Design of cities: in the age of Mars colonization

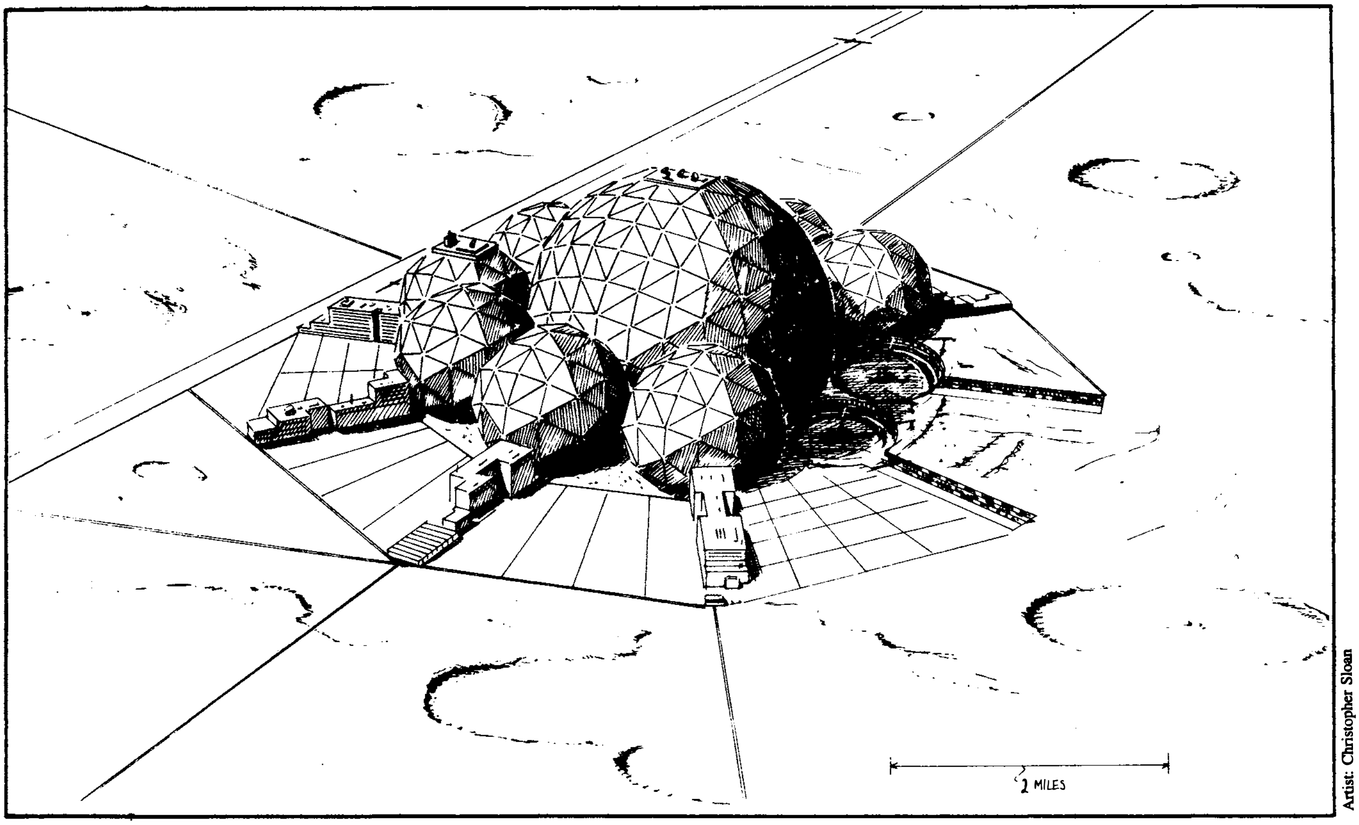
by Lyndon H. LaRouche, Jr.

Planning the colonization of Mars gives deeper meaning to the ages-old task of rendering man's habitation of unfriendly natural environments fruitful, healthy, and as agreeable as possible. We must consider features of the artificial Mars environment other than merely the molecular-biological requirements of the human being. We must take into account the importance of immunizing the psychological well-being of the colonists, against the eerily new kinds of stresses associated with prolonged exposure to the alien environments of space.

We must take into account, in a new way, both the physiological and psychological importance of the architectural design of the local environment in which the explorers and colonists work, and perform their normal personal functions away from the workplace. Admittedly, the permanent colonization of Mars is probably 40 years ahead; yet, even now, in the early stages of planning that colonization, and during the coming months and years, we must set some of the architectural guidelines for planning the future geometry of the new cities, the working space, and the ordinary living space, in which space explorers and colonists will work and live.

Increasing fascination with space-exploration, especially among the young, ensures that whatever we announce as necessary features of the colonization of the Moon and Mars, will have an increasing impact in reshaping the policies governing life here on Earth. Even in the stages when only a handful of Earthlings are actually venturing into space, increasing portions of the Earth-bound population will shift the popular sense of human identity toward the idea of mankind as a space-explorer and space-colonist. This will bring about an adjustment in popular values, a change in the way human beings think about human beings.

During the coming years, while flights deeper into solar space are still mainly in the planning and development phases, more and more people on Earth will look at life here on our home planet through eyes which are becoming, in the informed imagination, the eyes of the space-explorer. With ever-greater frequency, the suggestion will be made, that which we can accomplish in space might point toward the best solution for problems here on Earth.



Kepleropolis is our best guess on the appearance of the first city on Mars. The problem was to design a city capable of supporting 500,000 individuals. The main dome of 1 mile in diameter is built in a near-hemispherical crater and made of some as yet unidentified material which would be transparent, yet block cosmic rays. The sphere of the dome would be placed such that its "ecliptic" was at ground level. At surface level under the main dome would be a large educational/recreational park. Immediately subsurface would be administrative offices. Below that would be various levels of transportation, storage, and a central fusion power facility. Atop the dome is a 1-mile high observatory and communications station. Surrounding the main dome are 10 domes capable of supporting "neighborhoods" of 50,000 individuals each. They are linked to huge industrial buildings extending along 10 radii from the center of the main dome. Areas between the industrial buildings are devoted to terra forming, agricultural, or other activities related to the industries. This particular drawing shows the city while under construction.

This spillover of space planning into practice on Earth, is a sometimes indispensable, as well as a likely result of the growing popularity of space colonization programs.

Over the years immediately ahead, increasing attention to the design of future cities on the Moon and Mars will lead toward the easier recognition of the urgency of the establishment of many new cities on this planet, new cities designed and built—not only in the Sahara Desert—in ways influenced by our thinking about architecture in space. That connection is the subject area within which this report is situated.

To bring this matter within the reach of as many laymen-readers as possible, I begin with reference to some very ordinary features of my own adolescent introduction to "human engineering," to show how this led me to uncovering the scientific principles which should govern proper practice of architecture in space colonization.

'Human engineering'

My first gainful employment began before my 16th birthday, in a summer's job as what is called a "hand-dinker"—at 25¢ an hour—in a slipper-manufacturing firm. It represented about as low a level of skill as one might find in such a place. My assignment was to stand at a wooden block, with a die in the left hand and a shoe-cutter's mallet of several pounds weight in the right, and to punch out as many of the same object as I could, over and over again, each hour. At first, that work seemed to me about as boring as one might imagine. I quickly realized that it need not, and should not be boring.

My thoughts at that work-bench were on the subject of what is called "motion-study." The object of my inquiry, was to discover how I could accomplish the maximum of the desired result with the least effort—soon, I added: the least painful aftereffects experienced overnight and the following day. The mental image I adopted, was of the ordinary pendulum of a grandfather's clock: to achieve a rhythmical movement, in which my body fought itself the least in bringing about those motions, with the proper force, to achieve the optimal result.

My father had secured this lowly employment for me, as part of his program for training me as a management consultant in the shoe-manufacturing industry. Indeed, this did help to impel me toward the consulting profession. The scientific principle I confronted in seeking to master that lowly, repetitive toil, was an experience which guided my attention to the character and importance of "human engineering" of the operator's workplace, and of the traffic flow of materials and work-in-progress through the production center locally and the production facility as a whole.

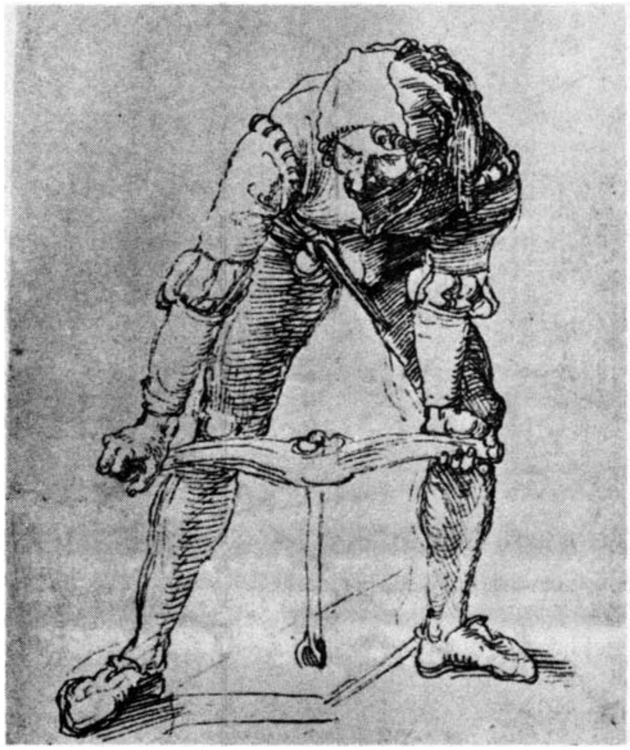
No person, but one who has developed the habit of looking at every experience in this way, should be considered qualified for the profession of "economist." Do not tell me silly money theories of how objects are bought and sold; tell me exactly how they are produced and how they are physically distributed. Tell me how much labor, of how many people, working under what conditions, is required to provide an acceptable standard of market-basket of goods for one household. Tell me not the importance of a certain amount of money in a salary or wage; tell me not merely the money prices of things. Tell me what kind of a life a year of a man's labor will, on the average, buy for his family household; tell me how you propose to effect economies of labor which will help to improve that life.

Only one who understands the importance of these questions, and has acquired the skills for answering them, is qualified to become an economist. These attitudes and skills are not sufficient, by themselves, to qualify a person as an economist; but, no person who lacks these rudimentary skills will ever be better than useless as an economist.

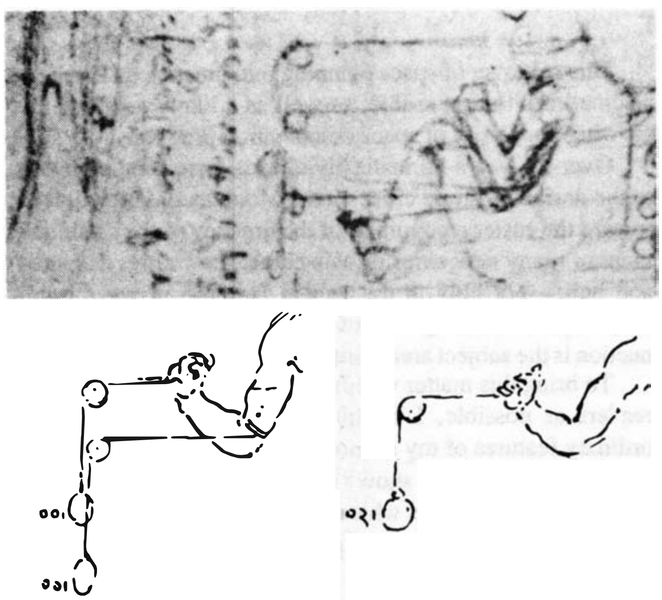
In recent decades, industrial "time studies" by teams of so-called efficiency experts have become notorious, as the higher-priced, trained industrial engineering was replaced, by the cheaper fellow hired off the street for his skill in wearing a white shirt while using a stop-watch and clipboard on the factory floor. Today, "time studies" are notorious, because the drift has been away from capital-intensive investment in economy of labor, toward increasing the labor-intensity of the workplace. As my own view of "hand-dinking" experience indicates, the purpose of industrial engineers' "human engineering" practice was directly the opposite to policies of labor-intensification; the purpose was to achieve greater productivity and quality with less effort by the operative.

The benefits of "humanistic engineering" (a better term than "human engineering") include such obvious economic gains to employer and employee as lower rates of industrial accidents, less cardiovascular and other illness, and so on.

