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Tools and technology, body and world: An exploration of technology transfer

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TOOLS AND TECHNOLOGY, BODY AND WORLD:
AN EXPLORATION OF TECHNOLOGY TRANSFER

by

JOHN EDWARD BRESHEARS

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IN PARTIAL FULFILLMENT OF THE
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ABSTRACT

Tools and Technology, Body and World:
an Exploration of Technology Transfer

by

John Edward Breshears

The tools we choose to perform a given task affect not only the result of the task but also how it is conceived. An examination of tools, tasks, and interdisciplinary technology transfer suggests that new ways of thinking, rather than increased efficiency, are the primary means of technological advancement. The history of the relationship of the human body to architecture can be seen as a progression from embodiment to projection to a new paradigm of extension, or prosthesis. These ideas, together with surveys of bridge types and prosthetic technology, lead to the design of a pedestrian bridge linking two existing buildings. The bridge is conceived and designed using the tools of medical prosthetics and orthotics. Human and animal vertebrae suggest structural principles from which a light-weight, articulated bridge form is developed to satisfy the requisite conditions.
ACKNOWLEDGMENTS

I have been fortunate to work with an exceptional committee on this thesis project. I would like to thank Richard Ingersoll, who first suggested the idea of a pedestrian overpass. Joel Conte is an outstanding teacher who went well out of his way to help with my analysis and to answer carefully a myriad of questions. Bill Sherman is an extraordinary critic who challenged the project on all levels with his enormous breadth of expertise and insight. He has pushed me to make the project what it is. I have benefited from a great deal of helpful conversation and thoughtful critique from each of the committee members.

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Chapter 1  INTRODUCTION
A tool is defined as anything used to accomplish a definite task. Technology is defined as the practical application of knowledge. The question arises of the relationship between the object (the tool), the definition (the task) and the knowledge applied to and received from the process. The common view is that the human in interaction with the world experiences it through the mediation of techniques (i.e. tools) which are arranged into patterns as techniques (processes) and then formulated into thought of action (technology). The common element throughout is the human, but whether it is he who acts as medium between tool and task, or whether it is the object which is actually the medium between body and world is a matter worthy of examination.

Sartre suggests that it is the instrumentality of things which reveal our body to us.  

Yet, in the same essay he suggests that, “we do not use this instrument, for we are it.”

Again the question of the configuration of relationships arises. Is the body revealed to us through tools, or is it in itself a tool - a medium between us and the world? The ways we choose and use implements to deal with a given problem may affect not only the outcome of the task, but even the way in which we conceive of the problem itself. Our tools affect our experience of the world.

This thesis will explore the idea that new ways of thinking, rather than increased efficiency, are the primary means of technological advancement. The design portion of the the project involves the development of a two-level pedestrian bridge in the Texas Medical Center using the tools and

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2Ibid. 427.
technology of medical prosthetics and orthotics. The research preceding this exercise comprises chapters on the nature and means of transfer of technology, the relationship of architecture to the body, a survey of bridge types (both structural and visual), and a brief survey of some methods and devices used in current medical practice.
Chapter 2  TECHNOLOGY: BEGGING THE QUESTION
...the lesson of the airplane lies in the logic which governed the enunciation of the problem and which led to its successful realization. When a problem is properly stated, in our epoch, it inevitably finds its solution.¹

A deterministic attitude toward technology in the Modern Movement is embodied in Le Corbusier's terse statement. The idea of the inevitability of a solution to a technological problem suggests a convergent, pre-ordained course of development. This is analogous to the direct correspondence between form and function, as suggested in Louis Sullivan's phrase. A direct correspondence between specific problem and unique solution or between task and tool, however, raises questions about the nature of tools and technological change.

Technology is defined as the practical application of knowledge, and it was clearly advanced in the field of aeronautics by 1930 when Le Corbusier wrote his statement.² A tool is defined as anything used to accomplish a definite purpose.³ The implementation of a technological solution then, by definition, must involve tools of some form. Furthermore, a tool is defined by its use. Anything can become a tool, and the occupants of the tool box can just as easily shed their identity and become objects. For the most part, however, tools used to perform new and different tasks are adapted from pre-existing tools.⁴ Technological change could be seen as analogous to a

¹Le Corbusier, Towards a New Architecture; (London: John Rodker, 1931) 110.
³Ibid.
⁴This view is supported in many sources. A good argument for the case is made in episode #360 of The Engines of Our Ingenuity, J. Lienhard, KUHF, University of Houston.
coral reef wherein tools live out their usefulness and die by giving a platform for another, more useful tool to be born.

The possibility of a transposition of the Modernist dictum presents itself in this view. The tool or solution does not necessarily become the inevitable response to a correctly posed question, but instead a tool may be posited as an answer which begs the question. Siegfried Giedion writes

*Tools and objects are outgrowths of fundamental attitudes to the world. These attitudes set the course followed by thought and action. Every problem, every picture, every intervention, is founded on a specific attitude, without which it would never have come into being. The performer is led by outward impulses - money, fame, power - but behind him, unbeknown, is the particular problem, that particular form.*

Here again the attitude to the world, or the statement of the problem, determines the thought, action, and solution to the problem. However, if we can read Giedion to place tools and objects in the same group, then their equivalence and implicit interchangeability suggest a non-deterministic idea of technology. Fundamental attitudes to the world could, at least in part, be outgrowths of tools and objects instead of the hierarchy that Giedion would have us believe. An evaluation of tools available, or at least conceivable, and the possible ways in which they might be used can suggest alternate ways of thinking about the problem, if not new problems altogether. This idea is that new ways of thinking, and not simply increased efficiency, are the primary means of technological change.

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Robert Maillart throughout his long career designed three-hinged arch bridges in reinforced concrete. He chose this bridge form because he had the tools to analyze it and did not have the tools to analyze the structurally indeterminate forms of a two-hinged or fixed arch.\footnote{These tools of graphic analysis led him to ask questions about the form and resolution of forces which eventually produced the Salginatobel and Schwandbach bridges, the masterworks of his oeuvre.} In a similar way, the very words we choose to describe the tools can effect the task at hand and the way it is considered. The example of a bow-string truss is appropriate. Calling it a beam stresses the structural behavior. Calling it an arch stresses the form. Calling it a suspension system stresses the method of assembly. Yet, all of these interpretations and descriptions are correct.\footnote{Yet, all of these interpretations and descriptions are correct.}

Choisy was another strong advocate of the idea that architectural form is the logical consequence of technique. His dictum "La question posee, la solution etait indiquee" (The question posed, the solution indicated) was transposed in a recent presentation made by the renowned engineer J. Schlaich;

