Colloquy of Mobiles Replica

Project Overview

Colloquy of Mobiles Replica

Project Goals

Research, Design, Fabricate, and Install

1. A Full Scale Replica of the Colloquy of Mobiles Installation from 1968.

2. Recreating the Spirit and Aesthetic of the Piece with reasonable accuracy.

3. Integrating as much CCS input as is feasible:

    - Expertise in Arts, Materials, Fabrication
    - Resources for Fabrication, Machines, Workshops

Exhibition Date May 11, 2018

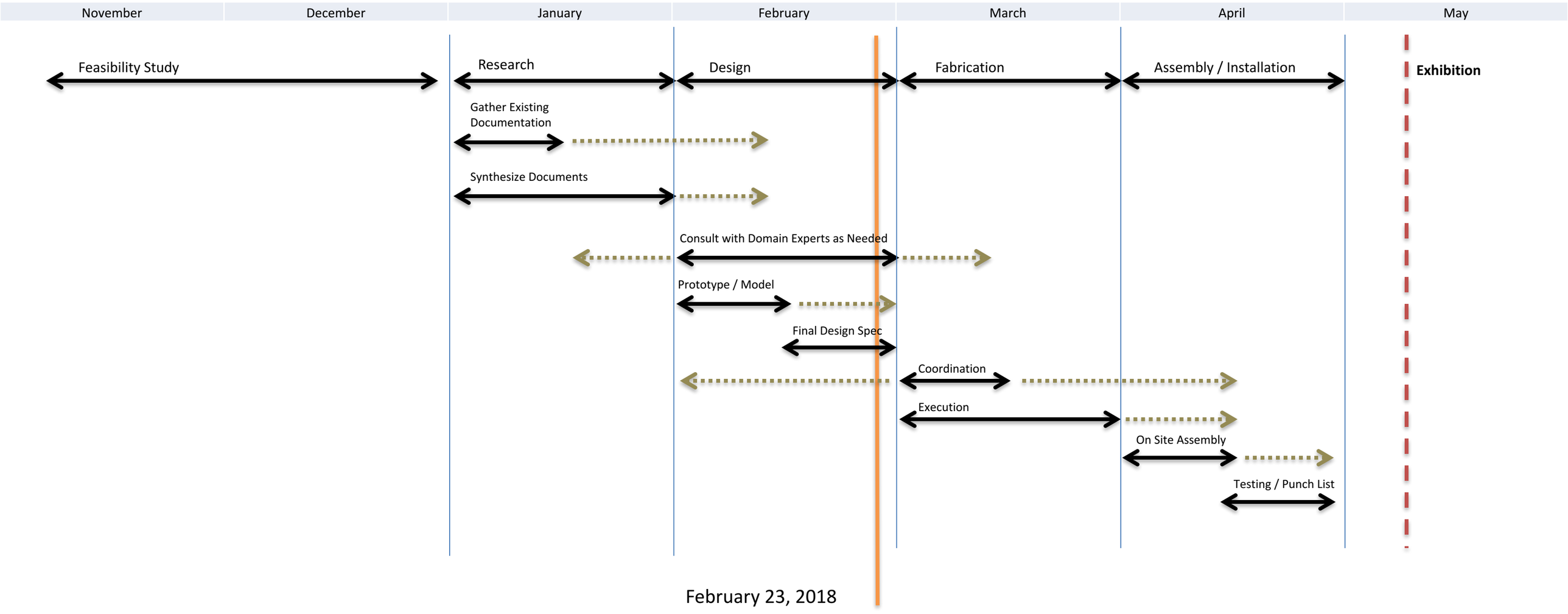
Colloquy of Mobiles Replica

Project Phases

Colloquy of Mobiles Replica

Project Phases and Schedule

Feasibility Study	**Research**		**Design**			**Fabrication**		**Assembly / Installation**		**Exhibition / Service Life Agreement**
	Gather Existing Documentation	Synthesize Documents	Consult with Domain Experts as Needed	Prototype / Model	Final Design Spec	Coordination	Execution	On Site Assembly	Testing / Punch List	Continued Support



Colloquy of Mobiles Replica

Project Phases and Estimated Budget

Feasibility Study	**Research**		**Design**			**Fabrication**		**Assembly / Installation**		**Exhibition / Service Life Agreement**
	Gather Existing Documentation	Synthesize Documents	Consult with Domain Experts as Needed	Prototype / Model	Final Design Spec	Coordination	Execution	On Site Assembly	Testing / Punch List	Continued Support

Budget Item	**Material Cost**	**Labor**
Oversight labor		$ 14,400.00
Oversight travel		$ 2,400.00
Armature	$ 800.00	$ 2,000.00
Mechanics	$ 1,500.00	$ 1,500.00
Wiring Harness	$ 600.00	$ 2,000.00
Sensing	$ 150.00	$ 1,000.00
Actuation	$ 200.00	$ 1,000.00
Computation	$ 350.00	$ 500.00
Communication	$ 100.00	$ 500.00
Software	$ -	$ 5,000.00
	$ 3,700.00	$ 30,300.00
	total	$ 34,000.00

Oversight and Services Labor Cost				
	Phase			
	Research	***Design***	***Fabrication***	***Installation***
Percentage of Total Fee	20%	50%	20%	10%
Phase Fee	**$ 2,880.00**	**$ 7,200.00**	$ 2,880.00	$ 1,440.00

February 28, 2018

Colloquy of Mobiles Replica

Project Components

Armature

Mechanics

Wiring Harness

Sensing

Actuation

Computation

Communication

Software

Colloquy of Mobiles Replica

Project Components

Installation Elements			
Component	**Description**	**Potential Materials**	**Dependencies**
Armature	the non-digital/electronic components of the installation responsible for structure and visual aesthetics of - the figural components of the piece, the mechanical components [actuation], sensing, and the computational hardware [brains]	Structure: Aluminium Strut, unistrut, perforated angle Plinth Surface: Fabric, foamcore, thermoplastic, Figure Composition: Fiberglass, resin impregnated fabric, thermoplastic	Aesthetics, design for reuse, design for travel, size of shipping containers, size of gallery and shop doors, size of gallery and shop elevators, weight, safety of audience, access to experience
Mechanics	the actuation components of the installation that enable movement of the sculptural elements	12v/24v Motors and Servos, motor control boards, gearbox, pulley, belts	Weight/inertia of sculptural elements, latency in actuation and positioning, safety of audience
Wiring Harness	The components of the system that deliver power and signal [if necessary]to the distributed sensing/actuation/and computation components	DC wiring, enclosure	communications protocol, distributed components current draw, DC power use, safety of audience
Sensing	The electromechanical components of the installation that enable the sensing of [at least] light	photoresistor, microphone, spectral analysis, limiit switch thermal imaging device, photodiode, microphone, CO2 sensing, etc.	how closely the piece recreates original technology, enabling other modes of interaction in support of installation reprogrammability
Actuation	The electromechanical components of the installation that enable the generation of [at least] light	LED, incandescent light, speaker	how closely the piece recreates original technology, enabling other modes of interaction in support of installation reprogrammability
Computation	The devices that receive input from sensing and generate output to deliver to actuators via communications protocol, as well as communicate with other computational entities.	Microelectronic computers i.e arduino, electron, raspberry pi, intel edison, TI launchpad, LittleBits, etc.	central vs distributed computational system, mesh vs star vs other network topology, complementary course skills and tools identification
Communication	The means of communication amongst computational components	antennae, wiring, communications protocol i.e. 3G, WIFI, hardwired, etc.	installation environment, security, internal network needs, external network needs, cloud computing, Alexa Voice Services, IBM Watson, latency issues
Software	The logic that runs on the computational platform that determines installation behavior and interaction with installation participants both human and machine.	Programming language, development tools, API/Libraries used to communicate with hardware	complementary course skills, tools, and level of integration. Hardware constraints [library/driver availability].

Colloquy of Mobiles Replica

Design Research

Colloquy of Mobiles Replica

Design Research: Existing Documentation

Gather and study existing documentation of the Colloquy of Mobiles.

A comment, a case history, and a plan. Pask, Gordon

Prose, Flowcharts, Schematic Diagram

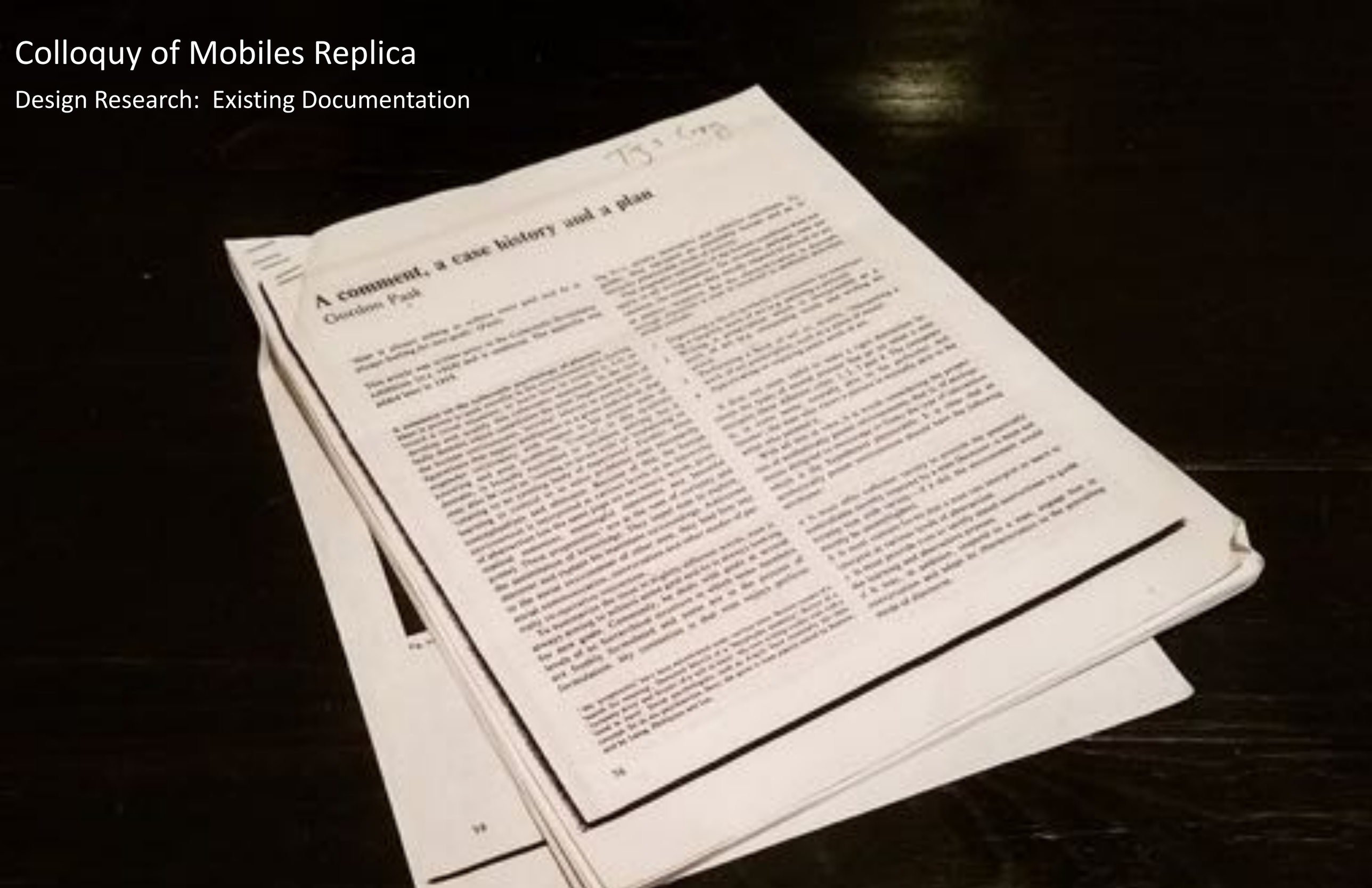
Photographs from archives

Video of installation from archives

Advisory Board Interviews and Correspondence

Colloquy of Mobiles Replica

Design Research: Existing Documentation



Colloquy of Mobiles Replica

Design Research: Existing Documentation

A comment, a case history, and a plan.

electronic parts are largely detailed. It is a socially oriented reactive and adaptive environment. Even in the absence of a human being, entities in the environment communicate with and learn about one another. But a human being can enter the environment and participate, possibly modifying the mode of communication as a result.

To begin with it was necessary to select a structural idiom; preferably (to avoid undue strangeness) an idiom that is accepted within the conventions of art. Rather arbitrarily, I chose to make the communicating entities mobiles and the environment into a community of mobiles. These, however, are powered mobiles, the motion of which is partially determined by instructions from a program (though there are hardwired components as well). They are also provided with computing systems to control their activity.

Next, it was necessary to equip the mobiles with a language in terms of which they can communicate. As a compromise between cogent visual effect and technical convenience, I chose an alphabet of visual signs and audible signs. Each mobile is able to emit and recognize several different colours and slow modulations of light and several different tones and slow modulations of sound. The syntax of the language depends upon interpretation rules built into each mobile (we come to these in a moment). But, as it stands, the language is no more than a code. Communication could be made to occur but only in the trivial sense of an epiphenomenon. To give meaning to the communication, the mobiles must be given a reason for talking to one another and a set of goals to aim for.

Scrutiny of the goal problem reveals the following desiderata (which may also be regarded as, in some sense, prerequisites for a meaningful community of mobiles which has a chance of being an aesthetically potent environment):

1. The goals of the several mobiles should be partially incompatible, so that the mobiles compete with one another.
2. Some of the goals should be incapable of attainment by any one mobile on its own. In order to achieve such a goal, at least a pair of mobiles must co-operate and in order to co-operate, they must communicate with one another.

A plan for an aesthetically potent social environment

The 'colloquy of mobiles' presented at the Cybernetic Serendipity exhibition is completely system-designed and its

Colloquy of Mobiles Replica

Design Research: Existing Documentation

A comment, a case history, and a plan.

3 The main goals of a mobile should be decomposable into sub-goals so that any mobile contains an hierarchical organization.
4 Co-operative interaction must involve main goals and sub-goals so that there are several levels of communication in the system.
5 The pursuit of the lowest level sub-goals should be carried out by autonomously acting programs embedded in each mobile. Whereas selection of these programs depends upon communication mediated feedback, their execution does not. This is one way (incidentally, a biologically important way) of decoupling the mobiles and maintaining their individual integrity.

As designed, there are two sorts of mobiles in the population, say 'male' and 'female'. They are arranged as shown on the plan of figure 34a and the elevation of figure 34b (this is probably the simplest arrangement, since configurations are possible and the size of the community can be enlarged without seriously affecting the design). The male mobile has two 'drives', *O* and *P* (associated with orange- and pure-coloured light) and its drive state is indicated visually by an upper display, *A*. Its main goal is to satisfy (or reduce) the *O* and *P* 'drives' which normally build up over time. It can do so, in the case of *O*, by projecting an intense beam of orange light from its central part, *B*, in such a way that it falls upon receptors in its upper part, *C*; in the case of *P* satisfaction it must project an extensive beam of pure light from *B* in such a way that it falls on receptors in the lower part, *D*.[1] In order to achieve this goal it must elicit the co-operation of a female who, unlike the male, is provided with a vertically positionable reflector capable of taking the beam from *B* and reflecting it back either to *D* or *C*.

First, of course, it must find a female. To do so, the male engages in motions that:

1 Rotate the bar linkage, *Z* and
2 Rotate each male about its point of suspension.

So far as the first motion is concerned, a sort of 'territorial' competition may take place between male I and male II, if their search instructions are in conflict, for example, if I has found a female and wants to remain stationary, but II wants to continue searching. The conflict is resolved[2] by an aggression display (in which the relative power of the males depends upon their drive states). So far as the second motion is concerned, the males are independent (though there is still a sense in which they compete for the available females).

Consider a particular state[3] of any one male, for example, the state in which male I has drive *O* greater than drive *P* and has not found a female to help it. In this case, male I emits out an intermittent directional visual signal which serves to identify it as 'male I' and its desire as 'O satisfaction'. It moves according to (1) and (2) above, further (1) is blocked by male II making a co-operative and receptive female (the females are normally in rotational motion, making much of it would the directional signal fall on the receptor *C* of a female who is willing to co-operate, she produces an identifying sound in synchrony with the intermittent light signal. Male I detects the correlation between the female and his light signal and stops his motion (unless he is prevented from doing so by male II). At this point, he triggers off an autonomous energetic event which consists in shining an intense orange light, for at least a minimum interval, in the direction of the located female. The immediate result is an increase in the *O* drive. However, male I anticipates subsequent reinforcement (which he will achieve if the female behaves appropriately and if the free moving part, C, is appropriately positioned during at least some of this behaviour). Reinforcement, which substantially reduces the *O* drive, is obtained if the *O* goal is satisfied; that is, if orange light falls on the receptor in *C*. Supporting reinforcement occurs, male I emits an identifying sound signal which is received by the co-operating female; the autonomous energetic event is prolonged and the *O* drive is decreased.

The co-operative encounter terminates after a short time if reinforcement does not occur, or if it is externally disrupted. Otherwise, it continues until the drive state of male I is modified so that he aims for a different goal.

[1] I shall not go into the details of the system, for its details are not yet worked out.

[2] The relevant rules are 'upper limit [drive *O* > drive *P* > lower limit', which indicate an *O* satisfaction search; 'upper limit > drive *P* > drive *O* > lower limit' which gives rise to the behaviour 'lower limit > drive *O* and lower limit > drive *P* in which case the male is satisfied and inactive; and 'drive *O* > upper limit and drive *P* > upper limit' which produces a search for either *O* or *P* satisfaction.

Colloquy of Mobiles Replica

Design Research: Existing Documentation

A comment, a case history, and a plan.

It is evident that the achievement of the *O* satisfaction goal involves an hierarchy of sub-goals and that communication in pursuit of these sub-goals takes place at various levels. Further, the selection of a main goal (such as *O* satisfaction) involves a still higher level process. Referring back to the list of *considerata*, we can check that the male members of the mobile community satisfy all of them.

Consider a female: she also has an *O* drive and a *P* drive. Unless both drives are satisfied (when she becomes inert) the female remains and searches for a male. According to her drive state, she is receptive to males offering *C* or *P* cooperation or to both. Suppose that she is looking for *C* cooperation and suppose she encountered male 1 in the state already described: on receipt of his intermittent directional signal, she puts his name 'male 1' and his condition 'O satisfaction' into a short term memory. Next, she emits the correlated sound which he can recognize and expects to receive the 'energetic' beam of orange light. If this does fall on her vertical reflector, *h*, she stops her rotational motion and starts a search, using this reflector, to position the beam on some part of male 1 that will give rise to a reinforcement signal; her goal is to obtain the conjunction of orange light on her reflector and the reinforcement signal from male 1; goal achievement reduces her *O* drive. Her likelihood of achieving this goal in the rather short time allowed for an uninformed encounter, depends upon the vertical reflector search strategy and this in turn depends upon her previous experience (upon what she has learned and placed in a long-term 'memory'). In ignorance of males, her vertical strategy is a haphazard search reflecting the beam up and down. However, if she has previously learned that reinforcement for *O* light comes from reflecting it upwards (at last on a *C* of male 1), then her strategy becomes a limited upwards search. A similar comment applies to *P* experience. Further, not all males are necessarily the same: some may like *O* light on *D* and *P* light on *C*; she can learn that trick also.

In any case the vertical search strategy terminates after a short time (and the rotational search is resumed) if a reinforcement signal is not received from the male.[1] If a signal is received, the vertical search is prolonged, possibly until the female drive state has been modified. The whole process is reconsidered in the accompanying flow-charts. There are five independent systems, three female and two male which are run asynchronously in parallel. The flow-charts of figures 35, 36 and 37 represent a female system and the flow-charts of figures 38 and 39 represent a male system.

This completes[2] our description of the social environment of mobiles.

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, for the mobiles are interacting already and inexplicably define the gambits involved in the process. Further, their community has quite an intriguing organization. At this level alone, the environment has the properties required of an aesthetically potent environment.

But the mobiles produce a complex auditory and visual effect by dint of their interaction. They cannot, of course, interpret these light and sound patterns. But human beings can and it seems reasonable to suppose that they will also aim to achieve patterns that 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.

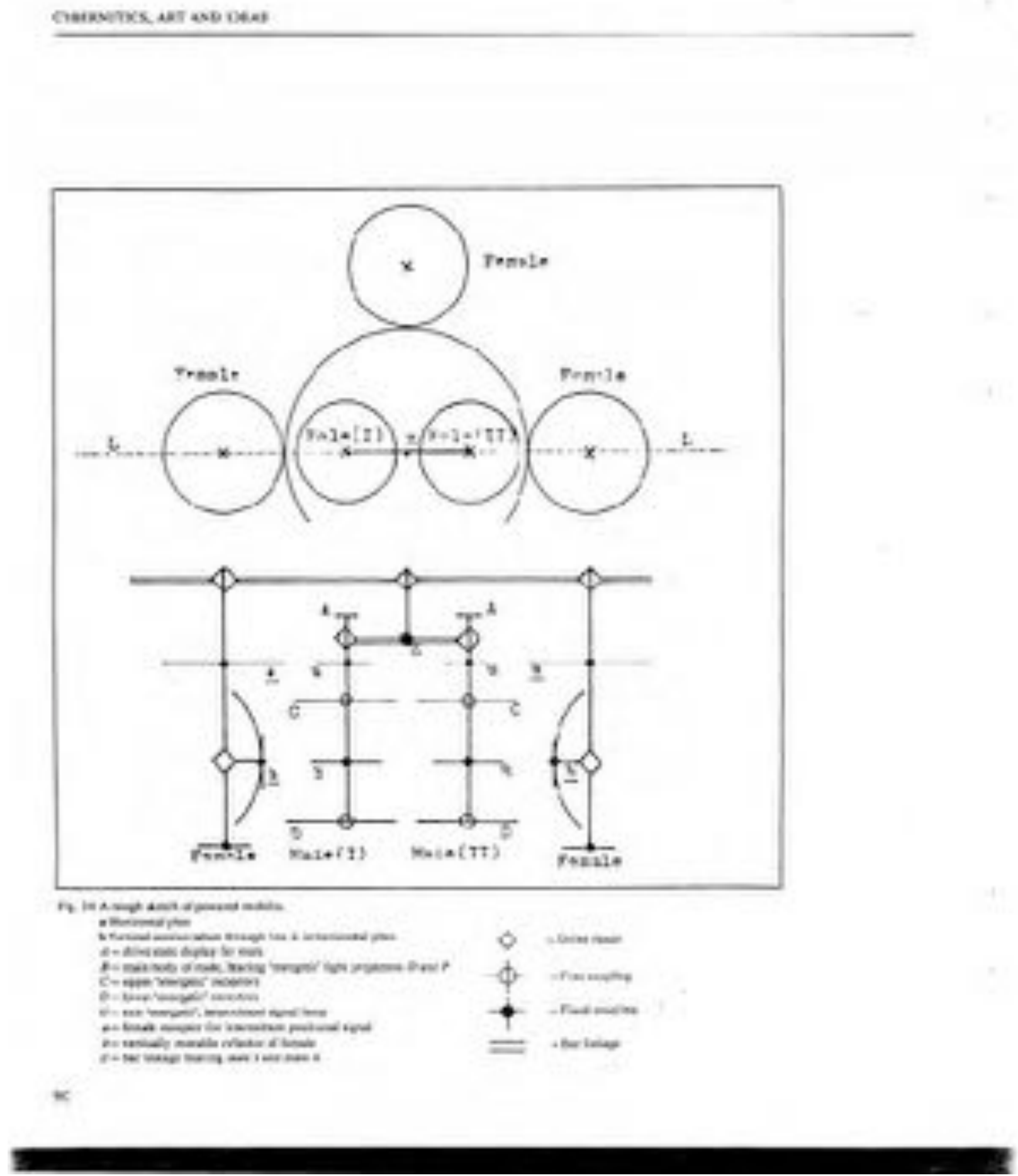
[1] The vertical search in the female form of the asynchronous process.

[2] We have cited special cases. The comment is, however, readily generalized to cover all minimal variations of the mobiles.

