficial pictures of forms. I do not want to function only as an entertainer for you are giving me your valuable professional time.

I think we, collectively as mankind, are at the most critical moment in history. A moment in which we, as individuals in the environment controlling mechanics and structural arts, have history's greatest opportunity to be of prime service to our total fellow men. I want to recite the structural principles which I think can be brought to bear importantly in relation to the opportunity of service. I can tell you that in the structuring which I have experimented with, I have found it quite possible to enclose space, while meeting the highest performance conditions, under the most hostile conditions of nature, such as hurricanes, avalanches, earthquakes - while using only about 1% of the weight of materials which we have been accustomed to using in prevailing architectural and engineering practices for enclosing equal volumes of space while providing equal performance characteristics. My later experiments in tensegrity indicate that the 1/100 ratio will be further reduced in important degrees. This means we now can house 100 human families where we have previously housed but one family and will soon be able to house increasing hundreds instead of one. You can understand both my sense of confidence and of urgency.

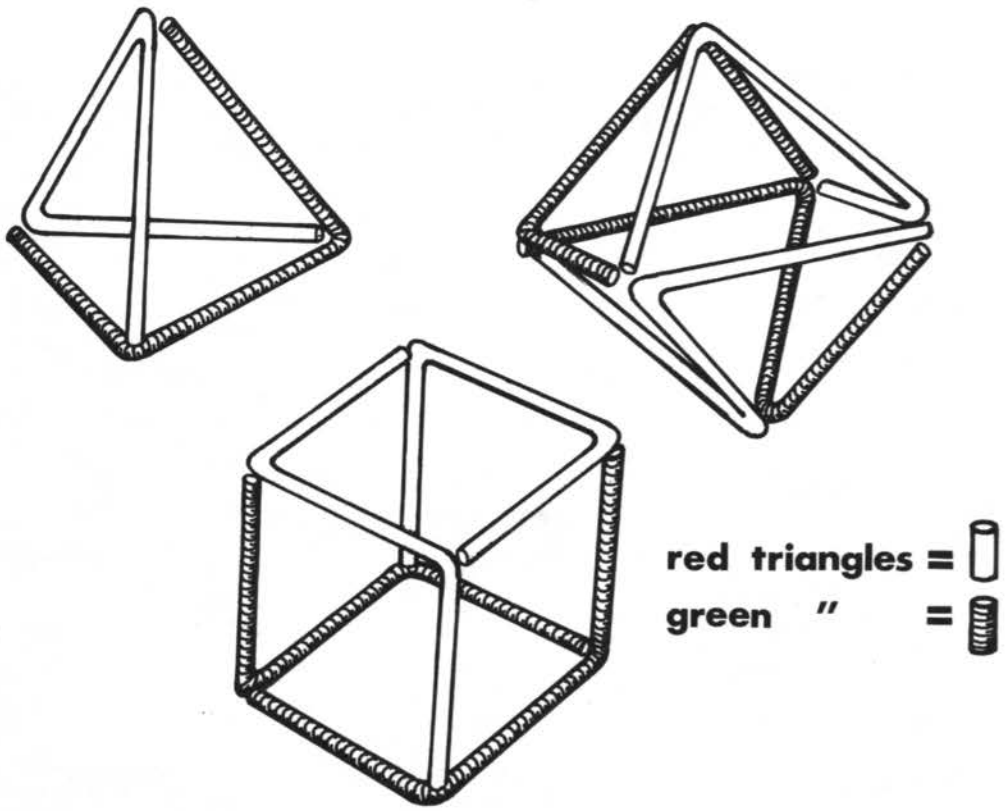
I am quite confident that you are going to realize as we go through this work, that it is now possible for us to make the world's resources which, as used today, are not adequate to provide highest prevailing standards in livingry for more than a minority of humanity, fully adequate to satisfy total man's increasing needs at ever improving standards of performance. When

we organize ourselves to employ improvements such as I have found to be possible and practical, we can get 100 improved structures and their mechanical equipment out of the same weight of materials that we now get only one.

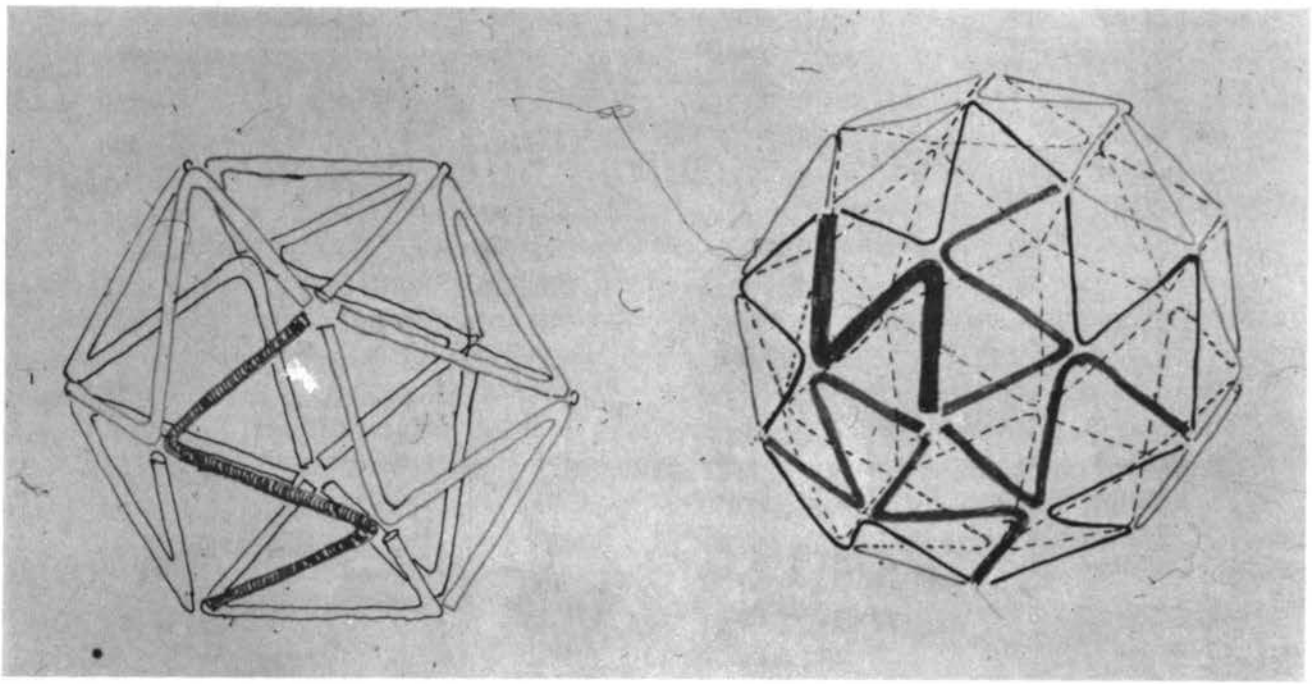
May I have the pictures and the lights - out.



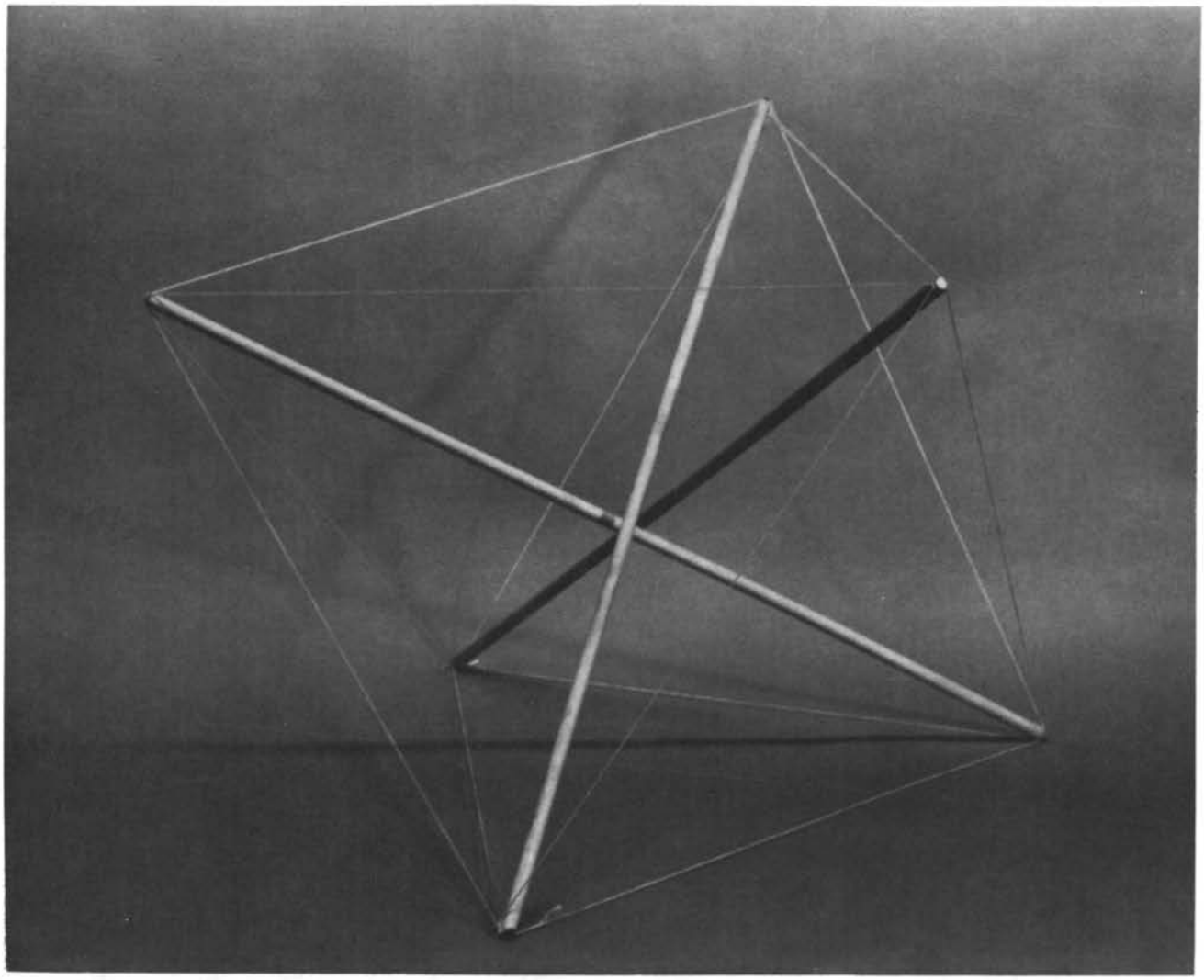
(D-1-118) This first picture shows you the positive and the negative triangles with the positive and the negative tetrahedrons which come together to make the tetrahedron as I showed in my hand models.



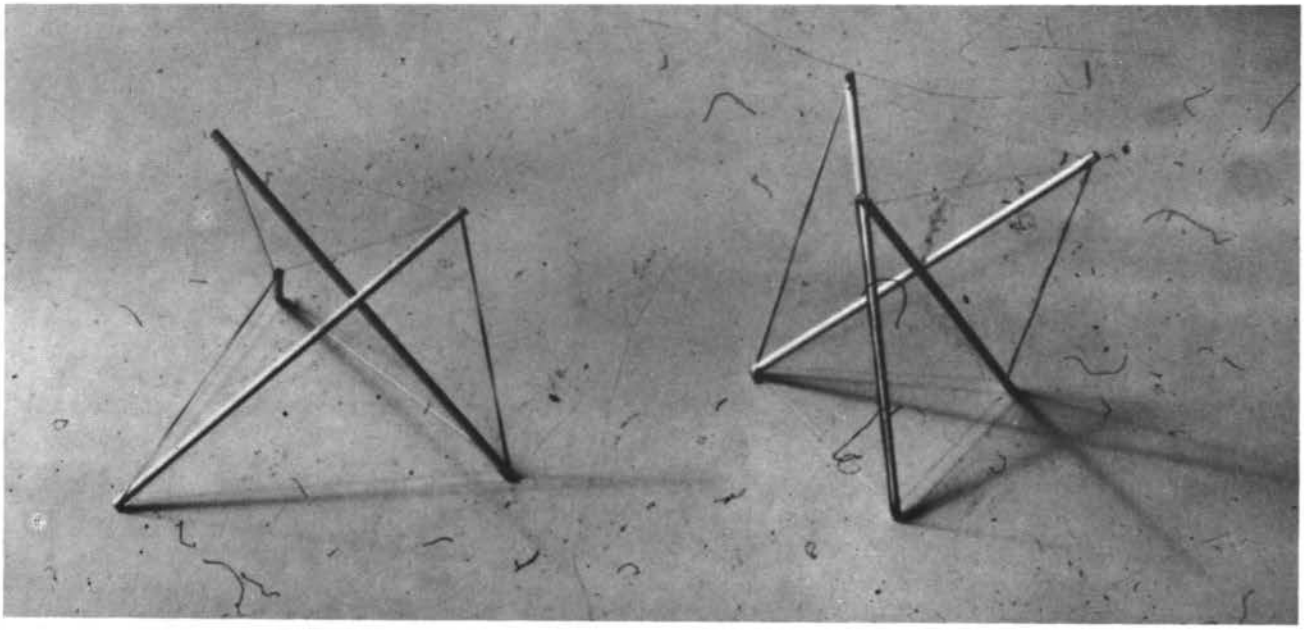
(D-1-119) Here we have the "open" form, red and green, positive and negative triangles making the tetrahedron. You can see the same open form red and green triangles complementing one another to make the octahedron; and same red and green triangles complementing each other to make the cube.



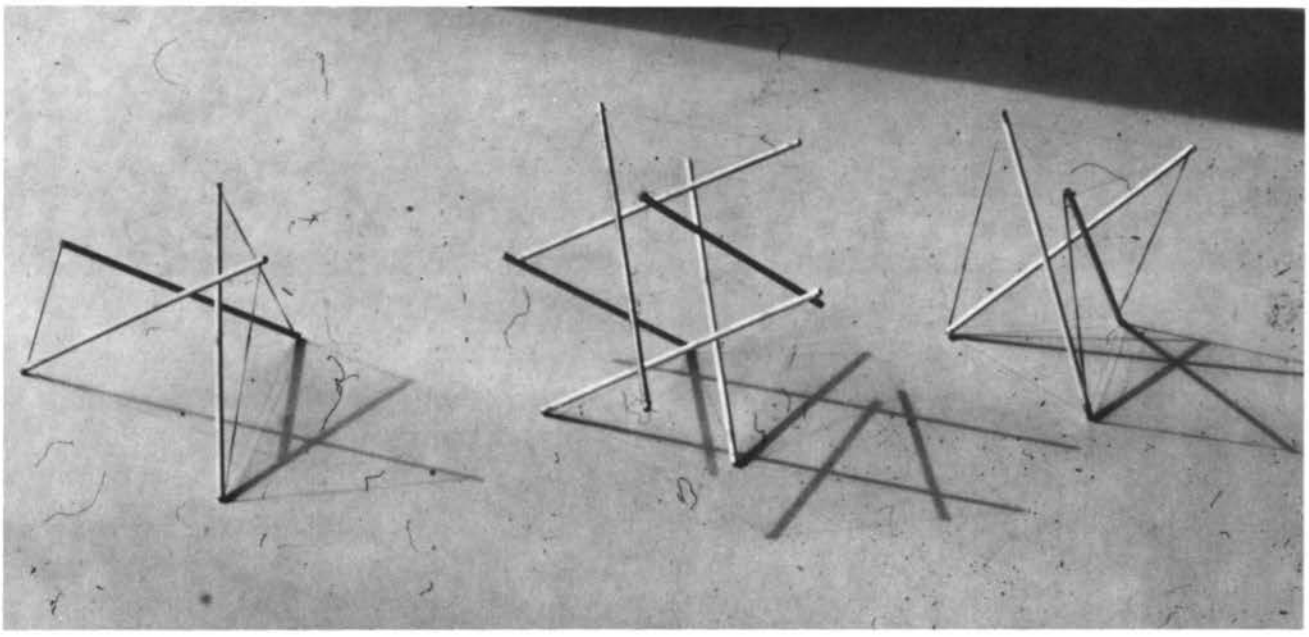
(D-1-120) You see here the positive and the negative open end triangles making the icosahedron. You find them here making further triangular subdivisions of the spherical icosahedron. The latter is a two-frequency geodesic sphere.



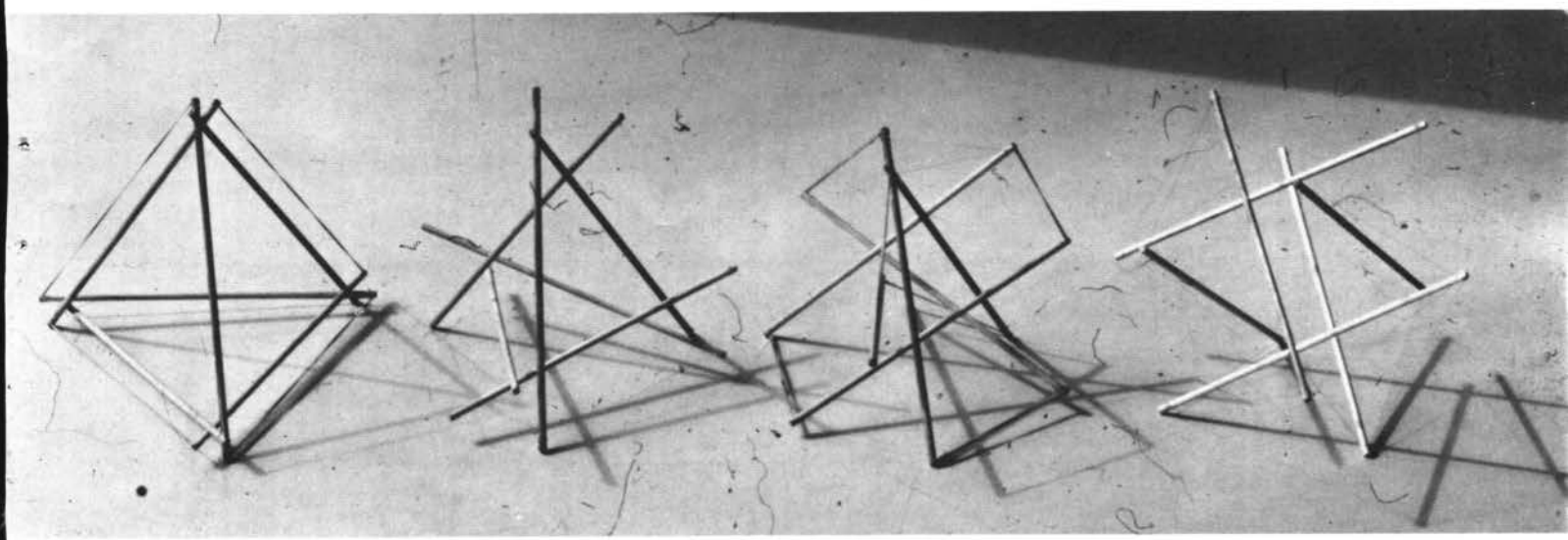
(D-1-43) Here we have the simplest form of tensegrity, - the octahedron with three compression members crossing each other - look at the shadows here - the three compression struts do not touch each other as they pass at center; they are held together only at their terminals by the comprehensive, triangular tension net. This three strut octahedron tensegrity was discovered by a man named Theodore Pope.



(D-1-121) Here we have the same three islanded struts of the tensegrity octahedron but mildly reorganized or asymmetrically transformed. The struts are the same length, but some tensions are lengthened while other tensional edges of the surface triangles are shortened - you can see quite clearly here that the compression members do not touch one another. One is a positive and one is a negative tensegrity octahedron.



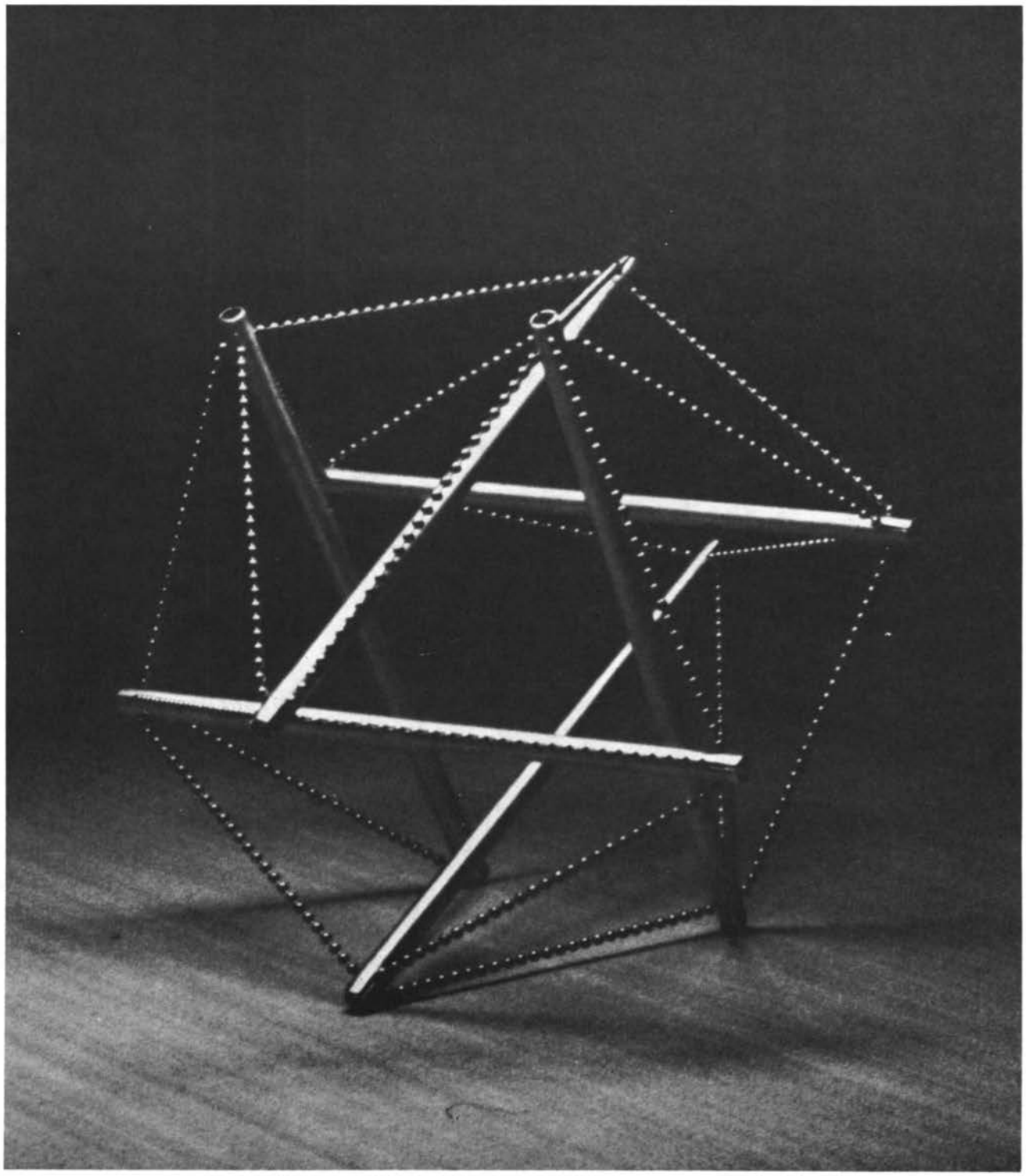
(D-1-122) They come together in the next picture and they make this new form, - the tensegrity icosahedron. This form has six members, three sets of parallels, and their ends are held together in tension. There are twelve terminals of the six struts (the two octahedra, - each with three struts of six ends, - combined) and when you connect up those twelve terminals you see the twelve vertices of the icosahedron. There are the 20 triangles of the icosahedron clearly described by the tension members connecting the 12 points in the most economical, omni-triangular pattern.

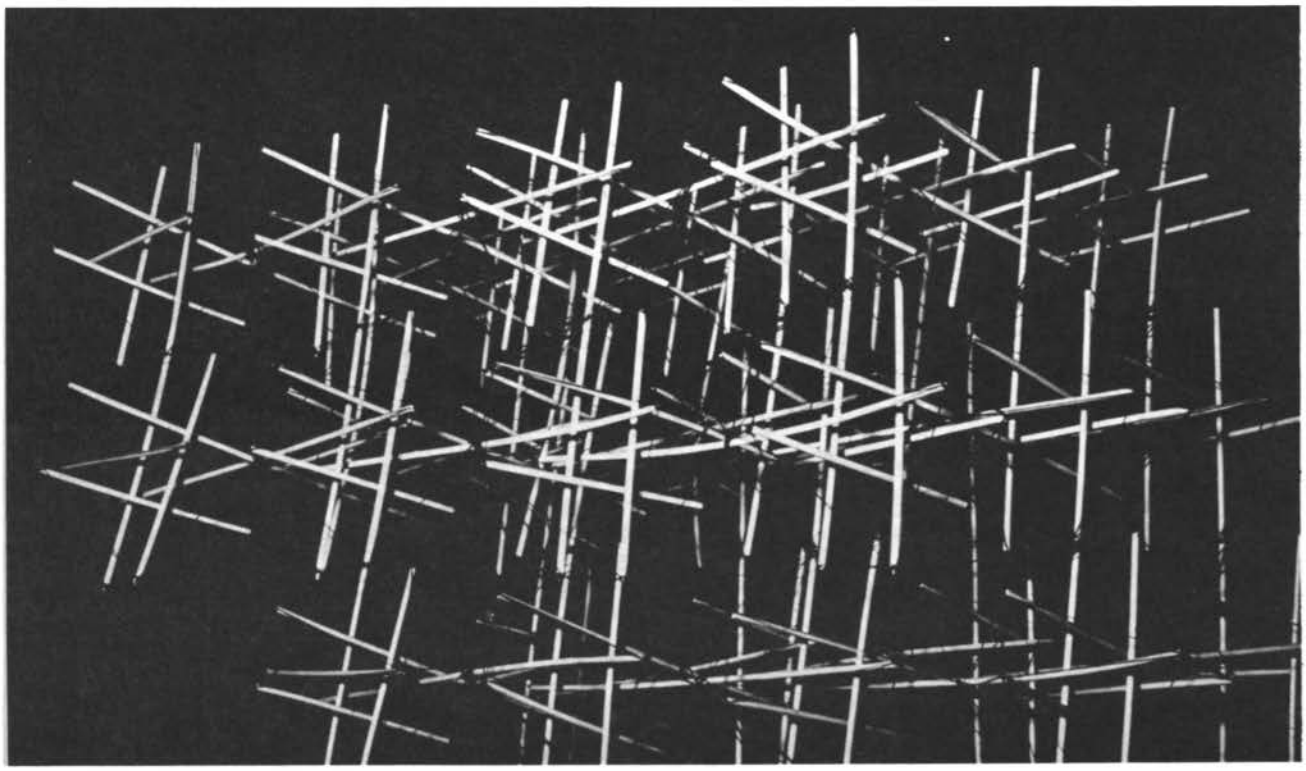


(D-1-123) Now you see those same six members as they transform in relation to each other. They go from the tensegrity icosahedron through the tensegrity octahedron phase and finally become the tensegrity tetrahedron. The same six members can transform from containing one volume to containing 18.51 volumes. The same six members transform through the full range of the three and only fundamental structures of nature. What I am showing you here are the principles actively operative in atomic nucleus behavior in visual inter-transformations. There are very extraordinary qualities in these structures. The tensegrity tetrahedron and tensegrity octahedron are volumetrically complementary and together will fill all space but the tensegrity icosahedron refuses to complement the tetrahedron or octahedron but isolates itself in space or goes on to make up triple bondedly into large octahedra which may then complement tetrahedra to fill all space.

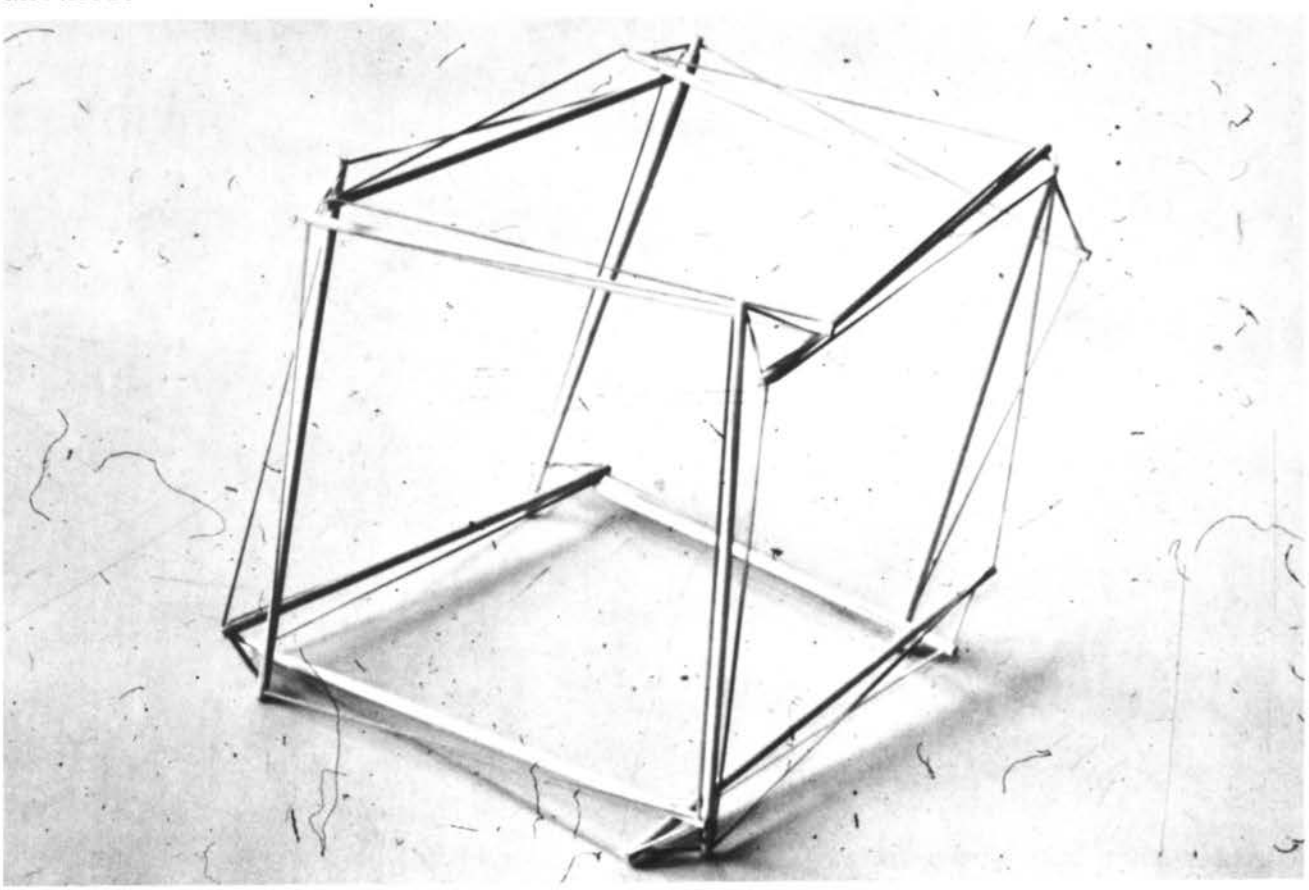
(D-1-33) Here we have a sturdier model of the tensegrity icosahedron. You take hold of any pair of parallel compression struts in this structure, with one hand seizing this strut and the other hand its parallel strut and you try to pull them apart; as you try to pull them apart, all six members will expand or recede from each other at a symmetrical rate and in an evoluting but ever omni-directionally symmetrical pattern. All twelve vertices will recede outwardly from their common center in perfect symmetry of expansion. If you put a load on the system here, the whole system contracts symmetrically, that is, all the vertices contract toward their common center at the same rate. This is not the behavior that you are used to in any structures of your previous experience. Though this compression member (parallel to the earth's surface) looks like an ordinary beam it does not act like a conventional engineering beam. Ordinary beams deflect locally or if fastened terminally in tension to their building, tend to contract the buildings in axial assymmetry. The tensegrity "beam" does not act independently but acts only in concert with the whole "building" which contracts only symmetrically when the beam is loaded. The tensegrity system is synergetic - a behavior of the whole unpredicted

by behavior of the parts. Old stone age columns and lintels are energetic and only interact locally with whole buildings. The whole tensegrity icosahedron system when loaded oppositely at two diametric points contracts symmetrically, and because it contracts symmetrically its parts get symmetrically closer to one another therefore gravity increases as of the second power and the whole system gets uniformly stronger. This is the way atoms behave.

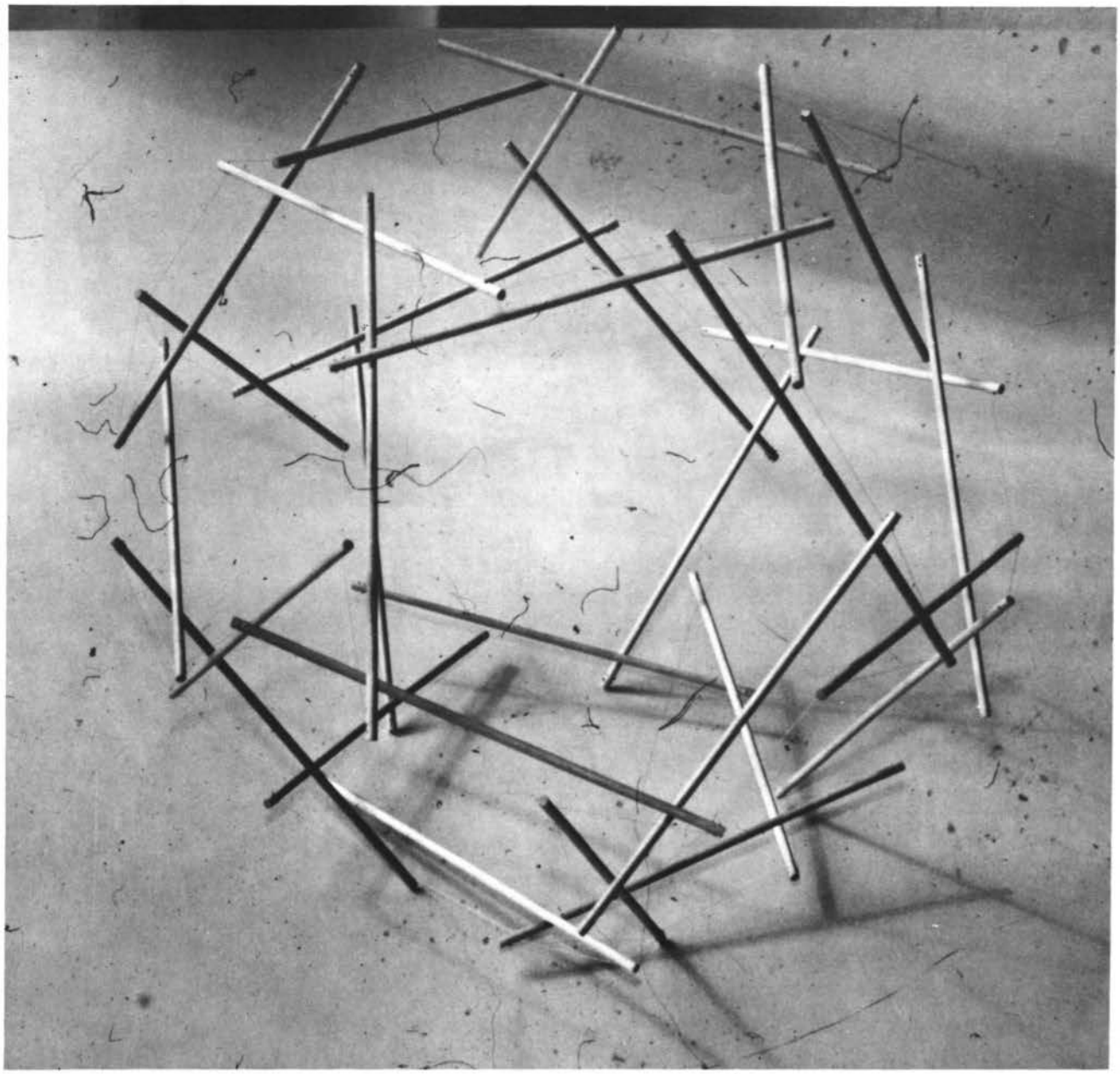




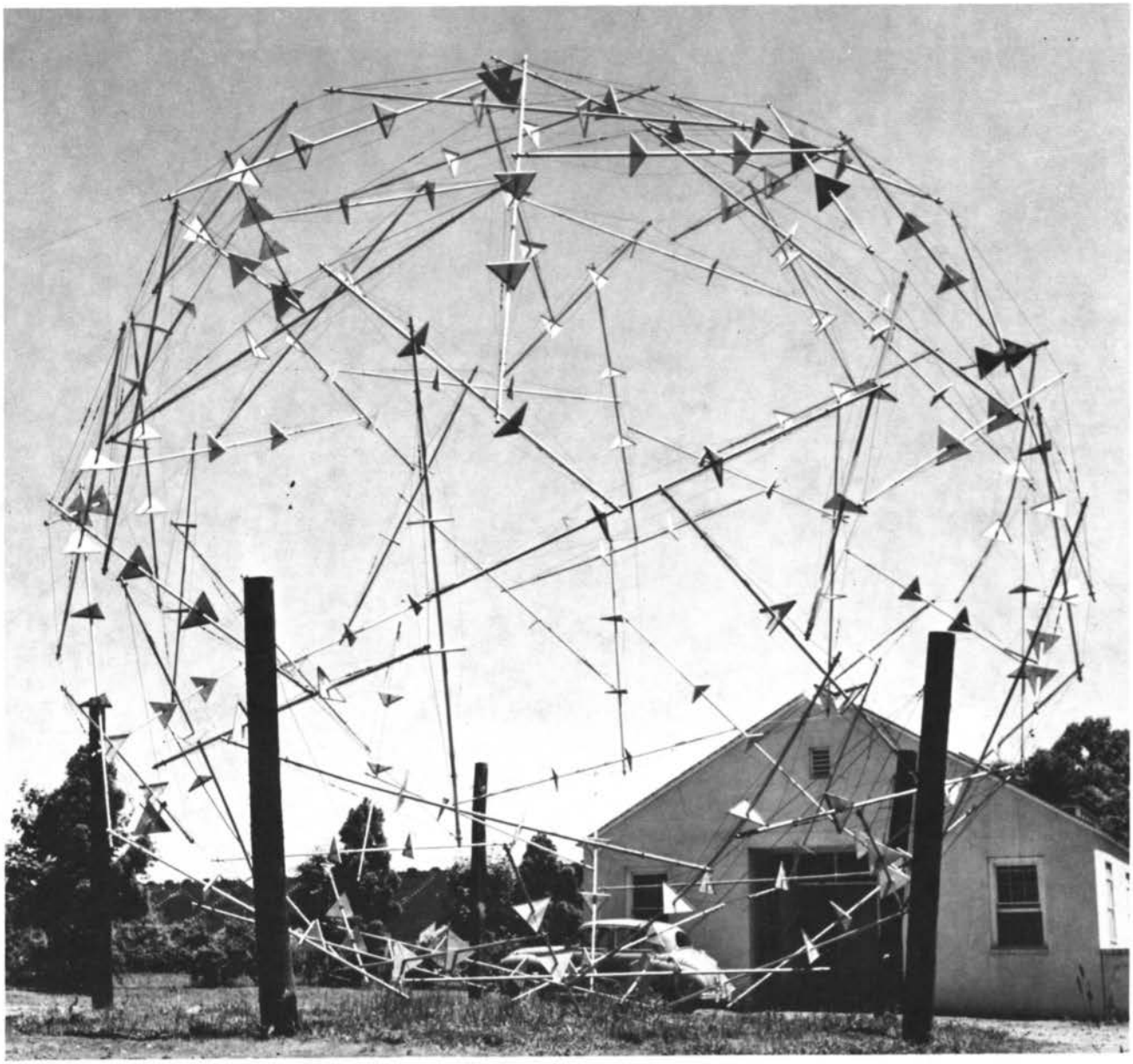
(D-1-44) Here we have a compound-complex of those six member, icosahedronal systems. They fill all space only as octahedra self collect in both internal and external tensional coherence. This complex is totally a tensional continuity, - a tensegrity. Compression members do not touch one another.



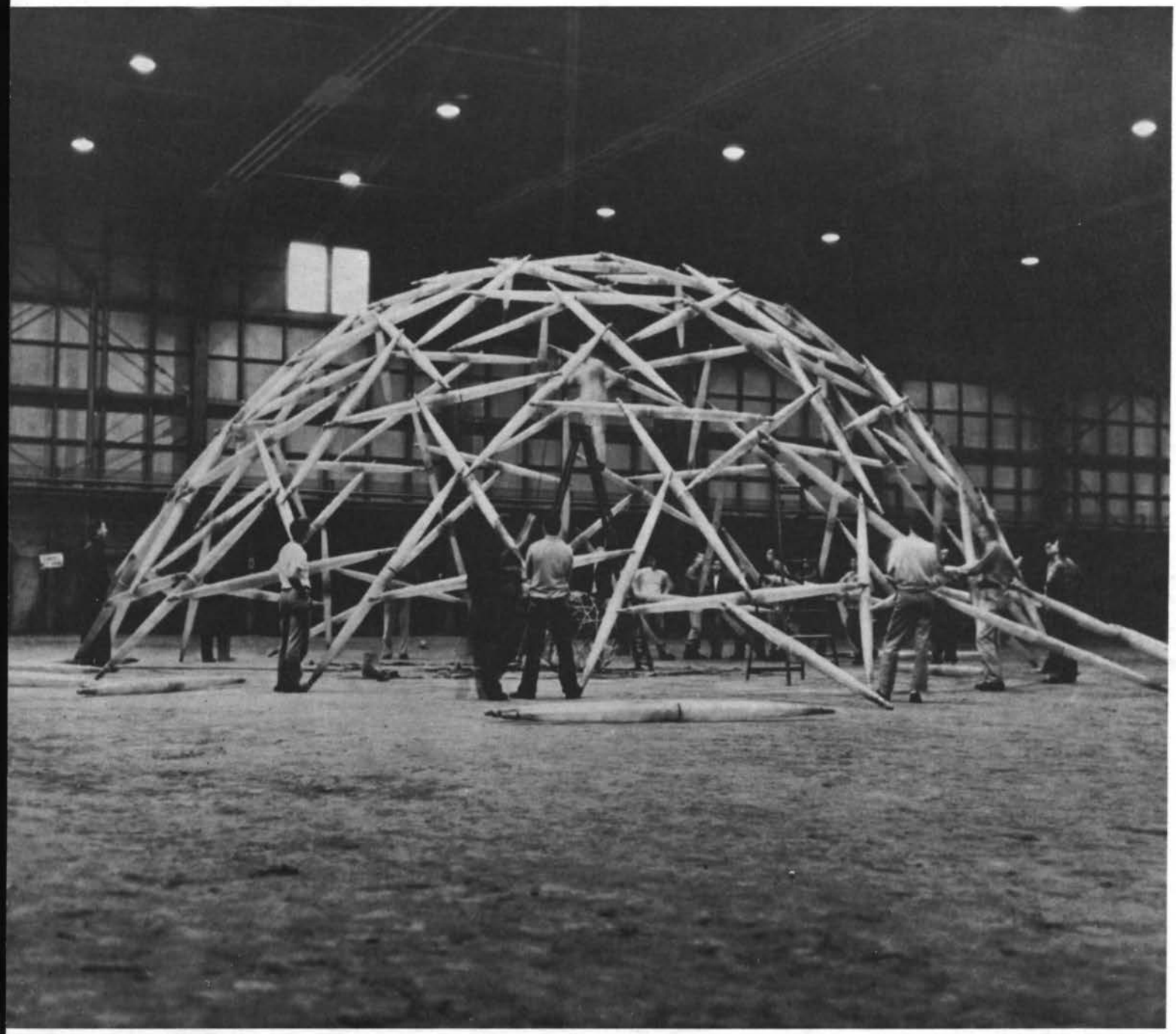
(D-1-125) Here we have the tensegrity cube, which is completely unstable. It consists of twelve struts instead of the six which transformed from tetrahedron to octahedron to icosahedron. Two sets of six,as tetrahedra grouped symmetrically together form a stable cube.



