# FLUID GEOGRAPHY

**The occasion for the following account was the Dymaxion Projection that Fuller had developed as a method for transferring geometric data from the surface of the globe to a polyhedron and then unfolding it to a plane in a way that was approximately faithful with respect to lengths, surfaces, and angles. The unique aspect of this method is that the unfolding of the "polyhedrized" globe can produce a number of possible layouts and thus lay bare the various ideograms of the world (→ *YPS*, pp. 250–275).**

**When the Dymaxion World Map was first presented to the American public in 1943 in *Life* magazine, it was with a focus on the events of the war. For Fuller relevance meant more than just the events of the day, namely, participation in historical processes and recognition of the nature of what drove them. Without the background of Fuller's question about the trend patterns of civilization and without his anthropological interests, he would not have seen, at least since the thirties, the modern world in a new and "different" way, namely, as a connected, inhabited archipelago: "One Continent in One Ocean" (→ *YPS*, pp. 252f.).**

**The text "Fluid Geography" continues a line of thought that had already been established in *Nine Chains to the Moon* (1938) and in the text on the Sperry gyrocompass (1940). It is one of Fuller's most lucid texts, an impressive demonstration of his entirely nonconformist way of thinking. The history of human civilization, the way he saw it, has its origin and its evolutionary energy in sea travel. Fuller distinguishes according to the cultures of the "East" and "West" and mentalities of traveling with the wind or against the wind. His account is fundamentally different from the usual Western view. "America" is no longer an offshoot of Europe but rather the historical locus of the current observable confluence of trends of historical evolution. The irony that is occasionally expressed in the text is thus not a way of distancing himself but rather the imperturbability of the contemporary who knows that the course of evolution is on his side.–CL**

RBF, "Fluid Geography," in *American Neptune* 4, no. 2 (April 1944): pp. 119–136. Reprinted in RBF, *Ideas and Integrities, A Spontaneous Autobiographical Disclosure*. Ed. by Robert W. Marks (Englewood Cliffs, N.J.: Prentice Hall, 1963), pp. 119–141.





It is a sailorman's credo that there is a generic difference between himself and a landlubber. While admitting that sailor blood sometimes may be trapped inland for several generations, he believes that it never loses its dynamic proclivities. Though landlubbers may frequent the seas by political appointment, tourist urge or commercial necessity, conscientiously memorizing nautical language and techniques, the sailorman believes that landlubbers are fated to wear these acquisitions only as paraphernalia, distinctly superimposed upon their static roots. He reasons, therefore, that, while a Kansas Citian may get to have four stripes, unless he has inherited seagoing corpuscles, he must remain strictly corny, not salty.

Irrespective of the validity of this credo, there exist fundamental differences between the practical requirements of the sailorman's and the landlubber's lives. By exigencies, sailors have come to be the only men of commerce dealing directly and daily with the mechanics of the stars. Confronted with large quantities of unknowns intervening between identified ports, they came early to rely upon instruments and skills of the intellect, upon scientific imagining. In principle, "blind flying" has been employed at sea for centuries. Without thinking of themselves as cosmogonists, sailors naturally develop a spontaneous cosmic viewpoint. They view the world from outside; they "come upon" the land.

But not so the landlubber. Though half a millennium has passed since Copernicus and Galileo urged upon educated people that the heavens were not turning about the fixed earth, landsmen in general and even their rock-mounted astronomers persist in "seeing" the sun "set" and "rise" in their personal lives.

Intending to help their children to grasp the "very difficult" concept of total heavenly motion, the landlubber theoreticians have devised planetariums within their great cities. Instructed by this device, the children approach personal conviction of the ceaseless motion of the planetarium heavens, only to be thrown into life-long confusion at the critical moment as the closing landlubber phrases come to their stimulated attention: "Now the sun is rising again in the East, the lights are coming on, the machine stops, and we return you to New York (to the practical life in which the sun, as a handy gadget, still zooms around the contentedly static earth)."

To the landsman "the East" and "the West" are places, to the sailorman they are directions in which he may move. To the sailorman entered upon the great Pacific, it is final proof of the landlubber's nonsense that the sun is not only forced to do this rising and setting act, but perversely to do so on the wrong stage. Viewed from the Pacific, the sun rises from the Occident and sets in the Orient.

By exigency, too, sailors constantly exercise their inherent dynamic sensibilities. The ceaseless universal motion of the sailorman's life persists in his brain, even when he is landed on the beach. For hours and days after he has come in from the sea, his legs go on adjusting him to the slowly heaving motion of Fifth Avenue. It isn't hard to convince a sailor that the watery, graymist horizon toward which he may be sailing is rolling down to reveal the sun, or that his circular horizon segment of the moment is one little wet spot on a great sphere, ponderously rotating to obscure the sun to the westward. He sees everything in motion, from the slopping of the coffee in the pot to the peregrinations of the major magnitude stars. Amongst all these relative motions, the pole star alone seems to float motionless as the world's mooring buoy in the sky.

To the static-minded landsman, it is an insensible statistic that the moon is about 239,000 miles away from the earth. To the sailorman, it is a natural sensation that the moon-earth pull is so great as twice daily to be able to lift many feet aloft the thunderous tonnages of water upon which he sails. By measured reasoning he "sees" the moon lifting the water as it circles after its rotating and orbiting mother-ship Earth. So fast is the orbiting that the sailor knows it is difficult to obtain an accurate navigational sight from the moon. However, to the static landsman, that

moon seems to hang motionless as a luminous flat medallion in the periodically glimpsed scene. To the landsman, a trip around the world means the conversion of a bank account or an Irish Sweepstakes prize into a procession of hotels; to the sailorman, it is the logical fulfillment of his work, punctuated by visits to the beach.

