7

GORDON PASK

FROM CHEMICAL COMPUTERS TO ADAPTIVE ARCHITECTURE

NOW, WE ARE SELF-ORGANIZING SYSTEMS AND WE WANDER AROUND IN A WORLD WHICH IS FULL OF WONDERFUL BLACK BOXES, DR. ASHBY'S BLACK BOXES. SOME OF THEM ARE TURTLES; SOME ARE TURTLEDOVES; SOME ARE MOCKING BIRDS; SOME OF THEM GO "POOP!" AND SOME GO "POP!"; SOME ARE COMPUTERS; THIS SORT OF THING.

GORDON PASK, "A PROPOSED EVOLUTIONARY MODEL" (1962, 229)

THE DESIGN GOAL IS NEARLY ALWAYS UNDERSPECIFIED AND *THE* "CONTROLLER" IS NO LONGER THE AUTHORITARIAN APPARATUS WHICH THIS PURELY TECHNICAL NAME COMMONLY BRINGS TO MIND. IN CONTRAST THE *CONTROLLER* IS AN ODD MIXTURE OF CATALYST, CRUTCH, MEMORY AND ARBITER. THESE, I BELIEVE, ARE THE DISPOSITIONS A DESIGNER SHOULD BRING TO BEAR UPON HIS WORK (WHEN HE PROFESSIONALLY PLAYS THE PART OF A CONTROLLER) AND THESE ARE THE QUALITIES HE SHOULD EMBED *IN* THE *SYSTEMS* (CONTROL SYSTEMS) WHICH HE DESIGNS.

GORDON PASK, "THE ARCHITECTURAL *RELEVANCE* OF CYBERNETICS" (1969A, 496)

Now for the last of our cyberneticians. Andrew Gordon Speedie Pask (fig. 7.1) was born in Derby on 28 June 1928, the son of Percy Pask, a wealthy fruit

Figure 7.1. Gordon Pask in the early 1960s. (Reproduced by permission of Amanda Heitler.)

importer and exporter, and his wife Mary, and died in London on 28 March 1996, at the age of sixty-seven.[1] Gordon, as he was known, was much the youngest of three brothers. His brother Alfred, who trained as an engineer but became a Methodist minister, was twenty years older. The other brother, Edgar, was sixteen years older and was Gordon's "hero and role model" (E. Pask n.d., n.p.), and it is illuminating to note that Gar, as he was known, distinguished himself by bravery in research verging on utter recklessness in World War II. He left his position as an anesthetist at Oxford University to join the Royal Air Force in 1941 and then carried out a series of life-threatening experiments on himself aimed at increasing the survival rate of pilots: being thrown unconscious repeatedly into swimming pools to test the characteristics of life jackets; again being thrown repeatedly, but this time conscious, into the icy waters off the Shetlands to test survival suits; hanging from a parachute breathing less and less oxygen until he became unconscious, to determine at what altitude pilots stood a chance if they bailed out; being anesthetized again and again to the point at which his breathing stopped, to explore the efficacy of different modes of resuscitation. He "won the distinction of being the only man to have carried out all [well, almost all] of his research while asleep," and the Pask Award of the British Association of Anaesthetists for gallantry and distinguished service was instituted in his honor in 1975 (Pain 2002). Gar was a hard act for young Gordon to follow, but he did so, in his own unusual way.[2]

Gordon was educated at Rydal, a private school in Wales, where he also took a course in geology at Bangor University. He was called up for military service in 1945, but "Gordon's career in the RAF was extremely brief. During his first week at camp, he passed out while doing the mandatory session of push-ups, and was returned home in an ambulance" (E. Pask n.d., n.p.). Pask then studied mining engineering at Liverpool Polytechnic, before taking up a place at Downing College, Cambridge, in 1949, where he studied medicine and gained a BA in physiology in the natural science tripos in 1953 (Pask 1959, 878). In 1956, he married Elizabeth Poole (E. Pask [1993] describes their unconventional courtship), and they had two daughters: Amanda (1961) and Hermione (adopted in 1967). In 1964, Pask was awarded a PhD in psychology from University College London and in 1974 a DSc in cybernetics by the Open University. In 1995, the year before his death, Cambridge awarded him an ScD (Scott and Glanville 2001; Glanville and Scott 2001b).

His first book, *An Approach to Cybernetics*, was published in 1961 and was translated into Dutch and Portuguese, and several other books followed (Pask 1975a, 1975b, and 1976a were the major ones; also Pask and Curran 1982; and *Calculator Saturnalia* [Pask, Glanville, and Robinson 1980]—a compendium of games to play on electronic calculators). A list of his publications (journal articles, chapters in books and proceedings, technical reports) runs to more than 250 items (in Glanville 1993, 219–33). At different times he was president of the Cybernetics Society and the International Society for General Systems; he was the first recipient of the *Ehrenmitgleid* of the Austrian Society for Cybernetic Studies and was awarded the Wiener Gold Medal by the American Society for Cybernetics.

From the 1950s onward, Pask enjoyed many university affiliations, including professorial chairs at Brunel University (in the Cybernetics Department, part-time, beginning in 1968) and the University of Amsterdam (in the Centre for Innovation and Co-operative Technology, beginning in 1987; Thomas and Harri-Augstein 1993, 183; de Zeeuw 1993, 202).[3] He also from time to time held visiting positions at several institutions: the University of Illinois, Old Dominion University, Concordia University, the Open University, MIT, the University of Mexico, and the Architecture Association in London. But the principal base for Pask's working life was not an academic one; it was a research organization called System Research that he founded in 1953 together with his wife and Robin McKinnon-Wood.[4] There Pask pursued his many projects and engaged in contract research and consulting work.[5]

So much for the bare bones of Pask's life; now I want to put some flesh on them. Before we get into technical details, I want to say something about Pask the man. The first point to note is that he was the object of an enormous amount of love and affection. Many people cared for him intensely. There are two enormous special issues of cybernetics journals devoted entirely to him, one from 1993 (*Systems Research* [Glanville 1993]), the other from 2001 (*Kybernetes* [Glanville and Scott 2001a]), and both are quite singular in the depth and openness of the feelings expressed. And this was, no doubt, in part because he was not like other men—he was a classic "character" in the traditional British sense (as were Grey Walter and Stafford Beer in their own ways). There are many stories about Pask. His wife recalled that "Gordon always denied that he was born, maintaining that he descended from the sky, fully formed and dressed in a dinner jacket, in a champagne bottle, and that the Mayor and aldermen of Derby were there to welcome him with a brass band and the freedom of the city." It is certainly true that he liked to dress as an Edwardian dandy (bow tie, double-breasted jacket and cape). At school, he built a bomb which caused considerable damage to the chemistry lab (which his father paid a lot of money to put right), and he claimed that "the best thing about his school was that it taught him to be a gangster." At Cambridge, he would cycle between staying awake for forty-eight hours and sleeping for sixteen (E. Pask n.d.). Later in life he became more or less nocturnal. His daughter Amanda told me that she would bring friends home from school to see her father emerge as night fell. Pask's ambition in studying medicine at Cambridge was to follow in his brother Edgar's footsteps, but as one of his contemporaries, the eminent psychologist Richard Gregory, put it, this story "is perhaps best forgotten." Pask apparently tried to learn anatomy by studying only the footnotes of the canonical text, *Gray's Anatomy*, and (Gregory 2001, 685–86) "this saved him for two terms—until disaster struck. He was asked to dissect, I think an arm, which was on a glass dissecting table. Gordon was always very impetuous, moving in sudden jerks. Looking around and seeing that no-one was looking at him, he seized a fire axe, swung it around his head, to sever the arm. He missed, There was an almighty crash, and the arm fell to the floor in a shower of broken glass. Perhaps it is as well that Gordon did not continue in medicine." Pask's partner in that ill-fated anatomy lab was Harry Moore, who later worked with Pask at System Research on many of the projects discussed below (Moore 2001). Among Pask's many behavioral quirks and conceits, one friend "marvelled at his perfect cones of cigarette and pipe ash that he appeared to preserve in every available ash-tray" (Price 2001, 819).[6] Richard Gregory (2001, 685), again, recalls that Pask "was forever taking pills (his brother was an anaesthetist so he had an infinite supply) for real or imagined ailments. These he carried in a vast briefcase wherever he went, and they rattled." Pask apparently felt that he understood medicine better than qualified doctors, which might have had something to do with the decline of his health in the 1990s. Other stories suggest that some of these pills were amphetamines, which might have had something to do with Pask's strange sleeping habits and legendary energy.

Musicolour

Pask's engagement with cybernetics began when he was an undergraduate at Cambridge in the early 1950s. Many people declared themselves cyberneticians after reading Wiener's 1948 *Cybernetics* book, but Pask took his inspiration from the man himself (E. Pask n.d.):

> The epiphany of his Cambridge life came when he was invited by Professor John Braithwaite, Professor of Moral Philosophy, to look after Professor Norbert Wiener, who was visiting Cambridge [and lecturing there on cybernetics]. Gordon who had been struggling for some years to define what he wanted to do, found that Wiener was describing the very science he had longed to work on, but had not known what to call. He had known for some time that what he wanted to do was to simulate how learning took place, using electronics to represent the nervous system . . . [and] in order to study how an adaptive machine could learn. Gordon decided to use his expertise in theatrical lighting to demonstrate the process.

This connection to the theater and the arts is one of the themes that we can pursue in several sections of this chapter. Pask had fallen in love with this world in his schooldays, largely through a friend who ran a traveling cinema in North Wales. At Cambridge, Pask "joined the Footlights club and became a prolific lyric writer for the smoker's concerts where numbers and sketches were tried out. [He also contributed] strange, surreal set design and inventive lighting for shows in Cambridge and in London. Gordon had made friends with Valerie and Feathers Hovenden, who ran a small club theatre in the crypt of a church on Oxford Street." In the same period Pask and McKinnon-Wood, also a Cambridge undergraduate, formed a company called Sirenelle dedicated to staging musical comedies. Both were fascinated with the technology of such performances: "Gordon used to come back [to Cambridge] with bits of Calliope organ, I would come back . . . with bits of bomb sight computer" (McKinnon-Wood 1993, 129). From such pieces, the two men constructed a succession of odd and interesting devices, running from a musical typewriter, through a self-adapting metronome, and up to the so-called Musicolour machine. As we shall see, Pask continued his association with the theater, the arts, and entertainment for the rest of his life.[7]

What, then, of Pask's first sally into cybernetics, the theatrical lighting machine just mentioned? This was the contrivance called Musicolour, for which, as his wife put it, "there were no precedents" (E. Pask n.d.): "Gordon had to design all the circuits used in the machine without any outside assistance.

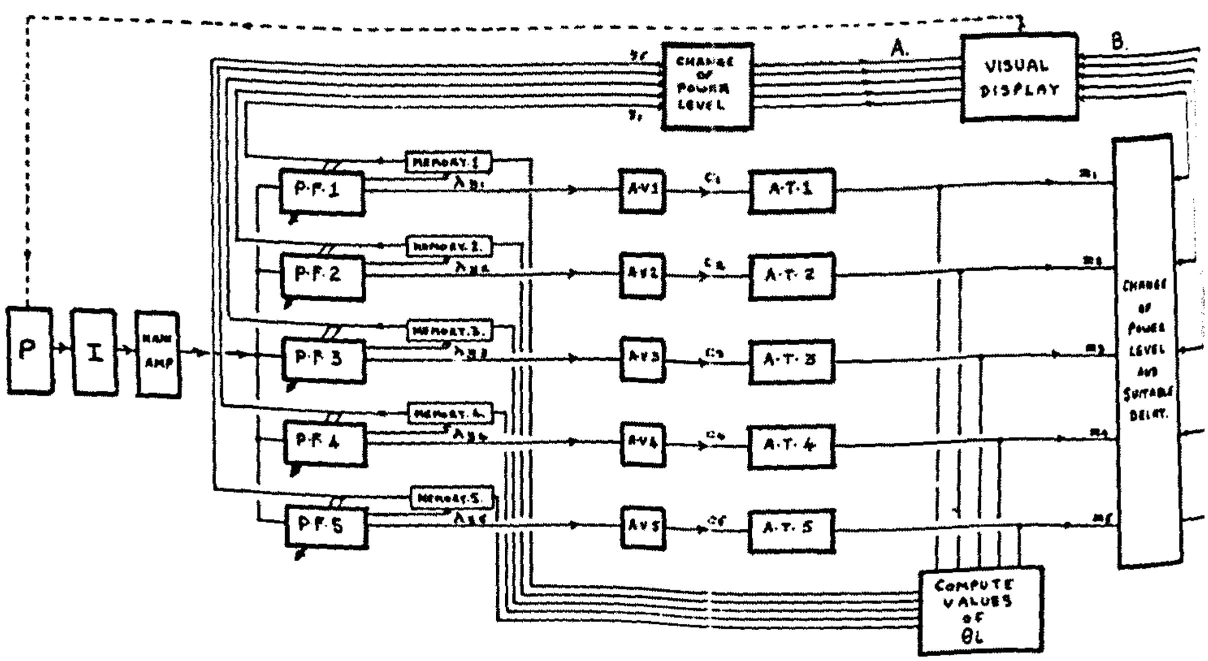


Figure 7.2: Musicolour logic diagram. The original legend reads, "Outline of a typical Musicolour system. *P* = Performer, *I* = Instrument and microphone, *A* = inputs, y_i, to visual display that specify the symbol to be selected, *B* = inputs, x_i, to the visual display that determine the moment of selection, *PF* = property filter, *AV* = averager, *AT* = adaptive threshold device. Memories hold values of (y_i). Control instructions for adjusting the sequence of operation are not shown. Internal feedback loops in the adaptive threshold devices are not shown." Source: G. Pask, "A Comment, a Case History and a Plan," in J. Reichardt (ed.), *Cybernetics, Art, and Ideas* (Greenwich, CT: New York Graphics Society, 1971), 79, fig. 26.

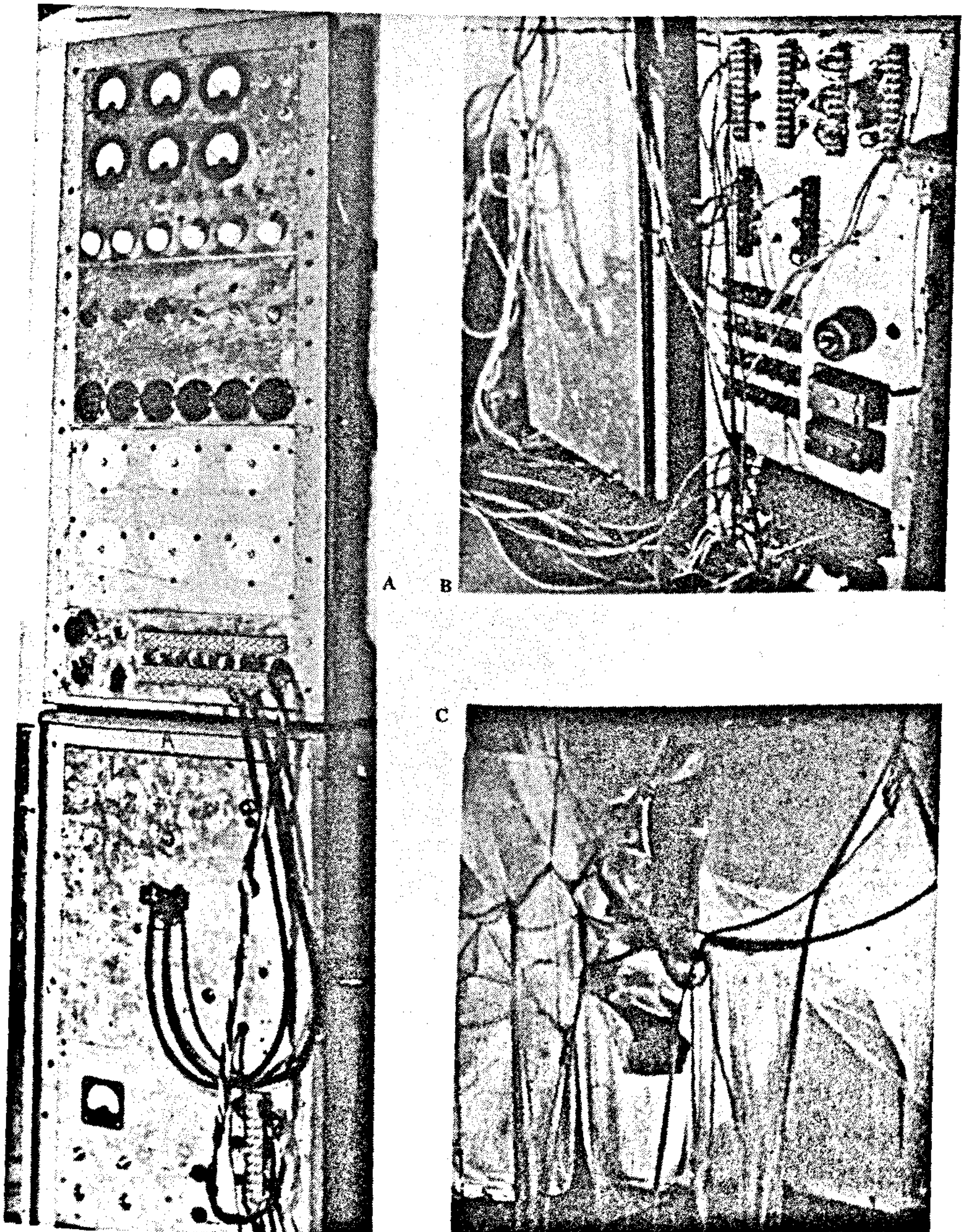


Figure 7.3. *A*, the Musicolour machine; *B*, its power supply; and *C*, a still photograph of a light show. Source: G. Pask, "A Comment, a Case History and a Plan," in J. Reichardt (ed.), *Cybernetics, Art, and Ideas* (Greenwich, CT: New York Graphics Society, 1971), 82, fig. 28.

He built the original machine in his bedroom, on a large, old dining table, which took up most of the room. The process took him several years, during which he took his Tripos examinations and graduated from Cambridge. . . . Gordon had sincerely wanted to be a doctor, like Gar, but once he had begun to work on his Musicolour machine, medicine took second place." Musicolour was a device that used the sound of a musical performance to control a

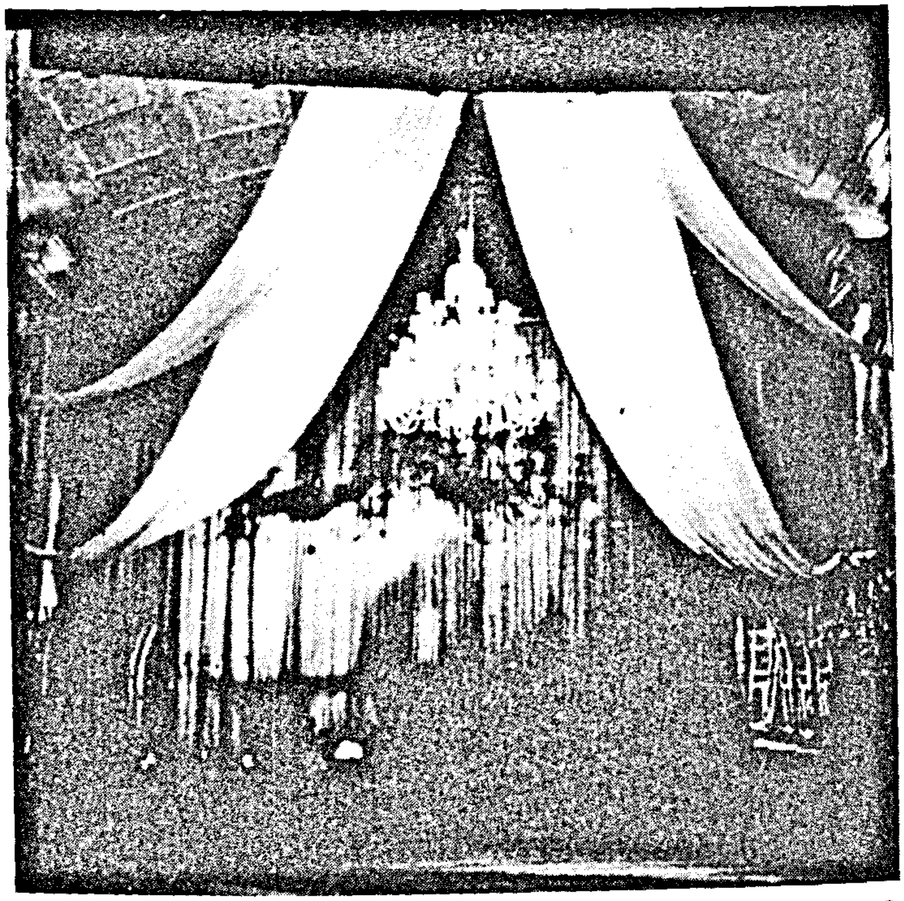


Figure 7.4. Musicolour display at Churchill's Club, London. Source: G. Pask, "A Comment, a Case History and a Plan," in J. Reichardt (ed.), *Cybernetics, Art, and Ideas* (Greenwich, CT: New York Graphics Society, 1971), 86, fig. 32.

light show, with the aim of achieving a synesthetic combination of sounds and light.[8] Materially, the music was converted into an electrical signal by a microphone, and within Musicolour the signal passed through a set of filters, sensitive to different frequencies, the beat of the music, and so on, and the output of the filters controlled different lights. You could imagine that the highest-frequency filter energized a bank of red lights, the next-highest the blues, and so on. Very simple, except for the fact that the internal parameters of Musicolour's circuitry were not constant. In analogy to biological neurons, banks of lights would only be activated if the output from the relevant filter exceeded a certain threshold value, and these thresholds varied in time as charges built up on capacitors according to the development of the performance and the prior behavior of the machine. In particular, Musicolour was designed to get bored (Pask 1971, 80). If the same musical trope was repeated too often, the thresholds for the corresponding lighting pattern would eventually shift upward and the machine would cease to respond, encouraging the performer to try something new. Eventually some sort of dynamic equilibrium might be reached in which the shifting patterns of the musical performance and the changing parameters of the machine combined to achieve synesthetic effects.[9] Musicolour was central to the subsequent development of much of Pask's cybernetics, so I want to examine it at some length here, historically, ontologically, aesthetically, and sociologically, in that order.