\textit{We can see that if the engineer has a strong aesthetic preference, he can utilize his professional background to find a technical justification for it. I have often observed that the stronger the visual superiority of a certain solution, the easier it is to find an honest technical support for it. Of course, it is desirable that such an iterative process not be necessary, but that both the visual and the technical satisfaction emerge simultaneously.}\footnote{We can see that if the engineer has a strong aesthetic preference, he can utilize his professional background to find a technical justification for it. I have often observed that the stronger the visual superiority of a certain solution, the easier it is to find an honest technical support for it. Of course, it is desirable that such an iterative process not be necessary, but that both the visual and the technical satisfaction emerge simultaneously.}

\footnote{For a more detailed account see David Billington, \textit{Robert Maillart's Bridges}, (New York: Princeton University Press, 1979)}

\footnote{see Figure 3.5}

\footnote{This example is taken from an address given by Tom Peters. See Deborah Gans, ed., \textit{Bridging the Gap, Rethinking the Relationship of Architect and Engineer}, (New York: Van Nostrand Reinhold, 1991) 92.}

\footnote{Ibid. 116.}
Here Schlaich was speaking in reference to the cooling towers at Schmehausen, Germany. His past experience and aesthetic preferences led him to propose a fabric membrane structure for the cooling towers with a cable-net placed on the outside to provide a visual order. The proposal begged the question of the optimum hyperbolic profile and the insulation of structural steel from the corrosive gases inside the stack. It also caused reflection on the nature of a cooling tower itself as simply a tube to guide exhaust gases in the correct direction without the need of structural capacity beyond supporting its own weight.

The non-deterministic view of technology allows for a human presence in the process as well. Acknowledgement that there is choice involved in the process and that most tools do not perform their functions automatically allows and requires the presence of a human medium between tool and task. Even Le Corbusier who, as a strict Modernist, propounded the direct relation of form to function, admitted the necessity of choice, although he presupposed a bias in the process.

The engineer therefore has his own aesthetic, for he must, in making his calculations, qualify some of the terms of his equation: and it is here that taste intervenes. Now, in handling a mathematical problem, a man is regarding it from a purely abstract point of view, and in such a state, his taste must follow a sure and certain path.¹

The late, renowned engineer Peter Rice stated this idea most eloquently in his work, although he puts it into words as well:

...this brings to mind another myth about technology. The feeling that technological choice is always the result of a predetermined logic. The feeling that there is a correct solution to a technical problem is very common. But a technical solution like any other decision is a moment in time. It is not definitive. The decision is the result of a complex process where a lot of information is analyzed and examined and choices made on the evidence. It is a moment in time and place where the people, their background and their talent is paramount. What is often missing is the evidence of human intervention, the black box syndrome. So by looking at new materials in a new way we change the rules. People become visible again.¹

In a recent address to the R.I.B.A., Rice gave an account of the process he had employed to realize the structure of the Centre Georges Pompidou in cast steel, a process extremely uncommon at the time but now used widely in off-shore drilling rig technology. Several months after the completion of the building, he witnessed an elderly woman, dressed in black, who was standing on the upper level of the building with her hand resting on the gerberette (the large cantilever bracket). She remained there for almost an hour, he reported, stroking the piece in silent contemplation.²

The Modern Movement's attitude toward the inevitability of technology was grounded in an Enlightenment idea of the rationality and ultimate comprehensibility of nature. Nature was the source of all technology.

²Ibid.
Our engineers produce architecture, for they employ a mathematical calculation which derives from natural law, and their works give us a feeling of harmony.¹

An examination of the history of innovation, however, reveals that this is hardly the case. Nature in most instances is far too complex to be replicated. In almost every case, an innovation based on an idea from the natural world must be highly abstracted, and usually a process of selection of which properties are to be replicated - what will be the actual function of the tool - must occur. For example, most early attempts at aviation, before the successes that Le Corbusier admired, were unsuccessful attempts to construct an ornithopter. An imitation of the flapping motion of a bird's wing proved far too complex. The property of lift had to be abstracted from that of propulsion and selected as the function of the tool came to be known as the airfoil. It was not until much later, with the invention of the helicopter, that the properties of lift and propulsion were accomplished with the same tool, and it appeared in a form unlike anything occurring in the natural world. Even in the task of replicating the body itself a direct imitation of nature falls short. Attempts to reproduce the body force the process of abstraction and selection, for nature is far too complex and disorderly to be both comprehended and replicated. The example of a prosthetic arm points this up: the two main types of prosthetic arm available are the cosmetic and the functional. (Figure 2.1) In the cosmetic, the visual appearance of the object is selected for replication at the expense of the function. In the functional hand, the technological aspects, albeit in a highly abstracted fashion, are reproduced.

Often the process of innovation results in a rejection or denial of nature in the creation of a new tool. The wheel as we know it does not exist in nature. Conversely, the method of propulsion we experience every day with the use of our legs has never been successfully replicated with technological means. Nature does not necessarily beget tools. Tools beget tools.

Peter Rice gave an interesting example in the same address mentioned earlier. The Pavilion of Future for the 1992 Exposition if Seville was inspired by an unfinished seventeenth century palace in Lisbon which comprised a very long and tall structural masonry wall. Utilizing current precision stone-cutting technology developed to produce stone veneers with tolerances to 1/2 millimeter, and the fixing principles developed to mount structural glass, the pavilion was realized in load-bearing masonry. Ironically, the tools used to formulate and realize the problem were themselves the result of the tool progression in the industrial revolution which made load-bearing masonry "obsolete."2

There is a long tradition of the transfer of marine tools and marine engineering techniques to land-locked uses, many of them applications in

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1This example was taken from Dr. John Lienhard, The Engines of Our Ingenuity, no. 465, KUHF, University of Houston
Figure 2.1 Various types of working and cosmetic prosthetic cosmetic arms.
architecture. The deck beams of ships were applied to large-scale industrial projects during the 19th century. Unaltered wrought and cast-iron beams were used in the formation of jack arches for early industrial buildings. Ship deck houses were used as prototypes for military huts during the Crimean and American Civil wars. These ship cabins were demountable in order to enable the loading and unloading of deck cargo, and they inspired a series of portable, panellized wooden construction shelters.¹

Most recently, Richard Horden made use of off-the-shelf, pre-fabricated yacht masts and spars to construct the structural frame for a house in 1985. This system suggested a modulor as well as panellized construction which also utilized pre-fabricated boat parts. Reminiscent of the kit-of-parts-assembled Eames house in California, this project is interesting because its tools have been found in another discipline and used to perform a task which has an entirely different result. Each of these three examples start from a radically different aspect of marine engineering, the first with the structure of the hull, the second concerning deck-mounted superstructures, and the third related to the rigging of sailing vessels. In each of these examples, the proposition of the tool has affected the conception of the problem and, hence, the result.

These examples fall under the heading of 'technology transfer.' The term was first defined some twentyfive years ago as the process whereby the techniques and materials developed in one creative field, industry, or culture are adapted

to serve in other creative fields, industries, or cultures. In view of the prior discussion of technology, this phenomenon of tool innovation is particular only in its self-conscious exploitation of multiple disciplines as potential sources of tools.

