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Toward the Future

By John McHale

Introduction

John McHale, author of this issue, is Executive Director for the World Resource Inventory, a study group concerned with the future utilization of man's resources. Various private, industrial and governmental study groups such as the World Resource Inventory are developing new materials and an ecological approach to the design of our cities and industrial outputs.

Continuous progress on all levels of human endeavor has been the accepted norm in our society since the beginning of the industrial revolution. Progress is expressed in more food, more industrial products, more energy, greater mobility and more leisure. Yet with affluence comes waste and the threat of ecological imbalance.

Our planet is basically a closed system, which recycles and regenerates energy and materials in a constant flow. The biosphere, a thin film of air, earth and water around the globe, is the "lifespace" which sustains our major activities through the various energy patterns and processes of interaction. Today's technology already interferes with the workings of the biosphere to a point that has prompted scientists to forecast great ecological disasters. This interference takes many forms and affects many areas. We pollute our lakes and rivers with raw sewage and chemicals, the air with carbon monoxide from our cars and the land with the "disposable" aluminum can.

Resources like minerals, waterpower, soil, forest and agricultural production have traditionally been viewed as everlasting. Today, however, it is clear that we have to increase our efforts to recycle minerals, preserve soil and forests and explore ocean depths for food and minerals. Non-material resources in our environment such as wild life, virgin forests and recreational waters must also be part of the same ecological approach and study.

Much of our industrial production is highly automated: we use sophisticated computers with machine intelligence, transplant human organs, increase our food supply by ocean-farming and fabricating synthetic protein, forecast and possibly control the weather. But we need to research the future, predict technology and its long range consequences, study the impact of scientific and technological progress, and form concepts for future social and economic development.

Man has to study and plan all human needs in terms of the planet as a whole. For the first time in the history of civilization it is not only possible to plan the future, but also to develop alternatives for the best future. P.S.

We are not fundamentally concerned here with a series of predictions about the next hundred or the next thousand years, but rather with the 'futures-orientation' itself as an intellectual and social attitude. We are concerned with ways of looking forward and with some of the implications of present scientific and technological developments on our styles of living.

In general, today's modes of confronting the future are vastly different from those of the nineteenth century Utopians. In that period, men were still preoccupied with the inevitability of progress, Western style, via a science and technology which seemed capable of ever greater mastery of man over nature. This was tempered somewhat by the Malthusian feeling that the future was limited to those able to prove their material strength and mastery – a viewpoint which, in its more negative aspects, is now largely confined to the military establishments.

Today we do not view the future quite in the same way, as a great evolutionary onrush, largely independent of man's intervention and tinged with various premonitions of doom whether or not he chooses to intervene.

We realize that man does not, in the end, 'master' nature in the nineteenth century sense, but collaborates with nature – his very existence depends on an intricate balance of forces within which he is also an active agent.

H. G. Wells' *Mind at the End of its Tether* marks the conscious end point of the older intellectual stance toward the future, and one may still see it repeated in those who cannot make the breakthrough to the next period. In essence, there is a kind of intellectual polarization taking place around the mid-twentieth century which separates the intellectual establishment into two – one, those who are still preoccupied with the world as conditioned by its pre-1900 parameters, and those who are attempting to recast and reorient their world view to one which is in many ways, quite unprecedented in human experience. The watershed of this dichotomy really lies much further back – around the Renaissance. The argument begins there about man's relation to, and conscious control of, his own forward development and reverberates down to our own period. At a particular point in time, the summation of certain discoveries and access to certain technical facilities suddenly invalidates the whole of one side of the debate. From this time forward, which one may locate as recently as World War II, one can isolate the two attitudes in the turn of a phrase, the use of a particular frame of reference.

An important point for the individual is, that once the switch in perspective is accomplished, a good deal of negative baggage drops away. The fundamental realization is that man's future is literally what he chooses to make it – and the conscious degree of control he may exercise in determining his future is quite

unprecedented. There are many alternative paths to as many alternate futures. Some we have already begun to take, others await our decision. As man gains more knowledge of the forces operative in, and external to, human society, he is forced to couch his questions about the future in the form of alternative possibilities of present actions in terms of their long-range consequences. The more knowledge, the greater the number of alternative paths and the longer the range of consequences.

This realization has been born in upon many sectors of society. Governments and industries alike, committed to long range programs of the most varied nature find that they are increasingly forced to think not of the next ten or twenty years but of the next fifty or a hundred. To launch a manned space vehicle to the moon in 1970 requires that you start work on it about ten years before. Other decisions are of a similar nature. But planning a series of manned rockets is relatively easy in present terms. You can forecast with reasonable accuracy the types of basic research in metal and other alloys which should be initiated this year so that their bulk production may be available in three years to phase with parallel developments in lubricants for near vacuum which you can predict will be available in four years and so on. By compiling the research trends and rates of technological development you can attain to variously workable ten, twenty or even fifty year predictions. Even such apparently straight-forward forecasting, however, is liable to swift alteration, through serendipity.

When we come to social planning, the situation is very different, but the need to introduce some predictable parameters and concomitant action has become even more urgent. We have viewed the unforeseen consequences of 'not predicting' – famine and disease are preventable catastrophes. On the local scale, governments now attempt to predict situations productive of disorder and violence. Industry has become increasingly preoccupied with the markets of the '70s or '80s, the future of this industry or that. Dealing with human futures re-introduces the capacity of human beings to determine their future. This is a central point. Given his present scientific and technological knowledge, man now has an enormously enhanced capacity to choose his future – both collectively and individually.*

The outcome of the 'futures' chosen will depend on the degree to which we predict them. If we conceive a specific course of action desirable, we will tend to orient ourselves toward it. The collective aspect of choice of

**Finding out what we want should become a major object of our attention... there is a vast difference between letting changes occur and choosing the changes we want to bring about by our technological means.*

Bertrand de Jouvenel, 'Utopia for Practical Purposes,' *Daedalus*, Summer, 1965.

futures is reflected in the growing concern of our local societies, with the allocation of public funds to various programs. We begin to agree that investments in pre-natal care, child welfare and pre-school education, etc., which may not 'pay off' for twenty or thirty years are realistic societal strategies. We attempt to legislate the future pollution of the rivers and the air, the future congestion of cities, on the same basis. The pattern of a desired future based on even the least factual or measurable prediction commits us to consensual action. Our prior 'collective' assumption is, increasingly, that the environment and form of our society are within our positive (or negative) control.

The individual's relation to his or her future has become, and is becoming, more flexible. Where a man, even in the advanced countries, would previously feel impelled to prepare himself for one occupation, profession or career, committed more or less to a particular geographic locality and determined for him largely by the circumstance to which he was born, we now have an emerging situation within which an individual may reasonably expect to change occupation, career role and geographic location many times in his lifetime. The future of the individual is based, again, on whatever expectation of the future he acquires. His paths towards this or that future, though conditioned in part by physical make up, 'talents,' etc., may be viewed as more largely determined by his particular conceptual mapping. As Dennis Gabor has suggested, we are now 'inventing the future.' Man's future is most likely that which he may most imaginatively conceive of, which, in turn, will determine his action towards its accomplishment. Life may be viewed as a great number of alternative possibilities—in life style, location, occupation, etc. The so-called 'threat' of leisure is no more than a widening of 'living' alternatives.

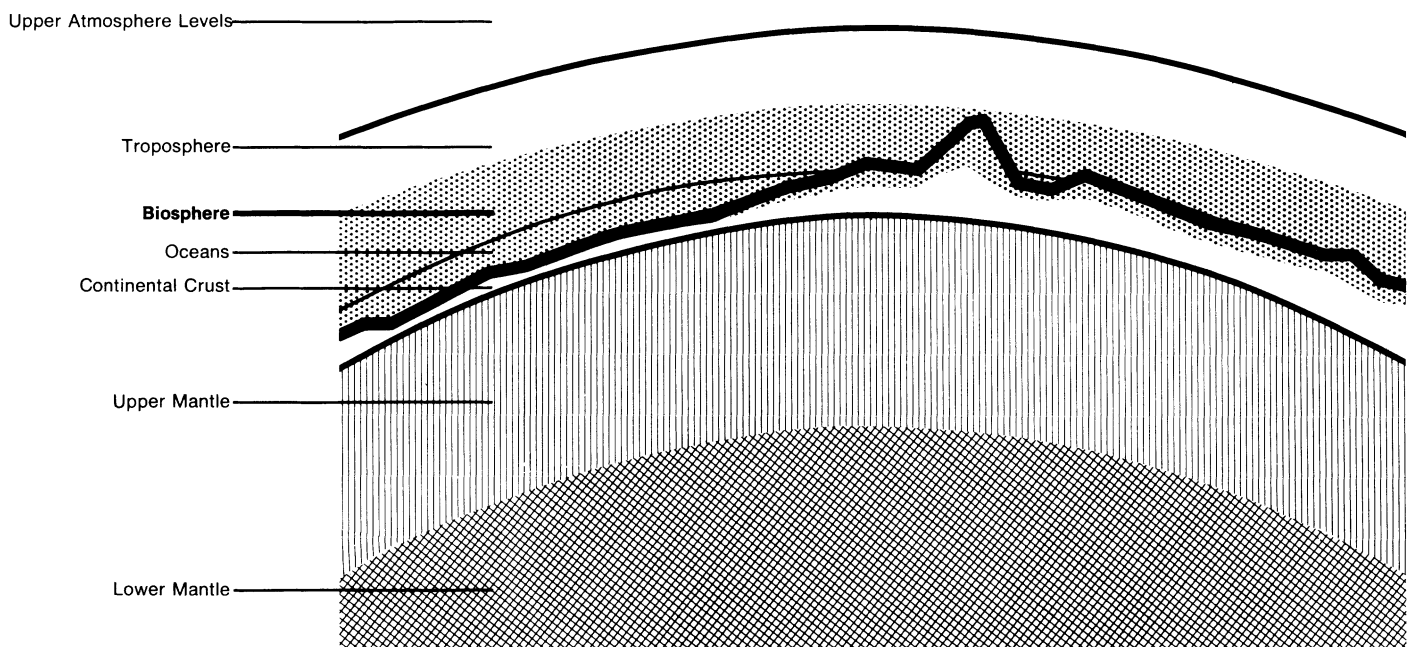
The future of the future becomes, therefore, what we determine it to be both individually and collectively. It is directly related to how we may *conceive* any specific or vague future to be. Such mental 'blueprints' are action programs, whether immediate or not depends on the individual and his collectivity, i.e. society. All actions have consequences and both may be effected on a larger scale, with further reaching contingencies than was ever consciously possible in human history.

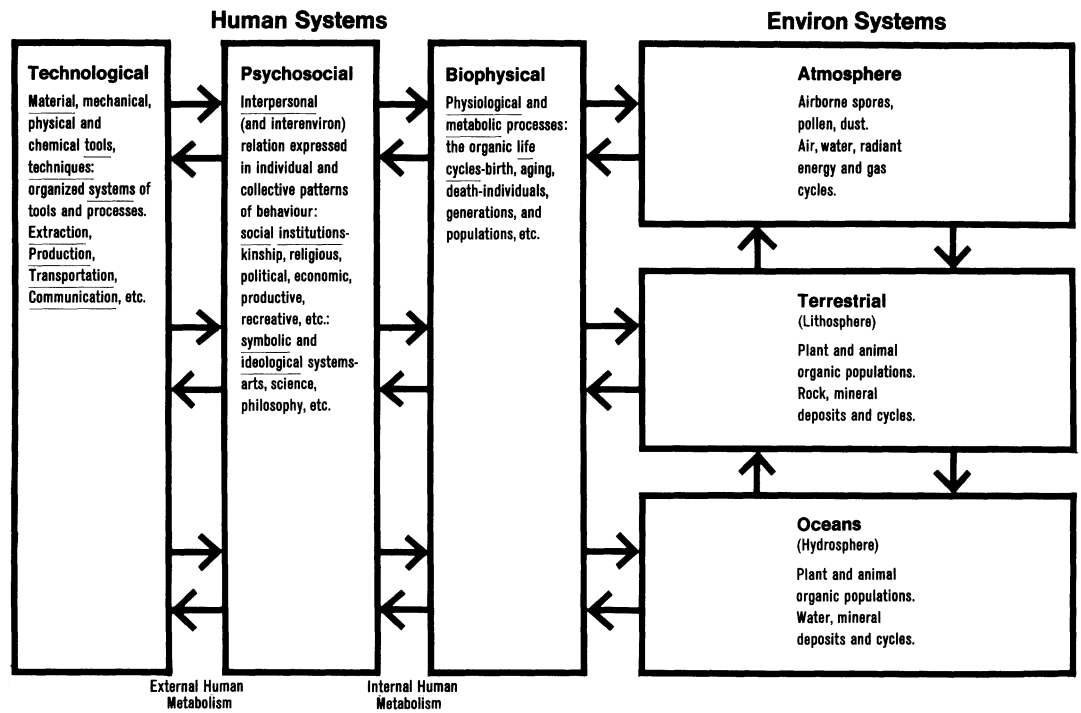
Though emphasizing change, we should also note that all change proceeds within a set of regulating patterns. Life on earth has been possible only during the past billion years through the relatively stable interrelationships of the variables of climate, the chemical composition of the atmosphere, the sea, the life-sustaining qualities of the land surface, the natural reservoirs and the water cycles.

Within the relatively thin bio-film of air, earth and waterspace around the planet, all living organisms exist in a delicately balanced ecological relationship. The close tolerances of this symbiosis are presently known to us in only the haziest outline. Apart from the relatively local disturbance of earth cycles through agricultural practices, man until quite recently did not have the developed capacities to interfere seriously with the major life sustaining processes. Since the Industrial Revolution, this has changed abruptly, and from this time forward the 'eco-system' also includes man's machines, their products and an incalculable capacity to alter the natural balances.*

The word, ecology, is significantly derived from the Greek *Oikos* meaning *house*, so in our references to human ecology, we are really talking about planetary housekeeping.

The biosphere is the "lifespace" surrounding the globe, consisting of air, water and earth. It extends about seven miles into the air and for thousands of feet below the earth's surface and sustains all our major activities through various interacting processes such as photosynthesis and the hydrological cycle.





Graph showing the concept of ecology, including psychosocial, technological and biophysical factors.

Writing on the human biosphere** G. Borgstrom, points out that the maintenance of three billion humans presently requires a plant yield sufficient to accommodate 14.5 billion other consumers. These other consumers, the animal populations, are an essential element in maintaining the humans by acting as intermediate processors for many plant products indigestible by man. Pigs, for example, consume four times more than America's 400 million people, when measured on a global scale. Despite mechanization, the world horse population still has a protein intake corresponding to that of 653 million humans – the population of China.

*The first great changes came with the advent of the Industrial Age, based on engines that used energy stored in coal beds, which built cities and navies, wove textiles, and sent steam trains across the widest continents.

Since then, with energy from petroleum and other sources, changes have come more swiftly. Today, radar telescopes scan the universe to record galactic explosions that occurred billions of years ago; oceanographic ships explore the undersea; electronic devices measure the earth's aura of unused energy and similar equipment traces inputs and outputs of single nerve cells; television cameras orbiting the earth send back photographs of entire sub-continent; electron microscopes photograph a virus; passenger planes fly at almost the speed of sound; and machines set type in Paris when a key is tapped in New York. These are only a few of the changes that our increasing supply of energy has made possible in the last 60 years.

Boris Pregel, 'The Impact of the Nuclear Age,' in *America Faces the Nuclear Age*. Edited by D. Landman and J. E. Fairchild, published by Sheridan House, New York, 1961.

** G. Borgstrom, *The Human Biosphere and its Biological and Chemical Limitations*. Global Impacts of Applied Microbiology Conference, Stockholm, 1963.

Yet in terms of balance, '... only one tenth of the caloric intake of the world household consists of animal products.' World food consumption is largely vegetarian with 90 per cent of the caloric intake and 60 per cent of protein coming from plants. This underlines the importance of each of the respiration/ excretion/ decomposition stages in the natural economy, with microbial activity as a key element in the recycling of materials. Amongst the non-human animal population in the food cycles, micro-organisms play a major invisible role.

The dependence of one-sixth of the world's food supply on 'artificial' nitrogen produced by the chemical industry, is another factor. To make one million tons of such nitrogen annually, we use a million tons of steel and five million tons of coal. But the greatest areas of developing crisis for man in the biosphere are water and air. Approximately 95 per cent of our water is in the ocean and the remaining 5 per cent of fresh 'cycling' waters are presently being used at a prodigious rate. Agriculture accounts for 50 per cent, using 400-500 pounds for each one pound of dry plant matter. This water/crop ratio varies as high as 1-1000 and 1-2000, so that agriculture in the lesser developed countries consumes as much water *per capita* as the technologically advanced – where 250 tons of water are used in producing a ton of newsprint and 25 tons for each ton of steel. When such uses are compounded with mounting waste and sewage disposal, the position is more severe. The increase of pollution in water and air has now become of national concern in many countries. An average industrial city of half a million people disposes of 50 million gallons of sewage a day and produces solid wastes at the rate of

about 8 pounds a person each day. Present solid waste disposal even in advanced countries is archaic.*

It has been noted that with present waste treatment, by 1980, effluents will be sufficient to consume all the oxygen of all the dry weather flow of 22 river basins in the USA. Within this discharge into rivers and streams goes also detergent materials, industrial wastes and pesticides from the land. Massive fish-kills of around 10 million in the Mississippi basin and the Gulf of Mexico, during 1960-64, were traced to pesticide run-off and other toxic agents from sources thousands of miles away.