Colloquy of Mobiles Replica

Design Research: Existing Documentation

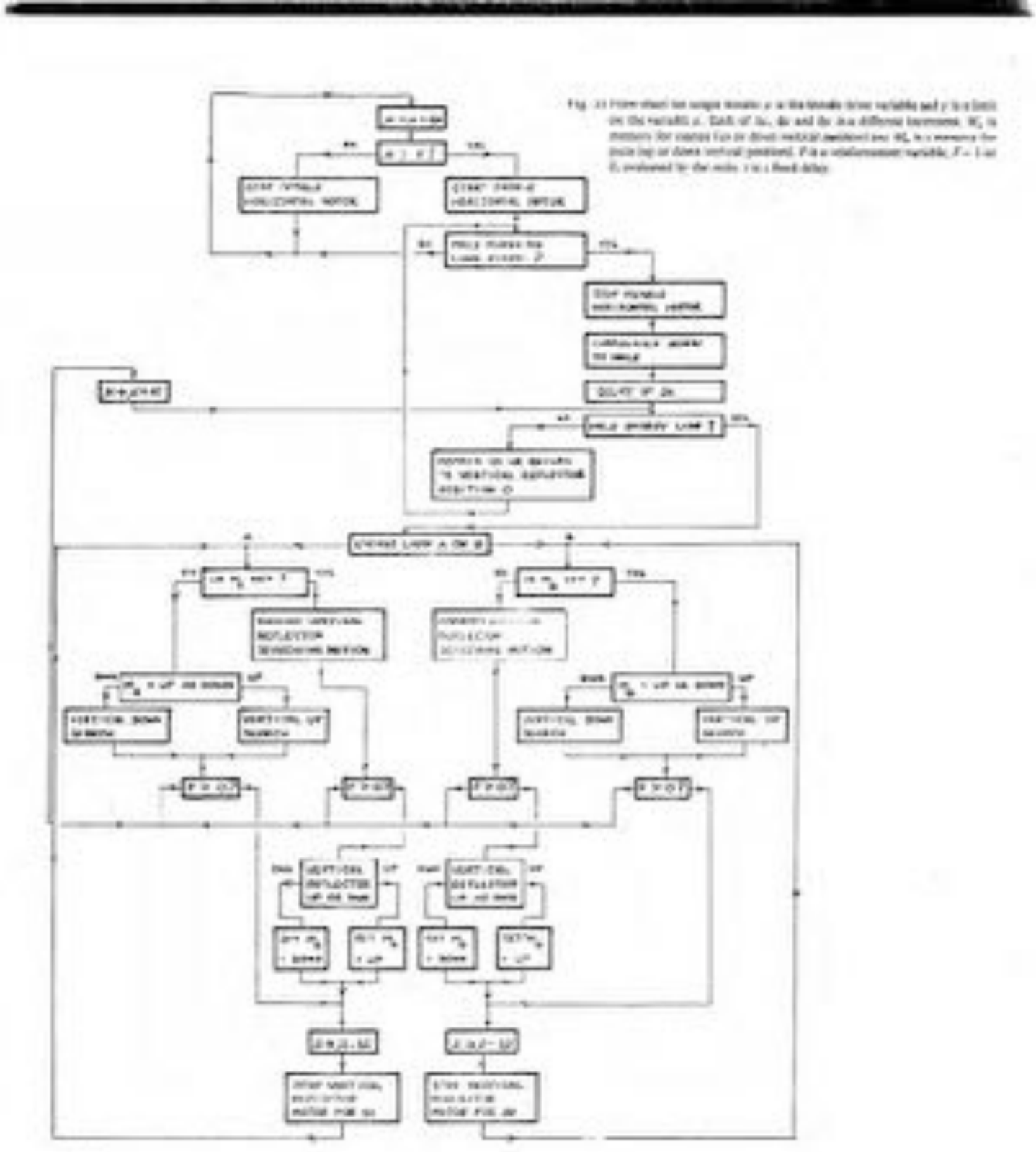
A comment, a case history, and a plan.



Colloquy of Mobiles Replica

Design Research: Existing Documentation

A comment, a case history, and a plan.



Colloquy of Mobiles Replica

Design Research: Existing Documentation

A comment, a case history, and a plan.

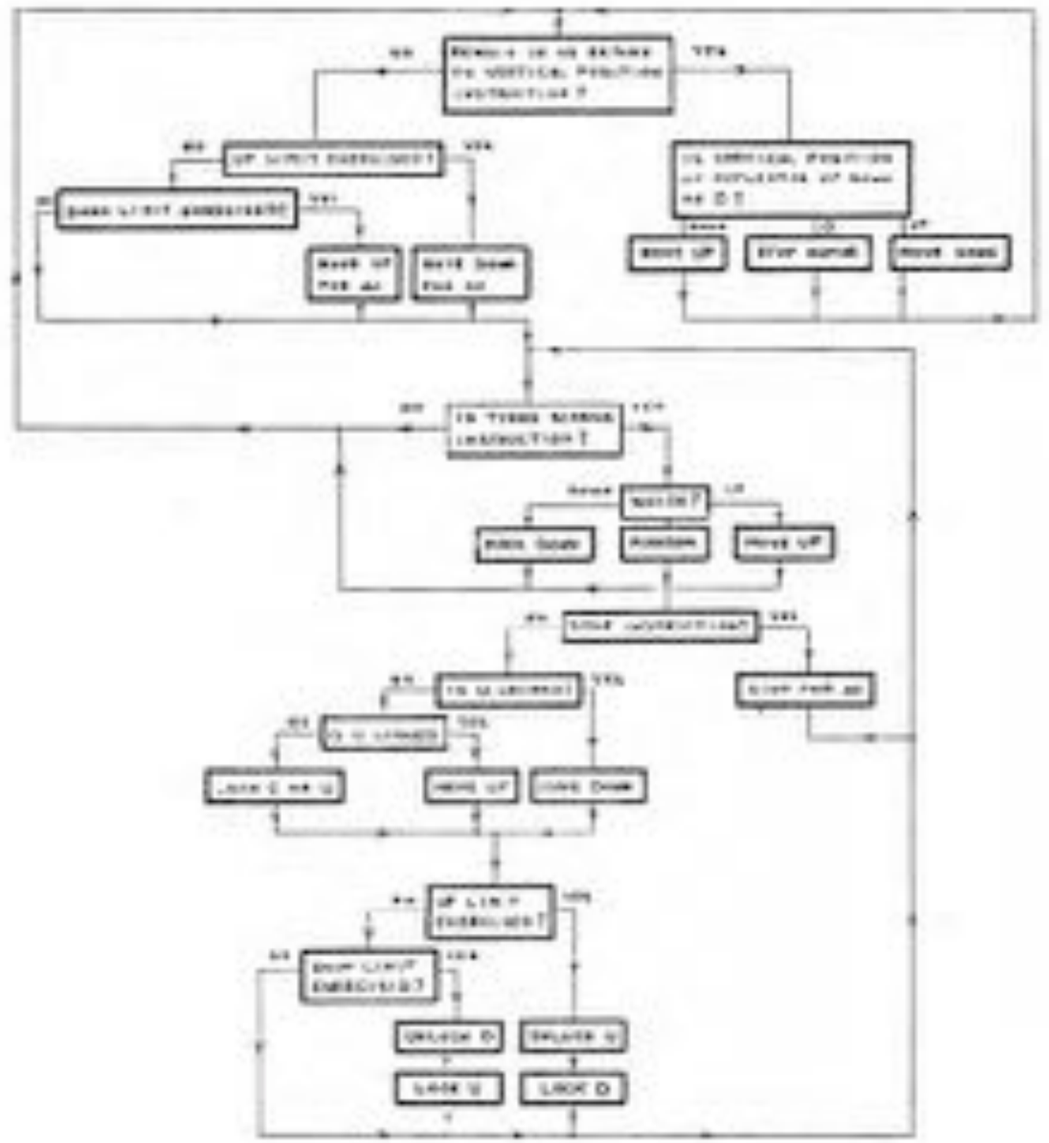
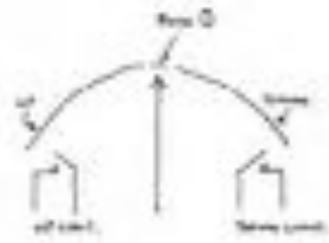


Fig. [illegible] Female vertical deflector sub-system. Flow-chart for control of vertical motion. This sub-system receives instructions from the main female programme, alternations from a pair of reed switches, and a protective relaying switch on the vertical deflector motor. D and U are sink relays.



Colloquy of Mobiles Replica

Design Research: Existing Documentation

A comment, a case history, and a plan.

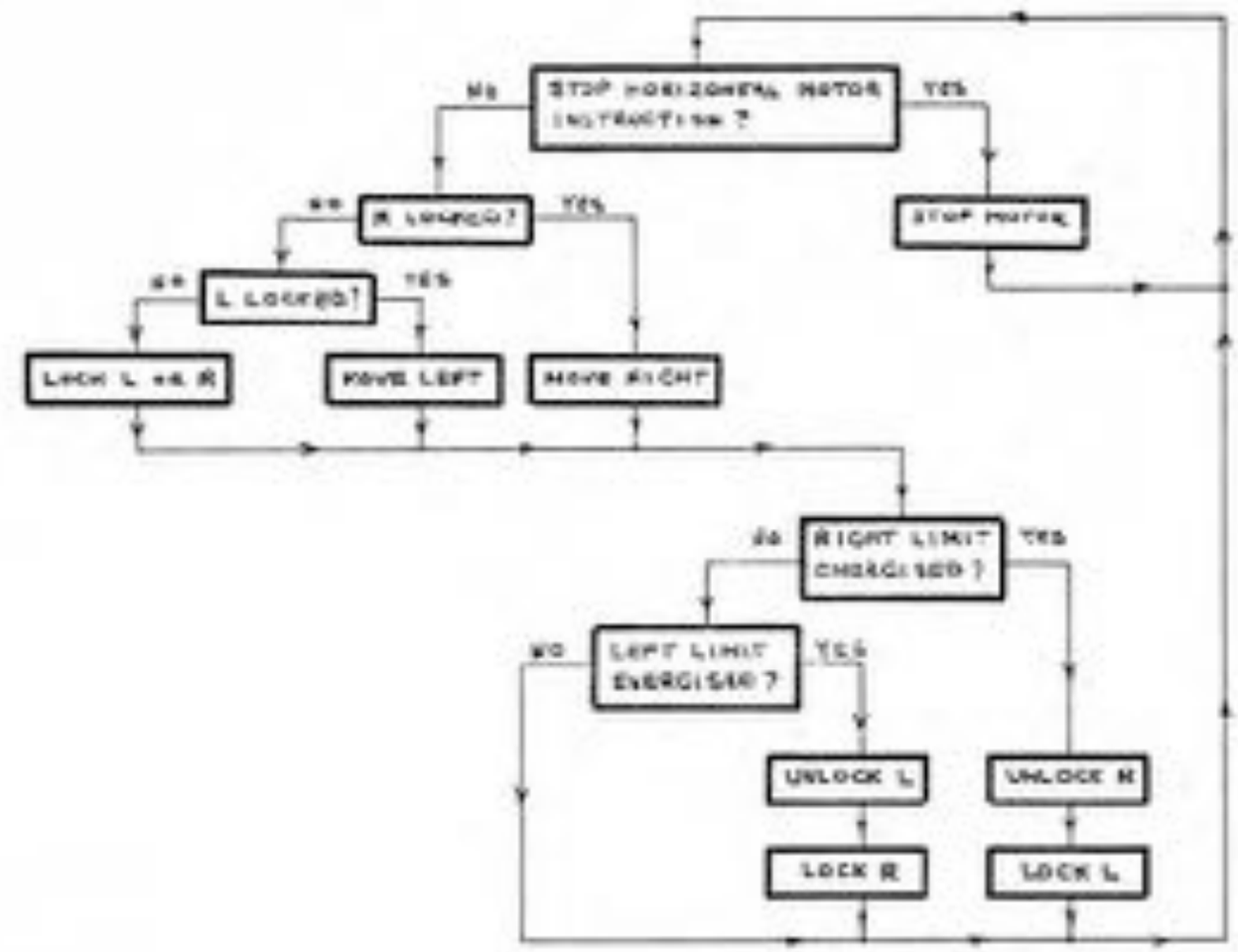
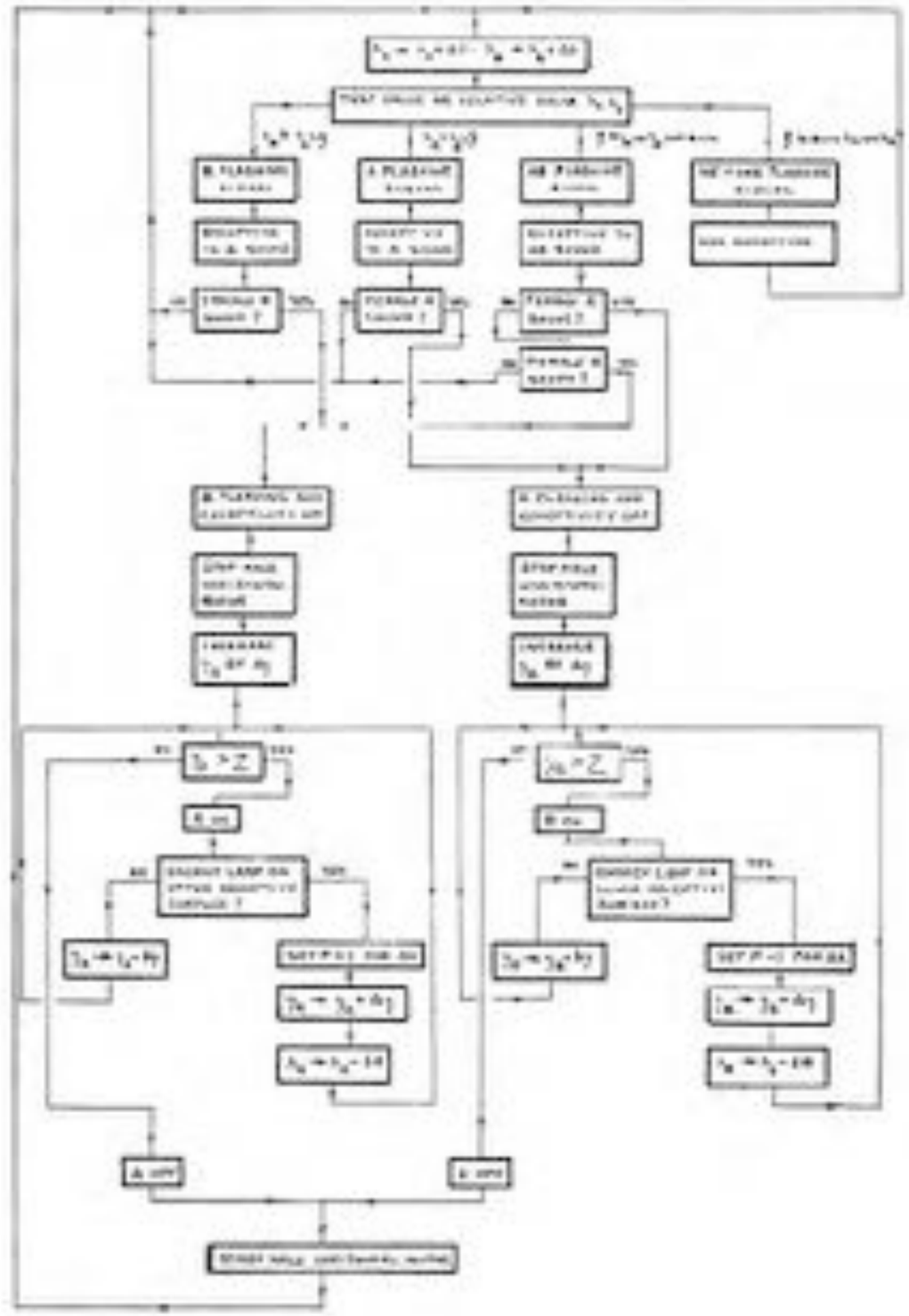


Fig. 17 Flow-chart for Senglo horizontal control sub-system. This sub-system accepts horizontal step instructions from the main Senglo sub-system, accompanied by no-right and left base signals. R and L = Lock relays.

Colloquy of Mobiles Replica

Design Research: Existing Documentation

A comment, a case history, and a plan.



Colloquy of Mobiles Replica

Design Research: Existing Documentation

A comment, a case history, and a plan.

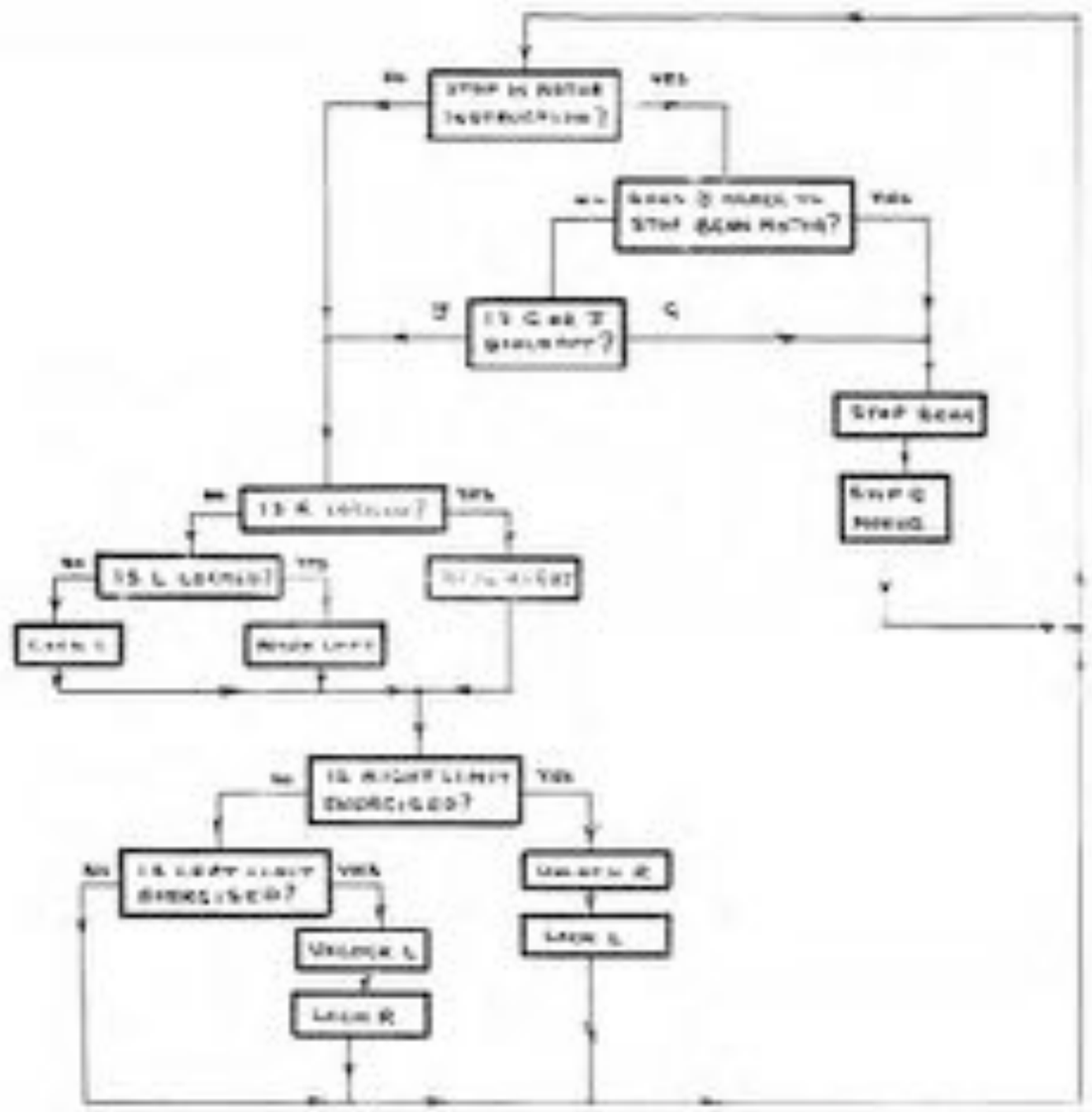


Fig. 39 Max's horizontal axis system. The main horizontal motor (H motor) for each main actuator, left and right limit signals. There are two routes, G and L, into flowchart as for G only. G and L are mounted on a common beam driven by a linear motor. The normal route for the H motor (G or L) and the beam motor is to be in motion. Their flags are stopped only when a stop instruction is effective. The beam motor, which plays a similar flow chart, is normally in quasi random motion scanning the entire work.

Fig. 40 A view of the 'colloquy of mobiles'

Colloquy of Mobiles Replica

Design Research: Existing Documentation Synthesis

Recreate the documents in contemporary form, checking for contradictions and errors.

Photographs from archives

- Process photos to extract details and evidence of original assembly.

Video of installation from archives

- Process to improve legibility and identify as built behavior of original assembly

A comment, a case history, and a plan

- Rewrite prose in contemporary scenario form
- Redraw diagram correcting inconsistencies
- Redraw flowcharts correcting inconsistencies
- Create contemporary design communication documents bridging prose and flowcharts
- Model and test algorithm to address unknown elements [like rates of change]

Advisory Board Interviews and Correspondence

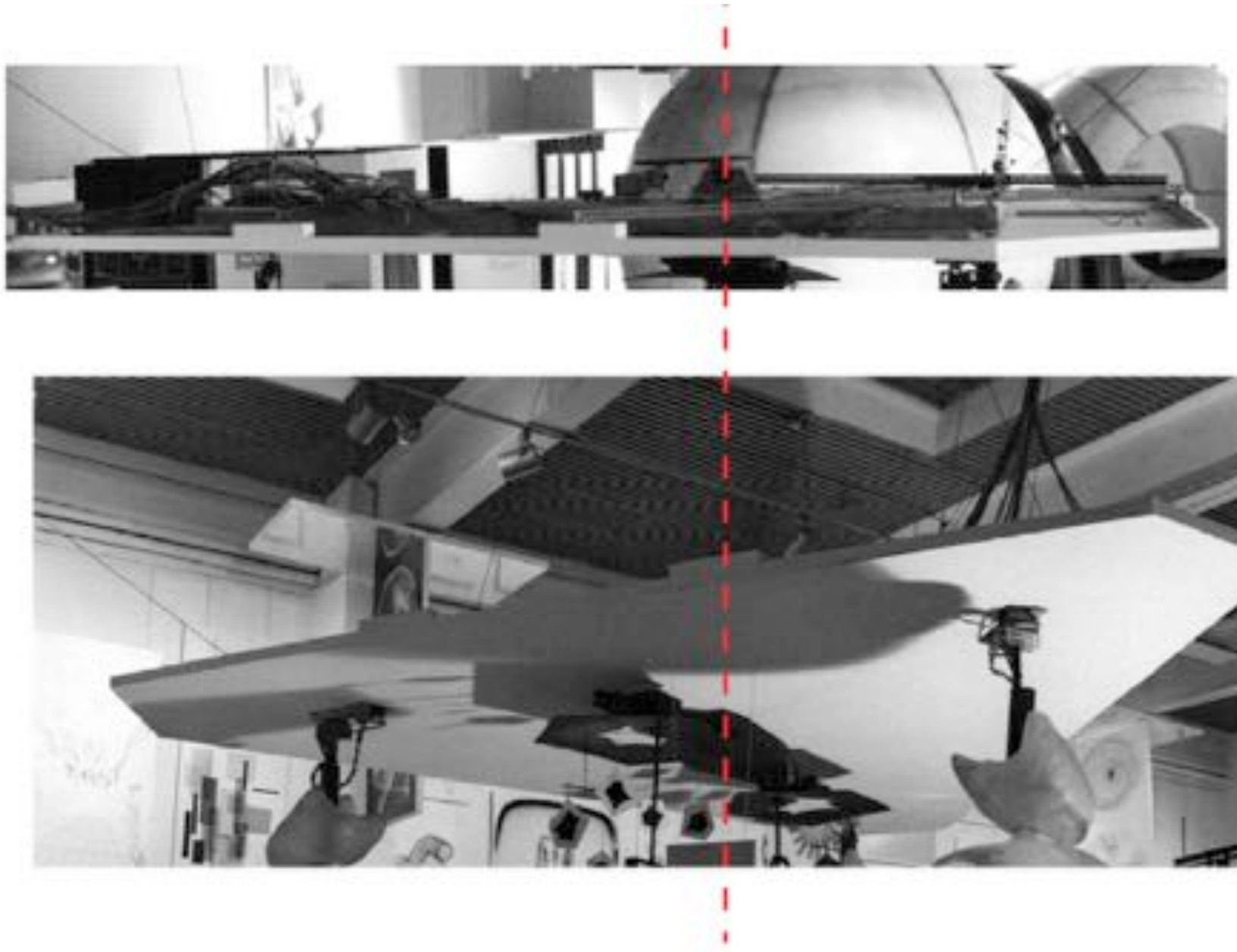
- Validate assumptions and probe open questions

