World Game Series: Document One

THE WORLD GAME: INTEGRATIVE RESOURCE UTILIZATION PLANNING TOOL

By R. Buckminster Fuller

World Resources Inventory
Southern Illinois University
Carbondale, Illinois 62901
U.S.A.

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Research: Neil Hansen, Mark V. Hansen, Michael Paterra, Max Ackerman, Medard Gabel, Ed Hauben, Ray Frenchman, Michael Ben-Eli, Bruce Ashley, Larry Jasud, Duncan Mitchell, Brendan O'Regan, Stephen Short

Graphics: Hollis Denn, Betsy Aspell

Secretarial Supervision. Naomi Wallace, Joan Eubanks

Senior Administrative Assistant: Dale D. Klaus

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LIST OF CHARTS, TABLES AND MAPS

PREFACE

Shakespeare, the consummate artist of the English language, appeared in the history of humanity just as evolution was achieving a differentiation in language, metaphor and visual display that stressed for a convergence, for an integration, in some kind of production Never before and never since has the time been as ripe as was Elizabethan England for a union of art and technology on the stage

Newton, Darwin and Einstein were similar playwrights of human evolution's converging metaphor-civilization. Each of these men powerfully integrated a coherent scenario they perceived as acted out by Nature. Each showed man's unique role as a contributor to the cast of this scenario by their own example, as a designer, of reducing the disorder in mankind's perceptian of the operations and events of its environment, its life support system, its Spaceship

Each of these men evolved a powerful script around which a cast of people gathered to test out the new metaphor, to enlarge upon it, if possible, and to ultimately form a production ensemble of gigantic proportions to achieve a new science of action in testing out the script. That is what a metaphor can do when it is powerful enough and when it is successfully delineated by the consummate artist of his era-that is what Buckminster Fuller has done with the design of his World Game.

Providence has provided a most sincere and enthusiastic cast of young people (in mind and heart) to test out the script's relevancy, to elaborate upon it when they can, and to further delineate its fine points. They have walked inside the metaphor and found it the answer to many of their most deep-felt concerns about their quality of life on Spaceship Earth. They bring away with them the firm conviction that the World could be made to work for everyone and this without humanity exacting the price of push-pull politics

Each World Game Workshop and/or Seminar achieves this optimum outlook on man's environment and life within his biosphere. Yet, the World Game has not yet, in truth, been played; for to play it one needs the computer tools, which are not yet commercially available, and the logic to ask the right questions. The energetic/synergetic geometry encourages such methodological ferment, but only Fuller has been able thus far to personalize and innovatively utilize the advantages accruing to applications of this kind of logic. The total accurate earth resources data, which the earth resources satellites promise to deliver, in fact still relies on individual, long-hand study through heavy tomes of statistics. Until all of this is facilitated by a fairly expensive physical facility and staff, the World Game is not played-it is merely acted-out by alert students who wish to demonstrate for themselves the relevancy of the metaphor

The student's enthusiasm each time reiterates again the timeliness of this new outlook. Nature does not deploy her resources haphazardly-neither physical, natural or human. There is a rationale which makes actors out of all of us in this huge scenario that we call "Universe."

In 1967, NASA announced a full-scale emphasis on earth resources survey via remote sensing planes and satellites, and at the same time, the international "weather watch" gained momentum. Of a sudden, engineers, geologists, geographers, physicists, foresters, agriculturalists, etc., became interested in the possibilities of total world surveys and of the value such surveys might have to world resource utilization. The sudden zoom from local considerations of resources development and deployment to possible world-wide involvement of such studies necessitated a new script, a new metaphor, a new style in thinking about the problem. In order to do so, a powerful interdisciplinary communication device was needed-one that essentially did away with the necessity of its being adapted to the special languages and instrumentation of a specific science. It must allow the maximum amount of "good thinking" (flow) and dialog about resource deployment and utilization. This communication device was Fuller's "World Game."

Beginning in May, 1968, the "World Game" was presented by Dr. Fuller to a White House sponsored conference, convened for this purpose, in Washington, D.C.; to the Muskie Committee to establish a select Senate Committee on Technology and the Human environment in March, 1969; to the Joint National Meeting of the American Astronautical Society and the Operations Research Society of America in June, 1969; and to the U.N. Conference on Human Survival in May, 1970. Originally proposed as the core curriculum at the new Edwardsville Campus of S.I.U., in 1961 (see "Education Automation" by R. B. Fuller, S.I.U. Press, 1962) and then as the theme for the U.S. Pavilion at Montreal's Expo '67 in 1964, it now became the main tool in the design of an environment for planning where good thinking about Spaceship Earth could prosper in a larger context than it had been able to in immediate, previous eras. This is the occasion for the printing of Document One to the World Game series. The World Game is presented here as the proposed tool to communicate design science, now extended to the total world environment, in order to "Make the World Work" It is dedicated to those whose vision and courage it inspires and educates to this most noble objective.

Thomas Broussard Turner
Director, Fuller Projects, SIU
January, 197 1

OTHER VOLUMES IN THE WORLD RESOURCES INVENTORY
(World Design Science Decade)

Phase I	(1963) Document 1:	Inventory of World Resources Human Trends and Needs by R. Buckrninster Fuller and John McHale
Phase I	(1964) Document 2:	The Design Initiative by R. Buckminster Fuller
Phase I	(1965) Document 3 :	Comprehensive Thinking by R. Buckminster Fuller
Phase I	(1965) Document 4:	The Ten Year Program by R. Buckminster Fuller and John McHale
Phase II	(1967) Document 5:	Comprehensive Design Strategy by R. Buckminster Fuller

(discontinued-published as "Utopia or Oblivion " by Bantam Books, $1.25)

Phase II	(1967) Document 6:	The Ecological Context. Energy and Materials by John McHale

(discontinued-published as "The Ecological Context" by George Braziller Books, $7.95)

DISTRIBUTION OF THE *WORLD DESIGN SCIENCE DECADE DOCUMENTS* WILL BE DISCONTINUED AFTER PRESENT SUPPLY IS EXHAUSTED.

World Resources Inventory
Southern Illinois University
Carbondale, Illinois
U.S.A.

A. WORLD GAME SCENARIO

A.1 Preamble and Memorandum to those interested in playing World Game

Preamble

All those who have attained high scholarly capability assure us that real education is self-education. They also say that this self-disciplining is most often inspired by great teachers who make it seem apparent that it will be excitingly worthwhile to take the trouble to bring one self to apprehend and then comprehend variously pertinent data, phenomena and derived principles. The intimate manuscript records of many great self-educated individuals show that they discern intuitively when and what it is that they want to learn. Thereafter they arrange to do so by four main strategies. The first is by self-conducted experiments, if they are scientists. The second is by going to those live humans who have educated themselves from direct experiences. The third is to contact through books those who have discovered and learned by direct experience but are now dead. Fourthly, they sometimes have recourse to the esoteric and often exquisitely valuable information contained within the word of mouth information system relayed almost exclusively from generation to generation by the directly experienced craftsmen artists.

I am certain that none of the world's problems-which we are all perforce thinking about today-have any hope of solution except through all of world around society's individuals becoming thoroughly and comprehensively self-educated. Only thereby will society be able to identify, and inter-communicate the vital problems of total world society. Only thereafter may humanity effectively sort out and put those problems into order of importance for solution in respect to the most fundamental principles governing man's survival and enjoyment of life on Earth.

Memorandum

To: All those inquiring about or concerned with the World Game
From: R. Buckminster Fuller

We are grateful for your interest in the activity which I have developed and identify as The World Game. I have described this branch of my work in considerable detail in several instances. My World Game testimony before the United States Senate's Subcommittee "On The Next Fifty Years" was recorded in the Congressional Record

The published reactions to my World Game have been favorable, but demonstrably confused. As with all such "news" events, some accounts are accurate but inadequate, some are inaccurate, and a very few are

excellent. The articles stress the potentially favorable results to be had, but fail to clarify the scientific process by which they may be arrived at

. As a consequence of the publicity, a very large amount of inquiry is coming to this office asking for details about The World Game. In many instances, individuals ask to be allowed to carry on World Game seminars in their geographical or scholastic areas

In view of the foregoing, I find it necessary to state that The World Game is a precisely defined design science process for arriving at economic, technological and social insights pertinent to humanity's future envolvement aboard our planet Earth The processes consist of mathematical procedures not only as incisive and complex as those involved in celestial navigation, or astro-ballistics, or the space program, but even more so-for, in addition to all the variables common to those sciences and The World Game, the latter involves also all the variables governing the planning of the 25-year programs of the industrialization of both Russia and China

When the Russians' five-year-stepped, 25-year plan was instituted, the Communist party's leaders were dealing with 150 million illiterate, impoverished, non-communist party people. Dealing with 750 million people makes China's problem much more complex. As compared to China's problem, the relatively greater complexity of The World Game ratio of China's 750 million people to the world's five billion human beings of 1985, for that is the probable number of world inhabitants fifteen years hence. That is to say The World Game is seven times more complex than China's quarter century industrialization and thirty-five times more complex than was Russia's industrialization problem. The World Game must find the specific means of making five billion humans a total economic and physical success at the *earliest possible moment without anyone being advantaged at the expense of another.*

The World Game deals in all the terrestrially available quantities of the 92 regenerative chemical elements and all of their isotopes. It deals with all that man has learned in all history regarding the generalized principles operative in the physical universe and all the vast ramifications of technology, industrialization, the behavioral sciences, ecology, *et al.*

The World Game is as meticulously geared to priority scheduling of "first things first" as is the gestation of a human being, or as is the gestation of any of the most scientifically implemented procedures of humanity's sometimes vast undertakings, such as world wars or moon landings

Unfortunately, in the past, man has applied his vast resources and his most incisive capabilities only to the waging of great wars-, or in preparation for such warring-the space programs having been undertaken by all nations strictly on the basis of the wartime advantages to be gained by ski-spying and astro-ballistics

The great 25-year industrialization struggles of Russia and China could only be held socially and ideologically together through the paramount working assumption of an ultimate show of arms with the rest of the world. The common assumption of ultimate war by the major political powers of our planet brought about the development of *World WAR Gaming Science* by the great powers' respective military strategists. World War Gaming Science involved all terrestrial resources. My *World PEACE Gaming Science* changes the basic assumption of fundamental inadequacy of total life support and applies total capability toward the success of all humans

While all the foregoing seems far too formidable to be coped with by an individual or cooperative groups of individuals, operating entirely outside the great national sovereignty establishments I was able, in 1927, to realize that these great capabilities could be mounted to all humanity's advantage if adequate economic support were mustered. What struck me profoundly at that time was that man's greatest productive and scientifically informed capability was being focused only on war simply because all the major governments in the world were convinced that Earth could not sustain the lives of the many humans that were born on the planet and, in fact, could sustain but a minority.

The great sovereign powers' world struggle game was that of "musical chairs" to decide, by warfaring at its ever most modernly lethal, who would be the fortunate ones to survive. But my 1927 thoughts were inspired by my 1917 observation of the first faint dawning streaks of technological information, which indicated ever-increasing capability to accomplish ever greater and more incisive tasks with ever less weight

of material, kilowatts of energy and minimum of time per each given accomplishment-while all the energy of universe-associative as matter and disassociative as radiation intertransformed without loss and the human intellect's "knowhow" continually increased.

This technological dawning, was first manifest in the swift increase of the horsepower of airplane engines, accomplished with ever less pounds of material per horsepower and in the wireless radio communications across oceans displacing the earlier vast tonnages of cable Malthus could not foresee that refrigeration and hermetic packing would hold foods in good condition for indefinitely prolonged periods, which foods in his time often rotted in the fields because there were not enough local consumers, and would perish before reaching the masses who dwelt at too great a distance thereby to be sustained Starting in 1917 the visibility of hundreds of such indicators urged me to inquire and preoccupy myself with research studies which might disclose whether the trending to do more with less could make possible the employment of the total resources of planet Earth in such a manner as to be able to support all of humanity at a sustainable level superior to any heretofore experienced or dreamt of by even the most successful of humanity's of the past or present. If this could be done, how long did my studies indicate it would take? By what series of design science strategies and steps was I able to discern that this total success for all humanity was feasible and chronologically predictable?

This self questioning, answered by experimentally disclosed data, was the beginning of what today I call The World Game. My 1927 studies did discover the feasibility of high standard and continuable sustenance of all humanity. They did disclose that unprecedented design science strategies could bring about such results Those involved in the 25-year industrial plannings of the Russian and Chinese programs have retrospectively found my World Game disclosures of 1927 to be widely congruent with the priorities, design science techniques and stages of development that emerged as essential in their experience

For all the foregoing reasons, it is important that any who are seriously interested in my World Game read with care exactly what it is that I have disclosed as evolving, and much that I have written about my disciplines in so doing

By 1927, at the age of 32, I had inadvertently acquired a widely variegated background of technological, scientific, U.S. Naval, construction, management, and economic experience which spontaneously and synergetically produced my philosophy which assumed that experience taught that all physical behavior problems of humanity could be solved best, most expeditiously and lastingly by competent rearrangement of the physical constituents of the environment and in such a manner as to induce human behaviors which, in turn, would be productive of overall and local advantage for all of humanity.

I had a powerful experience in primitive living on a small island located ten miles offshore in the State of Maine I was a proficient sailor, woodsman and technical device improvisor

I had been well-schooled in physics, mathematics, biology, having entered Harvard from Milton Academy with top honors in those subjects, and good grades in languages, history, ***et al.*** I had been captain of five successive small U.S. Navy craft, had completed a special course at the U.S. Naval Academy at Annapolis, had been a Watch Officer on large troop transports of World War One, and had been confirmed as a Lieutenant with number in the "Line" of regular U.S. Naval Officers. I had been personal Aide to the U.S. Admiral commanding the World War One overseas transports and personal Aide to the Commander of the U.S. Asiatic Fleet. I had become Assistant Export Manager of Armour and Company, the great packing house which produced basic foods and distributed them around the world. I had been national Account Sales Manager for one of the five leading U.S. truck manufacturers. I had organized six companies and built and equipped five factories in five states to produce the materials with which I built two hundred and forty structures ranging from factories to residences

When I invented and inaugurated World Peace Game playing and comprehensive anticipatory design science I had been married ten years (my wife and I celebrated our fifty-third wedding anniversary in 1970). On our tenth wedding anniversary we had experienced the infinite anguish of having our first child afflicted with the then "incurable" infantile paralysis, spinal menengitis. She died at the age of four after our three-year struggle to save her, all the while living under the conditions imposed by a weekly salary of fifty dollars. Two trained nurses took all the salary and this led me into deep debt. Five years after our first

child's death, our second child was born in 1927 just as all of my attempted production and building enterprises had been maneuvered by others "out from under" my economic control. Immersed in these environmental conditions and with no further economic support available from any other human beings, I undertook to do what I have described in this two-hundred word, unpunctuated sentence which, forty years later, was published by the Saturday Review:

What I Am Trying to Do

"Acutely aware of our beings' limitations and acknowledging the infinite mystery of the a priori universe into which we are born but nevertheless searching for a conscious means of hopefuily competent participation by humanity in its own evolutionary trending while employing only the unique advantages inhering exclusively to. the individual who takes and maintains the economic initiative in the face of the formidable physical capital and credit advantages of the massive corporations and political states and deliberately avoiding political ties and tactics while endeavoring by experiments and explorations to excite individuals' awareness and realization of humanity's higher potentials I seek through comprehensive anticipatory design science and its reductions to physical practices to reform the environment instead of trying to reform men being intent thereby to accomplish proto-typed capabilities of doing more with less whereby in turn the wealth augmenting prospects of such design science regenerations will induce their spontaneous and economically successful industrial proliferation by world around services' managements all of which chain reaction provoking events will both permit and induce all humanity to realize full lasting economic and physical success plus enjoyment of all the Earth without one individual interfering with or being advantaged at the expense of another "

It was my deeply and personally experienced familiarity with World War gaming, as played by the United States Navy and with large scale operations such as the handling of the fleet of 130 large ships which transported one million men over and back across the Atlantic Ocean, and with the Asiatic Fleet operations and world around food distribution management, broad building experience and factory operation that taught me of the necessity to do whatever you do with as greatly combined hindsight and foresight as humanity progressively may muster. I had learned the futility of "hot air" sessions and on the general public's ignorance of the essentiallity of *intuition, competence* and integrity-the three biggest words in my vocabulary

Since that 1927 period of self-examination, resolve and evolvement of a philosophy, 1 have reduced many problems solutions to practice and my many problems solutions to practice and my many reductions have come into the everyday environmental use of people all around our planet Earth.

All those who are inspired to look into The World Game must swiftly learn to realize that without such experience, self-examination, conceptual enlightenment, and highest resolve, my World Peace Gaming Science may not be entered into with any humanity-benefitting effectiveness

All who intuitively feel the urge to participate competently in it should first read all of my books in which my philosophy, my experience and self-disciplining strategies are clearly disclosed

A list of these books and related magazine articles, an excellent glossary of my personal disciplines, philosophy and techniques, has been prepared in my office and can be obtained upon written application

In 1969 I was asked if I would be willing to make a moving picture documentation covering the many technologic and philosophic facets of The World Game. Feeling it timely to multiply the number of individuals who might share my knowledge of the research disclosed, feasibility of attaining all of humanity's physical and economic success, and assuming that the documentary film medium and its eventual televised ability constituted the best means of such literacy and hitherto unenvisioned success, I agreed to make such a documentary film. It was my intuitive assumption that the most effective means for producing such a document would be by the filming of my disclosing to university students who chose to convene with me what the ramifications of my strategy of World Gaming consisted, and thereafter leading them in the design science implementation to a meager but sufficient degree for the students as a group to confirm my major data regarding world resources, human trends and needs, and thereafter employing my

"first things first" priority scheduling of design science formulations to explore both by numerical and graphic mathematics, whether the design science innovations were comprehensively tolerable to terrestrial man and what the magnitude of comprehensive advantage for humanity would be if they were instituted; also what the many side-effects would be of each design science move

This documentation was first instituted at Yale University. Finding the term time and other requisites too limited, a group of applicants from 26 universities and 16 disciplines were chosen from a nationwide influx of applicants who were convened in a workshop in New York City during the summer of 1969.

Fifty hours of documentary film footage were recorded, this being the minimum amount of time within which I was able to inform and instruct the students in sufficient degree so that they might experiment in organizing themselves into the first stage of simulated exploration of my design science strategy in World Peace Gaming. The 26 students verified my general World Resource Data through the United Nations and other World Planning authorities situated in New York and made enough simulated explorations of my design science strategy (in my order of priority of "first things first") to realize individually by personal experience that they, too, were suddenly realistically envisioning that all of humanity could become not only physically and economically successful, but that this could be accomplished within decades

Never again would they believe or disbelieve something somebody else had told them; they would henceforth start from experimentally disclosed data-no more axioms! It was as if they had come from a vast desert of ignorance and thirsty for knowledge had come upon a body of potable water sufficient to sustain all human life

The repercussions of the publishing of the World Game findings has tended to mislead many people into the feeling that they could undertake to play it without any special experience or preparation. A number of such hopefully initiated "World Game Seminars" have made it clear that individuals not properly led by myself soon become aware of their own inadequacy of experience and thought and become deeply and completely involved in self-examination with all its truthful and comprehensive thinking.

Such group preoccupations in self-examination someday could lead some of those individuals to gain the experience and knowledge which would qualify them to participate in the design science complexities of World Game.

Because many of these important excursions into self-examination were undertaken with the purpose of trying to play World Game, their detours were improperly identified as World Game. Because World Gaming does have high potentials for humanity, and does tend to stimulate interest and enthusiasm of increasing import that any activity which is not World Game as specifically defined by me should not be labelled World Game. Such activities may be appropriately identified as World Game Philosophy Seminars.

I invented the name World Game to identify my 43-year-long developed comprehensive anticipatory design science exploration. I have applied for copyright and trademarking of the name. Henceforth, the only activity to be identified as World Game is that which I have described in the earlier mentioned Congressional Record

The Southern Illinois University Edwardsville campus installation is not yet funded. The University may go forward with buildings to house the activities on the basis that the wired integration of the many university computers may obviate the need for an additional computer at S.I.U.'s Edwardsville campus. There is only the need for proper housing of the design science moves and their consequences

The use of accelerating and decelerating moving picture film to bring into human cognition those trends and processes which, at present, are nondirectly apprehendable by humans, as well as my world map to display the computer comprehensively processed data are all outlined in my Senate testimony

Several of the students who participated in my 1969 World Game documentary film-making have become so enthusiastic as to commit themselves to illumination of others regarding the human potentials they now envisage. On their own initiative, they have become proliferators of popular awareness of feasible hopes for humanity which had not previously existed. Far from wishing to dull this spontaneous enthusiasm, I admire extraordinarily the initiative of those individuals. I realize, however, that vast public misapprehension of what the World Gaming consists may have deleterious effects. I, therefore, wish to

exercise whatever credit my fellow humans may accord me by asking that all concerned make it clear that the full implementation of World Gaming, as I envisage it, has not yet occurred. I also ask that only those activities which I identify in writing as World Gaming be so identified to the public. To those who have been my students, who are attempting to follow my strategies meticulously in initiating studies outside of my direct work, I suggest that they identify their activity as inquiry into the strategies which I employ, but avoid professing that they are engaged in World Gaming

To those who have studied my:

(A) ***Priorities of the Design Decade (1962); Universal Requirements of a Dwellable Environment*** (1928), or,

(B) My series of developments of a means for conceiving the integrated significance of the ***Conning Tower*** (1932), the *Mini Earth* (1951), the *Geoscope* (1959); or,

(C) My series of Sky Ocean World Map projections as first published in 1938 in "Nine Chains to the Moon," and then in LIFE Magazine in March, 1943, which I attained as a topological transformation of the spherical Earth's surface data displayed as a World Map on a plane surface without visible distortion of either the proportionate size or relative shape of any of the data, while also avoiding any breaks in any of the continental peripheries, while projection altogether provides a non-distorted total world background upon which to show the disposition of the relative percentages of resources per capita and where they exist (either in mines or in recoverable scrap) in relation to where the various percentages of all humanity exist; or,

(D) My series of world economic charts developed progressively since 1927, as they appear in my "Nine Chains to the Moon (of 1938) or in my Fortune Magazine's tenth anniversary issue of Feb., 1940, or in my Six Volume Series of publications of "The Inventory of World Resources, Human Trends and Needs," 1951-1970,

It is comprehendable that the communications aspect of my work can be vastly augmented by the use of computers and by the use of television, video and the miniturizing trend of cassettes of video communication. It is also clear that millions of people and multi-billions of dollars are at work in developing just such equipment, personnel and know-how, all of which will swiftly catapult the World Game's results into the most important spot news of our next quarter century. Therefore nothing needs to be done, other than responsive servicing by my associates, students, spontaneous colleagues and myself to keep this aspect of World Game evolution in high gear

While a special computer of unique capability would have been of great advantage yesterday to my World Game work,-today the wired integration of the leading universities' computer facilities provides tie-in capability to an ever more effective total machine to accommodate the World Game at any one headquarter's locale

What is ***not clear*** to 90% of those enthused over our insights-regarding total humanity's potential success,-which "long hand" World Gaming over the last forty-three years without a computer has empowered me to select the most effective scheduling of my time, thought and actions and make many multi-decade ahead predictions-now "come true,"-IS THAT THE WHOLE STRATEGY OF WORLD GAMING IS ACCOMPLISHED BY SIMULATED EMPLOYMENT OF MY COMPREHENSIVE, ANTICIPATORY DESIGN SCIENCE WHICH ALONE HAS SHOWN ME HOW TO PROGRESSIVELY ALTER THE FUNDAMENTAL CONDITIONS UNDER WHICH HUMANITY EXISTS AND TO DO SO BY FEASIBLE AND LOGICAL MEANS.

Fall, 1970

A.2 R. Buckminster Fuller's Presentation to U.S. Congressional Sub-Committee on World Game

TESTIMONY OF R. BUCKMINSTER FULLER BEFORE THE SENATE SUB-COMMITTEE
MARCH 4, 1969 . . . . . .

reprinted from the *CONGRESSIONAL RECORD:* ADDRESS BY
R. BUCKMINSTER FULLER TO THE NAVY LEAGUE OCEANIC-MARITIME
SYMPOSIUM, FEBRUARY 17, 1970
MAY 15, 1970 . . . . . .

reprinted from the *CONGRESSIONAL RECORD:* ADDRESS BY
MR. MELVIN PRICE OF ILLINOIS ON THE WORLD RESOURCES SIMULATION
CENTER PROPOSED IN ILLINOIS
MAY 21, 1970 . . . . . .

TO ESTABLISH A SELECT SENATE COMMITTEE ON TECHNOLOGY AND THE HUMAN ENVIRONMENT

HEARINGS
BEFORE THE
SUBCOMMITTEE ON INTERGOVERNMENTAL RELATIONS
OF THE
COMMITTEE ON GOVERNMENT OPERATIONS
UNITED STATES SENATE
NINETY-FIRST CONGRESS
FIRST SESSION
ON

S. Res. 78

TO ESTABLISH A SELECT SENATE COMMITTEE ON TECHNOLOGY AND THE HUMAN ENVIRONMENT

MARCH 4, 5, AND 6, APRIL 24, AND MAY 7, 1969

Printed for the use of the Committee on Government Operations

Statement of R. Buckminster Fuller, Research Professor
Southern Illinois University, Carbondale, III.

Mr. Fuller. I will describe quickly the World Game It is an organization of computer capability to deal prognosticatingly with world problems. It is played with the information contained in the six volumes entitled, "Inventory of World Resources, Human Trends and Needs," compiled and published by my office at Southern Illinois University. Game theory, as outlined by the late Princeton Professor, John Von Neuman, is employed by all the powerful nations today in their computerized reconnoitering in scientific anticipation of hypothetical world wars III, IV, and V. The joint chiefs of staff of all the major power states of the world play their "World War Games" on the working assumption of the validity of Thomas Malthus' 1810 dictum that there is not enough human sustenance aboard our planet to support all its people; that the people reproduce themselves at a geometrical rate, and their support resources only at an arithmetical progression rate. And the major states compound Malthus' assumedly fundamental inadequacy of life support concept with Darwin's dictum of survival only of the fittest; wherefore all the world's military and political establishments assume eventual Armageddon. The Von Neuman concept of variable factors and lethal dueling options is governed by the mathematics of game theory. It is nicknamed "drop dead" or "sum-zero " In playing their war games, military establishments consider themselves apolitical They assume that it is the contradictory political ambitions arising from fundamental resource inadequacy which cause wars and that when the opposing political systems break into full-scale conflagration of war the military establishments are brought in as fire departments to put the war fire out-but "out" exclusively in favor of their respective sides-wherefore under war conditions the military themselves will use political as well as physical means for resolving the war in their respectively preferred ways

Having been an officer in the Regular U.S. Navy during and following World War I, 1 became conversant with comprehensive world strategies, as well as with world war gaming theory and general systems theory. Reviewing such world war gaming thoughts in 1927, I discovered that if we assumed that no tactical blunders were made on either side, then the critical win or lose factor lay specifically in the design of ships of the sea and ships of the air and that the ship which could produce the greatest hitting power and deliver it most promptly the greatest distance in the least time, with the greatest accuracy and the least effort for each pound of material, kilowatt of energy, and minute of resources invested in the ship, its dueling equipment, supplies, and operational routines would always be the ship that **stayed on** top of the ocean; the other ship went in to the sea's bottom

This leads me to discover that experience showed that there are always many more variable factors to be controlled in firing from a steerable ship moving swiftly upon a heaving sea toward another steerable ship speeding upon a heaving sea than enter into the problem of firing from a fixed dry land position toward another fixed position on the same dry land. In fact, all the variables of the known physical universe enter into the art and science of naval logistics and ballistics Men on land could lock and shutter massively their stone-built houses windows and doors at the coming of night's darkness and discontinue any external considerations until morning. But men on the sea could not shut off their ships plunging onward in the darkness nor discontinue any of the formidable, external-environment conditions nor the internal conditions of their stomachs and nervous systems as their whole organism responded to the ship's response to the mighty turbulence at the interface of the frequently opposed sky-ocean's and water-ocean's wave-size, frequency, and directional complexities of patterning all of which if not competently and constantly coped with by both the ships' masters and their crews would result in the floundering of the ship and perishing of its human complement.

As a consequence, human life at sea has always been a 24-hour, year-in-year-out concern whereas life on land has been a 12-hour-per-day, seasonally varied preoccupation of less than one-third of man's total time and vital thought-provoking concern. At sea there are no holidays and on land there are not only weekly days off but many church, national, and family days off. At sea the physical experiences accumulate and integrate at a rate and severity magnitude which challenge and induce anticipatory design

invention and calculation stratagems which multiply manifold more powerfully and rapidly than do they transpire in the affairs of man living on the dry land. Mathematics, navigation, and design science engineering, as well as metorology, and geography all had their beginnings at sea. Because 99 percent of humanity lives normally upon the dry land, the logic of its economic thinking lacks spontaneously some of the critical variables of the universe which, however, perforce of fundamentals had to be scientifically incorporated in all man's effective coping with world-ocean and sky-ocean undertakings Ergo, "war games" as played theoretically by Navy admirals are inherently generalized systems games, whereas those war games played by Army generals are inherently special case or limited systems games

For instance, on the land the general's fort or dugout does not have to float-the heavier, thicker, higher, deeper, and wider its inert walls the more secure does the army feel. The navy is an approximately defenseless operation; effectively armored ships were proven to be an impossibility with the advent of air power. Navies are fundamentally offensive. After only a few minutes of "contact" of its principal ships of the sea and sky, the war is all over and who is to run the world for the next decade is clearly established. Armies dig in and fortify for interminable time. The army's and navy's grand strategies are diametric concepts

So in the sea and the air stratagems, we discover the historically most secretly classified capability to win that has never been considered by economic man in his dryland deliberations. That world conquest winning factor is the one of doing more with less. To make that clear, we witness that between the 1919 end of World War I and 1929, two divergent histories in horsepower per pound of the reciprocating engines of the automobile and the airplane transpire. The automobile engine weighed about 7 pounds per horsepower throughout that decade. During that same period the airplane engine went from 7 pounds to less than 1 pound per horsepower while gaining manifold in reliability and without consuming more fuel per horsepower. That demonstrated that our resources could really be stretched to do much more with much less of everything

In today's economic books there is not one sentence about doing more with less. Everyone knows what ships and airplanes weigh-the Queen Mary 85,000 tons but not even the architects, let alone the public at large, know what any of our land buildings weigh. Weight is not in the language of land architecture; not even within 100,000 ton approximations. If you don't know what buildings weigh then you are not thinking in terms of performance per pound let alone of more performance per each pound to be accomplished by the incorporation of this and that newly and scientifically discovered physical principle.

Because manifold larger cargoes can be carried by ships of the sea than by any land creatures or vehicles, and because three-quarters of our planet is covered by water, and because all the lands of the planet are touched by the world ocean, and because the ocean waters are physically open to all; up to World War II when sky-ocean vehicles began to tip the world-control scales, whoever held physical command of the world water ocean commanded the political economic patterning of our entire planet earth And how the control was attained and maintained was the world's most closely guarded secret Thus: navies in contradistinction to land-based armies are inherently concerned with the whole world. Navy war games pay no attention to sovereign borders. There is no sovereign law at sea save of the sea's single sovereign

Double the length of your ship and you increase her hull's friction and drag surface by four but you increase your volume of payload by eight and the longer the ship of given design the faster she goes. Chrome-nickel steel won't rust and is six times as strong as rustible mild steel of the same weight and dimensioning

A very important example today of the doing-more-with-less principle of the sea and sky craft evolution would be the 1¼-ton communications satellite which is now outperforming the transoceanic communication capability of 175,000 tons of copper cable. Such 700,000-fold increases in performance per units of invested resources are the kinds of magnitudes which, historically speaking, can be accomplished almost overnight. In 1927 I gave the name ephemeralization to the design science strategy of "doing ever-more with ever less." Because of all the foregoing realizations I saw in 1927 that it might be possible that

we could do so much more with so much less that we could not only discredit the Malthusian dictum but also, and far more importantly, that we might be able to take care of everybody aboard our planet earth with a very much higher standard of living than anybody has ever known or dreamed of experiencing

I next saw that if that could be done then, the theory of John von Neuman's war gaming, which holds that ultimately one side or the other must die, either by war or starvation, is invalid. Therefore, I saw that we had a heretofore unconsidered alternative way to play the world game in which as with mountain climbing, the object would be to find all the moves by which the whole field of climbers would win as each helped the other so that everybody successfully reached the mountaintop and all returned safely to its base This is a mathematically permitted alternative of game playing but it has never been played in any of the war games of the great nations of the earth. To humanity's general scientific illiteracy, it has been inconceivable that there are invisible chemical and physical principles such as that of the transistor lurking invisibly in the landscape waiting for men to discover them, and thereby also to discover that by doing more with less there could be more than enough to support all humanity at a higher standard of living than any humans have as yet known whereby realization of lasting peace might occur around our planet for the first time. But that is what science has discovered in the last few decades to be possible. But science also finds that such an accomplishment is not possible without eliminating our world around frustrations of the essential resources integration by the competitive sovereign systems

We have organized at Southern Illinois University, and we hope it will soon be in operation, a $16 million computer implemented program for playing just such a mutual success seeking game in a dramatically visible way. It will be so photogenic that it will become popularly and repeatedly broadcast on the world's TV circuits. Thus society may come to realize not only what is happening but also what could happen in an omnifavorable way

Our world game will be played electronically by remote controls on a giant model of our earth globe opened out into its flat projection which will be the size of a football field. (See my world map.') World leaders will be invited to play the game and to introduce any new data they deem to be missing and the computers memory banks will retain all the data ever fed into it as well as remembering all the plays that have been previously made and their respective outcomes. No opposed politicians may ever yield to their adversary without a trial of relative strength. To yield prior to such a trial of strength is to be either a traitor or a fink. Trial of ultimate political power, in international Malthusian-Darwinian terms, always leads to war. For this reason, political leaders avoid arbitration by third parties as subject to subtle corruptibility. 'But gradually society in general and its political leaders are beginning to yield mutually to computerized solutions of lethally vital disputes, where the computer has been given the problem in the terms of the question-in which way do both sides profit the most?

There are a myriad of economic trends and other vital evolutionary events taking place today which are invisible to humanity only because they are too fast or too slow for man to apprehend and to comprehend them. We will be able to accelerate or decelerate such evolutionary events by electronic controls as played visibly on our football field sized playing surface

Humanity has a very limited optical spectrum, wherefore man can see today only one-millionth of the total physical "reality" as the latter is evidenced by the full range of the electromagnetic spectrum. Man used to think of reality as everything that he could sense with his eyes, ears, nose, taste, and touch We have learned only since about 1930--when the first technical chart of the great electromagnetic spectrum was published-that man has sensorial tunability and is sensibly aware of only one-millionth of physical reality. The little rainbow color band of human "seeing" is less than one-millionth of the stretched out reality of the invisible colors, of all the 92 regenerative chemical elements of associative energy or of the various radiations of energy in its disassociative phase

In addition to the electromagnetic frequencies spectrum we have also a motion spectrum. The sense of motion is produced by an overlapping continuity of afterimages of a plurality of optically tunable separate and sequentially occurring electromagnetic frequency events just as music is produced for the hearing by a metrically momentummed sequence of both separate and resonantly overlapped sound frequency notes. Motion is visual music made possible by the spontaneous retention in the brain of a series

of separate still picture frames of our separate sense experiences scanned and reviewed in the brain at a vastly accelerated sequence rate. Our brain discovers that each successive electromagnetic picture is just a little different from the ones before and our dawning awareness of that increasing difference constitutes our motion sense

The overall range of our human, motion spectrum is even more limited in respect to the full range of cosmic motions than is our optical frequency spectrum tunability in respect to the total electromagnetic spectrum. We can't see the atoms in motion; we can't see the stars move, though their motions are thousandsfold faster than our fastest rockets; we can't see the trees grow; we can't see the hands of the clock move. Most important of all, we cannot see the abstract weightless thoughts in the minds of other men. When we survey the total inventory of motions and informations which we can sense we find it to be very limited. The significance of all the foregoing is appreciated when we realize that it is only such phenomena as can be seen to be moving or changing by the public that are politically recognized and heeded That is why public opinion and vote sampling has come into ever more reliable use

Our computerized world game is designed to accelerate the too slow and decelerate the too fast of all the known vital trendings and thereby to bring them dramatically within popular consideration and our world game's solution. The game will show clearly how the trends are going to affect everybody's lives everywhere around earth and how they could be taken advantage of in ways favorable to all humanity

As the general system of vital trends becomes visible and its components are seen to integrate synergetically, we also will begin to discern ways of using the world's resources to ever higher and more universal human advantage. We will soon learn popularly how to play the game to explore for ways in which we may use the world's resources so that we may be able to make our whole planet successfully enjoyable by all humanity without any human profiting at the expense of another and without interferring with one another, and how to do so in the shortest possible time

We had been playing the world game by longhand mathematics long before the computer. As we simulated our plays in the precomputer era of the late 1920's and early 1930's we found out that it is possible to say scientifically that our planet earth can successfully support all humanity for all generations to come. Between 1900 and today we have gone from less than 1 percent of humanity to 40 percent of humanity enjoying a higher standard of living than any king had known before the 20th century.

During the same period, the amount of chemical materials per each world human have been continually decreasing due to the population increasing much more rapidly than geologists have been discovering physical resources to support humans aboard our planet It follows that during that same period we didn't amplify fortyfold those enjoying a super-to-royalty standard of living by finding and exploiting more resources. We did it only by doing more with less. That is the only possible explanation. During that same period, we also approximately doubled Western man's longevity and his relative health has been correspondingly improved. Even more importantly, during that same period humanity eliminated many misinformations from the starting environment of its new life, while implementing the new life to apprehend information from all around our planet in split seconds by giving the new life a vivid awareness of all other humans around our space vehicle Earth never before experienced by humanity. That is why the young of our day are demonstrably skeptical of the only myopically conditioned opinion reflexes of their elders. The ever-idealistic young do not know what to do about their intuition that all old customs are treacherous, other than to attack them having no positive alternatives

So we found that man was inadvertently becoming successful. We also found that all the technology' which brought this about has been an inadvertent fallout from man's exclusively war anticipating acquisition of vastly more with less industrial production capabilities and subsequent conversion to peaceful ends of that technology first produced only for military purpose.

We had blast furnaces for making battleships for 50 years before a piece of steel went into a skyscraper on the land. We first developed all the great electric generators for sea use. We had refrigeration at sea for 30 years before we brought it ashore. Thomas Malthus, of 1800, could not anticipate that 100 years later refrigeration would preserve foods so satisfactory that they could reach safely and economically all the world's stomachs

I find man utterly unaware of what his wealth is or what his fundamental capability is. He says time and again, "We can't afford it." For instance, we are saying now that we can't afford to do anything about pollution but after the costs of not doing something about pollution have multiplied manifold beyond what it would cost us to correct it now we will spend manifold what it would cost us now to correct it. That is a geometrical compounding of inevitable expenditures.[2] For this reason I find that in satisfying humanity's vital needs highest social priority must be assigned to the development of world around common knowledge of what wealth is. We have no difficulty discovering troubles but we fail to demonstrate intelligent search for the means of coping with the troubles. This is primarily due to our misconditioned reflex which says that "we can't" afford to do the intelligent things. We discover with scientific integrity that wealth is simply the measurable degree to which we have rearranged the physical constituents of the scenery so that they are able to support more lives, for more days at such-and-such standards of health and nourishment, while specifically decreasing restraints on human thought and action, while also multiplying the per capita means of communication and travel all accomplished without increased privation of any human. Wealth has nothing to do with yesterday, but only with forward days. How many forward days, for how many lives are we now technically organized to cope? The numerical answer is the present state of our true wealth.

I find that our wealth consists exclusively of two fundamental phenomena: the physical and the metaphysical. The physical in turn consists of two subdivisions. One is the physical/energy associative as matter and the other is energy dissociative as radiation. After science discovered the speed of light it went on to discover that when energy was lost from one system it was gained by another local system. It is never lost from the universe. Energy is inherently conserved, so the energy component of wealth cannot be depleted

The other prime constituent of wealth, the metaphysical, is contributed by human intellect. Man's muscle has only a self-starter, button-pushing function Man's mind comprehends and masters the energy of Niagara Falls. His muscle cannot compete with Niagara. Humanity's unique function is that of his mind's ability to discover generalized principles and to invent effective ways of employing those principles in rearranging the physical constituents of the scenery to ever greater metabolic regeneration advantage and metaphysical freedom of humanity. We discover that every time man makes an experiment, he always learns more. He cannot learn less. We have learned therefore that the intellectual or metaphysical half of wealth can only increase. The physical cannot decrease and the metaphysical can only increase, wherefore wealth, which results from the synergetic interaction of both the physical and metaphysical, can only increase. Which is to say-net-that wealth can only increase with each reemployment, and the more intelligently and frequently it is reinvested the more rapidly it increases. This is not disclosed in any books on economics. It is not recognized by the body politic.

So I say to you, man has acquired all the right technology within only 60 years to amplify from less than 1 percent to 40 percent the proportion of all humanity who are now economically successful with the possibility of elevating all of humanity in ever greater degree within another 25 years all of which enabling technology humanity said it couldn't possibly afford until the military said, "This is the way your enemy is going to fight the war. You either acquire an equal 'or better. technology or die." To which the people responded, "Though we think we can't afford it and though we don't know how we can pay for it, if we have the energy resources plus the know-how and human time to produce that technology we will go ahead and produce it and find out later how to pay for it," not realizing that in investing our time and know-how in producing it we were paying all that would ever be realistically required to pay for it. The constituents belonged in truth to no one That physical phenomena which had originally been commandeered by illiterate sword and gun seizure and had been deeded thenceforth under guarantee of arms as property and that the paper equity had been loaned out at interest and compounded arbitrarily as a debt imposed by law on someone did not alter the fundamentals of this situation.

Your Senate hearing gives me a short but welcome opportunity to talk thus about all that man has learned fundamentally from his 2 million years aboard our spaceship earth wherefore I wish to point out vigorously to you that we are indeed aboard an 8,000-mile-diameter spherical space vehicle. We were excited during the Christmas days when we first looked at the earth from the moon, but I heard our

President speaking "down to earthedly" to the astronauts about their going up to the moon. There is no up or down in the universe. We find so-called practical man saying, "Never mind that space stuff, let's get down to earth."

And we retort "Where is that? Where is 'down' and what and where is that nonspace existing, theory avoiding earth?"

Despite their ignorant urging of "Never mind that space stuff, let's get down to earth" we find that our little 8,000-mile-diameter planet earth, together with the moon, is flying formation at 60,000 miles-per-hour around the sun. Earth is a beautifully designed spaceship equipped and provisioned to support and regenerate life aboard it for hundreds of millions of years, even until the time when so much energy of universe has been collected aboard earth as to qualify it to become a radiant star shortly before which man will have anticipatorially resituated himself on other planets at nonincineratable distance from the earth nova

Considering our present dilemmas aboard our planet and earnestly seeking fundamental clues to both their cause and solution, we may note that we start our children off with a geometry whose lines and planes go (we say) to infinity. The little child says, "Where is that?" The teacher can't answer because she has never experienced infinity. The teacher is dispensing absolute nonsense. Modern science deals only with experimentally acquired data Man is as yet "thinking" only in terms of a flat earth People still talk about the "four corners of the earth" and the "wide, wide world." Within his total lifespan average historical man has seen only about one-millionth of the surface of his planet earth He is not to be blamed for thinking of it as flat He still cogitates unrealistically in terms of infinity. He thinks he has infinite room to dispose of all pollution and infinite resources to be brought into play as he exhausts first one then another. But he is wrong. His reflexes are self-annihilatively conditioned. Earth is a closed system. A tiny, biosphere enclosed, spherical spaceship

Humanity on this North American continent is the beginning of a world man. We are not a nation. Nations are tribes of people who have been isolated for a long time and have, of reproductive necessity, inbred-grandfathers with granddaughters-and have adapted themselves to exclusively local physical conditions

We are not going to be able to operate our spaceship earth successfully nor for much longer unless we see it as a whole spaceship and our fate as common It has to be everybody or nobody,

It is very encouraging therefore that you as representatives of the people see tit to bring us together to consider these matters

I have to ask you, sir, are you familiar with the word "synergy"?

Senator Muskie. Not as well as I would like to be

Mr. Fuller. You understand what it means?

Senator Muskie. Yes.

Mr. Fuller. I have been a visitor at 320 universities and colleges around the world and always have asked those university audiences "How many of you are familiar with the word 'synergy'?" I can say authoritatively that less than 10 percent of university audiences and less than 1 percent of nonuniversity audiences are familiar with the word and meaning of synergy. Synergy is not a popular word. The word synergy is a companion to the word "energy." Energy and synergy. The prefix "syn" of synthesis meaning "with, to integrate" and the "en" of energy means "separating out " Man is very familiar with energy, he has learned to separate out, or isolate certain behaviors of total nature and thus has become familiar with many of the separate natural behaviors such as optics. But the only partially isolatable behavior is always modifyingly employed by the whole. If humans had to purchase their many separate organs, stomachs, livers, endocrine glands, tongues, eyeballs, and bowels and thereafter to assemble those parts into logical interfunctioning, they would never do so. All those parts had to be preassembled and unitarily skinned in and coordinately operated by multiquadrillions of atoms in the brain which after 16 years of practical spontaneous coordination becomes so aesthetically acceptable one to the other that as it sings, dances, and smiles one is inclined to procreate with the other.

Synergy is to energy as integration is to differentiation

The word "synergy" means "Behavior of whole systems unpredicted by behavior of any of the systems parts." Nature is comprehensively synergetic. Since synergy is the only word having that meaning and we have proven experimentally that it is not used by the public, we may conclude that society does not understand nature

Cyril Stanley Smith, science historian of MIT, makes clear that we have come to a point in development of materials wherein we realize that the complex behaviors of alloys are never explained or foretold by their constituent chemical elements' crystalline or molecular parts.

I find all of our world society is operating exclusively in parts. We know this because the word synergy is unknown popularly and it is the only word that means "behavior of wholes unpredicted by behavior of their parts."

This proves that society does not even think that it has a need for such a word. This discloses that society does not think that there are behaviors of wholes unpredicted by the parts. It thinks statistics and probability are all that we need but if "probability" and "statistics" were of any power at all we could not have a stock market or gambling for we would know exactly how things are coming out and no one would bet against the probability Because nature is entirely synergetic and because your problems of representing a society ignorant of such fundamentals are greatly increased you need to pay great attention to learning how to comprehend synergy and thereafter how to educate all of humanity in the shortest time how to comprehend and usefully cope with omni-synergetic universe

I will give you one very simple example of synergy. All our metallic alloys are synergetic. We will examine chrome-nickel-steel. The outstanding characteristic of metallic strength is its ability to cohere in one piece We test the metals tensile strength per square inch of cross section of the tested sample The very high number of pounds-per-square-inch tensile strength of chrome-nickel-steel has changed our whole economy because it retained its structural integrity at so high a temperature as to make possible the jet engine which has halved the time it takes to fly around the world. The prime constituents are chromium, nickel, and iron. We will take the highest ultimate tensile strength of those three. The iron's ultimate tensile strength is about 60,000 pounds per square inch. Nickel's ultimate is about 80,000 p.s.i. Chromium is about 70,000 p.s.i.

Ultimate tensile strengths of the other minor constituents: carbon, manganese, et cetera, added together total about 40,000 p.s.i. If we use the same tensile logic as that applied to a chain and say that a chain is no stronger than its weakest link, then we would assume that chrome-nickel-steel would part at between 40,000 and 60,000 p.s.i. But we find experimentally that is not the case. We find by test that chrome-nickel-steel is 350,000 pounds a square inch which is 50 percent stronger than the sum of the strength of all its alloys. To prove so we add 60,000, 70,000 and 80,000 which comes to 210,000. To this we add the 40,000 of minor alloying constituents which brings the sum of the strengths of all its alloying to only 250,000 pounds a square inch. The explanation for this is Newton's gravitational law which noted the experimentally proven fact that the relative mass attraction of one body for another is proportioned to the second power of the relative proximity of the two bodies as expressed in the relative diameters of the two bodies. If we have two spherical bodies of equal mass at a given distance from each other and insert a third spherical body of the same mass half way between the two we do not double the mass attraction between any two of the three. We increase the attraction by 2 to the second power which is 4. Halving the distance fourfolds the inter-mass attraction. When we bring a galaxy of iron atoms together with the chromium atoms and a galaxy of nickel atoms they all fit neatly between one another and bring about the multifolding of their intercoherency. But there is nothing in one body by itself that says that it will have mass attraction. This can only be discovered by experimenting with two and more bodies. And even then there is no explanation of why there must be mass attraction and why it should increase as the second power of the relative increase of proximity. That is synergy.

There is an important corollary of synergy which postulates that the known behavior of the whole system and the known behavior of at least three of the parts of the system makes possible the discovery of the other parts of the system and their respective behaviors. The Greeks discovery that a triangle always

consisted of six parts; the three edges and three angles; and that the triangle's angles always added up to 180". This gave them the ability to discover the lengths and angular degrees of all six if they knew the dimensions of any three of the six parts. Synergy invoked the scientific concept of general systems theory-first known as "the theory of ships." Because your senatorial committee is concerned with a synergetic complex of intergovernmental operations you are dealing with inherent synergy. And you are representing a society that is unaware of the overriding synergetic behaviors of nature And because as such a governmental body you have chosen to explore for ways and means of democratic governments becoming more farsighted and effectively responsible we realize that synergy and its derivative general systems theory can give you the clue to realization of your more effective responsiblity to society.

Our school systems are all nonsynergetic. We take the whole child and fractionate the scope of his or her comprehending coordination by putting the children in elementary schools-to become preoccupied with elements or isolated facts only. Thereafter we force them to choose some specialization, forcing them to forget the whole. We start them off with planes and straight lines which run into infinity which no scientist has ever produced experimentally and therefore we defy the child to comprehend and require that they accept and believe that it is logical to assume "infinity" and therefore to give up the child's innate propensity to learn by experiment and experience, recourse to which exclusively experimentally informed reasoning made possible Einstein's epochal reorientation of all scientific theory. We stuff our children's heads with such nonsense as straight, continuous surfaces and solids paying no attention whatever to the fact that science has discovered no solids, nor any continuous surfaces. Science has found only discrete energy packages such as the atoms whose electrons and nucleons are as discretely remote from one another as is the Earth remote from the Sun. As a consequence of this theoretical mish-mash and our deliberate discard of the child's innate experimental techniques for self-teaching thereby, we find our world society looking askance upon its presently conjured, news-invented concept of its most prominent, inexorably developing fate with none of its predictions coming true and with all of the progenitors of the variously frustrated ideologies becoming progressively vindictive and intransigent

Society talks, about technology as something new All society thinks of humans' physical organism as being transcendental to technology whereas our organisms are the most superb technological designs in all universe Humans' organisms are entirely automated

By automation I refer to any reciprocally interacting system operating independently of conscious human guidance

None of those present at our Senate committee hearing know what they are doing right now with the breakfast foods they loaded aboard an hour or so ago. None of them are saying, and consciously following through on it, "I am going to send the orange juice to this and that gland to make each of the million hairs on my head grow in this and that shape and color." It is all automated. People haven't the slightest idea why they are born at 7 pounds and why they grow to 107 or 170 and stop. It is all automated.

What we call technology is the externalization and amplification of our original integral functions and capabilities. Your hair is not you else you could not cut it off. In our technology we have not invented and developed any new functions

If the great design of the universe had wished man to be a specialist man would have been designed with one eye and a microscope attached to it which he could not unfasten. All the living species except human beings are specialists. The bird can fly beautifully but cannot take its wings off after landing and therefore can't walk very well. The fish can't walk at all. But man can put on his gills and swim and he can put on his wings and fly and then take them off and not be encumbered with them when he is not using them. He is in the middle of all living species. He is the most generally adaptable but only by virtue of his one unique faculty-his mind. Many creatures have brains. Human minds discover pure abstract generalized principles and employ those principles in the appropriate special cases. Thus has evolution made humans the most universally adaptable, in contradistinction to specialization, by endowing them with these metaphysical, weightless invisible capabilities to employ and realize special case uses of the generalized principles. I think, Senator Muskie, that your bill is excellent. Your intuition is sound, but I think that its

words worry me because they suggest that humans may be more of an authority on what evolution and the universe are trying to do than is the fact

I would-point out that all of the great scientists have discovered that we have an invisible, abstract, utterly weightless a priori universe. I hear it popularly said the scientist brings order out of chaos. All of the great scientists find the reverse to be true. Scientists experiment, hypothesize, and experiment again to test their hypothesis. Suddenly some of them discover a theretofore unknown generalized principle which adds to science's awareness of the eternal resources of a priori order in universe. They are further amazed to find as time goes by how complete is the interrelatedness of all the separately discovered principles. None ever contradict the others. There apparently is a great integrity wedding all of the a priori principles. A generalized principle of science cannot be so classified if any special case exceptions to its behavior are found. Because the generalized principles cannot be such unless they are eternally true, the discovery of them by science implies an eternity of meaning, order, and integrity lying behind our ignorantly and innocently accepted special case and only superficially different experiences

But the most advanced scientists of today, for instance the leading astrophysicists, discover that regardless of how much we separate out and subdivide our physical experiences with energy, as matter, that the protron and neutron, which are not the same but are interchangeable by accommodation of their respective subsidiary teammates-always and only coexist. You can, by bombardment, separate out momentarily some of the atoms' minor "nuts and bolts" particles but you cannot eliminate atoms from the universe nor dispense with their always and only coexisting but never the same protons and neutrons and their intercomplementary intertransformative energy equating, kinetic balancing.