With 'people kills' the toxic agencies may go unnoticed for much longer. Some 500 new chemical compounds come into industrial use yearly in one country alone, with practically no legislative attention to their long-range deleterious effects which may be nonspecific as to pass for normal deterioration. In the past hundred years the CO₂ concentration in the atmosphere has been increased by about 10 per cent – no small argument in favor of banning *with the bomb* the comparably lethal uses of coal and other fossil fuels as energy sources. Four thousand Londoners died from air pollution in one week in 1952, one thousand in 1956.**

In addition to fouling the atmosphere, it has been calculated that certain elements, e.g. argon, neon, krypton, etc., indispensable to life are now being 'mined' out of the atmosphere by industrial operations at a faster rate than they are being produced by the earth's atmosphere/hydrosphere/lithosphere process.

This cursory overview is not without consequence for the future of architecture and environment planning.***

Air pollution is not a 'local' problem – the air is not restrained within municipal or national boundaries, nor are the waters of the planet. In terms of any such planning, even the year 2000

**But there are no consumers – only users. The user employs the product, sometimes changes it in form, but does not consume it – he just discards it. Discard creates residues that pollute at an increasing cost to the consumer and his community.*

Waste Management and Control, US National Academy of Science – National Research Council Publication 1400 (1966).

***Air pollution affects almost everything in our environment... from clothing, skin and lungs to metals and paints... its damage costs are estimated in the US alone between \$7 and \$9 billion annually.*

Dr. Karl W. Wolf, *Conference on Space, Science and Urban Life*, Seminar B. NASA 1963.

*****The town and city planner and public health specialist of tomorrow will have to take a far more comprehensive view of human ecology than most of them yet dream of; and the costs of safeguarding human health, including the psyche, can no longer be put 'on the cuff' no matter what they may do to conventional economic progress.*

Wm. Vogt, 'Man's Ecological Dilemma,' *Natural History*, December 1965.

is too short range. As a generation on the 'hinge of history' we must accept the challenge of imaginative extrapolation of human requirements beyond 100 or even 1000 years. Where it may be pleaded, for example by special interest groups, that we have enough coal, oil and gas reserves for 500 years, their continued use at the present rate is obviously precluded by their adverse effects on the eco-balance. Leave them in 'storage' – until a more evolved society may use them less prodigally and dangerously.

Some of the mandatory requirements for the merely adequate maintenance of the eco-system are already clear. We need to recycle our minerals and metals; increasingly to employ our 'income' energies of solar, wind, water and nuclear power, rather than the hazardous, and depletive, 'capital' fuels; to draw upon microbiology and its related fields to refashion our food cycle; to reorganize our chaotic industrial undertakings in new symbiotic forms so that the wastes of one may become the raw materials of another; to redesign our urban and other 'life style' metabolisms so that they function more easefully.

The technological systems which we have evolved are now global in their operation and their efficient ecological operation is now interlocked with the maintenance of the entire human family on the planet.

Our present level of technological operations already interferes substantially with the natural cycles of energy and materials in the biosphere within which all of our major life processes are toward outer space.

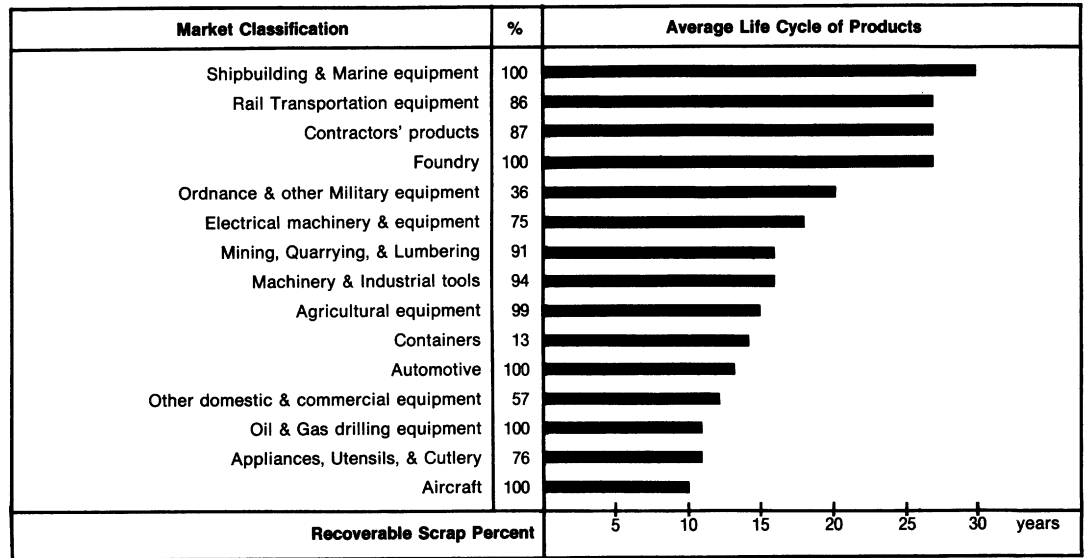
Is it too soon to inquire if these factors, plus others, may be contributing to an upset of nature's delicate balance? Are we slowly overturning the oxygen-carbon dioxide system upon which all life is dependent? Is that cycle being disturbed by high oxygen consumption and low oxygen yield? Are we thus shifting certain basic weather patterns upon which our various civilizations have come to depend?*

It is patently no longer adequate to consider any such 'problems' in isolation or with sole regard to their unilateral solution at local, regional or national levels – whether they be pollution, hunger, lack of adequate shelter, population pressures, etc.

The minimal set of basic questions we need to ask ranges far beyond those required for local solutions to our various problems. Many of the problems are only problems because of a parochial concern with this, or that, economically or politically 'convenient' set of solutions. There are no wholly local solutions any more – as there are no major human problems which are not also global. The basic questions revolve around the overall ecological maintenance of the entire human community.

**2nd Progress Report of the Subcommittee on Science Research and Development: Committee on Science and Astronautics, U.S. 89th Congress, 1966.*

Graph showing the recovery rate of iron and steel in various market classifications.



What are the optimal conditions for human society on earth? There is obviously no fixed answer to such a question. But there are the various physical factors of adequacy in food, shelter, health, general welfare, and the concomitant access to the individually preferred physical and social facilities which make life meaningful and enjoyable. We have gradually arrived at sets of such conditions, as in the various bills of human rights—like that of the United Nations.

Whether such 'ground rules' may be practical or not, we do in effect approach them, however tentatively, when we try to legislate for some human welfare or environmental control measure. The time is overdue for much more than tentative or local measures. To design our way forward through our present critical transitions, we need to adopt some more positive and operational indicators of the optimal conditions for the fulfillment of human life. By this, we do not mean optimal determinants which may be valid for all time and all people, i.e., some set of absolutes. The variable and changing nature of human values make this not only undesirable, but unrealistic, in that one set of values in development may considerably modify others. But such considerations may still be flexibly accommodated and yet allow adequate definition.

We may tackle this in other ways by asking various fundamental questions about our planetary society. Which activities are most inimical to this; which more positively sustain, and forward, the human enterprise?

What are the physical limits and constraints in the overall ecosystem, with regard to our growing technological systems?

What are the relevant human limits, e.g., the biological limits; air, food, water; temperature, space, speed and noise tolerances.

What are the irreplaceable resource limits, e.g., both the physical energy and material re-

sources, and the human, individual, social, and genetic resources?

Or in other words:

What are the physical operational parameters for the planet—the ecological or housekeeping rules which govern human occupancy?

These are very large questions, but they are those to which we must now apply ourselves—in many different ways and over a very long period. Some of the answers we already know, in part. Others are, in some senses, ultimately unanswerable—that they may be so is the more reason to ask them—if only to probe the limits of our knowledge.

We are now developing the technological capacity to deal with such questions, even on the global level, via the computer and its ancillary technologies. It is, perhaps, not entirely irrelevant that 'cybernetics,' as used to describe this new field of human enquiry, was derived from the Greek word for 'steersman.' It is precisely such large scale 'navigational' aids which we require to help guide our planetary undertakings forward.

As we go toward 2000, it will behoove us to accept the facts, that the resources of the planet can no more *belong*, by geographical accident, to any individual, corporation, country or national group than the air we breathe. National ownership of a watershed or key mineral deposit is as farcical a proposition as our supposedly national sovereignty of an 'air space.' The situation we face now is analogous to that which was fought over locally in the nineteenth century with regard to pure food legislation, public health and child welfare, etc. The same arguments will, no doubt, be raised again about the rights and privileges of the individual—to poison, swindle and infect his neighbor, or his own descendants. Our most important discoveries, therefore, may not lie solely with technological innovation—but with social invention. We begin to recognize more clearly that our societal institutions,

the ways in which we organize ourselves to live together in human fashion are not immutable, but are as much man-made 'invented' forms as television or the car. The city or nation state were comparatively recent inventions of this order which may now, in certain areas of their functioning, be dangerously obsolescent. Just as we have consciously learnt in the past few decades to organize the process of scientific and technological innovation, and its applied development over long time spans, so must we orient ourselves towards more consciously controlled and experimental social innovation. The design of new forms of human organization is already under way in many areas of public and private life and is even more evident at the international level. The UN, for example, is a second generation 'bench' prototype of the League of Nations. We now need to initiate new phases of research and development toward more viable forms of this magnitude. Our evolving planetary society must become like a great learning machine in which man's intelligence (now) intervenes and directs the process which remains, nonetheless, basically an experimental process.

Without touching upon the more familiar problems of war, hunger and human disease, even a cursory glance at our eco-system is sobering. It should be apparent to all, that we now live in such close community, and within such delicate 'life' margins, that all our actions are now cast on a planetary scale and that our gross ecological errors may reverberate for centuries.

It may be pertinent to review initially some areas of possible import to 'local' environ control problems. Where not of immediate applicability, these may furnish directive paradigms towards the resolution of such problems.

Space technology has provided the key image of scientific and technical progress for years. The strongest impetus to the various space programs may be a combination of chauvinism and weaponry, with their most tangible by-product: an entirely new way of regarding our planet, man himself and his relationships to it.* Sketching the main import and possible implications of space technology is difficult because of the extraordinary way in which it has affected, and been affected, by so many areas of scientific enquiry. Almost every branch of science, physics, chemistry, etc., through biology, medicine to psychology to para-psychology, and all forms of engineering have been pressed into its development, so that it seemingly draws upon the entire accumulation of human knowledge for the past 200 years. The reasons for this convergence are to be sought within its central purpose. To transport and maintain the human organism off the earth and outside its sustaining envelopes requires a 'duplication' of the earth itself—a protective enclosure and complex life support system which is, in effect, a rudimentary Earth in miniature. A developed space vehicle, with

its protective shields and energy collectors and converters, its internal 'closed system' ecology for the cycling of air, water and wastes, and its sensors and communicating devices, is a micro-miniaturized version of our planetary vehicle.

Ideally a space capsule should be a microcosm of the terrestrial world: there is no air except the breathable atmospheres carried along or continuously regenerated; there is no water except that carried or regenerated; there is no food and no biological 'sponge' to soak up impurities, no waste-disposal apparatus operating through a long biological chain. Up to now prepackaged food has been used on space flights, stored water, atmospheres which are known to be safe and primitive waste disposal methods (plastic bags). But with longer space flights, because of the large cumulative weights involved, exhaled carbon dioxide will have to be reconverted to oxygen, water reclaimed from the air, wash water and urine and trace contaminants removed. Food may even have to be produced on board. Some of these needs are far off, but work goes forward to ensure that they can be met.

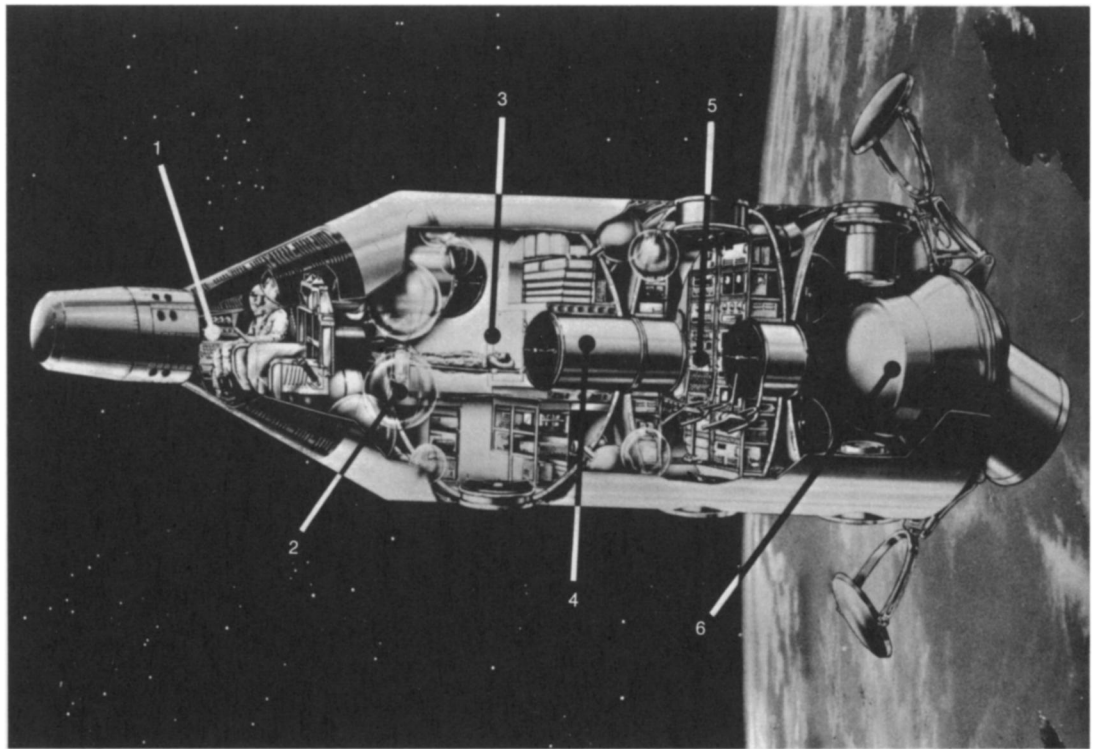
There are innumerable ways to organize regeneration, storage and dumping in the air, water and food cycles needed to keep astronauts alive. On a 420-day return trip to Mars, a crew of six will breath about 5000lb. of oxygen, exhale about 5800lb. of carbon dioxide, eat about 5000lb. of food (dry weight) and use about 30,000lb. of water for drinking, reconstituting their dried foods and general personal hygiene. If the carbon dioxide is absorbed chemically, as in the Mercury and Gemini capsules, about 6200lb. of chemicals will be needed. Clearly a recycling process is required.

**The question is not so much whether we can make better baking dishes out of rocket nose cone materials, or whether a highly effective device hand tailored for space at enormous cost will have mass production possibilities. The question is rather whether a society can take on with some confidence of success seemingly impossible tasks, though compatible with physical laws. In space work, society does organize itself to analyse the problem, marshal the resources, and see through to completion in timely fashion with much concurrent pushing of the state of the art. With this kind of experience, we can now take on other grand tasks which earlier man saw society needed but previously were equipped with neither the boldness nor the engineering and organizational tools to undertake... By the end of the next ten years, the concrete economic return should be considerable and routine. We should have fairly complete global weather reporting... widespread use of the communications systems for point-to-point linkage of all major points of the world... world-wide navigation and traffic controls for shipping and aviation—a great stock of observation techniques of direct value to farming, forestry, water management, fisheries, mining, mapping and geodesy and geophysical studies of all kinds.*

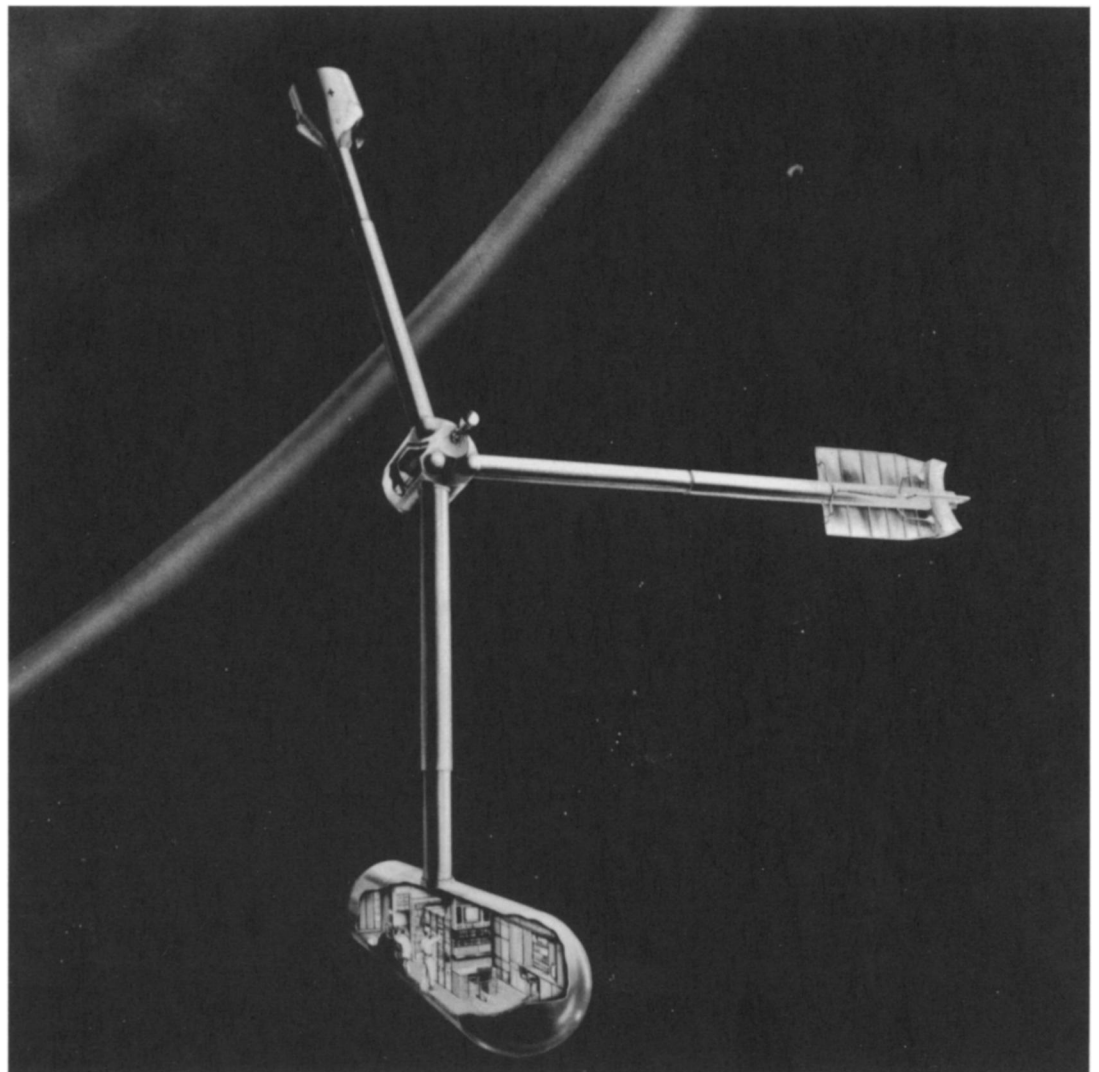
Charles S. Sheldon, *Space Age in the Fiscal Year 2001*, 4th Goddard Memorial Symposium, Washington, D.C., March 1966.