Colloquy of Mobiles Replica

Design Research: Existing Documentation Synthesis Photos of Installation

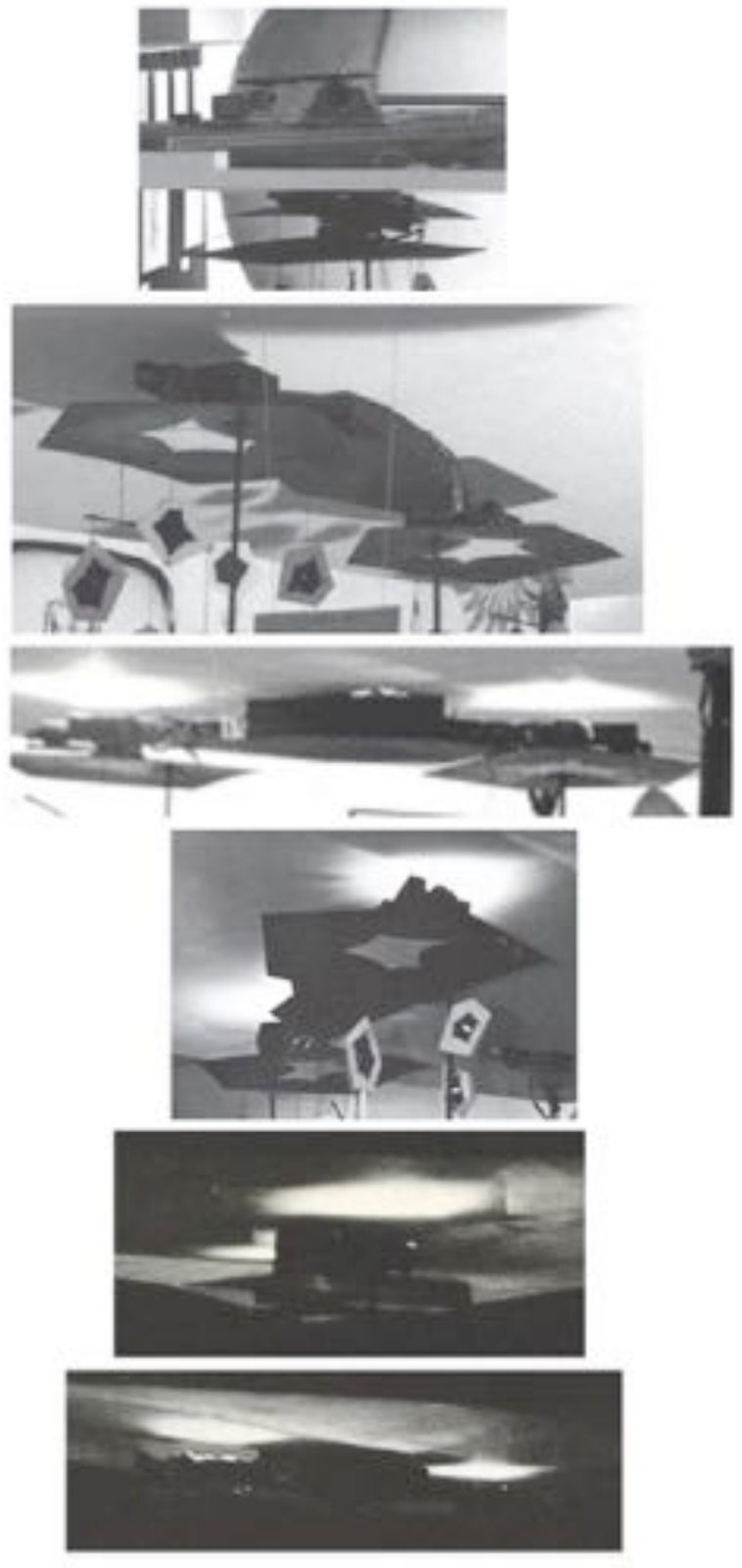
Colloquy of Mobiles Replica

Design Research: Existing Documentation Synthesis Photos of Plinth



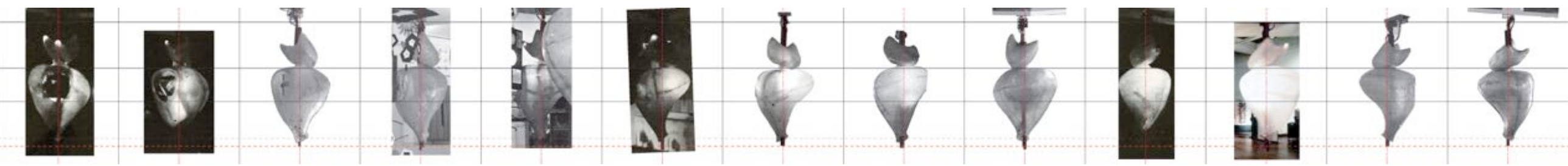
Colloquy of Mobiles Replica

Design Research: Existing Documentation Synthesis Photos of Bar



Colloquy of Mobiles Replica

Design Research: Existing Documentation Synthesis Photos of Female



Colloquy of Mobiles Replica

Design Research: Existing Documentation Synthesis Photos of Female

Colloquy of Mobiles Replica

Design Research: Existing Documentation Synthesis Photos of Male

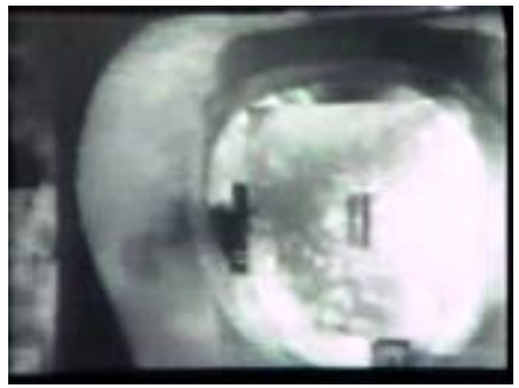
Colloquy of Mobiles Replica

Design Research: Existing Documentation Synthesis Photos of Male

Colloquy of Mobiles Replica

Design Research: Existing Documentation Synthesis

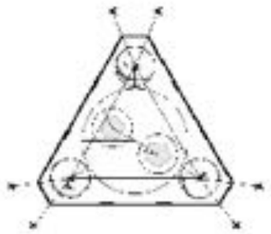
Video of installation from archives > Process to improve legibility and identify as built behavior of original assembly



Colloquy of Mobiles Replica

Design Research: Existing Documentation Synthesis Redraw Diagram Correcting Inconsistencies

…



The as built geometry for the installation is a truncated equilateral triangle

Male drive state display ***A*** illuminates underside of plinth

The Male non-’energetic’ intermittent signal lamp ***U*** (***U*** in key***, u*** in diagram) is in the center of main body ***B***

The Female receptor for the intermittent positional signal ***a*** is in the center of reflector ***b***

The Male upper and lower ‘energetic’ receptors are in the small forms suspended above and below the main body ***B***

The axis of rotation for the vertically movable reflector ***b*** of female is horizontal through center of reflector

No figures are fixed to the ground

All figures are suspended from plinth

Missing drive state display for female

Missing upper female light displays

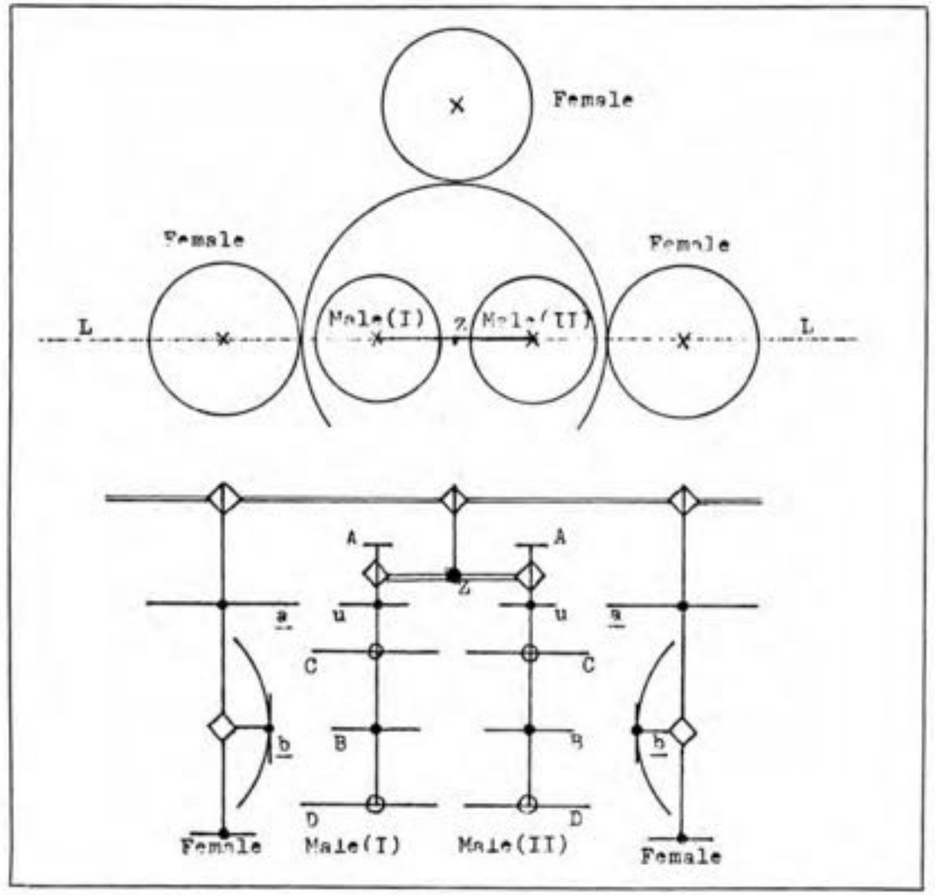


Fig. 34 A rough sketch of powered mobiles.
a Horizontal plan
b Vertical section taken through line *L* in horizontal plan.
A = drive state display for male
B = main body of male, bearing 'energetic' light projectors *O* and *P*
C = upper 'energetic' receptors
D = lower 'energetic' receptors
U = non-'energetic', 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

Colloquy of Mobiles Replica

Design Research: Existing Documentation Synthesis Redraw Diagram Correcting Inconsistencies

…

The as built geometry for the installation is a truncated equilateral triangle

Male drive state display ***A*** illuminates underside of plinth

The Male non-'energetic' intermittent signal lamp ***U*** (***U*** in key***, u*** in diagram) is in the center of main body ***B***

The Female receptor for the intermittent positional signal ***a*** is in the center of reflector ***b***

The Male upper and lower 'energetic' receptors are in the small forms suspended above and below the main body ***B***

The axis of rotation for the vertically movable reflector ***b*** of female is horizontal through center of reflector

No figures are fixed to the ground

All figures are suspended from plinth

Missing drive state display for female

Missing upper female light displays

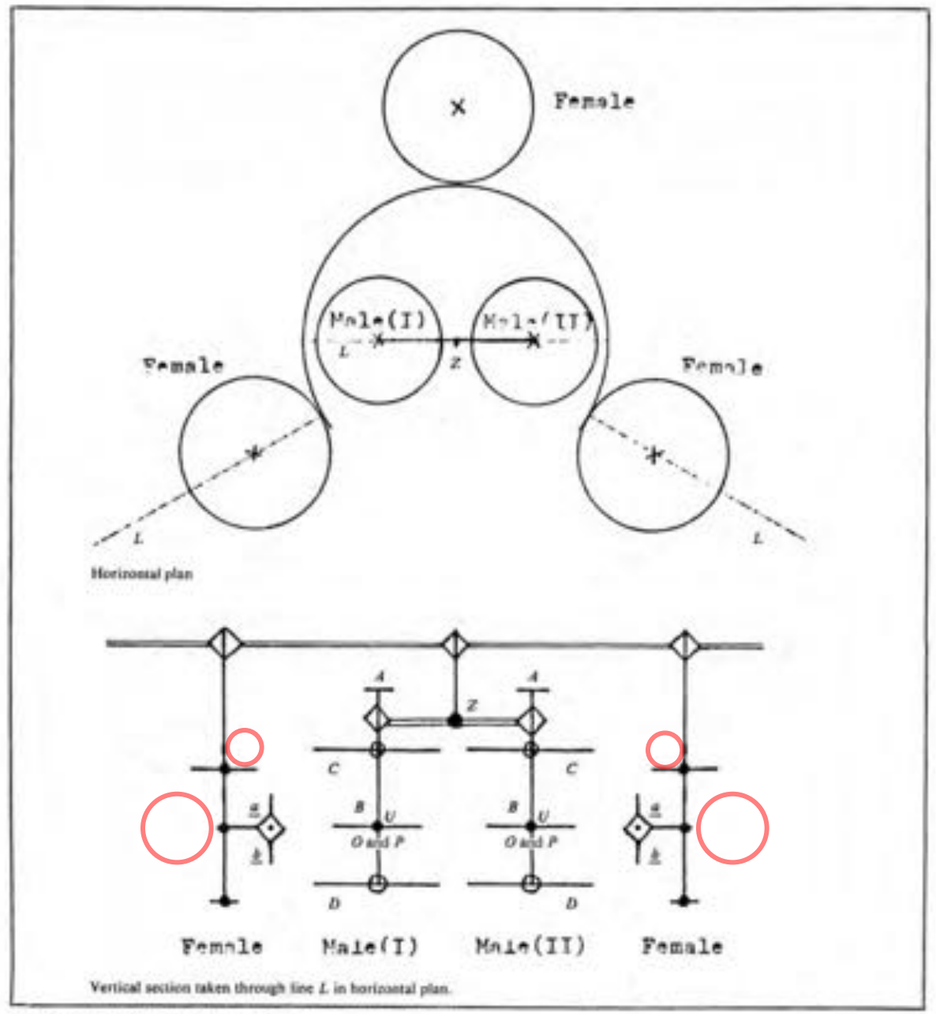


Fig. 34 A rough sketch of powered mobiles.

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

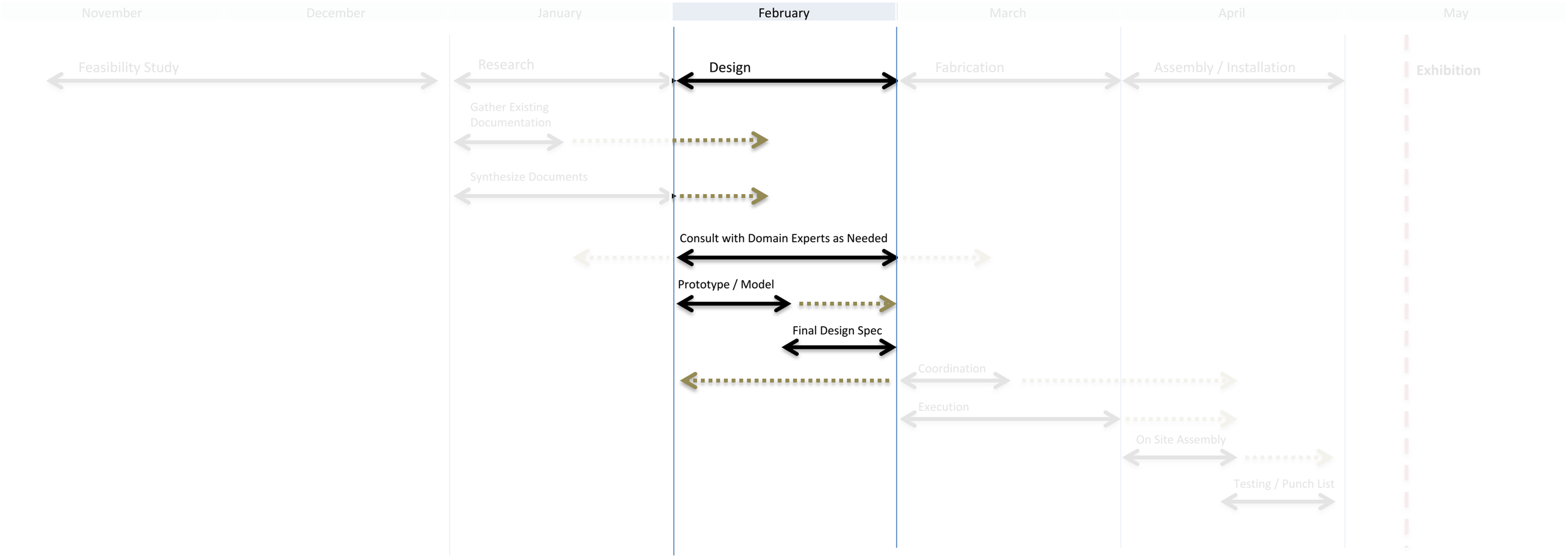
Colloquy of Mobiles Replica

Design Development

Colloquy of Mobiles Replica

Design Development: Project Phases and Schedule

Feasibility Study	Research		**Design**			Fabrication		Assembly / Installation		Exhibition / Service Life Agreement
	Gather Existing Documentation	Synthesize Documents	Consult with Domain Experts as Needed	Prototype / Model	Final Design Spec	Coordination	Execution	On Site Assembly	Testing / Punch List	Continued Support



Colloquy of Mobiles Replica

Design Development: Consult with Domain Experts

Colloquy of Mobiles Replica

Design Development: Consult with Domain Experts

Project Components

Armature	CCS Artists and Fabricators, CCS Building Operators
Mechanics	IIT Robotics Expert on Motors and Controllers, T McLeish, and CCS Faculty
Sensing	T McLeish and CCS Faculty
Actuation	IIT Robotics Expert on Motors and Controllers, T McLeish, and CCS Faculty
Computation	T McLeish and CCS Faculty
Communication	T McLeish, CCS Faculty, and CCS IT Stakeholders
Wiring Harness	T McLeish, CCS Faculty, CCS IT Stakeholders, and CCS Building Operators
Software	T McLeish and CCS Faculty

Patrick Karnia

Chido Johnson
Neil
Steve
Dan
Anne
Michael Evans
Dexter
Leith
Nikki
80/20
Andrew Schachman

Colloquy of Mobiles Replica

Design Development: Consult with Domain Expert Leith Campbell

Colloquy of Mobiles Replica

Design Development: Consult with Domain Expert Chido Johnson

Colloquy of Mobiles Replica

Design Development: Consult with Domain Experts Neil and Steve

Colloquy of Mobiles Replica

Design Development: Prototype / Model

Colloquy of Mobiles Replica

Design Development: Prototype / Model

Prototyping Responsive Environment Elements to Recreate Colloquy of Mobiles system modules using available technologies

Installation Elements			
Component	**Description**	**Potential Materials**	**Prototype/Model**
Armature	the non-digital/electronic components of the installation responsible for structure and visual aesthetics of - the figural components of the piece, the mechanical components [actuation], sensing, and the computational hardware [brains]	Structure: Aluminium Strut, unistrut, perforated angle Plinth Surface: Fabric, foamcore, thermoplastic, Figure Composition: Fiberglass, resin impregnated fabric, thermoplastic	Study scale and form of plinth Study scale and form of female figure Study scale and form of male figure
Mechanics	the actuation components of the installation that enable movement of the sculptural elements	12v/24v Motors and Servos, motor control boards, gearbox, pulley, belts	Study control and torque relative of motors under load due to weight of figures
Wiring Harness	The components of the system that deliver power and signal [if necessary]to the distributed sensing/actuation/and computation components	DC wiring, enclosure	Study aesthetics of wiring Study transmission across pivoting characters
Sensing	The electromechanical components of the installation that enable the sensing of [at least] light	photoresistor, microphone, spectral analysis, limiit switch thermal imaging device, photodiode, microphone, CO2 sensing, etc.	Study light sensing in ambient conditions Study reflected light sensing in ambient conditions Study sound emitting + sensing in ambient conditions
Actuation	The electromechanical components of the installation that enable the generation of [at least] light	LED, incandescent light, speaker	Study movement of mirror Study movement of Female Study movement of Male Study display lights
Computation	The devices that receive input from sensing and generate output to deliver to actuators via communications protocol, as well as communicate with other computational entities.	Microelectronic computers i.e arduino, electron, raspberry pi, intel edison, TI launchpad, LittleBits, etc.	Study
Communication	The means of communication amongst computational components	antennae, wiring, communications protocol i.e. 3G, WIFI, hardwired, etc.	Study communication protocol appropriate for system considering distance, resistance, latency,
Software	The logic that runs on the computational platform that determines installation behavior and interaction with installation participants both human and machine.	Programming language, development tools, API/Libraries used to communicate with hardware	Study algorithm and implement for analysis

Colloquy of Mobiles Replica

Design Development: Prototype / Model Armature

Colloquy of Mobiles Replica

Design Development: Prototype / Model Armature

Build prototypes of physical components recreating Colloquy of Mobiles forms and materials to address the following issues.

Plinth

- Scale — CAD Model rendering photo match with original photos and videos, scale model
- Structure — CAD Model, consult with domain experts, consult with CCS building ops
- Skin — Materials research with domain experts, material samples, material mockup

Female

- Scale — CAD Model rendering photo match with original photos and videos, scale model
- Structure — CAD Model, consult with domain experts
- Shells — Materials research with domain experts, material samples, material mockup
- Illumination — Materials research with domain experts, material samples, material mockup

Male

- Scale — CAD Model rendering photo match with original photos and videos, scale model
- Structure — CAD Model, consult with domain experts
- Materials — Materials research with domain experts, material samples, material mockup
- Illumination — Materials research with domain experts, material samples, material mockup

Colloquy of Mobiles Replica

Design Development: Prototype / Model Armature

…

The as built geometry for the installation is a truncated equilateral triangle

Male drive state display ***A*** illuminates underside of plinth

The Male non-’energetic’ intermittent signal lamp ***U*** (***U*** in key***, u*** in diagram) is in the center of main body ***B***

The Female receptor for the intermittent positional signal ***a*** is in the center of reflector ***b***

The Male upper and lower ‘energetic’ receptors are in the small forms suspended above and below the main body ***B***

The axis of rotation for the vertically movable reflector ***b*** of female is horizontal through center of reflector

No figures are fixed to the ground

All figures are suspended from plinth

Missing upper female light displays

Missing drive state display for female

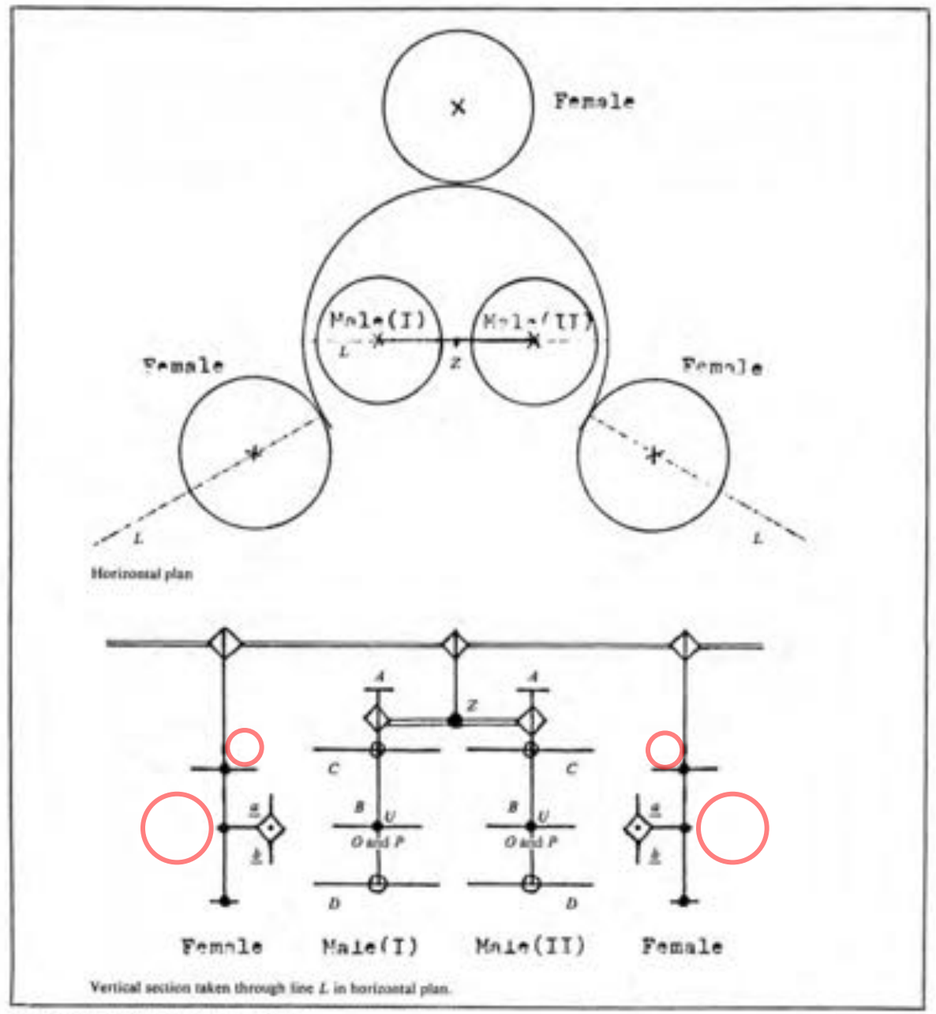


Fig. 34 A rough sketch of powered mobiles.