Mr. Robert Cunningham of the Department of Mechanical Engineering at Rice University is currently involved with cross-disciplinary technology transfer. The initial desire to provide a better prosthetic hip implant has led him and a group of his students to draw on his extensive experiences in the field of petroleum engineering. This knowledge has led to a definition of the problem of fixing an implant into the bone in terms of producing an internally-locking shaft which, after installation, may be be adjusted to bring the collet-butt into compression. The problem is analogous to the fixing of the drilling tool onto the packer rod as used in oil drilling rigs, and these are the tools which have been adopted to formulate the task in realizable terms.

Contemplation of the post-loading requirement of the task led the group to propose a second solution based on reversing the principle of the child’s toy known as the Chinese Finger Cuff. In this case, the tools of weaving, the way the warp and weft of a fabric are joined to produce the bias of the fabric, are exploited. An axial contraction in the cylindrical cuff occurs when it is radially expanded through the injection of a self-hardening plastic.

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2Interviews with Robert Cunningham, Department of Mechanical Engineering, Rice University, Houston Texas, October - November, 1992.
3The author is indebted to Mr. Cunningham and his group of students for sharing their ideas and thought processes in this exercise in technology
Tools are defined by their uses and, most of the time, new tools, or their new uses, are descended from other tools. The obvious implication is that the larger the body of tools one has to draw upon, the wider the range of possible approaches to a task. This idea is embodied in the term technology transfer, which implies a cross-disciplinary search for new tools with which to formulate and solve tasks. Inherent also in the term is the potential for new tools to affect our thought processes and, hence, our understanding of the world.

transfer. For reasons of Copyright, the details of these projects must be left deliberately vague in this thesis.
Chapter 3  BRIDGES
...man's will to union seems to be resisted not only by the passive separation of space, but also by an active, specific configuration. by overcoming this obstacle, the bridge symbolizes the expansion of the sphere of our will over space. Only for us are the banks of the river not merely in different places, but "divided." If we did not link them together first in our aims, our needs and our imagination, our concept of separation would have no meaning. ... the bridge takes on an aesthetic value when it accomplishes a union of the separate not just in reality and for the satisfaction of practical aims, but renders it immediately visible. The bridge provides the same fixed point for the eye, linking up parts of the landscape, as it does for physical bodies in practical reality. ... To the eye the bridge stands in a much closer and less haphazard relationship to the banks that it unites than does the house to its land and foundations, which are hidden underneath it.1

The following is a survey of the structural types of bridges and their visual implications.

---

Figure 3.1  Bridge Structure Schematic Types
THREE-HINGED ARCH; THERE MAY BE NO MOMENT OF ECCENTRICITY AT ANY HINGE. THEREFORE, THE LINE OF PRESSURE (RESOLUTION OF FORCES PASSING THROUGH THE ARCH AT ANY GIVEN POINT) MUST PASS THROUGH ALL THREE HINGES.

TWO-HINGED ARCH TWO-HINGED AND FIXED ARCHES ARE STIFFER THAN THE THREE-HINGED ARCH, ALTHOUGH INTERNAL STRESSES DUE TO THERMAL VARIATIONS ARE HIGHER.

FIXED ARCH THE GENERAL RULE OF THUMB FOR THESE TYPES OF ARCHES IS THAT THE LINE OF PRESSURE MUST REMAIN WITHIN THE MIDDLE-THIRD, OR 'KERN' OF THE ARCH.

TIED ARCH THE THRUST OF THE ARCH IS TAKEN BY PLACING THE TIE IN TENSION.


Figure 3.2 Arch Bridge Types
Figure 3.3  Bridge Across the Marne, Luzancy, France
1948-50, Eugene Freyssinet
One of a series of five bridges Freyssinet designed using his revolutionary pre-stressed concrete/post-tensioned steel method
Figure 3.4  Pont du Gard, Nimes, France
  c. 50 B.C.
  Fixed, continuous masonry arches. The lower spans are 20-25m.
Figure 3.5  Salginatobel Bridge, Graubunden, Switzerland
1929-30, Robert Maillart
90 m span. The bridge is a three-hinged arch of reinforced concrete with a hollow-box deck.
Figure 3.6  Garabit Viaduct, St. Flour, France
1884, Gustav Eiffel
165m span. The bridge is a two-hinged arch of wrought iron.
Figure 3.7  Project for a Bridge Over the Wisconsin River, Spring Green, WI
1947, Frank Lloyd Wright
60m span of reinforced concrete arches.
Figure 3.8  Europa Bridge, near Innsbruck, Austria
1964  Six-span continuous girder bridge with orthotropic deck comprising a steel plate stiffened by flat ribs.
Figure 3.9  Proposal for a Long-Span Highway Bridge
1948, Paolo Soleri
Folded slab of reinforced concrete.
Figure 3.10  Firth of Forth Bridge, Scotland
1883-89, John Fowler and Benjamin Bowles
Steel cantilever bridge with two 1700-foot main spans. Interim spans are 350 feet.
Figure 3.11  Severn Bridge, England
1967  Three-span suspension bridge. Deck is an orthotropic box girder comprising a steel plate stiffened by trapezoidal box ribs.
Figure 3.12  Brooklyn Bridge, East River, New York
1883, John Roebling
The bridge is a hybrid between a suspension and a cable-stay. Roebling
included the inclined cable stays as a stabilization against wind deflections.
Figure 3.13  Pedestrian Bridge, Duisberg, Germany
1958 (originally built for the Brussels World's Fair)
18' 6" span. Cable-stay bridge with a harp configuration. Steel
Figure 3.14  Alamillo Bridge, Seville, Spain
1988, Santiago Calatrava

Reinforced concrete. The weight of the massive, inclined tower takes the place of the cable back-stays in maintaining tension in the cables.
Figure 3.15  Ganter Bridge, Simplon Highway, Switzerland
1980, Christian Menn
Reinforced concrete. Hybrid cable-stay bridge with the stays encased in concrete to accommodate a curving form in plan. 174m span, 150 foot tower height.
Figure 3.16  Project for the Ruck-a-Chucky Bridge, California
Myron Goldsmith
Hybrid cable-stay bridge in which the stays are anchored directly into the face of the cliff. 370 m span.
Chapter 4  BODY AT THE END OF THE CANE
This is why my body extends across the too which it utilizes; it is at the end of
the cane on which I lean against the earth; it is at the end of the telescope
which shows me the stars; it is on the chain, in the whole house; for it is my
adaptation to these tools.¹

The history of the relationship of the body to architecture can be seen as a
progression from the corporeal idea of embodiment to the psychological idea
of projection, as Vidler points out.² A continual progression implies
continual change, and its extrapolation suggests the technological idea of the
body as a tool.

Thoughts about the body and its relationship to architecture can be grounded
in the Vitruvian/ Renaissance concept geometric purity. The so-called
"Vitruvian Man" is a human figure inscribed simultaneously within a circle
and a square. (Figure 4.1) The navel of the figure is at the exact center of the
composition. Attributes of balance, symmetry, scale, and proportion as well
as the perfection of geometry are equated here with the human form.