The History of Musicolour

In the early 1950s, first at Cambridge and then at System Research, Gordon and Elizabeth Pask and Robin McKinnon-Wood sought to turn Musicolour into a commercial proposition, beginning in 1953 at the Pomegranate Club in Cambridge—"an eclectically Dadaist organisation"—followed by "a bizarre and eventful tour of the north country" and an eventual move to London (Pask 1971, 78). McKinnon-Wood (1993, 131) later reminisced, "I think my favourite memory of MusiColour was the time we demonstrated the portable version to Mr Billy Butlin [the proprietor of Butlin's holiday camps] in his office.... Shortly after his arrival it exploded in a cloud of white smoke.... I switched it back on again and it worked perfectly." The first London performance was at Bolton's Theatre and took a traditionally theatrical form. In a piece called "Moon Music," a musician played, Musicolour modulated the lights on a stage set, and, to liven things up, marionettes danced on stage. The marionettes were supposed to move in synchrony with the lights but instead dismembered themselves over the audience (Pask 1971, 82–83). The next show was at Valerie Hovenden's Theatre Club in the crypt of St. Anne's Church on Dean Street. There, in a piece called "Nocturne," attempts were made to link the motions of a human dancer into Musicolour's input—"this proved technically difficult but the aesthetic possibilities are indisputable" (86). Then (86), "since the system was costly to maintain and since the returns were modest, the Musicolour enterprise fell into debt. We secured inexpensive premises above the King's Arms in Tabernacle Street which is a curiously dingy part of the City of London, often engulfed in a sort of beer-sodden mist. There, we set up the system and tried to sell it in any possible way: at one extreme as a pure art form, at the other as an attachment for juke boxes." The story then passed through Churchill's Club, where waiters "dropped cutlery into its entrails [but] the audience reaction was favorable and Musicolour became a permanent feature of the spectacle." After that, Musicolour was used to drive the 120 kilowatt lights at the Mecca Locarno dance hall in Streatham, where, alas, "it became clear that in large scale (and commercially viable) situations, it was difficult or impossible to make genuine use of the system."[10] "Musicolour made its last appearance in 1957, at a ball organized by Michael Gillis. We used a big machine, a small machine and a collection of display media accumulated over the years. But there were other things to do. After the ball, in the crisp, but fragrant air of St. James's Park, the Musicolour idea was formally shelved. I still have a small machine. But it does not work any longer and is of chiefly sentimental value" (Pask 1971, 86–88). We can follow the subsequent mutations of Musicolour in Pask's career below, but one other aspect of its historical development is worth mentioning. As mentioned above by Elizabeth Pask, Gordon had an enduring interest in learning, and we should see how Musicolour fitted into this. The point to note is that in performance the performer learned (performatively rather than cognitively) about the machine (and vice versa), and Pask therefore regarded Musicolour as a machine in which one could learn—scientifically, in a conventional sense—about learning. Thus, in the show at Bolton's Theatre (Pask 1971, 83, 85–86),

> it was possible to investigate the stability of the coupling [between performer and machine]. In this study arbitrary disturbances were introduced into the feedback loop wihout the performer's knowledge. Even though he is ignorant of their occurrence, these disturbances are peculiarly distracting to the performer, who eventually becomes infuriated and opts out of the situation. But there is an inherent stability in the man-machine relation which allows the performer to tolerate a certain level of disturbance. We found that the tolerable level increases as the rapport is established (up to a limit of one hour at any rate). . . . Meanwhile, John Clark, a psychiatrist, had come to the theatre and we jointly observed some phenomena related to the establishment of rapport. First, there is a loss of time sense on the performer's part. One performer, for example, tootled away on his instrument from 10 p.m. to 5 a.m. and seemed unaware that much time had passed; an hour, he thought, at the most. This effect . . . was ubiquitous. Next, there is a group of phenomena bearing on the way in which performers train the machine. As a rule, the performer starts off with simple tricks which are entirely open to description. He says, for example, that he is accenting a chord in a particular passage in order to associate a figure in the display with high notes. . . . Soon . . . the determinate trick gives way to a behaviour pattern which the performer cannot describe but which he adopts to achieve a well-defined goal. Later still, the man-machine interaction takes place at a higher level of abstraction. Goals are no longer tied to properties as sensed by the property filters (though, presumably, they are tied to patterns of properties). From the performer's point of view, training becomes a matter of persuading the machine to adopt a visual style which fits the mood of his perfor-

> mance. At this stage . . . the performer conceives the machine as an extension of himself, rather than as a detached or disassociated entity.

In this sense, Musicolour was, for Pask, an early venture into the experimental psychology of learning and adaptation which led eventually to his 1964 PhD in psychology. I am not going to try to follow this scientific work here, since there was nothing especially cybernetic about it, but we should bear it in mind in the later discussion of Pask's work on training and teaching machines.

Musicolour and Ontology

Musicolour was literally a theatrical object; we can also read it as another piece of ontological theater, in the usual double sense. It staged and dramatized the generic form of the cybernetic ontology; at the same time, it exemplified how one might go on, now in the world of theater and aesthetics, if one subscribed to that ontology. Thus, a Musicolour performance staged the encounter of two exceedingly complex systems—the human performer and the machine (we can come back to the latter)—each having its own endogenous dynamics but nevertheless capable of consequential performative interaction with the other in a dance of agency. The human performance certainly affected the output of the machine, but not in a linear and predictable fashion, so the output of the machine fed back to influence the continuing human performance, and so on around the loop and through the duration of the performance. We are reminded here, as in the case of Beer's cybernetics, of the symmetric version of Ashby's multihomeostat setups, and, like Beer's work and Bateson and Laing's, Pask's cybernetic career was characterized by this symmetric vision.

Beyond this basic observation, we can note that as ontological theater a Musicolour performance undercut any familiar dualist distinction between the human and the nonhuman. The human did not control the performance, nor did the machine. As Pask put it, the performer "trained the machine and it played a game with him. In this sense, the system acted as an extension of the performer with which he could cooperate to achieve effects that he could not achieve on his own" (1971, 78). A Musicolour performance was thus a joint product of a human-machine assemblage. Ontologically, the invitation, as usual, is to think of the world like that—at least the segments that concern us humans, and by analogical extension to the multiplicity of nonhuman elements. This again takes us back to questions of power, which will surface throughout this chapter. In contrast to the traditional impulse to dominate aesthetic media, the Musicolour machine thematized cooperation and revealing in Heidegger's sense. Just as we found Brian Eno "riding the algorithms" in his music in the previous chapter, a Musicolour performer rode the inscrutable dynamics of the machine's circuitry. That is why I said Eno should have read Pask at the end of the previous chapter.

Second, we can note that as ontological theater Musicolour went beyond some of the limitations of the homeostat. If the homeostat only had twenty-five pregiven states of its uniselector, Musicolour's human component had available an endlessly open-ended range of possibilities to explore, and, inasmuch as the machine adapted and reacted to these, so did the machine. (Of course, unlike Ashby, Pask was not trying to build a freestanding electromechanical brain—his task was much easier in this respect: he could rely on the human performer to inject the requisite variety.) At the same time, unlike the homeostat, a Musicolour performance had no fixed goal beyond the very general one of achieving some synesthetic effect, and Pask made no claim to understanding what was required for this. Instead (Pask and McKinnon-Wood 1965, 952),

> other modalities (the best known, perhaps, is Disney's film "Fantasia") have entailed the assumption of a predetermined "synaesthetic" relation. The novelty and scientific interest of this system [Musicolour] emerges from the fact that this assumption is not made. On the contrary, we suppose that the relation which undoubtedly exists between sound (or sound pattern) and light (or light pattern) is entirely personal and that, for a given individual, it is learned throughout a performance. Hence the machine which translates between sound and vision must be a malleable or "learning" device that the performer can "train" (by varying his performance) until it assumes the characteristics of his personally ideal translator.

The Musicolour performer had to find out what constituted a synesthetic relation between sound and light and how to achieve it. We could speak here of a search process and the *temporal emergence of desire*—another Heideggerian revealing—rather than of a preconceived goal that governs a performance. In both of these senses, Musicolour constituted a much richer and more suggestive act of ontological theater than the homeostat, though remaining clearly in the homeostatic lineage.

One subtlety remains to be discussed. I just described Musicolour as one of Beer's exceedingly complex systems. This seems evidently right to me, at least from the perspective of the performer. Even from the simplified description I have given of its functioning, it seems clear that one could not think one's way through Musicolour, anticipating its every adaptation to an evolving sequence of inputs, and this becomes even clearer if one reads Pask's description of all the subtleties in wiring and logic (1971, 78–80). But still, there was a wiring diagram for Musicolour which anyone with a bit of training in electrical engineering could read. So we have, as it were, two descriptions of Musicolour: as an exceedingly complex system (as experienced in practice) and as actually quite simple and comprehensible (as described by its wiring diagram). I am reminded of Arthur Stanley Eddington's two tables: the solid wooden one at which he wrote, and the table as described by physics, made of electrons and nuclei, but mainly empty space. What should we make of this? First, we could think back to the discussion of earlier chapters. In chapter 4 I discussed cellular automata as ontological icons, as exemplifications of the fact that even very simple systems can display enormously complex behavior—as the kinds of objects that might help one imagine the cybernetic ontology more generally. One can think of Musicolour similarly, as a material counterpart to those mathematical systems—thus setting it in the lineage running from the tortoise to DAMS. And second, we could take Musicolour as a reminder that representational understandings of inner workings can often be of little use in our interactions with the world. Though the workings of Musicolour were transparent in the wiring diagram, the best way to get on with it was just to play it. The detour through representation does not rescue us here from the domain of performance.[11]

Ontology and Aesthetics

As one might expect from a cybernetician with roots in the theater, ontology and aesthetics intertwined in Pask's work. I have been quoting at length from an essay Pask wrote in 1968 on Musicolour and its successor, the Colloquy of Mobiles (Pask 1971), which begins with the remark that (76) "man is prone to seek novelty in his environment and, having found a novel situation, to learn how to control it. . . . In slightly different words, man is always aiming to achieve some goal and he is always looking for new goals. . . . My contention is that man enjoys performing these jointly innovative and cohesive operations. Together, they represent an essentially human and inherently pleasurable activity." As already discussed, with this reference to "new goals" Pask explicitly moved beyond the original cybernetic paradigm with its emphasis on mechanisms that seek to achieve predefined goals. This paragraph also continues with a definition of "control" which, like Beer's, differs sharply from the authoritarian image often associated with cybernetics (76): "'Control,' in this symbolic domain, is broadly equivalent to 'problem solving' but it may also be read as 'coming to terms with' or 'explaining' or 'relating to an existing body of experience.'" Needless to say, that Pask was in a position to relax these definitions went along with the fact that he was theorizing and exploring human adaptive behavior, not attempting to build a machine that could mimic it. Musicolour, for example, was a reactive environment; it did not itself formulate new goals for its own performances.

Pask's opening argument was, then, that "man" is essentially adaptive, that adaptation is integral to our being, and to back this up a footnote (76n1) cites the work of "Bartlett . . . Desmond Morris . . . Berlyn . . . Bruner . . . social psychologists, such as Argyll," and, making a connection back to chapter 5, "the psychiatrists. Here, the point is most plainly stated by Bateson, and by Laing, Phillipson and Lee [1966]." Of course, Bateson and Laing and his colleagues were principally concerned with the pathologies of adaptation, while throughout his career Pask was concerned with the pleasures that go with it, but it is interesting to see that he placed himself in the same space as the psychiatrists.[12]

Pask's essay then focused on a discussion of "aesthetically potent environments, that is, . . . environments designed to encourage or foster the type of interaction which is (by hypothesis) pleasurable" (Pask 1971, 76):

> It is clear that an aesthetically potent environment should have the following attributes:
>
> *a* It must offer sufficient variety to provide the potentially controllable variety [in Ashby's terms] required by a man (however, it must not swamp him with variety—if it did, the environment would be merely unintelligible).
>
> *b* It must contain forms that a man can learn to interpret at various levels of abstraction.
>
> c It must provide cues or tacitly stated instructions to guide the learning process.
>
> d It may, in addition, respond to a man, engage him in conversation and adapt its characteristics to the prevailing mode of discourse.

Attribute *d* was the one that most interested Pask, and we can notice that it introduces a metaphor of "conversation." An interest in conversation, understood very generally as any form of reciprocally productive and open-ended exchange between two or more parties (which might be humans or machines or humans and machines) was, in fact, the defining topic of all of Pask's work.

Having introduced these general aesthetic considerations, the to the essay then devoted itself to descriptions of the two machines—Musicolour and the Colloquy of Mobiles—that Pask had built that "go *some* way towards explicitly satisfying the requirements of *d*." We have already discussed Musicolour, and we can look at the Colloquy later. Here I want to follow an important detour in Pask's exposition. Pask remarks that (77) "*any* competent work of art is an aesthetically potent environment. . . . Condition *d* is satisfied implicitly and often in a complex fashion that depends upon the sensory modality used by the work. Thus, a painting does not move. But our interaction with it is dynamic for we scan it with our eyes, we attend to it selectively and our perceptual processes build up images of parts of it. . . . Of course, a painting does not respond to us either. But our internal representation of the picture, our active perception of it, does respond and does engage in an internal 'conversation' with the part of our mind responsible for immediate awareness." This observation takes us back to the theme of ontology in action: what difference does ontology make? It seems that Pask has gone through this cybernetic analysis of aesthetics only to conclude that it makes no difference at all. Any "competent" art object, like a conventional painting, can satisfy his cybernetic criterion *d*. So why bother? Fortunately, Pask found what I take to be the right answer. It is not the case that cybernetics *requires* us to do art in a different way. The analysis is not a condemnation of studio painting or whatever. But cybernetics does suggest a new strategy, a novel way of going on, in the creation of art objects. We could try to construct objects which foreground Pask's requirement *d*, which explicitly "engage a man in conversation," which "externalize this discourse" as Pask also put it—rather than effacing or concealing the engagement, as conventional art objects do. Cybernetics thus invites (rather than requires) a certain stance or strategy in the world of the arts that conventional aesthetics does not, and it is, of course, precisely this stance, as taken up across all sorts of forms of life, that interests me.

Beyond the mere possibility of this cybernetic stance, the proof of the pudding is obviously in the eating, though Pask does find a way of recommending it, which has more to do with the "consumption" of art than its production: "The chief merit of externalization . . . seems to be that external discourse correlates with an ambiguity of role. If I look at a picture, I am biased to be a viewer, though in a sense I can and do repaint my internal representation. If I play with a reactive and adaptive environment, I can alternate the roles of painter and viewer at will. Whether there is virtue in this, I do not know. But there might be." So, the cybernetic stance invites both a change in the nature of art objects and, once more, a shift in the power relation between artist and audience, somehow entraining the audience in their production and evolution, as we also saw in the previous chapter in the case of Brian Eno. In the Musicolour performances at Churchill's Club, for example, "we also used the system when people were dancing and discovered that in these circumstances the audience can participate in the performer-machine feedback loop just because they are doing something to music and the band is responding to them" (88), though this turned out not to be the case in the larger setting of the Streatham Locarno.

The Social Basis of Pask's Cybernetics

It is clear that the social dynamics of Pask's formative venture into cybernetics bears much the same marks as the others discussed in earlier chapters. There is, first of all, the undisciplined mode of transmission of cybernetics. Pask did not train to be a cybernetician by enrolling in any disciplinary program; instead, a chance meeting with Norbert Wiener served, as we saw, to crystallize Pask's agenda, an agenda that already existed, though in a relatively formless state. Second, as we have also seen, Pask's first project as a cybernetician was undertaken in an undisciplined space outside any conventional institutional structure—he built the first Musicolour machine in his rooms at Cambridge, out of the detritus of war and a technological society. I mentioned bits of Calliope organs and bomb sight computers earlier; Elizabeth Pask (n.d.) recalled that Gordon and Harry Moore built Musicolour from "old relays and uniselectors junked from post office telephone exchanges"—the same components that Walter and Ashby used in their model brains. One could speak here of a lack of material discipline as well as social discipline. Like our other cyberneticians, then, Pask's cybernetics bubbled up outside the normal channels of society. And along with this undisciplined aspect went the protean quality of Pask's cybernetics: Pask was entirely free to follow his own inclinations in developing his cybernetics in a theatrical direction, a more or less unprecedented development.[13] At the same time, this lack of disciplinary control helps to account for another aspect of the novel form of Pask's cybernetics—his abandonment, already in the early 1950s, of the idea that cybernetic systems seek by definition to pursue fixed goals.

One can think along much the same lines about the fate of Musicolour itself. Pask's recollection, quoted above, that "we . . . tried to sell it in any possible way: at one extreme as a pure art form, at the other as an attachment for juke boxes," goes to the heart of the matter. It was not clear what Musicolour was. It did not fit well into the usual classification of material objects. It had something to do with music, but it wasn't a musical instrument. It drove a light show, but it wasn't just lighting. It was an object, but a pretty ugly one, not an art object in itself. One could say that Musicolour was itself an undisciplined machine, incommensurable with conventional forms of entertainment, and the different modes of presentation and venue that Pask and his friends explored in the 1950s have to be seen as a form of experimentation, trying to find Musicolour a niche in the world. In the end, as we have seen, the world proved recalcitrant, and, like that other odd art object, Gysin's Dreamachine, Musicolour was a commercial failure. Mention of the Dreamachine perhaps reminds us that in the later sixties light shows of all sorts—not all using strobes, and some very reminiscent of Musicolour displays—were de rigueur. But by that time Musicolour had been forgotten and Pask had moved on to other projects. One can only wonder what the Grateful Dead might have got out of one of Pask's devices.

And finally, Pask himself. One should probably understand the boy who built bombs and said that school taught him to be a gangster as someone who enjoyed a lack of discipline—not as someone forced into the margins of society, but who sought them out. No doubt for Pask much of the attraction of Musicolour and cybernetics in general lay in their undisciplined marginality. And this, in turn, helps us to understand his post-Cambridge career, based in a private company, System Research, free from any demands, except that of somehow improvising a living. Now we can pick up the historical thread again.

Training Machines

Pask did not lose interest in adaptive machinery after Musicolour, but he had the idea of putting it to a different and more prosaic use, returning to his formative interest in learning. In the mid-1950s, "there was great demand in the commercial world for keyboard operators, both for punch card machines and typing," and Pask set out to construct an adaptive keyboard trainer. He later recalled that the "first Self Adaptive Keyboard Trainer (SAKI) was constructed in 1956 by myself and prototyped by Robin McKinnon-Wood and me" (Pask 1982, 69; see fig. 7.5). This was displayed at the Inventors and Patentees Exhibition at the Horticultural Hall in London, a meeting also regularly frequented by one Christopher Bailey, technical director of the Solartron Electronic Group, who had "from time to time, made valuable contacts with the

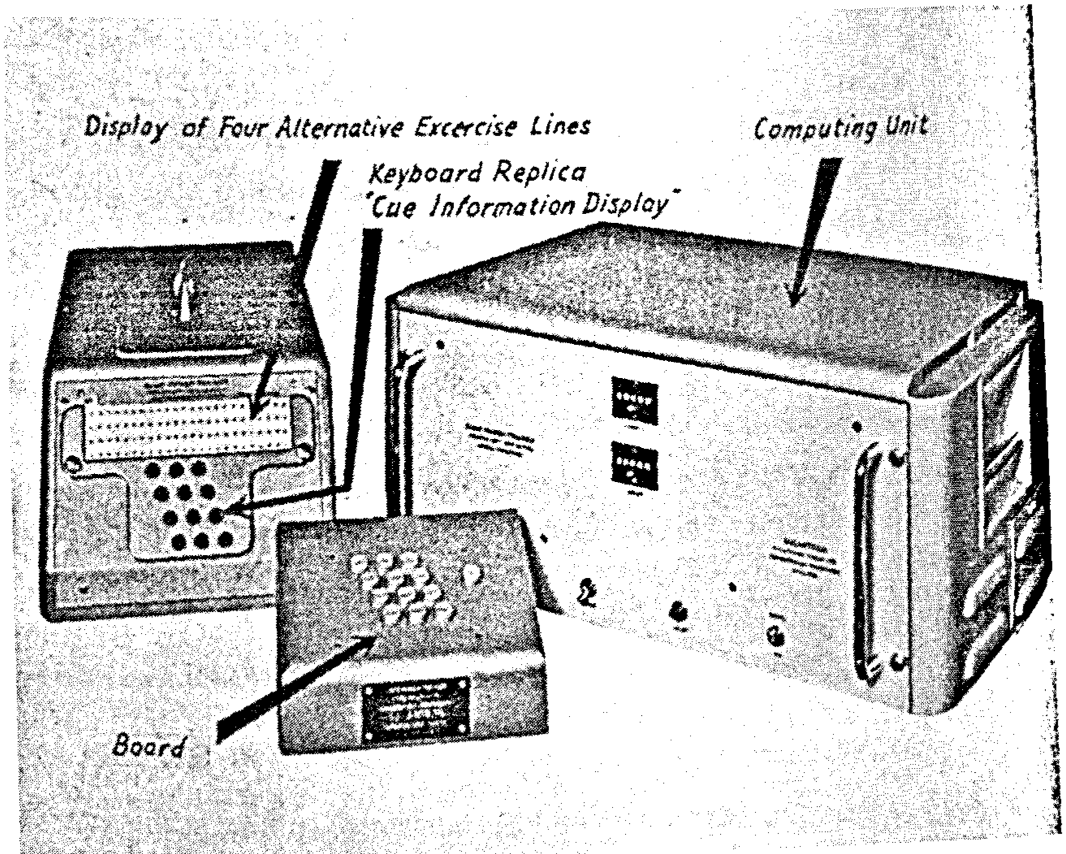


Figure 7.5. SAKI. Source: Pask 1961, pl. II, facing p. 33. (Reproduced by permission of Amanda Heitler.)

less loony exhibitors." Pask got into conversation with Bailey about Grey Walter's robot tortoises, and Bailey in turn proposed that Solartron, which was already expanding into the area of AI, should support the development of adaptive training machines by Pask and System Research (E. Pask n.d.; McKinnon-Wood 1993). Thereafter (Pask 1982, 69, 72),

> Bailey participated in the design and development of this and other systems; notably: EUCRATES [figs. 7.6, 7.7] a hybrid training machine and trainee simulation; a device for training assembly line tasks; a radar simulation training machine and several devices for interpolating adaptively modulated alerting signals into a system, depending upon lapse of attention. The acronym SAKI stood, after that, for *Solartron Adaptive Keyboard Instructor* and a number of these were built and marketed. Details can be found in a U.K. Patent granted in 1961, number 15494/56. The machine described is simply representative of the less complex devices which were, in fact, custom-built in small batches for different kinds of key boards (full scale, special and so on). The patent covered, also, more complex devices like EUCRATES. . . . In 1961 the manufacturing rights for machines covered by these patents were obtained by Cybernetic Developments: about 50 keyboard machines were leased and sold.

A genealogical relationship leading from Musicolour to SAKI and Eucrates is evident.[14] Just as Musicolour got bored with musicians and urged them on to novel endeavors, so these later machines responded to the performance of the trainee, speeding up or slowing down in response to the trainee's emergent performance, identifying weaknesses and harping upon them, while progressively moving to harder exercises when the easier ones had been mastered.[15] Stafford Beer tried Eucrates out in 1958 and recorded, "I began in total ignorance of the punch. Forty-five minutes later I was punching at the rate of eight keys a second: as fast as an experienced punching girl" (Beer 1959, 125).[16] SAKI was an analog machine; like Musicolour, its key adaptive components were the usual uniselectors, relays, and capacitors. Later versions used microprocessors and were marketed by System Research Developments (Sales). SAKI itself formed the basis for the Mavis Beacon typing trainer, widely available as PC software today.