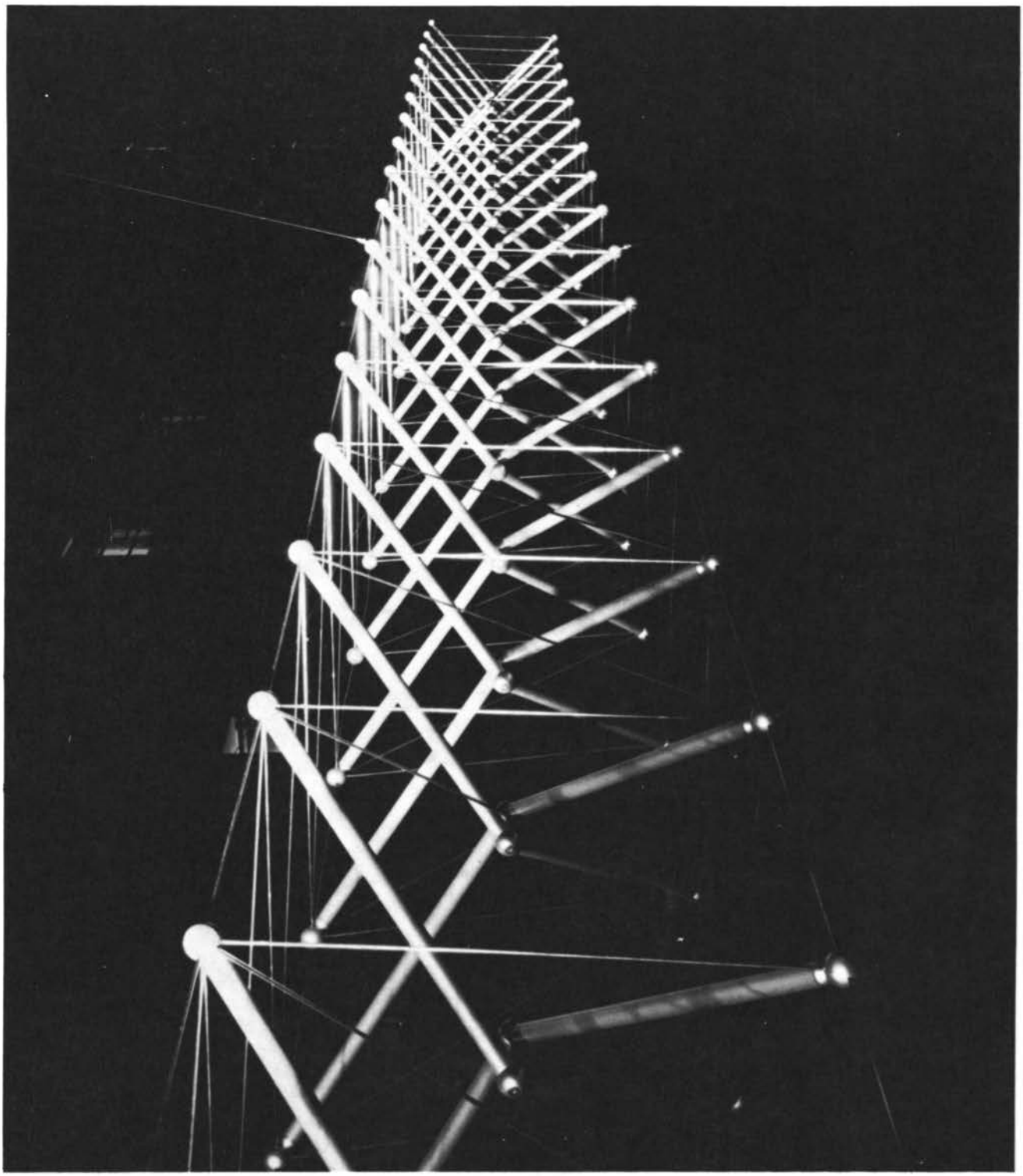
(D-1-124) Here we get into multi-strut tensegrities. They always consist of the same groups of three struts we started off with. These are the same three, positive or negative, triangular function members which as an action, a reaction and a resultant gave you the original triangle - the open and closed negative triangles.



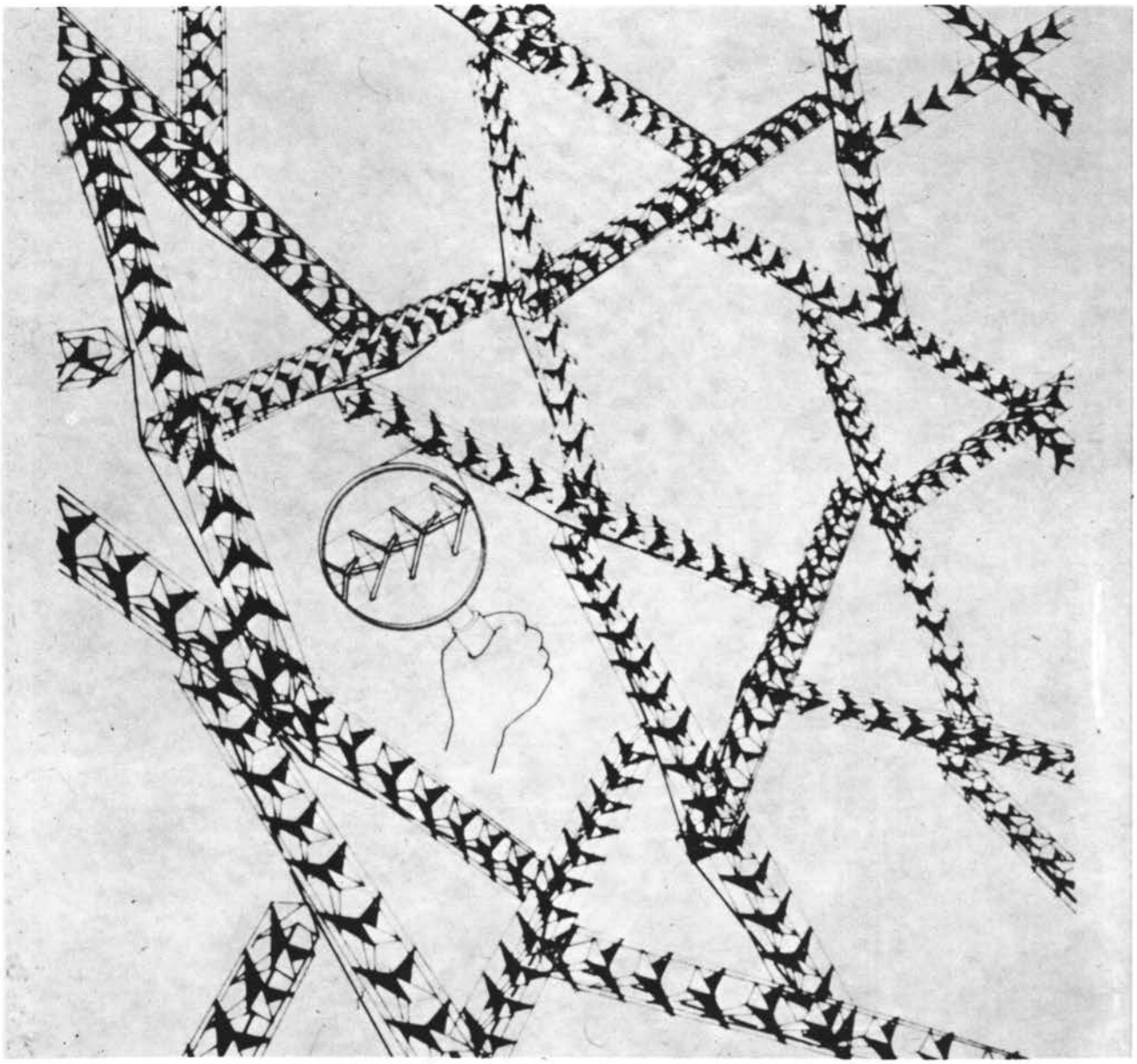
(P-4-1) This picture was taken at Princeton University in the U.S.A., about ten years ago. We manufactured and assembled a 40 foot tensegrity sphere of 90 struts. A snow plow ran into this structure on one side and way around 180 degrees from the point of impact a member bent. The loads were distributed completely symmetrically in all directions from the point of impact until finally they came together again at the other pole. There the forces converged in full concentration as waves develop on spheres.



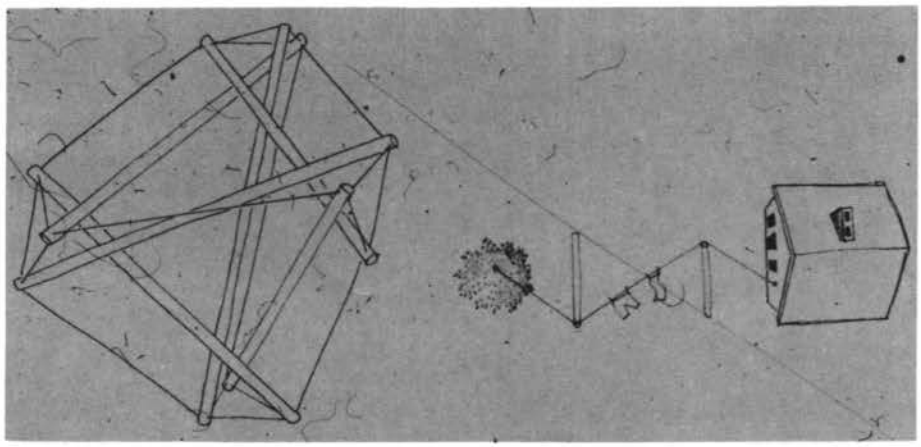
(M-19-13) This is a large 40 foot diameter tensegrity sphere at the University of Minnesota, U.S.A., in 1958. Its struts are made of polyester fiber glass and you can see that these compression members are not touching one another.



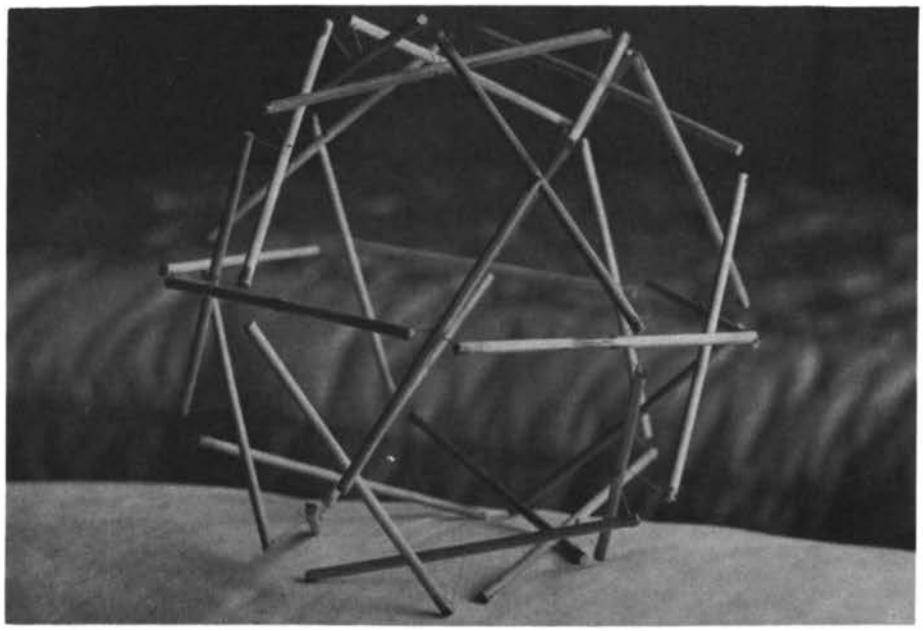
(M-21-10) Here we have the same tensegrity principles, but instead of being a spherical structure it is a linear structure. It is a tensegrity mast at New York's Museum of Modern Art. If you study this you will see independent tetrahedral groups superimposed.



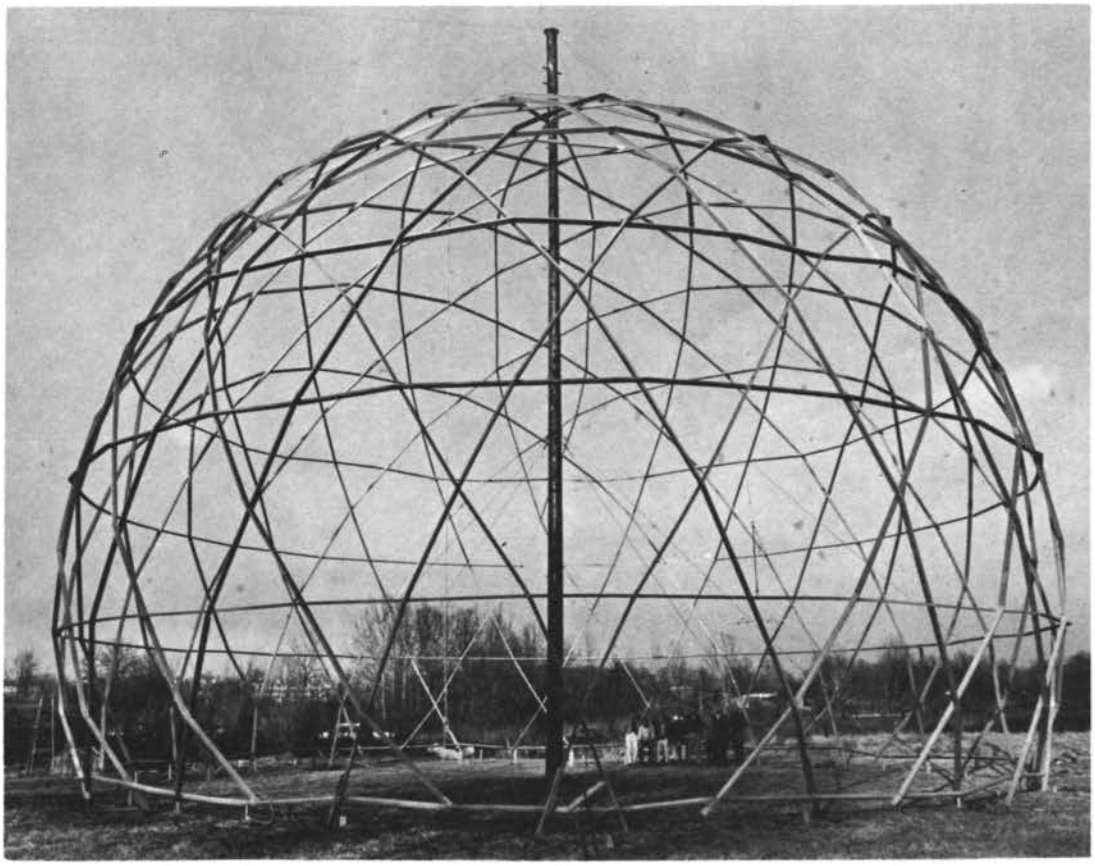
(D-1-126) Now we can take those tensegrity masts, - or struts, - and we can substitute them for the individual (so called solid) struts in the tensegrity spheres which I have already shown you. Now in each one of the separate tensegrity masts, acting as struts, in the tensegrity spheres it can be seen that there are little (so called) solid struts. I can substitute a miniature tensegrity mast for each of those "solid" struts. I find the sub-miniature tensegrity masts within the tensegrity struts of the tensegrity sphere have very very tiny solid struts and I substitute a sub-subminiature tensegrity mast for each of those "solid" struts and so on to sub, sub, sub-subminiature tensegrities until we finally get down to the size of the atom and this becomes completely compatible with the atom for the atom is tensegrity and there are no "solids" left in the entire structural systems. There are no solids in structures, ergo no solids in Universe. Q.E.D. In other words, there is nothing incompatible with what we see about us as structures at the visual level and what we are finding out to be the structural relationships in nuclear physics.



(D-1-127) There are other interesting and surprising behaviors in tensegrities. In this picture you are looking down from a helicopter upon a house and a tree with a clothes line stretched between them. You want to make the clothes line taught in order to hang your clothes to dry. You put up a strut here shoving against the line and another strut there shoving against the line in the opposite direction. The line taughtens and bends first this way and then that always yielding away from the shoving struts. But in the spherical tensegrity constructions, whenever a tension line interacts with a compression strut, the line does not yield in a direction away from the strut. The line yields toward the strut. The islanded compression member pulls on the tension member.

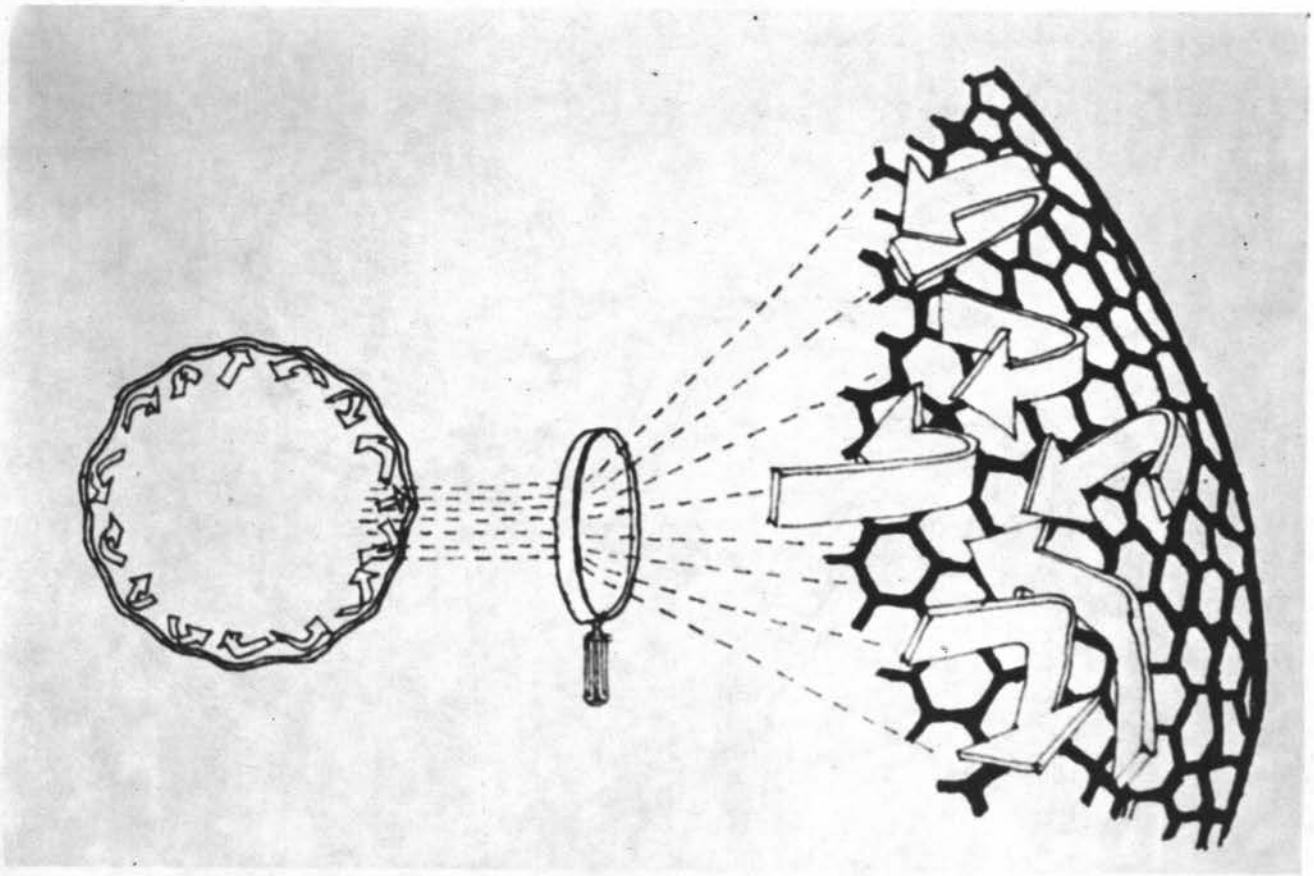


(D-1-99) When we remove a compression member from a tensegrity sphere of more than the three struts, of the original triangular-group, the tensegrity sphere doesn't collapse. It gets "soft" or "loose" locally. The compression member when released on one end does not shove by the tension member to which it was fastened. It is not fastened in shove, or sheer. It pulls away simultaneously from the tension members at both of its ends and when released pops only outwardly from the sphere's center. When inserting a strut into a tensegrity sphere you are pulling the strut into the structure, i.e. only towards its center, and it pulls on the two adjacent tension member to which it is fixed, - trying to escape outwardly from the systems center.



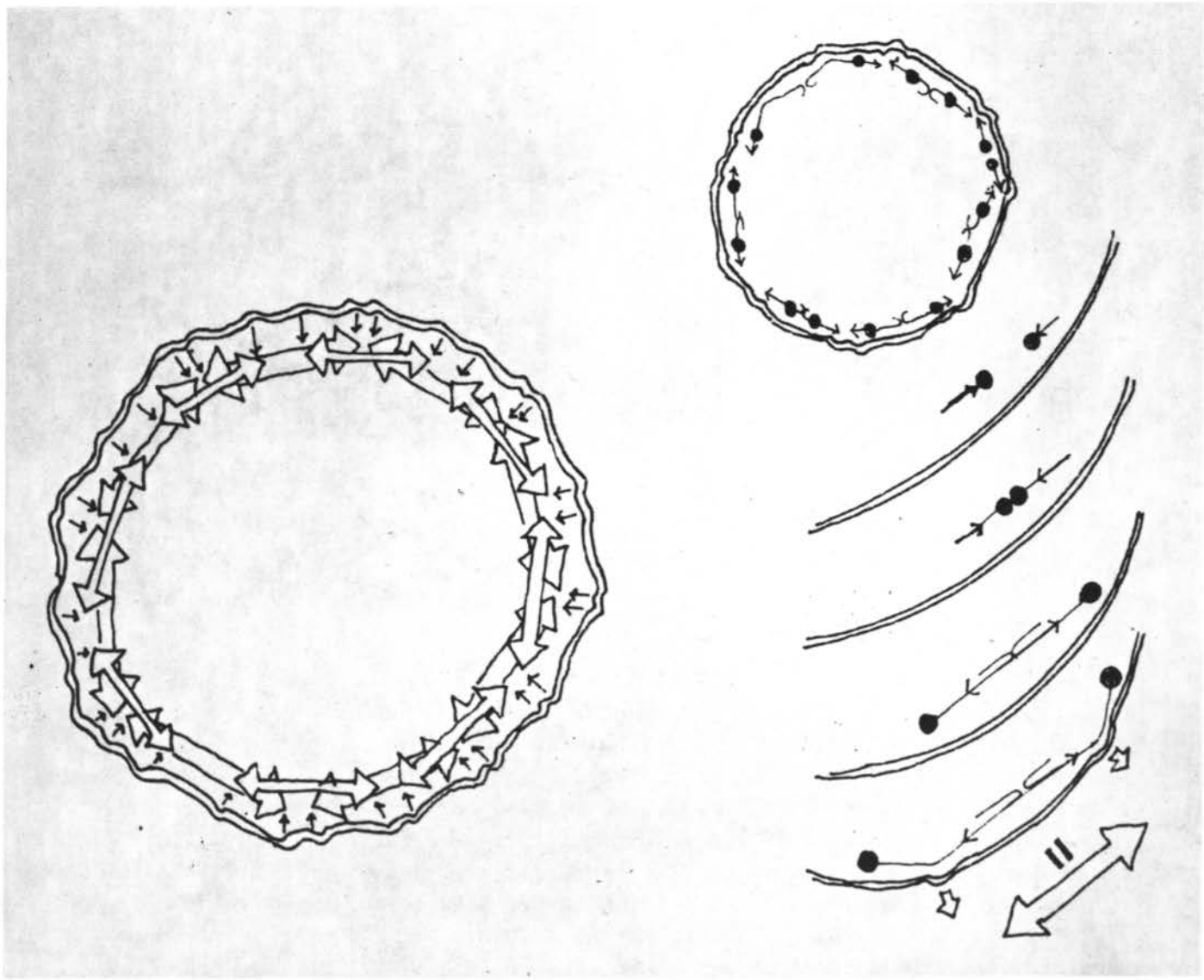
(T-11-15) As we increase the frequency of triangular module subdivisions of the sphere, and thus increase the numbers of compression struts, the struts get progressively halved in length while their volumes and weights shrink eightfold. At the same time the arc altitude between the smaller arcs and chords of the sphere decreases and finally we get to the condition where the compression members get closer and closer to the adjacent compression members which they cross. Finally we get to the point where the space between them is the same dimension as the girth diameter of the struts. We can then let them "kiss" touch. We may then lock them tensionally together in their "kiss," but when we do so remember that they were not pushing one another when they kissed and we locked them in that position of non structural coincidence. They are therefore not fastened in sheer even though their "locked kiss" gives a superficially "solid" appearance.

Here is a tensegrity 3/4 sphere structure at Southern Illinois University which is 72 feet in diameter. It is made out of clear-grained 2" x 4" wood struts in which the frequency of modular subdivision of the structure has been increased until the tensegrity struts just kiss touch. One radial tension bolt goes through the point of contact to lock them in kiss. This structure was designed to withstand full hurricane and full arctic snow loads. It is however so economical that the cost of the materials in American dollars was only $450. The space inside the dome is adequate to house five floors ten feet vertically apart, with a total of 22,000 square feet of interior floor space. For $450 material cost it is possible to structure a building with 22,000 square feet of floor space. 2¢ sq. ft. The whole structure may be skinned in with another 100 pounds of transparent non stretching, high strength, all weather, DuPont Tedlar.



(D-1-101) Now I would like to give you a better or more fundamental and synergetic explanation of what we have been speaking about in tensegrity structures. In this picture we have a spherical pneumatic balloon. People think spontaneously of a balloon, as a continuous skin, or a solidly "impervious" unitary and spherically closed membrane holding the gas. People say that because the gas can't get out and because the gas is under pressure, the pressure makes the balloon spheroidal. This means the gas is pushing the skin outwardly in all directions. But if we look at this skin with a microscope, we find that it is full of holes. It is not a continuous film at all, because it is full of holes. Instead it is in fact a net. If we look at the net atomically we will see that the tensional net's threads are discontinuous being in reality "Milky Way" like constellations, great energy aggregates cohering only "gravitationally" to act as the "webbing" of the pneumatic ball's net. In a gas balloon, we do not have a continuous membrane of film. There is no such thing as a continuous "solid" skin or "solid" anything in the universe. But we do have a network pattern, - a network of energy actions which is intersperced with vast spaces or lack of energy events. But the spaces between the energy action net are smaller than are the internally captivated and mutually interrepelled gas molecules, wherefor the gas molecules which are complex local, low frequency energy events interfere with the higher frequency net webbing events. The pattern is similar to that of fish, crowded in a net, and therefore running tangentially outward into the net in approximately all directions.

(D-1-102) It became evident that what makes a gas balloon's exterior tension "net" have the shape that it has is that some of the molecules are too large to escape and, crowded by the other molecules, are hitting the balloon. But the molecules do not huddle together at center and then simultaneously explode outwardly to hit the balloon skin in one omnidirectionally outbound shock-wave. The molecules near the surface are coursing in chordally

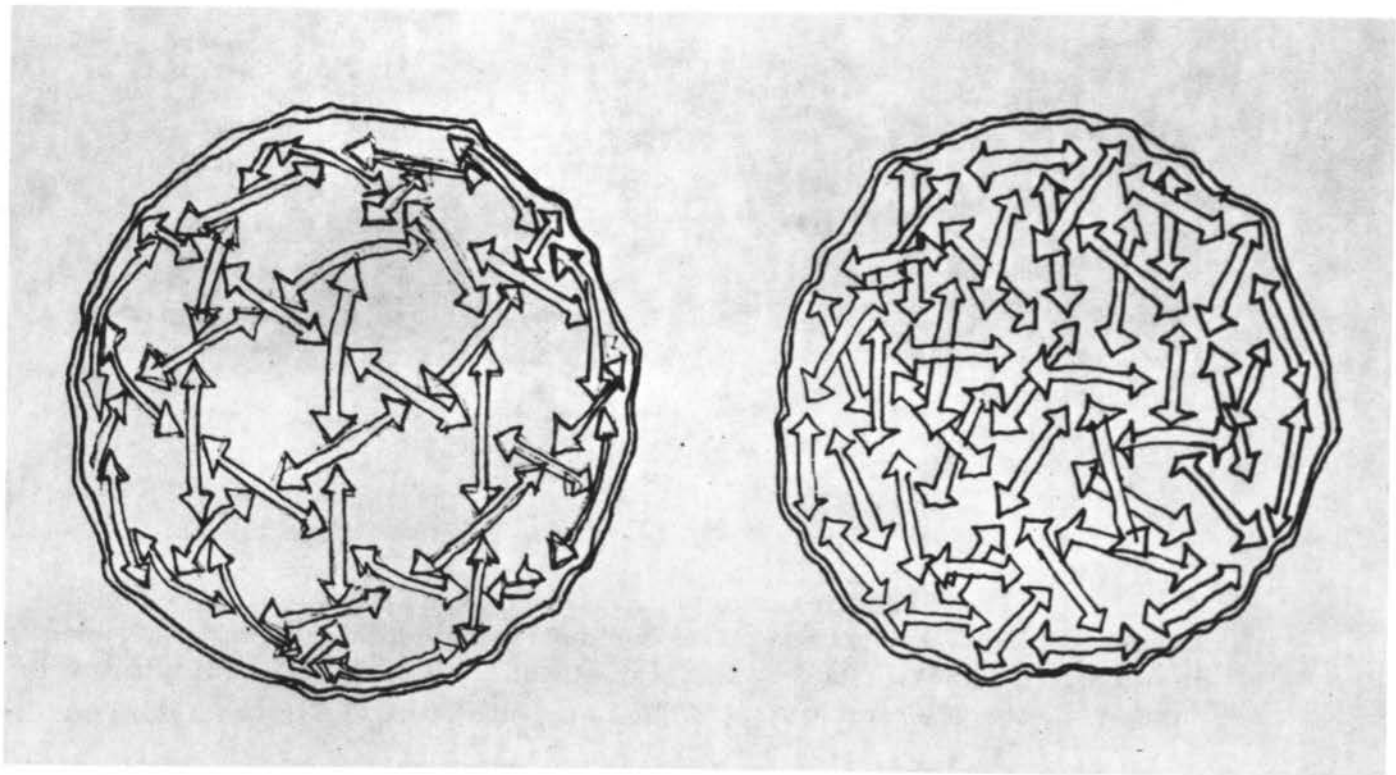


D-1-102

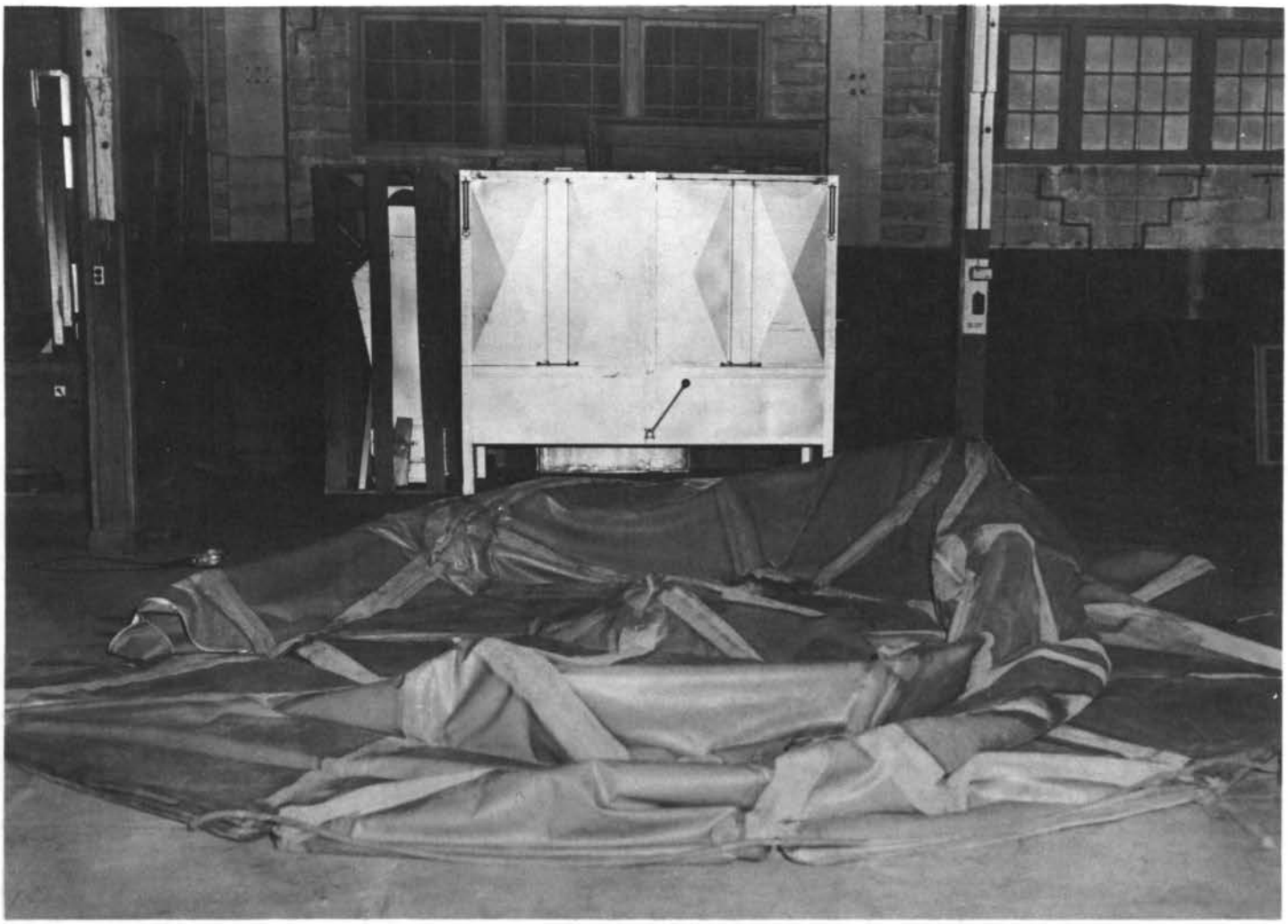
ricocheting patterns all around the inner net's surface in the manner shown in this picture. I therefore saw that, - because every action has its reaction, - that it would be possible to pair all the molecules so that they would behave as can two swimmers who dive into a swimming tank from opposite ends, meet in the middle of the tank and then, employing each other's inertia, shove off from each other's feet in opposite directions. This pattern indicated that we could have each and all of the paired molecules bounce off their partners and dart away in opposite directions, with each finally hitting the balloon net and pushing it outwardly as they each angled off in glancing blows in new directions, but always toward the net at another point where in critical, repelling-proximities they would all pair off non simultaneously but at high frequency of re-repellment shove offs to ricochet off the net in approximately all directions at such a frequency of events as to keep the net stretched outwardly in all directions.

A great many of you must have been in a country where there is snow. Every child, when playing in sticky snow - makes a big mound of snow and then usually hollows out the big mound with his hands or a shovel or stick in order to make a cave and then looking at the hollowed mound from outside

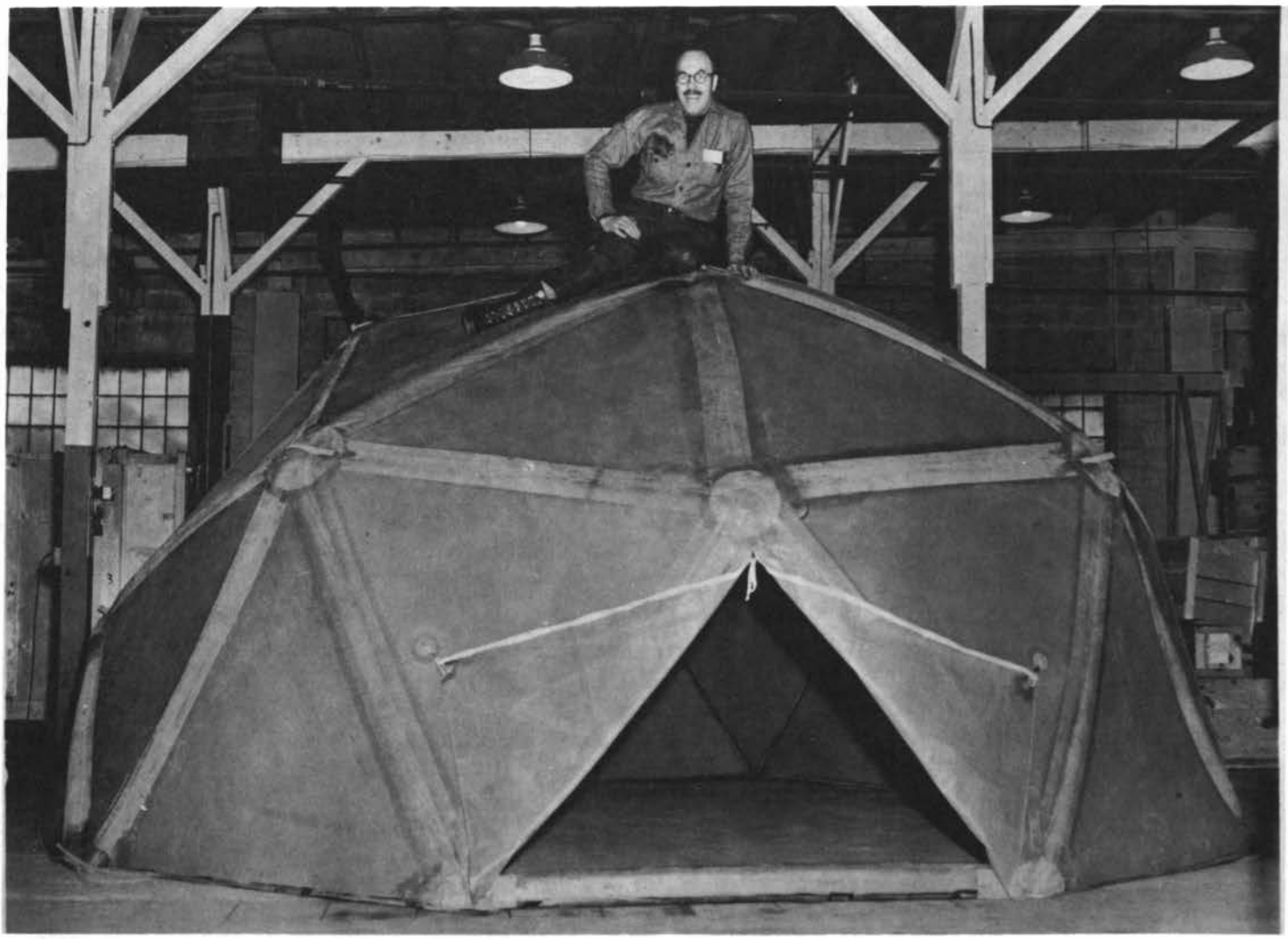
discovers that he has made a rough dome. Next he discovers (that is if he wants to think about it,) - and I did, - that whatever makes that structure standup and span space is not dependent on what was at the center because the snow has been taken out of the center. Whatever makes it stand up has to do with the circumferential interactions of the snow crystals and their molecules and the latter's atoms. I then found out by experiment that I could put not only one hole but many holes through the snow dome shell and it continued to stand up. As a consequence I saw that it would be possible to take a pneumatic balloon, pair the molecules and get rid of all the molecules at center that were not hitting the balloon - for it is only the molecules that hit the balloon at high frequency of successive bounce-offs that give the balloon its shape.



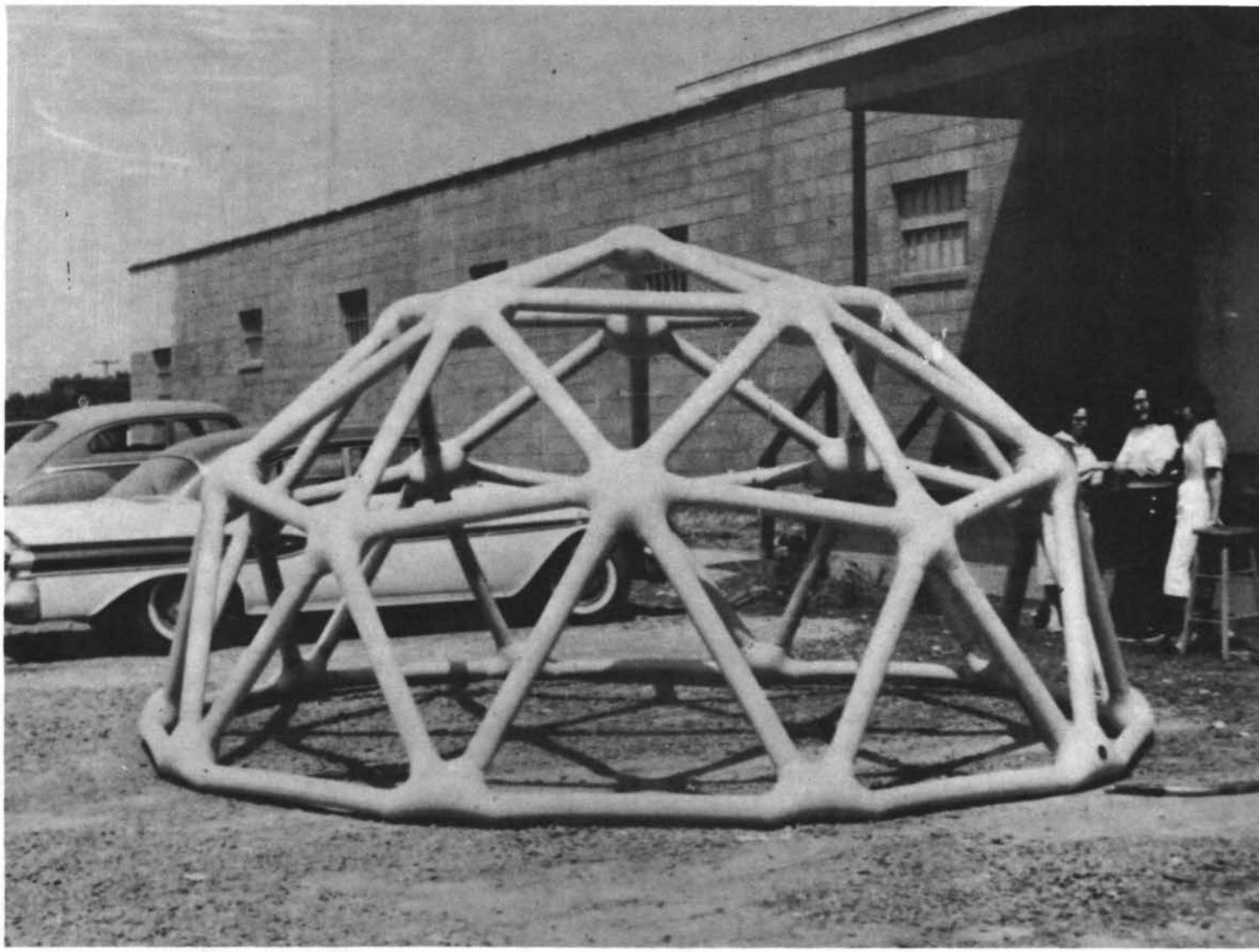
(D-1-103) That is also exactly what happens in a three-way grid tensegrity-geodesic spherical grid. In the balloon we get paths of these positively and negatively paired, kinetic molecules reacting from one another in a random set of directions. If they went into one path only they would make a single circle which would push the balloon outwardly only at its equator making a disc and allowing the poles to collapse. If they made a two way stack of parallel lesser circles as a cylinder, the cylinder would contract axially into a disc. A two way grid would make only unstable squares and diamonds which would elongate into a tubular snake. But once we have three or more sets of angularly independent circularly continued push-pull paths, they must inherently triangulate by push-pull stabilization of opposite angles. Triangulation means self-stabilization which creates omni-directional symmetry, which makes an inherent three way spherical symmetry grid which is the geodesic structure.