The skilled industrial engineer did not need to refer to a stop-watch very often. The norms of movements of eyes and limbs, once established, gave the industrial engineer handy reference tables of a sort he understood, because he had learned to construct such tables as part of his professional



Classical studies of motion in the human body from the Renaissance. Above: Albrecht Dürer, pen and ink study of a Young Man leaning forward and working with a large drill (journeyman joiner), around 1500. Below: Leonardo da Vinci sketches showing the estimation of human muscular effort with the help of a dynamometer. The force is measured in pounds which represent the lifting capacity of the group of muscles under scrutiny. In the sketch above, no fewer than six different cases covering the whole body are examined, while in the sketches below, Leonardo tries to compare the force of the arm in different positions and points of attachment.



Source: *Leonardo the Technologist*, by L. Reti and B. Dibner, Burndy Library, Norwalk, Conn. 1969. From Paris Ms. H (written ca. 1494) fol. 43v and 44r.

education. He worked essentially as I thought through the best methods for hand-dinking. He thought about the physical geometry of the movements of man, machine, and work-in-progress; once he had mapped those qualitative features of the job, he could assign allowed times for each required motion with far greater accuracy than a platoon of time study boys studying the same workplace.

As a youth, I saw this problem expressed in a brutal way each time I stood in a shoe-manufacturing payroll line-up myself, or observed the operatives punching out and leaving the plant at the end of the day. I could identify accurately the nature of the occupation of the older operatives, merely from observing their bodily movements as they passed the time-clock. Their bodies were distorted by the combination of labor-intensity with the peculiarities of the organization of the workplace; so, one could spot the lasters, the welters, and so forth, from the posture of their arms, torsos, and way they walked.

Sadly watching that parade, one recognized the human importance of making operatives more the masters of their machinery, less an increasingly crippled appendage of the machine.

For this reason, I learned to hate technological stagnation bitterly. In "humanistic engineering," we work to change the geometry of the workplace, to the effect of simplifying the motions, and reducing the effort required of the operative, with special emphasis on eliminating the kinds of repetitive motions which are unhealthful. We recommend to the employer: "build this . . . change the lighting, so . . . this change in the tooling of the workplace," and so on. In a climate of investment in technological progress, there is gain in profit and quality by the employer, and personal and income advantages to the operative, too.

Trading so many dollars' worth of unnecessary exertion by the operative, against an investment which costs actually less per unit of output than the amount saved in terms of unnecessary operative's exertion avoided, is the normal way in which productivity increases with gains to the operative as well as the employer. This is true up to the point that paid-out dividends become too large a portion of gross earnings, or borrowing costs for new investments in capital stocks become much too high.

The humanistic professional might measure his personal satisfaction from his work, by reflecting on the image of twisted bodies of middle-aged operatives parading past the time-clock. The personal conscience of the true professional is: that saddening spectacle, and everything akin to it, must be eradicated systematically from our production.

The gains effected so, are not merely physical ones; the mental ones are more or less as important. In the longer time, it is the mental gains which are of the utmost importance. The employer who says to his employee, "I don't pay you to think," is not the genius-laden tycoon he might think himself to be. The secret of the superior productivity of U.S. labor, in times dating from earlier than our recent 20 years of "post-industrial" drift into technological stagnation, was precisely that U.S. farmer's and industrial operative's superior ability to think while working.

Every good industrial manager agrees. He might inform you of the steady gains in quality of product and productivity which industrial firms obtained through the employees' suggestion box. He might also instruct you on the subject of increased accident-proneness among operatives for whom a lower premium is placed on thinking as integral to the operative's role at the workplace. A more profound, more valid general argument could be made: The biophysics specialist might suggest that we correlate brain alpha-wave activity in persons with their ability to sustain continuing technological progress efficiently—and to avoid accidents on the job, or while driving a motor vehicle.

In general, as the level of skill and technology are increased, production depends increasingly upon a more active role by the operator's capacity for effective kinds of problem-solving innovations, as an integral part of the workplace.

Think of space colonization as what it is: essentially, very high levels of skill and technology by every person involved.

The chief flaw in the relatively better sort of industrial engineer practiced up to about 20 years ago, was the lack of attention to what should have been recognized as the underlying principles of motion-theory. Industrial engineering education should have included at least two years' span of study of the relevant work of Leonardo da Vinci, Albrecht Dürer, Raphael, and Johannes Kepler. Had such studies been promoted as they should have been, a good industrial engineering graduate would have understood the principles which govern economy of labor. He would have mastered also, the rudiments of applying classical principles of aesthetics to architecture and urban design, and understood these subjects properly from the standpoint of "humanistic engineering."

General design of a city

At the end of World War II, significant numbers of the leading scientists in Germany were gathered into a pool at Aachen, awaiting reassignments. Some of these applied their skills to planning the reconstruction of the war-ruined Ruhr district. Part of their design was implemented. Other elements, if not implemented, nonetheless influenced thinking about reconstruction policy.

Since about 1977, I had been engaged in studies for the economic development of Africa, including the urgent need for building cities of a new type in black Africa, as an indispensable, central feature of any successful effort to develop black Africa in a general way. My own work in the latter connection gave my associates an advantageous standpoint for recent examination of the work of the Aachen circles; leading features of the Aachen designs coincided on key points with principles of design I had come to view as elementary through my own work.

Such is science. Different groups of investigators, in different times and places, but working from the same general store of knowledge, converge on the same result. The right principles of design of cities, are not matters of local tastes; they are as universal as is the nature of the individual human being who, as the inhabitant of the city, is the measure of its proper design. The unchangeable principle governing the proper design of a city is elementary; it is the same for a city on Earth as it is for a permanent colony on Mars.

The proper design for a city, is a study of motion of people, the goods they use, and their activities. The general scheme for design is therefore the principle of least action—which I shall describe at a later point in this report. It is sufficient, for the moment, merely to state as an assertion, that the definition of least action required for this purpose is harmonic orderings cohering with those determined by the Golden Section of the circle. For reasons to be made clearer, the significance of the Golden Section suffices to show that the general design of a city is implicitly a proposition in Gauss-Riemann topology.

I shall develop this theme by stages, after I have described the general arrangements.

The simplest form of result has three features: 1) The paradigmatic form, for approximately level regions, is spherical, with one hemisphere lying above the surface, and the other below the surface. Let us term the circular cross-section of the sphere at the surface-level the "ecliptic," as in the ecliptic of the solar planetary orbits. Then, 2) The harmonic organization of the ecliptic is analogous to Kepler's arrangement of the orbits of the Sun and its eight major solar planets, as divided by the domain of the shattered ninth planet, today's asteroid belt lying between the orbits of Mars and Jupiter.

The Sun, tuned to a Keplerian F, is the central educational park of the city. The orbits of Mercury, Venus, Earth, and Mars, correspond to the administrative and residential areas of the city. F-sharp, the asteroid belt, is the boundary between the inner city and the outer, "industrial" planets.

Since the design of the city is based on least-action movement of human activity (per capita, per hectare), it is the transport system—for persons and freight—which appears as a delimiting feature of the internal design. In the modern form of the city, this movement is on distinct levels: walking, passenger rapid transit, subsurface transit of freight, subsurface transit of activities by utilities.

Thus, the subsurface hemisphere is defined in terms of subsurface movements of people and freight, and in terms of stores of essential goods: the density of the subsurface structure increases as a function of per capita motion per hectare as we proceed inward from the "asteroid belt" to the "Sun," the educational and classical cultural activities situated within a large, educational and recreational park. So, within the inner part of the "solar complex," the density of activity increases as we near the "Sun."

Beyond the asteroid belt, the per capita density of activity per hectare in industrial use, again increases, initially relative to the average for the inner portion of the complex as a whole, and then diminishes again, as the eye travels toward the outermost orbit of these "outer planets."

Throughout the complex, the density of movements per capita per hectare is harmonically distributed as in planetary orbits: these are defined in terms of transport systems, especially the subsurface rapid transit, freight, and utilities. The spokes and rims of these transport orbits are cut by a plane self-similar spiral of movement, radiating from the "Sun," and intersecting the spokes and wheels of the outward and lateral movements.

The spokes are twelve in number, and the inner orbits are four. So, the spokes are named North, Northeast by North, Northeast, Northeast by East, and so on. The orbits are named for musical tones, Kepler-style. The spiral-way is known as the Gaussway.

This signifies that such a city has a finite maximum population. If more population is to be accommodated, an additional city must be developed, linked to others by high-speed magnetic-levitation rapid transit links—at nominal speeds of about 300 miles per hour. (Indeed, magnetic levitation is used throughout the surface transit systems for movement of persons and freight.) How large is that finite maximum?

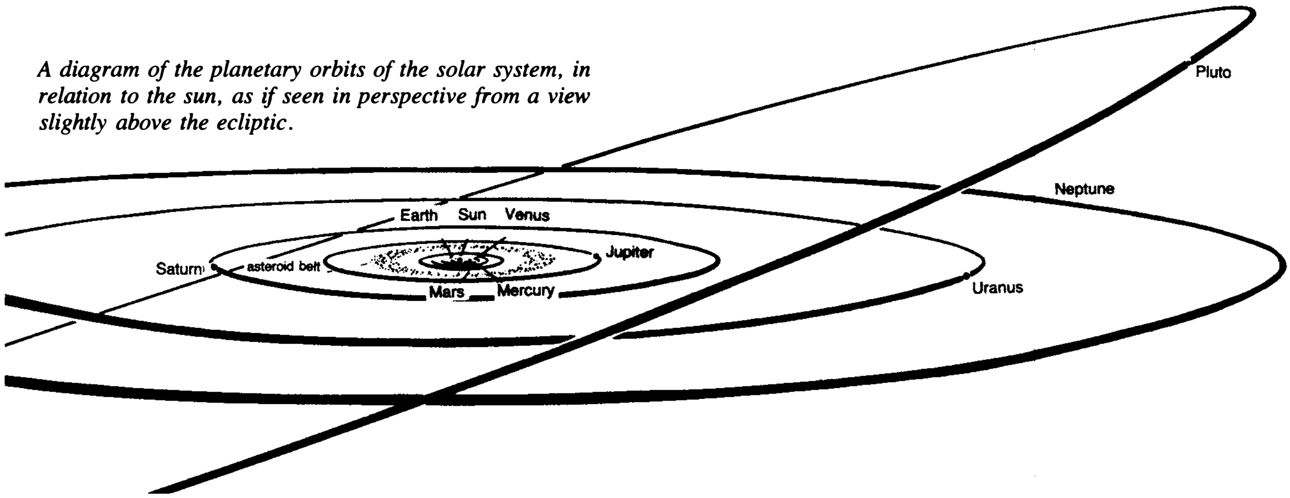
At first glance, three factors appear to decide this: 1) The unit-area and volume required by an average person's mean-free-path motion within the city: the congestion factor; 2) The ratio of lapsed time expended in normal travel by a person within the city, to time spent in other activity; 3) The size of the "Sun."

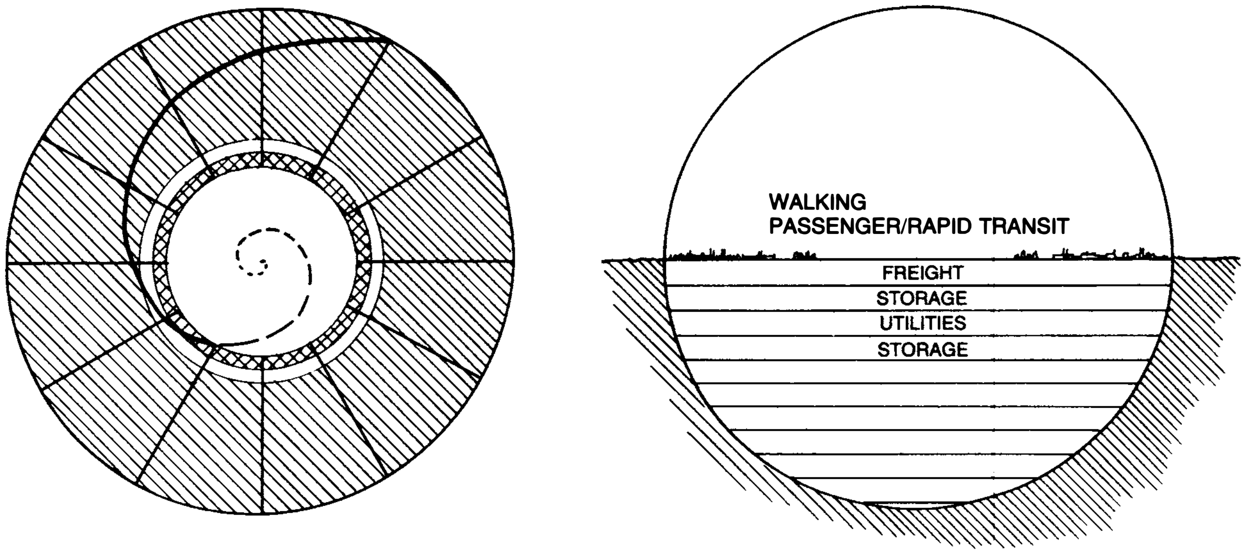
These three factors must take two other sets of factors into account. The first of those two other sets of factors is, that each design of a city is delimited by my six primary constraints for a Riemannian representation of technological progress: 1) Level and rate of improvement of per capita masket-basket content, in quality and quantity; 2) density and rate of increase of usable energy available per per-capita unit of per hectare population-density; 3) level and rate of improvement of effective energy-flux density of modes of applied technology; 4) ratio of rural to urban labor force employment in the region in which the city is functionally located; 5) ratios of employments of the urban labor force, in terms of scientists and kindred professionals per hundred members of the labor force employed as operatives, and in terms of capital-goods producing to household goods producing operatives; 6) the general level and rate of advancement of technology in practice. These six factors define the true basis for measuring individual activity levels within the city as a whole.