These scientists point out therefore that there never could have been chaos There had perforce always to have been the orderly fundamental complementarity. All the legendary ways of looking at universe as having had a beginning in disorder have for the 3 last years been completely upset by the astrophysical inventorying of the relative abundance of the fundamental atomic isotopes and their intertransformational accounting on a cosmic scale. We find we are now confronted with an apparently eternal a priori order. The idea of probability gradually converting a disorder to order is invalidated. There is an a priori synergetic integrity of universe which has allowed humanity to be born ignorant. That is manifest. It is not then a derogatory statement to say man is ignorant. He also is born utterly helpless. It is part of the equation of universe that "utter helplessness" be complemented by an a priori competence of universe to "care for" the helpless. Mothers do not have to invent a mammular gland and a breast to feed their babies. The mother doesn't invent the oxygen for the baby to breathe. These essentials were invented by the a priori competence of the universe. Therefore I find man ignorantly pretentious in assuming that he is responsible for either yesterday's or tomorrow's success. I am worried about the possibility of thinking in your committee, occurring exclusively about the U.S. portion of spaceship earth; trying to block off a little static area and within it thinking about private enterprise as being utterly competent to cope with these larger ways of looking at things

Top management says, "I have got to make profit this year or I don't remain the president of this company" and goes on to rationalize, "I can't afford. to arrest the pollutants that are emitted by our factory stacks because if I do, I can't compete with other companies operating outside this area who are not arresting pollutants." So the polluting industries say to the city governments, "If you require that we arrest our pollutants we will move to an area where we're not so required." And the politicians say, "Don't move, we need you as our tax base to pay all the salaries of our political machine obligations." Finally there will be so much pollutant in the sky that the sun's radiation will be unable to keep on generating life on earth. Trying to clean the sky instead of gathering the pollutants at the nozzle and waiting until millions of lives deteriorate, humanity will pay a thousandfold what it would have cost to arrest, precipitate and collect at the stack. Here I find humanity and its democratic political gaming not only utterly incompetent but a menace to survival

If your committee is going to be successful, it is going to have to take a very, very large viewpoint and do so very abruptly. Science is finding out that there is a very much more complex. inexorably and accelerated process going on in evolution than is popularly understood

I find humanity's general strategies in every known economy and ideology to be quite inadequate. This is why we are developing our World Game as the swiftest way in which to get humanity to understand both its dilemma and its potential egress from it.

I have one more document which I would like to present to this committee. I had the press bind an advanced copy of the pages for my book which will be published on April 1 by the Southern Illinois University Press It is called "Operating Manual for Spaceship Earth."[3] The philosophy, I think, might be of use to you and your committee.

Muskie. Thank you very much , Dr. Fuller. We are delighted to have it along with your paper "World Game."

(The material submitted follows:)

World Game by R. Buckminster Fuller-How It Came About, April 1968

In 1964 the United States Information Agency asked me to consider the design of a building and an exhibition which might be adopted as the United States entry in the Montreal World's Fair of 1967, later known as "Expo '67."

I made a proposal and the exhibition part of it was rejected. I was asked to continue, however, as the architect of the U.S.A. building to house an exhibition designed by others. Insofar as I know I was the only one considered as architect of the building. I think this was because of the success the United States had experienced with my world around, air-delivered, geodesic dome, trade fair pavilions and the U.S.A. MOSCOW Exhibit dome of 1959, which was purchased by the Russians as a permanent building after the United States exhibition was concluded

Fortunately my U.S.A. geodesic dome for Expo '67 proved a **success.** Also, but more gradually however, it is being realized by many that my rejected idea for the American exhibit is looming into ever greater prominence as a highly desirable social facility. I will therefore review the concept and development of my original idea.

I told the United States Information Agency in 1964 that by 1967 the regard of the rest of the world for the United States would be at its lowest ebb in many decades-if not in the total two centuries of the U.S.A.'s existence. Since each country's World's Fair exhibit would be well published all around Earth, I felt that it would be very important that the United States do something that would tend to regain the spontaneous admiration and confidence of the whole world. This could be done by inaugurating at Expo '67 a computerized exploration for the most universally creative and economically sound internal and external U.S.A. policy formulation.

What I proposed was based on my observation that world people had become extraordinarily confident in the fundamental reliability of the computer and its electronically controlled processes. I know that a great many people will contradict me, but I had predicated my conviction-of society's subconsciously established confidence in the computer's reliability-upon vital, therefore undeniable, behavior facts

I refer to the equanimity with which world-around air jet travelers now commit their lives to the computer's reliability. I have been flying regularly, both as pilot and passenger since 1917. I have been an almost constant airlines' passenger since the first building of the commercial planes with aluminum in 1930. In the early days the ten to twenty air passengers were generally and genuinely nervous about their safety, particularly when their airplane's course ran into thunderstorms. The passengers knew that the pilot would do his best to get them through the troublesome condition. His own life was at stake. But the passengers also knew that the pilot had to guess his way through the clouds not knowing exactly where he was nor whether the invisibility reached all the way to the ground. Everybody in the plane sat tensely and later admired the pilot's skill, courage, and cool skill in getting through the blind condition. But without question all were frightened until a clear view was restored of the Earth lying below at a safe distance

As I now fly around the world in jets in the company of 125 to 135 passengers, we frequently find ourselves coming in for a landing in the night and fog. But everybody is occupied in reading, sleeping,

listening to the music or talking. They pay but little attention to the flying conditions. Why? If they thought the pilot had only his personal senses to get them through the mess they would be very very apprehensive and rightly so. Under such conditions it would be a pure miracle if he accomplished a safe landing However by learning to use the modern electromagnetic communications devices and "blind flight" routines, he is able to come in for a safe and comfortable landing with his 75 ton jet ship hitting the runway at speeds well over 100 miles an hour. The reason this is both feasible and safe is because it is entirely instrument controlled, with ample "fail safe" standby equipment. The pilot has to employ faithfully the instrumental data and indicators and, sometimes also aided by ground operated instruments and personnel, is guided with reliable precision to a safe landing, under "zero visibility" conditions.

The pilots' senses are used only to see and hear the instruments and to coordinate his hands and feet to operate the right buttons, pedals and levers Within the short decade of successfully routined, automated instrument landings humanity has thus *come* to risk its life in high confidence of the successful performance of automated instruments.

It is thus proven that society has established fundamental confidence in the reliability of properly maintained and programmed computers. The fact is that in going from here to there by some kind of transport in 1968 the most dangerous way is by automobile. Next most dangerous is by railroad, and it is safest to go by airplane. That is a new era condition brought about by the extraordinary degree of reliability of computerized controls. As a consequence much more automation is about to take place and the computers to do the myriad tasks are proliferating at an amazing and popularly unrecognized rate.

On the working assumption that humanity now has established Implicit confidence in the computers and automated instrumentation, I proposed in 1964 that the United States' Expo '67 exhibition should have a 400 foot diameter 5/8 sphere building similar in shape to the 250 foot diameter building actually built for Expo '67. In the basement of this building would be housed an extraordinary computer facility. On entering the building by 36 external ramps and escalators leading in at every ten degrees of circumferential direction the visitors would arrive upon a great balcony reaching completely around the building's interior quarter-mile perimeter. The visitors would see an excitingly detailed one hundred foot diameter world globe suspended high within the 400 foot diameter 5/8 sphere main building. Cities such as New York, London, Tokyo, and Los Angeles would appear as flattened out basketball sized blotches with the tallest buildings and radio towers only about one-sixteenth of an inch high.

Periodically the great spherical Earth would seem to be transforming slowly into an icosahedron-a polyhedron with twenty (equilateral) triangular facets. The visitors would witness that in the processes of these transformations there are no visible changes in the relative size and shape of any of the land and water masses of the 100 foot diameter miniature Earth. Slowly the 100 foot diameter icosahedronal Earth's surface will be seen to be parting along some of its triangular edges, as the whole surface slowly opens mechanically as an orange's skin or an animal's skin might be peeled carefully in one piece. With slits introduced into its perimeter at various places it would be relaxed to subside into a flattened-out pattern as is a bear skin rug. The icosahedronal Earth's shell thus will be seen to gradually flatten out and be lowered to the floor of the building. The visitors would realize that they were now looking at the whole of the Earth's surface simultaneously without any visible distortion of the relative size and shape of the land and sea masses having occurred during the transformation from sphere to the flattened-out condition which we call a map. My cartographic projection of the "SKY OCEAN WORLD" functions in just such a manner.

This stretched out football field sized world map would disclose the continents arrayed as one world island in one world ocean with no breaks in the continental contours.

The great map would be wired throughout so that mini-bulbs, installed all over its surface, could be lighted by the computer at appropriate points to show various, accurately positioned, proportional data regarding world conditions, events, and resources. World events would occur and transform on this live world map's ever evoluting face

I propose that, on this stretched out reliably accurate, world map of our Spaceship Earth, a great world logistics game be played by introducing into the computers all the known inventory and whereabouts of the various metaphysical and physical resources of the Earth. This inventory which has taken forty years

to develop to high perfection is now housed at my Southern Illinois University headquarters

We would then enter into the computer all the inventory of human trends, known needs and fundamental behavioicharacteristics.

I proposed that individuals and teams would undertake to play the "World Game" with those resources, behaviors, trends, vital needs, developmental desirables, and regenerative inspirations The players as individuals or teams would each develop their own theory of how to make the total world work successfully for all of humanity. Each individual or team would play his theory through to the end of his predeclared program. It could be played with or without competitors.

The objective of the game would be to explore for ways to make it possible for anybody and everybody in the human family to enjoy the total earth without any human interfering with any other human and without any human gaining advantage at the expense of another

To accomplish the game's objective, the resources, pathways and dwelling points around the surface of our eight thousand mile diameter, spherical Spaceship Earth must be employed by the players in such a way that the world's individual humans would each be able to exercise complete actional discretion; and would have such freedom of decision regarding the investment of their time in their waking hours that they would be able to travel independently, or in groups, either to-and-fro locally, or continuing intermittently on around the world, dwelling from time to time here or there, finding everywhere facilities to accommodate their needs in an uncompromising manner The game would seek to use the world's resources, interprocesses and evolutionary developments in such a way that all the foregoing would be possible. It might involve moving whole city-sized groups of buildings from here to there in a few hours

Let us assimilate World Game playing as I envision it, in order also to envision the kind of information most probably to result from such forward reintegration of our present world inventory of systematically differentiated-out physical and metaphysical variables

First we are confronted with the present type of custom-tolerated frustrations of otherwise efficient designs. As things are now organized all big businesses have to make profits to provide a living for those dependent upon their corporate shares. To make the most profits, businesses exploit peak loads and bottlenecks. They want the highest earnings out of their apparatus and payroll investment. One eight-hour, or shorter shift a day usually seems most profitable. Airports, restaurants and transportation services try to operate only when every seat can be filled Their owners attempt to close down and save payroll and energy costs at all other times. This accelerates further the tendency to concentrate all business and travel into a few coming-and-going hours in the ever later "morning" and ever earlier "evening" with an ever longer lunch period during which most of the critical executive decisions are made. (The latter are incidentally all the as yet nonautomatable decisions.) For sixteen hours each day the airports, "downtown" restaurants, offices, and wholesale businesses are extraordinarily quiet or altogether closed. This gives people so much time to spend their money in their home neighborhoods that business gets a second chance at them in the widely deployed shopping center supermarkets which operate near their homes. Their home hours being sixteen hours long the supermarkets are geared to as nearly full automation as labor unionism will permit in order to be able to stay open sixteen hours a day with the minimum of human attendants working in two or three eight hour shifts

All the beds and bedrooms around the world are empty two-thirds of the time. All the automobiles are empty and motionless five-sixth's of the day There are two main causes of this vast uselessness Firstly, we try to do everything at peak loads. Secondly, we try to "own" too many objects that we use too infrequently to justify "ownership."

Assimilating the running of the world by computer we see quickly that we must find ways in which humans can be induced to employ all equipment all the time, thus smoothing out the peaks and valleys and eliminating the 66% empty time and servicing 100 percent instead of only 40 percent of humanity.

You may say, "Oh. I want to own my own bed. You can't possibly do that kind of thing to me!" Answering you I point out that as we go into any motel or hotel room today we find a clean, fresh bed, "made-up" as far as we can see of all new linen. Everything about the room is apparently "brand new."

You come into any modern telephone booth within which as far as you can tell is a new telephone and you may be the first and last ever to have used it

I have owned fifty-five automobiles in my sixty years of driving. I have an unblemished driver's license. I drive about fifteen thousand miles a year, but I'm not going to own any more automobiles because I found that I was leaving my automobiles at airports and never getting back to them. I now fly about a quarter of a million miles a year and find it much simpler to rent a car at the airport of each briefly visited locality. I get a fresh new car. As far as I can see it is just nicely broken-in but otherwise show-room new. All the insurance, car licensing, and maintenance problems are eliminated. It saves me much negative time, costs less, and gives greater satisfaction. Instead of "buying" a new car every year, I now "buy" a new one twice a week at less expense. I "own" it only as I use it. The idea that equipment is satisfactory only as permanent property is no longer valid. Many customs of humanity that have long defied political reform on strictly ethical or ideological premises are about to evaporate on a practical obsolescence basis. The computerized World Game may obviate vast manslaughter revolutions by disclosing in advance and thus accelerating the elimination of, "unwanted" or "unfair" customs and practices. Such obsolescence is unanticipated by the political revolutionaries; who, had they known the evolution was about to establish the desirable conditions by new invention and insights might have foregone vast and unnecessarily continuing mayhem.[4]

Amongst other grand strategies for making the world work and taking care of everybody is the design science revolution of providing ever more effective tools and services with ever less, real resource investment per each unit of end performance. For instance, a communications satellite, weighing only one-quarter of a ton is now out-performing the transoceanic communication capabilities of 175 thousand tons of copper cable

The World Game will explore for, and experiment with, more-for-less uses of our resources so that instead of taking care of only 44% of humanity at a high standard of living, we can take care of all of humanity at an even higher standard of living than man has as yet conceived

In playing the game I propose that we set up a different system of games from that of Dr. John Von Neuman whose "Theory of Games" was always predicated upon one side losing 100 percent. His game theory is called "Drop Dead." In our World Game we propose to explore and test by assimilated adoption various. schemes of "How to Make the World Work." To win the World Game everybody must be made physically successful Everybody must win

Most games have not been thought of that way except for such group ways-and-means explorations as mountain climbing. Von Neuman's game theory relates to World War strategies for mastering the Planet Earth's economic and political activities, as it has been played over the great ages, particularly as played in the last century where elimination of the competitor was accomplished by delivering the greatest hitting power, the greatest distance, with the greatest accuracy, in the shortest time with the least effort, under the most widely varying environmental circumstances. Von Neuman's game theory derived from past experiences, first of the British Navy and later of the American Navy, as gained in their operations around the three-quarters of the Earth's surface which is covered by water

Before the airplane had developed to its supremacy over the battleship the mastery of the Earth was accomplished through mastery of the sea. You can float fantastic fortresses that you can't possibly move over land to the most effective places to control the world's ever shifting lines of supply. The resources of the Earth are so unevenly distributed that the control of the lines of supply in turn controlled industrialization's ability to make the most powerful, incisive and efficient tools and weapons of the moment's known organized production potential Whoever controlled the seas ruled the world

The United States Navy and its war college have for years played the war games seeking the most effective means for controlling the world and meeting any challenge of any enemy. The Navy (or Von Neuman) game is played in the terms of the optimum logistics and ballistics permitted by the thus far mastered world resources, total geography and total humanity. However the world war games have always been played on the axiomatic assumption (now proven false) that Thomas Malthus and Darwin were correct in concluding; firstly, that there would never be enough of the world's resources to support more than a

small minority of humanity: and secondly, only "the fittest would survive." Wherefore, axiomatically it always had to be you me

By the year 1900 so many vital statistics and world resource data had been collected that the modified working assumptions adopted in the 20th century's world war games no longer maintained that it was just a matter of you ***or me*** surviving Thus ever more scientifically gleaned odds indicated that less than 1% of humanity would be able to live out its potential four-score and ten years of life while at the same time affording an adequately fed, medically attended, and culturally literate standard of living.

Vital statistics and insurance acturians showed that the average ***world*** man in the year 1900 probably was going to die, as he had throughout all known history, with an average life span of only 27 years (42 if in the U.S.A. where conditions were more favorable). Those odds were the working basis of the naval officers' assimilated world war games of 1900. 99% of humanity had "everything to win and nothing to lose" by waging war. Better to "have at it" while you are young and strong than to wait to rot away in the slums

In abrupt contradiction to the foregoing working assumptions, and only within the last decade (1958-1968), science has been able to say authoritatively that it is now feasible to take care of all of humanity at an ever higher standard of living than has as yet been realized for anyone but that we can't possibly do so if we continue the economic and political restraints of the you-or-me cold, warm or hot, warring or the world's production, distribution and consumption restrictions imposed by the world's militarily maintained sovereign boundaries

All the sovereign boundaries of the powerful nations were established and are maintained on Malthus' now invalidated assumption that there is not and never will be enough of the life regenerating resources to support more than a meager minority of humanity and that the lands embraced by the most powerful world states had much higher promise as an operating base for sustaining life than had the excluded lands. The lands were claimed by the sword. They were taken under conditions of abysmal ignorance and general illiteracy, when no one knew of the chemical riches and lever-moving, inanimate energies hidden within the "natural" landscape

A world-around game of musical chairs was forever being played in which each time the music of so-called peace ceased there was ***only*** one ***chair of continuing life*** to accommodate every one hundred people. With cessation of the (people-being-polite-to-one-another) music there ensued the periodic Armageddon wherein war, disease and other disasters eliminated the vast numbers of humanity that could no longer be supported. These past experiences and the long overshooting momentums of bureaucratic systems together account for the fact that all the as yet powerful World States assume such Armageddon to be forever inevitably recurrent. The great states therefore doggedly maintain their respective sovereignties and their preparedness for the ultimate trial of physical power To fortify the very concept of sovereignty they keep inventing and officially reorganizing the sovereignties of ever littler and weaker nations who with false pride of recognition and admission to membership in the Union of World Nations vigorously defend as fundamental the concept of sovereignty as a step to political autonomy and freedom quite oblivious to the fact that their respective exclusive physical resources cannot' support any but a primitive hunting, fishing, and grubbing life. They altogether overlook the reason that they had previously been ruled by others was that the others had been economically motivated to seize and rule them in order to participate in the powerful advancement of living standards provided exclusively by industrialization which operating at minimum adequacy involved free intercourse and interaction of all the world-around very disorderly distribution of the 92 chemical elements whose unique behaviors and their chemical combinings were altogether essential to the success of the industrial process

In complete contradiction to all the war experts' assumptions, between 1900 and today, in just two-thirds of a century, while the world's population has approximately doubled, we have at the same time also gone from less than 1 percent of humanity to 40 percent of all humanity enjoying a higher standard of living than was known to or was dreamed of by any monarch before the twentieth century. This was not only unexpected by any economists but is inexplicable in the terms of formal academic economics. It is this

utterly surprising reversal of yesterday's expertise which inspires the "initiation" of our World Game playing

We see then that during that same period of the two-thirds of a century, within which humanity was escalating from less than 1 percent to 40 percent of its numbers enjoying a higher standard of living than any historic king's, that the per-world-man amounts of the world's total metallic resources were continually diminishing Yet it was out of these ever diminishing per-capita metallic resources that all the machinery was contrived which in turn produced the high standard of living support of the forty-fold greater percentage of a simultaneously doubling human population

All the metals that have been mined and put to work are now invested in machinery and structures which operating at full capacity can take care of only 44 percent of humanity. That full capacity rate is 4 percent more than those actually being served. The unrealized difference is due to inefficiencies occurring in the use of the equipment.

How then can we explain that during the two-thirds of a century in which we rose from less than 1 to 40 percent of all humanity enjoying a higher standard of living (than had been realized by any pre-twentieth century monarch), that this realization occurred *despite* a continually diminishing percentage of metals per each world man-a ratio occasioned by human population increasing faster than humanity's discovery of new metallic ores

We can't say that the eighty-folding (40 percent of twice the original population) of the number of humans being taken care of, was accomplished by a greater exploitation of physical resources per capita We can explain the escalated physical success only by the fact that we have produced vastly higher end products and services performance with ever less tune, energy and weights of resource invested per each accomplished unit of end functioning, within our comprehensively evoluting, world around technological complex.

All the historical concepts of economic security of dry land man are predicated on doing more with more, that is, with wider, heavier and higher walls to protect him, more and more food in ever bigger gram bins and ice boxes, more and more money in ever bigger and more numerous banks-"secure as the Rock of Gibraltar." But this grand economic strategy of ever more profitable "tonnage" which assumes the heaviest and the- biggest must be the most successful is no longer valid. It ceased to articulate its validity in the economic indices of 1925 when "energy consumption" supplanted "tonnage" as the most sensitive and end-telling characteristic of the vitality of industry. (See *Fortune's* 10th Anniversary issue of 1940.) Despite *tonnages'* post-1925 invalidation the long-tune, conditioned reflexes of society and their economic intercourse conventions keeps this obsolete socio-economic viewpoint as yet "operative" for the 99 percent of humanity dwelling around the dry land surfaces of Earth.

Thorough investigation discloses that the *doing more with* less originated in the science of designing the combined cargo and weapons carriers of the sea and sky, where the ship of the sea had to float and the ship of the sky had to be *lifted* by pulling or pushing its wing foil through the air at supra-hurricane speeds. The ships of given sizes and tonnages of displacement which did the most with the least could out-perform all others and gave their possessors mastery of the planet Earth The doing-more-with-less technology which has now eighty-folded the numbers of economically successful humans came into being entirely within the "top secret" weapons carrying technology of the *sea, sky,* and *space.*

So the great economic change that has come about in the last two-thirds of a century has not come as a consequence of the declared policy of any of the political ideologies. To prove that statement we will employ the mathematical strategy of "Reductio ad absurdum." Let us take (hypothetically) all the machinery, engines, motors, pipes and wires away from all the countries around the world: from the communists and the capitalists alike: from the Europeans, Asians, North and South Americans, Africans and Australians, and dump all that machinery in the ocean. We find that without the industrial network of machinery, within six months two billion people (not two *million*) i.e. half of humanity-would die of starvation. That is how intimately the world's machinery is tied into the regeneration of human life. Since that proved to be a disastrous idea we will leave all the machinery where it now is and will leave all the people who know how to run that machinery at their jobs, and instead we will (hypothetically) take away

from all the world's countries, all the politicians of all and every kind of ideology and we will send them on a perpetual trip around the Sun accompanied by all their militarists. We will melt up all the guns and other weapons and stock pile the metals for manufacturing more machinery, to produce goods and services for more humans. As a consequence of the politicians' removal (computation quickly indicates) that as many people as had been eating would keep right on eating but that with the international political boundaries removed-the politicians being no longer present to enforce their barrier schemes and laws-man would stop "plowing under" and instead begin shipping more food and goods freely across the borders

Freed of their arbitrary political boundary controls humanity soon would stop the nonsense of using all of its highest scientific and technical capabilities only to knock one another out of the sea, sky or space. We would have to change the working assumptions We would accept and test science's word, that it is now possible to take care of all of humanity at a higher standard of living than any have ever known, *provided* we eliminate the sovereignties and stop wasting our resources on weaponry and experimental warfare

I propose that if anyone playing the game employs ideological biases and attempts to enforce the dominance of one by another through resort to guns that such players be disqualified. The game must be won by peaceful means, by the use of intelligence and proper use of our resources. The players will not compete. They will engage in cooperative exploration to see how all humanity can win a successful, pollution-free, life.

Prizes will be given in succession to those who computer accounting shows have attained the support of progressively greater numbers of human beings than had previously been attained. After final attainment of the support of all humanity at an unprecedentedly high standard of living prizes will go to those who discover ways of measurably accelerating the rate at which total success of humanity is attained. Then prizes will be given to those who successively improve the living standards for all while living within our "income" energy and not upon our savings account energy supply and thus guard the living of future generations of humanity to come. Finally, prizes will go to those who open progressively greater vistas of human and metaphysical interest in Universe, and to those who progressively enrichen human experience and reinspiration of others

Quite clearly the game will develop into a design revolution, not just of the tools themselves but of the services, and of the ways in which we organize the use of the computers; for instance, in programming the ticketing of people from here to there, in keeping the important tactical information available, and in keeping track of every available hotel bed and bath in the world. It is also perfectly feasible for the computer to keep track of every seat in every airplane around the world, the empties would be clearly registered. It is feasible for the computer to program any man's travel anywhere around the world, local or long distance, without having one man interfering with another.

Out of the large number of U.S.A. and Russian spy satellites now orbiting the Earth there has been an extraordinarily surprising fall-out of information vital to humanity. The spy satellites are equipped with sensors. The sensors can recognize the specific temperature of different types of woods, flesh, furs, metals, etc., each of which has specific temperature characteristics. Every system gives off energy. The sensors are able to pick up unique electromagnetic and thermodynamic frequencies, and to identify the whereabouts of discrete quantities of a multitude of unique objects. Recently one satellite has inadvertently been identifying, locating and counting the number of beef cattle grazing around Earth. Other sensors have been able to tell exactly what and where the living grain crop is. For the first time in man's Earthian history he can learn exactly where both his shifting and fixed resources are.

We have also reporting of the Earth's total weather patterns These can and will be correlated with the total crop patterns. We will know where the rains are, where the cattle and crops are and how the weather may eventually be guided to insure the crops. Thus we are to have extraordinary correlation of information resulting in the adequate support of all humanity. We will also know where all the people are and how they move about

Thus our confidence in the computers is progressively enhanced

Society has learned that no politician can ever yield to another politician. To do so means "losing face." But any politician can yield to the computer without "losing face." In fact he gains applause for his

logic and wisdom in so doing, for all of humanity is in agreement that for even a brilliant, beautifully trained, astronaut to defer to the computer is not an admittance of intellectual or physical inadequacy nor of incompetence or poor judgment. Quite the reverse. It is the astronauts superior knowledge of the computers' capability and his superb coordination with and reliance upon the strategems and tools of science which win society's spontaneous confidence and admiration

The most trusted senior airlines pilot does not "lose face" when he says, "It is not up to my physical senses to get us through the clouds. I cannot possibly navigate through the night and cloud with my bare senses "

The politicians are going to confess the obvious-that "No human beings can keep in mind all the special interests of all people and all the whereabouts and unique interbehaviors of all the resources of the Earth." No human beings can persuade other people to behave in various unfamiliar, untried ways, but the computer can integrate and disclose the critical information, and be completely convincing to all in respect to which of various programmed patterns the computer selects as being of the most long run benefit and least cost to society Any one of us can yield becomingly to the computer

I am quite confident that as the world game is played progressively it will disclose a myriad of politically untried, unprecedented yet amazingly effective ways of solving hitherto unsurmountable world-around problems

These unprecedented computer disclosures will not only be kept track of by the computer but will become "big news" items of the world's press, and of the international news wire services As man gets into more and more critical proximity to a full scale World War Three, due to the inherent political biases and intransigence, the people of the world will begin to say in increasing numbers, "Now that we can see a way in which this and that can be done, as indicated by the computerized World Game, we must obviously adopt the policies indicated by the computer."

The popular pressures will gradually force world politics to yield to the computer-indicated, mutually-beneficial world programs. There will ensue a series of world "summit conferences" and a series of computerized treaties of the world powers.

The computers will show all men everywhere that automated machinery can produce much more wealth than man's muscles and conditioned reflexes. The computers will indicate that everyone in the world must go back to school and learn about all of humanity aboard Spaceship Earth and of their combined potentials. The computer will stop humanity from competing as a machine against the machine. It will put everyone in research and development. It will allow the machines to generate copious wealth. The computer will show that when everyone has gone back to school or into research and development at a tax free, generously adequate income-peak *loads* and *bottlenecks* will subside-service capacity will swiftly increase, birth rates will decelerate further.

The World Game playing computer will disclose the vast overall, longtime economy of paying whatever it costs to eliminate pollution at sources. The computer will show the overall long-run increase profit and economic advantage to society of switching our prime moving away from expenditures of our fossil fuel energy savings account, and *to* energy income sources

Now what happened about my original, 1964, "World Game" proposal was that the United States did not adopt it.

I was asked by Mr. John Gardner, then head of the Carnegie Foundation, to have lunch with his staff to discuss their possible support of our Southern Illinois University world resources inventorying and its publishing. To emphasize the importance of that inventory I told them about the U.S.'s rejection of my World Game for the resource inventory at Southern Illinois University would be the prime essential to the playing of the game. When I completed my description of the game and its rejection by the government to the assembled officers and staff of the Carnegie Foundation, John Gardner said, "That's such a good idea I think all the foundations in the United States should get together to pay for, install and *run* it at the Montreal World's Fair." Right after the luncheon however, Mr. Gardner was asked to join President Johnson's cabinet and his Washington problems averted his thoughts from my World Game

Southern Illinois University, where I am a Professor, is about to celebrate its centennial. Though the

charter for Southern Illinois University had been granted by the State of Illinois in 1869 the University did not begin operations until 5 years later in 1874. For those and other reasons Southern Illinois University is planning to have its centennial run for 5 years-from 1969 to 1974.

President Delyte Morris and some of his University officers asked me to make suggestions regarding their plans for the 5-year centennial. They wished to inaugurate some kind of activity that would bring world scholars and leaders in many fields to Southern Illinois University. To attract them Southern Illinois University foresaw that they would have to initiate some fundamental contribution toward humanity's realization of its highest potential. I then told them about the World Game. This interested them. Since that meeting they have tentatively undertaken to make the World Game one of the features of their centennial. Obviously, we won't be able to start full-scale operation in 1968, but we probably can get it going before the 5-year centennial celebration is completed.

The whole idea has progressed. A feasibility study has been completed. It indicates a sixteen million dollar budget for buildings, computer equipment, and general maintenance.

The legislature of the State of Illinois has passed a bill appropriating four million dollars as a "matching fund" to be activated only by another twelve million dollars to be appropriated by others, e.g., the Federal Government, foundations or private enterprise; the Governor of Illinois signed the bill into law; the fact that the State of Illinois has already subscribed matching funds should be very attractive to foundations and others who may consider backing the World Game Usually the foundations and the Federal Government are quicker to act than are the States.

As yet there has been no soliciting of aid from either the federal government, foundations or private enterprise; but that is about to be started

There is another powerful factor that needs to be considered. I have learned from a major American publisher that the news rights on this World Game are going to be extremely valuable and that some publisher may be willing to pay as much as a million dollars for first news publishing rights on the progressive disclosures of the World Game playing. The concepts to be disclosed will become more important than the Gallup Poll releases. The public reaction to the World Game's proposals may well be processed by regular Gallup and other polls

Since human babies and children demonstrate an intense interest in all things in all directions from the stars to the atoms, from whales to butterflies, and from wintry indoors to summery outdoors it is obvious that they are not designed to be specialists If nature intended humans to be specialists, she would have delivered them at birth with *a* vast variety of integral equipment, for instance with one eye and a microscope attached. Nature designs all kinds of specialist birds with integrally attached wings which greatly hamper the birds hobbled walking

Humans are unique amongst all living creatures in their degree of general adaptability to all the extremes of environmental changes, which include. the capability of the human to extract generalized principles from his special case experiences and his teleological capability developed thereby to rearrange the environment, as by the generalized principle of leverage. Man is teleologically equipped to cope with and survive within extreme variations of the environment that would be lethal to any naked human or other living species Man can put on and take off his wings and telescopic eyes

We may conclude that human society's deliberately cultivated specialization is unnatural and debilitating to both its group and individual welfaring and evolutionary development. We may well ask how it happened that the entire scheme of advanced education is devoted exclusively to ever narrower specialization

We find that the historical beginnings of schools and tutoring were established, and economically supported by illiterate and vastly ambitious warlords who required a wide variety of highly specialized brain slaves with which to logistically and ballistically o'erwhelm those who opposed their expansion of physical conquest. They also simultaneously DIVIDED and CONQUERED any and all "bright ones" who might otherwise rise within their realms to threaten their supremacy. The war lord vitiated their threat by making them all specialists and reserving to himself exclusively the right to think about and act comprehensively. The war lord made all those about him differentiators and reserved the function of integration to himself.

So important were the brain slaves' developing schools, as assets of the physically mighty, that they had their own sons and their henchmen's (noble's) sons attend the brain developing schools as liberal arts bachelors in order to familiarize themselves with the ramifications of this most important resource for effectively detailing the realm's capabilities, which they, the top men, would secretly integrate into the grand strategy of their realms' conquests and the guarding and maintaining of this ruling might, over the commonwealth productivity of the realms' peasantry and the latter's support of the non-productive soldiers. They then schooled their "noble birth" sons, equally diligently, in the mastery of arms, horses and fighting men. So old and dignified by time have such brain slaves developing schools become, that their origins have been forgotten and remain as yet unrediscovered by an ever more widely literate society whose often illiterate political leaders always have been assured of election through their promises to get the rich man's schooling facilities for their low-or-no-income constituents

Now, biological and anthropological scientists have discovered and verified that *extinction* of past biological species and human tribes always has been the consequence of overspecialization

The extinctions are consequences of the following set of scientific facts

"A." Nature's high energy devastations are far less frequent than her low energy disturbances of the regenerative biological life patterns. In the physical interchangings and local transformations of universe the numbers of occasions on which nature will have large amounts of energy concentrated at any one locality to effect great changes is far less frequent than the number of times she will have small amounts of energy at any one locality to effect small changes. Insects and microbes are far more frequent and numerous than are tornadoes and earthquakes

"B." When inbreeding toward greater biological specialization occurs, the concentration of similar genes tends to dominate at the expense of general adaptability. Specialized, ergo, generally vulnerable species may survive during long periods of low energy environmental confrontations, all the time increasing their special advantage while losing their unused general adaptability. Inevitably however the infrequent high energy change imposing event occurs. Bereft of general adaptability, the specialist is unable to cope with the unfamiliar and overwhelming magnitude and velocity of events. Thus devastated they became extinct.

Humanity lost its physical world masters soon after World War One, when they too abandoning their comprehensive command to the world military, became extinct through their over-specialization in exclusively sensorial judgments and their brain slaves scientists wandered off into the vast and utterly non-sensorial ranges of the electromagnetic spectrum's (invisible) reality

With the old pirate masters extinct, society accepted unquestioningly the momentum of the utterly specialized educational trending. Specialization was never questioned as being other than logical, inevitable and desirable

Humans as super-specialists have now developed the atomic energy capability to blow themselves to eternity, with no integrating capability to turn the vast energies to the comprehensive advantaging and regeneration of all humanity, and thus avoid swift, self-imposed extinction.

But evolution, apparently intent to continue man's existence aboard Spaceship Earth as its most effective metaphysical protagonist, has produced the anti-body to his extinction. The anti-body to his extinction is man's invention and development (under exclusively cold warring auspices) of the electronic computers. The computers are about to make humans obsolete, as either intellectual specialists or as specialized muscle and conditioned reflex automatons. The computers and automation can completely out-perform man as either specialized intellectual differentiators or as wealth producing tools which will be able to secure humanity's forward days of metabolic regeneration. The computers can work all night, at super human speeds, selecting the blues from the *greens* under environmental conditions intolerable to man.

So the computer will, as an enormously expanded and accelerated brain facility, enter into an omni-man-serving function altogether replacing the inadequate public policy formulations of politicians. Men will act as local managers of the computer discovered ways and means of serving the best interests of all men for the longest foreseeable ages

The programs that the computers will select as being most favorable for all humanity will go far beyond man's ignorant ways of assessing what he "can afford." The computer will demonstrate that he can afford nothing short of the best, which is to make all the Spaceship Earth a successful developmental environment for universe exploring man.

* * * * * * *

In 1810 the U.S. Treasury Department calculated by a national census that the total wealth present in the U.S.A.'s developed facilities and undeveloped wilderness was worth a total of three billion dollars. The telegraph and railroad were as yet undreamed of, let alone the whole array of modern scientific technology and industrialization. The wisest and most farseeing citizens of 1810 would have said that any such technology as has been since developed was only the conceptioning of lunatics and that society could only afford to invest its annual income and not its capital to develop man's further economic advantages

This would have meant 5% of three billion dollars to be invested annually in research and development; that is, one hundred and fifty million dollars a year. For a 1.50 year period, 1810-1960, that would have meant that we could only have afforded to make a total 150 year's cumulative investment of 150X$150,000=22½ billion dollars.

Forced entirely by next war, or present war, emergency conditions in the United States during those ensuing 150 years, we say that we have "spent" 1,000 times that amount in acquiring all the vast tool networks of industrialization which are now, altogether, producing an annual income close to a trillion dollars. This earning figure means, on a conservative basis, that the physical plant of our U.S.A. industrialization, which includes highways, *et al*, is worth twenty-two trillion dollars. This is to say that while we thought we were "spending" a thousand fold what we could afford, we have established instead an entirely paid for, in fact, wealth producing capability worth at least one thousand times what we thought we had "spent" $22,000,000,000→$22,000,000,000,000. What we have now

Our capital obviously isn't spent as the organized energy processing national plant to produce more wealth for more people for more of their healthy years.

In 1810 the U.S.A. Treasury found there were one million U.S.A. families and one million human slaves, or an average of one per family, with no steam engines, motors or any other work producing machines than the one slave per family could provide. Now only one hundred and fifty years later we have over 1,000 inanimate energy slaves per each family, and no human slaves, with the inanimate energy slaves being utterly tireless and able to work 24 hours a day, year around, under physical conditions intolerable to humans

All this is to say that as the computer confronts man with the price tag of the work that has to be done in the next three decades to make all of his planet Earth a success for all humanity, it will be preposterous of organized society to say we cannot afford to do these things. But the probability from the past record is that despite all the political hand wringing world society will buy the chance to be successful, and once again we will find that wealth can only increase and that we will in fact demonstrate that we could and did afford to be logical. Wealth is irreversible, andhaving attained all we need for all, we will be so obviously wealthy as to be able to afford to make eternally wise everyday decisions

Who dares to buy the World Game package, no matter what its initial cost will convert the trend of humanity toward extinction into a trend toward universal physical and metaphysical success

These are the thoughts and insights evoked by the first assimilated playing of the World Game

1. Dymaxion Map-patented and copyrighted (1946) as first map with no visible distortion in a planar (flat) projection.
2. Originally sidestepped because we believed erroneously that we "couldn't afford" their correction.
3. Dr. Fuller's book, "Operating Manual for Spaceship Earth," Southern Illinois University Press, 1969, retained in subcommittee files.
4. See B.F.'s article in I.B.M.'s Think Magazine, Jan.-Feb. 1968.
5. Our world game will be in effect a world brain. It will free world mind from occupations of brain slavery. Human minds employ the world brain to solve the problems of all humanity thus escaping the previous recourse only to the individual opinions of too myopically preoccupied ill-informed men.

Your opener has convinced me once again that we ought to listen more here

You know, we had a little bit of a discussion, I guess you might call it an argument, on the Senate floor about a month ago with respect to this very committee.

Implicit in what you had to say were several things of interest

One, we are too preoccupied about the effects and thought causes. We don't really understand the causes of all of the manifestations of nature and man's impact upon nature, and so we get all tangled up in causes

For example, I had to justify the budget for this subcommittee on the Senate floor. And so I was asked what this committee did. And I mentioned that one of the things we were trying to do was create this select committee on technology and the human environment. "Well, why do we need it" was the question "After all, we have a Public Works Committee which deals with air and water pollution, and you in that committee produced a lot of effective legislation to deal with it, so why do you need this special committee that trespasses upon the jurisdiction of the Public Works Committee?"

Well, my answer was that the legislation we produced was produced as the result of man's mistakes in the past and what we are trying to do is understand this environment in order to avoid those mistakes

You made so many very useful observations and illuminating observations

Did I understand you to say that 40 percent of humanity now enjoys a higher standard of living than any king did prior to this century?

Mr. Fuller. That is right.

Senator Muskie. Well, this is an interesting perspective which I have never had before If that is true, I suppose it is a basis for optimism. But then a second point you made was a lot, if not all, of the important technological advances which we have enjoyed and which perhaps contributed to that result is the product of our military activities. If it weren't for the pressure of war, we would not have developed the technology which has made possible the high standard of living we now have. So I understand that is the point you made.

Mr. Fuller. Yes.

Senator Muskie. I think you made it very clear the cart really is before the horse as we consider that.

Mr. Fuller. I would like to mention, sir, that evolution is inexorably at work, and in order to get man to do what needs to be done when he is ignorant, the built-in drive of fear is provided. I am saying to you, for instance, that if your committee cannot persuade our Government to enact laws which will develop enough of the right technology ***to*** do this and that which evolution is intent upon accomplishing, then that technology will appear in China or elsewhere and thus get into the bloodstream of evolutionary realizations. The faculties of man, his brain, his mind, his inventive capabilities are all part of these a priori principals operating in the universe. And evolution is articulating itself in a very important kind of way.

To be able to really understand you have to teach and maintain this comprehensive degree of thinking I would say that man has a function in the universe, this we discover clearly

We know scientifically that all local physical systems are continually giving off energies. We call this entropy. Due to each of the local systems unique periodicities, and so forth, the given off energies are diffuse and randomly released in respect to other systems. 'Thus the physical universe is continually expanding and increasingly disorderly. Fundamental *complementarity* requires that there must be some phase of universe where the universe is contracting and increasingly orderly

We look at all the stars and find that we "see" them only because they are giving off energies in increasing disorder. We call this radiation. We find only one place in the universe where we know energies are converging, collecting, and being stored and that is our spaceship earth * * * our planet. In the International Geophysical Year, world-around measurements indicated that approximately 100,000 tons of stardust are accumulated daily' aboard earth from other stars. Thus energy is being collected here as matter. We also are collecting an enormous amount of radiation from the other stars, primarily from the sun but also as cosmic radiation from myriads of other stars. The energy either as stardust or radiated increments arrives in a very random frequency pattern. We may state it to be experimentally proven that our special space vehicle earth is at least one mobile energy collecting center in contradistinction to the stars which are

energy distributors. The sun's energy radiation is not being reflected off earth as from a mirrored ball. It is refracted, or angularly deflected, by the atmosphere. Thus the sun energy as heat is impounded in the atmosphere to produce weather changes. Thus also are the waters refractionally heated by the sun's radiation Thus by a series of relay stages is energy impounded aboard our spaceship earth to regenerate life by the photosynthesis of the vegetation which is a beautiful process whereby the random energy receipts are transformed chemically into beautiful, orderly molecules which are beautiful structures. Here you see the turnaround from disorder to order-from entropy to syntropy.

All the biologicals are converting chaos to beautiful order. All biology is antientropic. Of all the disorder to order converters, the human mind is by far the most impressive. The human's most powerful metaphysical drive is to understand, to order, to sort out, and rearrange in ever more orderly and understandably constructive ways. You find then that man's true function is metaphysical. Man's physical function is the same as that of all other biological life; to impound and regenerate physical life which means inherently to produce reconstructive order of every variety. The metaphysical, absolutely weightless function in universe, unique to humans, is that of continually looking for the generalized principles which are operative in all the special case experiences. Thus has humanity discovered that it could move and constructively rearrange multiton rocks that man's individual muscle could not move. He succeeded by his weightless mind's discovery of the generalized principle of leverage. Thus also did mind discover the principles of electron conductivity, whatever that may be, for electromagnetics, though discovered and used by man, is as yet a fundamental enigma

These generalized principles were all found to be operating a priori to man. Man simply finds and employs. He does not put anything into the universe. We must realize that technology was not put into the universe by man. The universe is the comprehensive system of technology. Humanity is discovering and beginning to employ it. The human mind has the capability. The human mind invented the computer as an extension of humanity's integral computer, information storing and retrieving system, the brain. The computer and the automated technologies they command are about to take over all specialized tasks from humans, thus saving humanity from becoming extinct, for biological science and anthropology have learned incontrovertibly that extinction is always the consequence of over specialization.[5] The human mind, as Einstein's metaphysical, weightless intellect, discovered and noted in written symbols the equation of the physical portion of universe-that physical portion of universe which consists entirely of energy; energy in two diametrically opposed, intercomplementing and intertransformable behavioral conditions. The one phase is energy associated as matter symbolized as M, and the other phase is energy disassociative as radiation, symbolized as C-and the rate of the associative phase is in terms of second power of the Michelson; Morley measured speed of light which is scientifically notationed as C^2 which equals the rate of growth of a radiation "bubble's" spherical surface growth, $E=MC^2$.

In Einstein's perceptivity and initiative we have the metaphysical mind taking the measure of the physical This relationship is irreversible We have no suggestion that energy will ever conceive of and write the equation of intellect. The Nobel prize in physics was given in 1956 for discovery of this irreversibility principle of the complementarily but non-mirror-imaged balancing of positive-negative events. Evolution thus became recognized as irreversible We find here the clue to the coherence and integrity of the universe which can never lose its energy quota. Universe is the minimum perpetual energy conserving complex of technological intratransformings. Metaphysical intellect and its ability to comprehend and master the intertransformative technology of universe and to reconvene and reconcentrate the physical disorder into conserved order is possibly the highest order, separately discernible function in universe. Mortal, physical human bodies have the function of providing a regenerative succession of fresh physical vehicles for the mortal-because entropic-articulation of metaphysical immortality. The long-held popular conception of the existence of two kinds of physical substances-one called animate and the other inanimate-the first rather mystically maintained and the other subject to stark chemical analysis, was altogether invalidated as science closed in on the assumed threshold between the animate and inanimate at' the virus level only to find that there is no threshold and that all the phenomena followed strictly inanimate physical laws. So we

find the real separation of the life and the inanimate when humans die and no weight is lost. Life is metaphysical and syntropic The inanimate is physical and entropic

Humans have high destiny, possibly the most important in universe. And if the human team aboard space vehicle Earth does not make good at this particular occupation of this particular planet there are probably billions times billions of other planets with human crews aboard who will reboard Earth at some time to operate it properly. We are then a necessary function of universe. If you are going to be wise in this committee, you are going to have to look at things in these big ways

I think we are going to have to find some other kind of candidates to run for the Senate for that kind of wisdom.

From Congressional Record

Proceedings and Debates of the 91st Congress, Second Session

May 15, 1970

Extensions of Remarks

Address by Mr. R. Buckminster Fuller

Hon. Gerald R. Ford of Michigan in the House of Representatives

Thursday, May 14, 1970

Mr. Speaker, the views of Mr. R. Buckminster Fuller are usually original in approach and always stimulating He gave a very interesting speech at the Navy League's Oceanic Maritime Symposium last February, a transcript of which has just become available. It follows:

Keynote Address by R. Buckminster Fuller at Navy League Oceanic-Maritime Symposium, February 17, 1970

Thank you very much. I always find it necessary when I am greeted so warmly, and hear myself spoken of in a way that I hardly recognize, to point out that I am confident the only reason I have ever been heard of is because I set out to deliberately be a comprehensionist, in a world that seems to be completely preoccupied with specialization. I became a comprehensionist because, by good fortune, I did go into the Navy and I did get to the Naval Academy in a special course at the time of World War I. One of the things that impressed me very much was that Alfred North Whitehead at Harvard, who had come to us from Europe, pointed out that Harvard was instituting a new phase of advanced education. He said that, whereas the advanced scholar at the European University could find the authorities on various specilized subjects-and did make it their business to find them-there were no specialized schools as part of the general university. But Harvard was the first to institute completely separate specialized schools, with separate campuses, separate faculties and separate buildings in graduate schools Whitehead pointed out that America applauded, and one school after another, first the private schools and then the public schools, copied this specialization

America liked the idea of all-star teams and felt that the development of advanced expertise would mean that we would have great stars and that this would be very good for the commonwealth. But Whitehead brilliantly pointed out that the stars who were selected for specilization were the brightest ones and we deliberately tried to persuade them to go on to graduate schools. These individuals, particularly the scientists, were specialized, with all their energies focused on their narrow fields. In other words, they went out linearly. Though this gave them great linear acceleration, it also resulted in creating ever increasing separation, one from the other. This specialization did not permit them to integrate their work, which is what society hoped they would do. Thus, because we had deliberately sifted out the bright ones and made them specialists, and the specialists couldn't put their own work together, the task of putting things together was left to the not-as-bright, and that is pretty much the way it is in our world today. The more specialized, the more brilliant the work of the specialists, the less effective and competent seems the ability to make our total world work, since this same brilliant work requires more generalized political positions.

At any rate, at the Naval Academy I found this strategy of education being completely reversed. There, they were sorting out the bright ones and deliberately setting out to make them generalists, with capabilities in many directions. This made me think a whole lot. It was very clear, for example, that three quarters of our earth was covered with water and that the waters were outside the laws of any of the lands. The water areas of the earth were therefore occupied by whoever was able to master them, since no sovereignty could be expressed over this three quarters of the earth. There would be simply one great

master, and great wealth was to be realized through such mastery by those who were simply able to dispose of the others

As we were brought up in our history, we learned of the great empires, Ghengis Khan, The Roman Empire and Alexander. All these empires grew up when Man was thinking of the earth as a flat surface. An empire in those days was a postage stamp, a rough-edged postage stamp of civilization. Outside of it you encountered very unreliable people, wild people, and then beyond, you came to the dragons

It was never pointed out to us in our history that the British Empire was the first spherical empire. Nor that the others were planar empires. And because they were planar empires they went to infinity. Because they went to infinity the number of variables that would be operative in an infinite system would be infinite in number and if you didn't like what was going on, there was always a chance you could find one of the gods who would take care of it. People had a whole lot of hope in those days.

160 years ago Thomas Malthus, the first economist in the history of Man, was receiving the vital statistics from a closed system, from the spherical British empire. Because of the closed system, his data showed that humanity apparently is reproducing itself much more rapidly than it is producing to support itself

Later, in Malthus' second book, printed in 1810, we found that Man seemed to be reproducing himself at a geometrical rate and producing the support only at an arithmetical rate. We have from Thomas Malthus the first closed system, seemingly scientific, statement that there was not nearly enough to go around, and man was designed to be a failure. Only relatively few can survive. Those who survived in those days were the "ins" of their time. They were the masters of what we call the British Empire, not merely the British Isles. They were masters of the world; they commanded the seas. They had the most unsinkable of the fleets.

The British took their scientists around the world to see what resources there were in this closed system. Darwin was amongst them. Darwin was able then, with other biologists, to identify what seemed to be all the living species He found great interrelatedness among the designs of species, and Darwin developed his theory of evolution

I want you to realize that Darwin could not have developed a theory of evolution in a planar earth that went to infinity, because he would have had to include dragons to the nth power. You can only have this kind of competent thinking when you realize you have closed systems and know what the closed system is. Thus, we have in the last century Malthus making seemingly scientifically clear that there was nowhere nearly enough to go around in this closed system, and we have Darwin explaining his theory of evolution and survival of the fittest. At this same time, those masters of the earth by virtues of their mastery of the seas were saying that they were apparently the best informed and the most powerful, and therefore the fittest.

After a century and a half of this kind of thinking in state craft, nobody yet knows just how much or how many could really be supported Despite various alliances, the working assumption is that Armageddon is inevitable because there is not enough to go around. For the young individuals who had the muscle, it was: better get your sword while you can because if you don't claim yours while you are strong you will rot in the slums where men die at the average age of twenty-seven. Even some at the Naval Academy are still carrying a sword. This precept carried over to the mass organization of States, looking out for the Armageddon each carrying its sword or gun

Now there have evolved some new conditions for man and strangely enough as a consequence of our own Navy. The fundamental something I find is the great difference between the ways of thinking about the sea and about the land. It is in no way understood by our world's society at large, 99.9% of man being landed. And I find that even though the Navy thinks in a characteristic way, they themselves do not realize the difference in the way they think from the way the landed man thinks.

But I would like to point out that on the land men who had found a place where they seemed to be able to prosper found themselves having to guard it. There were a great many who had not been prospering who came their way very hungry and who would give their life to displace them.

So the great strategy of survival on the land had been by fortification. You built a fortress around a well and put up strong walled granaries. When you saw people coming who were going to bother you, you took all your food inside and left nothing outside. The people arrived hungry and you who were eating well inside watched from your walls. When they were good and weak, then you went out and decimated them. That worked very well for thousands of years. On the land men thought of their security in terms of the width-the heavier the walls and the higher the walls, the bigger the grain bin-the bigger, the bigger-the more secure. And that is still the primary thinking of our fellow men.

But if you went to sea in a stone boat, it wouldn't do you any good. At sea, there is no law outside of your own. If you have two great men, with two great aspirations at sea, clearly whoever wants to run the show sends the other man to the bottom

Granted that Archimedes discovered his beautiful principle of displacement in a bath tub; on land, men had learned about floating earlier. Two ships of the same size, displacing the same amount of water, were understood to float exactly the same amount of weight. You see your rival building a ship on the ways. He has learned from the sea, as you have, various tricks and knows this to be the right size ship for him, it is going to be a beauty. And you know what the length is, you know what the beam is, you know what the draft is, and, thus, very easily, you know all she can weigh. So, you can build one the same. But, if you know, as a result of sailing around the world, that in a place called Sitka, the spruce trees make better spars, you know that in a place like the Philippines you can get better fibers for your ropes and in Egypt, better sails, your ship need not be quite the same. When you're stalking your enemy forty miles over the curvature of the earth and you wait to make contact, and when it is really blowing and he has to take off the sails because his mast is not as strong and his ropes are not as strong as yours, he is the one who goes to the bottom. Whoever then, with the same weight, could do the most with the least was the one who stays on top. And you never knew until contact who had found the strongest ropes. In other words, at sea everything depends on doing more with less

Whoever had the best gear so that in the shortest time sail could be gotten on or off, whoever had most energy in the muscles on board his ship, the most adequate metabolic support, whoever could get the most out of a pound and a minute and an erg is the one who is going to prevail. That's all there was to it then. The Sea was the most extraordinary laboratory of engineering for doing more with less, and really doing more with less was such a fundamental secret of navies that this is the secret you found necessary to hide. Anybody could see the size of your ship but they didn't know what you could do with that kind of tonnage So this is the most classified thing we had and drawings were methodically done away with as fast as you built your ship. So there is not a book, there is not a chapter, there is not a sentence in any book about economics about doing more with less

And this is the very essence of the Navy And then, of course, it became the essence of the air because in the air we had to do even more with less because your aircraft couldn't float. She had to be pulled through the sky at hurricane speed to give her lift. And you had to do more with less weight of engine and weight of fuel and so forth. Once in the air, the doing more with less became an even more prodigious battle.