This attempt to develop a theory of unity led to the body being projected
directly onto buildings and urban plans. The buildings were granted
authority by virtue of their anthropomorphic forms. The view emerged of a
building as a complete organism to which nothing could be added nor
removed without destroying the delicate balance of the whole. Alberti wrote

¹ Jean Paul Sartre, Being and Nothingness, (New York: Washington Square
Press, 1956) 428
² Anthony Vidler, "The Building in Pain; the Body and Architecture in Post-
Figure 4.1  The Vitruvian Man. From Cesariano's edition of Vitruvius.

Figure 4.2  Francesco di Giorgio Drawing from Cod. Magliab.
that "the building is in its entirety like a body composed of its parts."

Francesco di Giorgio produced plans of basilicas and cities with the generating and governing human figure superimposed. (Figure 4.2) Filarete was especially descriptive in his analogies of body and architecture;

*Just like the eyes, ears, nose, mouth, veins, viscera, the organs are arranged in and around the body as a function of its needs and necessities, one should do likewise in cities.*

His imagery is particularly intriguing when it goes beyond the dominant metaphor of his epoch to consider the possible imperfections that can occur with the anthropomorphic idea. A building can:

*b[ecome sick and die; sometimes it is cured from its illness by a good physician...a number of times it can recover, thanks to a good physician, until its death at its allotted hour. A few are never ill and suddenly die; others are killed by men for some reason or another.]*

Filarete does not elaborate, unfortunately, on how or from what a "good physician" might cure a building, but the analogy between building technology and medicine is an intriguing one. He uses the metaphor further to adjust his thinking about building in a final analogy in which the architect is seen as the mother of a building. He/she conceives the building by dreaming of it and mentally examining it from every angle, as a woman carries a child in her body. The building is then given birth, and the architect is responsible for nurturing it all the way through its realization "because the

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2 ibid. vol. 1 book 2 15-16.
The idea of man's perception of the world by means of his body has been around at least since the time of the ancient Greeks. The philosophy of Protagoras is embodied in the phrase "man is the measure of all things." Whether developed out of ideas about bodily perfection or pure expediency, the earliest units employed to measure the physical world were taken from and named for parts of the human body. The inch, foot, and yard all correspond roughly to various body parts, and it is easy to visualize the inscription of the body onto its surroundings through a comparison of proportion: body to world. A pound or even a kilogram is roughly the mass of any fairly dense material that we can hold comfortably in our hand. The truth of Protagoras' words extends beyond the corporeal to the sensory experiences of man as well. A single degree, Fahrenheit or Celsius, is about the smallest humanly perceptible temperature difference. One volt can be detected on the tongue, and our ears are sensitive to approximately one pound per square inch of pressure change. A kilowatt or a horsepower are bodily-correlated measures of energy, being about the maximum one could expend in a short sprint, running up the stairs for example, or the most we can absorb without being injured in an activity such as sunbathing or taking a hot shower.1 Whatever the prevalent paradigm of corporeal significance, the use of these units of measure suggests that the body is always inscribed into the world through common human experience.

1John Lienhard, The Engines of Our Ingenuity. no. 373, (Houston: KUHF, University of Houston, 1989)
The ideals of the human body presented in the "Vitruvian Man" endured well into the twentieth century, particularly in the Ecole des Beaux Arts. In other circles of thought, however, ideas about the relationship of body to architecture progressed. In the eighteenth century, Kant, Edmund Burke, and the Romantics described things not so much in terms of their attributes of beauty but in terms of their capacity to evoke emotions of fear and terror. Out of this idea of the sublime, a more extended form of bodily projection onto architecture developed. In it, the building no longer represented the whole or parts of the body but was seen as objectifying various states of the body, both physical and mental. In an essay with the curious title of \textit{Prolegomena to a Psychology of Architecture} Wolfflin wrote in 1886;

\begin{quote}
\textit{We judge every object by analogy with our own bodies...We always project a corporeal state conforming to our own; we interpret the whole outside world according to the expressive system with which we have become familiar through our own bodies.}\textsuperscript{1}
\end{quote}

The idea of bodily projection onto architecture is more removed from the Renaissance relationship of direct inscription or embodiment. Early in the twentieth century the ideas of projection were reinforced by the theories of Sigmund Freud. In his theory of bodily projection an object is invested with organic properties allowing it to become a surrogate for some part of the body. Normally, these "object-surrogates" are created by describing the objects in terms of the body part; eyeglasses, a microscope, or a camera could be an eye; skyscrapers and obelisks were equated with the penis; and dwelling places and shelters were wombs. In a more technological analogy a pump could stand

\begin{footnotes}
\end{footnotes}
in for the heart, an electrical circuit for the nervous system, and a computer
for the neural system.

The relationship of body to architecture seemed to expand still further in the
twentieth century. Early Modernists sought to universalize abstraction and
to redefine the relationship in terms of motion and sensation. Cubist
painters dismembered the classical figure to develop an expression of
movement and simultaneity. The body was reformulated to represent a
higher order of truth. Valentine de Saint-Point, the only woman to author a
Futurist Manifesto (entitled The Manifesto of Lust), reaffirmed the idea of
bodily projection onto space while simultaneously calling for the abstraction
of this bodily sensation from its cultural meanings.

...lust is the expression of a being projected beyond itself. ...It is the
communion of a particle of humanity with all the sensuality of the
earth....We must stop despising desire....LUST IS A FORCE. 1

These cries were made in the brief, written piece which vibrates with energy
and motion. She referred to her work at the Comedie des Champs-Elysees in
Paris, December, 1913, as "a dance of ideas:" wherein dance was a means of
interaction with her surroundings; a sort of post-facto inscription of her body
onto its surroundings.

Early Modernist architects, following more closely the Enlightenment
principles, seemed to be more interested in the rational sheltering of the body
than in its mathematical inscription or emotional projection. In the work of

1V Valentine de Saint Point, "The Futurist Manifesto of Lust," in The
Le Corbusier, man was still the measure of his surroundings, but not the generator of its form. The Modulor was non-idealized anthropomorphism; man shaped by the forces of the epoch. (Figure 4.3) There is a corporeal presence in the architecture, but it is located off to one side rather than at the dominant center. The body is inscribed in the architecture, but not through a transcendent embodiment or projection. Instead its inscription is much more mundane; the Modulor is literally incised into the beton brut of the Unite d'habitation.

The shift in conception of the relationship of body to world here is from the idea of projection to that of extension.

