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Mr. Sam Chambliss
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Severna Park, Maryland

Dear Mr. Chambliss:

Thank you for your letter of June 26 and its news items updating us on what has transpired so far on the 117 foot Geodesic Hangar; and of its probable completion date towards the end of July.

Replying to your question regarding loadings anticipated for the dome, the drawings as completed by Geodesics Inc. at Raleigh, N. C., for the Marine Corps were dimensionally designed for full Arctic snow and wind loads. For further information regarding design strategy governing the products of Geodesics Inc., I suggest that you read "A Study of Shelter Logistics for Marine Corps Aviation", Final Report June 1955, by Colonel H. C. Lane, Head, Aviation Logistics and Material Branch, Headquarters, U.S.M.C., approved by W. O. Brice, Lieutenant General, U. S. Marine Corps Assistant Commandant of the Marine Corps (Air). This should be in the Washington Aluminum Company's files or in their library. If not, Colonel Woodruff or his office may be able to loan you a copy.

I don't think you will be able to use the ratio of four pounds of completed structure per square foot of enclosed floor area as a unique structural accomplishment in publicizing the 117 footer. (See ARCHITECTURAL FORUM, August 1951, "Geodesic Domes: Bucky Fuller's Spidery New Framing System Will Roof a Cubic Foot and Support Seven Pounds With Each Ounce of Structure"; also ARCHITECTURAL FORUM, August 1952, "How Domes are Designed for Minimum Metal and Minimum Labor", by Vernon Reed; also see ARCHITECTURAL FORUM May 1953, "Ford Motor Company Builds a Geodesic Dome"; also ENGINEERING NEWS RECORD, May 28, 1953, "Ford Rotunda Geodesic Dome"; also LIFE Magazine, June 8, 1953.) This 93 foot diameter Ford Geodesic dome, complete with skin and ventilators weighed 16,500 pounds and covered a projected floor area of 6,792 square feet. This gives a ratio of 2.42 pounds per sq. ft. Mr. Fuller considered this a heavy Geodesic dome, for he had doubled his required safety factor because it was his number one big Geodesic dome. Despite the safety factor beefing, the Ford Dome weighed 1/29th the weight of the lightest conventional dome possible under prevailing engineering practices of June 1953. The Ford Motor Company had proof of this fact in that their own engineering building on the same Dearborn grounds as that occupied by the Ford Rotunda was receiving at the same time the best conventional dome of approximately the same size as that of the Geodesic dome covering the Rotunda. This Engineering Building dome of the Ford Motor Company weighed 29 times as much per square foot of projected area as did the Ford Motor Company's Geodesic dome covering its Rotunda court. The Rotunda Geodesic dome was also a permanent dome, and it required only one quarter of the installation time of its 29 times heavier counterpart. The Ford Motor Company states that the Geodesic dome's cost reflected these time and weight savings.

Geodesics Inc. has just completed (June 1956) two 100 foot diameter Geodesic domes. One for the Mid-America Jubilee at St. Louis, and the other for shipment by air in one DC-4 to Kabul, Afghanistan to serve as the U.S.A. Pavilion at an International Trade Fair. These two domes are each 14% larger in projected floor area than the Ford Rotunda Geodesic dome. They are both designed for the same extremes of hostile environment loadings as those governing the Marine Corps Geodesic domes.

As these two 100 footers are in the same stress and dimensions magnitudes as the 117 foot U. S. Marine Corps hangar, they may be used to evaluate the Marine Corps hangar's relative structural efficiency. Each of the new 100 footers for St. Louis and Kabul have a ratio of only 1.37 pounds of combined structure, skin, anchors, ventilators, and doors per square foot of enclosed floor area.

This is a record, not only for Geodesic structures, but also for all history's clearspan structures in this stress and dimension class. The ratios change with increasing clearspan diameters, so comparisons must be made only for comparable spans and working loads.

We are about to produce a 100 foot Geodesic also able to cope with maximum stresses and other adverse conditions of most hostile world environments, at a ratio of only .625 pounds of combined structure, skin, ventilator, doors, anchors, et al, per sq. ft. of enclosed floor area. This information is off the record inasmuch as Mr. Fuller and Geodesics Inc. are prohibited by the contracts from releasing public information on these items.

This information is mainly to help you steer your course toward discovery of unique, ergo newsworthy, aspects of the U.S. Marine Corps' 117 foot hangar - and it has many such newsworthy aspects.

