Motion Machines: Design and Fabrication of Corporeal Tectonics

JEFFREY BALMER
University of North Carolina at Charlotte

INTRODUCTION

> The tasks which face the human apparatus of perception at the turning points of history cannot be solved by optical means, that is, by contemplation, alone. They are mastered gradually by habit, under the guidance of tactile appropriation. (Benjamin 1968: 248).
>
> The perceiving mind is an incarnated body. (Merleau-Ponty 1963: 3).

A Motion Machine develops relations among the body, space, and tectonics, and informs the way in which we construct and comprehend our environment.

PEDAGOGICAL OVERVIEW

The Motion Machine is a project that has been assigned to undergraduate students in their first or second semester of architecture studio at Iowa State's College of Design. Two primary objectives are contained within the pedagogy of the project: One is to establish explicit connections between the body (its tactility, its mechanics and its measure), and the creation of architectural space. The second objective is to instill an awareness of, and an appreciation for, the physicality of architecture, the matter of its matter, at an early point in the sequence of design studios.

Through assigned readings, students are introduced to the long pedigree of influence that the body has exercised in the evolution of architectural discourse. From Vitruvius, lessons are drawn from the role that the proportions of the human figure have played in the development of the orders of classical architecture. From Le Corbusier, students learn of a modernist re-interpretation of the proportional canons of antiquity. And from contemporary conceptions of anthropometrics and ergonomics, from the height of a doorknob to the rise and run of a stair, students witness attempts by the building industry to establish quantifiable 'norms' for the design of all elements of spatial production.

Students are also introduced to artists whose works engage preoccupations that intersect with those of the Motion Machine. The pioneering photography of Muybridge and Marey is introduced, establishing the seminal effect of their motion studies upon figures such as Duchamp and the Futurists. The avant-garde choreography and stage sets of Schlemmer are highlighted, as are the wearable sculptures and mechanical contrivances of contemporary German artist Rebecca Horn. Arthur Ganson's intricate, elegant machines are shown in a series of short films, as is Fischli and Weiss's *The Way Things Go*, a film which documents their cascading sets of cause and effect using common household objects and substances.

In addition to absorbing these historical and visual precedents, the students were faced with all of the challenges associated with *making*. Various issues relating to fabrication were stressed throughout the development of the project: the inherent properties and possibilities of materials; transformation of off-the-shelf products and mechanisms; the detailing of joints and connections. In struggling to fashion their projects from what they can obtain and adapt, students experience first-hand the myriad negotiations between means and ends, between cause and effect. The unfolding necessities of each project truly becomes the matrix of invention.

MOTION MAPS

The first phase of the project, the precursor to the Machine itself, is the Motion Map. Individually, the students are asked to choose a bodily motion for which they have an affinity, a specific gesture, action, or set of positions in space that they themselves have performed. After crafting a precise description of this activity in words, which asks for a thorough account of every necessary relationship, progression and development from moment to moment throughout its duration, students are instructed to graph the selected action. In the form of a drawing/collage/photomontage, this phase also asks students to incorporate more subjective or associative components aligned with the activity, in addition to the documentary analysis of the mechanics of the act.

One realm of associations that students aim to draw upon might be labeled as the subjective, interior, or *sensory* stimuli generated by the activity: what does it feel like to be enmeshed in this action? What is one consciously aware of, or oblivious to? To what thoughts or associations is one drawn while in the midst of carrying out the prescribed series of movements? Even more challenging, how can these fleeting stimuli, so ephemeral in essence, be made visible? How might they be graphed within the field documenting the mechanics of the act? What is the most evocative, yet legible, means of conveying this information? And what, if any, are the spatial implications brought about by invoking these associations?

A second set of associations might be described, inversely, as the objective, external, or *associative* markers of this same activity: what are the iconic references generated by this activity? What are some of the shared, symbolic allusions aligned with these gestures? These associations are by their nature more readily identifiable as a set than the more ephemeral realm of sensory stimuli. However, the greater challenge here is for the student to appropriate the most cogent icons from the overall set of associations, and to then adapt and transform these markers to best augment the mix of elements vying for inclusion within the final composition of the Map. What combination of these associations best strikes a balance of richness and clarity?