...our concern is with the mechanical system that surrounds us, which is no more than an extension of our limbs; its elements, in fact, artificial limbs.¹

The world is conceived as a mechanical system, and the objects which inhabit it act as extensions of the body. Le Corbusier implies an objectification and concretization both of the world and of the body. The idea that the body can exist in-and be supplemented by-the concrete objects of reality suggest that the

Figure 4.3  The Modulor. The system of Proportions developed by Le Corbusier Based of the human figure.
body is no longer a delicately-balanced whole but an incomplete object. From the idea of body as embodiment to the idea of body as projected, the conception becomes one step further removed in the body as objectified and modifiable. It should be stated, however, that Le Corbusier did not include all of the world in this conception. Only certain objects could act as artificial limbs, which he designated *objets membres humains*. Other objects in the world, the *objets sentiments*, maintained an emotional or psychological relationship to the body more in keeping with the paradigms of the Cubists and Futurists. The different relationships of object to body Le Corbusier explained as differing configurations to the "technico-cerebero-emotional equation."¹ This implies a clear categorization. The *objets sentiments* occupy the cerebero and emotional types of relationships, and the *objets membres humains* - the objects of architecture and design-relate to the body through a mechanism of technology. The tasks of architecture were defined and then solved through the tools of prosthesis.

A similar shift in the perception of the body/object relationship is seen in Surrealist painting contemporary with Le Corbusier. The depictions of the body undergoing metamorphosis could suggest its co-existence and interchangeability with objects in the world. Max Ernst's *The Attirement of the Bride* (1940) depicts the human form altered through its supplement of objects, questioning the exact relationship between the two. (Figure 4.4) In *L'Aurore* by Paul Delvaux, the human figure is depicted undergoing metamorphosis into tree-like objects. (Figure 4.5) It is unclear whether the process is stable or in motion, nor is clear which way the metamorphosis is proceeding. Exactly where the body ends and the object begins is not discernable. By challenging the way we look at the body in relationship to objects, the Surrealists here challenge the way we conceive of that relationship.

¹ibid.
Figure 4.4  *The Attirement of the Bride*, Max Ernst, 1940
Figure 4.5  L'Aurore, Paul Delvaux, 1937
The body as an object in the world raises the question of its relationship to other objects in the world. Its possibility of being supplemented by other objects implies its ability, likewise, to supplement the world. The body itself is a prosthetic device; it is the ultimate limb (real or artificial, body or object) for experiencing the "mechanical system that surrounds us." The leap in thought was made eloquently in the philosophy of Jean-Paul Sartre who, like his existentialist colleagues, was rethinking the relationship of the body to the Modern world. In Sartre's view, the body is not an a priori for the recognition and apprehension of all other things. Instead it manifests only "the individuality and contingency of our original relation to instrumental things."¹ Distinct from being embodied in, Sartre's body must be immersed in and subjected to the world before it can even recognize itself as a body. It knows itself because it is defined in relation to complexes of instruments.

"I live my body in danger as regards menacing machines as for manageable instruments. My body is everywhere: the bomb which destroys my house also damages my body in so far as the house has already an indication of my body. This is why my body extends across the tool which it utilizes: it is at the end of the cane on which I lean against the earth; it is at the end of the telescope which shows me the stars; it is on the chain, in the whole house; for it is my adaptation to these tools. "In particular," he writes, "our body is not only what has been called 'the seat of the senses,' it is also the instrument and the end of our actions. ... far from the body being first for us and revealing things to us, it is the instrumental-things which in their original appearance indicate our body to us."²

¹Jean Paul Sartre, Being and Nothingness, (New York: Washington Square Press, 1956) 401-470
²Ibid.
Anthony Vidler makes the contrast clear.

Thus, where in classical theory since Alberti the house is a good house only in so far as it is constituted analogically to the body, and the city a good city for the same reasons, in Sartrean terms the body is seen to exist only by virtue of the existence of the house.¹

If the history of the relationship between body and architecture is regarded as one of increasing removal from the corporeal to the psychological, then the successive paradigm could be removal to the technological. The body, like the tool, is defined by its use. Both are the instruments through which we experience the world. Hence, how we use them affects not only how we perceive but how we conceive the world we inhabit.

Chapter 5  PROSTHETICS AND ORTHOTICS
Prostheses, as I have discussed it, implies that the body is incomplete - a point of view corroborated by psychoanalysis, where the body is experienced characteristically as a sense of loss, or a lack. Whilst industrial design normally deals with objects outside and independent of the body, there is also the possibility of it serving to enhance the body, to make it whole again, or to compensate for corporeal deficiencies. ¹

Prosthesis, from the Greek roots pros (to) and thesis (place). The requirements of the prosthetist are as follows: a knowledge of the anatomy and function of the missing part, a knowledge of materials used in prosthetics fabrication, a knowledge of the fabrication, and a personal, caring relationship with the patient. Orthotics, from the Greek roots ortho (straight) and statikos (to cause to stand). The three fundamental ways in which orthoses function are as follows; to control the moveable segments of the musculoskeletal system, to compensate for and absent function, usually partial or complete paralysis of key anti-gravity muscles, or a correction of limb or spinal deformities.

The following is a survey of methods, techniques and devices currently in use in the fields of medical prosthetics and orthotics.

Lever arms acting on the hip joint. Moment produced by body weight applied at center of gravity of body, X, acting on lever arm, B-X, must be counterbalanced by moment produced by abductors, A, acting on shorter lever arm, A-B. Lever arm A-B may be shorter than normal in arthritic hip. Centralization of head shortens lever arm B-X, and lateral reattachment of trochanter lengthens lever arm A-B.

Hoop stresses. Axial loading of component produces wedging effect of stem and surrounding cement, which produces hoop stresses as illustrated. Uniformity of hoop stresses depends on uniformity of contact of cement or stem with bone in medullary canal and cone-like configuration of stem and cement mass.

Figure 5.1
Fig. 16-88  Amstutz reattachment of greater trochanter. A. Insertion of crossed wires through femur. B. Stabilization of trochanter with holder for drilling of holes. C. Insertion of wires through holes in trochanter. D. Fitting of trochanter to femur. Bone is padded and pounded with mallet to place distal edge against femur. E. Tightening of wires and tying of square knots with Kirschner wire bows. F. Reattachment of trochanter. (Modified from Zimmer U.S.A., Inc. Warsaw, Ind.)

Figure 5.2
The centers of rotation of the femur relative to the tibia. The instant centers are circled. 'IN' is the outline of the intercondylar notch, used as a reference. If a single point is chosen for the center, the best location is at 2. The inset shows a graphical construction for determining the centers. 1-6 are the positions of the cruciates from 0° to 60° degrees of flexion.

Figure 5.3
The similarity of the pulley and patello-femoral joint.


The forces in the knee joint shown in two planes for 10 percent into the stance phase of ascending stairs and descending stairs.

Figure 5.4
Technique for Insall-burstein II posterior stabilized knee system.