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

Colloquy of Mobiles Replica

Design Development: Prototype / Model Armature Full Scale Replica Photo Match with Existing Photos

Dimensionally accurate CAD
Model with parametric
dimensions and interactivity

Colloquy of Mobiles Replica

Design Development: Prototype / Model Armature Full Scale Replica Photo Match with Existing Photos

Dimensionally accurate CAD Model with parametric dimensions and interactivity

Colloquy of Mobiles Replica

Design Development: Prototype / Model Armature Full Scale Replica Photo Match with Existing

Dimensionally accurate
Model with parametric
dimensions and interac

Colloquy of Mobiles Replica

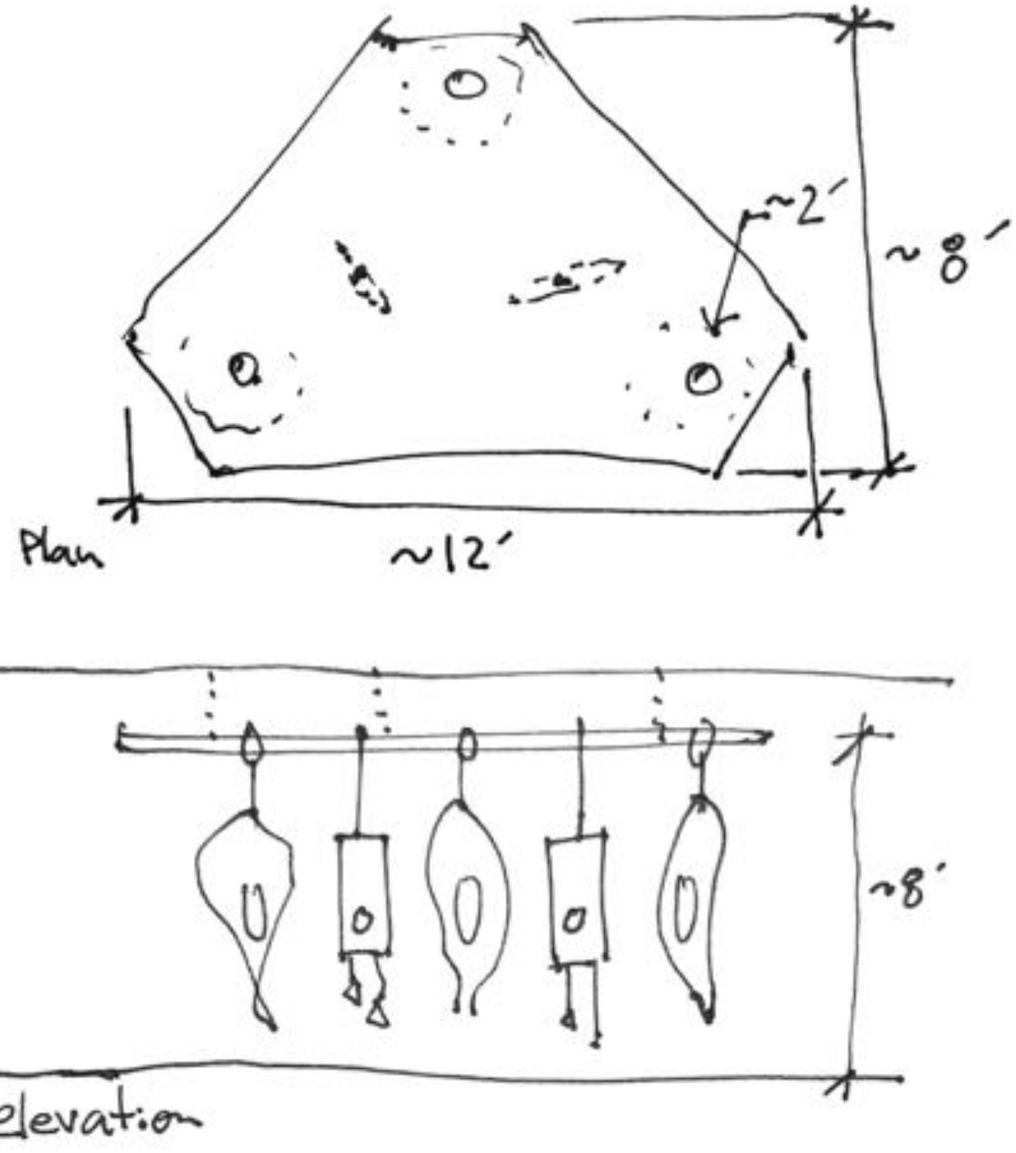
Design Development: Prototype / Model Armature Full Scale Replica Photo Match with Existing Photos

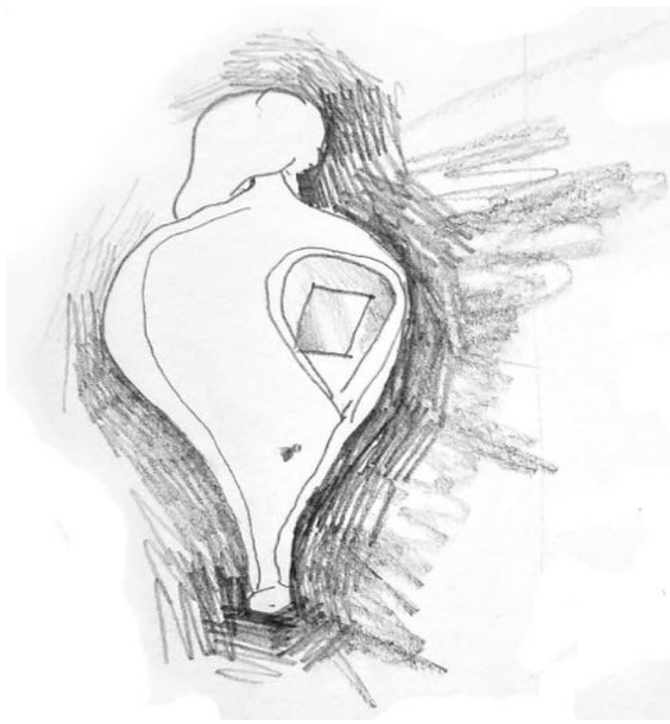
Dimensionally accurate CAD
Model with parametric
dimensions and interactivity

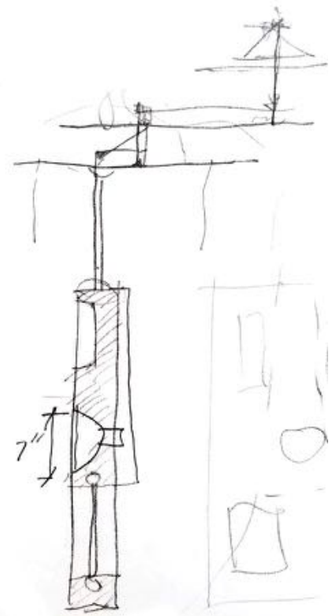
Colloquy of Mobiles Replica

Design Development: Prototype / Model Armature Full Scale Replica

…





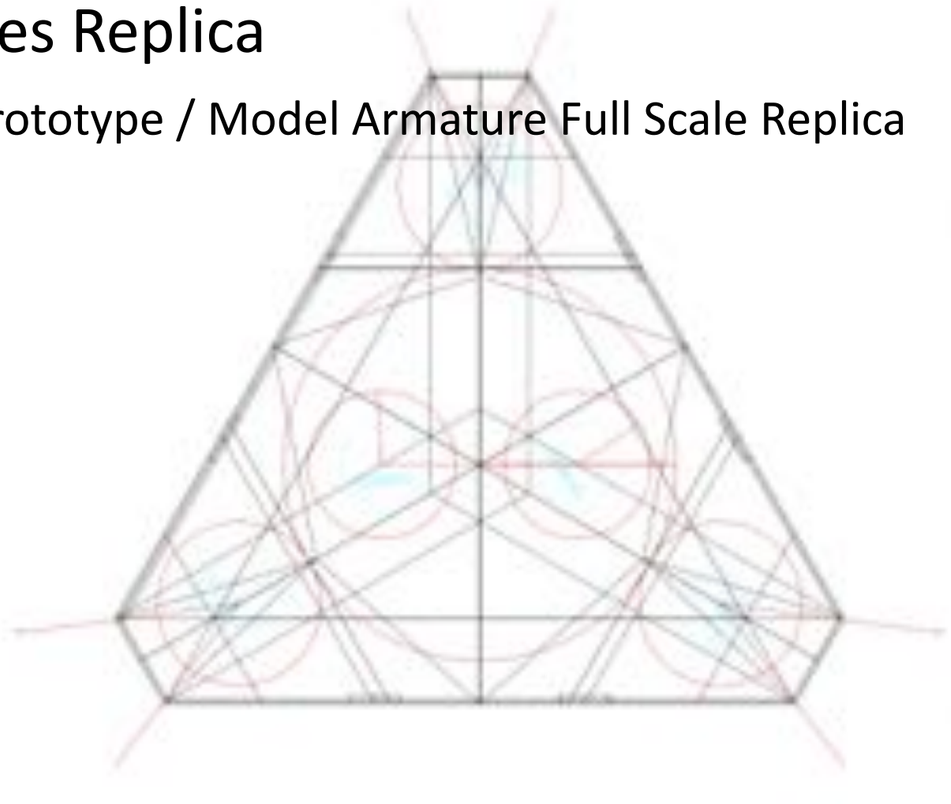


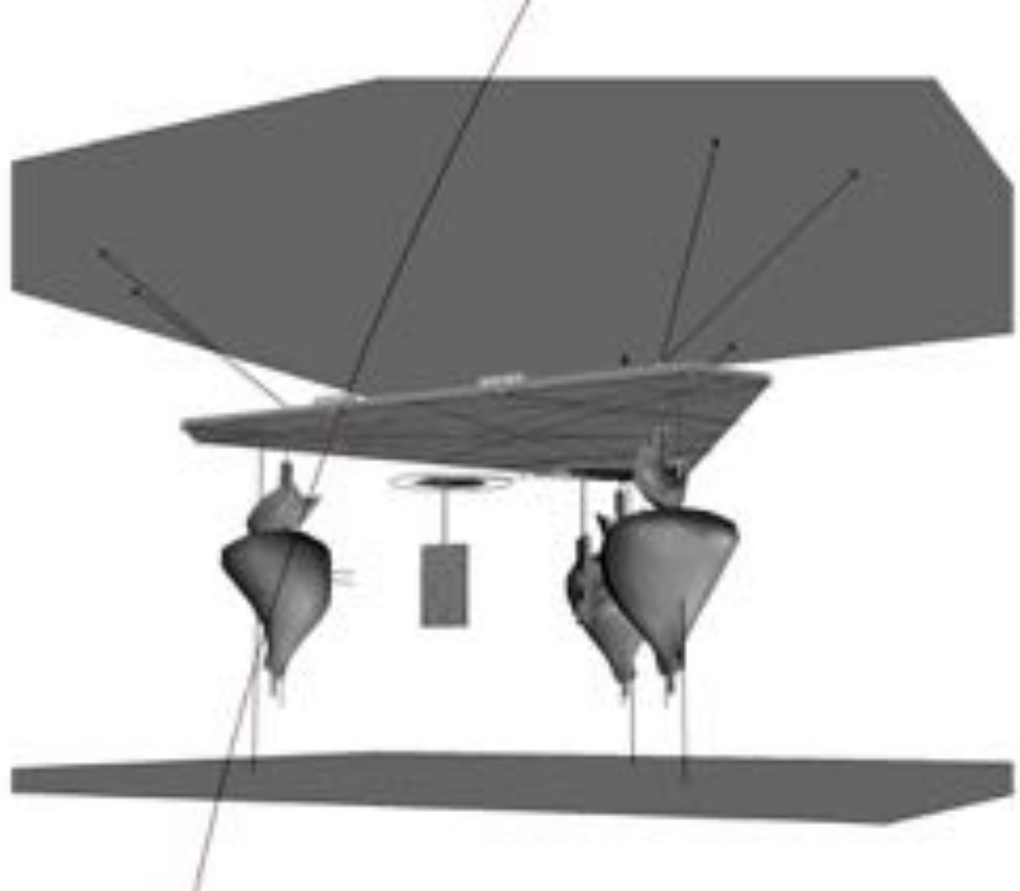
Colloquy of Mobiles Replica

Design Development: Prototype / Model Armature Full Scale Replica

"The Colloquy covered a floor area of 15 x 12 feet (5 x 4 metres) and consisted of five powered mobiles suspended from powered beams 11 feet (3.75 metres) above the ground. It was therefore big enough for people to walk into and interact with. It was intended for operation in the dark or under fairly dim lighting conditions."

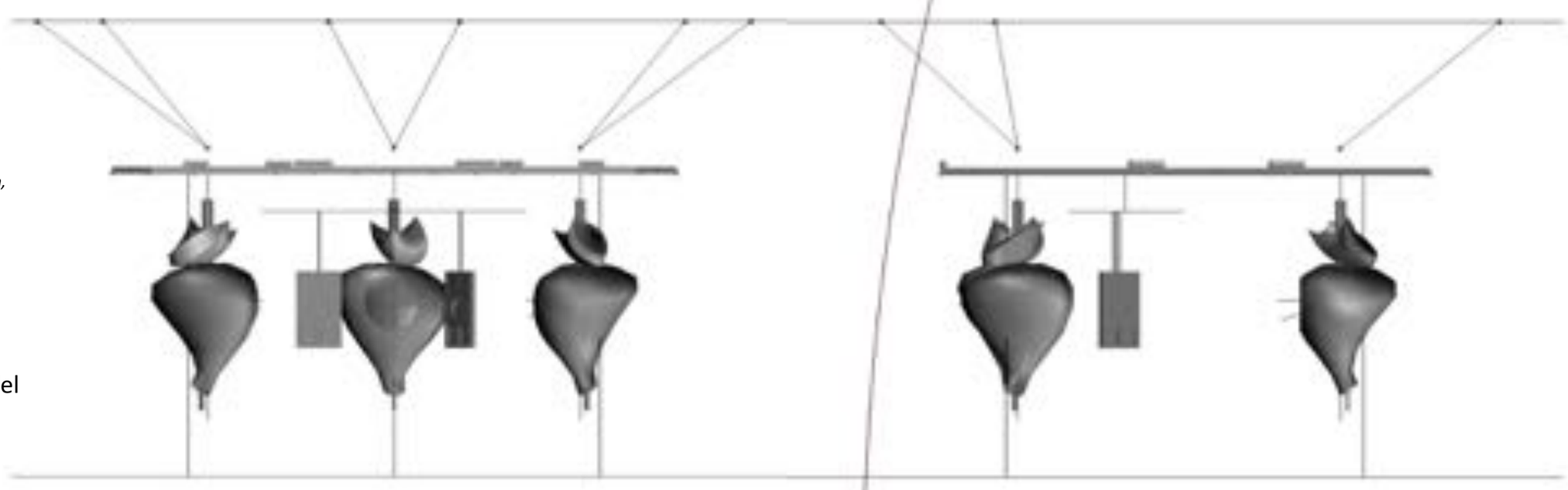
-MICRO MAN: Computers *and the Evolution of Consciousness, Dr. Gordon Pask with Susan Curran, 1982*





"…all the mobiles were physically identical,…"

--MICRO MAN: Computers *and the Evolution of Consciousness, Dr. Gordon Pask with Susan Curran, 1982*



Dimensionally accurate CAD Model with parametric dimensions and interactivity

Colloquy of Mobiles Replica

Design Development: Prototype / Model Structure

mounting plates for servos
page 627-643
http://catalogs.8020.net/app.php?RelId=6.7.0.5.2&bookcode=egt13flx

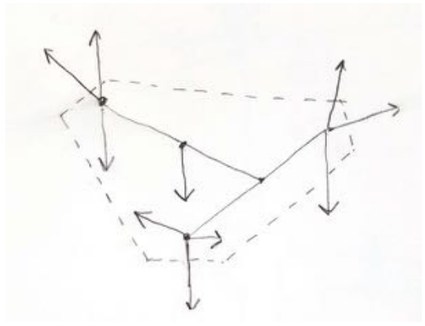
We also can custom make you a part.

contact one of our distributors to help.
They house our design and technical staff
https://www.8020.net/distributor-lookup-results?zip=48202

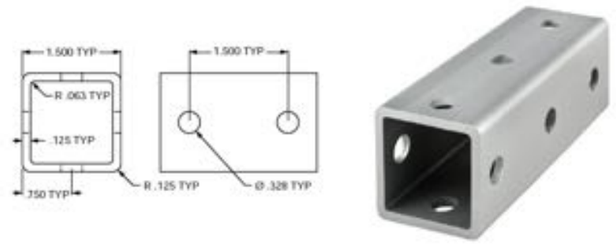
http://neffautomation.com/branch-locations/

structural data on assemblies and profiles
https://8020.net/university-tslot

Section	lb/in	Structural Length	Total Weight
1545	0.2927	219.779455	64.32945
1030	0.1112	219.779455	24.43948



Internal Forces

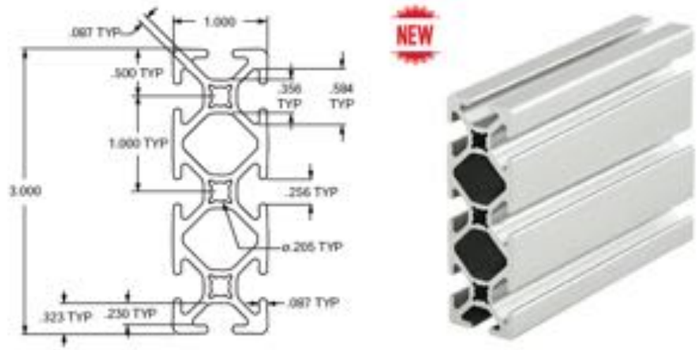


Part No.	Series	Stock Length	Material	Grade	Finish	Moment of Inertia	Surface Area	Yield Strength	Modulus of Elasticity	Weight
6000 *	15	180" or 150"	Aluminum	6105-T5	Clear Anodize #204-R1	--	0.6775 in.²	35,000 psi	10,200,000 lb / in.²	0.0660 lb / in.
6101-Black-FB		per inch			Black Anodize					

* The above profiles are sold per inch or stock length.

Standard Machining Services

Service No.	Series	Service Description	Reference Page
7010	15	Cut to Length	847
7245	15	Access Hole	858



Part No.	Series	Stock Length	Material	Grade	Finish	Drop Lock	Moment of Inertia	Surface Area	Yield Strength	Modulus of Elasticity	Weight
1030-S *	15	144", 342"	Aluminum	6105-T5	Clear Anodize #204-R1	2"	Ix = 0.126"⁴ Iy = 0.062"⁴	1.131 in.²	35,000 psi	10,200,000 lb / in.²	0.1101 lb. / in.
1030-S-Black-FB		per inch			Black Anodize						

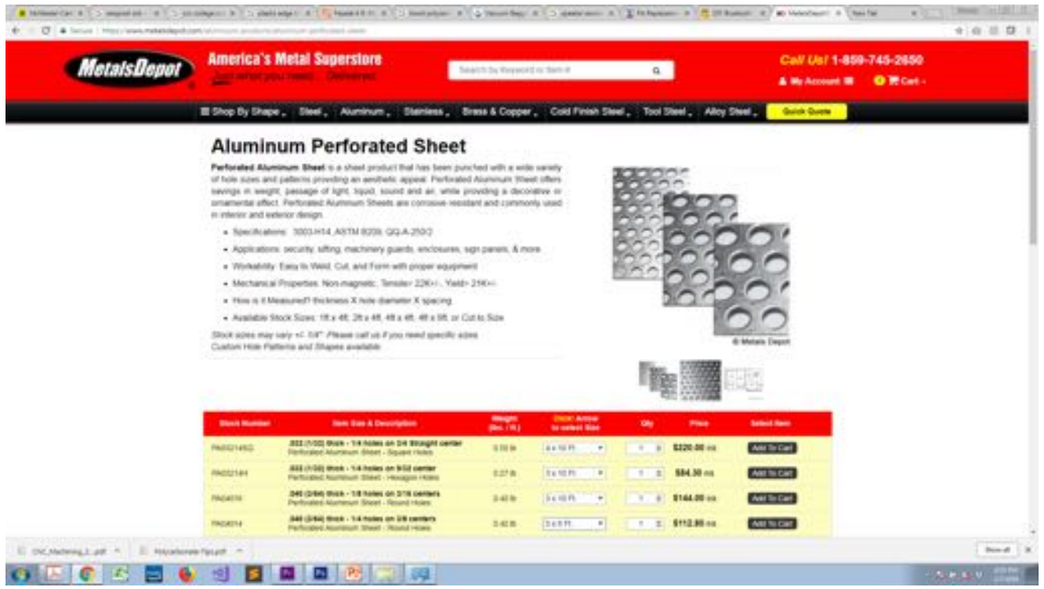
* The above profiles are sold per inch or stock length.

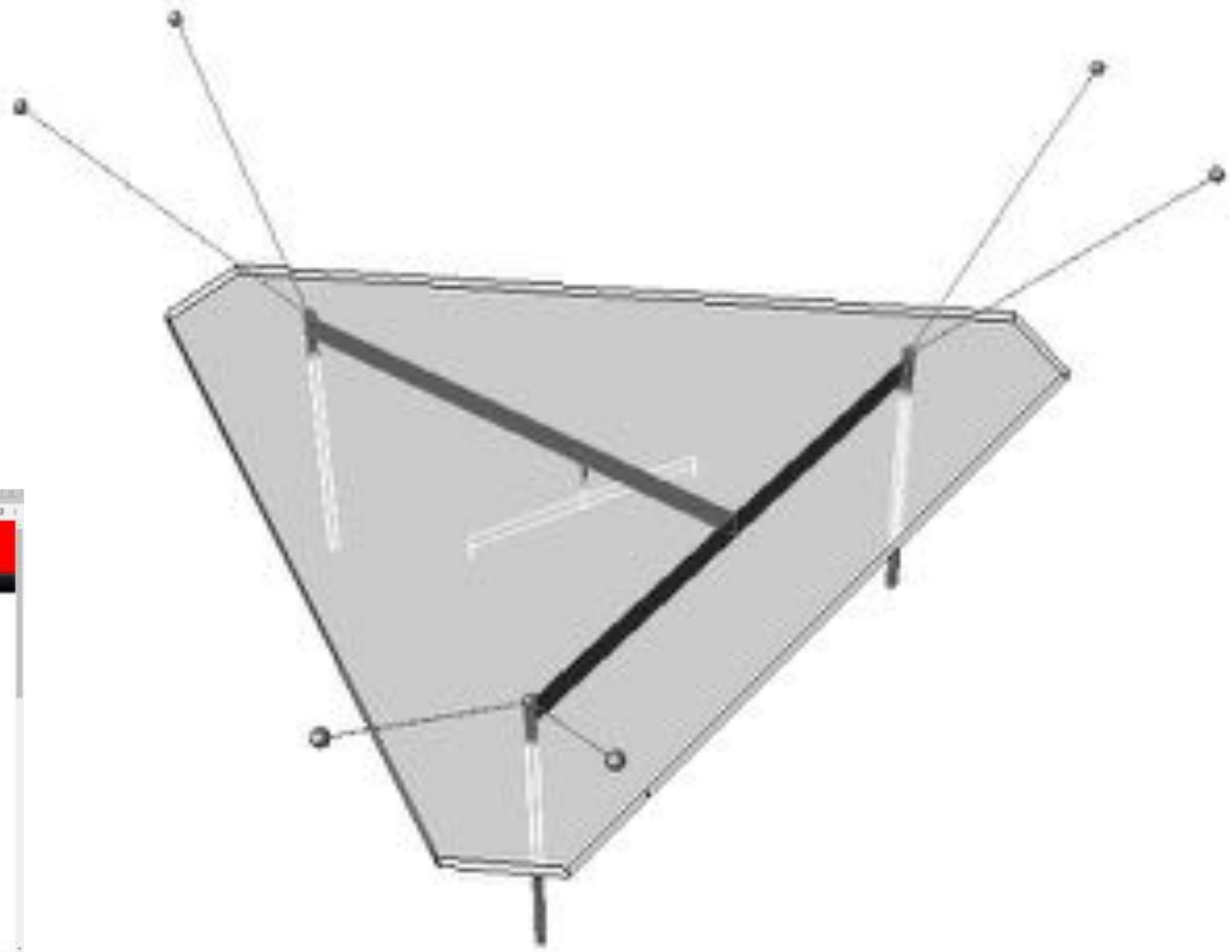
Colloquy of Mobiles Replica

Design Development: Prototype / Model Plinth

Plinth surface concerns

- Fire safety
- Weight
- Structural Stability





Plinth Surface from Above

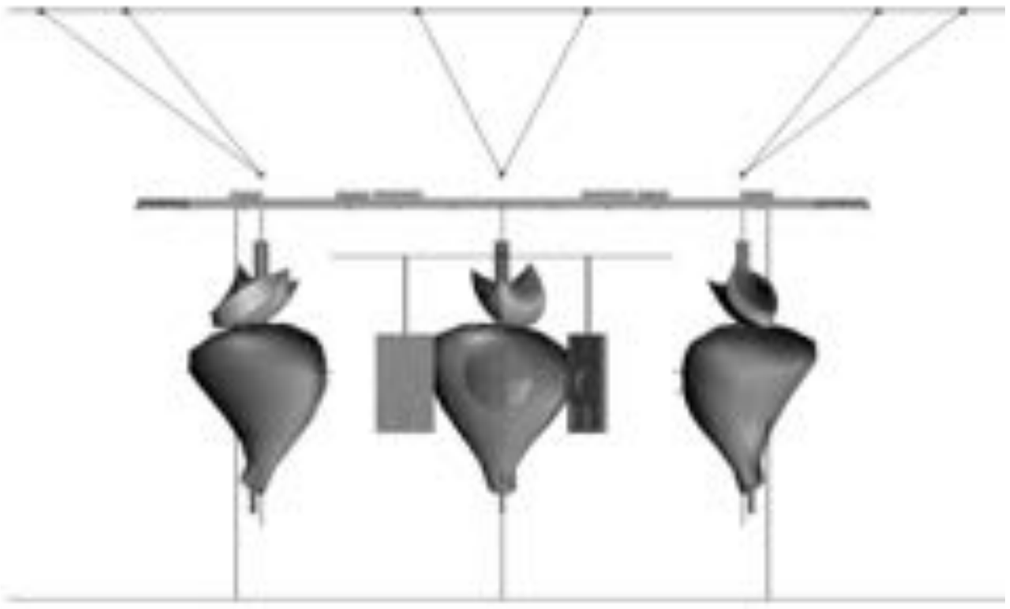
1/32" Perf Aluminum Sheet					
	lb/ft	ft	lb/ft^2	ft^2	lbs
option 1	0.27	3.00	0.09	118	**10.62**
option 2	0.50	4.00	0.13	118	**14.75**

Colloquy of Mobiles Replica

Design Development: Prototype / Model Armature

Estimated Weights

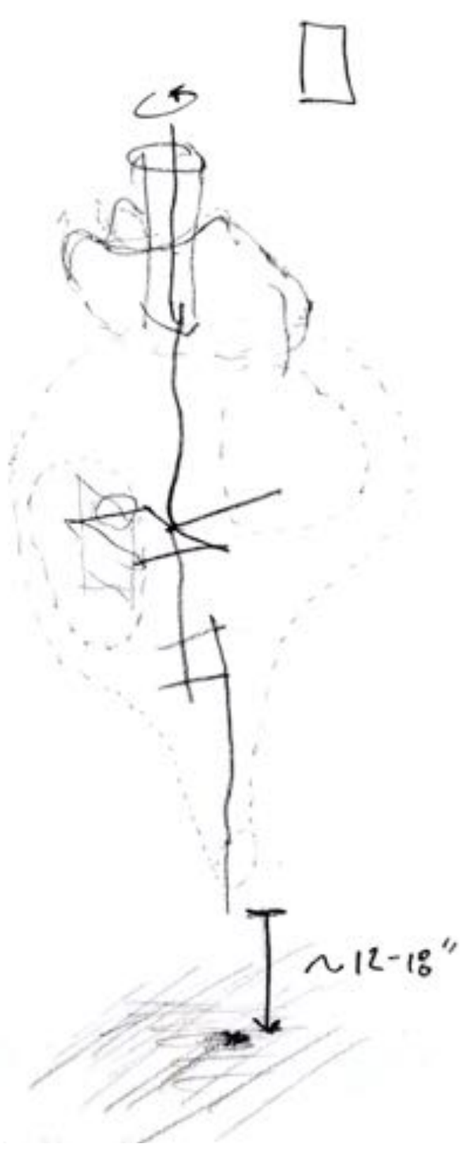
Component	**Weight x Count**	**= Total Weight**
Females	50 x 3	= 150
Males	25 x 2	= 50
Plinth	30 x 1	= 30
Structure	75 x 1	= 75
Assembly Total		= 300 lbs
Not To Exceed		= 500 lbs