While it seems that a preposterous case of rationality versus irrationality can be made in favor of the sailor, what is really being demonstrated here is a principle transcending identity with either the sailor or the landsman. One common observation of an effect of that principle is "Necessity is the mother of invention." The sailor is much better acquainted with that trying dame than is the landsman, if for no other reason than because land activities generally are based on eight-hour workdays, after which the office and factory are shut down; whereas the sea can never be shut down. While physical laws persist both on land and sea, their slow articulation on the dry, crystalline land could be disregarded for two-thirds of the day. The landsman stables the horse, garages the car, or merely walks into his house and sits down. Inertia, unchallenged, promotes careless philosophy. Every day the seafarer is exposed to three times the necessitous experience, for even when off watch he is still in a dynamic environment. Moreover, the mutability of the liquid state and the proportions of tonnage and velocity to which the sailor is continuously exposed are many times those encountered on the land. Thus by compounding of factors, technology advances far more rapidly at sea.

If we will remember that leverage, for instance, as a universal principle, may be abstracted from immediate identity with sea gear for reapplication on the land, we can readily understand how the technical advantages gained on the sea gradually come to satisfy land emergencies. In the light of this technical leadership, we can understand why rule of the world derived from rule of the sea.

Frequency of technical emergency is accelerated to an even greater extent in the gaseous state. Airmanship emergencies require the most exquisite of solutions. In short order, aeronautical engineering has reapplied to its needs all of maritime technology. While the air technology may not as yet have taken complete leadership away from the technology of the sea in the pacing of man's affairs, it hastens inexorable to such predominance.

With the land as the bottom of the new unbroken air ocean, as so brilliantly taught in the 1930's by George T. Renner of the Civil Aeronautics Authority to elementary school America; with sailors, aviators, and landsmen all crossbreeding into a dynamic world citizenry; and with historical events accelerated from a frequency interval of centuries to intervals of hours, all men are, so to speak, now in the same boat and are necessitous, among other items, of a precise means for seeing the world from the dynamic, cosmic, and comprehensive viewpoint.

The map on page 129, which is the primary exhibit of this chapter, was invented for this purpose, and while it is certain to be bettered by subsequent inventions (it is for the moment the most reliable comprehensive projection) it describes the earth's surface with the minimum total score of distortions from the many well-known geometrical processes inherent in translation of the angle and scale information from a spherical to a flat surface.

Presently, we will discover why distortion is at a minimum. The mechanics of this projection, for those who enjoy inspecting the intricacies of the engine room, will be exposed toward the close of this article. The mathematics will be found to be as neat and stark as the buckets within a turbine casing. But for the moment what is important is that the trend forecaster can rely implicitly upon the impression of shapes and relative sizes and distances to be derived from this comprehensive device. We may, therefore, proceed at once to ascertain the inherent advantages and make trial of their ability to reveal major trends in world affairs.

This new projection is particularly successful because it makes possible the reassembly all on one plane of each and any of the continents without broken contours. Further, it makes possible the assembly of those whole continents in any of the arrangements in which they occur relative

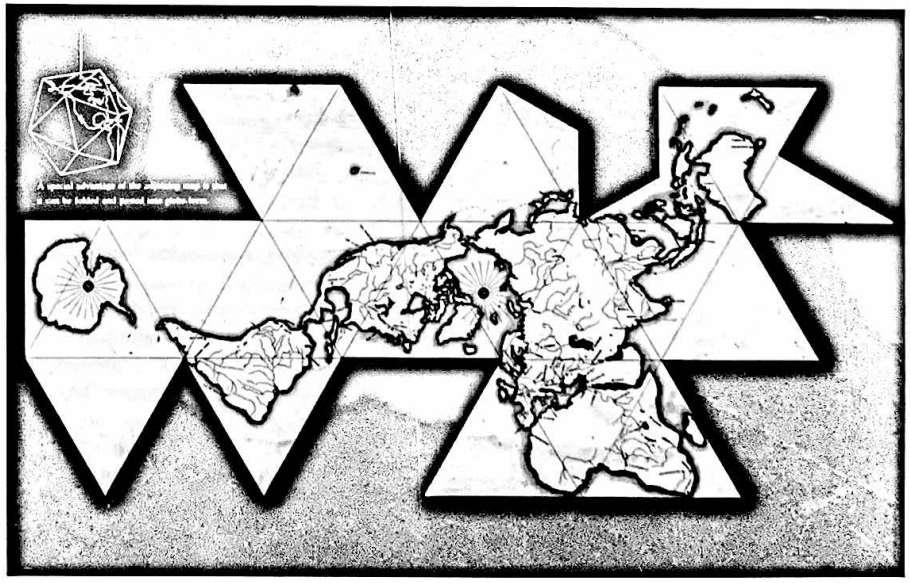


to one another on the globe, as one explores successively the infinite number of great circle continuities. This new map is unique in that the continental contours are transferable in unbroken integrity from their spherical disposition to the flat map representation without perceptible deformation or modulation of size and with uniform scale measured in great circle arc segments bounding each component section.