The link to Solartron in the development of adaptive training machines was very consequential for Pask and System Research. Much of Pask's paid work

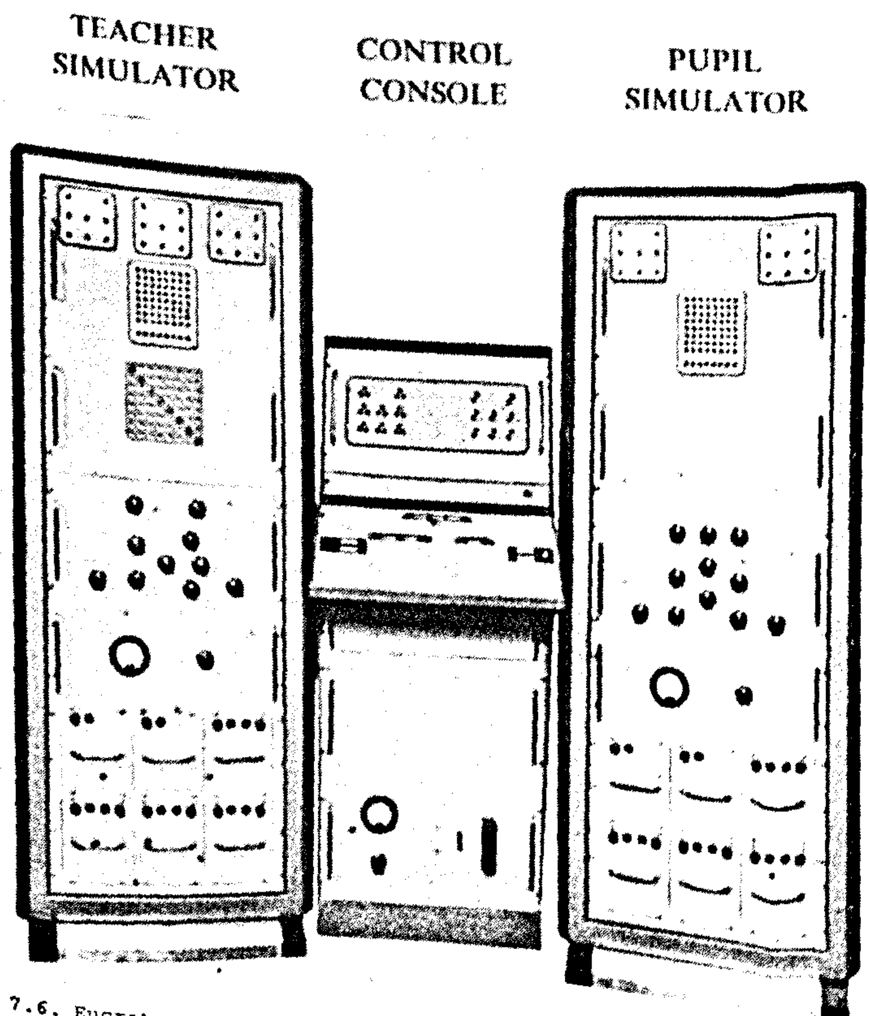


Figure 7.6. Eucrates. Source: Pask 1961, pl. I, facing p. 32. (Reproduced by permission of Amanda Heitler.)

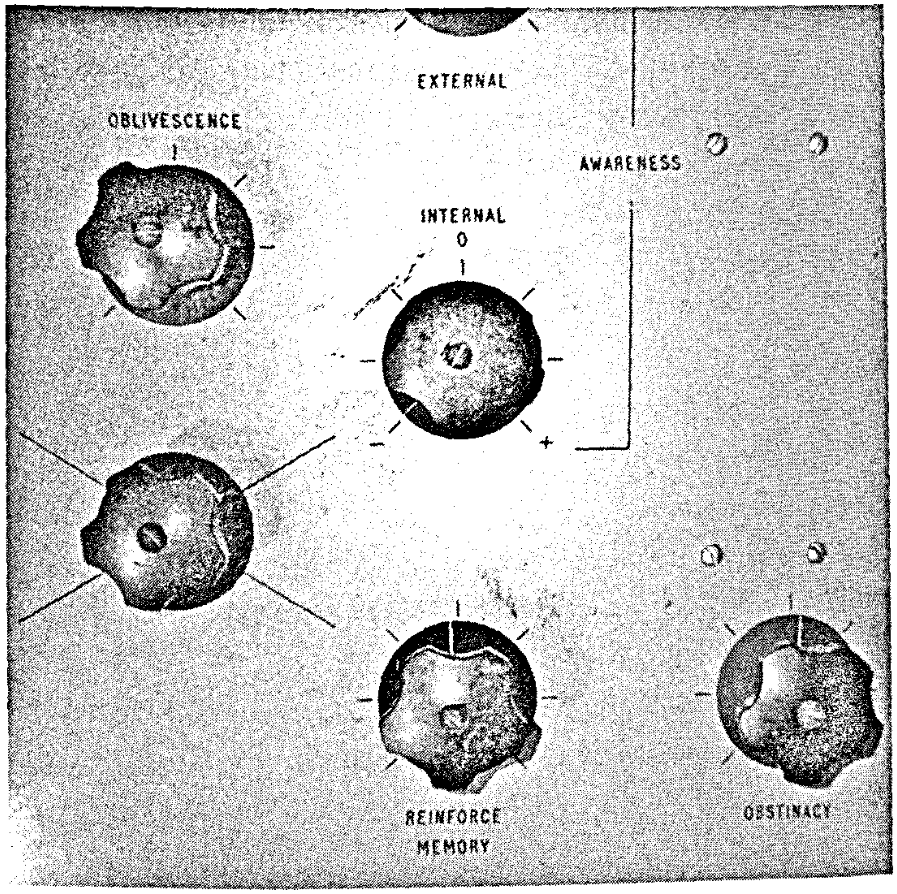


Figure 7.7. Eucrates: detail showing settings. (© 2002 by Paul Pangaro.)

from the late 1950s onward centered on the development of adaptive teaching and training machines and information systems, as discussed further below. And again this episode illustrates some of the social oddity of cybernetics—a chance meeting at an exhibition, rather than any more formalized encounter, and, again, the protean quality of cybernetics, as a peculiar artwork metamorphosed easily into a device for teaching people to type. From an ontological point of view, we can see machines like SAKI as ontological theater much like Musicolour, still featuring a dance of agency between trainee and machine, though now the dance had been domesticated to fit into a market niche—the machine did now have a predetermined goal: to help the human to learn to type efficiently—though the path to the goal remained open ended (like coupled homeostats searching for equilibrium). Interestingly from an ontological angle, Beer recorded witnessing a version of the Turing test carried out with Eucrates. As articulated by Turing, this test relates to machine intelligence: the textual responses of an intelligent machine would be indistinguishable from those of a human being. Pask's demonstrations with Eucrates were a performative rather than representational version of this: "So my very first exposure to Gordon's science was when he sat me in a room with a monitor, in the capacity of metaobserver, and invited me to determine which screen was being driven by the human and which by Eucrates. It was impossible. The behaviour of the two elements was converging, and each was moving towards the other" (S. Beer 2001, 552).

Teaching Machines

The machines we have discussed so far—Musicolour, SAKI, Eucrates—were all directly concerned with performance and nonverbal skills. In the 1970s, however, Pask turned his attention to education more generally and to machines that could support and foster the transmission of representational knowledge. CASTE (for Course Assembly System and Tutorial Environment) was the first example of such a machine, constructed in the early 1970s by Pask and Bernard Scott (who completed a PhD with Pask at Brunel University in 1976; see fig. 7.8). Figure 7.9 shows a more sophisticated version, Thoughtsticker, from around 1977.[17]

There is no doubt that Pask was extremely interested in these machines and the overall project in which they served as markers, or of their worldly

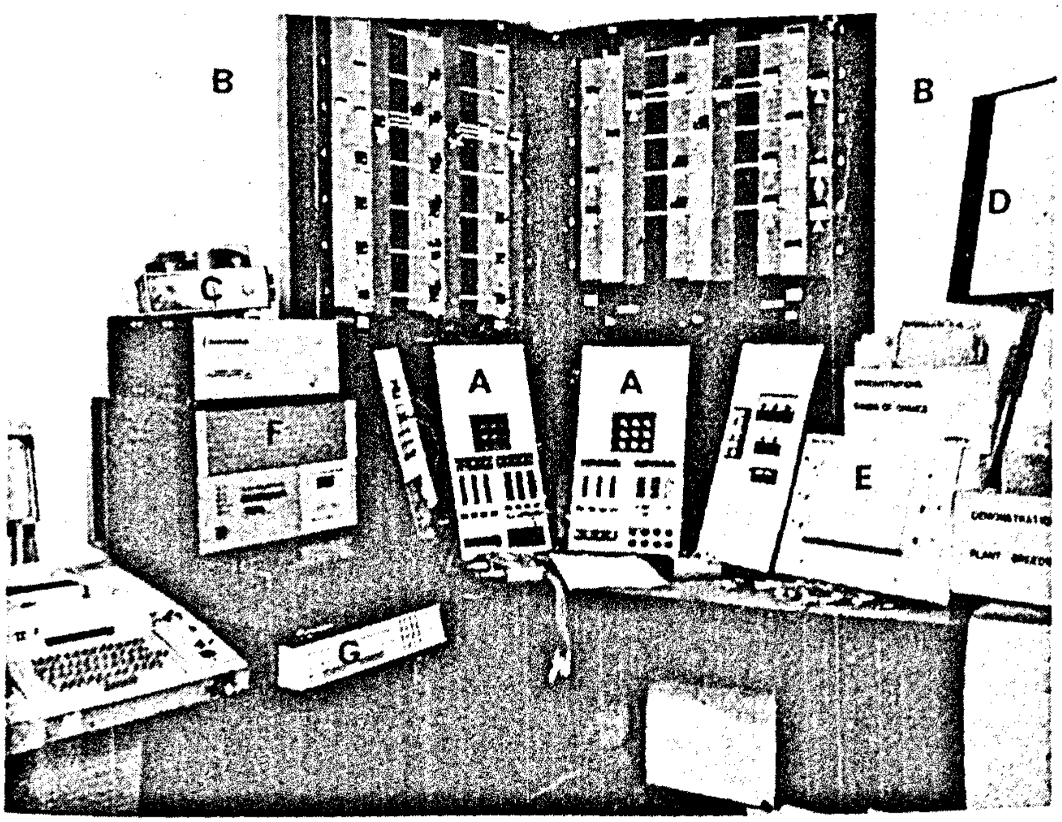


Figure 7.8. Intuition, a portable version of CASTE. Source: G. Pask, "Conversational Techniques in the Study and Practice of Education," *British Journal of Educational Psychology*, 46 (1976), 24, fig. 3. (Reproduced with permission from the *British Journal of Educational Psychology*. © The British Psychologcial Society.)

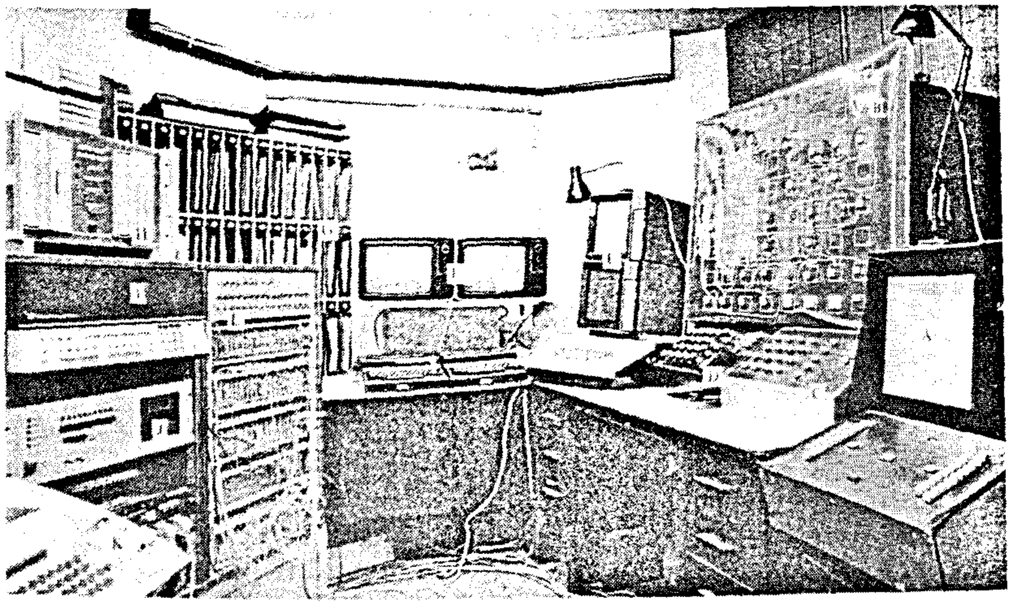


Figure 1. An epistemological laboratory. The figure is placed first to give an idea of how empirical results are obtained but many of the labels will not be intelligible until, at a later stage in the paper, the functioning of the equipment and the types of man machine transactions are spelled out. The key is as follows:

A. Random access slide projector with control keyboard, for displaying slide mounted graphics.
B. Entailment mesh display with overlay multi sheets, containing 60 node positions and 4 × 60 independently addressed coloured signal lamps and touch sensors.
C. Tutorial mode keyboard with special function keys.
D. Course assembly mode keyboard with special function keys.
E. ARDS graphic display tubes with control unit and keyboard used for displaying "pruned" meshes.
F. Video display units with control keyboards used for topic text input–output.
G. Pigeon holes filing system with slots for 60 files and containing 3 × 60 independently addressed signal lamps and 60 sensors.
H. Dual drive floppy disk unit.
I. CAI 32k computer.
J. Digital Cassette unit used as mass storage device.
K. ASR 33 teletype used for "hard copy" output.
L. Electronics rack, containing special electronics and system interface.

Figure 7.9. Thoughtsticker. Source: G. Pask, "Organizational Closure of Potentially Conscious Systems," in M. Zeleny (ed.), *Autopoiesis: A Theory of the Living* (New York: North Holland, 1981), 269, fig. 1.

importance in sustaining him and System Research, but I am going to give them relatively short shrift here. The reason for this is that much of the technical development in this area circled around the problematic of representing articulated knowledge within a machine, and that is not a key problematic of this book. Pask quickly arrived at the position that bodies of knowledge consist of sets of concepts related to one another in what he called an "entailment mesh" (Pask and Scott 1973) an idea which was itself central to what he called "Conversation Theory" and later to his "Interaction of Actors" theory (Pask 1992). I leave it to others to explore the historical evolution of this aspect of Pask's work, set out in three books (Pask 1975a, 1975b, 1976a) and many papers, all of which are, in Bernard Scott's words (2001a, 2), "notoriously difficult" to read.[18]

Here, then, I will confine myself to a few comments. First, CASTE and its descendants remained clearly within Musicolour's lineage. CASTE was another aesthetically potent environment with which the student could interact, exploring different routes around the entailment mesh appropriate to this subject matter or that, being invited to carry out the relevant performative exercises, with apparatus at the laboratory bench if relevant, responding to queries from the machine, and so on. Again we find the performative epistemology that I have associated with cybernetics in the earlier chapters—of articulated knowledge and understanding as part and parcel of a field of performances. Thoughtsticker went so far as to interact with the subject-experts who fed in the contents of entailment meshes—generalizing aspects of the mesh in various ways, for example, and checking back about the acceptability of these generalizations. In this version, the very content of the mesh was, to a degree, a joint product of the human and the machine, as I said earlier about a Musicolour performance.

Second, we can note that, again like Musicolour, Pask's teaching machines also functioned as experimental setups for scientific research, now in the field of educational psychology. Pask and his collaborators toured schools and colleges, including Henley Grammar School and the Architectural Association, with the portable version of CASTE and made observations on how different learners came to grips with them, echoing Pask's observations in the fifties on Musicolour. These observations led him to distinguish two distinct styles of learning—labeled "serial" and "holist" in relation to how people traveled around the mesh—and to argue that different forms of pedagogy were appropriate to each.

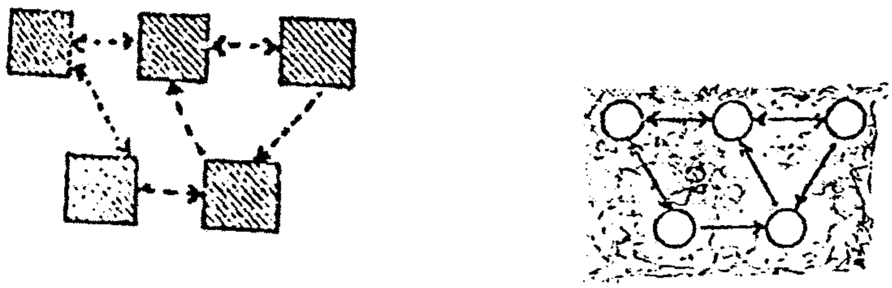
Third, we can return to the social basis of Pask's cybernetics. The very ease with which one can skip from a general sense of "adaptation" to a specific sense of "learning" as manifested in schools and universities suggests that education, if anywhere, is a site at which cybernetics stood a good chance of latching onto more mainstream institutions, and so it proved for Pask. In 1982, Pask and Susan Curran (1982, 164) recorded that "over a period of 11 years (five of overlapping projects and a six-year research project) the Social Science Research Council in Britain supported a study by System Research . . . on learning and knowledge." Around the same time, Bernard Scott (1982, 480) noted that "despite the painstaking way in which Pask prepared the ground for the theory's presentation [conversation theory], it is fair to say that it has not won general acceptance in psychology. The dominant attitudes were too strong." But nevertheless, "the theory (through its applications) has had far greater impact in educational circles and is recognised, internationally, as a major contribution to educational praxis" (on which see B. Scott 2001b).

Pask was integrally involved, for example, in pedagogical innovation at Britain's new Open University (OU). David Hawkridge joined the OU as head of their Institute of Educational Technology in 1969. He knew of Pask's work on SAKI and hired Brian Lewis who had worked at System Research as his deputy (Hawkridge 2001, 688–90):

> [Lewis] lost no time in introducing me and other Institute staff to Gordon, his great friend and former boss. In fact, quite a few of us went on expeditions down to System Research Ltd in Richmond in the early 1970s, and came back bemused and sometimes confused. What was Pask up to and could it be turned to advantage in the OU? I suggested to Brian that we should ask Pask to be our Visiting Professor (part-time). That would regularise the Richmond visits, and Brian said he thought Gordon would be delighted to give a few seminars at the Institute. I had little idea what these might involve, but the Institute had just won a large grant from the Ford Foundation, and Gordon's appointment (and, indeed, Bernard Scott's as a consultant) seemed entirely appropriate. He was the pre-eminent British scholar in our field. . . . It was probably Brian who suggested to Gordon that there was a DSc to be had from the OU if only he would submit all his publications. Finding sufficiently knowledgeable referees for his case was not easy, but I had the pleasure of seeing him receive the award to great applause. I think he was delighted with it, and with the robes.[19]

There is much more that could be said on Pask's teaching machines, but I want to close this section by noting that his work on these devices led him to a distinctive general perspective on mind.[20] In earlier chapters we saw how, in different ways, cybernetics shaded into Eastern philosophy and spirituality. None of this figures prominently in Pask's work, nor does religion in general (though he did convert to Catholicism shortly before his death: Amanda Heitler, personal communication). But a 1977 essay, "Minds and Media in Education and Entertainment," is worth examining from this perspective. Here the initial referent of "mind" was the human mind, and the "media" were the usual means of communication between minds: speech, texts, information systems like CASTE. But (Pask 1977, 40)

> there is no *need* to see minds as neatly encapsulated in brains connected by a network of channels called "the media" [fig. 7.10a]. . . . I am inviting the reader



a b

Figure 7.10. Two views of minds and media: *a*, linked minds. *Squares*, organisms; *arrows*, media as channels of communication. *b*, embedded minds. *Circles*, individuals; *arrows*, communication as program sharing and linguistic interaction between individuals. Source: Pask 1977, 40, figs. 1, 2.

> to try out a different point of view; namely, the image of a pervasive medium (or media) inhabited by minds in motion. Thus, media are characterized as computing systems, albeit of a peculiar kind. But the statement neither asserts nor denies the homogeneity of a medium. In our present state of knowledge, it seems prudent to regard the medium as heterogeneous, and rendered modular by the existence of specially unrestricted regions (brains, for example), capable of acting as *L* [language] processors (though I have a hankering to imagine that these regions are ultimately determined by programmatic rather than concrete localization). It is surely true that rather powerful computerized systems greatly reduce the differentiation of the medium and coalesce the specially restricted modules, so that "interface barriers" are less obtrusive than they used to be [fig. 7.10b].

Here one might be tempted to think of recent work in cognitive science on "distributed cognition"—the observation that much "mental" activity in fact depends upon external, "non-mental" processing (e.g., Hutchins 1995). But something more is at stake. Even with Musicolour and SAKI, Pask had been impressed by the strength of the coupling established between human and machine, which he argued fused them into a single novel entity: "The teaching machine starts to work, in the sense that it accelerates the learning process and teaches efficiently, just when we, as outsiders, find that it is impossible to say what the trainee is deciding about—in other words, at the stage when interaction between the teaching machine and the trainee has given rise to a dynamic equilibrium which involves parts of both" (Pask 1960a, 975); "although the physical demarcation of the student and the machine is definite, the subsystems representing the student's region of control and the adaptive machine's region of control are arbitrary and (relative to any given criterion) have limits that are continually changing" (Pask and McKinnon-Wood

1965, 962). Pask thus switched gestalt entirely, in favor of an image of mind as an all-pervading medium, with human minds as inflections within the overall flow.

This decentered image of mind as all pervasive, and of individual brains as finite localized nodes, is common to much Eastern philosophy and spirituality, though Pask did not quite put it like that: "There is little originality in the view put forward. The McCluhans [*sic*] (both Marshall and Eric in different style) say that media are extensions of the brain; poets, mystics, and sorcerers have expressed similar sentiments for ages" (Pask 1977, 40). It bears emphasis, however, that like the other cyberneticians, Pask did not simply equate cybernetics with Buddhist philosophy or whatever. We could say that he *added* to Buddhist philosophy an engineering aspect. If Eastern philosophy has been presented for millenia in the form of a reflection on the mind, this lineage of Paskian machines running from Musicolour to Thoughtsticker staged much the same vision in the mundane material world of entertainment and teaching machines. In this sense, we could think of Pask's work, like Beer's, as a sort of spiritual engineering.[21]

Chemical Computers

SELF-ORGANIZING SYSTEMS LIE ALL AROUND US. THERE ARE QUAGMIRES, THE FISH IN THE SEA, OR INTRACTABLE SYSTEMS LIKE CLOUDS. SURELY WE CAN MAKE THESE WORK THINGS OUT FOR US, ACT AS OUR CONTROL MECHANISMS, OR PERHAPS MOST IMPORTANT OF ALL, WE CAN COUPLE THESE SEEMINGLY UNCONTROLLABLE ENTITIES TOGETHER SO THAT THEY CAN CONTROL EACH OTHER. WHY NOT, FOR EXAMPLE, COUPLE THE TRAFFIC CHAOS IN CHICAGO TO THE TRAFFIC CHAOS OF NEW YORK IN ORDER TO OBTAIN AN ACCEPTABLY SELF-ORGANIZING WHOLE? WHY NOT ASSOCIATE INDIVIDUAL BRAINS TO ACHIEVE A GROUP INTELLIGENCE?

GORDON PASK, "THE NATURAL HISTORY OF NETWORKS" (1960B, 258)

Much of Pask's cybernetics grew straight out of Musicolour: the trajectory that ran through the trainers and educational machines just discussed and the work in the arts, theater, and architecture discussed later in this chapter. But in the 1950s and early 1960s there was another aspect to his cybernetics that was not so closely tied to Musicolour and that I want to examine now.[22] This was the work on "biological computers" already mentioned in the previous chapter. Some of this work was done in collaboration with Stafford Beer, but here we can focus on the best-documented work in this area, on what I will now call "chemical computers"—though Pask often referred to them as "organic computers," in reference to their quasi-organic properties rather than the materials from which they were constructed.[23] Beer again figures in this story, though it is clear that the initiative and most of the work was Pask's.

As discussed in the previous chapter, at the center of Beer's vision of the cybernetic factory was the numinous U-machine, the homeostatic controller which not only kept the factory on course in normal conditions but also adapted to changing conditions. Beer's experiments with biological systems aimed at constructing such a machine. In his publications on chemical computers, which first appeared in 1958, Pask set his work in a similar frame, and a review of this work might help us understand the overall problematic more clearly. The opening paragraph of Pask's essay "Organic Control and the Cybernetic Method" (1958, 155) is this: "A manager, being anxious to retire from his position in an industry, wished to nominate his successor. No candidate entirely satisfied his requirements, and after a prolonged but fruitless search, this manager decided that a control mechanism should take his place. Consequently he engaged four separate cyberneticians. Each of them had been recommended in good faith as able to design a control mechanism which would emulate and improve upon the methods of industrial decision making the manager had built up throughout the years." Among other things, this paragraph is evidently a setup for distinguishing between four versions of what cybernetics might be and recommending one of them, namely, Pask's (and Beer's). There is no need to go into the details of all four, but a key contrast among them is brought out in the following hypothetical conversation. One of the cyberneticians is trying to find out how the manager manages (158):

Manager.—I keep telling you my immediate object was to maximise production of piston rings.