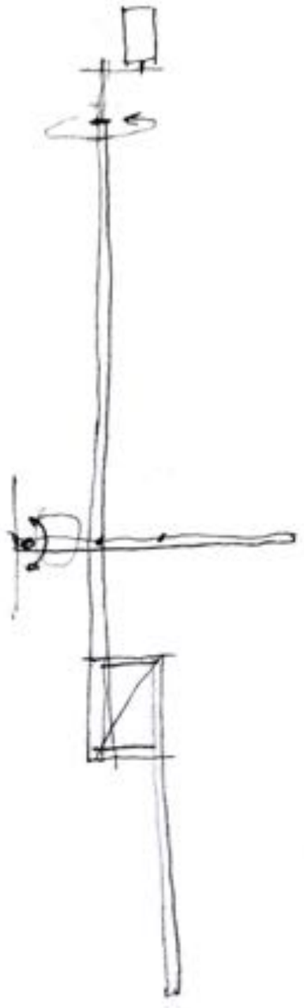
Colloquy of Mobiles Replica

Design Development: Prototype / Model Armature Full Scale Female Figure

System Components

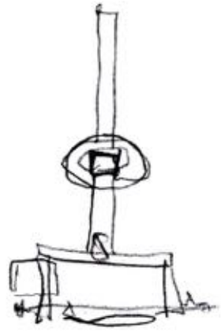


System Structure

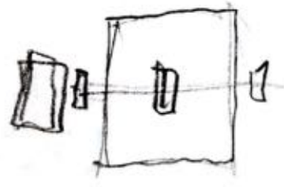


Structure Right Elevation

Fiberglass Enclosure Material
(Examples from Robert Taplin)

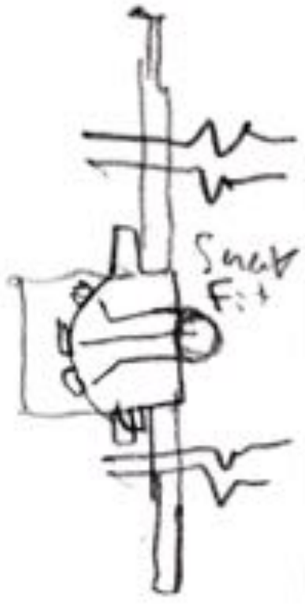


Structure and Mirror Assembly
Top View



Mirror Assembly Elevation

Mirror Sensor
Elevation



Mirror Sensor
Section

Colloquy of Mobiles Replica

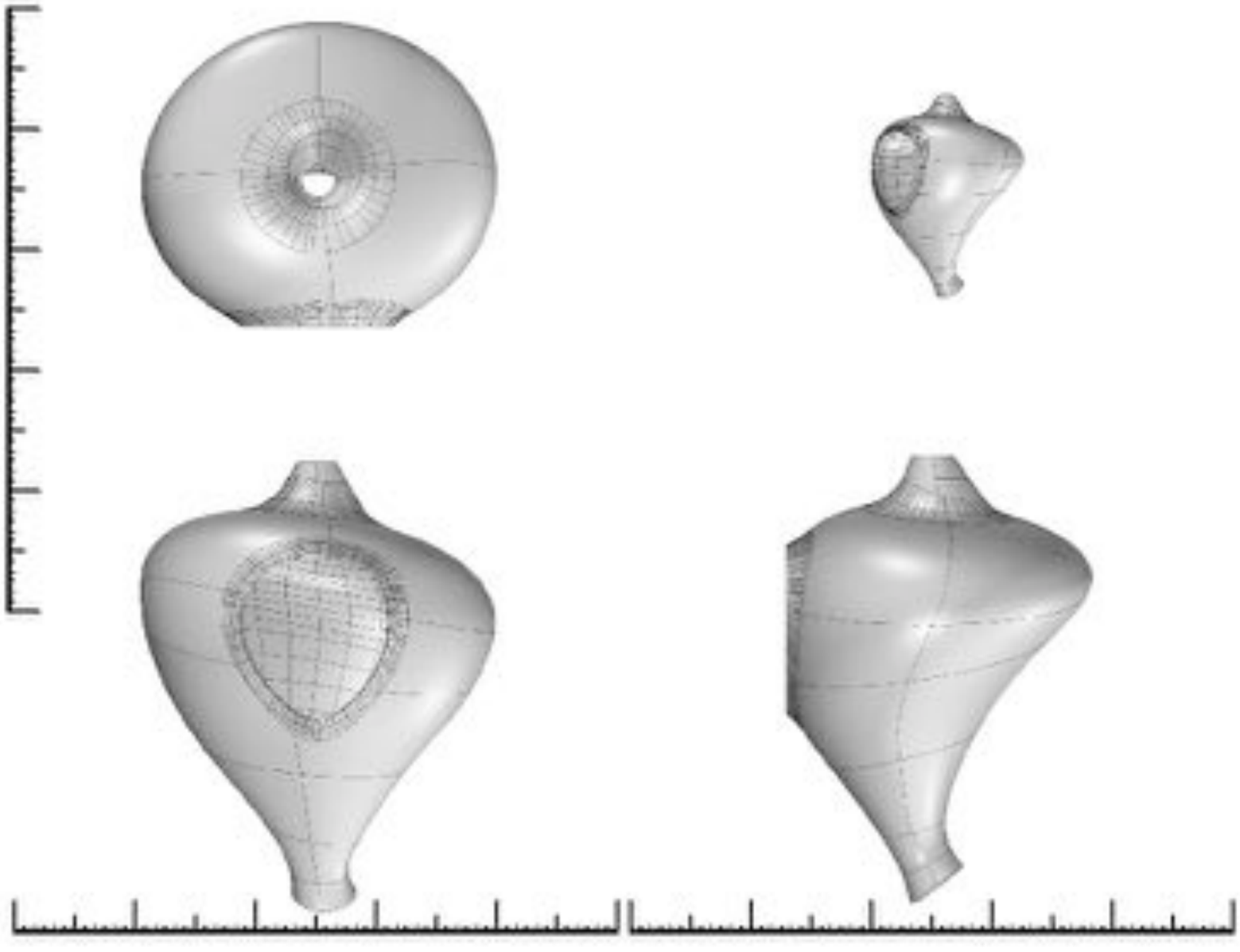
Design Development: Prototype / Model Armature Full Scale Female Figure

Installation Photo

CAD/CAM Model Print at 1/6 Scale

Colloquy of Mobiles Replica

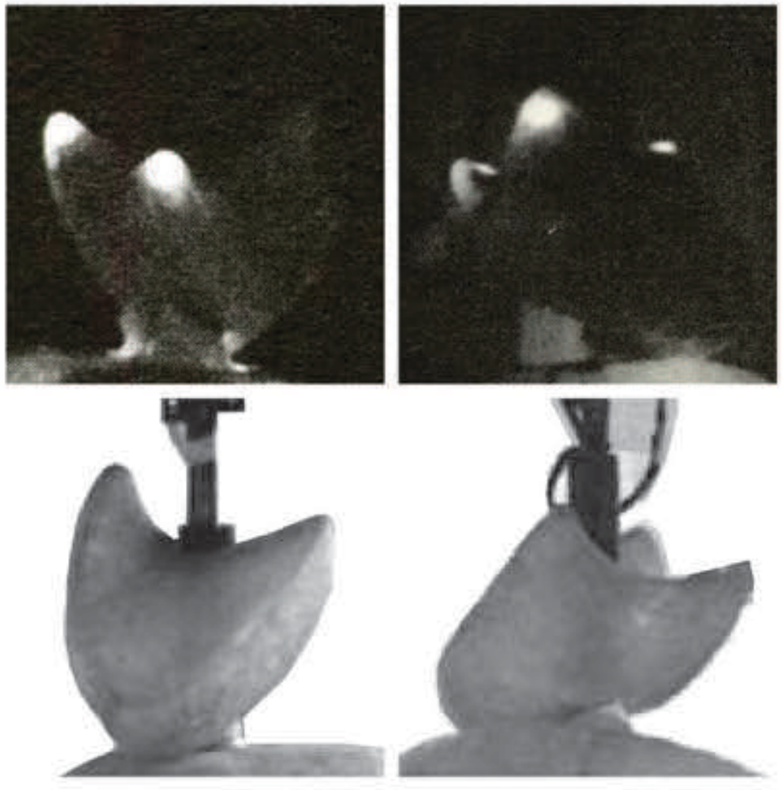
Design Development: Prototype / Model Armature Full Scale Female Figure



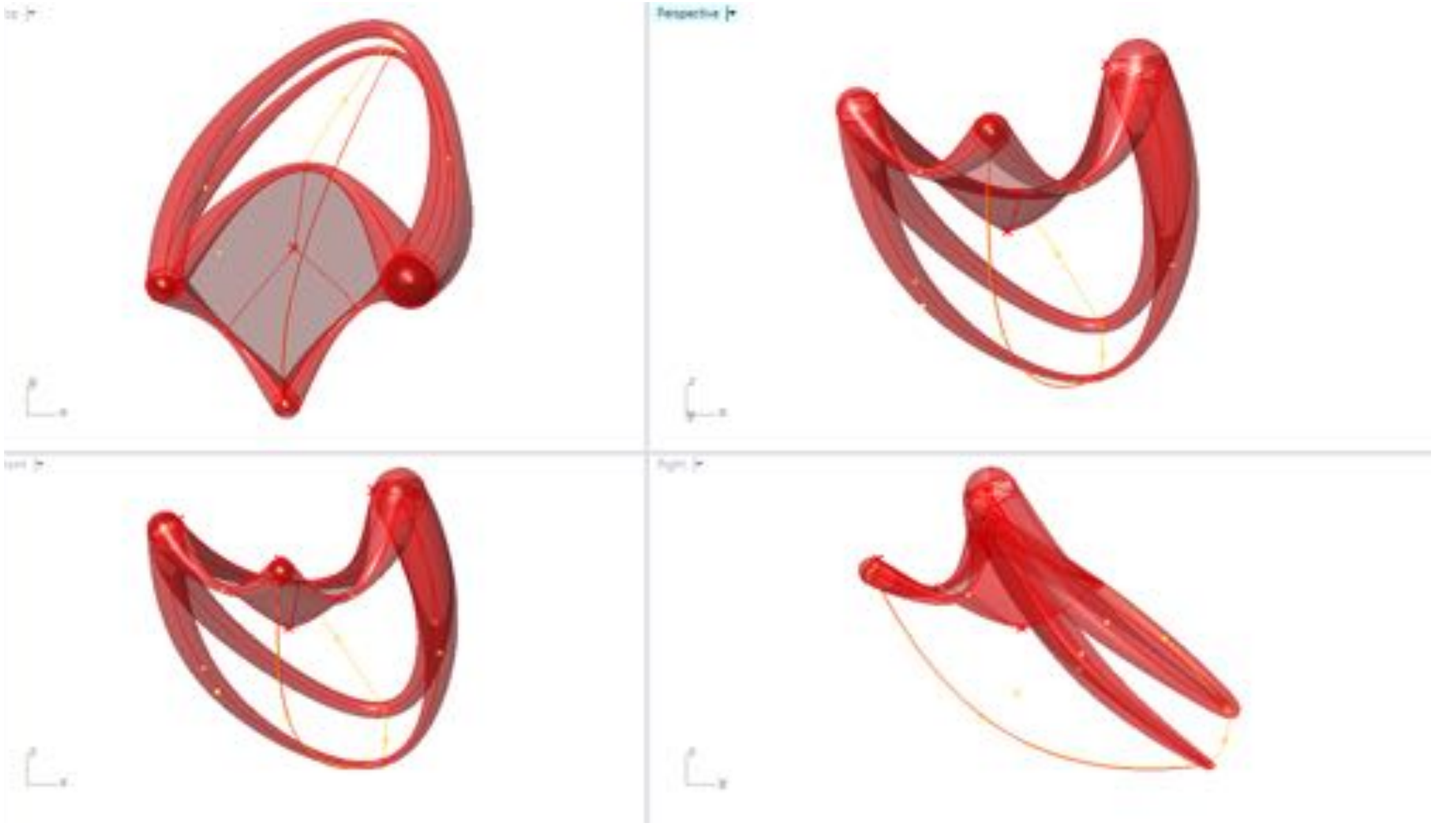
CAD/CAM Model for Fabrication

Colloquy of Mobiles Replica

Design Development: Prototype / Model Armature Full Scale Female Figure



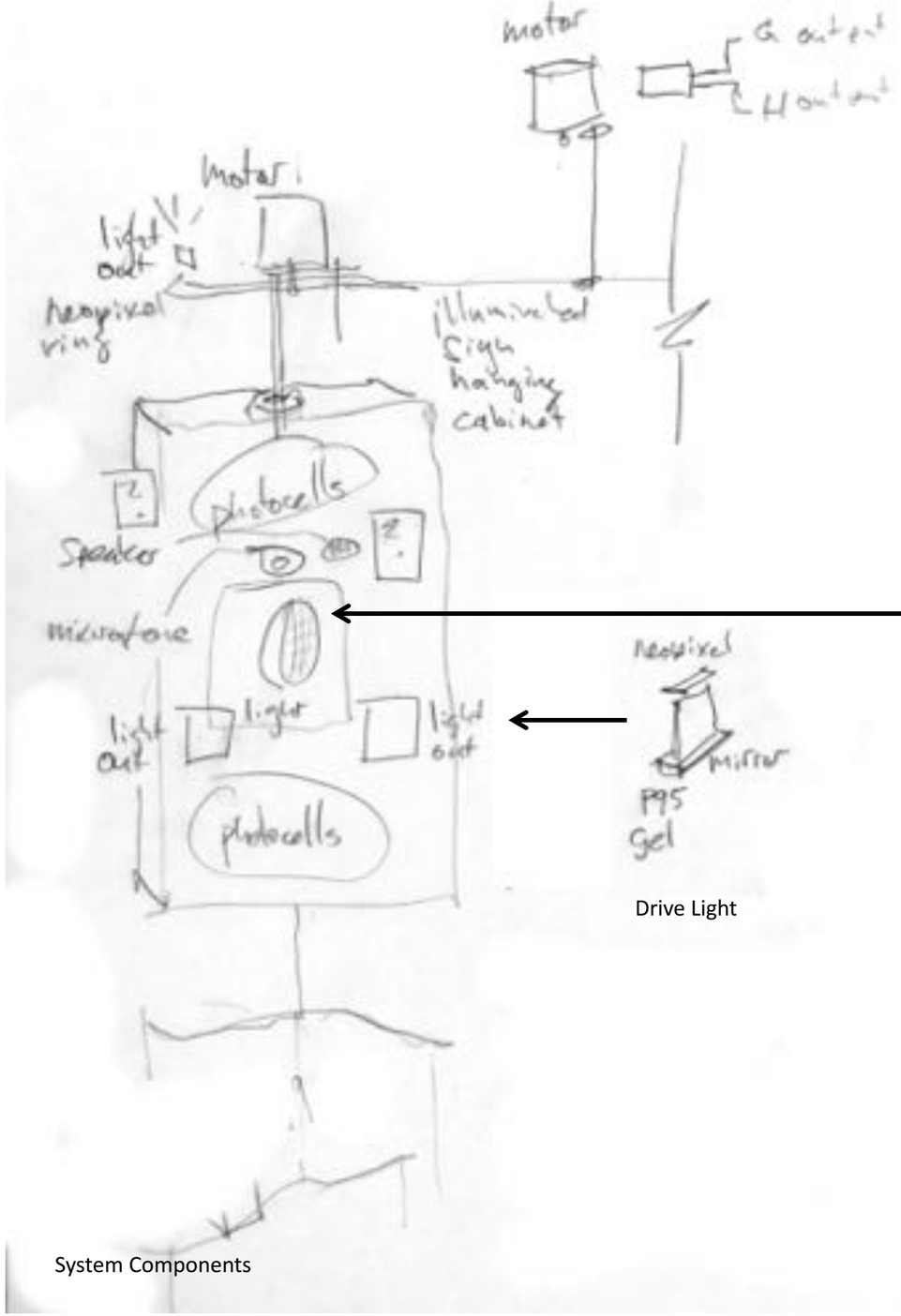
Installation Photo



CAD/CAM Model in progress

Colloquy of Mobiles Replica

Design Development: Prototype / Model Armature Full Scale Male Figure



System Components

Energetic Light

Drive Light

Amplifier

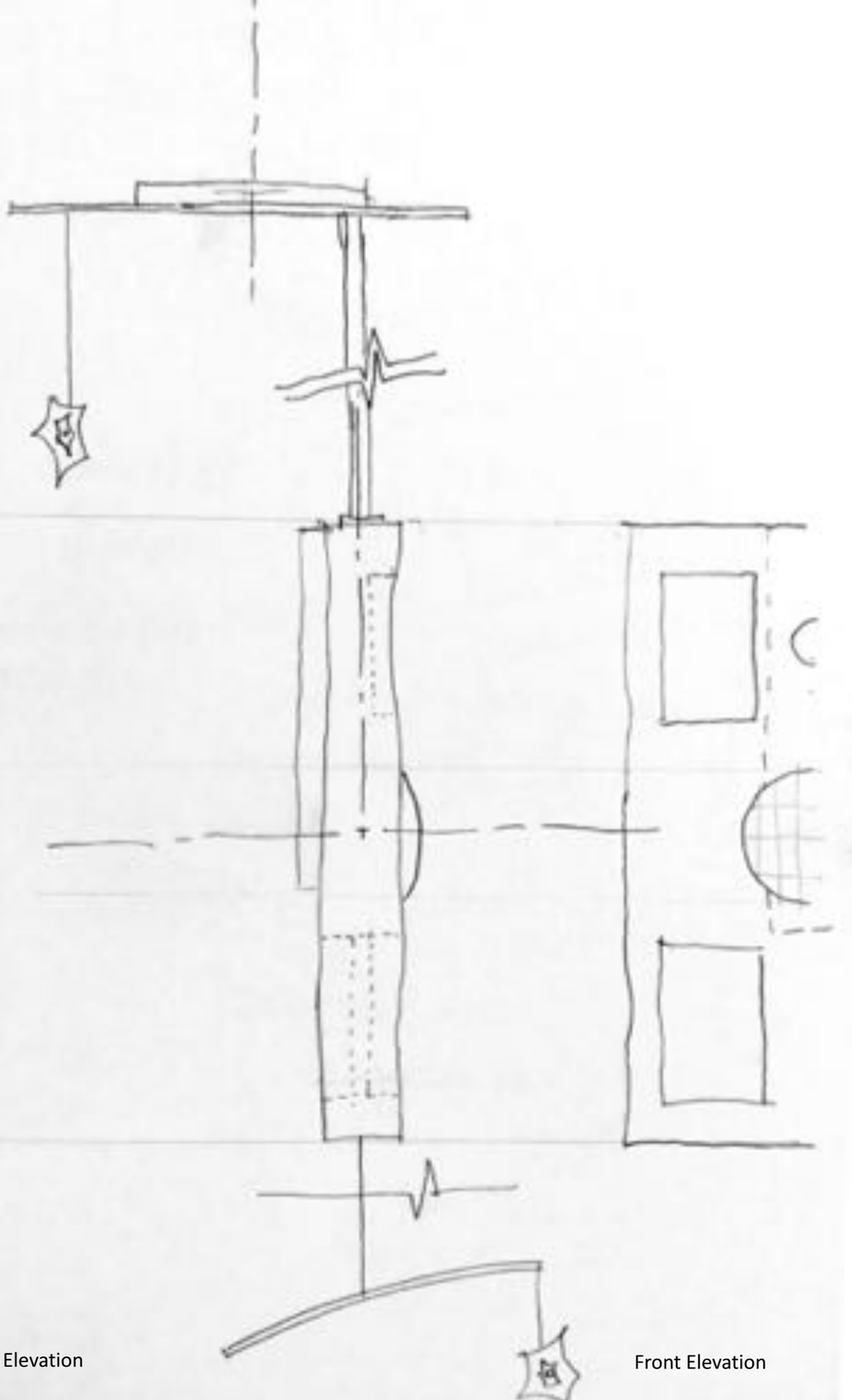
Speaker

Audio Response

Microphone

Spectral Analyzer

Audio Receiver



Left Elevation

Front Elevation

Colloquy of Mobiles Replica

Design Development: Mechanics

Colloquy of Mobiles Replica

Design Development: Prototype / Model Movement and Control of Figures

Drive Motors

The as built geometry for the installation is a truncated equilateral triangle

Male drive state display ***A*** illuminates underside of plinth

The Male non-'energetic' intermittent signal lamp ***U*** (***U*** in key***, u*** in diagram) is in the center of main body ***B***

The Female receptor for the intermittent positional signal ***a*** is in the center of reflector ***b***

The Male upper and lower 'energetic' receptors are in the small forms suspended above and below the main body ***B***

The axis of rotation for the vertically movable reflector ***b*** of female is horizontal through center of reflector

No figures are fixed to the ground

All figures are suspended from plinth

Missing drive state display for female

Missing upper female light displays

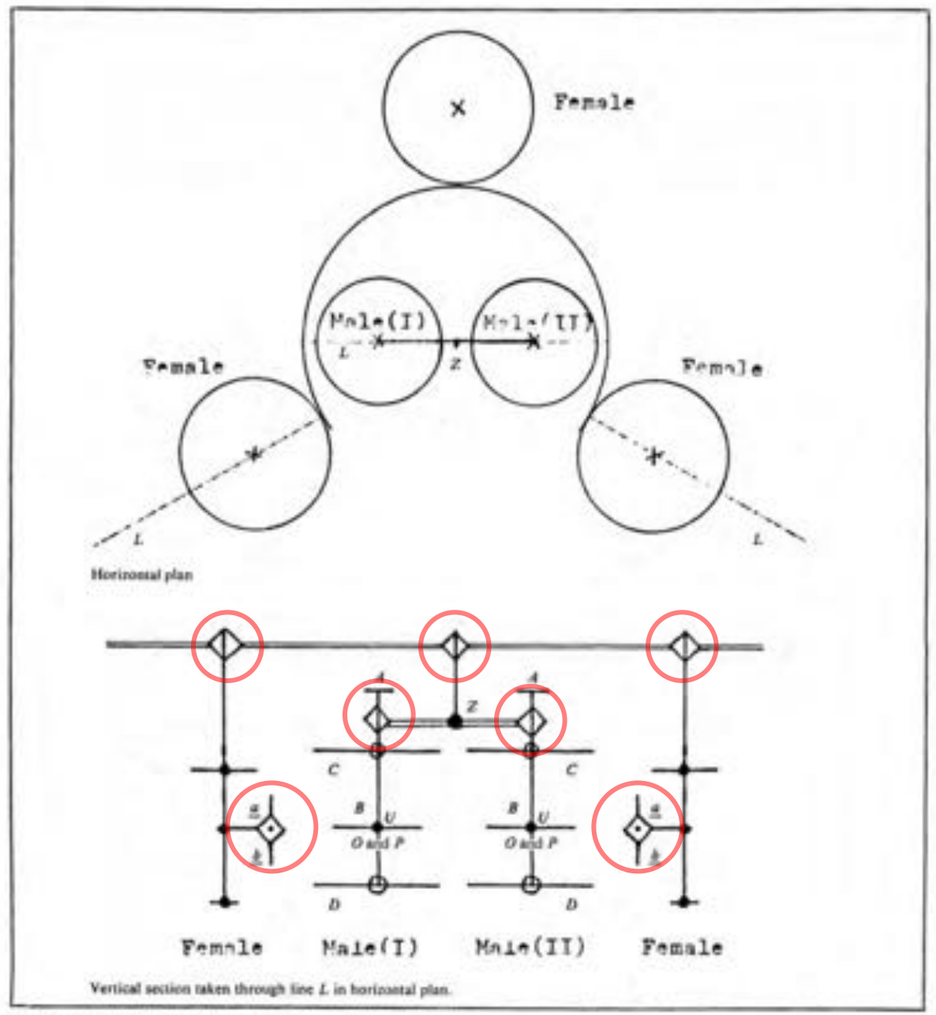


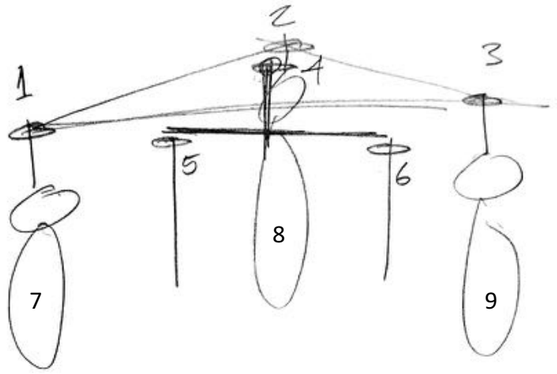
Fig. 34 A rough sketch of powered mobiles.

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

Colloquy of Mobiles Replica

Design Development: Prototype / Model Movement and Control of Figures – Servo Motors

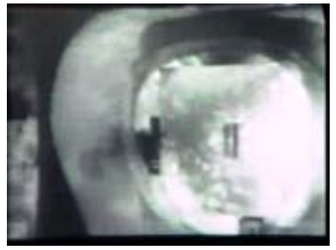


Rotation of figures about Z axes.