Manned orbiting laboratory:

1. Gemini capsule
2. spheres for cryogenic fuels
3. living compartment
4. airlock
5. laboratory
6. camera



Interplanetary manned space vehicle, designed by Lockheed Missiles and Space Company. At the top of the three-spoked configuration is a modified Apollo command module with an attached retro rocket section. The large chamber at the end of the bottom spoke is the mission module where work will be accomplished. At the end of the right spoke is the mental work and life support system. The hub, where the three spokes join, is a shielded shelter against solar flares. Astronauts reach each chamber through the hollow spokes. The entire vehicle rotates around the hub to provide gravity.



The closed ecological system, for long duration space flights, is an obvious prime requirement. The weight/volume penalties on non-regenerative life support systems which would carry sufficient air, water, waste storage, etc., on a single use basis is impractical for other than the briefest mission.*

The basic human functions furnish the parameters of the overall eco-system requirements. Man's required physiological intakes are food, water and oxygen. His 'output' materials are solids, including undigested materials, metabolic wastes (shed skin, hair, fingernail clippings, etc.) and salts; expired gases, including carbon dioxide and water vapor; liquids, respiration and perspiration moisture, urine and faecal water.

His daily metabolic turnover is in balance so that the main considerations in the physical aspect of the 'ecology' design are the 'looping back' of various exchanges to form a closed system. For example, in breathing, we exhale about 2.2lb. of CO₂ per day; on earth this is largely taken up by growing plants which convert it to oxygen and food in various parts of the photosynthesis cycle. In a closed space craft, the CO₂ can be funnelled outside, absorbed through chemical combination (as in the Gemini capsule), fed to an oxygen recovery unit or used in a 'food cycle' resembling the terrestrial man/plant exchange. The ideal system would be a completely regenerative, self-sustaining one in which water and oxygen would be recovered from metabolic wastes – air conditioning, temperature regulation, food synthesis, preparation and disposal, sanitation and hygiene requirements, etc., would be linked in one integral system. The present state of the art is exemplified in an inter-planetary mission scheme for the launch period between the 1970s and mid 1980s. Emphasis is placed on the air and water recirculation systems which are integrated in certain aspects with temperature conditioning, waste management and atmospheric conditioning. The food cycle remains open as an area of critical forward development.**

Omission of the food cycle from the above scheme reflects the comparative development lag in this area. Biological systems under review have almost all dropped the earlier 'algae' based models, or other photosynthetic units, because of their light energy requirements. The more recent approach is the chemo-synthetic using microbial populations which assimilate carbon dioxide and urea obtaining their energy from hydrogen rather than from 'light' conversion – hence work in the dark. As (theoretically) edible products, these organisms are protein, fats, carbohydrates and water. Various other 'biosynthetic' processes include combinations of bacteria, algae, turnips, sweet

*H. W. Matson, 'Keeping Astronauts Alive,' *International Science and Technology*, June 1966.

**E. S. Mills, R. L. Batterton (Douglas Missile and Space Systems Division), *Interplanetary Mission Life Support System*, 1965.

potatoes and reportedly a small colony of duck weed which is at present in orbit. The Russians have broached the idea of a carefully programmed chicken battery re-using processed wastes, algae, etc., to achieve an endless chicken supply. Serious studies have also been put forward for using edible materials for all internal partitions, control knobs, furnishings, etc., expendable at various mission stages.

Space medicine, human factors, etc., now under the heading *Bioastronautics* offer an extraordinary range of information for the terrestrial designer.

Telemetry, for example, the sensing and transmitting of information on the state of a man or an object at great distances owes its recent rapid development to 'space' activity. This can be used obviously in any situation where monitoring at a distance is required, but at present finds its most positive developments in medicine. In ways which are now beginning to revolutionize hospital design and various chemical procedures, this family of devices would allow two-way telemetry, via, for example, micro-miniature surgically embedded sensors, feeding data to centralized computer or human/machine diagnostic and treatment centers, thus creating new forms of medical surveillance and care.

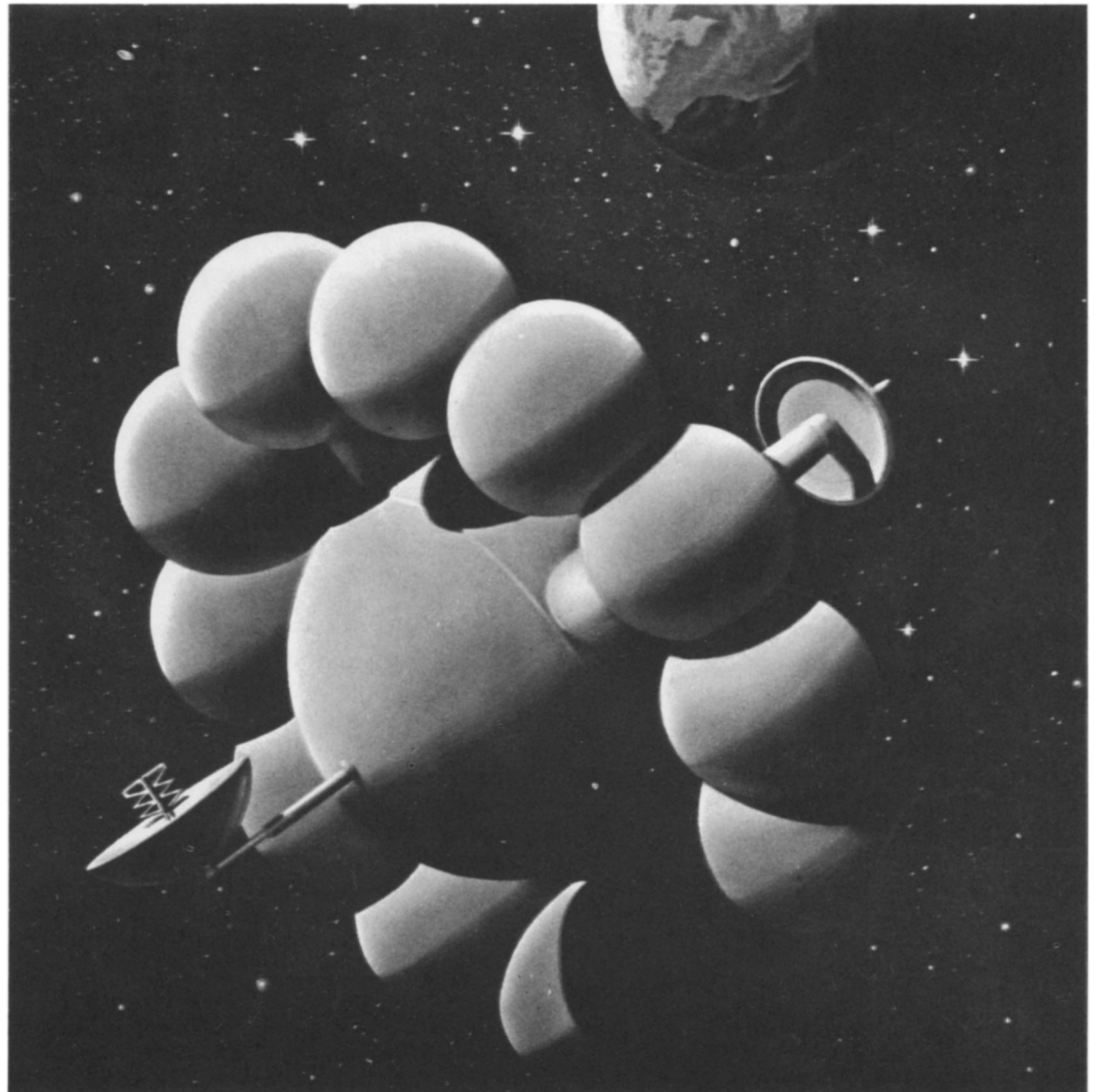
The structural aspect of spacecraft construction has a similar wide - spectrum view as that displayed in life support systems. These structures which will perform under the most rigorous conditions, take loads, insulate, protect against radiation and meteoroids are intensively computed on a stricter performance/per pound basis than in any other type of environment control instrument. To come close to this ideal, the (space) structure designer must work on the level of fundamental concepts – even at the molecular level, e.g., 'whisker' fibres of 0.2 micron diameter are being spun into composite matrices of flexible, metallic materials.

In terms of external configuration, form is determined by functional criteria, but in ways that bear little relation to the use of this slogan by other designers. Apart from the projectile type launch vehicle and present 'cone'-shaped manned orbiting capsules, space structures now in orbit, or under development, present an extraordinary range of design strategies. These range from rigid structures of various types exhibiting greatest variety in the unmanned 'Surveyor' and 'Nimbus' types – to developments in the variable-geometry folding, self-expandable structures which have been pioneered by Buckminster Fuller. The latter are particularly under investigation for manned lunar base needs for which large span enclosures will be required to fit into a nose cone for automatic opening and erection.

Similar close packing studies for the first space station include a full-scale three-story prototype of an inflatable structure of neoprene coated Dacron and foam rubber.

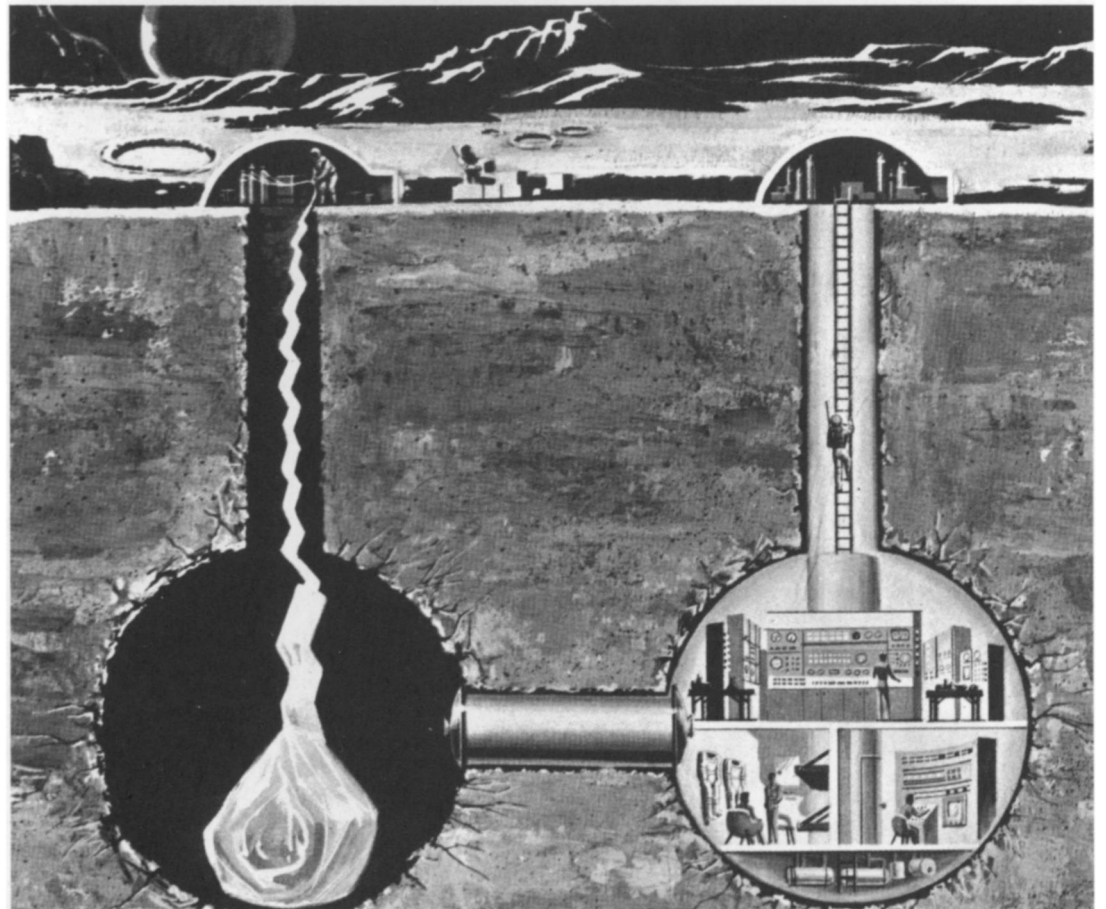
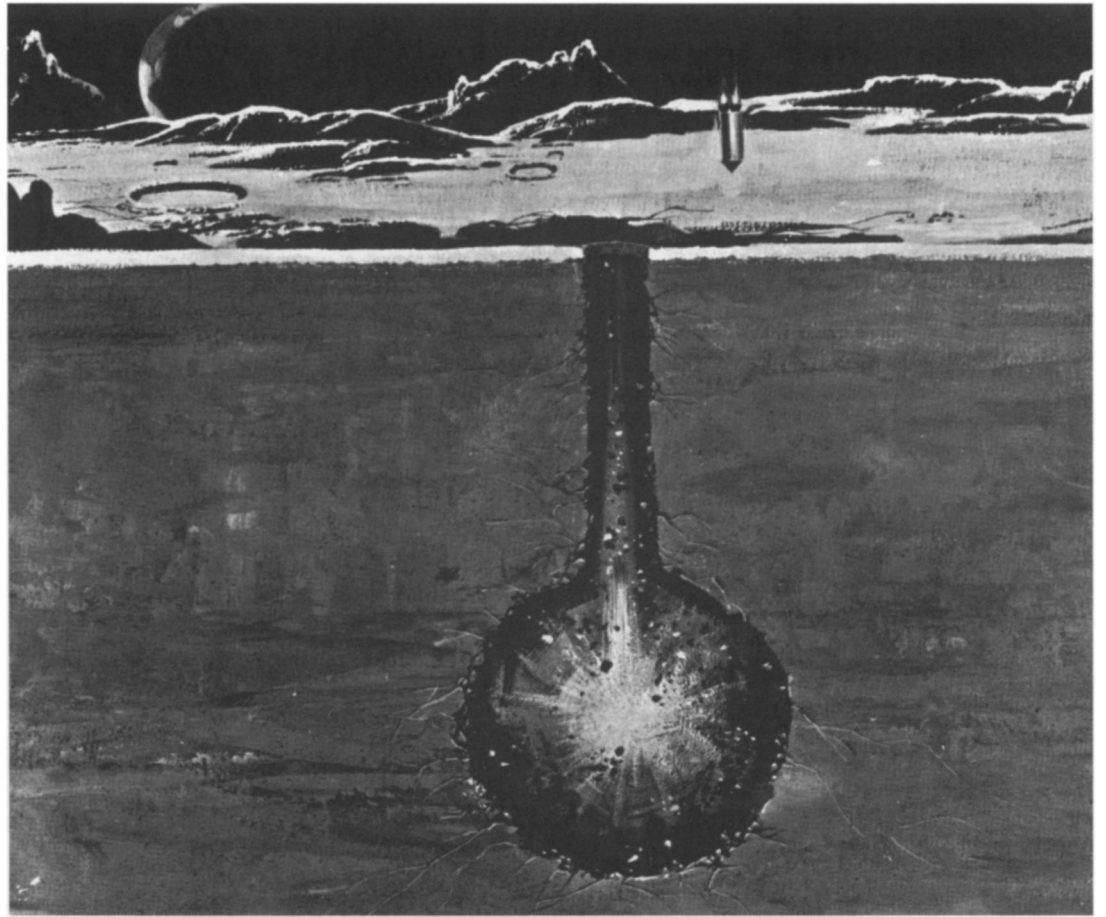
Like a giant inner-tube, the station connects to a central hub through a 'tunnel' spoke. Prototyped at 30ft. diameter, calculations allow for a 150ft. diameter station within which the crew would work in a 'shirt sleeve' environment with, of course, inflatable furnishings, etc. This macro-structure area, when compounded with lightweight/high strength advances in new alloys, metallo-plastic and other new composite materials, will soon begin to influence terrestrial structures. Micro-structuring is already an 'invisible' but enormously important 'spin off' from space research which may render obsolete many of the 'control' requirements of earth surface environment control. Presently visible mostly in the progressively smaller 'symbolic' gadgetry of the transistor radio, portable TV, etc., the development of micro-miniaturization is one of the most dramatic technical gains of the past two decades. About fifteen years ago packing densities of micro-electronic modules were around 10^4 parts per cubic ft, present off shelf components now run to 10^8 and 10^9 parts per cubic foot. At this scale, for example, more than 100 circuits comprising around 150 parts

are packed in a silicon wafer an inch wide and less than 1/100th of an inch thick. If trends hold, this capacity could reach 10^{15} per cubic foot within the next 30 years. The resulting electronic 'grown' components would begin to approach biological units with equivalent long life spans. Apart from weight/volume gains, the development of such micro-miniaturization was as much driven by *reliability* requirement—an equally important conceptual parameter of space technology. In terrestrial environment control, reliability, like most other factors, is of an extremely low order. In the hostile environ of space, crucial part failure can be the literal end of the mission. Within the 'systems engineering' concept in space technology, reliability, with weight/volume/efficiency, etc., is a key concern. Apart from exhaustive testing and extremely high reliability standards, another operational aspect is the 'soft ware' design of anticipatory schedules for emergency procedures and their integration in elaborate 'back up' and self-repairing sub-units. Typically, in life support areas, units may be split in parallel 'half load' for normal conditions to assume full load in