This is also affected in obvious ways, by the second additional set of factors, the demographic factors centered around the birth-rate per female of child-bearing age-intervals, and life expectancies.

All three sets of factors, taken together as part of a single function, are the primary determinants of the city's proper choice of maximum population levels.

A diagram of the planetary orbits of the solar system, in relation to the sun, as if seen in perspective from a view slightly above the ecliptic.





Two schematic diagrams of a hypothetical future city, on Earth or on Mars. On the left is the "inner city" with its educational park (the "Sun") at the center, and surrounding residential and administrative zones. The rims are analogous to the orbits of the planets Mercury, Venus, Earth, and Mars. The boundary of the inner city corresponds to the asteroid belt. A self-similar spiral from the "Sun" park to the asteroid belt is called the Gaussway. The right-hand diagram shows a vertical cross-section of such a city, with the functions to be situated in the upper or lower hemispheres, respectively. The heaviest increment of cost in the building of the city, will be the emphasis on building the deep substructure first, and then putting the upper portion of the city upon that prepared substructure.

In all these considerations, the irreducible quantum of action is the activity scale required for the average individual. The individual person's level of activity, per unit of population-density, becomes the definition of scale, with respect to which all other measurements are defined.

A good design for a beautiful city, is one which will be durable through a thousand years of technological progress. This presumes that the city is designed such that it easily adapts to the effects of technological progress.

It adapts so, in terms of increasing of the energy-density per per-capita unit of population-density. It adapts so, in terms of raising the level of effective energy-flux density per square centimeter cross-section of target-area of work. It adapts so, to related increases in mobility of persons. It adapts so, to the increase of the ratio of time expended in creative leisure, to that required for labor.

What remains constant is man. The biology of the person requires daily about six to eight hours of sleep, two to three hours expended in eating. We know today, or should know, that—for what might be termed pyscho-biological reasons—no acceptable substitute for the "nuclear family" as a mode of development of new individuals will ever be discovered. We know that maturation will never be briefer than a span of between 20-odd and 25 years, of which at least between 16 and 18 years must be within the setting of the family household.

From this, the design of the dwelling unit follows. The size of sleeping and bathing quarters, the need for dining areas and their dimensions, and so forth, are defined in an elementary way. Improvements in privacy of thoughtful activities, and other advances in quality of dwelling places are desirable, and will become more demanded as society progresses. Yet, walking through some better maintained, older areas of cities in Europe, and elsewhere, and from scholarship in the same matter, we see that the elements of design of a good space organization of the dwelling unit have not changed much over centuries, even thousands of years.

If we learn from those studies, by applying principles of "humanistic engineering" to what we learn, we can do much better today than any preceding generation of mankind, in building a city today, for whose design we will be thanked by its inhabitants a thousand years into the future.

Natural human movements

As I stated earlier, 20th-century industrial engineering wasted much of its efforts, and contributed a few important mistakes, by neglecting the rigorous study of the natural movements of the human body associated with such pioneers as Leonardo da Vinci, Dürer, Raphael, and Kepler.

Since classical Athens of Plato's time and earlier, it has been the central principle of classical aesthetics, that beauty of form and movement is limited to those harmonic orderings of form which are coherent with a harmonic series based upon the construction of the Golden Section of the circle. Classical Western aesthetics defines this as a rigorously definable standard of beauty for the form of music, poetry, painting, sculpture, and architecture.

This standard was embedded in Western civilization by such writings of St. Augustine as his *De Musica*. In the wave of city-building unleashed by Charlemagne, what were called "Augustinian principles" were the guide to the development of cathedral towns around such "Augustinian" works in light, acoustics, and form, as the famous cathedral at Chartres. Classical aesthetics was defended during the "New Dark Age" by such influentials as Dante Alighieri and Petrarch, and became the central theme of the Golden Renaissance at about the time of the 1439 Council of Florence. Brunelleschi's successful invention in architecture, completing the construction of the dome on the cathedral at Florence, was a signal point of reference throughout that century.

The single most influential scientific thinker of that entire period was Cardinal Nicolaus of Cusa. Cusa's revolution in scientific method first appeared in published form in his 1440 theological text, *De Docta Ignorantia* (*On Learned Ignorance*). This text included a revolution in ideas about geometry and physics, solving several classical problems left over from the work of such as Parmenides, Plato, and, most immediately, the Archimedes whose work on the quadrature of the circle Cusa directly corrected in his own 1440 book.

What Cusa actually accomplished, was the establishment of a true "non-Euclidean geometry." Instead of a system of deductive theorems, based on a set of axioms and postulates, Cusa showed that the physical laws of the universe could be represented by means of nothing more than geometrical constructions, constructions all based on no more than a single principle of physical geometry. This principle of Cusa's is rightly described as a "Maximum Minimum Principle." In geometry, it is recognized as including the so-called "isoperimetric theorem of topology," as that was elaborated by Bernoulli and Euler at St. Petersburg during Benjamin Franklin's lifetime. In physics, it is recognized as the Principle of (Physical) Least Action, as this was variously defined, geometrically, in various stages, by Fermat, Leibniz, and the work of Karl Gauss and his successors.

Following the publication of his *De Docta Ignorantia,* Cusa devoted a number of other published writings to matters of scientific method. Leonardo da Vinci was brought to systematic study of Cusa's scientific work through Leonardo's Milan collaborator, Fra Luca Pacioli, of *De Divina Proportione* fame. From the collaboration between Pacioli and Leonardo, nearly all of modern science was set into motion, together with several revolutions in painting and music.

Briefly, to assist the layman in following this, the part of Pacioli's and Leonardo's collaboration which is of direct bearing upon the understanding what we have identified as "the scale of individual human activity," is the following.

In one of his most influential dialogues, the *Timaeus,* Plato presents and discusses the fact, that in visual space only five regular solids can be constructed. These—the tetrahedron, the cube, octahedron, the dodecahedron, and the icosahedron—have been known since as "the five Platonic solids," or, simply, "the Platonic solids." Plato ascribes the proof of this to a collaborator working at the Cyrenaic temple of Ammon.

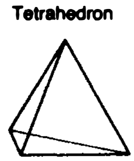
The importance of the "five Platonic solids," is that they are a crucial proof that visual space—as our eye-brain define the image of space for us—is not empty space stretching infinitely, in straight lines of Albertian perspective, to beyond the furthest imaginable extremes of the very, very large, and very, very small. What might appear, wrongly, to be empty space and time, has an efficient geometrical shaping, and this in a way which contradicts all of our childish intuitions about the universality of extension in straight lines.

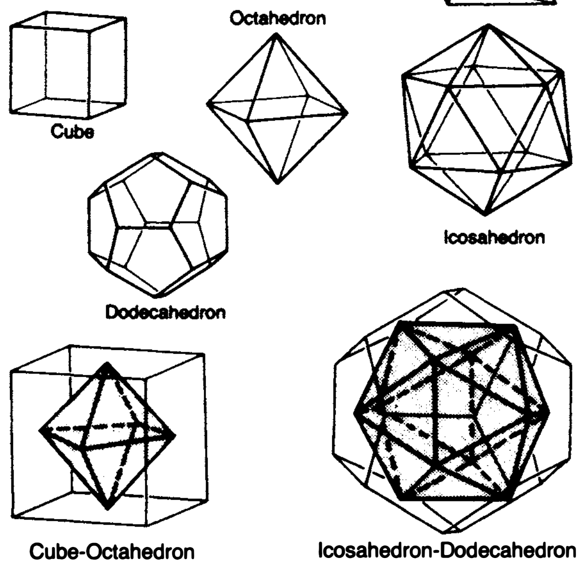
Thus, we say, physical space-time is self-bounded. This does not mean that our universe has some sort of fence around it. It means what is already clearly stated by the report that, in visual space, the only regular solids which can be constructed, excepting the sphere, are the five Platonic solids.

Plato already emphasized this notion of "self-boundedness" of visual space. For example, in his *Republic,* he supplies the usually misunderstood reference to what we call today "Plato's Cave." He warns that what we imagine ourselves to see, as images in visual space, are like shadows cast by firelight upon the wall of a darkened cave. Through our senses, we are able to know reality, but what our senses show us directly is merely the shadow of the reality.

Singularities of the Five Platonic Solids

Solid	Faces	Edges	Vertices
Tetrahedron	4	6	4
Cube	6	12	8
Octahedron	8	12	6
Icosahedron	20	30	12
Dodecahedron	12	30	20





The five regular, or "Platonic" solids.

Today, after the work of Gauss, Dirichlet, Weierstrass, Riemann, and so forth, we say, "Of course, that is true." Today, as especially in the case of "nonlinear" sorts of electromagnetic processes, we know that cause and effect occur outside the limits of our ideas of visual space. Cause and effect occur efficiently in what Gauss and Riemann enable us to define as a fully constructible geometry of the "complex domain." We can show also that the "shadows" recognized by our senses are a true, if distorted reflection, into "Euclidean space," of what actually is occurring within the physically real world of the complex domain.

Therefore, the study of the reasons for the uniqueness of the "Platonic solids" is the most fundamental line of inquiry in the physical sciences. What is the reason, that visual space should be "self-bounded" in the way this proof demonstrates? It should be obvious, that no amount of interpretation of empirical evidence, stated in terms of the physical space-time of Descartes, Newton, LaPlace, or Maxwell, is sound physics, unless we show that our observation of visual space has taken into account the reasons for the self-boundedness of the visual representation of physical space-time as a whole. Competent physical science begins, therefore, with rigorous proof that we have discovered the reason for this "self-boundedness" of visual space.

Pacioli recognized the importance of reconstructing the proof of the Platonic solids. He succeeded in producing a model of such proof which was improved upon by scientists such as Euler and Gauss during later centuries, but which that more advanced work shows to have been in the proper direction. Pacioli's and Leonardo's work shows that they properly grasped Cusa's contributions to the founding of modern scientific method. Leonardo, and Dürer, Raphael, and Kepler after him, established the basis for revolutionizing our approach to architecture and urban design, as well as establishing, in a related way, the principles of "humanistic engineering" which ought to inform the work of the qualified industrial engineer.

A scientist comes away from a study of Cusa's work as a whole, with the sense that the proper descriptive name for "science" is "an intelligible representation of the lawfulness of the universe." This was what study of Cusa's work imparted to Pacioli and Leonardo, and Kepler later. Although our subject-matter here is, the principles of architectural form which must govern the design of new cities, it is also urgent—especially if it is our goal to design cities to endure for a thousand years—that we show that those principles are premised upon unassailable truth. Therefore, we should sum up the proper meaning of "intelligible representation."

Go to a blackboard. Draw upon that board all sorts of shapes of lines, including the most arbitrarily irregular ones you are able to produce. These are "representations."

Now turn to face the classroom. Can you meet any challenge members of the class might pose to you, on the subject of these representations? Can you show under what circumstances each of those representations might necessarily exist? In other words, can you start from a single, most elementary principle of a purely constructive geometry? Can you, without aid of any additional assumptions (axioms, postulates), and without any resort to formal deductive reasoning, show how constructive geometry generates each and all of those representations you have drawn?

If you can succeed in meeting that challenge, in the fullest of its implications, you have met, in that degree, the challenge of "intelligible representations," as distinct from mere "representations." The most troublesome question you must face, is the very first question: What is the correct choice of "most elementary principle"? If you grasp what that question implies, you are prepared to appreciate the genius of Cusa's work.

