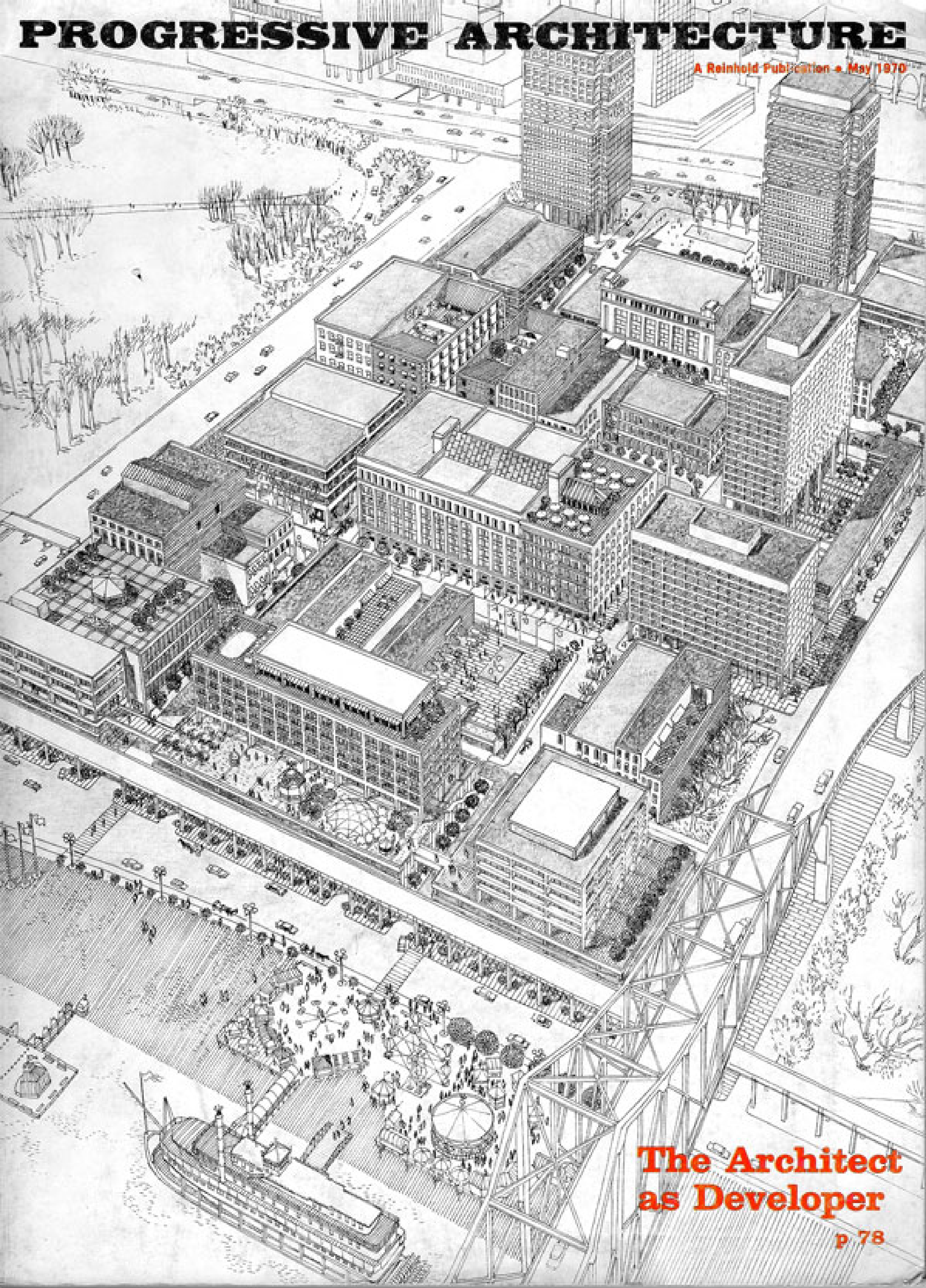
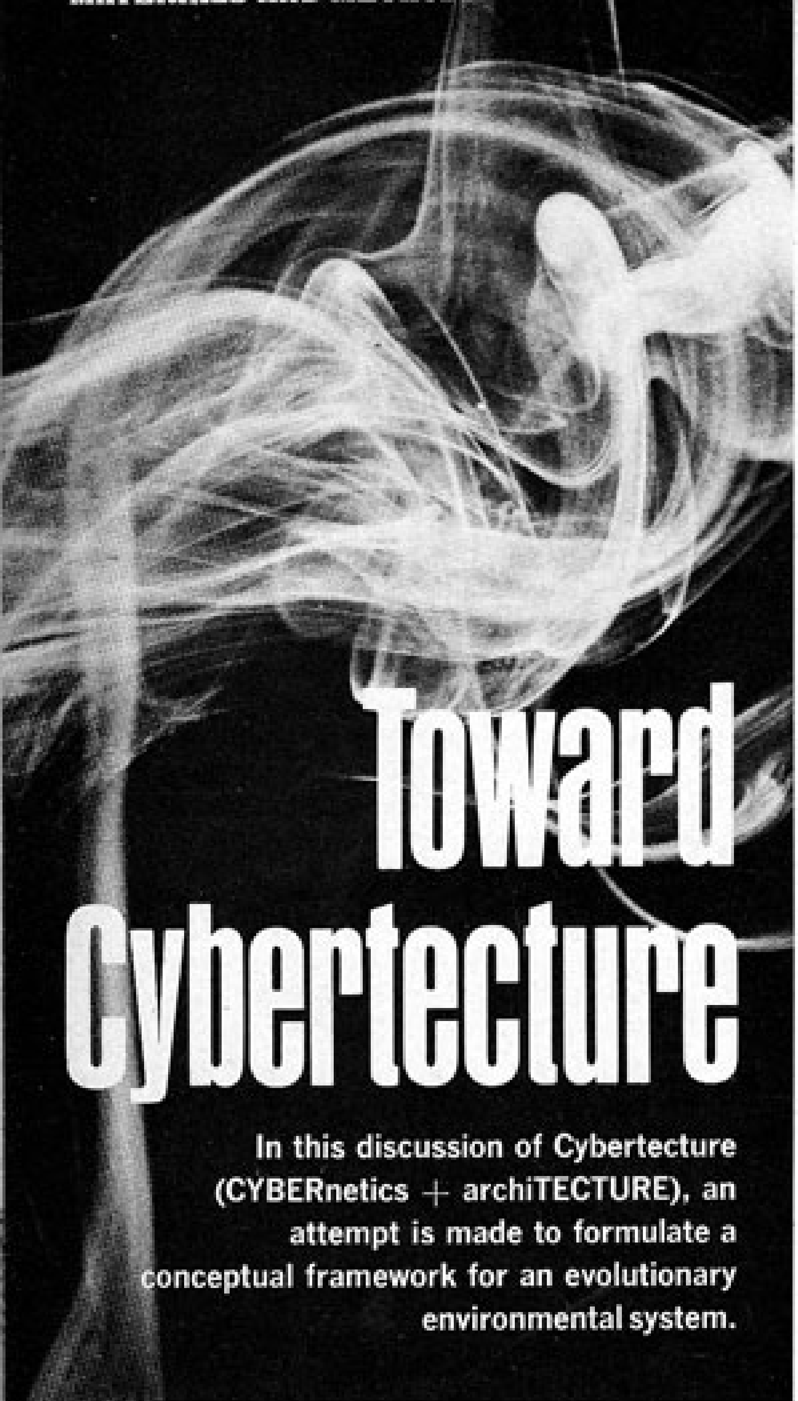
PROGRESSIVE ARCHITECTURE