Figure 5.5
Fig. 17-24  A. Assembled constrained prosthesis: 1. metal glenoid cup; 2. tightened metal locking ring; 3. Series-II humeral head; 4. position of eccentric screw holes on back plate; 5. central metal stem. B. Prosthesis with metal glenoid cup removed. 6A, polyethylene pieces fitted about humeral head and its peripheral lip placed through metal locking ring. C. Metal ring pulled over humeral neck polyethylene peripheral lip (shaded area). D. Disassembly shows that metal locking ring first fits over neck, and then polyethylene pieces are placed about head before insertion into attached metal glenoid cup. Since diameter of humeral head is same as inside diameter of plastic halves and rim diameter of the assembled plastic halves is slightly less than that of humeral head, it is not possible to force the metal head into its metal glenoid without first placing polyethylene halves about head. E and F. Detail of insertion. (From Post M, Haskell SS, and Jablon M: J Bone Joint Surg 62-A:327, 1980.)

Figure 5.6
Internal spinal fixation systems most commonly used for fracture-dislocations and unstable burst fractures.

Figure 5.7
Compression wire at base of extension bar for measuring forces.

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Figure 5.8

Eculo-nervic distraction apparatus.
Contouring and titling of L. rod to maintain lumbar lordosis.

Figure 5.9
Spinal model of use of compression instrumentation posteriorly in treatment of Scheuermann's disease.

Figure 5.10
Chapter 6  SYNTHESES
The definition of tools by their use enables us to re-evaluate tasks based on the tools and objects at hand, or at least those that are conceivable. Our definition of a problem in terms of the avenues that might possibly yield a solution presents us with an inductive conception of the world in which we exist. Differing tools, in addition to producing differing solutions to the task at hand, may also cause difference in the way we conceive of the task, suggest still other problems that were not seen as such before, and ultimately affect our experience of the world.

The history of the body and its relationship to architecture can be conceived as one of increasing removal from the corporeal to the psychological to the technological. The Vitruvian conception yielded the man embodied in the concrete object - the object was permeable. The Enlightenment removed man outside the object, but allowed the characteristics of his psyche to be projected onto the the concrete, affecting its form or character still in some way - the object was malleable. A more recent attitude is that the body has become concretized and gained full status in the world of objects, capable of existing and interacting with them on a level of parity - the body has become objectified.

In the Sartrean view, the body is a tool. It is the technology which produces our experience of the world. As a tool or an object, depending on how we use it, it begets other tools. New technology, despite this idea, is not produced solely through the imitation of nature. Adherence to the rational, comprehensible nature of nature was an Enlightenment fallacy. It stood, for example, as an obstacle to a theory for the prediction of fluid behavior in the
transition from laminar to turbulent flow until it was recognized as a fallacy and the Chaos theory was developed.

The example of prosthetics points out the shortcomings of a direct imitation of nature in the development of technology. Any operation of this sort requires a process of abstraction and selection. The transfer of the technology used in oil drilling rigs to the development of prosthetic implants suggests a connection between objects as tools and the body as a tool.

The problem of a pedestrian overpass is one of connection. It is a question of where to look for the tools that might help to frame the task. What are the questions which will lead to the answer? The location of the project in the Medical Center suggests connections to medicine and brings to mind Filarete's medical analogy of the building to a body which may live, suffer illness, undergo cures, and die. The connection of oil drilling rig technology to prosthetics suggests a possible connection of prosthetics to the technology of bridges.

Prosthesis is from the Greek roots pros (to) and thesis (place). The requirements of the prosthetist are as follows: a knowledge of the anatomy and function of the missing part, a knowledge of materials used in prosthetics fabrication, a knowledge of the fabrication, and a personal, caring relationship with the patient. Orthotics is from the Greek roots ortho (straight) and statikos (to cause to stand). The three fundamental ways in which orthoses function are as follows; to control the moveable segments of the musculoskeletal system, to compensate for and absent function, usually partial or complete paralysis of key anti-gravity muscles, or a correction of
limb or spinal deformities. These terms resonate with operations on the body and with the idea and practice of construction.

Two conditions for the design of a pedestrian overpass are notable. The first is lightness of weight necessary to avoid supplementary supporting structure within the building. The second is the requirement that the two buildings not be tied together rigidly in order to allow for differential movement between them and thermal expansion of the bridge itself.

In light of these prerequisites, the spine as a flexible, load-bearing structure comes to mind. The preceding chapter illustrated some of the ways in which the spine's load-bearing capacity and flexibility can be modified. A pedestrian bridge in which the compression members are articulated to allow a small degree of movement at each joint might result in a bridge which would allow a sufficient degree of movement overall, as well as allowing the members to be of a manageable size. The compression modules, analogous to vertebra and containing one of the levels of circulation, could be fabricated in a plastic or composite material with a forming process that would result in high strength and low weight. The continuous tension members, analogous to the muscles and ligaments of the body, could be inherently flexible continuous cables or diaphragms which could also accommodate the second level of circulation.

Along this line of thought, certain other tools come to mind. The Dynamic Truss, recently developed by Christopher McCarthy of Ove Arup and Partners, allows rotation between its compression members, maintaining its
structural continuity through the tension members.¹ (Figure 6.1) The Funicular Polygon of Revolution, advocated by Robert Le Ricolais, separates the circumferential tension members from the central compression member by exploiting the high radial compressive strength of a ring.²(Figures 6.2, 6.3) The figures have a certain formal resonance with the halo device shown in the preceding chapter. Finally, the Spreuerbrucke in Lucerne, Switzerland, comes to mind as a conceptual tool. The interior gables along this sixteenth century bridge are decorated by Caspar Meglinger with paintings of the Dance of Death.³ (Figures 6.4, 6.5) Experiencing this structure creates a direct link between a pedestrian bridge and the human body, specifically of the human skeleton.

³Paul Hilber, Der Totentanz auf der Spreuerbrucke in Luzern, (Luzern: Raber, 1925).
Figure 6.1  The Dynamic Truss developed by Christopher McCarthy.
Figure 6.2  Funicular Polygon of Revolution
Figure 6.3  Funicular Polygons of Revolution placed in a pair.
Figure 6.4  Spreuerbrucke, Lucerne, Switzerland. 1648c.
Figure 6.5  Figure from the "Dance of Death" series on interior gables of the Spreuerbrucke, Lucerne, Switzerland. By Casper Meglinger, 1595-1670.
Chapter 7  THE PEDESTRIAN BRIDGE
The project was designed as a replacement for an exiting, bi-level pedestrian bridge over Fanin Street connecting the Dunn Tower with the Scurlock Tower. The existing bridge is a glass-wrapped steel box truss with a sliding joint connection at the Scurlock Tower end. It weighs approximately 475000 lbs.

Various systems of articulated compression members were designed and studied for the new bridge. The chosen design incorporates short sections of thin-shelled tube which connect to each other with intermediate flanges containing a gasket of softer material. (see Figure 7.9) Movement at the joints is then accommodated through slight deformation of the gaskets, which, in turn, redistribute the compressive force equally around the circumference of the tube. The tubes themselves are constructed from a floor deck and a series of curved panels jointed at their edges. Various spanning conditions, including some incorporating an intermediate support tower which would provide a link to the street, were examined in model form and with a computer. (Figure 7.16) A finite-element analysis program entitled SAP 90 was employed to study the stresses in the various elements of the bridge. (Figures 7.1-7.3) A series of rings and spokes were developed to separate the compression from the tension members, as in Figure 6.2. This was a lighter, more efficient alternative to the heavy struts which would otherwise have been required.