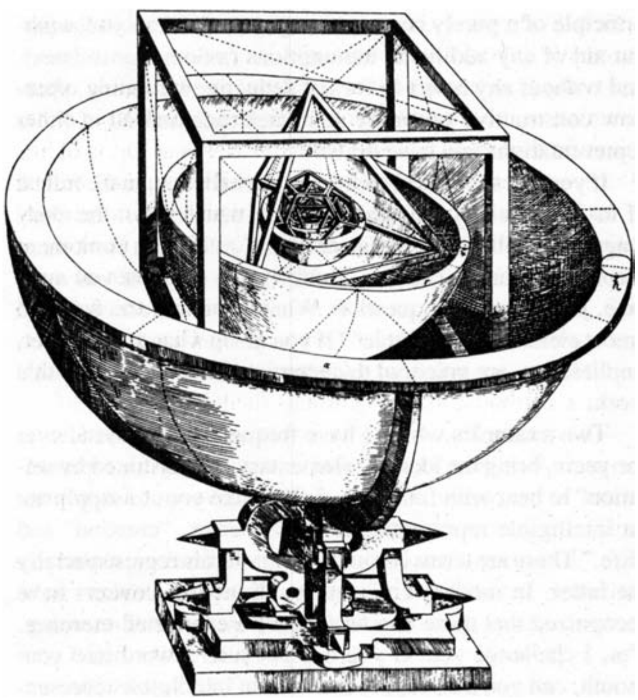
Two examples which I have frequently employed, over the years, bring the idea of "elementary intelligible representation" to bear with full force. I challenge you, to supply me an intelligible representation of two terms, "creation" and "life." These are terms common in our vocabulary, especially the latter. In modern civilization, all serious thinkers have recognized that these two terms have a connected meaning. Yet, I challenge you: If you can put such a word into your mouth, can you also supply me with an intelligible representation of what you mean by that word, or even any representation at all?

If you use as system of reasoning such as that of Euclid's *Elements,* these two words correspond to ideas for which you have no possible representation, and certainly no intelligible representation. Yet, already, Cusa did have an intelligible representation of both, and, Pacioli, Leonardo, and Kepler, a more elaborated such representation. This representation is the fundamental idea underlying a modern form of the science of classical aesthetics, and underlying the principles of functional form for design of new cities.

In formal logic, "creation" does not occur; it is merely asserted to have occurred. "Creation" is implicitly situated between two successive moments of existence, such that something which does not exist in the first, exists in the second. There is no representation of that which occurs between the two moments.

Perhaps the most famous case of use of formal logic to deny the existence of "creation," is that expressed by Immanuel Kant, most emphatically in his *Critique of Judgment.* Kant asserted that no intelligible representation of creative mental action, such as that responsible for fundamental scientific or artistic discoveries, is possible. Kant did not assert that "creation" does not exist; he argued, that since the human mind is, according to his view, incapable of providing an intelligible representation of an act of creation, mankind can not know "creation" as an idea.

Kant's argument is absurd, with one qualification. In deductive logic, it is axiomatically impossible to provide even a representation of the idea of "creation," and certainly not an intelligible representation.



Kepler's famous model of the planetary orbits as determined by a series of nested Platonic solids.

The word "life" encounters exactly the same difficulties as the representation of the word "creation." In formal logic, or in molecular biology, it is impossible to provide even a representation of "life" per se, let alone an intelligible representation.

Today, intelligible representations of "creation" are available to us even in mathematical physics, as the case of the Riemann Surface illustrates this most directly and simply. The same Gauss-Riemann physics, applied to a more advanced representation of the work of Pacioli, Leonardo, and Kepler, permits us to provide an intelligible representation of "life" per se, as molecular biology can not. Moreover, in the same context, we can show that both notions, "creation" and "life," are of the same characteristic.

This is no digression from the principal subject-matter of the present report. A correct understanding of these two terms is essential for a rigorous definition of what architecture must measure as "human activity," for the work of designing cities which will be of durable worth for a thousand years yet to come. That connection will become clearer as we progress.

Functionally, there is only one Platonic solid, the dodecahedron, each of whose twelve equal facets is a regular pentagon; the other four, the tetrahedron, the square, the octahedron, and icosahedron, are simply and directly derived from the dodecahedron, rather than the proof of their existence being derived separately from that for the dodecahedron. So, we must say that the dodecahedron expresses adequately the self-boundedness of visual space.

The construction of both the regular pentagon, and the dodecahedron, depends upon the prior construction of the Golden Section of the circle. So, the construction of the Golden Section represents the self-boundedness of visual space. In other words, the limit of constructibility of intelligible representations in visual space is constructions dependent upon the construction of the Golden Section.

This point is traced to its elementary root by aid of Cusa's solution to the problem of the intelligibility of the problem of attempting to square the circle, a solution whose result is reflected in a central way within his 1440 *De Docta Ignorantia.* Cusa implicitly eliminates the use of deductive method in geometry and in physics, and also eliminates all need to base geometry and physics on an initial set of axioms and postulates. From this point on, in the history of development of modern physical science along a pathway of progress, through the work of Leonardo, Kepler, Leibniz, Gauss, and Riemann, circular action is the only elementary conception upon which geometry and physics are premised.

Circular action is defined, topologically, as the least amount of perimetric action required to generate the relatively largest area or volume. Since volume exists, circular action must be understood as acting upon circular action in every interval, reciprocally. For purposes of identification, we call this "doubly-connected circular action." The analysis of possible constructions in visible space requires us to employ the notion of "triply-connected circular action."

That is the definition of the term "least action," not only in constructive (or, "synthetic") geometry. It is also the basis for definition of "least action" in the physics of Kepler, Fermat, and Leibniz. It is the point of derivation for the work of Gauss, Riemann, et al., in defining the form of least action in the complex domain: multiply-connected, (conical) self-similar-spiral action. Understanding the way in which the two definitions of physical (multiply-connected) least action are connected, is the mathematical-physics premise for those measurements of human activity central to proper architectural designs.

Pacioli and Leonardo already knew this universality of (circular) least action from the work of Cusa. For that reason, it was possible for Pacioli to elaborate a most respectable approximation of the stricter proof for the uniqueness of the Platonic solids. If universal cause-effect action is representable as multiply-connected circular action, all action in visual space is fundamentally underlaid by this form of physical least action. Hence, the self-boundedness of visual space, as shown by the Platonic solids, must be a constructible "property" of universal least action of this form. Hence, the Golden Section of least action, a construction itself derivable from nothing but this form of least action, is a sufficient demonstration of the necessary characteristic of the self-boundedness of visual space.

The most famous immediate application of this result, by both Pacioli and Leonardo as collaborators, was their definition of the form of life: All living processes are distinguished from ordinary non-living ones, in respect to morphology of growth and function, in the respect that that form is ordered as an harmonic series consistent with the harmonic series defined by the Golden Section.

Today, we qualify that discovery. Between the limits of the very, very large (astrophysics), and of the very, very small (microphysics), any process which is harmonically ordered in congruence with the Golden Section is either a living process, or is a special class of work done by a living process. Kepler, who based his founding of a comprehensive mathematical physics chiefly upon the combined work of Cusa and Pacioli-Leonardo, was the first to prove that the universe as a whole is governed by the same harmonic ordering. Some leading scientists among the writer's collaborators, are proving that a Gauss-Riemann correction for Keplerian laws of astrophysics also rules on the scale of organization of atoms and smaller scales of physics. With that qualification, Pacioli's, Leonardo's, and Kepler's geometrical (least action) definitions of living processes, is conclusively demonstrated today to be fully as accurate as Pacioli represented this to be at the beginning of the 16th century.

Thus, all of the movements and related functions of the human physiology are harmonically ordered least-action-based movements of this sort.

This standpoint governed several aspects of the work of Leonardo. In anatomy, he explored the Golden Section harmonics of the physiology of persons, horses, birds, and so on. In pioneering the principles of design of machinery, and the design and use of weapons, the same principles predominated. He revolutionized the science of perspective, by emphasis upon anomalies of visual space associated with the periphery of vision, rather than an Albertian, linear vanishing-point. This we note in viewing the originals of such master works of Raphael as the famous murals in the papal apartment, and the "Transfiguration" on display in the Vatican museum.

It can also be shown, that his general approach to application of hydrodynamics to not only water movements but also phenomena of electromagnetic radiation (including propagation of sound!), is based on the same principles of constructive geometry.

Thus, must "humanistic engineering" be reformulated in terms consistent with these principles of human physiology. Thus, must the design of new cities be adapted.

The form of mental activity

This is also true of the most characteristic form of human mental life, the aspect of human mental life which absolutely separates mankind from the beasts. The form of design of the city must be agreeable to the form of this aspect of human mental behavior, as well as the functional requirements of form imposed by human physiology otherwise. It happens that the form of mental behavior is also congruent with the harmonics of the Golden Section. We must make clear the most relevant points involved.

Man is the only living creature who is capable of willfully changing the form of his species' behavior for the better, and does this through creative discoveries bearing upon laws of nature. Scientific and technological progress are but the paradigmatic expressions of human existence.

Today, we know how to construct an intelligible representation of the creative mental processes involved in either scientific discovery or valid works of classical forms of art. However, there is no principle in this (Riemannian) branch of mathematical physics to this effect, which was not already stated in another way by the dialogues of Plato. Looking at the Socratic method retrospectively, in examples of such dialogues from the pens of Plato and Leibniz, the work on representation of nonlinear functions by Gauss, Dirichlet, Weierstrass, Riemann, and Cantor, permits us to show that Socratic method is such a nonlinear method.

The reason that creativity is not an intelligible idea in formal logic—Kant's argument, is readily illustrated by reference to the case of any scientific discovery of a new principle.

If the previous state of scientific belief is represented in a deductive way, there is no way that the new discovery can be represented as a deductive action in those terms of reference. A new deductive schema, representing scientific belief consistent with the discovered new knowledge, can be constructed; however, there is no deductive method by which the transition from the first to second deductive schema can be represented. This is Kant's problem.

If we compare the two deductive schemas directly with one another, a crucial difference is exposed. There is a difference among one or more of the postulates of the two arrays. The act of creative thought is reflected in the form of the changes in postulates which have occurred.

That is the characteristic of the Socratic method. In that method, every proposition considered is driven to deeper and deeper levels of critical examination, until the exposure of the axiomatic basis underlying the proposition is exposed. An inappropriate, or otherwise false postulate is exposed to light, and the appropriate change in postulate effected. The correct proposition is then constructed on this new basis.

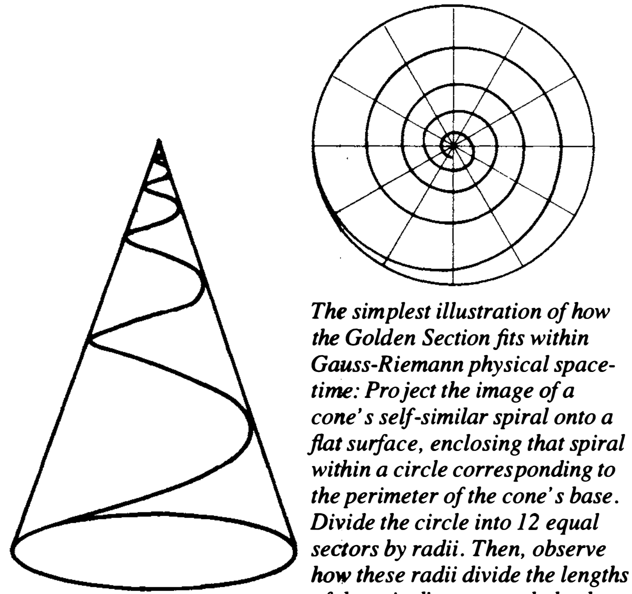
The two cases, the case of the deductive mathematical representation of two successive schemas, and the alteration of underlying postulates of propositions in Socratic method, are equivalent. The changes so encountered, in both cases, can not be made intelligible, or even represented directly, in deductive method; they have the form of a mathematical discontinuity. By definition, formal logic does not permit the construction of a continuous function which includes such a kind of discontinuity. Kant's problem.

For such cases, we require continuous "nonlinear" functions of a sort which exist only in the mathematical physics of Gauss, Dirichlet, Weierstrass, Riemann, et al. Consider as much explanation of this as bears directly on the scope of this report.

Like the physics thinking of Cusa, Leonardo, Kepler, and Leibniz, the physics of Gauss and Riemann is not based on the methods of deductive geometry or algebra. It is based on the method of constructive geometry. We may say, that it differs from earlier forms of synthetic geometry because it is the constructive geometry of the complex domain, rather than of visible space. However, although that statement is an accurate one, we must restate it differently, for our purposes here.

The difference is, that the mathematics of visible space's (shadow) images is based upon multiply-connected circular action, while Gauss-Riemann physical space-time is represented by a constructive geometry based upon multiply-connected (conic) self-similar-spiral action. A doubly-connected form of least action, in the latter case, immediately defines continuous functions which generate discontinuities without losing their quality of being continuous. Such functions are the minimal precondition for representing intelligibly notions corresponding to "creation" and "life" per se.