A Reinhold Publication • May 1970



The Architect as Developer

p 78



Toward Cybertecture

In this discussion of Cybertecture (CYBERnetics + archiTECTURE), an attempt is made to formulate a conceptual framework for an evolutionary environmental system.

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Man's unique position in nature makes him increasingly capable of diverting the forces of nature to his own purposes even as he is subject to its forces.

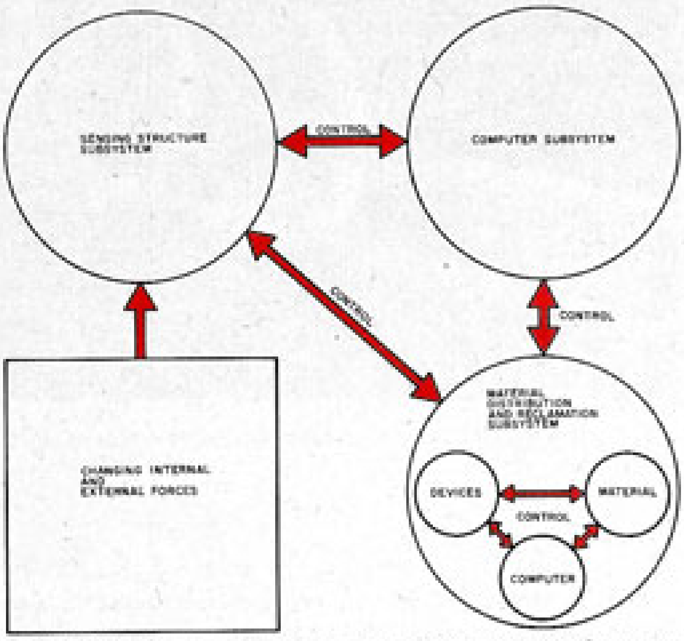
A very optimistic statement which even might be true, but designers and engineers are still struggling to employ the principles and mechanisms of the first industrial revolution to a significant extent. One hundred and twenty years after Paxton's Crystal Palace and 50 years after Ford's Model T, we still cannot refer to a large-scale building system based on mass-produced industrial components. The criteria governing present-day buildings are still paralyzed by the influence of linear thought processes, the concepts of "cause and effect," "energy and matter," the paradigm of Newtonian physics, and the first industrial revolution. The fact that buildings which require a longer planning period are often partially obsolete when "completed" proves the inadequacy of traditional architectural philosophy.