The doing more with less that came out of Navy and air has changed our world. In this century we've gone from less than one percent of humanity to forty percent of humanity enjoying a higher standard of living than any king we knew of before the 20th century. This is despite the fact that during that time the resources per capita has been continually decreasing. The way we got to taking care of forty percent of the people was by doing more with less. And this is not in the economics books. It is not in general policy either. This is what was hidden away. That is why I want to emphasize the curve of doing more with less today while we are thinking about the seas today and what is opening up on the oceans for mankind As we get going horizontally around our world, gravity is giving you brakes and stops you. A child learns quickly he can run and stop very fast When he starts falling out of a tree, gravity is pulling him, there are no brakes Man is very careful about the vertical coping with nature. With ships we have been obliged to keep this vertical constraint always in mind

On the land, our automobiles are so ill-designed conceptually that we have killed more people with

automobiles in this country than we have killed by all the warring men have done in all history. Just think of it. But the sea's threat of gravity was so great that men designed those ships very, very carefully. And man at sea has been very thoughtful of the other man at sea, the dramatics of that gravity are so great. With airplanes it is even more so. Now we really cope with it vertically in our rocketry, due to the dramatic awareness in our hearts of the power of gravity. The weight and the compactness of what you do has to be so great that we do so much with so little in that rocketry, and we do it so well, that astronauts of the various countries are almost getting into the kind of mileage we have done with air without the loss of one life. Not one life. This is how well it's been done. Just think of what we have accomplished there with so little weight and the reliability that has been established.

So I say that out of the curve of doing more with less, there is a fall-out. We had generators in the Navy for about twenty years before we had enough excess power to begin to sell it to the towns; then they just simply put it back into the candles. This old pattern of the land is simply so archaic, you can't find anybody who knows what a building weighs. I have met with architects all around the world and I say "Would you please tell me what the building we're in weighs?" Anybody? No hands "Just roughly within a hundred thousand tons?" No tons. If you don't know what a building weighs, you certainly don't know what your performance per pound is. I just want to point out that in our land economics we are not using any of the thinking that went into the sea. And it has been entirely a fall-out of the sea that is making man a success on the land today. First electricity. We had refrigeration on our battleships twenty years before it came out on the land. We were making steel in the blast furnaces for our ships fifty years before we put a piece of steel in a building on the land All this great change has come from the sea

There is great promise here, and the reason I am stressing this is that it bears on how to begin to think about what we are going to do about our world, and our world is in a mess. It is a horrible mess. You find the men on the land very short sighted. People on the land think in terms of agriculture, they think of this year's crop. This year's profit. When you do something at sea, you plan. Preparing a Navy was a design-science undertaking that takes at least twenty-five years; a generation And there's not a single thing in the Navy you pick off a tree. It all had to be designed. The most extraordinary, comprehensive, anticipatory design

And now a word on our astronomy. I find our society today talks about predictions as if it were something very new. But the astronomers have been able for a long time to be able to tell just what each one star is going to be doing for many thousands of years. That's why you can have a planetarium. Our universe is fantastically reliable-both macrocosmically and microcosmically. But here is little man on our little planet. The way air travel and air navigation is conducted it doesn't matter whether it is an Ethiopian flying it or an Indian. The power structure goes out the window once you are in the sky. The reliability is just magnificent. The integrity of navigation is absolutely transcendental to the sovereignty of nations. When we land the ground control takes over There is a little preference given to the airlines over the private plane here When you go through the customs gate, then all hell breaks loose

Throughout the universe, the only part that is unreliable is here at the surface of our earth. Man is behaving very badly in his great ignorance He thinks with the short sightedness of agricultural undertakings when to do anything really important you have to think at least twenty-five years ahead. Our governments come in for four years and so forth. Nobody has the authority to think really in a very big way, except in terms of the defense-outside the country. So, navies did think in big ways. They thought in enormous ways. Their thinking has been magnificent. The point we should remember on our planet earth curve is that all unexpected improvement is fallout of that competent long distance thinking.

We have gotten to the point where forty percent of humanity is being taken care of at a higher standard of living than anybody has ever known. Were it not for the preoccupation in a negative way of Russia and the United States for arming against each other, Russia's production could have affluence, truly affluent, and they would like to have it, after all their five year planning. Their fine productivity is still going into making weapons against everybody. If Russia is relieved from that, we will have more than fifty percent affluent. The majority of humanity would be affluent for the first time in the history of man. So long as ninety-nine percent were desperate, you always had a revolution. You couldn't help it. But with

more than fifty percent successful, we have a very different volition. Where the majority is successful, they realize they can never be happy till everybody is taken care of and we may have a very different switch in the situation

We are coming to that critical moment. When we go by the fifty percent point which will be somewhere in the early 70s, if we survive on the earth at all, then we will have politicians beginning to say how do we make the rest of man successful in the very shortest time. Up until now, I think we have been given a very great cushion for our ignorance on earth. I would like you to think a little bit of how ignorant we still are, because man tends to be very, very vain. But as a sailorman, you don't kid yourself. You don't pretend you know how to get through that fog if you haven't got a compass. You don't kid yourself. So I just pointed out to you that scientists had five hundred years to get themselves adjusted to the idea the world was round and they haven't done anything about it. They all still see the sun setting. And does anybody use the words "up and down?" Anybody in this room that doesn't use the words "up" and "down?" Show hands. Okay. The words "up" and "down" were invented to accommodate the concept of a flat earth going to infinity. All lines perpendicular to a flat surface only go in two directions-up and down.

We haven't adjusted at all to that new kind of a world that is a spherical world. We have known this theoretically for a long time, but we don't do anything about it in our senses, nor do we change any of our habits. We say we got on very well like this before, we are going to keep right on. If it is a flat earth, then again it goes to infinity. You have infinite room to pollute. You don't have to worry about pollution. And it has been your experience that it's so big that you always found more resources after exhausting the known ones But as a closed system, no!

You'd think that with our moon undertaking, we might really have had kind of a breakthrough with our senses. But Conrad spoke to the people of the world about being up here on the moon and the President congratulated the astronauts on going up to the moon and getting back here down to earth. And we hear people saying, "never mind that space up there now, let's get down to earth." You should say "where's that?" "Where is down to earth?" That's our flat concept still coming through Anybody who says you must be practical, let's get down to earth, doesn't know what he's talking about. Don't listen to him, ever

This is the mood you have to go into here talking about our resources Man, in his great ignorance has gone on polluting thinking of all that room. With infinite space, it's all right to be short-sighted. For this year's profits, we're out to burn up all of our fossil fuel. But why worry about our great-great grandchildren. It takes a good profit to get re-elected president of the board. The Lord has allowed us to be ignorant up to now so we would have enough experience to really learn something

By now we should have had enough experience to really learn something: To discover that our strength is not in our muscles; that our strength is in our minds; To discover the principle of leverage; To learn how to put levers one behind another around a wheel, put it under the waterfall; How to organize nature to develop work for us. Because all we mean by wealth is the ability to regenerate life on earth. I have asked many, many audiences around the world the following:

"No matter what you think what wealth is, and I am sure everybody in this room has a little different idea about what wealth is. Is there anybody in this room who will disagree with me when I say that no matter how much you have of it, you can't alter one iota of yesterday?" I never see any hands.

You can forget about yesterday if you want to think about wealth. It has something to do with today and tomorrow. It is a capability. And all it really means is the ability to regenerate life, this is metabolics. It is the mind, the metaphysical mind, and master of the physical.

We also in our great ignorance talk about the United States as a nation. We are not a nation, we are the most cross-bred phase of humanity. We are beginning to be world man. We are a little of all humanity. There have been pools of cross-breeding world man, India and Mexico before us. And in Mexico you see every shape of face, every shape of head, and every shade of color; there's no race. We have a new world man and cross-breeding on this continent and we have a lot of opportunity now. The resources are so abundant as to allow us to be very ignorant and to make enough experiments to find by trial and error what

we really have of any importance. And what we have is a mind. And we are really going to have to start using the mind now or we'll all perish very shortly.

I like to think that with our fellow men around the world we had great friendship until recently. In no time at all that friendship had deteriorated. There is a very negative attitude toward people on this continent. I don't suppose that everybody in America realizes how we've fallen out of esteem because we seem to be so shortsighted I travel around the world and find this to be the case Since we are shortsighted, we were very fortunate to inherit all the experience of those before us. Just remember that in China in 400 B.C. they had quaternary alloys. We inherited the information on the isolation of the chemical elements-only two of the 92 chemical elements were isolated in this country. We inherited all those kinds of capabilities. And the world has been looking to us askance, because we are very powerful and seemingly falling into the bad habits of yesterday's sovereignty. Just as the old people who had learned it wouldn't work any more were giving it up, we were seemingly stressing our great power

I think it is very important to begin to talk more about our oceans. I see our oceans as the great teacher that taught us engineering, taught us navigation, forced us to really develop mathematics, forced us to use the capabilities of the mind. The little man on that boat feels awfully tiny on that sea. If he doesn't really use this thing, he's lost. Now consider all of humanity are passengers aboard our little space ship earth, superbly supplied, superbly designed So superbly designed that it has been able to support humanity for four million years without even knowing it was aboard ship. That's quite a design! To be foolproof for four million years. But it's not infinitely foolproof.

So it would be very great if the message goes out from America that the world's people are shipmates who have for the moment suffered considerable setbacks simply due to the fact that we have been slow in achieving an adequate wage for humanity so humanity could enjoy universally the benefits. A seaman can think of the kind of things we can do that would be of very great importance. Society, all around the world, is doing all the right things for the wrong reasons. We have been backing up into our future. This is particularly true to the oceans. We have developed the atomic submarine in a very big way, first here and now Russia, for the wrong reasons, to be sure, but another fallout from the sea.

The submarine is a very big affair-you want to take a cargo from Buenos Aires to Europe, you couldn't change anywhere, you couldn't swap your goods and trade at sea Two ships could not dock beside each other. They would perish. But with a submarine we get down below the turbulence and we can change cargoes at sea We could have underwater cities anywhere around our earth If we begin to have underwater transfer of our world resources, I think all the sovereignties would just break down. Their customs are broken.

Once you realize there are now in your hands the tools to really use the kind of mind you have as a seaman, it is time to begin to try to make the old world work. And I do travel enough around the world to tell you this. I'm sure most of you really know it, but I find myself in meeting with the Russians, with Norman Cousins committee, with the Russian Academy of Science, there is a very good will and the thinker, the intellectual, everywhere agrees as to the will of man to try to cooperate and to try to make things work. Here I think of the sea as a great safety factor, of the great design of man on earth to have still this three-quarters of the earth which was almost unapproachable by man reserved for the last chapter. Having made a mess of the earlier part, the sea is still there and great, even though we have robbed it of so many of those whales and other things

I am going to discuss a map. As a sailor, I found it important to be able to see our earth without the distortions we get with mercator and polyconics, polar asmuthals and whatever. I found a method of transferring the data from a sphere to a plane without any visible distortion of the relative shape or the relative size of any of the parts, and without any breaks in the continental contours. The dymaxion map. This shows one world island and one world ocean without any visible distortion. If you cut it and round its edges, it makes an icosahedron. If you look at that icosahedron alongside the globe you will find no discrepancy between them. The data, the way it seems to read, reads just the way the globe does. Here some day is one world island and one world ocean, and that one world ocean is then waiting for all of us to find our final great support.

For very long, the poles have been frozen. Man has not thought tactically in terms of the north pole. Even though very spectacular things have been done, we don't think that way very much yet While we can negotiate the pole very readily today, we have had the enmity between Russia and North America, so we don't think of it in this way. But look again at this map. One can reach ninety-five percent of humanity from anywhere in America without going near the Atlantic or Pacific. Here is one way; this is a "strip map" of our tomorrow.

It is fortunate that in a sense that our oceans will be abandoned We have already seen passenger ships decline very, very suddenly. And what will be the significance of a Port of New York or of San Francisco in terms of a north-south air axis. There are great investments in a place like New York and San Francisco and they will fight very hard to try to keep traffic coming their way. But it is not in the new traffic pattern; they are side shows. People will get to New York to see the theater but not on their way to Europe. We will learn to accept this new orientation and to see the ocean as a great garden around that one world island

Coloring is an important dimension of a map. Coloring on my map is the weather. We typically have weather reported to us in its extremes-the highs and the lows, the wetness or dryness or coldness or hotness. But you find the real difference between, one place and another, however, for instance is how cold does it get, not how hot does it get. The cold pole of the northern hemisphere gets as warm in mid-summer at noontime as does equatorial Africa. But equatorial Africa never gets as cold as it does in Northern Siberia. Hot is very universal. Cold is unique and the colder it gets the more annual variation you have, the more kinds of environment you have to adjust to

So if you are born in Africa near Lake Victoria, you'll invent a boat to cross it. But if you were born in more northern latitudes, in the summer you invent a boat and in the winter you invent sleds and ice skates. Invention is precipitated by the confrontations man has. The central Arctic bullseye, in which is the temperature control, the climate control, of the northern hemisphere affects almost all of humanity. Australia, South America and the bottom of Africa are exempt. All the rest is in the Northern Hemisphere. If I put color dots on the map as the colors of men's skins around the world, you will find they correspond exactly to the weather. The colder it gets, the whiter they get, the hotter it gets, the blacker they get. If you have to hibernate and you have to inbreed as people did for thousands of years under those special conditions, you get bleached out. They also need hair to cover them when they have to take off their clothes, and they're out in the sun. And just look at the African, look at his hands and the bottoms of feet. They're white And there's no race

We have men who have been inbreeding for long periods, isolated from one another, getting very special characteristics. And your sailor man kept going around the world, cross-breeding with all of them and he's a kind of swarthy inbetween

I've spent a long time belaboring these points. I do find it a practical matter with the kind of competence we have today to consider floating cities that are not going with the waves. The waves are simply going through them A very practical matter It would be very easy to go down below the turbulence and have submarine cities. Also very easy within protected waters to have floating cities. And we probably will do a lot of that. Cities have been designed completely anarchistically. We have all our urban troubles-and people don't even know what the buildings weigh Everybody does things independently

When you design a ship, one man designs it She's organic And when she becomes obsolete you melt her up and make a much better one. But we don't have this kind of logic on the land. And that kind of logic is going to have to prevail in the land. I like the kind of thinking that we do as sailors, and as cross-breeding world man. As we talk to our fellow man and the word gets around the way we are thinking, we are not thinking in yesterday's ignorant way. No longer do we believe it's got to be you or me. We have discovered in our kind of technology it is very practical to consider all of us. We are going to all have to survive or none. And the kind of technology and the kind of attitude out of which that will come is the kind of attitude which has come out of the sailor man.

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World Resources Simulation Center

(Mr. Price of Illinois asked and was given permission to extend his remarks at this point in the and to include extraneous matter.)

Mr. Price of Illinois. Mr. Speaker, decisionmaking to utilize resources for the betterment of our people and of people in other lands entered a new era with the advent of satellites and computers. Satellites which gather information on natural and manmade resources combined with computers which store and integrate this data for countrywide and worldwide peaceful development, provide the opportunity to make the United States and the world work better for human inhabitants.

My bill which I introduced on May 6, H.R. 17467, authorizes the National Aeronautics and Space Administration to make grants for the construction and operation of a World Resources Simulation Center to make available to Federal, State, and local agencies and to private persons, organizations, and institutions such information, which they will find valuable and useful in their planning and decisionmaking.

Significantly advanced comprehensive information gathering by satellite and human intelligence, well coordinated by computer and displayed visually for study, is a chief aim of this legislation

The association at one computer center of pertinent satellite-obtained information with statistics and other data already available through Government and private sources, and its intermix and visual presentation to decisionmaking Government leaders in the executive and legislative branches, Federal, State, and local, will permit more intelligent use of national and world resources.

Dissemination, study, and use of this information by industry, commerce, labor and individuals, as well as by educational, health, conservation, and civic organizations, is contemplated as a contribution to a healthier society University, college, and school work already begun in this field will receive strong impetus and strengthen constructive approaches to improving mankind's status, at the same time providing further evidence of U.S. dedication to peaceful resolution of world ills.

The natural, physical, and human resource data thus made available, will expand the decisionmakers' awareness of all possible alternatives for resource utilization, and can lead to better solutions and clearer directions in achieving national goals

The spectacular achievement of sending human beings on manmade satellites to circle the earth's moon satellite and twice placing these humans on the moon, required a scientific development and a coordination and deployment of men and machines, with a dependence on computer technology on a worldwide scale of incalculable proportions. The National Aeronautics and Space Administration has demonstrated that many contributions of immense value to our improved health and well-being flow from the Nation's space program. One of these benefits now possible for the first time is establishment of the World Resources Simulation Center, as contemplated in this legislation

Such problems afflicting our society today as the alarming increase in pollution of our air, water, and soil; shortages of food and housing; urban decay and inadequate mass transit facilities all require more concentrated and comprehensive attention, as we earnestly seek workable solutions. The program contemplated in H.R. 17467 will significantly contribute to such progress without in any way adding another Government department to accomplish tasks already assigned. Rather H.R. 17467 will enable agencies, both public and private, now engaged in these endeavors, to have at their disposal a new and productive information tool, which will help them gain clearer insight and make more competent judgment to accomplish their worthwhile purposes. It is my belief and conviction that this legislation and its implementation through the National Aeronautics and Space Administration will provide a dynamic and positive force giving new direction and impetus to our national aim of finding workable answers to many ills disturbing our economy today

Efforts in this direction by such a distinguished man as Buckminster Fuller, who has prepared basic data on world resources development, have now proliferated at many educational institutions. This program, known as World Game, which constitutes an initial test operating program for the World Resources Simulation Center, shows signs of becoming a new teaching tool of significant proportion

It is self evident that young people in every State in the Union are groping for new direction in this troubled world, and I am happy to report that on their own volition students and teachers are already engaged in the World Game and resource simulations which H R 17467 envisions on a comprehensive scale

World Resource Simulation Seminars have been conducted with full documentation in New York and Illinois, and are now spreading to colleges and universities in California, Washington, Massachusetts, Minnesota, Ohio, Kansas, Connecticut, and other States, as well as Edmonton and Montreal, Canada, and Oxford, England.

That space technology can contribute not only to a better understanding of the universe, but to the betterment of mankind on spaceship earth, has long been felt. Now this possibility can become a reality. This is my purpose in introducing this legislation

At this point in the *Record,* I ask unanimous consent to include the following material which is supplemental to the purposes of H.R. 17467.

The following is taken from an article in the Reader's Digest, November 1969, entitled "Meet Bucky Fuller, Ambassador From Tomorrow" by Fred Warshofsky:

Even the most rebellious students find a dynamism and understanding in Buckminster Fuller that they don't expect from anyone on the far side of 30. They are set afire by his current crusade, which, simply stated, is to use the science of design to reform our environment-but in accordance with nature's laws and not man's. The age-old assumption that political reform can bring about peace and plenty is fallacious, he contends. At the root of our troubles is the Malthusian and Darwinian assumption that there is not enough in the world to go around-not enough for even a majority of mankind to survive more than half of its potential life-span. This "you or me to the death" situation leads to showdown by arms. An alternative to politics-the design science revolution-alone can solve the problem.

To demonstrate this idea, Fuller is currently trying to involve the world's leading thinkers and as many students as possible in a Fuller creation called World Game. The goal of World Game is to "predict in advance, and solve before eruption, potential problems associated with world resources and bearing on human poverty and suffering "

This can be done, Fuller believes, by discarding assumptions that there is not enough to go around, and adopting Fullerian theories that we can do more with less This is to be achieved, says Fuller, by upping the performance per each unit of invested world resources until so much more is accomplished with so much less that a high standard of living will be effected for all humanity. Fuller cites the communications satellite: weighing only a quarter of a ton, it now outperforms the communications capabilities of 150,000 tons of transoceanic cable

This past summer, after ten days of lectures by Fuller on his views of the universe, 22 students spent their vacation in New York City determining a way to provide 2000 kilowatts of power per year to every man, woman and child on earth. The goal was determined when, after developing an inventory of the world's resources, it became obvious to the group that power was the key to making the world work for man Where enough energy was available, hunger was banished and industry boomed

The group's "solution" called for a world grid of hydroelectric power. The reasons: water to turn the generators is available in many of the low-power areas of the world; and hydroelectricity has fewer by-products to pollute the earth

Eventually, World Game will be computerized so that the hundreds of different possible solutions to the world's problems can be delineated

The following is taken an article in the Saturday Review cover story, May 2, 1970, entitled "Inside Buckminster Fuller's Universe" by Harold Taylor:

The objective of the World Game is to work out ways of how to make humanity a continuing success at the earliest possible moment-in other words, how to make the world work.

Fuller started a pilot project for the game last summer at the New York Studio School of Painting and Sculpture with twenty-six students from physics, biology, art, architecture, and anthropology in a six-week session, during which he spent two weeks talking about his ideas. The main body of work was done in student research projects on contemporary social and cultural trends, using films, libraries, United Nations documents, and government reports in order to compile specific data about the whole Earth. For example, exact information was assembled on world population growth, the sources and extent of physical energy in the world, the uses of atomic energy as fuel for industrial production, and the amount of protein and food substances to keep the whole world alive at a high level of nourishment. Particular kinds of questions were asked about world trends and facts relevant to preserving the environment, such as how much copper, aluminum, and steel are involved in food production, what the world per capita consumption of fibers is, how much gasoline was burned by cars last year, what are the essentials a country must have in order to industrialize.

Answers to questions such as these became necessary to play the World Game, and the need for investigation of new questions and the invention of new questions themselves sprang from the fact that the students, individually and in teams, were out to solve practical world problems, one of which was how to feed the entire world at what the students called a "bare maximum."

Fuller's long-run plan for the project is to have students in universities around the world work at the problems in teams, exchanging ideas and information from country to country, and making proposals based on their studies to the United Nations and the leadership of their own and other countries. To this international information network will be added new information fed into computers from satellite scanners, which, as Fuller points out, are not only collecting shared information about weather trends on a whole-Earth scale, but are inadvertently telephotoing the whereabouts and number of beef cattle around the surface of the entire Earth, along with the exact condition of the world's crops at each season of the year

The students in the Studio School World Game worked out preliminary solutions (scenarios) for satisfying what they considered to be the two most vital needs of the world population, electrical energy and food supply, and then went on to preliminary studies of world housing needs, medicine, income, communications, and transportation They ended the six weeks with presentations of their findings in charts, drawings, graphs, and written statements, having made, in the course of working together, a chart four feet high and sixty feet long around the game room to present some of their basic data for use as they went along

*The following is a report **of** the first World Game Workshop, New York City, Summer 1969, by Gene Youngblood: **

Last week I introduced the concept of Buckminster Fuller's World Game, mankind's first practical alternative to politics. I described the physical hardware and the metaphysical software which constitute World Game Headquarters at the World Resources Inventory, Southern Illinois University. I gave a brief description of how the system works, and explained that it is-now possible for anyone anywhere to take positive constructive action in shaping the destiny of our society completely outside the realm of politics as we know it.

Following is a report on the first World Game Seminar *as* conducted by Fuller and Edwin Schlossberg at the New York Studio School from June 12 to July 31 of this year. The seminar was offered as a prototype of the World Game and should not be considered a formal "playing," since the necessary computer systems were not yet available. However, this report should demonstrate the vast scope and authority of the World Game even when practiced by amateurs without the optimum technological facilities

Schlossberg, 24, is working on a Ph.D. in physics and literature at Columbia University, considering both of them as languages. He teaches a combined course in physics and literature. He is a generalist, a comprehensive thinker, a poet, a revolutionary, a technoanarchist. He publishes GOOD NEWS, a periodical of the whole earth design systems revolution. The remainder of this article is in his and Medard Gabel's words, taken from the World Game Report:

We worked with the students in mind. We worked to develop a research and design team to effectively deal with the data and concepts necessary to play World Game. The first four weeks of the seminar were devoted to input. Mr. Fuller thought aloud about his ideas, concepts, inventions, and discoveries. The students did individual research into trends, energy sources, and many other information areas. They were constructing a base on which to develop ideas about the whole earth. We saw films, read extensively, and traveled through the minds of the others in the room. We watched as man successfully stood on another body in space and could see the earth as a spaceship. The students were working to make visible the coordination of that spaceship in order to accelerate the trend toward physical success for all humanity.

Each day the growth of the students and the growth of World Game was extraordinary. Without fear, without competition, the students worked together to realize World Game as fully as they could. The last three weeks were intense with research and organization on how to display the findings that were being made. The energy and information grew visibly before us. We were working at the frontier and each student was working at his frontier. It is dramatic to see human beings so concerned with the operation and well-being of the earth. Mr. Fuller said at the start of the project that it was the most important work to be done

I. Pre-Scenario Facts.

Our pre-scenario facts consist of the conceptual tools which we found ourselves using most often in our dealings with the whole earth. They are by no means even an attempt at being complete, but are merely a general frame of reference for us, as individual participants, to fit our respective specializations into. To a large extent the specifics of World Game left with its participants; what is here is the general base we started with and evolved through as our individual understanding and refinement grew

Finding the needs of one man led us to finding the needs for mankind. As we began to deal with man on the collective level we realized the need for establishing a frame of reference, or conceptual tool, to deal with collective mankind's needs. The "bare maximum" was what evolved. Rather than take what was throught to be the bare minimum for mere subsistence levels, we elected to establish levels which would allow man to realize, not his minimum potential, but his maximum potential, anything less than this being, by our definition, sub-human. So, in looking at calorie levels, we found the highest calorie needs to be that of pregnant women who need 3300 cal/day, and that of working men who need 3500 cal/day. Thus if we could insure that caloric level for the world, no one would be deprived. We did the same for protein levels. Between 30 and 45g of total protein per day is the minimum level of protein that must be replaced by the body. We therefore took 90g of protein/day as the bare maximum which should be available to everyone. We then asked: How many acres per capita are necessary to produce the bare maximum food requirements?

In order to supply mankind with his internal needs we found it necessary to evolve a bare maximum parameter for external metabolics which would guarantee the maintenance of man's internal metabolics. This bare maximum is 1242 energy slaves per capita by the year 2000 (Note: one "energy slave" is defined as a machine or system equivalent to 37.5 million foot-pounds of energy). Broken down, that is 15,000 kwh and eight metric tons of coal-equivalents per capita per year. This non-linear yardstick for establishing external relative levels of the development of man's potential to be "human" was arrived at by taking the projected U.S. needs for the year 2000 (present need is 7000 kwh), because it was the maximum. Using these parameters we found that mankind will need a total 100 trillion kwh, 8.5 x 10^{15} calories, and 21.9 x 10^{7} tons of protein in the year 2000. (We used the U.N. figures on projected populations for these calculations)

One man needs per day today:

Internal Metabolics

1.4 lbs. pure air
5.0 lbs. pure water
3500 Calories
90 grams of protein
12 milligrams iron
0.8 grams calcium
0 86 grams phosphorus
vitamins and minerals
5-9 hours sleep
63-77 degrees Fahrenheit
medical attention

Efficiencies of Power Sources:

fossil fuel (coal and oil)	***40%***
nuclear power plants	***40%***
magnetohydrodynamics	***55%***
fuel cells	***40*** to 60%
thermoelectric	***40%***
thermionic	10%
heat engine	***32%***
solar furnace	***70%***
silicon battery	15%
fission	10%
hydroelectric	***80%***
fusion	***90%***

it takes 371 kwh to produce 1 automobile

(What is the net physical wealth of world man? How are we presently using our resources?)

daily newspapers ('62):

Asia	1736
Oceania	114
Europe	***2403***
USSR	***457***
Africa	188
N Amer	2161
L Amer	***765***

World ('65) book production (titles)	450,000
periodicals	***200,000***
journals, tech. reports	***200,000***

radios per 1000 inhabitants ('60):

Africa	***28***
N Amer	***720***
Asia	***22***
Europe	***220***
Oceania	198
USSR	***205***
world avg	130

Calories used in different activities (per hour)

lying in bed	***77***
sleeping	***65***
sitting at rest	100
walking slowly	***200***
standing	105
working (painting, carpenting)	***240***
running	***570***
swimming	***500***
walking upstairs	1100

world food production in '67:

570.82 million metric tons animal products
1,457.65 million metric tons vegetable products

trends towards:

use of 92 basic elements
transportation of man around earth
abstraction
specialization
comprehensiveness
doing more with less
self-fulfillment
increased life expectancy
higher education
automation
non-ownership (leasing)
multiple citizenship
increase of energy slaves/cap
increased leisure
increased weather prediction
omni-directional (away from linear)
miniaturization
autonomy

We compared bare maximum requirements with present per capita consumption. We sought to establish a bare maximum communications system for the world. We learned what percentage of world people can presently be guaranteed the bare maximum. We sought to find the bare maximum for world transportation. We asked how much bulk food is produced in calories? How much copper, aluminum and steel is involved in food production? (At present, it takes 42 kwh to produce one metric ton of food.) We sought to find the average per capita protein consumption for the world (68 grams, of which 20 are animal protein).

In order to correlate the vast amounts of data we were accumulating about the world, we devised a chart with which we could clearly display visually our basic working information. This chart was a triangular grid on which one of the three axes were the 22 major geographical areas of the world and their individual countries. The second axis consisted of, in five-year increments from 1965 to 2000, figures on population, population density, calorie and protein intake, total kwh, metric tons of coal-equivalents and energy slaves. The last axis could indicate up to 20 possible world trends for each area and country. We used thirteen: fossil fuel potential, life expectancy, mortality rate, arable land, housing, amounts of copper, aluminum and steel, food literacy, reinvestable time and hydropower.

The chart was four feet high and stretched 60 feet around the game room. We also employed two lo-by-15 foot Dymaxion maps with five clear acetate overlays each to visually present our data on a geographical whole earth. Information about the world's metals sources, world man, the power network, alternate power sources, present population and Year 2000 population projection, food production and transport, was presented on seven of the overlays while three remained free for use during game playing

II. Scenario.

Once we knew what mankind had and what he needed to have, we began to experiment with ways he could go about getting his needs. These ways we called "scenarios." (What are the ways in which man may be enabled to participate more effectively in his relation with the universe?). Throughout our work we found ourselves returning to one common denominator: Can you industrialize an area without electrical power? How can man take care of all of his essential physical needs so as to allow himself to develop his unique metaphysical abilities? Whether we had researched food, communications, travel, housing, or economics, we always returned to electrical energy once we began to formulate any hypothesis about satisfying man's needs. In order to enable people to be fed properly we found that they would first have to have a sufficiently high input of electrical energy to process, transport, and store food and dispose of wastes. We found that, when dealing with collective mankind, it was imperative that we attend to man's external metabolics first, and these would then take care of individual man's internal metabolics. Thus the "Energy Scenario" became our first move in the World Game.

After researching and then plotting the world's electrical network (generating stations and transmission lines) we devised a way of developing and improving its overall efficiency as the first step towards the bare maximum for all mankind. (How long would it take to get a minimum of kwh distributed throughout the world?) By utilizing the world's hydroelectric power (rivers and tides), without any further development of thermal plants, and taking advantage of the increased efficiency of super-high voltage long-distance transmission lines (one million volts, 1500 miles) in a day/night seasonal hookup, we were able to demonstrate that with present methods, technologies, projected population figures, metals resources, and efficiency levels in power generation and consumption, it would be possible to bring everyone on earth to a minimum of 2000 kwh per year by 1980.

The present kwh level of Europe is 2000, and as such not below our projected bare maximum of 15,000 kwh for the year 2000, because with Europe's level of industrial development it would be possible to raise the per capita kwh to 15,000 by the year 2000. We asked: How much copper wire is needed to carry the power necessary for the year 2000 for both industrial and home use throughout the world? How far ahead can we conceive a future life-style? What's the time-lag between installation of electrical energy and an adequate food supply? How much metal is involved to produce the kwh needs for the year 2000?

When the energy input of an area is raised, there is a corresponding rise in communications capacity which in turn increases the necessity of the "have-nots" to become "haves." (In 1938 Fuller determined that when the equivalent of the work that could be done by 200 human slaves was available in electrical and other energy units used by a family of five, that family is included among the "haves.")

In the scenario, the vast hydroelectric potential of both South America and Africa is utilized to raise their respective levels to the per capita figure of 2000 kwh, and the surplus is transmitted via the electric network to areas where there are deficits of electric power. Because we do not have a global network at the

present time, the U.S. and other industrialized countries produce and use during the night hours only a small percentage of their electrical power capacity. With a global electric grid, power could be generated at day and night total capacity and transmitted to the daytime peak needs around the earth. (Using our present technology, can we provide electrical needs for everyone without polluting our air beyond endurance? What is pollution?)

The scenario utilized hydroelectric power for other considerations than what is presented above; besides the efficiency and pollution problems of thermal plants, it became overwhelmingly apparent that our "savings account" of fossil and nuclear fuels would soon be depleted at the bare maximum level of consumption. Our constantly-replenished "income" energies were the obvious choice. The amounts of metals, principally copper, aluminum and steel, that would be needed for such an undertaking are within grasp of earth's present economic and industrial development: approximately 9000 tons of steel per 1000-million watt hydroelectric plant, and 60 tons of steel and 25 tons of aluminum for a mile of power line at present efficiencies. (How can we accelerate efficiency throughout the world?) We chose to keep efficiency levels and technological competence at present levels to show we could do this today, with what we have. (How much metal is needed for 100 miles of power lines? When is a game a game?)

After demonstrating man's potential competence for bringing the world average per capita kwh up to 3613 with no one below the present European level of 2000 kwh, stage two of the electric scenario began. Utilizing increased efficiencies, technological progress such as laser-beam power transmission, and some of the earth's varied income energy sources (What is the potential kwh from wind power? Tidal power?), the per capita level of kwh is brought up to the 15,000 bare maximum in the year 2000.

Furnishing an area with enough electric power for its industrialization brings to that area the potential to satisfy its bare maximum food requirements. Knowing from the energy scenario that we could count on using two per cent of the total electric power for agricultural uses, we then looked at ways to increase the per capita calorie and protein levels to the bare maximum. (What percentage of electric energy is essential for food production?) A startling fact which became obvious upon looking at food production was that the world produces more than enough to feed its people adequately, but that in transport, storage and processing, 90 per cent of the tonnage of food is lost (how do we identify waste?). If we could bring methods to increase worldwide efficiency, at the rate we increased food production in the past, the world could feed its population for some time to come.

Shipping food halfway around the globe is inefficient. For example, in 1967, Asia imported and exported the same amount of rice. Ships could be used to transport materials not native to a particular area, or the metal from the ships could be used more profitably elsewhere. Part of the electrical power set aside for agriculture could be used to increase efficiencies in short transport to some areas with low farmihg efficiency. The increased use of fertilizers and farm equipment, in addition to the increase in knowledge of farming brought about by higher communications capabilities, would help bring the needed increase in efficiency necessary to have the entire population at bare maximum by 1980.

The efficiency would be somewhere between the U.S.'s (feeding about two people per acre) and 'Japan's (feeding six people per acre). It would be difficult to'raise the world's efficiency to that of Japan's, using her methods, because a tremendous amount of manpower would be drawn into agriculture. (Approximately 40 per cent of Japan's people are engaged in agriculture as opposed to nine per cent in America.) There are many new ways to produce food. Examples: using algae (chlorella and others) for food; feeding bacteria plant wastes such as stalks, sawdust, and letting them convert these to food for man; and synthesizing amino acids. However, we didn't employ them in our scenario because we did not want to make a move which would assume changing people's food habits

At present, most of the important variables in farming are not controlled because the system is as yet open In a closed system such variables as weather effects, insect pests, loss of water and nutrients would be controlled, or the detrimental effects eliminated. One experimental system could feed 500 people per acre-which would mean a population of six billion people could be fed using only 24 thousand square miles of land. (We're now using around 7 million square miles.) This would be approximately the area Japan uses to feed her people today

Given enough electrical power, the external metabolics, the earth could feed as many people as she needed-up to 7.8 trillion, for example, on presently-farmed land using the aforementioned experimental system. From this scenario we went on to examine some of the effects these scenarios would have on other areas of man's life

I I I. Future Directions.

After working out scenarios for satisfying what we considered the two most vital bare maximums-external electric energy and internal food supply-we evolved into some of the possible synergetic scenarios that would result from the first moves. The establishment of bare maximum levels of the above throughout the world would engender the need for bare maximums in housing, medical attention, income, communications and travel.

The housing scenario we were working on clearly showed the inadequacy of our present system. At the present rate, the use of metals in housing would prove to be totally insufficient. Metaphysically-engendered materials such as plastics will have to be developed if we are to solve mankind's housing needs The housing scenario encompassed more than just the shelter needs of the world As it evolved we saw that it would encompass communications and mobility. With the trends of increasing mobility throughout the world, we foresaw the possibility that no one would be staying at any one place long enough to warrant the construction of "permanent" shelters. As a total service facility, the housing needs would encompass not only shelter but communications-with its own resultant education, medical information and attention, personal telephone contact with anyone, anywhere, and mobility with anyone going anywhere. These would be accomplished via closed-circuit television and telephone to a world central medical, educational, and travel-routing computer system

Some future directions and scenarios we touched upon were the possibilities of a world guaranteed annual income; the potential of fluidics as a source of energy; information and automation; the use of heat pollution from thermal electric plants to heat soil to improve crop output; the efficiency-gain by using gasoline or alcohol to run electric power plants and electricity to run cars; the production of alcohol from algae, farm wastes, or garbage and its substitution for gasoline in present-day combustion engines; the laser beam transmission of power and information; the amount of reinvestable time that will be available to mankind as a result of freeing him from the drudgery of having to earn a living (by bringing man to the bare maximum food and energy levels by the year 2000 we will have 16 trillion more hours per year to reinvest into metaphysical regenerative functions); the increase of efficiency rates for power production and consumption, communication, transportation, etc., and the possible surplus and increase of efficiency through the stabilization of the population.

**First appeared in the Los Angeles Free Press, December 26, 1969.*

A.3 Fortune Magazine Resource Inventory of 1940 and Data Sources

This is the published manifest of
R. Buckminster Fuller's inventory work
which was begun in 1927

Volume XXI

Fortune

Number 2

The United States of America

IN SEARCHING for a suitable way for FORTUNE to commemorate its tenth anniversary many ideas were examined. In the end it was felt that nothing could be more suitable than the setting forth of our own experience of the economy that we have been reporting for the past ten years. This issue, therefore, differs from every other issue of FORTUNE in that it is a peculiarly intimate and personal expression. It is, however, an expression of a large and objective reality, which must be documented and understood for what it has become: the most important nation in the world. FORTUNE was founded at the peak of the 1929 boom, in the conviction that American industrial life represented an achievement worth recording. But during most of its existence FORTUNE has found itself reporting on an economy whose dominant psychology was not one of achievement, but of failure. Now at last, at the end of a decade, the idea in which FORTUNE was conceived is ripe, we believe, for reassertion. The reassertion must not be, and is not here, merely emotional. It recognizes and meets the inherent and critical problems. But it recognizes also that the problems of the U S. are mostly the result of the achievements; and that they can be solved only in that light.

Contents for February 1940

Cover by A. Petruccelli

Fortune article charts are being updated and will appear in *World Game Document 2.*

U. S. Industrialization

Definition of industrial man . . . Estimate of his achievement in the U. S. . . . Analysis of his present predicament . . . Announcement of a new era.

THE word industrialization has meant many things to many people. It has meant squalor and soot, poverty and dispossession, the need for sanitation, a revolution in culture. It has meant the exploitation of labor, the prediction that capitalism would collapse: but it has also meant the full dinner pail, emancipation, the spread downward and upward of the middle classes, the enlightenment of capital far beyond the predictions of its critics. On the economic front industrialization has meant a series of problems, each more difficult than the last: problems in supply, marketing, and demand; problems in prices and financial control; problems in investment and savings, in producers' versus consumers' goods. Concerning few words has there been more confusion or less enlightenment.

But the historical fact here referred to under the word industrialization is a great change-a revolution-in the life of the individual. The basis of this revolution is the tool, the extension, by which man is enabled to accomplish more than with his bare hands. The most elementary tools are levers and wheels; but industrial man has evolved infinite series of tools, infinite extensions to his hands, his legs, and his five senses. From simple levers to production lines, from simple chemical reactions to new substances under the sun, from simple electric current to electronic tubes, these extensions have increased immeasurably his power over space and time. The process has not been merely mechanical but organic and evolutionary. It has transformed the species into a new kind of species, whose extensions raise each of its members far above the levels of the past. It has created a new kind of life, augmented and hitherto unimagined.

Industrialized man is augmented over mere man in many ways. He is augmented as a worker because the tools of modern industry enormously increase his power to accomplish work. He is augmented ***as*** a capitalist or owner because of the endless opportunities offered for the development of tools in the competition of tools. And he is augmented as a consumer by the great variety of products, tools, and extensions available to him for his personal satisfaction and the development of his faculties. The problems of our time, which appear so insuperable, are problems arising out of industrial achievement and are mainly problems of adjustment to the achievement: the worker does not get paid enough for his vast work power; the capitalist cannot seem to take advantage of his almost infinite opportunities: the consumer has to pay too much for the products and extensions he requires. One result of these maladjustments is the unemployment described on page 94. And another has been a sense of defeat.

The unemployment is a critical problem which will take a long time and many sacrifices to solve. But the sense of defeat that has given rise to an "emergency psychology" has so little substantiation in the industrial facts that it is difficult to understand how intelligent men, and even some leaders, have succumbed to it. It arises from a failure to define the purpose of industrialization. A definition is important because, in framing one, it becomes perfectly clear that the tools and extensions of industrialization do not exist for their own sake. They exist for the individual, known in this connection as *the consumer.* The entire producers-goods industry, for instance, whose purpose is the making of tools, is quite secondary to the real purpose of industrialization. That real purpose may be defined as an ***increase in the*** power lo consume: to consume not only as a simple animal but as a member of a new species whose potentialities of enjoyment, use, and knowledge are infinitely extensible. Industrialization, to be sure, enables man to consume more of the purely animal necessities such as food and clothing. But also, and more characteristically, through the use of what are called consumers' durable goods (automobiles, airplanes, refrigerators, radios, typewriters, etc.) it enables him to convert raw materials like oil, coal, gas, electricity, cement, plastics, wood pulp, chemicals, and dyes to the expanding purposes of life. The index of civilization is the individual's power to consume-to make use of-the resources of nature.

Now the fact is that all during the so-called "depression" this power to consume, this augmentation of the individual, has proceeded faster than ever before in history. It has proceeded faster than in the second half of the nineteenth century, when the railroads and the steel mills were being built. It has proceeded faster than in the gay nineties, or the expanding tens and teens of the twentieth century. It has proceeded faster, even, than in the booming twenties, hallowed in the charts of economists. Yet this accelerating progress has received relatively little attention. It has not been observed. And the reason why it has not been observed ***is that,*** in computing progress, we follow the economist in reducing everything to the dollar. Clearly, in order to achieve an increase in his power of consumption, man needs a complex economic system; and, clearly, the dollar is vital to the healthy functioning of that system. But it is not necessarily the *measure* of the system.

This fact becomes clear if we stop to make a fundamental distinction. There are ***two*** ways of measuring the individual's power to consume, one of which may be called potential, the other actual. The potential power to consume may be defined as the power of the best-equipped, most augmented individual. The rich man in 1850 could not have bought the extensions available to even modest incomes in 1940. His power to consume was of necessity far less than the power of the rich man today. And this potential power-potential in the sense that it may not yet be distributed to all-may be taken as the basic yardstick of civilization. The actual power to consume, on the other hand, may be defined as the per *capita* power to consume--the average of all individuals in a given economic system. The actual power to consume measures the ***extent*** of industrialization. Since industrialization is based upon mass production, the potential and the actual are always linked together in some degree. And of course the degree varies. In this sense the private airplane (one for every 9,692 persons in the U S.) is much more potential in character than the radio (nearly one for every three persons). While the effort of every industrial system must be to increase the actual power to consume to the greatest possible extent, the potential, in a growing system, must always remain ahead of the actual.

This distinction bears strongly upon the question of why dollar measurement leads the investigator astray. A classical economic

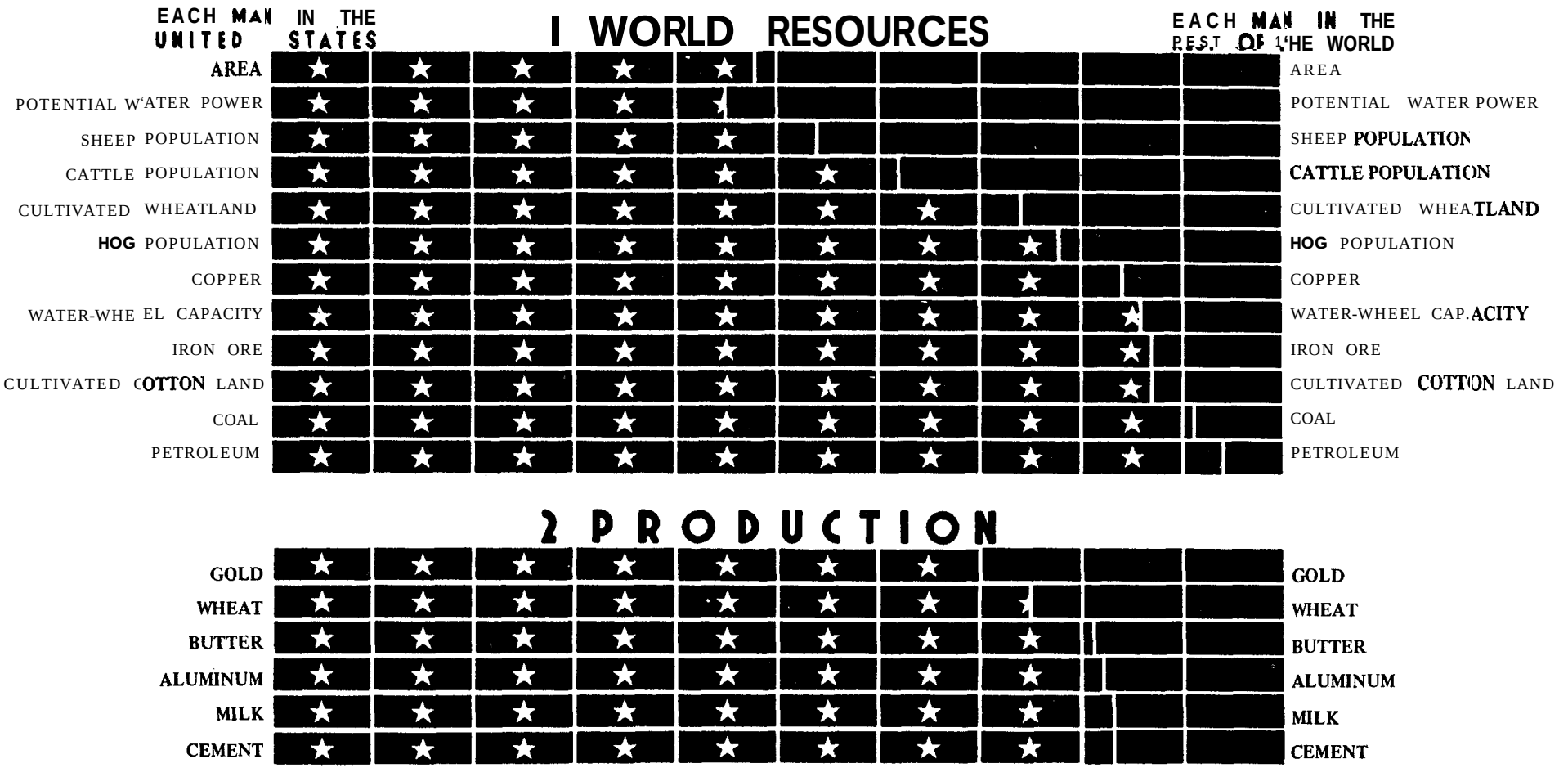
The charts and interpretations in this portfolio of U.S. Industrialization were prepared in collaboration with R. Buchminster Fuller, consultant on FORTUNE'S ***editorial staff.***

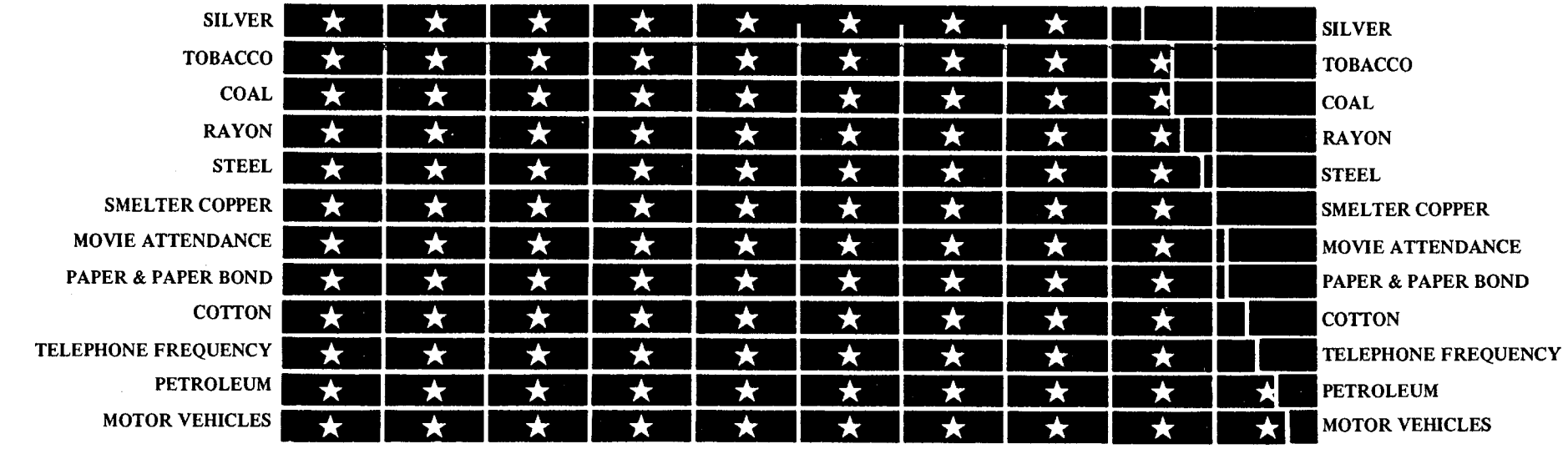
I

GROUP I

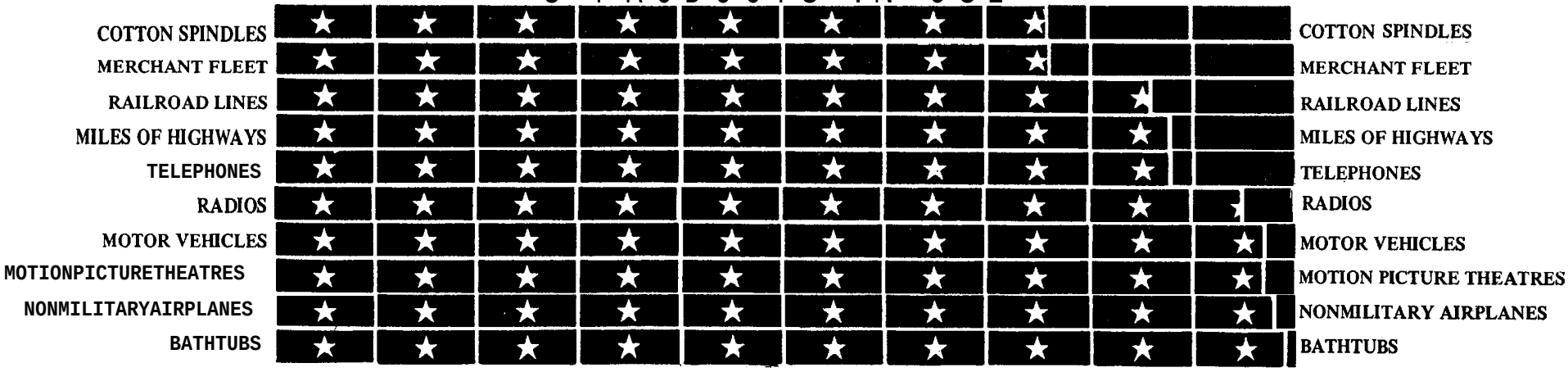
THE U.S. vs. THE WORLD

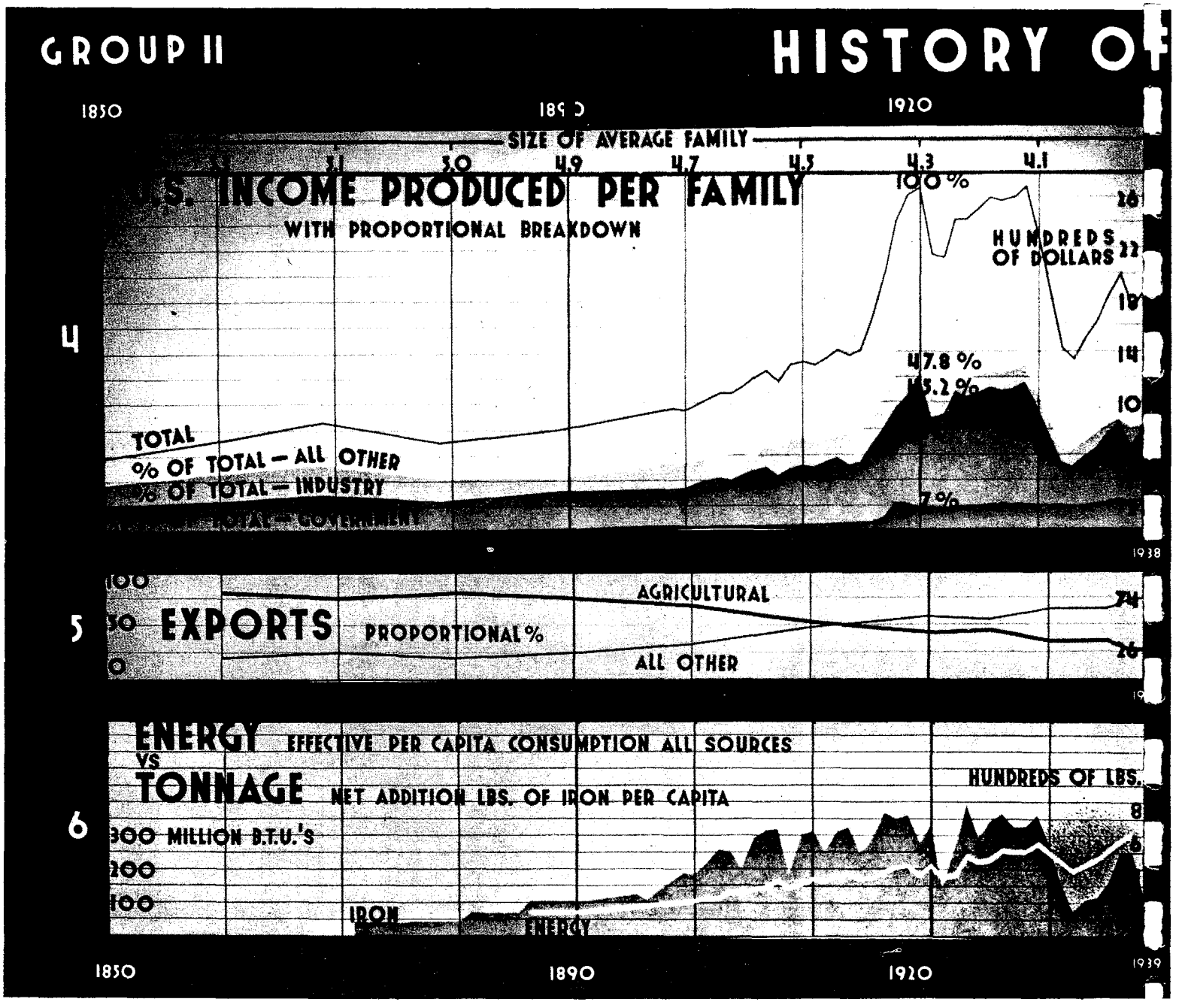
OF THE FOLLOWING, THESE ARE. THE RESPECTIVE SHARES





3 PRODUCTS IN USE





THE EVOLUTION OF AN INDUSTRIAL ECONOMY

The above charts provide a capsule description of the U.S. economy. Chart 4 (top) shows income produced per *family*, 1850-1939. Chart 5 shows the relative gain of "all other" (chiefly industrial) exports over agricultural exports. Chart 6 provides the key to the present article. Abandoning dollar figures, it shows the net addition of new iron to the economic system (black area), in hundreds of pounds per capita: versus the effective consumption of energy (white line) from mineral fuels and waterpower in B.T.U.'s per capita The decline of the iron curve, coupled with the rise of the energy curve, is symptomatic of the basic change from a tonnage, or producers'. economy. to an energy economy dependent for its growth upon the consumer.