One example of this exercise is illustrated in fig. 1. The mapping of *Playing Scales* is divided into three horizontal registers. Along the midsection, we find the plan of a piano keyboard, centered on A below middle C. Above this register we see musical notation indicating the rise and fall of musical scales. Superimposed above this are a layered series of hands drawn at distances along the end positions of the rise and run of the notes: in other words, the scale shifts are determined by the shifting scales. On the bottom register, the player's hand is superimposed over a section of the piano hammer – suggesting a correlation between the hinged joints of the hammer mechanism, and those of the mechanism of the player's thumb and fingers. To the right, the superimposition of hand and hand-sewn loafer suggests that the pedals of a piano are 'played' in a way analogous to the keys.

A second mapping, Fig. 2, charts a physiological-psychological matrix of affects of running. The top horizontal register records the release of energy through the metabolic Krebs-cycle conversion of carbohydrates into usable energy. A corresponding retrograde bottom register links the corresponding build-up of lactic acid within muscle tissue. The middle register, which illustrates a Muybridge-like series of stop-action photographs, gradually lightens from left to right to exemplify mood-response to the release of endorphins during sustained aerobic activity.

The latter, and primary, phase of the project is that of the Motion Device itself. Students are asked to sort themselves into groups of two or three, and to select a motion, either from within the set described by their Maps, or an entirely new choice. Students are encouraged to select their construction materials from among as diverse a range of substances and ready-made objects as possible, a search tempered, naturally, by the economic realities of budget. This initial search has, among other things, the benefit of habituating the students to thoroughly investigating the scope and nature of materials available to them, both on the shelves of local suppliers and salvage yards, and, increasingly, among the almost infinite array of specialty suppliers online. This searching not only familiarizes students with the ends to which these materials are normally put, it also encourages them to transcend and adapt them

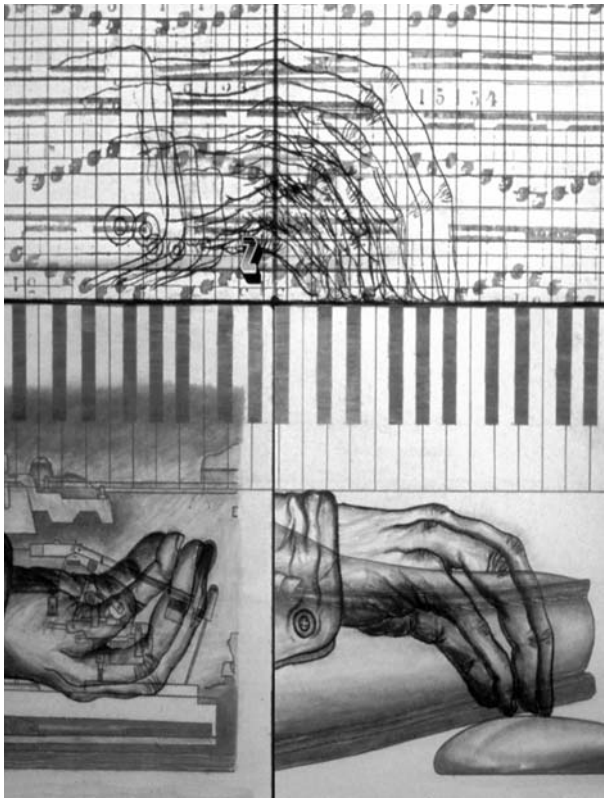

Fig. 1. *Playing Scales*: An example of a Motion Map

for entirely unexpected uses, geared towards the esoteric, even improbable, requirements of each project.