Meanwhile, the second industrial revolution is in process. Computer systems have begun to supplement and replace the human nervous system. This facilitates radically new forms of man-machine symbiosis. The generating force is man's renewed and increased awareness and scientific exploration into the phenomena of organization. This principle is not derived from categories like "energy" and "matter"; it is a value expressed by the structured manner in which a system, using control and communication (cybernetics), functions.

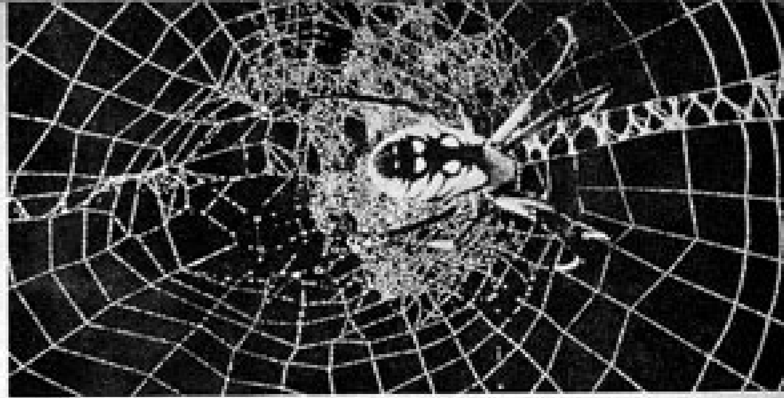
Life is a self-regulating process. All living systems tend to adapt themselves to a set of specific purposes by evolution which results from internal and external selective forces. Organizational patterns and mechanisms created by evolution, in turn, make the evolutionary process possible. They have been at work and subject to continuous "improvement" for six or seven hundred million years. Thus all existing forms of life constitute an enormous wealth of experience from which we can draw. If we examine and consciously integrate the principles and mechanisms of evolutionary processes into technology, we will discover man-machine and machine-made environments with new unheard-of capabilities. We can no longer analyze, conceive, and create isolated elements and processes. We must examine the effects of elements upon each other and properties of entire systems, their performance depending on various degrees of complexity. Cybertecture (CYBERnetics + archiTECTURE), abbreviated CT, is an attempt to formulate a conceptual framework for an evolutionary environmental system. The space-time continuum is organized ecosystematically, i.e. as it relates to a complex of ecological community and environment, forming a functioning whole in nature. The effort is to explore an alternative to the wealth of romanticisms and piecemeal operations which are the generators of the ever increasing chaos of our habitat. All components of nature are in flux, subject to continuous change. The capacity of living systems to organize materials in a complex and determined manner is the characteristic feature of life.

CT is structured and performs in a manner analogous to open living systems. Its "organized complexity" does not depend so much upon the number of elements within it but rather upon the number, or richness, of relations among its elements. The physical components of CT consist of three subsystems **(1)**:

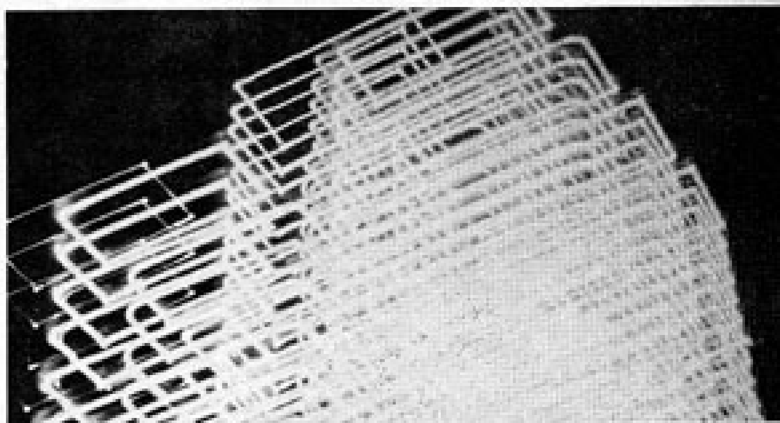
A. The computer which compares essentially to the brain.



1. The Cybertecture structure and the interrelated subsystems governing form and function.



2. The spider web is formed from a glandular secretion which varies according to direction, speed, and quantity of building material needed.



3. The time-lapse photograph of a light bulb produces an intangible analogy to the biological spider web example.

B. The material distribution and reclamation which compares to the mechanisms that facilitate metabolism.

C. The sensing structure which compares to the body of a living organism.

A. **The computer subsystem** is the highest coordination center of CT, communicating with and controlling the sensing structure and the material distribution and reclamation subsystems. It serves as a pattern recognizing, analyzing, synthesizing, and decision making tool. It emits impulses that cause immediate or delayed physical or organizational change of the environment in accordance with criteria designed to provide optimal environmental solutions and to determine the frequency of change.