Cybernetician.—Right, I see you did this on a budget of £10,000.

Manager.—I bought the new machine and installed it for £8,000.

Cybernetician.—Well, how about the remaining £2,000?

Manager.—We started to make ornamental plaques.

Cybernetician.—Keep to the subject. That has nothing to do with piston rings.

Manager.—Certainly it has. I didn't want to upset Bill Smith. I told you he was sensitive about being a craftsman. So we tried our hand at ornamental plaques, that was my daughter's idea.

> *Cybernetician.*—Which costs you £2,000.
>
> *Manager.*—Nonsense, Bill Smith enjoys the job. He is a responsible chap, and helps to sober up the hot heads, no it's worth every penny.
>
> *Cybernetician.*—Very well, as you please. Just one other enquiry, though. What is an appropriate model for this process? What does it seem like to manage a piston ring plant?
>
> *Manager.*—It's like sailing a boat.
>
> *Cybernetician.*—Yes.

In case the reader might miss the significance of that final "yes," Pask comments that "they might continue to infuriate each other indefinitely." This "cybernetician" is infuriated because he wants to extract some rules from the manager that can be run on a computer, or perhaps find some statistical regularity between the firm's inputs and outputs that can be likewise encoded. The manager, in contrast, insists that running the factory is not like that; that genuinely novel solutions to problems are sometimes necessary, solutions not given in prior practice and thus not capturable in algorithms, like spending £2,000 just to keep Bill Smith happy for the overall good of the firm. Hence his very cybernetic final reply, that managing a firm is like sailing a boat—a performative participation in the dynamics of a system that is never fully under control (taking us straight back to Wiener's derivation of "cybernetics," and reminding us, for example, of Brian Eno's approach to musical composition).

In this essay, Pask makes it clear that he does not take the search for algorithms to be the defining aspect of cybernetics. People who take that approach are "rightly electronic engineers examining their particular kinds of hypotheses about managers" (Pask 1958, 171). In effect, Pask makes here much the same contrast I made in the opening chapter between symbolic AI and the branch of cybernetics that interests me and to which Pask and our other principals devoted themselves. Pask was interested in machines that could sail boats, to which we can now turn. We can look at how Pask's chemical computers functioned, and then how they might substitute for human managers.

Threads

Figure 7.11 is a schematic of a chemical computer. A set of electrodes dips down vertically into a dish of ferrous sulphate solution. As current is passed through the electrodes, filaments of iron—"threads" as Pask called them—

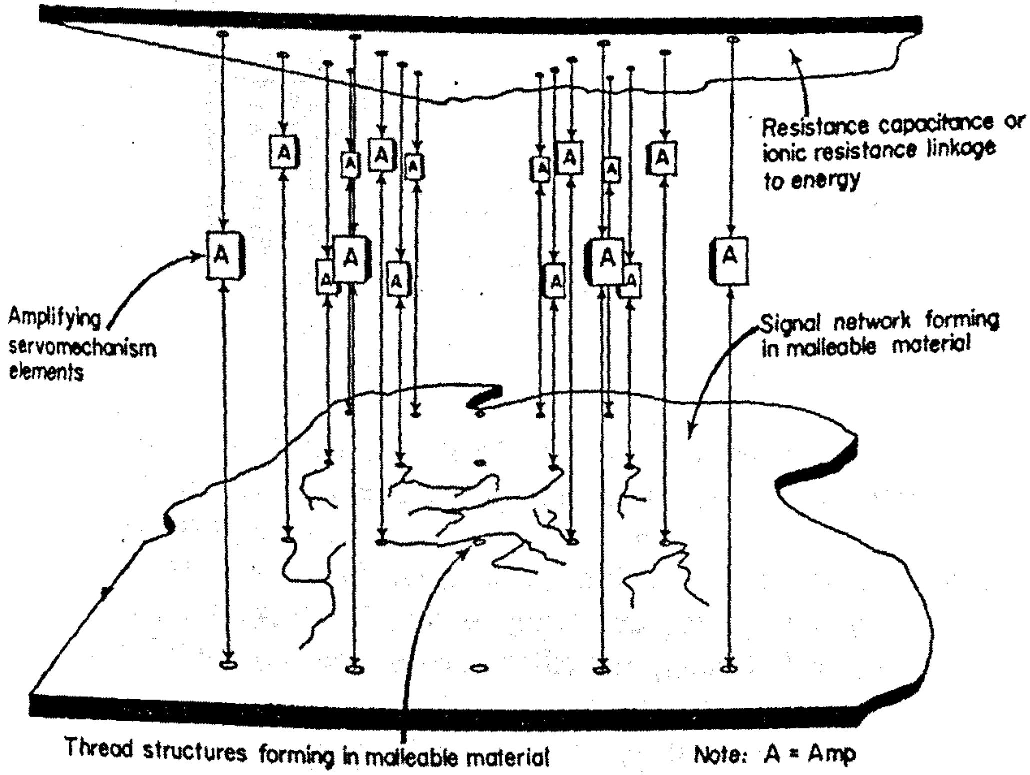


Figure 7.11. Schematic of a chemical computer. Source: Pask 1960b, 247, fig. 4.

grow outward from their tips into the liquid: figure 7.12 is a photograph of a stage in this process. Very simple, but so what? Three points about such devices need to be understood to appreciate Pask's vision. First, the threads are *unstable*: they grow in regions of high current density but dissolve back into solution otherwise. Second, the threads grow *unpredictably*, sprouting new dendritic branches (which might extend further or dissolve)—"The moment to moment development of a thread proceeds via a trial process. Slender branches develop as extensions of the thread in different directions, and most of these, usually all except the one which points along the path of maximum current, are abortive" (Pask 1958, 165). Such a system can be seen as conducting a search through an open-ended space of possibilities, and we can also see that in Ashby's terms its has the high variety required of a controller: it can run through an endless list of material configurations (compare the space of thread geometries with the twenty-five states of the homeostat). Third, as extensions of the electrodes, the threads themselves influence current densities in the dish. Thus, the present thread structure helps determine how the structure will evolve in relation to currents flowing through the electrodes, and hence the growth of the thread structure exhibits a path dependence in time: it depends in detail on both the history of inputs through the electrodes and on the emerging responses of the system to those. The system thus has a

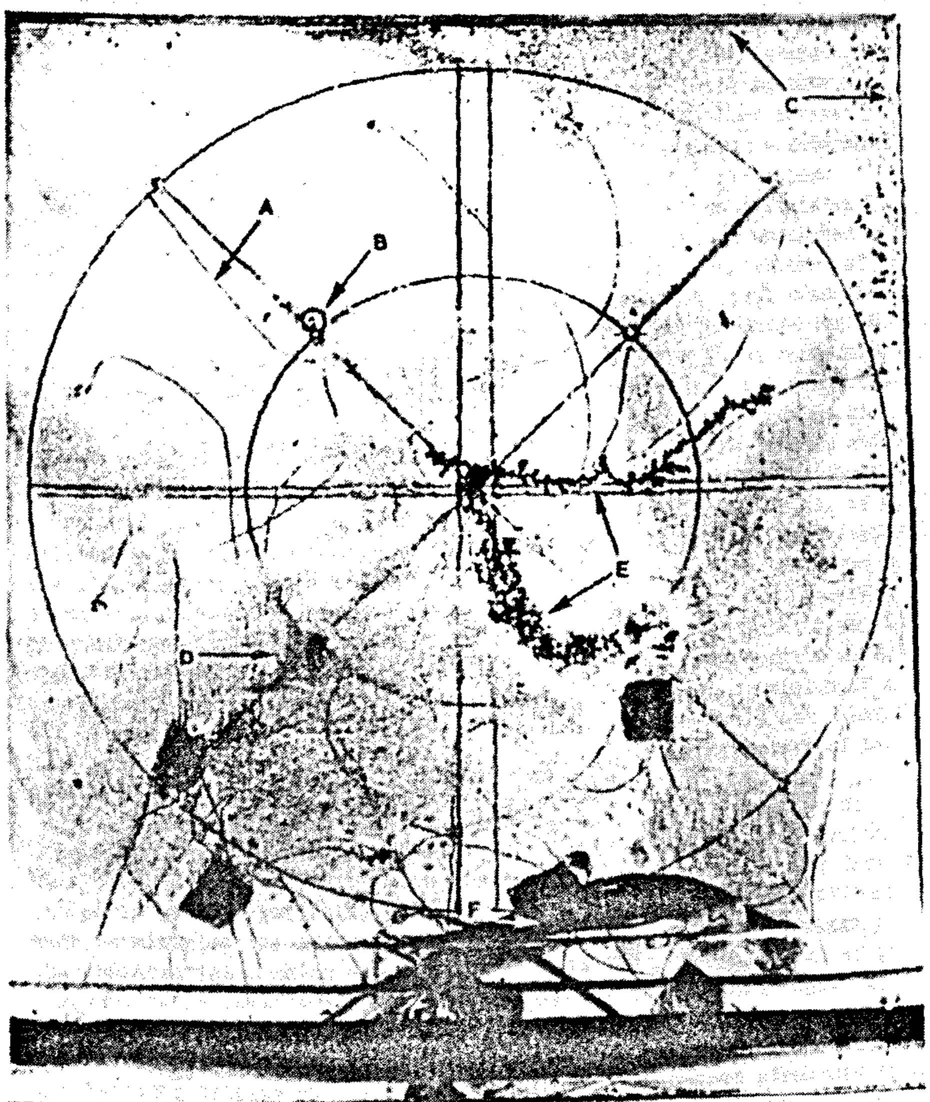


Figure 7.12. Threads growing in a chemical computer. *A*, connecting wires for electrodes; *B*, platinum pillar electrodes; *C*, edges of glass tank containing ferrous sulfate; *D*, chemical reaction in progress; *E*, "tree" threads being formed; *F*, connecting cables. Source: Pask 1959, 919, fig. 12.

memory, so it can learn. This was Pask's idea: the chemical computer could function as an adaptive controller, in the lineage of the homeostat. In this, of course, it was not so far removed from Musicolour and SAKI, though realized in a much more flexible and lively medium than that supplied by uniselectors, relays, and capacitors.

The question now becomes one of how such a system might be interested in *us*: how can a chemical computer be induced to substitute for the human manager of a factory? As with Beer's biological computers, the answer is simple enough, at least in principle. Imagine there are two different sets of electrodes dipping into the dish of ferrous sulphate with its thread structure.

One set is inputs: the currents flowing through them reflect the parameters of the factory (orders, stocks, cash-flow, etc.). The other set is outputs: the voltages they detect represent instructions to the factory (buy more raw materials, redirect production flows). There will be some determinate relationship between these inputs and outputs, fixed by the current thread structure, but this structure will itself evolve in practice in a process of reciprocal vetoing, as Beer callled it, and, as Ashby would have said, the combined system of factory plus controller will inevitably "run to equilibrium." Like a set of interacting homeostats, the chemical computer and the factory will eventually find some operating condition in which both remain stable: the factory settles down as a viable system, in Beer's terms, and the chemical computer, too, settles down into a state of dynamic equilibrium (at least until some uncontrollable perturbation arrives and disturbs the equilibrium, when the search process starts again).

The magic is done—well, almost. Pask thought through at least two further complications. First, there is the question of how to get the process of coupling the computer to the factory going. One answer was to envisage a "catalyst," a system that would send current through the "least visited" electrodes, thus fostering a variety of interactions with the factory and enabling the computer to interrogate the factory's performance on a broad front. Of course, second, the procedure of simply letting the computer and the factory search open-endedly for a mutual equilibrium would almost certainly be disastrous. Who knows what terminally idiotic instructions the computer would issue before stability was approached? Pask therefore imagined that the manager would be allowed to *train* the controller before he retired, monitoring the state of the factory and the machine's responses to that and approving or disapproving those responses by injecting pulses of current as appropriate to reinforce positive tendencies in the machine's evolution, as indicated in figure 7.13. Pask noted that this kind of training would not take the form of the manager dominating the controller and dictating its performance; there was no way that could be done. In fact, and as usual, the interaction would have to take the form of a "partly competitive and partly collaborative game" or conversation (Pask 1958, 170): "After an interval, the structured regions [in the controller] will produce a pattern of behaviour which the manager accepts, not necessarily one he would have approved of initially, but one he accepts as a compromise." Thus the manager and the controller come into homeostatic equilibrium at the same time, in the same way, and in the same process as the controller comes into equilibrium with the factory. "At this point the structured region will replicate indefinitely so that its replica produces the same

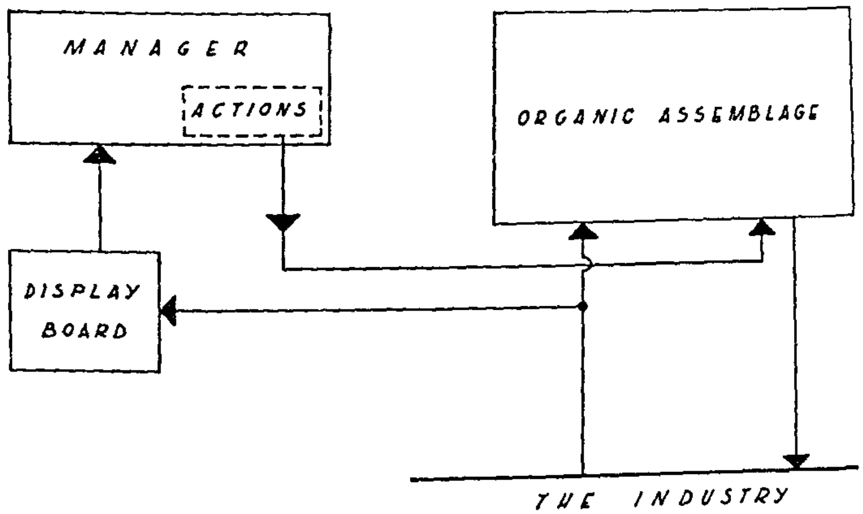


Figure 7.13. Training a chemical computer. Source: Pask 1958, 169, diagram 2.

pattern of behaviour. The manager may thus be removed and the assemblage will act as an organic control mechanism in the industry" (169).

Not much new commentary is needed here. As ontological theater, Pask's chemical computers were in much the same space as Beer's biological ones, staging a direct performative coupling between exceedingly complex dynamic systems (the threads, the factory, the manager) free from any representational detour—a coupling originally enacted by Musicolour in Pask's career and that could take us all the way back to Walter's tortoises, except that the threads displayed more variety than the tortoise and, of course, they grew without any painstaking design, exploiting the liveliness of matter instead (and taking us back to Ashby's thoughts on evolutionary design in chapter 4, as well as Beer in chapter 6). As I said in the previous chapter, I am struck by the imagination required to even begin contemplating the use of an electrochemical device such as this as an adaptive controller for any sort of system. It is hard to imagine arriving at such a vision within the symbolic AI tradition, for example.

But there is another striking feature of Pask's chemical computers that remains to be discussed. We have forgotten about Bill Smith. His function in the hypothetical conversation with the cybernetician is to introduce a consideration of what Pask called the "relevance conditions" for control systems, the question of what variables the system needs to pay attention to, the ones that figure as its inputs and outputs. Bill Smith's contentedness was not something the manager needed to think about under the old regime of production—Bill was happy enough—but suddenly becomes a key variable when the new machine is installed and his work is deskilled. Now, it is one thing to design a control system when these relevance conditions are fixed and known in advance, but quite another to control a system where the relevance conditions change and have continually to be found out. This brings us to the most magical aspect of Pask's chemical computers—an aspect that went forgotten until an important and very insightful essay published by Peter Cariani in a 1993 festschrift for Pask, to which Stafford Beer added historical detail in a 2001 tribute in a similar volume.

New Senses

Beer recalled that in 1956 or 1957 he was visiting London from Sheffield and spent most of the night with Pask at the latter's flat in Baker Street, as he often did. They first had the idea of exploring the robustness of Pask's chemical computers by chiseling out sections of established threads and seeing what happened. It turned out that the systems were very robust and that the gaps healed themselves, though in an unexpected way—instead of joining up from either end, they traveled along the thread until they disappeared. "And yet these demonstrations, though exciting at the time, were somehow recognized to be trivial" (S. Beer 2001, 554–55):

> "Adaptation to the unexpected" should mean more than this, and yet there must be limits. I was already developing my theory of viable systems, and often used myself as an example. But what if someone pulled out a gun and shot me. Would that be proof that I am not after all a viable system? Surely not: the system itself would have been annihilated. We fell to discussing the limiting framework of ultrastability. Suddenly Gordon said something like, "Suppose that it were a survival requirement that this thing should learn to respond to sound? If there were no way in which this [sound] 'meant' anything [to the device], it would be equivalent to your being shot. It's like your being able to accommodate a slap rather than a bullet. We need to see whether the cell can learn to reinforce successfully by responding to the volume of the sound."
>
> It sounded like an ideal critical experiment. I cannot remember what exactly the reinforcement arrangements were, but the cell already had them in place in order to study the rate of adaptation to input changes, and we had created various gaps in the filigree by now.[24] And so it was that two very tired young men trailed a microphone down into Baker Street from the upstairs window, and picked up the random noise of dawn traffic in the street. I was leaning out of the window, while Gordon studied the cell. "It's growing an ear," he said solemnly (*ipsissima verba*).

A few years later Gordon was to write [Pask 1960b, 261]:

> We have made an ear and we have made a magnetic receptor. The ear can discriminate two frequencies, one of the order of fifty cycles per second and the other of the order of one hundred cycles per second. The "training" procedure takes approximately half a day and once having got the ability to recognize sound at all, the ability to recognize and discriminate two sounds comes more rapidly. . . . The ear, incidentally, looks rather like an ear. It is a gap in the thread structure in which you have fibrils which resonate at the excitation frequency.

This, then, was the truly remarkable feature of Pask's chemical computers. One way to put it is to note that the "senses" of all the cybernetic machines we have discussed so far were defined in advance. At base they were sensitive to electrical currents, and at one remove to whatever sensors and motors were hooked up to them. Pask's chemical computers, however, acquired new senses which were not designed or built into them at all—hence "growing an ear," but also acquiring a sensitivity to magnetic fields (a quite nonhuman "sense") in other experiments. If the homeostat, say, could adapt to new patterns within a fixed range of input modalities, Pask's chemical computers went decisively beyond the homeostat in searching over an open-ended range of possible modalities. If we think of the chemical computers as model brains, these brains were, at least in this one sense, superior to human brains, which have not developed any new senses in a very long time.

One possibly confusing point here is that Pask and Beer trained the computer to acquire the faculty of hearing and responding to sound—as if they somehow inserted the sense of hearing into the computer even if they did not explicitly design it in from the start. But to think that way would be to miss a key point. One should imagine the computer not in the training situation but in use—as hooked up to a factory, say—in which the coupled system was running to equilibrium. In that event, in its trial reconfigurations, a sound-sensitive thread structure might come into existence within the chemical computer and find itself reinforced in its interactions with the factory in the absence of any intervention from the experimenter whatsoever. In this scenario, the machine could thus genuinely evolve new senses in its performative interactions with its environment: hearing, a feeling for magnetic fields, or, indeed, an indefinite number of senses for which we have no name. And, as both Beer and Cariani have emphasized, no machine that could do this had been built before—or since, unless very recently: "It could well have been the first device ever to do this [develop a new sense], and no-one has ever mentioned another in my hearing" (S. Beer 2001, 555).

The Epistemology of Cybernetic Research

A CYBERNETIC HYPOTHESIS IS SOMETHING WHICH THE . . . CYBERNETICIANS DIG FROM THE OUTLANDISH SOIL OF THEIR ORGANIC ASSEMBLAGES.

GORDON PASK, "ORGANIC CONTROL AND THE CYBERNETIC METHOD" (1958, 171)

BUT, MORE IMPORTANT THAN THIS IS THE QUESTION OF WHETHER, IN SOME SENSE, THE NETWORK IS LIKE MY IMAGE OF MYSELF BEING A MANAGER (THIS PART OF THE INTERVIEW IS DIFFICULT, FOR THERE IS NO VERBAL COMMUNICATION . . .). ON THIS TEST, I SHALL ACCEPT THE NETWORK IF AND ONLY IF IT SOMETIMES LAUGHS OUTRIGHT.

GORDON PASK, *AN APPROACH TO CYBERNETICS* (1961, 113)

Throughout this book I have discussed the performative epistemology that I associate with cybernetics, the idea that representational knowledge is geared into performance, a detour away from and back to performance. It might be useful to come at this topic from a different angle here, via Pask's own epistemological reflections on his work with chemical computers, where he articulated a distinctive understanding of the "cybernetic method." Pask concluded his essay "Organic Control and the Cybernetic Method" (1958) by discussing cybernetics as a distinctive form of *practice*. He first defines a generic figure of an "observer" as "any person or appropriate mechanism which achieves a well defined relationship with reference to an observed assemblage" (Pask 1958, 172).[25] He then makes a distinction between what I call two "stances" that the observer can take up with respect to the object of inquiry (172–73):

> Any observer is limited by a finite rate at which he or it may make decisions. Since the limit exists we shall distinguish a *scientific observer* who minimises interaction with an observed assemblage and a *participant observer* who, in general, tries to maximise his interaction with an assemblage. If observers were omniscient there would be no distinction. A scientific observer decides whether or not the evidence of an observation leads him to accept each of a finite set of hypotheses, and may, as a result, determine his next observation. Since he is minimally associated with the assemblage he may determine his next observation

> precisely. . . . A scientific observer seeks to confirm as many hypotheses as possible.

Leaving aside questions of confirmation versus falsification, here we recognize a standard stereotype of the hypothesis-testing scientist. Note that on this stereotype, the scientist's access to matter passes through representations: a hypothesis is a verbal formulation—"If I do X then Y will happen"—itself embedded in all sorts of statements, theoretical and empirical. On the other hand (173; my italics),

> a cybernetician is a participant observer who decides upon a move which will *modify* the assemblage and, in general, favour his interaction with it. But, in order to achieve interaction he must be able to infer similarity with the assemblage. In the same way cybernetic control mechanisms must be similar to the controlled assemblage. The development of this similarity is the *development of a common language*. . . . [The cybernetician needs] to adopt *new languages*, in order to interact with an assemblage. [There is] an ignorance on the observer's part, about the kind of enquiry he should make. A common language is a *dynamic* idea, and once built up must be used. Thus if a conversation is disturbed it must be restarted, and one of the structured regions we have discussed must continually rebuild itself. . . . A cybernetician tries, by interaction, to bring about a state of a macrosystem which exhibits a consistent pattern of behaviour that may be represented by a logically tractable analogy.

There is, I think, an original philosophy of science adumbrated in these few sentences, which deserves a brief exegesis. Most important, the emphasis is on performative interaction with the object to be known, modification which might promote further interaction. One can recall here the earlier discussion of chemical computers and of the manager coming to terms with the controller in the same way as the controller comes to terms with the factory—by each interfering performatively with the other until some mutually acceptable, not pregiven, equilibrium is found. What Pask adds is that cyberneticians learn *in general* about their objects in just the same way: they interfere with them as much as possible in an exploratory fashion to see what they will do, with each observation provoking new, situated interferences. But what, then, of Pask's references to language and analogy? Does this return us to the hypothesis-testing model he just associated with "science"? No, because, first, Pask does not regard language as a given and stable medium in which hypotheses can be formulated and judged. The cybernetician does not know the appropriate terms—the language, the relevance conditions—for describing his or her object in advance; they have to be discovered in interaction with that object. Further, we know we have found suitable terms (not a true description) when we use them to construct a model of the object which enables us to understand its behavior when subject to additional interferences. Cybernetic interference produces *new languages* in which to address and interrogate its object.