(B-19-2) Here we have a large twenty foot diameter double pneumatic bag, consisting of two concentric pneumatic bags, one 4 inches inside of the other. Their skins are attached to each other by a forest of thread-size tension members. The pattern is a geodesic triangular grid.

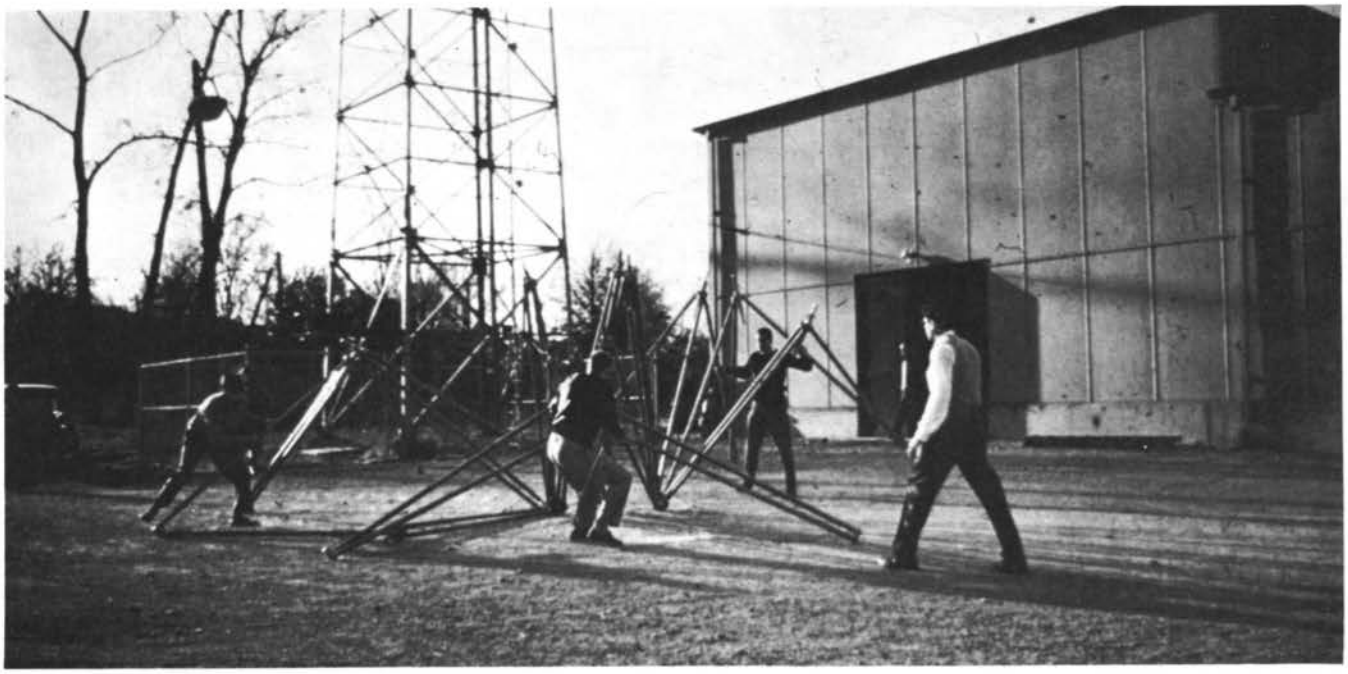


(B-19-3) We introduce air into the space between the two and the paired molecules trying to escape outwardly from common center of action makes the outer of the joined skins take this hemispherical shape pulling the inner skin outwardly. The structure shown is, incidentally, one which was air delivered to an arctic ice island which drifted over the north polar region in the International Geophysical Year.

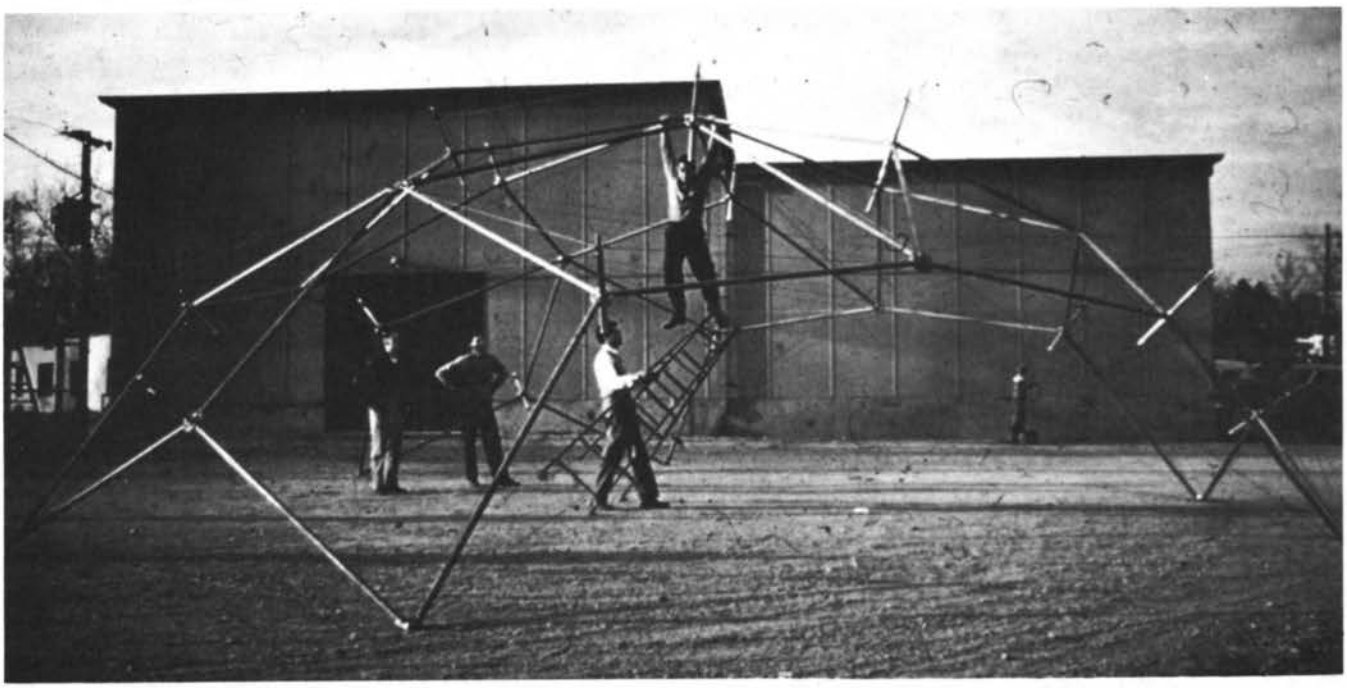


(P-21-1) We see next the interior triangular areas of the surface triangles of the geodesic pneumatic dome "holed-through" with triangular holes, leaving only a 3-way, - triangulated geodesic, tubular, tensegrity, pneumatic grid. The geodesic triangulation of the web-skin verified that we had hollowed out the interior molecules as in the snow dome and also verified that the spherical shape was the resultant of a three way triangular stability. As with the pneumatic geodesic in our only superficially solid metal geodesic domes it is the pattern of the atoms within the molecules and the molecules of aluminum or iron hitting outwardly against the geodesic tensional mass coherence grid that gives it its most natural, comfortable, least effort shape.

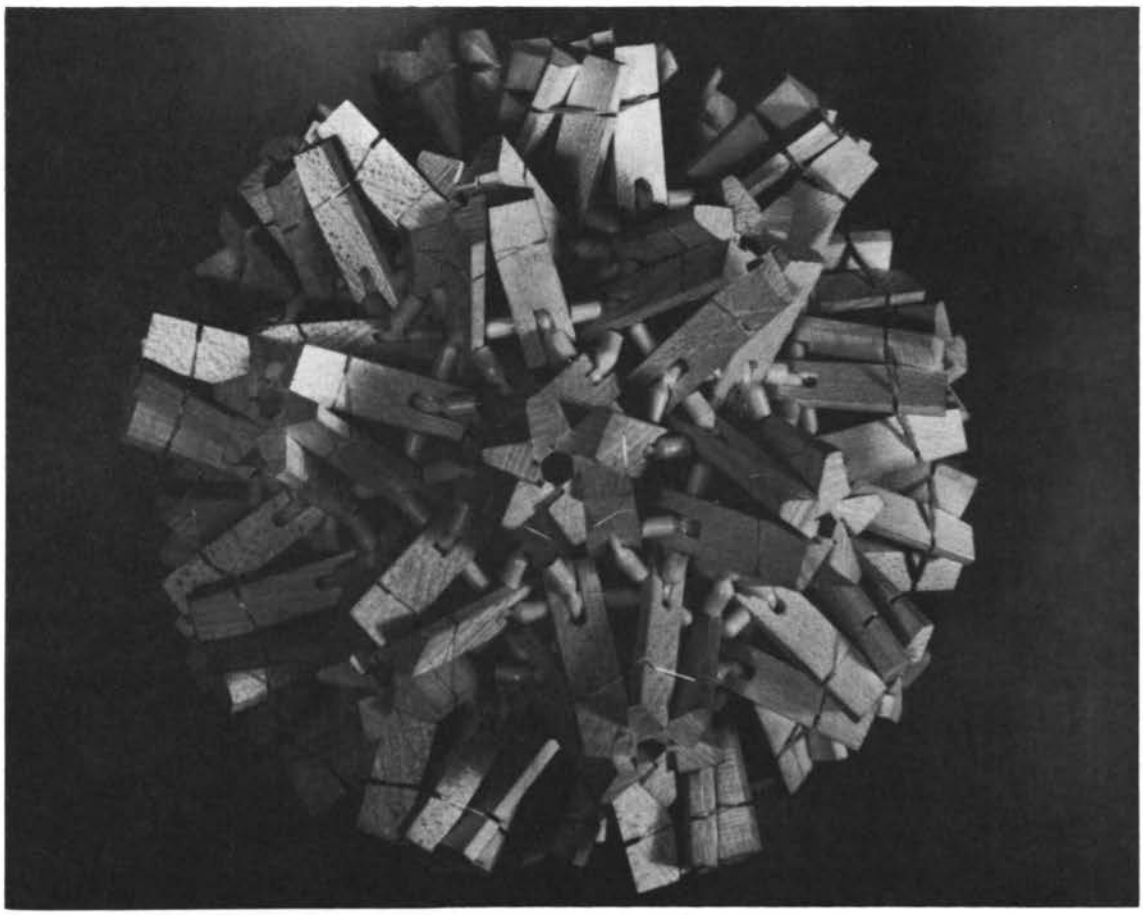
(W-5-34) Here we have a structure which follows the pneumatic-tensegrity principle in another way. We made it at Washington University in St. Louis, U.S.A. in 1953. You may possibly be looking at the prototype of the structural principles that we may use in sending the little scientific dwelling to the moon. As you see all the structural members are in parallel in this first picture so that they may be transported in minimum volume in a rocket capsule. The parallel struts of light weight magnesium alloy consist of sets of three fastened together with a ball joint in tripods. Each set is like a camera tripod with three tubular magnesium legs. It has ball joints at the tripod head. Then all the tripods' feet are fastened together with ball joints in clusters of 5 and 6 tubular-tripod feet per ball joint. We have a little mast coming out of the top of each tripod. This mast is pushed out automatically by a piston in a cylinder. We put 200 pounds of gas pressure inside the cylinder and this gas pressure will push the masts on all the tripods outwardly from each of the tripod heads. The pushed-out masts each have three tension members leading to their respective tripod's feet. As the masts are pushed out by the 200 pound pressure the tension members pull the legs of the tripods outwardly from one another. The tripods all open wide with their ball joint feet fastened together in hexagons and pentagons. There is a triangular net of aircraft cable in a regular geodesic "star" spherical grid, - like the pneumatic ball's tension net, that restrains the tripod legs from moving any further outwardly from one another than is necessary to form a dome or sphere.



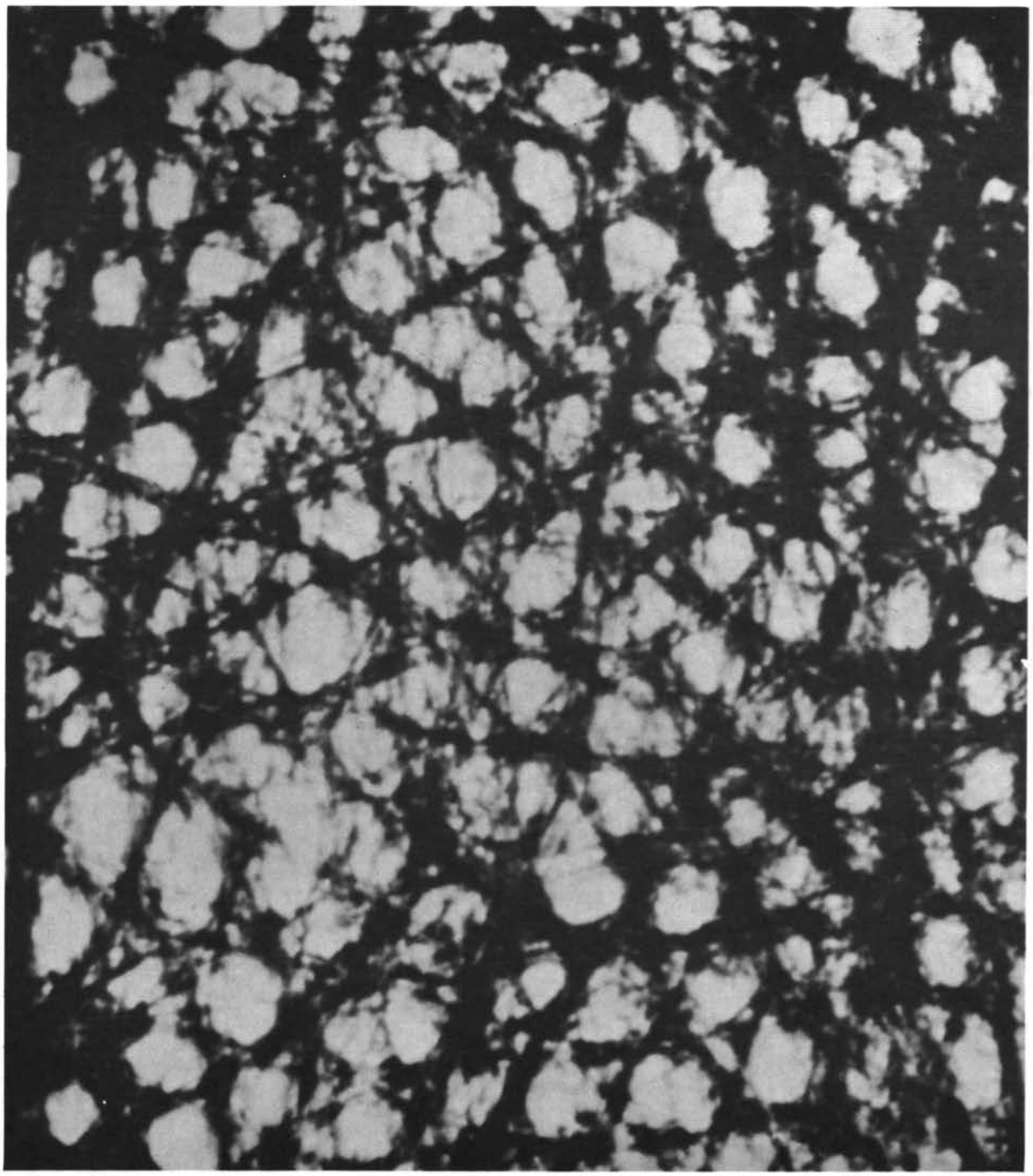
(W-5-35) The students pull the lanyard, unleashing the FLYING SEED POD-parallel strut assembly.



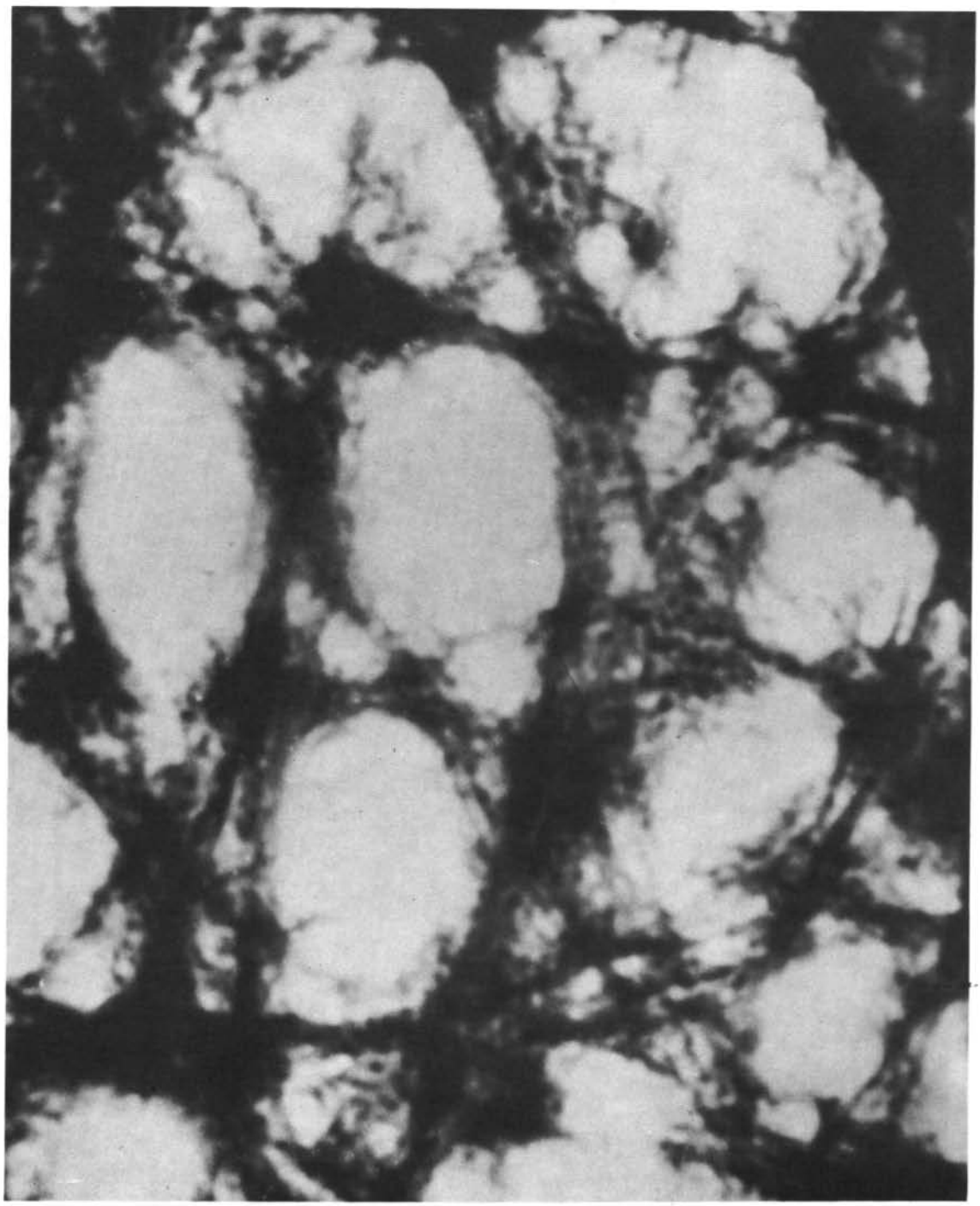
(W-5-36) The tensegrity, geodesic, pneumatic flying-seed-pod, - moon structure pops open in 45 seconds by itself. This same principle may be realized without the ball joints by using the tensegrity-webbed, universal joints that I have shown to you in earlier pictures. We have the proven ability to capsule,parallel packaged, geodesic, tensegrity structures for rocketing to the moon, or to the top of an earth mountain or to other far earth points to be self-opened in seconds.



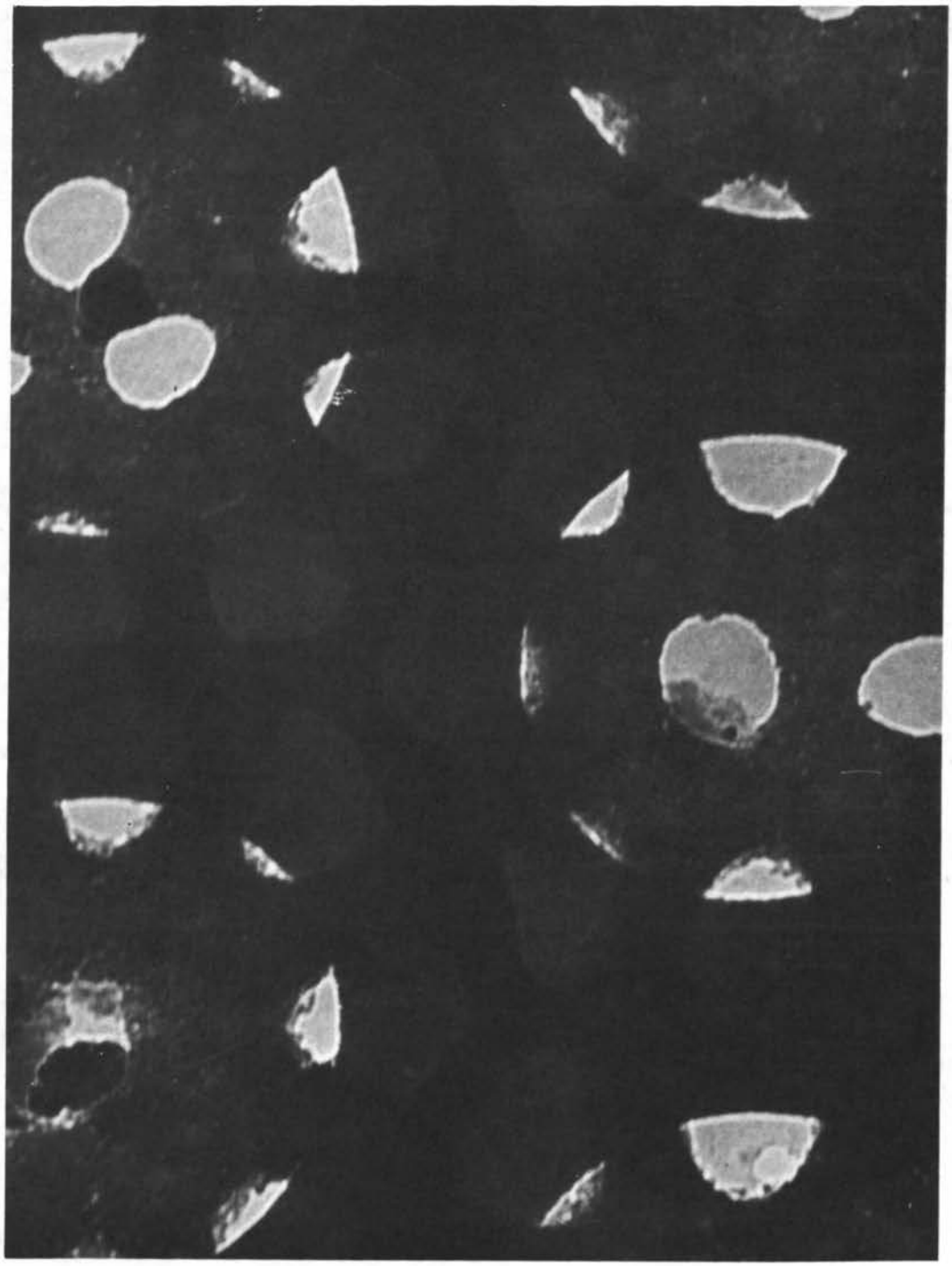
(D-1-113) The Washington University, St. Louis, moon structure, the flying seed pod's structural principles and their logistic patterning are doubly interesting because they have turned out also to be the structural, self-realization system employed by the protein shells of all the different types of viruses. About 3 1/2 years ago molecular biologists in England and later their colleagues in America, - working in teams were trying to explain the protein shells of the viruses with x-ray diffraction photographic analysis. These virus scientists discovered that the viruses' protein shells were all some type of geodesic structure. Having previously seen my geodesic structures they corresponded with me and I was able to give them the mathematics and show them how and why these structures occur and behave as they do. We have now found this polio virus structure to be the same structure as that which I showed you a minute ago as the possible moon structure. In the polio virus instead of having the tripods on the outside and the clusters of 5 and 6 feet on the insides, the polio virus has the five and six way jointings outside and the tripods or three-ways on the inside. -- This is a model of the polio virus that you are now looking at. It has the five and the six on the outside and the three on the inside. This polio model was made by Doctor Donald Casper, - a nuclear physicist and Director of the Children's Cancer Research at the Boston Children's Hospital, a colleague of the English virological team.



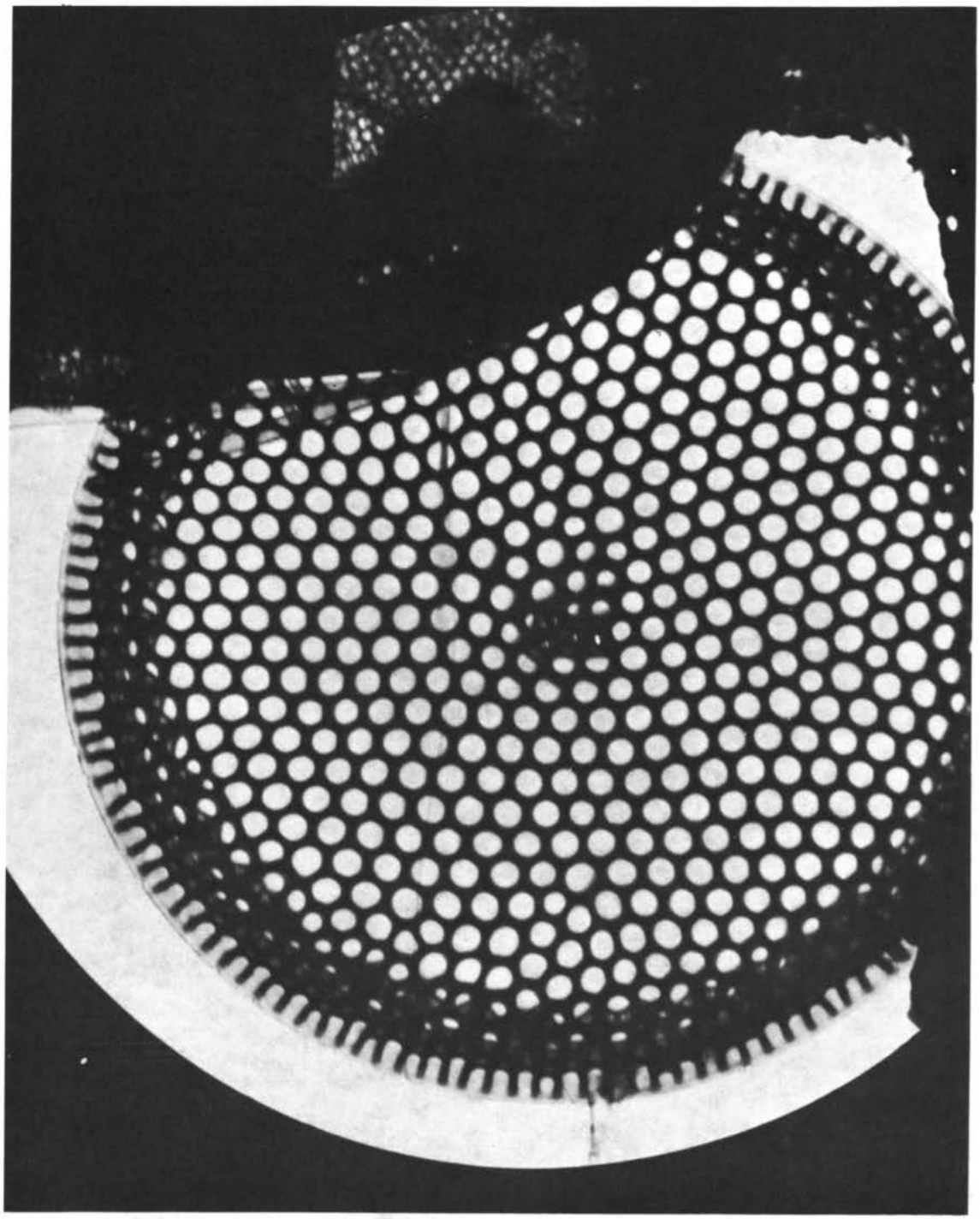
(A-12-5) This shows the outer tissue structure of the human testes greatly magnified. We see the same tensegrity geodesic triangulation.



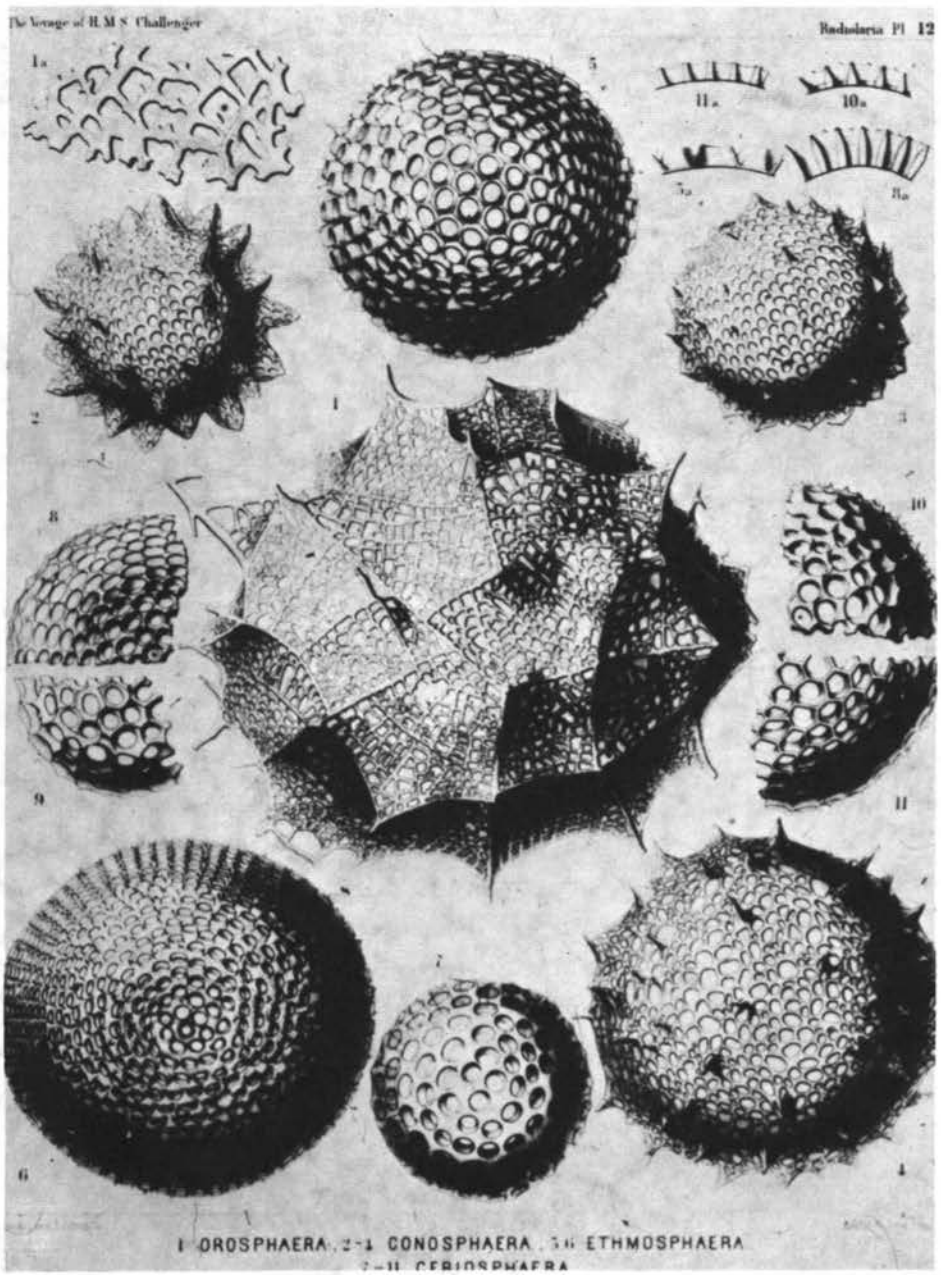
(A-12-6) What we are looking at here is a greatly magnified photograph made of the cornea of the human eyeball and this is the first photograph ever made of that structure. It was made by Dr. Von Hochstetter, Head of the Department of Anatomy of Western Ontario University in Canada. We are apparently finding spheroidal structures in nature all the way from the atomic nucleus outward through the virus levels manifesting the three-way grid of tensegrity geodesics.



(F-8-9) This is a picture of the micro plants, - the algae and diatoms.

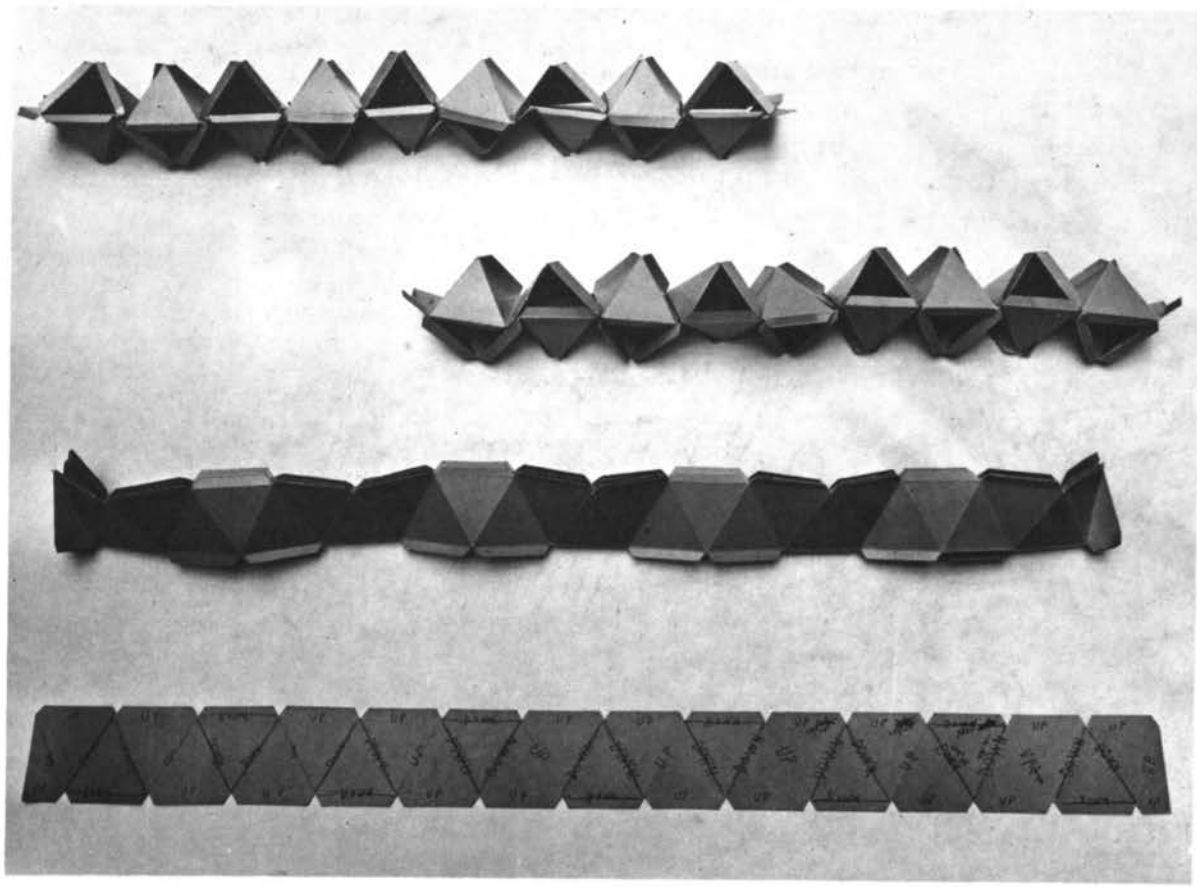


(F-8-5) This is also the diatom photographed at the Max Plank Institute in West Germany with an electron microscope. These micro plants grow in both fresh and sea waters.

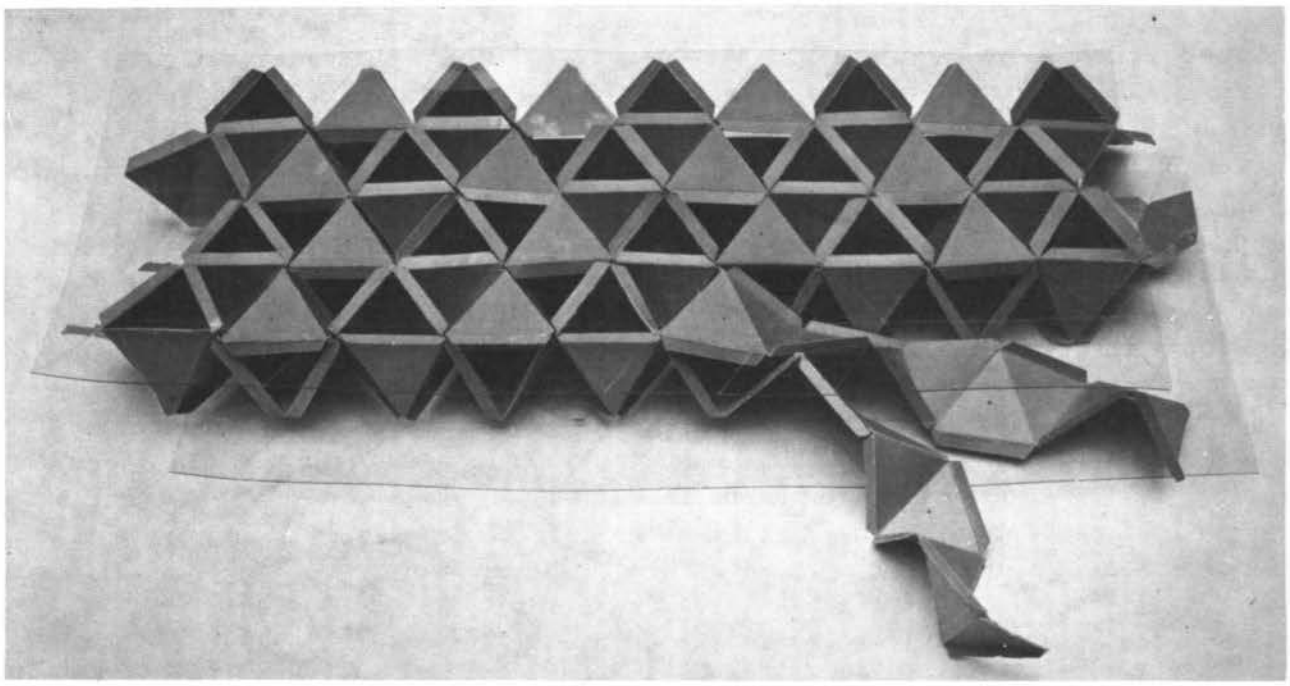


(R-4-1) And here we have the micro animal structures, the radiolaria which if you study them, will always show that they are based on either the tetrahedron, the octahedron or the icosahedron. This picture was drawn by English scientists almost a century ago as they looked through a microscope at these micro-sea structures.

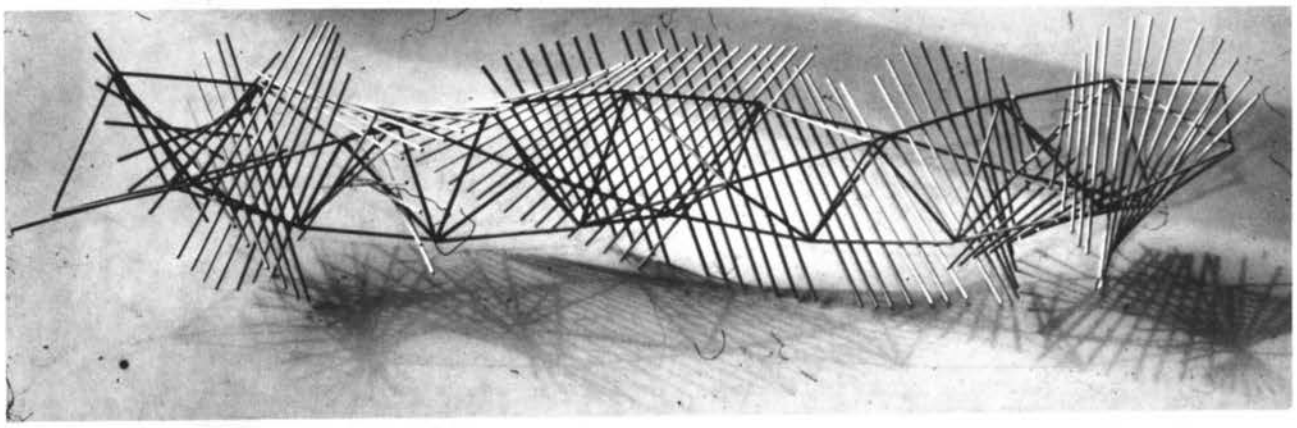
Today I have given you first some fundamental structural principles and subsequently shown you their use by nature. I didn't, however, start by studying these structures of nature seeking to understand their logic. The picture of the radiolaria has been available for 100 years, but I didn't happen to see it until after I had produced the geodesic structures from the mathematical sequence of developments which I reviewed for you earlier. In other words I did not copy nature's structural patterns. I did not make arbitrary arrangements for superficial reasons. What really interests me therefore in all these recent geodesic tensegrity findings in nature is that they apparently confirm that I have found the coordinate mathematical system employed in nature's structuring. I began to explore structure and develop it in pure mathematical principle out of which the patterns emerged in pure principle and developed themselves in pure principle. I then realized those developed structural principles as physical forms, and in due course applied them to practical tasks. The reappearance of these structures as recent scientists' findings at various levels of inquiry are pure coincidence, - but excitingly validating coincidence.