A stipulation of the project description is that the Machine must translate the selected motion into a mechanism that is capable of scribing, scrawling, or otherwise marking an architectural surface. This translation was pre-scribed in order to direct the mechanics of the device from one set of vectors (corporeal) through to another (territorial), transforming the motion, rather than merely having it mimicked. The translation was also desired as a means of reinforcing the pedagogical aim of establishing connections between the body and architectural space, or more generally between (human) figure and ground.
One example of this project is illustrated in fig. 3. The selected motion was *sculling*, and the origin of the construction, perhaps inescapably, is that of an antiquated rowing machine, discovered at a thrift store. This mechanism was modified for mobility: it was hoisted on wheels for movement along a straight track, replicating the fluid, linear

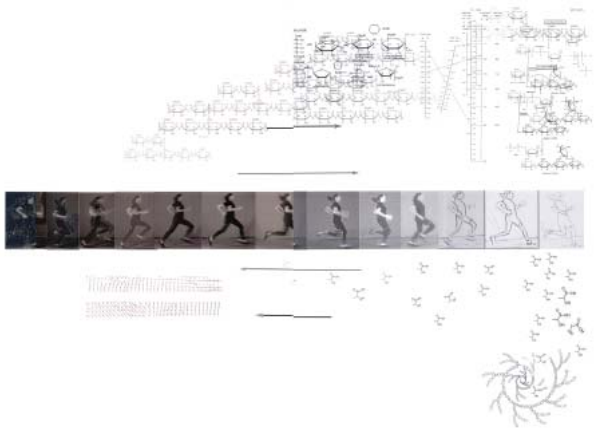

Fig. 2. *Running*, Keihly Moore, 2006

motion of the scull within its narrowly defined lane of water. Propulsion was provided by a pair of come-alongs, simple store-bought winches designed to move heavy loads by incremental ratcheting, whose reciprocating actions replicated the stroking of oars. The surface scribed was that of a bed of wet concrete, such that the Device resembled an elaborate sidewalk-finishing machine. Its wheels served to strike a control joint between the edge of the concrete and the adjacent wooden formwork. And as a final touch, a pair of concentric steel rings pressed down upon the smooth, drying concrete in a reciprocating motion, repeatedly incising upon its surface a pattern reminiscent of the circular ripples created by the withdrawl of oars from water at the end of each row stroke.
This project has been formulated in two distinct variations. In the first instance, the size and scope of the project was not specified. In the case of the Sculling Device, the length of the concrete track extended for the full length of the studio. Owing perhaps to this penchant for gigantism, in its subsequent formulations, the project was modified to make the Devices more compact and portable. Portable in the truest sense of the word: in this second iteration, students were required to *wear* their Machines.

This change not only had the desired effect of keeping the projects within reasonable boundaries of size and budget, it also tended to refine the scale of the detailing, and enhanced the role played by more supple and responsive materials.

Fig. 3. *Sculling Sidewalk Device*

Fig. 4. *Pumping*: An example of a prosthetic Motion Machine

One example of this second iteration of the Machine is illustrated in fig. 4. Driven by the characteristic action of the cardiac muscle, the device employs several parallel iterations of *pumping*: the device is primed with the aid of a bicycle pump. Air pressure is stored with a series of rubber inner tubing arranged along the arms (the wearer becomes literally 'pumped up'). The inner tubes serve as pressurized bladders, forcing water from large tubular reservoirs (colored red and blue, imitating the essentially bicameral structure of the heart) through a network of narrower tubing. The pressurized system culminates in a 'crown', a circular tube fitted with an array of fine brass nozzles, which, when sufficiently pressurized, delivers a halo of fine, pigmented mist. This rendering of the 'perspiring brow' engulfs and cools the wearer, eventually settling upon the white Tyvek haz-mat suit worn underneath the system of tubes, and the white canvas set upon the floor beneath.