But second, as in his usage of "conversation," it seems clear that Pask's sense of "language" is not necessarily verbal or representational in the usual sense. The model that grows in the cybernetician's interaction with some object might be nonverbal—as in the "model" of the factory that builds up in the chemical computer as it comes into equilibrium with the factory—and it may be a material object which bears no resemblance at all to the thing modelled—a thread structure does not look like Bill Smith happily making ornamental plaques; the homeostat does not look like a brain. Or it might be a conceptual construct—one of Stafford Beer's models of the Chilean economy, for example. All that matters is that the model facilitates continued commerce with the object itself.

Where does this leave us? Clearly, Pask's account of the cybernetic method indeed points to a performative epistemology. Second, we can think of his chemical computers as a vivid act of epistemological theater. The thread structures stage for us the idea that knowledge (of the factory, of the manager) need not take a representational form. Third, Pask's contrast between the scientific and the cybernetic methods warrants some brief elaboration. One could sum up the findings of the last twenty years and more of science studies as the discovery that real scientists are more like Paskian cyberneticians than his stereotype of them. They, too, struggle open-endedly with their objects and invent new languages and models to get to grips with them (Pickering 1995). But we need to think here of Pask's two kinds of observer and their different stances with respect to the world. Such open-ended struggles indeed happen in scientific practice, but this is thrust into the background of the modern sciences and forgotten, effaced, in the "hypothesis testing" model of science. And the argument I having been trying to make throughout this book—albeit with an emphasis on ontology rather than epistemology—is that these stances are consequential. Although we are all in the same boat, they make a difference: cybernetics, in its practices and in its products—chemical computers that develop new senses being a striking example of the latter—is different in its specificity from the modern sciences. This is, of course, precisely Pask's argument rehearsed earlier in the context of aesthetics and Musicolour—cybernetics suggests an unfamiliar and productive stance in science, as well the arts, entertainment, and teaching.[26]

CAs, Social Science, and F-22s

Pask discontinued his work on chemical computers in the early 1960s, and we should think about this along the lines already indicated in the previous chapter. Like Beer's biological computers, Pask's chemical ones were a valiant attempt at radical innovation undertaken with no support, more or less as a hobby, typified by "two very tired young men" trailing a microphone out of a window as the sun came up over Baker Street. We could also note that even within the cybernetics community, no one, as far as I know, sought to emulate and elaborate Pask's efforts—this in contrast, for example, to the many emulators of Walter's tortoises. Meanwhile, from the later 1950s onward typing trainers and teaching machines held out more immediate prospects of paying the rent. But one spin-off from Pask's research is interesting to follow briefly.

In an attempt to understand the dynamics of his threads, Pask undertook a series of numerical simulations of their behavior, which involved a form of idealization which is now very familiar in the sciences of complexity: he represented them schematically as two-dimensional cellular automata (chap. 4). In these simulations the dish of ferrous sulphate was replaced by a two-dimensional space, with "automata" residing at the intersections of a Cartesian grid. These automata evolved in discrete time steps according to simple rules for persistence, movement, reproduction, and death according to their success in exploiting a finite supply of "food." The early chemical-computer publications reported "hand simulations" of populations of automata, and in 1969 Pask reported on a set of computer simulations which prefigured more visible developments in work on cellular automata and artificial life a decade or two later (Pask 1969a).[27] Interestingly, however, Pask framed his account of these computer simulations not as an exploration of chemical computing but as a study of the emergence of norms and roles in social systems. Over the past decade there has been something of an explosion of social-science research on computer simulations of populations of automata.[28] It is not clear to me whether Pask's work was a formative historical contribution to this new field or whether we have here another instance of independent reinvention. What is clear is that this contemporary work on social simulation, like Pask's, can be added to our list of examples of ontology in action.[29]

Pask's interest in automata and simulation will reappear below in his work in architecture. But let me close this section with two remarks. First, following Cariani (1993, 30), we can note that the move from chemical computers to numerical simulation was not without its cost. The chemical computers found their resources for developing new senses in their brute materiality; they could find ways to reconfigure themselves that had not been designed into them. Pask's simulated automata did not have this degree of freedom; their relevance conditions were given in advance by the programs that ran them. No doubt this, too, had a bearing on the erasure of the chemical computers even from the consciousness of cybernetics.

Second, while one should beware of exaggeration, we can observe that cybernetic controllers are back in the news again. "Brain in a Dish Flies Plane" (Viegas 2004) is one of many media reports on a project strongly reminiscent of Pask, Beer, and even Ashby (who, we recall, discussed the virtues of homeostatic autopilots). In work at the University of Florida, rat neurons (in the style of Beer's biological computers) were grown in a dish and connected into the world via a sixty-channel multielectrode array (à la Pask). When this device was hooked up to an F-22 fighter jet flight simulator, "over time, these stimulations modify the network's response such that the neurons slowly (over the course of 15 minutes) learn to control the aircraft. The end result is a neural network that can fly the plane to produce relatively stable straight and level flight." Another version of the philosopher's apocryphal brain in a vat, though not so apocryphal any more, and robustly connected into the world of performance rather than seeking to represent a world of which it is not a part.[30]

The Arts and the Sixties

We have traveled a long way from Musicolour to chemical computers via typing trainers and teaching machines. For the remainder of this chapter I want to return to Pask's work in the theater, the arts, and architecture, picking up the story in the early 1960s (that is, in work that ran in parallel to his work on trainers and teaching machines). I am interested in three projects in particular: Pask's plans for a cybernetic theater; his robotic artwork, the Colloquy of Mobiles; and his contributions to architecture, beginning with the London Fun Palace. These projects are interesting in themselves as fresh instances of ontology in action, and they are also worth contemplating as yet more instances of crossovers from cybernetics to the distinctive culture of the 1960s. At an early stage in their careers, the Rolling Stones were apparently "roped in" to try out the adaptive machines at System Research (Moore 2001, 770).[31]

Pask's student Ranulph Glanville had a fleeting association with Pink Floyd, who lived nearby, and built a piece of electronic equipment for them—a ring modulator; he also did a sound mix for Captain Beefheart (Glanville, email, 16 August 2005). More consequential than such contacts with the iconic bands of the sixties, however, were Pask's contacts dating back to his undergraduate days with Cedric Price (Price 2001, 819), one of Britain's leading postwar architects, and with the radical theater director Joan Littlewood. If we pursued Pask's projects chronologically, the order would be Fun Palace, cybernetic theater, Colloquy of Mobiles, but for the purposes of exposition it is better to begin with the theater and to end with architecture.[32]

Cybernetic Theater

Joan Littlewood (1914–2002), the founder of the postwar Theatre Workshop in Britain and of the Theatre Royal in Stratford, London, writer and producer of *Oh, What a Lovely War!* and many other plays that marked an era, occupies an almost legendary place in the history of British theater (Ezard 2002).[33] She recalled that she had heard stories about Pask in the 1950s and that he had "flitted across my life from time to time like a provocative imp. . . . He had some idea of what we were up to. I wrote to him a couple of times. He seemed to be as *de trop* in English society as we were. They simply did not know how to use him—the Yanks did." The reference to the Yanks is an exaggeration, but, as usual for our cyberneticians, de trop sounds about right. Littlewood and Pask first met in person, presumably in the late 1950s, at System Research, "a normal looking house, from the outside, but we were standing in a labyrinth of wires, revolving discs of cardboard, cut from shredded wheat packets, little pots and plugs, while through it all a small, perfectly normal baby girl [Hermione Pask] was crawling in imminent danger of being electrocuted from the looks of things, though she was cooing contentedly" (Littlewood 2001, 760).

Here is Littlewood's recollection of a subsequent conversation with Pask (Littlewood 2001, 761): "I told him about two Red Indians taking their morning coffee in the Reservation Cafe and discussing last night's film. 'I thought we were going to win till that last reel,' said one. 'It would be fun,' I said, 'if the Red Indians did win for a change.' This caused a spark. He knew that I worked with inventive clowns. 'We could have a set of different endings,' he said. 'At least eight and the audience could decide which they wanted,' 'How?' 'By pressing a button attached to their seat, quite simple.'" The upshot of this conversation was a thirty-page 1964 document entitled "Proposals for a Cybernetic Theatre," written by Pask on behalf of Theatre Workshop and System

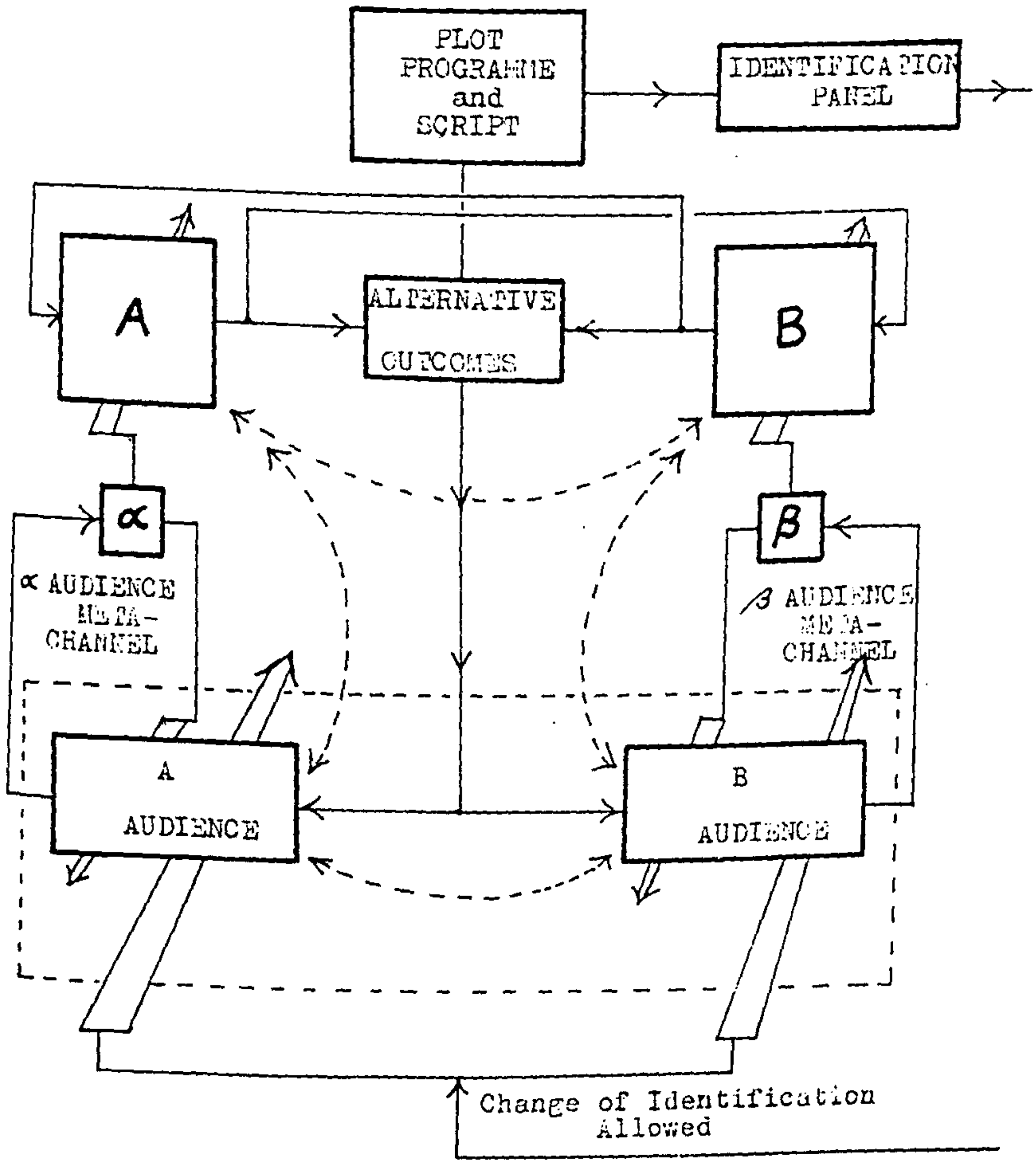


Figure 7.14. Logic diagram for a cybernetic theater. Source: Pask 1964b, 25, diagram 10. (Reproduced by permission of the North American Pask Archive.)

Research. In it Pask describes in considerable detail how audience and actors could be coupled together via feedback loops in determining the substance of any specific performance. Pask's basic idea here was that of a new kind of play, which would retain certain set-piece structural elements, specified in advance, but which would include alternative routes of plot development between the set pieces in an entailment-mesh-like structure, including the possibility that the trajectories might redefine the significance of the fixed elements.[34] During the performance, members of the audience could signal their identification with one or another of the principal actors (designated *A* and *B* in fig. 7.14). At specified branchpoints, the audience could also use levers to advocate different choices of action for their chosen character, drawing upon both their understanding of how the play had developed thus far and also upon "metainformation" on their character's thinking at this point, developed in rehearsal and provided in real time by "interpreters" (alpha and beta in fig. 7.14) via headphones or earpieces. The interpreters in turn would then use hand signals, or perhaps radio, to let the actors know their supporters' inclinations, and the play would proceed accordingly. Depending on how the play developed from these branch points, the audience was free to change identifications with actors, to make further plot decisions, and so on.

I thought this plan was totally mad when I first came across it, but when I read Littlewood's obituaries I realized that, unlike her, I still wasn't cybernetic enough (*Guardian* 2002, 12, Richard Eyre): "She didn't disrespect writers, but she had a contempt for 'text' and the notion that what was said and done on stage could become fixed and inert. She believed in 'the chemistry of the actual event,' which included encouraging the audience to interrupt the play and the actors to reply—an active form of alienation that Brecht argued for but never practised."[35] Pask's proposal indicated that in 1964 (Pask 1964b, 2)

> an initial experimental system (a physical communication system) is being constructed and will be used to determine a number of unknown values required for the efficient realisation of the mechanism. The experimental system will be used informally in Theatre Workshop and will accommodate an invited audience of between 50 and 100 people. Next it is proposed to build and install a large system accommodating an audience of between 550 and 750 people and to use it for a public presentation. . . . There are many intriguing dramatic problems that can only be solved when a suitable performance has been developed and a large system is available to embody it.

I do not know whether the experimental system was ever constructed, but it is safe to say that Pask's proposal to scale it up found no backers. A shame, but it is still instructive to reflect on these ideas.

We can see the cybernetic theater as yet another manifestation of Pask's ontology of open-ended performative engagement and the aesthetic theory that went with it. The cybernetic theater would be an "aesthetically potent environment" for both actors and audience in much the same way as Musicolour and the later training and teaching machines were. The same vision will reappear below with respect to art and architecture: it was, in fact, an enduring theme that ran through all of Pask's projects. Of course, the structural elements of the play meant that plot-development would not be fully open ended; nevertheless, Pask argued that the cybernetic theater would mark a significant departure from existing theatrical practices and experience. As in the previous discussion of Musicolour, Pask was happy to acknowledge that "a [conventional] theatrical audience is not completely passive, in which respect, amongst others, it differs from a Cinema audience or a Television audience. There is a well attested but badly defined 'Feedback' whereby the actors can sense the mood of the audience (and play their parts in order to affect it)." Thus "this control system [i.e., feedback from the audience] is embedded in the organisation of *any* dramatic presentation," but "its adequacy may be in doubt and its effectiveness is hampered by *arbitrary* restrictions. To remove these restrictions would not render a dramatic presentation something other than a dramatic presentation although it might open up the possibility for a novel art form" (Pask 1964b, 4, 5). Again, then, we have here a nice example of how ontology can make a difference, now in a new form of theater.

And, following this train of thought, it is worth remarking that Pask's cybernetic theater was literally an ontological theater, too. One might think of conventional theater as staging a representational ontology, in which the audience watches a depiction of events, known already to everyone on the other side of the curtain, suggesting a vision of life more generally as the progressive exposure of a pregiven destiny. I have repeatedly argued that a different ontological moral could be extracted from cybernetic devices, but in the case of Pask's cybernetic theater no such "extraction" is necessary—within the frame of the play's structural elements, the audience was directly confronted with and participated in an unforeseeable performative becoming of human affairs. In the cybernetic theater, then, the ontology of becoming was right on the surface.[36]

A few further thoughts are worth pursuing. One is historical. We can note a continuity running from Pask's notion of an explicit feedback channel from audience to actors to his friend Stafford Beer's experimentation with algedometers in Chile in the early 1970s. In the previous chapter we saw that Beer's devices were prone to playful misuse, and Pask was prepared for something similar in the theater, wondering if "many people will participate in a more experimental or mischievous manner"—seeking somehow to throw the actors off balance, as had Beer's subjects. Pask remarked that "unless there are statistically well defined and concerted attempts to upset the system this should not pose a real problem," but nevertheless, "various devices have been embodied in this design to avoid 'illegal' manipulation of the response boards. We assume that 'illegal' manipulation is bound to occur either mischievously or by accident" (Pask 1964b, 15, 18).

Second, we can note that, as in all of Pask's projects, the cybernetic theater undercut existing power relations. Most obviously, the audience was given a new weight in determining the substance of each performance in real time. The role of actors was likewise elevated relative to writers and directors in their responsibility for making smooth traditions from one plot trajectory to another. And, at the same, Pask's vision entailed the integration of new social roles into theatrical performances: the interpreters who provided meta-information to the audience, the technicians who would wire up the feedback channels and maintain them, even the cyberneticians as new theorists of the whole business, quite distinct from conventional theater critics.

And third, we need to think about the kind of company that Pask kept. In the 1960s, Joan Littlewood was one of the most successful directors in British theater: "She had three shows in the West End by 1963, triumph on a Lloyd Webber scale, and to incomparably higher standards" (Ezard 2002, 20). In his collaboration with Littlewood just one year later, Pask thus crossed over from the narrow world of typing trainers into one of the most lively and visible currents of British popular culture. It is therefore worth examining precisely which current he stepped into.

The key observation is that, unlike Andrew Lloyd Webber, Littlewood was an avowedly antiestablishment figure, who understood theater as one of those technologies of the self we have discussed before, aimed now at reconstituting British society. After studying at RADA (the Royal Academy of Dramatic Art) she moved first from London to Manchester, which brought her "closer to the counter-culture she sought," and where she worked for the BBC, the *Manchester Guardian*, and "small leftist agit-prop groups dedicated to taking drama to the people of the north." The Theatre Union, which she cofounded in 1936 with the folksinger Ewan McColl, "saw itself as a vanguard of theory; its productions were influenced by Vsevolod Meyerhold, the Stanislavsky disciple who was the first director of postrevolutionary Soviet drama until Stalin purged him." During World War II, her group was "often splendidly reviewed but [was] always refused grants by the Council for the Encouragement of Music and the Arts, the Arts Council predecessor. She and McColl were blacklisted by the BBC and by forces entertainment group ENSA as subversives." Her group renamed itself Theatre Workshop after the war and supported the early Edinburgh Fringe Festival—the alternative to the high-culture Edinburgh Festival—and rented the Theatre Royal on Angel Lane in London in 1953 for £20 a week—"a dilapidated palace of varieties reeking of cat urine"—before making its first breakthrough to the West End in 1956 with *The Good Soldier Schweik* (Ezard 2002, 20). "She was wholly unclubbable," wrote a fellow theater director, "a self-educated working-class woman who defied the middle-class monopoly of theatre and its domination by metropolitan hierarchy and English gentility. She believed in realising the potential of every individual, being in favour of 'that dull working-class quality, optimism,' a necessary virtue in a life dedicated to demonstrating that political theatre wasn't always an oxymoron" (*Guardian* 2002, Eyres).

Pask's involvement with the theater in the sixties did not, then, lead him into the high culture of the British establishment, but rather into the countercultural, antiestablishment milieu, here typified by Littlewood, that somehow succeeded, for a brief moment around that decade, in becoming a defining formation in British culture. We have examined before the ontological resonances between cybernetics and the counterculture—flicker and the Beats, Bateson and Laing's radical psychiatry, Beer and Eastern spirituality—and Pask's alignment with Littlewood should be understood in just the same way. We can return to this theme below, but we can note now that this alignment also doomed cybernetics to going down with the ship. Cybernetics has itself continued up to the present, but its visibility in popular culture declined with the overall decline of the counterculture. Littlewood herself seems to have become disgusted with the form of life that went with being a successful London theater director. "Success is going to kill us," she wrote in the mid-1960s. "Exhausted and miserable, she walked out at the crowning moment when she and Raffles had managed to buy the [Theatre Royal]. She disappeared alone to Nigeria to work on an abortive film project with the writer Wole Soyinka. She returned but never recaptured the momentum: if it meant diluting standards or becoming a full-time impresario, she did not want to" (Ezard 2002, 20).

Cybernetic Serendipity

In the 1960s the ICA, the Institute for Contemporary Arts, in London was Britain's center for new developments in art. If something exciting and important was happening in Britain or abroad, the ICA aimed to represent it to the British public.[37] Conversely, a show at the ICA ratified a new movement or whatever as, indeed, exciting and important. Jasia Reichardt, who had organized the first show of British Pop Art in London, *Image in Progress*, at the Grabowski Gallery in 1962, joined the ICA as assistant director in 1963, where she organized a show on concrete poetry in 1965, *Between Poetry and Painting* (Reichardt 1971, 199). In the autumn of that year she began planning "an international exhibition exploring and demonstrating some of the relationships between technology and creativity." In 1968, "there was enough financial support for it to go ahead," and her exhibition, now called *Cybernetic Serendipity*, opened at the ICA on 2 August and closed on 20 October 1968 (Reichardt 1968a, 3, 5).[38] The exhibition was divided into three parts (Reichardt 1968b, 5):

1. Computer-generated graphics, computer-animated films, computer-composed and -played music, and computer poems and texts
2. Cybernetic devices as works of art, cybernetic environments, remote-controlled robots and painting machines
3. Machines demonstrating the uses of computers and an environment dealing with the history of cybernetics

As one can gather from this list and from figure 7.15, "cybernetic" in *Cybernetic Serendipity* should be interpreted broadly, to include almost all possible intersections between computers and the arts, including, for example, computer graphics, one of Reichardt's special interests (Reichardt 1968b). But two of our

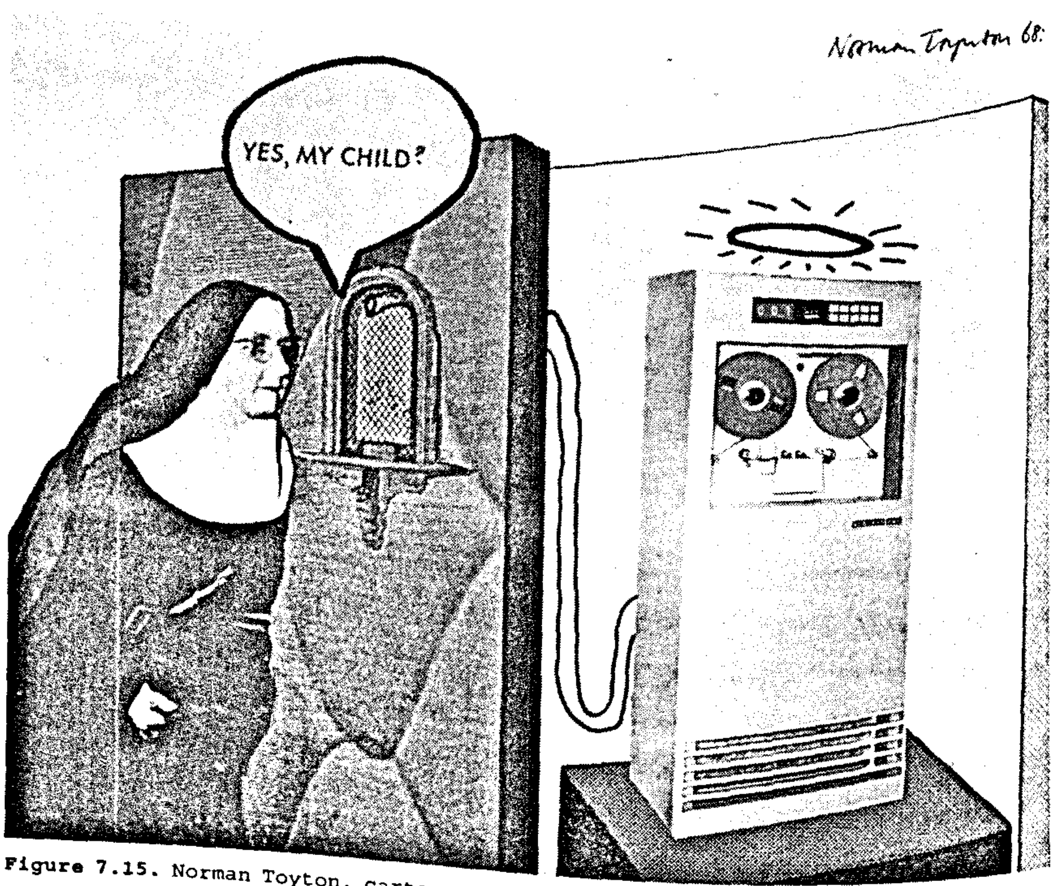


Figure 7.15. Norman Toyton, cartoon of computer confessional. Source: J. Reichardt (ed.) *Cybernetic Serendipity: The Computer and the Arts* (London: W. & J. Mackay, 1968), 8.