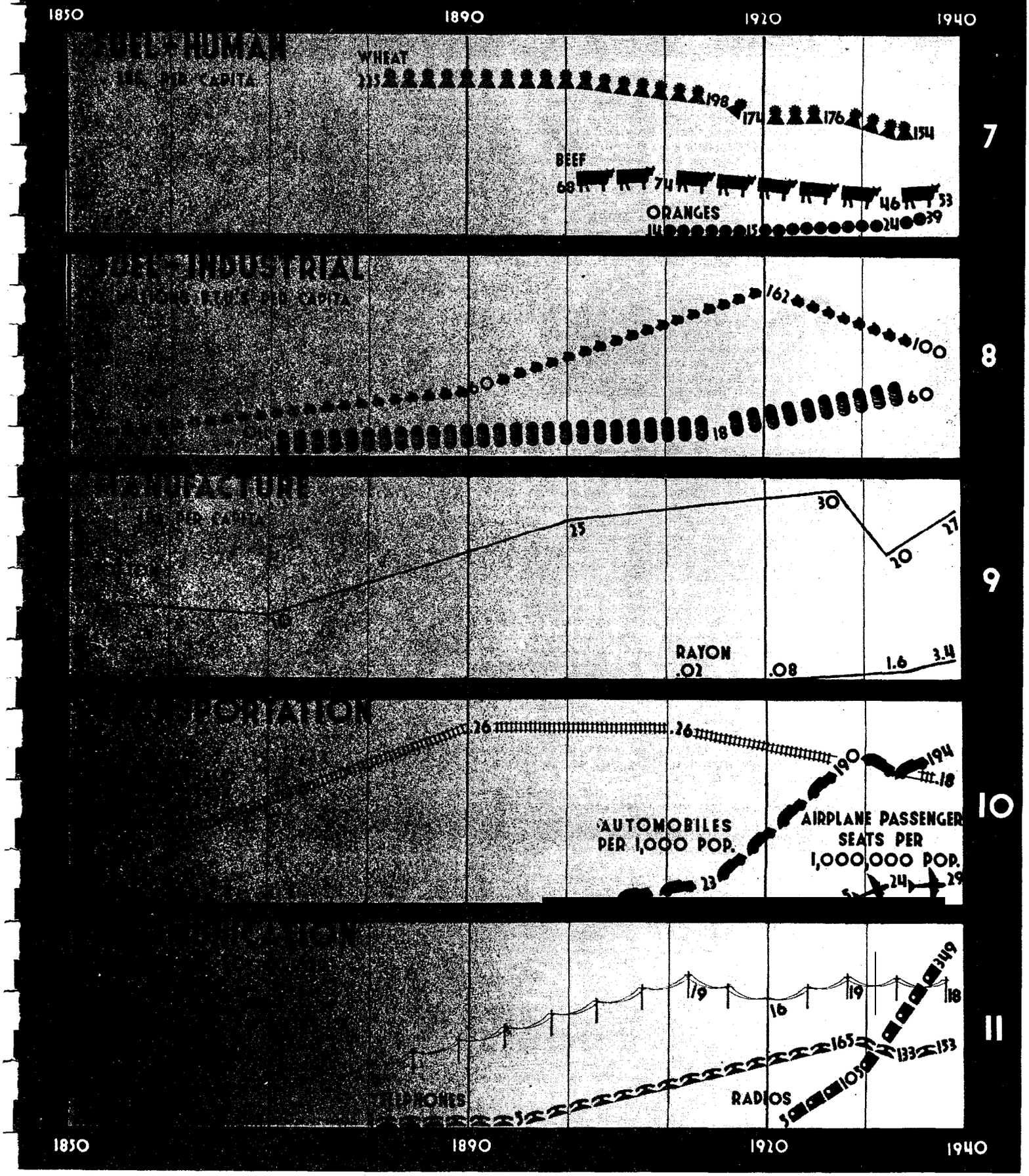
solution for the present "stagnation" would be an increase in capital investment. There is no question that this would help the economy; money would be spent, and this would increase the actual power to consume. But an increase in the rate of investment, or any other such measure, would not necessarily increase the potential power to consume. It would not necessarily advance the progress of industrialization in this most basic sense. The progress of industrialization will depend rather upon what kind of investment is made. The potential is not at all increased when a railroad buys new cars that are obsolete in design; it is very little increased when the federal government builds a new post office where the old one had served: but it is very much increased when the chemical industry puts a fraction of the above investment into the development of a new solvent; it is very much increased (or was, during the growth of the automobile) when the government builds concrete highways. Some capital investments increase *both* the potential and the actual power to consume. Others increase only the actual. And projects can be imagined that might have relatively little effect upon either.

Thus, in measuring our industrial system and in proposing solutions to its problems, it is necessary to use industrial measurements as well as dollar measurements; it is necessary to measure with such elements of progress as units per capita, tons, thermal units, kilowatt-hours, watts. and engineering indexes of viscosity, flux, torque, and efficiency. To talk about income and expenditure, price, capital promotion, or investment, without taking the engineering factors into account, is both futile and confusing. For while the power to consume-in both senses-is certainly affected by the economic factors, it does not spring from them.

The measurement of industrial progress is the purpose of the accompanying portfolio of charts. Beginning with the simplest static charts on page 51, and ending with the extraordinary Illustration of U.S. industrial power on page 57, the portfolio

PROGRESS

GROUP II



shows some of the hidden and irresistible forces that, before our eyes yet beyond them, are making a new world. These charts are not economists' charts; only six out of the fifty are concerned with the dollar, and none of these pretends to make basic measurements. They are industrial charts whose purpose is to illustrate the dynamics of progress in the U.S. In some cases this has necessitated original computation; in others it has called for a liberal use of estimates designed to show not absolute quantities but trends.*

Group I: *the* U.S. vs. *the world.* Like almost all the charts in the portfolio, these three are per capita charts. And they do not show quantities, they show ratios. Thus, to take cattle (in Chart 1, showing per capita resources), there are fewer cattle in the world (about 700,000,000) than there are people (about 2,125,000,000), and there are more cattle in the rest of the world (about 633,000,000) than there are in the U.S. (about 67,000,000). But in the U.S. more cattle are divided among fewer people than in the rest of the world. Thus, if all the cattle inside the U.S. were to be distributed to the people in the U.S., and those outside were to be distributed to the people outside, each citizen in the U.S. would find himself in possession of half of one, whereas each citizen in the rest of the world would get less than a third of one. The ratio between these shares is about one and two-thirds to one-which is the point illustrated by the chart. Similarly, if the world's known reserves of coal were distributed, each U.S. citizen would own 24,450 tons, whereas each citizen in the rest of the world would own only 2,465 tons; and this ratio of ten to one is what the chart shows. The ratios are shown in terms of the divisions in each horizontal bar of the charts, the blue divisions with white stars standing for the U.S., the red divisions for the rest of the world.

Chart 1 shows the ratio in per capita ownership of some of the most important resources. Chart 2 shows the per capita ratio in the *production* of certain rep resentative resources and manufactured goods, both agricultural and industrial. No effort has been made to compile a complete list, but for those shown it will be seen that the world approaches most closely to the U.S. in its per capita gold production, where the ratio favoring the U S. is only about seven to three. The ratio for the per capita production of automobiles is about thirty-seven to one.

Chart 3 is the most striking of this group, showing the ratio of *products in use.* In this, the real measure of the standard of living, U.S. leadership falls scarcely short of the fantastic. In the least dominant categories (cotton spindles and merchant marine) it leads by more than three to one. In radios in use the ratio is about eighteen to one; in automobiles, about thirty-three to one: in nonmilitary airplanes, about forty-three to one; and in bathtubs an almost incredible hundred and forty to one. Such has been the progress of the individual under the libertarian system.

**The derivations of some of these charts are exceedingly complex. FORTUNE will be glad to send a mimeographed memorandum concerning them to anyone interested.*

Group ZZ: *history.* This group divides itself into two parts. The three charts (4 to 6) on page 52 show the over-all characteristics of the economy, and the five on page 53 (7 to 11) show a few examples of the means by which these characteristics have been developed.

Chart 4 is a record, furnished by the National Industrial Conference Board, of national income produced from 1850 to 1939, translated to a per family basis. Prior to 1900 these figures are little better than informed guesses, and the 1939 *figure is* a rough estimate. Nevertheless, the trends are certain. The purpose of the chart (which is one of the few employing dollars) lies with the lowest three lines. These show the sources of income-that is, the proportions coming from government (13.6 per cent estimated in 1939), *industry* (41.9 per cent in 1939), and *all other,* such as agriculture, service, trade, and finance (44.5 per cent in 1939). The dominant feature here *is* the gradual rise in the proportion of income derived from *industry.* This rise is accompanied by a decline in *all other* (chiefly agriculture) and a rise in *government.* It is probably safe to predict that in the near future *industry* will cross *all* other-that is, will contribute more than half of the nongovernmental income. In reality it already does; some large but indeterminate portions of service and *trade* are generated directly by industry.

The persistent rise of industry is even more clearly shown in Chart 5, which divides U.S. exports into *agricultural* and *all other.* Nonagricultural exports began to rise sharply in the middle nineties, crossed the agricultural exports about 1912, proceeded upward slowly, spurted in the late twenties, and spurted again in the late thirties. The result is that the relative dollar value of the two is almost the reverse of what it was in 1850.

Chart 6, which follows, is the most important of all, providing the key to the entire portfolio. Industrialization is achieved by harnessing matter and energy, and its basic yardsticks are therefore tons and kilowatt-hours. If these are used to measure industrialization a startling and altogether critical trend emerges, namely, an increase in the consumption of energy and a decline in the amount of matter, or tonnage, annually added to the system. This fundamental trend can be measured in a number of ways, of which the one chosen in Chart 6 is the simplest. Here iron is taken to rep resent matter, for the purpose of comparison with energy, not only because it is the basic raw material of industry but also because it actually enters into the mechanics of practically every form of industrial energy production. The net annual addition of iron to the system (shown by the black area) is computed by adding the tonnage of all imported iron and steel to the tonnage of pig production in this country, and by deducting from this total all exports of ore, of iron and steel scrap, and of finished goods made of iron and steel (in tons). Thus what is really being measured is the addition of atoms of Fe (in tons) to the economic system.

The importance of these figures does not lie with their absolute accuracy (which would be virtually impossible to obtain) but with the trend that they show. And the trend is unmistakable. The absorption of iron by the economy increased at an accelerating rate through the nineties and the early twentieth century. It continued to rise slightly until 1923 (with a violent break in 1921), when it reached its all-time peak with a total of nearly 780 pound2 per capita. *During the rest of the twenties it diminished slightly,* and in 1930 it broke violently. In 1932 it reached a low of 150 pounds per capita. It returned briefly to the level of the early twentieth century, and then, in 1938, dropped again-to a level not much higher than that of the nineties. For 1939 it will have recovered some what: but it shows no sign of real recovery.

The consumption of kilowatt-hours, meanwhile, has steadily risen. Since matter and energy are measured in different units, there is no telling where the curves should cross. The points shown (in 1921 and then again in 1930) are extremely suggestive, though quite arbitrary. In any case it is clear that the energy curve has had a persistent rise, with a slight acceleration during the twenties just as the tonnage curve was leveling off. The depression did not set energy back so much as it did tonnage: and-most significantly-energy recovered at the steepest rate in its history, has since made a brand-new high, and is definitely pointed upward.

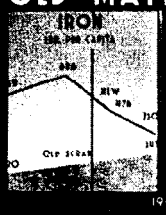
The meaning of this twofold trend will become more apparent as we proceed. It is profoundly descriptive of the economy. Meanwhile, however, a glance at the other charts of Group II (on page 53) will help to visualize the dynamic processes at work. These charts divide themselves into two groups. Charts 7, 8, and g show per capita consumption trends; Charts 10 and 11 show per capita trends of products in use: but the common characteristic of both groups is a progression from old forms to new and violently expanding ones. Such fundamentals as wheat, coal, cotton, railroad trackage, and telegraph-wire mileage ail show a per capita leveling off and decline. But against these declines new products, better adapted to high industrialization, produce steeply rising curves: oranges (an Industrialized commodity), oil, rayon, automobiles, airplanes (measured in passenger seats), telephones, and radios. The rise of these new products vastly increases the consumption of energy. The process is most clearly illustrated in Chart 10 on

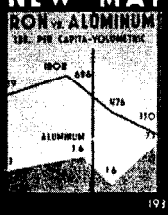
DYNAMICS OF PROGRESS

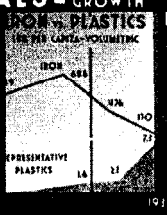
GROUP III

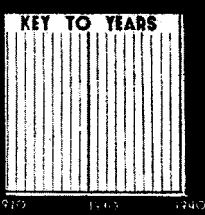
OLD MATERIALS - RECIRCULATION

NEW MATERIALS - GROWTH

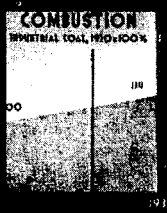


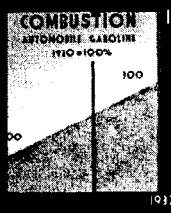


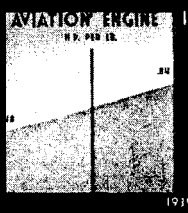


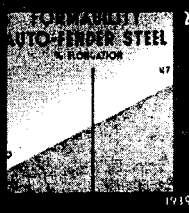


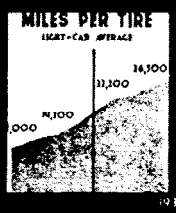
EFFICIENCY

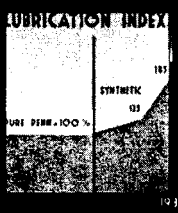


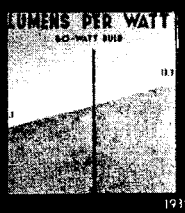


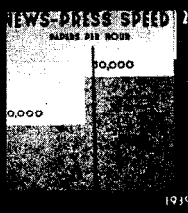


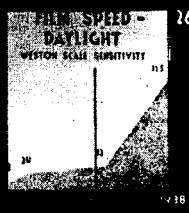


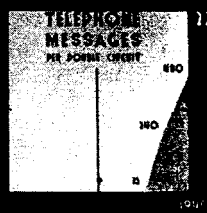




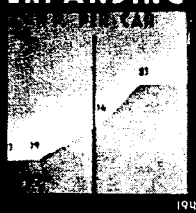


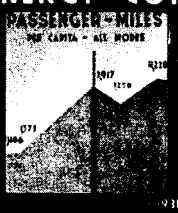


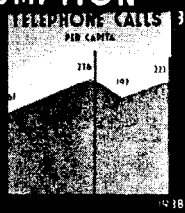


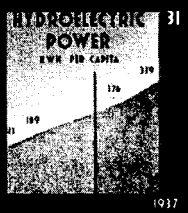


EXPANDING ENERGY CONSUMPTION

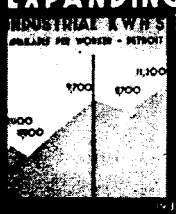


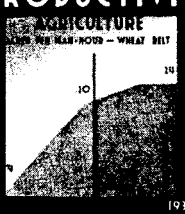


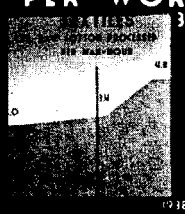


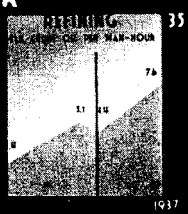


EXPANDING PRODUCTIVITY PER WORKER

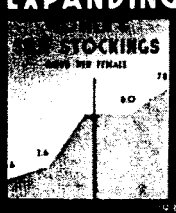


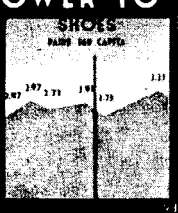


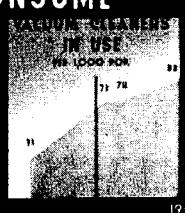




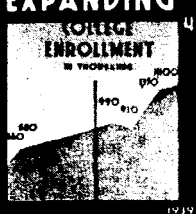
EXPANDING POWER TO CONSUME

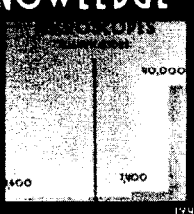


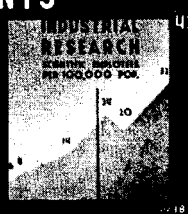


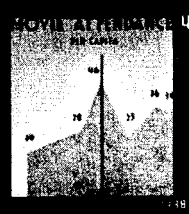


EXPANDING KNOWLEDGE AND AMUSEMENTS



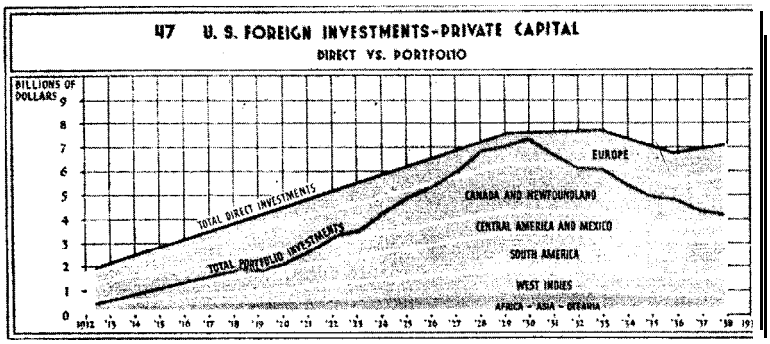




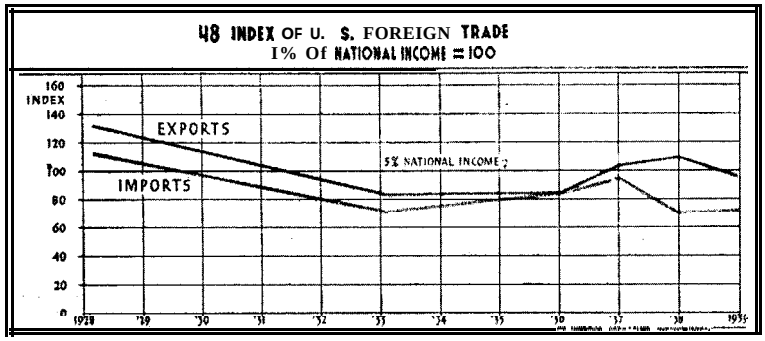


GROUP IV

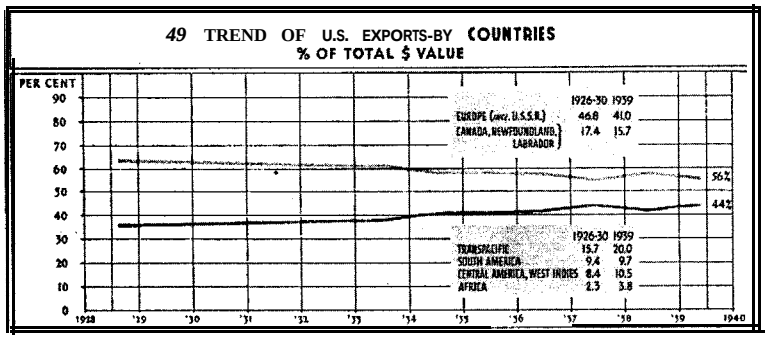
U.S. ABROAD



This group of charts is designed to show trends in U.S. foreign trade. The above (47) is a breakdown of total U.S. direct investments in other lands. During depression direct investments have held up well; portfolio investments (foreign equities) have suffered. Biggest net profits (1938): Transpacific and Africa, 10 per cent on capital invested.



This chart (48) provides an index of foreign trade, using as a base (equals 100) 5 per cent of national income each year. In the late twenties this index shows exports above 100. They helped to sustain the boom. The export line did not again exceed 100 until 1937-38, and then wavered. Note violent decline of imports.



The exports shown in Chart 48 are here analyzed (Chart 49) by countries. All countries whose proportion of the total has declined since 1928 are grouped together (blue line): and similarly, those whose proportions have risen are grouped together (red line). Exports have declined to old industrial areas, increased to neophyte industrial areas.

transportation. Clearly, the expansion of railroad-track mileage, bringing with it a huge expansion in rolling stock, was a big factor in the consumption of tonnage during the latter half of the nineteenth century and the early years of the twentieth. The addition of the automobile increased this tonnage absorption But automobiles also became a big factor in supplying iron scrap (a curve shown in Group III, page 55); hence, while causing a rise in the consumption of energy, they have not caused an equivalent rise in new iron requirements. But no sooner had the automobile curve begun to flatten out than that of the airplane began to rise. Here, of course, tonnage was reduced to a minimum, energy pushed to a maximum-an example that is rather more symbolic than actual since the airplane's total consumption of energy is still relatively infinitesimal.

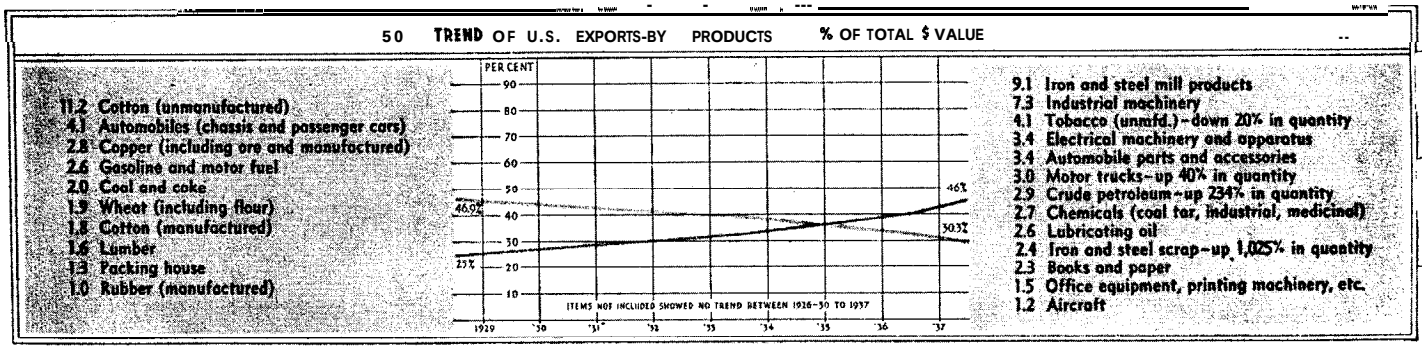
If the charts of Group II are considered as a whole they suggest that the period from 1850 to 1939 can be divided into three. During the first subperiod, from about *1850* to about 1890, the nation was busy laying railroad track and communication lines It absorbed large quantities of iron and other tonnage material: and it drew its energy almost entirely from coal. During this period the people did not think of the railroad, or the telegraph, or even the older cotton mills and foundries, as representatives of a new order of existence. The economy was still primarily agricultural and the wonders of industry were considered to be no more than adjuncts to the old order.

In the gay nineties, however, there appeared a series of technological advances and of almost unbelievable inventions, which rapidly changed the character of the system. Thereafter vast tonnages of heavy materials were absorbed in the rush to build a national plant capable of capitalizing on those inventions; tonnage rose faster than energy. This is the period of shrewd opinion and wild guessing-attributes that led to success because the possibilities of good fortune in almost any industrial attempt were exceedingly high. It was also the period in which the principles of mass production were born: Frederick (Speedy) Taylor showed the steel industry how to cut the labor cost in every ton of steel; and a decade later Henry Ford practically revolutionized the world with his moving production line. These latter developments were not to bear their full fruit until the next era, but meanwhile the character of life was definitely changed; people became conscious of industrialization though still ignorant of its full import. In 1912 nonagricultural exports crossed and exceeded agricultural exports: oil began its long climb toward coal as a major energy source. To all this the World War added the final impetus. And in 1920, at the end of that second era, the U.S. emerged as the greatest industrial nation on earth.

It is perhaps too early to make a clear analysis of the modern period, which would seem, according to these charts, to extend from about 1920 to the present day. One guess, however, can be hazarded. In terms of national income this period has been characterized by a violent expansion during the twenties and a violent contraction during the thirties. These vast swings have led some students of the economy to assume that two periods are involved: one an extension of the nineties, the other a new, *contracting* era signalizing a decline in the standard of living.

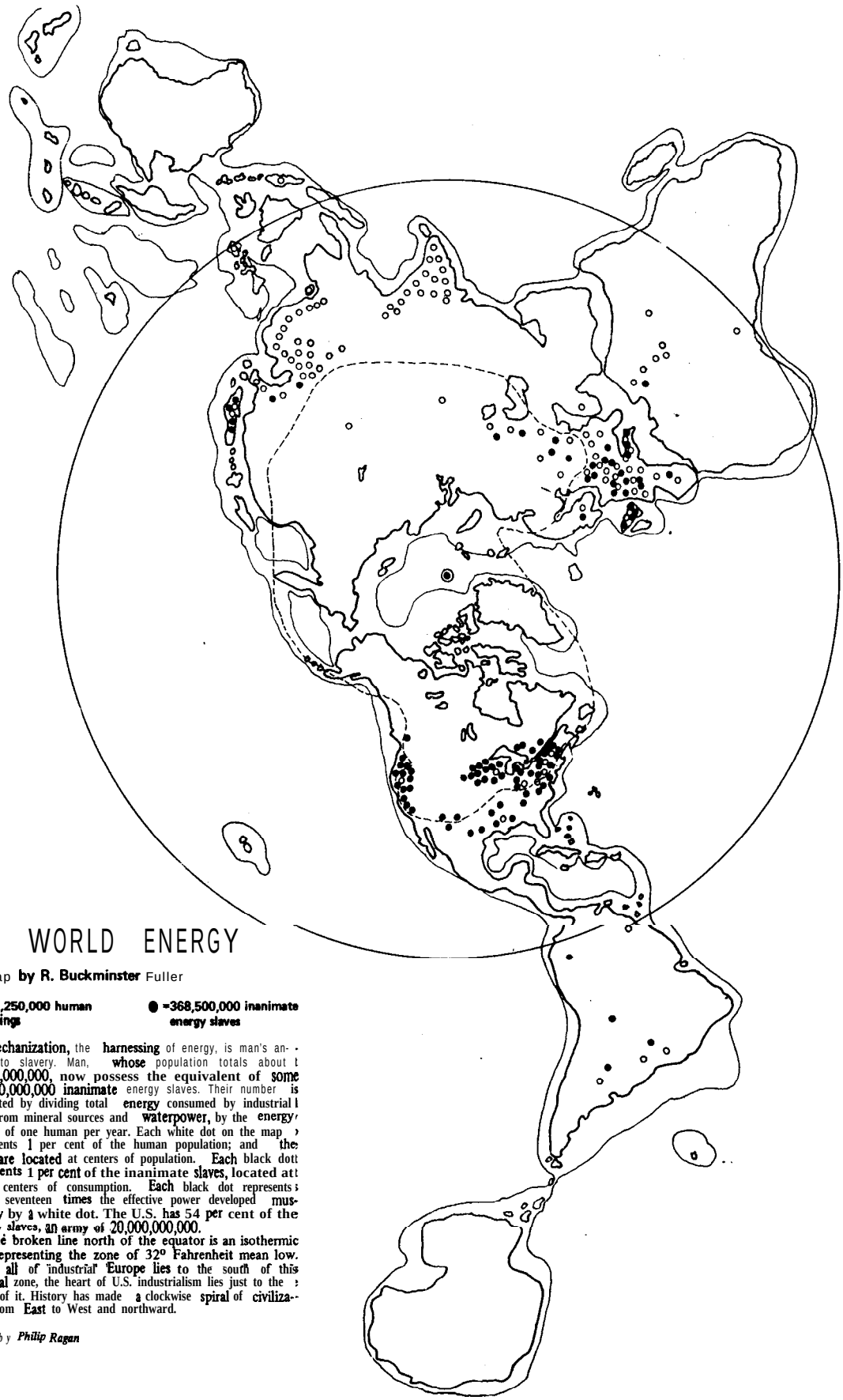
It does indeed seem to be true that the nature of the economy was radically and abruptly changed about 1930, where we

[Continued on page 158]



Charts by Elmer Smith

Here (Chart 50) exports are analyzed by types or categories. All categories whose proportion of the total has decreased since the 1926-30 average have been grouped together (blue line); and all whose proportion has increased have been grouped together (red line). Those that have decreased are listed (with percentages) in the small box on the left, and those that have increased, on the righr It will be seen that most decreases have occurred in agricultural and consumers goods. Only exceptions. tobacco, which has increased in dollar volume, declined in quantity; books and paper, and automobile parts. And most increases have occurred in producers' goods.



WORLD ENERGY

A Map **by R. Buckminster** Fuller

0 **=21,250,000 human beings** ● **=368,500,000 inanimate energy slaves**

Mechanization, the **harnessing** of energy, is man's answer to slavery. Man, **whose** population totals about **2,125,000,000, now possess the equivalent of some 36,850,000,000 inanimate** energy slaves. Their number **is** estimated by dividing total **energy** consumed by industrial **man** from mineral sources and **waterpower,** by the **energy** output of one human per year. Each white dot on the map represents 1 per cent of the human population; and the dots **are located** at centers of population. **Each** black dot **represents 1 per cent of the inanimate slaves, located at focal** centers of consumption. **Each** black dot represents about seventeen **times** the effective power developed **muscularly by a white dot. The U.S. has 54 per cent of the energy slaves, an army of 20,000,000,000.**

The broken line north of the equator is an isothermic line representing the zone of 32° Fahrenheit mean low. While all of industrial **Europe lies** to the south of this **thermal** zone, the heart of U.S. industrialism lies just to the north of it. History has made **a** clockwise **spiral** of **civilization** from **East** to West and northward.

Executed by Philip Ragan

Industrialization

have arbitrarily crossed the tonnage and energy lines in Chart 6.* But it is probably sounder to think of the period 1920-39 as one transition period than as two periods. This assumption is well substantiated in the charts of Group III (page 55), where many of the factors that have caused the vast increase in energy consumption of the thirties are shown to have been already on the rise during the twenties. The economy has changed from a tonnage economy to an energy economy. But this change began before 1930 and does not coincide with the depression.

Group III: *the elements* of *progress.* In order to simplify the astounding record of the past eighteen or twenty years the charts of this group have been smoothed to show trends rather than annual variations. Reading are given at key points on every trend line, and in most cases only three or four points are necessary. Every curve on the page is up. And the burden of the exhibit is that certain forces that began to make themselves felt in the twenties have all but revolutionized the economy during the thirties; that these forces are still pointed upward; and that they signalize not the end of an old era but the beginning of a new and more spectacular one.

Materials. The group begins with two charts (12 and 13) showing one of the major reasons why tonnage has fallen off. The supply of iron scrap has reached 245 pounds per capita per annum, and while this is not enough to provide for all of industry, it is enough to furnish about 40 per cent of the net domestic iron requirements. The situation in copper is even more marked. With regard to this metal it would seem that a kind of "scrap point" is being reached at which the annual supply of scrap (about 13.6 pounds per capita) could almost take care of the entire domestic demand for copper. Chart 14 shows the growth of aluminum, contrastedwith the now familiar curve for iron.† The curve for plastics is violently upward. These two curves, aluminum and plastics, are reminiscent of the railroad-automobile-airplane progression and the other progressions shown in Group II. Industrial progress is effected by constant replacement of old materials and Inventions with new materials and inventions, the constant aim being the production of more with less. Usually the new materials and inventions are not strictly comparable to the old. Thus, aluminum and plastics can be more realistically measured by volume than by weight. Hence, the poundage has in each case been multiplied by a volumetric factor for the purpose of comparison with iron.

Efficiency. The net new tonnage requirements of the economy are reduced by the piling up of scrap. At the same time, the efficiency of the industrial plant has been increased to the vast benefit of industry, and ultimately of the consumer. Thus there has been a rise in the number of kilowatt-hours that can be derived from a pound of coal, from .33 to .7 I, or 115 per cent (Chart 16). There has been a rise of 34 per cent in the conversion of B.T.U.'s of Industrial coal into horsepower, or kinetic energy (Chart 17); and a rise of zoo per cent in the conversion of automobile gasoline B.T.U.'s to tractive effort (Chart 18). These factors are important in figuring the energy output of the economy because they mean that more energy is obtained from each ton of coal that is mined or each barrel of oil that is recovered; and they have been figured into the energy curve in Chart 6. Together with other factors, not the least of which is the introduction of new metals, they have been responsible for a vast increase in the horsepower output of engines per pound of weight. This is shown most markedly in aircraft engines (Chart 19), where horsepower -per pound has been one of the limiting factors in the development of the art. Without the spectacular rise in this ratio modern airplanes would not exist.

At the same time, advances in metallurgy have produced steels more perfectly adapted to the demands of the engineers—hence more efficient. One example is the automobile fender (Chart 20), for which specially formable steel has been developed, leading to great economies in manufacture. Another is steel cable for bridges (Chart 21), which has increased in tensile strength from 160,000 pounds per square inch in 1870, when the Brooklyn Bridge was undertaken, to 225,000 in 1927, when the George Washington Bridge was undertaken—a development that has brought about longer spans and heavier loads. More familiar to the average citizen is the spectacular increase in average miles per automobile tire, from 11,000 to 26,500 (Chart 22). One development has been the increase in the efficiency of lubricating oil as measured by the lubrication (or so-called viscosity) index (Chart 23). For half a century, until 1929, pure Pennsylvania oil was the most efficient and was given an index number of 100. Then the chemists began to produce synthetic oils, which. by 1938, had reached an index value of 185 in laboratory tests, nearly double that of 1929. This means not only that the oil lasts longer but that the moving parts that it lubricates also last longer-another tonnage saving.

Almost equally spectacular has been the increase in the amount of light, as measured in lumens, that can be derived from a watt of electrical energy (Chart 24). In another field there was a vast and sudden increase in the speed of newspaper presses—from 30,000 to 50,000 papers per hour (Chart 25). In still another, the sensitivity index for photographic film has leaped upward (Chart 26), practically revolutionizing this extension of the human eye. And finally, a virtual revolution has been effected in the transmission of messages over telephone cable. With the equipment of 1920, only three messages could be carried over two pairs of cables at one time; whereas today about 480 messages can be carried. For each telephone message sacrificed twelve teletype messages can be substituted.

Expanding energy consumption. The most significant effect of these increases in efficiency has been a direct expansion in the consumption of energy. No better example of this could be had than that of the automobile (Chart 28). Whereas Europeans have sought economy, the u. s. has sought power in its passenger vehicles, with the result that the average maximum horsepower per car rose from 28 in 1920 to 85 in 1936. This has meant increased energy consumption, partly because of the increase in power, partly because of the increase in distances traveled owing to higher speeds. Another indicator has been the increase in passenger-miles traveled per capita per annum (all forms of transportation) from 1,486 in 1920 to about 4.200 in 1938 (Chart 29), a rise of 180 per cent. But besides traveling, Americans have. been busy talking: telephone messages per capita (Chart 30) have increased 39 per cent, from 161 to 223. Finally, in its search for energy the U.S has harnessed its rivers to such good effect that the per capita kilowatt-hours from this source have increased from 143 in 1920 to 339 in 1939, or 140 per cent (Chart 31).

Expanding productivity per worker. Industrialization, as already pointed out, increases the power of everyone, not least of the worker; one of the most impressive measures of the expansion during the thirties is the rise in worker productivity. This has come about in many ways, but chiefly by putting more horsepower at the worker's disposal. Thus in the Detroit area (Chart 32) the industrial energy consumed per worker has risen from 4,400 kilowatt-hours to 11,200 kilowatt-hours during the last eighteen years. On the farm the same trend is evident. In the wheat belt a man worked .14 acres per hour in 1920; now he works .24. The textile industry extended its work power from the processing of three pounds of raw cotton per man-hour in 1920 to 4.8 pounds in 1938, an increase of 60 per cent (Chart 34). The oil-refining industry (Chart 35) showed a similar increase; and by the improvement of machinery and other measures the bituminous-coal industry raised its output from .499 to .658 tons per man-hour, an increase of 32 per cent (Chart 36).

Expanding power to consume. The vital objective of the industrial system is the consumer, as already set forth, and the increases already shown in efficiency, in energy production and consumption, and in worker productivity, have inevitably benefited him. If dollar measurements are used these benefits are often obscured. It is only in units consumed per capita that they can be truly summarized. During the "depression"

**It will be noted that, while this crossing is admittedly arbitrary, one would have to introduce considerable distortion in the chart to avoid crossing these lines in the early thirties.*

†Aluminum scrap cannot be readily measured because this metal is so universally alloyed. A great deal of aluminum scrap is sold in its alloyed form.

many consumers' articles showed a vigorous expansion in these terms. No attempt is made here to cover the list, but a few representative samples (besides those already pictured in Group II) are shown in women's silk stockings (Chart 37), sales of pairs of shoes (Chart 38), vacuum cleaners in use (Chart 39), bathtubs in use (Chart 40), and sales of electric bulbs (Chart 41).

Expanding knowledge. During the so-called depression, then, there has been a violent expansion in the use of certain new materials, in efficiency, in the consumption of energy, in the productivity per worker, and in the consumption of many products. Nor has the violent push of a new era stopped there; great advances have been made in the means of obtaining knowledge, which will in turn create new future demand. Thus the resolving power of microscopes (Chart 43) has increased from 3,600 diameters to 40,000, an increase of 1,011 per cent in man's power to explore the invisible and to carry industrialization further. The same trend is shown in the violent rise in the employment by industry of research technicians (Chart 45). This rise of 433 per cent, from 1920 to 1938, was touched on in FORTUNE'S "U.S. Frontier" editorial for October, 1939; and it too guarantees more progress in the future. Equally indicative are the rise in college enrollment (Chart 42) and the rise in high-school attendance (Chart 44). Even the movies, with their vast power to create awareness and new desire, have pushed upward. Discounting the "depression rise" in 1930 as an abnormality, movie attendance has risen from nineteen admissions per capita per year in 1922, to thirty-four in 1938—a net gain of 80 per cent.

The "depression"

IT IS now possible to analyze the modern period, from 1920-39, with a clearer understanding of the forces at work. Turning back to our key, Chart 6, page 52, it is necessary to note, first, that the basic trend shown therein is not causal but symptomatic. Thus, to take iron, the decline in the absorption of this material did not result in a change in the economy; on the contrary, a change in the economy caused the decline in absorption. The nature of that change can be summarized in two points.

First, when iron is put into producers' goods, such as steel rails, bridges, buildings, factories, and even heavy machinery, it stays there for a long time; it is lost, so to speak, from the circulatory system. Thus, when an economy is building its producers' plant, vast annual tonnages of iron will be added to the system, the net absorption will be high. These machines, however, are used to make machines for the consumer (consumers' durable goods) such as automobiles, refrigerators, typewriters, bicycles, etc.; and the consumers' machines rapidly wear out. When they wear out they are junked and returned into the circulatory system in the form of old scrap, to be remanufactured into more consumers' goons. As an economy reaches a high consumer stage, therefore, its net iron requirement will decline: or, vice versa, a decline in the net iron requirement is the first sign that an economy is entering the consumer stage. All this is irrespective of exports, which are eliminated from the net figure. It would of course be possible to have an actual rise in iron mining and pig production, though a decline in the net domestic absorption, provided exports were increased.

Second, increases in efficiency of the kind shown in Group III enable an economy to produce more energy for each ton of iron absorbed. Thus, an old-style turbogenerator weighed twenty-three and a half pounds per horsepower; a comparable modern one weighs only about seven pounds. The latter will consume more energy per *ton* of *material* than the former. A virtual revolution takes place in the energy tonnage relationship in the transportation industry when we introduce the airplane engine, which weighs slightly more than one pound per horsepower, instead of the automobile engine, which weighs nine or ten, or the locomotive, which, deliberately made heavy for tractive purposes, weighs seventy-five. This point is crucial. Manifestly, if the progress of industrialization (i.e., of increasing the power to consume) were to stop, a decline in the tonnage curve would sooner or later result in a leveling off, or even a decline in *the* energy curve. If automobiles, for example, were no more powerful today than they were in 1920 the recirculation of automobile scrap would not necessarily result in an increase in the energy consumption per capita. If, however, industrialization is advancing, the same amount of scrap will result in the consumption of more energy. Thus it is possible to conclude that if the absorption of matter and the consumption of energy *both* decline, then indeed an economy may be finished. But if a decline in the net absorption of matter is accompanied by a rise in the consumption of energy, industrialization is proceeding in a healthy and vigorous manner-that is to say, the system is expanding. Moreover, this latter trend over any considerable period of time would mark a clear transition from a crude producers' economy to an advanced or highly evolved consumers' economy.

Now this is exactly what has happened during the modern period, 1920-39. The first shift came in the period 1923-29, when new plant was still being built but not fast enough to maintain the rate of tonnage absorption. If the effect of this change had been noticed at all, it would have been noticed first in the mining industries and in the production of pig iron. But it was not noticed even there because all industry, including mining and other producers' industries, was sustained by enormous exports financed by Wall Street. These exports were chiefly consumers' goods, but they absorbed big tonnages of ore and pig, and also supported other producers'-goods industries. It was not until exports collapsed (from a value of $5,157,000,000 in 1929 to $1,576,000,000 in 1932) that the change *that had* already begun was felt.

The effect of the decline in exports would have knocked the props out from under the producers'-goods industry in any case. But the effect was intensified by the fact that the nation had an even bigger and better plant in 1932 than it had had in 1923. New plant, of course; would still have to be built; replacements and improvements would still have to be made; hence some of the producers'-goods industries (notably the machine-tool industry) would prosper-and have prospered. But the wild prosperity that comes from finding new tons of valuable industrial materials under the earth, mining them and smelting them, was not to be expected. Moreover, owing to technological advances, the productivity of the plant already in existence was greatly increased. This meant that a large increase in consumption could be registered without creating any corresponding need for an expansion of the plant. Accordingly, the capital market collapsed, idle funds accumulated, and fear spread. The situation was characterized as an "emergency" by the political leaders. Business was blamed. And many persons, some in high office, opined that the country was in for an era of contraction and a declining standard of living.

It is manifestly impossible to review here the various stimulants and antidotes that have been administered to revive the supposedly sick industrial system. They have not revived the system chiefly because they have failed to put the emphasis where the emphasis belongs. The important fact is not that an old era has passed, but that a new era has been born. And in the last analysis the central economic problem of this new era is a simple one. The central economic problem is *not* a revival in the producers' industry, although that would help. Nor can it be a revival in "investment" in the old sense of the word. The central economic problem is simply the conversion of a high potential power to consume into an actual power to consume: a wider distribution of progress.

The great differential that links potential and actual consuming power is *price;* and what the new era cries for is a drastic decline in many 'lines of industrial prices. The most cogent example of the effect of price is to be found in Chart 22 (Group III), which shows the enormous rise in miles per automobile tire. Much of this rise has been achieved simply by putting more rubber on the tires; yet costs have been saved, both in the price of crude rubber and by an increased productivity ot labor in the tire factories; and these savings have been handed on to the consumer, with the result that the cost per mile of every tire has radically declined, and sales have increased. This is the method by which potential is translated into actual consuming power.

This is quite in accordance with classical capitalist theory, which holds that while technological advance creates unemployment, it will also create new sources of employment, providing the cost saving is passed on to the consumer. A lower price in one article saves the consumer money that he can then *use* to buy another article, thus increasing the volume of the latter and creating a new demand for labor. Industrial price cutting, in other words, actually increases the purchasing power; and a high purchasing power must result in a high rate of consumption and an improved labor demand. Whether this principle is capable of sustaining an indefinite advance without any assistance from an expansion in the producers' industry is a matter for debate. But it would patently be capable of starting an advance: and if an advance were started the next steps would become far more obvious than they are today.

But a decline in prices can be brought about only in the presence of an intangible factor that has hitherto baffled everyone. This is the factor of confidence. Concerning this word there has been a lot of confusion. Emphasis has been put on the need for confidence in making new investment; but in view of the shift in the nature of the economy, this emphasis is both unrealistic and academic. The realistic requirement is, rather, that the businessman should have confidence in the consumer: he must have confidence that if he decreases his prices and his profit margins he will get a corresponding rise in volume. He has not been confident of this and he has consequently held his prices high enough to be sure to cover his overhead and fixed charges ar the present volume.

This failure of business confidence in the consumer has been due partly to a lack of business imagination. But it has also been partly justifiable because consumers themselves, lacking confidence in the future, tend to save too much against the rainy day that everyone has been taught to expect. They do not spend so much as they might if they had confidence in the future. It cannot be argued, of course, that the situation can be solved by a cut in the rate of savings of the average consumer. The bulk of the savings comes from the upper brackets; and the upper upper brackets, at any rate, have presumably almost reached the limit of their power to consume. Nevertheless-again-a *start* could be made. The release of one or two or maybe even three billions a year from the unfruitful purchase of insurance policies, "safe" bonds, or just plain cash accumulation ***may be that very pump primer that we have been needing all along.***

The chief hope, therefore, of starting to convert our great potential into actual consuming power, is to lay the facts of industrialization before the people. The new era, the new requirements, the new duties, ***the new hopes*** should be announced. But this has not been done; and the result has been theorizing in *vacuo*. To this general observation should be added the caveat that participation in a war would ***apparently***

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change the entire situation. Vast tonnages of metal would then be absorbed, not only in building a big national munitions plant but also by shooting iron at the enemy. If this happened the "solution" would be provided via producers' goods, just as in the past. But since the object of industrialization is to increase consuming power, and not to destroy, nothing would really be solved. The true solution would merely once again be deferred for another generation.

Group IV

The U.S. abroad. There is one other factor in the present situation that bears heavily upon the future prosperity of the U.S. In Group I the U.S. standard of living was shown versus that of the rest of the world. In Group IV the relationship of the U.S. to the rest of the world is shown in the more tangible terms of foreign trade.

Explanations of these charts will be found under the charts themselves on page 56. They are presented by way of a reminder that, although (barring war) the U.S. has built its primary industrial plant for some time to come, the rest of the world has not. Reliable figures are not available, but those that FORTUNE has obtained indicate that whereas the tonnage curve for the U.S. is falling, that for the rest of the world is now rising. The rest of the world, considered as a whole, is building its plant, and one way to revive the U.S. producers' industry would be to participate in this building.

This possibility raises a number of problems that cannot be entered here, but it is worth noting that considerable participation already exists. First, as Chart 47 shows, direct investments of private capital outside the U.S. totaled 7.7 billion in 1933 and some 7 billion in 1938. The "depression," in short, did not by any means wipe out these investments. They are now near the level of the late twenties-whereas, as shown in Chart 6, the U.S. domestic absorption of tonnage is back at the level of the nineties. On the other hand, portfolio investments (i.e, U.S. ownership of foreign equities) have dropped much more severely.

As for exports, Chart 49 shows a steady rise in shipments to industrial neophytes such as Central America, the West Indies, South America, Asia, Oceania, and Africa; and a decline in exports to industrial Europe (including the Soviet Union) and to Canada (including Newfoundland and Labrador). Tracing this trend further

[Continued on page 164]

DISTRIBUTION OF WORLD POPULATION AND INDUSTRIAL ENERGY

The left column below gives comparative figures for effective world-energy consumption (average 1937-39), computed at 4 per cent efficiency. The column titled inanimate-slave population is arrived at by dividing the figures of column one by 37,500,000. This figure represents the foot-pounds of physical work that it is estimated a man may maintain over a year, less the energy required for self-locomotion. Countries whose animate and inanimate populations are under 1 per cent of the world's have been distributed proportionately to countries above 1 per cent (exception, Canada).

	Effective consumption all energy in quadrillions of foot-pounds	Inanimate-slave population	Per cent of total world inanimate slaves	Human population	Per capita energy slaves
United States	746	19,899,000,000	54	130,000,000	'53
Canada	69	1,842,500,000	5	11,000,000	167
All other America	55	1,474,000,000	4	130,000,000	11
Total Americas	870	23,215,500,000	63	271,000,000	86
Germany (greater)	111	2,948,000,000	8	109,000,000	27
Great Britain	69	1,842,500,000	5	45,000,000	41
France	55	1,474,000,000	4	42,000,000	35
Italy	4s	1,105,500,000	3	44,000,000	25
U.S.S.R.	69	1,842,500,000	5	169,000,000	11
All other Europe	55	1,474,000,000	4	157,000,000	9
Total Europe	401	10,686,500,000	29	566,000,000	19
Japan and China	83	2,211,000,000	6	557,000,000	4
All other Asia	0	0	0	567,000,000	0
Total Asia (except U.S.S.R.)	83	2,211,000,000	6	1,124,000,000	X
Total Africa	28	737,000,000	2	153,500,000	5
All other	0	0	0	10,500,000	0
Total World	1,382	36,850,000,000	100	2,125,000,000	17

Estimates by R. Buckminster Fuller

(Chart 50), we find a very marked rise in the exportation of industrial capital goods, a trend consistent with the thesis that the rest of the world is now building its industrial plant.

It is clear that the exportation of private capital in direct investments, together with the exportation of capital goods, whether producers' or consumers', can provide partial solutions to the domestic savings problem, on the one hand, and the stalling of the domestic tonnage economy on the other. In so far as outlets can be found in this direction, some of the pressure for converting the domestic economy almost overnight into a consumer economy will be taken off. Hitherto the barrier to this line of development has been our own unwillingness to ***participate*** in world trade by admitting imports. Our tariffs have brought forth tariffs and quotas against us. International trade has thus been blocked, and at present the situation is further complicated by war. But the need is now so great that something must be done. As pointed out in the last article of this issue, the U.S. frontier is becoming international. It is necessary for the U.S., while reforming its economy, to work for a new world order in which it may confidently share.

A foreign policy, formulated with some of the determination that characterized the announcement of the Monroe Doctrine, but adapted to the needs of the 'modern situation, will be essential to the re-establishment of that confidence which, as we have seen, American business and the American consumer must have. Such a policy might well be based upon the declared intention of the U.S. to *help* raise

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the standard of living of the rest of the world, and particularly of its neighbors. The vast discrepancy in the standard of living inside the U S. and outside of it-as shown in the charts of Group I-is, assuredly, neither just nor democratic. It is not even wise: for it creates a fundamental imbalance in the world from which the U.S. itself is now suffering.

THE U.S. citizen is not accustomed to thinking of himself as an internationalist, and it may be a generation or so before the idea sits easily in his head. But whether he thinks of himself as such or not, he ***is.*** His internationalism is the result of his great power, a power such as no mere citizen has ever had, nor for that matter, many kings. The dimensions of this power are illustrated on the map on page 57, which shows the power of the American in terms of manpower slaves. It is estimated that one man, besides carrying his own weight, can do 150,000 foot-pounds of work in an eight-hour day, a total of 37.5 million foot-pounds per year. On the other hand, the energy consumed by the U.S., 1937-39, from mineral fuels (coal, oil, gas) and waterpower was sufficient -(after allowing for the inefficiency of conversion) to produce 746 quadrillion foot-pounds of work. That is the equivalent of the work of 20 billion human slaves, or 153 per capita. In addition, of course, the inanimate slaves are more serviceable than humans. No number of human slaves could enable the citizen to fly or to drive a car at eighty miles an hour. But for purposes of comparison the figure will serve.

And the comparison with the rest of the world is almost incredible. While topped by Canada on a per capita basis. the U.S. actually has 54 per cent of all the world's 36,850,000,000 inanimate slaves. On the map the comparison is simplified by the use of white dots (for actual population) and red dots (for the inanimate-slave population), but in the table on page 163 it is hroken down by countries and continents. Whereas the U.S. has 153 slaves per capita, Great Britain has only 41, Germany only 27, France only 35. Africa has only 5. And Asia, without Japan and China, has virtually none at all. The average for the entire world, including the U.S, is only 17. The relative supremacy of the U.S. in these primary terms is something that no empire in the world, probably not even Rome in the days of human slavery, has ever equaled.

This supremacy carries with it a responsihility. It is easy for us to turn back to the history books, to trace the errors that the Roman people made and the errors that the emperors made; to watch the crumbling and decay of that great civilization. It is not so easy to measure or to analyze our own civilization-or even to realize that it is ours. But this we must now do. By industrialization we built a new civilization. And during the last fifteen or twenty years, by further industrialization, we have created the possibility of an entirely new era for mankind. It is time now to get to work to make that era a reality.