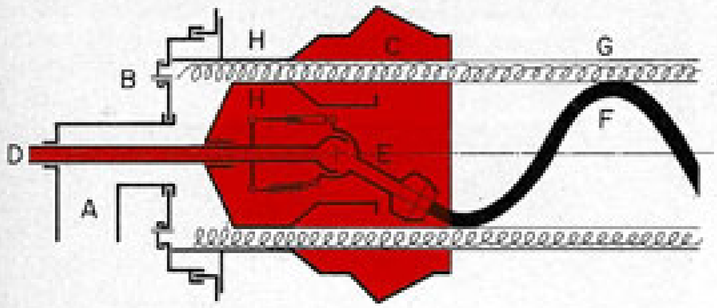
B. **The material distribution and reclamation subsystem** is the metabolic mechanism, manipulating the sensing structure. It adjusts the physical environment to immediate, desired or projected needs of the user. It can transform the material into different states to make it suitable for any desired purpose. Certain qualities can be achieved by changing material properties during any phase of the existence of the material within the system by chemical reaction, radiation, heating and cooling, mixing, and the like. The sensing structure is constituted of materials, the properties of which allow it to be transported, distributed, shaped, and reclaimed by means of gases, fluids, gravity, electromagnetic or electrostatic energy, mechanics, or any combination thereof. We can think of a host of possible material distribution and reclamation methods. The most widely used by nature takes advantage of the fact that chemical changes meet the most favorable conditions once they take place in liquids. For instance, approximately three-fourths of the tissue in a human adult consists of water. Although we can speculate the employment of colloidal solutions, it seems more feasible at present to investigate the mechanical aspects of this subsystem.

A spider in its web (2). The thread, a glandular secretion, is composed of thousands of elementary threads issuing from an equal number of nozzles. To build the structure, the generating body constantly has to control and change direction, speed, and the quantity and quality of the issuing material.

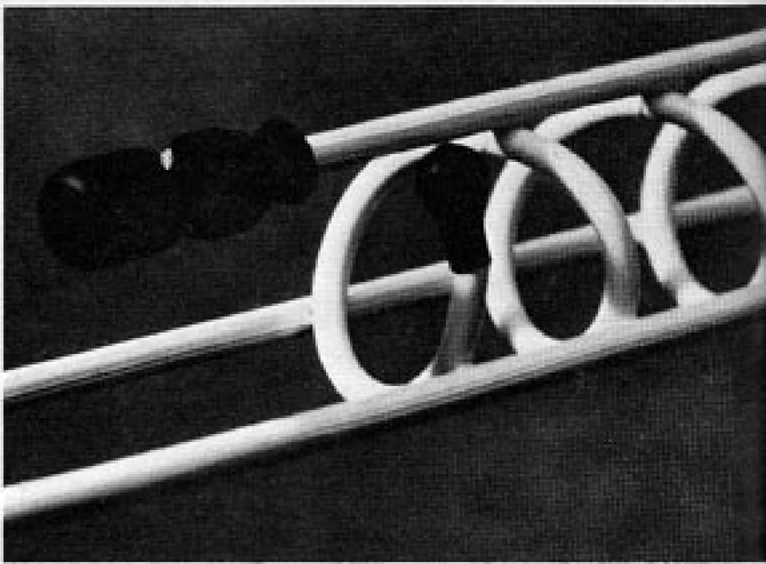
This time-exposed film recorded the controlled movement of a light bulb (3). It was produced in analogy to the foregoing biological example.

It is possible to simulate 3-dimensional structures utilizing light tracks and employing techniques known in fabric production such as plain, satin, crepe, basket, twill, leno, pile, as well as knitting and weaving techniques. Replacing the bulbs with material distributing and reclaiming devices, we can visualize a new breed of building processes and structures.

Here a longitudinal section through a nozzle moving in space and generating a structural element (4). The raw material A and D is pressed through the nozzle. B is a rotating device which places linear reinforcement within the material. C is a curing chamber, employing heat, radiation, or chemical reaction to harden the issuing material. D is a rotating hollow axle through which material is pressed to the revolving distributing head E. H is an adjustable



4. Longitudinal nozzle section, hypothetically moving through space and generating a structural element.



4a. The basic building system consists of three rods of filler material and a continuous coil of a structural element.

forming wall. F and G is the issued structural material.

Various moving nozzles to provide other basic forming possibilities (5). The structured material issues to the right in each diagram.

Methods to reclaim material include: melting, cooling and breaking, grinding, chemical dissolving, application of ultrasonic vibrations, decomposing by radiation. Controlled devices such as those described have the capability to build, change, and reclaim structural or nonstructural material without traditional formwork.

A schematic side view of the basic organization of material distribution and reclamation hardware (6). This is a subsystem using a mobile mechanical device (7). A are all-directional powered joints with rheostats. B are adjustable hydraulic arms. C is the sensing structure material being distributed or reclaimed by the device D. The sensors E and the roentgenologic camera F provide data about the exact location of every part of the mechanism in space. All sensors and steering devices in the powered joints, arms, and nozzle are connected to the computer G, through H, which might contain accessory machinery, material, etc. The computer directs and controls the technical operations of material distribution and reclamation, communicating with a larger computer subsystem.