This implies immediately the question, where does the Golden Section fit within Gauss-Riemann physical space-time? The answer is elementary. To illustrate this in the simplest way, project the image of a cone's self-similar-spiral onto a flat surface, enclosing that spiral within a circle corresponding to the perimeter of the cone's base. Divide the circle into 12 equal sectors by radii. Then, observe how these radii divide the lengths of the spiral's arm, and also how the spiral arm divides the length of the radii. The divisions are those corresponding to the Golden Section.



The simplest illustration of how the Golden Section fits within Gauss-Riemann physical space-time: Project the image of a cone's self-similar spiral onto a flat surface, enclosing that spiral within a circle corresponding to the perimeter of the cone's base. Divide the circle into 12 equal sectors by radii. Then, observe how these radii divide the lengths of the spiral's arm, and also how the spiral's arm divides the length of the radii. The divisions are those corresponding to the Golden Section.

Since creative mental activity, as typified by the generation and assimilation of fundamental scientific discovery is the characteristic form of human mental activity to be considered in the design of cities, what we have identified as the principle of measurement for human physiology, is also the principle of measurement for human psychology.

Why Keplerian harmonics

I have reported earlier, that the design of the city is based upon Keplerian harmonics, with the qualification that we must employ the correction of Kepler's calculations supplied by Gauss-Riemann physics. Since nearly all university textbook and classroom instruction on the subject of Kepler's work, is rather savagely incompetent, that matter must be cleared up immediately, before indicating how Keplerian harmonics apply to the design of cities.

Kepler informs us that his solar hypothesis was built entirely around two central sets of notions, those of Cusa and those of Pacioli and Leonardo. The hypothesis around which the entirety of his work was organized, was Cusa's solar hypothesis as amplified by the work of Pacioli and Leonardo to which I made reference above.

Whether Kepler had access to the relevant sermons of Cusa, as well the works of Cusa printed for publication during the 15th century, I can not say at present. He certainly knew very well the work of Archimedes to which Cusa referenced his own discovery of what we term today the isoperimetric theorem. In crucial parts of his construction of the solar system, Kepler worked as if he knew how Cusa had treated the problem stated by Archimedes' theorems on the quadrature of the circle, as a maximum-minimum problem.

Kepler applied to Cusa's solar hypothesis the work, and associated theological, cosmogonical standpoints represented (chiefly) in Pacioli's *De Divina Proportione*. Hence, the Golden Section was central in his work, and the role of the Platonic solids subsumed by the Golden Section. Kepler's system gives us nine orbits for the principal planets: four inner planets, four outer planets, and a ninth planetary orbit lying between the two sets.

Gravitation occurs in Kepler's astrophysics as a characteristic of the self-bounded character of the visual form of physical space-time. So, Kepler's laws implicitly state the mathematical function for universal gravitation, which he links to electromagnetism as defined by Gilbert's *De Magnete*. If we examine this feature of his physics from the standpoint of the later work of Gauss, Riemann, et al., Kepler's gravitation is not as a force acting between physical bodies, but the physical effect of the geometry of least action in self-bounded physical space-time.

In other words, Kepler's space is not empty space, not mere distance between interacting bodies; it is not the space of Descartes, Newton, or LaPlace. Kepler's space-time is an efficient agency. Indeed, looking at Kepler's construction of his three laws with the eyes of Gauss or Riemann, there is no distinction among matter, space, and time in Kepler's physics. Matter is physical space-time. In that specific sense, but only that sense, we may say that space-time acts directly on matter. We continue to relate our references to Kepler's work as that work would be explained from the standpoint of a student of Gauss and Riemann.

All of the 17th and 18th century opponents of Kepler's methods and results were proven to be incompetent through the work of Gauss at approximately the beginning of the 19th century. Since these opponents of Kepler based the fundamental principles of their physics on the same premises used to attack Kepler, Gauss's proof showed not only that Kepler's physics was correct, relative to the erroneous arguments of Galileo, Descartes, and Newton; this proved also that the entire physics of Galileo, Descartes, and Newton was axiomatically wrong throughout.

The center of Gauss's empirical proof for Kepler, and against Galileo, Descartes, and Newton, was the case of the asteroids' orbits.

Kepler had insisted, that a planet had once existed between the orbits of Mars and Jupiter. Kepler had given both the location and harmonic-orbital values for this planet. The fact that, until the end of the 18th century, no rubble from a destroyed planet was found in such an orbit, was considered evidence of Kepler's error. Indeed, if it could have been proven that no planetary body had ever occupied that position, this would have shown a pervasive flaw in Kepler's work as a whole.

In each case, following the discovery of Pallas and Ceres, Gauss recognized that these were fragments of Kepler's missing planet. He used Kepler's orbital values for that planet to predict the next relevant appearance of each asteroid. This successful prediction vindicated the entirety of Kepler's work on principle; after that, there was no scientific basis for continuing to regard the work of Galileo, Descartes, and Newton as competent physics.

Thus, it was proven experimentally, that our universe is not organized on the basis of "forces" through which bodies act upon one another at a distance. It was proven that our universe is not made up of separate qualities of matter, space, and time; only physical space-time exists, and to the effect that it must appear to our senses as if the geometry of empty space acted efficiently on ponderable, discrete bodies within it.

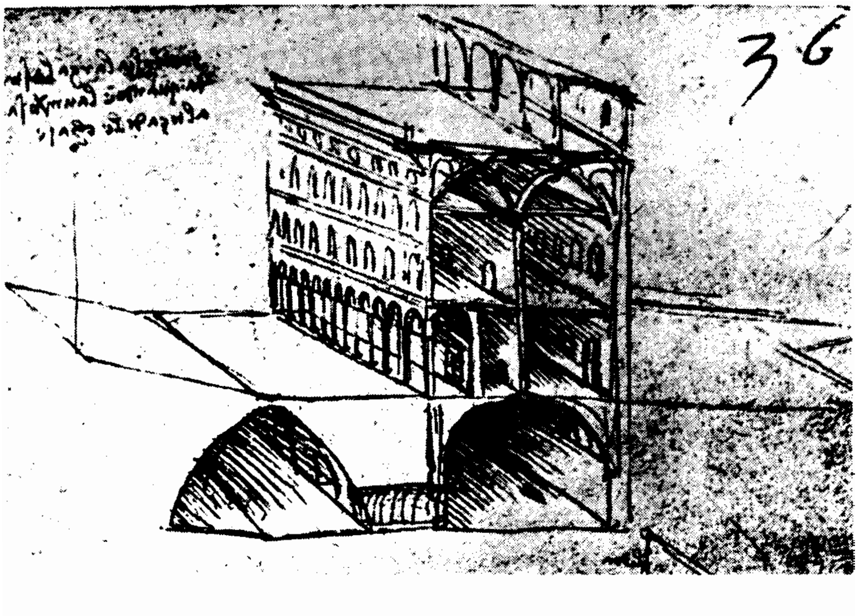
There are three features of Kepler's work which have the greatest relevance for the design of cities. 1) Although Kepler's calculations for orbits are not precisely accurate, his three laws are. These laws apply to the orbits of lunar bodies, and to modern discoveries in astrophysics in other matters. Kepler's discoveries were all essentially sound, if imperfected ones, and his general hypothesis is correct. The Gauss-Riemann corrections in Kepler's physics point the way to refining the laws and the calculations. 2) Physical space-time is harmonically ordered according to a universal principle of least action, rather than organized by means of action-at-a-distance interactions through forces. The correct measurement of least action for visible space is the projection of Gauss-Riemann least action's effects upon the manifold of visible space. 3) The universe as a whole is "negentropic," not "entropic."

It is the latter of the three points listed to which we turn our attention immediately.

All functions which have an harmonic ordering consistent with the Golden Section represent reflections of multiply-connected self-similar-spiral action occurring in the domain of the complex manifold. These occur only in two kinds of cases within our universe. Either they are the products of action by living processes, or they represent least-action as expressed at the extremes of astrophysics and microphysics.

All processes which are harmonically ordered in a way congruent with the Golden Section belong to a single class of phenomena. They are processes which statistical thermodynamics classes as "negentropic." Unfortunately, although we can explain, on the basis of Gauss's constructive-geometric basis for probability, why such processes should appear to be "statistically negentropic," the usual statistical analysis of such processes is intrinsically an incompetent one.

Curiously, Isaac Newton was one of the first to warn of the incompetent results which result from attempting to explain fundamentals of physics from the deductive standpoint in mathematics, on which the statistical methods of LaPlace, Boltzmann, et al. are based. The superimposition of a deductive mathematical schema upon the analysis of phenomena, will seem to show that our universe is running down, in the



Leonardo da Vinci's urban designs: The drawing on the left from Institut de France manuscript B (fol. 36) shows one of Leonardo's designs for a two-level town construction, in which the lower levels of the houses would be accessible by a network of canals, allowing complete separation of services and utilities from the educational and administrative activities going on above ground. On the right is Leonardo's map of Milan (Codex Atlanticus 72b) in ground plan and perspective view, done in preparation for an ambitious plan to upgrade the canal transportation network.

sense of a mechanical timepiece. This fact, of which Newton warned the readers of his work, is the simplest, adequate definition of what statistical thermodynamics call "entropy."

It is assumed, on such a statistical basis, that our universe is running down. It is widely assumed, that this is proceeding to such effect, that the increase of the universe's entropy as a whole is both the direction and ultimate, natural measurement of the passage of time.

That assumption of "universal entropy" is directly contrary to the astrophysical evidence, as the construction of Kepler's three laws proves the case.

We must measure "negentropy" and "entropy" in a different way. We must discard deductive mathematics, statistical methods included. We must employ the only available alternative, constructive geometry. In the latter case, we have the following relevant results: 1) The sense of "negentropy" is supplied as processes undergoing harmonically ordered growth congruent with the Golden Section's ordering of the visible manifold. 2) This means that "negentropy" can be measured in terms of the increasing number of discontinuities generated by the continuing process of such harmonically ordered growth. Mathematically, this is expressed in the form of Cantor's transfinite functions, as a harmonically ordered increase of the density of discontinuities within some arbitrarily small interval of action adopted as a unit of measurement. 3) This means that "entropy" must be measured as reversed "negentropy." As life is the paradigm of "negentropy," death and decomposition are the paradigm of entropy. Yet, entropy harmonically occurs in different geometric ordering than for negentropic processes.

That is sufficient description of the background to permit us to proceed to the matter of applications to the design of new cities.

Cities as 'negentropy machines'

Successful economic processes belong to the class of negentropic processes.

On first examination of its physical characteristics, a successful economic process is typified by a continuous process of increase of the combined quality and quantity of the standard market-basket of physical goods consumed per capita. This presumes a corresponding increase of output by the operatives producing these physical goods. It presumes technological progress's causing such increases of the productive powers of labor, and improvement of the varieties and qualities of products.

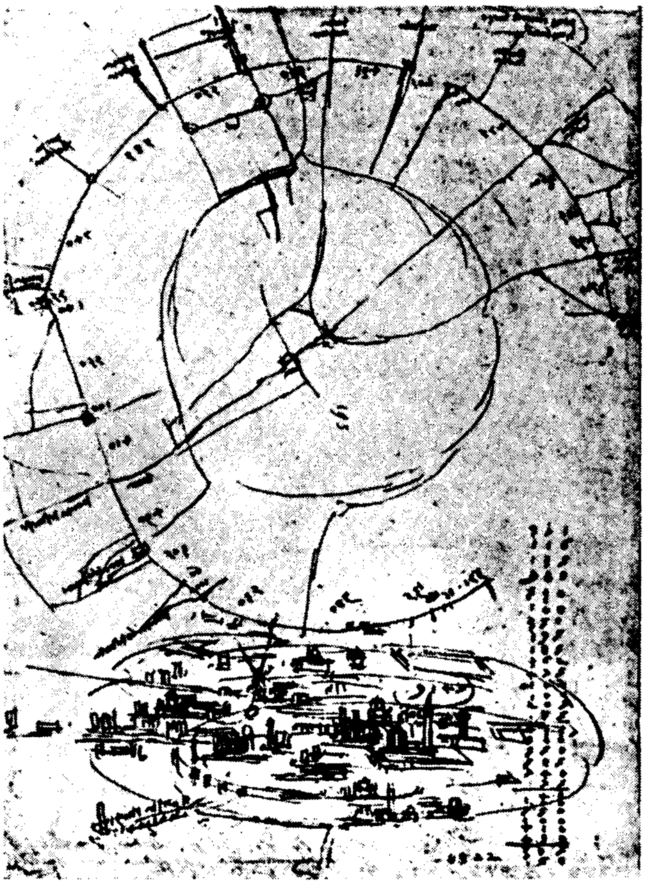
It is also an improved mastery of land area. This occurs to the effect that less land area per capita is required to sustain a population in a higher standard of living, than the land area required to produce a relatively poorer standard of living at an earlier time.