Unblemished by the peripheral sinuses necessary, first, to the scoring open and, secondly, to the peeling of any solid, this continental contour integrity is the joint result of a new mathematical discovery on the one hand and, on the other, of emancipation from the formal cartographic tyranny traditionally imposed by the Poles.[1]

As indicated in the miniature arrangements surrounding the large map, there are many alternate assemblies, the components of which always total up as a complete map of the world. Each, by "picture psychology," focuses attention on the central portion of its mass, yet retains all other factors in appropriate contributory status. For instance, one of these pictures is the sailorman's One Ocean World, fringed by the shoreline fragments which are his particular concern. It discloses the relative vastness of the Pacific and emphasizes that ocean's longest axis, from Cape Horn to the Aleutians. Oriented about the Antarctic, the waters of the Indian and Atlantic Oceans open out directly from the Pacific as lesser gulfs of the *one-ocean*.

To convince himself that picture psychology is not an esoteric mystery of painters, the reader has only to compare the impressions derived from looking first at the one-continent arrangement and then at the one-ocean assembly. Turning away and reporting his impressions, he would be inclined to testify that these maps were composed of different components; that the *one-continent* map was comprised of seventy-five per cent dry land area, that the *one-ocean* map was comprised of ninety per cent water area. The fact is that both maps are composed of the same pieces. Though less dramatic than the example presented, the many other possible arrangements are endowed with equally unique psychological differences. Each of the arrangements is as important as any other, depending upon the geographical location with which the individual has habitually been identified.



129 Dymaxion World Map (Air-Ocean World), icosahedral version, RBF and Shoji Sadao, 1952. The North and South Poles are freely arranged rather than in the centers of the plane (cf. the *Life* version of 1943, → *YPS*, pp. 245ff.)

The sailor may ascertain by inspection the most advantageous courses to his many world ports from the tactical center of that watery workaday world. So far as he is concerned, the whole world is one ocean, one-quarter of whose uneven bottom crops up through the surface in peaks and plateaus. When he comes in to the shore, he is coming in to the peak of a mountain range about five miles high. To our modern cosmic sailorman, coming in to an airfield in Tibet over the Himalayas is approximately the same sensation as coming in to Puerto Rico over the Antilles ranges, rising abruptly 30,000 feet above the Nares Deep.

There are also many rearrangements of the map to emphasize whole continental masses. By means of these elective arrangements, our thinking may be realistically insinuated within the special geographical environment of the people of any one world are as predicated upon their own set of conditions of direction and proximity to all the rest of the surrounding world. It is in this feature that we discover the dynamic leverage afforded our world appraisal by this device. No longer need the American continents, for instance, with only twelve per cent of the world population, occupy relentlessly the central and non-distorted portion of the world map, assigning fifty-two per cent of the world's population to an insignificant, fragmented, and distorted Asiatic borderline position.

In the particular assembly chosen for the large display, one sees all the continents linked together without visible distortion, without a break in their contours, for the first time in history.

The sailorman's interest in world history relates only to the net difference in means of travel between component parts of his unit globe. All history "pays off" to him in total sustainable knots. The shrinking dimensions of his world are computed in relative velocities.

We can see by experiment with this map why he laughs at the suggestion that "East is East and West is West and never the twain shall meet," for he sees that men as individuals have not only moved in the total course of time in all directions over the face of the earth, but that they emigrated essentially out of one major pool of civilization, which was Indo-China. Here East and West were originally one. From this one major pool there grew two main spearheads which we have come carelessly to identify as unrelated. This division into East and West occurred as the offshoots drew into diametric global positions in the course of their eventual encirclement of the earth. Growing out of the same unit mass of civilization, the eastbound and westbound spearheads progressively absorbed the lesser sources and their tendrils in Africa and South America, as well as the interweaving complex migrations.

The differences between the two spearheads existed only in the effects of environmental changes upon their cumulative technologies. The spearheads attained extreme diametric east-west remoteness in the period approximately called the Dark Ages.

The sailorman, alert to currents, can see the flows of history as the static historian fails utterly to do. He sees how some people have turned adversities into technical advantages, how they have gradually reduced the limitations to their elected motions, and how they have in fact accelerated their movements.

Let us retrace on the new map the major civilization flows in order to see more clearly the historical significance of our present dynamic world conditions.

Both major migrations appear as the gradual extensions of the horizon by successive generations. Because everything flows in the direction of least resistance, and because the heat to the south was too great, as was the cold to the north, the least resistant directions were approximately east and west. The next extensions of the generations are directionally random because the geography is random, but they are extremely uniform in the unseen thermal latitudes.

Establishment of these two great world trendings was unplanned by any systematic organization of society. These divergent trends are the articulation of biological forces demonstrating progressive equilibrium everywhere throughout the universe. Their dynamic inter-relationship, as modified by the total geographic scene, determines our fate.



Springing jointly from the Indo-China area, the spearheads both start in an easterly direction, but split at the Malayan tip.

One main stem grows in a general northeasterly direction along the islands close to the Chinese and Siberian coast, along the Aleutians and eventually down the coast of the Americas, with myriads of subsidiary spearheads penetrating inland from all along the main tendril. The nearer to the beginning of the main stem, the larger and more plentiful were the branches.

As offshoots of this first major spearhead coasting northeasterly, many tribes penetrated the Mongolian hinterland, passaging westward to the north side of the enormous Himalayan ranges. The vastness of this region lost them for millenniums, even to the point of seeming extinctions so far as the people still remaining in the land of their origin were concerned. Historically, these lost migrants are not heard of again in India until, as the Mongols, called Moguls, they come over the mountains in the days of Genghis Khan to rule their sedentary forbears. During the course of the thousands of miles and thousands of years of the many separate inland trekkings, the appearances of the individuals develop distinct and unique characteristics. Many demonstrate color evolution as a result of sustained changes in radiation conditions.