(a)

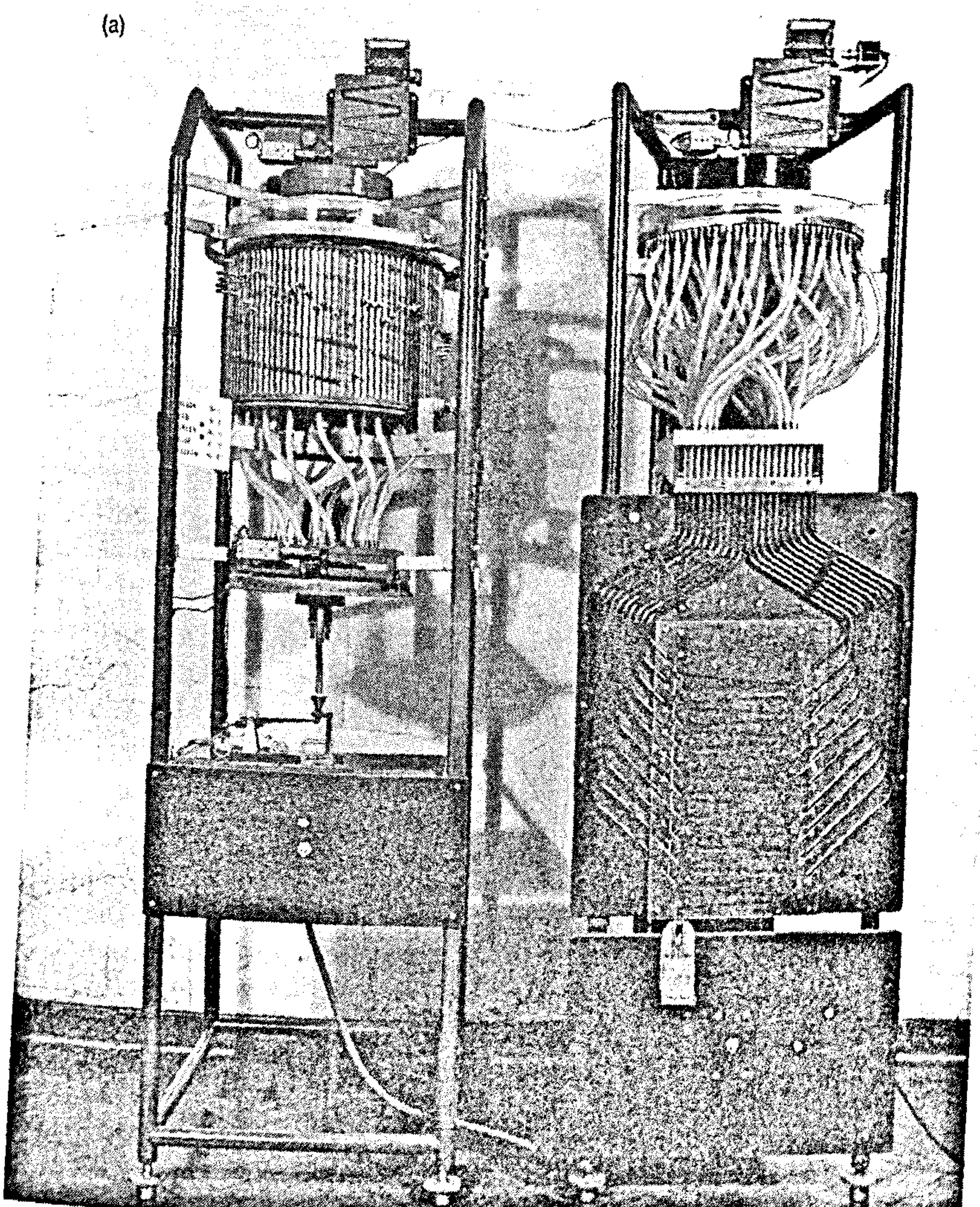


Figure 7.16. Beer's stochastic analog machine. Source: S. Beer "SAM," in J. Reichardt (ed.), *Cybernetic Serendipity: The Computer and the Arts* (London: W. & J. Mackay, 1968), 12.

cyberneticians showed their work at the exhibition, Stafford Beer and Gordon Pask.[39] Beer's contribution was a futuristic-looking electromechanical device for generating random numbers as inputs to Monte Carlo simulations of steel production, SAM, the Stochastic Analogue Machine (fig. 7.16), which was described in an accompanying poem by Beer (Beer 1968b; for more details on SAM, see Beer 1994a). I want to focus here, however, on Pask's exhibit, which he called Colloquy of Mobiles (Pask 1968, 1971; see fig. 7.17).[40]

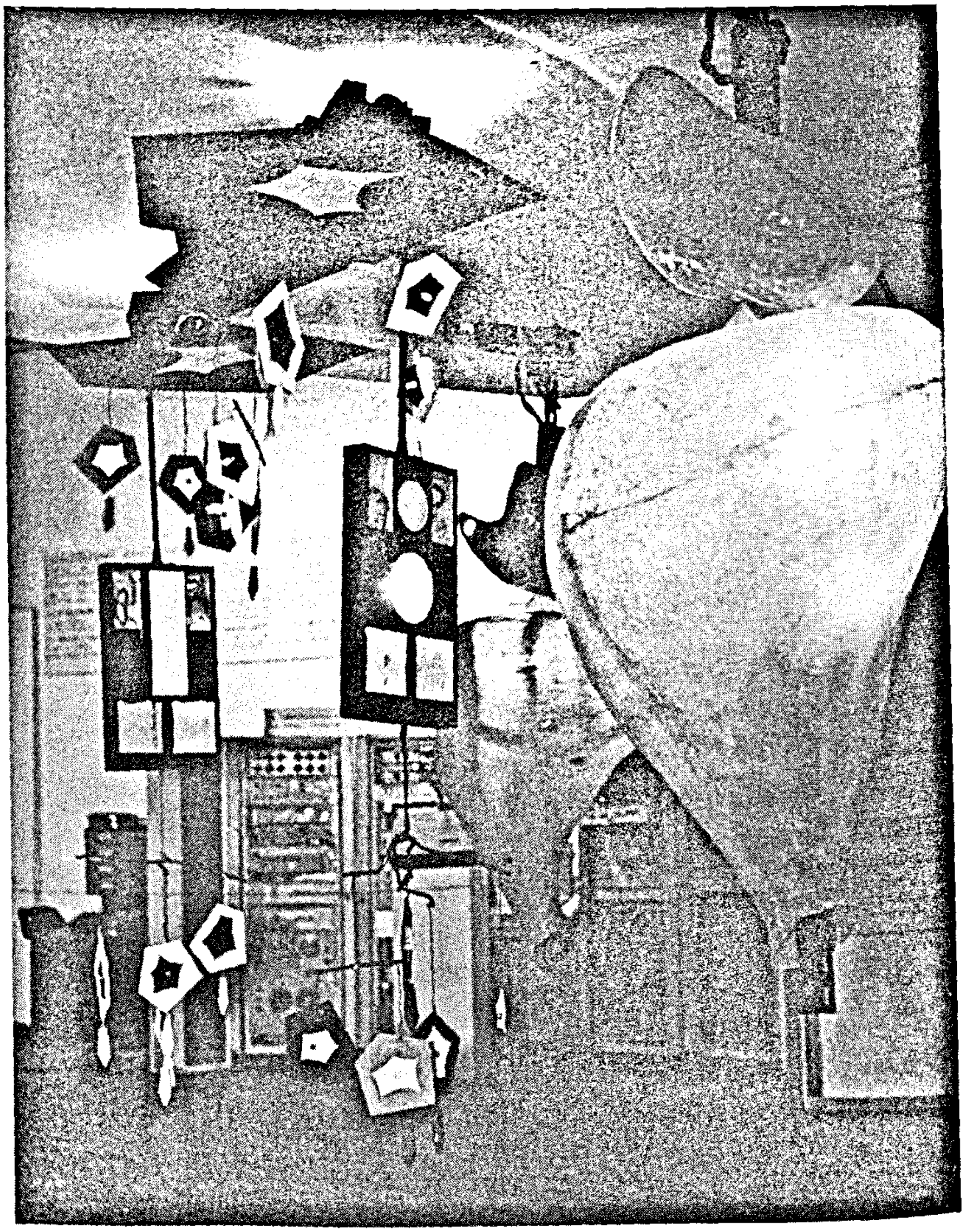


Figure 7.17. Photo of the Colloquy of Mobiles. Source: G. Pask, "A Comment, a Case History and a Plan," in J. Reichardt (ed.), *Cybernetics, Art, and Ideas* (Greenwich, CT: New York Graphics Society, 1971), 96, fig. 40.

Like all of Pask's creations, the Colloquy was a baroque assemblage. Perhaps the best way to think of it is as a sophisticated variant of Walter's tortoises.[41] As we saw in chapter 3, the tortoises were mobile, phototropic robots which in combination engaged in complex mating dances, and just the same can be said of the components of the Colloquy. Pask's robots were, in one way, somewhat less mobile than Walter's. As shown schematically in figure 7.18, the Colloquy consisted of five robots, three designated "female" and two "male," each suspended from above. Their mobility consisted principally in their ability to rotate on their axes, driven by electric motors. The males each had two "drives," designated *O* and *P*, which built up over time (as charges on a capacitor) and were indicated by the intensity of either an orange or a puce light on the robot. These lights were reminiscent of the tortoises'

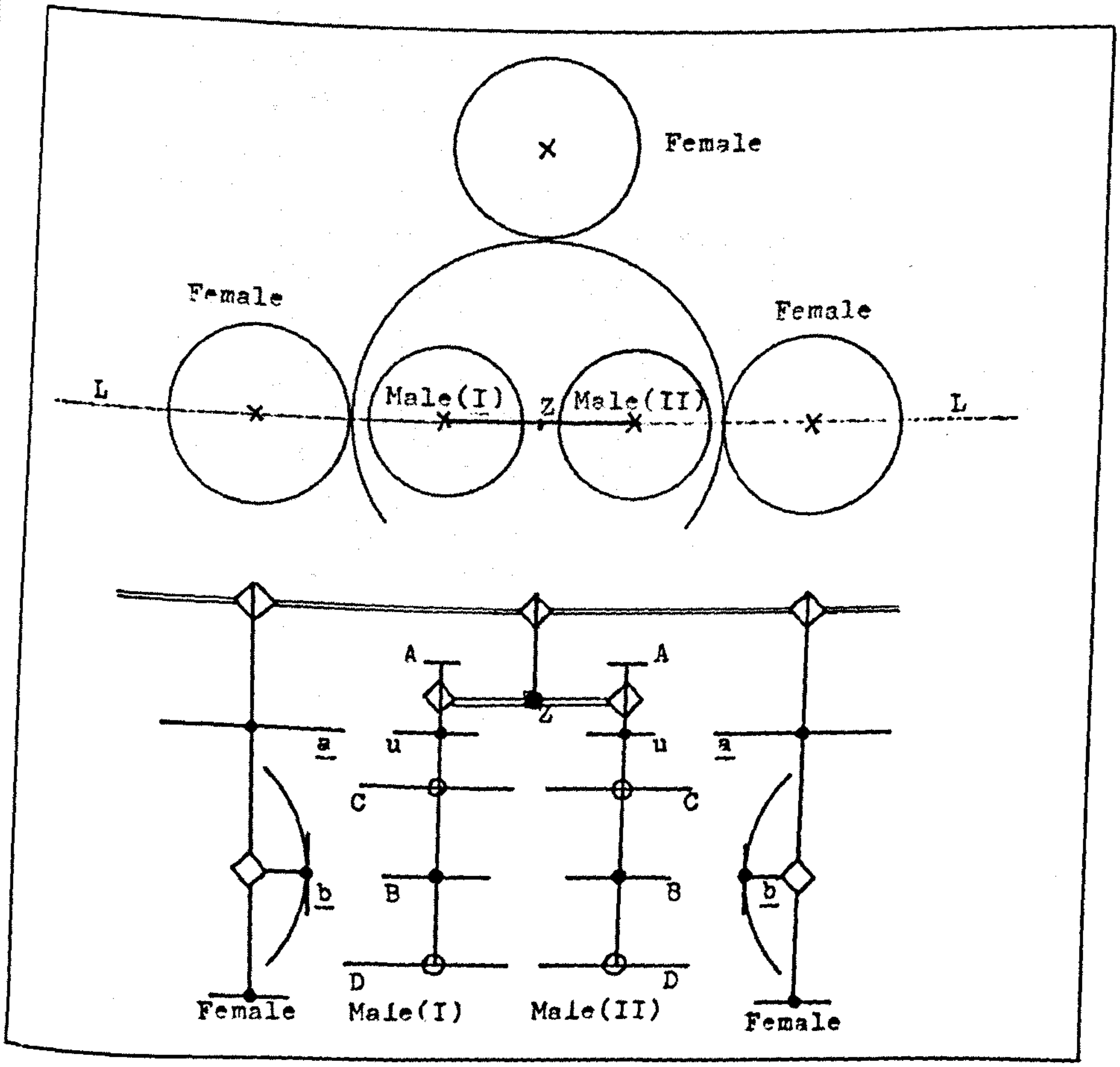


Figure 7.18. Plan of the Colloquy of Mobiles. *Top*, horizontal plan; *bottom*, vertical section taken through line *L* in horizontal plan; *A*, drive state display for male; *B*, main body of male, bearing "energetic" light projectors *O* and *P*; *C*, upper "energetic" receptors; *D*, lower "energetic" receptors; *U*, non-"energetic," intermittent signal lamp; *a*, female receptor for intermittent positional signal; *b*, vertically movable reflector of female *Z*, bar linkage bearing male I and male II; ◇, drive motor; ⊕, free coupling; ◆, fixed coupling; ═, bar linkage. Source: G. Pask, "A Comment, a Case History and a Plan," in J. Reichardt (ed.), *Cybernetics, Art, and Ideas* (Greenwich, CT: New York Graphics Society, 1971), 90, fig. 34.

running lights but were not the crucial feature of the Colloquy; much more complicated signaling was involved in the latter.

Each male sought to "satisfy" its drives, first by locating a female while spinning on its axis (an equivalent of the tortoise's scanning mechanism) via an intermittent directional visual signal which indicated both its identity and its desire (*O* or *P*). If a female picked this up and was interested in *O* or *P* satisfaction herself, she would respond with an identifying sound synchronized to the male light. The male receiving this would then lock onto the female (just as the tortoise locked onto a light source) and emit an intense orange or puce light from its central part (*D* in fig. 7.18). If this fell upon the reflector of the female (*b*) she would reciprocally lock onto the male and commence a scanning motion of the reflector, up and down. The object of this was to reflect the beam back onto the appropriate part of the male, *D* or *C* in figure 7.18, depending whether the drive in question was *O* or *P*. If the female was successful in doing this, the male drive would be satisfied (temporarily, until the charge on the capacitor built up again); the male would also emit a "reinforcement" sound signal, which would discharge the female's drive. The overall behavior of the setup was controlled by purpose-built electronics, which received and instigated sensory inputs and outputs from each robot and switched the motion of the robot from one basic pattern to another in accordance with flowcharts such as that shown in figure 7.19.[42]

Thus the basic arrangement of the Colloquy of Mobiles and the principles of their mating, but we can note some further complications. First, the males hung from a common bar (fig. 7.18), which meant that they competed for females: a male in search mode could disturb the other which had locked onto a female. This made for a more lively performance and added another dimension of interest for the viewer. Second, the males could differ in which receptor (*C* or *D*) was the target for satisfaction of *O* or *P* drives, and the females could adapt to this by remembering which direction of scanning (upward or downward) was successful for which drive for each male. And third, the Colloquy was open to human intervention. As Pask wrote before the exhibition (1971, 91),

> The really interesting issue is what happens if some human beings are provided with the wherewithal to produce signs in the mobile language and are introduced into the environment. It is quite likely that they will communicate with the mobiles. . . . The mobiles produce a complex auditory and visual effect by dint of their interaction. They cannot, of course, interpret these sound and light

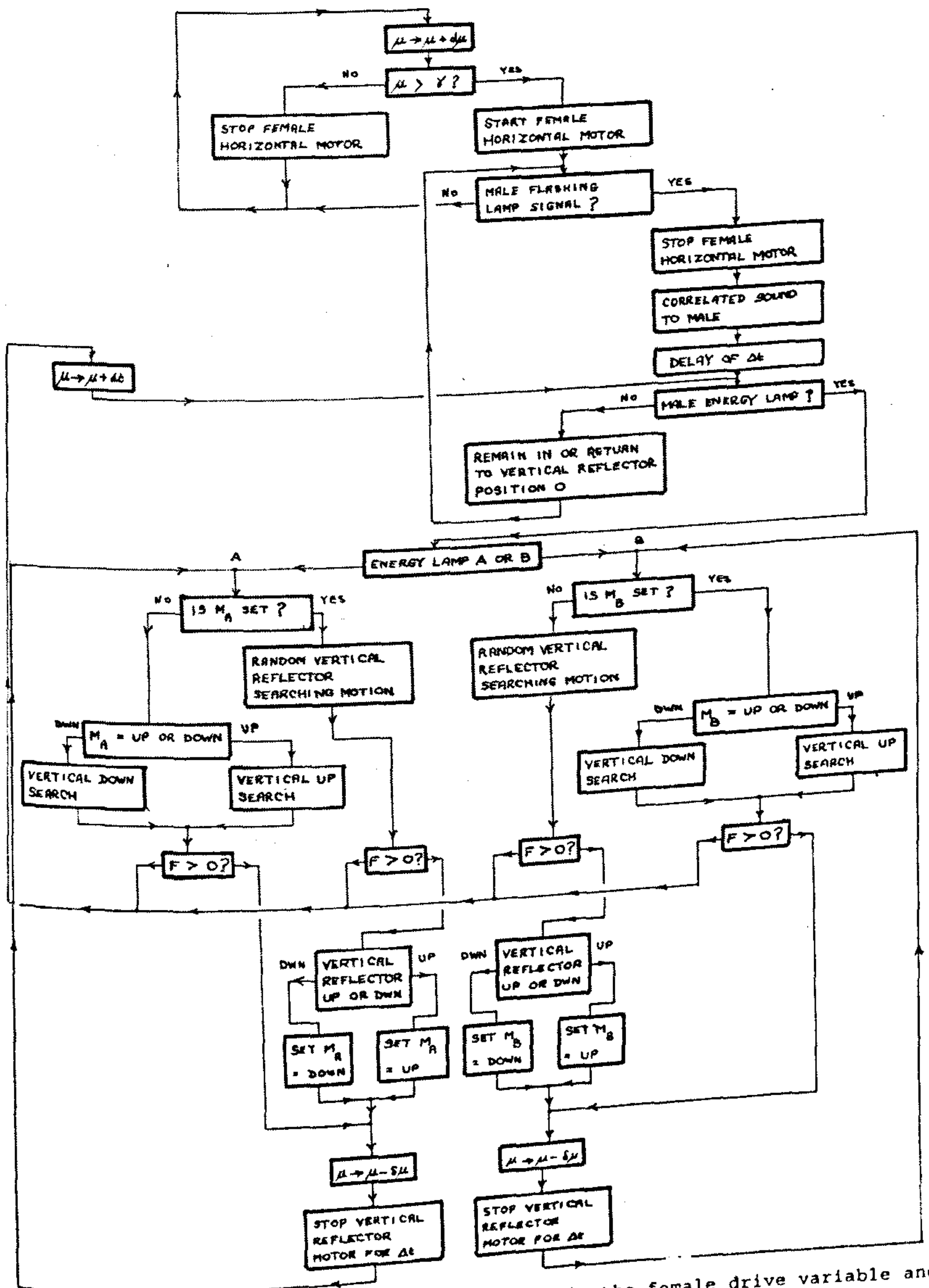


Figure 7.19. Logic diagram of a female robot. μ is the female drive variable and γ is a limit on the variable μ; each of Δμ, dμ, and δμ is a different increment; M_A is memory for orange (up or down vertical position); *MB* is memory for puce (up or down vertical position); *F* is a reinforcement variable, *F* = 1 or 0, evaluated by the male; *t* is a fixed delay. Source: G. Pask, "A Comment, a Case History and a Plan," in J. Reichardt (ed.), *Cybernetics, Art, and Ideas* (Greenwich, CT: New York Graphics Society, 1971), 92, fig. 35.

> patterns. But human beings can and it seems reasonable to suppose that they will also aim to achieve patterns which they deem pleasing by interacting with the system at a higher level of discourse. I do not know. But I believe it may work out that way.

In an October 1968 appendix to the same essay, Pask (1971, 98) recorded that this prediction concerning human involvement had proved to be "quite accurate, though entrainment is not nearly so effective with even moderate ambient illumination level." In other words, interaction with the Colloquy was best achieved in the dark. According to John Frazer (personal communication, 30 September 2004), people used womens' makeup mirrors to redirect the robots' light beams. One visitor to the exhibition recalled, "Some of the visitors stayed for several hours conversing with the mobiles" (Zeidner et al. 2001, 984).

— — — — —

What can we say about the Colloquy as ontological theater? Evidently it was in the same space as Musicolour, staging open-ended performative encounters between its participants, now multiple concurrent dances of agency among the five robots. In this instance, however, the participants in these dances were all machines, putting the Colloquy in the same space as the mirror and mating dances of Walter's tortoises and Ashby's multihomeostat setups. Like Walter and Ashby's machines, the Colloquy did not evolve in a fully open-ended fashion—the robots had a finite range of behaviors and fixed goals—but the introduction of human participants modified the picture, making possible a more fully open-ended range of possible performances by the human-Colloquy assemblage. As Pask noted in above quotation, the humans could engage with the robots at "a higher level of discourse," finding their own goals for the behavior of the system, just like a Musicolour performer but in cooperation with a different opto-electro-mechanical setup. It is also worth noting that the Colloquy foregrounded the role of language, communication, and signaling more sharply than the tortoise or the homeostat. One can indeed speak of signaling in connection with the tortoises, say: they responded to the presence or absence of light, and also to thresholds in light intensity. But the combination of different lights and sounds in the Colloquy (and the limited possibilities for robotic movement) brought this signaling aspect to the fore. Once more, then, we can say that the Colloquy was a piece of epistemological as well as ontological theater, and again I want to note that its epistemological aspects were geared straight into the ontological ones. The various modes of signaling in the Colloquy both were precipitated by the robots' performances and served to structure them, rather than to construct self-contained representations of the world. As usual, the Colloquy also staged a vision of a performative epistemology.[43]

The Social Basis Again

We can return to the question of the social locus of cybernetics, and the story bifurcates here. On the one hand, *Cybernetic Serendipity* was socially serendipitous for Pask. At the exhibition he met an American, Joseph Zeidner, then on the staff of the U.S. Office of Naval Research, later of the U.S. Army Research Institute. And the upshot of this meeting was that the U.S. military was among the sponsors of Pask's work on decision making and adaptive training systems over the next fifteen years. This takes us back to the lineage of training and teaching machines discussed earlier, and I will not explore the technicalities of that work further. We should bear in mind, however, that these machines were the bread and butter of Pask's life for many years. And we can also note that here we have another example of the typically nomadic pattern of propagation and evolution of cybernetics: from Musicolour and entertainment to typing trainers via the meeting with Christopher Bailey at the Inventors and Patentees Exhibition, to the Colloquy and thence to research on decision making for the U.S. military via the ICA.[44] In this section, however, I want to stay with the art world.