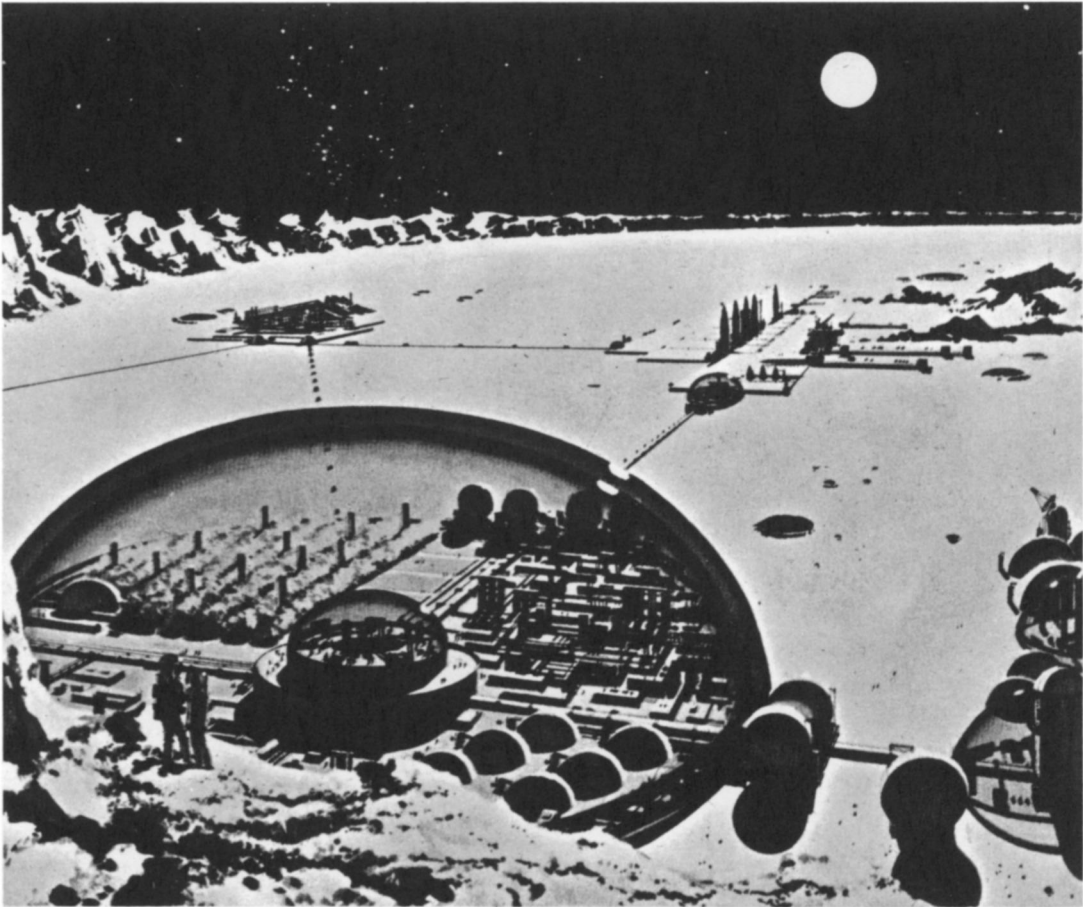
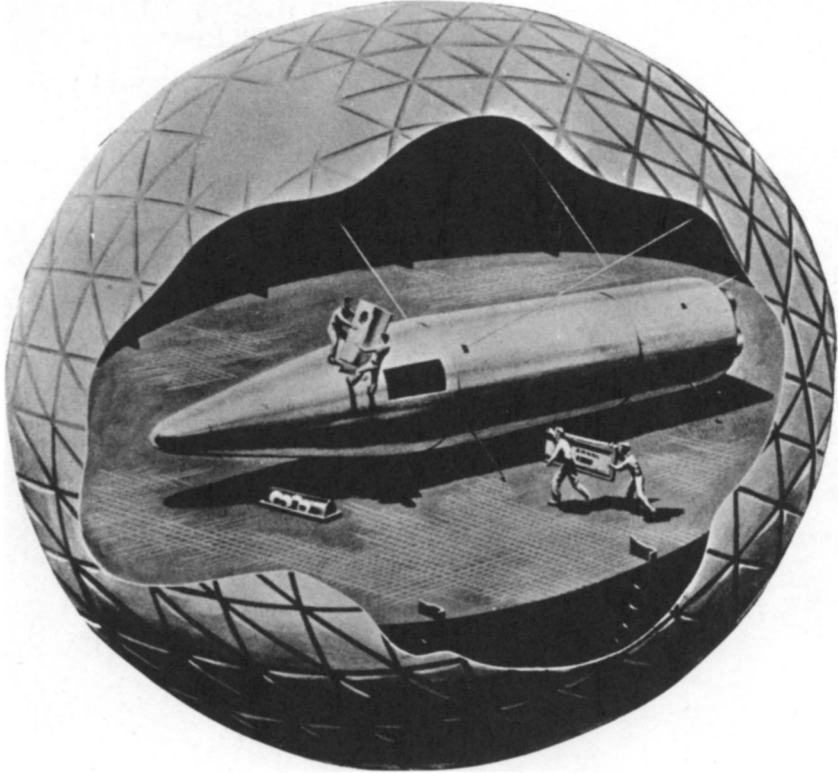


Space laboratory constructed with empty rocket propellant tanks.

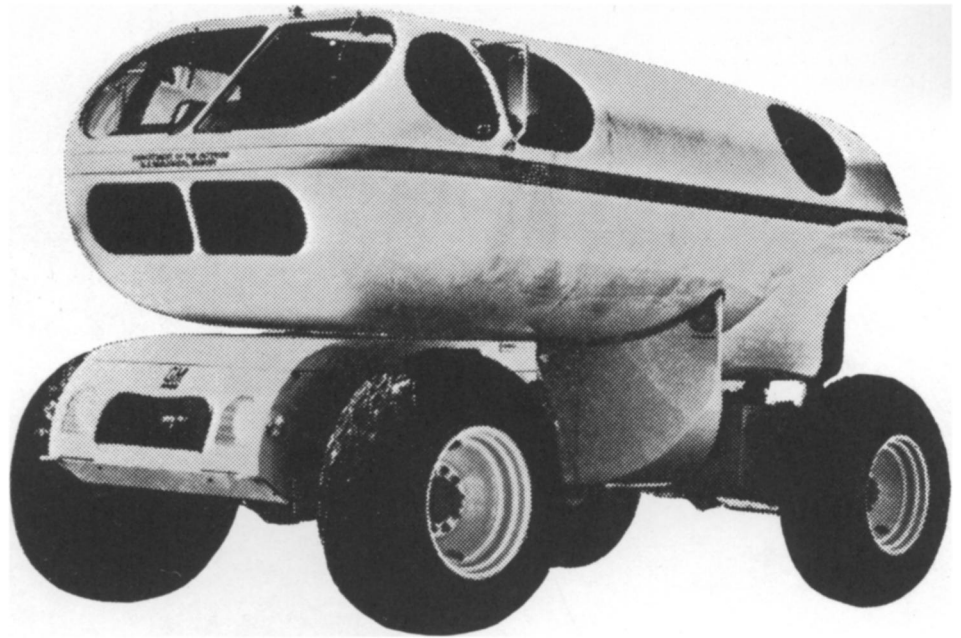
Proposal for excavating living quarters on the surface of the moon using a controlled nuclear blast set in a special rocket cone.



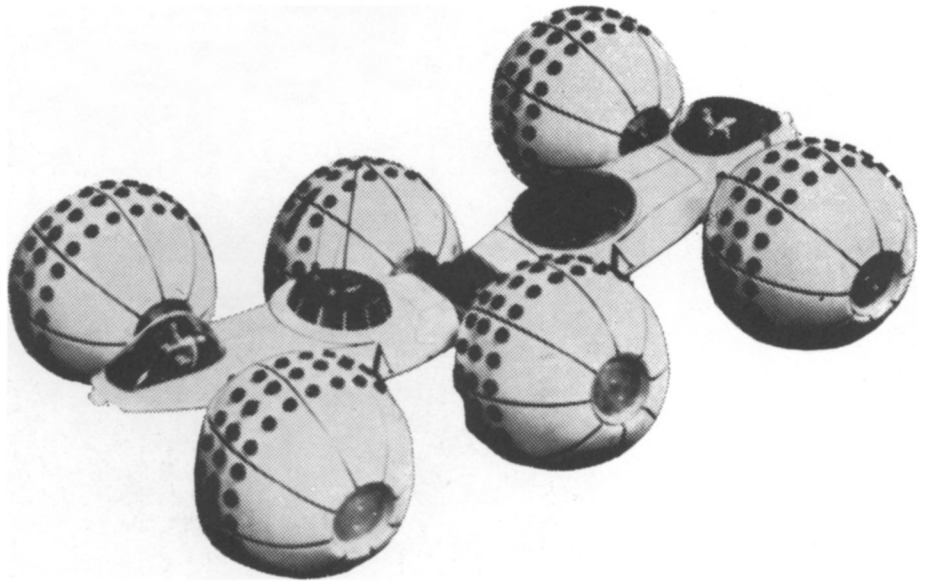
Space garage in the form of a geodesic sphere.



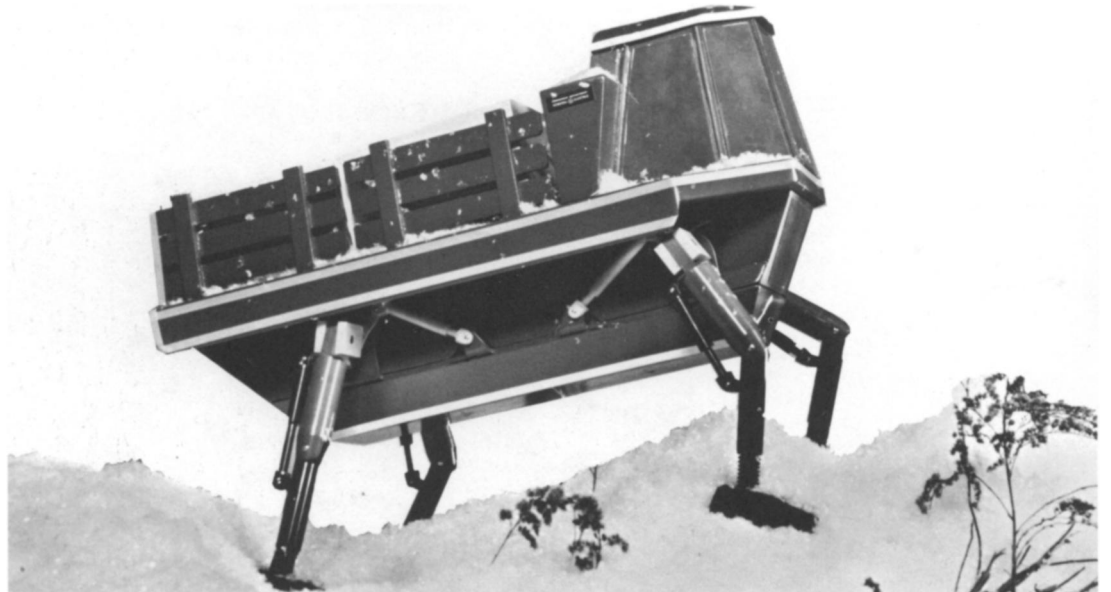
Moon colony covered by a dome similar to Buckminster Fuller's Manhattan proposal.



Study-lab used to test instruments for spaceships in the volcanic fields of Southern California.



Moon crawler, designed by General Motors Ltd.



Walking truck, operator-manipulated by controls on limbs and torso, to transport goods over rugged terrain at up to 5 mph.

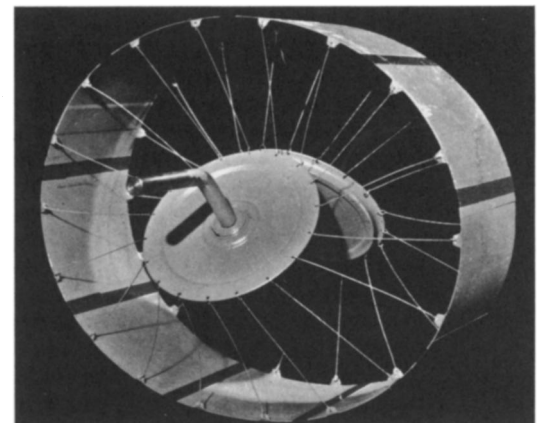
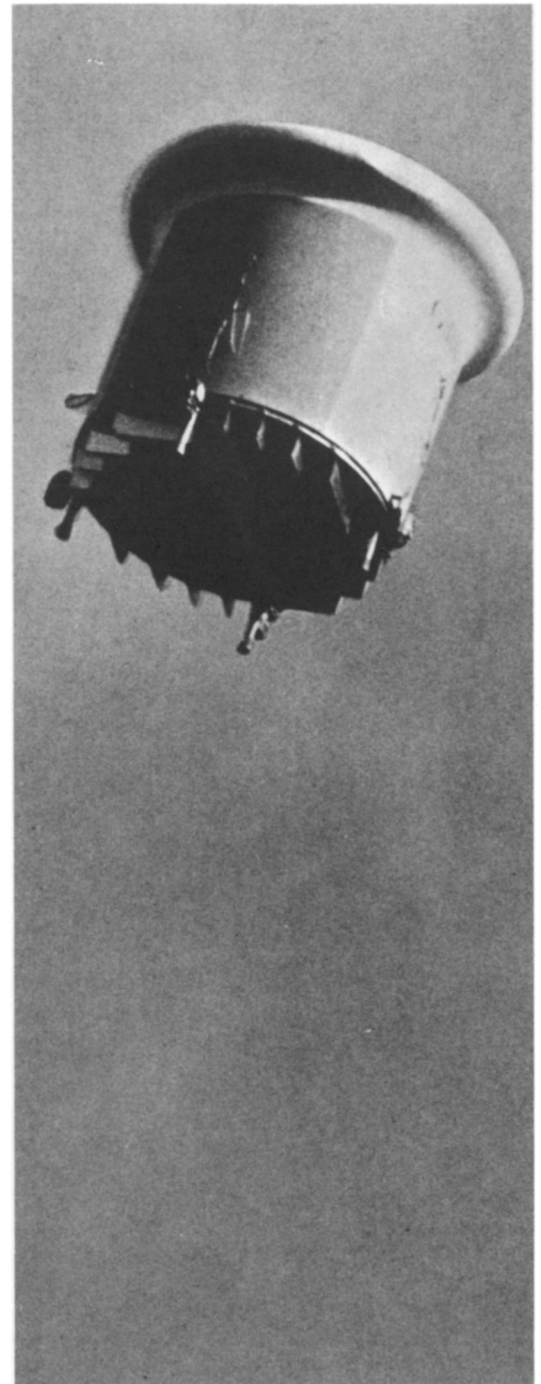
Ducted fan vehicle, motorized for observation, carrying a wide variety of sensors to relay information from positions inaccessible to humans.

the event of either failing. Electro-mechanical modules are interchangeable allowing emergency repair piracy from one area to another. As far as possible, control/maintenance functions may be degraded successively on malfunction—from automatic to semi-automatic, to eventual manual operation of all vital units. The contrast with the design of terrestrial operations is acute, say in relation to the US power grid failures and the general lack of anticipatory design in our local environ control.