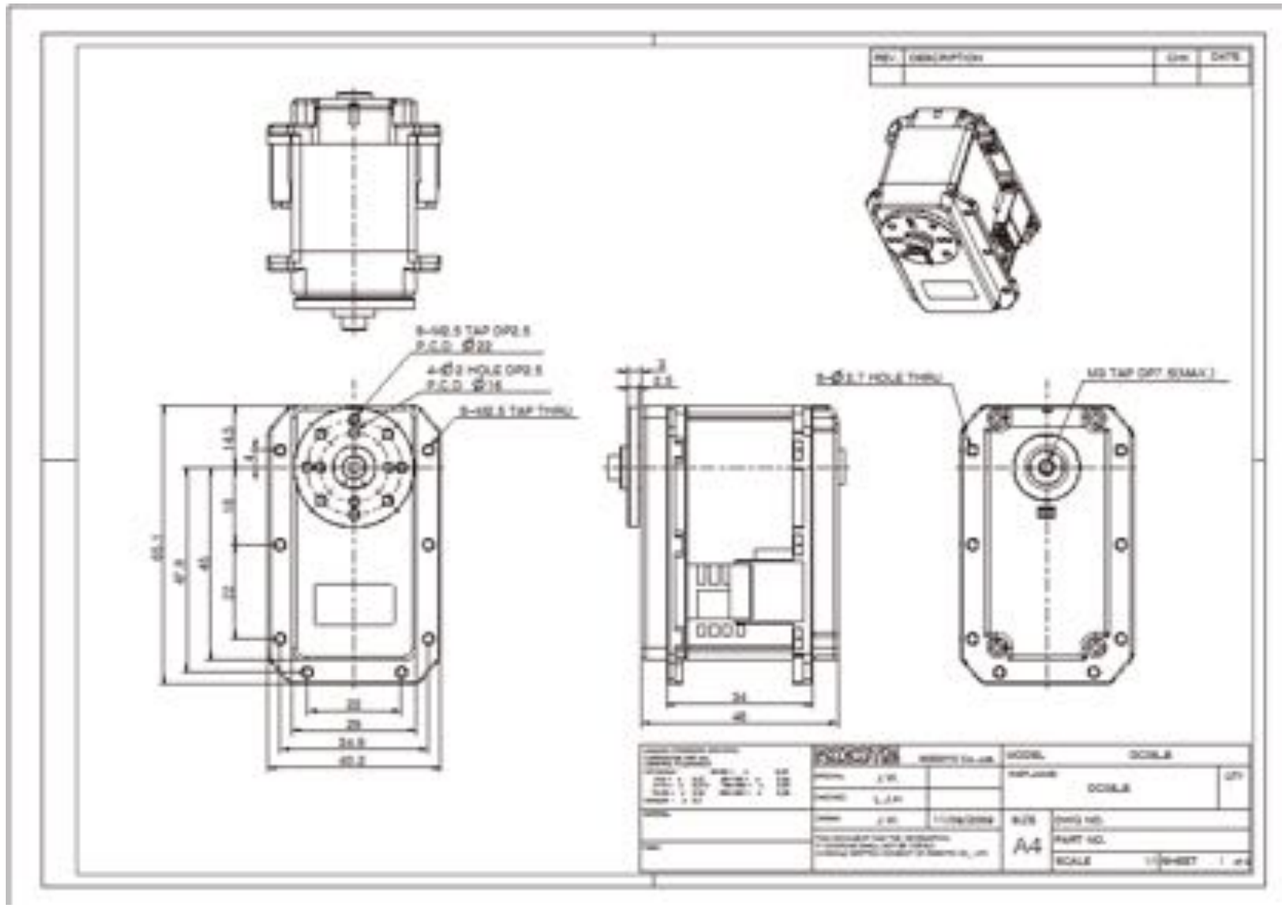
A total of 9 servo motors drive figures.

- 1 Drive motor for each of 3 Females
- 1 Drive motor for each of 2 Male figures
- 1 Drive motor for Male linkage bar
- 1 Drive motors for each of the 3 Female reflectors

Low torque will be required to turn the lightweight figures about their axes.



Female reflector



MX-106T Stats			
Operating Voltage	14.8V	12V	11.1V
Stall Torque*	102 kg·cm	85.6 kg·cm	81.5 kg·cm
	1,416 oz·in	1,189 oz·in	1,132 oz·in
	10.0 N.m	8.4 N.m	8.0 N.m
No-load Speed	55 RPM	45 RPM	41 RPM
Weight	153g		
Size	40.2 x 65.1 x 46 mm		
Resolution	0.088°		
Reduction Ratio	1/225		
Operating Angle	360° or Continuous Turn		
Max Current	**5.2A @ 12V**		
Standby Current	**55 mA**		
Operating Temp	-5°C ~ 85°C		
Protocol	TTL Asynchronous Serial		
Module Limit	254 valid addresses		
Com Speed	8000bps ~ 3Mbps		
Position Feedback	Yes		
Temp Feedback	Yes		
Load Voltage Feedback	Yes		
Input Voltage Feedback	Yes		
Compliance/PID	Yes		
Material	Metal Gears &		
	Engineering Plastic Body		
Motor	Maxon RE-MAX		
Manual Download	MX-106 Manual		
Controller List	USB2Dynamixel		
	CM-530		
	CM-700		
	Arbotix		

5.2A @ 12v = 62.4W
62.4W x 9 = 561.6W
561.6W = 4.68A @ 120v AC

Estimated MAX power requirement for Motors and Control is 5A @ 120vAC

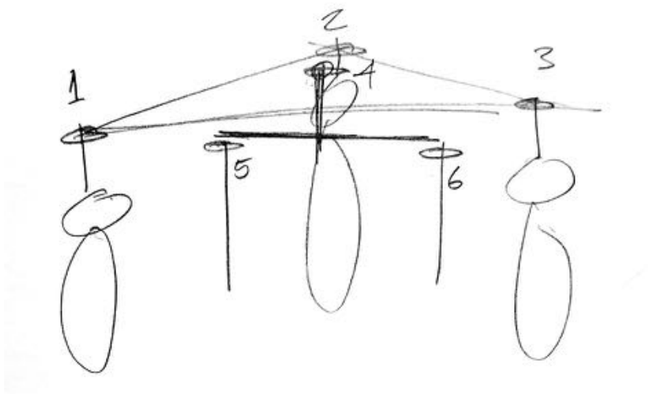
estimated running power is 1A.

12V 5A switching power supply
PRODUCT ID: 352

Colloquy of Mobiles Replica

Design Development: Prototype / Model Movement and Control of Figures

Rotation of figures about Z axes.



A total of 6 motors drive figures. 1 Drive motor for each of 3 Female and 2 Male figure, and 1 drive motor for Male linkage bar.

		Torque →	τ = F × L		
τ lb·ft	τ oz·in	force in pounds	force in oz	radius in feet	radius in inches
1.5	288	1	16	1.5	18
3	576	2	32	1.5	18
2	384	1	16	2	24
4	768	2	32	2	24

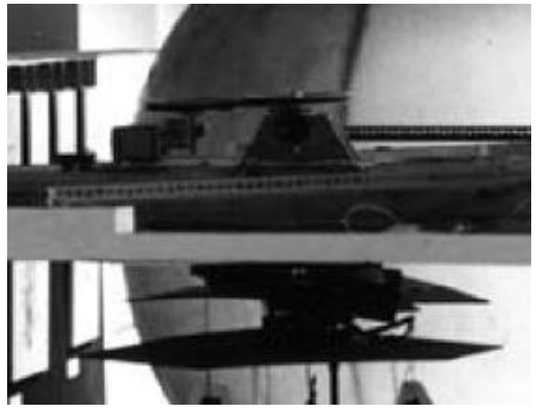
Torque output comparison.

Estimated MAX power requirement for Motors and Control is 12A, estimated running power is 2A.

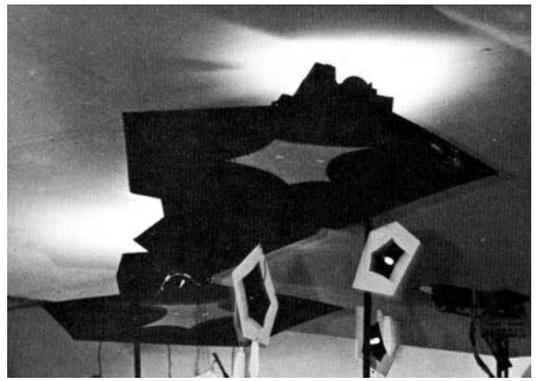
To supply 5A at 12V suggests a power supply with Input: 100-240V 50/60Hz 1.3A Max

MX-64T Stats			
Operating Voltage	14.8V	12V	11.1V
Stall Torque*	74 kg·cm	61 kg·cm	56 kg·cm
	1033 oz·in	849 oz·in	778 oz·in
	7.3 N.m	6.0 N.m	5.5 N.m
No-load Speed	78 RPM	63 RPM	58 RPM
Weight	126g / .278lb		
Size	40.2 x 61.1 x 41.0 mm		
Resolution	0.088°		
Reduction Ratio	1/200		
Operating Angle	360° or Continuous Turn		
Max Current	4.1A @ 12V		
Standby Current	100 mA		
Operating Temp	-5°C ~ 80°C		
Protocol	TTL		
Module Limit	254 valid addresses		
Com Speed	8000bps ~ 3Mbps		
Position Feedback	Yes		
Temp Feedback	Yes		
Load Voltage Feedback	Yes		
Input Voltage Feedback	Yes		
Compliance/PID	Yes		
Material	Metal Gears & Engineering Plastic Body		
Motor	Maxon RE-MAX		

Low torque will be required to turn the lightweight figures about their axes.



Top view of central bar and motor/belt mechanism..

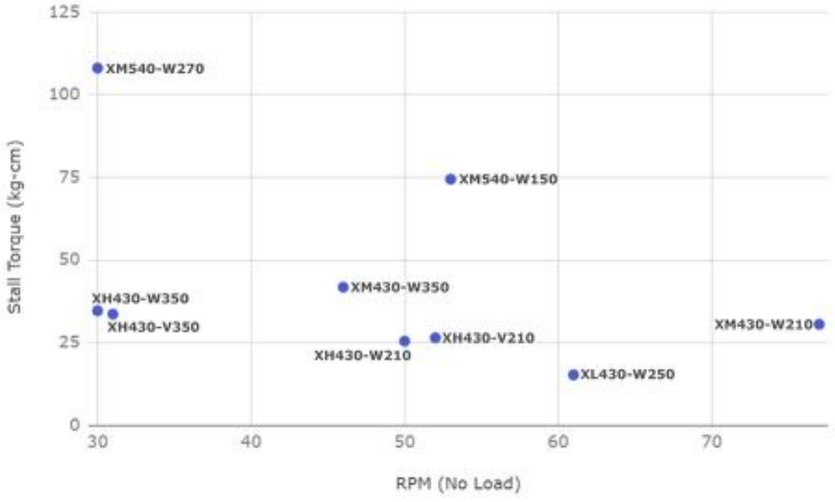


Underside view of central bar and motor/belt mechanism for Male figure.

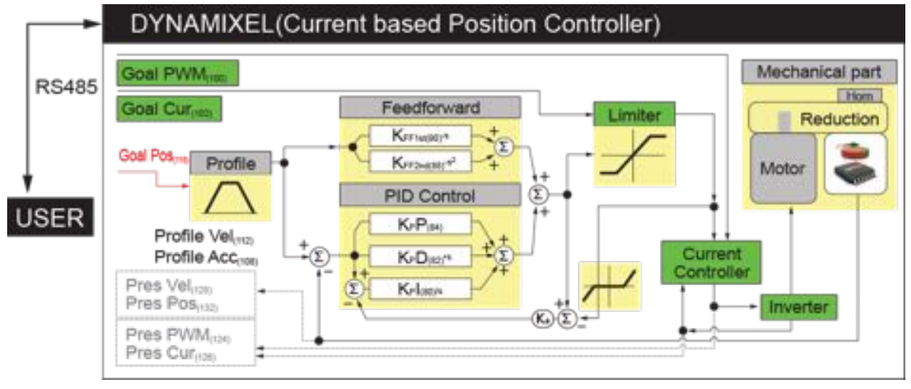
Above view of motor/belt mechanism for Male figure.

Colloquy of Mobiles Replica

Design Development: Prototype / Model Movement and Control of Figures



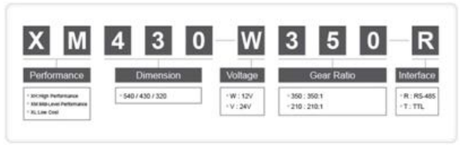
http://www.robotis.us/dynamixel/



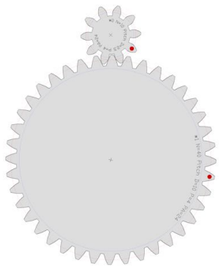
http://support.robotis.com/en/product/actuator/dynamixel/dxl_mx_main.htm

http://www.trossenrobotics.com

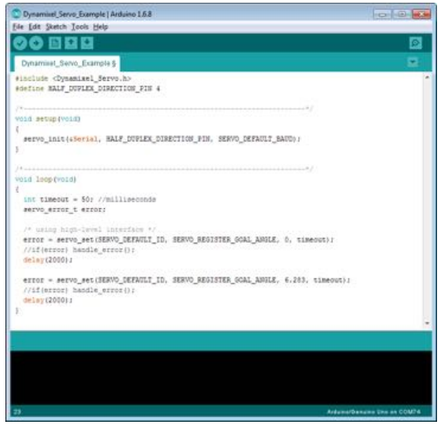
http://www.oppedijk.com/robotics/control-dynamixel-with-raspberrypi



http://www.andymark.com/



http://geargenerator.com



https://github.com/michaelkrzyzaniak/Dynamixel_Servo

6 Port AX/MX Power Hub
Item #: IL-3PHUB
Availability: In Stock
InterbotiX Labs
$4.95

250mm 3 Pin DYNAMIXEL Compatible Cables - 10 Pack
Item #: CBL-BIO250
Availability: In Stock
InterbotiX Labs
$14.90

Barrel Jack Female Pigtail Lead
2.1 - 5.5mm
Item #: CS-CT5089
Availability: In Stock
$2.95

Power Supply 12V - 5A (2.1mm Jack)
Item #: POW-12v5a
Availability: In Stock
Top Power Co
$19.95

Colloquy of Mobiles Replica

Design Development: Wiring Harness

Colloquy of Mobiles Replica

Design Development: Prototype / Model Armature

…

The as built geometry for the installation is a truncated equilateral triangle

Male drive state display ***A*** illuminates underside of plinth

The Male non-’energetic’ intermittent signal lamp ***U*** (***U*** in key***, u*** in diagram) is in the center of main body ***B***

The Female receptor for the intermittent positional signal ***a*** is in the center of reflector ***b***

The Male upper and lower ‘energetic’ receptors are in the small forms suspended above and below the main body ***B***

The axis of rotation for the vertically movable reflector ***b*** of female is horizontal through center of reflector

No figures are fixed to the ground

All figures are suspended from plinth

Missing upper female light displays

Missing drive state display for female

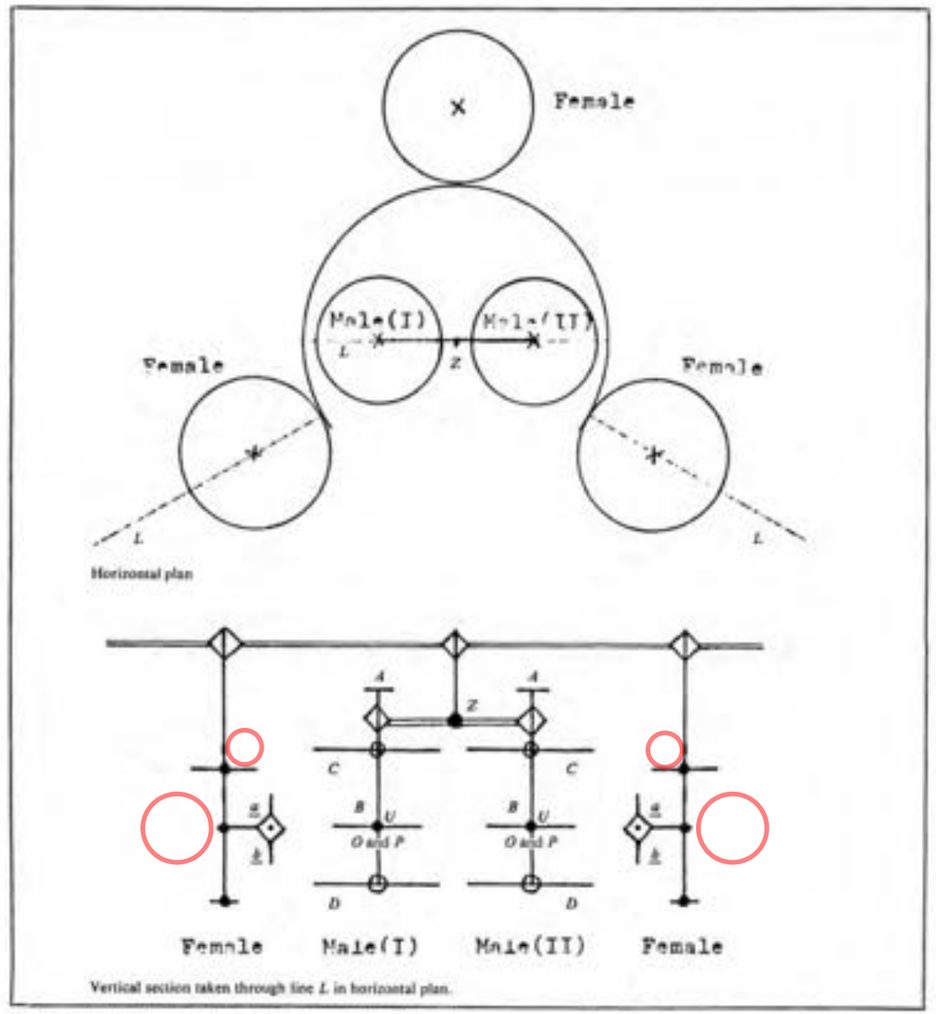


Fig. 34 A rough sketch of powered mobiles.

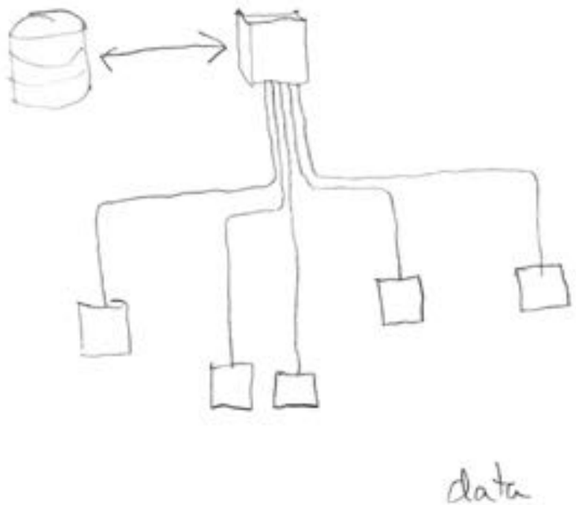
A = drive state display for male
B = main body of male, bearing 'energetic' light projectors *O* and *P*
C = upper 'energetic' receptors
D = lower 'energetic' receptors
U = non-'energetic', intermittent signal lamp
a = female receptor for intermittent positional signal
b = vertically movable reflector of female
Z = bar linkage bearing male I and male II

= Drive motor
= Free coupling
= Fixed coupling
= Bar linkage

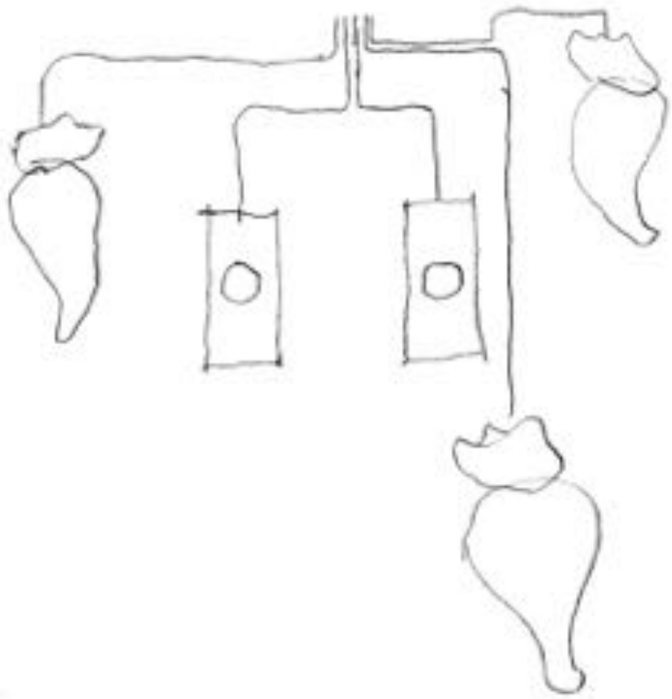
Colloquy of Mobiles Replica

Design Development: Prototype / Model Wiring Infrastructure

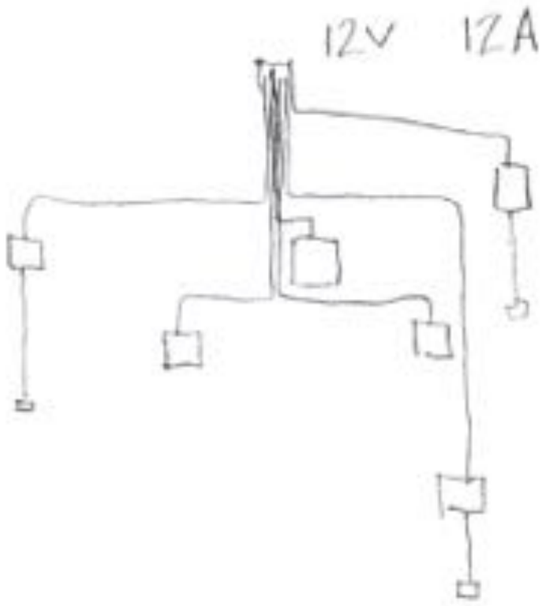
...



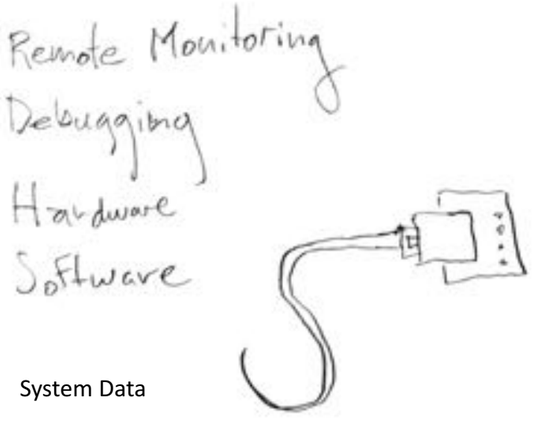
System Data



System Data



System Motor Power



System Data

Colloquy of Mobiles Replica

Design Development: Sensing

Colloquy of Mobiles Replica

Design Development: Prototype / Model Armature

…

The as built geometry for the installation is a truncated equilateral triangle

Male drive state display ***A*** illuminates underside of plinth

The Male non-’energetic’ intermittent signal lamp ***U*** (***U*** in key***, u*** in diagram) is in the center of main body ***B***

The Female receptor for the intermittent positional signal ***a*** is in the center of reflector ***b***

The Male upper and lower ‘energetic’ receptors are in the small forms suspended above and below the main body ***B***

The axis of rotation for the vertically movable reflector ***b*** of female is horizontal through center of reflector

No figures are fixed to the ground

All figures are suspended from plinth

Missing upper female light displays

Missing drive state display for female

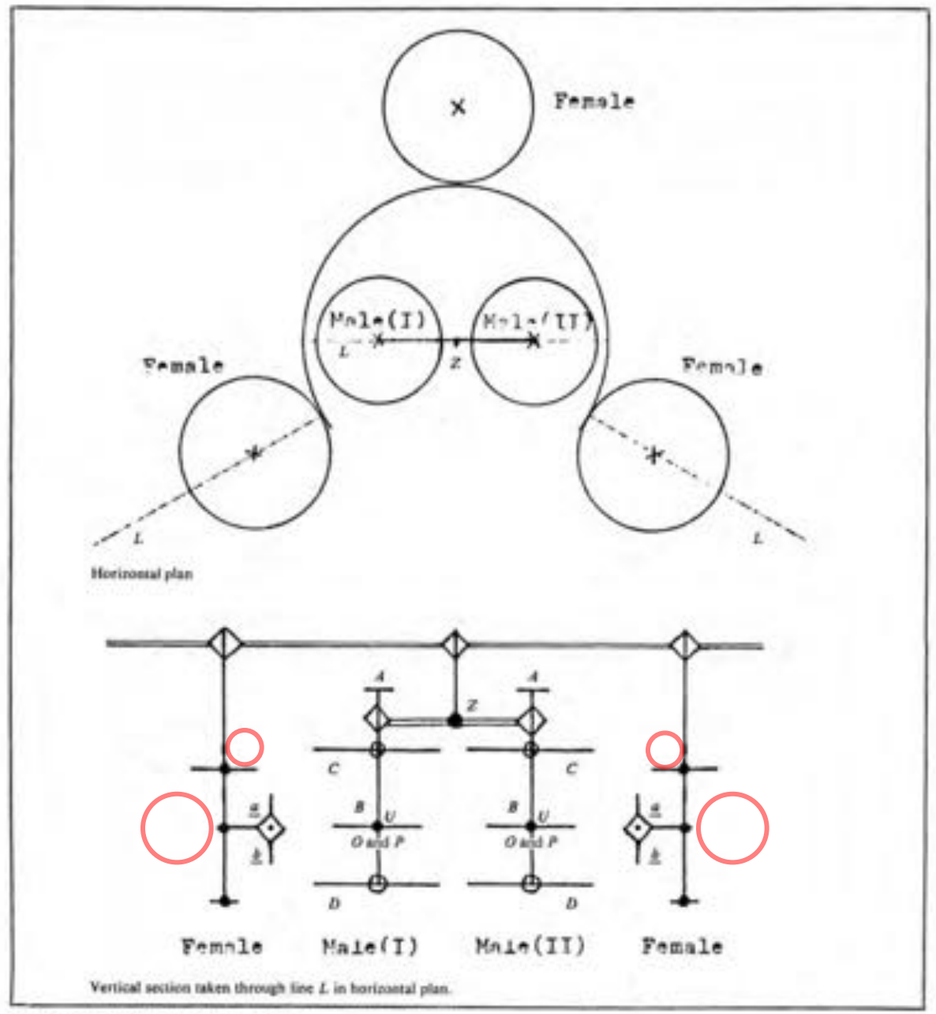


Fig. 34 A rough sketch of powered mobiles.