So, the proper mathematical function in the science of physical economy is expressed in terms of rate of increase of the population's potential population-density. This function is elaborated in terms of the set of set constraints identified earlier. It is a "nonlinear," continuous function of the general form of a Riemann Surface function.

Assume that a city satisfying this function's requirements, has reached the limit of population growth built into that city's design. Let us consider the "equilibrium condition" so defined.

First, as to population.

The fecundity remains constant, at the same rate after the population limit is reached, as earlier. So, the limit of population growth is expressed in terms of the number of households, and the number of persons limited only by the number of households comprising the total census of households. The



"excess population" is deployed to populate new cities, including some on Mars.

Second, as to employment.

The labor force is defined as a function of the total population of labor force age. Of this, initially, on Earth, about half should be employed as operatives employed in production of household goods, producers' goods, or development, maintenance and operation of basic economic infrastructure (transportation, water management, communications, production and distribution of energy supplies, and basic urban sanitation). About one-tenth or more are employed as scientists, engineers, in direct management of production as such, medical professionals, or in teaching of the young. Unemployed members of the labor force, and persons in other occupations, combined, are kept within the limit of less than 40% of the total labor force, preferably less than 35%.

Within this composition of employment, several interrelated shifts occur as both the level and rate of technological progress are advanced. A smaller percentage is employed in production of households' goods, relative to growth in the ratio employed in the production of producers' goods. In production of producers' goods, there is increased emphasis on employment in the machine-tool class of production. The ratio of scientists and related professionals to the total size of the labor force rises. Gradually, there is a shift of employment from operatives' categories into science categories.

In social life.

As technology advances, the average school-leaving age rises in the direction of equivalence to a terminal degree in physical sciences. As the working day is shortened, the leisure so generated is consumed largely in adult education; this is aimed significantly at upgrading the technological competencies of the labor force as a whole, but also for the enriched development of the character of the adult individual, through scientific "leisure hobbies" and participation in the life of classical forms of art, in addition to travel.

Hence, the "Sun" of our city is at the city's center, a complex of facilities for secondary and higher education, for conduct of classical fine art, and similar activities, situated in a park and garden zone in the center of the city. Knowledge in the form of science and fine art are the heart of the city, the driving-force of the city's development. By affirming this, in such a fashion, we make the development of the character of the citizen to the fullest of its potentials the mainspring of life within the city.

Such design of the city, defines a knowledge-intensive society, and knowledge-intensity as the driving force of the city's maintenance, growth, and economic as well as cultural development. The energy driving the city, is produced in the outer orbit of the "outer planetary" region. This supply of energy is constantly increasing, per capita and per hectare, for the city as a whole. The effective energy-flux density with which this energy is applied to the target-areas of work, is also increasing. Yet, these energy supplies, their growth, and the shaping of their application, are always under the control of knowledge radiating from the city's "Sun."

The administration and commercial functions of the city are most proximate to the central park. Here, the density of land usage, per capita unit of human activity, is at the highest, and the structures, correspondingly, generally the tallest.

As we move outward, the density of movement per square hectare attenuates harmonically.

Beyond the F-sharp orbit separating the inner from outer city, we reach first the orbit of densest land use by the labor force's productive activities. The three further orbits each represent a less dense employment per unit of productive activities, including the power-generating complex for the city.

Beyond the last orbit, there is permanent agricultural, forest, and related uses of land, until the outer boundaries of the next city or township are encountered. No suburban sprawl is to be permitted, for ecological reasons, as well as economic ones.

Agriculture is at the verge of a fundamental revolution, and the agricultural needs of permanent colonies on Mars will be a goad to more rapid advancement in these directions. The amount of agricultural product per hectare is about to increase by an order of magnitude, through methods which popular opinion today would, somewhat inaccurately, associate with large, multi-story "hydroponics" factories. The social system which has served the United States so well, family- and intra-family-operated entrepreneurial farming, should be protected and preserved, thus ensuring the best rate of improvement of quality of product, together with the highest rates of effective innovation.

Yet, we know that the maintenance of highly productive biomass, in the forms of crops, pasturage, water management, and well-managed woodlands, is essential to maintaining the general environment. The best way in which to accomplish this, is to entrust this work to entrepreneurial farmers, counting this maintenance of cultivated farm, pasture, and forest land as part of the necessary cost of agricultural production as a whole.

It must be our object to break the pattern of suburban sprawl, driven only by speculative gains, which is destroying so much of the land area of the United States today. We can effect all the qualities of beauty, privacy, and function, which might be sought through modes of surburban sprawl, in well-designed new cities, designed to remain viable for up to a thousand years or more. The initial investment per cubic meter of volume of dwelling constructed, will be much higher (at first), but the average annual cost of possession, in terms of maintenance and amortization combined, will be much less.

The judicious channeling of very low-cost public credit, loaned through the banking system and governmental capital improvements agencies and authorities, will make this change in construction policy feasible. The accelerated demand for the new types of materials and other products used for such construction, will expand the turnover and investment rates in such industries to the point of fostering a rapid rate of technological advancement in those industries. This increase in productivity, in a large sector of the economy as a whole, will rapidly lower the effective average physical costs of construction, for the city-building and kindred programs as a whole; the expansion of investment in advanced technologies in that sector, will spill over into the economy more generally. Within less than a generation, perhaps, the costs of housing and other construction for new cities' designs will fall to levels of per capita social cost below those of today.

The heaviest increment of cost in the building of the city, will be the emphasis upon building the deep substructure first, and then putting the upper portion of the city upon that prepared substructure. This is the cheapest way of building substructure of a city. With the proper designs, and use of the proper materials, this substructure will be cheaper to maintain, and to improve technologically, than present alternatives. The combined cost of amortization and maintenance of this substructural investment will drop to below that of what is presently considered a conventional city.

The utilities built into the city will last for centuries, and will be cheap to maintain for per capita unit of activity which those utilities support. The savings in movements of persons and goods will be greater than the apparent added initial costs of amortization of the investment, with none of the costs which the cities and their inhabitants of today endure in the forms of street traffic congestion, pollution, time delays, and costs.

It is not necessary, in this location, to detail the technologies involved in building the city. We know that such things can be done with technologies existing or in sight today. It is sufficient to supply the architects and their fellow professionals the set of criteria to be met, and leave it to such professionals to do what they do best.

We know, with a fair degree of certainty, the general nature of the scientific advances likely to occur during the next hundred years. A glance at some of the leading facts this involves, guides our attention to those principles which show why our new city should endure in its original design for a thousand years, or perhaps even two or more thousand.

For the coming 50 years, inorganic physics will be dominated by the development of controlled thermonuclear fusion as mankind's new energy source, and by increasing use of the technologies of "nonlinear" electromagnetic radiation. During the first half of the next century, the new levels of technology will be associated with per capita increases in energy consumption by up to 1,000 times that of today: space colonization will write "terawatts" for power units, where the largest power-producing units today measure output in "gigawatts." Technologies of production will increase the energy-flux density of process applications to the levels of coherent gamma-ray pulses, and coherent "particle beam" radiation in the direction shown by the "free electron" laser: effective energy-flux density will increase more rapidly than the quantity of energy consumed per capita.

For thousands of years to come, biological science will be dominated by the presently emerging new science of optical biophysics. By the middle of the next century, mankind shall leap beyond the limitations of fusion energy, to more powerful technologies based upon what are now termed "matter/antimatter" reactions. Gigantic "radio telescopes," many miles in effective aperture, placed in or near the orbit of Mars during the middle of the coming century, will enable astrophysicists to explore the most anomalous astronomical objects within our galaxy and beyond, and to assist thus in proving the discovery of new physical principles, previously unknown to physical science.

Powerful fusion engines will enable mankind to reach any destination within the region of the inner planets within days of flight. However, even the extraordinary efficiency of fusion power involves a delimiting factor of fuel load on spacecraft. Special tricks would permit limited forms of manned exploratory flight into the region of the outer planets, and development of deeper space terminals based on the logistics of the Mars colony would assist the exploration of the outer region of the solar system. Yet, manned deep-space flights beyond the solar system must wait upon the development of a more powerful, more efficient propulsion system.

The mastery of what we call the "matter/antimatter" reaction, is the visible pathway for developing techniques for deeper space explorations.

So, the next 100 years' technological progress can be summed up as shaped by two successive singularities in the continuous development of improved "energy technologies." This implies, as I stress now, that there exists a "nonlinear" continuous function, through aid of which we can project, beyond a third and a fourth singularity, into hundreds of years yet to come, and might do this with as much accuracy as would be of any practical use to us in the coming decades' planning of the design of new cities to be built within our solar system.

With that in view, one can return attention now to the subject matter of foreseeable changes in the life of our new city, as a result of such technological progress.

We know two things:

1) We know that the definition of man, as man is properly defined by knowledge up to the present time, will not change. Through aid of optical biophysics' mastery of the spectroscopy of the mitotic process, we will be enabled to improve greatly the maintenance and repair of the human organism, to control the aging of tissue to significant degree, as well as achieving early conquest of cancer, and the most challenging kinds of viral infections. The increase of mean life expectancies to the age of 120 years or more, and kindred extension of the upper age limit for defining the active labor force, are likely changes. However, no foreseeable change would change the required mean free-pathway of the motions of human beings. The nuclear family household must persist, unchanged, for thousands of years to come.

For such reasons, the spatial organization of the new city need not be changed from those specifications of spatial organization which are optimal for today's technologies.

2) Presently developed levels of knowledge in the Leibnizian science of physical economy, enable us to foresee how the foreseeable directions of advance in technology will introduce modifications of technologies integral to the functioning of the city as such. The six constraints, cited above, for the LaRouche-Riemann function in physical economy, permit us to foresee these changes with as much accuracy as is required for the design of the new city.

Essentially, the spatial requirements of organization of the city will not change. What will change is the per capita (and per square meter, and per cubic meter) quantity of energy consumed, and the effective energy-flux density of the use of that flow of energy supplies.

Think of the spatial structure of the new city as the basic structure of a machine. This does not change. Think of the changes introduced as analogous to alterations of the tools developed for attachment to that machine, in company with rather continual increases in energy-flows into the machine as a whole.

All of the changes will take the form of a combined, interdependent increase of energy-density and energy-flux density per cubic meter in the volume of structure represented by the new city as a unified machine for living.

In designing the new city today, the architects must think clearly of both the kinds of modifications to be introduced to the city's spatial organization of structure over the coming centuries, and think also of how we can ensure that the needed kinds of improvements in energy- and energy-flux densities can be installed with the least time and effort.

Consider again, some things that will not change. The physical-geometrical function of a chair, a bed, a table, and of personal "space for mean-free-action" by persons, in all functions, will not change. The amount of fresh water required will not exceed the proper design limits specified for a new city today, even though there may be qualitative changes in the technology of fresh water management. The amount of air required will not change, although cleaner air will be achieved by aid of qualitative changes in technologies.

Within the city, and in travel to nearby population centers, a maximum speed of about 300 miles per hour achievable with magnetic levitation, will remain acceptable specification for generations yet to come. It is probably the case, especially on Mars, but also probably on Earth, that supersonic or even hypersonic speeds of continental travel of pressurized cabins through long reaches of evacuated, subsurface tube may appear during the next century. This will not affect the internal and nearby requirements for the new city itself.

The spatial design impact of the changes is foreseeable. Today's architects must simply leave room for installation of such changes within initial structures, and must provide the ready access needed for effecting such installations with the relatively greatest economy of labor.

The harmonics of the design will never change. What will change is the level and rate of increase of effective negentropy, per capita, and per cubic meter.

A beautiful city

The general requirement must be, that wherever each function of human activity is to be served, the form of design employed shall be the principle of harmonic ordering congruent with the Golden Section.

This includes the proportions of rooms, the relative scales of the rooms of a dwelling place, the relations of windows to room sizes, and everything else blended into a harmonic unity. Here, the architect must became at once a composer of classical polyphony, a painter with the informed eye of a Leonardo, a Raphael, a Rembrandt, and a physicist in the spirit of Kepler.

Such harmonic composition will coincide with the optimal agreement with the physiology of human least action. It will provide the optimal acoustics, the optimal distribution of light, of air movement, and so forth. The physiological requirements, so addressed, are consistent with the psychological ones.