Many of these tribes reappear westward all the way from the Mediterranean to the Arctic Sea. They arrive in successive waves, for instance, as the Hellenes in Greece, and the Hungarians and Tartars along the Danube. Some of these tendrils double back toward the Pacific. Fragments of their more recent and vivid easterly motions have sometimes obscured from anthropologists the preponderantly westward pattern of the early Asiatic migrations.

Somewhat similar technical evolution characterized all of these people's wayfaring. They were constantly on the move because of the sharp changes of the northerly climate and vagaries of the sparse vegetation. Because of this mobility, they developed very sheer efficiency in their mobile living and hunting apparatus and in their survival routines. These wandering hordes, equipped for their inland migration with already-efficient technologies won from the sea, subsequently devised portage efficiencies which enabled them to overpower the more easy-going southerly peoples as they encountered them.

Despite this impressive inland migration, the greatest mass of the easterly spearhead's main stem stayed near the sea and fished and farmed along the fertile shores of the many river mouths of the China coast, where their progeny still exist as a teeming marginal life.

Reeling our continuity backward millenniums to the original ancient pool of civilization in Indo-China, let us inspect the coursings of the second major spearhead.

This second spearhead, which broke off from the first at the Malayan tip, drifted out into the myriad islands intervening between China and Australia. Though part of this seaward drifting was by accident, part of it must have been attempted by choice and, as such, constituted considerably more daring than that demonstrated by the people who hugged the coast. The separation of the spearheads constituted a first screening of psychological types. This psychological screening imposed by elective dealing with the dramatically presented problems of the unknown offshore deeps has been repeated constantly in subsequent history. For this reason sea history plays an important part in developing the psychological factors of modern problems.

Subsisting on the less fertile soil of the islands, and of necessity forced to wander from time to time, the people of the westerly spearhead learned to navigate or control their course of direction between the islands, to identify their chances with the favorable winds. Gradually they learned to make the passage even with less favorable winds, by quartering down wind, and, finally, by right-angling. In time they developed techniques for sailing better than abeam to the wind. From this broad reaching they learned to point up even closer toward the direction from which the force came.

Eventually they learned to turn the forces to their service, rather than to fight them or to give way to them. They discovered that they could challenge their fate successfully. Next they learned

to translate this angular wind advantage into increased speeds. Out of this technical about-face, accomplished by the island sailors of the southwest Pacific, grew the second major world migration, tending to girdle the world in a northwesterly direction. This second migration got underway in its ultimate direction at an accelerating technical advantage over that of the northeasterly-bound or number-one spearhead.

Developing its technology at a slower pace, the major north-easterly spearhead came naturally and in due course to evolve the square-rigger out of its down-wind sailing junk. The fore-and-aft rigs of the northwesterly-bound spearhead evolved from the swift South Seas proa or double-ended outriggers and catamarans. This second spearhead, having competed its U-turn and was now westbound in the face of the prevailing winds, renegotiated the Malayan tip. It then worked westward along Indian Ocean shores until it reached the Persian Gulf.

How can we be so sure of all this? Because in marked contrast to the fragmentary character of man's land-evolved mechanics, dug up only from ruins, every one of the boats and sailing types evolved throughout these earliest historical motions of man are still in use and may be found in operation today under the very same rules of technical logic and thinking as characterized their slow invention in the very same environment and part of the world where they were created. It is not necessary to guess how these ancient technical developments were used and, therefore, what they implied. What is more, boats were able to carry larger cargoes of the components of civilization than could be carried overland by men or beasts. Boats may be found in every phase of transition. Choosing at random, we witness, for instance, the single log evoluting into the compound log-raft bearing a straw-thatched hut, or the hollowed-out hulls replaced by ribbed and stretched skin kayak evolving into the canvas-decked outrigged rowing shell, or the half-raft-half-hull sampans, or the portable American Indian canoes, or the round basket boats rolling down the banks of the Tigris and Euphrates Rivers. The dhow, demonstrating a great advance in sailing technique, is today the work boat of the Persian Gulf. It is the same fore-and-aft rig with which man negotiated the westerly passage of the Indian Ocean.

In design, building technique and materials, the dhow follows the practices of Biblical and pre-Biblical times. It can point up into the wind more closely than the best of the America's Cup Defender sloops, though the handling of a dhow's spars is most crude and difficult by comparison.

Beating up the Red Sea and negotiating the Arabian Desert in the first overland navigation by caravans, the dhow builders again fashioned the same kind of ships in the Mediterranean, where they appear to have been the early vessels of the Phoenicians.

The major westerly spearhead is here wedded with the Hellenese tendril from the faraway northeasterly spearhead, as the peoples of the Peloponnesus and Phoenicia clash and integrate. This marks the first important phase of our intimate history of civilization. The conjunction of their respective advanced techniques, occurring under more favorable climatic conditions than those to which the Hellenes had been forced to accustom themselves, compounded to bring forth a civilization so distinctly in command of its environment as to provide the first large increments of time in which to demonstrate the arts, sports and philosophy. The two Asiatic migrations and the sea-borne spearheads are the mobile flanks to and the provision of leadership for the progressively settling-down population in their wake. The latter come to make up the great body of early Mediterranean population. This cross-breeding pool is that we call Western Civilization.

The fundamental difference between the Asiatic peoples and those of Western Europe and the Americas is intimately associated with these two fundamental histories of technical relationships to forces. While neither the major northeasterly nor the major northwesterly spearheads blindly opposed the forces, they respectively demonstrated diametric methods of using them. They demonstrated diametric attitudes toward life and death themselves—of ready commitment of self to death by the eastbound Asiatics, and stubborn refusal of it by the Westerners. To the Asiatic,



riding serenely down-wind, often over the horizon never to return, it is logical and noble that life may be suddenly terminated. He does not question the forces, the omniscience of the deities. Any back-eddying on the down stream flow is ignoble. Hara-kiri will cancel the ignominy.