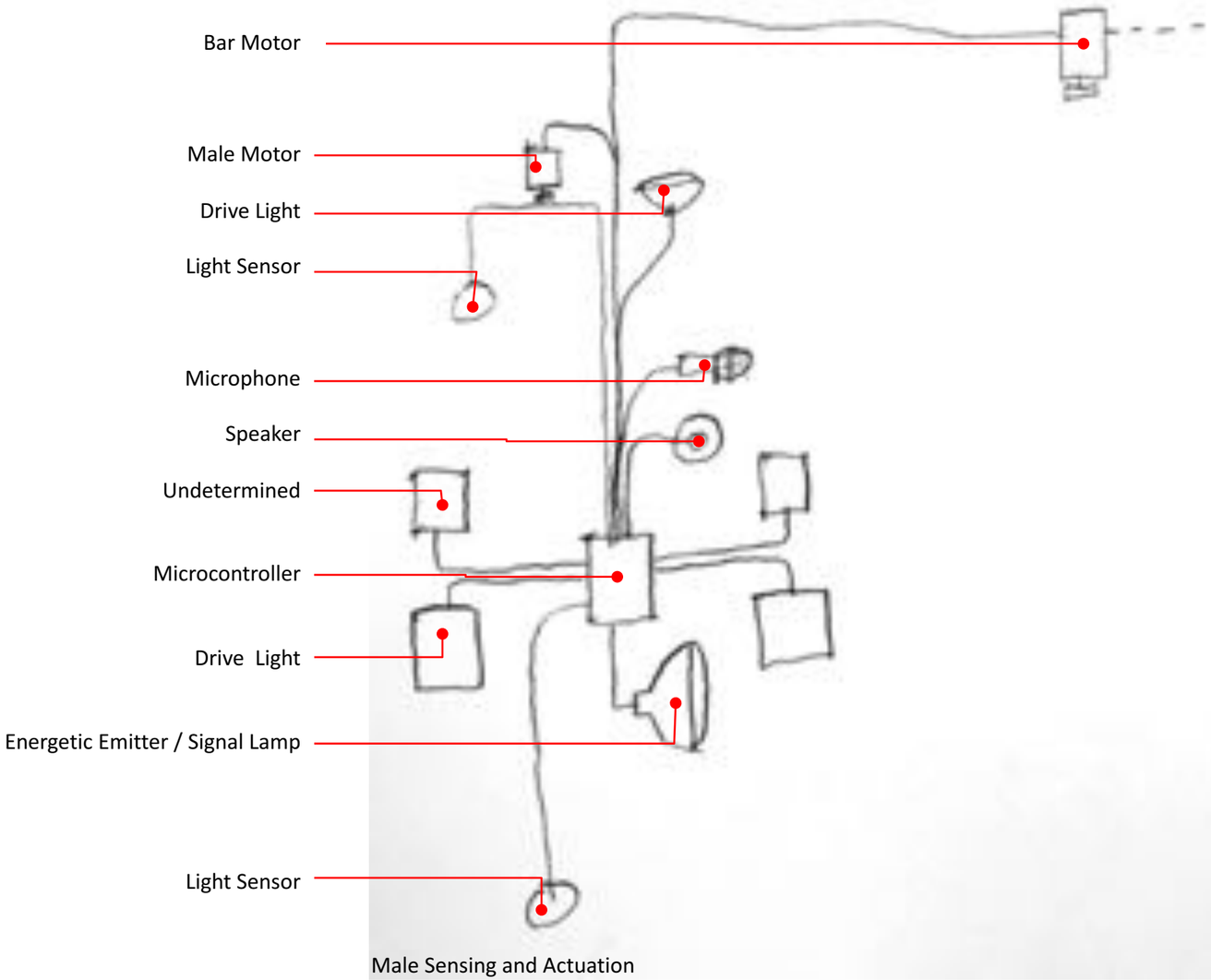
A = drive state display for male
B = main body of male, bearing 'energetic' light projectors *O* and *P*
C = upper 'energetic' receptors
D = lower 'energetic' receptors
U = non-'energetic', intermittent signal lamp
a = female receptor for intermittent positional signal
b = vertically movable reflector of female
Z = bar linkage bearing male I and male II

= Drive motor
= Free coupling
= Fixed coupling
= Bar linkage

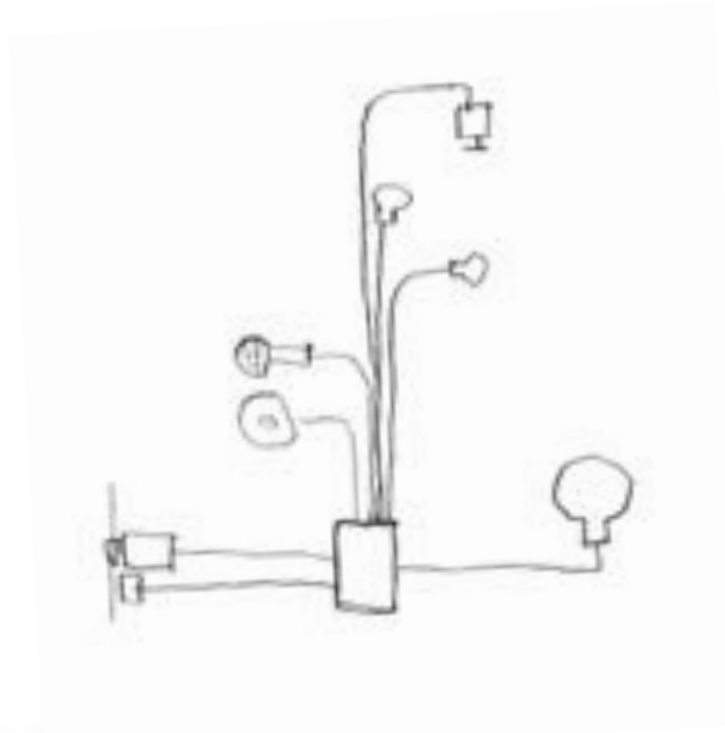
Colloquy of Mobiles Replica

Design Development: Prototype / Model Sensing Wiring Infrastructure

...



Male Sensing and Actuation



Female Sensing and Actuation

Colloquy of Mobiles Replica

Design Development: Prototype / Model Sensing Wiring Infrastructure

...

Bar Motor

Male Motor

Drive Light

NeoPixel Ring - 24 x 5050 RGBW LEDs w/ Integrated Drivers - Natural White - ~4500K
PRODUCT ID: 2862
$19.95

Light Sensor

Microphone

Speaker

Undetermined

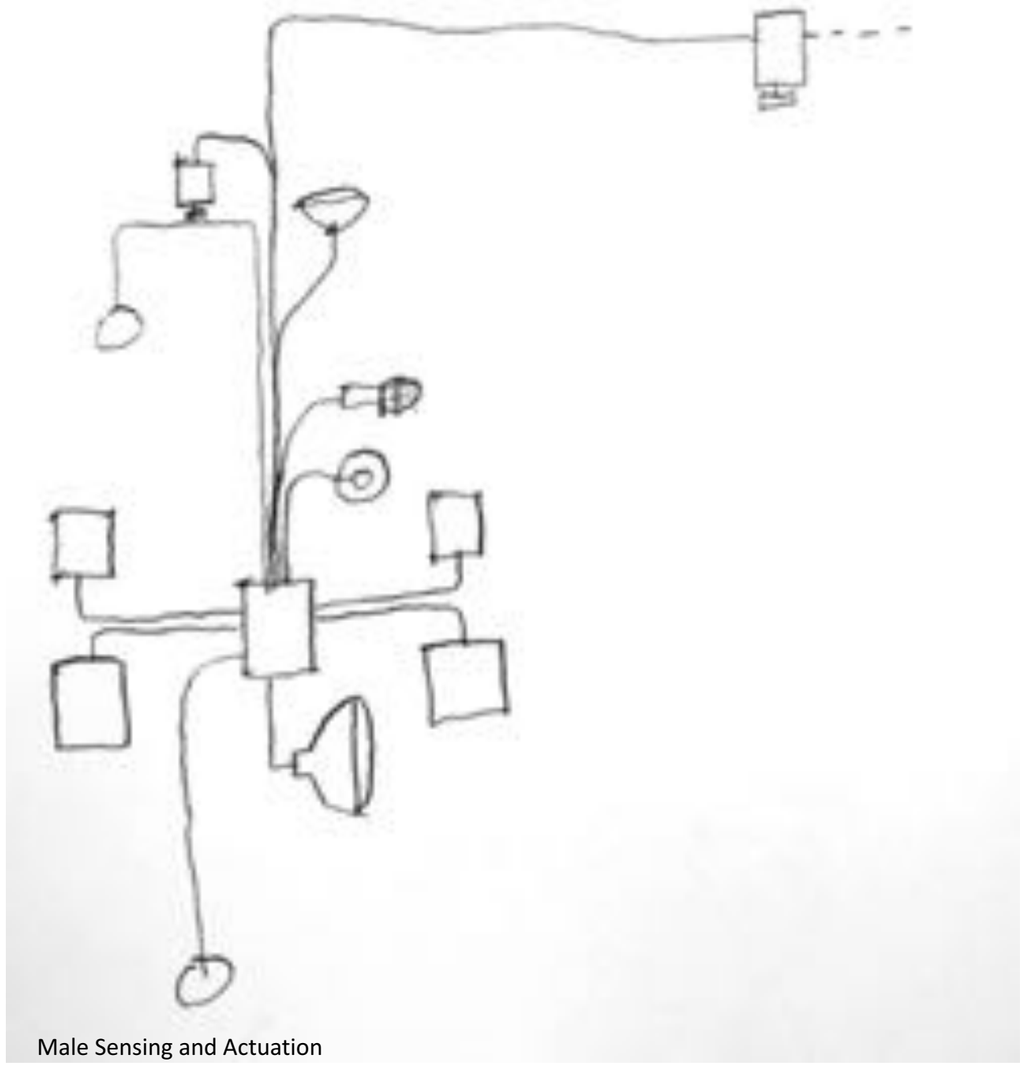
Microcontroller

Drive Light

NeoPixel Stick - 8 x 5050 RGBW LEDs - Natural White - ~4500K
PRODUCT ID: 2868
$7.95

Energetic Emitter

Light Sensor

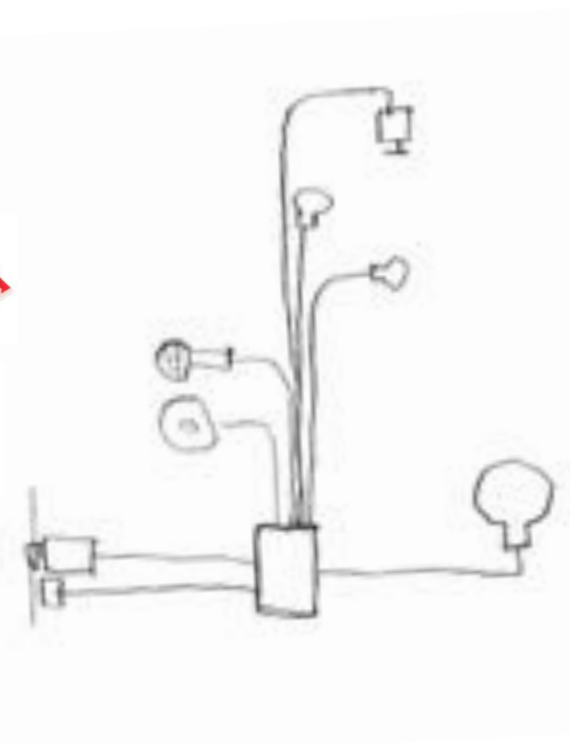


Male Sensing and Actuation

Colloquy of Mobiles Replica

Design Development: Prototype / Model Sensing Wiring Infrastructure

...



NeoPixel Jewel - 7 x 5050 RGBW LED w/ Integrated Drivers - Natural White - ~4500K
PRODUCT ID: 2859
$6.95

Adafruit NeoPixel Digital RGBW LED Strip - White PCB 30 LED/m
PRODUCT ID: 2832
5 meters (full reel)
$89.75

Female Sensing and Actuation

Female Axis Motor

Undetermined Light

Undetermined Light

Microphone

Speaker

Drive Light

Microcontroller

Mirror Motor

Light Sensor

Colloquy of Mobiles Replica

Design Development: Prototype / Model Audio Transceiver

Audio Source

Amplifier

SparkFun Mono Audio Amp Breakout - TPA2005D1
In stock BOB-11044 ROHS Open Source Hardware
$7.95

https://www.sparkfun.com/products/11044

Speaker

Speaker - 0.5W (8 Ohm)
In stock COM-09151 ROHS
$1.95

Dayton Audio ND90-4 3-1/2" Aluminum Cone Full-Range Neo Driver 4 Ohm
In Stock
$21.35

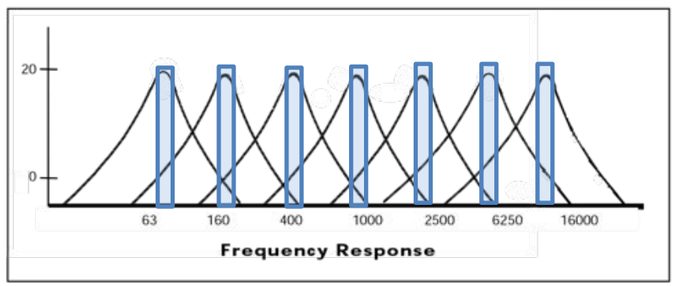
Audio Receiver

Microphone

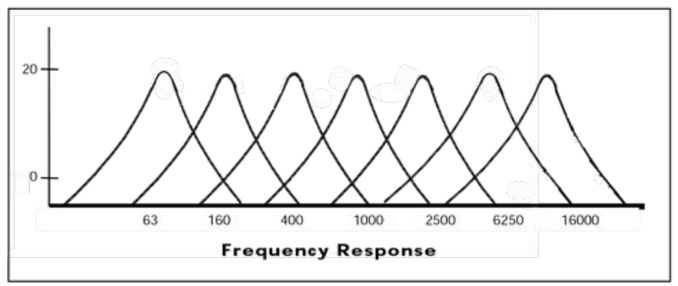
SparkFun MEMS Microphone Breakout - INMP401 (ADMP401)
In stock BOB-09868 ROHS
$9.95

Spectral Analyzer

Graphic Equalizer Display Filter - MSGEQ7
In stock COM-10468 ROHS
$4.95



Audio Source Target Frequency Modes



Spectral Analyzer Frequency Response

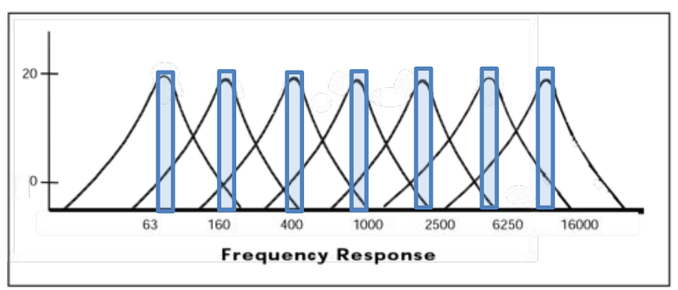
Colloquy of Mobiles Replica

Design Development: Prototype / Model Audio Transceiver

Microcontroller

Amplifier

Speaker



Audio Source Target Frequency Modes [Hz]
63, 160, 400, 1000, 2500, 6250, 16000

Use of the tone() function will interfere with PWM output on pins 3 and 11 (on boards other than the Mega).

It is not possible to generate tones lower than 31Hz.

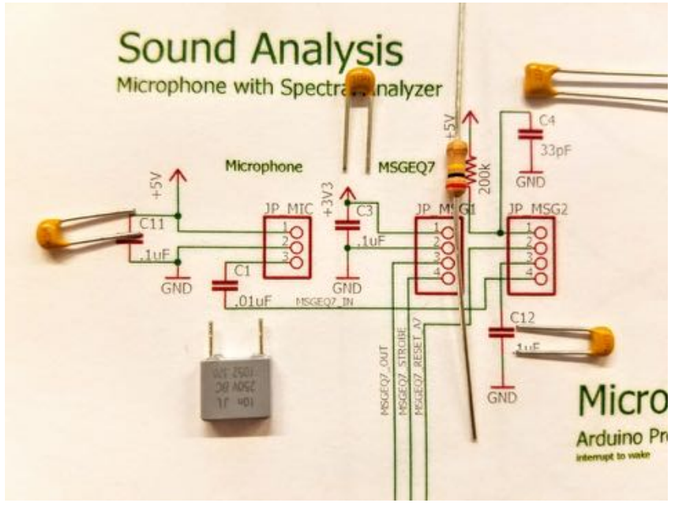
Colloquy of Mobiles Replica

Design Development: Prototype / Model Audio Transceiver

Determine configuration of microphone and speaker for audio transciever.

Use a standard cell phone microphone and a 7 band spectral analyzer to cluster sounds heard and build signal models.

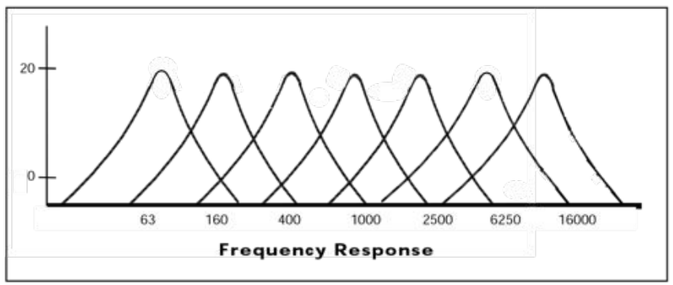
Use a standard speaker to transmit sounds generated by the microcontroller.



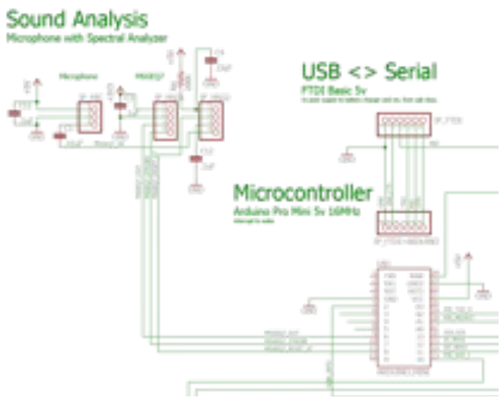
Audio Receiver

Microphone

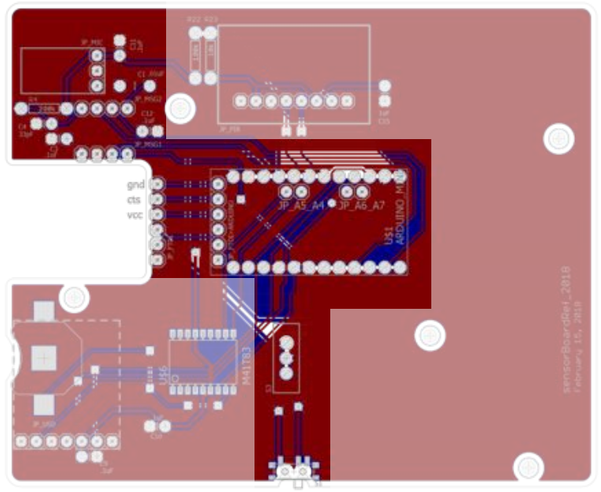
Spectral Analyzer



Spectral Analyzer Frequency Response



Sound Receiver Schematic

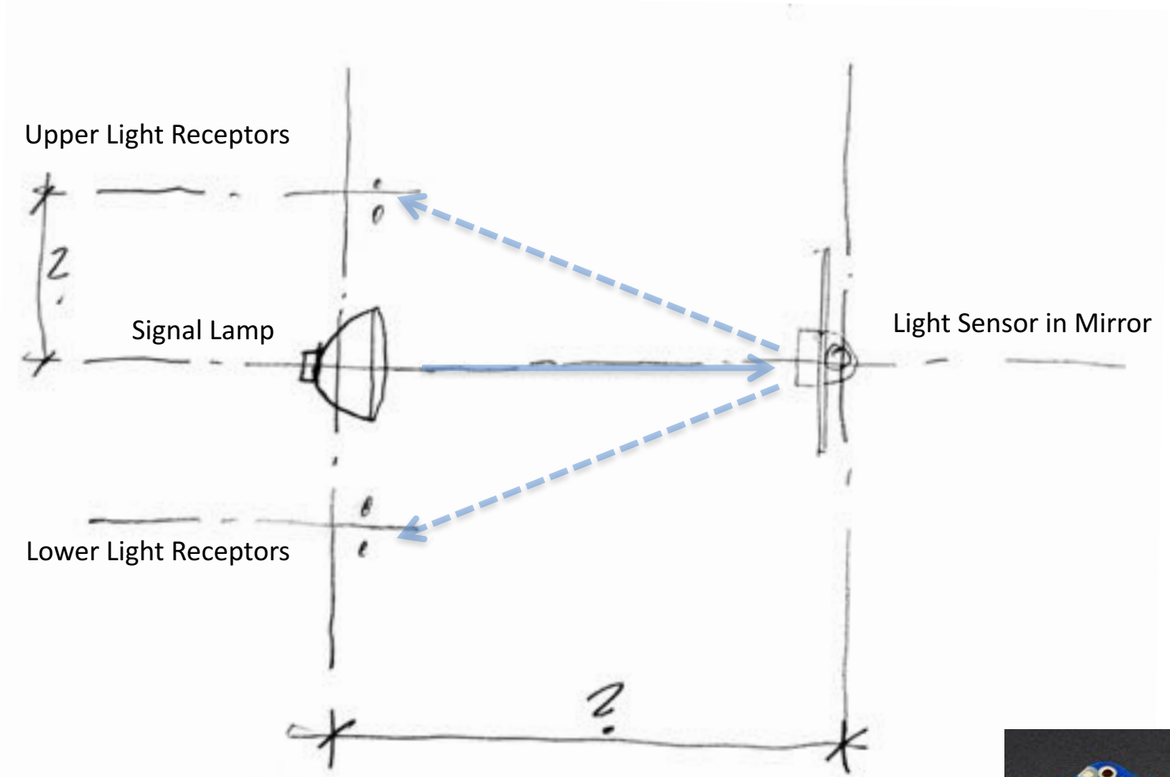


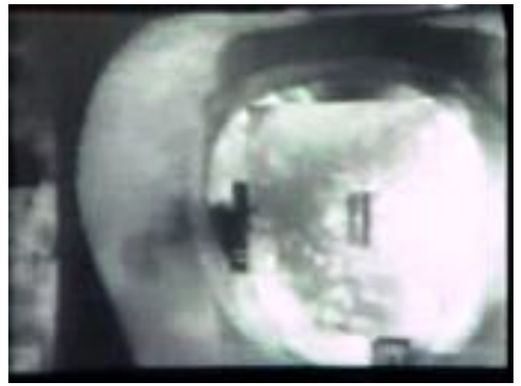
Sound Receiver Circuit

Colloquy of Mobiles Replica

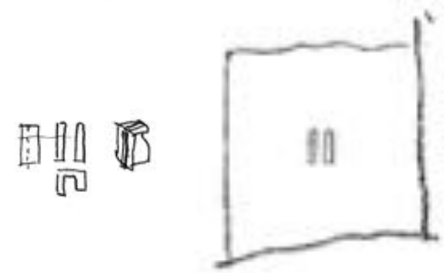
Design Development: Prototype / Model Intermittent Signal Light

Intermittent Signal Light





Video of Light Sensor in Mirror



Light Sensor in Mirror

NeoPixel Ring - 24 x 5050 RGBW LEDs
w/ Integrated Drivers - Natural White - ~4500K
PRODUCT ID: 2862
$19.95