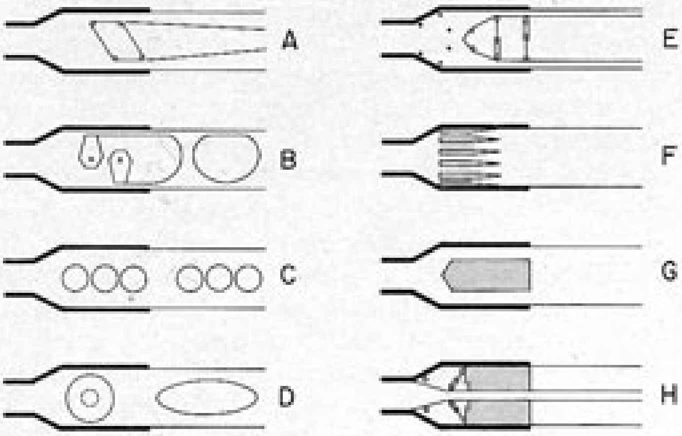
Several distribution and/or reclamation devices could be teamed up on a project and operated simultaneously. Data relevant to the performance of CT about time, space, and material such as quantity and location of material and sensors in space, the mode and time of distribution and reclamation, molecular change, etc. are processed and stored in the computer memory for later retrieval (8).

C. **The sensing structure subsystem** constitutes the physical environment in which human activities take place. It provides a constant flow of information about changing internal and external conditions which is processed by the computer subsystem. Internal and external sensors are part of the structure, operating in analogy to nerve cell receptors. The sense modalities are: vision, hearing, taste, smell, sensibility for balance, warmth and cold, compression and tension, and kinesthesis, giving information of all parts of CT in space. The threshold sensitivity can be determined by the computer subsystem.

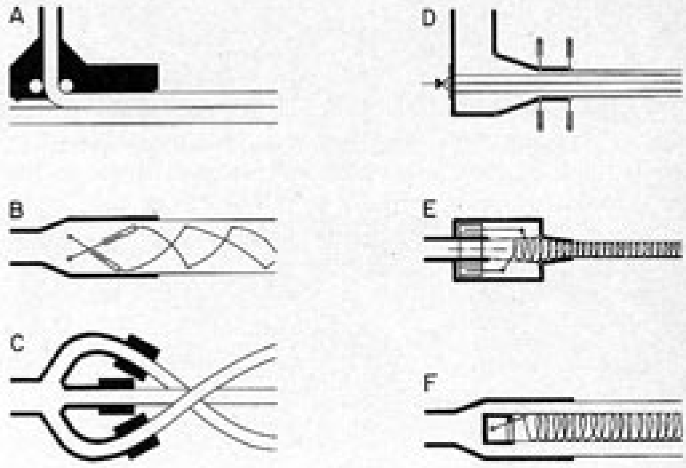
The material constituting the sensing environment has to have quite different characteristics than those of present-day building materials. Once these leave the generating machinery they no longer are subject to controlling and forming processes and assume a specialized one-way character. This does not allow for change or economical reuse. Designed for special purposes only, the performance potential of such "linear" materials is very limited. The underlying concept here stems from analytic technology which isolates functions as a result of abstraction.

Living systems use a very few basic materials yet highly complex organizations of all kinds are built and these have the capacity to adapt themselves to a vast variety of functions. Bone is a good example to illustrate this concept. It consists of collagen and deposits of tricalcium phosphate, and calcium carbonates. Here a section through a bird bone, an outstanding minimal structure with optimal performance. Always using the same basic materials and construction methods, bone systems achieve the utmost flexibility. The wide adaptive range is clearly reflected by the contrast of the massive bone of a dinosaur alongside the delicate filigree of a hummingbird's skeleton (9, 10).

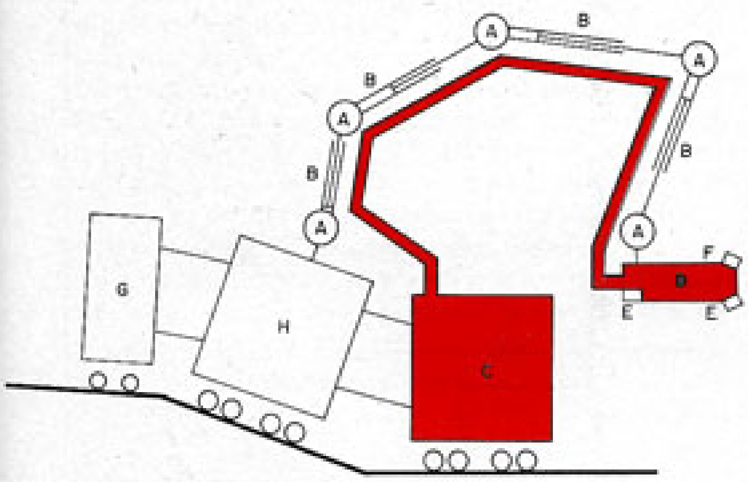
Some groups of modern materials seem to promise to meet the requirements of flexibility and versatility. Among these are alloys, ceramic compounds, and organic as well as inorganic plastics. The latter can