The western-bound spearhead people of Europe, and of the Americas in particular, were repeatedly shuttling to windward and back, working the adverse force. The challenge provided by death has invoked amongst them the advancement of technology in general but in particular in medicine, resulting in marked extension of the life span. The unnaturalness of death to these people has caused its threat to outweigh ignorance and tradition in the vital emergencies and to admit science at the eleventh hour in a popular application, the extent of which has not been equalled in any of science's other potentials.

It is sound scientific speculation that the Garden of Eden episode documents the first psychological difference between easterly- and westerly-faced peoples. Adoption unto himself by the individual of the deity's knowledge of good and evil as first exhibited in the legendary beginning of the west-bound civilization, illustrates this fundamental difference between flowing with forces and turning them by rationalization into multi-direction advantage.

Both concepts are noble. One concept obtains immediate serenity by complete commitment to the sagacity of the Almighty, mysteriously bespoken by all events beyond the seeming control of His routine functions. The other concept wins serenity by faith in the ultimate over-all sagacity which therefore assumes welfare of the many to be implicit in every adversity. It gains its nobility, however, by assuming personal responsibility to discover and nurture into realization the universal benefits which, though tendered by the Almighty, must be earned by truthful labor.

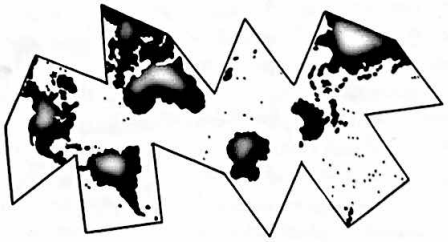
Reaching the Americas by the uphill route, the northwesterly spiral had acquired a myriad of technical advantages proportional to the multitude of adversities. This technically enhanced spearhead of society we have appropriately identified as the industrial. The American industrial civilization has been likened to a salmon which insists upon climbing waterfalls in order to propagate. Now ages old, no logic could justify sudden cessation of that force-eating northwestly trend.

Of course, East was to meet West. They met first in Greece and thereafter repeatedly as Vandals, Huns, etc. But they met for the first time after having come completely around the world from opposite directions, when European voyagers met the American "Indians." Of course, the westerly-bound were certain to go into the psychologically strange encounter under adverse conditions. Of course, the westerly-working were ultimately certain to turn the impact of the major trend forces to advantage. Already the westbound have pushed the eastbound three-quarters of the way back.

These population and technology flows are implicit in the comprehensive concept of the world which the accompanying map dramatizes, and typify the big motions that the sailor comes naturally to comprehend and cogitate by realistic imagining faculties. He also sees the whole world, its waters and its atmospheres, its electrical properties, as a continuously and reliably operating dynamical system.

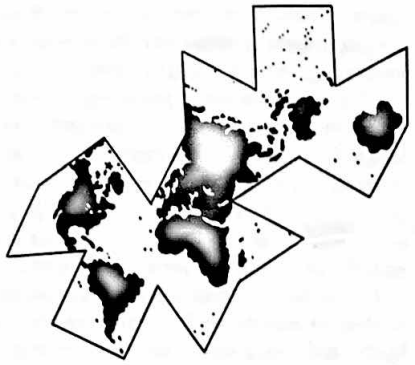
Long before the movies came along to provide Disney-like educationals, Rear Admiral Alfred Thayer Mahan, U.S.N., described for popular envisioning how the British sailormen had surreptitiously discovered that there was only "one ocean," near to whose center in the low-forty latitudes around the Antarctic, there roared a made-to-order, one-way merry-go-round to carry them swiftly eastward to the Orient, and from there swiftly eastward again into the Atlantic. Thus the English and Europeans logically spoke of China and India as the Far East.

Lieutenant Matthew Fontaine Maury, U.S.N., without any benefit of sympathy in his enterprise, but inspired by the cosmic eyes of the sailorman, made the preposterous proposal that the daily and regular log entries of the sea captains about weather conditions, wind directions, current drifts, etc., be methodically reported into a central record, despite the fact that the data

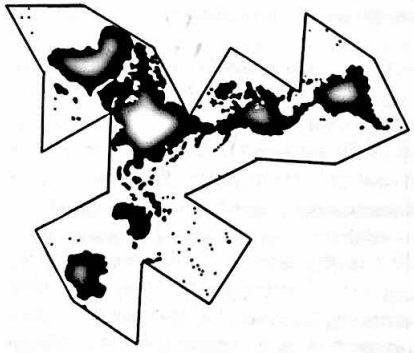


**EAST BY SAIL—TO THE ORIENT VIA GOOD HOPE**

From the Spanish Main via the Piratical Indian Waters. 12,000-mile great circle route from New York to Australia.

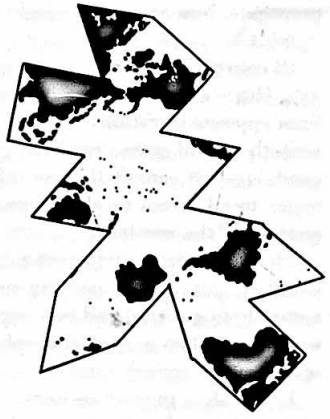


**EAST BY STEAM TO THE ORIENT VIA SUEZ**



**ONE CONTINENT**

Bottom of the Aeronautical Ocean



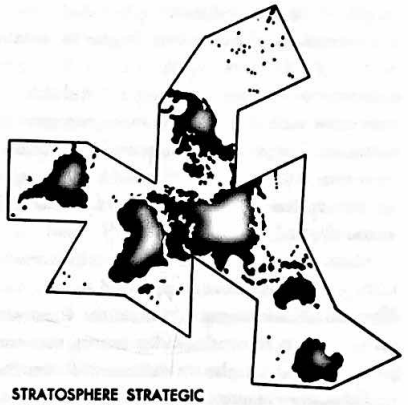
**ONE OCEAN**

Admiral Mahan named it. The British discovered and used it.