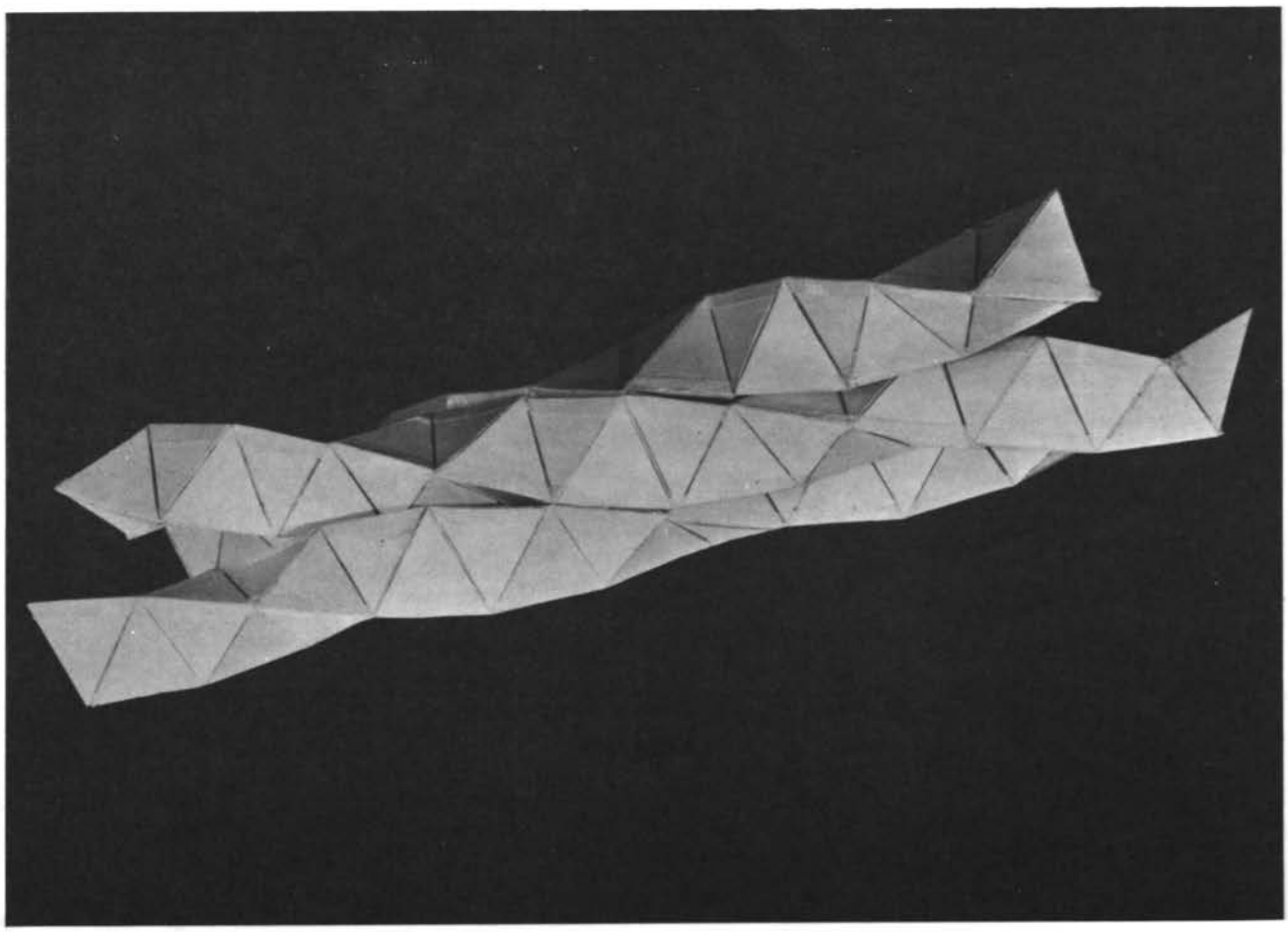
(O-2-3) Here for instance was one of my experiments in triangulation; forming this continuous pattern strip which is a 60°, angular, "come and go" alternation of very high frequency energy events of unit wave length. This strip folded back on itself becomes a series of octahedrons and tetrahedrons.



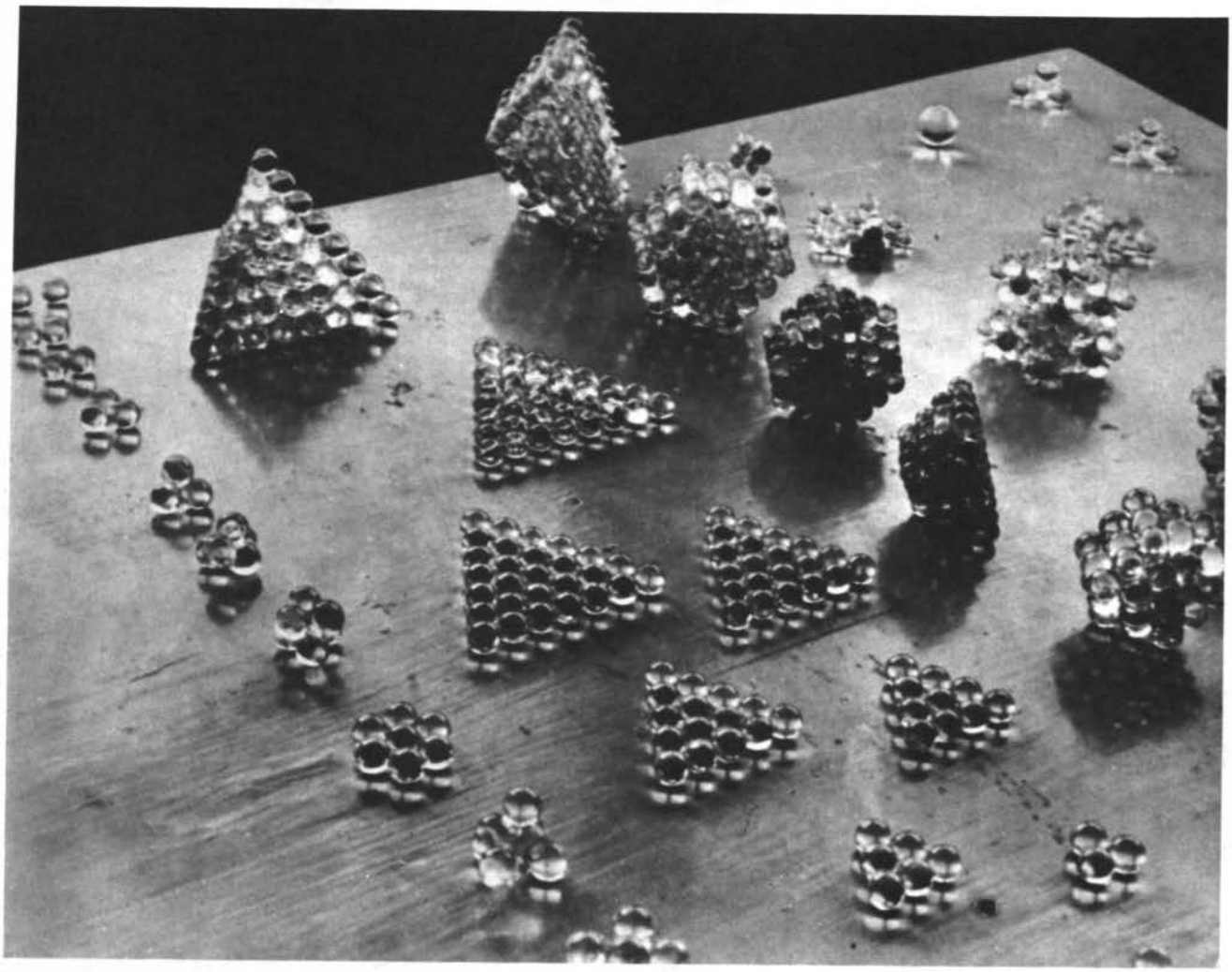
(O-2-30) The octa and tetra production of the last picture then grow into what I call the octtet truss - whose omni-directional growth fills all space with all the lines or vectors being of identical length and all the triangles being equilateral and all the vertices being, omni-directionally, evenly spaced from one another. This is the pattern of "closest packing" of spheres.



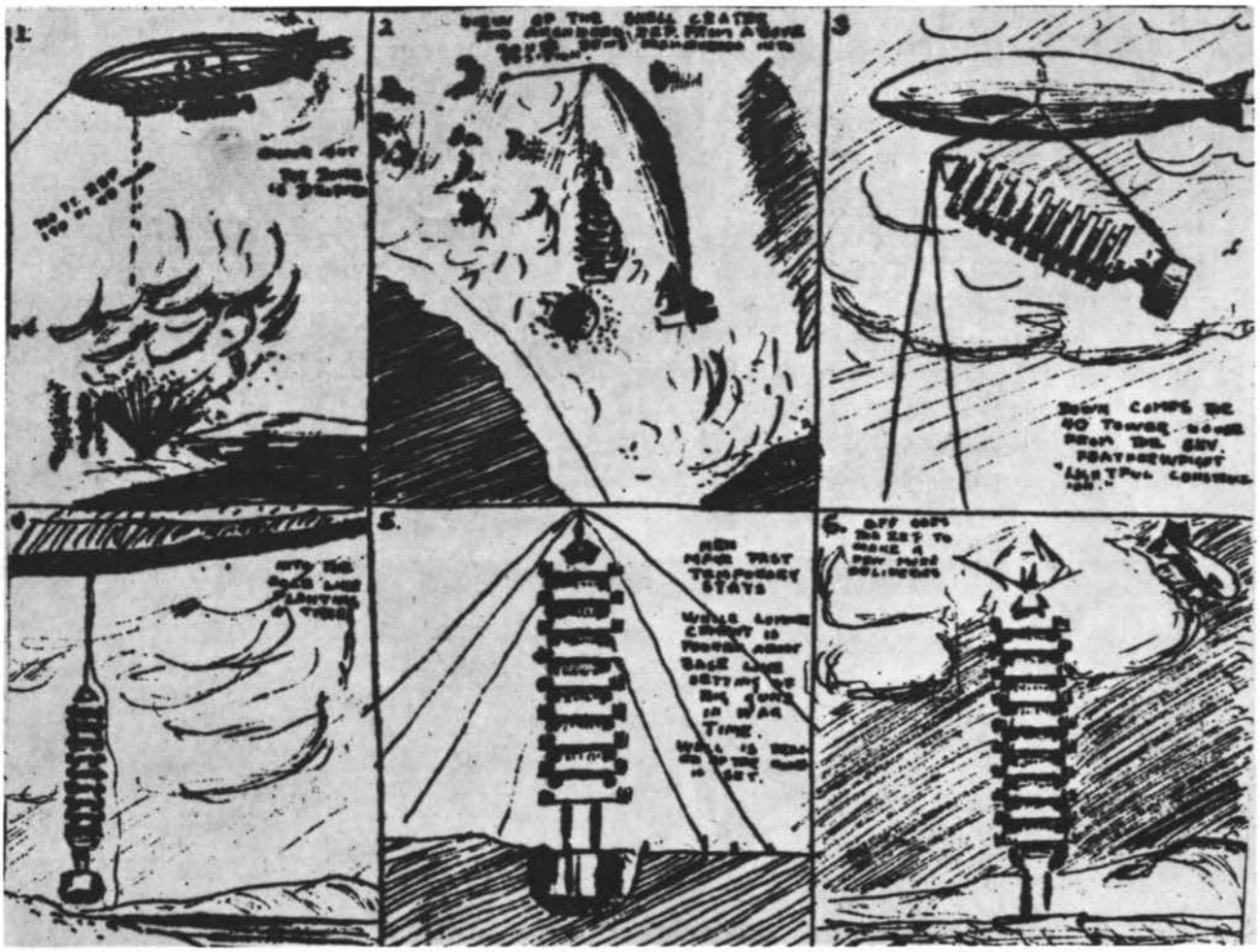
(D-1-128) Then we get into columns of tetrahedra or what I call a tetrahelix.



(D-10-3) The next picture with considerable probability may explain the structuring of DNA models or the control of the fundamental patterning of nature's biological structuring as contained within the virus nucleus. It takes just 10 triple bonded tetrahedra to make a helix cycle, which is a molecular compounding characteristic also of the Watson, Crick model of the DNA. When we address two or more positive (or two or more negative) tetrahelixes together the positives nestle their angling forms into one another (as do the negatives nestle into one anothers forms). When so nestled the tetrahedra are grouped in local clusters of 5 tetrahedra around a transverse axis in the tetrahelix nestling columns. Because the dihedral angles of 5 tetrahedra are $7^{\circ}20'$ short of 360°, this $7^{\circ}20'$ is sprung-closed by the helix structures spring contraction. This backed-up spring tries constantly to unzip one nestling tetrahedron from the other, or others, of which it is a true replica. These are direct (theoretical) explanations of otherwise as yet unexplained behavior of the DNA. Furthermore the four chemical compounds, - guanine etc, whose first letters are G, C, T and A, of which DNA always consists, in various paired code pattern sequences such as GC, GC, CG, AT, TA, GC (in which A and T are always paired as are G and C) are demonstrable by equivalent variations of the four individually unique spherical radii of two unique pairs of spheres which may be centered at the four tetrahedra vertices giving the tetrahedra four unique asymmetries in any variation of series which will result in the steerability of the shaping of the tetrahelix prototypes all of which can account for the pattern controls effected in all biological structures by DNA.



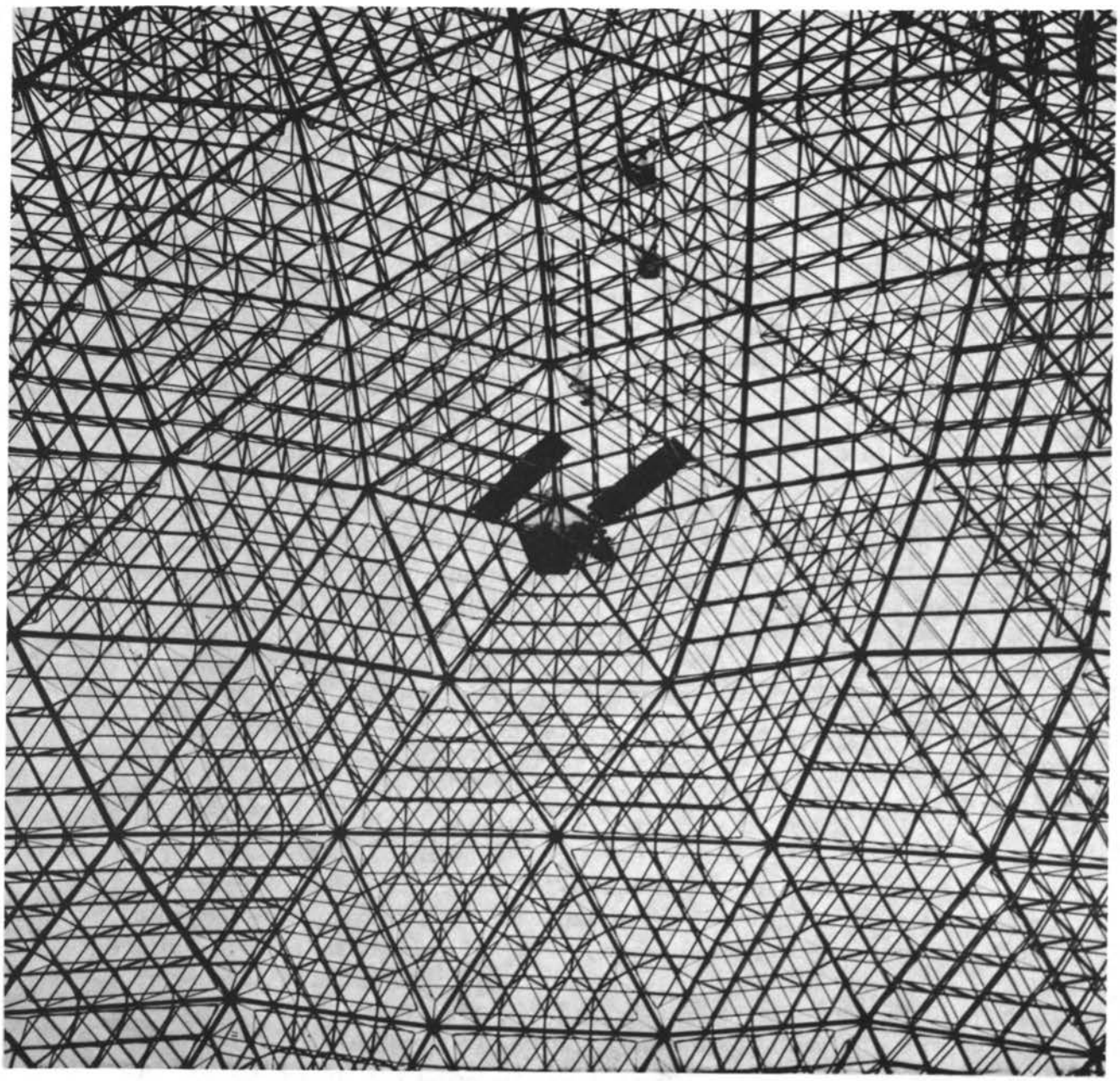
(E-2-1) This picture shows many patternings of the spheres in closest packing where however all the spheres are of the same size. They assemble in all the forms of tetrahedrons, octahedrons and icosahedrons. So much for the mathematical theories of structure. I will now review my employment of the structural and synergetic principles in comprehensive, anticipatory, design science.



(A-1-4) In 1927 I gave myself a theoretical problem which turned out to be feasible in high performance per pound engineering. I gave myself the problem of delivering large structures by air. Why? We can assemble large structures under preferred environmental and mechanical conditions as for instance we build airplanes at high advantage in the controlled environments within a factory and with a galaxy of efficiently arranged jigs, fixtures, templates and powerful tools. I can deliver an ocean ship from the "ways" into the sea with ease and without obstructions. There is nothing to obstruct the ship; I can deliver an airplane into the sky, nothing to obstruct it; but if I try to make large buildings in a factory and try to deliver them over highways or railways, they will run into highway or railway tunnels and bridges which are too small for their passage. These holes through mountains occurred because of man's having to transport heavy loads overland at almost level grades pulled only by friction-overcoming locomotives. To accommodate the latter man punched holes through mountains, etc. Therefore in 1927

I thought of the idea of trying to deliver large structures by air to be above all obstacles. Therefore I gave myself a problem in 1927 of delivering a ten-deck apartment building to the north pole, during the arctic summer. In designing my ten-deck apartment I used the wire wheel principle. The wire wheel is a tensegrity structure because the island of compression in the hub is completely islanded from the compressional "atoll", - the rim. These two compressional areas are cohered in stability by the minimum of twelve tensional spokes. I found that I could make a ten-deck building so light that it could be carried by the Graf Zeppelin, suspended horizontally under the Zeppelin's belly. The Graf, upon reaching the arctic site, could drop a bomb, make a crater, lower the building into the crater, plant it like a tree and fly back home leaving the building occupied. I saw that all this was feasible even though in reality I would not be enabled to use the Graf Zeppelin and even though I would not have, for another quarter of a century to come, the necessary high weight-strength alloys which I had assumed to be available by 1952 in making my 1927 calculations.

(D-5-29) In 1927, a rendering made by my wife, of my theoretical application of these structural and chemical principles to the development of the little one-family scientific dwelling machine, which could be air-delivered to remote places and would have to have autonomous equipment for re-circulating the energies taken out of our metabolic process wastes. I also went into development studies of the kind of transports necessary for such roadless airportless spots. The Dymaxion 4D Transport seen below the Dymaxion House was the prototype conception of my prototyping experiments begun in 1933 to produce the omni-medium, wingless, twin-jet stilts, transport.

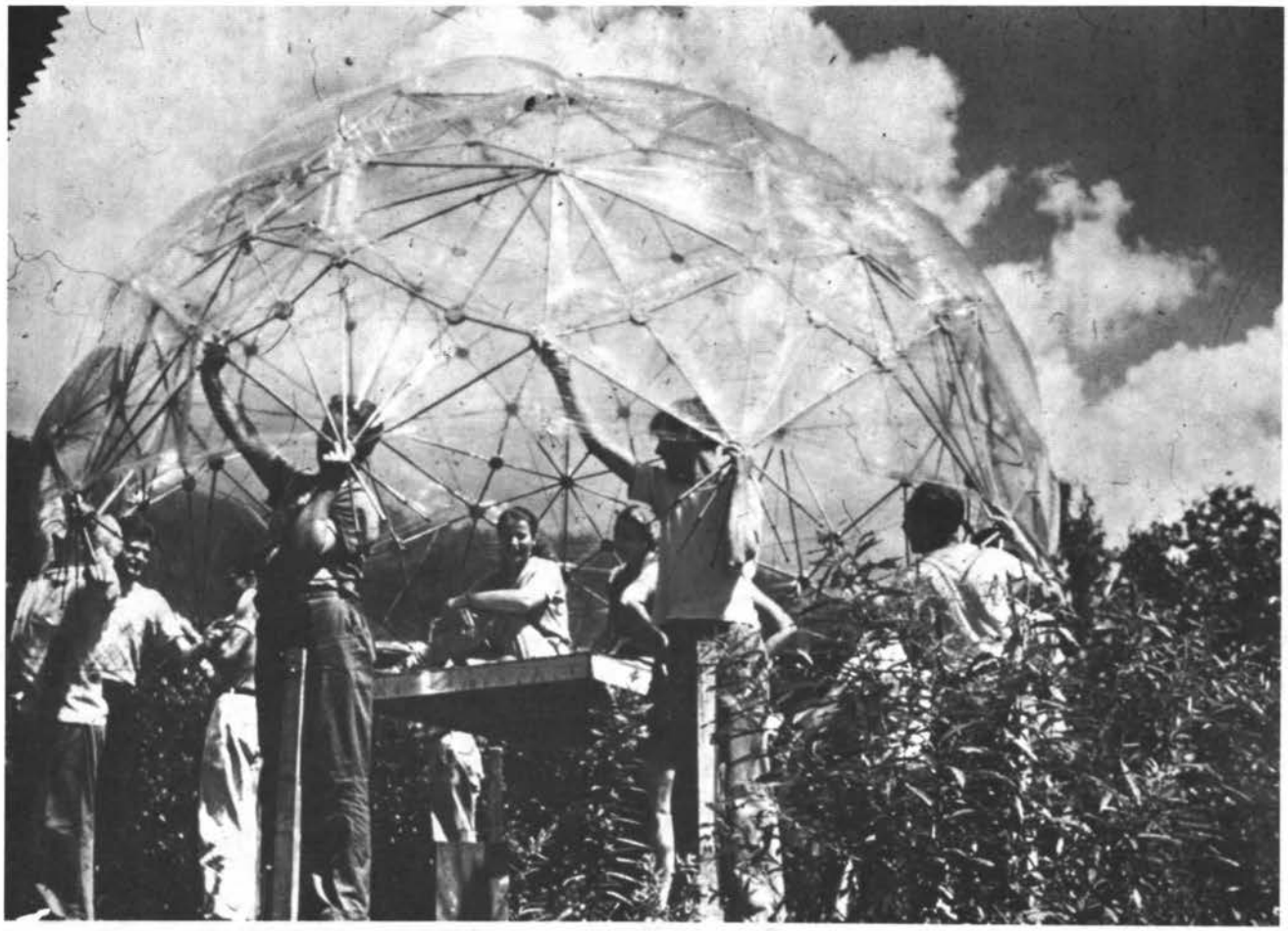


(F-2-30) As I made my original studies in 1927, I began to predict rates at which the tensile strengths of ferrous and non-ferrous alloys were increasing as well as the rate at which plastics were beginning to develop. There was a predictable average of about 25 years before the favorable chemical conditions would exist to make possible the working stress assumptions which I had used in designing the air deliverable structures for the feasibility studies which also theoretically employed the Graf Zeppelin and its theoretical north pole delivery. Right on schedule, in 1952, twenty-five years after I had started my work in 1927, the Ford Motor Company came to me and asked me if I could install one of my geodesic domes over their Rotunda building in Dearborn. This was the first time during that predicted twenty-five years hiatus that anyone had come to me for actual procurement of any of my slowly evolving light weight

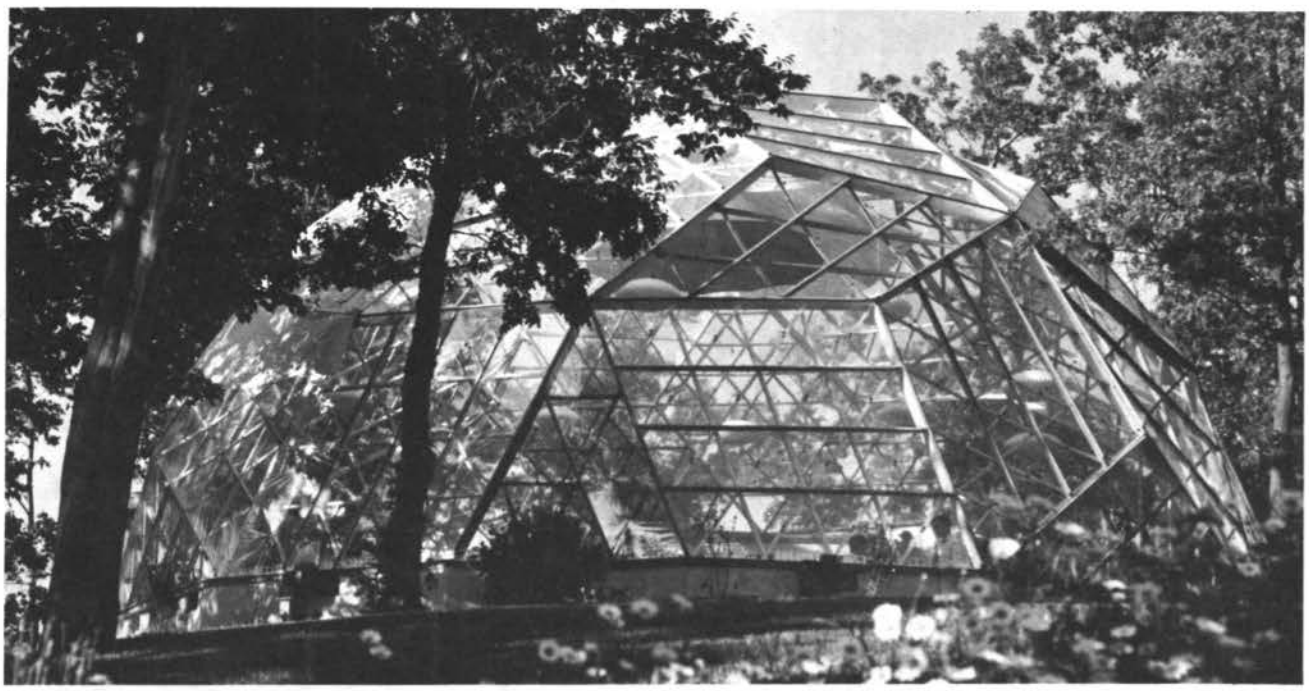
structures. I mention this lag to encourage the architectural students in relation to their up-coming ten-year development of a complete world redesign which will need organized patience on their part.

I made up my mind that if you really develop the tools and abilities, and don't waste any time or effort trying to persuade people to look at what you are doing, and you find out whether your, (theoretical) scientific designs will work or not; that when and if they do work, someone will say, "What is that?" and you will tell them, and the news of your invention will get around and in due course if what you have developed is needed in an emergency, the world will come to you for it. They may steal it from you if you are not protected, but will use it and the world will be advantaged in new degrees. That is what happened to me in the Ford Rotunda Building dome episode in which I was protected by patents. It has happened to me on innumerable other occasions. History will come to the world architectural students if they do a competent job.

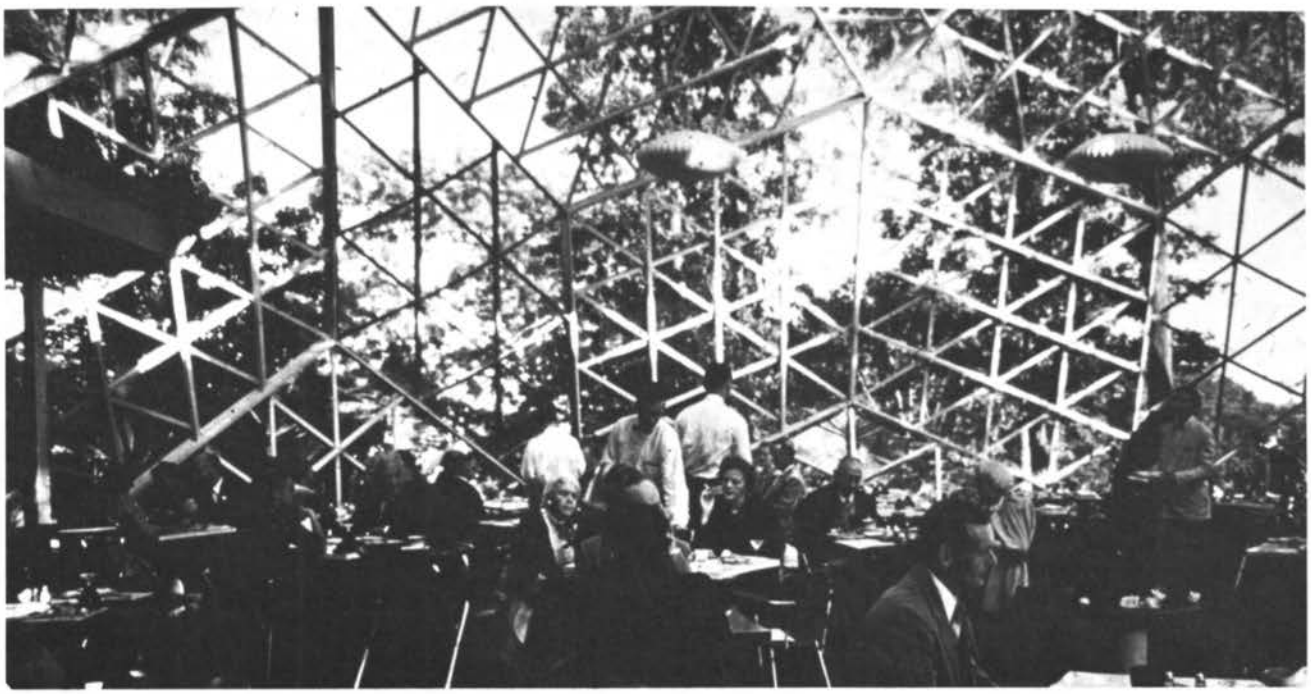
In connection with "competence" I would like to tell you something about accurate dimensioning. The Ford Motor Company geodesic dome was made out of aluminum struts, stamped out of aluminum alloy sheets. Sheet aluminum is made at high speed and at lower costs than for any other metallic production form. We also carried out the dimensioning of this Ford Dome to a one thousandth of a second of arc accuracy. You might say "Why did we need to make things as accurate as that?" I can tell you. The answer is that in fastening two pieces of metal together with rivets in mass production technology you have to prepunch all the matching holes so accurately that the parts are interchangeable. If you make the holes a little large to make sure of getting the rivets through, then it permits the two parts to slide which develops a shearing action. If you can make the holes very tight, then there is no room for this shearing action to occur, and the strength of the total structure becomes synergetically greater. In making the Ford Motor Company, Dearborne, Michigan, Rotunda covering dome we carried out the dimensionings with tools made on the indexing machine in a lathe which holds the dimensions very much finer than the human eye can see or possibly "lay out." The Ford geodesic dome's structure was twice as strong as it would have been if it had been laid out by the naked eyes, even of the best sheet metal workers in the world. As a consequence I was able to make the Ford Dome with one-half the weight that it would have required if we had kept the dimensions at the human visibility level. This explains as a typical example why it is that I have been talking to you about all of our advanced industrial technology having already gone into the invisible, high strength realms. You are not used to that kind of dimensioning in architecture where from 1/8 to 1/4 inch is "close enough." You have not realized that you can actually make twice as many buildings by simply bringing the dimensions into subvisible tolerance. This is not a matter of aesthetic fastidiousness. It is a matter of two buildings for the price of one of yesterday's.



(P-1-9) Here we have a platform suspended from a geodesic dome. Three people are sitting on the platform. Students are testing the way earthquakes would affect such a structure by alternately removing the separate students' supports along the base of the dome. We found that the stresses induced by this wave generating pattern were absorbed in the first row of triangles above the equator.



(W-4-19) This is a geodesic dome restaurant of 2,000 square feet at Wood's Hole, Massachusetts which uses the parabolic principle. I covered it with a very thin clear plastic film skin of Dupont Mylar, and it went through Hurricane Carol in 1953. Some of the local diamond skins were punctured by flying objects such as broken off tree branches, but the punctured skin did not tear open and blow away.

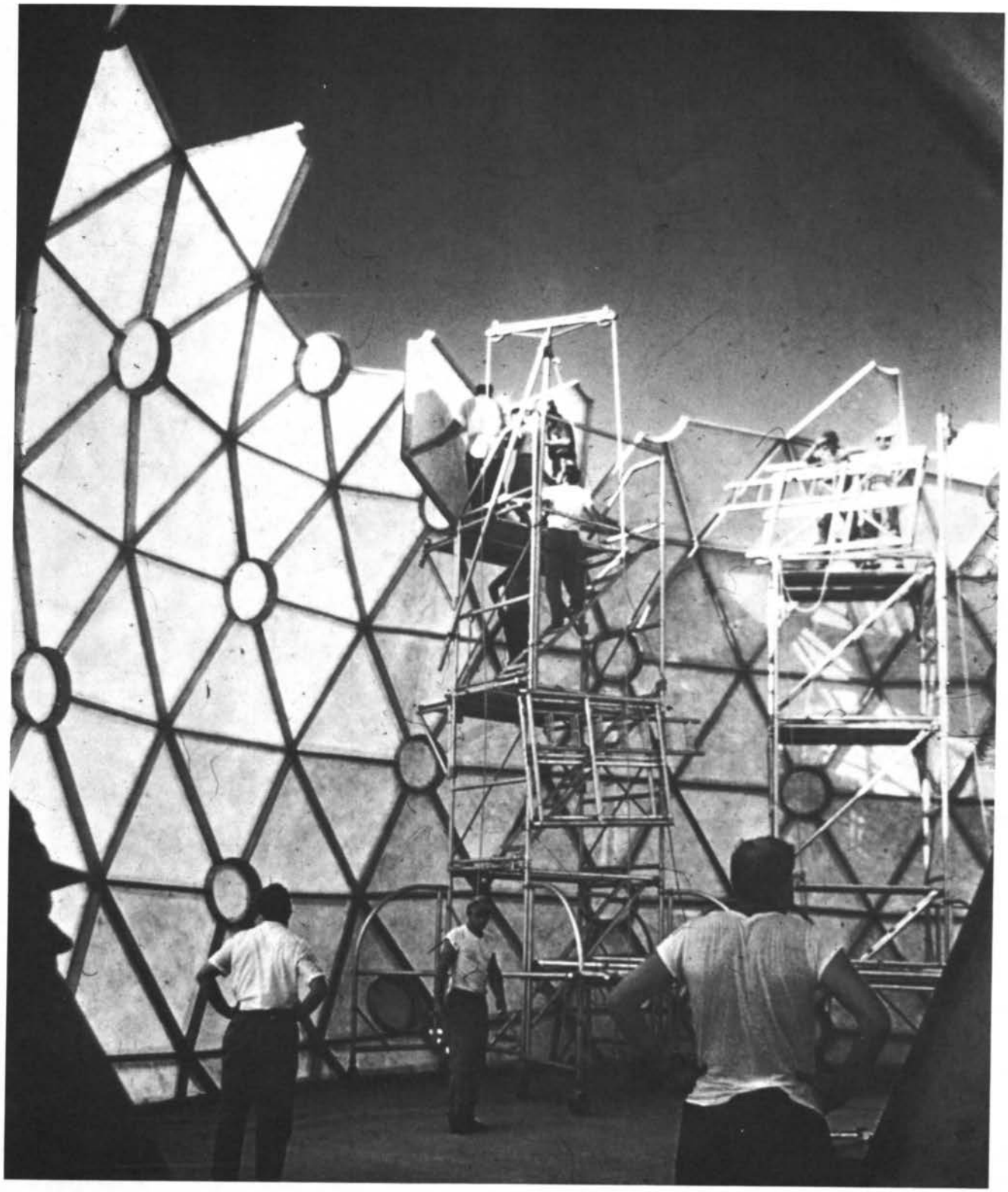


(W-4-26) This is the inside of the Wood's Hole restaurant. Sitting inside it, you just didn't see any skin membrane at all. It began to seem that we were approaching a time when the construction would become entirely invisible. It was a delightful restaurant, but the owner could not

get the local banks to take a mortgage on it because the bank said they could not see any value there. So the following year the dome owner covered our geodesic dome structure with a heavy opaque plastic which reduced the dome's attractiveness but convinced the bankers that it had substantial value and they took the mortgage.

(L-5-18) This was the beginning of use of our geodesic structures for radomes to enclose the articulating radar equipment which is used by the defense early warning system of the United States along the northern arctic perimeter. Because the large radar antenae had to articulate they had to cover it by a dome invisible to microwaves. The radomes had to be able to go into the arctic and withstand enormous storms, wind, snow and ice.

(L-6-75) The following picture is one of our geodesic radomes tested for the arctic. They are made out of polyester fiberglas and the diamond shaped, pan-edged pieces are made with bolt holes in their adjacent flanges. All the mathematics must be done very accurately to permit these pieces to be interchangeably bolted together. We hold our spherical trigonometry calculations to an accuracy of one/one thousandth of a second of circular arc. The geodesic radome structures go up in an average of 14 hours a piece, in the arctic.



Our Air Force Radomes were installed in the arctic mostly by eskimos and others who had never seen them before. The mass production technology made assembly possible at an average rate of 14 hours each. One of these radomes was loaned by the U. S. Air Force to the Museum of Modern

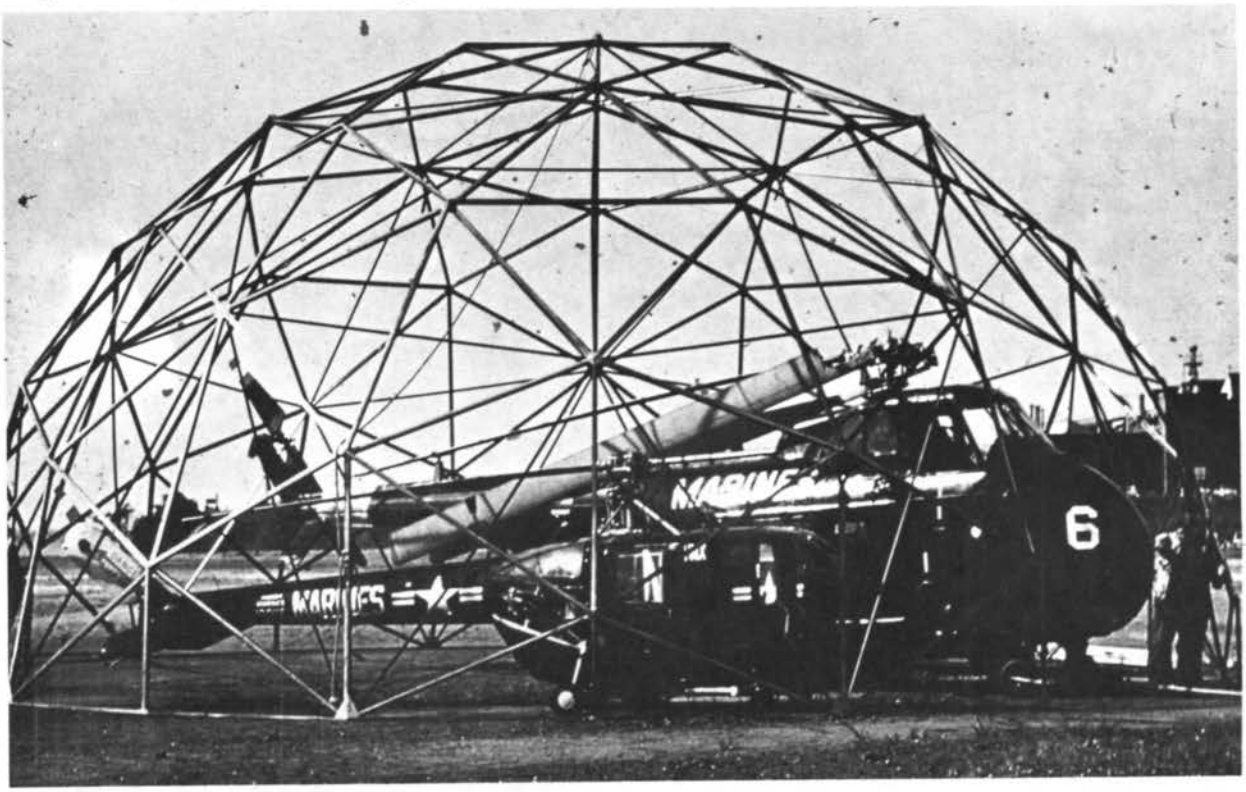
Art in New York City for an exhibition of my work in 1959-1960. It took regular building trades skilled labor one month to assemble the dome in New York City. American labor fought a great and worthy battle to win the working man's share of the synergetic productivity of industry. Labor's battle proved doubly worthwhile because it inadvertently brought about mass purchasing power. Without mass purchasing power you cannot have mass consumption, and without mass consumption you cannot maintain mass production. You cannot have the mass production of industrialization without an original investment of a vast capital effort of work and that original capital came first and long ago from serfdom or outright slavery. In order to bring industrialization to benefit comprehensively emancipated man, you must have mass purchasing power, - which in due course will underwrite automation which in turn will eventually produce so much wealth as to be able to free man's time for further education and research to increase the wealth being generated by unimpeded automation. American labor will not yield that unimpedement until it is clearly demonstrated that all men will prosper directly by so doing. American labor did bring about the vast purchasing power in industry, but in so doing, it established all kinds of rules which inadvertently protected the obsolete inefficiencies of building. I inspected Mr. Pani's Mexico City housing development. It is exciting to see what a good standard of living he has been able to give to humanity here at such a low price. But we have to consider the fact that the low cost in comparison to the U.S.A. costs reflected the low labor rates in Mexico -- U.S. labor would have been paid ten times as much for that kind of work. Mexican labor will not be able to buy industrial products at these low rates and Mexico's industrialization will have to wait for that purchasing power.

When the kind of structure which goes up in the arctic in 14 hours takes a month in New York City, clearly there has been an inordinate shunting of social wealth in a direction in which legitimate value was not added to the product. That is an indirect, illogical, and therefore indefensible way of distributing wealth for it hides the new advantages and therefore retards the growth of those advantages as wealth generaters of commonwealth. We must be very careful in judging the new, high production technology structural experiments not to have our fundamental tactical information distorted by ill conceived labor tactics. We have very real social problems which must be solved by realistic acceptance of the facts rather than deferred from realistic consideration of the inherent new wealth generating advantages by hiding the new technical advantages under the wing of individually conceived palliatives which are operated by old rules that do not permit the real advantages to be recognized by the labor movement's management. We are going to have to bring industrial mass purchasing ability to all of humanity. But first we are going to have to get labor rates evened up, - up, all around the world, in order to have every man's raw time

worth as much as any other man's time, when translated into purchasing power per kilowatts or pounds of specific metal goods. Next we are going to let automation take over after we find ways to pay everyone dividends from its wealth making to keep up purchasing power at a maximum and thereby to regenerate the industrial evolution advance.