Nothing comes from nowhere, and we can certainly equip Pask's Colloquy with a pedigree. There is a whole history of automaton construction and machine art more generally (in which Jacques de Vaucanson's famous duck usually figures prominently) into which the Colloquy can be inserted. The Colloquy was a moment in the evolution of that tradition, distinguished (like many cybernetic artifacts) by its open-ended liveliness and interactivity. But the point I want to focus on now is that this pedigree is hardly a distinguished one and lurks, instead and as usual, in the margins of social awareness, "marginalised by both Art History and the histories of Engineering and Computer Science" (Penny 2008).[45] No doubt there are many reasons which could be adduced for this, but here we should pay attention to the oddity of machine art when seen against the backdrop of the cultural mainstream. As I stressed earlier concerning Gysin's Dream Machine and Pask's Musicolour, works like the Colloquy are odd objects that are refractory to the classifications, practices, and institutions of the modern art world. They are strange and nonmodern in just this sense. They are machines and thus, for the past couple of centuries, associated more readily with the grimy world of industry than with the lofty realms of high art; they lack the static and quasi-eternal quality of paintings and sculptures, foregrounding processes of becoming and emergence instead; as discussed before, interactive artworks tend to dissolve the primacy of the artist, thematizing real-time interplay between artwork and "user" (rather than "viewer"); they also threaten the social demarcation between artists and engineers; and, of course, they need more and different forms of curatorial attention: a sculpture just stands there, but machine art requires technological servicing to keep it going.[46]

In this sense, the marginality of machine art, including cybernetic art, is just the other side of the hegemony of modernity, and what calls for more thought is the move toward cultural centrality of works like the Colloquy. But this is no great puzzle. In earlier chapters we have seen many examples of crossovers fostered by an ontological resonance between cybernetics and the sixties counterculture, and that the Colloquy briefly positioned Pask in a sort of countercultural artistic vanguard can, I think, be similarly understood. Strange art hung together with novel forms of life in many ways.[47] The other side of this connection is that, as I said earlier, cybernetic art went down with the countercultural ship and very quickly lost its presence in the art world. "Cybernetic Serendipity might be considered the apogee of computer-aided art, considered as a mainstream art form. . . . [But] the late 1960s were both the apogee and the beginning of the end for . . . the widespread application of Cybernetics in contemporary art. . . . Cybernetic and computer art was [after the sixties], rightly or wrongly, regarded as marginal in relation to both the traditional art establishment or to avant-garde art practice" (Gere 2002, 102–3).[48]

— — — — —

After the sixties, then, "Kinetic, robotic, cybernetic and computer art practices were largely marginalized and ignored. With the odd exception . . . no major art gallery in Britain or the United States held a show of such art for the last 30 years of the twentieth century."[49] "But this does mean that . . . other kinds of art involving technology did not continue to be practised," even if they no longer commanded the heights of the art world (Gere 2002, 109,110). Much of the contemporary art discussed in chapter 6 under the heading of hylozoism—by Garnet Hertz, Eduardo Kac, Andy Gracie—is robot art, though I focused on the biological element before. Simon Penny's work is at the Paskian engineering end of the spectrum.[50] And these names are simply a random sample, examples that I have happened upon and been struck by.[51] Beyond these individual efforts, however, we can note that some sort of institutional social basis for this sort of art has also been emerging. Charlie Gere (2002, 110) mentions the Ars Electronica Centre and annual festival held in Linz, Austria, since 1979 as a key point of condensation and propagation of such work, and also that having directed the Linz festival from 1986 to 1995, Peter Weibel moved to direct the Zentrum für Kunst und Medientechnologie (ZKM) in Karlsruhe, Germany, itself a "highly funded research centre and museum dedicated to new media arts."[52] As in previous chapters, here we find traces of the emergence of a new social basis for cybernetics and its descendants, now in the sphere of art, not within mainstream institutions but in a parallel social universe (echoing the ambitions of Trocchi's sigma project).

And to round off this line of thought, it is instructive to think of the career of the British artist Roy Ascott, whom we encountered in the previous chapter as the man who first introduced the musician Brian Eno to cybernetics. Ascott was the leader in Britain in introducing cybernetics into art, having first encountered the field in 1961, reading the works of Ross Ashby, Norbert Wiener, and Frank George (Shanken 2003, 10). As head of foundation at Ealing College of Art, he introduced the Ground Course (1961–63), focused on cybernetics and behaviorism, which "fundamentally affected the work of those who taught it and of their students" (Stephens and Stout 2004, 31, 41).[53] Despite his influence on British art in the 1960s, Ascott has been "largely ignored by the British art establishment. The Tate Gallery . . . does not own any of his work. He has, however, achieved international recognition for his interactive work, and his teaching" (Gere 2002, 94). Indeed, in 2003 Ascott became the founding director of a novel pedagogical institution called the Planetary Collegium, "a world-wide transdisciplinary research community whose innovative structure involves collaborative work and supervision both in cyberspace and at regular meetings around the world." Those altered states and technologies of the nonmodern self we have been discussing also loom large in the collegium's self-description:

> The Planetary Collegium is concerned with advanced inquiry in the transdisciplinary space between the arts, technology, and the sciences, with consciousness research an integral component of its work. It sees its influence extending to new forms of creativity and learning in a variety of cultural settings. Far from eschewing the study of esoteric or spiritual disciplines, it seeks to relate ancient, exotic, even archaic knowledge and practices to radically new ideas emerging at the forward edge of scientific research and speculation, and thereby

to new forms of art and cultural expression. It seeks dynamic alternatives to the standard form of doctoral and post doctoral research while producing, if not exceeding, outcomes of comparable rigour, innovation and depth.[54]

The Fun Palace

THE HIGH POINT OF FUNCTIONALISM IS THE CONCEPT OF A HOUSE AS A "MACHINE FOR LIVING IN." BUT THE BIAS IS TOWARDS A MACHINE THAT ACTS AS A TOOL SERVING THE INHABITANT. THIS NOTION WILL, I BELIEVE, BE REFINED INTO THE CONCEPT OF AN ENVIRONMENT *WITH* WHICH THE INHABITANT COOPERATES AND *IN* WHICH HE CAN EXTERNALIZE HIS MENTAL PROCESSES.

GORDON PASK, "THE ARCHITECTURAL RELEVANCE OF CYBERNETICS" (1969A, 496)

If the sixties were the decade of interactive art, they were also the decade of interactive and adaptive architecture. In Britain, the Archigram group of architects built almost nothing, but the designs featured in *Archigram* magazine were iconic for this movement. Ron Herron's fanciful Walking City (fig. 7.20) in 1964 caught the mood, adaptive in the sense that if the city found itself somehow misfitted to its current environment, well, it could just walk off to find somewhere more congenial. Peter Cook's concept of the Plug-In City was a bit more realistic: the city as a mesh of support services for otherwise mobile units including housing—the city that could continually reconfigure itself in relation to the shifting needs and desires of its inhabitants.[55]

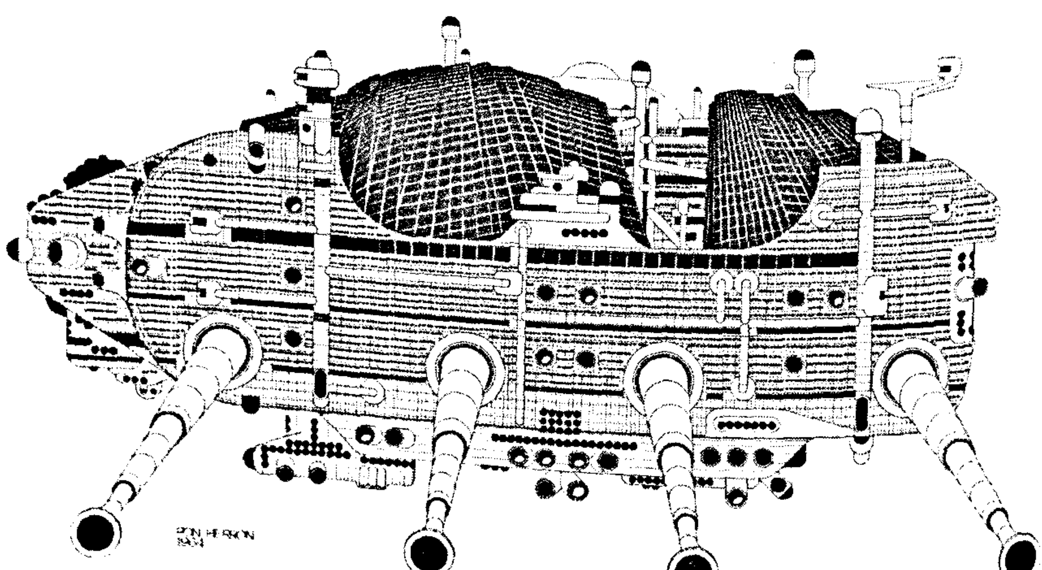


Figure 7.20. The Walking City, 1964. Source: Sadler 2005, 39, fig. 1.32.

At a relatively mundane level, the interest in adaptive architecture could be seen as a reaction to the failure of postwar urban planning for the future of London (Landau 1968). If the planners could not foresee how London would develop, then perhaps the city should become a self-organizing system able to reconfigure itself in real time in relation to its own emerging situation. This idea, of course, takes us straight back to Ross Ashby's ideas of evolutionary design and, in another register, to Beer's and Pask's biological and chemical computers that evolved and adapted instead of having to be designed in detail: the city itself as a lively and adaptive fabric for living.

At a more exalted and typically sixties level was an image of the city as a technology of the nonmodern self, a place where people could invent new ways to be, where new kinds of people could emerge. Metonymically, Archigram's Living City installation at the ICA in 1963 included a flicker machine (taking us back to Grey Walter and Bryan Gysin; fig. 7.21), Much of the inspiration for this conception of the built environment came from the tiny but enormously influential Situationist International group centered on Guy Debord in Paris, which had come into existence in the 1950s. As a founding document from 1953 put it, "The architectural complex will be modifiable. Its aspect will change totally or partially in accordance with the will of its inhabitants. . . . The appearance of the notion of relativity in the modern mind allows one to surmise the EXPERIMENTAL aspect of the next civilization. . . . On the basis of this mobile civilization, architecture will, at least initially, be a means of experimenting with a thousand ways of modifying life, with a view to mythic synthesis."[56]

Closely associated with Archigram and sharing its enthusiasm for adaptive architecture while maintaining an "avuncular" relation to it, was the architect Cedric Price, mentioned earlier as a fellow undergraduate of Pask's at Cambridge (Sadler 2005, 44), and Price was Pask's link to architecture. Around 1960, Joan Littlewood "turned . . . to a childhood dream of a people's palace, a university of the streets, re-inventing Vauxhall Gardens, the eighteenth-century Thames-side entertainment promenade, with music, lectures, plays, restaurants under an all-weather-dome" (Ezard 2002). This Fun Palace, as it was known, is one of the major unbuilt landmarks of postwar British architecture (fig. 7.22). Cedric Price was appointed as the architect for the project, and "I thought of Gordon [Pask] and Joan did too. He immediately accepted the post—unpaid as I remember—as cybernetician to the Fun Palace Trust. It was his first contact with architects and he was extremely patient. He immediately formed a cybernetic working party and attracted those he wanted to join it too. The meetings became notorious—and Trust Members attended" (Price

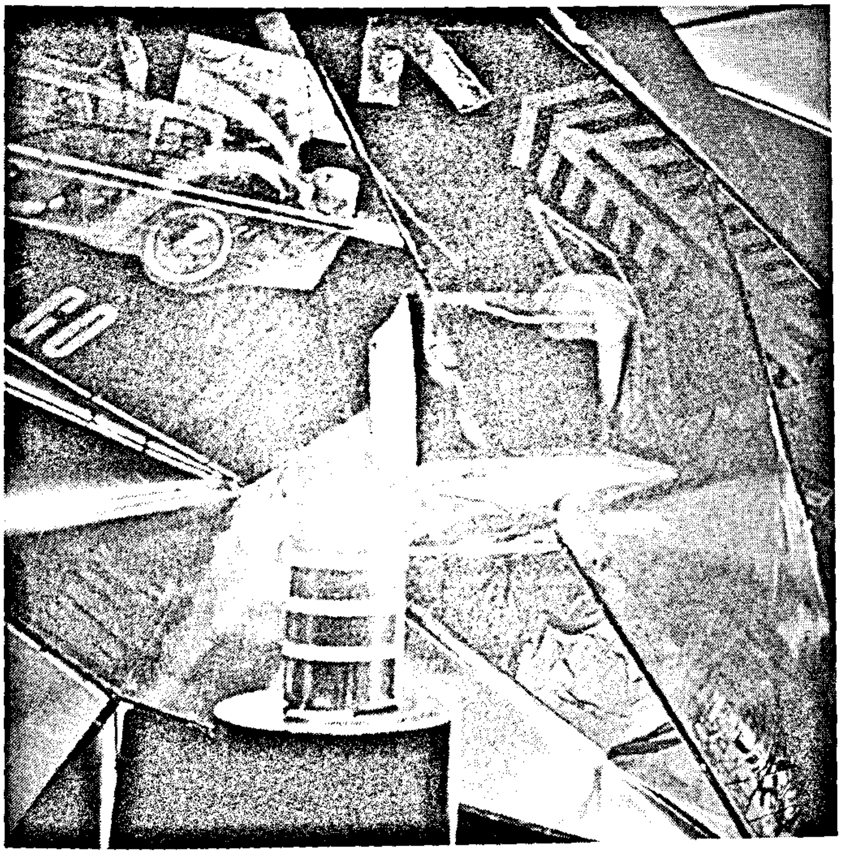


Figure 7.21. Flicker machine at the Living City, ICA, 1963. Source: Sadler 2005, 57, fig. 2.6.

1993, 165). "Pask agreed to join the Fun Palace team and organised the Fun Palace Cybernetics Subcommittee, and along with Littlewood and Price, he became the third major personality behind the Fun Palace" (Mathews 2007, 75).[57]

What was the Fun Palace? Like Archigram's designs, but at a much more practical level, the Fun Palace was intended as a reconfigurable adaptive space that could support an enormous variety of activities that changed over time (Landau 1968, 76):

> The activities which the Fun Palace offered would be short-term and frequently updated, and a sample suggested by Joan Littlewood included a fun arcade, containing some of the mechanical tests and games which psychologists and engineers usually play; a music area, with instruments on loan, recordings for anyone, jam sessions, popular dancing (either formal or spontaneous); a science playground, with lecture/demonstrations, teaching films, closed-circuit T.V.; an acting area for drama therapy (burlesque the boss!); a plastic area for modeling and making things (useful and useless). For those not wishing to take part, there would be quiet zones and also screens showing films or closed-circuit television of local and national happenings.

This program called for an architecture which was informal, flexible, unenclosed, and impermanent; the architecture did not need to be simply a response to the program, but also a means of encouraging its ideas to grow and to develop further. With an open ground-level deck and with multiple ramps, moving walkways, moving walls, floors, and ceilings, hanging auditoriums, and an overall moving gantry crane, the physical volumes of the spaces could be changed as different usages were adopted. The kit of parts for these operations included charged static vapor barriers, optical barriers, warm air curtains, a fog dispersal plant, and horizontal and vertical lightweight blinds. In the Fun Palace, no part of the fabric would be designed to last for more than ten years, and parts of it for possibly only ten days.

A large number of people worked on the design of the Fun Palace, and it is impossible to spell out in detail Pask's individual contributions. At the level of content, the Cybernetics Subcommittee suggested dividing the Fun Palace into six organizational zones, and "Zone one was dedicated to the various types of teaching machines that Pask and his Systems Research had already developed." Stanley Mathews describes the Littlewood-Pask cybernetic theater as part of the overall conception of the Fun Palace (Mathews 2007, 114, 116).[58] Like the flicker machine at the Living City, the machines and the theater can be seen as metonyms for the entire building.[59] More broadly, Pask's contribution appears to have been to see the Fun Palace on the model of Musicolour—as an aesthetically potent environment that in its inner

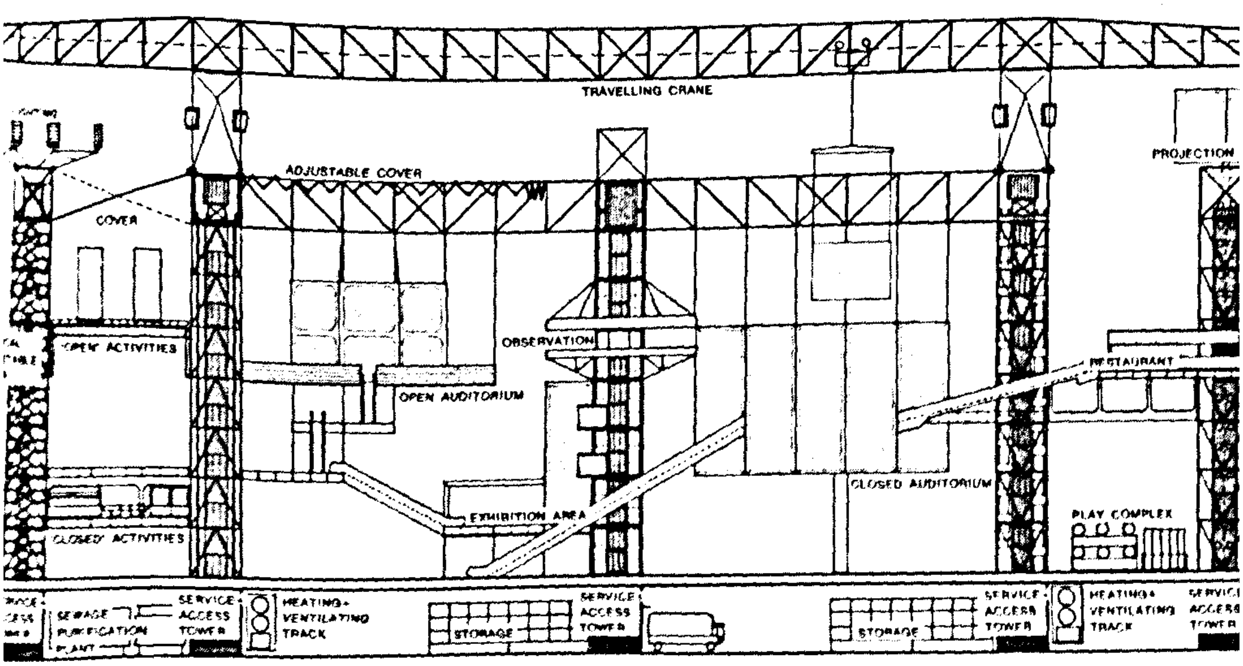


Figure 7.22. The Fun Palace. Source: Landau 1968, 73, fig. 56.

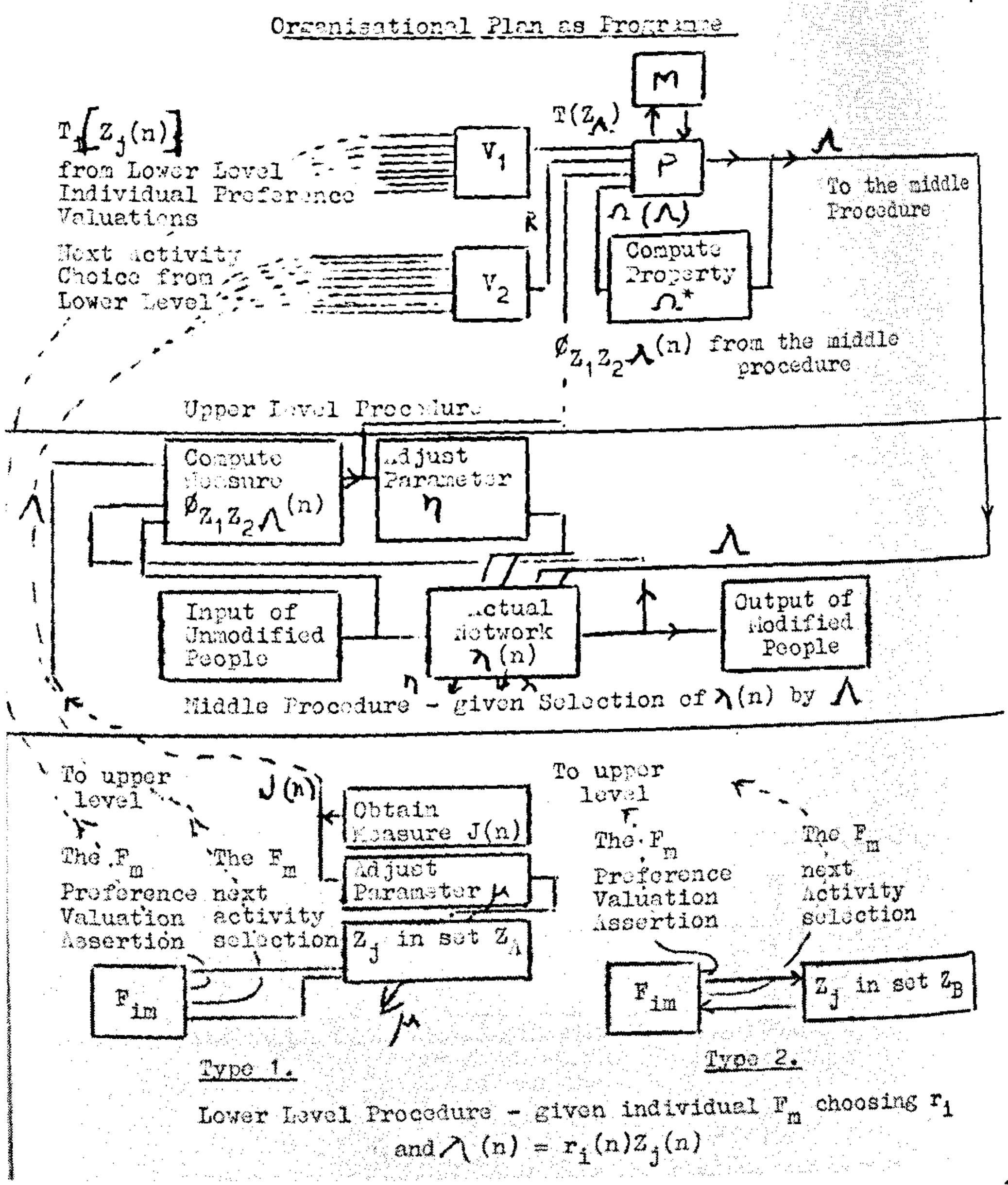


Figure 7.23. The Fun Palace's cybernetic control system. Pask 1965, 3, diagram 1. (By permission of Cedric Price Fonds, Collection Centre d'Architecture/Canadian Centre for Architecture, Montréal.)

reconfigurations both reacts to emergent patterns of use and fosters new ones.[60] Hence, I think, Roy Landau's reference to the Fun Palace as "encouraging . . . ideas to grow and to develop further." In a 1969 essay, Pask argued that cybernetic architecture would "elicit [the inhabitant's] interest as well as simply answering his queries" (Pask 1969a, 496), citing Musicolour and the Colloquy of Mobiles as examples of what he had in mind. Figure 7.23 reproduces Pask's 1965 logic diagram of the "cybernetic control system" for the Fun Palace, which features "unmodified people" as input and "modified people" as output—echoing the Situationist analysis of adaptive architecture as a transformative technology of the self.[61] Alexander Trocchi and his sigma project (chap. 5) made the connection, since he was allied with the Situationists in Paris and friends with both Price and Littlewood in London (with whom he met regularly in 1964) (Mathews 2007, 112–14).