134 Four layouts of the surface of the earth as four historical determined interpretations of the world (1946). Above left: With the sailing ship around the southern tip of Africa. Above right: After the opening of the Suez Canal, 1869. Below left: The modern air-ocean world in the age of the airplane; the world as a single continent. Below right: British Empire.

**NORTHWARD TO THE ORIENT AND NORTHWARD TO EUROPE**

Old and new worlds on either hand. Russia overhead and McKinder's World Island trisected.



**STRATOSPHERE STRATEGIC**

European triangle controls the altitude merry-go-round.

1 In the March 1, 1943, issue of *Life* I published a world map on the dymaxion projection, with thermal latitudes shown in color. The dymaxion grid was there oriented from the North Pole, placed symmetrically at the center of a *square*, and the Greenwich meridian cut across the *square* at 90°. This was irrespective of the favor to the land masses (obtained in the map published in *the Neptune)*, *Life* deeming it essential that its readers recognize the familiar polar landmark which none of them had ever seen.

My first world map, entitled "Dymaxion Traffic Chart" was published in 1927 in my book, *Time Lock*. It is a perspective projection of the land hemisphere with the French Riviera at its center, and shows the North Pole a fifth of the way down to center, and the Aleutian Chain at the very top. Most of the Americas, Africa, Europe and Asia can be seen, though the southern half of South America, Southern California, Capetown and the Indo-China to Australia areas are missing. Numbers of little airplanes are shown, flying the logical world air routes—circling the Arctic as a major traffic turntable, as well as crossing through Europe to Dakar, over the Atlantic to Natal and up the chain of the Americas. Spotted all through the then-unpenetrated Arctic and tropics are shown a number of dwelling machines, modern environmental control devices which would make possible maintenance of service-conditions for the airports in these then-unlivable areas. To the best of my knowledge, this is the first world map which shows the comprehensive air traffic. It was republished in *the Architectural Record*, January, 1934, p.10.

My second world map, copyrighted in 1934 and again published in 1938 as an end paper for my book *Nine Chains to the Moon*, was my first experiment with unique projection methods. It was a one-continent map in which all visible error was massaged into the ocean areas. It was done with an integrator and a series of center lines from centers of areas, a method impossible for popular duplication or for any navigational means. Its main purpose was to clarify the one-continent concept which joins the chain of continents together over the Aleutian route. It was subsequently used in the February, 1940, issue of *Fortune* to demonstrate the relationship of world pupulation and the world energy slaves, and has been hung in the Smithsonian Institution.

135 Two further arrangements of the surface of the earth using the method of the Dymaxion Projection. Left: From North America northward to both Europe and the Orient. Right: Stratosphere strategy, Europe in the center controls the carousel of the jet stream. RBF in *American Neptune*, 1944.

might be years in reaching headquarters. Silly, impossible, impractical. But Maury, gradually accumulating information, began to advise sea captains that if in January they took one route and on the fifteenth of March another, they would reach their destination ahead of uninformed competitors. So impressively right did his predictions turn out to be that the United States then lent itself with vigor to his world-measuring program, adding this dynamic newcomer to the early universal language of green and red running lights, lighthouses, and bell buoys—all of them the common language of the world sailormen. The collection of data and scientific forecasting urged by Maury has developed directly into today's forecasting meteorology that guides successful world flight.

However, in Maury's time the down-wind sailing advantages, which could have been popularly employed, never appealed to adversity-embracing northwest spiralers in North America. The Americans wanted to do it the hard way. Noting that the English had monopolized the easterly and down-wind sailing below the continental tips, Americans forwarded their great seagoing tonnages right up onto and across their continent.

Thus, the American railroads developed out of the ocean steamer technology. Seagoing technology went up on the land onto steel rail canals. By principle, they brought up onto the land their ship masts, yardarms and lifting tackle, as cranes and winches to build bridges and great buildings. It was this ability, demonstrated most dramatically by the American transcontinental railways. To transport unprecedented tonnages, formerly carried only on the water, that was recognized by Sir Halford Mackinder, the English political geographer, and subsequently by Karl Haushofer, the German geopolitician, as tantamount to converting the dry lands to the functions of oceans. This concept formed the nucleus of the present mechanized warfare and automatically precipitated a reassortment of world economic and military factors.

As the industrial host of the northwest spiral populated the western American coast, it met direct flows of the easterly spearhead for the first time. Soon thereafter its into-the-wind sailing technology literally took the spearhead aloft to inaugurate the trans-oceanic service phases of the air age westward across the Pacific. The flying ships were heavier than air and therefore were borne aloft entirely by energy-control technology. Thus, once more, they discounted the easiest-way technology whose balloons appeared centuries earlier on the China coast. Abandoning even motorized and directable lighter-than-air craft, the northwestly spiral's airplane technology preferred to count upon obtaining its buoyancy, one hundred per cent, on projections of the intellect. Now proven far swifter, safer, and higher flying, this modern stratospheric sailorizing is demonstrating dramatically to the static-minded landsman that he is indeed living in an all-motion dynamic universe.