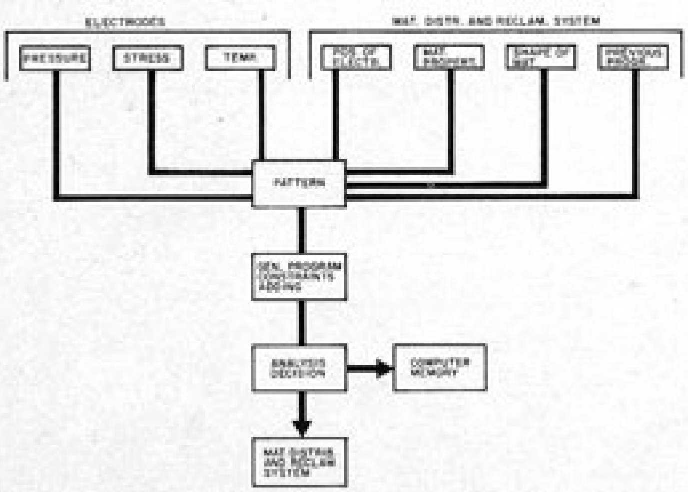
5. A variety of nozzles that could be used to generate alternate shapes.



6. A schematic side view of the basic organization of material and distribution hardware.



7. Several distribution and reclamation devices could be used simultaneously.



8. Data relevant to the performance of CT would be processed and stored in a computer for further reference.

be engineered for a variety of functions which brings them closest to the requirements of the ideal material.

The circulation of material in CT is illustrated here **(11)**. Material which is no longer needed goes through the phases of reclamation, regeneration, and redistribution to perform another function.

Entire structures of CT may consist of plantlife supporting material with built-in chemical, water, gas, heat, and light dispensing systems. These can control, initiate, and end plant growth. Seeds or seedlings can be mixed into the structural or nonstructural plantlife supporting material during the process of distribution or implanted afterwards. Certain seeds can have a plastic coat that will dissolve after a calculated time interval and permit the access of water for germination. Thus time sequences of plant growth can be planned in fixed programs by employing such techniques as seed coating, or planned with flexible programs through such systems as electronic or chemical actuation or stimulation.

The subsystems A, B, and C constitute Cybertecture. This is a process-oriented entity characterized by the principles employed by multivariant systems: a. Feedback; b. Ultrastability; c. Multistability.

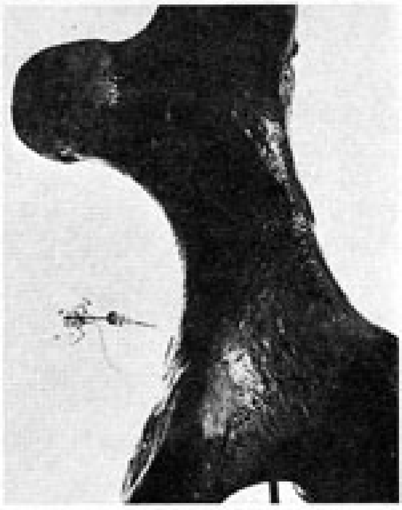
The trial-and-error method, depending upon the selection of new parameters by mere chance, and used by all living organisms, is an important factor of CT.

CT performs as illustrated: Internal and external forces render CT unstable **(12)**. The change in state is perceived and forms a pattern which is the model of internal and external conditions. The decision making stage can be reached by the shortcut A, or by the problem solving and planning routine B, resulting in a predictive model. The decision making process takes into account former models and subroutines retrieved from the computer memory bank. The predictive model is manipulated until it evolves the optimal solution. The material distribution and reclamation subsystem is activated and adjusts the environment. The stable state is reestablished until new forces disturb the system again, originating its further adaptation.

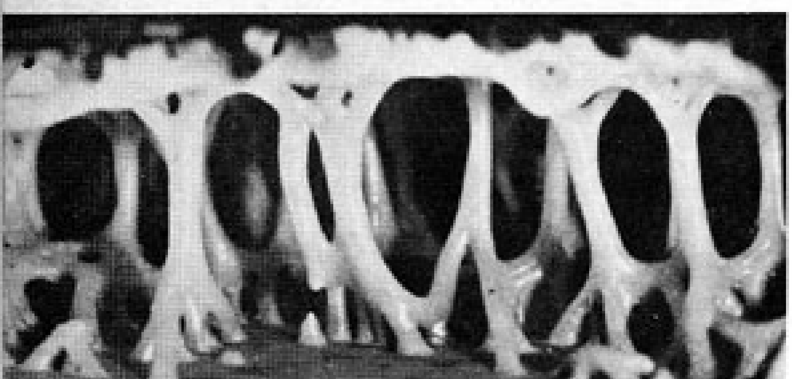
Change in state is perceived by the sensing structure subsystem of CT 1 (**13**). The sensory input is processed and becomes the effector output activating the material distribution and reclamation subsystem. Its manipulation results in CT 2. If CT 2 is disturbed, it evolves into CT 3 and so forth.