Data Sources for Charts in Fortune Article

GROUP I-U.S. VS. THE WORLD

A Demonstration That Comprehending Resource Data is More Complex and Greater Than the Sum of Data Collection or Analytic Data Processing Systems Alone

Chart 1

1. Area-Statistical Yearbook of the League of Nations 1938-39 (in square kms)
2. Potential Water power-in hp is based on ordinary minimum flow. Figures from release 81147, U.S. Dept. Interior, Geological Survey, May 1939 called "Developed and Potential Water Power of the World"
3. Sheep and lamb population-world population is a department of agriculture estimate for 1931 to 1935 given to me over phone by publishers of Commodity Yearbook. U.S. figure is a 1931-35 estimate taken from Yearbook. Although the figure is now rather old the ratio is probably still about the same which is the only thing shown on our chart. However, in using figures in text of story we can get very recent U.S. population estimates but latest on world is for 1931-35.
4. Cattle-above source.
5. Wheatland under cultivation-figure difficult to get because most estimates exclude China and Russia. The figure we used is taken from League of Nations Statistical Yearbook 1938-39 which includes Russia but excludes major part of China, Iran, Iraq and some of Asiatic Turkey. (In hectares.)
6. Hog-above source
7. Copper-from book in library on world resources published in 1936 by National lndustrial Conference board (morgue number 669.3 na) (In tons)
8. Water wheel capacity in constructed plants-from same source as figures on potential water power. Figures are for constructed plants of 100 hp or more at the end of 1938 and are in hp.
9. Iron Ore-Figures are for iron ore deposits that are suitable for industrial use (i.e. by methods that can be used commercially today.) They were given to me over phone by Mr. Hollander of National Industrial Conference board and were compiled in Feb. 1937. (Metric tons.)
10. Cotton land under cultivation-Stat. Yearbook League of Nations 1938-39 (Hectares)
11. Coal-Figures from Energy Resources & National Policy published by the National Resources Committee Jan. 1939 (in net tons.)
12. Petroleum-An off the record guess of the American Petroleum Institute given to me over the phone by Mr. Van Covern. We must not quote the API on them (In bbls.)

Chart 2

Wherever possible production figure given is a 3-year average of 1936-37 and 38

Production

Petroleum-figures from Mr. Van Covern of American Petroleum Institute (bbls.)
Smelter Copper-metal statistics, 1938 (short tons)
Steel-Figures from American Iron and Steel Institute (long tons)
Coal-Minerals Yearbook 1939 (includes lignite and in metric tons)
Motors-Facts & Figures 1939 put out by National Automobile Association (all motors)
Cotton-Commodity Yearbook 1939 (500 lb bales)
Wheat-League of Nations Yearbook 1938-39 in quintals. Figure excludes major part of China, Iraq, Iran, and part of Asiatic Turkey. Had to use 1937 figure to get in Russian prod.
Gold-American Bureau Metal Statistics 1939 (fine ounces)

Silver-American Bureau Metal Statistics 1939 (fine ounces)
Aluminum-American Bureau Metal Statistics 1938 (metric tons)
Rayon-League of Nations yearbook 1937-38 and 1938-39 (Metric tons)
Milk-League of Nations yearbook 1937-38 and 1938-39 (in hectolitres) Figures cover as far as possible total production of milk by cows, buffaloes, goats, goats and ewes. In certain cases figures refer only to cows' milk but in many others the exact scope of the series is not specified. Some series in the table are restricted to whole milk entering dairies and factories. Where the original statistics are given by weight, an average specific gravity of 1,03 1 has been assumed
Wheat-Commodity Yearbook, 1939
Paper & Paper Board-League of Nation's Yearbook 1937-38 and 1938-39. (Metric tons) World total does not include Hungary, Spain and certain minor producing countries outside Europe.
Cement-League of Nation's Yearbook 1937-38 and 1938-39. (Metric tons) This table covers as far as possible both natural and artificial (Portland) cements. Figures exclude Manchuria, Spain.
Tobacco-(in quintals) League of Nations Yearbooks, production data refer, as far as possible to dried leaves. Countries not included in the total: China; Iran; Honduras and the unimportant production of Costa Rica; Guatemala, Salvador and Jamaica; Peru, Ecuador, many states in India.
Movie Attendance-Film Daily Yearbook
Telephone Frequencies-number is per annum completed calls per person. From Mr. Benton and Mr. Fick of the A.T. & T.
Butter-Yearbook League Nations. (Metric tons.) Table covers as far as possible creamery and farm butter.

Chart 3

Products in Use

Telephones-Mr. Benton of A.T. & T.
Railway lines-Yearbook railroad information published by Committee on Public Relations of the Eastern Railroads 1938 edition (main track)
Motor Vehicles-1939 Auto Facts & Figures (all kinds of registrations)
Miles of highway-Jan. 1, 1938 figures from Automotive World News, Sept. 1, 1939 vol. 1 number 25, Auto Aer. Trade Div. Dept. of Commerce.
Non-military airplanes-Horan in Washington. His figures from Civil Aeronautical Authority. However, Europe makes little distinction in military and non-military airplanes so figures not too good.
Radios-Figures given me by Dr. Calwell of Radio Today (we must give Radio Today credit somewhere in story I called several places for these figures but was always referred to Radio Today World Almanac also uses Radio Today figures RCA referred me to Radio Today as a very reliable source)
Cotton spindles-Cotton Textile Institute
Motion Pictures Theatres—Film Daily Yearbook 1938
Merchant Fleet-1938 figure Yearbook League of Nations 1938-39 (total gross tonnage). The totals include also sailing vessels; for some countries, especially Japan, Turkey, Greece, and the U.S.S.R. these data are not available. Sailing vessels fitted with auxiliary power are included among steamers or motor-ships, according to the type of the auxiliary engines. In Canada and U.S. vessels other than wooden on Great Lakes included U S S R figures do not include vessels on Caspian Sea
Bathtubs-figure given to me by Mr. Baugh of Blaker Co., adv. agency for American Radiator. Mr. Baugh called Chicago for us and got figures from Plumbing & Heating Industries Bureau. According to them every sixth person has a bathtub in the U.S. and we have 90 per cent of the tubs. Elsewhere there is a bathtub for every 1300 persons. However, in refiguring on the basis of one bathtub to every six here or 21,680,000 bathtubs which is 90 per cent of the world figure would give a world figure of 24,090,000 tubs for the entire world. This would give a bathtub to every 828 persons in the rest of world instead of one to every 1300.

GROUP II-THE HISTORY OF PROGRESS

Chart 4

Income Group

Figures are from the National Industrial Conference Board and are based on total realized production income, which the board explains as follows:

"The realized production income total includes salaries and wages, entrepreneurial income, dividends, interest and net rents and royalties received both from private enterprises and from government"

Family population was given to me over telephone from National Industrial Conference Board by Miss Meyers. They are Bureau of Census figures and are not strictly accurate as they include in addition to normal or private families, certain aggregates of population, such as institutions, hotels, boarding houses and construction camps. However, they are the only figures that go back to 1850 and have been used by the Board in some of their tables.

Chart 5

Exports-proportional per cent Agricultural and all others.
Chart by Walker She got figures from Statistical Abstract

Chart 6

Energy and Iron Tonnage

Energy-effective per capita consumption all sources.

Figures are taken from a table compiled by Bureau of Mines called Annual Supply of energy from mineral fuels and water power in the United States in B.T.U.'s. The government has compiled these figures by using the same constants for each producer of energy from 1871 to 1937. They are:

1 lb. bituminous coal	13,000 b.t.u.
1 lb, anthracite coal	13,600 b.t.u.
1 bbl. petroleum	6,000,000 b.t.u.
1 cu. foot nat. gas	1,075b.t.u.

Water power fuel equivalent is calculated from the kwhrs of power produced wherever available. Otherwise the fuel equivalent is calculated from the reported hp of installed water wheels, assuming a capacity factor of 20 per cent for manufactures and mines and of 40 per cent for public utilities. 1936 and 1937 anthracite figures do not include bootleg coal

These figures were divided by the population figures to get the per capita

For the years 1920 to 1937 we added our own estimated increase in coal and gasoline efficiency for each year in a rising volume starting with zero over 100 per cent for 1920 and in coal reaching 34 per cent of half the coal used in 1937. For gasoline we used zero in 1920 and finally reached 300 per cent for half the petroleum in 1937. Based on a 300 per cent increase in auto hp in these years with no increase in gas consumption. I found the percentage rise each year by drawing a triangle on graph paper and counting the squares for each year. We used half the petroleum because about half goes into motor fuels. Although not quite half the coal goes into the three groups we used (railroads-freight and passenger-and iron making) the amount varies from year to year and our estimates are arbitrary.

Iron Tonnage

Net Addition (Per Capita Pounds Iron)

This figure is to show the amount of new iron required per capita annually. To arrive at it we subtracted from pit iron production all the iron that went out of this country and added to it the imports.

(We did not use iron ore because its weight is not all pure iron. Pig has almost the same specific gravity as that of steel.) The iron going out of the country included all steel and iron and scrap. Because there is also a considerable amount of iron going out in the form of machinery we took the yearly dollar figures on machinery exports and divided them by two to get a figure on the number of pounds that went out in the form of machinery. This is certainly not an accurate figure as machinery includes much copper.

Aluminum, cast iron, etc. Also the price varies all over the map. But the figure in the total makes little difference inasmuch as it is much below a million a year and our total figures are up in billions of pounds. To get the pounds of iron that went out in the form of automobiles we took the auto exports and multiplied them by 1.6 tons which is somewhere near the amount of steel in a car. This figure is also negligible in the whole picture. We did not bother with machinery entering this country or with automobiles. The amounts of each are negligible when considered in terms of billions of pounds. After getting the net pounds (i.e. all iron exports subtracted from pig production and imports added to pig production) we divided the figures by the population for each year and arrived at our per capita requirements of iron. In this particular chart the line shows a year to year per capita movement. However, in the postage stamp charts (iron and iron scrap, iron vs. aluminum, and iron vs. plastics) the line has been straightened out by averages to show the high spots and the general trend

Chart 7

Fuel-Human
Wheat-Bureau of Agricultural economics, Dept. of Agriculture.
Beef-Agricultural Yearbook. 1939 figure an estimate of the Bureau of Agricultural Economics.
Oranges-Bureau of Agricultural Economics (estimates by the bureau)

Chart 8

Fuel-Industrial (millions b.t.u.'s per capita.)

Coal and Oil

B.T.U.'s for each taken from Bureau of Mines table called annual supply of energy from mineral fuels and water power in the United States. The figures were divided by the population. (explanation of these figures of the bureau in part on energy and tonnage.) The figures used in these two lines are exactly as the bureau gives them with no additional increases for efficiency. In order to get a figure back to 18.50 (Bureau of Mines table goes back only to 1871) we took the anthracite and bituminous coal production of 185 1-l 860 yearly average and converted it into B.T.U.'s.

Chart 9

Cotton-Manufacture pounds per capita. Textile Economic Council of N.Y.
Rayon-figures from Textile Economic Council in New York.

Chart 10

Transportation-miles railroad track, statistical abstract-main track.
Transportation-automobiles per 1,000 pop., registration for passenger cars. Automobile Manufacturers Assoc
Transportation-airplane passenger seats per 1 ,000,000 pop., air transport **Assoc.** (Passenger seats available in commercial planes only.)

Chart 11

Communication-miles telegraph wire per 1,000 pop., Mr. Benton A.T.&T. and Stat. Abstract.
Telephones-Benton A.T.&T.
Radios-all radios including cars and home made sets-Radio Today

GROUP III-DYNAMICS OF PROGRESS

Chart 12

Iron-New Mined (Procedure Explained Elsewhere)

Scrap-The production of ingots and castings were subtracted from pig iron production (including ferro alloys). The difference represented scrap used in the production of the ingots and castings. To this difference was added 10 per cent to account for scrap wasted in production of steel. This final figure we used for our scrap iron line. Mr. Rose of the American Institute of Scrap Iron and Steel said this was probably the best way to get scrap figure as scrap figures not reported in uniform way for earlier years. This figure includes only scrap used in the steel industry and does not include scrap used in industrial plants which is not reported. Many companies produce their own scrap which they reuse. This never gets out into the trade

Chart 13

Copper-New Mined

Figures are from Mine yearbook Copper scrap Fuller's figure from Phelps Dodge chart

Chart 14

iron vs. Aluminum-(Same Iron Line Used)

Aluminum-apparent consumption from Mineral Yearbook 1939. This was multiplied by 2.9 to get it's size up to that of iron. The specific gravity of aluminum, according to chemist at Aluminum Co. of America, is 2.7. That of iron is 7.85 to 7.88 (Handbook Chemistry & Physics 1939) Therefore, 7.85 divided by 2.7 equals 2.9. We multiplied 2.9 times- the aluminum consumption figure to get volumetric size of aluminum and divided this by population.

Chart 15

Iron vs. Plastics

There are no correct figures on plastic production because the definition of plastics is so elastic. The only way we could arrive at a figure was to add the coal tar resin production to the non-coal tar resin. These figures given to me by Mr. McMillan of Standard Statistics. But he was not able to give them to me for certain years so we estimated the missing figures from a Department of Commerce chart on the production of synthetic resins

Mr. Pechin of Dupont says that if we use these figures for plastics production we must drop a footnote saying: This covers coal tar, cellulose and other types of plastics. (Imports and exports according to him relatively unimportant and no way to get correct figures.)

Volumetric-specific gravity various types of plastics runs all the way from 1.16 to 1.63 and more or lower but 1.35 probably best figure to use as average according to Mr. Randolph Dupont. This divided into 7.85 equals 5.81. This was multiplied by plastic production and then divided by population.

Chart 16

Combustion (kwhr's per lb. coal)

Pounds of coal per Kwhr from Edison Electric Institute. These figures converted to kwhr's per lb. of coal to make a rising trend.

Chart 17

Combustion-Industrial Coal, 1920—100%

According to our estimate the coal efficiency of coal used in locomotives and in the steel industry has increased 34 per cent over 1920 when the figure stood at 100 per cent. This we call industrial coal. This excludes the efficiency increases in coal in other industries such as utilities, in the home where the iron fireman is becoming so popular, in factories, etc. Therefore, our figure shows only a portion of the increase in fuel efficiency.

We have called 1920 100 per cent because the Bureau of Mines has used constant fuel equivalents from 1871 to the present time without allowing for any fuel efficiency increase. For instance, a pound of coal in 1871 was reported at 13,100 b.t.u.'s and is still reported that way. (This is for bituminous coal.) Natural gas has always been at 1,075 b.t.u.'s, etc. We arbitrarily added the 34 per cent to the 1937 total, drawing a straight line beginning at the 1920 point in order to show a rising line.

To get the 34 per cent: In the Minerals Yearbook for 1939 in a table called Fuel Economy are figures showing the pounds of coal required for 1,000 gross ton-miles freight for 1919-1920 and for 1937; for a passenger train car mile; and for making a ton of pig. These we converted into the amount of work done by one pound of coal for the two dates and determined from that the percentage increases in efficiency for the three groups. The next step was to find out the amount of coal used in 1937 by the three groups and weight each of the three percentage figures in order to get an average figure for all

The procedure was as follows:

Pounds coal consumed per 1000 gross ton miles freight 19 19-l 920	170	lbs
1 ton mile	.17	lbs.
5.88 ton miles	1	lb.
Pounds coal consumed per 1000 gross ton miles freight 1937	117	lbs
1 ton mile	.117	lb.
8.55 ton miles	1	lb.
Increase in efficiency from 5.88 ton miles to 8.55	45.4	%
Pounds coal consumed per passenger car-mile 1919-1920	18.5	lbs.
.054 car miles	1	lb
Pounds coal consumed per passenger car-mile 1937	15.1	lbs.
.066 car miles	1	lb
Increase in efficiency from .054 car miles to .066	22.2	%
Pounds coal (coking) consumed per ton (2240 lb) pig produced in 1918	3,577	lbs
.626 lbs. pig	1	lb.
Pounds coal (coking) consumed per ton (2240 lb) pig produced 1937	2,917	lbs
.768 lbs. pig	1	lb.
Increase in efficiency from .626 lbs. pig to .768 lbs. pig.	22.68	%

Therefore we have the three increases in efficiency from 1920 (roughly) to 1937.

freight coal . . . . . 45.5 %
passenger coal . . . . . 22.2 %
pig coal 22.68%

To weight these percentages:

Coal consumed by locomotives in 1937 . . . . . 82,667,000 tons

(In ICC blue book coal consumption of railroads for 1936 was broken down into passenger and all other loco coal. The percentage of coal used then for passenger locos was 15.06%. We applied this 1936 percentage to the 1937 total which, although probably not accurate is enough so for our purpose. Applying this percentage to the 1937 figure you get the breakdown as follows:)

Freight loco coal in 1937 . . . . . 70,266,950 tons
Passenger loco coal . . . . . 12,400,050 tons

(To get the coal consumed in furnaces for making pig we had to start with coke figures. In 1937, 52,375,469 tons of coke were produced. Of this 33,571,349 were consumed in pig furnaces or 64%. Total coal used in making coke was 74,502,200 tons. 64% of this is 47,681,000 tons so that many tons of coal were used in making pig.)

Therefore:

Coal consumed in three groups we are considering:

	Tons	*group inc. in efficiency*	*% of whole in tons*	*group inc. times percentage*
Freight	70,266,950	**45.4 %**	**53.90**	**2447.06**
Passenger	12,400,050	**22.2 %**	**9.51**	**211.122**
Pig	47,681,000	**22.68%**	**36.57**	**829.4075**
	130,348,000		**99.98%**	**3487.59**

3487.59 divided by 99.98 equals 34.88% average efficiency of group.

(In getting average group efficiency it was necessary to consider whole in terms of parts For instance, if the freight had been 20 million tons, passenger 10 million, and pig 10 million we would have taken freight efficiency times 2; passenger and pig times efficiency once, added them together and divided by 4 which would have given average efficiency In our figures we considered freight efficiency at 53 9 parts, passenger at 9.51, etc. The percentage of the whole should have added to 100% but there is not room on the calculating machine to do figures to the last digit. Figures in making these estimates from 1939 Minerals Yearbook pages 773,807, and 889.)

Chart 18

Combustion (Gasoline in Automobiles)

Because amount of miles obtained from gasoline has remained practically the same we took the increase in horsepower (27.5 in 1920 to 81.5 in 1937) to show the increase in efficiency in the use of gasoline. Horsepower figures from Mr. Davies of the Auto Mfgs. Assoc. and are for maximum developed horsepower-an average for all new passenger cars sold

Chart 19

Aviation Engine (Hp per lb.)

Pounds per horsepower from N. V. Clement of United Aircraft in Hartford. We changed figures to hp per lb

Chart 20

Formability of Auto Fender Steel (% of *Elongation)*

Figures from Mr. Rose of Iron & Steel Institute. Percentage steel can stretch without breaking.

Chart 2 1

Tensile Strength (1,000 tbs. per sq. in.)

Figures from Mr. Bergen of Roebling-New York office.

Chart 22

Miles Per Tire

Figures from W. F. Bloor of Goodyear in one of his tables and were given to me over the phone by Mr. Iron in the N.Y. office. They are for the average mileage per tire of light cars which comprise 60% of the total registration.

Chart 23

Lubrication Index

Figures given Fuller by M. R. Fenske, State College Penn., and rechecked with Mr. Fenske by wire. The top figure of 18.5 is now known to research and development groups but not at present being marketed.

Chart 24

Lumens Per Watt (60-watt Bulb)

Figures from Mr. Powell of General Electric.

Chart 25

News Press Speed (Papers Per Hour)

Figures from Mr Strong, mechanical superintendent *N.Y. Times*.

Chart 26

Film Speed

Figures from Mr. Kisner of Eastman Kodak. Figures rechecked with Weston and Mr. Graubner of Pictures, Inc

Chart 27

Telephone Messages (Per Double Circuit)

Figures from John Mills of Bell Laboratories.

Chart 28

Horsepower Per Car

Figures from Mr Davies, Automobile Mfgs Assoc Maximum developed h p average all new passenger cars sold

Chart 29

Passenger Miles (Per Capita All Modes)

Figures compiled by H. F. Hale, Equitable Life Assurance Society.

Chart 30

Telephone calls per capita-Mr. Benton, A.T.&T.

Chart 31

Hydroelectric Power (Five Year Average)

Figures per capita from Statistical Abstract.

Chart 32

Industrial KWH's Available Per Worker-Detroit

Figures from Major Bennion head Edison Electric Institute. He got them from table by Harry Snow of Detroit Edison which were published in June 1938 bulletin of the Institute. 1938 figure from Mr. Snow by wire. Mr. Snow says that if Detroit Edison is to be quoted we must permit company to check use of figures for accuracy before printing

Chart 33

Agriculture (Acres Per Worker Wheat Belt)

Figures through 1936 from WPA report on Changes in Technology and Labor Requirements in Crop production; Wheat & Oats. Figures are for both total United States and for wheat belt. In order to get figure brought up to date (WPA report not continued) Horan found for us number man hours per acre for 36 to 39 for the entire United States. This figure is almost the same as for the period 1934 to 1935. Therefore we assumed that the figure in the wheat belt must also be the same so we made a flat line for 1934 to 1939 of .24 acres per man hour.

Chart 34

Textiles (Lbs. Raw Cotton Processed Per Man Hour)

Mr. Torrens of Cotton Textile Institute gave us figures on man hours per year in industry and raw cotton consumed Man hours divided into cotton equals pounds of cotton processed per man hour We did not use square yard figure to show production per man hour inasmuch as there are so many kinds of yard goods and these require different amounts of time to make.

Chart 35

Refining (Bbls. Crude Oil Per Man Hour)

Figures from WPA report page 329 Technological Employment and Output Per Man, Petroleum & Natural Gas

Chart 36

Bituminous Goal-WPA report Bituminous coal mining Vol. 2 Mechanical Employment and Output Per Man.

Chart 37

Women's silk stockings-from Mr. Hartman of the National Assoc. of Hosiery Mfgs. Consumption in U.S.

Chart 38

Shoes (Pairs Per Capita)

Includes all shoes made wholly or partly of leather including household slippers-information from Mr. Drew of Tanners Council. Consumption in U.S.

Chart 39

Vacuums in Use (Per 1000 Pop.)

Estimated by Electrical Merchandising (McGraw Hill) Figures given me by Miss Cook. Figures not available before 1923.

Chart 40

Bathtubs in Use (Per 1000 Pop.)

Figures from Mr. Radder of Plumbing & Heating. All bathtubs figures very rough. 1920 estimate not available so took ratio of bathtubs sold in 1929 and applied this percentage to production in 1921, 22, and 23 and 1924 to get production of bathtubs. Then allowed for 50,000 tubs junked a year and subtracted production from 1925 figure of bathtubs in use to get estimate for 1920. Exports and imports at that time negligible. Mr. Radder said it was all right to arrive at figure that way.

Chart 4 1

Electric Light Bulbs-Domestic Sales Per Capita

Figures from Mr. Powell, General Electric. Figures for only large bulbs sold (not Christmas tree decorations)

Chart 42

College Enrollment-figures from statistical abstract and from Horan. Figures are for total students of collegiate grade in regular session.

Chart 43

Microscopes-Magnifications

According to Bausch & Lomb magnification has been at 2500 since 1920. According to Mr. Kramer of Carl Zeiss figure was at 3600 in 1920, moved up to 5400 about 1934. Dr. Vladimir K. Zworykin, of the Electronic Research Laboratories of RCA, said the top magnification is now 40,000. He is the person who demonstrated the new powerful microscope that uses electrons before the American Assoc. for the Advancement of Science at a meeting held in Richmond last December. At that time another machine was invented which magnifies up to a million but Dr. Zworykin told me that that was not a microscope but a shadowgraph. Therefore the highest is 40,000. The earlier microscopes were optical.

Chart 44

High School Attendance

Figures from Statistical Abstract and later figures from Statistical Summary of Education 193536, Bulletin 1937 Number 2 and from a release called Back to School-Back to Work, published in September 1939. Both these two last sources published by Department of Education.

Chart 45

Industrial Research (Scientific Employees Per 100,000 Pop.)

Figures from Growth of Industrial Research in the U.S. by George Perazich, WPA, National Research Project Report, June 1939.

Chart 46

Movie Attendance (Per Capita)

Film Daily, figures given to me over phone by Mr Andrus

GROUP IV-U.S. ABROAD

Chart 47

U.S. Foreign Investments-Private Capital

Direct investments-figures from American Direct Investments in Foreign Countries 1936; from several issues of Balance of International Payments; from A New Estimate of American Investments Abroad by Paul Dickens of the Dept. of Commerce and another book by him, American Direct Investments in Foreign Countries

Portfolio-Figures given to me over phone by Paul Dickens of Dept. of Commerce. Some of the earlier figures have never been published

Chart 48

Index of U.S. Foreign Trade (5% of National Income Equals 100)

First we did a work sheet on which we drew three lines. One showed total exports (excluding reexports) in dollars. The second, imports for consumption. The third line is 5% of total production income (figures National Industrial Conference board). After doing this we straightened the 5% line and drew the export and income lines by figuring for each year (averages for 1926-30 and 193 l-35) the percentage gain or loss over the income line

Chart 49

Trend of U.S. Exports by Countries

We took the value of U.S. exports to geographical sections of world for each year (1926-30 and 193 1 to 1935 average) and figured the percentage of each to the whole. Then we grouped Southern America, South America, Asia and Oceania and Africa in one category and Europe and northern North America in another and added for each year the total percentages to show the trend of exports over the period of years. Figures from Summary U.S. trade with the world 1937 and latest from Survey of Current Business March and November 1939.

Chart 50

Trend of U.S. Exports (By Products)

First a work sheet showing quantity increase or decrease in commodities exported between 1920-26 to 1937 in terms of the whole each year. In another group we showed the commodities that increased in dollar volume and those that decreased in terms of the total exports each year. The down group was composed primarily of agricultural and consumer goods; the up group of industrial producers, equipment and materials. We added each group together for each year (1926-30 and 1931-35 estimates) and drew our lines to show the movement of the two groups The commodities that showed no change during these years we left out of our groups. Figures for these commodities are from Summary U.S. Trade with World 1937.

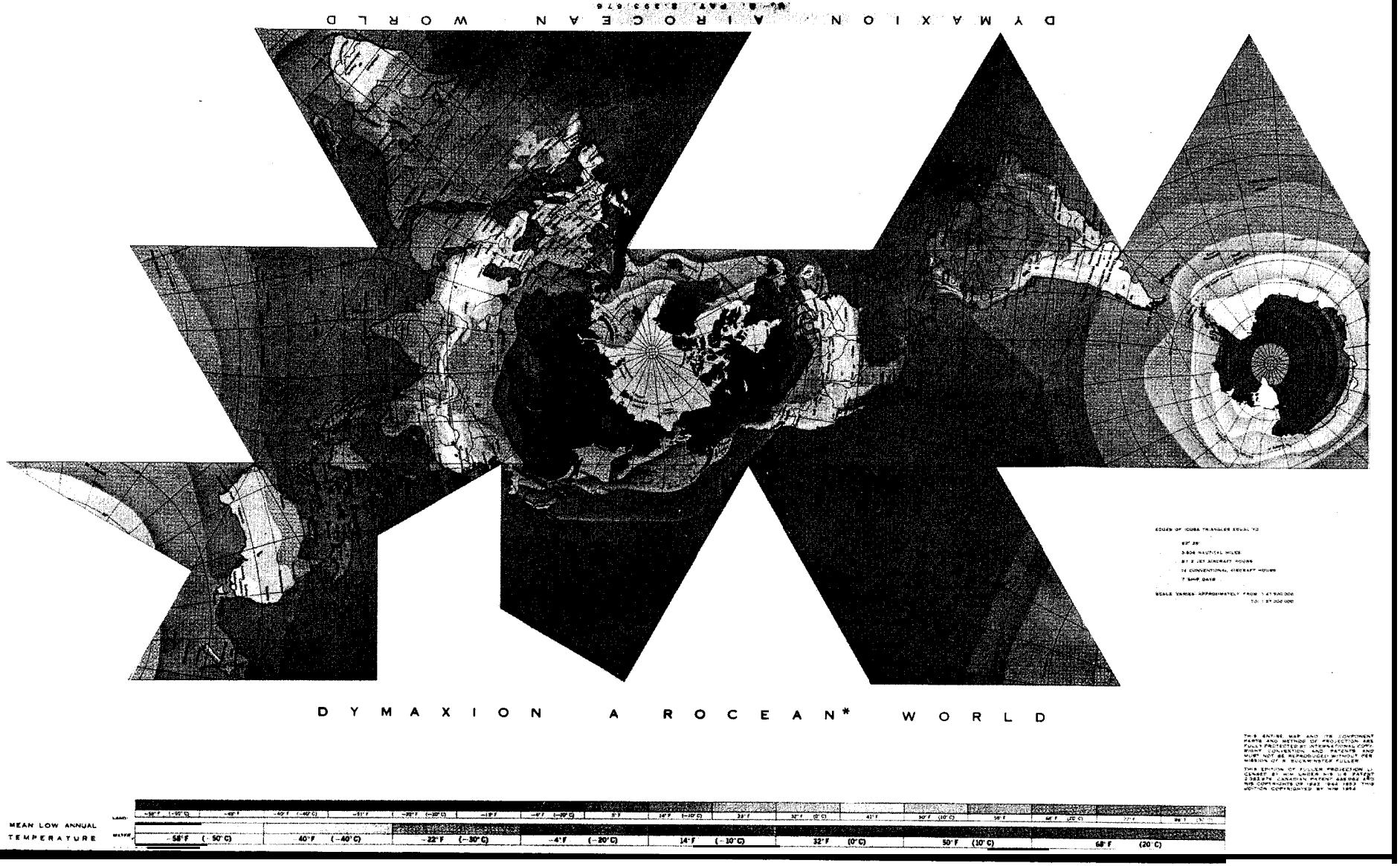
A.4 The Fuller Dymaxion Sky-Ocean World Projection; World I/World II'

"You are probably thinking that my world map is 'interesting,' but that you would rather have a 'regular' map. Our concept of the 'regular' map is typical of our mental fixation in the educational process. On the Mercator, as you know, the North Pole area is so completely distorted that it is seemingly thousands of miles from Greenland to Alaska. Many thousands of miles are indicated at the top edge of the Mercator between North Pole points one mile apart-completely misinforming. The Mercator map tends to show Europe and Asia split in two, so that 'never the twain shall meet,' as Kipling said. The Americas are in the center. The 'tops' of the continents don't join together at all, and there are the great open blank spaces of the Arctic and Antarctic. Those were very very good maps for the era of sailing when the Arctic and Antarctic were unexplored 'infinities.'

"My world map has strange sixty-degree angle-edge patterns. If you will cut out along the edges and bring. them together, you will find that the map will make an icosahedron-that is a 'solid' faced with twenty equilateral triangles. If you will compare the data and graphic patterning with that of a globe, you won't find any fault with it at all. It will seem to be saying just what the world globe says. The shape of the land masses is correct; there is no visible distortion of the relative shapes or relative sizes of its geographical features. This is a pretty good map because no other projection will do that. The polar aximuthals, the polyconics; and the Mercators-the prime 'regular' types-all have a very good distortion in them. My map does not. I discovered a topological transformation between spheres and planes. I was able to get a United States patent ever granted on a method of projection. Though my map is hung in many distinguished men's offices, the fact is that it is not hung in the schools. The big map companies go right on turning out maps that, as far as I am concerned, are extremely distorted, misinforming, and obsolete.

"Let me point out next that when you transfer the projected data from the surface of a sphere to a plane you have to break open the spherical skin in order to 'peel' it. There will be various angular cuts in the periphery of the skin when it is layed out flat, just as when you take the skin off an animal. The openings along the edge are called sinuses. The sinuses on my map all occur in the water. None of the cuts go into the land. Therefore, I am able to take all of the data off the earth globe and make it accurately available to you in the flat. You can't see around the world globe; in fact you can only read one fourth of the globe at any one time; so it is good now that you can see all the data at once in the flat without visible distortion or breaks in the continental contours. My map in effect shows one world-island in one-world-ocean. We have been aware that only one quarter of the earth's surface is dry land, but we have not acknowledged that there is one ocean We speak of at least three oceans When this one-world-island is rotated, you say, 'I see the United States now and it is right side up.' The fact is, there is no such orientation in the universe as so what you mean is your habitual way of looking at things. This map can be cut into triangles. You can put them together in many different ways. The arrangement

see foldout ►



*AIROCEAN, an early descriptive word identifying the above projection, was changed in later years to SKYOCEAN. The terms are identical in meaning.

cold turned Hitler's tide. This was due, then, to the fact that the concept of go north to cold is wrong. This is ignorance again typical of the educational fallacies. I am sure that parents are still going to teach this geographical error to their children, but the fact is that where 76 per cent of humanity now exists it is 'go east, go cold' and in only 24 per cent of the world's land is 'go north go cold, go south go warm' true

"We can also look at the colors on the map and compare them with the colors of men's skins. The map temperature colors have to do with the radiation, the inhibition of energy from the sun. As we get into the great cold areas, the skin gets very, very white. Men have to hibernate a great deal of the time. In other parts of the world they could be naked with a great deal of sun. The colors of the map are related then, also to the color of pigmentation of the skins. This has something to do with the solar system and nothing to do with some mysterious 'different kinds of tribes' around the faces of the earth. If there are any special differences in the shapes of noses or heights of men, it has to do very much with the long isolation of men and the developing of certain amounts of hybridism in relation to adapting to special local conditions."

see No Race, No Class, page 166

'***R. Buckminster Fuller,*** Education Automation ***Southern Illinois University Press, Carbondale, Ill. 1962. pp.*** *18-22.*

World One

WATEROCEAN

U.S. Patent 2,393,676
Canadian Pat. 448,064

This is the fundamental pattern of inherently divided lands, and their respective peoples' energies, economics, mores, dreams and volitions

This pattern dominates all pre-World War One history

Water routes represented the shortest distances between the otherwise remote lands and peoples. Water routes represented the most economical lines of communication. Long distance communication consisted alone of written or face to face transmission-most swiftly completed by water.

The tonnage commerce of inorganic and organic world resources could only be accomplished in water borne vessels. Only token commerce and slow messages could be accomplished via the backs of men or animals traveling the long way-via the plains and mountains around about the headwaters. The divided peoples thought and spoke of their own uniquely predominant oceans as constituting separate oceans-Atlantic, Pacific, Indian.

The great one Waterocean world pattern depicted on the facing page was unseen by world people. It was and is, in fact, one ocean with one central island-Antarctica-clockwise around which races west-to-eastward the winds and waters. This gigantic merry-go-round-called the "roaring forties" (entered into at 40 degrees south latitude)-is now known as the southern hemisphere's jet stream area. Ships out of the Atlantic, Indian or Pacific Oceans were swiftly borne west-east by the merry-go-round to choose their re-entries into those oceans and their local lands

Whoever commanded the unsinkable ships (islands) commanding the mouths of the local bays, harbors, estuaries, channels and passages, and commanded the islands and capes which governed entrance upon the merry-go-round-then they governed the world. It is only now discernible by world peoples that centuries ago the masters of the unsinkable British Isles had discovered, held secret and commanded until World War One this Waterocean World

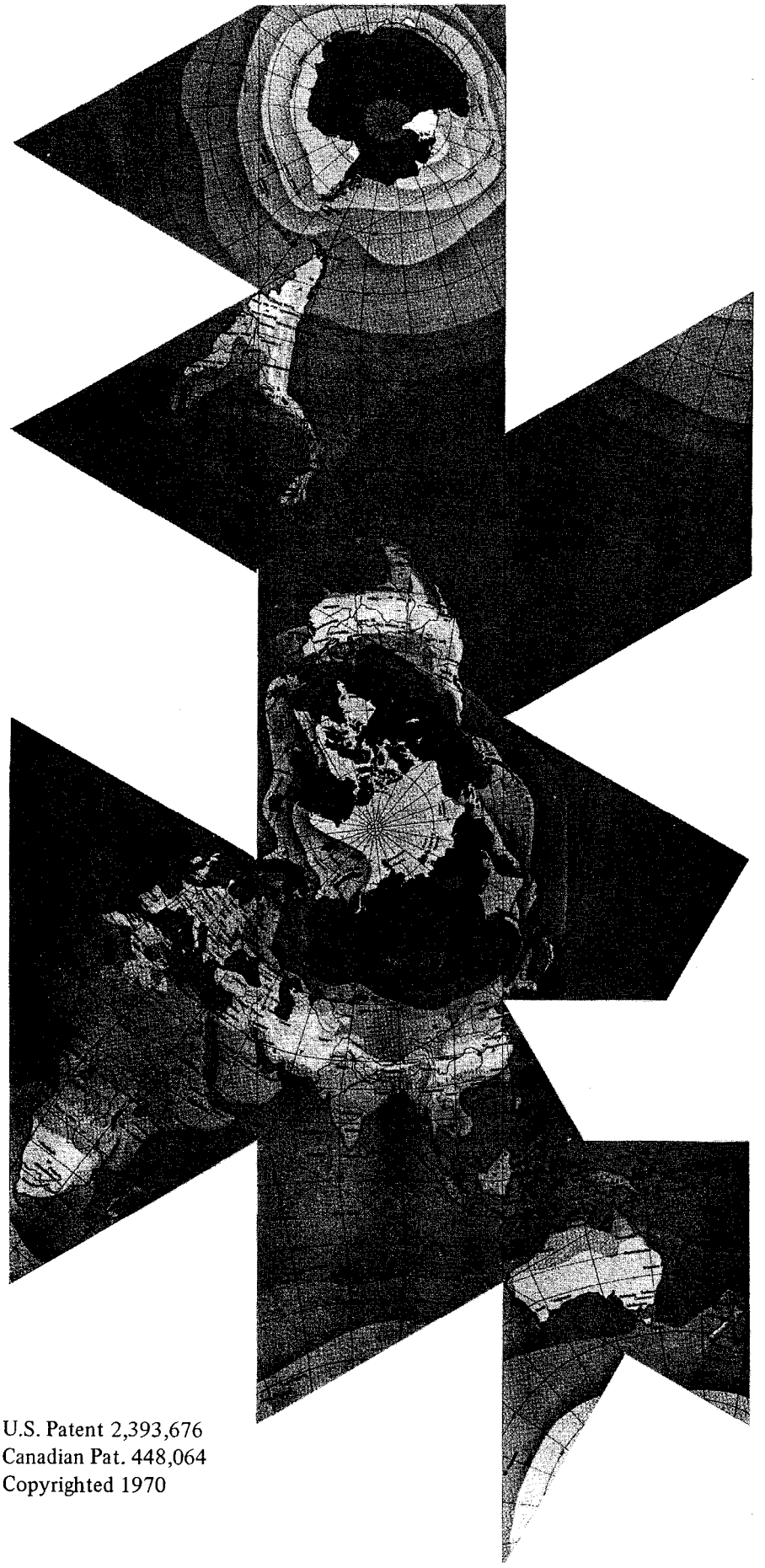
With only the unpeopled Antarctica at their back, and holding fortified bases at the southern extremities off South America, South Africa and Austral-Asia, they came from the south upon the "soft bellies" of the essentially northern hemisphere dwelling people. Only one-quarter of the earth's surface is land; approximately 85% of the land and 85% of the people are situated north of the equator.

The entire pattern of the world's cities and their positionings grew out of the commerce and communication flows of the Waterocean World

Because the key to World One's dominance lay in the water reaches invisibly remote from public sight and ken, the battles for its dominance were remote and often unknown to world peoples. Its masters were inherently invisible. The high priority technologies and resources were usurped by the invisible masters for their invisible struggles for Waterocean World dominance This was a struggle not only of men against men, but also of men against the sea-its daily sea-quakes and avalance-magnitude shock impacts; etc

The glories of technology and wealth went to the sea and much of it eventually to the sea's bottom. The unwanted, inferior technologies and resources were left to "make do" with the inferior magnitude physical problems of the remotely pre-occupied struggling humanity upon their respective separate lands

The theoretical interlinkage of the peoples over the North Pole was utterly hidden in that approximately infinite direction of impenetrability. In the popular "infinity" lay the seemingly inherent insurance of the success of the grand strategy of the one invisible ocean world and its secretly known, most favorable dynamic routings



U.S. Patent 2,393,676
Canadian Pat. 448,064
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World Two

SK YOCEAN

This is the fundamental pattern of inherently integrated lands and their respective peoples' energies, economics, mores, dreams and volitions

This pattern dominates all post World War Two history

It centers about the North Pole, around which, counter-clockwise west-to-eastward, races the northern hemisphere's jet stream at 200 to 400 miles per hour.

88% of the world's people dwell in the Asia-Europe-Africa quadrangle on one side of the Pole. The remaining 12% dwell in the Americas on the other side of the Pole. Approximately all shortest routes between the people in North America to the 88% on the other side of the Pole lie over the Arctic. The Atlantic and Pacific Oceans on either side of North America are routes to nowhere. Shortest distance from North America to South America is over Central America and the West Indies-not over the Atlantic or Pacific.

Voice to ear communication between all peoples anywhere around the world is approximately 186,000 miles per second. In terms of mores, languages, politics, they are as yet months, years and generations apart In the terms of human needs and longings for understanding, they are as one

In the swiftly accelerating range and frequency of world peoples' comings and goings, the inherent barriers of mores, politics and languages will swiftly dwindle and disappear. All of the pattern of world affairs will become visible to all its people. Ambitions of individuals or of minorities to seize dominance of the Airocean World are inherently visible "spot news." Democratic mastery of the whole pattern by all the people is inherent and inevitable. The intellectual and technological integration accelerates the constant trend to serve more needs of more people with higher standards with ever more efficient investment of overall resources per given function

This process of doing more with less may be capsuled as "ephemeralization." The more ephemeralization advances the more flyable becomes any one cargo. The trend of the Airocean World is toward an entirely airborne technology. Cities and towns will trend to become Airocean bottom cloverleafs integrating highways and airways. The highways and airways will become a unitary world network. Sea and waterport cities will trend to diminishing cargo interchange significance and increasing recreational and abstract process significance

The industrial revolution's railroads and trucks were the beginning of the disappearance of the age-long dominance of the water borne traffic. Railroads and trucks represented shiploads "sailing" over a new Landocean

With man's penetration to the North Pole, discovery of wireless communication and invention of trackless, omni-directional, heavier-than-air flights at the beginning of the Twentieth Century, the swift obsolescence of World One's Waterocean was certified. World War One and World War Two and their twenty-two year interim represent the transitional period from a predominantly Waterocean World to an Airocean World

All the pain of this fundamental historic transition is inherent in the momentum of ignorance of man in general concerning the inexorableness of the fundamental reorientation of his life experience.

The operational principles of physical universe persist throughout man's approximately ignorant endurance of the transition. But as men learn more of the persistent verities and integrities of universe, they discover the fundamental necessity of reorientation of knowledge in respect to those verities

Einstein's Relativity, born at Twentieth Century's opening, and its security in comprehended dynamic equilibrium becomes the newly acquired norm of the Airocean World, replacing the no longer tenable static norm of "at rest" and "death" and its invalidated securities of mass and inertia.

Lincoln's industrially catalyzed awareness that "right" had come to ascendency over "might" is of the essence despite all ignorantly detoured chaos of transition

There are no invisible masters of World Two. Visible masters are anathema in World Two. World Two is inherently governable only by the complementary integrities of initiative of the individuals of democracy.

By R. Buckminster Fuller, June 1956

A.5 Telegram to Senator Edmund Muskie

TELEGRAM TO: United States Senator Edmund Muskie
of the State of Maine

From: Buckminster Fuller
of Bear Island
Penobscot Bay
Sunset Post Office
Maine 04683

March 15, 1971

Have inspired recollection
Great scope your understanding
Major evolutionary events
As manifest during my 1969 testimony
Your senatorial planning committee.
Am therefore confident you will realize
There is dawning, world-around comprehension
Of the existence of a significant plurality
Of alternative energy source options
Available for all-Earthians' vital support,
Which, as an example
Now intuitively fortifies
Maine's farsighted citizens' and friends'
Spontaneous expression of abhorrence
For any petroleum refineries
Of crude oil storages
Anywhere along its
Complexedly meandering
Deep-tide coastline.

There is also dawning awareness,
Particularly amongst world-around youth
That because humanity is born
Helpless, ignorant, and naked
Nature must anticipatorily provide,
Protect and nurture humanity's regeneration
By spontaneously assimilatible
Environmental resource availabilities
Under omni-favorable conditions.

Because now dispelled by experience
Humanity's originally permitted ignorance
No longer may be, self-excusingly, pleaded
As justification for failure to employ
The now known to exist
Omni-self-supporting technical capabilities
To produce unprecedentedly advanced
Standards of living
And freedoms of thought and actions
For all humanity,
Without any individual
Being advantaged
At the expense of another,
All of which feasibilities
Are inanimately powerable
Well within our daily energy income
From extra-terrestrial sources
And all accomplishable without pollution.

Graduated only partially
From stone-age, berry-picking,
And also only partially
From the agrarian-age-conditioned reflexes
Humanity is graduating again only partially,
Into the Industrial age
And again only partially
Into the space age.

By tapping the billion years' long
Safe-depositing of fossil fuel energies,–
As petroleum and coal, within the planetary crust
Humanity was self-startered
Into inauguration of world-around
Electromagnetic energy resources integration,
Accomplished exclusively
By industrialization's
Ever-evolving knowledge
Regarding ultimate feasibility
On non-biologically harvested
Metabolic support of all humanity.

Humanity had to be self-startered
Into bounteously underwritten
Trial and error gropings
From whence gradually emerged
Mind-discovered comprehension

Of some of the eternal principles
Governing the availability and feasible employment
Of cosmically-constant, astronomical quantities
Of inherently inexhaustible energies
Of self-regenerative Universe.

Because humanity now has learned
How to gear directly into the inexhaustible energy
Of the main engines of Universe
It is no longer justified in attempting
To accommodate its ever-expanding,
Knowledgeable functioning in Universe
By ignorantly keeping its foot on the self-starter
To obtain its evolutionary propulsion
Only from the swiftly exhaustible
Fossil-fuel storage battery energies
Or from its perishable, one-season crops.

Driving a car by its self-starter
Will exhaust the storage battery
Before the car is out of the garage.
Self-starters should only be used
To gear into the replenishingly regenerative powers
Of the main engine.

Realistic accounting
Of the time and foot pounds
Of energy-work, invested by nature,
In the land-born agriculture's–
And seaborn algae's
Impoundment of Sun energy,–
Exclusively by photosynthesis,-
And its progressive conservation
As dead organic residues progressively covered
By wind and waterborne dustings
Siftings and siltings
Buried and sunken
To critical, gravitationally actuated,
Pressure depths and temperatures
Within which unique conditions
The hydrocarbon residues
May be chemically converted
Into coal and petroleum,
Discloses an overall
Time and pressure
Energy accounting cost
Of one million dollars per gallon of petroleum,
(Of of its energy equivalents in coal)
As calculated at the present
Lowest commercial rates
At which kilowatt hours of energy
May be purchased from public utility systems.

Failure thus to reckon
The fundamental metabolic costs,
Is to be economically reckless.
Further reckless expenditures
Of our planet's
Fossil fuel energy savings account
To which future generations
Needs must have emergency access
As a self-re-startering recourse,
Is equivalent to drilling a hole
From the sidewalk into a bank vault
Pumping out money
And calling it free-enterprise discovery
Of an energy wealth bonanza.

Physical energy,
Convergent as matter
Or divergent as radiation,
Compounded by weightless metaphysical know-how,
Have altogether provided the means
For Earthians' progressively greater participation
In Universe's inexorable
Evolutionary transformings,
The participation being accomplished exclusively
By Human-intellect directed ingenuities,
In progressive rearranging
Of the physical furnishings
Of our spherical, space-boat home,
In such a way as progressively to support
Ever-more lives
In ever-more ways
With ever-increasing health.

Naught gets spent but human time
As cosmically inexhaustible energy
Is tapped exclusively
By intellect-discovered and employed
Cosmic principles
Which to qualify as principles
Must be eternal.

Real wealth
Is universally self-regenerative energy
Harnessed by mind to regenerate
Human lives around our Planet,–
Increasing wealth means
More regeneratively self-supporting days ahead
Of ever increasing domain and ranging
For more lives
First within Earth's biosphere
And subsequently by ever-increasing exploration
Within Earth's extra-terrestrial
Cosmic neighborhoods.
Such ever-evolving greater know-how wealth
Provides the means
With which specifically to augment
The ever-expanding, anti-entropic
Intellectual responsibilities of humanity
As local Universe's local problem solver
Which problem solving is human intellect's exclusive,
Complementary and essential functioning,
In support of total, scenario-Universe's
Self-regenerative integrity.

Physics shows
That universal energy is undiminishable.
Experience teaches
That every time humanity initiates
Intelligibly logical experiments
Human intellect
Always learns more.
Intellect cannot learn less
Intellect is growthfully irreversible.
Both the physical and metaphysical advantage gains
Of intelligently invested know-how,–
As competent energy-transforming,–
Always produces
Inherently irreversible wealth growth
Consisting of non-reducible physical energy
And irreversibly expanding know-how,
Which together can only increase.

This is contrary to yesterday's
Now scientifically and technically obsolete
Concept of a self-exhausting,
Ergo, progressively expendible–
And ultimately spent Universe,
With assumedly progressive failure phases
And their negative economic accountings
Whose bankruptcies are as yet employed
By all political economies,
Together with their depletion tax evasions
Covering only physical property depletions
With no capitalization, nor depreciation allowances
Of the metaphysical competence of humanity's mind
Without which there would be
Neither human life self awareness
Nor its wealth
Of capable conceptioning.

Modern physics renders it incontrovertible
That celestial energy is non-exhaustible.
Only the fossil fuel savings account
And perishable human muscles
And the self-startering, but limited,
Hydrocarbon impounded energies
Are terrestrially exhaustible.
While not escaping Universe
Their energies are no longer available
To Humanity aboard the spherical space vehicle Earth.

Humanity's economics
Are as yet ignorantly geared
Exclusively to the limited
Annual energy harvesting cycles
And bankruptcy accounting
Of ignorance permeated yesteryear's
Human brain reflexing
As conditioned, by floods, fires, droughts and
pestilence,–
And frequently ruined crops,
Whereby millions of humans perished.

Brilliant and potentially effective
Managerial capabilities and leadership potentials
Are as yet diminishingly extruded
Through minuscule accounting and customs apertures,
Which force those capabilities
To concentrate exclusively and myopically
Only upon *this* year's production
This year's election and
This year's profit
While blindly overlooking
The infinitely reliable cyclic frequencies
Governing the 99 percent of reality
Lying outside human sense apprehending
And lying outside this year's considerability
Which vast, invisible reality
Is the great electromagnetic spectrum
And its astrophysical event recurrency rates,
Which range from split-second atomic frequencies
To multi-billion year astrophysical lags
All of which cyclic event reoccurrences
Are guaranteed to humanity as absolutely reliable
By the exclusively science-discovered
Cosmic behaviors' integrity.

All of these non-directly detectable
Cosmic reality events
Are now feasibly employable
By humanity
Through human mind's
Comprehensively gleaned instrumental technologies.

Humanity's yesteryears' energy support
At first exclusively by seasonal harvest
And later by fossil fuel storage exploitations,
Has failed frequently in the past.
Despite the industrial revolution's
Momentary fumbling and mess–
As occasioned uniquely by the myopia
Generated by 'this year's accounting' limitations–
It now is discernible scientifically–
That unwitting Earthians
Gradually are being shifted
Over an epochal threshold,
Successful crossing of which,–
If not totally frustrated by reflexive inertias,–
Will witness the successful
Gearing of all humanity
Into the eternally inexhaustible, energy system
Of omni-self-regenerative celestial mechanics.

However
Humanity is as yet acquiring
Many human support increasing
Techniques and practices
For all the wrong reasons,
We only expand wealth production
Under mass-fear mandates
Of war preparations' emergency powers.
We could acquire, peacefully and directly
A total humanity supporting productivity
And comprehensive enjoyment
Of our whole planet
By a drudgery and disease emancipated
Human family
Simply by deciding to do so
Thus could we avoid the concomitant
Wastes of life and energy
Inherent in acquiring industrial productivity
Only as excused by war threats–
Whatever we need to do
And know how to do
We can afford to do!
This is the cosmic law
Now in clear scientific evidence,
And the more love,
The more satisfactory the wealth augmentations.

Whether history entrusts you or others
With progressively greater responsibilities
At this crucial-to-Earthian's-survival moment
Will undoubtedly be predicated
Upon whether you, they, or both of you
Adequately comprehend these epochal transitional events
And are able to render intelligent support of them.

The State of Maine's Bay-of-Fundy's
Twice-a-day, seventy-foot tides
Are pulsated by Sun-compensated, Moon-pulls,
Those tides will be pulsated twice daily

As long as the Moon and Earth
Co-orbit the Sun,
Fundy provides more economically harvestable,
Foot-pounds of energy daily
Than ever will be needed
By all humanity
Anywhere around Earth–
In order to attain and sustain ever-higher
Standards of living,
Greater and more healthful longevity
For all humanity
Than heretofore has been experienced
Or even dreamed of by anyone human.

It is economic ignorance of the lowest order
To persist in further surfacing and expenditure
Of the Earth's fossil fuels–
Our storage-battery of "savings-account" energies,–
Which must function only to make spaceship Earth
fail-safe
For all future generations to come.

It is even more ignorant and irresponsible
To surface and transport oils
Of Arabia, Venezuela. Africa and East Indies
To refineries and storages on the coast of Maine
Thus putting into ecological jeopardy
One of the world's
As yet most humanly cherished
Multi-islanded, sea coast wildernesses.
In view of Fundy's tidal energy wealth
Such blindness is more preposterous
Than "carrying coals to Newcastle."
It is accelerated human suicide.

On the other hand we must recall
That Passamaquoddy's semi-completed
Tidal generating system
Was politically abandoned
On the officially stated,
Ignorant, political-economics assumption,
That electricity could not be transmitted
Beyond 350 miles
And therefore could not reach
Any important industrial centers.

It is known in political actuality
That Passamaquoddy was discontinued
Through the combined lobbying efforts
Of Maine's paper pulping and electric power industries
Whose political policy logic was persuasive
Despite that those two industries
Have together succeeded
In polluting Maine's prime rivers
To kill all but a pittance
Of the Maine coast's once vast fishing wealth.

