a master architect and inventor of the geodesic dome unveils his visionary plan for a floating, self-contained community

I HAVE BEEN ASKED many times: "What would you do if you were building commissioner of the United States of America or even of the entire world?"

I would resign. I am an inventor and so have far vaster prerogatives than any politician. Edison, Bell, Marconi and the Wrights needed no licenses from anyone to light the night, to shrink the earth and to interlink all humanity. So I will pass up any hypothetical political appointment, but will accept the housing challenge as an inventor.

The drawings of the tetrahedral city on these pages represent an entirely feasible and practical new way for men to live together economically. The drawings cannot be understood, however, without knowing

The author's city of the future consists of three triangular walls of 5000 living units apiece, the walls and base forming a tetrahedron; each unit faces the sky over a spacious terrace. The large cutaway drawing shows a huge public garden at the bottom of the interior of the superbuilding, which the sun pierces through broad openings at every 50th floor. Its transport system (in red) includes funicular as well as interior vertical and horizontal units. Though shown here on land, the city also can float.

article By R. BUCKMINSTER FULLER

CITY OF THE FUTURE

A drawing of the 200-story city superimposed on a photo of the outskirts of Tokyo vies for attention with Mount Fuji. The lowermost figure in the small cutaway drawing is at the back of the downstairs level of his duplex. Seven stories above him is a section of one of the three city centers that rim the structure. Here the transport system has a terminus at a community park, complete with lagoon, palms and shopping center in geodesic domes. Offices and maintenance facilities (in brown) line the transport tracks.

ILLUSTRATIONS BY REEO SHINN

the trends in housing and cities that lead up to them. And their full appreciation requires knowledge, too, of the importance of technology—and therefore of the inventor—in human affairs.

Yesterday's capitalists disliked inventors, who made the capitalists' machines obsolete. Businessmen were powerful enough to persuade society that inventors were screwballs. All that is changing; businessmen now find change profitable and inventors are becoming respectable. Inventors pay attention only to physical laws—which alone govern what man ultimately may do in the universe. If humanity succeeds, its success will have been initiated by inventions and not by the debilitating, often lethal biases of politics.

Our higher potentials are unrealized because environmental conditions have frustrated man's potentials. We have learned much, however, through recent behavioral-science research. For instance, we know that environmental conditions determine how much of the child's total brain potential will blossom into effectiveness.

Politics undertakes to reform only man, not his environment. For decades, society has tried to reduce automobile accidents by reforming drivers—with arrests, fines, behavioral exhortations and laws. I always thought that, instead, it is physically possible to prevent accidents: by split-level crossings, banked turns and divided highways. In 1906, people said, "You can't do that, it would cost millions." After trying unsuccessfully for 61 years to reform the drivers, and after seeing a greater mortality on our highways than in World Wars One and Two combined, society has at last undertaken to reform the driving environment. A 51-billion-dollar national highway program has already safely multiplied the 1906 auto speeds fivefold, while greatly reducing the accident rate per passenger mile.

Inventions alone have raised the number of people enjoying an advanced standard of living, from one percent of all humanity in 1900 to 40 percent in 1966, despite continuously diminishing natural resources. That same advantaged 40 percent are also living three times the number of years that man lived only a century ago. All of this has come about through inventions. Inventions have induced appropriate social reform, but only as accessories after the fact of invention itself.

Take away all the inventions from humanity and, within six months, half of us would die of starvation and disease. Take away all the politicians and all political ideologies and leave all the inventions and more would eat and prosper than do now.

My task as an inventor is to employ the earth's resources in such a way as to support all humanity while also enabling all people to enjoy the whole earth—all of its historical artifacts and its beautiful places—without one man interfering with another and without any man enjoying life at the cost of another.