Regarding an inquiry to you from a magazine as to whether designers and engineers other than Mr. Fuller have been involved in the U.S. Marine Corps' 117 foot hangar, the answer is no other prime engineer-designer is involved.

There are a host of secondary, tertiary, quarternary, etc., engineering and design functions amongst the gamut of functions which finally result in the development of a "secondary" and finally a "production" prototype of complex, high stress industrial end products.

This large corps of sequitor-stage engineers is especially required in the usual three step development of prototypes of altogether new industrial species, for instance in the design developments of large and complex "vessels". This statement includes vessels of the sea, vessels of the air, vessels of the roads and rails.

This large, sequitor-stage engineering corps is also required for development of the entirely new air deliverable, swiftly installable, immediately occupiable, large scale species Geodesic environment controls. This is not surprising because the new Geodesic domes are inverted vessels suitable for man occupancy under the most hostile environment conditions obtaining anywhere around the Airocean's turbulent bottom. These extreme Airocean bottom conditions which challenge the structural capability of the inverted Geodesic vessels, are frequently equivalent to the operational stressing of the "all-seas" or "all-skies" going vessels.

It is inherent in the industrial pattern and magnitude of enterprise, in contra-distinction to the craft pattern and magnitude of enterprise, that there must be hundreds-leading-into-thousands of "hair combing" engineering design processes between the prime, comprehensive design complex of the prime comprehensive designer's uniquely conceived and successfully demonstrated initial industrial step-one prototype, and the secondary, or cleanup prototype, and the tertiary, or final, industrial reproduction prototype.

The differences between industrial phenomena and craft phenomena are well known in their extremes; for instance, the differences between mass-production of automobiles and the hand-embroidery of needlepoint chair covers. The plural and single designing functions are well defined in respect to these extreme cases.

However, the modus operandi governing design and development of structures for land occupancy now vacillates between yesterday's and today's designs, and between craft and industry techniques of design and production. This no-man's land - part nonsense, part scientific with many half-breed functions in between is true of the building activity to such a confusing degree that your magazine's question is a very reasonable one.

In the 1956 architectural world all important buildings have an architectural designer and a less well known, but far more important, engineering designer. In the client, architect, and engineer tripartite relationship, the client pre-designs by strict economic conventions, definitions and limits. It is as if the sick were to diagnose themselves and then tell the doctor what to do for them. Worse, it is as if the patient were in all seriousness to tell a beautician what to do for him without altering the patients self diagnosis, and then the beautician were to "design" the operation and then command a real doctor to perform the beautician's aestheticized version of the patient's self-diagnosed command-treatment - without killing the patient - so the patron-patient may, despite his continuing pains, be able to say "how right I was".

It is the number one economic paradox of this moment in history that the client designs for the architect, and the architect in turn designs without any required fundamental knowledge of the industrial world's comprehensive economics, or of engineering, or of science and its mathematical structuring progress.

The client is supposed to know his own economic fundamentals and what the client doesn't know in fundamental economics and therefore fails to include, the engineer is supposed to catch. However, the arbitrary forms the architect determines upon independent of those declared economic purposes of client and engineer often becomes the a priori, visibly schematic statement of the problem and its solution to be implemented by the engineer whether the visible scheme is technically valid or not, - for instance the validity of a fifty story building resting upon a quadrangular fence of plate glass windows, - or the validity of a marble, or stainless steel, veneer skin holding up a skyscraper's mass as the architect says to the public it is. When architects are employed, the engineer must arrange a hidden structure which in no way denies the superficial scheme inferred to exist in the architect's dream-up.

The engineer must implement the architect regardless of the enormously inefficient weights. So grotesquely inefficient have been the results of client-before-architect-before-engineer arrangements, that weights of conventional buildings have never been published or even known by the architects or their clients, or by the magazines which publish their architectural products.

Of course the engineers have had to calculate the weights of the monstrosities in order to calculate the hidden structural dimensions which will implement the falsely plausible architecture. But the engineers keep those astronomical figures to themselves. Because of the astronomically inefficient weights characterizing client-over-architect-over-engineer design authority, the buildings they undertake are structured of the most inexpensive materials. Frequently, the materials must be the leftover resources of dirt and gravel else they could not be afforded by world economics.

Only through exquisite competence of prime engineering and sequitor engineering follow-ups, may structures become so efficient as to justify their employment of the high performance limits only available in the full gamut of scarce and rare chemical structure alloyings. The utter demands of air vessel pay load efficacy under most hostile environment conditions has provided an unrelenting goad toward exquisite structural design mastery which now has broken through to establish irrevocably the epochally new aeronautical structural arts, thus escaping the otherwise utterly paralyzing inertias of the age old building ignorance.