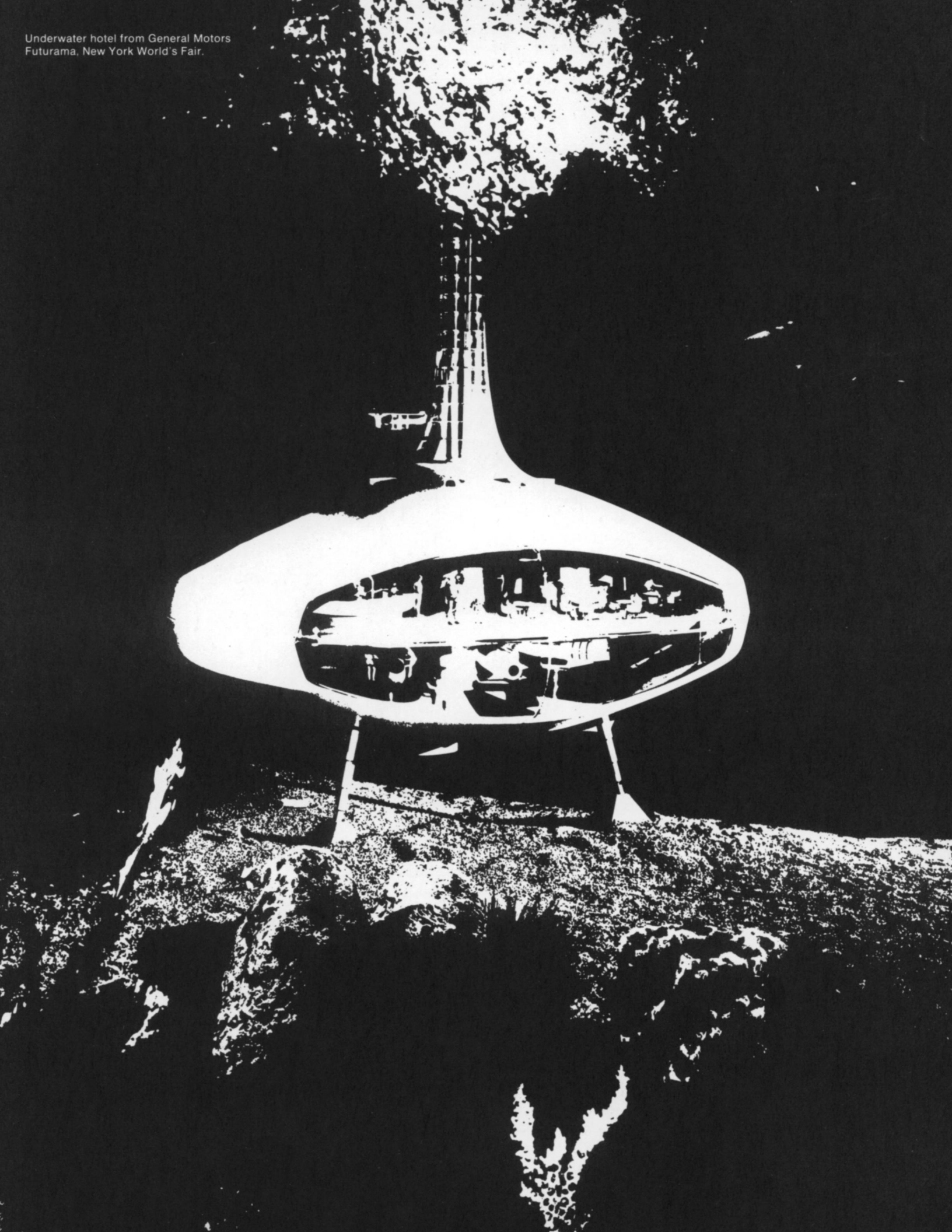
There are so many other technical advances currently available both in thinking and in actual hardware that any attempt even to mention them in this kind of essay would read like a catalogue. For example, new energy conversion and storage elements, communication devices, servo-mechanisms, etc. It may be more useful to give a brief overview than to provide further detail.

The next stage in space of specific import for architects will be the lunar base and manned space stations. Both the central concept of large-scale enclosure, life support and other requirements, are close to their traditional function. Current thinking on lunar base design goes in many directions, most of which will be explicit from accompanying illustrations in this section. Ancillary transport equipment designs vary from Buck Rogers type jet suits (already part operational for the recent Gemini/Agna docking program), to balloon wheeled mobile laboratories, moon trains of various type, transport modules as mobile bases, flying platforms, etc. The moon race aspect brings in the Soviet work in space. So far, due to local accessibility of materials, the emphasis has been on US equipment and thinking. Though roughly parallel in technical development, there are certain interesting cultural differences in approach. The first obvious one would be that the Russians already have a woman cosmonaut. NASA officials have been rather silent on this aspect. A second difference may be the view of man as a component in the system. The Russians tend to emphasize even more rigorous training of human functions (extra-sensory perception, etc.) with less reliance on a tailored environment for the astronaut. This is a more rough and ready approach than the US emphasis on a 'shirt sleeve' cabin with its greater dependence on machine augmentation of human function. Other interesting divergencies may be found in the available translated material. Russian extrapolation of present technological development seems more literary and poetic in imagery. This may be a characteristic of translation. One paper, entitled 'A Trolley Bus Line in Space,' describes a rocket rail system for interplanetary travel, using an 'ion drive' engine, which runs between solar electrical station 'guidelines' furnishing additional drive energy and guidance. Others often refer to Yefremov's novel, *Andromeda Nebula* and various science fiction works in discussion of travel to other galaxies.

Metalastic wheels designed for moon vehicles.



Underwater hotel from General Motors
Futurama, New York World's Fair.



Whilst neither so heavily funded, nor so dramatically in evidence as outer space developments, under-ocean research may have even greater impact on our immediate manner of living.

The oceans cover more than 70 per cent of our planetary surface. In terms of space, resources and exploratory challenge, it is rather like having another world at our disposal. The comparatively shallow continental shelves *alone* afford a work/research/recreation area three times the size of the US—about half the area of the earth lowlands where most of humanity lives. More pertinent is the fact that four-fifths of the planet's animal life and the bulk of its vegetation are underwater—yet comparatively little of these are at present used as food.*

Our knowledge of the oceans is rudimentary. As man's locally most 'hostile' environ for centuries, only the surface was traveled upon and its depths not investigated till recently. Barely one per cent of all sea organisms have been studied and the cyclic migrations of its larger creatures have been little charted.

As with outer space, much of the present impetus to explore the oceans is largely of military origin, e.g. the nuclear powered submarine as missile launch platform. But already the vast economic potential and obvious scientific interests have encouraged the general area of research and development. Official interest in the ocean may have just begun in time to prevent further spoilage, particularly of the coastal shelves. Old sea minefields still render parts of the latter unsafe and will do so for some time to come; indiscriminate sewage and industrial wastes have ruined other areas. Overfishing has led, not only to greatly reduced catches, but to the near extinction of certain species like the great sperm whale. A new hazard is the disposal of radio-active wastes in the sea.

The design criteria of undersea vehicles and environ control structures are, in some aspects, the reverse of those for outer space exploration. In building to withstand very great outside pressures, there is less configurational freedom in external hull design; also, hull weight varies sharply according to operating depth. Propulsion speeds are slow, drag and resistance are to be overcome, and there are special problems of surface coating in conditions of chemical erosion, microbial growths, etc. At greater depths no external work may be carried out by human operators and remotely controlled manipulators are required. Vehicle speed, relative to energy source, gives certain limits. For example, to double a submerged vehicle's speed requires roughly eight times more pro-

*The ocean is the ultimate repository of everything eroded from the continents. Over 40,000 million tons of material are washed into the oceans every year by rivers. The winds also transport many millions of tons of materials per year.

John L. Mero, 'Mineral Wealth from the Ocean Depths,' *Discovery*, July 1964.

pulsion power. Communications problems are, again, different from those in space flight.

The most singular differences in the two areas would be in travel speeds—and that the maximum ocean depth penetration has already been made relatively early in its exploration. The bottom of the deepest ocean trench known, the Challenger Deep, 35,800ft., was reached by the bathyscaphe Trieste in 1960.

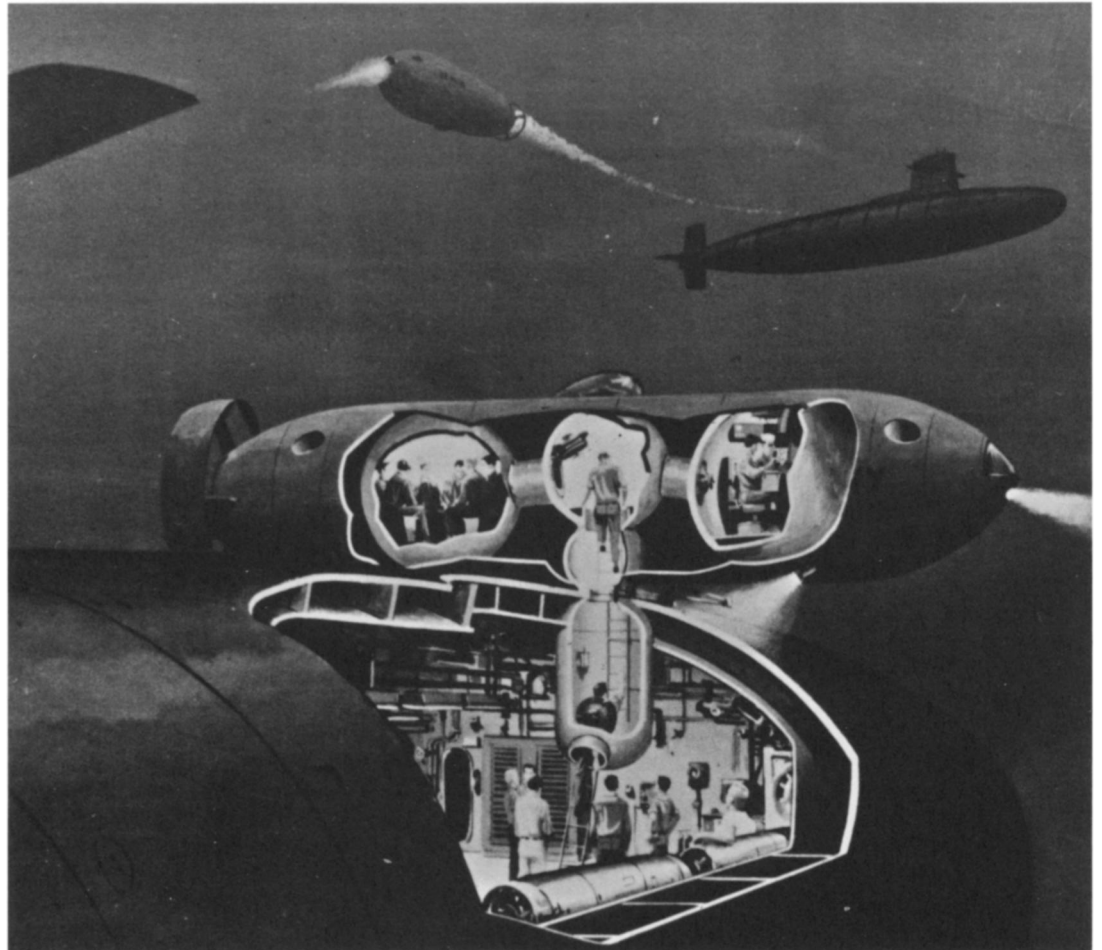
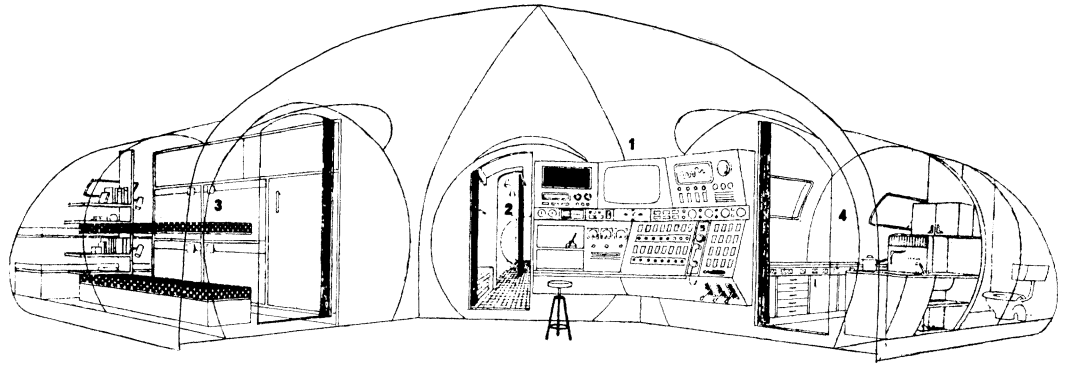
Apart from scuba equipment used in shallow waters, or heavy diving-suit gear limited to about 200 feet, present commercial undersea vehicles are two to five men units having a top speed of about four knots with working depths up to a few thousand feet. Some of these are equipped with external remote manipulators for specimen collection. In development are larger, more maneuverable, longer range vehicles. Separation of the manipulatory system from the manned vehicle is also being pursued. The latter, called *telechiric* systems are essentially a family of general purpose work robots. Equipped with arms, sonar and television, these machines are an extension of their human operator who may be in, under, or on the sea.

Though many of the undersea craft illustrated are for variable depth use, the most immediately significant area for the establishment of work environment controls are the continental shelves—averaging between 600 and 800 feet depths. These comprise about 10 per cent of the total sea floor area only, but are estimated to contain half of the ocean's important biological population and many of its mineral deposits and will, therefore, be the first area to be fully exploited. The pioneer in undersea living and working is, of course, Jacques-Yves Cousteau who set up the first manned undersea work station in 1962 off Marseilles. In Conshelf One, as it was called, two men remain submerged for a week at 33ft. depth and worked outside daily for five hours at depths up to 85ft. Conshelf Two, 'the first human colony on the sea floor,' as Cousteau has called it, was 36ft. down in the Red Sea and housed five men for a month, including a two man work-camp at greater depth. Both Conshelf One and Two were cylindrical and domical structures tethered by umbilical communication cables, supply pipes, etc., to surface and shore stations. Conshelf Three, a spherical structure weighing 140 tons, was established at 328ft. off Cap Ferrat, housing six men for thirty days. During this time, the oceanauts breathed a helium/oxygen mixture inside the base, and conducted heavy duty work for up to seven hours per day outside.

An unusual first time communication link was made when Conshelf Three's crew spoke by telephone to the crew of the US Navy's similar experimental station, Sealab II—205ft. down off the coast of LaJolla, California.

Both these deep submergence projects demonstrate the practicality of opening up the whole continental shelf area in particular to research, mining, sea-farming, exploration and

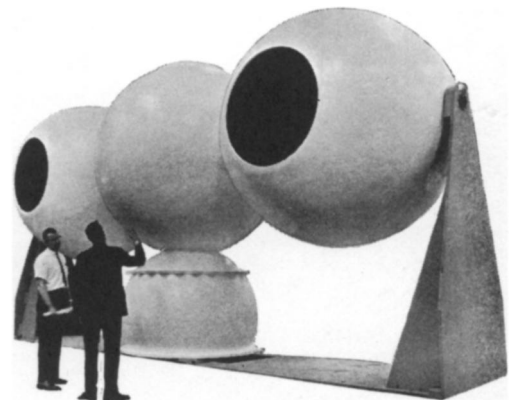
Diagram of Jacques-Yves Cousteau's *Conshelf Two* starfish house built for use in the Red Sea.



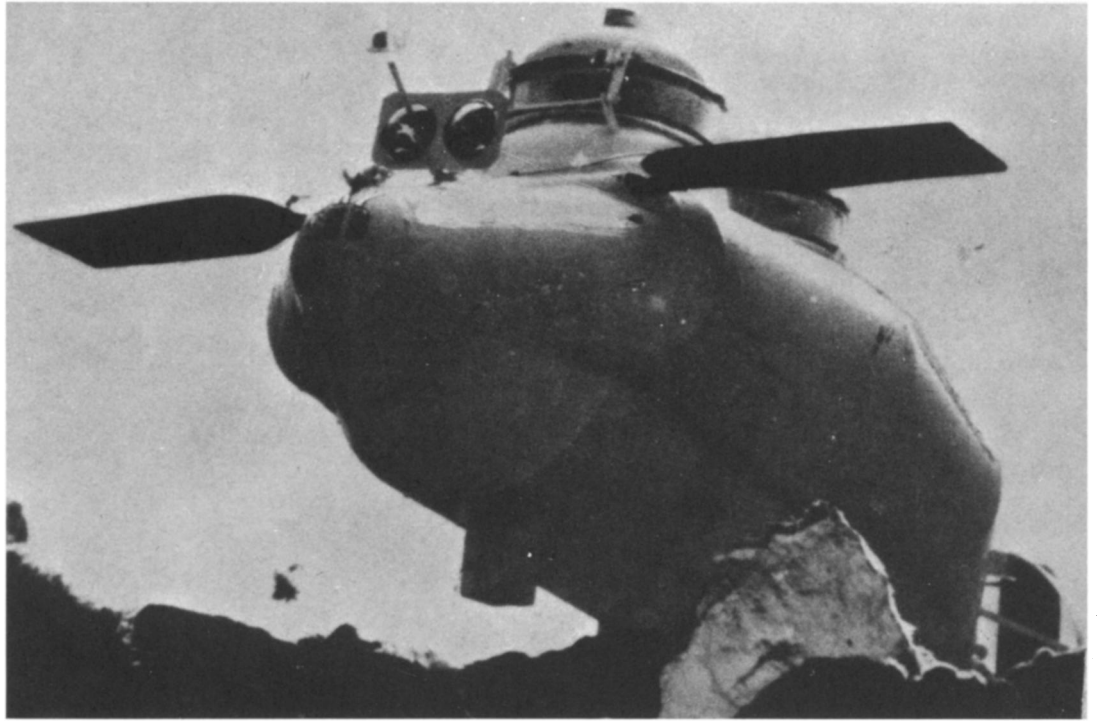
U.S. Navy rescue submarine: proposed design for vehicle to retrieve 24 men at a time from a distressed craft.

recreation in the near future. In effect, this new continent could become habitable within the next decade. For our basic requirement of recycling vital resources, the oceans provide much more frequent ecological recycling than the land area. Fish and other organic populations have higher growth rates, vegetation has less capricious weather problems for sea harvesting. In terms of mineral resources, Mero, referring to the nodules of very high ore content accumulating on the Pacific floor, suggests that, '...as these nodules are being mined, the minerals industry would be faced with the very interesting situation of working a deposit that grows faster than it could be mined or consumed.'