In case a mechanical material distribution and reclamation subsystem is employed, CT, to begin with, can be organized as shown here where the black skeleton represents the superstructure and the white represents infrastructure (**14**). A moving nozzle generates or reclaims the superstructure; another device, running on and operating from the superstructure, generates and adjusts the infrastructure (**15, 16**).

Such a structural system offers a lower degree of

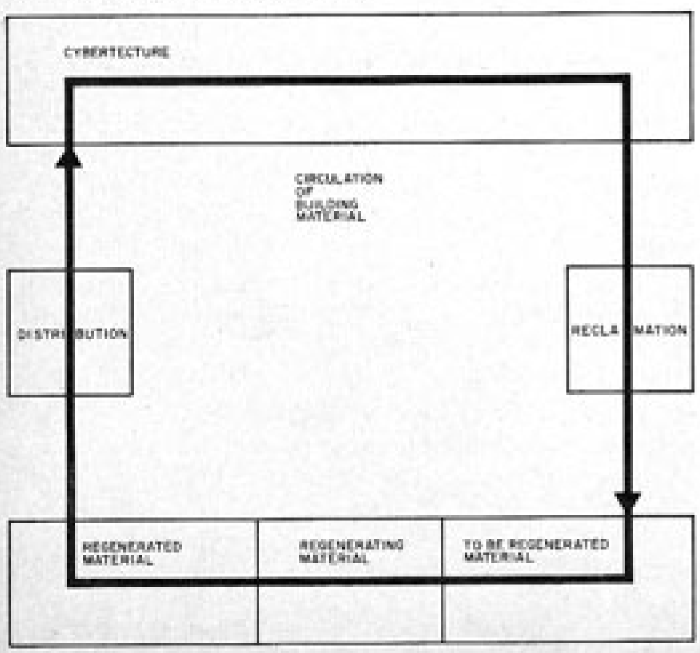


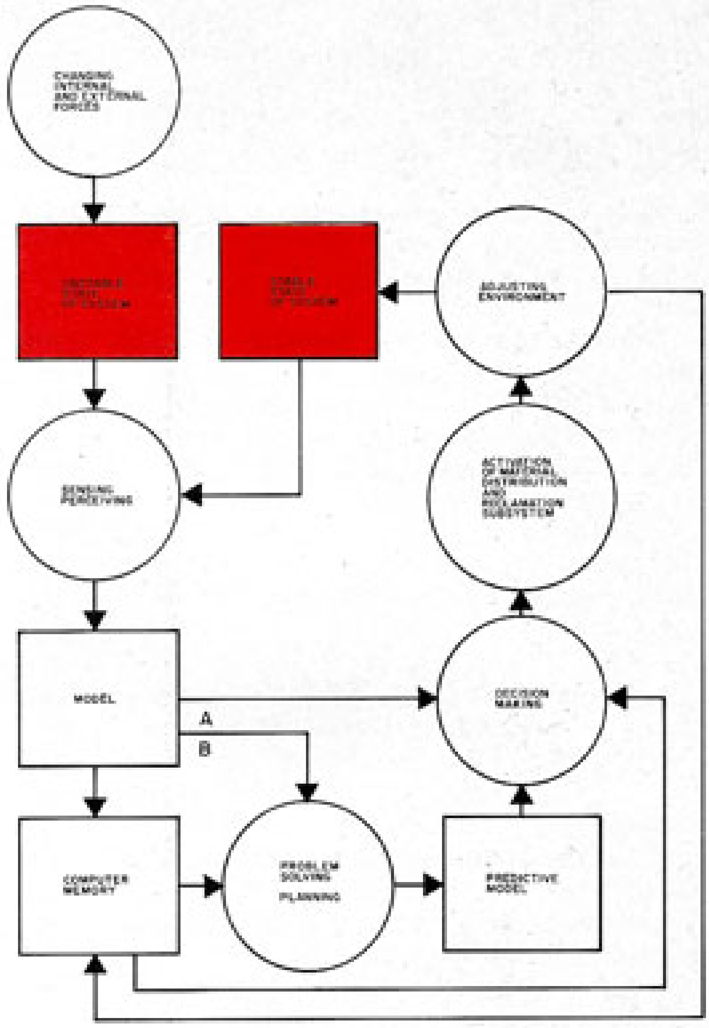
9. The same basic material was biologically used by nature to form a massive dinosaur bone and a hummingbird skeleton.



10. A magnified section through the bone of the hummingbird wing shows the filigree structure that produces such high relative strength.