A second example of this project is illustrated in fig. 5, also cardiac in inspiration, but focused in this case on the act of *running*. The system is driven by the pivoting action of the arms as they swing from the shoulders in tandem, activating a series of fine cables. The cables, wound round minute roller bearings, cause two pair of plastic bellows to alternately contract and expand. Contained within a clear plexiglas framework, each bellows delivers pressurized air through fine flexible tubing towards the nib of a technical (or 'drafting') pen. The nib is simultaneously fed from a linked reservoir of India ink. Within the aerated chamber of the pen nib, fluid is forced out through the tip, delivering a fine, but very distinct, jet of ink onto wall surfaces adjacent either side of the passing runner. The Device is synchronized so that ink is emitted on the lower pair of nozzles only when the wearer's arm is pulled back – pressure is reversed with each forward stroke.

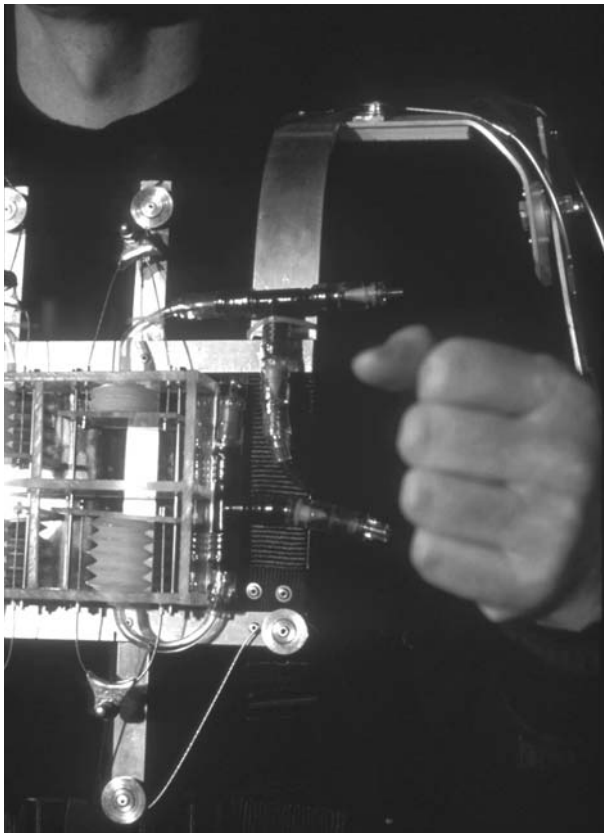

Fig. 5. *Running Device*

CONCLUSIONS

Having examined the trajectory of student work throughout the span of their five-year degree, both pre- and post-implementation of the Motion Machine project, my colleagues and I came to the following general conclusions:

First and foremost, students gained a significant advantage in developing skills related to making: both in the initial design development, involving linking concept to material assemblage, and in the fabrication and modification of the constituent parts of the objects. This experience appears to have given these students a palpable advantage over students of a similar background and maturity from the class groups immediately preceding implementation of the project.

Confidence gained in a palpable mastery over assemblage and fabrication was subsequently evident in the greater degree of sophistication and completeness students were able to exhibit in studio work, including 'traditional' use of drawings and models (both physical and digital) in building design projects. Analogies between the 'putting together' of these design objects and the 'assembly' of a complete and substantial set of drawings seem to have been intuitively gained by the students who had proceeded through the Motion Machine project to subsequent semesters of design studio leading to graduation.

In general, a measured improvement within the undergraduate program was evident throughout, and subsequent to the extended period during which this project was routinely given to all members of the undergraduate class in their first full year of architectural design studio.

ACKNOWLEDGMENT

The project pedagogy was first developed in Spring, 1998, design instructors Jeffrey Balmer, Dan Hisel, Lesley Lokko, and Jason Vigneri-Beane (Hisel co-ordinator). The project was most recently assigned in Spring 2006, design instructors Jeffrey Balmer, Cameron Campbell, Alex Gino, and Kevin Lair (Balmer and Campbell, co-ordinators). Special credit is directed to Dan Hisel as inaugural co-ordinator for this project at Iowa State

REFERENCES

Benjamin, Walter, 1968. The Work of Art in the Age of Mechanical Reproduction, from Illuminations. New York: Schocken.

Merleau-Ponty, 1963 The Primacy of Perception. Evanston, IL: Northwestern University Press