The first thing I must understand in order to undertake this task is the history of man's dispersal around the globe. In chapter one, humanity lived in huts on rafts beside the rivers, lakes, bays and oceans. Fish were plentiful and the rafts kept men safe from wild animals on shore. Some of these raft dwellers were blown out to sea, preponderantly eastward around the earth's surface. In the second chapter of history, men learned to sail to windward, following the sun, to which they intuitively attributed their metabolic regeneration. Almost all of the past 6000 years of recorded history took place during chapter two's westbound movement. In the Eurasian continent, this westward motion finally funneled into western Europe. As humanity converged, it crossbred. Western Europe represented an amalgam of previously isolated "nations." These nations had developed unique local subsistence patterns through millenniums of inland, inbred adaptations. Those in the north had become bleached and blond; those isolated in the hot equatorial sun had become darkened. Further inbreeding heightened the differentiations. Along the waterfronts, the sailors crossbred and their skins became pink or swarthy.

Crossbreeding Europeans, intermingling with the Angles and the Jutes, poured into the British Isles to crossbreed even more. Westbound Indian Ocean people and others inhabited Africa —inbreeding, ever darkening their skin. Then western Europeans jumped westward across the Atlantic to the Americas. For 11 successive generations, they have settled farther westward. As they moved westward, they crossbred acceleratingly, not only with their own westbound, "chapter-two" Eurasian stocks but with the Eurasian stock of chapter one, which had drifted eastward to the American continents between 30,000 and 10,000 years earlier. Into the North and South American continents and their islands there also flowed westward, by both slave trade and migration, a swiftly crossbreeding homogenization of the inbred African tribesmen.

In California, at the mid-point of the Western shores of America, crossbreeding man has become so genetically integrated that he frequently is unidentifiable with any of the earlier inbred national characteristics of Eurasia. Chapter two climaxes in the emergence of world man, who is poised on an epochal springboard. He will fly both skyward and into the seas' depths and thus open chapter three of history—that of universe man, who will enjoy free, four-dimensional occupancy of the universe. Man will free himself from local time and geographical bases and will progressively discard encumbrances, giving all heavy, static and economically nontransportable properties to libraries, museums and universities, scrapping them as he is able to rent superior devices and services everywhere around the earth.

Before envisioning the way this new and eminently mobile man will live, we must have a clear idea of the development of the home and of the city. On the old farmstead, there were a great many buildings—the great barn containing hay and cows, stables, corncribs, silos full of fermenting ensilage, a woodshed, a pigsty, a carriagehouse, a cold cellar and a warm cellar. All these buildings and many others on the farms are disappearing or have disappeared, because machinery in the house has displaced the functions the buildings performed. Small electric-refrigerating devices took the place of the icehouse and the icebox system. Electric current took the place of wood, woodshed and stove. In two decades, the windmills, formerly found on every farm, have also gone. Still, the layman fails to understand what Corbusier meant when he said, "A house is a machine to live in."

When the early homesteaders went onto the land with few or no tools, they had to spend every minute of daylight working in the fields or building their energy-controlling structures. The design of their farmhouses told the story—little boxes with vertical walls going down into the ground. There were no porches or stoops. There were a few windows, enough for the farmer's wife to see where he was and to see if Indians were coming. When tools, and more tools, came to shorten the time taken to do a given job, the farmer gained more time for leisure. Finally, he had enough time before twilight to sit and look at the scenery, and he built porches around his house. As he began to have more and more time, he put screens on the porches. With still more time, he put glass windows on the porches. Sitting on his porch, he watched other people go by.

Then came the automobile, which, in effect, put wheels under his glassed-in front porch, so that instead of waiting for people to pass by, he could drive down the street to look for them. Because we are conditioned to think of the house as static, we fail to realize that the automobile is as much a part of the house as was the addition of a woodshed. The automobile is part of the house, broken off, like a hydra cell, to enjoy a life of its own. Young people who used to court in the parlor, then on the glassed-in front porch, now do their courting in the porch on wheels, often driving their mobile parlor to the drive-in theater.