Space-effort harvested,
Scientific know-how and the computer capability
Have together made possible
The present inauguration
Of one million volt transmissions
And a 1,500 mile delivery range
Of feasible, underground, electric power network systems.
Many Passamaquoddies could be plugged
Into the invisible underground,
Transcontinental, time-zone spanning,
Electrical energy network integration
And thence relayed to Alaska
While picking up Canadian Rockies water power
Along the way.
The integrated North American network
Could not only be trans-linked
Through Mexico and Central America
Into an Amazon-to-be-powered
South American network
But also across the Bering Straits
From Alaska to Russia
To join with their now completed
Eastern extension of Western Russia's network
Which Eastern Asian network
Now brings into use
The powerful, northward flowing, into-the-Arctic
Siberian river systems.

This now feasible, intercontinental network
Would not only integrate
America, Asia and Europe's networks
But would also integrate
The night-and-day, spherically cycling
Shadow-and-light zones of Planet Earth
And this would occasion
The 24-hour use
Of the now only fifty percent of the time used
World around standby generator capacity
Whose fifty percent unused capacities
Heretofore were mandatorily required
Only for peakload servicing of local non-interconnected
energy users.
Such intercontinental network integration
Would overnight double
The already-installed and in-use,
Electric power generating capacity of our Planet.

And lying well within
The progressive 1,500 mile hookup reachability
From an American-Russian power integration
Are the intercontinental networks of China, India and
Africa.

It is everywhere around the world
Incontrovertibly documented
That as the local kilowatt hours
Of distributed electrical energy increase
The local birth rate
Is commensurably diminished and longevity increases.
In respect to any of its specific geographical areas,
The birth rate of that area
Trends in inverse proportion
To electrical energy generation and distribution.
The sudden world population bulge
Which has occasioned
Dire population increase predictions
Was occasioned first by the failure to die
Of those who used to die
And secondly by the continued new birth acceleration
Only within the world's
As yet non-industrialized countries.
As world industrialization
Will be completed
By twentieth century's end
The ever-diminishing birth rate

Of the industrial countries
Will bring about world population stabilization
By 2000 A.D.

Universe has no pollution.
All the chemistries of Universe
Are essential
To its comprehensive self-regeneration.
The ninety-two regenerative chemical elements
Associate, disassociate and intertransform
In a wide range of time-lag rates.
All the dumped chemistries
Spoken of ignorantly as "pollution" or "waste"
Are always needed ***elsewhere***
In the intelligent integration
Of World-around energy regenerating economics.

All the sulphur
Coming annually
Out of all the industrial chimneys
Around our Earth
Exactly equals
The amount of sulphur
Being taken annually
From the Earth's crust
To keep industry going.

And while the unwanted chemistries
Are in high concentration
Before going out the stacks
Or down the flush
They can be economically distributed
To their needed inter-functioning,
But after they go out
From the stacks or the nozzles
They are so diffuse
As to be uneconomically recoverable
And in their diffuse state
Often become toxic
To various biological species,
The ultimate overall costs of which to humanity
May easily be the cessation
Of all terrestrial life.

Conversion of yesterday's preoccupation
With major energy harnessing
Exclusively for the armed killing
Of humans by humans
Now can be comprehensively redirected
To intelligent and responsible production
Of a total-humanity sustaining system
And to that system's self-regenerative support.

Swift realization of all the foregoingly considered
Epochal transition of human affairs
From a "might" to a "right"
Accounted and inspired
World economics
Is now scheduled for swift realization
By inexorable evolutionary events
To be accompanied
By maximum social stresses
With only one alternative outcome
To its total human advantaging–
The alternative is human extinction
Aboard our Planet.

All thinking humanity
Young or old
Not only will condone
Reversal of public position taking
When it is predicated upon
Better and more inclusive information
Than was at first available
In fact it will think even more favorably
Of the integrity
Of those who admit error for humanity's sake
At the risk of losing previous political support.
So well informed is the young society
Which now is taking the world initiative
That only such integrity
Of long distance thinking
And unselfish preoccupation
Can win its support.

I pray you will make your stand
Swiftly and unambiguously clear
As being against any further incursions
Of petroleum into Maine
Or of pipelines in Alaska.

I pray that you will concurrently
Initiate resumption of Passamaquoddy
Together with initiation of a battery
Of such Fundy tidal energy convertors
With combined capacities
Sufficient for celestial-energy support
Of all human life aboard our Planet
To be maintained successfully
Until Earth-based humanity
Has successfully migrated
Into a larger cosmic neighborhood functioning.

B. WORLD GAME PACKET

B.I Fuller Statement on World Game

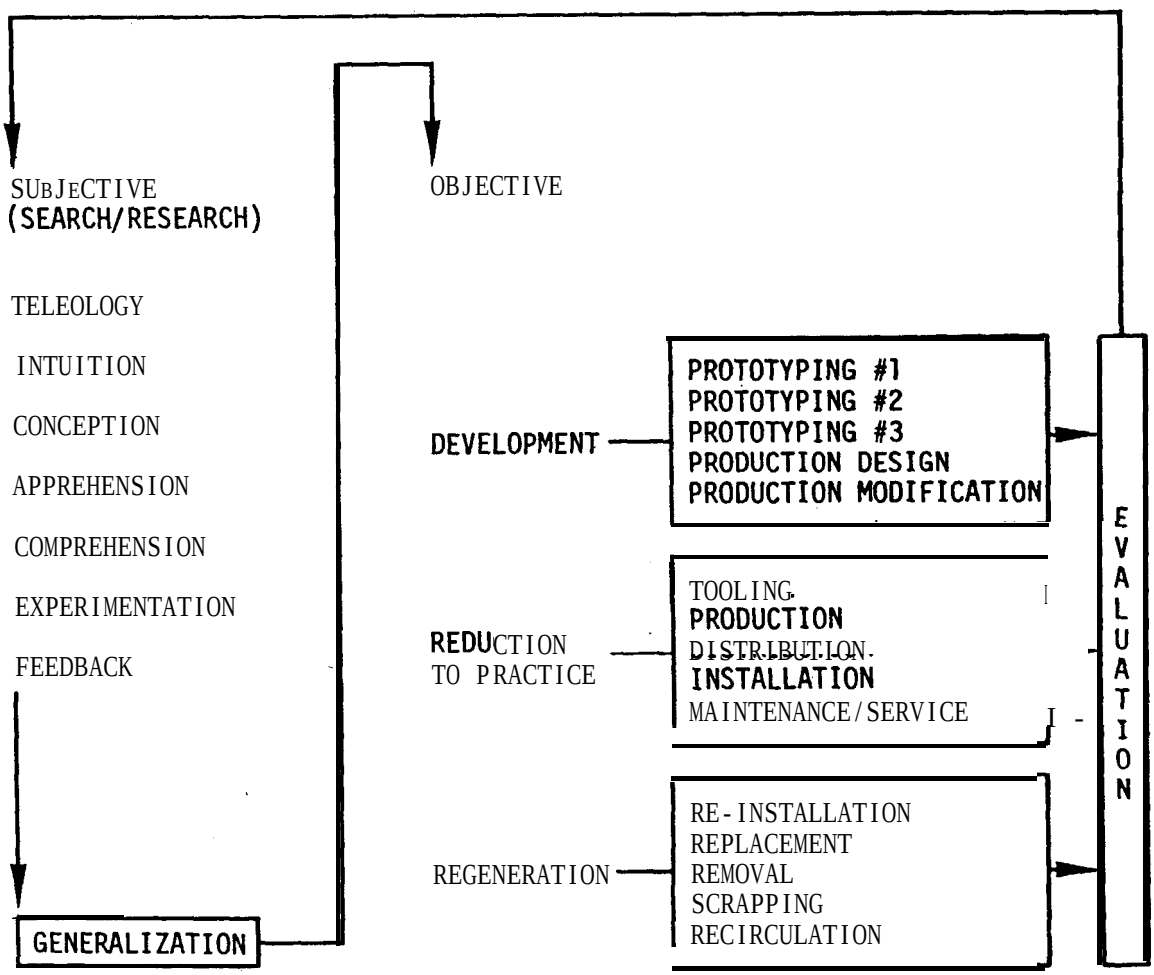
The ***World Game*** is a scientific means for exploring expeditious ways of employing the World's resources so efficiently and omni-considerately as to be able to provide a higher standard of living for all of humanity-higher than has heretofore been experienced by any humans-and on a continually sustainable basis for all generations to come, while enabling all of humanity to enjoy the whole planet Earth without any individual profiting at the expense of another and without interference with one another, while also rediverting the valuable chemistries known as pollution to effective uses elsewhere, conserving the wild resources and antiquities. The ***World Game*** discards the Malthusian Doctrine which is the present working assumption of the major states. Malthus held that humanity is multiplying much more rapidly than it can supply resources to support itself, and compounds with Darwin's survival of the fittest, to assume that only the side with the greatest arms can survive. The ***World Game*** demonstrates that the Malthusian doctrine is fallacious. If we apply to direct human support all the high technology resources now going into the world's annual 200 billion dollar war preparation, all of humanity can be brought to economic success within 'one quarter century. This eliminates the fundamental raison d'etre of war. The ***World Game*** employs design science to produce progressively higher performance per units of invested time, energy, and know-how per each and every component function of the world's resources. The ***World Game*** makes it possible for intelligent amateurs to discover within a few weeks of simulated design revolution illustrated on the World Map that the foregoing premises are valid.

R. Buckminster Fuller
Summer, 1969

B.2 Design Science by R. Buckminster Fuller

World Gaming

Through comprehensive, anticipatory, design science exploration, the most expeditious ways of making the world work-the moves, or plays of the World Game-take place.



The above outline illustrates the discipline Design Science. For a more detailed outline, see "Universal Requirements for a Dwelling Advantage,"

Man has evolved from an individually local rejuvenation, one of agrarian farming, to that of a collective non-local rejuvenation, industrialization; i.e. from individual internal metabolics to group external metabolics.

This evolutionary leap was a natural step fostered by the increased efficiencies of doing more with less resultant from having mass needed items and functions taken care of by centralized efficient mass production and distribution rather than decentralized primitive individual production and consumption.

The 2.5 year plans of Russia and other rapidly evolving, (rapidly needing) areas of Earth can be viewed as just such endeavors: They are the creation of an external metabolic system.

The "25 year plan," in 5 year increment steps, towards the realization of an external metabolic system, or "industrialization," is the overall guiding outline of World Game strategies for world development. The 2.5 year plan, with its 5 year incremental steps, consists of:

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,-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 the 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 mph 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 industrializations 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.

"The design scientist takes the initiative-like the medical scientist-and does not operate on the basis of having to be retained by a client to carry out the client's prime design concepts. Design science-as the objective, applied, discipline accomplished by combined industrial design, engineering, architecture, and all the sciences-is so organized **as** to provide effective anticipatory strategies for formulatipg and managing the evolution of mankind's external, metabolic regeneration of the industrial self-organisms in the same anticipatory service manner that the medical profession has anticipatorily dealt with individual man's interior, organic processes of metabolic regeneration.

"The design scientist undertakes fundamental invention, self-underwriting, development and experimental proof of invention as demonstrated for instance by the Wright Brothers wherein the design science professional will be equipped with all of the economic, legal and technological knowledge necessary for reducing such inventions to going industrial practice.

"To realize such breakthrough magnitude inventions-commercially, militarily, or even socially– involves the individuals preparing himself for the competent taking of the initiative in a whole new industry and its progressive development, testing, proto-typing, tooling marketing, servicing, maintaining, operating and phasing-in of progressive evolutionary components within the totally new industrial system together with designed phasing-out of the' obsolete equipment and functions made obsolete by the new industry. This, in turn, releases metals, and other materials, time and energy resources for reinvestment in the newest phase of the evolutionarily emerging system.

"For instance, the design scientist would not be concerned exclusively with the seat of a tractor but with the whole concept of production and distribution of food, which might possibly lead to developing a whole new industry of hydroponic factories for automated growing, canning, and packing the food within large ¾ sphere, geodesic greenhouses, within which are circularly operating, planting, cultivating, pruning and harvesting mechanisms, in a tree-like arrangement. He would initiate a total industry."

-R. B. Fuller, W.D.S.D. No. 5 1962

B.3 How and Where to Begin

As the medical scientist's research is referenced to the internal metabolics of the individual human body, the design scientist's research is referenced to the external metabolics of humanity.

The World Game, the comprehensive planning tool, will make visible through large scale computer simulation and display the reactions and resultants of these comprehensive, anticipatory, design science explorations. In the terms of other more familiar games, this is the "game board" of the World Game upon which "moves" are made. "Winning" in the World Game is making the world work, making mankind a success, in the most efficient and expeditious ways possible.

Until the ultimate World Game facility is realized, there will be no World Game. But moves or strategies of resource utilization that will enable humanity to be successful can be tested and evolved "long-hand" until then. Dr. Fuller has been playing the World Game in this manner since 1927.

One powerful and dramatic strategy, dealt with long-hand, was the world-encompassing high voltage electrical energy hook-up which was worked on at the first New York World Game seminar. The students there proposed the inter-connecting electric grid on p. 100 as a way of getting everyone on Earth enough energy to satisfy their basic needs. By utilizing the world's hydro-electric potential, without any further development of thermal plants and taking advantage of the increased efficiency of super high voltage (1 ,000,000 volts) long distance (1500 miles) transmission lines in a day/night and seasonal crossing hook-up, they were able to demonstrate that with present methods, technologies, projected population figures, metals resources and efficiency levels in power generation and consumption, it would be possible to bring everyone on Earth to a minimum 2000 Kwh per year by 1980. (For more details, see *World* Game *Report* and "Geosocial Revolution"-R. B. Fuller, *Utopia or Oblivion.)*

Other strategies from this and other World Game seminar groups have dealt with food, transportation, education and pollution. The latter defined pollution as valuable chemistry-a resource-but in the wrong place. This strategy demonstrated the efficiency, economy, and feasibility of eliminating pollution by utilizing it as a resource-i.e.-sulfur dioxide removed from industrial smoke stacks where it is concentrated (an above ground mine) and put back into the industrial process where it is needed as sulfuric acid or sulfur.

As man's external metabolics become more and more controlable, the need for his internal metabolics to reproduce in great quantities goes down. When the external metabolics function competently, the internal metabolics are automatically serviced; when the internal metabolics are serviced, the organism lives longer, and the longer the organisms live, the larger the population becomes, given the same rate of birth. Nature shows that when more and more of the organisms live, the birthrate begins to drop. The oak tree

produces vast amounts of seeds because the chances of one acorn becoming an oak tree are extremely slim; as the chances improve, the reproductive rate decreases-as the mammal reproductive rates illustrate. The higher the chances of survival the lower the birthrate. Thus, the human birthrate is lowering as the charts on page 16.5 illustrate -as the external metabolics-the survival capability-(represented by kilowatt-hour) goes up.

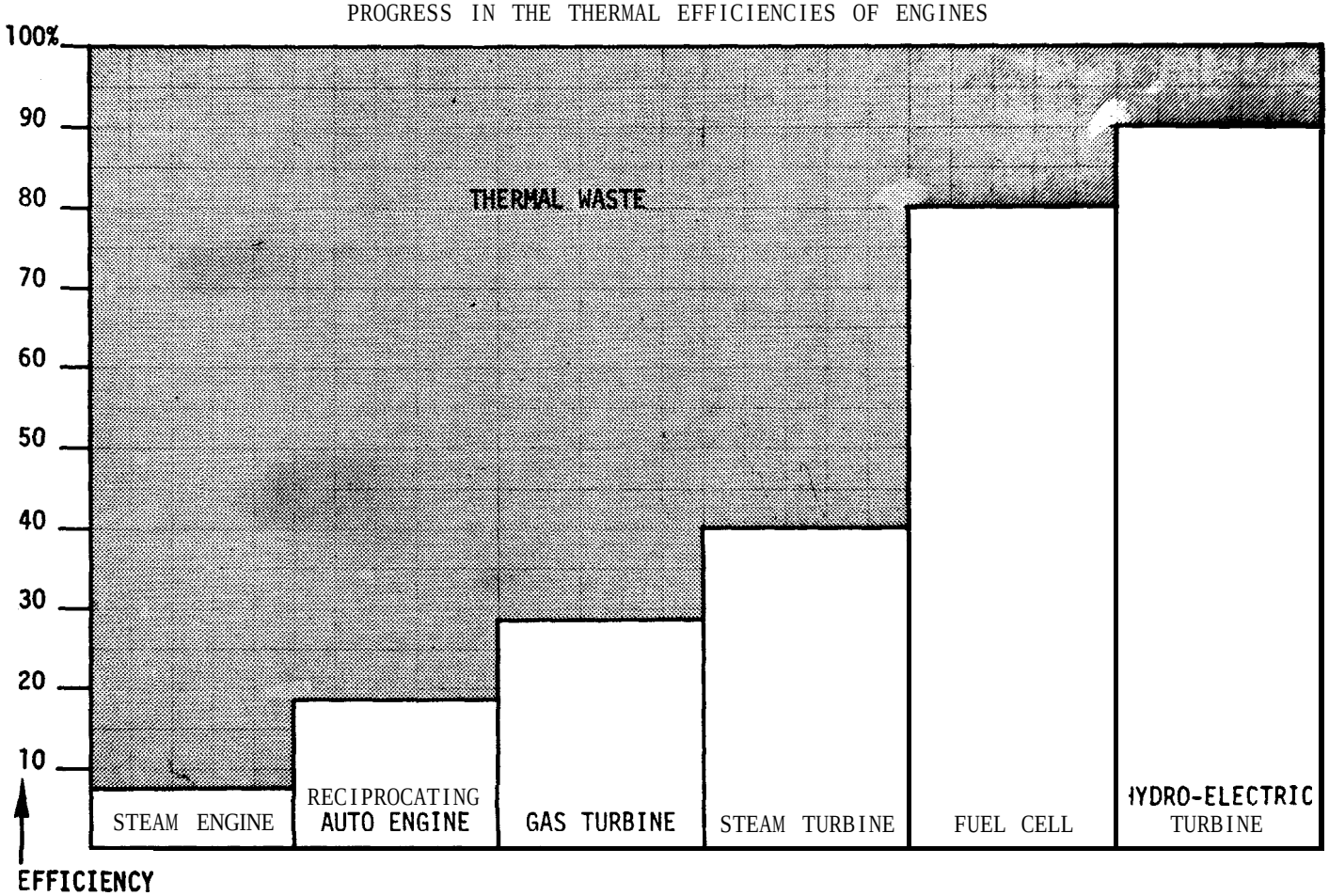
HOW: More with Less

The comprehensive, anticipatory, design science capability to effect greater resource performance per each pound, kilowatt, and man hour of invested resources is the crux of each design science World Game strategy that makes it powerful, efficient, and immediately relevant to our needing World. As the birthrate graphs help to illustrate, despite the increased population and decreased resources of the Earth, the more with less capability of design science is continuingly raising the standard of living.

The comprehensive recirculation of all the chemical constituents of the resources involved in man's external metabolics results in a more with less resource utilization. For example, each time copper is scrapped, melted down, and recycled, it is re-employed at a higher rate of efficiency. The first copper telephone wires carried one message per wire, subsequent more with lessing improvements carried 2, then 4, 16, 250, then in the thousands, and now with the satellites, it has gone wireless. From millions of tons of copper to next to no tons of copper. From visible to invisible.

The more comprehensively resources are dealt with, the more they are recycled. As recirculation increases, "pollution" goes down, as nature dramatically demonstrates. There is no pollution in nature, everything is recycled; the fallen leaves become next year's flowers; the carbon dioxide of mammals becomes oxygen from the plants.

PROGRESS IN THE THERMAL EFFICIENCIES OF ENGINES



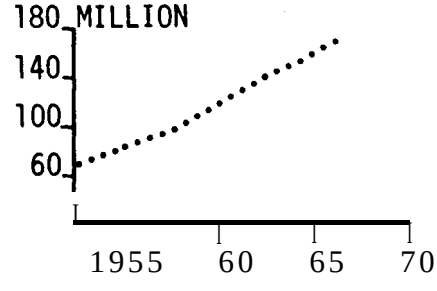
Recirculation, when viewed comprehensively, is more efficient than mining, processing, and refining. Whenever efficiency goes up, wastage, "pollution" go down. Design Science and the World Game seek the *most* efficient means of employing the world's resources.

Where to Begin

For any group or individual who wishes to pursue his or their interest in Design Science exploration and the World Game, the most powerful place to begin is with the writings of Dr. Fuller. All of his books plus the World Design Science Decade documents are first priority. The individual or group interests can be channeled more effectively after digesting and assimilating the philosophy, experience, and self-disciplining strategies found therein.

With this in mind, one of the most powerful tools that the individual or group can use is that of making visible the heretofore invisible. By plotting a trend, any trend, one can begin to see the direction of things, dramatically. Comparing two or more trends of significant import-one can begin to anticipate future crises, or crucial points, and anticipatorily design strategies to meet the contingencies of the future (the present future).

A trend can best be made by forming an inventory-the information, facts, and statistics related to a resource topic-and expanding this through time. For example, all the passenger vehicles in the world in 1968 numbered approximately 170,000,000. This is made into a trend by expanding it through time–



At present, there are at least two approaches to formulating and documenting World Game strategies. One is mentioned above-inventory, trend, then inductively come up with a strategy to anticipatorily meet the needs you see. For example-another trend, that of Carbon monoxide (CO) production, when compared with the automobile trend would lead one to the conclusion that somewhere around the year 2000, the CO from the increased number of automobiles would do irreparable harm to the planet. One could anticipatorily design a CO-less engine to meet that emergency, or better yet, a total pollutionless transport industry. Another approach is a deductive one-that is, start off with the strategy, and then document your intuition of it through the inventories and trends that are relevant to it.

The World Game refers to a strategy or a combination of strategies, with their documentation, as a "scenario." The scenario encompasses a logical sequence of events (the strategy) which shows how, starting from the present, a future evolutionary condition might evolve step by step; "longhand," it is a synergetic synoptic view of as many developments as can be grasped and as may appear relevant to the experimental simulation of the proposed possible reality. "Shorthand," or through computer simulation, all relevant variables and their omni-interaction will be automatically displayed-both visually and through computer read out.

The World Game "long hand" mode of operation next entails the "post-scenario." This is the synergetic interplay and relative qualitative evaluation of two or more different scenarios with their resultant overlapping, opposing or complementing functions; it is the feedback mechanism leading to new strategies and scenarios that overcome seemingly "impossibilities" and/or gross inefficiencies of any

scenarios taken separately. The general criteria for one strategy's "merit" over another strategy's merit is based on:

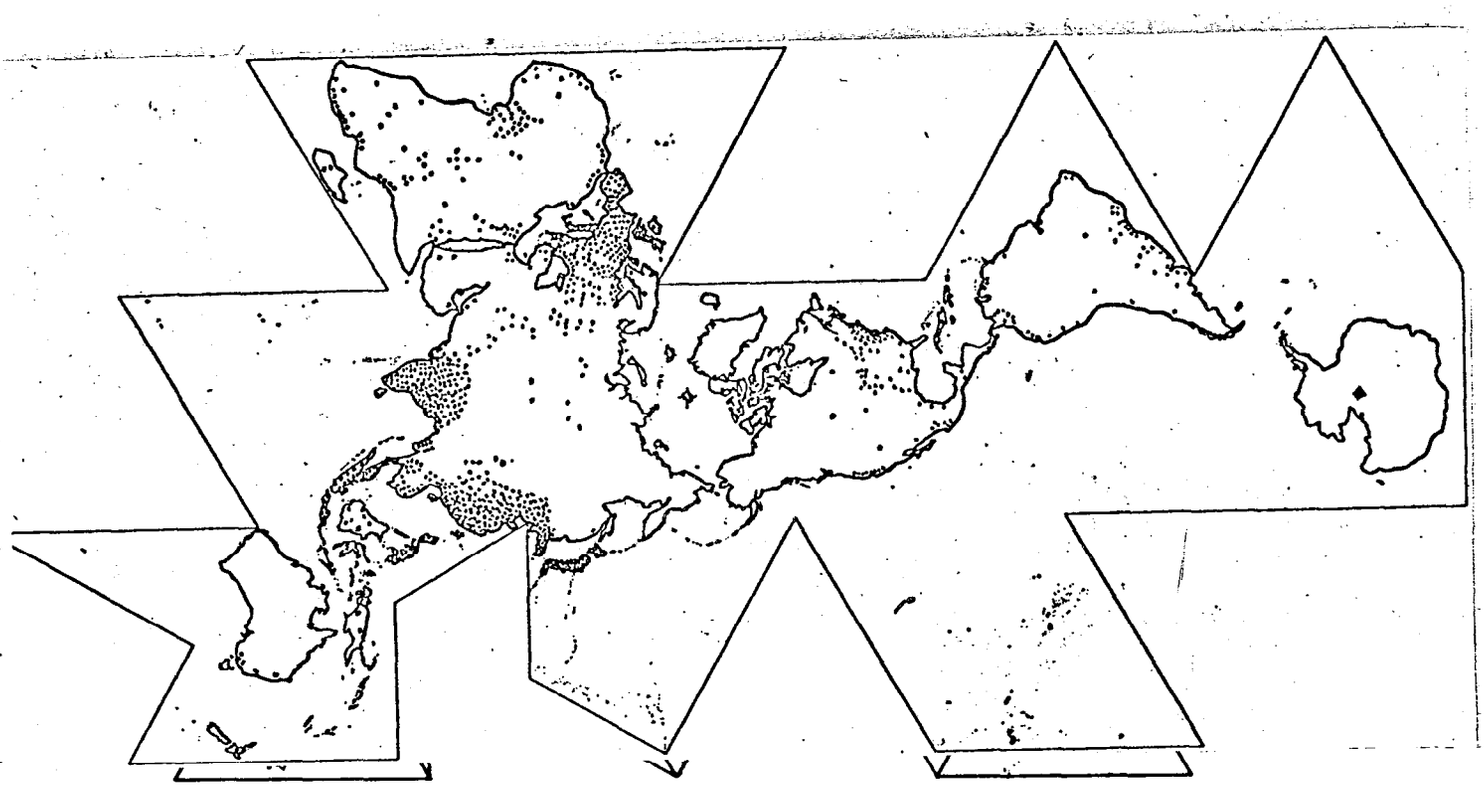
(1) whether it enables mankind to be a "success?'
(2) whether it can do same quicker
(3) whether it can do same quicker and utilizing 'Earth's income (non-depletable) resources of energy and materials
(4) whether it can do all above'plus metaphysically'enhancing mankind.

The design scientist utilizes information as the contemporary house builder utilizes bricks, mortar, wood and nails; he creates a structure of information. It is a comprehensive anticipatory structure of information; it-is-a structure that is designed'to meet the comprehensive needs of the anticipated future; it creates its own realization by acting as a low pressure zone by offering humanity a viabie alternative that is far superior to existing modes and alignments of the resources involved! The design scientist& main medium then is inform&on, and as such, is accessible to anyone. His tools are conceptual.

It is both possible and directly feasible that the individual human being, through comprehensive anticipatory design science, can advantageously affect the entire Earth. Dr. Fuller's many discoveries, inventions and strategies that have been adopted and incorporated throughout the world are testimony to this. The synergetic sum of the comprehensive anticipatory design science use of information is the creation of an alternative for the world; an alternative that comes to be realized because of its fundamental advantages for all of humanity. The design science alternative will be clearly advantageous and superior to the existing configurations of resources because it will be comprehensive-i.e., total Earth, with no sovereign distinctions and prejudices. Logical configurations of the Earth's resources become more readily apparent when the system/Earth is conceptually closed.

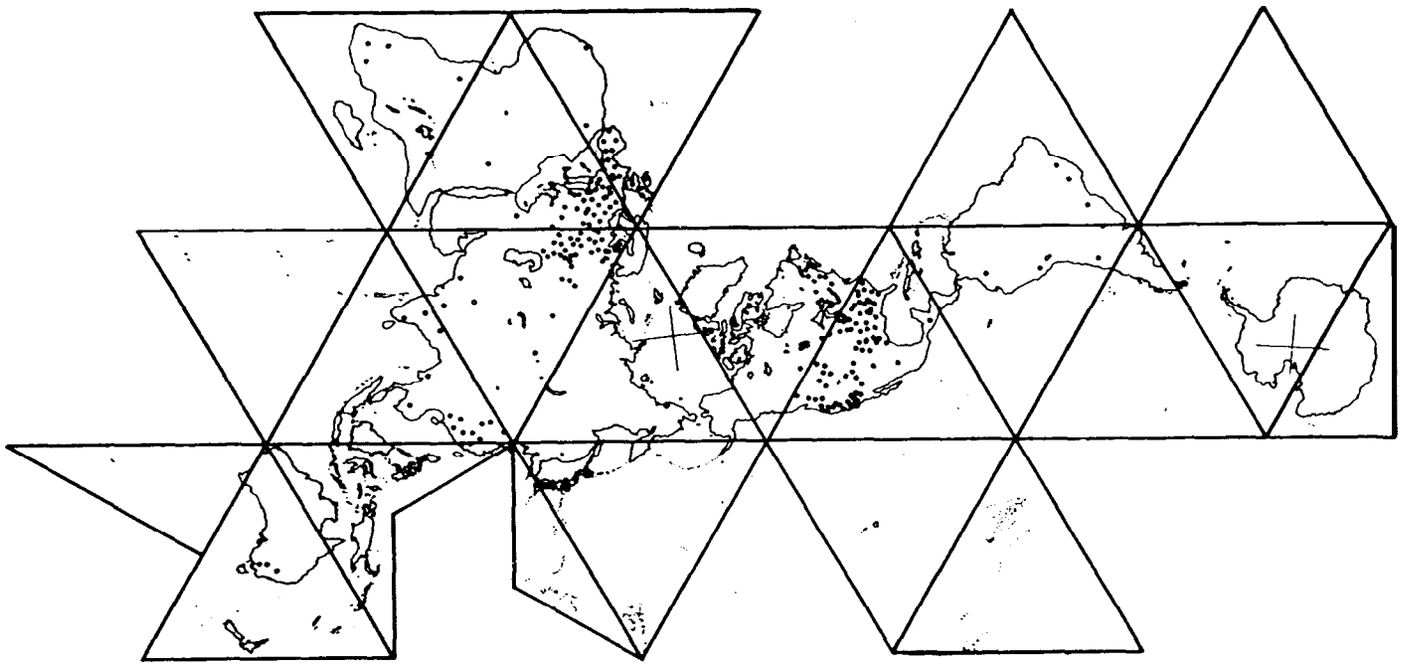
Information/data for comprehensive anticipatory design science exploration can be found in the World Design Science Decade Documents, the United Nation's Statistical Yearbooks, and the United Nation's Demographic Yearbooks, most World Atlases, and innumerable organizations and institutions dealing with their respective specializations on a world wide basis (see Section D of this document for such references): The information is there-New York, **Moscow,** Lima, Cairo, New Delhi, Tokyo, Fairbanks, as well as Oskaloosa, Carbondale, and all points between. The tools for structuring that information are available. Within your mind lies the only necessary ingredients-intellect, energy, and incentive.

The intellect to know that you can design a better world and with which to assimilate the tools a comprehensive anticipatory design scientist needs; the energy to apply that intellect comprehensively; and the initiative to *do if.*



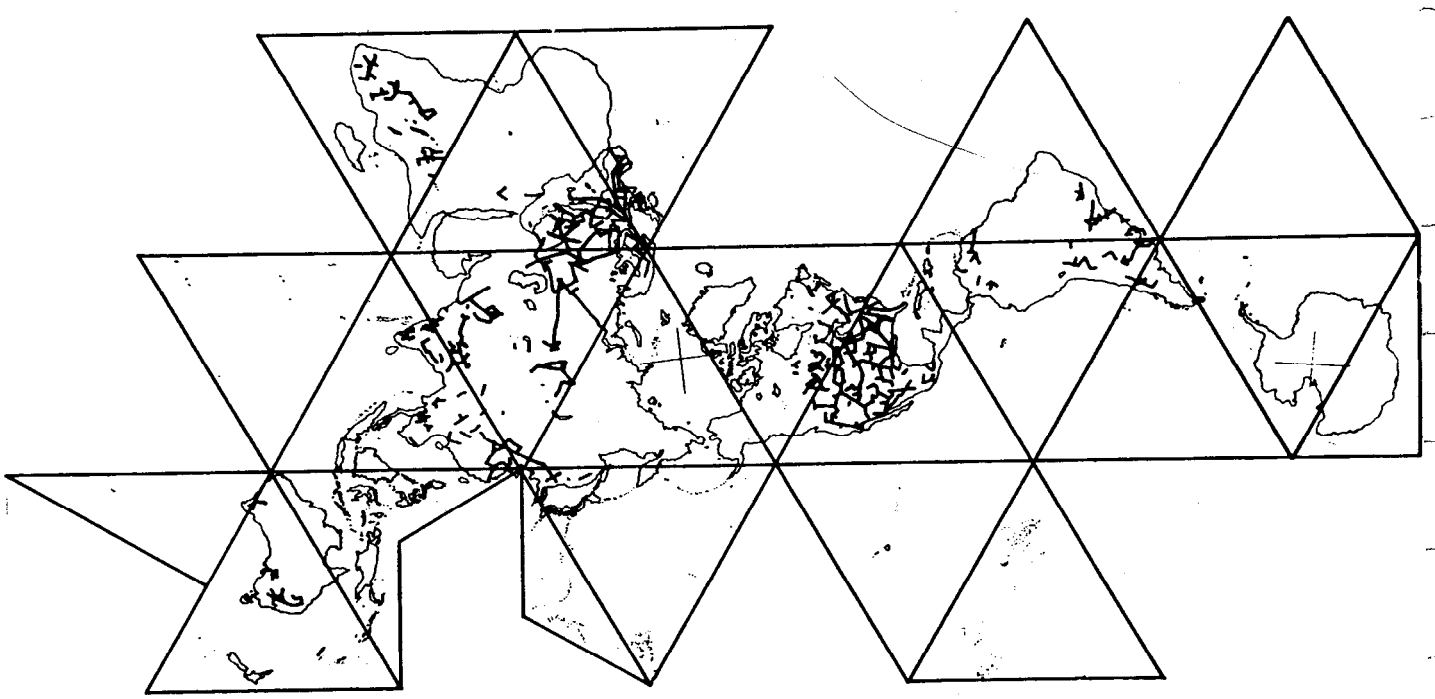
POPULATION/1970
ONE DOT REPRESENTS 3'5 x 10^6

AN ENERGY SLAVE IS AN INORGANIC ENERGY-PROCESSING DEVICE WHICH IS AN EXTERNALIZATION OF ONE OF THE INTERNAL FUNCTIONS OF MAN. IT IS A COMPOSITE MEASURE OF THE LEVEL OF INDUSTRIALIZATION; IT IS FOUND BY TAKING THE TOTAL AMOUNT OF ENERGY CONSUMED AND CONVERTED TO EFFECTIVE WORK BY MAN. AND DIVIDING THIS BY THE AMOUNT OF WORK ONE MAN IS ABLE TO DO IN A YEAR, THIS GIVES THE MAN YEAR EQUIVALENTS OF WORK BEING DONE FOR MAN BY HIS INANIMATE SLAVES.

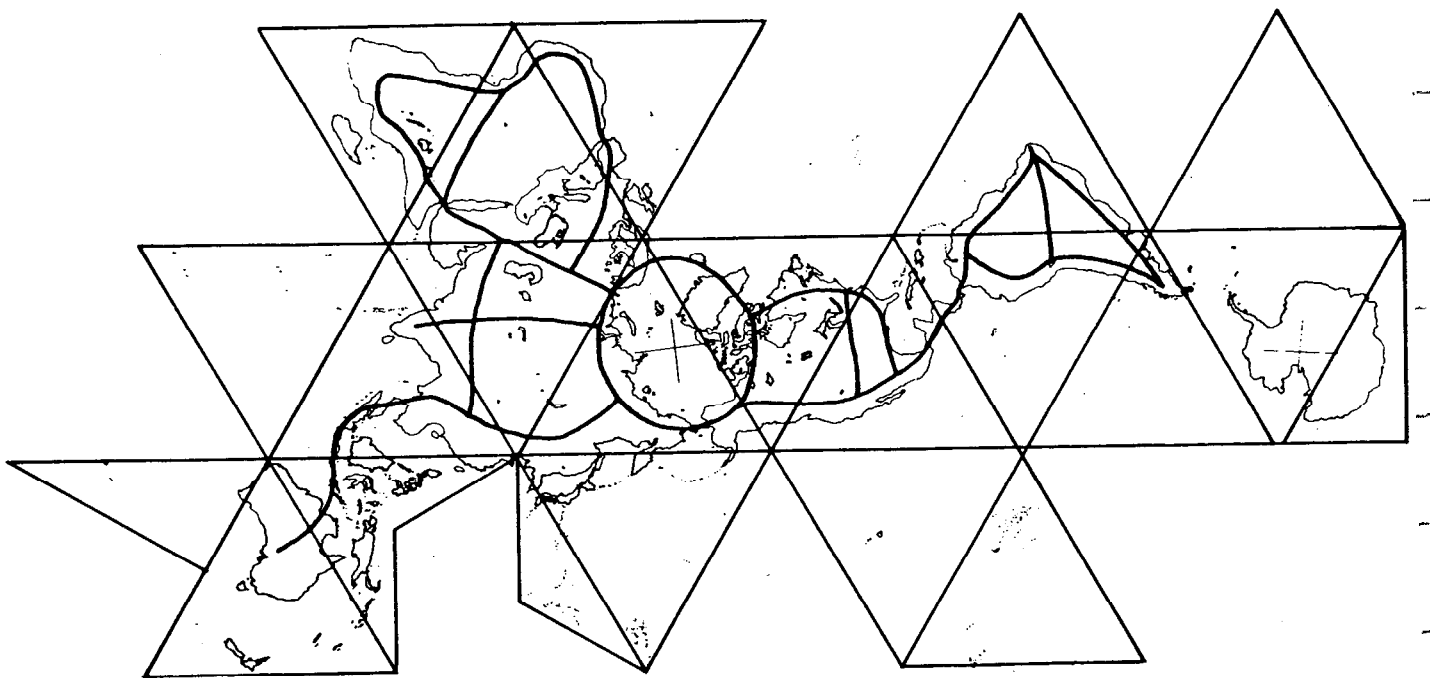


ENERGY SLAVES/1970

ONE ENERGY SLAVE EQUALS 37,500,000 FOOT-POUNDS
ONE ENERGY SLAVE EQUALS 14.1232 KILOWATT HOURS
ONE ENERGY SLAVE EQUALS .0017654 TONS (METRIC) OF COAL EQUIVALENT



INTERCONNECTING ELECTRIC NETWORKS/1968
220 KILOWATTS



HIGH VOLTAGE TRANSMISSION NETWORK (PROJECTED)

B.4 World Game "World View"/frames of reference

The World Game "world view" or frame of reference which follows is a partial documentation of the conceptual tools which those working on the World Game or in Design Science have found to be most effective for dealing with the information that comprises their environment. They are the tools the Design Scientist uses to structure the medium he is working within-that of information-just as the craftsman uses his hammer, nails, and saw to structure his environment. They are a partial listing and are added to periodically as we become more conscious of the tools through using them. Evolution dictates there be no definitive list; what follows then are the more obvious components of our frame of reference. They are to be viewed as a whole, a synergetic process of omni-interaction, rather than as individual parts

WORLD GAME "WORLD VIEW"/FRAMES OF REFERENCE ARE COMPOSED OF:

The Conceptual tools presently being employed to build World Game and called progressively:

World-Town Plan- 1927
Conning Tower- 1932
Earth, Inc.-l946
Mini-Earth- 195 1
Geoscope-1954
World Game-1961

As conceived by Buckminster Fuller, and published in:

Shelter Magazine- 1932

Educating Automation- 1961
World Design Science Decade-Vols. 1, 2, 4, 5
Ideas and In tegrities
Operating Manual For Spaceship Earth
No More Second Hand God
Utopia or Oblivion
World Game: How It Came About

Dymaxion World of Buckminster Fuller
by Robert W Marks
Buckminster Fuller
by John McHale

1 *UNIVERSE:* The aggregate of all humanity's all-time, consciously apprehended and communicated experiences
We start all problem-solving and definition with universe, and thereafter subdivide progressively to identify a special local problem within the total of problems.

2 *MAN'S SUCCESSFUL FUNCTIONING IN UNIVERSE:* The anti-entropic (syntropic) half of the omni-equating Universe
Man's syntropic functioning in Universe deems him a "success": That is-to fulfill his function he must be an ever expanding physical, converging metaphysical success. World Game strategies deal with the means of realizing man's success as efficiently, as effectively, as possible. World Game starts with Universe and the potential success of man within that Universe

3 *THE GENERALIZED PRINCIPLES OPERA TING IN UNIVERSE:* The omni-inter-accommodative laws of nature governing all special case experiences whether they be in Physics, Chemistry, Biology, Psychology, Sociology, etc. By employing generalized principles, World Game players have the integrity of the entire Universe backing them up and are thus as effective and efficient as possible

4. *SPACESHIP EARTH:* Earth is an automated Spaceship speeding rotatively at 66,000 miles per hour around the sun, which in turn, is on its own course at 6.0 kilometers per second within the Galactic Nebula The awareness of Earth's mobile patterning within the cosmos gives the perspective needed to deal with the overall evolutionary event-patterning aboard our spherical space-vehicle Earth, rather than the minute details.
The automated events transpiring aboard Earth lend powerful advantages to those who comprehend the automation and attempt to work with it in the most long-term, humanly advantageous ways rather than ignorantly attempting to control or oppose it. Both Earth's and humanity's automation are biological

5. *GENERAL SYSTEMS THEORY:* A synergetic tool for competent and comprehensive problem solving
Synergy is the behavior of whole systems unpredicted by any of its parts, e.g. mass attraction of inert matter masses-i.e., gravity, in which there is no characteristic of one of the massive bodies by itself which could predict that it will be attracted by or attract another body. The Earth, considered only by itself, could not predict that it will attract the moon or be attracted by the moon. Only the behavior manifest by any two such astronomical bodies can reveal the attraction This is synergy It is a corollary of synergy that the known behavior of the whole system and the known behavior of some of its parts makes possible discovery or true prediction of the behavior of the remainder of its parts. World Game strategies utilize synergetic General Systems Theory to enable them to be as comprehensive and correct as is presently possible

6. *MORE WITH LESS:* The comprehensive, anticipatory, design science capability to effect greater resource performance per each pound, kilowatt and man hour of invested resources. All World Game strategies deal with ways of doing more with less for the entire planet in such a manner as to effect the total success of total humanity in the quickest and most eternal way possible The comprehensive, recirculation of all chemical constituents of resources involved results in a more with less resource utilization. For example, each time copper is scrapped, melted down, and re-cycled, it is re-employed at a higher rate of efficiency. The first copper telephone wires carried one message per wire, subsequent more with lessing improvements carried 2, then 4, 16, 250, then in the thousands, and now with the satellites, it's gone wireless. From millions of tons of copper to next to no tons of copper. From visible to invisible.

7. *GAME THEORY:* A method for the mathematical exploration and study of decision-making in challenging situations

8. *DEFINE THE PROBLEM, NOT THE SOLUTION:* A problem adequately defined is a problem adequately solved: An inadequate or inaccurate problem definition frustrates solution or provides false solution assumptions

World Game mode of operation/experience involves foremost the accurate definition of the problem. By evolution/refinement of problem definition the strategy for problem elimination unfolds; when definition is complete, strategy is complete and problem's solution is manifest. The more adequatt!y we state the problems of today, the more apparent will the solution of tomorrow become. To the degree we can define the problems of today, we can refine our perception of the future. The aspects of the future which relate to our problem will afford us a key to unlock as many of the complex interrelationships of the future as we care to deal with, plus synergetically shedding more light on the present. In terms of the instant-"now''-both the past and the future are equally knowable. History can be known only as well as the future. The "realness" or "presence" (pre-sense) of each is equally tangible

9. *MAKE VISIBLE THE INVISIBLE:* The facts of experience set in order and communicated by decelerating the events which are too swift to be differentially comprehended or by accelerating the events where trending is unapprehended because the rate of transformation is too slow to attract attention and thereby permit comprehension of the trend significance. Part of the "problem" consists of making all vital but invisible evolution visible to others. World Game does so by:

   a *Inventory:* The gathering/accumulation of information, facts, and statistics related to a resource topic and its documentation. The World Resources Inventory is the foundation of the World Game.

   b *Plotting the historical trend curves:* A resource inventory expanded through time

   c. *Strategy:* Simulated exploration of two (or more) synergetically interrelated trends initiated operationally by the human mind.

   d *Scenario:* A logical sequence of events (a strategy) to show how, starting from the present, a future evolutionary condition might evolve step by step; a synergetic synoptic view of as many developments as can be grasped and as may appear relevant to an experimental simulation of a possible reality (the interaction between inventories, trends, and brain)

   e *Post-scenario:* The synergetic interplay and relative qualitative evaluation of two or more different scenarios with their resultant overlapping, opposing or complementing functions; the feedback mechanism leading to new strategies and scenarios that overcome seemingly "impossibilities" and/or gross inefficiencies of any scenarios taken separately. The general criteria for one strategy "merit" over another strategy merit is based on:

      (1) whether it enables mankind to be a "success"

      (2) whether it can do same quicker

      (3) whether it can do same quicker and utilizing Earth's income (non-depletable) sources of energy and materials

      (4) whether it can do all above plus metaphysically enhancing mankind

   f. *World Gaming:* The synergistic process of interrelating all of the above, evolving and refining the definition of the Earth's problems leading predictively and instrumentably towards the earliest possible syntropic, omni-success of all humanity

10. *PREFERRED STATES:* World Game evolving definitions of success; that which will enable a man or mankind to achieve his highest potential level rather than his bare-minimum subsistent level. When defining the problem, these are the optimum directions in which we move; in which a strategy is aiming towards:

   a *Energy:* Availability of enough energy for the healthful internal and external metabolic regenerating and functioning of Spaceship Earth and its human passengers, living and to be

living, all accomplished at the highest rate of economy and efficiency,
-which is, based on present day inventories, trends and rates of power generation and consumption of Earth; leading to 1242 inanimate, non-biological energy slaves per each living world human, per year in 2000 A.D.
-which is equivalent to 15,000 kwh and to 8 metric tons of coal per capita per year at present day efficiencies

b *Internal metabolics, or Food:* Availability of enough food for the healthful functioning and satisfactory metabolic regeneration of all mankind, based on the consumption of calories and protein at the rate of 3500 calories and 90 grams of protein per capita per day, equivalent to: 8.5 x 10^{15} calories, and to 21.9 x 1 0^{7} tons protein in the year 2000.

c. *Health/Medical Care:* Availability of the best health restoring and sustaining devices known to man and the preventive medicine of a healthful environment for all mankind at all times.
Anticipatorially adequate healthful environment involves:

d *Housing/Shelter:* Availability to all mankind adequate shelter to cope with all deliterious environmental impingements and to do so at a high rate of economy and efficiency.

e *Communicators:* Availability to all mankind of means to communicate with anyone wishing to be communicated with at the highest rate of economy and efficiency.

f *Transportation:* Availability for all mankind, his goods and services, to be able to go anywhere in the world at a high rate of economy and efficiency.

g. *Education:* Availability of the best comprehensive education in all spheres of life for all mankind; and to anyone who wishes to learn anything, everything pertaining to his special interest

h *Recreation:* Availability of enough leisure, facilities, and know-how, for all mankind to develop to his, society's and Earth's maximum potential and satisfaction.

1. *Logistics:* The most efficient and economic metabolic interrelationship of all the above. (See "Universal Requirements of a Dwelling Advantage" by Buckminster Fuller)

11 *BARE-MAXIMUM:* The preferred state on a per-capita basis, that is, as a conceptual measuring stick for determining the strategies' relative successes or failures. The bare-maximum can be applied to a strategic play to determine how many people on Earth it will take care of.

12. *WEALTH:* Intellect and energy; measured by the amount of forward days for how many humans with which we are technically organized to cope. Because energy can neither be destroyed nor created, and "know-how" of intellect can only increase with each experiment, or experience, wealth consisting of both the physical and metaphysical can only increase with each and every re-employment.
Wealth and the bare-maximum are World Game measurements of success; the ultimate bare-maximum wealth at this point in our evolution is total success for all humanity, now living or ever to become living

13. *INTERNAL/EXTERNAL METABOLIC'S:* The harnessed inanimate energy of sun produced, water falling, or sun and moon produced tidal pulsations, or wind power or the biological automated logistics of our bodies-veins, nerves, muscles, etc.-constitute internal metabolics; electric generators which they actuate, the highways, air lanes, pipelines, electric lines, etc., are mankinds external metabolics
World Game strategic experience has shown that by dealing with mankind? external metabolics, individual mans' internal metabolics are automatically serviced

14. *MODELS:* The graphical, functional and mathematical orderings and simplifications of the omni-complicated and inter-related processes of the World. The conceptual simplifications of "reality" into the vectors of an interacting process which can be dealt with on a scientific basis

15. *DYMAXION MAP PROJECTION:* A distortion-free map projection showing the entire Spaceship Earth as one unit, in one visualization

All World Game inventories, trends and related data can be geographically displayed upon the Dymaxion Sky-Ocean Map without any visible distortion of the shapes, sizes, or true proportionality of the data and its true significance

16. *TOTAL ENERGY ACCOUNTING.* The comprehensive accounting of all energy-energy disassociative as radiation and energy associative as matter; World Game deals with the deployment of the physicals aboard Spaceship Earth; all physicals are energy; hence comprehensive accounting of the Earth's resources must deal with energy in all of its manifestations, i.e.,-how much energy is tied up in the buildings of the Earth, etc. Energy is the common denominator of all Comprehensive Anticipatory Design Science; it is the media of *all* design. Design Science will use total energy announting as its yardstick measurement for it is more with less advantaging

17. *25 YEAR ECONOMIC ACCOUNTING:* Design Science strategies utilize an economic structure which is based on a 25-year accounting, rather than the "standard" one-year accounting Annual accounting is geared to nature's "self-starters" i.e.-agriculture, depletable resources; 25-year accounting is geared to nature's main engines-i.e.-industrialization, recyclable resources.

18. *ABUNDANCE ECONOMICS:* Design Science's more with less advantaging has proven the Malthus dictated scarcity ethic, which is the working assumption of the world's major states, is fallacious. The scarcity ethic dictates that there is not enough of the World's resources to go around; Design Science's abundance ethic/economics frame of reference dictates that there *is* enough for everyone if we utilize the Earth's resources comprehensively and anticipatorily

B.5 World Game Format Outline for Scenarios

1. Preferred state bare-maximum definition of success.
2 Strategy of the process for attaining same; time "goal" for process attainment.
3 Required data for comprehensive documentation of strategy
   a) inventories
   b) trends
4 Sequence of events and synoptic view of as many developments as can be grasped and as may appear relevant to Scenario

Examples of World Game Scenario Development Outline

A. *Energy- 1969*

1. Bare-maximum:
   Availability of enough energy for the healthful internal and external metabolic functioning and satisfaction of Spaceship Earth and all mankind, living and to be living, at the highest rate of economy and efficiency
2. Strategy:
   Utilizing Earth's most efficient means of electrical energy production-hydroelectric (rivers, ocean tides and currents)-without any further development of pollution causing, capital energy resource depleting thermal electrical generating plants, and taking advantage of the increased efficiency of super high voltage (1,000,000 volt) long distance (1500 mile) transmission lines in a day/night and seasonal hook-up, demonstrate the capability with present methods, technologies, projected population figures, metals resources, and efficiency levels in electrical power generation and consumption, to bring everyone on Earth to a minimum 2000 kwh per year by 1980, and, utilizing new technologies in the generation, transmission and consumption of electrical energy to bring mankind to the level of 15,000 kwh by the year 2000.
3. Data:
   a) inventories:
      1) population of Earth and its distribution,
      2) location of Earth's electrical network: generating stations, broken down into thermal and hydroelectric, and transmission lines
      3) location of quantities and qualities of Earth's metals resources

4) efficiency levels in power generation and consumption
5) levels of power consumption and production
6) division of electrical power consumption-how much for agriculture, industry, home, etc.
7) amounts of metals involved in generation, transmission, and consumption of electrical energy
8) per-capita consumption of electrical energy by area
9) world electrical energy generation average annual rate of growth
10) metals production.
11) fossil fuel reserves.
12) total metals, scrap, mined and estimated to be mined in world.
13) metals allocations.
14) location of, and kwh available from, potential river and tidal generating stations.
15) amounts of coal used in thermal electric generating plants.
16) amounts of pollution resulting from same.
17) amounts and types of metals required for long-distance high voltage transmission lines
18) etc.

b) trends

1)-18) expanded through time: 1900-2000

4. Earth's existing electrical power generating plants and transmission lines are progressively integrated and supplemented until they are all inter-connected in a day/night and seasonal hook-up and bare maximum is met. Construction begins early 1970 on transmission towers, lines and hydro-electric plants. By 1973, North America is hooked up with Northeastern Siberia via the Bering Strait, Western Europe is hooked with Eastern Europe and Russia. 1974-1976: First hydro-electric generating plants in South America, Central America, Africa, India, and China completed and integrated into network. 1977-1980: First tidal hydro-electric generating plants in Nova Scotia, Alaska, Greenland, Japan, China, India, Australia, England, and South America completed and integrated into network; rest of river hydro-electric plants completed and integrated into now completed network, thereby assuring mankind a minimum 2000 kwh per capita per year with the world overall average per capita kwh at 3613 kwh.

Next, utilizing Earth's other income energy sources (solar, geothermal, ocean currents, and wind) with reasonable and foreseeable technological advances to tap and transmit these sources of electrical energy effectively and efficiently, the per capita level of kwh is brought up to 15,000. As the energy to an area is increased, the amount of reinvestible time increases. As the amount of reinvestible time (that time devoted to metaphysically regenerative functions vs the non-reinvestible time of biological subsistence functions) increases, the amount of know-how increases, and as know-how increases, the ability to do ever more with ever less increases. As this proceeds, Earth's wealth increases, thus insuring Mankind's total regenerative success more and ever more, thereby eliminating the "have nots" of Earth by making them "haves," and giving permanent peace the foundation it needs

B. *Food- 1969*

1. Bare-maximum:
   Availability of enough food for the healthful functioning and metabolic satisfaction of all mankind.
2. Strategy:
   Get enough electrical power to sub-bare maximum food areas thereby increasing their over-all efficiency by assuring the capability to store, transport, and process the existing food crops and products wasted and spoiled due to lack of energy, and increasing production efficiency to feeding three to five people per acre by the increased use of fertilizers, farm equipment, and know-how, thereby having all mankind at the bare maximum by 1980.