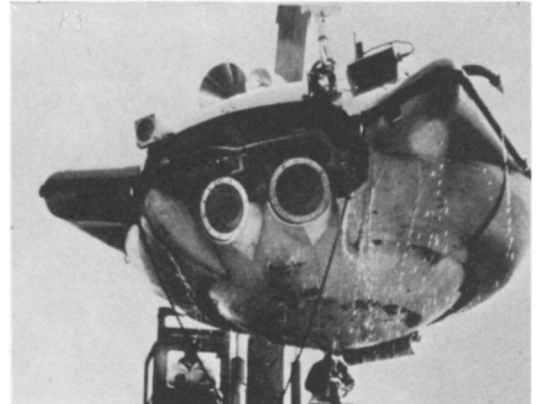
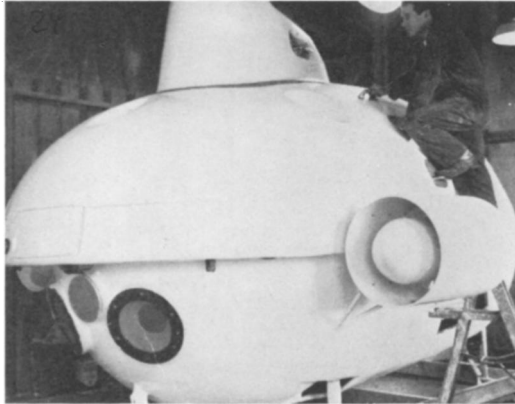
Prototype pressure spheres for U.S. Navy rescue submarine.



**American Submarine Model 300,
American Submarine Company.**

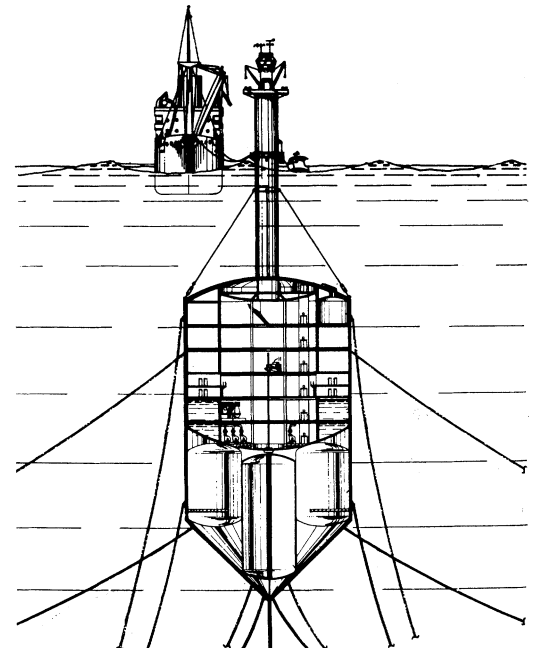


**Pisces, an undersea vehicle, equipped
with scanning systems for mining,
geological and geophysical studies,
International Hydrodynamics Co., Ltd.,
Vancouver, B.C.**

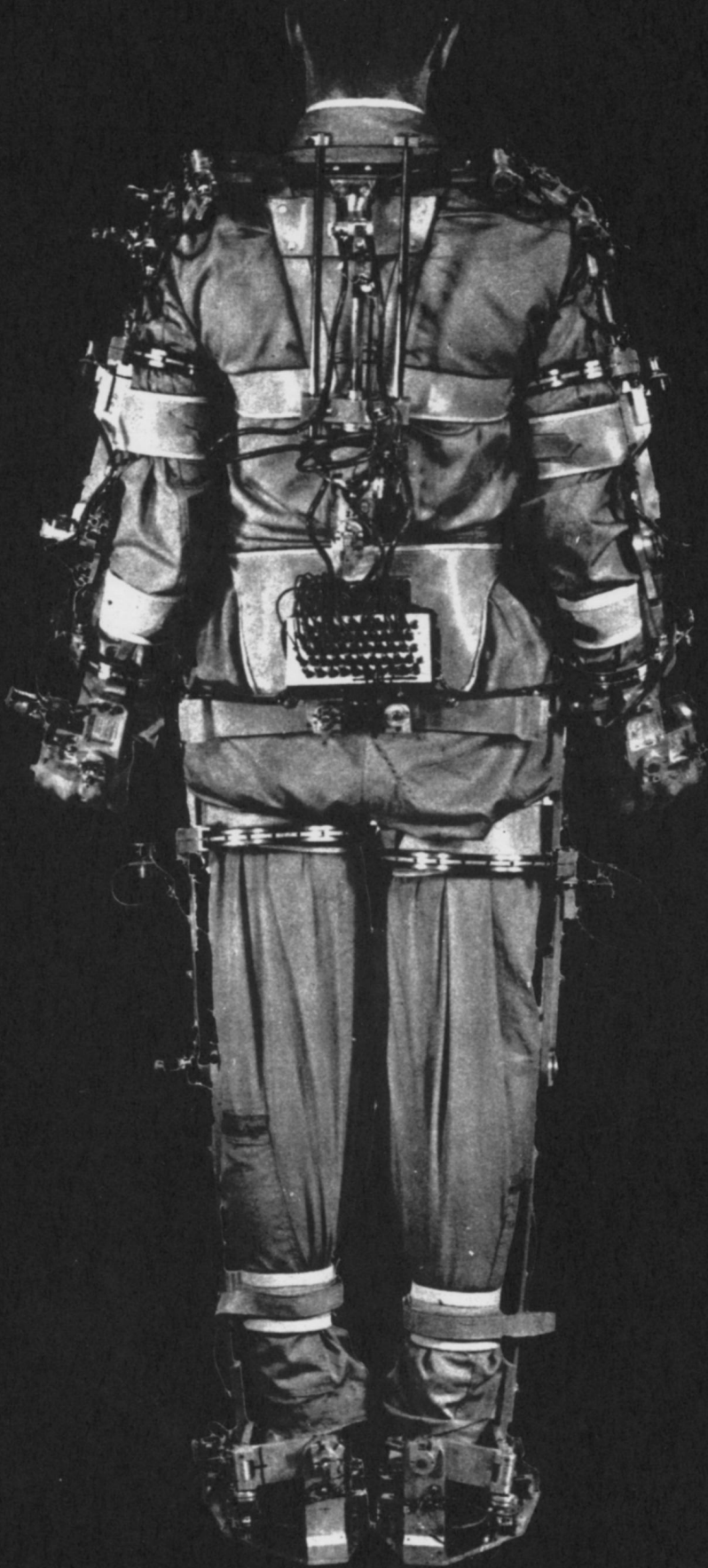


**Diving Saucer, owned and operated
by Jacques-Yves Cousteau and the
Westinghouse Electric Corporation.
(far right)**

**R. Buckminster Fuller's undersea island,
designed for use as offshore drilling rig
or for any manned underwater operation,
can be towed into position floating
horizontally on the surface.**



Exoskeletal harness to increase man's mechanical performance. Picks up motor impulses from nerves and muscles and feeds them to mechanical muscles.



Implicit in all discussion of the human environment is the essential mobility of man, the ways in which he has extended himself physically. In the historical phase of this mobility, he spread out into every area of the planetary surface; now in the beginning of a second phase he has become vertically mobile, out into space and inwardly to the bottom of the oceans.

The record of technological development is one of a progressive overlay of another form of evolution on the natural genetic process. We may date this second evolutionary period, from man's first use of tools, as marking the point when he became an active agent in his own development—when his species survival was no longer dependent on natural selection. The *consciousness* of this active participation in his own development occurred quite recently—in a first groping manner around the time of the Renaissance. The consciousness of his possible *control* over his own *future* development, one would place even more recently, possibly in the decade between 1940 and 1950.

The key to this evolutionary control is the way in which man has augmented and amplified his given organic capacities through various means. The simplest was the primitive hand tool, which, physically extending the limb, amplified the hitting and leverage power of the arm and hand. Such simple tools have now become complex assemblies of tools which amplify many-fold the combined energies of large numbers of men. The automated factory is not only a series of augmented hands, but of extra brains or control systems.

In this fashion, the basic organic functions are nodes from which may be demonstrated the many stranded aspects of man's sensing, monitoring and control of his environ. From the skin as protective enclosure, we may go to clothes, houses, to cars, planes, space capsules and submarines—as mobile skins giving progressively greater protection against environmental extremes. From the eye, we extend vision, and, therefore, survival advantage, through the microscope and telescope, the photo and television camera and on to sophisticated systems which record, amplify and relate complex visual and aural patterns of great magnitude.

We might also examine, in parallel with man's exploration of horizontal and vertical (outer and inner) space, his exploration of *invisible* space—the widening band of his sensorial monitoring of the electro-magnetic spectrum. He can now see in the infra-red, ultra-violet and X-ray frequencies, *hear* in the radio frequencies, and, may more delicately *feel* through instruments than with his most sensitive skin area.

The amplification of human function is not confined to physical instruments. Ideas and concepts also shape the environment, through language, signs, symbols and images. The invention of the zero may have had as comparable an impact on planetary affairs as

the atom bomb. Where ships and airplanes have extended man's physical mobility, so the arts and other communication vehicles—print, film, TV—have enormously extended man's *psychical* mobility in space and time. The larger psycho-symbolic conceptual systems—religion, philosophy, science itself—are as powerful agencies in environ shaping as the most developed physical energies.

The most striking extension of all has been the general increase in human life expectancy. The control of disease, advances in surgery, etc., are specific aspects of a general advance in man's knowledge of himself.

Having gained some survival edge on the external environment pressures through even this recent period of industrialization, man has turned more attention to his own processes. Undoubtedly some of the most interesting research on human functions has come from space medicine. Fitting machines to man, and conversely, for long sojourns under severe conditions, has given rise to many questions about human physiological design.*

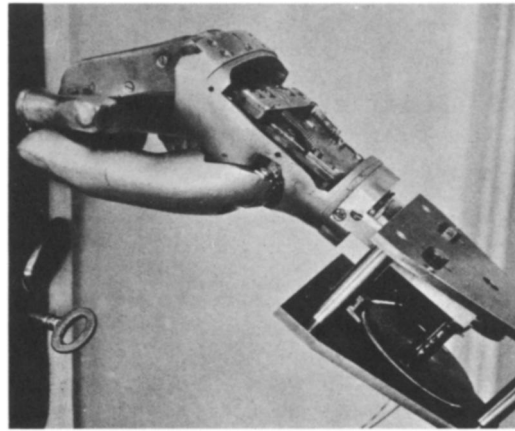
Dr. T. Freedman and G. S. Lindner propose the investigation of direct modification and augmentation of human to superhuman capacities. They point out that humans around the world have already developed such capacities in varying degrees—living at high altitudes where we normally can't breathe, maintaining normal skin temperature in sub-zero cold, thriving on otherwise dangerously ill-balanced diets. Underlining that man can be improved, they indicate that, 'trances and suspended animation, long in the same boat as the Indian rope trick, are now legitimate objects of research under the names of hypnosis and hypothermic hibernation.'

Various biomedical modifications are already routine—artificial organs and extensions of organs, electronically controlled artificial limbs, organ transplants. The artificial limb attachment is one of the most interesting examples which, though produced in response

**Every other component from nuts and bolts to rocket fuel comes in a wide variety of sizes, shapes, strengths, physical and thermal properties. The human sub-system is unfortunately manufactured in only one basic model, and the engineer is stuck with it. He can ask for a hex nut or a six-way switch, but a six hundred human is not in stock.... These are intolerable limitations, and up to the present decade only two traditional approaches have been used to cope with the problem... we reluctantly accept the need for a human pilot and provide him with a minimum life support system which he carries on his back.... The other extreme is the all-out engineering approach. Here the engineering department asks the human factors group to supply them with a schedule of numbers specifying the weird dimensions and feeble mechanical properties of human properties, the engineers then demonstrate their virtuosity by providing what we have come to call a 'shirt sleeve' environment.*

T. Freedman, MD and G. S. Linder, *Can Man be Modified*, North American Aviation Technical Report, 1963.

Pressure sensitive artificial hand activated by either learned muscle control pattern or remote electronic control.



to human defect through birth or amputation, is capable of much further application. The problems of delicacy of control and requisite power of manipulative and holding action in artificial hands reached an advanced stage of solution in 1963. Key difficulties had been power source and directive control operation which were solved by two Soviet scientists* who amplified bio-electrical muscle currents in the limb stump to trigger micro-miniature servo-mechanisms for the hand movements. These were versatile enough to unscrew a light bulb, lift up to nine pounds and bend each finger joint.

The use of electrical energy drawn directly from the host body itself to power various internal and external devices directly, or to use for remote control of other mechanisms, has far reaching possibilities. Apart from self powering various artificial organs, heart pacemakers, etc., this could also be used for transmitting signals for operating other controls at a distance, or acting as receiver/activators of metabolic control signals from remote medical centres.

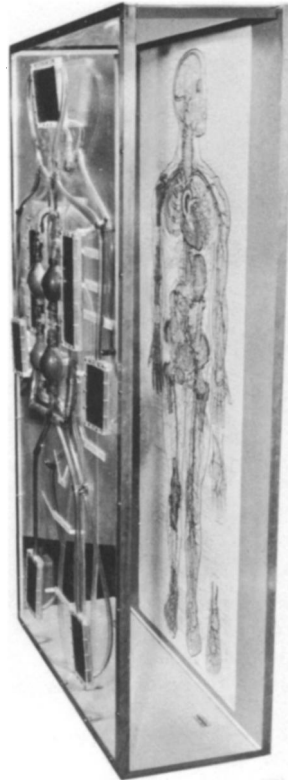
With new valves for damaged hearts, synthetic tubes, clips, transplanted organs, assists and metabolic amplifiers of various kinds, the human body may now enter an era of synthetic regeneration. This field is now more than simply spare parts medicine. 'Surgery is essentially an engineering discipline... the integration of electronic circuits into the human body as functioning and permanent parts... is going to become very important within the next ten years** The name now given to this swiftly developing field is bio-engineering. Describing his recent work on a systems model of blood flow for diagnostic procedures, Columbia University Professor of Engineering Richard Skalak, pointed out that this interaction of biological, medical and engineering sciences is already under way in other areas such as water supply, waste disposal, air pollution, food preservation and public health.

We may sense again this growing eco-systems approach as beginning to operate at both the macro extremities of human environ control – within the human body itself and outwardly to encompass the entire planetary body.

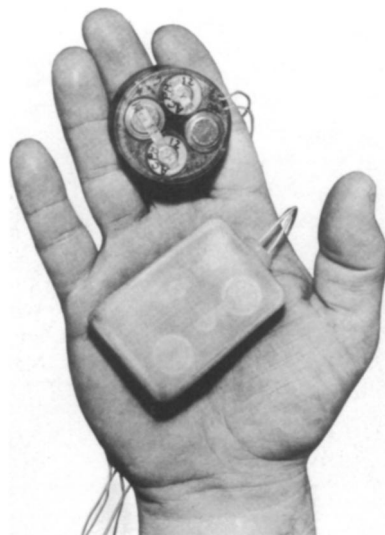
Electro-mechanical circuitry within man is only part of the present trend towards massive augmentation of individual human capacities through engineering. Professor Thring, Head of the Department of Mechanical Engineering, London University, lists some future branches as robot, telearchic (remote control) ocean, weather. He divides out robots (from telearchic machines) as those which do not require a human operator to carry out their tasks but rely on previous programming. Describing the use of robots and telearchic remote manipulators

*A. E. Kobvinsky and V. S. Gurfinkel, *Time*, December 1963.

**A. Kantrowitz, Dir. Cardiovascular Surgery, Maimonides Hospital, *Electronic Physiologic Aids*, New York, 1963.



Blood-flow simulator, designed by Prof. R. Skalak.

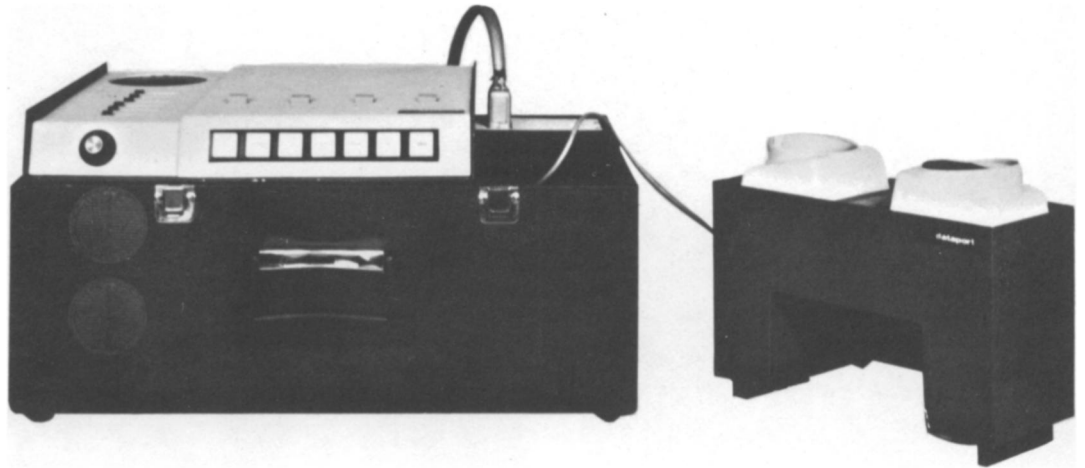


Battery-operated implantable cardiac pacemakers.