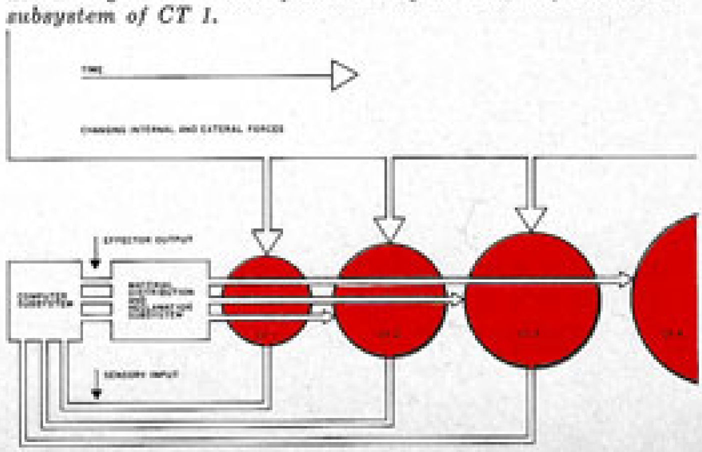
11. The diagram shows the circulation of CT as it is reclaimed, regenerated, and redistributed.





12. Internal and external forces render CT unstable. The change in state is perceived and forms a pattern which is the model of external and internal conditions.

13. Change in state is perceived by the sensing structure subsystem of CT 1.



flexibility than less rigidly conceived environments which integrate both the sensing superstructures and infrastructures (17). The system does, however, have the advantage of relatively uncomplicated control and communication which facilitates an easier start into its dynamic existence.

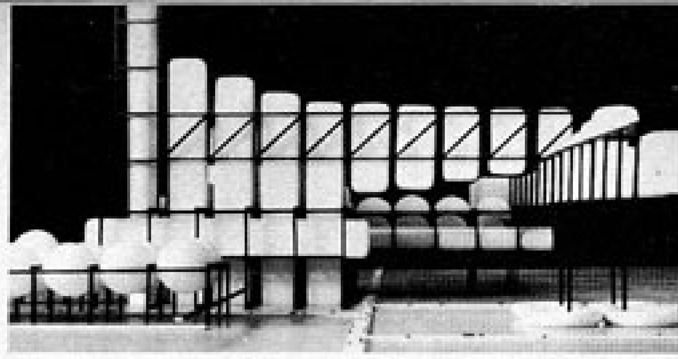
CT can be initiated in any kind of environment: above or under earth, under water, or in outer space. But it is evident that CT calls for socio-political and economic systems radically different from those presently existent (18).

Change more and more is becoming the essence of human culture. The increasing frequency of change in all dimensions will document itself in CT.

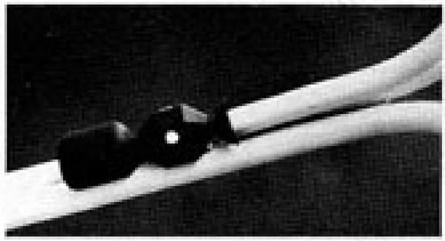
Being a teleological system that employs self-improving software and hardware, it can draw "unorganized" matter into its system like a seed which becomes a plant. Constantly learning how to adapt itself to changing conditions, CT gradually can enrich its wealth of characteristics of living systems. Then it is only logical that CT can incorporate the total space-time continuum and evolve to higher and higher levels of organization. Finally, there is no reason to believe that its artificial intelligence will not surpass the capacity of the human brain, bringing forth unknown consequences. But apart from these speculations, CT can serve this, its main purpose: It will create a habitat which, being the result and generator of human activities, is highly responsive to changing needs of the individual as well as society.

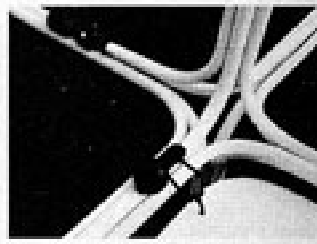
During the greater part of his evolution, man has had to adapt himself to his environment in order to survive. Cybertecture is a concept to reverse a historical process radically.

Photography: (no. 2, 9, 10) Andreas Feininger

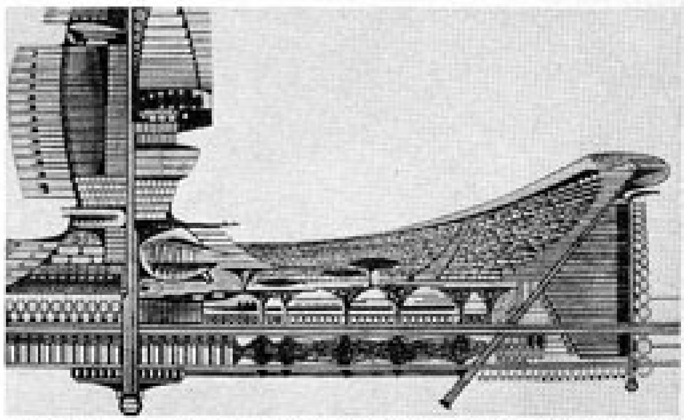


14. Here the black skeleton represents the superstructure and the white structure represents the infrastructure.





15, 16. A moving nozzle generates or reclaims the superstructure, another device running on and operating from the superstructure generates the infrastructure.



17. The degree of flexibility is limited when CT is generated as indicated in the two preceding photographs but has the advantage of relatively uncomplicated controls.

18. Cybertecture initiated in an underwater environment allows free movement in three dimensions, as it would in outer space, generating and regenerating itself to meet almost instantaneous requirements.