Ask anyone who has an impressive residence what that residence weighs and he will be sure that you are joking. Ask his architect and he will hope that you are joking, for he won't know, and because engineers are not often employed in residential buildings, the architect won't even have an engineer to ask what that weight may be.

Landed buildings as occupied by men, for instance as first-class residences, weigh, as Mr. Fuller has been able to demonstrate, from three hundred to three thousand times as much as is necessary to afford the occupants security against all hostile environment actions, while at the same time affording them optimum prevailing standards of living conditions within efficiently operating economic levels. The concrete foundation for a one-family residence is often of a total cross-sectional compressive ability (per square inch of horizontal material) greater than that required for the compressive loads of the Golden Gate Bridge. This client-over-architect-over-engineer design authority and its ambiguity of responsibilities probably explains why the magazine makes the inquiry that it does.

Mr. Fuller is leading the art and science of structurally enclosing and mechanically advantaging of man out from the ignorant conditions prevailing in the age-old building craft. (The building crafts are ofttimes erroneously spoken of as the building "Industry", only because of the monstrous tonnage and dollar magnitude inefficiency which bulk up the building activity as the major category of the so-called "heavy" industries.)

Mr. Fuller has now succeeded in establishing the fact that man-occupiable structures and their mechanical services may be economically and practically realized at the presently highest attained levels of scientific technology operating within the most advanced phases of industry. These most advanced phases are those operative in the aeronautical industry which produce "frames", power plants, instruments, and controls at tolerances, inspection effectiveness, and reliability ratios of performance per units of invested resources which better the technological levels governing the design and production of automobiles ten to one "right across the board" in respect to all end-product frame, power plant, instrument and control functions.

Your present task of informing the public in relation to the 117 foot Marine Corps dome, relates to the beginnings of the third phase of Mr. Fuller's one-third century breakthrough to a true building science and industry. Stage one was Mr. Fuller's own full scale production and experimental proof of his design. This took him twenty-seven years, from 1927 to 1953. This story was completed when the Ford Motor Company as a spontaneous industrial customer of first magnitude importance underwrote Fuller's designing of class A tooling and short run mass production of components for the Ford Rotunda Geodesic Dome, and publicly announced their satisfaction with Fuller's prime design breakthrough. Stage two was that of the Marine Corps' acceptance, evaluation, and modification of Fuller's design breakthrough. This took three years. Stage three is that in which the Marine Corps formally turns over Fuller's structure to industry for both reproduction development and

reproduction acceleration. It is therefore very important that you be adequately informed by me in regard to the differences existing between present Washington Aluminum undertaking and those relating to the conventional client, architect, engineer redesigns with their builders left to figure out how on earth the complex scheme is to be realized by the conventional building crafts.

A prime comprehensive design scientist in both the industrial enterprise equation and in the common law is one who, acting on his own ideas, experiences, and initiative and subsequently operating on his own responsibility, capital and credit succeeds in going:

- beyond the idea stage

- beyond the fractional scale model and drawing stages

- beyond the full scale mockup stage

- beyond the critical stage of testing component materials and subsidiary theories involved in full scale realization of his ideas; and comprehensively satisfying every industrial logistic factor and all prevailing economic laws conceives, calculates, invents, details, fabricates (or causes to be fabricated), and assembles the foregoing complex of satisfied functions, and thereafter personally tests and allows others to test the integrated functioning of this complex association of advantages and thereby proves that new and fundamental degrees of increase of man-advantage over the a priori prevailing physical environment factors, have thus been realized by this demonstrated design complex which is economically reproducible by industry and thereafter goes:

- beyond all those stages of accomplishment and (as yet holding the initiative in all ways) succeeds in organizing and arranging the actual industrial tooling, production, assembly, and working demonstration that the industrially reproduced complex product embodies every physical and economic advantage earlier demonstrated in the hand tool and machine tool primary prototype, and goes

- beyond that and delivers an industrially soft tooled and/or partially hard tooled reproduction or reproductions of his original complex prototype design, and delivers one or more of these reproductions to spontaneously occurring customers, who in turn experiment and prove the end product, and thereafter make public announcement of their satisfactory evaluation and proof of the earlier pronounced advantages; then

- that design initiator and producer, if he as yet holds his economic and technical initiative uncompromised, is

- a Prime Designer and Prime Contractor, and

- if he so wills in his own right, he has the prime economic and moral prerogative of allocating the production and distribution of his products to those who (in his estimate) are the most efficient producers and distributors of his category of goods and services within the broad industrial network.