In 1920, 85 percent of the cost of production of a single-family dwelling in the United States went into the house's shell

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and foundation. Only 15 percent of the general contract went into what we call "mechanical inclusions." In North America, that 15 percent covered a kitchen sink and a furnace. There was no electrical refrigeration at that time. Only a small percentage of houses had indoor toilets. Only a very small percentage had electrical wiring. But the post–World War One "fallout" of advanced technology brought one mechanical inclusion after another. By 1940, 45 percent of the general contract went into mechanical inclusions. At the present time, 65 percent of the general contract goes into mechanical inclusions, which embrace wiring and plumbing, as well as the obvious machinery. During this same period, the size of the various domestic machines has continuously decreased. The sewing machine, for example, has shrunk from a very big device to a small one. As transistors and other miniaturizations are developed, the machinery of the general contract continuously produces more service with smaller apparatus and less effort. Through the years, the cost of the electrical current to power mechanization has continuously decreased, despite increased costs in all other directions. Concurrently, the size of the house also decreased as servants were replaced with machines, which eliminated servants' rooms. Family size has also decreased as life expectancy continues to increase. But despite the continual decrease in the size of individual homes, the cost per cubic foot of the enclosing structure has rocketed upward. Clearly, machinery is giving man more and more for less and less, while the structural arts give man less and less for more and more.

House trailers are modern, lightweight aluminum boxes, full of the mechanical devices that reflect the improved standard of living—and minus the expensive house. The home-trailer business, despite its product's lack of aesthetic appeal and despite cultural inertia, has become a major industry, without any Federal subsidy, while the whole home-building business has been kept going only by 40-year Government mortgage-loan guarantees and, even so, has been in fundamental decline for 20 years.

But the conditioned reflexes of society make laws that force the mobile-home-owner to emulate the static horizontality of the real-estate business. Zoned trailer parks grow up everywhere, to capture the swiftly multiplying mechanical-house packages. Rapidly expanding fiberglass, plastic and metal boat production is turning out houseboats, motor cruisers, sailing cruisers—all containing living machinery of the highest order. Mooring or storage of these boats is also absurdly horizontal, in harbors or marinas. Visionless realtors, backed by Government funds, operate indiscriminately in acquiring low-cost options on farmland, upon which they build houses on speculation. This continuously reduces the productive per-capita land area and unbalances the ecological regeneration of life on earth. Despite the fact that one out of five Americans now moves every year, we are forced by Government-backed realtors to buy homes on decades-long mortgages.

Man was designed with legs—not roots. Over 10,000,000 humans have now traveled more than 3,000,000 miles around their spinning spaceship, the earth's surface, in contrast with the 30,000 miles per lifetime averaged by all humanity prior to the year 1900. So ignorantly, myopically and statically conceived—and so obsolete—is the whole housing art that its death led to the crash of 1929. Since then, its ghostscript has been kept in rehearsal by the U. S. Government, at a total underwriting cost to date of 200 billion dollars.

But the reactionary bias of real-estate agents and land developers is really trivial in the face of the technological advances we are about to make. The advances, as usual, will find much of their impetus in the weapons systems of great countries.

Now that scientific warfare has gone into space, it has been necessary for science to package human environmental and metabolic-regeneration systems for economic delivery by rocket. To do so, science must understand man as a process. When astronauts go beyond the vacuum-bottle-and-sandwich excursion limits, all the regenerative conditions provided naturally by the great biological interactions within the biosphere around the earth's surface will have to be reproduced—in a miniaturized and capsulized human ecology. All the apparatus to accomplish this will be contained in a little black box weighing about 500 pounds and measuring about 20 cubic feet. With the little black box, a man in space will be able to regenerate his many organic processes, needing only small annual additions to the recirculating chemistry. The first men living comfortably in space will be watched on TV by billions on earth. Humanity will be swiftly educated in an entirely new set of environmental-control mechanics.

Though the first black box will probably cost the United States and Russia well over seven billion dollars, it will be mass-reproducible on earth at around two dollars per pound. A $1000 box could rent profitably at $200 a year. An individual or family could take a black box (costing approximately $18 a month) and go to any wilderness—mountaintop or island—and enjoy essential services superior to those now available in any city complex. The black box will constitute the first direct application of science to making man a physical and economic success anywhere in the universe—which, of course, includes on earth.