A first-order approximation of the weights and resulting bearing force of the new bridge suggested that the intermediate tower was not necessary. A single, simple spanning configuration between the buildings was selected. The upper, private level of circulation was accommodated within the
compression members, while the lower, public level of circulation became an open deck on the tension members. A non-load-bearing staircase was introduced to connect the lower deck to the street at either end, creating a public overpass.

The compression members would be fabricated from s-glass fiberglass in a thin, double-walled construction. The members would then retain a translucence, with views out restricted to the transparent strips within the joints between panels. (see Figure 7.21)
Figure 7.1  Structural force resolution in various skeletons.
Figure 7.2 Conceptual model I.
Figure 7.3  Conceptual model II.
Figure 7.4  Conceptual model III.
Figure 7.5  Study models of various spanning conditions.
Figure 7.6  Finite Element Analysis of moments about transverse axis in a single compression panel.
Figure 7.7  Finite Element Analysis of moments about transverse axis in one half of the span of the compression modules.
Figure 7.8  Detail study model for an articulated joint modulor system. (I)
Figure 7.9  Detail study model for an articulated joint modulor system. (II)
Figure 7.10  Model as two simply supported spans with intermediate support tower.
Figure 7.11  Model of full span using a system of rings and spokes.
Figure 7.12  Site plan.
Figure 7.13  Elevation
Figure 7.14  Upper level plan.
Figure 7.15  Lower level plan.
figure 7.17  Axonometric: stages of construction.
Figure 7.18  Perspective.
Figure 7.20 Sectional model.
Figure 7.21  Model of connection to building.
Figure 7.22  Site model.
Figure 7.23 Site model.
Chapter 8  POSTSCRIPT
The drawings and photographs in the preceding chapter illustrate the process and the result of the exercise in technology transfer. Throughout the exercise, the discussion has focussed on a rigorous, logical development of the concepts drawn from prosthetics and orthotics of the spine. 

The author attempted to maintain the idea of the spine as an analogy rather than as a metaphor. The tools for the task were intended to be an understanding of the structural principles of vertebrae, which could then be applied to develop a new bridge form, rather than the idea of the spine itself, which might have lead to a metaphorical re-interpretation of the nature of a bridge.

The process allowed a great deal of freedom for exploration in the design. At each step, both the architectural and the structural implications were considered, and both of these aspects were developed in parallel. Based on these decisions, the new bridge design would weigh approximately 195000lbs which is 41% of the weight of the 475000 lb existing bridge. This weight can be born by the structures of the buildings themselves without introducing extra support. The required freedom of motion within the span is achieved through the articulated joints. The architectural and spatial implications of this new bridge form must be conveyed through the material in the preceding chapter.

Both the process and the product of the exercise seem to provide compelling evidence that the tools we choose affect both the outcome and the conception

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1An account of the discussions held at interim reviews during the exercise is given in the Appendix.
of the task at hand. The resulting bridge form stands, resonating with the human body, as evidence to its unique means of conception and provides validity to the argument that new ways of thinking are the primary means of technological advancement.
APPENDIX
n.b. Verbal presentation was too long for the total allotted time.

SHERMAN - There is a conflict between the directions the two models are taking. One looks like its biological origins, and the other has abstracted some structural principles from the spine and put them into a more architectural form. What is your intention in terms of form at this point?

What is striking in the study of prosthetics is that the solutions result from very clear engineering solutions. Their attraction is often produced by the contrast between the clearly biological form which does one thing and the clearly engineered form which does another. To go through this and then come back to something expressive of the biological form seems to miss an opportunity to abstract and learn from the principles and then to try to find another form besides the one in which it occurs. Try to learn from the spine without being literal.

CANNADY - Will you continue the analogy of anatomy? Structure has to do with the bones, but the building refers back to the entire animal in which the skin protects the bones, etc. In a building the structure is not exposed for the same reasons. There are the considerations of fire-proofing, etc. It will be interesting to see how the structure is revealed.

CONTE - One of the models is complete and resists forces in all directions, the other does not. The model on the right (aluminum and copper) has two clearly different mechanisms to resist the forces. Shear and torsion are resisted by the plate, flexure is resisted by the cables which have the form of the moment diagram.
SHERMAN - Will there also be a cable that ties the two struts together underneath? Perhaps this should be a member capable of taking tension.

CONTE - There could be a stability problem if the struts are too thin and the cable tension too high. The struts could be subject to buckling.

SHERMAN - An architectural opportunity arises here because you are dealing with a bi-level bridge. The one model already suggests two spaces - one through the blocks and one through the space created by the cables beneath. There could be two very different levels; one exterior and exposed, the other enclosed.

INGERSOLL - That would address one of the main problems of the medical center which is that you never have a choice about whether or not to go outside.

BRESHEARS - The opportunity to place a support at the property line on the east side of Fanin also suggests the possibility of a stair connection directly to the street.

SHERMAN - This is required by law in Minneapolis, for instance. The connection prevents the street from being completely destroyed by the sidewalks being lifted into the air and privatized. You could introduce the same kind of ethic in this project.

The point of the exercise is that you are trying to reach something more efficient than just the standard bridge in terms of structure.

CONTE - Yes, but do you start with a certain a priori shape and try to justify the structural efficiency afterward, or how do you proceed?

SHERMAN - This is an important question. It lends a whole new layer of credibility to the exercise beyond the merely formal.
CANADY - The search for efficiency will probably make the project more beautiful. It will be an interesting challenge to see how you cover it, fireproof it, etc.

Post- script:

INGERSOLL - What problems do you need to address now? You present almost as though it were accomplished.

BRESHEARS - architecture (space), fabrication (materials & processes), structure (justification in terms of efficiency and aesthetics)

INGERSOLL - What other layers of program might there be? Layering the program could add richness and help with the design decisions. What kinds of spaces will be created in the bridge and how will they be used?

John Breshears
Comments from the Mid-term Review

February 25, 19993

William Sherman
Richard Ingersoll
Joel Conte
Joe Self
Don Stull

SELF - I know what Prosthetics are, but what are Orthotics?

BRESHEARS - The Greek root of Prosthetics is "to place" or "to replace." The root of Orthotics is "to make to stand erect."
STULL - I have a question about this model (plexiglass). In that model there are two bridge experiences, an outdoor and an enclosed?

BRESHEARS - Yes, one of the aims of the project was to develop a different bridge structure which would lead to a different bridge form and different spatial experiences. The double level of circulation offers the richer possibility of two spatial experiences.

SELF - Do these models actually work, or are they illustrative? That is, do they work in the sense that if you were to apply pressure or load, would they actually react?

BRESHEARS - They work to a certain extent, but admittedly, they are more illustrative than anything else.