Here the real principle of isolationism demonstrated its own fallacy. Isolationism was something deeper; it was staticism, blind inertia. When you have a whole continent to yourself, thousands of hours away from others, you can play ostrich or any other game, year in and year out, and you can falsely attribute your advantage to Santa Claus or any other cause and no one can deny the error. But if you want to play ostrich on Broadway, you are liable to get knocked over from behind.

Now, as land and air navies grow rapidly, while colliding in cataclysmic demonstrations sailorman's viewpoint becomes ever more popularly cogent. And the viewpoint, enhanced manyfold by new instruments and instantaneous, world-girdling communication, begins to see the spinning little world even more neatly. As yet somewhat ahead of popular comprehension, the modern sailor has investigated the higher reaches of the world's thin wrap of atmosphere. He sees that not only does the Earth spin eastward, but that the water upon its surface, though displaying many a back-eddy, also spins eastward in net motion and at a greater velocity than the easterly spinning of the earth below it. Freer still of land obstacles, he finds that the atmosphere also spins in an easterly direction at an even faster rate, and that the atmosphere's main flows



circle primarily around the Arctic and Antarctic Circles, while its back-eddies articulate storm-breeding counterspirals downward at the Poles, with a steadily flowing back undertow the Earth's Equator known as the "trade winds."

Thus the sailorman discovers, to the surprise of the staticminded landsman, that the earth is spinning in space under its own momentum at a slowly running-down speed, but that forces are pulling the Earth around, the elements in their more plastic condition pluming forward to reveal the pull. Thus also the sailorman discovers, to the surprise of the landsman, that it is only one-third the distance in the stratosphere from Kamchatka to Alaska as from Alaska to Kamchatka, provided one's plane can average two hundred miles per hour. He also discovers that a seventy-mile-an-hour dirigible could not make that stratosphere flight at all. He discovers that he was wiser than he knew in ticking to his intellect flying.

By flight in the stratosphere Arctic Circle, in present transoceanic equipment, it is much quicker to go to Russia from Alaska via Greenland, and to go from Norway to Minneapolis via Siberia and Alaska, than to back "uphill" via Greenland. This is information that yesterday's practical people would have said was of no importance. It will certainly not be many years before this is more important information to most people than the Pennsylvania Railroad timetable is now. Our new map has the ability to demonstrate relatively greater air distances by appropriate arrangement.

The sailorman knows that the library globe is mounted in an azimuthal circle, and its polar axis is tipped only to demonstrate the theory of the earth's motion relative to the sun. Observing how much complication is introduced to inadequately reveal a somewhat irrelevant fact, the twentieth-century sailor classifies this library globe as a pretty contraption, as beguiling and misleading as the planetarium in its ineffectiveness. Forced to deal more realistically with a spherical world, he found the globe was a miniature plaything, too small to provide him with important navigational data beyond the most sketchy plans of great voyages. A globe large enough to reveal working data on hazards and aids to navigation would lose any ship in its vast innards. Sailormen need both sectional charts and comprehensive maps.

Then, too, it became evident that one can never see the whole world at once by means of looking at the globe. One cannot see even half of it, due to the rapid increase of curvature tangential to the lines of perspective. The viewer, holding the picture in his brain, could spin the globe and piece together the imaginary continuity.

A typical landlubber invention designed to correct this shortcoming was once exhibited in a New York City museum. This globe was big enough to permit the viewer to stand inside. The usual exterior surface data was inverted to the interior. However, unless one could see through the back of his head, vision was limited as before to less than one half the surface. Though hailed by the intelligentsia, this item disgusted the sailor.

Preposterously distorted in its polar regions, Mercator's cylindrical map, tangential at the Equator, was none the less preferred by the sailor to the globe. He found Mercator's map could be unrolled to represent the whole world. So long as man's comings and goings were centered within the warm belt girdling the Earth at right angels to its axis, the Mercator map was a pretty satisfactory affair.

But as suddenly as cities have been wiped out by air bombings, there has come upon the people the necessity for seeing the world as vividly as the sailorman has. Suddenly, within months, people have come to realize that they can girdle the planet in an infinite number of directions. The world has been surprising itself by coming in its own back doors and down its own chimneys from every unlooked-for direction. This has called for a revolution in map making and in cartographical principles such as history has never seen. A need has risen for new methods of peeling data off the globe and for assembling the peelings in such a manner as to gain useful knowledge of the spherical coursings.

While still imbued with the static pictures and the traditional thinking, people viewed the first appearance of the new maps as novelty. Any inclination to comprehension of the relative merit of the different maps as a result of comprehension of the principles by which they were constructed was thrown into utter confusion by the welter of pedagogic terms. Sinusoidal, conformal, azimuthal, gnomonic, orthographical systems, scared the layman away from making criticism of the appearance of Australia as a kidney bean three times the size of South America. Feeling the progressive urge to global comprehension, he produced a mass market for commercial globe manufacturing, but after a few swift inspections, these were relegated to decorative functions from their role as daily tools. Much more important to him were the newspaper maps of the daily war scenes. Out of the newspapers and the novelties, people are beginning to see that there are some interesting new angles and proportions. Unfortunately, most landlubber cartographers prefer to impress people with the difficulties and aesthetics of their art rather than with implications of the dynamic geography of a world-industrializing people.

People are catching on that great circles constitute the spherical straight line and that there is an important continent at the Antarctic and not a jagged, icy fringe along the bottom of an east-west Mercator layout. This advance in popular awareness is despite the fact that during World War II the traditional suppliers of maps provided streamlined equatorial Mercator world maps for all the allied war offices and accessory bureaus, upon which maps the ocean distances between Greenland and England appear greater than those between Tokyo and San Francisco.