3. Data:
   a) Inventories:
      1) World population and its distribution
      2) Per-capita calorie and protein intake by area and average for world.
      3) Arable land of earth.
      4) Agriculture production location
      5) Daily and yearly world food requirements.
      6) Amount of kwh needed to produce a ton of food.
      7) Amount of calories used in different activities.
      8) World food production
      9) Livestock: types and quantities of food consumed
      10) Amounts of food consumed vs the amount grown
      11) Means of transporting, storing, and processing food
      12) Efficiencies of production.
      13) Types and quantities of fertilizers, farm equipment.
      14) New foods
      15) Etc.
   b) Trends:
      Number 1 through 15 expanded through time: 1900-2000.
4. As electrical power becomes available to sub-bare maximum food areas in 1973-1976, fertilizer production plants, farm equipment, and the technical know-how of their use becomes available; simultaneously, refrigeration, canning, freeze-drying, vacuum packing, high speed efficient transport and distribution increase the overall efficiency levels to halt all potential food spoilage and wasteage by 1980. By 1978 per capita calorie intake for world is 3000, with no one below the bare minimum caloric intake of 2500. Starvation is eliminated; life expectancy increases, mankind is collectively well-nourished and healthy for the first time in history of Earth.

6.6 World Game Pre-Scenario Integration Outlines

1 Take preferred state bare-maximum definition of success.
2 State strategy for the process of attaining same; time "goal" for process attainment.
3 List required knowledge to document strategy.
   a) General data
   b) Inventories
   c) Trends
   d) Efficiencies
   e) Etc.
4. List questions to be answered

Examples of Pre-Scenario Integration Ou tline

A. *Transportation- 1969*

1. Bare-maximum:
   Make available to all mankind, his goods and services, the ability to go anywhere in the world at a high rate of efficiency and economy.
2. Strategy:
   Concentrate on the omni-directionality and speed of air transportation and use the U.S. as bare-maximum to find out how much materials, land, etc., will be needed for bare-maximum to be met in developed areas of the world.
3. Required Data:
   a) Inventories:
      1) Where all roads are in world
      2) Where all train tracks are in world
      3) Where all sea lanes and river lanes and ports are in the world
      4) Where all air lanes and ports are in the world
      5) The types of airplanes, helicopters, etc , and their capacities and speeds
      6) The amounts of materials used in transport facilities-planes and ports

7) The amount and locations of Earth's population
8) The production capacities of airplane, etc., production plants

b) Trends:
1) The growth of transportation networks from their beginning to 2000 A.D.
2) The increase in efficiencies of transports from beginning to 2000.

4. Questions:
a) What type of transportation is most efficient? Most economical?
b) How many square miles do airports in the U.S. take up?
c) How many passengers are flown?
d) How much food is consumed on airplanes?
e) How much pollution do planes give out?

B. *Communication- 1969*

1 Bare Maximum:
Availability to all mankind of means to communicate with anyone wishing to be communicated with at the highest rate of economy and efficiency.

2. Strategy:
Make inventories of all communication networks; project present usage in U.S. to the world to see if it can be done using present methods, etc. Find out what will be needed for everyone to have the bare-maximum.

3. Required data:
a) Inventories:
1) World population and distribution
2) World television, radio transmission stations
3) World televisions, radios
4) World telephone lines
5) World telephones
6) Newspapers, circulation
7) Technical journals
8) Communication satellites
9) Computer, where, how many
10) Etc.

C. *Housing/Shelter- 1969*

1. Bare-Maximum:
Availability to all mankind of adequate shelter from all undesired environmental impingements at a high rate of economy and efficiency.

2. Strategy:
Inventory worlds present state and determine what will be needed to melt the bare-maximum.

3. Required data:
a) Inventories:
1) World population and distribution
2) World housing
3) World housing needs
4) Materials of shelter const.
5) Amount of materials needed to meet bare-maximum
6) World population mobility
7) Etc

D. *Education-1969*

1 Make available the best comprehensive education in all spheres of life for all mankind; and to anyone who wishes to learn anything, everything pertaining to his special interest

2. Synthesize all knowledge using computers and learning-resource centers that make education instantaneously available to anyone who wishes to learn anythiag This system should be available to the world by 1982, or as soon as possible

3 Required Data:

a) Inventories:

1) Number of computers in existence in the world.
2) Location of computers in the world.
3) The role of computers in education.
4) Growth of computer capability.
5) Satellite methods and laser beams to synthesize computers and knowledge banks. Communication capability.
6) MAPS-literacy, locations of institutions of higher learning, locations of computers, newspapers-circulation, communications satellites-receiving station location, world telephones, world population and distribution, number of college graduates by country
7) Teacher per student ratio in the world; the effect on this ratio by the introduction of audio-visual equipment
8) Occupational changes, percent of population in school

b) Trends:

Numbers 1 to 8 expanded through time.

4. Questions:

a) What are the present and future roles of the computer in education?
b) When will we have home computers?
c) How will home computers relate to formal education?
d) How many computers will be needed for education?
e) How many teachers and instructional aids will be needed with the increased role of the computer?
f) How effective are satellites and what types of information can they relay?
g) How should an educational network work?
h) What information should be stored in computers and what information should be in learning resource centers?
i) What is a learning resource center?
j) When is it necessary to have face to face contact in learning?

E. *Energy and Health/Medical Care (alcohol substitution)- 1969*

1. Make available enough energy for the healthful internal and external metabolic functionings and satisfaction of Spaceship Earth and all mankind living and to be living at the highest rate of economy and efficiency

Make available the preventure medicine of a healthful environment.

2 Substitute alcohol made from the organic waste of the world for gasoline in all internal combustion engines thereby eliminating carbon monoxide air pollution and stopping the wanton consumption of Earth's irreplaceable capital energy resource oil. Substitute alcohol burning internal combustion engines for all coal burning thermal electric generating plants thereby simultaneously eliminating the coal produced sulfur dioxide air pollution, increasing the overall efficiency of electric generation, constructively utilizing the garbage/waste of the world and slowing down the consumption of Earth's

irreplaceable capital energy resource coal. Carbon monoxide and sulfur dioxide to be completely eliminated as the major cause of air pollution, and world's garbage/waste to be utilized in the production of alcohol by 1976.

3. Required data:
   a) Inventories:
      1) Amounts of oil mined and amounts used for gasoline
      2) Amounts of gasoline consumed in world
      3) Amounts of carbon-monoxide resulting from same.
      4) Other uses for oil
      5) Amount of organic garbage/waste in world
      6) Amounts of alcohol presently produced; where and how
      7) Etc.
   b) Trends:
      Number l-3 expanded through time- 1900-2000.
4. Questions:
   a) What are the relative efficiencies of gasoline and alcohol?
   b) How much alcohol can be produced from a given quantity of waste?
   c) What is needed to produce alcohol?
   d) How many alcohol producing plants will be needed?
   e) What type, if any, pollution would you be getting from alcohol?
   f) Etc.

F. *Health/Medical Care and Recreation (Guaranteed Fellowships/Annual Income)- 1969*

1 Bare-maximum:
The preventive medicine of a healthful environment and the availability of enough leisure, facilities, and know-how for all mankind to develop to his, societies, and Earth's maximum potential and satisfaction

2. Strategy:
Give to anyone in the world desiring it, anywhere in the world, a guaranteed annual income commensurate with the middle-class economic survival levels of their particular locality, plus making available to anyone who wishes it, a Fellowship to do research and development in any field which they deem important. Eliminate welfare and all other half measures presently used. To be paid for by the increase in wealth occurring from the increased amounts of re-investable time and its resultant increase in energy and know how

3. Required data:
Inventory of:
   a) World Population and Distribution
   b) Economic Levels of Same
   c) Amounts of Wealth Needed to Realize Strategy
   d) World Production Capacities
   e) Amounts of "goods" produced and bought now
   f) Amounts projected to be needed after present guaranteed annual income
   g) Amounts (present) of re-investible time
   h) Projected amounts of re-investible time after guaranteed income and fellowships
   i) Present "worth" of time per hour by locality and for whoie Earth

C. INFORMATION TO BEGIN STUDYING WORLD GAME

C.I Fuller Research Techniques for Compiling and Displaying Data by Michael Paterra

The World Resources Inventory Human Trends and Needs is a comprehensive inventorying of the regenerative physical and metaphysical resources of the earth. It has the advantage of Professor Fuller's forty-four years experience interpreting global history and the trending patterns of world people's movements and needs. The ultimate objective is a great logistics game with a computer containing an inventory of human trends, known needs, and fundamental behavior characteristics, i.e.-the World Game.

The purpose of this discussion is to offer various research techniques for investigating scientifically what could happen if the world's population were to apply its experience based information and the highest technology directly to the problem of making man a success on earth. Such investigations will reveal the surprising patterns of humanity's successes, and the potential success for 100 percent of humanity

Per World Man

Absolute figures, generally, do not take into account the regenerative aspects of the evoluting industrial process and the complex interaction of the tools which create real wealth.

Nature's functions are complementaries of the total world relation to the universe inventory of the 92 regenerative chemical elements. These chemical elements are not things, but are complementary behavior patterns. What a country or area actually has, at some point in time, is a temporal and dynamic series of patterned relationships, which can only be related to what all other men have. To be ecologically sound and economically accurate, all accounting should be Per World Man (PWM)

SELECTED *PRODUCTION* SERIES OF *PER WORLD MAN* DATA

	unit	*1953*	*1965*	*1969*
WORLD MAN NUMBERS	millions	2728	3295	3552
Wheat	kilograms PWM	74.60	81 .00	89.20
Barley	"	25.40	32.20	38.40
Maize	"	57.40	68.90	74.60
Rice	"	72.00	77.10	83.00
Cotton	"	6.20	3.50	3.23
Wool	"	0.75	0.78	0.78
Meat	"	7.70	21.20	22.20
Milk	"	103.20	112.60	112.00
Natural rubber	"	0.65	0.72	0.80
Fish catches	"	9.25	16.30	17.80
Coal	"	548.50	609.70	584.50
Crude petroleum	"	241.90	455.50	576.30
Pig iron	"	61.60	95.90	115.50
Crude steel	"	85.90	134.70	156.30
Copper	"	0.90	1.30	1.40
Zinc	"	0.92	0.97	1.20
Lead	"	0.66	0.63	0.70
Tin	"	0.07	0.04	0.05
Aluminum	"	0.79	1.60	2.14
Cement	"	65.24	128.40	149.20
Electricity	kwh PWM	0.46	1.00	1.27
Motor vehicles	units per 1000	2.98	5.80	6.37
Newsprint	kilograms PWM	3.56	5.20	5.80
Nitrogenous fert.	"	2.31	5.00	7.50
Sugar, raw	"	14.16	19.70	19.60
Wheat flour	"	16.12	32.40	31.95

SOURCE: United Nations, *Monthly Bulletin of Statistics,* February 1971 and the United Nations, *Statistical Yearbook 1967.*

Compiling Information and Data

The series of inventory charts depicting global scientific advances evidence man's ever accelerating capability for success with a minimum amount of invested resource. The units of measure for trending this information should be performance per unit of invested resource Per World Man, per unit of time. The following are a few selected examples of performance measures:

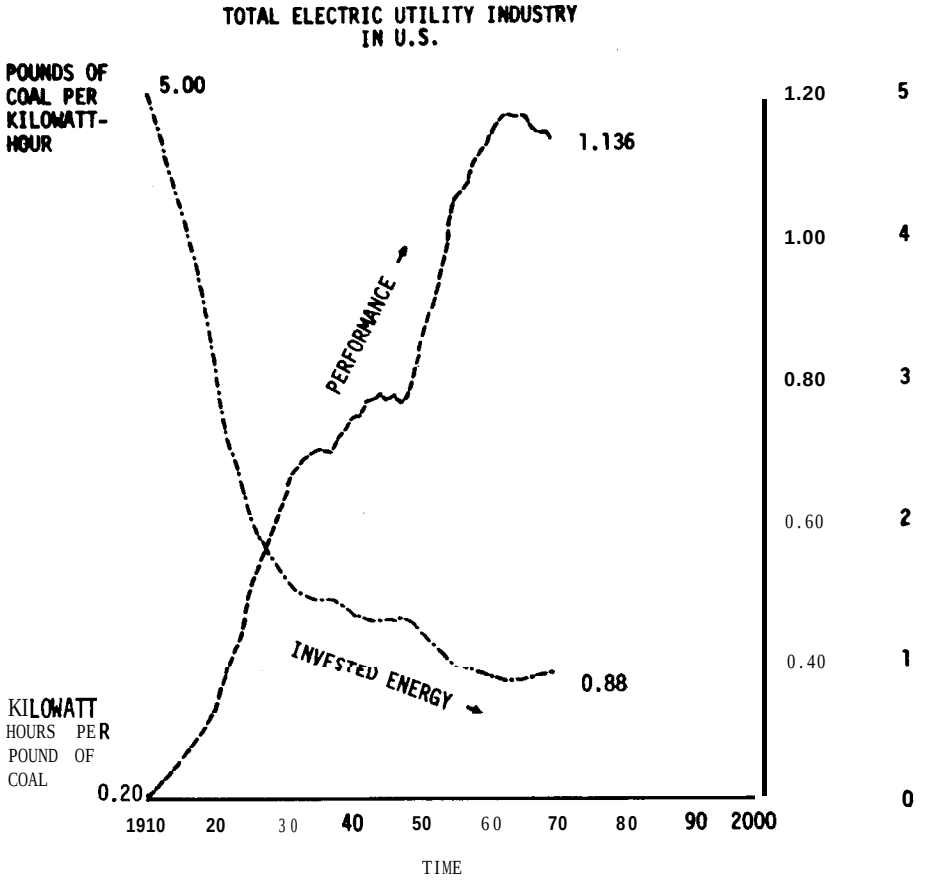
Horsepower per pound
Miles per tire
Lumens per watt
Acres per man-hour
Pounds per square inch
Instructions per second

The following chart, inventory 16a, measures performance per unit of invested resource in terms of kilowatt hours of electrical energy generated per pound of coal for the years 1910 to 1969. Performance is sloping positively from left to right Conversely, energy consumption per unit of invested resource is sloping negatively from left to right, as increasingly less coal is required to produce one kilowatt hour of electricity.

Data plotted in this manner reveals performance per unit of invested resource increasing per unit of time and energy consumption per unit of invested resource decreasing per unit of time. Such information demonstrates man's ever increasing ability to "do more with less"

Taken together, the production of coal per world man and the performance per pound of coal invested in electrical energy generation, as the branching effects of a tree, illustrate scientifically the precessional patterning accelerating acceleration of more-with-lessing

Ephemeralization, the comprehensive effects of more-with-lessing, will bring about an ever higher standard of living for all humanity.



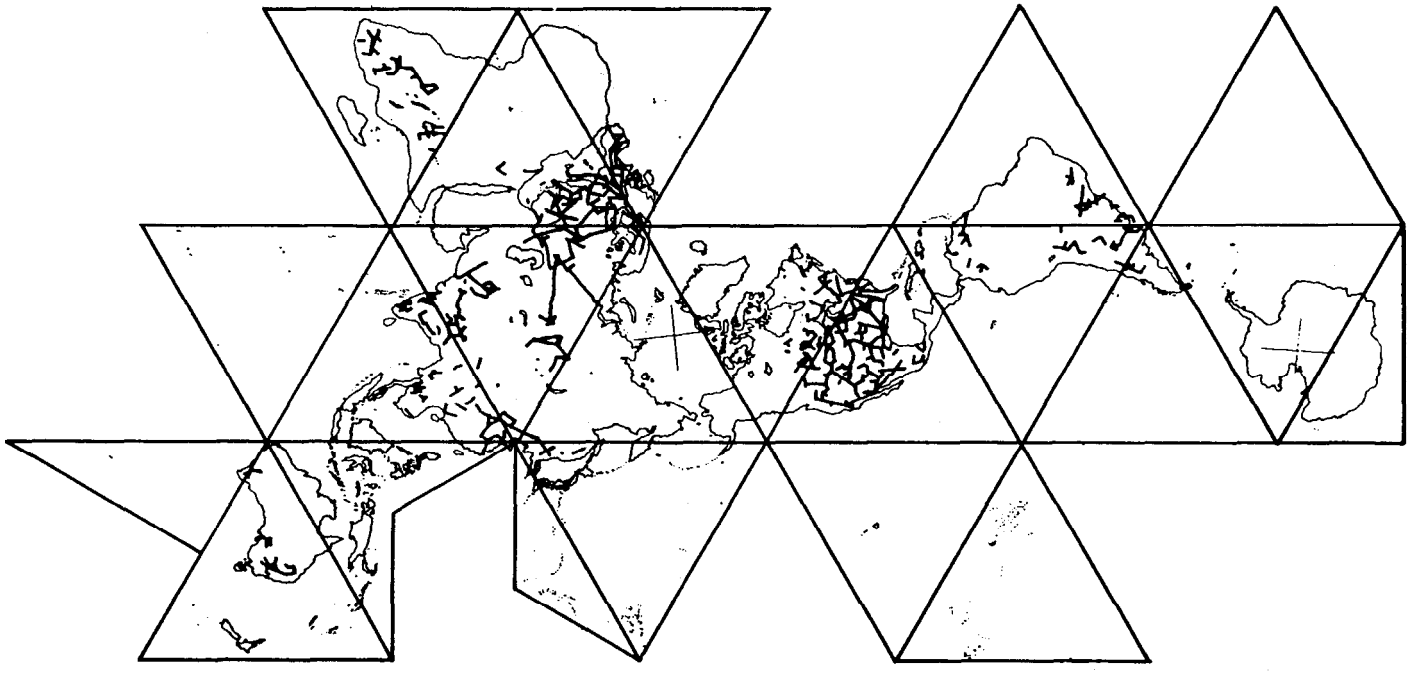
Inventory 16a

It is possible to define the gap between what is currently feasible and what is necessary. There is, for instance, a gap between the performance of the world's solid waste regenerating systems and the quantity of solid waste generated in the great cities of the world. Since it is necessary to recycle all 92 regenerative chemical elements, one problem defined for the design scientist is to explore for regenerative resource technologies

Another advantage is the ability to project future advances for anticipatory planning. Having identified what needs to be done, it is necessary to determine what the critical variables are and when they are expected to be reached. Fuller's 1927 investigations into the tensile strength of wire cable (pounds per square inch) and the load capacity of the helicopter enabled him to predict the feasibility of air delivering shelter anywhere in the world by 1952.

Displaying Data for Information

The series of inventories displayed on the Dymaxion Sky-Ocean World Map (see pp. 99) details world resource reserves, material flows, and the trend patterning of people's movements and needs. Taken together, area production and world reserve relations, either per world man, or on a world percentage basis, proportionally illustrate the disparity between those who have and who have not. An example of this is the World Electrical Energy Grid Scenario discussed in the World Game Package.

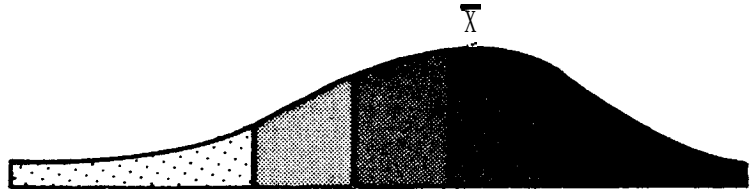


INTERCONNECTING ELECTRIC NETWORKS/1968 **220 KILOWATTS**

Steps in Preparing Data for Displaying on Dymaxion Map

1 Select resource to be displayed (e.g., Wheat Production)
2. List countries-Rows
3. List Years (1957-1969)—Columns
4. Fill in cells with data on resource being studied (e.g. Wheat Production)
5. Sum continental sub-divisions (e.g. Northern Africa)
6. Sum continental data (e.g. Africa)
7. Determine weighted mean by summing each column of data (preferably by continental sub-divisions) and dividing sum by *population* of all sub-divisions for that year.
8 This weighted mean then becomes the dividing line (so many countries will be above the mean and so many countries will be below the mean).
9. Determine per-capita value (for each country and year) on each resource and then rank order countries according to this per capita value.

10. Divide the countries above and below the mean into three equal groups, e.g., if a total of 120 countries makes up our sample then the division into 3 above and 3 below would look like this if 25% of them are above the mean:



120
x 25
600
240
3000

11. This allows six gradients for a display system going from darkest for highest value (or most of a resource) to lightest for least value.

N.B. If percentages appear in cells instead of actual raw data, then multiply percentage by total amount of resource for world to get back to raw data for that cell.

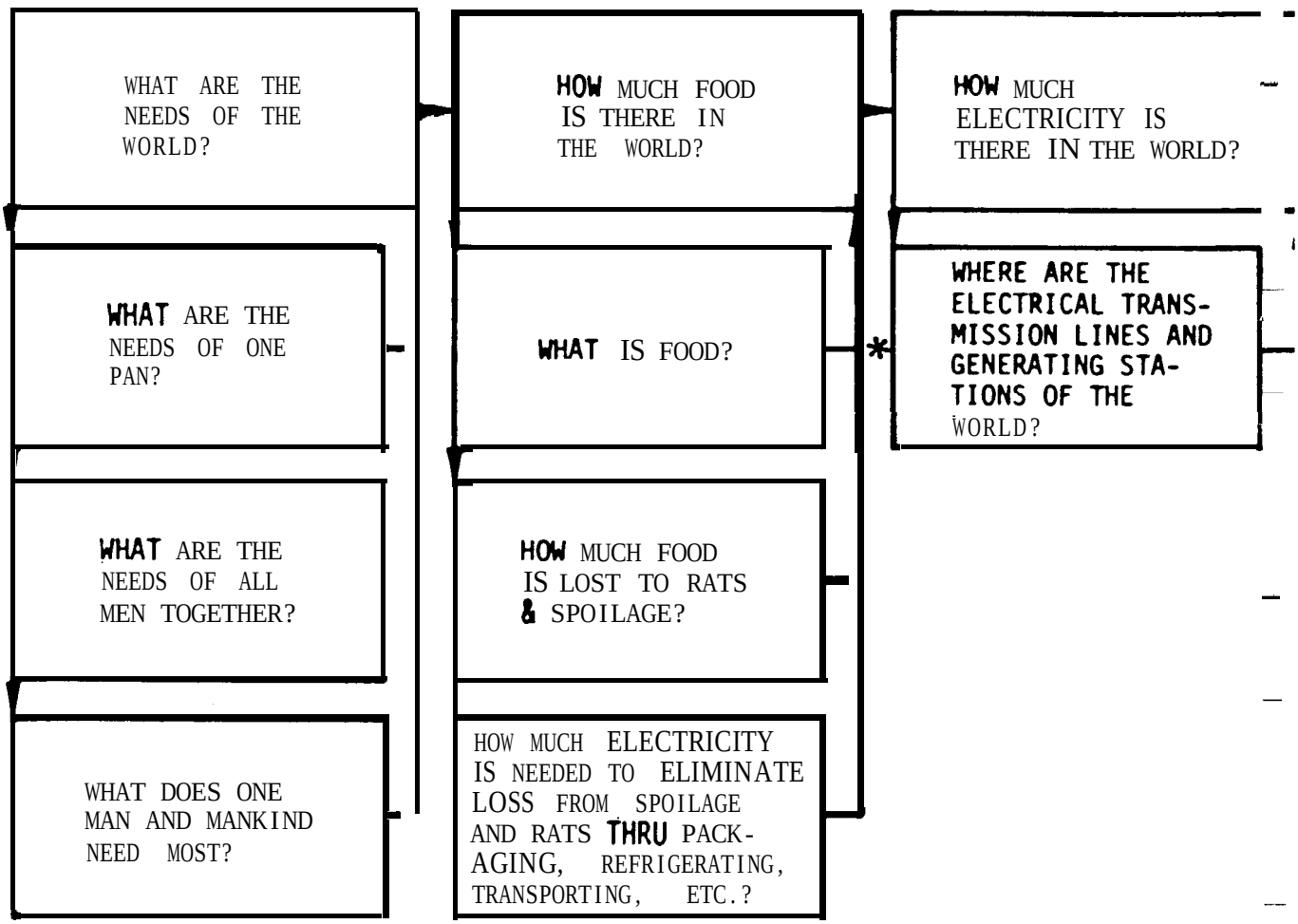
Spring, 197 1

C.2 Examples of Data Handling Techniques

The following flow charts are specific examples of data handling techniques and problem solving organization used by two World Game related projects. The first two are from the first World Game seminar in New York City in 1969; the second set of five is from a Design Science workshop held at the University of Southern California in Feb. of 1971. The charts are illustrations of the exploratory process and events that the participating students went through. They are linear, and hence suffer as the actual explorations were not quite this direct, but they are nevertheless a valuable aid and guideline to the student who wishes to know where to begin or where to go This is how two groups of individuals did it; another groups' efforts will of course, be different.

The two sets of charts are dissimilar and hence afford a greater range of possible alternatives, both in terms of the process the participants went through and the organization that structured their exploration. The New York flow charts are the post-facto documentation of that groups explorations and data gathering experiences. The U.S.C. flow charts were done prior to the workshop and were used as a structure for the time, energy, and intellect of the participants, as well as a graphical explanation of the project itself. A further, more detailed explanation will be found as an introduction to these specific charts.

CHART I



* SEE CHART II

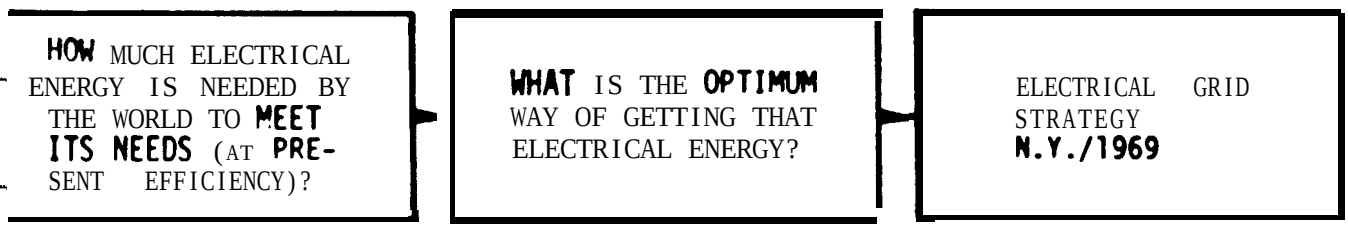
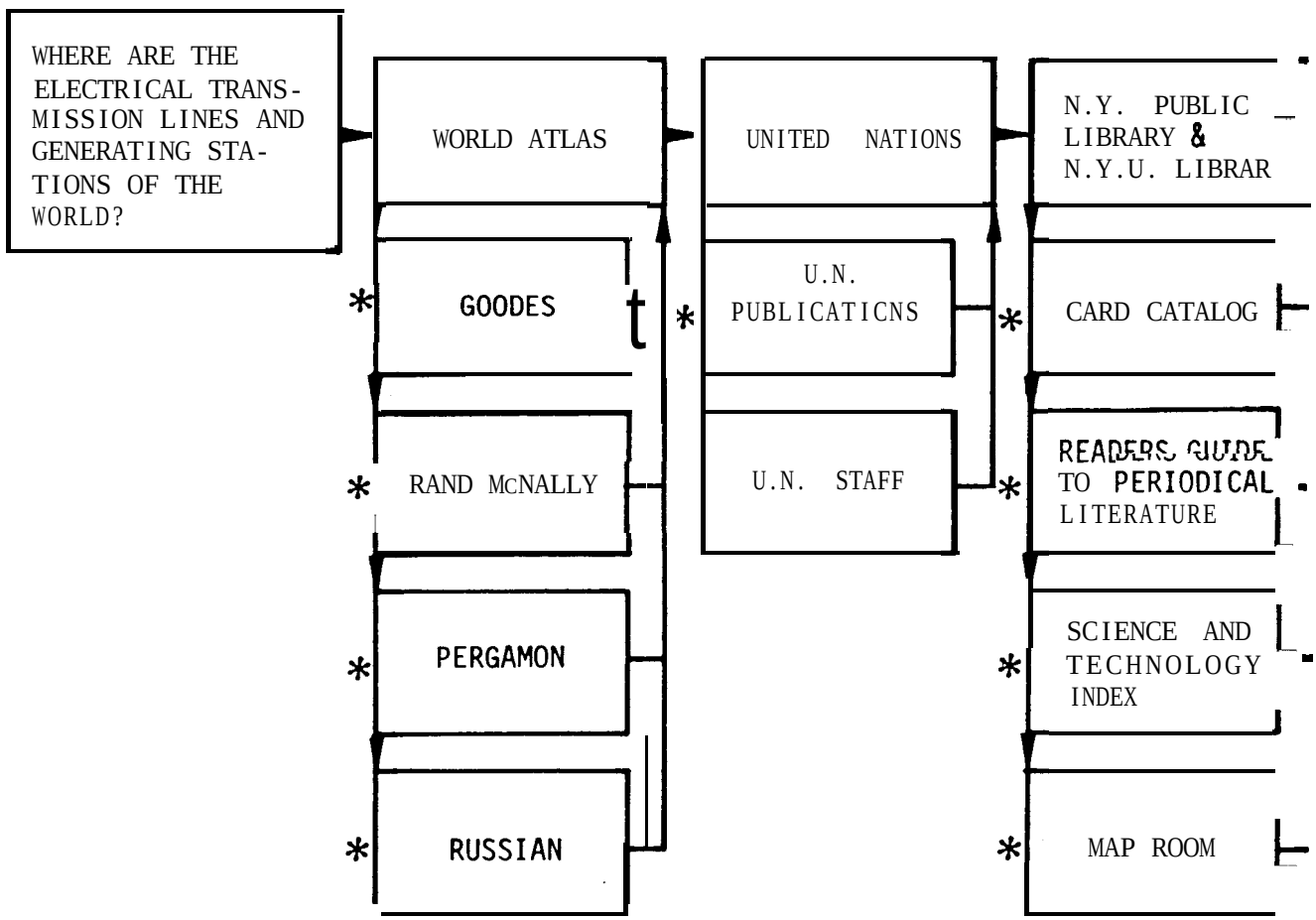
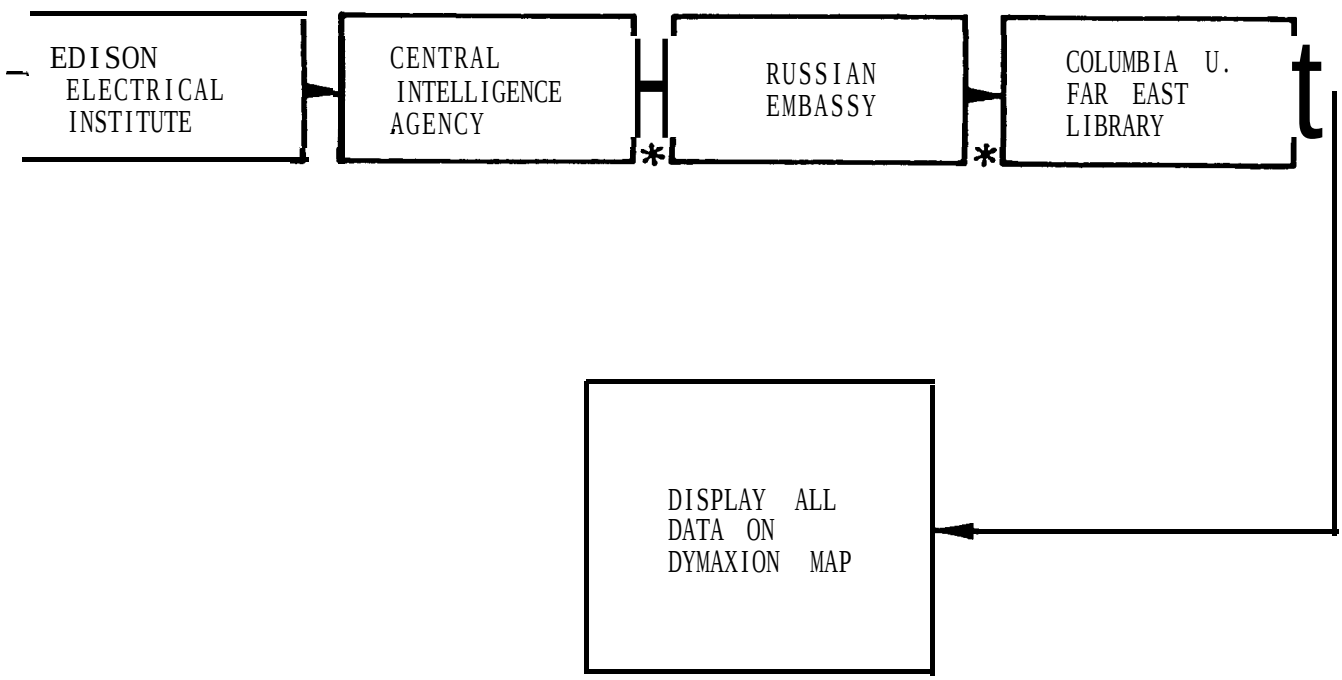

HOW MUCH ELECTRICAL ENERGY IS NEEDED BY THE WORLD TO MEET ITS NEEDS (AT PRESENT EFFICIENCY)?
WHAT IS THE OPTIMUM WAY OF GETTING THAT ELECTRICAL ENERGY?
ELECTRICAL GRID STRATEGY
N.Y./1969

CHART II

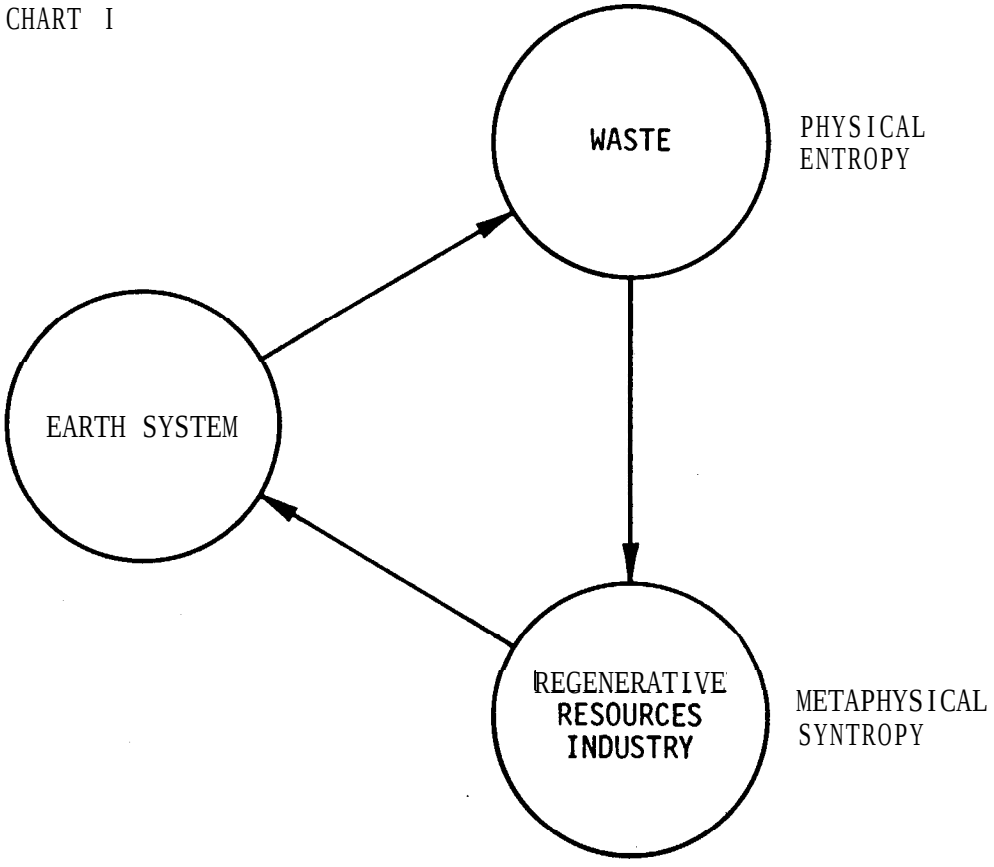


*HELPFUL


EDISON ELECTRICAL INSTITUTE
CENTRAL INTELLIGENCE AGENCY
RUSSIAN EMBASSY
COLUMBIA U. FAR EAST LIBRARY
DISPLAY ALL DATA ON DYMAXION MAP

A preliminary exploration into the documentation of a Regenerative Resources Industry was the chosen topic for research at a workshop held at the University of Southern California. Just what an industry of this nature would involve led to a chart of the information required to describe it.

CHART I



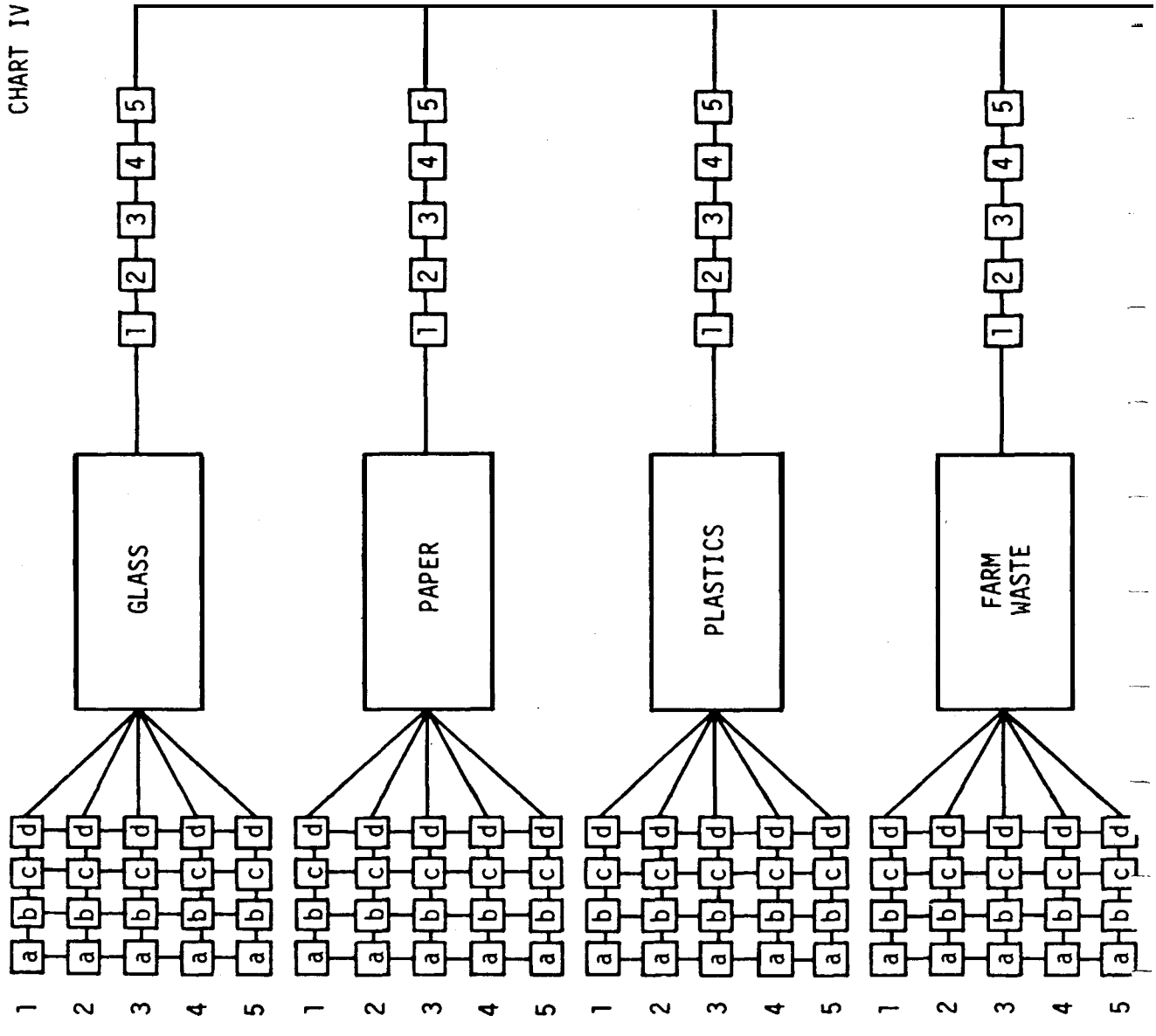
(c)	(d)
HOW MUCH CAN WE RE-USE?	WHAT RE-CYCLING TECHNOLOGIES ARE NEEDED?
WHERE CAN WE RE-USE?	WHAT RE-CYCLING TECHNOLOGIES ARE POSSIBLE?
WHAT ARE THE EXIST-ING TECHNOLOGIES FOR RE-CYCLING IT?	HOW FAST DOES I? RE-CYCLE NOW?
WHAT RESOURCES ARE NEEDED?	HOW IS THE RE-SOURCE COLLECTED?
WHAT WOULD HAPPEN IF IT WERE NOT RE-CYCLED?	HOW DOES IT NEED TO BE COLLECTED?

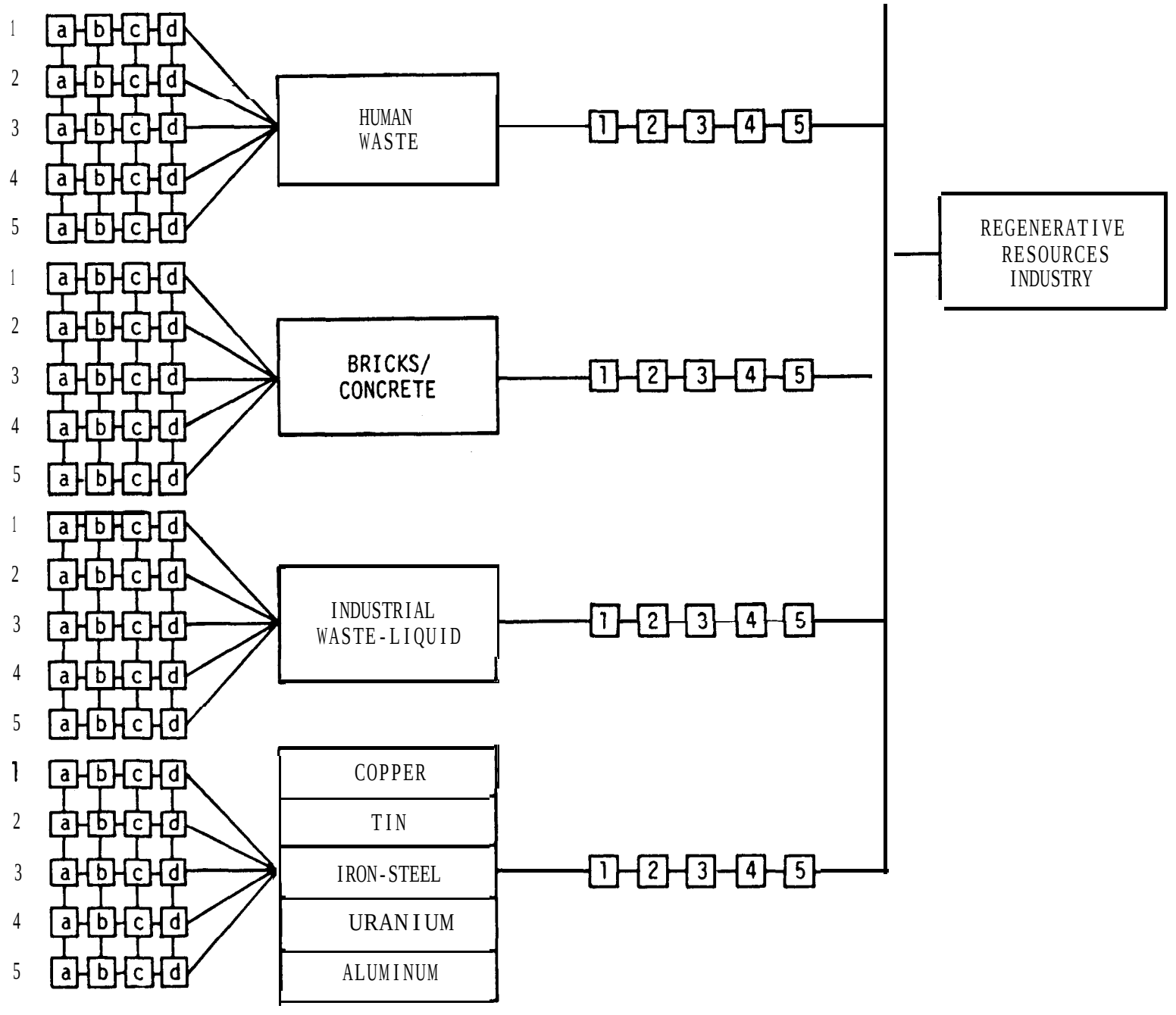
ANSWER THE FOLLOWING QUESTIONS FOR ALL RESOURCES 1-12

1 WHAT BASIC REGENERATIVE PROCESSES ARE REDUNDANT?
2 HOW CAN ALL 12 RESOURCES BE COMBINED INTO ONE INDUSTRY? ONE FACTORY?
3 WHERE SHOULD IT BE LOCATED?
4 HOW LONG SHOULD IT EXIST?
5 WHAT WILL BE THE BY-PRODUCTS OF THIS INDUSTRY/FACTORY?

This chart served to identify for the whole scheme so far outlined just what questions needed answering

The next consideration was what was the best method of organizing a group of people as comprehensively informed participants in the gathering of the data required. This led to the scheme shown in Flow Chart IV:




1 a b c d
2 a b c d
3 a b c d
4 a b c d
5 a b c d
HUMAN WASTE
1 2 3 4 5
BRICKS/ CONCRETE
INDUSTRIAL WASTE-LIQUID
COPPER
TIN
IRON-STEEL
URANIUM
ALUMINUM
REGENERATIVE RESOURCES INDUSTRY

Charts III and IV relate intimately and to simply illustrate the workings of this scheme we shall consider a number of examples.

Stage I

If we take the topic Glass as an example, we see that Unit I would concern itself with answering from Chart III questions I (a) (b) (c) and (d) i.e. what is glass, how is it made, etc.

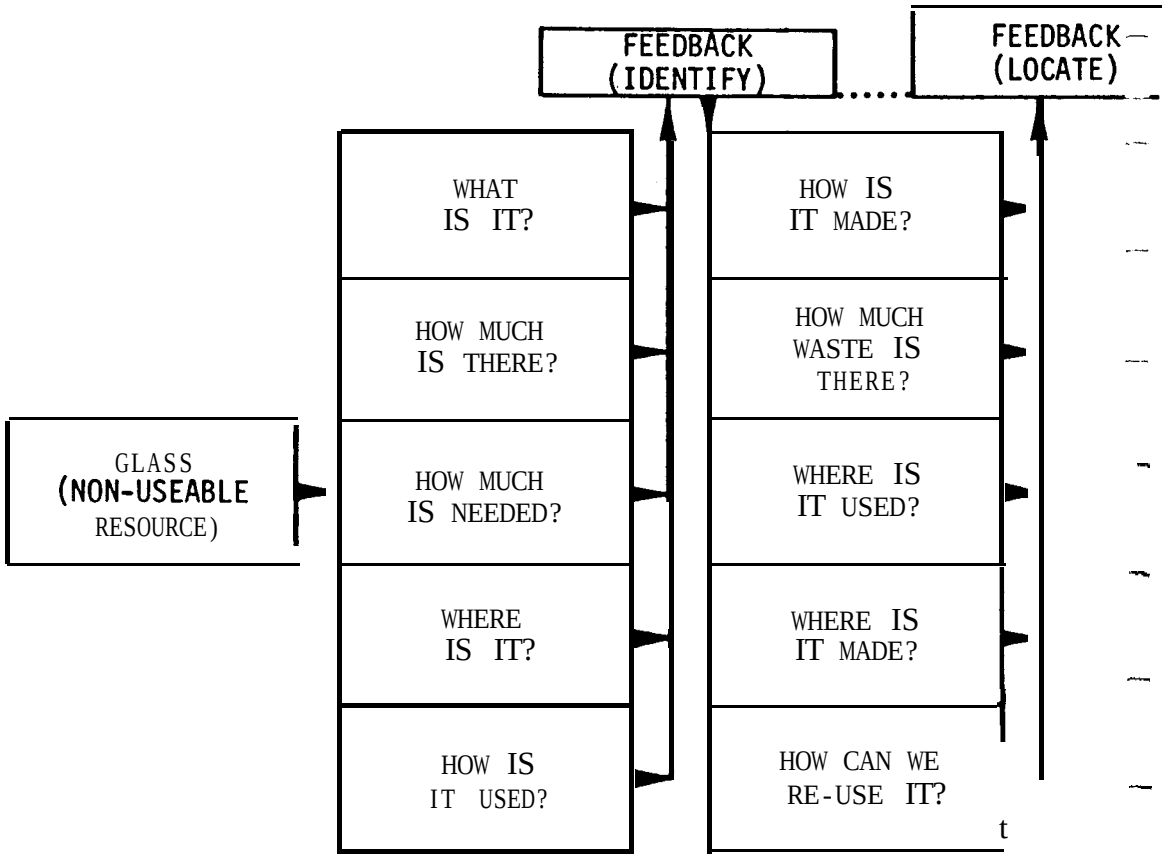
Simultaneously other groups would gather similar information for Paper, Plastic, Farm Waste, etc. so that in the first work period this set of questions would be answered for all topics under consideration. **At** the end of this period copies of the information gathered by each group should be made and distributed to all other groups. This procedure would ensure that all the participants while gathering somewhat specialist information would in fact be comprehensively informed as to what information was being gathered by the whole group as a unit

Next a similar operation for questions 2 a,b,c, and d would be performed, the information shared, and so on. Thus, if we wish to know what 3d under Plastics means, we find from Chart III that it relates to the question: How fast does Plastic recycle at the present time?

Stage II

When answers to all the questions indicated have been gathered and shared with all other participants, Stage II of the operation can begin i.e. integration of the information. Here 1 refers to Stage II question 1

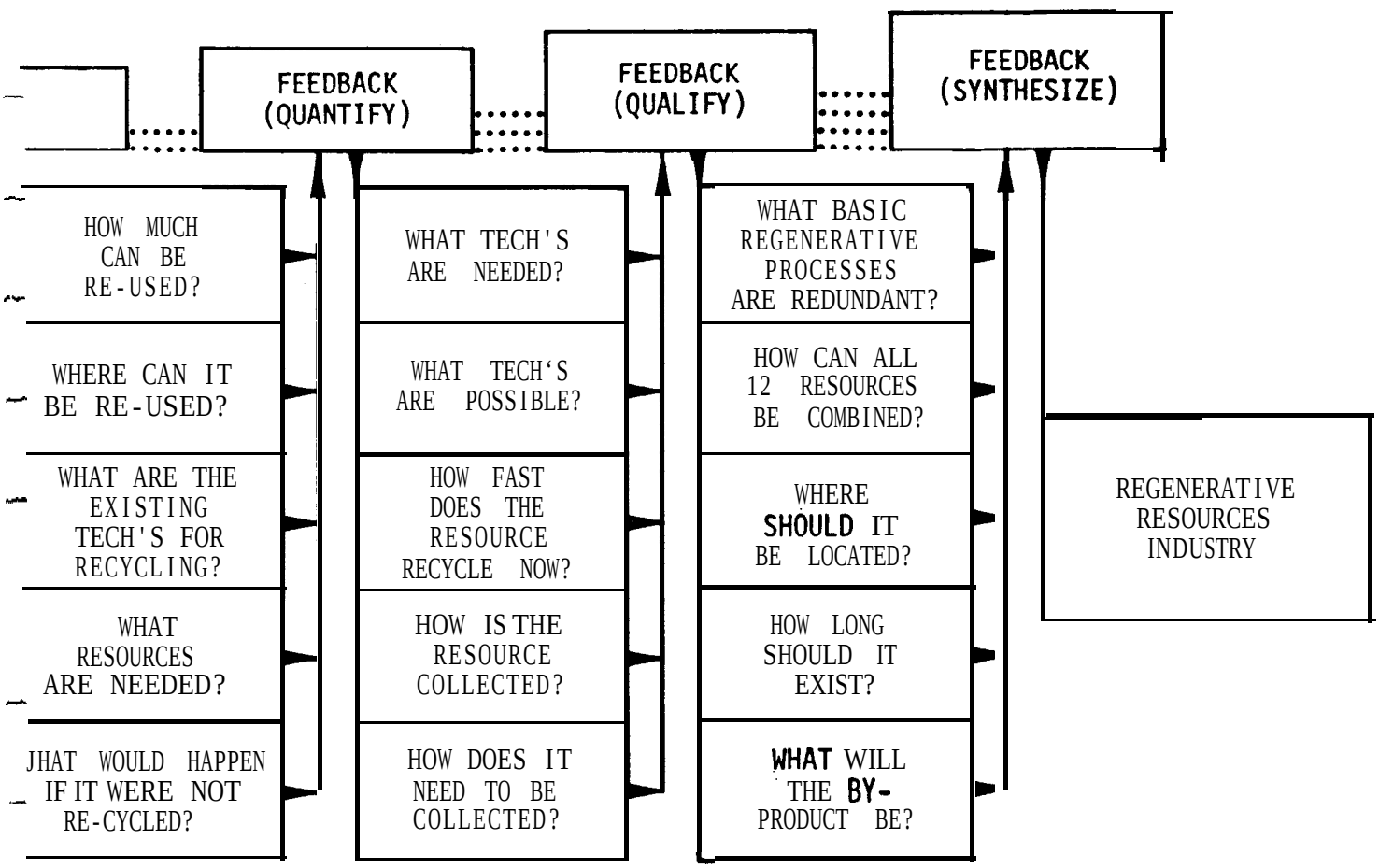
CHART V: EXAMPLE OF INFORMATION FLOW



of Chart III. Similarly 3 for Farm Waste means from Chart III: Where should a regenerative resources industry be located? Thus, each group must ascend through questions 1 through 5 being aware enroute of the information gathered by all other groups. The 5 questions of Stage II were to be answered by each "unit"; they are integrative questions which lead the students to synthesize all the data of preceding questions This would be then followed by each of these groups presenting their results to one another and then integrating this information to form the basis of their explorations into the chosen topic of the workshop-in this particular case a regenerative resource industry

Chart V illustrates the flow of information through the organization while emphasizing the relations of each question to the whole scheme and in particular the importance of feedback to the comprehensive nature of all information gathering.