(L-6-76) This is one of those radome structures up in the arctic.

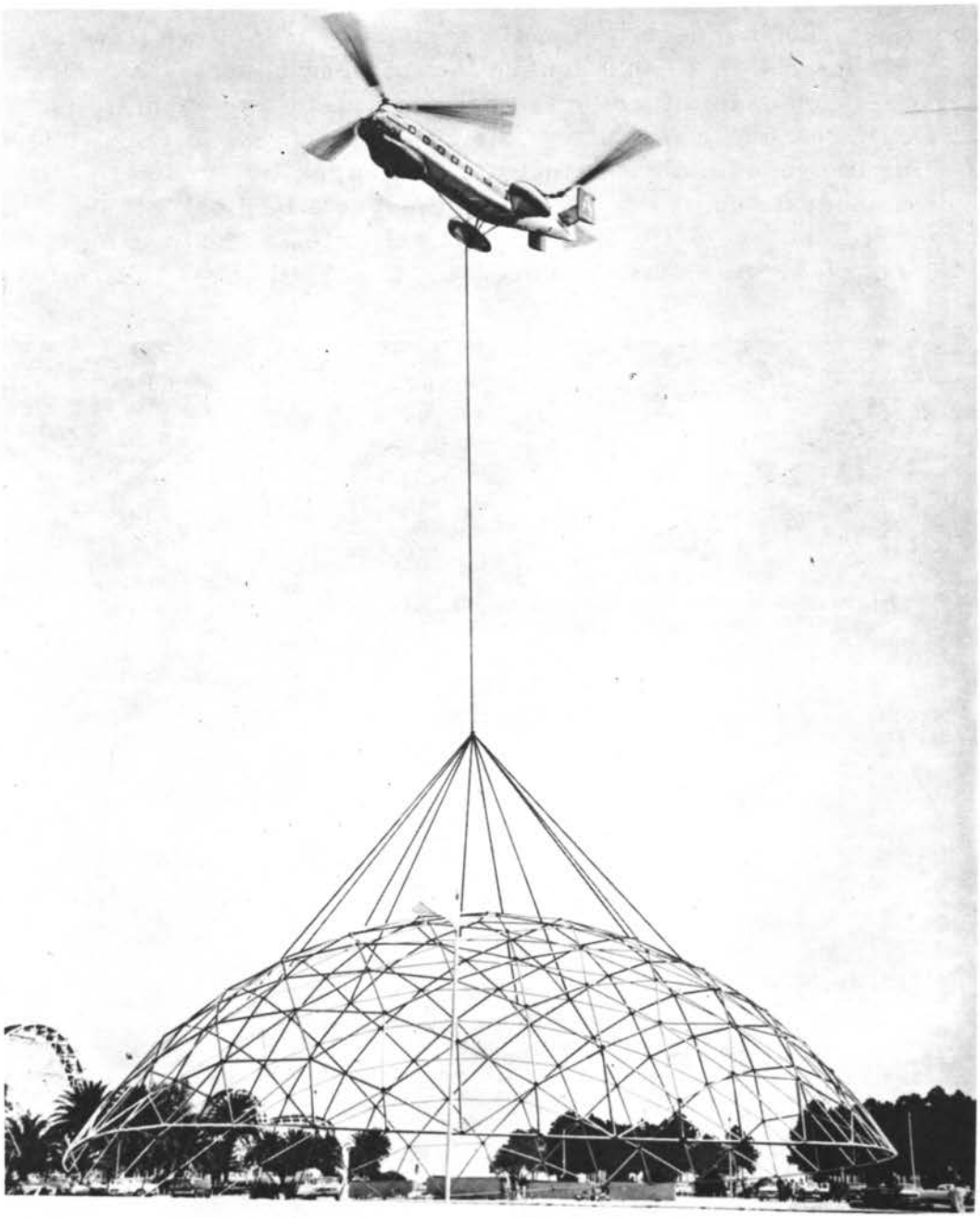
(M-8-15) The next picture is of a geodesic hangar made out of magnesium. It is one of the United States Marine Corps 55-foot advance-base hangars with three helicopters inside, two of them small ones and a large one. They come out and the large one takes to the air.



(M-27-10) With the United States Marine Corps flying my domes from aircraft carriers into land positions and operating them successfully in remotest and most unfavorable physical environment conditions I began to see

my 1927 dreams of air deliverable buildings come true. This is a United States aircraft carrier and here we have the helicopter taking off the geodesic structures, fully skinned in, and flying them off to the land at 60 nautical miles per hour. The domes, assembled on the hangar deck are elevatored to the flight deck.

(M-8-16) The large helicopter carries the three-helicopter hangar away at a 60 knot speed. This was back in 1954.



(F-4-1) This is one of two geodesic domes that we made three years ago (1960) for the Ford Motor Company. The Ford Motor Company later used this dome for their main exhibition at the 1962 Seattle World's Fair, having moved it all over the United States as a tractor exhibit pavilion. It is 114 feet in diameter and it has 10,000 square feet of floor space. It has twice the floor area of my 1952 Ford Rotunda dome and weighs only one quarter as much. That is an eight fold gain in performance per pound in eight years. In this picture the Ford geodesic, 1960, 10,000 square foot floor space dome is being lifted by one helicopter. The first Marine Corps lift you saw started with

a 30 foot diameter geodesic in 1954, i. e., about 900 feet of floor space then a 55 footer in 1955, i. e., 2000 square feet of floor space. In 1960 we flew this 114 foot diameter geodesic with 10,000 square feet of floor space, - a twelve fold gain in six years. The rate at which the helicopter's lifting capacity is being increased and the rate at which both the size and lightness of our geodesic structures are being improved indicates that within another five years we will be able to deliver a geodesic dome large enough to cover a baseball stadium, i. e. 700 ft. in diameter at a velocity of sixty nautical miles an hour in one single air lift. This, clear span, air delivered geodesic will cover fourteen acres.

(K-5-11) This is the Fuller-Kaiser Aluminum Company Geodesic dome. The Kaiser Company is one of my 125 patent licensees. Carrying on as an individual it is essential to my experimental frontiering initiative to take out patents. In mass production industry, unlike the craft arts, the public is the only patron. The inventor must take patents in order to control the corporations which intervene between the inventor and the public. In the world of book writing the hand penned books were originally produced by the author under the direct funding of his wealthy life patron, the King or the Pope or a Feudal Lord, etc. When mass production industry began with the printing of books, the publishers were forced by the writers' guild to recognize the copy-

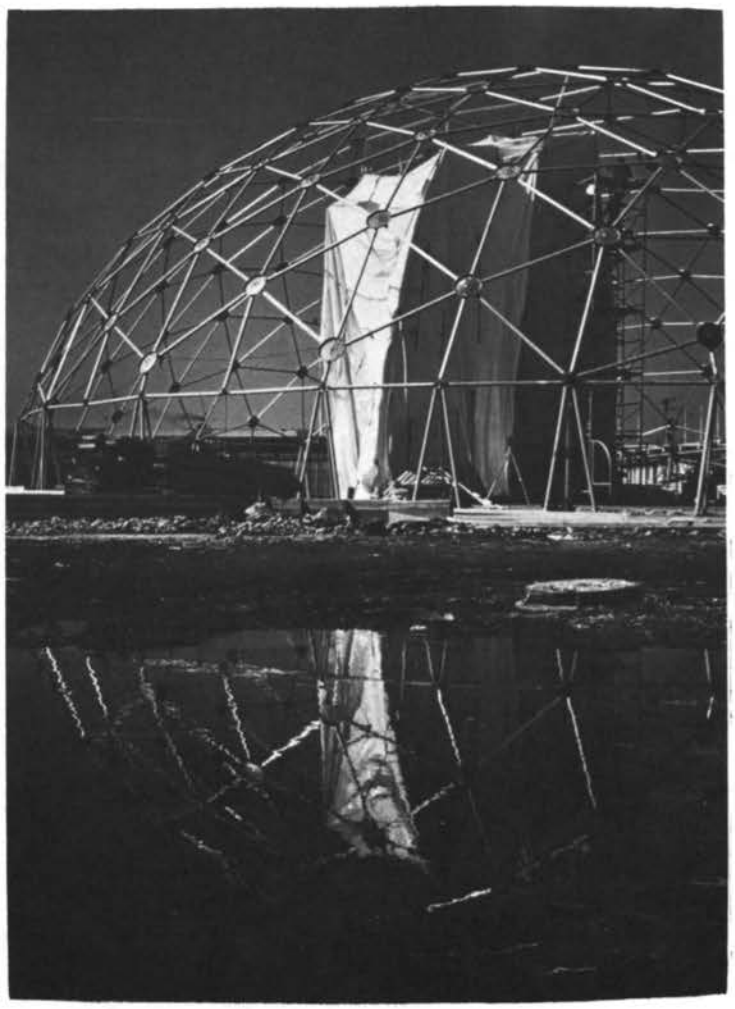
right of the authors. Books don't write themselves nor do buildings and machinery design themselves unauthorized by some individual. In architecture you have been operating in the craft world of the preprinting process. You make one building for your wealthy client. When however we bring buildings into high performance industry the scientific prototype cost is prohibitive unless mass produced. Then the architect must have his patent recognized by industry for the architect's new client is the mass consuming public with whom he has no direct dealing. I now have over 125 large corporations who came to me for licenses to produce my structures. I did not approach them. Incidentally, when they came to me, their patent attorneys said to my patent attorney, "the first thing that my company had me do was to try to get around your patent. I only come to you because we can't get around your patents." I can tell you that you never would have heard of me if I had not taken patents. Corporations today try to produce anonymously. They try much harder than does Soviet Russia to prove that the individual does not exist, until he is president of the corporation. You architects too will have to learn to take patents to permit you to deal with industry instead of with the craft arts. This particular Kaiser dome is one of many that have gone up around the world. It is the Kaiser geodesic dome which went up in Hawaii in 1958. It is 145 feet in diameter and went up in 22 hours.

(K-5-2) At the 22nd hour after commencement of this building assembly the Kaiser Company brought the Hawaii Symphony Orchestra in and at the 23rd hour after building start they were having a concert. Incidentally the acoustics turned out to be excellent. The Kaiser company had assumed that the acoustics inside a bare aluminum dome would be unsatisfactory, as they expected their sheetmetal to echo. But with the audience in place, the conductor of the Hawaii Symphony Orchestra said that "These are the best acoustical conditions under which I have ever conducted."

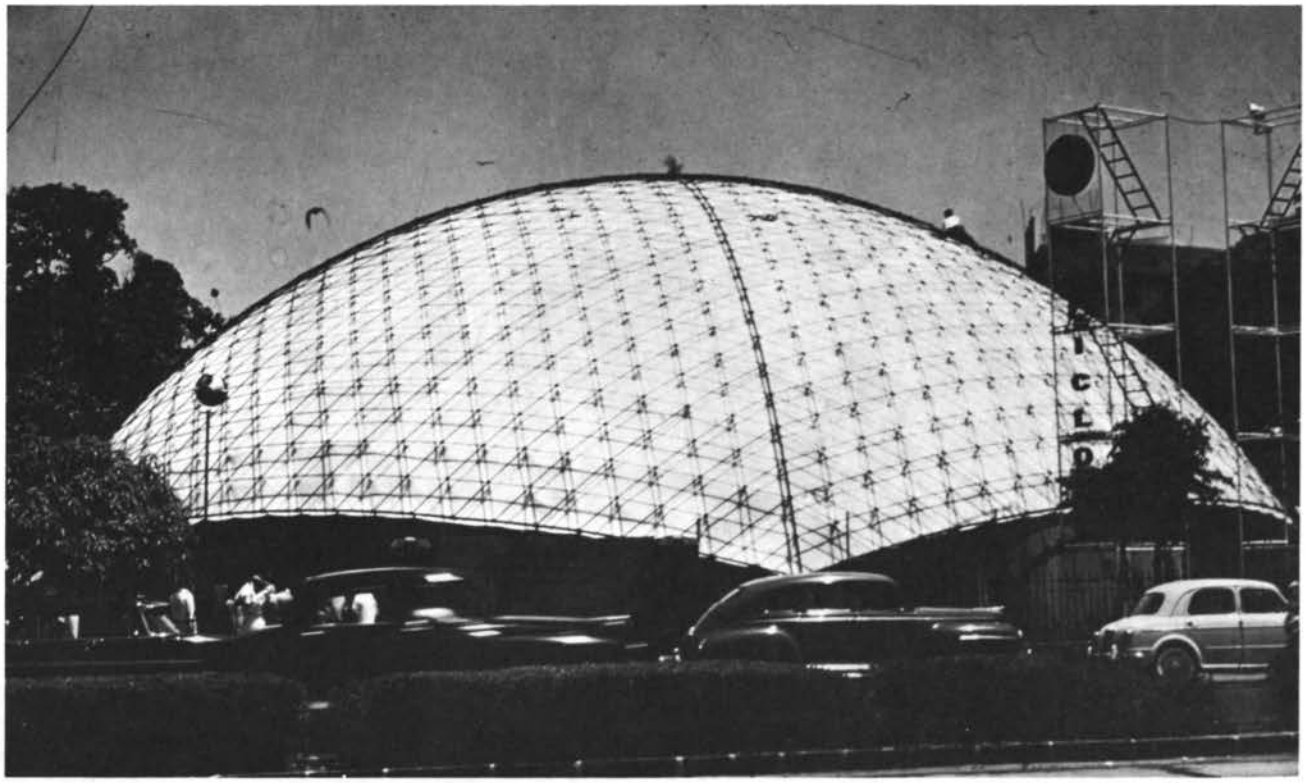
(K-2-28) This is the first of our United States, Department of Commerce, Trade Fair domes. It was erected in Kabul, Afghanistan in 1957. The U.S. Department of Commerce came to me in an emergency and with a very small budget. We were given thirty days to design and produce this structure, which we succeeded in doing. It had to be so designed that it could be folded up and put into one DC-4, which was all that was available for that task. It had to be flown across the ocean to Afghanistan, accompanied by only one of my engineers. All its parts were color coded so that the Afghan people were able to erect it by putting the red end to the red hole on the hub and the blue to the blue, etc. The Afghans didn't know what they were building at all. They thought it was meant to be a conventional rectilinear structure, but suddenly found they had produced a hemispherical structure. They were bogle eyed and excited. The workers began to shoot-the-shoots down the taut nylon-geon-skin of the dome. The king of Afghanistan acclaimed the dome.

World society is accustomed to the concept of an architectural design which is erected by skilled craftsmen who's skill, a priori, permitted the architect to design the kind of building which the craftsmen build. It was up to the architect to keep in mind that which the craftsmen could build.

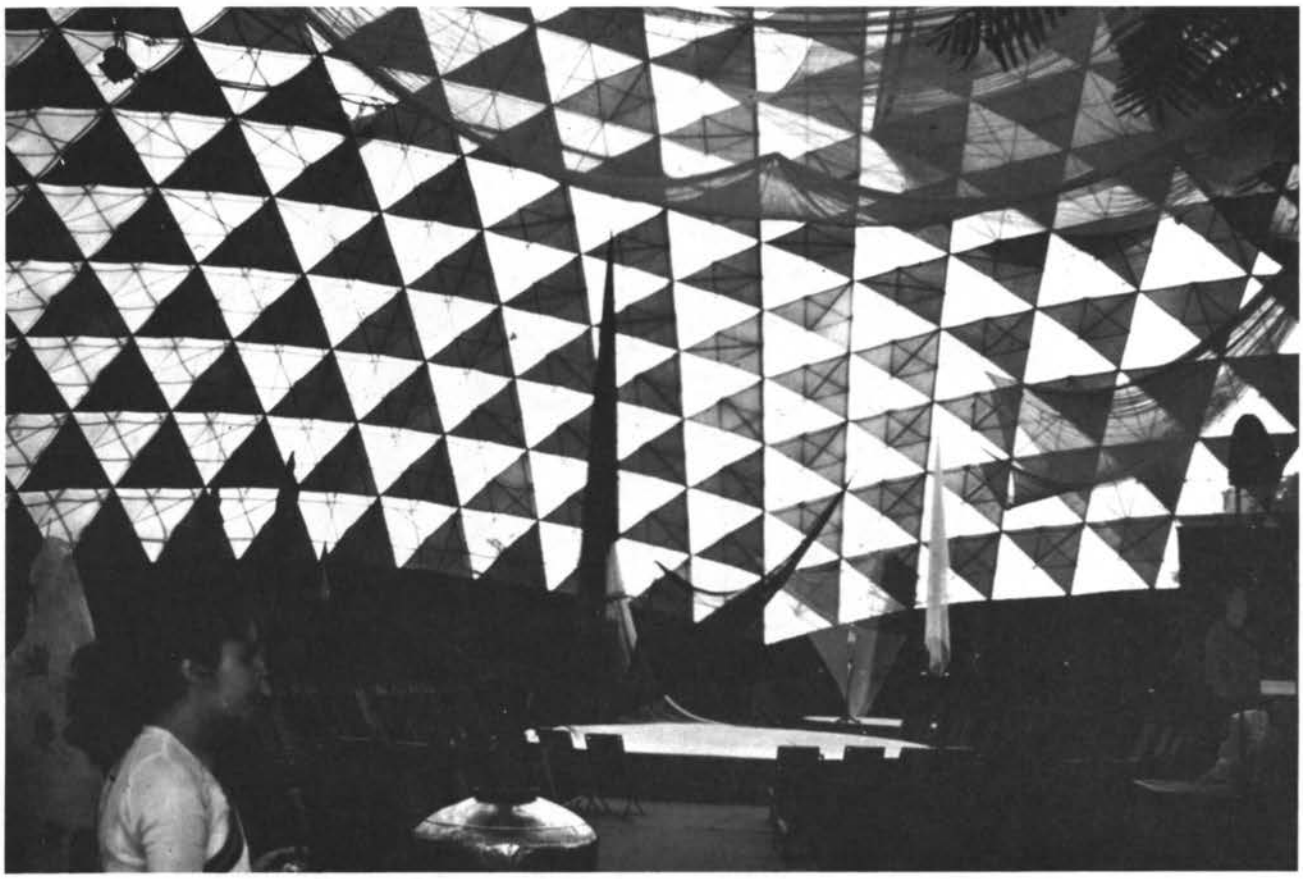
In the case of our Afghan dome, when the Afghan people saw that the Afghan workman had put up a new dome structure they attributed its spherical success to the Afghans' craft skill. They said to the Afghan workmen-shooting the shoots down the dome-"You are good dome builders." The workmen replied "Yes we are" and the Afghans applauded. So they said it was obviously Afghan architecture - a modern plastic and aluminum super-yurt. This made our dome the hit of the Kabul 1957 Trade Fair and the U.S.A. Department of Commerce who had originally taken on the dome only as a last minute emergency device to stay within budget yet meet a challenge decided to see if this unexpected geodesic virtue, of popular appeal, would meet with equal favor elsewhere. It did, time and time again.



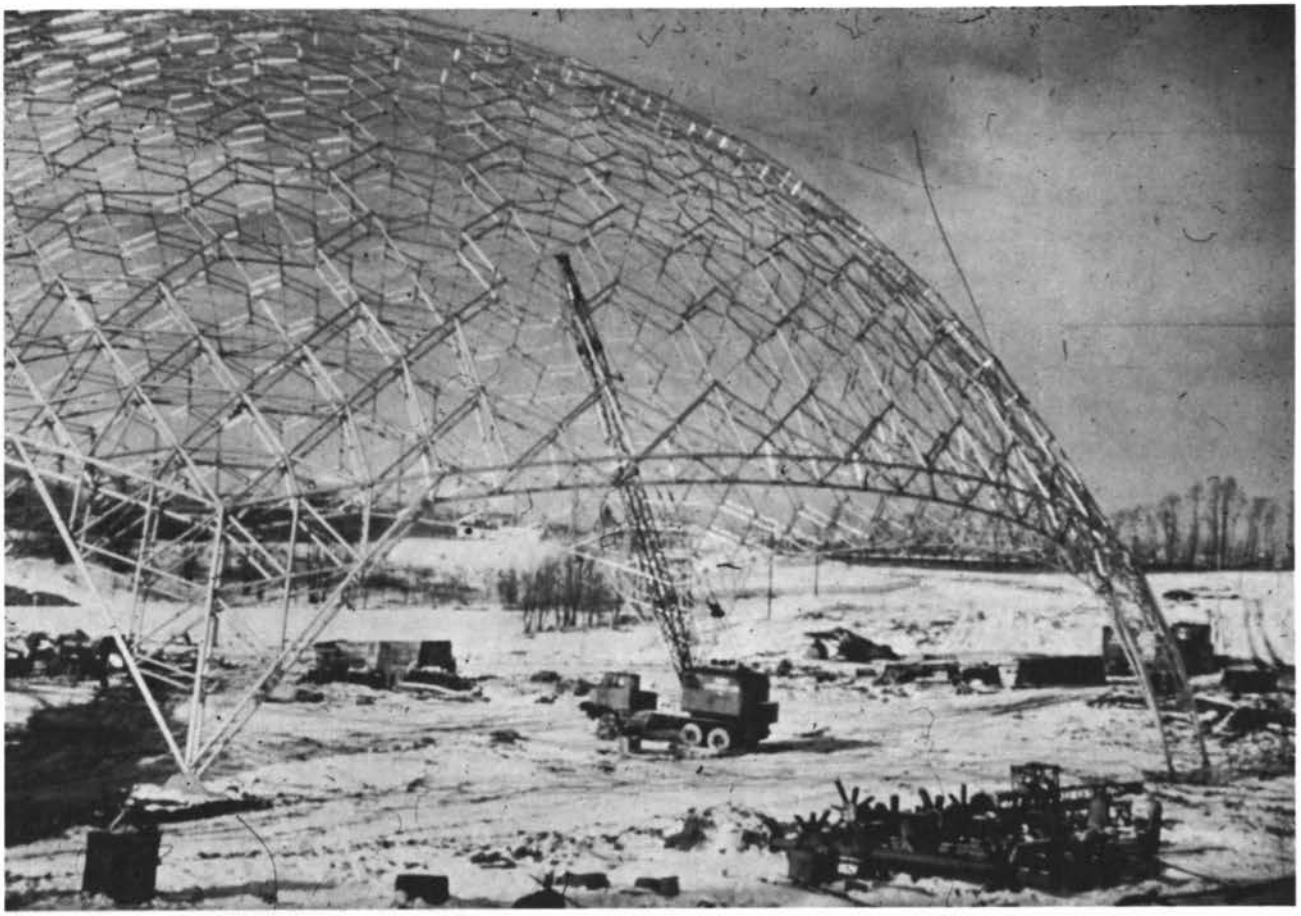
(T-7-10) That is a picture of the same Afghan dome which being 100% demountable, without parts loss or deterioration, went on economically in disassembled condition successively by air to New Delhi, Bangkok, Burma, Tokyo, the Philippines, and then down to Lima, Peru, on the west coast of South America and is now back in Africa again. This geodesic dome is now on its second local-stop, trip around the world by air. It now has many counterparts doing the same.



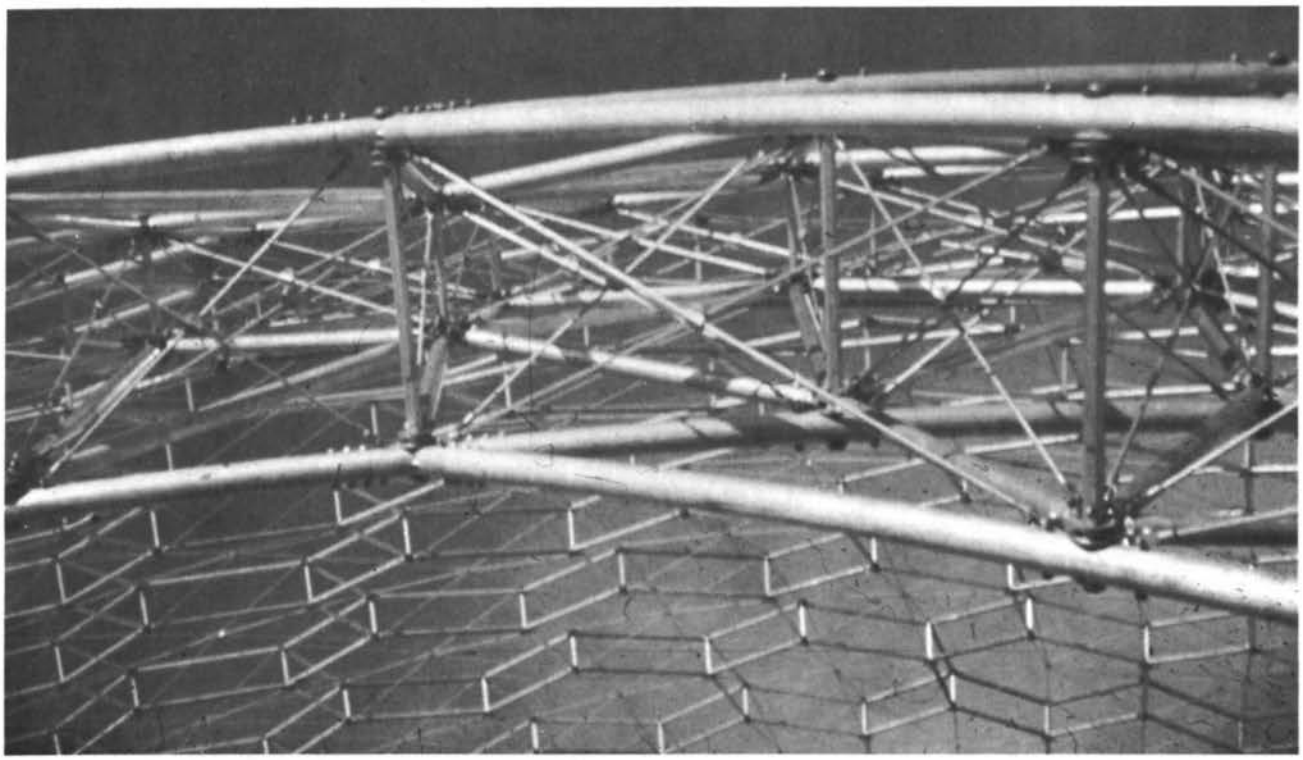
(B-20-9) This is one put up first in Bombay, India by Mr. Gautam Sarabi in 1958.



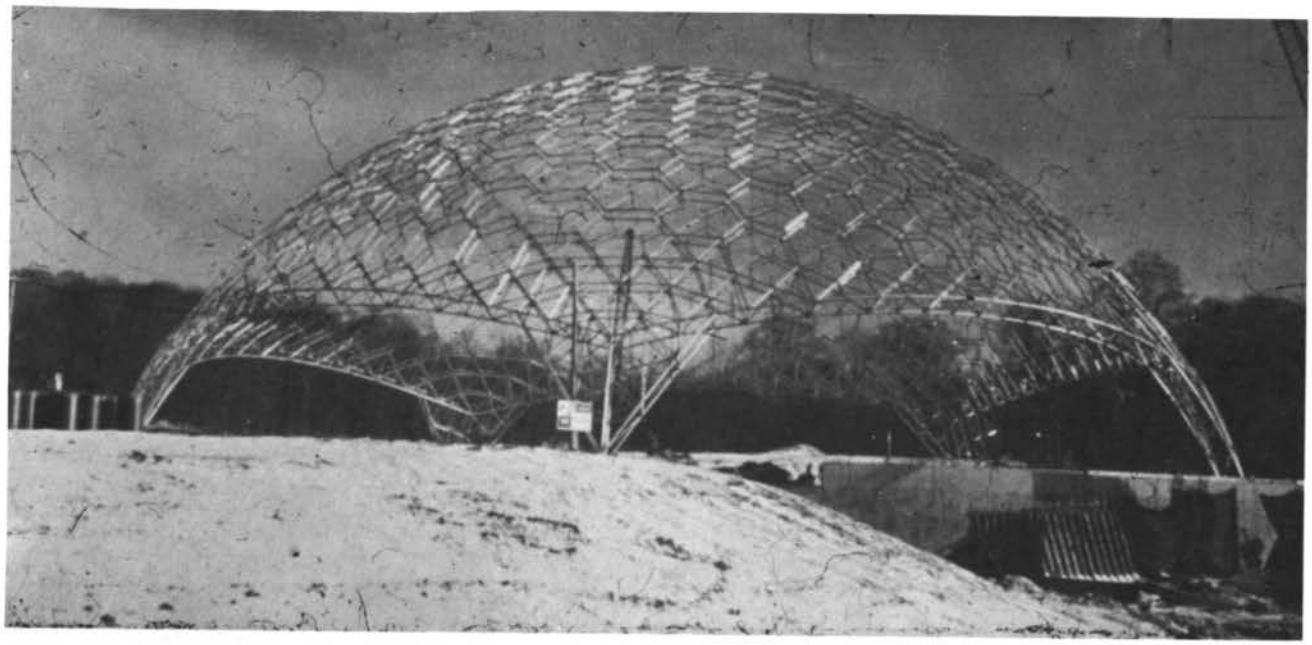
(B-20-10) It is a geodesic, theater in-the-round, dome in which the Calico Company (who long ago originated that famous name for their Hindu cotton cloth) show their famous fabrics.



(A-8-12) This is the American Society of Metals aluminum geodesic domed national headquarters building in Cleveland, Ohio, erected by my licensee North American Aviation in 1958. It is 265 feet in diameter.



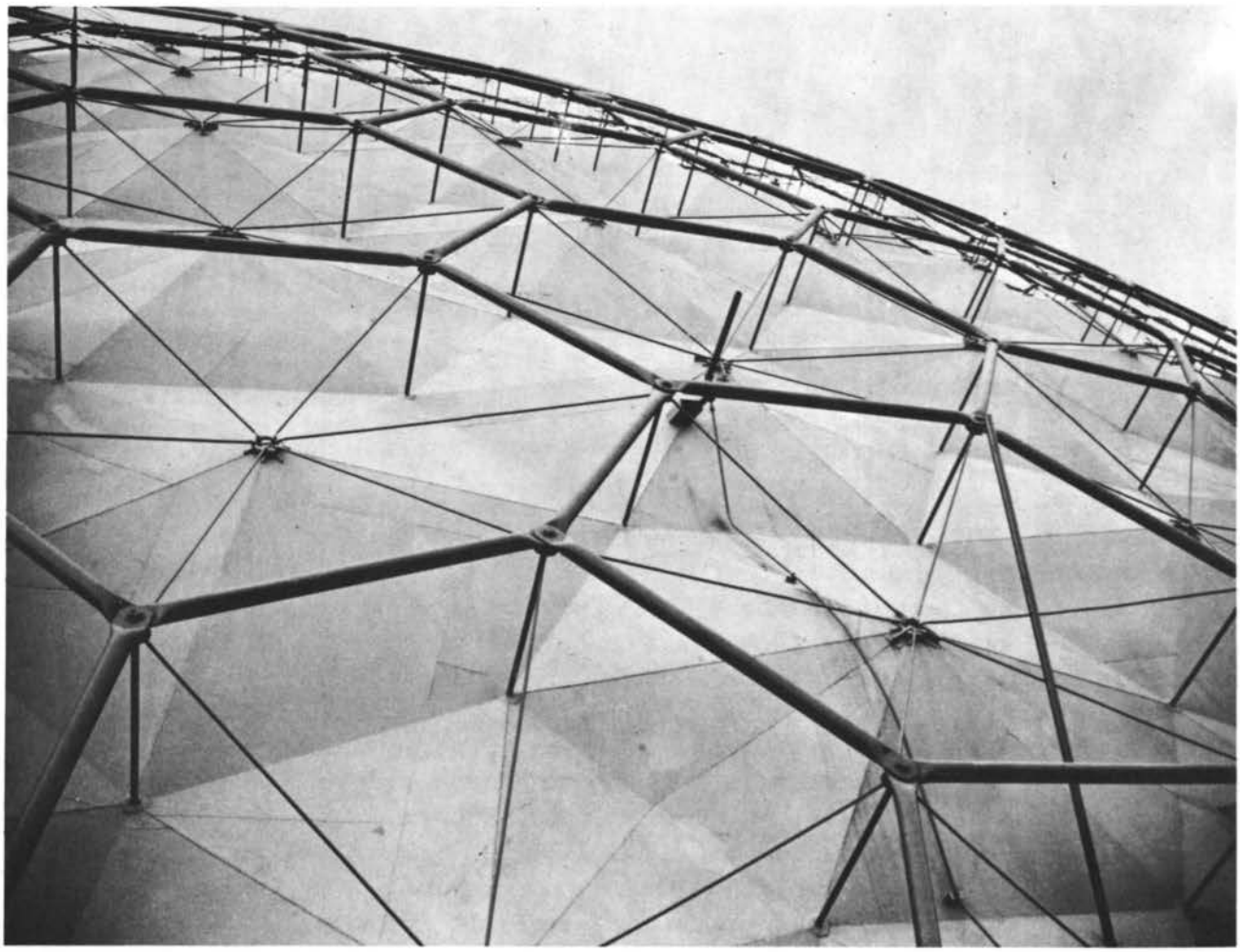
(A-8-13/A-8-14) The same American Society of Metals Dome.



(A-8-14)

(U-2-71) This is in Baton Rouge, Louisiana, 1959. It is a geodesic dome 384 feet in diameter, made out of sheet steel suspended from a steel tube frame. It was put up by my licensee the Union Tank Car Company. The

compression members form an hexagonal grid. It has 8-inch steel tubes but in this picture from an airplane they are so relatively small that you can't see them. This 384 foot dome will cover a full American football field with its end zones, a running track around it, with room for generous, circular segment, grandstands on either side of the field and track.

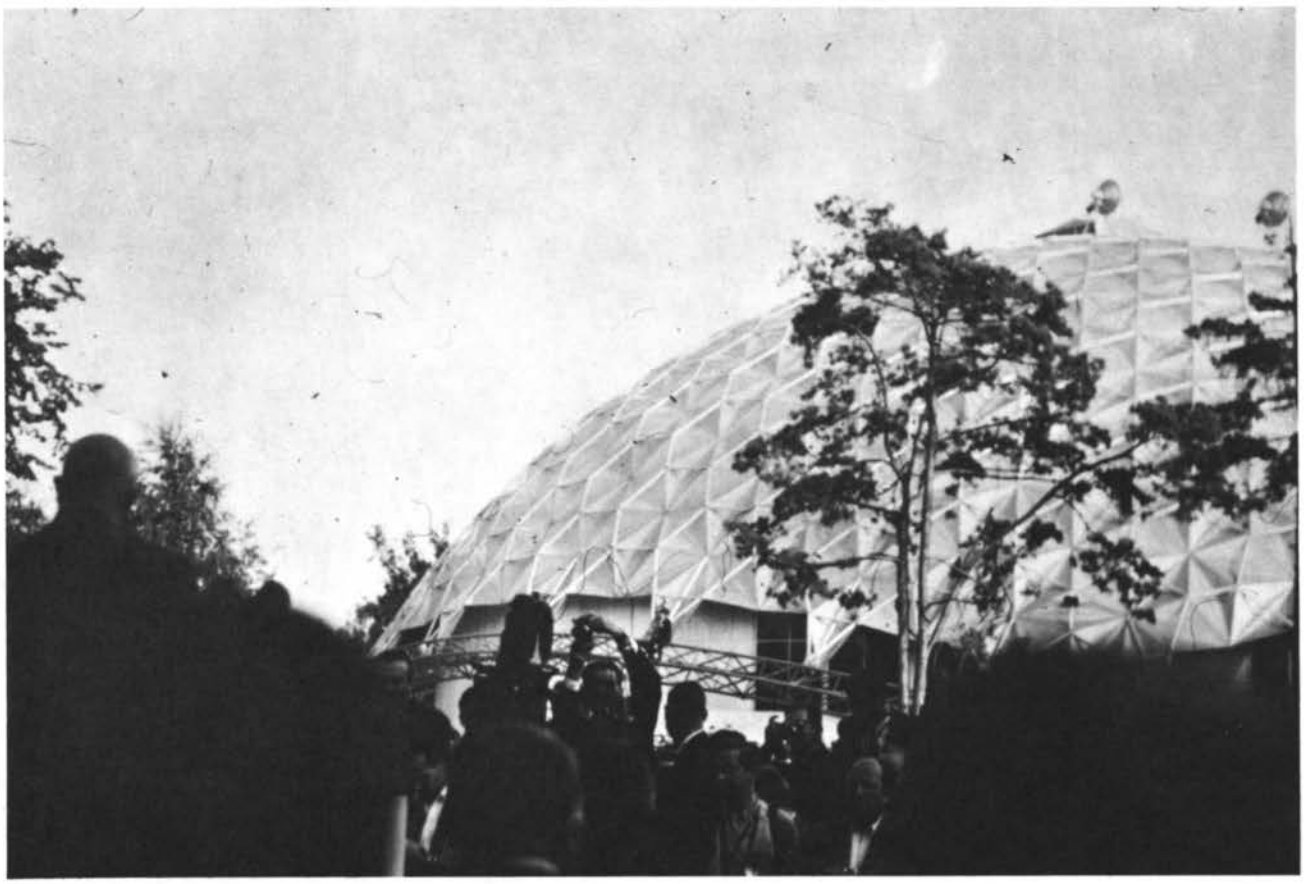


(U-2-78) Here you can see the 8-inch steel tubes which you couldn't see from a distance in the previous picture. The steel skin is not of steel plate thickness but is just thin guage steel sheet, welded together, with the steel skin suspended and stretched outwardly toward the tubular steel frame hubs just as are the fabric or plastic domical tents of the U.S. Trade Fair geodesics.

(U-2-75) another one of the 384 foot diameter domes at Woodriver, Illinois.

I'll tell you of an exciting experience. I went to Seville, Spain for the first time last summer. For a half century I have been excited about the stories of Seville cathedral and the elders of Seville who, centuries ago, had resolved to erect a structure "so great that those who came after us will think us mad to have attempted it." It took five generations of men to complete Seville cathedral. For a half century I was inspired by that story of their long distance daring, patience and vision. I looked at the enormous vistas between the great stone columns of Seville. I was certainly impressed; forgetting about my own building experiences and explorations. Suddenly I found myself proceeding to measure the ground plan of Seville cathedral as well as its profile height. Seville is the second largest cathedral in the world. St. Peters in Rome is the largest. I found to my amazement that one of my 384 foot steel geodesic domes such as the one at Woodriver, Illinois, or the one at Baton Rouge, Louisiana, could be dropped down over Seville cathedral to enclose the entire cathedral within the geodesic's uncolumned clearspan interior, without touching the cathedral below at any point. The weight of the Woodriver, Illinois, 384 foot geodesic dome is equivalent in weight to the weight of only four of the interior stone columns of Seville Cathedral's forest of an hundred and more columns let alone the weight of its stone shell, its buttresses and foundation. Our 384 foot Woodriver-Baton Rouge type geodesic dome has 115,000 sq. feet

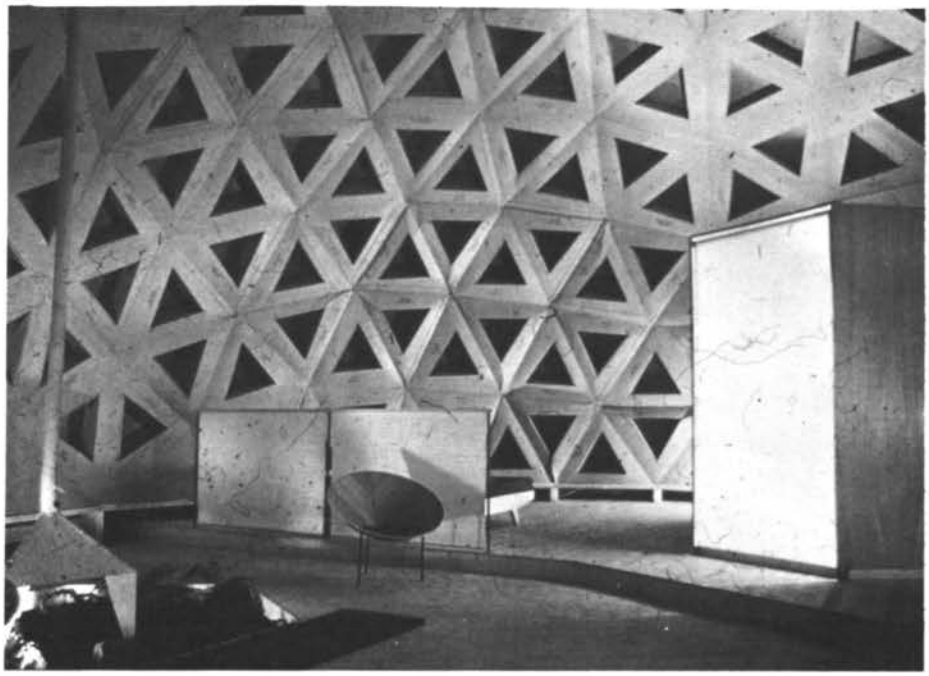
of floor space, - almost three acres, - and has a volume of 15,000,000 cubic feet, 23 times the volume of St. Peters' dome in Rome and weighs only 1200 tons. One U.S.A. Polaris class submarine weighs three times as much as our 384 ft. dome.



(M-36-1) This is the American Pavilion at the U.S.A. 1959 National exhibit in Moscow. It is the 200 foot diameter Kaiser-Fuller type. It is called the "Golden Dome." In the picture Mr. Kruschev is speaking at its opening ceremony. After the Fair was over, the Russians purchased the dome from the U.S.A. for its full manufacturing and erection cost and it is now a permanent structure in Sokolniki Park in Moscow. It is used in the winters as a sports palace and in the summers as an international exhibit space. It has been used for the National exhibits of Japan, France, England, etc. The Russians, possibly some of them are here tonight, were very cordial to me on that 1959 U.S.A. exhibit trip and they told me that they expected to use my geodesic dome principle in some of their future, very large, enclosures.

(P-20-1) This is just a children's playground with some small geodesic domes. Note that the pieces are of flat plywood bent into accommodation of a spherical structure. I call these geodesic plydomes.

(P-20-4) The reason that I am showing this picture is because it is interesting mathematically that you can take a flat sheet of plywood and bend it simultaneously on five cylindrical axii. You can bend each of its four corners and you can also bend it in its middle and it thus becomes a spherical diamond, or a pair of compound curvature triangles.