People are learning that "via the North Pole" is the shortest great-circle distance from America's midst to the center of population of the world. But when they were told during the war that Tarawa represented the first major gain in the direction of Tokyo, they were not well enough versed in their geography to realize that announcement that the Marines had taken the North Pole would have put the United States closer to Tokyo's center, and that the Marines were actually farther from Tokyo than Chicago is from London. And even those professional geographers and military tacticians who did know that these were the proportionate distances by great circle, have not, unless skilled in the dynamic sailorman's thinking, realized that in the terms of the air motions which twist the great circle courses all out of shape, the North Pole is a third nearer to Tokyo than Tawara, when full advantage is taken of atmospheric motions.

Because of this latter fact, it becomes obvious that the kind of map that static cartographers produce can only partially educate the people—that is, up to the realistic great-circle concept. All known traditional projection methods fall far short of providing a comprehensive, sectional cartographical device which may be mutably arranged in any direction in such a manner as to bring focus to bear on any of the dynamic inter-relationships of the world's surface affairs.

One such sailorman's mid-twentieth-century invention is the mutable map presented here. Appropriately, its faces represent the facets of the monometric construction shown in the accompanying drawing, which drawing represents the vector equilibrium of a sphere.

Unlike all known preceding projections, which represent transfers of spherical data to plane surfaces tangent to the sphere only at one point, as in the case of the azimuthal or gnomonic projection methods, or only along one central line, as in the case of the Mercator, or only along one or two segmental arc lines, as in the conics, this projection is one in which the coincidence with the projected sphere occurs all along the complete boundary of each section of the projection, thus retaining the unique cartographical feature of being the only projection in which uniform great-circle scale characterizes the logical terminal edge of each section to be projected, that scale being maintained intact after transfer from the sphere to the flat surface of the map.

Sailorwise, this new projection is made from the cosmic viewpoint—that is, the astronomical zenith and the center of the earth always remain, respectively, vertically above and below each and every point of the surface of the cartographic data. Not only is this true in its spherical arrangement but also in its planar projection into the sections of the comprehensive map.



Because the enclosing border scale cannot be elongated, distorted or contracted, and represents a great circle bent flat into a one-dimension line, the adjustment of the contained spherical surface segment to a plane surface segment must be satisfied by interior contraction of the data instead of by exterior stretching, as in all other methods of projection. Because of this feature the several pieces fit neatly together, being the mutual sides of adjacent polygons and being separated by the same great circle or straight line. Because the area of a circle increases as the square of its radius, the same error outwardly disposed must be distorted to four times greater extent than by inward disposition.

The segmentation of the earth's surface into eight triangles and six squares is not in any sense a matter of esthetic choice. It represents one known subdivision possible by means of this universal-projection viewpoint, for the radial and chordal lengths must be identical in order to allow this symmetrically hinged opening of the sphere.

Having six axes and four dimensions, its parts may be rearranged to unpeel the globe continuously in all directions. Gnomonic projections through the surface facets of any of the regular polyhedrons will serve to provide a variety of sectional world surface maps. Striking an optimum between angular contraction and numbers and sizes of pieces, an icosahedron is the least distorted, for these projection purposes, of any of the regular solids. However, the spherical vertexes of the icosahedron's twenty triangles must be reduced from 72° to plane triangular vertexes of 60°, a reduction of twenty per cent, which percentage times the number of pieces gives the total distortion. On the other hand, the Dymaxion's fourteen pieces accomplish translation with a distortion of only sixteen per cent, the Dymaxion's spherical triangles being only 70° and the vertexes of the square bearing the same percentage relationship between the spherical and the plane figure.

The Dymaxion projection method of transferring spherical data to the plane surface is extremely simple. Because of its universal viewpoint, it need deal only with the surface of the sphere and the plane surface of the map. A lattice of four great circles is formed about the sphere, each intersecting the other in such a manner as to subdivide each circle into six symmetrical arcs of 60°. This lattice provides fourteen spherical surface areas, eight of them triangular, six of them quadrangular. These spherical triangles and squares are equilateral. The surfaces of these triangles and squares are then interwoven with great circles and the squares by a two-way grid of great circles. These grid lines spring from uniform scale modular subdivisions of the 60° arc sections in as fine a degree as is desired.

The geographical data coinciding with these grids is then transferred to eight equilateral plane triangles and six plane surface squares. For purposes of this translation, the plane triangles and squares have been prepared as follows: Their surfaces are subdivided by respective three-way and two-way grids of straight lines. These straight lines spring from modular subdivisions of their boundaries which correspond in scale and number to the subdivisions of the original spherical arc segments of 60°. The spherical geographical data is then posted to corresponding positions in the appropriate plane grid spaces. The spherical great circle grids are thus treated as constituting straight lines in the plane geometrical surface. The principle of treating great circles and straight lines as constituting one and the same thing, effects the distribution of the angular contraction in a concentric disposition on the plane sections.

The key to understanding why this method accomplishes its translation with a minimum of distortion is that it treats the 180° spherical gores in two ways. The irreconcilable conditions of convergence and parallelism, characterizing the terminals and mid-part of the 180° gores, are treated separately and symmetrically as triangles and squares respectively. All other projections impose the advantage of one feature against the advantage of the other by trying to solve both convergence and parallelism by one grid. These resolved gore parts of the Dymaxion map, by treating these conditions separately, allow four-dimensional unwrapping of the sphere.