All the charts together illustrate the process and organization-from general overview of the actual project to the specific structure of the group-used by the University of Southern California workshop. The content of this organization and process was chosen to facilitate a more comprehensive and scientifically exact study being carried out by the World Resources Inventory



C.3 Published Data Sources on World Resources

1 UN ***Statistical Yearbook*** (annual)
Publishing Sales Section, United Nations, N.Y., N.Y. 10017. $13.50

2 US Bureau of Mines, ***Minerals Yearbook,***
Vols. I and II, (annual) U.S. Government
Printing Office, Washington, D.C. (latest edition: 1968). $6.25

3. ***F.A.O.*** *(U.N.)* ***Production Yearbook*** (annual)
Columbia University Press, International Documents Service,
136 S. Broadway, Irvington on Hudson, N.Y. 10533 $9.00

4. ***U.N.E.S.C.O., Statistical Yearbook,*** (annual)
U.N.E.S.C.O. Publications Center, 317 East 34th St.,
N.Y., N.Y. 10016 $14.00

5 ***U.N. Demographic Yearbook,*** (annual) (1968)
Publishing Sales Section, United Nations, N.Y., N.Y. 10017. $12.50

6 ***U.S. Department of Agriculture: Agricultural Economic***
Economic Research Service Studies
U.S. Government Printing Office, Division of Public Documents,
Washington, D C 20402

7. ***A Directory of Information Resources in***
the United States
U.S. Government Printing Office, Division of
Public Documents, Washington, D.C. 20402

C.4 Data Centers with Additional World Resources Data Availability

1. National Referral Center for Science and Technology
Library of Congress, Washington, D C 20540

Services.

The Center's aim is to establish the most direct contact possible between people looking for information and those who can provide it. The Center makes a sharp distinction between referral and reference activities. Since it is concerned principally with people and places, it does not cite books, journals, and other bibliographic sources

The *Center:*

Collects data on the nation's information resources
Refers inquirers to pertinent sources of information
Publishes directories of information resources
Analyzes the nation's information network
Covers all fields of science and technology, i e physical, social, biological, and engineering sciences

2. National Center for Educational Statistics

Services:

The design and execution of all statistical information programs in the Office of Education. NCES coordinates collection of statistics on all programs, and assists other units in OE and in the field in developing statistical programs and surveys

Located at:

Department of Health, Education, and Welfare
Office of Education
Washington, D.C. 20202

3. Knowledge Availability Systems Center
University of Pittsburgh
Pittsburgh, Pa. 15213

Services:

It is an interdisciplinary organization made up of engineers, computer scientists, chemists, information scientists, administrators, researchers; innovators who operate a technical information system. Information from some of the world's largest technical files is made available through the KASC system to the academic and industrial community. KASC is a NASA regional dissemination center, one of six in a national network.

4. BLS Information System
U.S. Department of Labor
Bureau of Labor Statistics
Washington, D C 202 12

Services:

A computer-based system for storage, retrieval, and analysis of quantitative data. Although originally developed for use with the Bureau's extensive volume of data on manpower, the system is applicable to other types of data, and its features may be of interest to anyone concerned with numerical data storage and retrieval

5. Science Information Exchange
Smithsonian Institution
09 Madison National Bank Bldg
730 M Street, N.W.
Washington, D.C. 20036

Services:

To facilitate effective planning and management of scientific research activities supported by U.S. agencies and institutions by promoting the exchange among participating agencies of information on all types of current basic and applied research. This includes the accumulation, organization, analysis, and maintenance of a comprehensive inventory of current research project summaries, and the making of this information available to the scientific community in a form such that maximum use can be made of this data by the scientist and research administrator.

6. Educational Resources Information Center
Bureau of Research
U.S. Office of Education
Room 3013, FOB No. 6
Independence Ave , N W
Washington, D.C. 20202

Services:

To keep teachers, administrators, educators, and social scientists abreast of the significant findings of current educational research and development activities. ERIC is a nationwide information network consisting of a central staff at the Office of Education and 19 clearinghouses, each of which focuses on a specific field of education. The clearinghouses acquire, review, abstract, and index the documents announced in research in education and disseminate them through the ERIC document reproduction service

7 Environmental Control Administration
2720 Twinbrook Parkway
Rockville, Maryland 20852

Services:

The administration conducts, coordinates, and supports a national program for the prevention and control of environmental hazards and health problems. This is accomplished through the operating bureaus of community environmental management, solid waste management, rediological health occupational safety, and health and water hygiene. In carrying out its mission, the administration collects, analyzes, evaluates, and repackages data in the various areas enumerated above. One of the major functions is that of establishing criteria and standards designed to protect the health of the nation in these areas. The administration conducts its own research, in addition to supporting studies through the grant mechanism. The nature of the work in the administration requires a broad range of specialists, e.g., biochemists, epidemiologists, oceanographers, toxicologists, pharmacists, biologists, hydrologists, and others in various engineering disciplines

8 Medical Literature Analysis and Retrieval System
Bibliographic Services Division
National Library of Medicine
600 Rockville Pike
Bethesda, Maryland 20014

Services:

The MEDLARS system stores, analyzes, and retrieves bibliographic citations to biomedical literature. The computer-based system is used to prepare Index Medicus and other indexes and bibliographies for publication, and to retrieve on demand citations to scientific publications.

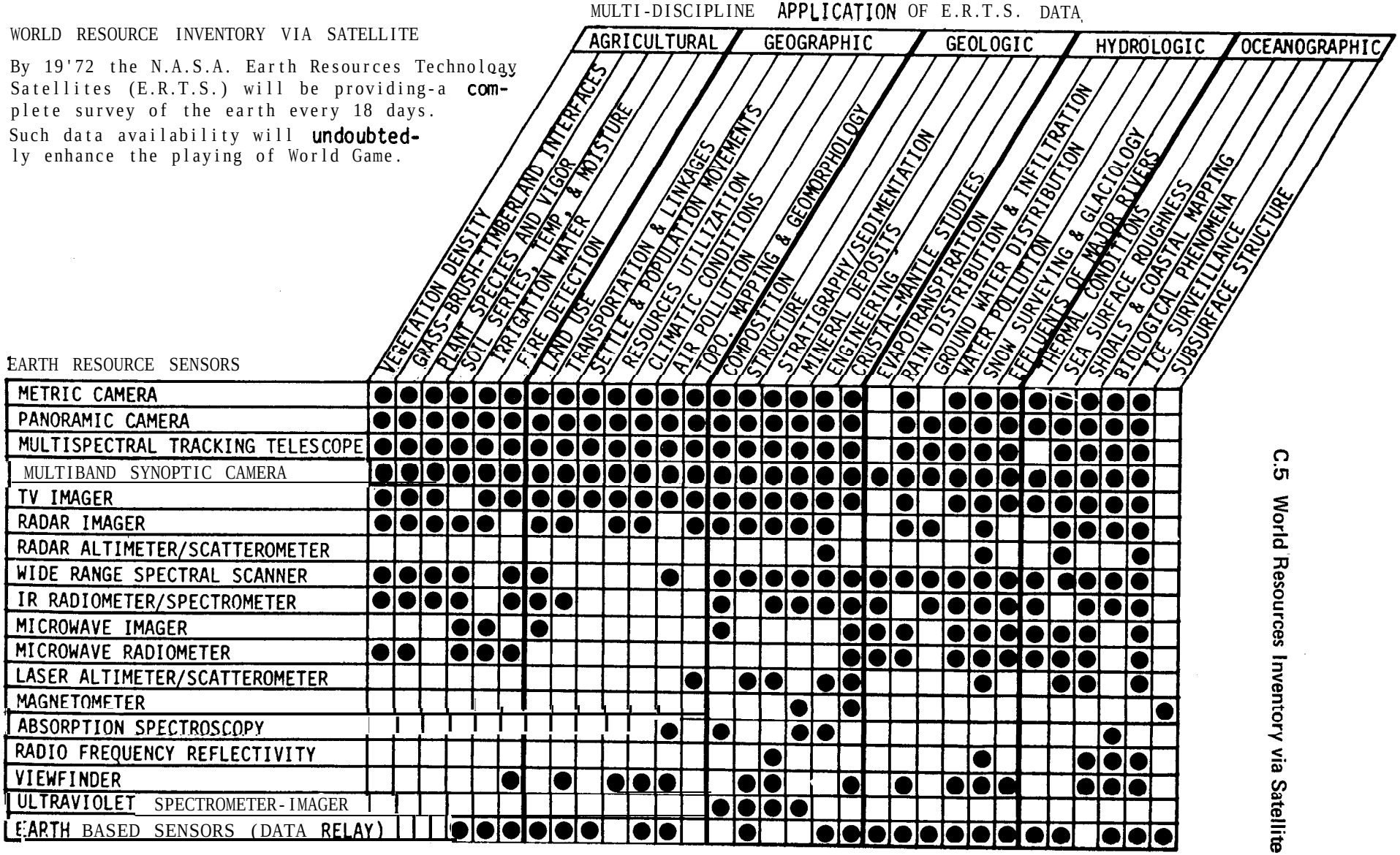
9. National Center for Health Statistics, Public Health Service
330 C Street, S.W.
Washington, D C 20201

Services:

The Center serves as the national source for general purpose vital and health statistics, and develops programs to obtain health, demographic, and related statistics which serve present and future needs of all segments of health and related professions and organizations. The Center collects, compiles, analyzes, evaluates, and publishes vital and health data in such areas as natality, mortality, marriage and divorce, morbidity, disability, use of medical care, hospital discharges, health and health care of institutional populations, health manpower, health facilities, etc. The Center also has an active international statistical program. The professional staff includes survey statisticians, analytical statisticians, mathematical statisticians, physicians, dentists, demographers, sociologists, etc
Information, retrieval, health, statistics, demographics, government

WORLD RESOURCE INVENTORY VIA SATELLITE

By 19'72 the N.A.S.A. Earth Resources Technology Satellites (E.R.T.S.) will be providing-a complete survey of the earth every 18 days. Such data availability will undoubtedly enhance the playing of World Game.



C.5 World Resources Inventory via Satellite

D. READINGS

D.l Universal Requirement for a Dwelling Advantage by R. Buckminster Fuller

The 'Universal Requirements' checklist, dealt with in this essay, was drawn up by Fuller in 1927 as a scientific control for the development of the Dymaxion house. It was published first in *Shelter* magazine in 1991, and appeared In revised form in his book, 'Nine Chains to the Moon', in 1938. A further updating of the list formed part of a booklet, 'Designing a New Industry'. which related to the 'Wichita House' project (1945–46). This booklet amplifies the industrial logistics necessary to the implementing of the 'Universal Requirements', and details broad prototyping procedures.

The present version was revised in 1949 with minor additions 1999. Exhaustively detailed, in accord with the author's maxim, that, 'in the adequate statement of a problem lies its solution', it is a comprehensive attempt to list every requirement, and meet most contingencies, likely to occur to man In relation to shelter. In the light of Fuller's proven design competence in many fields, this is no Utopian manifesto; in each major section the author has himself carried out the research and conducted the pragmatic reductions to practice. Historically-minded readers may compare it with similar documents originating inside architecture. i.e. the CIAM Congress reports. Its main difference for our present purpose is that of immediate practicality. Fuller's forecasts, check-limited as they are by scientific charting of resource availability and industrial trends, have shown an awkward habit of being fulfilled. His 'comprehensive anticipatory design' is no promotional catchphrase but a required survival technique.

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 acientiflc advantage
toward advancement of world living
standards—
to ba 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 *survive/-despite,-*
despite preponderant submission
to ignorance,—
ignorance of future probabilities
end 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 • clentifk 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 .a 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-inifiafive, *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*

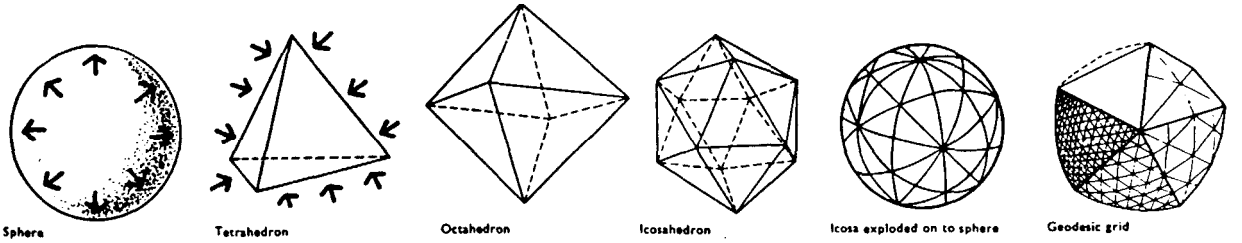
B. Implementation and insulation of synergetic feedback of higher order accruing to spontaneous group realizations of newly evolving potential

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 It 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.



Sphere Tetrahedron Octahedron Icosahedron Icosa exploded on to sphere Geodesic grid

Expended 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 es yet available **technology—*However*—(new era** essence). Since accomplishment of **higher physio-chemical** *stress* **abilities** in, for instance, supersonic flight end **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**	6 bombardment
2 tornado	9 forest fir.
3 hurricane	10 tidal **wave**
4 typhoon	11 plague
5 e valench.	12 radio activity
6 landslide	13 lethal gases
7 volcanic eruption	14 BW (bacteriological warfare)

b. **Dangerous**
Probably annual, of borderline 'disaster' magnitudes
1 **gale**
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)

. vandals	**e fanaticism**
b **marauders**	t **commercialism**
c meddlers	**g** materialism
d politfcr	

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

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

2. ***Rejection,*** or ***deflection*** for delayed or immediate us. es
a. energy, admitted into direct work es. 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 us.
2 **wired—for** direct **use**
3 valved-for direct or delayed use
4 stored-in **cistern,** tank or battery for delayed us.
5 stored-in thermal bank or compost bins, etc.

IS 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** end 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 rang. 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 ● xtertor 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. **Fuelling 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 conning 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 end 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 es yet incomplete. undigested, **ungestated** as complete teleologic regeneration.

IIIC Home **Magnitude means of displaying,** ● xpoeinp, **experimenting and measuring of 'target'** or 'trend to **target'** or 'trend **following'** ● uumptlon **of-realization-initiative-and-articulation,—** i.e. 'vital navigation' or 'teleology'. i.e. personal and social and cosmic feedback **contro;.** 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) Microcosmic	nuclear particles atoms molecules cells, genes	atomic charts periodic, etc. spectrographiccharts molecular models biological slides
2. ***Geo-visible*** (de-finite) Geographical *(visible, near)* Earth	crystallographic biologic sub-surface surface envelope	globes, maps, geological stratification **maps** world and local physiological data spectrum charts
3. ***Astro-visible*** (de-finite) Macrocosmic (visible, **remote**)	comets asteroids planets **stars** nebula	star globes **star** charts
4. ***Supravisible*** (finite) Comprehensive Omni permeative	abstracted **'generalised'** principles gravity radiation number sets group behaviour phenomena probability transformations independent of dimensions infinity	**energetic** geometry **devices** (vectorial. formative, transformative, number)

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.

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,-

IV **Realization**

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 end 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. oersonai 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 **assumed** 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 • □• 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 a '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** end 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 end 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** replace 'mockup' parts

l. Physical tests of parts and sub-assemblies with 'obvious' corrections end 'necessary' replacements (not 'improvements' or **'desirables'** which must be deferred until second prototype is undertaken after **all-comprehensive** physical tests have bean 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-ffrture tune-up

e' Parts and assembly testing

f' Field operation scheduling

❑ ' 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

3. 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 end 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 par total design

17. Elimination of special operator technique forming

13. Elimination of novel special soft tool designing

lg. 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

23. 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

down go the number of babies. I found, after the Civil War, and after World War I, and World War II, momentarily for about five years, they had more babies. And man didn't really consciously do that-the young people did not consciously do this. There was a bulge. When you knocked out a lot of people, it broke the smooth curve-she bulged. It was stuck for about five years, and it was during that five years after World War II that all the great talk began about the population explosion. When the people were not dying on one hand, and making more babies to make up for their kids that got killed in the war. So evolution seems to have some very powerful curves which you (the World Resources Inventory staff) are trying to find-not trying to invent. Now I then began to look at the industrialization, and I found that industrialization is the key factor to cutting down on the birth rate and much more than any other thing. Incidentally, as you are talking industrialization, all kinds of things go along with it-it's an information system. It isn't just one piece of machinery. It's a knowledge system-an information system. It's a total environment, and by environment, I mean that to each human being environment is everything that isn't me. This means all the behaviors, just everything that isn't me. All the behaviors that are not me, all the events that are not me. It's a very complex affair. Then when industrialization comes in, the events are very different from the way they were before, and within them contraceptives may become a thing that happens really due to the industrial communication, to the kind of rubber you can make or whatever it is. All these things are interrelated, so I can't identify this at all with any attempt to cut down the number of babies. I don't think there is any conscious attempt any more than there is the inadvertent killing and making more babies to make up for the killing in the war.

I found then that if industrialization was achieved-birth rate went down. I found that the earliest known main industrialization where we can get a total, tight package would be in England. And what it took England 200 years to do, the United-States which started as a land of colonists, very fresh, duplicated in 100 years simply because they started off with the advantages that accrued to the other one. They didn't have to make the same mistakes all over. They had lots of new tools. So they had really a fresh start, lots of experience, no invested capital in machinery that you had to keep on using because you say it works pretty well, therefore, I can't afford to get the new one. Then in this same period of industrialization from pure agricultural to industrial which took England 200 years, the United States 100, Russia did in 50. Now we're halving the time. I'm quite confident that China is going to do it in 25. This means by 1975, China is going to be affluent. She starts with the jet, she never has a primitive tool problem. She starts with the computer there, she starts with the transistor already there, she starts with fission already there, and she starts with thousands of years of really philosophic conclusions from much experience. Very, very wise people. And with the industrial opening up and our really ignoring her, she really has more iron there than we and didn't know it was there. Because she had a feudal law and these dull Mandarins didn't realize what was underground. They will go up just like a rocket curve into orbit. I then expect this same halving to occur and India will do it in about 10-12. They are going to elevate so rapidly that they are going to surprise the world. My own figures then are that we will somewhere around 1985—as short a time away as that-we will begin to see population stabilization coming in. Japan is already stabilized-the first in all history to stabilize. They first did it through legalizing abortion, and then they went around with the doctors talking to the women, etc., and town by town very carefully got up a beautiful exposition of what really is involved, and women began to do it themselves, and then they didn't have to do the abortions It stabilized

With industrialization newer in places like China, will the United States keep improving its industrialization? I mean will we be able to keep up?

In industrialization each one gets his investments and then he tries to keep exploiting that machinery over a long time. That's one reason why the losing countries in the wars like Germany and Japan came out so well because all their obsolete equipment got knocked down and they put in everything new. And they kind of entered what you call a new generation of capability.

So the United States is no longer just a nation but it is a world man, and we have a world man coming around the world. He came once from. the West to the East as the Indians both coming over the Bering straits and crossed by rafts in the lower Pacific, and then he gets more or less centralized in Mexico. Then we have coming around the world the other way sailing into the wind rather than going with the currents as

Myth of the Population Explosion

". . . . I found, then, children per family (household) going down . . . . life-expectancy beginning to improve as in came the waterworks and in came little technology. The life expectancy begins to improve and down goes the number of children per family (household). So these are the two curves that cross each other

In the last three years, the absolute number of babies produced has been less each year. For a long time, it has been less per thousand (people)

The really "big bulge" is because all the people did not die, particularly right after birth. . . . So that the bulge is working up then to a time when there will be a great, great many people who are very old. But the amount coming in at the bottom is lessening very rapidly. So one reason why there was a seeming explosion was that a lot of people did not die that used to die.

Source : R. Buckminster Fuller. November 1969 Address to the World Resource Inventory Staff.

0.5 Prospects for Humanity by R. Buckminster Fuller

(reprinted from Saturday Review)

THE PROSPECT FOR HUMANITY

in ***SR under the title 'Notes on the Future." It is adapted by him from the last chapter of his forthcoming book, "Design Science," which embodies his lectures and conversations as Harvard's 1961-62 Charles Eliot Norton Professor of Poetry. Mr. Fuller, inventor of the geodesic dome and the Dymaxion three-wheeled automobile, was a personal friend of the founding editors of SRL-Henry Seidel Canby, Christopher Morley, Amy Loveman, and William Rose Benét. He was one of the original contributors to the magazine.***

August 29, 1964 . September 19, 1964 . October 3, 1964

By R. BUCKMINSTER FULLER

THE SCRIPTURES were right: the meek have inherited the earth. But they do not know it. Though irrevocable, the will has not as yet been finally probated in the court of public comprehension. The will says, "The prospects for humanity are metabolically excellent, intensely interesting, culturally fabulous, and of ever greater intellectual challenge."

But the will, it must be noted, makes all of humanity its beneficiary. It does not favor or promise unique prosperity to any exclusive blocs of humanity. For the professional secretariat of the Daughters of the Punic Wars; for political spoils systems; for national sovereignties; for annual trade balancing with gold and its concomitant exchange depressions and resultant human wage- and purchasing-power inequities; for any negative social, economic, or psychological differentiations of human origins or color; for might-makes-right; for purchasable accoutrements, architecture, equipment, and gadgets of distinction; and for the plethora of behavioral obnoxica imposed or induced by the supposed inexorability of the Malthus-Darwin theorem of survival only for the slickest fittest, ***it is curtains.***

The will of history reads "for everybody or for nobody," and since we balk at "for nobody" it has to be "for everybody." And that's the way it is going, lickety-split and the world around.

I did not say that everybody will be happy and every event a joy. Far from it. If your chief happiness has been that of possessing at the expense of others you will be sunk. This revolution is not being effected by pulling the top down. It is being effected by pulling the bottom up. It ***is*** being effected by doing more with ever less in such a manner as to take care of all without taking away the functional capabilities and fundamental advantages of any. The surprise -constantly doing vastly more with ever fewer physical resources per function—is our legacy from the millennia-long armaments struggle to do more with less in a world where a pea-size transistor now does more than an army of yesterday and a fistful of atomic fuel takes a large ship around the earth.

It is an easy matter to foresee the trend of physically dramatic events during the next twenty-one-year generation. We will go to the moon and start communicating with humans in other parts of the universe and open up entirely unexpected new realizations of the significance of man in the universe. We will probably learn that Darwin was wrong and that man came to earth from another planet and monkeys are hybrids degenerated by overlong inbreeding of isolated humans. We will penetrate the ocean depths, enlarging our world threefold. We will float large colonies of humans around the world in tensegrity geodesic cloud-island spheres taxi-serviced by helicopters. And, because every action has its reaction, as we achieve new magnitudes, millionfolding our forward undertakings in time, so will we millionfold our knowledge backward in time. The archeological, anthropological, and ecological history will be as stimulating to mankind as will be the extension of knowledge through realized technology.

Within the next twenty years our theme song may well be "Anything Buck Hogers can do, WC will do better," whether it be strapping on our jet-stilts knapsack and jumping Peter Pan-wise to our office window ledge (properly dressed, of course) and winging outward and homeward by automatically steered, collision-avoiding beam controls, or conversing over satellite-relayed, private-beam television with anyone, anywhere around the world or in space.

If you don't credit this forecasting, witness the contracting time spans between man's successive historical advances in circumnavigation of the earth. His first known circumnavigation is in a wooden sailing ship, circa-I-500. His second advance is by steel steamship in the mid-nineteenth century. His third breakthrough is by aluminum airplane in the late 1930s. His fourth breakthrough is in a super alloy rocket capsule in 1957. The times required for these circumnavigations-approximately three years by sailing ship, three months by steel steamship, three days by aluminum airplane, and an hour by rocket capsule-clearly show that by 1985 almost anything you can dream of can and will have happened and that man will be living in an entirely new, responsibly conscious relationship to the universe.

I could go on to put meat and muscle on the bones of such forecasting, but since the comics and science fiction have made the coming actualities physically anticlimactic I find it much more rewarding to consider how we may be getting from here to there in the familiar terms of day-to-day economic, political, and cultural reorientations and to speculate on how they may come about. To do this I must take inventory of emerging trends that seem significant.

Trend No. 1. Medical science, through development of interchangeable human parts, both organic and inorganic, may be about to develop the continuous or deathless man. It is now concerned with rendering the integral, mostly internal, corporeal organisms of man ever more adequate to the evolving environment. The architectural scientist has become concerned with rendering the extracorporeal, external organisms of man-the world network of industrialization-ever more successfully adequate to the evolving environment. This is being accomplished by a comprehensively redesigned use of resources in such a manner that the continually decreasing per-capita resources of the earth, which now serve only 44 per cent of humanity with industrial advantage, will be made to serve 100 per cent of humanity at a higher standard of living than has ever been known anywhere by anybody. This is to be done by broad introduction of higher-performance techniques; for example, by substituting wireless for wire in communicating systems, or by scrapping all the two-ton prestige automobiles and producing out of the recovered metals twice as many one-ton cars of higher operating econ-

omy and closer parking capability. Most importantly, in response to the automation-engendered unemployment problem, this design-science revolution may be acceleratingly accomplished by paying everyone to go back to high school, college, university, and research and development laboratories, leaving physical production to ever-increasing automation.

Trend No. 2. The university student, having attained his first freedom of initiative, his optimum level of metabolic efficiency, bodily coordination, and general outlook, finds that his idealism is concurrently exposed to an awareness of powerful intellectual and technical disciplines. At the same time he is the recipient of frequent science-technology breakthrough news, such as under-the-polar-ice passages of atomic submarines and new achievements in rocketry and electronics. He also receives an overabundance of news concerning world want and political stresses that break into ever more frequent crises.

Logically, the student becomes exasperated and says, "Why can't we make the world work? All the negative nonsense is the consequence of outworn, ignorant biases of the old-timers. Let's join forces and set things to rights." Parading in multitudes, students demand that their political leaders take steps to bring about peace and plenty. The fallacy of this lies in their mistaken, age-old assumption that the problem is one of political reform. The fact is that the politicians are faced with a vacuum and you can't reform a vacuum. The vacuum is the apparent world condition of not enough to go around-not enough for even a majority of mankind to survive more than half of its potential life span. It is a "you or me to the death" situation that leads from impasse to ultimate showdown by arms. Thus more and more students around the world are learning of the new and surprising alternative to politics-the design science revolution, which alone can solve the problem.

The students are thrilled to realize that it is themselves they must turn to in order to make the world work, through practical use of their university science and technology resources and their laboratory-supported design science capabilities. The students know that they need no more license to invent the tools that will make the world work than the Wright brothers needed a license to invent one of the most needed more-with-less tools-the airplane. The student's task is clear-cut. It is to increase the over-all efficiency of the world's mechanical devices from their present 4 per cent to an over-all efficiency of 12 per cent. This is easy, since over-all efficiences up to 80 per cent are now feasible. The students know that if thev invent the.right tools, the tools will be used, given the right emergency. And they know that their design science revolution is bound to work because the emergencies to foster its realization are already here. Their revolution is a bloodless revolution that brings peace in the only way it may ever become effective—by elimination of the physical wants that always underlie war.

Trend No. 3. There are now in the world several thousand powerful high-capacity, information-storage, electronic computers. The number of them approximately doubles yearly. That means a quarter-million of them by 1970, 250 million by 1980, and 8 billion by 1985—more than two per each world human. The computers, both large and small, are machines for mathematical pattern cognition and recognition storage, retrieval, and coordination; 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 and generalization. Differentiation identifies, evaluates, selects, and separates the uniquely developing patterns. Integration ratiocinates comprehensively the coordination rates and magnitudes of complex interactions, developments, or transformations.

To appreciate our state-of-computer-affairs, we first must be aware that throughout the last fifteen years many philosophers have been disturbed by the claims of some cybemeticians that computers are soon to displace the human intellect. If, instead, they had confined their prediction to the effectiveness of the human brain in respect to the computer, some of their claims might in time prove valid. For a long time philosophers assumed that the computer could not ask original questions. They said that the computer can only re-ask a question man has taught it 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. Otherwise the question could not be assessed as "original." The surprise demonstration came about approximately as follows: You can teach a computer to play games, for instance to play checkers. You can also teach a computer to play backgammon. You also can build a computer with enough parts to permit it to play both backgammon and checkers at the same time.

Now, both backgammon and checkers are played at different rates. Furthermore, the checker. moves are simple and direct. Backgammon is complex. Therefore the same computer, playing both games concurrently, completes the checker moves far more rapidly than the backgammon moves. The backgammon rate is not an even wave-length 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 because the latter is too short to accommodate both moves, the machine has to decide which it will play first. It has to ask itself and then decide, "Which is more important, checkers or backgammon?" If the machine has stored enough information on variable factors, including previous decisions, it may soliloquize: "Poor people play checkers and rich people play backgammon. I'd better cast my vote for the priority of backgammon because my memory storage also tells me that all the poor people are becoming rich and will emulate their conditioned-reflex image of being rich." From this moment, rightly or wrongly, the machine's storage contains this prospero-proletarian predilection.

"Which is more important, checkers or backgammon?" is an original question that had never been asked by man of himself or of the machine. We find that the asking of original questions is a consequence of interferences, whether in the computer or the human brain.

As far as the computer's differentiating function as judged by experts is concerned, it can be said that the computer is about to make man obsolete as a specialist because the machine can differentiate and seek out much more accurately, swiftly, and persistently than man can. The computer can stay up all night, night after night, selecting the greens from the blues under humanly intolerable conditions of heat, cold, smells, etc., yet never tire. That the machine is to replace man as a specialist, either in craft, muscle, or brain work, is an epochal event. The computer as superspecialist produces, multiplies, and administers "automation." Because the computer is superior to man as specialist, comprehensive world automation has always been developing inexorably and is now inexorably imminent.

The scientist-philosophers of computer integration say that because the asking of original questions is a consequence of interferences, and because interferences are products of time sequences, it follows that original questions are both functions and products of time. There must be a great number of moves and a vast number of computer components before enough time can elapse to develop new types of secondary or tertiary interferences that in turn may from time to time provoke original questions. The human brain as a com-

puter 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 an extracorporeal computer with that many transistors, storage cells, and other components. The experts also point out that, dealing in integrative complexity as a function of time, the human brain has always been dealing in complexity and has also been integrating comprehensive, historical continuity of human-experience-reflexed, design evolution relayed by human genes. Therefore, the experts say, we would have to have man-made computers running for 1,000,000 years or so in order for them to develop an equivalently integrated complexity. 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.

We can have an integrator calculating, designing, and automatically manufacturing and putting together a geodesic dome in a giant jig, after which an automated "sky tug" helicopter will carry the dome away to install it and prepare it for human occupancy, thus providing a telephone-system type of inventing, developing, installing, maintaining, relocating, and continually self-improving service industry, able to provide telephone-ordered "instant housing." Such a computer-controlled housing and livingry service industry is even now feasible at 1 per cent of the weight, time, and energy involvement per unit of volume and living equipment found in conventional high-standard suburbia or Park Avenue skyscraper technology.

In relation to the computer-tool hookups of automation, it is to be noted that all tools are externalizations of originally integral functions of human organisms. But estemalized functions such as that of the cupped hand to hold water are capable, when translated into ceramic cups, of holding hotter or more acid liquids than the human hand could. This is to say that the limits of capability of the externalized functioning are extended but are not unique in principle. Whereas the craft tools developed by man operated independently, the industrial tools develop interdependently. The machine lathe requires the blast furnace and vice versa. Individual craft tools are the externalized counterpart of the individual's separate functions, while industrial tools are the organic externalization of man's integral metabolic regeneration. The whole process of human life from conception through gestation to birth is entirely automated. After birth, despite parental ignorance of the process, the child grows from seven to seventy pounds and then as a youth often goes to one hundred and seventy pounds. Biological growth is entirely automated. For at least 2,000,000 years, men have been reproducing and multiplying on a little automated space ship called earth, in an automated universe in which the entire process is so successfully predesigned that men did not even know that they were automated, regenerative passengers on a space ship and were so naive as to think they had invented their own success as they lived egocentrically on a seemingly static earth.

Both the universal and the local ecological automation is so successfully designed as to allow man the luxury of thinking and acting "consciously" in meager and often perverse degree and even of meddling with the evolutionary mechanism without putting the mechanism's many degrees of freedom of action into jeopardy.

With our human-computer brains, we will not now consciously relate the mechanical computers' significances with other important information.

Trend No. 4. At the American Association for the Advancement of Science's annual 1961-62 meeting, among the thousands of papers presented, there were two of special interest to us. One dealt with all the biological species that have become extinct, the other with human tribes that have become extinct. These independent papers searched for common characteristics that might account for the extinction. 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—overspecialization. Evolution involves constant change. When living species become so specialized that they cannot adapt to an unexpectedly large jump in evolutionary events they are "out."

Now, men in our industrial and educational system have become more and more specialized. Everyone, wanting economic security, has seemed to think that as specialist he could command the toll gate of an expressway to unique and essential information. He thought: "A great many people will have to go through my specialization toll gate and I'll have a special, education-guaranteed economic security."

Trend No. 5. When we combine a) the trend toward increasing specialization with b) our knowledge that overspecialization leads to extinction, we realize that our unwitting human trend toward extinction was about to be realized as we developed the ability, through hyperspecialization in mathematical physics, to take the atom apart and thereafter to develop fission and fusion. The scientists, as specialization's victims, knew nothing of how to control the military, commercial, or political evolution of their discoveries. But just as we are about to blow ourselves up, we discover that nature has invented man with a built-in safety factor, an automated self-destruction-arrester. The safety factor is the built-in propensity not only to invent and develop tools of destruction but also inadvertently to invent constructive tools that render the destructive inventions obsolete. In this case the computer was immediately adopted by the military specialist to control the performance of rocket weapons. Here comes the surprise: The computer is now making man to some degree obsolete as a specialist. Therefore, since it was overspecialization that was leading us toward self-extinction, man has inadvertently invented his own anti-self-extinction device. First diverting man from becoming extinct through overspecialization, the computer and its automation will go on to produce enough metabolic capability to provide lavishly for all humanity. It will thus eliminate the you-or-I-must-die corollary, or the Malthus-Darwin theorem of survival only-of-the-fittest.

This means that the computers will soon eliminate war as an evolutionary function by providing enough wealth to supply all mankind. To give man adequate "purchasing power" to keep industrialization in accelerated regeneration, we will pay all of humanity to go back to the schools, to the universities, to the advanced scholar laboratories, where they will generate progressively higher standards of living from fewer resources.

Trend No. 6. Displaced as a specialist, man is now being forced to become preoccupied exclusively with integrative patterning considerations. This means an epochal reorientation. All the educational systems from now on must forsake specialization and cultivate powerful generalization. Everybody will be taught to be comprehensivists. Fortunately, that will come naturally because man is born to be comprehensive. It is his most unique biological characteristic. As he cross-breeds he becomes more comprehensively adaptive. Only inbreeding brings specialized capability. The greater the degree of freedom and acceleration, the higher the probability of cross-fertilization.

Architects constitute the last species of professiona! comprehensivists, for they try to put things together while the vast majority, the specialists, have been concentrating on taking things apart. The trend of world students will henceforth be toward becoming architects—that is, comprehensive and cooperative design-science artists.

-A brand-new type of university will probably be required. The conditioned-reflex disease of "categoryitis" with which world society and its bureaucracy are chronically infected is going to make the university's renaissance difficult. Uni-

versities will be vulnerable to displacement by superior educational enterprises; e.g., the USA and other major world governments will probably adjust their disarming economies by giving multi-billion-dollar contracts to the former armaments prime contractors, such as Boeing, Douglas, Lockheed, and General Dynamics to enable these organizations and their scientific staffs to apply their powerful problem-solving capability to the new educational and communications problems of a one-world and space-age society. The big armaments contractors have become in effect the "super graduate schools." They have sequestered all the classified "advance mformation" and are therefore in a position to handle education, which is destined to be history's largest and most durable industry. Today's universities must compete or die.

Trend No. 7. In order to understand the hazards of these transitions, we must also understand another major trend. In the trends to disarmament, mankind has already disclosed its joy at the accomplishment of only a token reversal of the weaponry race. Man now hopes his politicians can go further toward disarmament, and the total world compulsion to disarm is felt with increasing force. As a consequence we will probably cut down, slowly, on armaments.

Russia, in her forty years of successive five- and three-year plans, gave priority to all of the heavy industries and then to the lighter industries essential to war. Sixteen million deaths by starvation was the price Russia paid for the priorities to get herself industrialized. She has deferred applying scientific industrialization to the direct raising of her standard of living. She now hopes to do so but is frustrated by the need to focus productivity on the continuing arms race with the U.S. Therefore Russia needs to attain disarmament, or she will not be able to continue to stall off the people's demand for the higher standards enjoyed by the Western world. But disarmament is stalled in the U.S. because the country cannot keep its economy going through the "irrigation system" now fed at the top through annual weaponry undertakings without seemingly subscribing to "socialism." In wartime emergencies, national management of economic activity is exempt from charges of socialism, but by custom and law such centralized authority is forbidden in peacetime. To avoid this embarrassment and to keep our economy healthy, wartime emergency powers are extended to meet the threat of the next war. This extension is called "cold war." The U.S. knows that the world needs and wants disarmament and that its socialism-avoiding subterfuge becomes increasingly evident to the rest of the world and thus less tenable. The government and powerful Washington lobbies of the armaments contractors, supported by the labor unions, are seeking ways in which to keep the economic irrigation system fed from the top while also attaining progressive disarmament.

What is necessary is to keep the multi-billion-dollar annual expenditure in new technology flowing to the prime contractors so that it can flow successively through the wages-and-dividends sluiceways and irrigate all industries and business in succession. For every time the paper dollars run through the system, the inventory of tooled-up capability to handle any production is improved and more of the previously untapped universal energy is piped into the system. Each time the dollars go through we get vastly richer. The old-timers call this "spending"; they need a course in semantics. They should understand what wealth really means in the industrial age. It is to the old pirate's gold as an ocean is to a glass of water. For an instance, the major nations of the earth invested $2.5 trillion in the development of the airplane during the fifty years following the Wright brothers' invention. Since there is only $40 billion in minted gold in all the world, which is only one-sixtieth the airplane's price tag, the wealth that developed the airplane was obviously not the bankers' gold of yesterday. The wealth employed by all the industrial nations of the earth today is the organized metabolic capability wealth. It consists of two basic ingredients: energy and intellection. The energy itself consists of two subingredients-energy as electrochemical matter and energy as electromagnetic radiation. The physicists' law of conservation of energy states that "energy may be neither created nor lost." The physicists are the authority for the irrefutable fact that wealth cannot be lost; therefore it cannot be spent, which means lost. If any old-timers want to argue, send them to' the physicists.

Where do the old-timers think all the quadrillions of today's industrial wealth came from? Certainly not from any gold bankers or feudal inheritances. The old static realities are obsolete.

SCIENCE, having been employed almost exclusively in weapons development, will find itself progressively unemployed. The weapons-producing companies and the weapons-support industries, having high capabilities but dwindling contracts, are going to struggle ruthlessly to find other profitable enterprises. They will move overnight into the living as opposed to killing arts. We have already noted their probable move into' education. Another probable move is into the arts and services usually and mistakenly spoken of as housing.

All you have to do is have a meeting with advanced industrial technology management to realize their inherent ineptitude in respect to the art and science governing the living service industry. Talk about a "house" and the industrialists immediately think about stamping out an aluminum or plastic replica of a Cotswold cottage, or they think of stamping out curtain walls or partitions: "You have to stamp out ***something.***" That is as far as their brains, conditioned by advertisements and traditions, permit them to go in the byways of categoryitis.

The scientists' "house"'-catalyzed concepts are even less imaginative and useful. The carriage, railway, and steamship industries of 1904, and their financial backers, directors, and top industrial managements, did not invent the airplane; nor did the university professors or the scientific societies. There is nothing in the present pattern of building that gives a clue to the ramifications of the upcoming world-habitat service industry.

Just as prototype inventions were the keys to the establishment of the aeronautical industry, so will prototype inventions be the key to this vast new industry. Many of the prototype inventions are already on hand. Others are developing in the U.S. and Russian man-in-space programs. What is most needed now is a clear definition of the functions of the world service industry that must be established to accommodate the forthcoming world citizen, requiring, at some times, living facilities in culture centers around the world and, at others, rest in remote places all the way from the tropics to the poles, which permit man. to be intimate with nature's every phase without being punished by the intimacy.

If the professional architects of the world are too slow to support their architectural students' initiative in undertaking scientific redesign, then both industry and science will begin to stumble into the living field and it will become a historical fiasco. That could easily happen within the next five years.

The world architectural profession has just about five years to start the architectural students and design-science students developing the capabilities to take, hold, and develop the world's design-science initiative. Architects are going to have to give themselves powerful mathematical abilities. Fortunately, our research discovery of the omni-rational arithmetic of the tetrahedronally coordinate comprehensive mathematical system, employed bv nature in all her transformative inter-accommodations, has now become confirmed by many scientific events. It provides a mathematical means adequate to the historical design-science task of redesigning the world's tools and services.

TREND NO. 9. We must now consider other powerfully favorable historical factors affecting establishment of the world-around living service. Between Russia and the United States, $6 billion has been appropriated to develop the little scientific house in which man will dwell in space or upon the moon. But we note that though architects profess to be master solvers of space problems, thus far they have not been called into any part of the U.S. space program. The professionals who have been called in are space medicine specialists, physicists, mathematicians, geologists, psychologists, chemists, engineers, biologists; but there are no architects.

I am confident, from my direct experiments, that architects can be trained quickly enough and in such a way as to be much more effective in the space program than are those scientists and businessmen who are now handling the program. The architectural scientists will be especially effective in defining the ecological problem and its solution, thus forestalling the fiasco implicit in the scientists', technologists', and industrialists' esthetically-weighted market-analysis misconceptions.

I have familiarity with the space program in the United States and have found that the big contracts given out so far have gone only to large corporations that have dressed themselves up with large staffs of scientists in order to substantiate their lobbying competitively with the universities. 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 among scientists, the medical man is objective. Chemical engineers but not chemists are objective. I have been amazed when I have been called in by the big corporations as a consultant to discover how little they understand of what seems to me to be proper statement of the scientific, structural, chemical, and mechanical aspects of the scientific sky-dwelling problem and its implications for man on earth. The problem is to reduce the dimensions of the ecological pattern from a vast tree-air-earth-worm-bird-bee-rain-wind relay system to a three-foot-diameter, closed-circuit system by which man is able to sustain high health for twelve months without sewer disposal or further input supply besides sun radiation.

In his 1926 introduction to *New World* Aldous Huxley hinted at a possible exception to his theme of an intellect-void, romance-vitiated, atheistic ahumanity. Mankind might, I gleaned, be inspired by a few leaders with a powerful and power-giving conviction of the existence in the universe of an intellect greater than that of man and of a universally operative integrity guarding and guiding all the inadequacies of man. Mankind, thus led, would work through many crises to attain physical success in the universe without cost to the manifold human freedoms, or any cost of individual joy in creative participation in the universal evolution. In his post-World War II second edition of *Brave* New ***World,*** Huxley revised the introduction, saying he tended to have a little more hope that his alternative theme might be realized. And in his succeeding ***Brave New World Revisited*** he disclosed an even greater hope that the happy alternative could occur.

It is probable that if the worlds architect-scientists do gain and maintain the design-science initiative, Huxley's desirable alternative may be realized. If, on the other hand, the architects or students in general fail to gain that initiative within the next five years, then the weapons industry's overwhelming invasion of the livingry field will occur and will swiftly evolve into Huxley's awful dream.

Why is it likely that if the weaponry industry and its scientist-slaves take over the livingry industry, life will move toward Huxley's unhappy dream? And why is it probable that if the world's architectural students take and hold the design-science initiative the world will trend toward 'Huxley's happy, but to him, improbable dream? To start off with, industrial corporations are too nearsighted while scientists are usually infinitely too farsighted. Industrial corporations tend toward a plastic-flowered heaven with sexy-scented, plastic, call-girl angels. The scientists tend toward test-tube babies and the deflation of the reproductive urge on the psychiatrist's couch. On the other hand, architectural students are realistically idealistic and have well-coordinated vision and a running start on what is needed. Industrial corporations are preoccupied with immediate profits and not with man's total success. They are interested in making money while architectural students are primarily interested in making man a total physical, cultural, and moral success.

Architectural-science students will in due course realize that they are designing an entire family of complementary instruments of livingry-similar in comprehensive functioning to the whole family of musical instruments. They will be willing to allow man the privilege of playing his own instruments and of composing. not only one-instrument music but of composing svmphonies for the whole family of livingry instruments. The new architect will be wise enough to confine his design science to augmenting the integral organic functioning of man so well that the external organics may be coordinated to operate as unself-consciously as do heaithy men's internal organisms. The design-science artist will leave man free to articulate the promptings of his soul in such a manner that each individual may enjoy his newly won and ever-increasing degrees of exploratory and creative freedoms without trespassing on one another and thus frustrating one another.

Optimism is usually thought of as constituting a mildly unwarranted hopefulness in respect to the future. But there is a reverse projection of optimism in the nostalgia-generated myths that recall only the rare and sublime moments of yesterday. Forgetting the negative, reverse optimism overemphasizes, thus deliberately shuts its eyes to reality, and is therefore unable to see the values immediately present.

I am convinced that we are swiftly emerging from the abysmal conformities of yesterday's illiterate, spit-punctuated profanity and monosyllabic verbalism, in which rags,, filth, diseased bodies, prevalent stenches, devastating superstition, and local bias reigned supreme.

Beginning with World War I, science, technology, and industry began the epochal and ever-accelerating shift from track to trackless, from wire to wireless, from visible to invisible, and from Newton's norm of changelessness to Einstein's norm of constant, disynchronous, evolutionary transformation. Man entered into the vast ranges of the electromagnetic spectrum. Within the electromagnetic spectrum, visible light is exquisitely minute. At the present moment in history 99.9 per cent of humanity's important physical evolution -scientific, technical, industrial, and biological-is taking place in that major portion of the universe of which man has no direct apprehension, but with which he does have exquisite instrumental hook-up.

THIS brings us to the historical era of invisible architecture. In invisible architecture the harmonics are apprehensible only by our intuitions and subconscious esthetics, and operative only in the twilight zone between conscious and subconscious awareness. This is the area of intuitive and esthetic formulation. Just as we may instruct ourselves to wake up in three hours and thirty-seven minutes and do so with reasonable accuracy, so

also does the subconscious measuring capability of man's eye judge, at considerable distances, tc a sixty-fourth of an inch accuracy, the diameter of the female leg.

One of the last trends of humanity that we take up is this ephemeral esthetic, its intuitive apprehending **and** conceiving capability, and its now looming major importance in the guidance of human affairs. I will discuss this trend from the viewpoint of my own experience with geodesic domes, which are so relatively ephemeral as to weigh an average of only 3 per cent of the weight of the best alternate clear-span solutions of structural engineering.

There are about 3,000 geodesic structures in fifty countries around the world today. They have all gone to their sites in the last ten years. Many, both near and far, have been delivered economically by air. In Ghana, Nigeria, and other tropical African countries people find that geodesic domes work nicely as large umbrellas. The air circulates in through the top and outward around the wide open bottoms. Geodesics in the Arctic and Antarctic, though light enough for air delivery, are strong enough to handle nature's fiercest winds, snow loads, and temperature extremes.

My kind-of work deals with how to find out the ecological problems involved and how to solve them, hoping thereby to bring about the occupant's satisfaction at the earliest possible moment. That is, I deal with the hows of mathematics and economics, the hows of industrial production and distribution, assembly, and service. I don't even consider how any structure is going to look until after it is finished. If, when finished, the structure seems beautiful, I know it is all right. To me, "beautiful" apparently emerges as an ejaculation, spontaneously released by my total set of subconscious control coordinates. "Beautiful" is probably ejaculated when my entire chromosomic neuron bank is momentarily in "happy" correspondence with my entire experience (memory) neurons bank. I speak of my brain as if it were a computer. It is.

THE great evolutionary engagement of man with the non-sensorially apprehensible yet physical universe, achieved only through instrumental hook-up as an extension of man's faculties, is utterly dependent upon the integrity of the instrumental functioning and the integrity of functioning of the adult intellect at a level of purity corresponding to that of the four-year-old child's, 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 Nature's great impulsive heart,
> Born comrade of bird, beast and tree
> And unselfconscious as the bee—
>
> And yet with lovely reason skilled
> Each day new paradise to build,
> Elate explorer of each sense,
> Without dismay, without pretense!
>
> 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 absorbs you, all
> Harmonious, unit, integral,
> Will shred into perplexing bits,—
> Oh, contradiction of the wits!
>
> And Life, that sets all things in rhyme,
> May make you poet, too, in time—
> But there were days, 0 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 subordination to total abstract concepts, may indeed be trending historically to permit the integral 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 being are entirely subordinated to subconsciously coordinated functions of the regenerative pattern of the whole individual life.

Humans dying in hospitals have often been weighed as they crossed the threshold between life and death. No weight is lost. Life is weightless, imponderable. When life has departed, the radiant heat, the brain-propagated energy waves, and the radiance of being are alike gone. The full physical inventory of the corpse remains-useless, reminiscent, but that is all. That is the way I read the data of man's significant exploring.

Margaret Mead said recently that God is rarely mentioned at scientific or social conferences. This is not so much a phenomenon of conferences as it is a characteristic of our times. Many think of science and the age of industrialization as atheistic. Scientists frequently have been asked by less educated men whether anything they observe through their microscopes or telescopes confirms religious dogma and the Scriptures-and, if not, must they not forsake Scripture and religion as having no fundamental significance whatsoever? Surprised by the question and unconvinced that they are atheists, the scientific specialists, also avoiding philosophical speculation as treacherous ground for reasoning, have been notably ineffective in refuting their atheistic status.

Cosmology and philosophy have been differentially dissipated in the era of increasing specialization. Total thinking is now almost completely legendary or speculative. For instance, it is a popular conception that the universe must have been begun in chaos, out of which it has happened from time to time that probability, reversing its law of increase of the random element, has surprisingly accumulated increasing order. It seems that this illogical increase of order accredited by the popular science cosmology has also from time to time been aided by scientists who "wrest order out of chaos." Finally, according to the legend, probability and science together have now provided us with an extraordinarily well-organized chemical, physical, and biological world within a universe of gratifying regularities.

The scientific record refutes this *a priori* chaos scheme. Every great scientist who has documented the events surrounding his major discovery has documented the fact that, in comparison to his crude hypothesizing, his discovery disclosed a sublime regularity of nature. The regularities of nature are governed by pure mathematical principles. Thus, since principles are inherently weightless and infinite-that is endless-the universe could never have been chaotic and thus has no beginning.

In 1930 Einstein wrote of the non-anthropomorphic conception of God and of the cosmic religious sense, asserting that the great scientists such as Kepler who had been called heretics were indeed the most profoundly religious men when appraised in a cosmic, non-anthropomorphic sense. Einstein said. "What an extraordinary faith in the orderliness of universe must have inspired Kepler to spend the nights of his lifetime alone with the stars."

Scientists, having developed double names for their overlappiug work (biochemistry, biophysics, etc.), are now finding their total field interconnected and unitary. This is a general trend of science. And so many scientists are now being educated that it may be forecast that within the next half-century not only science but much of educated society will have come naturally through its own explorations and experiences to discover the comprehensive order of the universe. Thus they will inadvertently develop a regeneratively inspiring faith in the order and integrity of the universe.

And because the complexities of this universe are only intellectually comprehensible, recognition of an intellect greater than and anticipatory to our own intellections is inexorably emergent in the integrating totality of scientific exploration. This means the personal, first-hand discovery by increasing numbers of humanity of non-anthropomorphic God, the great intellectual integrity of universal evolution.

APPENDIX

I. Organizing a World Game Operation/Various Options

1. World Game Program Kit to initiate a World Game Extension Study Group: World Design Science Decade documents, the World Game research document, the World Game reprints, ***Operating Manual For Spaceship Earth,*** the R. B. Fuller booklist, some large 3 x 5 Dymaxion maps, the Honeywell Fuller Projection, the punch out map, and a set of resource inventory slides. This is the minimum packet. It costs $50.00.

2. The maximum packet is to consist of the above plus the Robert Snyder movie-"Primer for Universe," the population movie, a set of resource inventory slides and a complete set of R. B. Fuller books. It costs ***$450.00.***

3. If you wish to set up a full-scale facility you will need the following list of items that groups working in Design Science and the World Game have found helpful. It would cost approximately $15,000.00 to set up.

Design Science and WORLD GAME WORKSHOP tools

A ***Facilities:***

1 Shelter

a) Large space for group meetings, preferably with portable rearrangeable lightweight partitions for easy breakdown into:

b) Smaller group areas

2. Communications

a) Plenty of blackboards, wall space, and bulletin boards along with their requirements.
b) 16-mm movie projector with screen.
c) Telephone
d) Xerox.
e) Micro-fiche reader and printer
f) Casette tape recorder players
g) Video-tape recorder and player
h) Typewriter.
i) Computer access

j) Library: documents, Dr. Fuller's books, reprints, tapes, films, World Game related books and articles, micro-fiches, games, geodestix.

k) Notebooks. (Columbia lab books have proved to be an incredible help: everyone hands in the carbon copies of their notes so every one knows what every one else is thinking/doing. Feedback sheets, composed of the most succinct parts of everyone's notes, have been utilized on a day-to-day basis and a week-to-week basis with good results.)

3. Supplies

a) Maps.
b) Paper, pens, etc.

4. Operating budget

a) *Documentational.*
(1) Printing.
(2) Photos.
(3) Computer program tapes.
(4) Video tapes.

b) *Graphics.*
(1) Paper.
(2) Pens, inks, paints, etc.
(3) Zip-a-tone.

c) *Informational.*
(1) Books.
(2) Magazines.
(3) Microfilm readers & print outs.
(4) Documents.
(5) Lab books.
(6) Abstracts.
(7) Charts.
(8) Maps.
(9) Computer time.

d) *Secretarial.*
(1) Xerox.
(2) Stationery.
(3) Salary.
(4) Postage.
(5) Phoning.
(6) Supplies.

e) *Staff*
(1) Salary
(2) Supplies.
(3) Student workers for: Computer punch-cards, typists.

B. *Staff:*

1. Participants will hopefully range in interest and experience in all fields-physical and social sciences, arts and humanities, computer related fields, as well as multi-disciplined generalists.
2. A secretary/librarian to maintain library and communications.
3. If the group is large (20-40), full time staff member(s) are a necessity. They should have had experience in World Game development and Design Science.