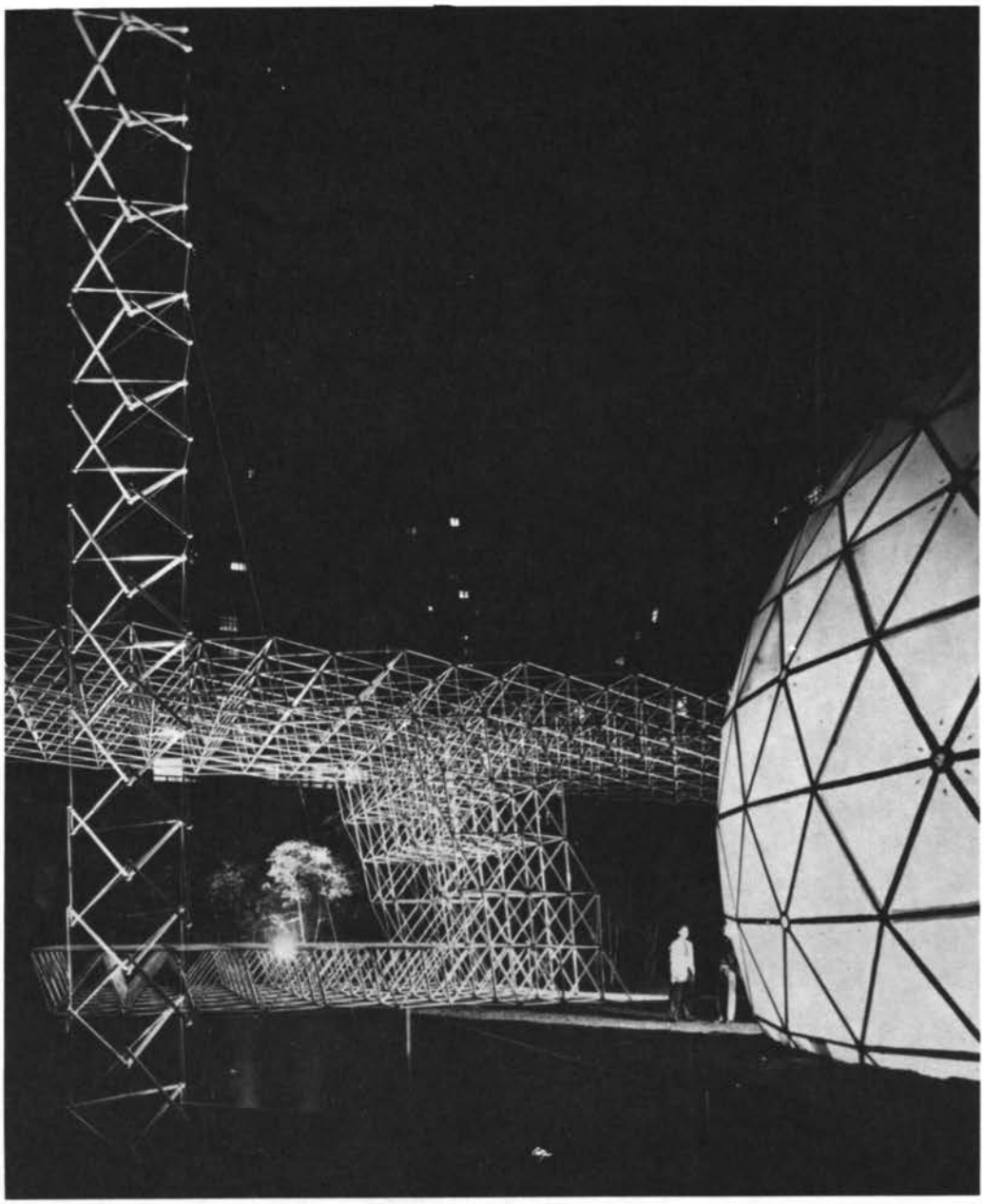


(T-2-11) This is a paperboard geodesic dome in Milan, Italy, in 1954, a 1,000 square foot bachelor's apartment. It was awarded the Triennale's Gran Preniro.

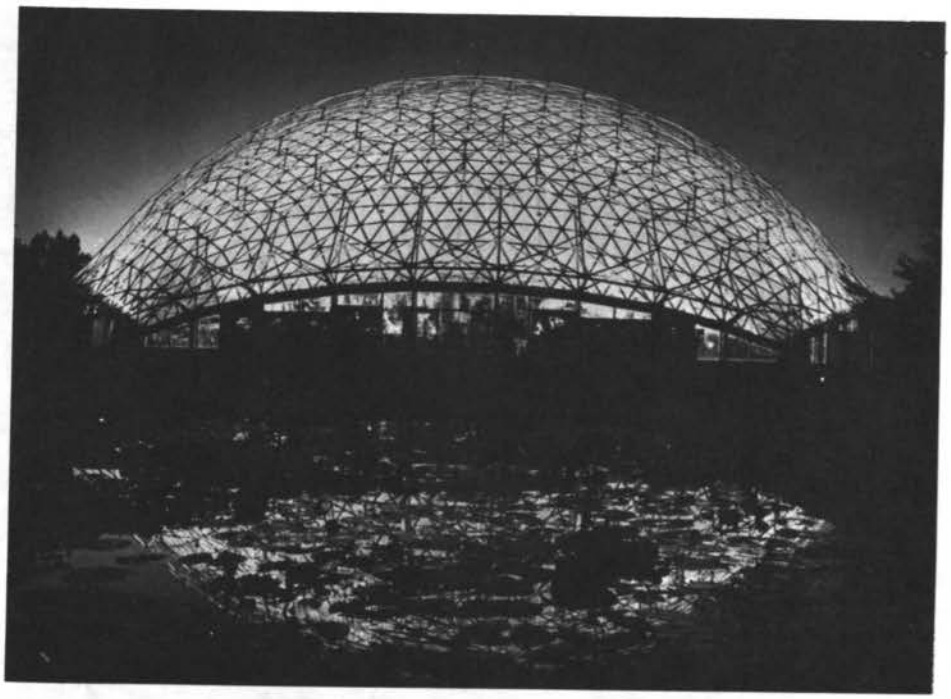
(M-32-18) These are some more foam core paperboard geodesic domes made by Monsanto Chemical Company, installed by the United States Peace Corp at Puerto Rico. I have had some of those paper domes go through hurricanes. They have to be tied down so that they won't blow away. They have to have some light wooden reinforcements inside their top sections to take full snow loads. Repainted every two years they will last for years.

(C-11-25) This is the inside of my own home in Carbondale, Illinois. We live in a domical geodesic structure.

(C-11-20) This is the 65 foot arc of my library in our Carbondale dome home. I sit in a free rolling stenographers chair and roll along the bookcase arc reaching every book without standing.



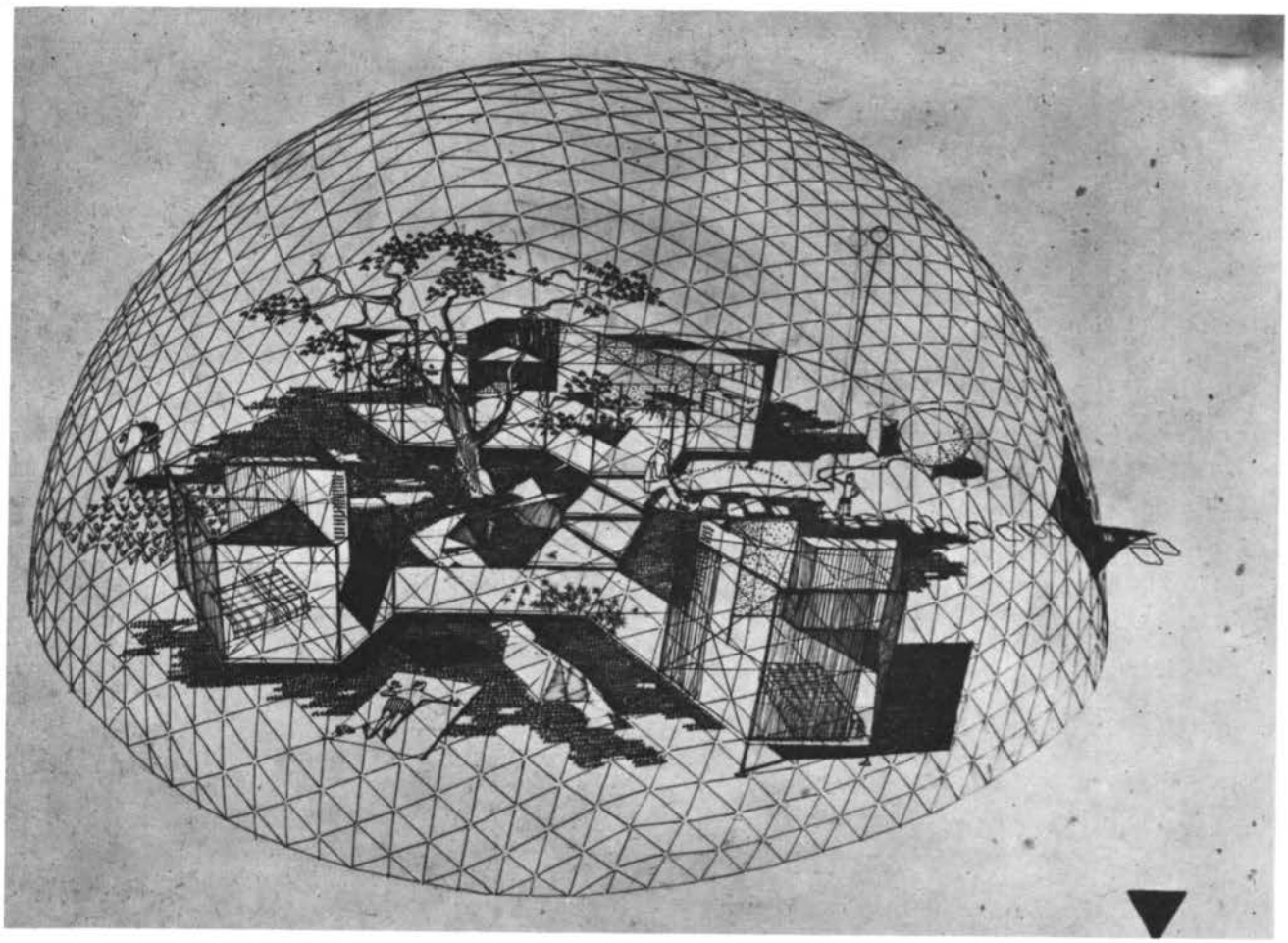
(M-21-7) Here are some of the new mathematical structures I talked about, a seventy foot cantilever octahedron-tetrahedron truss at the Modern Museum in New York City 1960-1961 shown with the one U. S. Air Force 55 ft. diameter, arctic type radome that took ten times as long to erect under New York City conditions as it had taken under arctic conditions. The tensegrity mast is also shown.



(S-13-22) This is the Climatron in St. Louis, Missouri, U.S.A. It has a delicately controlled variety of atmospheric environments in a single clear span space. It is aluminum truss geodesic with an acrylic skin.

(S-13-32) The Climatron has tropical gardens inside.

(S-13-30) To be able to control the geodesic Climatron's environment locally it maintains great differences in humidity and temperature at many points in the garden. Now in use for 3 years its acrylic skin has never required washing.



(M-11-6) Once you have learned that you can enclose a very large amount of space without interior columns and with very little material you find yourself and society to have progressed structurally beyond the need of making large home foundations. You need only to anchor and therefore do not need to break into the earth with earth movers. I saw that it would be possible to enclose a space, protecting us from the rain and wind, cold and heat while permitting us also to have our gardens inside. In effect we could dispense with the "house" as we have known it, - that is as a wood, brick or stone box. We are now able to live comfortably all year around in the gardens, obtaining local privacy by use only of secondary pavilions. We would enclose so much space as to be able to gain aural privacy just by positioning living areas at distances and could gain optical privacy by bushes, trees, nylon and paper partitions.

(N-10-1) This is a study I made to find out how large a tensegrity dome it is possible to make. I found that we can make geodesic tensegrity domes of any size we want. The earth is a geodesic tensegrity sphere. I carried out the stress, production and erection calculations for a geodesic-tensegrity structure two miles in diameter. I wanted to see what that would look like relative to familiar structural undertakings of man. I found that it is two miles across Manhattan Island in New York City from the East River to the Hudson River at 42nd Street, so I theoretically superimposed the two mile dome over mid Manhattan. The dome would be twice as high as the Empire State Building which stands near its center. The size of the structural members would be approximately the same as those of the masts on the S. S. Queen Elizabeth. The Queen Elizabeth is visible at her docks right here in the picture. You can see her stacks, but you can't see masts, therefore at this same distance

you also cannot see the dome's structural members. The structural members are so relatively small as to be as invisible as an aluminum, fine mesh, wire, fly screen, as seen from a distance. Therefore we find that as we get larger and larger, geodesic, tensegrity structures we get to the point where the structure itself tends to become invisible at any distance away from it at which the whole dome may be seen, simultaneously, - without moving our eyes or head.

There are about 3,000 geodesic structures in 50 countries around the world today. They have all gone to their sites in the last ten years. Many have been delivered economically by air. In Ghana, Nigeria, and other tropical African countries they find that they work nicely as large umbrellas, the air circulates through the top and in and out around the wide open bottoms.

When a structure is finished, and I find myself unhappy looking at it, then I know that it is a failure. But up to the time my structures (of any kind) are finished what they are going to look like has never been a tactical factor. My kind of work deals with the hows of mathematics, the hows of industrial production and distribution and assembly and service and with how man finally finds out the ecological problems themselves and how to solve them hoping thereby to bring total success to all men at the earliest possible moment. I don't even consider how any structure that I am evolving is going to look, until after it is finished. If, finished, the structure seems beautiful, I know it is all right.

Norbert Wiener of Massachusetts Institute of Technology gave the name cybernetics, i.e., - a modification of the Greek word meaning rudder control, - to the general science of computer development. There are now in the world several thousand of the powerful and high information storage capacity electronic computers. The number of them approximately doubles yearly. The computers both large and small are pattern processing machines of which the human brain is the prototype. As with the human brain all pattern processing consists of two main classes; - Differentiation and Integration, i.e., specialization vs. generalization. Differentiation identifies, evaluates, selects, and separates out the uniquely developing patterns. Integration discretely controls the coordination of complex interactions.

In the swiftly evoluting computer world there are a few scientists well informed concerning their art who at the same time have both the philosophic competence and inclination to write for us concerning the overall significance of the brain machine advances within the general scheme of life. I follow their literature. At the present moment the following constitutes the net state of computer affairs.

However to appreciate the situation we first must be aware that throughout the last fifteen years of computer development many philosophers

have been disturbed by the claims of some cyberneticians that computers were soon to displace the human intellect's functioning in Universe. If instead of designating the intellect for obsolescence they had confined their prediction to the relative effectiveness of the complex functioning of the human brain, in respect to the computer, some of their claims might in time prove valid. For a long time the philosophers said that the computer cannot ask an original question. They said that it can re-ask over and over again, in various ways, a question which it has been taught by man to ask.

Despite the philosophers' wishful predictions the computer has now demonstrated its ability to ask an original question; - and it did so without being instructed to do so. This demonstration came about as follows. You can teach a computer to play games, for an instance, - to play checkers. You can also teach a computer to play backgammon. You can build a computer with enough parts to permit it to play both backgammon and checkers, at the same time, as two separate game developments. Computers are actuated electronically at certain fundamental, cyclic-event, interval frequencies. Computers are electro-magnetic oscillation systems each having its uniquely highest operational frequency. Computer frequency intervals are akin to wave lengths.

Now, both backgammon and checkers are played at inherently different rates. The checkers' moves are simple but in backgammon you have to shake and roll the dice before you make complicated moves. Therefore, the same computer playing both games completes the checkers moves rapidly and the backgammon moves slowly. The backgammon rate is not an even multiple of the checker rate. Therefore as with disynchronous high frequency twin motors there develops a secondary low frequency, intermittent recurrence of coincident cycles, or interferences. Suddenly the machine has to make both the checkers and backgammon moves at the same time. Because the computer has a given wave length interval within which to make moves and the latter is too short to make both moves the machine has to decide which it will play first. It has to ask itself and then decide "Which is most important, checkers or backgammon?" The machine has to make a decision so, if it has stored enough variable information and previous decision data, it may soliloquize; - "Poor people play checkers and rich people play backgammon. I'd better cast my vote for the priority of checkers because my memory storage also tells me that we are trending toward socialism." From this point on, rightly or wrongly, the machine's storage contains this proletarian predilection.

"Which is more important checkers or backgammon?" is an original question which had not been taught to the machine. We find that original question asking is a consequence of interferences, whether in the computer or the human brain. We find then that original questions are second derivative events in the computer life. Instruction to ask an original question is not entered in the original computer programming.

In relation to the computer and the present significance of its development, as judged by experts, as far as the machine's differentiating function is concerned it can be said that the computer is about to make man obsolete as a specialist, due to the fact that the machine can differentiate much more accurately and swiftly than can man. The computer can stay "up" all night, night after night selecting the blacks from the whites under humanly intolerable conditions of heat or cold yet never tire. That the machine is to replace man as a specialist, either in craft or brain work,is epochal information.

When it comes to assessing the integration functioning of the same, new, powerful computers I do not refer to several kinds of historically available "integrators." There was one that has long been used, by the designers of ships to calculate hull or sail dimensions. This integrating tool is attached to the base line of a drawing board. It has a track and a moving arm with which to trace the outline of a sail or a hull. The machine integrates the complex motions and you may read the sail area on a tabulator while at the same time a pointer will show the center of pressure on the sail. There have been very few of these very useful Swiss integrators. A quarter of a century ago Vannevar Bush, while president of Massachusetts Institute of Technology, developed, in 1936, a machine which could only integrate as in the calculus. The modern computers can both integrate and differentiate or both.

What we are considering, exclusively, right now, is the function of integration in an omni-purpose modern computer. The scientist-philosophers dealing in computers point out that inasmuch as original question asking is a consequence of interferences then it follows that original questions are functions of time. There must be a great number of moves and a vast number of computer components before enough time has elapsed to develop new types of secondary or tertiary, etc., interferences which in turn may sometimes provoke original questions. The human brain as a computer mechanism consists of approximately a quadrillion times a quadrillion atoms in coordinate interpatterning. It will be a very long time before man will be able to develop a computer with that many transistors, storage cells, etc. The experts point out also that dealing in integrative complexity, as a function of time, that the human brain always has been dealing in complexity and integrating in a comprehensive, historical continuity, due to the relaying of the information regarding human experiences which is provided by the human genes. The cummulative sum of conditioned reflexes developed in all men are carried on throughout the total evolution of man whereby a child crys or stands "instinctively" by inherited genes command. Therefore, the experts say, we would have to have man-made, machine computers running for a million years or so in order for them to develop an equivalent integrative complexity to that with which the human brain now copes, - integratively. In other words the experts do not see any immediate, or even far distant competition, by the machine computer with the human brain in the

functions of complex integration, ergo of generalized, comprehensive, coordination abilities. We can, - and do, - have some very good limited, and therefore secondary complexity, mechanical integrators but they are and will continue to be only resourceful "specialists". We can have an integrator calculating, designing, manufacturing and putting together one of our geodesic domes in a giant jig but that would be a very low order of complexity.

We, with our human-computer brains, will now compound those expert assessments of the mechanical computers' significance with other remotely occurring, but important information.

At the American Association for the Advancement of Science's annual meeting last year, there were, amongst the thousands of papers presented, two which are of special interest to us. One was a paper dealing with all the biological species that have become extinct. The other paper dealt with human tribes that have become extinct. These independent papers searched for common characterists that might account for the extinctions. In both cases it became clear that all the biological species that have become extinct and all the human tribes that have become extinct became extinct for one reason, - over specialization. Evolution involves constant change. When living species become so specialized that they cannot adapt to an unexpectedly large interference jump in evolution they are suddenly "out." That is easy to see.

What we now can see also is that men in our industrial and educational system had become more and more specialized. Everyone, wanting economic security seemed to think that as specialists they would each command the toll gate of an expressway to unique and essential information. They thought; - "A great many people are going to have to come through my toll gate and I'll have my economic security."

When we combine (a) the major trend of industrial society to increasing specialization, with (b) our knowledge that over-specialization leads to extinction we realize that our own trend to extinction was about to be realized when we developed the extraordinary theoretical ability, through hyper-specialization in mathematical physics, to take the atom apart and thereafter to develop fission, and fusion which the military specialists and political specialists automatically seized upon for super-energy controlling of rocket deliverable bombs. The scientists as specialists did not know how to control either the military or the commercial, or the political developments of their special discoveries. They did not know how to stop men from using the atomic bomb. Just as we were about to blow ourselves up we discovered that nature, as the invention total universe, had not only invented man but had invented man with

the ability to invent and develop tools as externalizations of man's integral, specialized organic functioning which also included the ability to invent the computer, which was immediately adopted by the military specialists to control his rocket weapons. But here comes the synergetic surprise. The computer is now making man obsolete as a specialist. Therefore, man has, inadvertantly, invented his own anti-extinction devise.

Displaced as a specialist, or differentiator, man is now forced to become preoccupied exclusively with integrative patterning considerations. (con-sider-ations means associating and contemplating star pattern aggregations.) This means an epochal re-orientation of man. All the universities, all the educational systems from now on are going to be giving up specialization and are going to generalization. Everybody will be taught to be a comprehensivist. It is going to come naturally because man is born to be comprehensive. It is a unique biological characteristic. As he cross-breeds he becomes more comprehensively adaptive. Only in-breeding brings specialized capability, by breeding-out general adaptability. Architects constitute the last specie of professional comprehensivists for they try to put things together while the vast majority, who are specialists, take things apart.

The historical turnabout is going to be difficult. Even in our best universities, despite an intuitive realization of the coming reorientation manifest here and there by intellectual leaders, the theory of education is as yet pre-occupied with even greater trending to specialization. A brand new type of university will probably be required to force the old ones to reform or become obsolete. The conditioned reflex disease of "Categoryitis" with which world society and its bureaucracy are infected is going to make the university renaissance difficult.

In order to understand the transition hazards, we may also compound the computer catalyzed reorientation with another major trend. In the trends to disarmament mankind has disclosed its joy at the accomplishment of only a miniscule, token reversal of the weaponry race which humanity has gotten into through over-specialization. Man now hopes his politicians can go further in the disarmament. The politicians feel that urge and though they are supposed to look out exclusively for their own respective sides, and not to look out for all men, the total world compulsion to disarm is felt with increasing force. As a consequence we will probably cut down, slowly, on the armaments.

Science having been employed almost exclusively in weapon development will find itself progressively unemployed. The weapon producing companies and the weapons support industries, direct and indirect, having high tool capabilities but dwindling contracts are going to struggle ruthlessly to find other profitable enterprises. They may move, - over night, - into the livingry (vs. killingry) arts.

All you have to do is have a meeting with advanced industrial technology management to realize their ineptitude to perform in the potentially evoluting livingry service industry. Talk about a house and the industrialists immediately think about stamping out an aluminum replica of a Cotswold Cottage. That is as far as their brains have conditioned them to go in the byways of categoryitis. The scientists' "house" catalyzed reflexes are even worse.

If you architects are too slow in your support of your architectural students initiative in undertaking the world redesign then both industry and science will begin to stumble into the livingry field and it will become an historical fiasco. That could easily happen within five years.

You have just about five years to get those architectural students and design science students around the world developing the capabilities that they are going to have to have to hold and maintain the world's industrial economics' design-science initiative. You're going to have to give yourselves powerful mathematical abilities. Fortunately our research discovery of the tetrahedronal coordinate system employed by nature, now confirmed by many scientific events gives you a ready made tool adequate to your historical task.

In summing up, as I have said before, between Russia and the United States six billion dollars have been appropriated to develop the little scientific house in which man will dwell on the moon. Though you as architects profess to be the master solvers of space problems you are not acknowledged as such masters of space problems by the political administrations representing the public opinion, for architects have not been called into the space program. The men who have been called in are doctors for space medicine, physicists, psychologists, chemists, engineers, but no architects.

I am confident, from my direct experimental exploration, that architects can be trained in such a way as to be much more effective in the space program than are those scientists and business men who are now handling the program. I have familiarity with the space program in the United States and I have found that the big contracts have been given out, so far only to large corporations who have dressed themselves up with large staffs of scientists in order to substantiate their lobbying for contracts. The space scientists of the successful bidders for space contracts are given the problem of how to develop the space dwelling. They are not design scientists - they are subjective scientists. Design science must be objective.

Scientists are inherently subjective operators; - they are trained to make faithful observations and to theorize about the schemes of nature into which their data may fit, but not to consider the significance of their findings

as objectively employable. They are too specialized to comprehend complex integration potentials and industrial realizations. Alone amongst scientists the medical man is objective. Chemical engineers but not chemists are objective. I find that the space contracting corporations are groping for solutions. I have been amazed when I have been called in by the big corporations as a consultant to discover how little they understand what seems to me to be a proper statement of the scientific sky-dwelling problem, its effective solution and its implications for man on earth.

In his introduction to "The Brave New World" Aldous Huxley discussed briefly a possible exception to the theme which his book developed of an, intellect-void, romance vitiated, atheistic humanity, to be regenerated only by computer decisions, conceived in test tubes and identified only by robot numbers. In his brief introduction Huxley discussed one possible alternative to that awful fate for humanity. - In that alternative mankind would be inspired by a few leaders with powerful and power giving conviction of the a priori existence in universe of an intellect greater than that of man and a universally operative integrity guarding and guiding with comprehensive anticipation all the inadequacies of man. Mankind thus led would work through many crises to attain physical success for man in universe without cost of human freedoms, or cost of individual joy in creative participation in the universal evolution. In his post World War Two second edition of "Brave New World" Huxley revised the introduction. Almost a quarter century after the original publication, Aldous Huxley said that he tended to have a little more hope for the realization of his originally dismissed alternative theme as that which might occur. Again in his succeeding "Brave New World Revisited" his introduction disclosed an even greater hope that the happy alternative might be realized.

It is probable that if you architects do gain and maintain the world's design science initiative that Huxley's alternative may be realized. If on the other hand you fail to gain the world's design science initiative within the next five years through your students' world redesign activity - then the weaponry industry's invasion of the livingry field will occur, thereafter, trending swiftly to evolve into Huxley's awful dream.

Why is it likely that if the weaponry industry and its scientist slaves take over the livingry industry that life will trend toward Huxley's unhappy dream? And why is it probable that if your architectural students take and hold the design science initiative that the world will trend toward Huxley's happy, but improbable dream. To start off with industrial corporations are too near sighted while scientists are usually infinitely far sighted, while architectural students are realistically idealistic and have well coordinated vision. Industrial corporations are preoccupied with immediate profits

and not with total man's success. They are interested in "making money" while you are interested in making man a total success.

You and your architectural students will realize that you are designing an entire family of complimentary instruments of livingry, - similar in comprehensive functioning to the whole family of musical instruments. You will be willing to allow man the privilege of playing his own instruments and of composing not only for one instrument but also symphonies for the whole family of instruments. You will be wise enough to confine your design science to augmenting the integral organic functioning of man so well that the external organics may be coordinated to operate as unselfconsciously as do healthy men's internal organisms. You will thus leave man free to articulate the promptings of his soul in such a manner that each individual may enjoy his exploratory and creative freedoms without unselfconsciously, - ergo inadvertently, trespassing on one another and thus inter-frustrating one another.

Optimism is usually thought of as mildly unwarranted hopefullness in respect to the future. But there is a reverse projection of optimism operative in the nostalgia generated, myths which extract the rare and sublime moments of yesterday from their, low grade ore, matrix of negatives.

I, myself, am convinced that we are swiftly emerging from the abyssmal conformities of yesterday's illiteracy, profanity, spit-punctuated, momosyllabic verbalism, old age beginning at 20 and probable death at 27, rags, filth, diseased bodies, prevalent stenches, devastating supersition and local bias, and above all the ignorant conformity with the concept that individualism is attainable through physical differences and through self-prestige acclaiming superficialities.

Beginning with World War I, Science, Technology and high priority industry began the epochal and ever accelerating shift of field from track to trackless, from wire to wireless and from visible to invisible. Man entered into the vast ranges of the physical realities of the electro-magnetic spectrum. Within the electro-magnetic spectrum the visible light frequency band is exquisitely minute. At the present moment in history 99.9% of all of humanity's important physical evolution, as an extention of its communicable and operational consciousness, is transpiring in that major portion of universe with which man has no direct sensorial tuning. This great evolutionary engagement of man with the non-sensorially apprehendible yet physical universe is achieved only through instrumental hook-up as an extension of man's faculties.

The word "form" infers direct sensoriality. The word "conformity" likewise infers direct sensoriality, - it means dealing only with forms.

I am convinced that it is only man's inertial ignorance and its superstitution conditioned reflexes that bind him, unrealistically, within the nonsensical illusion of conformity. I am also convinced that three eyes and two noses do not make for pleasingly increased individualism. I am impressed that despite the physical and numerical uniformity of healthy biological species' equipment inventories, that science has never found two individuals whose life patterns develop alike. To start off with there are the fundamental differences in finger prints.

Furthermore, I am sure that the truly unique pattern development integrities of the individual are utterly abstract. I am convinced for instance that love, happiness and life itself are all weightless, i.e., imponderable.

Humans about to die in hospitals have been carefully weighed as life departed. No weight was lost. Whatever life is, it is imponderable. I am convinced that "we", the utterly abstract integrities, regenerate our own waves and ripples in the physical apparatus and environment which we employ just as stones create waves and ripples in the different liquids into which they are thrown. I am convinced that those waves and ripples are not the liquid milk, kerosene, or water into which the stone happened to be thrown. If we dump milk upon water and quickly drop a stone into the milky area, the waves rippling in the milk roll on from milk into water. The wave is neither milk nor water. The wave is an abstract pattern integrity, just as is the abstract concept of an angle. Waves are weightless patterns. The room we sit in is permeated by thousands of weightless waves, each of unique character. You can tune in hundreds of wide frequency range radios within your room and each can bring in a different program from a different part of the world because the individual weightless waves were flowing through trees and house walls. That extraordinary world of weightless, invisible waves is governed by mathematical laws and not by the opinions of men. The magnificient orderliness of that ever individually and uniquely patterning weightless wave universe is not of man's contriving. The infinite variety of evolutionary complexities, inherent to the orderliness of complementary principles operative in the universe, is of unending synergetic uniqueness.

Those fortunate grownups who are able to divest themselves sufficiently from the conditioned reflexes imposed upon them by yesterday's ignorance, often loving and fearful, may regain the coordinate sublimity of the four-year-old child whereof Christopher Morley wrote in 1922. -

"The greatest poem ever known
Is one all poets have outgrown
The poetry, innate, untold,
Of being only four years old.

Still young enough to be a part
Of natures' great impulsive heart,
Born comrade of bird, beast and tree
And unconscious as the bee,
And yet with lovely reason skilled
Each day new paradise to build.
Elate explorer of each sense,
Without dismay, without pretence,
In your unstained, transparent eyes
There is no conscience, no surprise
Life's queer conundrums you accept
Your strange divinity still kept.
Being that now enthrals you,
All harmonious, unit, integral,
Will shed into perplexing bits. --
Oh contradiction of the wits --
And life that puts all things in rhyme
May make you poet too, in time,
But there were days, oh tender elf
When you were poetry itself."

By my calculations there is mathematical probability that progressive mastery by man of the physical coordinates of nature and their progressive sublimation by man as separate categories, and subordination to total abstract concepts, may indeed be trending historically to permit the intregal being of the child to remain unfractionated throughout the total life span. For instance, we are unaware of our own tongues until we bite them. When in health and "good form" the total myriad component functions of our physical organic being are entirely subordinated to subconscious coordinate functioning, commanded by the integrity of the individual life. When life has departed, the full physical inventory remains -- useless, reminiscent, but that is all. That is the way I see things. I am convinced that creativity is a priori to the integrity of universe and that life is regenerative and conformity meaningless.

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THE FIVE TWO-YEAR INCREMENT PHASES
of the
TEN-YEAR WORLD FACILITIES REDESIGN

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THE FIVE TWO-YEAR INCREMENT PHASES
of the
TEN-YEAR WORLD FACILITIES REDESIGN

I append our outline of the five design science phases of our ten-year world tool redesign program. In dealing with the forward phases of this program it is essential that we arrange these phases in terms of natural, evolutionary priority of consideration for each of our successive two-year design science increments of the ten-year world student program. In considering these successive increments we should emphasize the continuing aspect of each stage as overlapping and interweaving regeneratively with the other stages - despite moving emphasis of the priority phase. There are no artificial partitions between each stage. They are all aspects of a continuing, dynamic process;- the natural hierarchy of evolutionary development requires that they be arranged and dealt with in the following order and under the following headings: -

Phase 1. World Literacy re. World Problems - World Industrio-Economic Literacy and its design science solution by dramatic educational tools for realization of the world resources inventory of human trends and needs, - not only by the students themselves, but by the world's people. Together with dramatic indication of potential solution. by design science, upping of the overall performance of world resource units to serve 100% instead of present 44% of humanity.

Phase 2. Prime Movers and Prime Metals - Review and analysis of world energy resources - differentiation between 'income' and 'capital' energies - design of more efficient energy utilization.
Analysis of circulation and scrap recycling of prime metals. Redesign towards comprehensive and more efficient use and reuse 'assemblies' with higher extraction of performance per unit of all invested prime metals in use.

Phase 3. Tool Evolution - Differentiation and evolution of machine tools - the integration of these tools into the industrial complex; review and analysis of generalized and specialized tools - automated processes and control systems-redesign and replanning of total world tool complexes and instrumentation systems. i.e., total buildings, jig assembled by computer within optimum environment control air delivered ready to use in one helilift.

Phase 4. The Service Industries - Analysis of world network of service industries, i.e., telephone, airways, communication services, hoteling, universities. General extension of dynamic network operating principles into formerly 'static' areas of environment control both internal and external. Frequency modulated, -- world planning of three shift, 24-hour use of facilities, i.e., most industrial facilities as yet operating under obsolete agricultural dawn to dusk, single frequency usage. Trans-sonic 1800 m.p.h. air travel transcends day-night and seasonal characteristics. Men literally jump out of night into day and out of winter into summer in minutes. Thus, local patterns of facilities employment trending swiftly into 24-hour succession of users., i.e., electrically lit telephone booths by roadside.

Phase 5. The Evoluting Contact Products - Usually phrased as 'end' products - there are in effect no end products but only the contact instruments of industrialization's human ecology services which are the plug-in or latch-on terminals of service industries, e.g., the telephone, transportation and other communication units, the motel (bathroom and bed) - and eventually the world-around environ control service unit.

HISTORICAL BLAST OFF INTO THE
SPACE AGE OF MAN

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Chart A

THE 160 YR. INDUSTRIAL REVOLUTION AS ARTICULATED IN THE U.S. OF AMERICA

The United States of America's population constitutes the most advanced degree of ethnic cross-breeding of man. In Chart A we witness the United States economy not as that of a unique sovereign nation, but as that of the economic conditions signalling mankind's blast-off into world around orbit and astro exploration. Here we witness the acceleration of man's ecological sweep-out from that of an individual man's life long average total motion of thirty thousand miles, a distance which characterized the total to-and-fro motion of all the generations of man up to the dawn of the twentieth century, now converted in 80 years to an average lifetime sweep-out of three million miles for America's most motionful types closely followed by average Americans and world man with this acceleration continuing to accelerate as we obviously enter into an utterly new magnitude of man's ecological patterning in universe.

Curve #1 shows the wholesale price of copper expressed in gold, valued at $35 per ounce, from 1800 to 1960. This line is an overall descending line, despite dramatic fluctuation pinnacles at the beginning of the 19th century brought about by the American Revolution and the Napoleonic Wars and again in the 1860's brought about by world civil wars, in turn occasioned by the fundamental shift from an agricultural to an industrial world economic domination. The third fluctuation pinnacle is that of World War I. The 4th pinnacle occurs in World War II. A fifth pinnacle was occasioned by the switch from world finance capitalism to military capitalism and the latter's arbitrary price fixing and metals stock piling for an assumed World War Three. This copper price curve clearly demonstrates the momentary inflationary detourings from the overall economic evolution which latter continually produces more goods and services for more people for less and less physical cost per capita.

Despite phenomenal increase in man's accelerated motion, velocity, frequency and distance of communication we find, at the same time, as curves 3 & 4 disclose, so rapid an increase in the performance per pound or kilowatt invested per given function that the amount of copper, per capita, (curve 4) in the United States has decreased constantly in the last 30 years, from 180 pounds per capita to 130 pounds per capita and probably will continue to do so until it levels at 100 pounds of copper in use per each world human.

While the energy consumption per capita (curve 3) peaked in 1945, it has fallen off markedly (for an energy saving in gas, electricity, oil, etc. equivalent to the energy of 2 tons of coal per capita per year for every American) despite a vast increase in the realized motion, communication and manufacturing rates, home airconditioning, clothes-washing and dishwashing machines, etc., occurring simultaneously as is seen in curve 10 which shows an almost vertical rise in the rate of electrical apparatus production.

Curves 7, 12 & 14 all relate to passenger miles per capita per annum. Curve 7 is the railroad passenger miles per capita per annum. Having risen steadily for 50 years from its mid nineteenth century beginnings, U.S.A. per capita, per annum railroad passenger miles peaked in 1917 at which time automobile passenger miles per capita,

per annum, (curve 12) had risen in a decade to equal the railroad travel. The automobile passenger miles increased steadily thereafter while railroad passenger miles declined until the depression of 1929 temporarily decreased the automobile travel for two years and again when gasoline rationing of World War II reduced the automobile travel temporarily whereafter it gains swiftly to the present moment. Meanwhile the railroad passenger miles fell off swiftly until the mobilization of World War II and the automobile gas rationing when because of vast troop movements the railroad miles again rose temporarily to equal the automobile travel. Since 1945 the railroad passenger miles have fallen off again to their alltime low since 1883 and are now exceeded by the continental U.S.A. domestic passenger miles per capita per annum air travel (curve 14) which had its "big business" debut only thirty years ago during the "depression's" depth. If we were to include the passenger miles per capita per annum air travel outside the United States' continental borders, by U.S. citizens only it will be seen that the U.S. citizenry's total annual foreign air mileage will soon exceed the 4000 miles per year average domestic travel of every one of America's 180 million citizens. Clearly, U.S.A.'s crossbred citizenry annual motion pattern is exploding ecologically from that of a locally tethered man to that of freely flying world man.

CHARTS IN THIS SECTION FOLLOW AS LISTED BELOW

Chart A-1: Curves 1. U. S. Copper in terms of U.S. Gold $35 per oz. Scale - 5¢ per lb. per inch current price.

2. Population of U.S.
Scale - 18,000,000 per inch.

Chart A-2: Curves 3. Consumption of Energy in Equivalent Tons of coal per capita per annum. Scale - 1 ton per inch.

9. Barrels of Petroleum per capita per annum in U.S.
Scale - 2 barrels per inch.

11. Annual Electric Power Production
Scale - 80 billion kwh per inch.

Chart A-3: Curves 4. Pounds of Copper distributed in U.S. per capita
Scale-20 lbs. per inch.

10. Annual Electric Equipment Production
Scale - 1,500 million dollars per inch.

Chart A-4: Curves 7. Railroad Passenger Miles per capita per annum
Scale - 200 miles per inch.