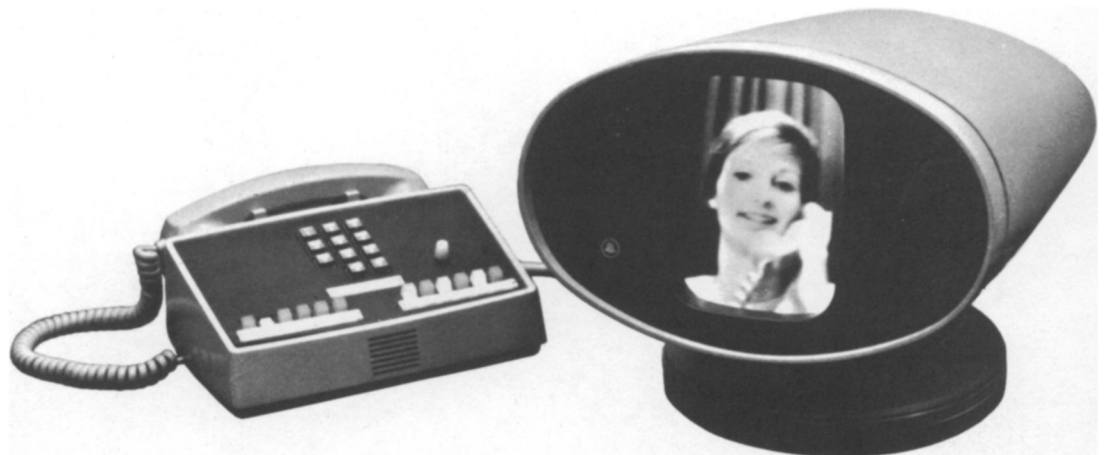
Telephone adapter for transmission of electro-cardiograms of patient's pulse directly to doctor.



Telephone system in which punched card dials business machine and receives replies and instructions. (top right)

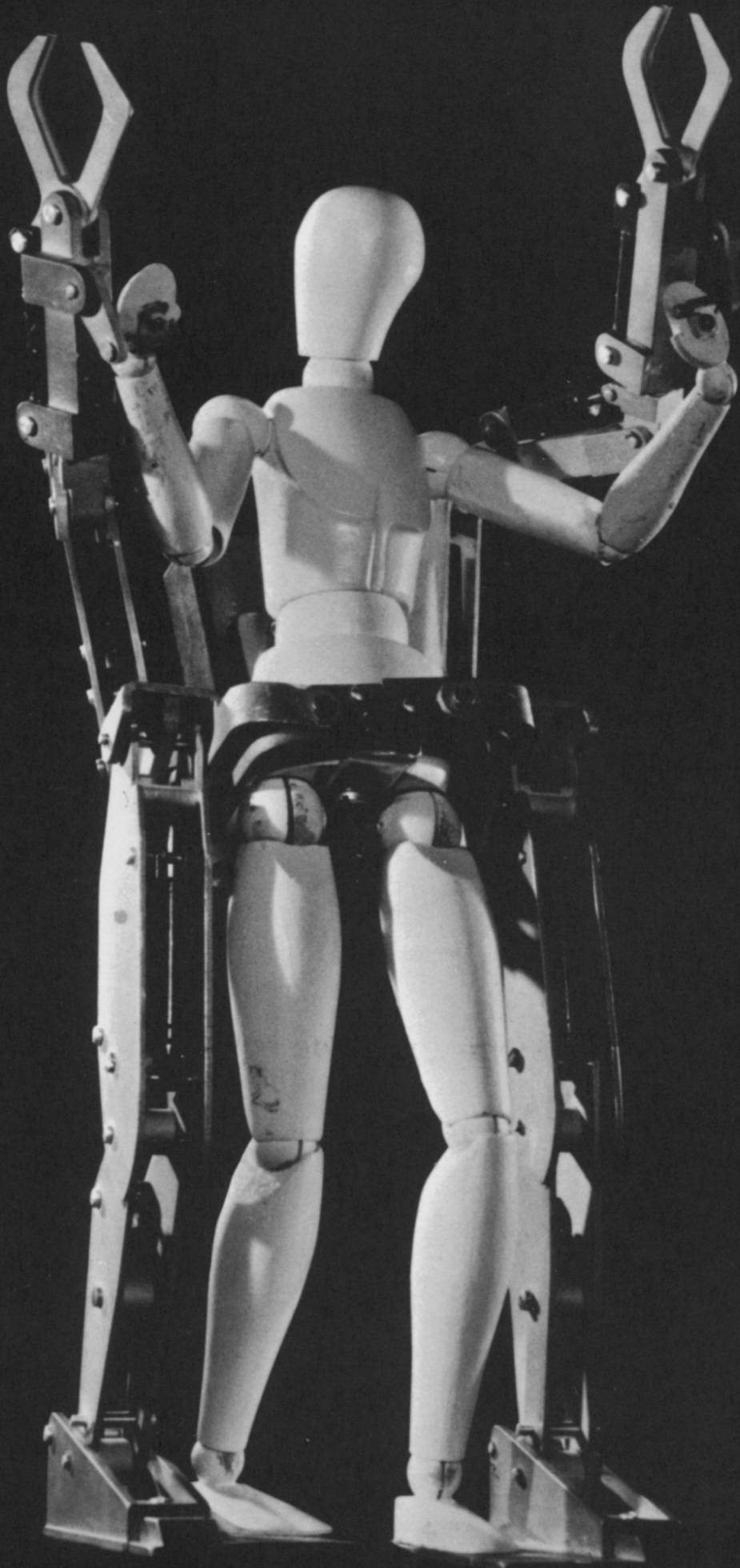


Portable computer terminal with complete type-in and print-out facilities.



Picturephone, transmits visual images as well as sound.

Hardiman, a set of mechanical muscles, strapped to a human and controlled by hydromechanical servo-valves enabling lifting at a fraction of the force.



as due for developmental use in the next ten years in the home, industry, mining and in the ocean and aerospace areas, he underlines many of the points we have already commented upon, but particularly draws attention to the 'Moral Spectrum of Machines':

— to put the machines that the engineer can develop on a moral spectrum based on the extent to which the machines help or hinder human beings to realize their potentialities and thus to lead satisfactory lives. Machines primarily developed to kill, maim or hurt... harm human health through by-product noise or effluents must come at the bottom of the scale.*

This forms part of a growing dialogue about the professional commitment of science and engineering hitherto considered as 'value-free' disciplines which has also been extended recently to the social sciences.** Professor Thring introduces an idea which may be extremely pertinent to the future role of architectural and environment planners—that such work should be governed by some form of Hippocratic Oath as in medicine. In considering the future of any form of technological and social innovation, this is indeed a question of fundamental priority. The single or combined decisions of many individual professionals now materially affect directly, or indirectly, the welfare and often the lives of millions of people around the world. The weaponeers have no problem in calling upon the individual's sense of responsibility to his fellow X...ians at a moment's notice, yet, the innovation of a higher responsibility to the planetary human family is still considered rather too idealistic. The range of illustrations in this present essay, selected on the basis of most forward technological capacities, show the enormous imbalance in negative weaponry priorities. An interesting comparative series could be made of the number of matched world problems to which such technology might be applied.

A further example of military tool developments, which have positive potential, are the Hardiman and Walking Truck concepts. Hardiman is the latest in a series of physical power assists, based on an external metal skeleton with electro-mechanical muscles, which give the wearer giant strength. Seemingly cumbersome now, one can easily extrapolate this development, via ultra-light high-strength alloys, to a harness no heavier than an overcoat. The next step, obviously, would be to implant the exoskeleton to create an anatomically modified super man.

The results of this inward exploration may be infinitely more powerful than any physically extended voyage to Mars or to the bottom of the Challenger Deep. The territory is as

*M. W. Thring, 'The Place of the Technologist in Modern Society,' *Journal of RSA*, April 1966.

**e.g. the recent controversy over 'Project Camelot' and Michigan State University's CIA Vietnam relations, etc.

unknown, and for centuries we have endeavored to exorcize the demons and control the energies which have emanated from its depths. Our present inward probings and mappings may now illumine those aspects of human nature, the fears, belligerence and self-destructiveness, which have been a numbing constraint on all futures dialogues.

Man has always been able to induce the death of others by some agency or other. Life-inducing power has been more or less a matter of chance. His recently acquired capacities to prolong life already create population problems. These, again, may seem mild when he expands prolongation to precise genetic control of human characteristics before and after birth with the capacity to modify, by many present and emergent means, the emotional, mental and physical aspects of the human organism. Coupled with this is the possibility of creating new types of living systems based on quite different biochemical configurations.

Medicine is already preoccupied with the ethical and legal problems of the point of death ambiguity using current life prolongation and resuscitation techniques. Reconstituting men long dead, once a favorite storyline in horror films, is predicted by one zoologist as possibly routine within a century—'once the genetic code is determined... hundreds of thousands of duplicates (of a past genius, for example) can be created.* At another part of the spectrum, a group of persons have formed a Life Extension Society—freeze, wait, re-animate—to cryogenically freeze and store living persons, those for example with incurable diseases, to await future medical advances.

The concept of bio-engineering, or bio-electrochemical engineering as it might be called, is evidence of the cross-disciplinary fusing which now confronts all academically defined fields. The boundaries have suddenly vanished as new knowledge, of itself, has created new disciplinary configurations, or areas in which there are no longer any discernibly separate disciplines. The task of adjusting our educational institutions to this new order will require social inventiveness of no mean scale. Accompanying the 'mixmaster' aspect of the various sciences there is a corresponding difficulty in labeling their attendant technologies. Defining the four which he suggested might have the greatest implications for future society, one scientist recently suggested computer technology, management or 'systems' science, social engineering and bio-engineering. We may note that these sound relatively separate, but closer examination reveals a great many features in common.

Cybernetics does furnish one nodal link for the four technologies above, and for many others, and, both in its conceptual theory and

*Professor E. Carlson, UCLA, *AP Wire Service*, April 10, 1966.

identifiable technological penetrations, has been one of the major change accelerators. It may be considered as an extension of the human nervous system and intelligence. Significantly, its recent origins were during the World War II period—firstly in developing self-correcting guidance and control feedback mechanisms for anti-aircraft guns; secondly in the operations research methods of applying logico-mathematical techniques, network theory, etc., to problems of military logistics. From the fusion of both these areas, plus ancillary developments in electronics, etc., came the computer and the systems theories based on complex multi-variable planning needs.

In general, much of our present computer usage simply regards the machine as a superfast and efficient clerical assistant. The real trend, however, is, on the one hand, towards a closer individual/computer rapport so that it becomes a generalized intelligence amplifier, and on the other, towards specific types of computer systems to assume the routine operation and maintenance of all the basic physical metabolism of human society.

The architect, planner and other professional may now work closely with the computer without the need to spell out, step by step, programs in advance. He may talk to the machine directly during processing, view compiled output at any stage and further manipulate data in many alternative forms. The architect is now reinstated in his prime creative role. Instead of his remaining merely the coordinator of various specialists—in structure, lighting, air-conditioning—these may be encapsulated in memory units to be drawn upon as required. This man/computer symbiosis is now developed to the point where the machine also instructs its user and indicates possibilities for closer interaction. You don't have to read the manual but may consult the machine directly with the order, 'I want to do something, instruct me.' This mode of working may now be carried on at a distance with remotely linked viewing and operating consoles and, at the present developmental rates, it will obviously reach the portable, possibly 'clip on' stage before long. Micro-control components are, as we have seen, now available in many forms, and computer memories become progressively smaller in volume and larger in bulk storage capacities. There would be, of course, no need to carry such memory units, but more feasibly, to have call-up linkages to many types of such central libraries.

Various types of equipment, available now, like Sketchpad, Rand Tablet, etc., have been described in detail elsewhere, so that there is no need to elaborate on their capacities here. The computer is involved in so many areas of individual work in this way that any review of separate fields and modes would tend to cover all the sciences—and the arts.

Implicit within both individual and social relations to cybernetics is the emergence of a new symbiotic growth in the eco-system of the

planet. Other types of machines are merely mechanical extensions, 'there is only one organism—man—and the rest are there to help him.'*

But recently, as in his natural symbiotic relations with plants and animals, man's relationship to cybernetic systems has been subtly changing, towards a more closely woven interdependency resembling his other ecological ties.

This point has often been alluded to in terms of intelligent machines dominating man, but the possibility is more clearly that of the type of organic partnership which characterizes his other 'natural' relations. As Licklider suggests in one of the key papers on this topic:

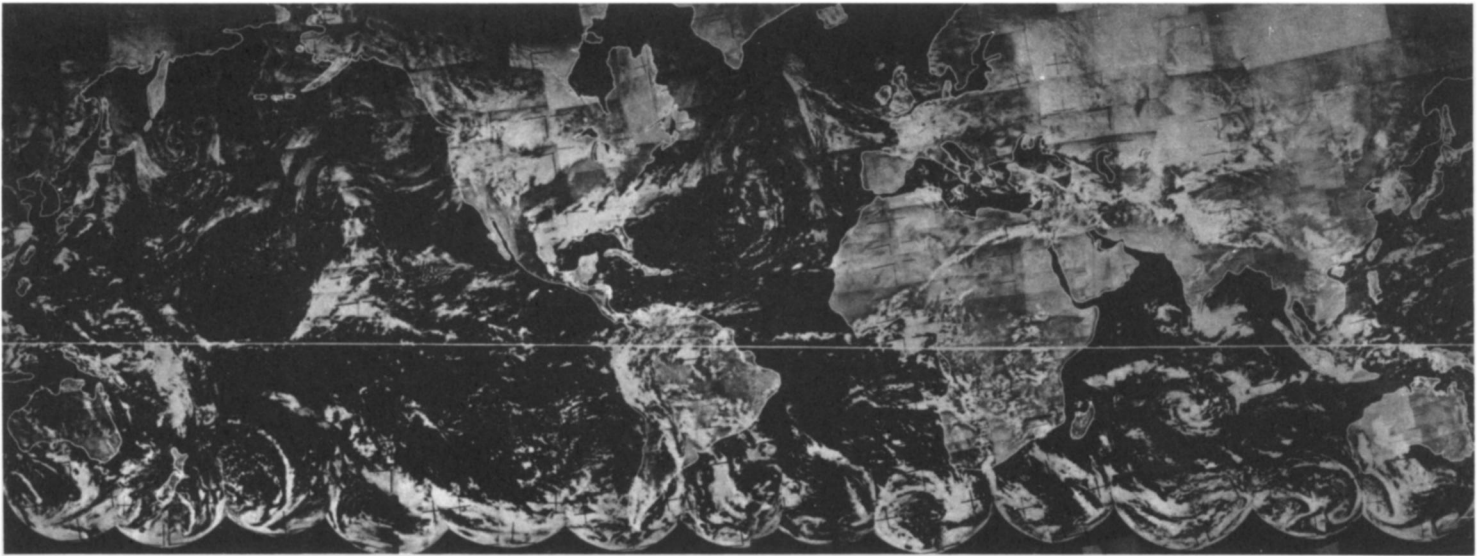
'It is estimated that it would be 1980 before developments in artificial intelligence make it possible for machines alone to do much thinking or problem solving of military significance. That would leave, say, five years to develop man/computer symbiosis and 15 years to use it. The 15 may be 10 or 500, but those years should be intellectually the most creative and exciting in the history of mankind.'**

This is being borne out in the phenomenal growth of knowledge in the past few years, both with the expanded capacities to process information via the computer and in the primary sector of knowledge discovery and communication. In this area, however, we still confuse somewhat the accumulation of *new* facts with *new* knowledge. The extension of knowledge, e.g. in science, has not been through the simple addition of new facts but marked rather by the intuitive grasp of ways in which a great mass of factual information may be simply and elegantly structured into new conceptual wholes. The process is not towards greater complexity but towards simpler and more inclusive concepts, now evident in every field.

The most pervasive aspect of the developing man/computer symbiosis, and the most immediately important in large-scale societal effects, has been the automation of production and services in the advanced economies. Man is clearly no longer required as a mechanical energy converter, as part of an assembly line or as a routine worker. Many such tasks have been taken over by automated machine—process and product wealth may be generated with less and less input of human energy, intervention and decision. This aspect of automation is only the more visible and easier to grasp. The extent to which automated systems have now assumed the operation of the invisible metabolics of advanced economies is more far-reaching. Apart from completely automated factories and continentally linked automatic inventory dispatch and control operations, the

*J. D. North, Boulton Paul Aircraft Ltd., *The Rational Behaviour of Mechanically Extended Man*, September 1954.

**J. C. R. Licklider, *Man-Computer Symbiosis*, IRE Transactions on Human Factors in Electronics, March 1960.



First complete view of the world's weather, assembled from 450 photographs taken by satellite, Tiros IX, during a 24 hour period.

whole energy conversion and transmission system of vast areas are increasingly under automated control. Over 80 per cent of the US's electrical capacity is, for example, controlled at present by automatic dispatch systems.

The use of the computer in the simulation of processes with large numbers of interacting variables is now commonplace. Simulation of physical systems is relatively simple compared to that of social systems, of the interactions of nations; but advances are also being made in the latter area. In large-scale economic, business and politico-military simulations, actions which might take weeks or months to occur in real time may be run through in a few days.

Prerequisites for such simulation, for increasing the *predictive* capacity of the organism in its environment, are adequate information and communications. It is interesting, therefore, to observe the exponential growth of information accumulation, and the parallel expansion of information and communication systems to the global level.

The most advanced development of such systems at present is, of course, in support of military prediction, planning and control procedures. When ICBMs may be launched to strike anywhere in the world in less than 30 minutes, the factors of speed in information handling of incoming data and outgoing corrections of hour by hour posture are enormous. Add to this the given figures of operational air forces of 15,000 aircraft, 1000 missiles and a quarter of a million personnel, and we have a global operation of considerable size. The facilities developed match up to the requirement. Operational data referring to the location and state of the above components, to global weather conditions, intelligence, materials inventory, transport and location is constantly being fed into such centers, and may within seconds be flashed on screens for simultaneous viewing of its complex relationships. Aircraft in flight may be contacted swiftly

anywhere in the world and direct telephone contact made immediately through one handset with more than 70 subordinate centers spread halfway around the world.