Contrary to the cults of Romanticism and Modernism which have spoiled our great Western European tradition of classical art, nothing is beautiful unless it is consistent with harmonic orderings based on the Golden Section. Such is the beauty inherent in all living animals and plant life. Art must emulate the principle of life on this account, but it is not art unless it does something more than that.

The composer of classical fine art must start with principles of beauty, and must never conclude with any result which is not congruent with beauty. Yet, this defines the character of the particular medium in which the artist works; it does not suffice to define the stirring of that medium of beauty as art. Art is not a business of selecting by mere intuition those random stirrings of the medium seen to have the pleasing quality of beauty.

Beautiful art is art because it is composed by an accomplished artist. What defines such a composer of art is the exact same mental quality which defines the accomplished scientific discoverer: the development of the composer's creative powers of mind, together with the composer's moral character. The composer of great art works in the medium of beautiful harmonic orderings as the scientific discovery works in his or her medium. The same powers of mind, perfected to such work in the one medium, or the other, are at work.

It is this creative endeavor, in the medium of beauty, which defines great art.

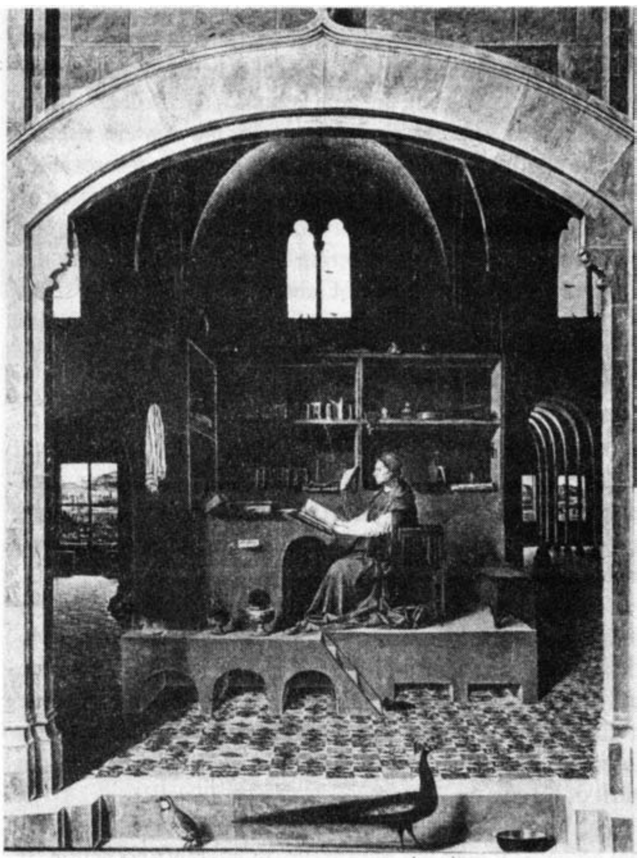
For that reason, the general quality which all great art shares in common, in whatever artistic medium, is that it contains nothing not fully susceptible of intelligible representation, as I have identified "intelligible representation" above. Furthermore, the entire composition is itself susceptible of such intelligible representation, to such effect that the uniquely creative features of the development of the composition are the kernel of the artistic idea.

There is never anything arbitrary, "Romantic," in classical art. It is always delimited by the principles of harmonics associated with the Golden Section in visual space, and perfect well-tempering in classical musical composition. No principle contrary to that definition of classical beauty, no deductive sort of arithmetic principle (e.g., the 12-tone system of the musical "modernists), must be tolerated. The "idea" associated with classical art is never akin to what we encounter so often in the Romanticist "program notes" of the concert program, record jackets, or art exhibition. The idea of a classical artistic composition is the elaboration of the specifically creative feature of the composition's development.

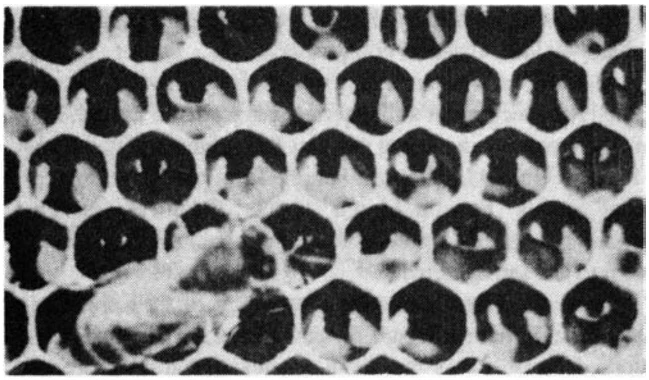
A great architect, like a great classical painter—such as Leonardo or Raphael—is thus a professional who might have become a great musical composer or performer, who applies the same intelligible creative principles to a different medium. The architect's medium is the humanistic science of physical economy expressed as art, governed by the same principles as great classical art.

We must free ourselves of the heritage of both Kant's *Critique of Judgment* and the evil Prof. Karl Savigny's arbitrary, irrationalist separation of science (*Naturwissenschaft*) from the arts (*Geisteswissenschaft*). This means, inclusively, that in architecture, there is no proper distinction between "art" and "function." It means, as I have stressed throughout this report, that the principles of classical artistic composition are always in implicit agreement with the best solution to a problem of function, so much so, that wherever a purported functional design deviates from the rigorous standards for classical beauty in artistic composition, the deviation represents an elementary error in the principles of functional design adopted.

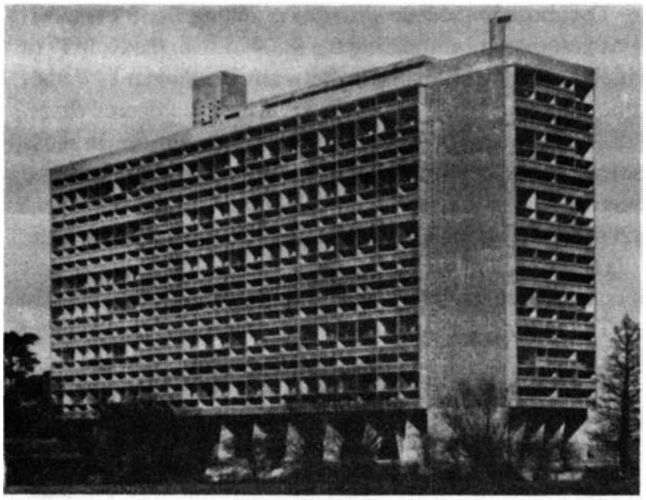
All architecture is a machine for use by human beings. It must agree with the requirements of the whole human being. This wholeness is expressed by human activity in its wholeness. All human activity is activity directed by the self-developmental characteristics peculiar to the human mind. As I have shown as a matter of principles, both the physiology of individual mean-free-pathway least action, and the char-



"Some things will not change: the physical-geometrical function of a chair, a bed, a table, and of personal 'space for mean-free-action' by persons, in all functions, will not change." The painting shows "St. Jerome in His Study," by Antonello da Messina, ca. 1456.



Above: The bee's honeycomb. Below: The beehive-like "Unité d'Habitation" by the irrationalist architect LeCorbusier, in Nantes (France), 1952-57. Bees' constructions are not harmonically ordered in congruence with the Golden Section. "This case illustrates an absolute separation in principle, from architecture for lower forms of life, and for humanity."



acteristic human creative mental activity, are forms harmonically ordered in congruence with the Golden Section in visual space. That architecture which is defective as classical art, is therefore also defective in function.

Reference Johannes Kepler's famous dissertation on the subject of the snowflake. Focus, within that paper, on the discussion of the constructions by the bees, constructions which are excellent for bees, but not for human beings. The construction is not harmonically ordered in congruence with the Golden Section. This case illustrates an absolute separation in principle, from architecture for lower forms of life, and for humanity.

The most sensitive architects and students of classical painting are more notably aware of the fact, that the experiencing of the visual space in which persons' activity occurs, has an important psychological effect upon the persons experiencing that organized space. Leonardo and Raphael are of outstanding importance in any systematic study of this matter, particularly so because their own recognition and use of this principle is so directly, immediately situated with respect to the underlying principles involved.

In the experiencing of the organization of visual space, our minds draw upon the same kinds of powers of judgment we experience in the beauty of well-performed classical polyphony. Today, because of important researches into the organization of the relationship between the eye and the visual cortex of which it is functionally an integral part, we can understand the validity of Leonardo's principles of hemispherical perspective in a refined way. Although, to the extent of my present knowledge, the study of the acoustical functions of the brain are less well-mapped than those for the visual cortex, we know that Riemann's approach to the physiology of hearing was sound on principle; and, from knowledge of well-tempered polyphony, we know that the principles adduced for vision are congruent with those for the sense of beauty in hearing.

So, we know, that the same principles of creative composition expressed by such as Bach, Mozart, Beethoven, Schubert, Chopin, Schumann, Verdi, and Brahms—although not those of Romantics such as Lizst and Wagner—express in a musical medium the same underlying, proper principles of a great architectural composition. We should speak, without a sense that we might be indulging ourselves with mere metaphor or even hyperbole, of architects as composers. We should say this with an eye cast directly toward Leonardo and Raphael, but also with a sense that the musical reference is not merely analogy.

The standard should be: "intelligible representation of a beautifully artistic fulfillment of nothing but the functional purpose of the construction." The architect must start with function. By applying "Keplerian" harmonics to the understanding of that human function as an integrated whole, the problem to be solved, function, is stated also, and by no accident, in precisely the form which transforms a science of architecture into a practice of classical artistic composition, without moving one millimeter from science.

The creative solution is always in response to a problem posed in terms of satisfying the need of a human function, rather than decoration superimposed, as a kind of flamboyance, upon the structural "cake." No arbitrary sort of "pleasing effect" is to be sought as mere decoration.

Since the architect is a human being, as the great classical composer is a musician, the architect designs by aid of traveling in his imagination through each mean-free-pathway activity of the persons inhabiting the city. He visualizes, in this imagination, using each part of the city for one or another of the functions of which the totality of their lives are each composed. He does this with a refined eye, doing from his more advanced standpoint in professional knowledge, more or less what I first learned to do in economic science standing, still at the age of 15, at the dinker's bench in that slipper factory.

The principles of beautiful harmonics he carries with him on this tour of the imagination, thinking of these principles not so much as ideas of beauty, but rather in terms of the harmonics of least-action movements of human individuals. The examination of each of the movements along this tour from the standpoint of Golden Section harmonics, defines for him an array of problems in geometric topology. The summation of these problems, is the total problem of this same form, the topology of the city as an integrated whole.

So, the composition of architectural design occurs in such a way, that it could be explained entirely as creative solution to the functional problem of topology so defined. It could be provided an accurate intelligible representation so.

Nonetheless, the result is a classical artistic composition in the strictest sense.

The successful solution to the topological problem of ordering human least action, will always be a "Keplerian" kind of harmonic ordering, with the included types of qualifications I have noted earlier in this report. The optimal result will seem to borrow from classical strophic forms of poetry, as does classical musical composition. Every human movement within the city, will have a characteristic harmonic value in a "Keplerian" system; the idealized, least-action form of movement facilitated by the design, is susceptible of being stated in terms of "Keplerian" harmonics.

Consequently, the coherence of design, incorporating all of the topological solutions included, can be expressed in the manner of classical musical composition. This is more or less the same as to say that we can represent the composition of major paintings by Leonardo and Raphael in terms of principles of classical musical composition.

The architects intrude personally, as classical artists, into the composition as a whole—put their artists' signature on the composition—by the way in which they elaborate the composition as a whole.

The most famous case of this from classical music, is the history of compositions based on treatment of a collaboration between Frederick the Great and Johann Sebastian Bach, "The Musical Offering." This represents a solution to a central problem in well-tempered polyphony, a solution which played a leading role within the later development of classical composition.

Major composers based some of their outstanding works on this: Mozart, Beethoven, Schubert, and Chopin, for example. A few examples from this history are sufficient to illustrate the point I have made on the architect's personal artistic signature on a design.

Mozart's intensive study of Bach's method of composition is reflected most strongly among compositions presented beginning 1783. He took up Bach's "Musical Offering" discovery directly in his famous keyboard sonata, K. 457. Then, he improves greatly upon Bach's discovery in his "Dissonant" quartet, and sums up that result in the Fantasy (K. 475), which he prefixed to the sonata K. 457. Mozart's principal musical-scientific advancement beyond Bach, on this point, is his introduction of the "Keplerian" F-sharp, omitted in Bach's treatment and in his own K. 457. The implications of this F-sharp addition shaped the treatment of this Bach subject by later classical composers.