Visitors to London will have noticed that the Fun Palace does not exist. Despite a lot of work from a lot of people, political support especially within the Labour Party, and the inclusion of such notables as Yehudi Menuhin and Lord Harewood among its trustees, the project collapsed in the second half of the 1960s, and the building was never even begun. One can cite many of the usual mundane reasons for this: the problems of finding a site, getting permissions, and, not least, raising money.[62] But another problem more germane to our theme came up again and again: the sheer difficulty of saying what the Fun Palace was. Like the Dream Machine and Musicolour before it, the Fun Palace failed to fit easily into any of the accepted architectural categories. Not only did it deliberately aim to cut across the usual demarcations—combining the arts, entertainment, education, and sport in all sorts of guises, familiar and unfamiliar, including participation in what were usually taken to be spectator activities—the broader aim was to experiment: to see what might emerge from combining these opportunities in an adaptive space. This, of course, left outsiders to the project free to project their own nightmares on it, and, as Littlewood's obituary in the *Guardian* put it, the very phrase "Fun Palace" "evoked for councillors a vision of actors copulating in the bushes," and Littlewood's "support dissipated in a fruitless search for a site" (Ezard 2002).[63]

Two thoughts before we leave the Fun Palace. The first goes back to the social basis of cybernetics. We can think once more about amateurism. I noted above that Pask's work on the Fun Palace was voluntary and unpaid, done out of interest and for fun and, no doubt, belief in the worth of the project. Here I can just add that, as Mathews (2007, 120) puts it, "like Price, Littlewood had a 'day job' and worked on the Fun Palace on the side." Again we have the sense of something welling up outside the structure of established social institutions and without support from them.

We can also think in this connection about the relation between modern architecture and buildings like the Fun Palace. The last sentence of Landau's *New Directions in British Architecture* (1968, 115) reads: "So if architecture is becoming . . . anti-building . . . perhaps it *should* be classified as not architecture . . . but this *would* signify that it had taken a New Direction." Mary

Lou Lobsinger (2000, 120) picks up the negative and describes the Fun Palace as "the quintessential anti-architectural project." We are back with the "antis"—with the Fun Palace facing contemporary architecture in much the same way as Kingsley Hall faced modern psychiatry. In neither case does the "anti" amount to pure negation. Adaptive architecture was *another* and *different* approach that crossed the terrain of established forms. If mainstream architecture aspired to permanent monuments, aesthetic and symbolic forms drenched in meaning, and fitness to some predefined function, the Fun Palace was envisaged as just a big and ephemeral rectangular box from the outside and a "kit of parts" on the inside. The heart of antiarchitecture lay in its inner dynamics and its processes of transformation in response to emergent, not given, functions—none of which existed (or, at least, were thematized) in the modern tradition. Here we have once more antiarchitecture as nomad science, sweeping in from the steppes to upset, literally, the settled lives of the city dwellers (the Walking City!), and a Situationist architecture as Heideggerian revealing—as keenly open to new ways to be—in contrast to an architecture of enframing, growing out of and reinforcing a given aesthetic and list of functions. Ontology as making a difference. No wonder that "for those who thought architecture had a visually communicative role . . . [Price's] work was anathema to everything architecture might stand for."[64]

Second, we can go back to the critique of cybernetics as a science of control. Mathews's account of Price's work in the 1960s takes a strange turn just when Pask appears at the Fun Palace. Speaking of a 1964 report from the Cybernetics Subcommittee, Mathews (2007, 119, 121) picks out what he considers a "rather frightening proposal" discussed under the heading of "Determination of what is likely to induce happiness" and continues:

> This . . . should have alerted Littlewood that the Fun Palace was in danger of becoming an experiment in cybernetic behavior-modification. However, in a 1964 letter to Pask, she actually agreed with his goals, and seemed naively oblivious to the possibility that the project might become a means of social control. . . . The idea that the Fun Palace would essentially be a vast social control system was made clear in the diagram produced by Pask's Cybernetics Subcommittee, which reduced Fun Palace activities to a systematic flowchart in which human beings were treated as data [fig. 7.23 above]. . . . Today, the concept of "unmodified or modified" people would be treated with a considerable amount of caution. Yet, in the 1960s, the prevailing and naive faith in the endless benefits of science and technology was so strong that the Orwellian implications of modification went largely unnoticed.

What can we say about this? First, this is a pristine example of the sort of critique of cybernetics that I mentioned in the opening chapters, which is why it deserves some attention. Second, the cyberneticians asked for it. They were rhetorically inept, to say the least. They went on endlessly about "control," and "modified people" in figure 7.23 sets one's teeth on edge. It invites Mathews's slide to "behavior-modification," which is a polite way to say "brainwashing." But third, of course, I think the critique is misdirected. It hinges on what I called the Big Brother sense of control—of hierarchical domination, of enframing—and nothing in Pask's work on the Fun Palace contradicts the idea that he was in the same space as Littlewood and Price (and the Situationists before them) in trying to imagine a building in which, far from being stamped by some machine, people could experiment with new and unforeseen ways to be.[65] Littlewood was not being naive in agreeing with Pask's goals. The Fun Palace, from Pask's perspective, continued the lineage of Musicolour, a machine that would get bored and encourage the performer to try something new. On a different level, as I have tried to show in this chapter and throughout the book, the cybernetic ontology was one of exceedingly complex systems which necessarily escape domination and with which we have to get along—Pask's notion of "conversation"—and the Fun Palace was just another staging of that ontology. As I also said before, the control critique might be better directed here at the established architectural tradition, which in its symbolic aspect attempts, at least, to tell us what to think and feel, and in its functional guise tries to structure what we do: the factory as a place to work (not to play games, learn or have sex), the school as a place to learn, the home as the dwelling place of the nuclear family . . . This repetitious critique of cybernetics stifles its own object.[66]

After the Sixties: Adaptive Architecture

AN EVOLUTIONARY ARCHITECTURE. . . . NOT A STATIC PICTURE OF BEING, BUT A DYNAMIC PICTURE OF BECOMING AND UNFOLDING—A DIRECT ANALOGY WITH A DESCRIPTION OF THE NATURAL WORLD.

JOHN FRAZER, *AN EVOLUTIONARY ARCHITECTURE* (1995, 103)

The social history of adaptive architecture closely mirrored that of cybernetic art, reaching a zenith in the sixties with the Fun Palace and receding into the margins thereafter, but here we can glance briefly at some postsixties developments that connect to Pask.

With the Fun Palace as the nexus, the sixties were the decade in which Pask established an enduring connection with architecture more generally. Pask (1969) described cybernetics as a theory of architecture, much as Walter and Ashby had described it as a theory of the brain. Institutionally, Pask's closest relationship was to the AA, the Architecture Association school in London. Cedric Price, who had completed his studies at the AA in 1959 (Melvin 2003), taught there part-time during the Fun Palace project and "was delighted when Gordon agreed to sit on my architectural juries" (Price 2001, 819). Thus began an association between Pask and the AA that continued for the rest of his life: "His presence and inventions within the life of the Architectural Association are both legendary and of day to day relevance" (Price 2001, 820). Pask often spoke and gave workshops at the AA, and in the late 1980s he took up a continuing position there as an assistant tutor.[67] The connection to the AA in turn proved auspicious for the propagation of Pask's cybernetics: "Of 12 successful students Pask had at Brunel University, eight were architects and six came from the Architectural Association" (Scott and Glanville 2001). Archigram's Peter Cook (2001, 571–72) speaks of "a whole generation of young architects. . . . They are, of course, the direct progeny of Gordon." To close this chapter I want to review of few examples of Paskian architecture in practice running up to the present. What these projects have in common is the Paskian idea of a dynamically evolving relation between the human and the nonhuman.

At the level of complete structures, in 1978 Cedric Price had another attempt at designing a Fun Palace–style building that was reconfigurable in use, this time for the Gilman Paper Corporation. Again, the project was never completed, but Price hired John and Julia Frazer as computer consultants, and they constructed a working electronic model of the Generator project, as it was called.[68] "It was proposed to grid the site (a clearing in a forest in Florida) with foundation pads and to provide a permanent mobile crane for moving components, allowing the users of the building to become involved in its organization. . . . We were concerned that the building would not be changed enough by its users because they would not see the potential to do so, and consequently suggested that a characteristic of intelligence, and therefore of the Generator, was that it would register its own boredom and make suggestions for its own reorganization. This is not as facetious as it may sound, as we intended the Generator to learn from the alterations made to its own organization, and coach itself to make better suggestions. Ultimately, the building itself might be better able to determine its arrangements for the users' benefit

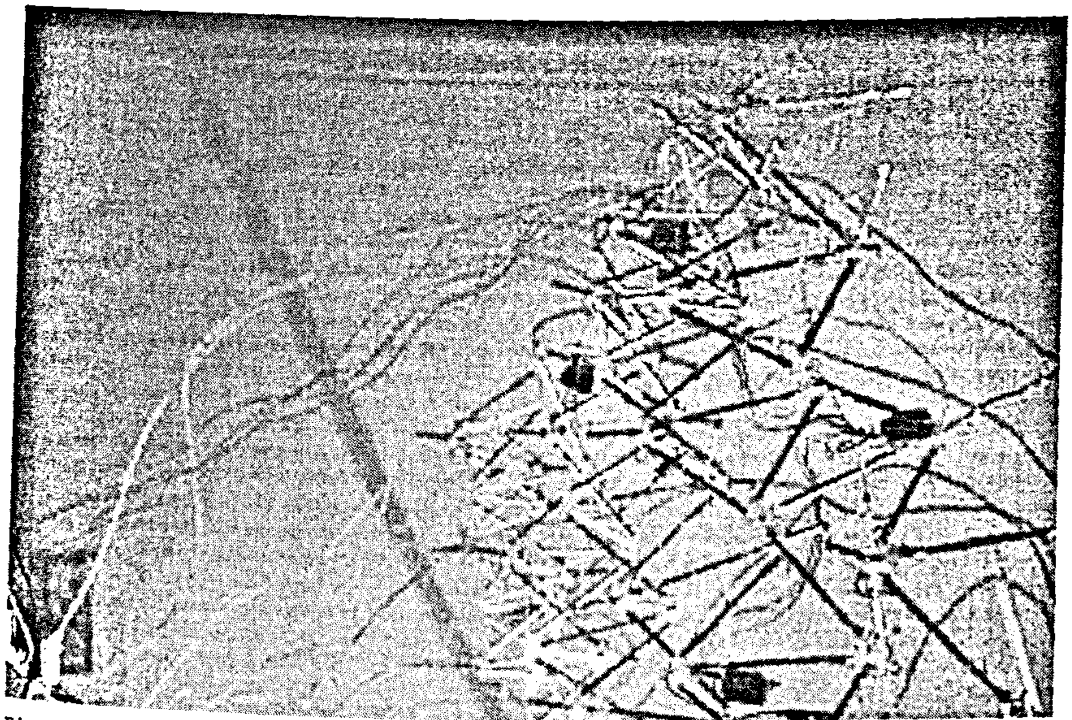


Figure 7.24. Digitally controlled architectural structure. Source: Silver et al. 2001, 907.

than the users themselves. This principle is now employed in environmental control systems with a learning capability" (Frazer 1995, 41). The reference to "boredom" here was an explicit evocation of the Musicolour machine.[69]

At a more micro level and closer to the present, a 2001 survey of projects at the Bartlett School of Architecture at University College, London, "Prototypical Applications of Cybernetic Systems in Architectural Contexts," subtitled "A Tribute to Gordon Pask," is very much in the Musicolour–Fun Palace tradition, assembling the elements for structures that can transform themselves in use (Silver et al. 2001). One project, for example, entailed the construction of a digitally controlled transformable structure—the skin of a building, say—a key element of any building that can reshape itself in use (fig. 7.24). Another project centered on communication via sounds, lights, and gestures between buildings and their users, reminiscent of the communications systems linking the robots in Pask's Colloquy of Mobiles (fig. 7.25).

In another tribute to Pask, "The Cybernetics of Architecture," John Frazer (2001) discusses the history of a big, long-term project at the AA, in which Pask participated until his death. The morphogenesis project, as it was called, ran from 1989 to 1996 and was very complex and technically sophisticated; I will simply discuss a couple of aspects of it in general terms.[70]

We have so far discussed cybernetic architecture in terms of relations between buildings and users—the former should somehow constitute an

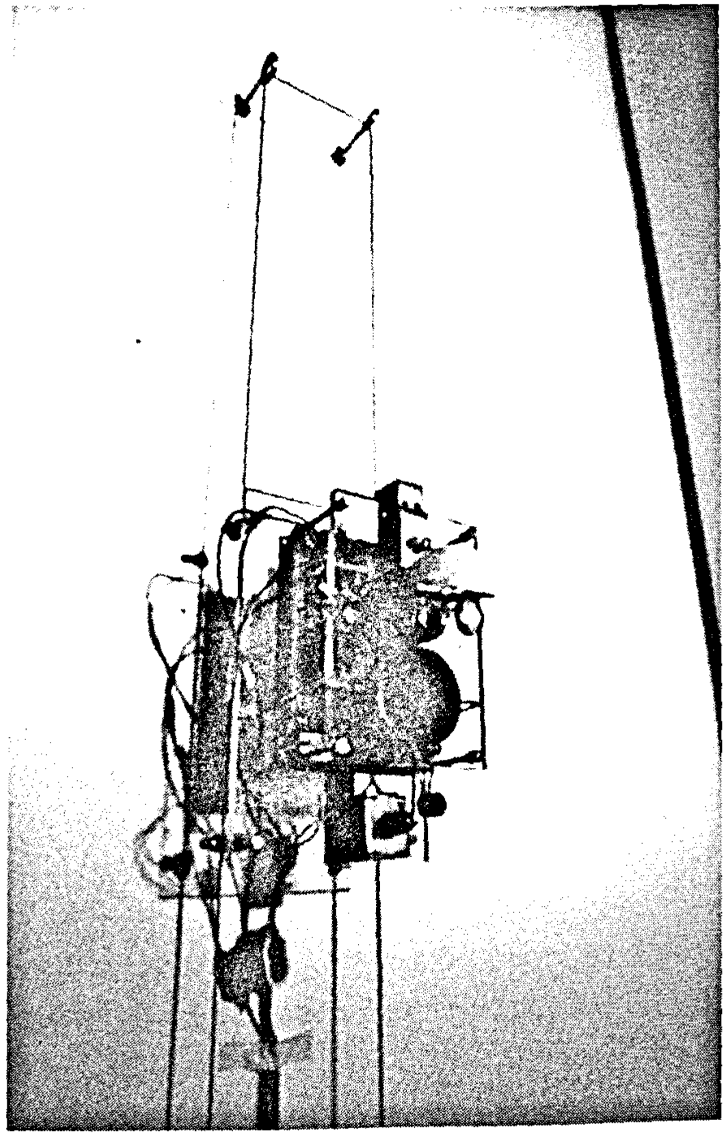


Figure 7.25. Architectural communication device. Source: Silver et al. 2001, 911.

aesthetically potent environment for the latter. But one can also conceive of another axis of cybernetic incursion into architecture, this time concerning the relation between the architect and architectural design tools. The classic design tool in architecture is the drawing board—a passive object on which the architect inscribes his or her vision. The drawing board is thus not an aesthetically potent environment in Pask's terms. And much of Pask's involvement with architecture focused on changing that situation, via the development of tools that could adapt to and encourage the architect—again on the model of Musicolour. This was a topic on which he collaborated with Nicholas Negroponte at MIT in the development of what Negroponte called the Architecture Machine—a computerized system that could collaborate more or less symmetrically with the architect in designing buildings—turning crude sketches into plans, indicating problems with them, suggesting extensions, and so on.[71]

Frazer's morphogenesis project took this idea of creating an aesthetically potent environment for design further, along at least two axes. One was to explore new ways of communicating with computers. "Our attempts to improve the software of the user-interface were paralleled by attempts to improve the hardware. The keyboard and mouse have never seemed to me well suited to manipulating models or graphics: a digitizing tablet might be closer to a drawing board, but it is rarely used that way. In any case, we were eager to get away from conventional, drawing board dependent design approaches." Around 1980 a system of cubes was developed, each with an embedded processor. These cubes could be assembled as model structures and could be read by a computer that would build up an internal representation of structures that were somehow patterned on the arrangement of cubes (Frazer 1995, 37).

Beyond this, the morphogenesis project sought to incorporate the idea that architectural units—buildings, cities, conurbations—*grow*, quasi-biologically, and adapt to their environments in time.[72] As we have seen, in the 1950s and early 1960s, Pask had experimented with inorganic analogue models of organic growth processes—the chemical computers—but he had moved on to mathematical experimentation on cellular automata in the later sixties, and the morphogenesis project likewise took advantage of novel mathematical structures, such as genetic algorithms and cellular automata, to simulate processes of growth, evolution, and adaptation within the computer. The architect would supply the computer with a "seed" structure for a building, say, which the machine would then evolve, taking account of coevolutionary interactions with the building's environment. At the same time, the architect could interfere with this process, in the choice of seed, by selecting certain vectors of evolution for further exploration, and so on. In this way, the computer itself became an active agent in the design process, something the architect could interact with symmetrically, sailing the tides of the algorithms without controlling them (and taking us back to Brian Eno in the previous chapter)—a beautiful exemplification of the cybernetic ontology in action. Figure 7.26 is a single example of this style of coevolutionary design, a computer simulation of how the city of Groningen might develop into the future taking account of interactions between the growing city itself, its inhabitants, and its geographic environment. The quasi-organic structure is evident. As the original caption says, the generating computer model behind it was inspired by Pask's work in the 1950s, and this was, in fact, the last student project that Pask himself supervised.

One can thus trace out streams of Paskian cybernetic architecture ramify-

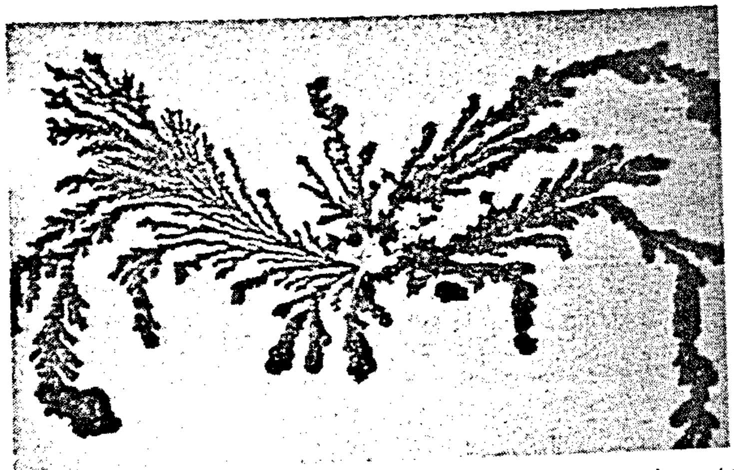


Figure 7.26. Groningen study. Source: J. H. Frazer, "The Cybernetics of Architecture: A Tribute to the Contribution of Gordon Pask," *Kybernetes*, 30 (2001), 641-51, p. 648.

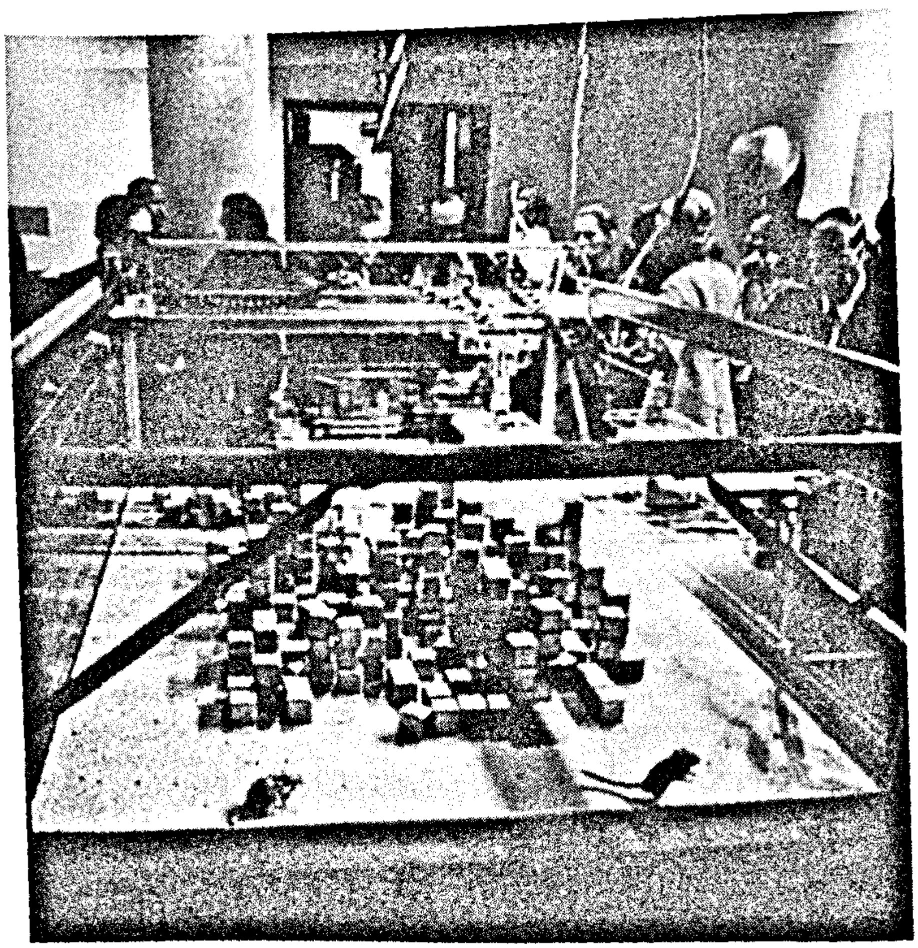


Figure 7.27. Gerbil architecture. Source: Nicholas Negroponte, *Soft Architecture Machines*, (Cambridge, MA: MIT Press, 1975), 46, fig. 1. (© 1976 Massachusetts Institute of Technology, by permission of the MIT Press.)

ing from the Fun Palace toward the present, in the development of design tools as well as building structures. It remains the case that nothing on the scale of the Fun Palace has yet been built, but perhaps the sixties might be coming back: in 2002 the Royal Institution of British Architects gave the Archigram group its gold medal (Sadler 2005, 7).

— — — — —

Let me end this chapter with one more, light-hearted, example of cybernetic architecture, an installation exhibited by Pask's collaborator, Nicholas Negroponte, at the Jewish Museum in New York from September to November 1970.[73] Close inspection of figure 7.27 reveals of a mass of small cubes inhabited by a colony of gerbils. The gerbils push the cubes around, as is their wont. At intervals, a computer scans the scene and either pushes the blocks back where they were, if they have not moved much, or aligns them to a grid in their new positions. The gerbils then go to work again, the computer does its thing once more, and thus the built environment and its inhabitants' use of it co-evolve open-endedly in time in ways neither the architect, nor the computer, nor the gerbils could have foreseen—just like a Musicolour performance.