In 1927, a single-family dwelling machine was proposed whose structure was similar to that of a wire wheel—laid horizontally on its side—with its axle elongated vertically to act as a supporting mast, around which the circular structure was supported. This high, carrousel-like dwelling machine had advanced living apparatus suitable for a family of six. It had a sun deck above and an airplane hangar and garage below the dwelling zone. It was finally prototyped in the aircraft industry in 1944. It weighed only three tons, which was approximately three percent of the weight of the equivalent facilities in conventional structures. It was popularly hailed. All that was lacking was the little black box to make this air-deliverable dwelling machine the world's most luxurious, remotely installable and economic family habitat.

The history of cities points to the same conclusions as the history of the home (which we can confidently predict will reach its logical conclusion with the perfection of the little black box). Cities developed entirely before the thought of electricity or automobiles or before any of the millions of inventions registered in the United States Patent Office. Cities developed as warehouse trading posts. All warehousing has gone out of the modern city. Warehousing has become dynamic and now is mostly done on wheels, wings or in ships. Cities were later used to house vast hordes of immigrants to work in the factories, which were also centered in the cities. Now the factories have also left the cities obsolete in terms of yesterday's functions. Trying to rebuild them to accommodate the new needs of world man is like trying to reconstruct and improve a wrecked ship impaled on a reef pounded by surf. The surf of technical obsolescence is invisible but much more powerful than the waves of the real ocean.

Mankind now converges in the old cities essentially for abstract, almost weightless activity. Columbia University, New York University, Fordham University and City College of New York are now the prime real-estate holders in New York City. Only a few cities can persist as prestigious cultural or stock-exchange centers—New York, London, Paris, Tokyo and a handful of others. These cities will turn into great universities as automation replaces humans who now function *only* as automatons.

A few elementary engineering concepts point clearly, I believe, to what the new cities will be like. For example, when we double the length of an airplane fuselage, we increase its surface area by four and increase its volume by eight. The surface area of a ship—rather

than the volume—governs its friction and drag. The larger the ship, the more economically its cargo may be carried. Yesterday's airplanes were limited in size because they required extremely long landing strips. The emerging generation of large airplanes—which will carry 700 to 1000 passengers or more—is being designed for vertical take-off and landing, which does away with the necessity for prepared landing strips.

To take advantage of the progressive economy gains of increasing size, leading airplane manufacturers already have planes on their engineering boards big enough to carry 10,000 passengers or their equivalent in cargo. The 10,000-passenger ship has a length equivalent to that of the Empire State Building. The leading aircraft manufacturers realize that it will be possible to produce Empire State Building–size skyscrapers in a horizontal position under factory-controlled conditions in mass production.

The Empire State Building was erected under conditions of wind, rain, heat and cold in the heart of New York City's traffic. One man was killed for every floor of the building. No men should be killed in the production of the horizontal skyscraper in the airplane factory. Such skyscraper-size airplanes may then be taken from their factory and—with vertical take-offs and temporary wings—flown horizontally to any position around the world. Using their vertical take-off equipment, they will be upended, anchored and braced to serve as skyscrapers. Thus we see that whole cities can be flown to any location in the world and also removed in one day, just as fleets of ships enter and leave ports.

If we build vertically, both out from and into the earth's surface, we may use less land and return good soil to metabolic productivity. We can also install vertical habitations upon and within the three quarters of the earth covered by water.

The new Queen Elizabeth is a luxuriously comfortable abode either at sea or in port. She is a mobile city. She is shaped to get passengers across oceans in a hurry. If such floating cities didn't have to speed, they might have an efficiently symmetrical shape. It is eminently feasible and economical to develop floatable organic cities of immense size. To visualize the various design-controlling conditions under which such cities could be constructed, imagine pinching a camera tripod's legs together, taking hold of the bottom of the tripod in one hand and trying to hold it vertically on the top of an automobile going 70 miles an hour, over rough terrain. As you opened the legs of the tripod—each time you spread them—the tripod would get steadier and steadier. This is the stabilizing effect obtained when tension stays are rigged from top to bottom on three sides of a mast, as with radio towers. It is equally effective to have the legs spread outwardly, as in the Eiffel Tower. When the three legs are spread apart so that the length of the edges of their base triangle equals the length of each of the legs themselves, the tripod attains its maximum stability. This conformation is that of the regular, or equilateral, tetrahedron. As the tripod's legs go farther apart than the regular tetrahedron, its top can support less and less load. Thus we learn that the most stable structure is the regular, equiedged tetrahedron.