Mozart's advancement in treatment of this appears famously in Beethoven's "Pathétique" fortepiano sonata, and in other works, including his last fortepiano sonata, Opus 111. The Opus 111, in turn, supplied Chopin the reference-point for his "Funeral March" sonata. Schubert's posthumously published C-minor fortepiano sonata is another treatment of the same subject.

From the standpoint of the topology of a "Keplerian" harmonic domain, the subject to which each composer addressed himself was the same musical-scientific problem. Yet, each introduced different sets of consideration in musical-scientific knowledge to the treatment of the subject. The compositions each differed thus, not only from those of other composers, but from the same composer's other settings of the same subject.

The most immediate difference among these compositions is shown by comparing the K. 475 with the K. 457 to which Mozart prefixed it, or between Beethoven's "Pathétique" and his Opus 111. There is, in these compared cases, a different choice of pathway of development. So, in those indicated cases, as in the others which might be cited, the creative-mental activity, although applied to the same general subject, was elaborated along a different pathway, to the effect that each of the compositions represents a unique sort of constructive-geometric intelligibility.

The architect's imbuing artistic coherence into the raw form of solution of the topological problem, is in no sense "mere decoration." The mind of the city's inhabitant requires that the city as a whole have the quality of intelligible coherence.

The human individual has, from birth, a double character. In the one aspect, the new-born infant is like a beast, seemingly controlled by what British philosophical liberalism denotes by "original and immediate instincts," as Adam Smith puts it, for "seeking of [sensual] pleasure, and avoidance of pain." The emotional correlative of this in the child and adult, is what we associate with the erotic impulse—something which explains Sigmund Freud, but which Freud is incapable of comprehending except in a perverted way. Yet, that same child or adult has a directly opposing character, associated with an opposing quality of emotion, designated in classical Greek by *agapē*—love of God, love of mankind, love of beauty, and love of truth.

The development of the individual character requires that the person become conscious of the distinction among the two qualities of experienced emotion, strengthen the *agapic*, and subordinate the erotic impulse entirely to those restricted occupations in which it is deployed under firm control of the *agapic*.

This *agapic* emotion is easily recognized in a child at constructive play. When that child discovers, what is for it the first time, a solution to a type of problem, the normal

The history of compositions based on treatment of a collaboration between Frederick the Great and J.S. Bach, "The Musical Offering," represents a solution to a central problem in well-tempered polyphony. Shown here are (a) the opening theme of "The Musical Offering"; (b) the opening measures of Mozart's fortepiano Fantasia K. 475, and (c) the opening measures of Beethoven's "Pathétique" fortepiano sonata.

child is elated. "A light seems to turn on inside the mind of that elated child." Insightful adults observing this, may find themselves close to "tears of joy." In contrast, the child, instead of solving the problem in, for example, block building, may strike angrily at this construction, scattering the blocks in his rage; that is erotic.

All creative mental activity is not merely associated with the *agapic* quality of emotion, but is energized by that emotional force, without which the "mind would turn off," and the solution not discovered. Contrary to some mystical speculations, the *agapic* emotion does not occur without a task-orientation in reality—although the erotic often does. It is a task-orientation associated with ideas of love of God, of truth, of beauty, and of mankind, which evokes this higher quality of emotion within us.

To produce a citizenry which is capable of greater use of these creative mental potentials, it is urgent to create a physical space-time for them, in which the dominant ideas expressed by human activity are those in agreement with the *agapic* force.

At this point, I can report without further argument of the point, that the *agapic* corresponds to the negentropic, and the erotic to the entropic. The city must be a visual space, so composed as to envelop the activities of its residents in a sense of artistic beauty. It achieves this, not by decoration, but by means of beautiful solutions to topological problems of essential functions.

A citizenry should have the means to speak only beautifully literate prose and poetry, as Dante Alighieri famously argues the importance of this. It should be subjected to nothing musical but the mastery of beautiful music. It should be surrounded with inspiring scientific and historical knowledge. The character of its young should be nurtured to the highest level of youthful potentials, by a classical-scientific, non-specialized secondary education along the lines outlined by Wilhelm von Humboldt. It should be imbued with familiarity of principles of beautiful artistic composition in visual space, and should be enveloped visually in such beauty.

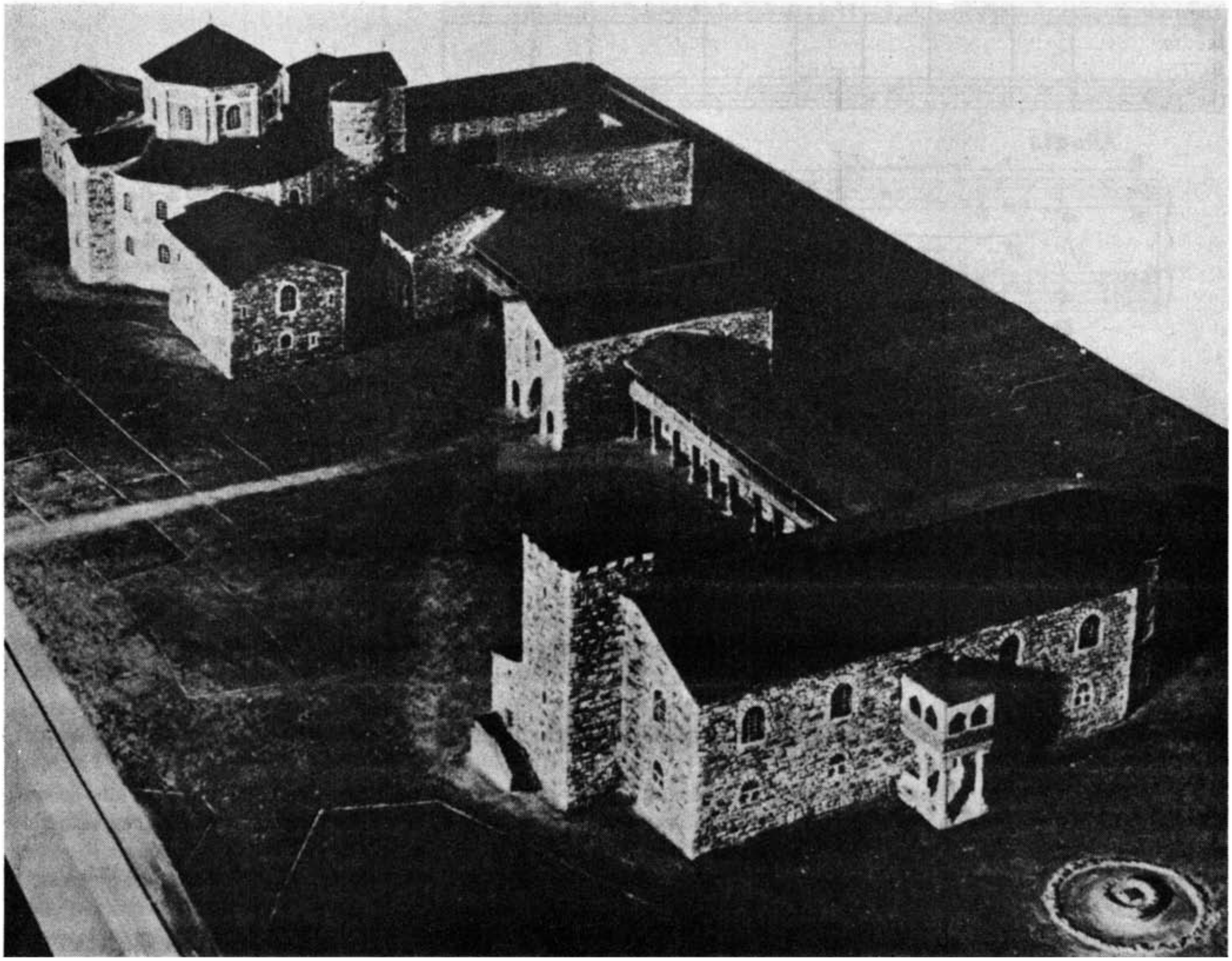
The physical cause for the effect known as man's increase of society's potential population-density, and for the accompanying increase of the productive powers of labor, is "purely psychological": It is the production of advances in ideas in a way consistent with scientific and technological progress. It is the manner in which such progress in ideas reshapes human practice, that the power to perpetuate human existence is derived. Whatever increases the development of the individual character, such that *agapē* and scientific creativity are fostered, is the greatest force which society might summon to solve all the so-called practical, physical problems of life.

Nothing could be greater folly, than to act on the assumption that *agapic* beauty is not essential to architecture, but merely spiritual, psychological. How could man exist, without command of that within himself, on which the existence of society depends absolutely?

Artistic beauty, thus deployed, enriches the mental powers of the population, fosters the strengthening of the *agapic* quality in human relations, and adds greatly to the strength of the city as a negentropic machine for promotion of advancement in the quality of human existence.

A sense of purpose

A city must not degenerate into a mere place for living and working. A city's existence must be ennobled by a higher purpose, as President Charles de Gaulle sought to uplift the French citizenry from cattle-like chewing of its own national cud, to a sense of France's unique purpose in service of the



Charlemagne's palace complex at Aachen, reconstructed model (Mainz, Römisch-Germanisches Zentralmuseum). In the wave of city-building unleashed by Charlemagne around 800, what were called "Augustinian principles" were the guide to the development of cathedral towns.

cause of civilization. Back to Cusa's *De Docta Ignorantia*: The city is a microcosm, which must consciously locate the meaningful purpose of its existence in the macrocosm.

Among all new cities, a citizen, asked what the city does, would respond automatically, to the general effect: "We are essential for making the world, and mankind better." The products of the city enrich the nation and the world. The citizen's contribution to the city's contribution to the nation and civilization generally, imbues the simplest of his or her contributions with the moral and efficient qualities of universality.

We wish that no person be homogenized by a city. We must impart the sense of the worth of individual, personal uniqueness in service of the universal, durable good. The citizen must have sound grounds to say: "I am unique, and I exist so because the general good needs the service of my uniqueness." This uniqueness is practically situated, not an arbitrary choice of "being different." There is always another task to be undertaken in the work of perfecting service to the good; there is always needed yet another person, peculiarly suited by commitment and development, to master the work of serving that unique, added need. What if that particular sort of work were no longer needed? The citizen would reply, "Then I should find something which required my unique dedication to service of the good."

The image of the working scientific seminar is a useful one, in further clarification of this point. In general, true scientific workers assemble in such seminars, not so often for a previously well-defined task; more often, the best practical results emerge simply from assembly to the vaguely defined common sense of sharing contributions to whatever useful purpose this process of sharing might itself suggest.

The right quality of such seminars is recognized among all accomplished scientific workers—at least, that is generally so. The exchange of published scientific papers approximates such seminars in some degree, but there is no adequate replacement for what such seminars contribute.

In the most fruitful seminars, what is exchanged is a discussion of preliminary experimental hypotheses. Finished results are brought in, as they bear upon this; but it is the discussion of preliminary hypotheses which is the most essential activity. The presentation of completed work, or work in progress, is usually the means for sparking the discussions; it is the discussions themselves, often moving in directions not anticipated by any among the participants beforehand, which are often the most notable benefit.

Unfortunately, in academic liberal arts today, one finds nothing comparable to the quality of such scientific seminars. In academic liberal arts today, there is no rigorous principle of reasoning, comparable to that in serious scientific work, and few trained in the liberal arts' professions are willing to tolerate the attempt to introduce socratic standards of rigor into the deliberative process. The new city must be designed to foster a change in that, and to spread the benefits of such change into the habits of exchanges of ideas among the citizenry generally.

The work of each and all of the citizens of the city must be integrated in a fashion akin to that of working scientists from various specialties attacking the problems of a common subject of interest in the most productive sorts of scientific seminars. This is another way of saying, that the *agapic* mood must rule: love of God, of truth rigorously sought and served, of mankind, and of beauty, is the shared motivation which binds social relations at higher levels of quality, and which thus fosters true freedom: the commitment to serving the common *agapic* purpose in one's own best way.

I do not recall a case, of a friendly, serious exchange with any person along such lines, from which I did not benefit in useful knowledge. Like my adolescent's experience with the dinker's bench, there is nothing useful from which something of value is not to be learned, sometimes with beneficial results far beyond what the circumstances might initially suggest. I love and treasure the uniqueness of each individual person, when the uniqueness is located in such a way.

That is the proper general mood and sense of social values in the new cities I wish to promote.

Do we wish to assemble forces for mastery of some important scientific problem? Build a new city with dedication to that and to future related sorts of tasks. For each other sort of important kind of purpose in service of the nation and humanity, build such a new city dedicated to that kind of work. Build new cities so, to uplift the quality and pride of entire nations, entire regions of this planet. We shall build new cities on Mars, around precisely such conceptions of function and purpose.

Now, therefore, let us begin to design and build.