Such worldwide systems are working examples of Marshall McLuhan's statement, 'Today, after more than a century of electric technology, we have extended our central nervous system itself in a global embrace, abolishing both time and space as far as our planet is concerned.'

The first recorded voice was heard from a satellite only eight years ago; four years later the first live telephone, television, data and facsimile transmission was made between Europe and the US via Telstar I and II. Since then, Syncom, Echo, and the Early Bird satellite relays have transmitted between Russia, Japan, the US and Europe.

The less obvious uses of such satellite repeaters, observers and relay stations is their direct scientific value. One of the latest of these, Nimbus II, specifically designed to monitor weather information, was sent aloft in May 1966 for a six-month work period. Its set of Vidicon automatic picture transmission cameras will photograph not only cloud cover and weather but anything as small as a half a mile in length on the earth surface. Pictures will be relayed automatically to 150 ground stations in 27 countries.

This example may seem much less dramatic than the TV transmission of human space walks, and moon surfaces viewed recently, but information gained by such workaday satellites may be of greater direct value to the solution of various world problems. The World Weather Watch scheme, proposed in 1965 as part of the UN International Cooperation Year, seeks the combination of such satellite reported data with global weather observation at various atmospheric levels, a fast world-wide high capacity communication system and a large size computer facility containing an adequate 'numerical model of the atmosphere.'

Vortex over North Atlantic, photograph taken by Tiros IX.



'With the World Weather Watch data, an adequate computer and global mathematical model, a vast array of experiments on weather and climate modification can be performed by numerical computation rather than in nature... full effect and potential hazard can be determined without risk to life or property. For example, a dam can be 'built' across the Bering Strait for an infinitesimal fraction of its real life cost, and we can evaluate its effect on the Kamchatka or Canada wheat growing season... we can model a megalopolis and its atmospheric cesspool, examine the extent to which it acts as an inadvertent weather modifier, then 'clean up' the atmosphere and see the difference. We can do this without taxes, political strife, vast engineering expense — in a computer.'*

In addition to conventional photography from satellites, multispectral sensing is also being employed with the infra-red, ultraviolet and other wave lengths such as X-rays and radar. Using infra-red, for example, it would be possible to have detailed surveys of traffic in and out of cities, of human occupancy of buildings through their heat patterns. Numbers of cattle on grazing range, changes in forests, fields and even animal bird migrations could be easily surveyed.

In 1966 the UN Secretary-General called upon Canada, Chile, France, the Philippines, the Soviet Union and the United States to endorse a proposed five year program of world surveys of minerals, energy and water resources. This will be a first step toward 'an orderly systematic approach to natural resources development in the world and the developing countries in particular.' The cost of this world resources survey of non-agricultural resources is set at \$10 million spread over the five-year period. The nine survey areas are:

*W. O. Roberts, National Center for Atmospheric Research, *Science*, Vol. 152, No. 3119, April 1966.

World iron ore resources.
Important non-ferrous metals.
Selected mines in developing countries with view to increasing ore reserves and production through application of modern technology.
Offshore minerals in developing areas.
Water needs and resources in potentially water short developing countries.
Potential for development in international rivers.
Potential geothermal energy resources in developing countries.
Oil shale resources.
Needs for small-scale power generation in developing countries.*

In developing the theme of the new symbiotic relation of man to his most advanced machines, we have emphasized those aspects of technological means, "that have been pressing humanity so rapidly towards a closely interconnected species, a species in full possession of the world and its abundance and with an adequate capacity for control and survival, that are reaching towards more mature and stable forms in this generation.** The impact of this evolutionary process on our individual viewpoints is already quite marked. Where tribal man became disoriented when separated from his local tribe, and early city and local state man could barely conceptualize his immediate surrounding environment, we are now in a period when men think casually in terms of the entire planet.

It would be usual here to run through some future extrapolations of present technologies; to review ways in which everyday life would be different in various kinds of super-mechanical and exquisitely organized environs. We could go on, at length, to discuss flexibly mobile automated 'homes of the future,' with food synthesizer/dispensers, 3D television, instant laundries and recycling garbage disposals which fuel atomic power plants. Or we could deal with air-conditioned cities with personalized weather control, phone booth matter transmitters, holidays on the Moon or under ocean or time travel. Discussing the 'population problem', the bomb and other more somber issues would allow the depiction of alternatively dark futures.

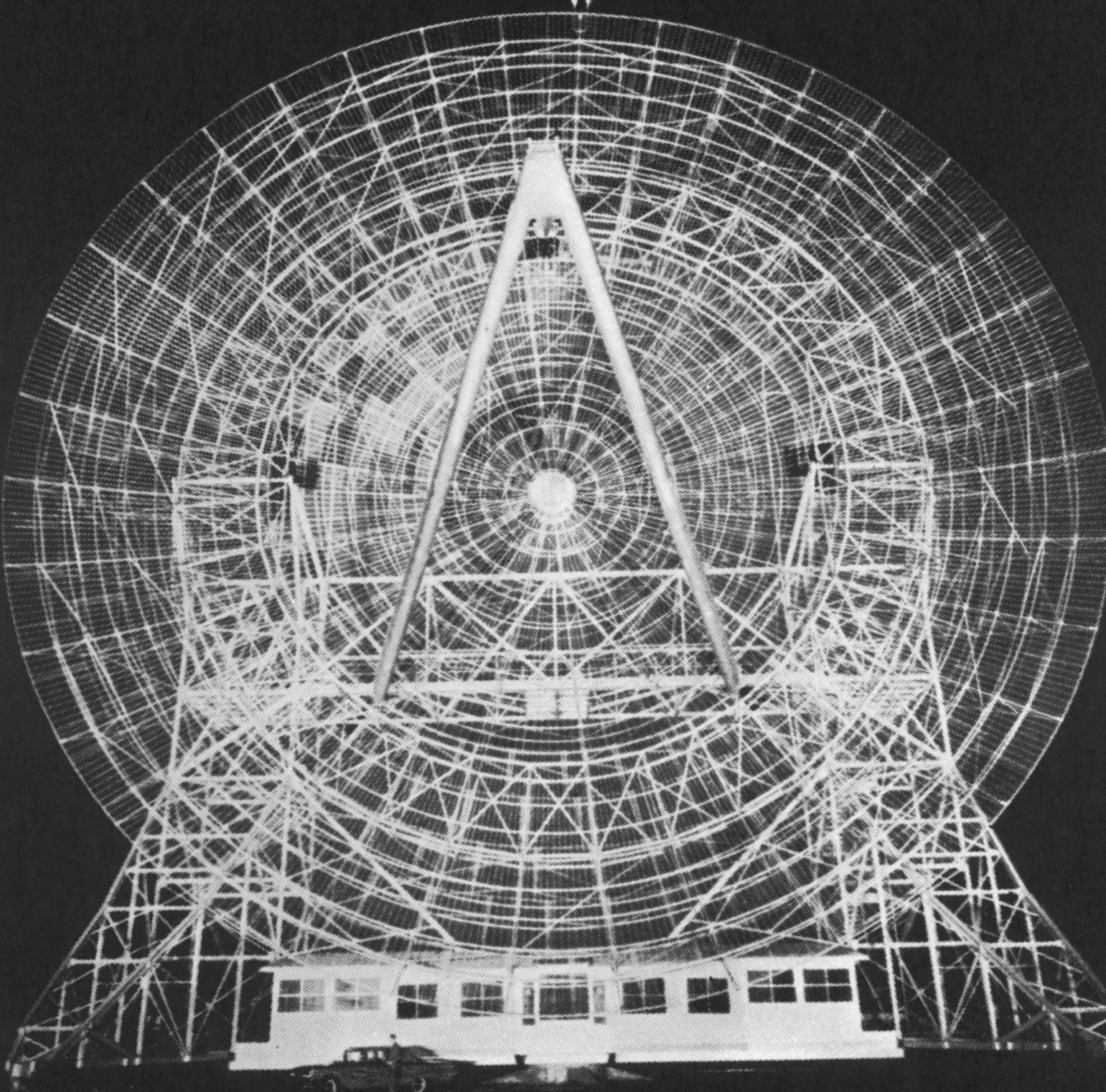
A more fruitful exercise, however, even if less stimulating, may be to try to examine our approach routes to the future in terms of individual and social attitudes. What are some of the human factors — not only the consciously measurable but also those which unconsciously influence human decisions and change orientation?

Man's future is determined, not only by what is probable and possible — but by what he determines as necessary, allowable and ultimately desirable. Our main emphasis has been on the technological means for refashioning the physical planetary environment, and, to the lesser degree, on the refashioning of man himself.

*UN Press Release, E. C. 2308, April 1966.

**John R. Platt, *The Step to Man*, September 1964.

Radar telescope at Stanford, California.



Man's present ability to evaluate and determine his future goals, or solve many of his most pressing problems, lags far behind his now enormous capacity to fulfill any goals he may set or solutions he may propose. Merely to underline his possibilities of choice and control in no way illumines any of the factors which prevent him from exercising such control.

This line of inquiry usually founders in a variety of factors lumped together under the term human nature. Yet even this major constraint is lessened nowadays when we accept the innate variety and plasticity of human behavior response. There are few instinctual human characteristics which have not been modified and shaped by learning and experience. Human nature is largely made by humans.

The most clearly identifiable organic drive is towards survival, and the strongest attitudes are those grouped around survival strategies. In seeking to define those factors which constrain positive change and seemingly negate our most inventive social strategies we would do well to re-examine some of the most cherished social attitudes, institutions and values which form the basis of human society. The key to many of our difficulties lies with the identification of those social orientations which have had great survival value in the past but which may now endanger our survival in the present—and cripple our approach to the future.

All of man's past historical experience was of marginal survival. His societies were based on the economics of scarcity. Bound to agriculturally determined cycles, life itself was dependent on capricious external agencies which were influenced only by propitiatory sacrifice. In such societies permanent value and meaning resided primarily in those external institutions, systems and objects which aided survival. Life expectancy was low and individual man, seemingly fleeting and impermanent, was prodigally expended in order that the group might survive. In a scant few hundred years, and more abruptly within the last century, this has all been changed. But the transition has been so swift and its effects so pervasive that the bulk of our attitudes is still molded by thousands of years of contrary experience. The strongest myths of all, therefore, still surround the nature of wealth, value and meaning and the degree of their dependence on external agencies for validation and support.

We refuse to accept the reality of potentially 'limitless' wealth inherent in our new symbiotic relation to automated technological process. The nature and full effects of such technological development is barely understood—even by those who have invented its components, organized its productive capacities and are responsible for its continued expansion. The stage of scientific and technical development which renders large-scale automated process possible also destroys all previous *intrinsic* value in physical resources or properties. From

this point on, broadly speaking, all materials are inter-convertible. The only unique resource input is human knowledge—the organized information which programs machine performance.

Typical of our obsolescent constraining myths are various ideological and political blocks towards effective social reorganization. Ownership of the means of production, transport and communications becomes conceptually unreal as the control, operation and further development of these outstrips the capacity of any private interest group and begins, in the case of large-scale undertakings, to go beyond that of national governments. With such fundamental change in the production of wealth, the real concern is with accountancy systems to regulate its equitable distribution. Our present systems of international regulation reflect a preoccupation with pre-industrial value standards.

Material possession is no longer a source of economic power and ownership—and no longer a necessary use relation between people and products. Use value has largely replaced owner-value. Technical means actually trend towards using and being less material.

Another outdated myth is that of the *expert*. International aid and development is very much the realm of conservative expertise. In city planning we usually recruit our experts from those responsible for the problems, and we hand over the solution of world problems to those whose record clearly disqualifies them from the task. Human labor is no longer the yardstick of productive wealth. The virtues of hard work towards self profit, whether in the accumulation of material or spiritual goods is largely eroded. One of its last strongholds is formal education which still accords high moral value in due ratio to difficulty and labor in learning. Cultivated aesthetic taste is also associated with the acquisition of hard-won 'understanding.' Even the most recent *programed* and *re-inforcement schedule* techniques of learning are still curiously biased on the relation of work to profit. We may see clearly that all our notions of the supposed virtues of imposed hard work and self profit are based largely on the economics of scarcity and on previous standards of marginal survival. We retain certain illusions and compulsions because we cannot design any other supports for the social edifice. In exacting 'gainful' mechanical work as required by pre-industrial society in return for sustenance and shelter, many of man's more important activities were relegated to marginal status.

In discussing such problems of futures planning—like the re-investment of work time in other areas—*values* are usually cited as the restraining factor. Many of our *value* setting authorities have lost their power to indicate goals and set value standards, i.e. the church, the family, the traditional humanities. Science is often suggested as possibly the only valid area with suffi-

cient strength to give directive authority. The substratum of the argument is probably finer than that. This western dialogue about values, science and man has been going on in intensified fashion since the Renaissance, when science overthrew the notion of an earth centered universe and began to erode the belief in a god centered one. On the other hand, what may have happened during the dialogue is that we have transferred our belief in God to a belief in science. It may indeed be salutary to examine the ways in which science itself has become the kind of system which purports to stand outside of, and be superior to, individual man. We may note that its most touted virtues lie in a series of abstract systems of arriving at *truth*, whose findings are evaluated in inverse ratio to the degree of fallible human judgment inherent in their method. The *value* of scientific method is the extent to which it is *objective* and independent of any specific idiosyncratic human observers.

It would be dangerous to accord science the function of an ideological sacred cow capable of generating new sets of human values. Considering all areas of human enquiry, science undoubtedly contributes greatly to our evolving value systems. Scientists themselves, however, have been as easily seduced by power, prestige and other inducements to cooperate in the most negative activities of man as other professionals. In the pursuit of alternate approaches to futures planning it may be useful to question the idea that science and its ancillary technologies will remain the major agencies of innovation in society—providing the mainsprings governing social change. We have relied, perhaps too much, on the notion that the individual and society could, at best, only adjust to changes forced by the pace of scientific and technological development and their attendant economic facts. Major innovative action directly affecting man and society has been increasingly accorded to hard science. The arts, humanities and soft sciences could only express or communicate reactions to changes in the human condition—after the fact.

There are many reasons for this point of view. Given man's preoccupation up to now with basic survival, the hard sciences at least provided usable information to help control better his physical environment. The other areas provided the trimmings to adorn his living and make it more meaningful. They could also record his social processes, measure his interactions with fellow men and review critically the various institutions which evolved, more or less unconsciously, as the result of fortuitous changes in his environment. The only applied social technology was politics as the sole mechanism for low-g geared social innovation and change. However, it only acted after the fact and, though we have more recently tried to set up agencies to deal with change in a less reflexive manner, they are still tied to political decisions and expedients.

In attempting to devise ways of reaching conclusions on future social changes, Bertrand de Jouvenel, for example, suggests a Surmising Forum, '... a free market for surmises, allowing the thoughtful members of the public to derive their own views of what is most likely, to discern what should be done towards what seems to them the most desirable among the possibles.'* One type of surmising forum, the US 'Commission for the Year 2000,' under chairmanship of sociologist Daniel Bell, has completed its first year's report. The aims of this distinguished interdisciplinary group are to 'sketch hypothetical futures' so as to enable better decisions to be made, measure social performance, anticipate developments and the kinds of political theory which might accommodate various alternative futures.**

The arts are often suggested as alternative areas in defining the edge of change in society. But, as traditionally regarded, they are no longer a canonical form of communication in society. The visionary poetry of our period or its symphonic equivalent is as likely to be found on TV, or in the annual report of an aerospace company, as in the book, art gallery or concert hall. The future of art seems no longer to lie with the creation of enduring masterpieces, but with defining alternative cultural strategies. But in destroying the formal divisions between art forms, and in their casual moves from one expressive medium to another, individual artists do continue to demonstrate new attitudes towards art and life. As art and non art become more interchangeable, and the masterwork may be a reel of punched or magnetized tape, the artist defines art less through any intrinsic value of the art object than by furnishing new concepts of life style.

It is evident that if we are to redesign life styles more flexibly and provide the type of multiple choice environ of which our tools now render us capable, we shall have to look for new paradigms. When we speak of change, we remain parochial and personally indifferent to its real meaning. For the west, this is most evident in its attempts to assist underdeveloped nations. Change is encouraged, but only in directions approved by the provider of assistance. We have introduced as many socially negative ideas as useful technologies. One key criterion, perhaps, for any futures planning, any conscious design of the physical environ or social organization, is the degree to which any such design assists or constrains human activity. This overall concept is largely missing from much of our present thinking. As an evaluative attitude, it needs to be employed at every level in social accounting—from tax procedures to education—to the your-system-or-my-system theme in our present international conflicts. Man and his evolving requirements are superogative to any system conceived of by man.

*B. de Jouvenel, 'Technocratic Age in France,' *Bulletin of the Atomic Scientists*, October 1964.

**American Academy of Arts and Sciences, 1966.



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John McHale is an artist and a writer and holds his Ph.D. in Sociology. As Research Associate and Executive Director of the World Resource Inventory at Southern Illinois University, he is engaged with long range studies of the utilization of man's resources on the global scale. A Fellow of the World Academy of Art and Science and of the Royal Society of Arts, England, in 1966 he was awarded the Medaille d' Honneur en Vermeil in France by the Société d'Encouragement au Progrès.

Mr. McHale has published extensively, in Europe and the United States on the impact of technology on culture, mass communications and the future.

As an artist and designer, he has exhibited widely in England and Europe since 1950. Design work during this period has encompassed graphics, exhibition design, television, film and general design consultation to organizations in Europe and the U.S.A. He also has produced several experimental and documentary films and taught and lectured in various institutions in England and the U.S.A.

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