Following this design science clue, we find that a tetrahedral city to house 1,000,000 people is both technologically and economically feasible. Such a hollow tetrahedral city can be constructed with each of its 300,000 families having terraced "outside" apartments of 2000 square feet each. The terraces would permit the storage of mobile trailers, houseboats and other mobile homes, leaving an additional 1000 square feet for a garden. The living units would be weatherproofed and would require no additional "walls," or external skins, to be fastened onto the tetrahedral city. Such a city would consist of an open-truss-framework "structural mountain," whose sides are covered with parked mobile homes. At night, it would be ablaze with light, as are the great petroleum refineries. All of the organic machinery necessary to its operation would be housed behind the three principal "walls" of the tetrahedron.

Tetrahedrons are also geometrically unique in that they grow symmetrically by additions to any one of their faces. Tetrahedral cities may start with 1000 occupants and grow to hold millions without changing their over-all shape and always providing each family with 2000 square feet of floor space. (The city illustrating this article, for example, while much smaller than the model discussed here, is technically identical.) Such a city would be so structurally efficient and therefore so relatively light that, together with its foundation—of hollow sections of reinforced concrete—it could float. The model floating city would measure two miles to an edge. Its foundation would be 200 feet or more in depth and several hundred feet wide. On land, the structure could float in a three-sided moat, which would make the whole city earthquakeproof. Or the structure could be floated out into the ocean to any point and anchored. The depth of its foundation would go below the turbulent level of the seas, so that it would be, in effect, a floating triangular atoll. Its two-mile base would provide landing strips for jet airplanes. Its interior,

"Here's the plan—you put a damsel in distress, then I rescue her . . . I put a damsel in distress, and you rescue her. . . ."

two-mile harbor would provide refuge for the largest ocean vessels.

The total structural and mechanical materials involved in production of a number of such 1,000,000-inhabitant tetrahedral cities are within the capabilities of several companies in the major industrial nations. Withdrawal of materials from obsolete buildings on the land will permit the production of enough of these floating cities to dot the oceans of the earth, at distances negotiable by relatively small boats. Because their foundations would be below wave turbulence, such cities would also permit mid-ocean cargo transfers, extraordinarily increasing the efficiency of material and passenger traffic. The cities would generate their own energy with atomic reactors, whose by-product heat would be used to desalinate sea water for the city's water supply. In short, these habitats would greatly facilitate both travel of all sorts and the coming large-scale exploitation of the oceans.

In 1954, the United States Marine Corps helicopter-lifted a geodesic dome large enough to house an American family. The latest helicopters being built for Vietnam can air-deliver geodesic domes large enough to cover a football field, including the end zones, the quarter-mile running track and side bleachers. By 1975, it will be possible to air-deliver geodesic domes large enough to cover small cities. (It is now possible to cover a large city in three months by delivering large subassemblies of a dome.)

There are already 5000 geodesic domes in 50 countries around the world, many so light and strong as to have been air-delivered.

Domed-over cities have extraordinary economic advantage. A dome calculated for mid-Manhattan has a surface that is only 1/85 the total area of the buildings that it would cover. It would reduce energy losses—either in winter heating or summer cooling—to 1/85 of the present level. It would obviate snow removal. The savings in ten years would pay for the dome.

Domed cities are going to be essential to the occupation of the Arctic and the Antarctic. The Russians are already experimenting with them in the Arctic. They will be used in desert areas to shield new growth from the sun, while preventing wasteful evaporation of piped-in, desalinized water. Gradually, the success of new domed cities in remote places will bring about their use in covering old cities, particularly where antiquities need to be protected.

The domes over our cities will be so high and their structural members so delicate as to be nearly invisible. They will bring shadow when shadow is desirable and sun when sun is desirable, always keeping out rain, snow and storms as well as exterior industrial fumes, while collecting rain water in reservoirs. The temperature inside the domes will be so stabilized that a semitropical atmosphere will exist. Inasmuch as there will be no rain or snow, people will live in garden-terrace skyscrapers, with screening only for privacy.