Mr. Fuller makes the apt distinction between crafts and industry that industry produces tools that regenerate tools - in a sequence of stepped-up magnitudes of energetic advantage of man over size, quantity, weight, velocity, heat, pressure, kinetics, and potentials; and progressively stepped-down tolerances of measurement and analysis of exactitude in respect to the inherently residual "approximation gap" of dimension and performance controls.

By the industrial step-up and step-down extension of advantage man reaches through to infra and ultra sensorial functioning of advantage in respect to the comprehensively operative energetic scheme of nature. The economic and technical gains are inherently interactive and regeneratively stimulating. The total integrated result is synergetic, that is, the whole behaves in an overall effectiveness unpredicted by any part or sub complex of parts of the subsidiary or component functions of the comprehensive integration.

Thus Mr. Fuller concludes that it is through industrialization that men attain and realize complex technical advantages which could not be produced, operated, used, or enjoyed by any one man (e.g. the Queen Mary) which technical advantages in themselves as a total integration lead irrevocably to their own regeneratively advancing performances at magnitudes ever more transcendental to the single-handed producibility, operability, and useability of any one man. (Galileo's "Accelerating Acceleration".)

Complex industrial tools and complex end products, however, may be conceived, designed, and initially engineered through to experimental proof by one individual - assisted not by other conceivers but by faithful performers of his first set of assigned cooperative tasks. Here lies the unique and enduring effectiveness of the individual in the otherwise formidably great synergetic effectiveness of the massive centralized authorities of great industrial corporations and their respective supporting hierarchies of political states.

However, the original inventor-designer-engineer-scientist cannot plead innocence to the complex of stimulating factors operating about him in the industrially evoluting environment previously created by the fabulously regenerative industrial evolution of tools conceived and produced by men that ever regenerate further to provide ever higher advantages for more people while always employing all the resources of all the world and all its histories of physical, chemical, energetic, intellectual, philosophical, psychological, and technical discoveries and experiments.

Industrialization, Mr. Fuller points out, is inherently concerned with totality and its generalized cases, whereas craft arts are inherently concerned with special cases limited by unique local factors of time, geography, resource, personality, intellect, as well as by techniques uniquely suitable for consummation by single and ofttimes unwordly individuals.

Operating within the industrial equation, Igor Sikorsky invented and designed the Sikorsky helicopter. Thousands upon thousands of engineers, scientists, designers, technicians, and business functionaries, many of them with high ranking academic degrees and notably unique personalities, have continually processed the unique Sikorsky design evolution day and night for 14 years. It would be specious and unfair to identify any one or any few of these thousands as the nameable design associates of Sikorsky - not because they are unworthy or because they have brought anything but the highest qualities to their tasks, but strictly because his was a prime designer function, and theirs sequitor functions, all of them obvious and inevitable consequences of his prime initiative.

This statement regarding Sikorsky would hold true even though the National Defense determined for a safety factor to require that Sikorsky license other manufacturers to reproduce Sikorsky's prototype. This statement would hold true even though the licensee were to make its own progressive design modifications under the Sikorsky license, even as would the Sikorsky Company itself proceed with its own design modifications independent of the licensee.

All who saw the NEW YORK TIMES, June 26, 1956, front page photograph of a fleet of Russian Soviet Helicopters hovering in maneuvers staged for U.S. Air Force General Twining recognized that those USSR helicopters were unlicensed "Sikorskys" even though they had been magnified in their lifting capacity and other dimensions. Those helicopters were strictly designed by Igor Sikorsky in the prime designer sense. It was paradoxical that Sikorsky despite that he was Russia's first pilot, had found it imperative to his own survival that he leave Russia at the time of the 1917 Revolution, and that the U.S.S.R. should now be reproducing his helicopter without his permission and as a military threat to his haven land, the haven land at this moment of individual initiative itself.

Sikorsky as a prime helicopter designer has not, however, preempted the helicopter design field any more than did Santos Dumond preempt the general airship design evolution by building his little motorized and directable gas-filled cigar skin, and flying it around the Eiffel Tower.

Hiller invented, designed, built, tested his own unique helicopter and his work has been refined by thousands of the secondary, tertiary, et al phases. So did Piasecki. So did Kamman. So did Bell. Each and every one of these prime designed helicopters can be recognized at a mile's distance by any air-minded kid. It is this recognizability even at a distance that so cleanly and comprehensively certifies the integrity of the prime designer's breakthrough initiative and irradicability as a prime regenerative function of history.