12. Auto Passenger Miles per capita per annum in U.S.
Scale - 500 miles per inch.

13. Airway mileage (revenue)
Scale 200 million miles per inch.

14. Air Passenger miles per capita per annum in U.S.
Scale 200 miles per inch.

Chart A-5: Curves 5. Telegraph Wire Mileage
Scale - 500,000 miles per inch

6. Miles of Railroad Track
Scale - 125,000 miles per inch

8. Miles of surfaced auto roadway
Scale - 250,000 miles per inch.

CHART A·1

1 U.S. COPPER IN TERMS OF U.S. GOLD $35 PER OUNCE
SCALE: 15¢ PER LB. PER INCH CURRENT PRICE

2 POPULATION OF U.S.
SCALE: 18,000,000 PER INCH

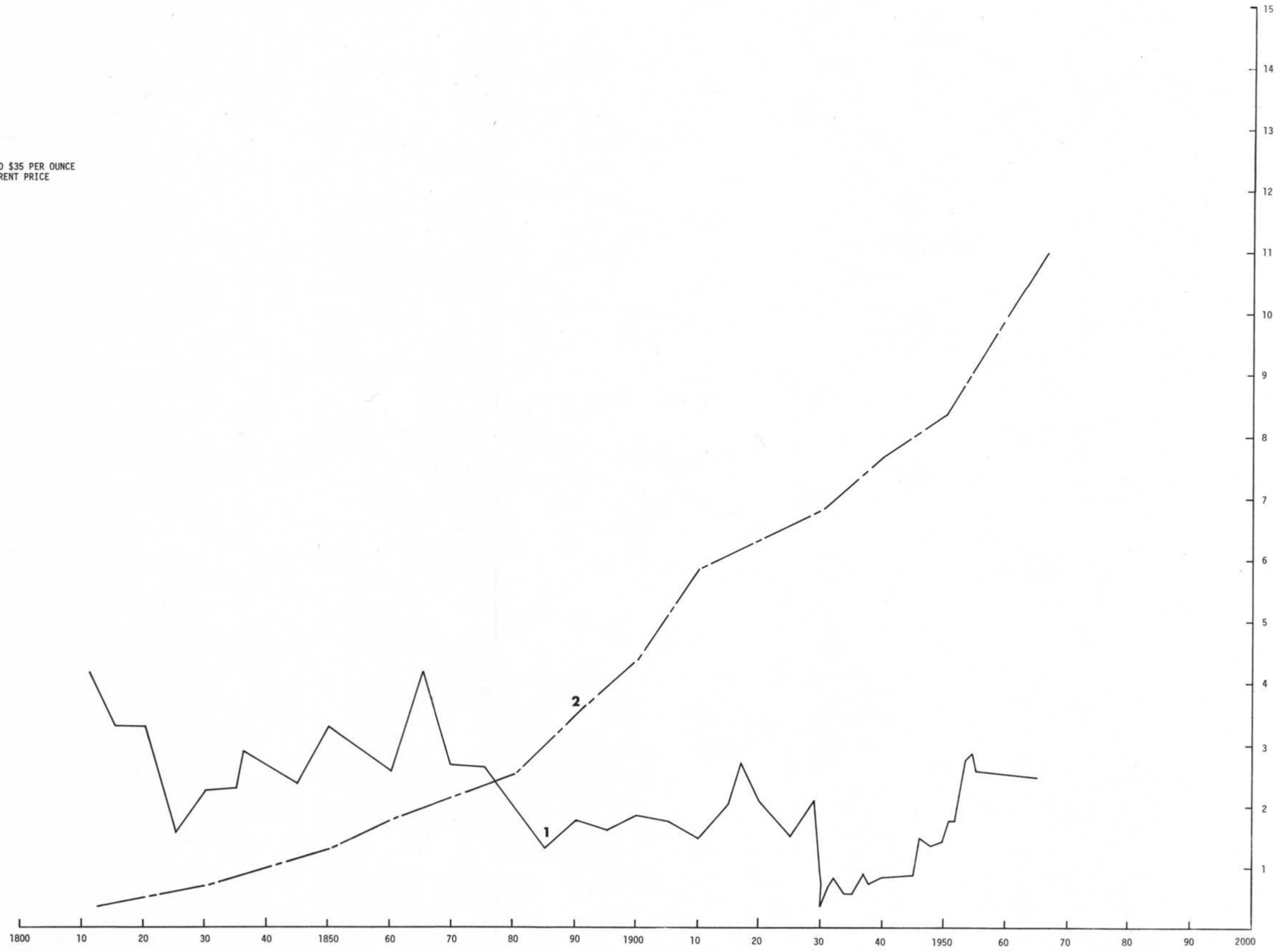


CHART A·2

3 CONSUMPTION OF ENERGY IN EQUIVALENT TONS OF COAL PER CAPITA PER ANNUM.
SCALE: ONE TON PER INCH

9 BARRELS OF PETROLEUM PER CAPITA PER ANNUM IN U.S.
SCALE: TWO BARRELS PER INCH

10 ANNUAL ELECTRIC POWER PRODUCTION
SCALE: 80 BILLION K.W.H. PER INCH

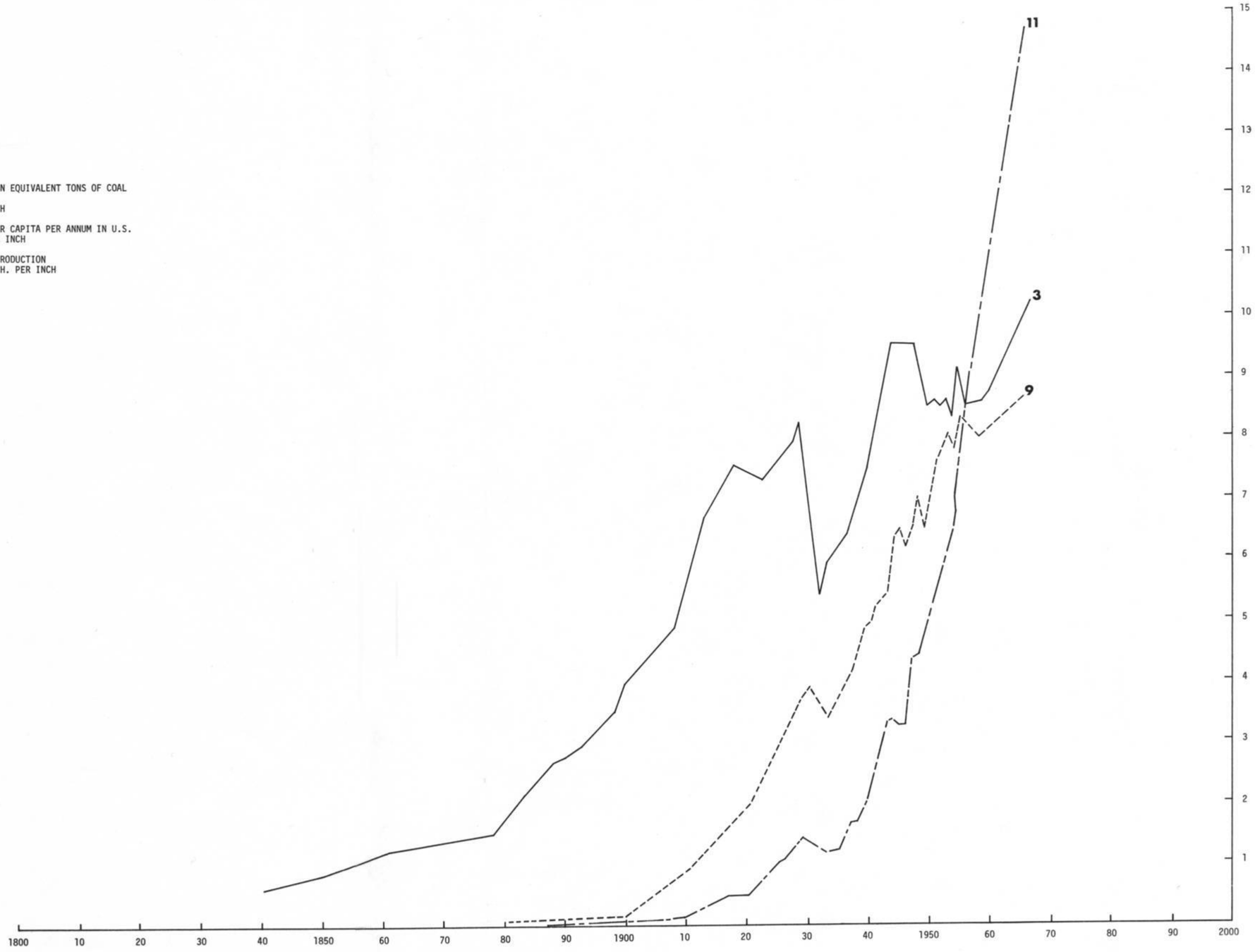


CHART A·3

4 POUNDS OF COPPER DISTRIBUTED IN U.S. PER CAPITA
SCALE: 20 LB. PER INCH

10 ANNUAL ELECTRIC EQUIPMENT PRODUCTION
SCALE: 1,500 MILLION DOLLARS PER INCH

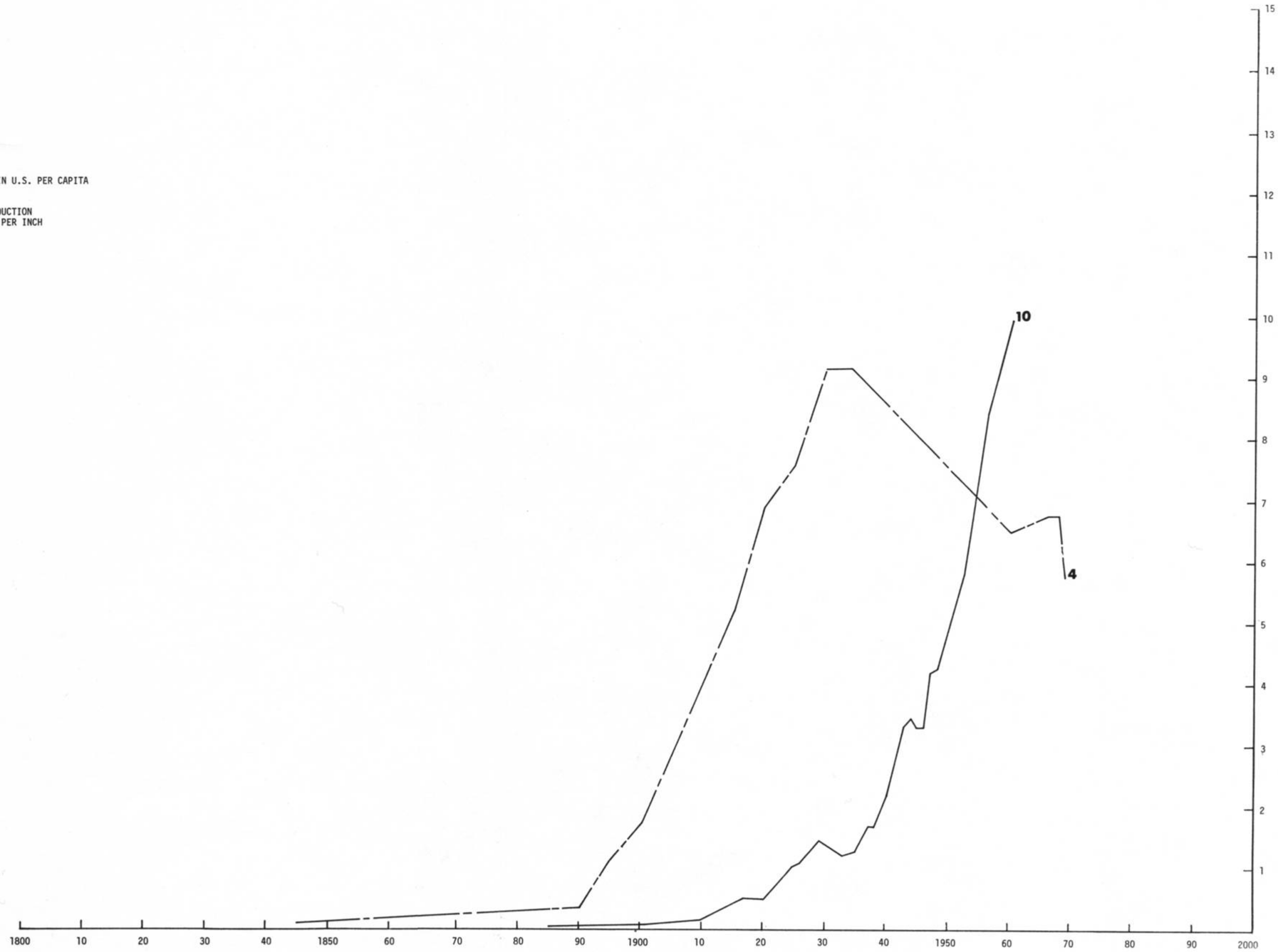


CHART A·4

7 RAILROAD PASSENGER MILES PER CAPITA PER ANNUM
SCALE: 200 MILES PER INCH

12 AUTOMOBILE PASSENGER MILES PER CAPITA PER ANNUM IN U.S.
SCALE: 550 MILES PER INCH

13 AIRWAY MILEAGE (CIVIL AND SCHEDULED DOMESTIC MILES FLOWN)
SCALE: 200,000,000 MILES PER INCH

14 AIR PASSENGER MILES PER CAPITA PER ANNUM IN U.S.
SCALE: 200 MILES PER INCH

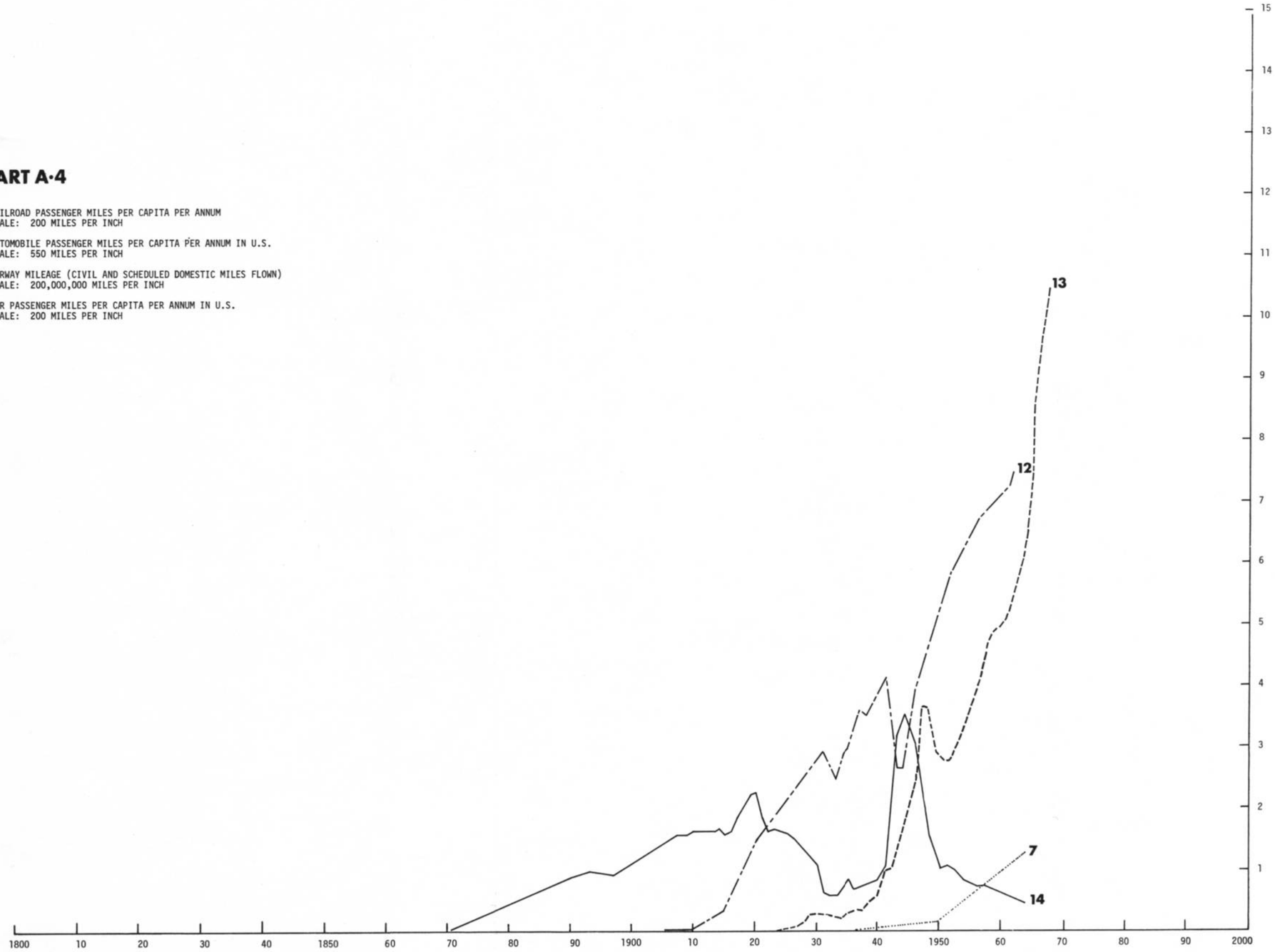


CHART A·5

5 TELEGRAPH WIRE MILEAGE
SCALE: 500,000 MILES PER INCH

6 MILES OF RAILROAD TRACK
SCALE: 125,000 MILES PER INCH

8 MILES OF SURFACE AUTO RACEWAY
SCALE: 250,000 MILES PER INCH

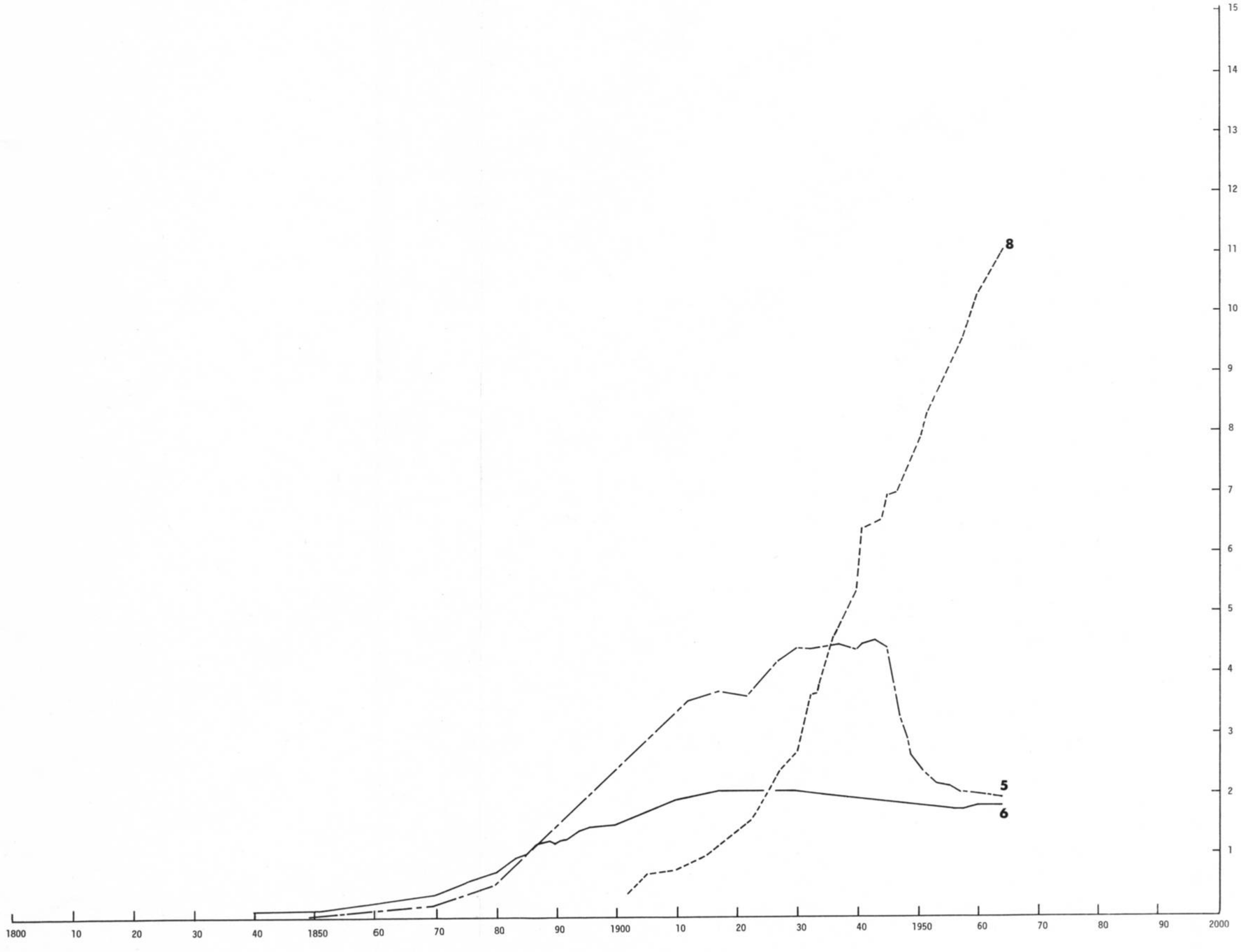


Chart B

AUTOMATION PERMITS GENERAL DISTRIBUTION OF WEALTH

Chart B dicloses the ten-year decline in cost per pound in automobiles and dollars per horsepower between 1925 and 1935. These reductions in the cost of living and of tools were a direct result of increased efficiency in scientific design of societies' tools as is clearly shown by the fact that the decline in price for the decade 1925-35 was entirely unaffected by either the colossal boom of 1925-29 or the historic depression of 1929-35. It is also clearly indicated by Chart B that the 1925 to 1935 curve in the reduction of fundamental costs marks the beginning of the economic effects of automation. The post World War One automation brought about great unemployment both on the farm and in the factory which in turn curtailed purchasing power and caused the general cessation in all business by 1933. The three fundamental "cost" lines level off from 1933 to 1942 as the New Deal put both ceilings and floors on all price rises or declines while enormously increasing employment by vast government underwritten or guaranteed project initiations. It can be said that the New Deal began thus to distribute the wealth being generated by automation's increased efficiency by spreading and expanding the purchasing capability of society through the invention of "jobs". World War II emergency conditions began to strain and sometimes break the price controls. High employment of war time meant wide increase in purchasing power which was however temporarily dammed-up for the duration of the war by priorities and price controls. The controls broke down progressively after 1945 and "costs" seemingly "shoot-up". However as Chart A shows, the regenerative efficiency gains in higher performance per pound in machinery and per unit of energy to run the machinery is continually operating therefore the seeming increase in cost of living and cost per pound of automobiles represents in fact two new developments. The first is the complex improvement and inclusion of new functions in both "living" and "automobiles". The relative performance per pound of the 1963 automobile is many fold that of the 1925 automobile. The second development was the intrusion into both the cost of living and the pounds per automobile (and every other manufactured product) of an enormous distribution of purchasing power through generalized employment added fortuitously, arbitrarily and deceptively to fundamental production costs. It was recognized that we cannot have the economic efficiency of mass production without the concomitant mass consumption. The expanded purchasing capability of the mass consumer essential to the health of industrialization thereby provided has brought about an artificial and highly deceptive "inflation." It is deceptive because it hides the fact that United States has instituted necessary wealth distribution, ergo buying power, but through arbitrary invention of jobs (and physically unnecessary) employment despite which the automation continues to generate sufficiently increased wealth to permit the luxury of false inflation without apparent harm to the economy. Inflation used to mean an increase in cost without increase in value. Todays cost increases have far greater, but indirect value increases. In evidence of the latter statement the dollars per horsepower remain steady despite seeming inflation because automation and science have continued to increase the performance per pounds and kilowatts rapidly enough to offset the inflation generated in the general cost of living. If there had not been the arbitrary inflation the dollars per horsepower as well as the cost of living and cost per pound of automobiles and all other products of a given standard would have fallen even more rapidly than they did between 1925 and 1935. In substantiation of the above conclusions it is to be noted again that the smooth decline of costs of living, horsepower and pounds of automobile went nonswervingly through the peak boom of the nineteen-twenties and the subsequent "crash" as though those periods had not existed.

Chart B

The economic facts shown by these charts are the industrial production technology, which reduced the manufacturing cost per pound of an automobile by Henry Ford in 1925 to 10 cents, (to which was added 12 cents a pound for the sale and distribution of the car, for a total of 22 cents per retail pound for "Fords") has been improved upon, as of 1963, several hundred fold (not to speak of the improved performance per pound of the automobiles, itself) wherefore the comparable production cost under today's technical conditions would mean a manufactured and distributed retail sales price of 7 cents per pound instead of the 22 cents per pound of 1925, or of 75 cents per pound shown on the chart as of 1963. The last thirty-eight years' thousand percent mark-up in the price per pound of the automobile represents the arbitrary distribution of purchasing power to American industrial society through adding onto basic production costs of the cost of increased dividends, wages, and taxes, to cover government engineered purchasing power expansion, all added into the cost per pound of product and cost per hour of services to keep the industrial system going. We can state it as an economic law that: Without mass consumption there can be no mass production; without mass distribution of wealth there can be no mass consumption. This chart shows clearly that a completely new accounting system is necessary for world society, one that can be clearly read in detail and fundamental logic by any literate human.

The Old World before 1914 was run by the commerce of the sea. The commerce was run by the pirates. The top pirate was "the law". The top pirates were the honored masters, the lesser pirates were outlaws. All pirates hid their prime wealth. Finance capitalism which followed piracy by taking the wealth from the pirates also carefully hid its wealth in complex accounting systems. The post World War I United States abhorring Socialism but inheriting capitalisms accounting system hid the distribution of wealth in false inflation lest that distribution be called socialism. Socialism is a way of organizing economic production inadequacy so that sacrifices and want are shared equally by all. Socialism is a moral way of sharing failure. Because automation can provide more than enough for all humanity socialism is now obsolete. What is now necessary is world accounting system that permits man to boldly account his physical success and abundance accomplished through the artist-scientist-inventor's technology and industry and entirely transcendently to political theories. This "accounting" system must be a world embracing system that treats every man's life hours as of equal value, when employed only as muscle and reflex machines, and differentiates and accredits for priority advantage the value to society only of the commonwealth multiplying conceptual contributions which effectively accelerate the regeneration and amplification of man's physical and intellectual advantage in universe and his enjoyment of life.

CHARTS IN THIS SECTION FOLLOW AS LISTED BELOW

Chart B: Curves 1. Urban Cost of Living

2. Cents per lb. of auto

3. Dollars per horsepower

Chart B

① URBAN COST OF LIVING (1953=100) 106 Index

② CENTS PER LB. OF AUTO (57¢)

③ DOLLARS PER HORSE POWER ($12)

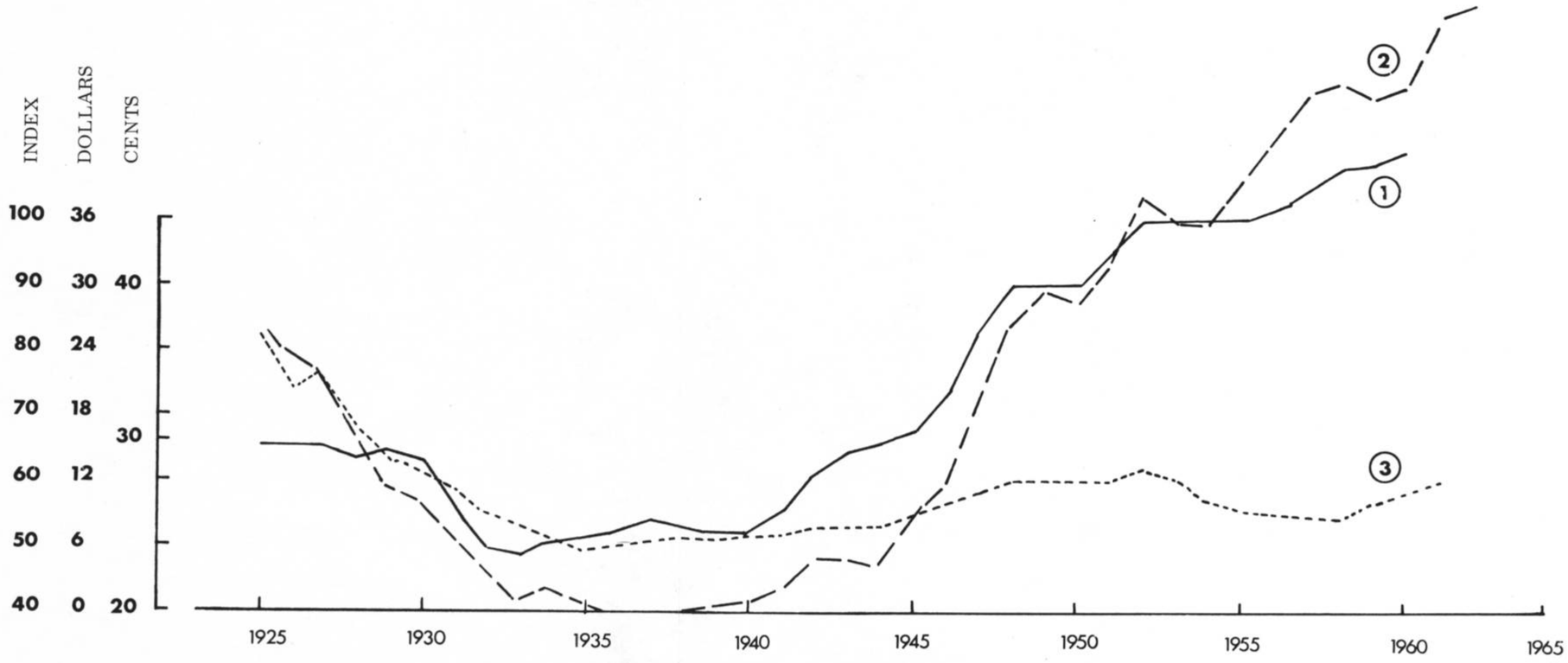


Chart C

THE VELOCITY OF THE AMERICAN FAMILIES' ACQUISITION OF THE MECHANICAL EXTENSIONS OF ITS APPREHENDING FACULTIES AND PHYSICAL CAPABILITIES TO FAVORABLY ALTER THE MAGNITUDE OF THE HISTORICAL SWEEPOUT AND PENETRATION OF HUMAN ECOLOGY IN UNIVERSE

In 1810, a generation after the American Revolution, a small percentage of the million families of the United States owned human slaves. But the United States as a unit economy possessed one million human slaves, --that is to say -- an average of one slave per each of its one million total families.

Chart C is the history of the human family's personal acquisition of newly invested physical equipment in the United States since the time of its first population census in 1790 and first economic census in 1810. The successful battle waged consciously and unconsciously by the individual design scientists and inventors to displace human slavery and drudgery by an inanimate mechanical energy slave population 300 for one, is clearly demonstrated. It is seen here that the human slaves, who were rated in the 1810 economic census as more valuable than the homestead buildings and furnishings became fundamentally obsolete as an energy-to-work converting machine with the invention of the dynamo and production steel in 1860 -- ergo -- the war to emancipate the human slaves politically was a political accessory after the fact of techno-physical emancipation. The political emancipation now lags a century behind. The machinery to produce one inanimate horsepower now costs $12 vs. $120 for a good live horse. The machinery to produce an inanimate one manpower costs only a few pennies. In the course of 150 years of industrial revolution the cost of feeding and keeping the living horse or the human slave to do 8 hours physical work has proven to be thirty-seven to one hundred times more expensive today than feeding the inanimate machines to do the same amount of work. The increased velocity atwhich technical apparatus has been acquired by the U.S.A. "family" is also clearly demonstrated. For instance, the rate at which telephones increased in use in America until the depression of 1929 is clearly shown, at which time they had reached a number almost equal to one per each American family. In 1949, immediately following World War II, we reached one telephone per family. Since 1929 the numbers of telephones have come to greatly exceed one per family with no deceleration in the new rate of increase. Automobiles in use crossed the one per family line in 1922. World War II brought about the arbitrary cessation of automobile production at which time the number of cars dropped well below one per family and group-riding to work was resorted to. In 1948, immediately after World War II, the numbers of cars again exceeded one per family and have since been increasing per family at an unabated rate.

Generally speaking, Chart C demonstrates the increasing velocity at which the American family acquired its new tools. The almost vertical ascent from none to one per family demonstrates the rate at which the industrial world can completely alter its environment controlling devices overnight. Those who think that the coming revolution in education of the whole world may take a long time should take note of the overnight acquisition of television sets by the U.S. families -- the humbler the dwellings - the more prominent the T.V. antenna, is the scene around the world.

Chart C

Chart C also demonstrates to the world architectural students the velocity with which design science can render total man a physical success on earth. The effectiveness of design science which specifically reforms the physical environment rather than attempting to reform man or man's spontaneous untooled behavior patterns by political means alone. The design science way is a way unopen to political theory or expediency.

CHARTS IN THIS SECTION FOLLOW AS LISTED BELOW

Chart C: Curves 1. Family Population of U.S.
Scale a) 5 persons per family
Scale b) 3.6 persons per family
(Overall scale - 8 million per inch)

2. Single Family Dwellings

3. Telephones in Use

4. Autos in Use

5. Radios in Use

6. Electric Refrigerators

7. Television Sets in the Home

CHART C

SCALE: 8 MILLION PER INCH

1 FAMILY POPULATION OF U.S. (5 PERSONS PER FAMILY)

2 SINGLE FAMILY DWELLINGS

3 TELEPHONES IN USE

4 AUTOS IN USE

5 RADIOS IN USE

6 ELECTRIC REFRIGERATIONS

7 TELEVISION SETS IN THE HOME

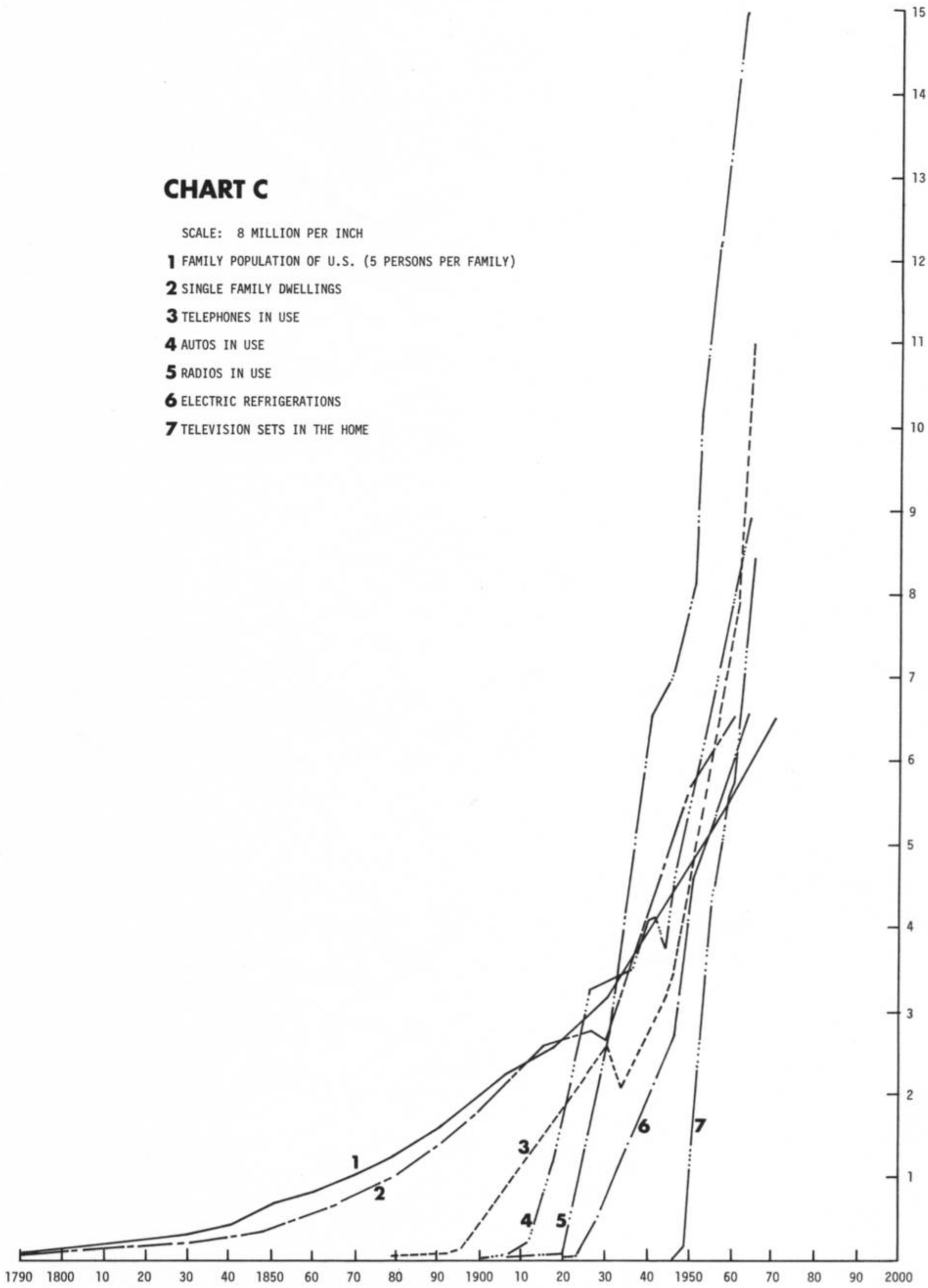


Chart D

COPPER THE ENERGY HIGHWAY OF INDUSTRIALIZATION

Economic Panorama of the First Century of Industrialization --
1862-1962 World's and U.S.A. Copper Production and Consumption

Copper has been and continues to be the prime accessory in man's historical harnessing and distribution of universal energies to do an increasing number of physical tasks for man. As man alters his economic patterning on earth he transforms his fate from that of a million year locally imprisoned, inbreeding, economic slave to an overnight mobilized, cross breeding, world encircling and universe exploring economic success.

Copper's efficiency in the conduction of electricity is second only to that of gold and silver. Gold and silver are too scarce -- ergo too expensive to be used for the prime conduction. Gold and silver are used to solder delicate connections. Copper is plentiful enough to be functionally used yet scarce enough to impose a constant application of highest technical efficiency in order that its functional capabilities may be enjoyed at a general profit. The history of man's production, consumption, use and regenerative reuse of copper constitutes the most sensitive, inclusive, wholesale and fundamental barometer of world industrial development and the latter's realistic emancipation of humans from at least a million years of privation, disease, starvation, premature death or slavery.

Due to the invention of "floatation" and "electrolytic refining" of copper and the vast copper requirements of history's First World War, in the one year 1917 alone, man took from the earth, smeltered, refined, manufactured, distributed and employed more copper than he had taken from the earth sum totally, during the whole million year history of men before him and continued in ensuing years at this new magnitude; therefore, though fascinating in ancient events, world copper history is enacted primarily in the twentieth century and not in the bronze age and the world copper history in relation to industrialization prior to the twentieth century is essentially miniscule. Only the second half of the first Industrial Century of 1862 - 1962 is of significance to our prognosticating, i.e., 1912 - 1962.

Copper made possible the bronze age and the first epochal transition of man from his stone age. The graduation from the stone age occurs as man using his brain crushed the stone and leached and smelted it and thus differentiated out its theretofor invisible fundamental structural, metallic components and reassembled those structural components into unprecedentedly higher performance, chemical structure alloys. By providing non-rusting high tensile metallic fasteners copper made possible man's fashioning of the first major cargo carrying, ocean-going, wooden framed and skinned vessels. Copper thereby initiated world commerce, and the industrial integration of around the world occurring high performance metals. In due course man found that he could substitute ferrous metals for the ribs and skins of the vessels which lasted long enough when painted to hold their ships together and the far more expensive and scarce copper was melted out of the ship fastenings and accessories and reshaped into new industrial equipment essential to the inauguration of railroading where early, uncontrolled rusting would have jeopardized the new high speed high tonnage enterprise. In due course railroad engineering substitutions were found for the expensive copper and copper alloy components which were melted out of the railroad inventory and were reemployed together with additional new copper taken from the mines to tool up the dynamos, electric motors and electrical conductors

which ushered in the new electrical era of industrialization. History witnesses copper continually implementing more important frontier undertakings of technology and industry as an "industrial era self-starter." Copper was thereafter continually melted out of one function and reemployed in another new one. Less than 15% of all the copper that has been mined by man in all his million year history has gone out of circulation and 14 of the 15% lies in well known geographical concentration in ships and cargos on the bottom of the sea from which it will soon be recovered so that 99% of all the copper mined by man will be continued in industrial recirculation, constantly upping the performance of new phases of industry and gradually being replaced after the industrial kick-offs to permit copper to continue in as yet unknown roles as the industrial frontiers-opening metal. Most recently copper is trending into smaller and smaller integral components each of lesser weight and into low percentage alloying functions as 3% copper in aluminum alloys, etc., ergo copper is trending to invisible functions.

As will be discovered by comparing new copper production peaks and copper scrap peaks there is an average 22 year lag in the total turn over of copper from one function to another. Up to 1917 the production of new copper taken from the ground was all that man kept account of. He thought of metals as being invested in buildings and machinery which would eventually go to the scrap heap down a one-way streed dead-ending in oxide powder oblivion. Because man had taken so much copper from the ground in 1917 and because there is only a 22 year lag before the copper comes back, as Chart D will show, in 1939 the old scrap from 1917's epochal production, followed by equal magnitude productions throughout World War I, burst upon the United States market like a flood (as I had fortunately predicted it would three years earlier to an incredulous and uninterested copper industry). As a consequence, in 1939, the U.S. and world copper cartel, in order to hold its price-line dumped the scrap excesses into Germany and Japan during 1939 to 1941 where it was reemployed to tool up the German and Japanese military offenses against the U.S.A. and the latter's world allies. Copper scrap appearing in the U.S.A. is now primarily exported in the post World War II years. The remaining unexported copper scrap recirculation in the U.S.A., which includes intra-mural recirculation within major industries such as electrical manufacturing, now exceeds U.S. annual consumption of newly mined copper.

This same excess of scrap commerce over new metal activity also characterizes steel making. 65% of all U.S.A. steel is now made from scrap. The fact that scrap is the prime metals resource of industrialization and will become increasingly dominant means that the monopoly ownership of mines and other natural unworked raw physical resources no longer controls fundamental undertakings of world industry. It also breaks down natural national resource deficiency and excess monopolies or disadvantages formerly governing world and political economic evolution. Further realization that scrap recirculation of the metals is to be from now on the prime source of the world's metals will also continuingly decrease the local geographical premiums on so called REAL estate. Special localities will have decreasing economic monopolies. The U.S.A. has approximately no tin ore resource and never has had workable tin ore. England was opened up by the Phoenicians and later colonized by the Romans due to its prodigious tin resources. Today England has mined out its tin and the U.S.A.'s tin scrap resource makes the U.S.A. a leading world tin resource nation as well as the world's major tin user.

Decrease in the significance of the world's dwindling below earth level ore reserves will bring about increasing emphasis on the value of abstract "ideas", -- "inventions" -- and complex forward conceptions which integrate the world industrial networks into a dymanic recirculatory system in which every reuse of the metals permits the articulation of higher performances per pound through the improved scientific and technical knowledge earned by each successive technical enterprise. For the latter reason we show the U.S.A. patent history curves on the copper history chart.

The U.S.A. and world copper curves clearly foretell the physical success of man which is being won by an increasing acceleration in the regenerative functioning of design science which reduces fundamental discoveries and conceptual inventions to feasibility and demonstrated "practice". The increase in regenerative functioning of design science will increase the frequency of the waves of advancing technology which in turn will continually increase the performance per pound of the recirculated metals until within a few decades the whole of humanity will be comprehensively, adequately, and ever more satisfactorily serviced by the recirculating world's metal resources. As this increasing recirculation of the metals occurs the metallic reserves below earth level will be continually decreasing per capita wherefore the increasing numbers of those serviced by the world's metals is a direct consequence of doing more with less with the acceleratingly recirculated resources rather than with the dwindling unmined, untouched or unknown reserves.

Chart D clearly shows the acceleration of World copper production in contrast to the U.S. production and consumption. The U.S.A. economy inadvertently set up a vast prototype network of industrialization for world adoption. But the prototypes are always immaturely over weighted and are always replaced with sequitur higher-performance-per-pound-and-watt generations of tooling and retooling and network rearrangements. As a consequence U.S. man's early industrial share of the total world's in-use copper has fallen from a mid twenties high of 180 lbs. per capita to 130 in the last 20 years despite that meanwhile U.S. man has been continually increasing his performance per lb. of the remaining in-use U.S.A. copper so that his technical advantage has been continually increasing. As he went from wire to wireless, from tubes to transistors he gained energy control advantage with lessening copper per unit of functional performance. This regenerative, design-science paced industrialization has brought about the general release of the vast body of old copper scrap in the U.S. to the rest of the world. In 1967 the vast copper production of World War II's 1945 peak will come suddenly into new magnitude of greater recirculation and this will mean a bounteous year of resources plentitude for industrial advance everywhere around the world but a headache year to world cartelism and obsoletely accounting authorities dealing only in yesterdays economy-of-scarcity criteria.

Of extraordinary importance in the interpretation of Chart D is the fact that the great peaks of production, consumption and scrap recirculation are not always identified with war though World War I's 1917 mobilization occasions the first major historical peak. On the other hand 1927, at mid-peace times, shows a far greater rise in world copper production than in the previous war. The latter 1927 peak shows that peacetime can increase the copper production and the latter's servicing of industry. 1927 represented the shift of the technical advantage gained in weaponry as of 1917 to the home economy. We call this the shift from dominant function as "killingry" to that of "livingry". 1945's, World War II, realization of enormous gains in technical advantage of weaponry brought about secondary application of that technology to the home front and as a consequence the phenomenal peak in copper production of 1960.

Chart D

Copper was extraordinarily intimate to weaponry and munitions in the days of big guns and mammoth shell casings. Now, copper has lost its weaponry significance in the rocket delivered warhead. The phenomenal rise in world copper production in 1960 to three times that of 1917 is essentially due to copper's use in the generalized tools of industry and to the domestic electrical equipment. Chart D may therefore be interpreted as revealing the fundamental break-away of world industry from preoccupation with tools of destruction to tools of construction. Chart D clearly foretells man's physical mastery of his earth environment for the benefit of all mankind.