Because of the geodesic domes, the increasing trend toward mobility will find expression not only in individual "homes" but also in entire cities. A 100-foot-diameter geodesic sphere weighing three tons encloses seven tons of air. In a 400-foot geodesic sphere—the size of several domes now operating—the weight of the air inside goes to about 500 tons, while the weight of the structure is only 15 tons. Here, the air-to-structure weight ratio is 33 to 1. When we get to a geodesic sphere one-half mile in diameter, the weight of the air enclosed is so great that the weight of the structure itself becomes of relatively negligible magnitude, a ratio of 1000 to 1. When the sun shines on an open-frame aluminum geodesic sphere of one-half-mile diameter, sunlight is reflected by the concave inner surface back into the sphere and gradually heats the interior atmosphere. When the interior temperature of the sphere rises only one degree Fahrenheit, the weight of air pushed out of the sphere is greater than the weight of the spherical-frame geodesic structure. This means that the total weight of the interior air, plus the weight of the structure, is much less than the weight of the surrounding atmosphere. The entire assemblage would then float into the sky.

As geodesic spheres get larger than one-half mile in diameter, they become floatable cloud structures. If their surfaces were draped with outwardly hung polyethylene curtains to retard the rate at which air comes back in at night, the sphere and its internal atmosphere would continue to be so light as to remain aloft. Such sky-floating geodesic spheres may be designed for altitudes of thousands of feet. The weight of human beings added to such prefabricated "cloud nines" would be negligible. Many thousands of passengers could be housed aboard a mile-diameter cloud structure. The passengers could come and go from cloud to cloud, or cloud to ground, as the clouds floated around the earth or were anchored to mountaintops. While the building of such floating clouds is several decades hence, we may foresee that—along with the floating tetrahedral cities, air-deliverable skyscrapers, submarine islands, subsurface dwellings, domed-over cities, flyable dwelling machines and rentable, autonomous-living black boxes—man may well be able to converge and deploy at will around the earth, in great numbers, without further depletion of our planet's productive surface.

As people live and move completely around the earth, changing from "summer" to "winter" in hours, the old concept of man as a cold-area or warm-area dweller—or as a fixed, static dweller anywhere—and all the old concepts of seasons and of work related to only daylight hours will gradually be eradicated from our conditioned reflexes. This will mean more efficient occupancy of environment-control facilities. Nowadays, at international airport hotels, people with one-to-eight-hour flight stopovers follow one another in rooms and beds that are made up as soon as each occupant leaves. The rooms are occupied, not on a noon-to-noon schedule but on a *use* schedule, which we may call a *frequency-modulation schedule*. Such frequency-modulated occupancy of rented space in mobile hotels or in dwelling machines will become man's fundamental life pattern.

The great world housing problem is an educational problem. By and large, man's inertias are overcome only by virtue of his own personal discoveries and his understanding of what is happening to him. There will be no instant world housing solutions. There are fundamental rates at which the educational gestation takes place. Publishers who try to exploit man's imagination by giving him only the end-product concepts, without showing how man will get from here to there, postpone the opportunities for helping man educate himself as to how these events may come to pass. I, for one, am unwilling to allow anyone to be amused by startling concepts of tetrahedral cities and air-deliverable Empire State Buildings while keeping from society the opportunity to understand the complex of factors that lead to such tangible results.

The comprehensive introduction of automation everywhere around the earth will free man from being an automaton and will generate so rapid a mastery and multiplication of energy wealth that we will be able to support all of humanity in ever greater physical and economic success anywhere around our spaceship, earth. Quite clearly, man free to enjoy all of his planet, free to research the bottom of his ocean and to re-explore earlier patterns of man's life on earth, will also be swiftly outward-bound to occupy ever greater ranges of the universe. Within decades, we will know whether man is going to be a physical success here or is going to frustrate his own success with his negatively conditioned reflexes of yesterday—bringing about his own extinction. My intuitions sense success, despite our negative inertias. But my intuitions will mean nothing unless man learns to understand and control the forces shaping him and the new patterns of living available to him.