Igor Sikorsky spent forty years at his aeronautical science and art and survived despite all manner of hardships, economical, psychological, and physical, before he gave his helicopter to the world as uniquely designed and flight proven by himself.

The Geodesic structure, recognizable at a distance by any kid, whether being transported through the sky or fixed to the land, is the product of forty years of forward battling by Mr. Fuller - not just to design a structure and its organic complex of services, but to design a whole new industry, just as Ford or Don Douglas had to design whole new industries to make their products economically available and useable by mankind.

The unique logistic effectiveness of the superficially simple Geodesic flowering grew out of a third of a century of expensive development and experimentation by Mr. Fuller. The spherical Geodesic structure is a design specie embodying in evolutionary essence the inventing, developing, and experimenting integration of his whole life.

Throughout two score years several thousand students, friends, and employed engineering and technical assistants, have all been involved in his important structural, mechanical, instrumental, mathematical, and economic initiatives. His eventual integration of the high priority science and research technology with the high speed generalized industrial equation, and his application of this integrated complex advantage to the comprehensive production and distribution of his scientific environment controls for the increasing advantage of man over his landed needs, would have been impossible without that full gamut of student and associate sequitor initiatives, cooperations, re-stimulations, and experiments.

Mr. Fuller has probably experienced the same intensity of cooperative and ofttimes dedicated associations of engineering and design assistance as have Igor Sikorsky, Glenn Martin, and other prime designers. He has experienced over and again all manner of economic, psychologic, and physical frustrations, as well as prolonged hardships. He has consistently invested all his resources, economic, intellectual, physical toward the earliest effective and uncompromised establishment of his specific new industry and its resultant high advantage environment controlling for man.

During this time Mr. Fuller has probably experienced the same small but painful percentage of super intense personality affiliations, repressed egos (seeking "mother - acclaim" et al) as have all the other pioneers. Often these are exceedingly clever and deft "fans" who are drawn to the pioneers because of the new vistas opened, wherein the unstable ego visualizes the dramatic quality of the pioneering inventions only as they relate to their ego's excitation in utter disregard of the authorship of the inventions and all that has gone before.

These "fans" see only the dramatic quality of the invention as it may be locally exploited for self-aggrandizement amongst their respective uninitiated personal communities. There is always an unfortunate percentage of these fanatics amongst the early joiners of the prime designer camps. They are part of the vicissitudes of the prime designer, and often force the prime designer to adopt an effectiveness in dealing with them that constitutes a fundamental discipline which once adopted stands the prime designer in important advantage in all manner of other circumstances involving broader aspects of the generalized case.

The answer to the question posed to you by the magazine, as you must thoroughly have anticipated by now is - No!

Mr. Donald, of Washington Aluminum Company, discussed with me on the telephone last week the fact that Mr. Fuller will be at the School of Fine Arts, Southern Illinois University, from July 9 through August 8. However, if Mr. Fuller is given proper advance notice, he will fly to Baltimore on whatever weekend is most convenient to Washington Aluminum Company.

Although I am about to leave on a trip to Afghanistan in company with the 100 foot Geodesic dome mentioned at the outset of this letter, I have arranged that a copy be sent to you within two weeks of a letter written by Mr. Fuller to Major King, which includes several items of direct interest to you in connection with Geodesic structures, the Marine Corps, the New Industry, and their associated relationship to the larger world picture. All these latter items might be of direct assistance in your development of unique and newsworthy aspects of your project.

Should you need to get in touch directly with an authority in regard to Geodesic matters, Mr. William Man Parkhurst, Geodesics' corporation attorney, will be glad to see that you are routed to the information you need on an authoritative basis and in a hurry. His address is 42 Broadway, New York 4, N. Y., telephone DIgby 4-5387.

We will greatly appreciate your kindness if you will send us page clipping of whatever news may appear regarding the 117 foot Geodesic Marine Corps hangar. We have heard that several items already have been published, but we have not seen them. We rely greatly upon our friends to assist us in our documentation.

Although I will be gone during the next couple of months or so, I'm sure that we'll be meeting one of these days, and then it will be your turn to "lecture" me about one of your favorite topics. So until that meeting I'll sign off with a warm summer adieu.

Faithfully yours,

John Dixon
Assistant to Buckminster Fuller

JD: dmc