CHARTS IN THIS SECTION FOLLOW AS LISTED BELOW

Chart D-1: (Overall Scale - 400,000 Tons per inch)

Curve 1. World Copper Production

2. All World Old Copper Scrap

3. U.S. Copper Production

4. U.S. Copper Scrap

Chart D-2: (Overall Scale - 6,000 Patents per inch)

Curve 5. Total U.S. Patents annually issued

6. U. S. Corporation Patents issued

7. U.S. Industrial Patents issued

CHART D-1

SCALE: 400,000 TONS PER INCH

1 WORLD COPPER PRODUCTION

2 ALL WORLD OLD COPPER SCRAP

3 U.S. COPPER PRODUCTION

4 TOTAL U.S. COPPER SCRAP

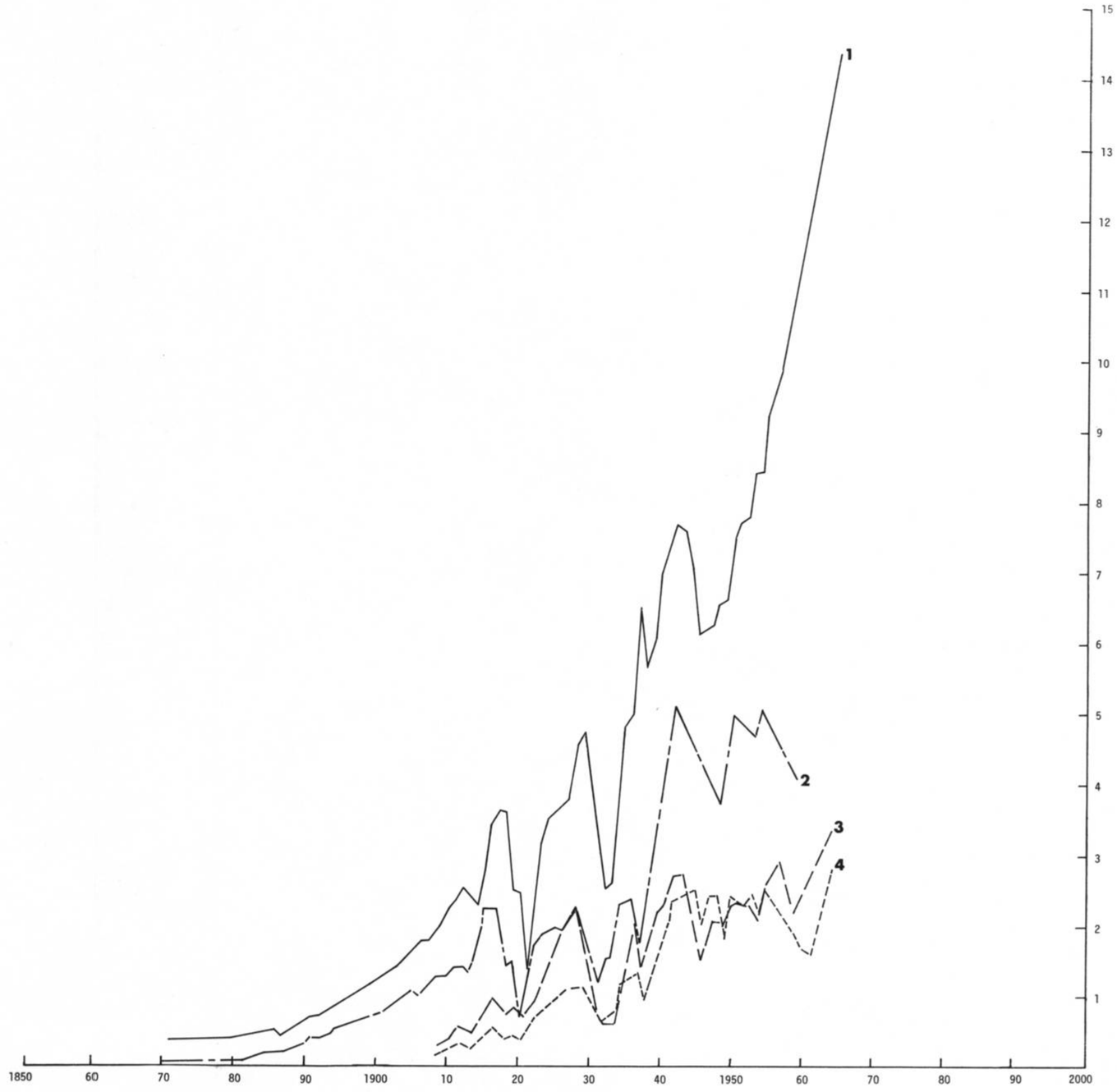


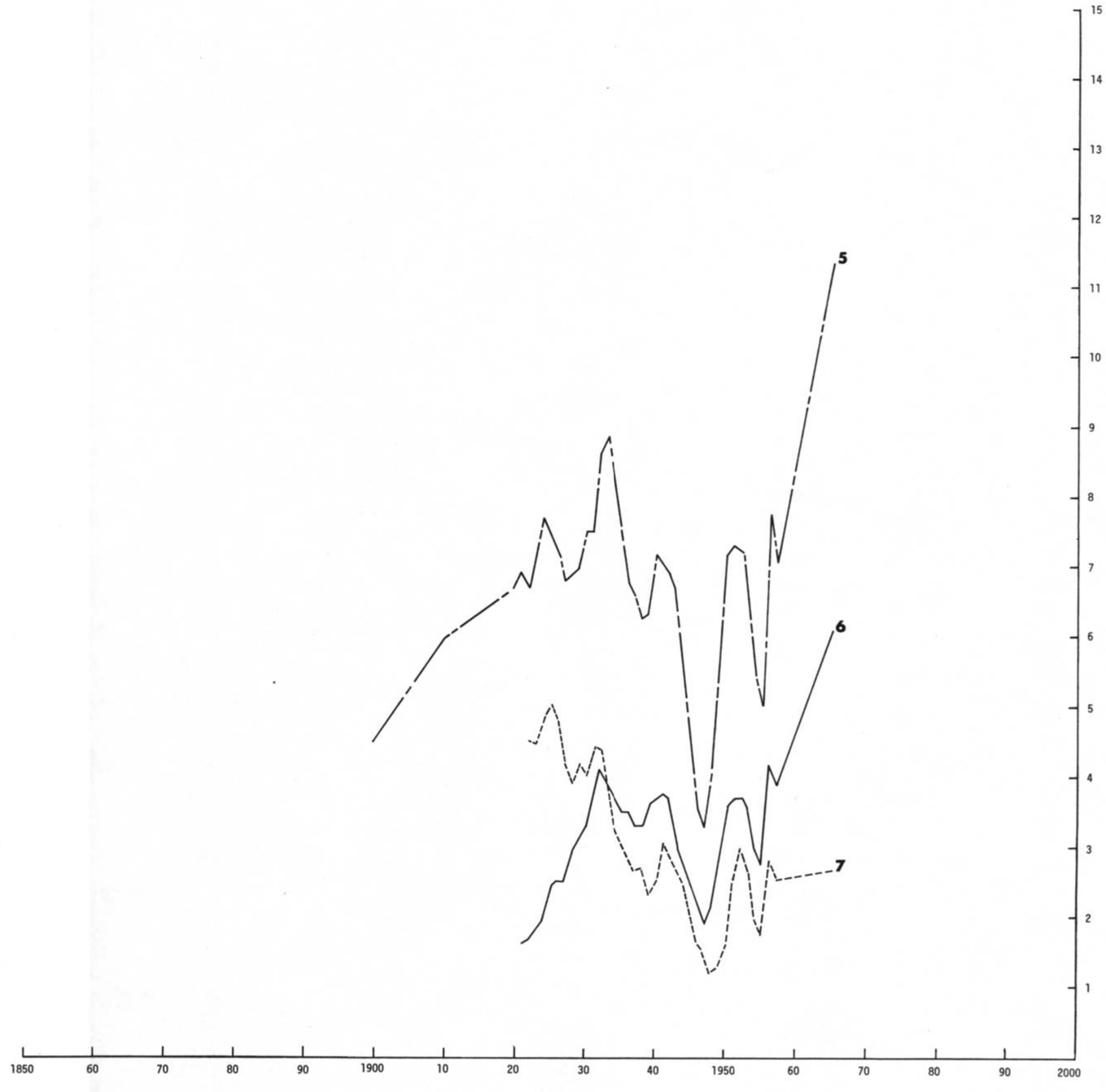
CHART D·2

SCALE: 6,000 PATENTS PER INCH

5 TOTAL U.S. PATENTS ANNUALLY ISSUED

6 U.S. CORPORATION ANNUALLY ISSUED

7 U.S. INDIVIDUAL PATENTS ISSUED



WORLD AND U.S. PRODUCTION AND CONSUMPTION OF COPPER CORRELATED TO U.S. POPULATION CURVE AND THE RECIRCULATION OF OLD COPPER

COPPER RECIRCULATION

Recirculated old copper as shown on the charts is that reported only by the copper smelting and casting industry. The reported, and curve charted, copper data represents only a limited portion of copper recirculation as it does not include old copper intramurally recirculated, by telephone, railroad, automobile, electrical manufacturers, ship-yards, etc. Intramural copper circulation never gets back to the primary or secondary copper industry refiners. The latter's figures represent total of officially reported recirculation. As far back as 1912-1919 the railroads reported to the Bureau of Mines annual intramural circulation of 13 to 20 thousand tons after deducting scrap "cashed" against new copper purchase. This intramural recirculation represented more than their outside purchase of new copper at that time - it is unofficially understood that recirculation intramurally in "telephone" and "auto", "aircraft" and "electronic" industries is today high and if these amounts were added to "producers" recirculation it is probable that it would tend to make world production figures parallel or top U.S. Population Curve, and "straighten out" the World Copper Production Curve. The following is a table of the "inventory" of "old" copper "in place" in U.S. industries with the respective estimated recirculation cycles in years for each category. Estimates of "shrinkage" in recirculation very from 5 to 25%. Authority, American Bureau of Metal Statistics and U.S. Department of Mines.

1936 INVENTORY OF COPPER IN USE IN U.S.A. IN TONS

		Cycle Yrs.
Railway Equipment, exclusive of Electrification	300,000	15
Railway Electrification, First Class	90,000	20
Urban Trainways and Suburban Lines	300,000	5
The Merchant Marine	320,000	15
The Navy	100,000	10
Motor Vehicles	700,000	7
Telephone and Telegraph	1,000,000	10
Light and Power, Public Utilities, Generation	90,000	20
Light and Power, Transmission and Distribution	2,000,000	30
Electrical Machinery and Apparatus, N.E.S.	2,500,000	10
Buildings	2,700,000	42
TOTAL	10,100,000	average 22.6*

*Weighted Average Years (This rate is slowly contracting: Now probably less than 22 years at present time. 1963)

It is estimated that on a basis of the overall historical ratio of "World" to U.S. copper consumption which, though evoluting towards ever larger world and lesser U.S., per capita, consumption, averaged 5:2 over the last 60 year period, that the world inventory of industrially recirculatable copper was in 1936 approximately 23,000,000 tons recirculating on a 23 year cycle. Allowing for "shrinkage" this meant a base re-circulation of approximately 1,000,000 tons of "old" annually. This has since been and will be progressively augmented by a proportion of the surplus of "new" copper production over the "shrinkage" replacement, after deducting all distribution to non-recoverable* status which now averages 10% of annual production. 1963 estimates indicate that the recirculatable world inventory of copper has more than doubled since 1936 and that the annual world recirculation is over 2 million tons of scrap.

A 1936 computation made by author indicates an overall world history loss of approximately 16% of all copper known to have been produced. An independent estimate by the American Institute of Mining Engineers reported in "Mineral Economics" in 1935 developed a figure of 15% for all-time-overall copper loss which checks closely our estimate. Of the 15-16% overall historical "loss" the whereabouts of its loss, primarily in munition-carrying and fighting ships during world wars I and II, are well known and recovery of that metal from ocean bottoms will be accomplished in the next twenty years bringing the percentage of all history's copper in world recirculation to 99%.

*Non-recoverable copper is that entering into alloys at so low a percentage, - say 2% of the alloyed metal, that the copper may only be extracted at high present energy cost. However the separation tasks become improved and energy costs are always descending wherefor these low percentage copper investments may be efficiently and profitably extracted in future years.

THE CUMULATIVE NATURE OF WEALTH

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WEALTH. The measurable degree of forwardly organized environmental control, in terms of quickly convertible energy, capacities and performance ratioed system capabilities per capita, per diem.

Wealth is now without practical limit. All the constituents of wealth are now demonstrably inexhaustible and are all on inventory to man's immediate willing. Science has hooked up the everyday economic plumbing to the cosmic reservoir.

You can now have your cake and eat it. The more you eat, the more and the better the quality of the cakes to be had by further production.

Science continually does more with less each time it obsoletes and scraps old inventions. Scrap is resolved to some part of the inventory of the ninety two regenerative chemical elements. Interim improvement in technical measurement of performance makes possible an ever higher magnitude of new performance by reuse of the same quantity of the original inventory of the chemical elements. Telephone messages per given cross section of copper wire increased from one to several conversations at the same time, then to scores, then to hundreds of messages taking place concurrently. So rapid is the rate of gain of telephone technology per given amount of copper that the telephone company has an almost inexhaustible mine of copper in its progressively obsolete equipment. The chief engineer of the Bell Telephone Company stated in 1936 that the stocks of copper owned by the telephone company, obtained from scrapping old equipment, would be sufficient for them to expand their service from the United States network to a world network without buying further quantities of new copper. This does not mean that they would always keep the wires. Part of the copper might go into the radio equipment between the long distance centrals.

The formula for common wealth production is: Ever greater investment of now unlimited energy in redesigned tools and end product. The energy investments may be in the form of heat treatments, precision tolerances, metallurgical alloying, etc.—always contriving to afford greater tensile strength, finer edge, greater wear, etc.; and the degree of greater performance thus accomplished is always a net increment of common wealth. Because more has been done with less, the balance can go into new degrees of mastery by man of his given environment.

Ever greater reinvestments of cumulatively advancing technology. This is the regeneration of intellectual advantage.

Result: The provision of higher magnitudes of performance per pound of the ninety-two regenerative chemical elements, and per hour of man's time, and per unit of energetic expenditure, —ergo, again net increment, of reinvestible performance advantage, i.e., wealth.

Footnote: The Cumulative Nature of Wealth is an extract from "Ideas and Integrities" by R. B. Fuller, published by Prentice Hall, Inc., 1963.

We could progressively scrap the whole paraphernalia of civilization's present mechanical equipment, both production and end product, replacing these with improved mechanics and products of fractional dimension as compared to the scrapped mechanics, while netting not only a higher standard of living performance for ourselves, but enough raw materials and improved know-how to expand the physical apparatus of our standard of living to serve not just our U.S.A. seven per cent but half the human family. The advantages gained by the latter would allow them in turn to develop new sources, sum totally providing the new advances of science and industry to serve all the peoples of the world. What to do about war surpluses here and abroad is clearly indicated in these truths. Scrap them one hundred per cent and reprocess the chemical elements into higher and more appropriate use forms, thus generating common world wealth. Spend ingenuity on brand new higher performance products rather than on makeshift application of obsolete gadgets.

Materials Equals energy as mass; physicists' law of conservation states that: energy can neither be created nor lost, ergo, there cannot be realistic energy depletion and borrowing from diminishing sources. There is no possibility of absolute debt * occurring in the new economics made available through the accomplishments of science. This is because the basic constituents of the wealth can no longer be depleted.

Know-how Technology (instrumented and documented intellect) improves with every re-employment because experience is consolidated in increasing degrees of precision, behavior and dimensional data.

Power Energy-larger and larger blocks of which, as inherent principles of an inexhaustible universe, become available to man's control account. The impoundment of ever greater blocks of energy within the arrangements of the ninety-two chemical elements to give higher degrees of performance of structure and mechanics constitutes the actual means of harvesting of universal wealth. It is as though the phenomena which we call raw materials, which are in fact our ninety-two chemical elements, were a fleet of cargo vessels into which we load ever greater cargoes of energy, and as we load them they give higher degrees of controlled performance. As a result, we increase our control over our fate and that is the function of wealth.

Faith Inexhaustible faith of man in the validity of himself as an effective factor in the biological equation of the universe, to which latter the principle of essential priority of the commonweal is implicit—that is, that the individual is a product and servant of a plurality (but that his best service to the commonweal

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* Because debt is a convention of traditional government, it will be increased to eventual absurdity. There is no other means of eliminating it in a democracy. Revolution could eliminate it only by democratic suicide.

can be indicated only by admonition of the individual intellect, which can best integrate all factors of the creative equations). In the principle of mass production industry, the significance of the individual as a machine of production continually diminishes and his importance as a consumer increases proportionally. The intellectual productive ability of science and technology which displaces the individual as a productive slave is cumulative to the whole history of intellect.

Through the new operating requirements of the transcendental industry, society must arrange a debtless system of increasing the availability of industrial services to all individuals and concurrently to an increasing number of their infinite needs in order to satisfy the science-industry-man equation. If not satisfied by creative ends, the forces now involved will be articulated to man's ultimate destruction because he lacked faith in his own validity– his validity as a never-ending, dynamic process of inclusion and refinement.

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1250 A.D. 1270 1290 1310 1330 1350 1370 1390 1410 1430 1450 1470 1490 1510 1530 1550 1570 1590 1610 1630 1650 1670 1690 1710 1730 1750 1770 1790 1810 1830 1850 1870 1890 1910 1930 1950 1970 1990 2010 A.D.

SAILING SHIP

STEAMSHIP

AIRPLANE

ROCKET

EARTH ORBIT IN MAN MADE ENVIRONMENT CONTROL: PRODUCT OF SUCCESSFUL APPLICATION OF HIGH PERFORMANCE PER UNIT OF INVESTED RESOURCES

PROFILE OF THE INDUSTRIAL REVOLUTION AS EXPOSED BY THE CHRONOLOGICAL RATE OF ACQUISITION OF THE BASIC INVENTORY OF COSMIC ABSOLUTES–THE 92 ELEMENTS

ALGORISMA INTRODUCES CYPHER INTO EUROPEAN CIVILIZATION FROM ARABS, THUS PROVIDING SCIENCE WITH PRACTICAL CALCULATING FACULTY

LEONARDO DA VINCI

COLUMBUS
COPERNICUS

GALILEO

BOYLE

LAVOISIER
WATT
WASHINGTON

AVOGADRO

MENDELEEFF
LINCOLN

STEEL DYNAMO

RADIO
AUTOMOBILE
FLIGHT
ELECTRONICS
TALKY

TECHNICAL ACQUISITION BY SCIENCE OF 92 ATOMIC ELEMENTS IS COMPLETED 1922 AND SUPER ATOMICS COMMENCE

103* LAWRENCIUM #103 Lw U.S.A.
102* NOBELIUM #102 No Eng., Swed., U.S.A.
101* MENDELEVIUM #101 Md U.S.A.
100* FERMIUM #100 Fm U.S.A.
99* EINSTENIUM #99 Es U.S.A.
98* CALIFORNIUM #98 Cf U.S.A.
97* BERKELIUM #97 Bk U.S.A.
96* PROMETHIUM #61 Pm U.S.A. Discovery disputed; claims to 1914
95* AMERICIUM #95 Am U.S.A.
94* CURIUM #96 Cm U.S.A.
93* PLUTONIUM #94 Pu U.S.A.
92* NEPTUNIUM #93 Np U.S.A.
91* ASTATINE #85 At U.S.A.
90* FRANCIUM #87 Fr Fr.
89* TECHNETIUM #43 Tc U.S.A.
88 RHENIUM #75 Re Gr.
87 HAFNIUM #72 Hf Netherlands, Hung.
86* PROTACTINIUM #91 Pa Gr., Aust.
85 LUTETIUM #71 Lu Fr.
84* RADON #86 Rn Gr.
83* ACTINIUM #89 Ac Fr.
82* POLONIUM #84 Po Fr.
81* RADIUM #88 Ra Fr.
80 XEON #54 Xe Scot., Eng.
79 KRYPTON #36 Kr Scot., Eng.
78 NEON #10 Ne Scot., Eng.
77 EUROPIUM #63 Eu Fr.
76 HELIUM #2 He Scottish
75 ARGON #18 A Eng-Scot
74 GERMANIUM #32 Ge German
73 DYSPROSIUM #66 Dy French
72 NEODYMIUM #60 Nd Austrian
71 PRASEODYMIUM #59 Pr Austrian
70 GADOLINIUM #64 Gd Swiss
69 SAMARIUM #62 Sm French
68 HOLMIUM #67 Ho Swedish
67 SCANDIUM #21 Sc Swedish
66 THULIUM #69 Tm Swedish
65 YTTERBIUM #70 Yb Swiss
64 GALLIUM #31 Ga French
63 INDIUM #49 In German
62 THALLIUM #81 Tl British
61 RUBIDIUM #37 Rb German
60 CESIUM #55 Cs German
59 RUTHENIUM #44 Ru Russian
58 ERBIUM #68 Er Swedish
57 TERBIUM #65 Tb Swedish
56 LANTHANUM #57 La Swedish
55 VANADIUM #23 V Swedish
54 THORIUM #90 Th Swedish
53 BROMINE #35 Br French
52 ALUMINUM #13 Al Danish
51 SILICON #14 Si Swedish
50 SELENIUM #34 Se Swedish
49 CADMIUM #48 Cd German
48 LITHIUM #3 Li Swedish
47 IODINE #53 I French
46 BORON #5 B French
45 BARIUM #56 Ba English
44 STRONTIUM #38 Sr English
43 CALCIUM #20 Ca English
42 POTASSIUM #19 K English
41 SODIUM #11 Na English
40 MAGNESIUM #12 Mg English
39 IRIDIUM #77 Ir English
38 OSMIUM #76 Os English
37 PALLADIUM #46 Rd English
36 RHODIUM #45 Rh English
35 CERIUM #58 Ce Swedish
34 TANTALUM #73 Ta Swedish
33 COLUMBIUM #41 Cb English
32 CHROMIUM #24 Cr French
31 BERYLLIUM #4 Be French
30 YTTRIUM #39 Y Finnish
29 TITANIUM #22 Ti English
28 ZIRCONIUM #40 Zr German
27 URANIUM #92 U German
26 TUNGSTEN #74 W Spanish
25 TELLURIUM #52 Te Austrian
24 MOLYBDENUM #42 Mo Swedish
23 MANGANESE #12 Mg Swedish
22 CHLORINE #17 Cl Swedish
21 OXYGEN #8 O English
20 NITROGEN #7 N Scottish
19 FLUORINE #9 F Swedish
18 HYDROGEN #1 H English
17 NICKEL #28 Ni Swedish
16 BISMUTH #83 Bi French
15 ZINC #30 Zn German
14 PLATINUM #78 Pt Spanish
13 COBALT #27 Co Swedish
12 PHOSPHORUS #15 P German
11 ANTIMONY #51 Sb German
10 ARSENIC #33 As (first recorded discovery) Bavarian

* Radioactive, No stable isotopes

9 ELEMENTS WERE ACQUIRED BY CIVILIZATION PRIOR TO HISTORIC RECORD OF THE EVENTS, PROBABLY IN ASIA MILLENIUMS AGO

CARBON	#6	C
LEAD	#82	Pb
TIN	#50	Sn
MERCURY	#80	Hg
SILVER	#47	Ag
COPPER	#29	Cu
SULPHUR	#16	S
GOLD	#79	Au
IRON	#26	Fe

NOTE: NUMBER BEFORE NAME OF ELEMENT INDICATES ORDER OF DISCOVERY. NUMBER FOLLOWING NAME IS THE ATOMIC NUMBER. LETTERS FOLLOWING ATOMIC NUMBER ARE THEIR SYMBOLS. NATIONALITY LISTING IS THAT OF DISCOVERER.

APPROXIMATE CUMULATIVE TOTAL OF KEY INVENTIONS OF SCIENCE AND TECHNOLOGY

9 8 7 6 5 4 3 2 1

150 450 1,450 10,000

1250 A.D. 1270 1290 1310 1330 1350 1370 1390 1410 1430 1450 1470 1490 1510 1530 1550 1570 1590 1610 1630 1650 1670 1690 1710 1730 1750 1770 1790 1810 1830 1850 1870 1890 1910 1930 1950 1970 A.D.

UNIVERSAL REQUIREMENTS CHECKLIST

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UNIVERSAL REQUIREMENTS OF A DWELLING ADVANTAGE

Teleologic Schedule by Buckminster Fuller

Check list of the
Universal Design Requirements
of a Scientific Dwelling Facility, —
as a component function
of a new world encompassing,
service industry, —
predesigned,
Rather than haphazardly evolved, —
and thus avoiding
a succession of short circuited
and overloaded burnouts
of premature, and incompetent
attempts to exploit the ultimate
and most important phase of
industrialization, to wit,
the direct application of highest
potential of scientific advantage
toward advancement of world living
standards—
to be accomplished by inauguration
of a comprehensive anticipatory
technology scientifically informed
of the probable variables and
possible randoms—
this new volition to succeed
the era of 'survival', —
that is survival-despite, —
despite preponderant submission
to ignorance, —
ignorance of future probabilities
and general behaviour of nature—
which heretofore 'survival', tolerated
lethal opportunism, wherein the
progressive deteriorations bred
emergencies which called upon
scientific ability to perform last
minute miracles but only as a
curative dispensation of morbid
inertia.

The universal design requirements of a scientific dwelling facility are that it accomplish comprehensive advantage for man over all primitive factors of energetic nature. That factors may be broadly classified in four parts as follows:

I. Essentially RANDOM and SUBJECTIVE phenomena

A. Exterior variables—factors of destructive or useful potential; of nakedly intolerable magnitudes, inescapably impinging

B. Interior variables—factors of destructive or useful potential; of nakedly intolerable magnitudes, inescapably impinging

C. Exterior constants of relative inertia forgotten through persistent obviosity and randomly re-encountered

II. Essentially ROUTINE and SUBJECTIVE phenomena—internal to dwelling—predictably periodic, rhythmic

A. Inescapable functions of the organic processes, internal to dwelling and external to man.

B. Inescapable functions of the organic processes, internal to dwelling and internal to man

C. Interior constants of relative inertia forgotten through persistent obviosity, and regularly rediscovered, e.g. furniture to be lifted with each house-cleaning.

III. Essentially RANDOM and OBJECTIVE phenomena—internal to dwelling—initiative, spontaneously intermittent—teleologic

A. Investment of earned increments of lifetime for free will regeneration of the advantage of life over a priori environment. Realization of man's potentials as an individual

B. Implemented and insulated spontaneity of feedback acceleration-continuity of the self amplifying individual

C. Instrumentation of 'home' magnitude physical realizations of man's potential as a continuous-man, i.e. a team of individuals overlapping and weaving around individual birth-deaths and separate generations, a Total Man who never sleeps, dies, nor forgets.

IV. Essentially INCISIVE and routine OBJECTIVE phenomena—external to dwelling—initiating a sustainable complex continuity=design realization of all men's joint potential—teleologic

A. Investment of earned increments of technical advantage of the science-industry complex in design realization of the complex dwelling facility service

B. Implementation and insulation of synergetic feedback of higher order accruing to spontaneous group realizations of newly evolving potential

C. Instrumentation of industrial or institute/university magnitude realization of man's potential as a continuous-man i.e. a team of individuals overlapping and weaving around individual birth-deaths and separate generations, a Total Man who never sleeps, dies, nor forgets.

Note: That I and II above are subjective and defensive and exclusive and that III and IV are objective and offensive and inclusive.

Note: That I defines the outer ramparts and II the inner defenses while III represents the inner initiative-taking and IV the full grown outer offensive—conquest—contact.

Note: That this arrangement is geometrically teleologic, i.e. omni-directionally convergent-divergent-propogative.

Expanded expression of four broad classifications of universal design requirements for a dwelling facility. Original topic of broad classification not repeated and referred to only by number.

IA Structural, mechanical or chemical interception and control of externally impinging factors, either by rejection, reflection, deflection

Through shunting, channelling, impounding, modulating and/or retiming of volumetric flows of variable external factors of nakedly-intolerable magnitudes

1. Immunization against aperiodic, energetic interferences, —externally impinging at intolerable magnitudes and heretofore classified as cataclysmic, —because exceeding the practical stress abilities of as yet available technology—However—(new era essence). Since accomplishment of higher physio-chemical stress abilities in, for instance, supersonic flight and snorkle submarine, the stress abilities of technology in general now far exceed the predictable stresses of the hitherto cataclysmic structural interferences—the 180 m.p.h. velocity of Antarctic hurricane or Pacific typhoon is now a relatively minor aeronautical velocity-of-interaction of designed structures. External impingements are classified in the order of frequency of probable occurrence and relative magnitudes

a. Cataclysmic
Improbably annual, possibly 'never', and least frequent, but of highest stress when occurring

1 earthquake
2 tornado
3 hurricane
4 typhoon
5 avalanche
6 landslide
7 volcanic eruption
8 bombardment
9 forest fire
10 tidal wave
11 plague
12 radio activity
13 lethal gases
14 BW (bacteriological warfare)

b. Dangerous
Probably annual, of borderline 'disaster' magnitudes

1 gale
2 local fire
3 flood
4 pestilence
5 lightning
6 selfishness (self-preoccupation pursued until self loses its way and self-generates fear and spontaneous random surging, i.e. panic, the plural of which is mob outburst in unpremeditated wave synchronizations of the individually random components)

a vandals
b marauders
c meddlers
d politics
e fanaticism
f commercialism
g materialism

c. Inclement
Of high seasonal frequency and
of low orders of stress or
of naked intolerability

1 fumes
2 hail
3 rain
4 snow
5 dust
6 electrolysis
7 oxidation
8 heat
9 cold
10 epidemic
11 vermin
12 insects
13 fungi
14 minor random missiles

2. Rejection, or deflection for delayed or immediate use as
a. energy, admitted into direct work as, for instance, radiation or electronic reaction, or
b. indirectly into work as, for instance, impounded wind (aeronautical) or water (hydraulic) power

1 piped - for direct use
2 wired - for direct use
3 valved - for direct or delayed use
4 stored - in cistern, tank or battery for delayed use
5 stored - in thermal bank or compost bins, etc.

IB Dynamic control of internally impinging factors

1. Interception of and dispellment of the momentum trends of ignorance, —through incorporation of experience informing natural design replacements, realized in physical principles
2. Interception and neutralization of bacteria by isolation of, —or by direct elimination
3. Elimination of physical fatigue

a. human robotism and drudgery by provision of adequate mechanics of technical advantage

4. Elimination of psychological fatigue (repression) by

a. removal of accident hazard through mechanical adequacy (don't proofing)
b. removal of arbitrary cellular limitations to permit free interaction of living functions
c. provision for selective privacy by push-button sound, sight and smell barriers surrounding any interior space

5. The elimination of emotional fatigue

a. factors stimulating nerve reactions to be automatically controlled in 'neutral' until voluntarily brought into play by the occupant through:

6. Provision of mechanics for wide range in selection of means and degrees of sensible realization of the prosaic or harmonic phenomenon

a. visual
b. aural
c. tactile
d. olfactoral, i.e. taste and smell

IC Control by anticipatory design over exterior constants of inertia forgotten through persistent obviosity and only randomly re-encountered

1. Constants of environment, i.e. the mud forgotten between rains, odorous winds from remote sources, snowdrifting
2. Control devices installed for seasonal duration only requiring inordinate time investments
3. Chemical accumulations (oxides, sludges, fumes)
4. Biological accumulations

a. vegetation, composts, weed
b. insect, animal residues, nestings, general growth changes

5. Surprise emergencies of environmental complex unique to locality, i.e. possible water, oil, gas springs and seepage

IIA Provision for (unselfconscious) (spontaneous) mechanical performance of inevitable organic routines of the dwelling and its occupants with minimum of invested attention or effort

1. Fueling of house (external metabolism)
2. Realignment of house
3. Scavenging of house

IIB 1. Fuelling of occupants (internal metabolism)
2. Realignment of occupants (sleep) by allowed muscular, nerve and cellular realignment accomplished by designed elimination of known restrictive factors.
3. Scavenging of occupants
a. internal, i.e. intestinal, etc.
b. external, i.e. bathing or pore cleansing
c. mental, i.e. elimination by empirical dynamics
d. circulatory: external, —atmospheric control
internal, —as respiratory functions.

IIC Control by anticipatory design over interior constants of relative inertia forgotten by fatigue cloture of feedback sensibilities and routinely re-encountered—(such as heavy furniture to be moved about daily for cleanliness operations, storages to be overhauled to obtain the tentatively retained devices of possible or infrequent use)
1. By provision of adequate occupational-specialty storage means
2. By home employment of travel equipment
3. By dimensional reduction (e.g. of collections of large data to microfilm)

IIIA Provision of ready mechanical means, complementing or implementing, all development requirements of the individual's potential growth phenomena, —allowing the facile, scientifically efficient, no-energy-or-time-loss, —spontaneous development of self desciplined education, by means of

1. Conning, i.e. selectively stimulated awareness of the momentary interactions of universal progressions
accomplished by means of facile references to vital data on
a. history
b. news
c. forecasts
calls for a comming facility combining book and periodical library, radio, television facilities,
systematically arranged incoming reports on
1 current supply and demand conditions
2 current dynamic conditions-weather-earthquakes—latest scientific research findings
3 social dynamics-surfacing of commonweal problems of comprehensive readjustment to new potentials and concomitant obsolescence factors
4 latest technical reference in
a texts
b movie documentation
c television university (soon evoluting to increasing importance and reliability as the autonomous dwelling facility becomes widely available)

2. Adequate mechanics of personal articulation (prosaic or harmonic) for the spontaneous investment of
the imagination-gestating intellectual-increments of experience, —(teleology)
which trend ever to satisfy the evolving needs-prosaic or harmonic—routine or plus.
This category of original articulations also includes the necessity or crystallization of universal progress

a. instruments are tools of communication
1 direct
2 indirect
3 aural
4 visual
5 tactile
a music, writing, drawing, measuring instruments
b wood, metal and chemical working tools
c typewriter
d wire-tape-and-disc-all-purpose-recorder-radio-phonograph
e easel
f photographic equipment—taking, developing, printing, projection

3. Recreation—appropriate equipment to full physical development
4. Procreation

IIIB Insulation, or isolation, of the instrumented initiatives
Private diaries, tape recordings, films, instrumentally recorded data as yet incomplete, undigested, ungestated as complete teleologic regeneration.

IIIC Home Magnitude means of displaying, exposing, experimenting and measuring of 'target' or 'trend to target' or 'trend following' assumptions-of-realization-initiative-and-articulation. —i.e. 'vital navigation' or 'teleology', i.e. personal and social and cosmic feedback control. The comprehensive 'frames'—relative to which display, exposure, experiments, measurement and progressive dynamic trend assumptions may be referenced is FOURFOLD

A Objective Aspect	B Subjective Aspect	C Consolidated Intellectual Advantage, or 'Aids'
1. Subvisible (finite)	nuclear particles	atomic charts periodic, etc.
Microcosmic	atoms	spectrographic charts
	molecules	molecular models
	cells, genes	biological slides
2. Geo-visible (de-finite)	crystallographic	globes, maps, geological stratification maps
Geographical	biologic	world and local physiological data
(visible, near)	sub-surface	spectrum charts
Earth	surface	
	envelope	
3. Astro-visible	comets	star globes
(de-finite) Macrocosmic	asteroids	star charts
(visible, remote)	planets	
	stars	
	nebula	

A Objective Aspect	B Subjective Aspect	C Consolidated Intellectual Advantage, or 'Aids'
4. Supravisible (finite) Comprehensive Omni permeative	abstracted 'generalised' principles gravity radiation number sets group behavior phenomena probability transformations independent of dimensions infinity	energetic geometry devices (vectorial, formative, transformative, number)

IV REALIZATION BY DESIGN

A Priori Design Realization Assumptions

Asking not
why, whither, nor whence
man-life?
But assuming
the accumulated experience evidences
that biological phenomena
in general
and man-life
in particular
function in universe
as the anti-entropic, —
the anti-random, —
the simple and complex organic, —
the systematically convergent phases
of the comprehensive cycling
of omni energy transformations
and therefore industrialization
constitutes the comprehensive, —
transformative expansion
of the man-life function in universe—
and therefore the realization that
man-life's extension
into cosmic measurement
already billionsfolds
the sensory limits of integral faculties
presages a further successful amplification
of the man-life function in universe
and therefore
that the regenerative ability of intellect
in extension, acceleration, and expansion
of the extra corporeal cosmic-functioning-stature
of the man-life in universe
is realizable
in comprehensive design initiative
relayed through industrialization
and therefore the function of
comprehensive design
is most naturally and effectively
preoccupied with omni-abetment

of the realization in full
of the potentials of the 'individual' complex, —
an organic atomic nebula
identified superficially as man—
man potential includes
regeneratively improving potentials
of sequential derivative orders
of increasing advantage of the organic
over the (random-entropic) chaos growths.
'Individual' man's highest potential
may be realized in terms of full interaction
of all men's potentials—
ergo man's universal function trends
to amplify first the pull potential
of the individual, —
but inherently multiplicative man-life.
Therefore
on first priority
in design consideration
is the full realization
of individual potential
in order to reach the second derivative, —
full realization for all individuals.
Keys to design realization
are the anthropological measurements,
of the limiting factors
of corporeal man,
beyond which extra-corporeal articulation
of the integral faculties
may be accomplished by extension in principle
through atomic-complex trains,
and energetic transformations
to cosmic stature advantage.
Universal conditions of design realization
commence with the static and dynamic
dimensions of man
and his basic behaviour involvements
of which there exists a wealth of data.

The whole program of realization is to be considered in the following order which breaks into two primary categories or phases: (1) the initial work to be undertaken by the individual prior to his engagement of the aid of associates and (2) original and initial work to be undertaken by the first group of associates. These two phases may be subdivided as follows:

IVA Research and development by initiating individual (prior to inauguration of design action and development action involving full-time employment of others).

Inauguration of a general work pattern as a natural pattern coinciding with best scientific procedure to wit:

Preliminary

Initiation of diary and notebook

Initiation of photographic documentation

Initiation of tactical conferences

PHASE I, INDIVIDUAL

1. Comprehensive library study of accrued developments within the pertinent arts*

a. past b. contemporary

2. Listing therefrom of authorities available for further information

a. local, personal contact b. remote, correspondence

3. Pursuant to information thus gained, calling at suggested local laboratories

a. university b. industry

c. setting up of informative tests for first-hand knowledge in own laboratory

4. First phase of design assumption

a. consideration of novel complex interaction unique to project

b. preferred apparatus from competitive field

c. design of appropriate flowsheets

5. Flowsheets submitted to

a. those competitive specialists who have proved helpful in step b and c

b. industrial producers of similar equipment and assemblies

c. make informative tests for closure of gaps supporting sssumed theory

6. Submit specifications and drawings of general assembly and unique component parts for informative bids by manufacturers

a. second redesign of flowsheet based on available and suggested apparatus, price information, etc.

7. Prepare report consisting of diary of above supported by photographic documentation and collected literature—with trial balance conclusions of indicated economic advantage (which, if positive, will inaugurate Phase II)

* Pertinent arts to be studied by the initiating individual include:

1. Anthropological data
2. Energetic Geometry, the philosophy of mensuration and transformation, relative size
3. Theory of structural exploration
4. Theory of mechanical exploration
5. Theory of chemical exploration
6. Energy as structure
7. Dwelling process as an 'energy exchange'
8. Dwelling process as an 'energy balance sheet'
9. Theory of structural complex

10. Theory of service complex
11. Theory of process complex
12. Theory of structural and mechanical logistics
13. Theory of complex resolution

PHASE II, COLLECTIVE

IVB Design and development undertaking—involving plural authorship phase and Specialization of full-time associates

Consideration of Relationship of prototype to industrial complex by constant review of principles of solution initially selected as appropriate to assumptions

Adoption of assumptions for realization in design of pertinent principles and latest technology afforded

1. Comprehensive survey of whole sequence of operations from original undertaking to consumer synchronization

Realization strategy #1 by individual (Phase I)

Realization strategy #2 by associates (Phase II)

a. Physical tests in principle of the design assumptions' unique inclusions not evidenced in available data

b. General assembly drawings (schematic) providing primary assembly drawing schedule reference

c. General assembly assumption, small scale models and mockup full size

d. Primary assembly, sub-assembly and parts calculations (stress)

e. Trial balance of probable parts weights and direct manufacturing costs (approximately three times material costs; includes labor, supervision and inspection) and forecast of overall cost magnitudes, and curve plotting, —at various rates of production, ratioed to direct costs per part and 'all other costs', —i.e. 'overhead', tool and plant 'amortization', 'contingencies', 'profit'

f. 'Freezing' of general assembly and its reference drawing

g. Drawing for first full size production prototype commences in general assembly, primary assembly, sub-assembly and parts

h. Budget of calculating and drawing time is set with tactical deadlines for each

i. Parts drawing and full size lofting and offset patterns

j. Prototype parts production on 'soft tools' commences

k. sub-assembly and primary assemblies with 'obvious' corrections and 'necessary' replacements (not 'improvements' or 'desirables' which must be deferred until second prototype is undertaken after all-comprehensive physical tests have been applied)

m. Photography of all parts and assemblies

n. Full assembly completed and inspected—cost appraised with estimates of possible 'improvement' savings to be effected

o. Static load tests

p. Operational tests

q. Assembly and disassembly tests

r. Photography of all phases

s. Packaging and shipping tests

t. Estimates of savings to be effected by special powered field tools
u. Opinion testing
v. Final production 'clean-up' prototype placed in formal calculation and drawing with engineering budgeted with deadlines
w. Parts cost scheduled by class 'A' tools and time
x. Production tool layout fixed
y. Production tools ordered
z. Production dates set
a' Lofting and offsets produced of full-size-test 'masters' and templates
b' Fabrication of special jigs and fixtures
c' Production materials ordered
d' Production tool-jig-fixture tune-up
e' Parts and assembly testing
f' Field operation scheduling
g' Field tools ordered
h' Distribution strategy in terms of initial logistic limitations
i' Field tests with special tools
j' Field tools ordered or placed in special design and fabrication
k' Test target area selected for first production
l' Production commences
m' First field assemblies with power tools
n' Maintenance service instituted and complaints
(1) alleviated
(2) analyzed
(3) change orders of parts instituted
o' Plans for 'new yearly model improvement run through all or previous steps—for original production
p' Cycle repeated

2. Production and distribution velocity assumptions

3. Plotting the assumed progressive mass-production curves to determine basic velocities of new industry

4. Tensioning by crystalline, pneumatic, hydraulic, magnetic means

5. Compressioning by crystalline, pneumatic, hydraulic, magnetic means

6. Consideration of manufacturer's basic production forms, — relative to proposed design components for determination of minimum steps, minimum tools, and minimum waste in realization

7. Establishment of priority hierarchies of effort

8. Time-and-energy-and-cost budgeting

9. Assumption of industry responsibility for field practices, not only in mechanical and structural, but in economic design

10. Designing for specific longevity of design appropriate to anticipated cycles of progressive obsolescence and replacement ability as ascertained from comprehensive economic trend curves

11. Designing with 'view to efficient screening of component chemicals for recirculated employment in later designs'

12. Maxima and minima stated and realized performance requirements per unit of invested energy and experience and capital advantage of tools and structures employed and devised

13. Logistics assumptions compacted shipping considerations as original design requirement in

(a) nesting
(b) packaging
(c) compounded package weight
(d) relationship to carriers of all types
(e) field delivery
(f) field assembly
(g) field service and replacement

14. Consideration of tool techniques

15. Consideration of materials' availability

(a) at time of design
(b) in terms of world economic trends
(c) in terms of world potential

16. Consideration of materials ratio per total design

17. Elimination of special operator technique forming

18. Elimination of novel special soft tool designing

19. Numbers of

(a) types
(b) repeat parts
(c) sub-assemblies
(d) primary assemblies

20. Numbers of forming operations

21. Number of manufacturing tools by types

22. Schedule of forming operations included on parts drawings

23. Decimal fraction man hours per operation

24. Designed-in over-all one-man-ability at every stage of operation

25. Schedule of design routines and disciplines

26. Establish a 'parts inventory of 'active and 'obsolete' drawings — from beginning

27. Establish a 'parts' budget of 'required' designs of 'parts' for assemblies and major assembly and general assembly and molds

28. Drawing dimension standards

29. Establish a numbering system of controlled parts

30. Establish purchasing techniques, jig and fixture, lofting techniques

IVC Industrial Magnitude means of etc.
This section repeats all content of IIIC except at Industrial magnitude instead of at Home magnitude.

PUBLIC RELATIONS To run concurrently with all phases of IVB

1. Education of public

Rule I: Never show half finished work
a. General magnitude of product, production, distribution. But no particulars that will compromise latitude of scientific design and production philosophy of IVB
b. Publicize the 'facts', i.e. the number of steps before 'consumer realization'
c. Understate all advantage
d. Never seek publicity
e. Have prepared releases for publisher requests when 'facts' ripe

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LIST OF ILLUSTRATIONS

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LIST OF ILLUSTRATIONS

World Design Initiative

Historical Blast Off into the Space Age of Man