STULL - I have a question in this model regarding the compression (i.e. tension) member (plexiglass model). The tension element has become a diaphragm and so can accept tension in two directions (i.e. the vertical plane and the horizontal plane. Is it necessary to have tension capability in this direction (lateral) as well in order to avoid lateral shifting? In other words, in this model (aluminum), tension is unidirectional, and in this model the tension is in two directions within the fabric. The reason I make this point is that I have often been on foot bridges where I thought, it is such a shame that this isn't open. I am sure if it were open there would be times when I would feel the opposite. to afford both experiences in the same structure without adding superstructure and so on is just wonderful, as is the study you are doing here. However, the second experience of openness in that (plexiglass) model only enjoys that economy absolutely if the stiffness of the membrane is required in the lateral plane.

I would like to say one other thing. I greatly appreciate the clarity of your presentation, both verbally and graphically. It is not necessary to work real hard to understand what it is you have done.

SELF - This model looks a lot like that one (spanning conditions models). One is on the site model. Are they basically the same?
BRESHEARS - They are models of two different spanning conditions.

SELF - I guess what I'm wondering about, maybe its just the model, but that really is just a tube. The bridge would really be much lighter or something else would be going on. Is that correct?

BRESHEARS - Yes, they are abstracted. I simply wanted to show the global spanning condition and so did not bother with the articulated compression elements.

STULL - But that is a compression element there. You have some real issues to finally confront given the vertical planes of it. That is the sandwich that is working in compression and so you have to structure openings into it.

SELF - You are closer in this spanning model to this model on the far end (flange & gasket detail) than to the other detail model, is that right?

BRESHEARS - Actually, the abstract spanning models are closer to the structure & skin detail model because the skin is continuous on the exterior. This gives an appearance closer to the tube of the spanning model. I am troubled by this because the discrete, articulated nature of the compression elements in this detail model are only experienced on the interior. In the other model they are experienced from both the interior and the exterior. This is closer to the idea have been working with from the beginning.

SHERMAN - Also that model (structure & skin) only works with the simplest moment diagram where the tension member is below the neutral axis. In the situations where the tension members reverse on themselves from bottom to top, you can't have the deck doing that. It would end up being suspended and non-structural at some points. It can do this with the ring structure (i.e. accommodate the various moment diagrams) because the cables can move up and around the continuous tubes.
BRESHEARS - And the point where the compression element passes through the ring can change - It can pass through eccentrically, altering the effective length of the moment arm.

SELF - So in this model (flange and gasket) one walks both on top of the elements and through them.

SHERMAN - And the only suspended of added, non-structural element in that model is the canopy which shades the upper level.

STULL - What has all of this taught you? The initial premise was to explore the application of technology to an architectural problem and then that was refined into the nature of tools and the things they make. I wonder about that phenomenon, but I will accept it as part of your thesis. After having gone through this very interesting and extremely competent and enlightened study, what does it come back to mean to me as regards creating or making human environments?

BRESHEARS - That is a difficult question. It has all been such an exploration. I'll make three points:
1: The paths of Technology Transfer, as such, are not easily identifiable, and so the need is to open one's eyes to the possibilities instead of to develop a specific method for effecting this phenomenon.
2: The Enlightenment ideas of the perfection of nature and the human body are still so persistent in our thinking today. There is a lot of validity in them, but a great deal of falsehood as well.
3: In designing this environment for people, I hope its origins will be evident in the finished product. I hope that in some way, possibly only phenomenologically, it will evoke a sense of the human body and that it was made by human beings for human beings. That is hard to talk about.

STULL - One of the most enjoyable aspects of your project to me is seeing a kind of deconstructionist imaging that is drawn from a rational process rather than stored images, which is a lot of what I've seen since I have been at this school off and on over the last eight weeks. That has something to do
with not repeating what you see but understanding the rules that make what you see and then using them.

SELF - It is an impressive display of the mind at work. It is wonderful to see it so clearly. There may be people who could better comment on the structural aspects than me. In my perspective, just trying to come up with a technology that is not antagonistic but that can actually support an understanding of the nature of the process and materials that you are studying is admirable. I really don't know how to tell you to go any further other than to say that it looks very impressive as a study.

I guess my only question is, it can work as a beautiful thing and as a machine, but in the end how do you evaluate it as a space? I guess traditional sections and perspectives seem a little foreign to what you are doing, but how do you convey the sense of space? Sitting here looking at these models is one thing, but how do you approach the problem of conveying what it feels like to actually pass through this thing? You might be able to find ways to reveal this thing.

SHERMAN - The important thing in that, and actually a two-level bridge has been a good instrument to keep it from becoming this, is that it doesn't become an object of structural expression. The structural forces that you are analyzing here are always being placed in the service of other ideas - architectural ideas and spatial ideas - and these become very clear about the boundaries of what is organizing your decision-making. A component of that is the spatial experience of this thing and not just the tectonic expression of the structure. The structural investigation is not an end in itself but is a means to another way of thinking. On one level it has a very rational basis, that is, trying to design a very light, efficient structure that allows a minimum of intervention in the existing buildings, but the other side of it is (and this comes back to some of the questions that may have to do with where put the hinge joints and struts) has to do with how the staircase connects into this thing and how the space above and the space below are different, and how the experience of those two are different. There are a lot of issues that are clearly architectural issues, beyond the engineering issues, and they will start to color the engineering decisions here. It is about walking that line between the two.
SELF - And it needs to be as rigorous in that respect (the architectural) as you have been so far. The tools, the ones we use - plan, section, perspective - may not be adequate. As Bill was saying, the zone of your "will" is here in space, but I wonder if it might not start with how you hit the ground here (tower base). Whatever markings and mappings that might happen here could begin to become something that points back to that thing somehow. What have you given yourself as constraints and parameters? Maybe you've decided that you can only touch the ground in this zone and that is part of the problem, but how one meets the ground finally, somewhere, could be an interesting part of the problem.

BRESHEARS - I neglected to discuss the staircase which creates two spans and allows direct access from the sidewalk.

SELF - I think Bill was suggesting that that could be the kind of entry point to the architecture, at least in terms of how it touches the city, how it touches the pedestrian. And you have got to find ways of studying that problem, of moving through that space.

CONTE - As an engineer I like the way you really express the structure as opposed to exposing it. You can see the resistance to flexural stiffness in the shape of the cable and you express resistance in the horizontal plane and the vertical plane. You will have to be careful when you design the tube elements. Again, the model is symbolic or abstract, but if the tube elements have a strong or heavy appearance, the need for the prestressed cables may be questioned. You will need to compromise between selecting a very slender and sufficiently stiff tube.

Why is the high point of the cable in that model (longer spanning model) not over the column? The correct configuration is that the cable would be counter-balancing by loading the beam downwards over the shorter span and the largest shear force would be taken at the section which is the weakest (over the column).

SHERMAN - The shear force would be taken as a point load.
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ARCHITECTURE AND BODY