Light Options

Adafruit ALS-PT19 Analog Light Sensor Breakout
PRODUCT ID: 2748
$2.50

GA1A12S202 Log-scale Analog Light Sensor
PRODUCT ID: 1384
$3.95

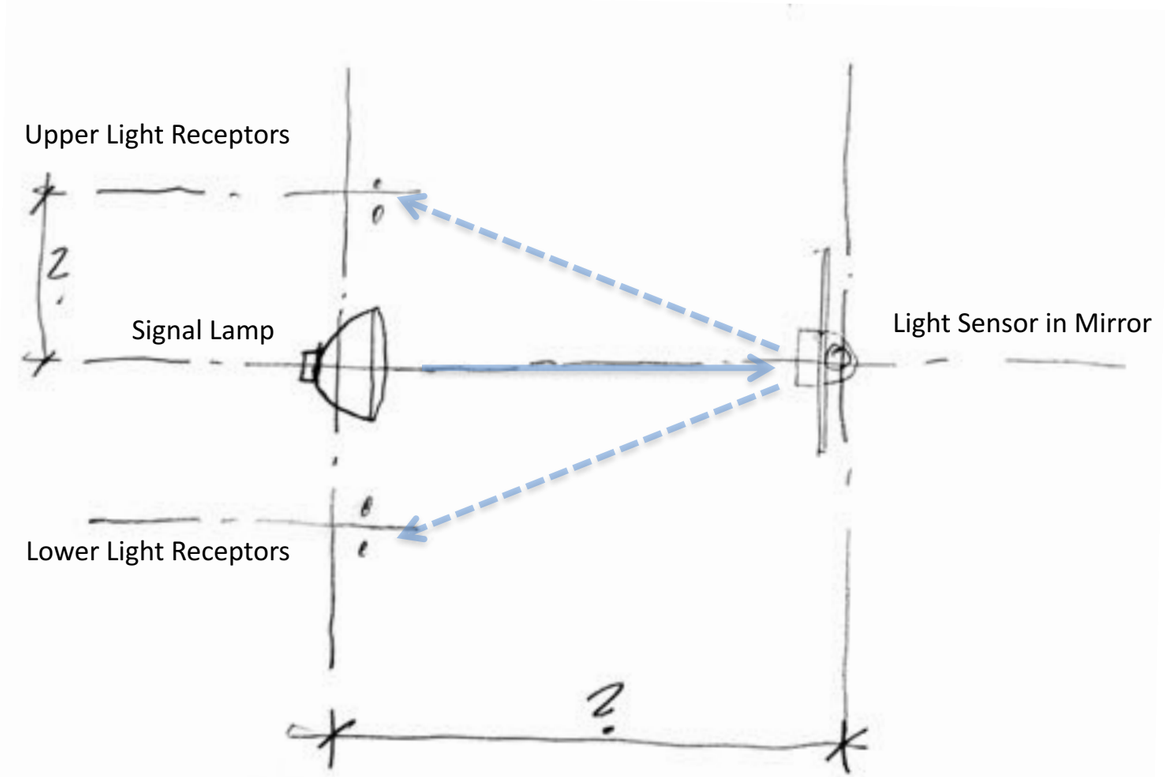
Adafruit TSL2561 Digital Luminosity/Lux/Light Sensor Breakout
PRODUCT ID: 439
$5.95

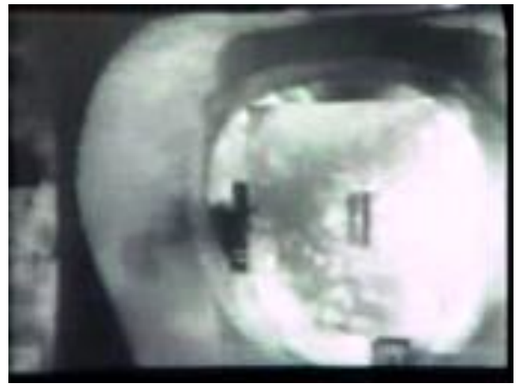
Light Sensor Options

Colloquy of Mobiles Replica

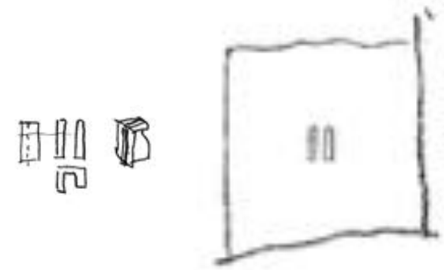
Design Development: Prototype / Model Intermittent Signal Light

Intermittent Signal Light





Video of Light Sensor in Mirror



Light Sensor in Mirror

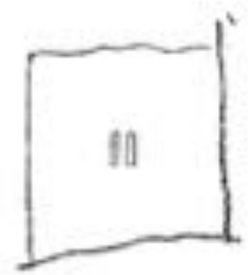
Servo motors have three wires: power, ground, and signal. The power wire is typically red, and should be connected to the 5V pin on the Arduino board. The ground wire is typically black or brown and should be connected to a ground pin on the Arduino board. The signal pin is typically yellow, orange or white and should be connected to a digital pin on the Arduino board. Note that servos draw considerable power, so if you need to drive more than one or two, you'll probably need to power them from a separate supply (i.e. not the +5V pin on your Arduino). Be sure to connect the grounds of the Arduino and external power supply together.

Light Sensor Options

Colloquy of Mobiles Replica

Design Development: Prototype / Model Intermittent Signal Light

Intermittent Signal Light



Light Sensor in Mirror

Determine which lamp and light sensor to use for the intermittent signal lamp

		Current Reading [Amps]		
		Barely On	On	Bright
Sylvania Halogen	High Beam			
	Low Beam			
Philips PAR 26	High Beam			
	Low Beam			
Neopixel Ring				

7” Sylvania Halogen

4.5” Philips PAR 26

NeoPixel Ring - 24 x 5050 RGBW LEDs
w/ Integrated Drivers - Natural White - ~4500K
PRODUCT ID: 2862
$19.95

Light Options

			Light Level Reading		
			ALS-PT19	GA1A12S202	TSL2561
Sylvania Halogen	High Beam	BO			
		ON			
		BR			
	Low Beam	BO			
		ON			
		BR			
Philips PAR 26	High Beam	BO			
		ON			
		BR			
	Low Beam	BO			
		ON			
		BR			
Neopixel Ring		BO			
		ON			
		BR			

Adafruit ALS-PT19 Analog Light Sensor Breakout
PRODUCT ID: 2748
$2.50

GA1A12S202 Log-scale Analog Light Sensor
PRODUCT ID: 1384
$3.95

Adafruit TSL2561 Digital Luminosity/Lux/Light Sensor Breakout
PRODUCT ID: 439
$5.95

Light Sensor Options

Colloquy of Mobiles Replica

Design Development: Prototype / Model Intermittent Signal Light

Determine which light sensor to use for the installation

ALS-PT19	Analog
GA1A12S202	Analog
TSL2561	I2C

Build test rig for logging sensor data in a variety of lighting conditions — data point,timestamp
Gather ambient light data over an extended period of time — various locations
Gather Lamp light in ambient conditions — various locations as possible
Algorithmic approach for identifying light peaks in ambient light conditions — mean, standard deviation, k-means clustering

Identify which sensor lamp pair has the greatest ability to discriminate between ambient and lamp lit condition at sensor.

	Light Level Readings [Mean and Standard Deviation][k-means clustering]		
Representative Gallery Spaces for Exhibition	ALS-PT19	GA1A12S202	TSL2561
Taubman Center Valade Family Gallery			
Taubman Center Hub on 7th floor			
Taubman Center 11th floor			
CCS Center Galleries			

Adafruit ALS-PT19 Analog Light Sensor Breakout
PRODUCT ID: 2748
$2.50

GA1A12S202 Log-scale Analog Light Sensor
PRODUCT ID: 1384
$3.95

Adafruit TSL2561 Digital Luminosity/Lux/Light Sensor Breakout
PRODUCT ID: 439
$5.95

Light Sensor Options

Colloquy of Mobiles Replica

Design Development: Prototype Hardware Notes

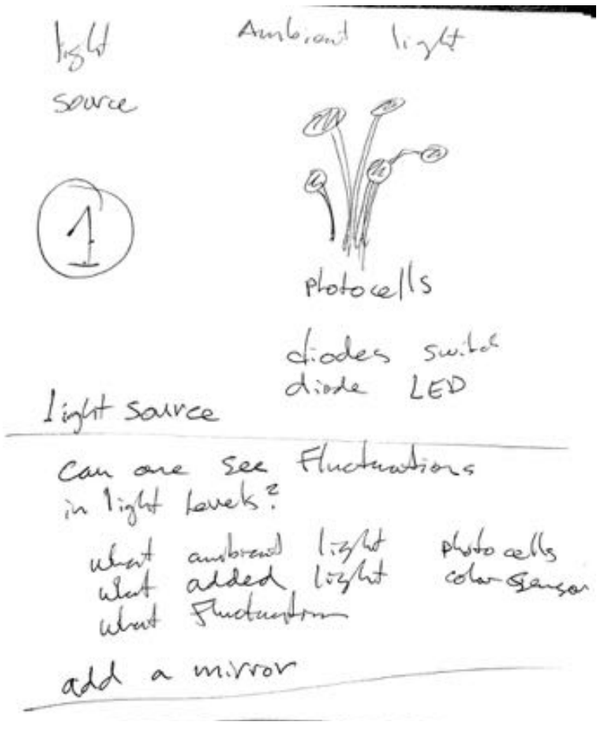
The board comes without built-in USB circuitry, so an off-board USB-to-TTL serial convertor must be used to upload sketches. For the 3.3V Arduino Pro boards, this can be a FTDI TTL-232R-3V3 USB - TTL Level Serial Converter Cable or the SparkFun FTDI Basic Breakout Board (3.3V). For the 5V Arduino Pro boards, use a TTL-232R USB - TTL Level Serial Converter or the SparkFun FTDI Basic Breakout Board (5V). (You can probably also get away with using a 5V USB-to-serial convertor with a 3.3V board and vice-versa, but it's not recommended.)

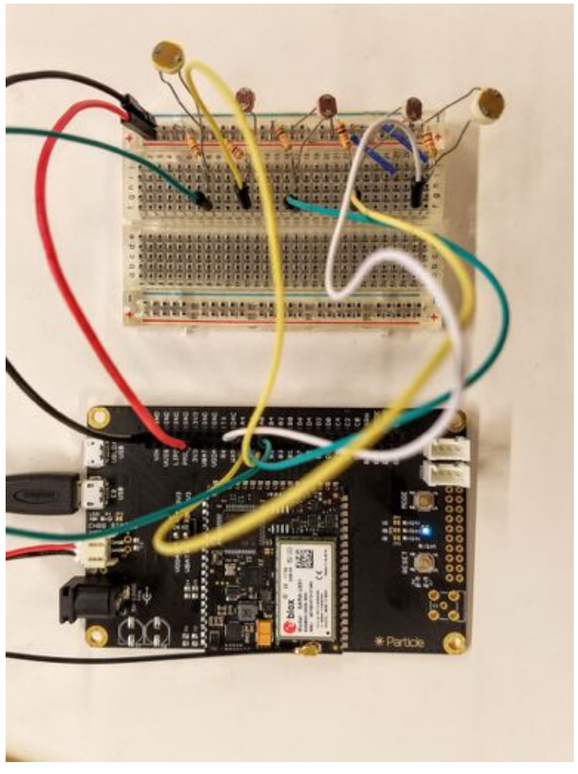
If using the FTDI cable on Windows, you'll need to make one configuration change to enable the auto-reset. With the board connected, open the Device Manager (in Control Panels > System > Hardware), and find the USB Serial Port under Ports. Right-click and select properties, then go to Port Settings > Advanced and check Set RTS on Close under Miscellaneous Options.

Colloquy of Mobiles Replica

Design Development: Prototype / Model Intermittent Signal Light

Model light signals using photocell.



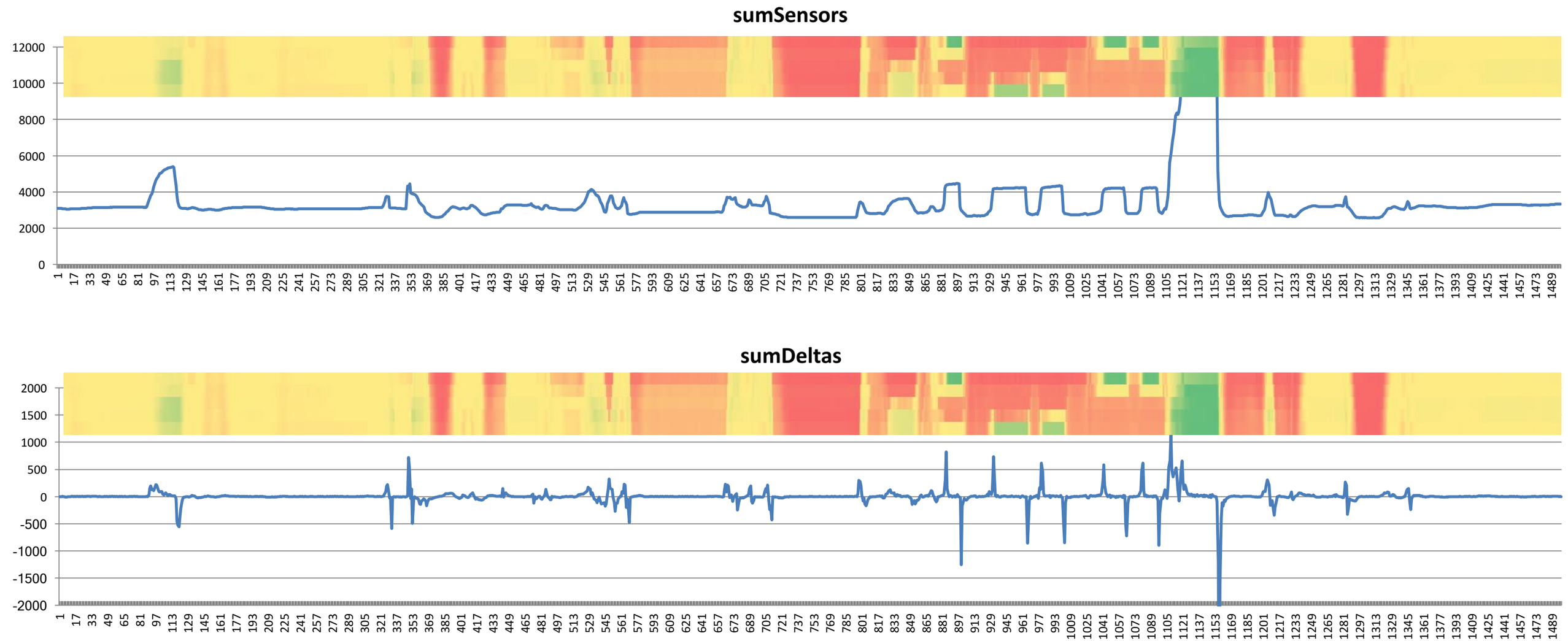


A	B	C	D	E	millis	time	dA	dB	dC	dD	dE	dMillis	sumSensors	sumDeltas
303	653	740	792	596	38399	2018-01-18T23:29:48Z							3084	0
303	653	739	791	598	38454	2018-01-18T23:29:48Z	0	0	-1	-1	2	55	3084	0
303	653	739	790	597	38509	2018-01-18T23:29:48Z	0	0	0	-1	-1	55	3082	-2
303	651	741	793	598	38564	2018-01-18T23:29:48Z	0	-2	2	3	1	55	3086	4
303	652	738	792	597	38619	2018-01-18T23:29:48Z	0	1	-3	-1	-1	55	3082	-4
303	652	738	790	596	38674	2018-01-18T23:29:48Z	0	0	0	-2	-1	55	3079	-3
303	652	737	788	592	38729	2018-01-18T23:29:48Z	0	0	-1	-2	-4	55	3072	-7
303	651	737	785	588	38784	2018-01-18T23:29:48Z	0	-1	0	-3	-4	55	3064	-8
303	650	736	783	587	38839	2018-01-18T23:29:48Z	0	-1	-1	-2	-1	55	3059	-5
303	652	735	782	585	38894	2018-01-18T23:29:48Z	0	2	-1	-1	-2	55	3057	-2
303	651	735	782	584	38949	2018-01-18T23:29:48Z	0	-1	0	0	-1	55	3055	-2
303	651	734	781	584	39004	2018-01-18T23:29:49Z	0	0	-1	-1	0	55	3053	-2
303	651	736	782	584	39059	2018-01-18T23:29:49Z	0	0	2	1	0	55	3056	3
304	652	736	783	585	39114	2018-01-18T23:29:49Z	1	1	0	1	1	55	3060	4
304	651	736	784	584	39169	2018-01-18T23:29:49Z	0	-1	0	1	-1	55	3059	-1
305	652	738	784	585	39224	2018-01-18T23:29:49Z	1	1	2	0	1	55	3064	5
304	651	738	785	586	39279	2018-01-18T23:29:49Z	-1	-1	0	1	1	55	3064	0
304	652	739	785	587	39334	2018-01-18T23:29:49Z	0	1	1	0	1	55	3067	3
306	653	741	787	586	39389	2018-01-18T23:29:49Z	2	1	2	2	-1	55	3073	6
305	653	739	788	587	39444	2018-01-18T23:29:49Z	-1	0	-2	1	1	55	3072	-1
305	652	741	788	588	39499	2018-01-18T23:29:49Z	0	-1	2	0	1	55	3074	2
305	653	741	788	588	39554	2018-01-18T23:29:49Z	0	1	0	0	0	55	3075	1

Colloquy of Mobiles Replica

Design Development: Prototype / Model Intermittent Signal Light

Model light signals using photocell.



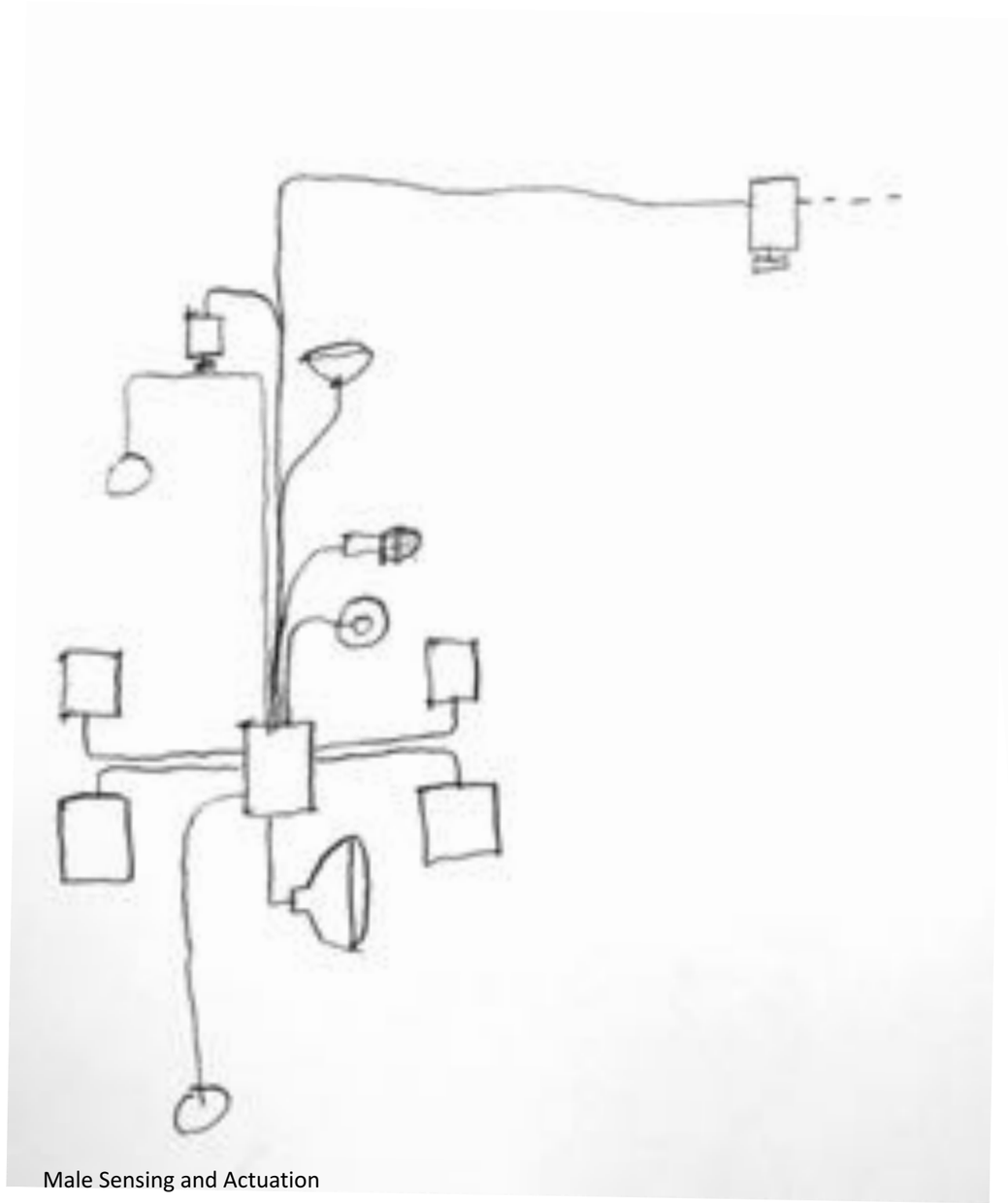
Colloquy of Mobiles Replica

Design Development: Actuation

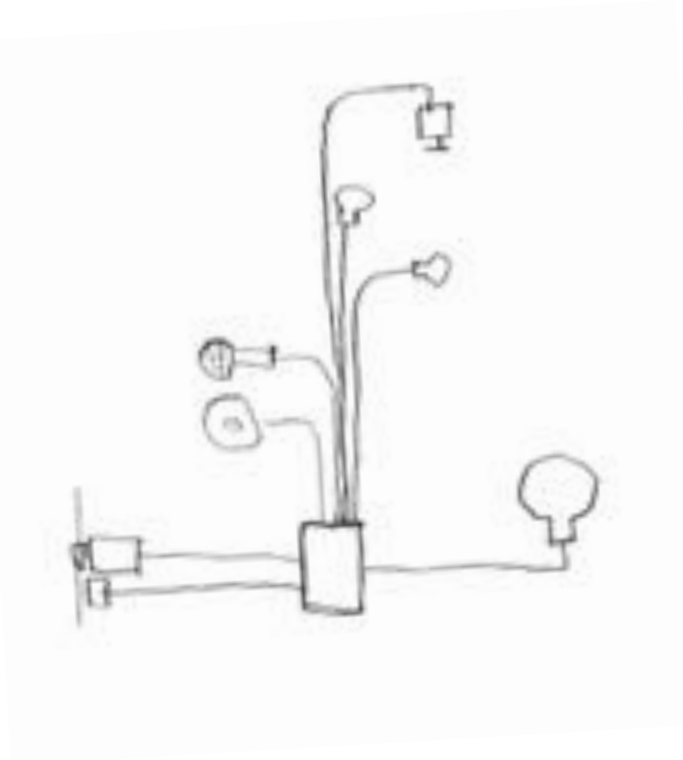
Colloquy of Mobiles Replica

Design Development: Prototype / Model Actuation Wiring Infrastructure

…



Male Sensing and Actuation



Female Sensing and Actuation

Colloquy of Mobiles Replica

Design Development: Computation

Colloquy of Mobiles Replica

Design Development: Prototype / Model Microcontroller System

Raspberry Pi Zero W

https://www.adafruit.com/product/3400

Particle Electron

USB Power
USB Data

Ethernet Data
Ethernet Power

Power Socket that wont come loose
Power source

Phone connector for sensor data

WIFI

Wiring Harness Concerns

Dependant on microcontroller
Dependant on servos
Dependant on sensing

Colloquy of Mobiles Replica

Design Development: Communication

Colloquy of Mobiles Replica

Design Development: Wiring Harness

Colloquy of Mobiles Replica

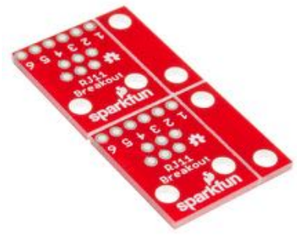
Design Development: Prototype / Model Microcontroller System

Wiring Harness Concerns

Dependant on microcontroller
Dependant on servos
Dependant on sensing

Raspberry Pi Zero W

https://www.adafruit.com/product/3400



$1.95

https://www.sparkfun.com/products/14021

https://www.sparkfun.com/products/132

$1.25

USB Power
USB Data

micoUSB connectors come loose, connection seems poor for moving parts

Ethernet Data
Ethernet Power

RJ45 connections are fairly secure

Power Socket that wont come loose

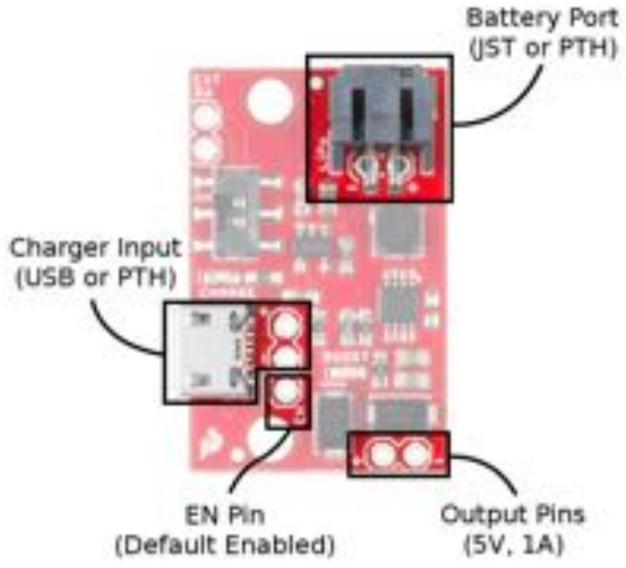
Phone connector for sensor data

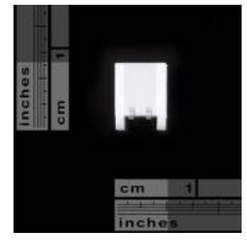
WIFI

Screw clamp connectors

Power bus

Plastic insulation electrical conduit





Colloquy of Mobiles Replica

Design Development: Prototype / Model Microcontroller System

Raspberry Pi Zero W

https://www.adafruit.com/product/3400

Particle Electron

SparkFun Qwiic Adapter
In stock DEV-14495 ROHS Open Source Hardware In Eagle Library
$0.95

USB Power
USB Data

micoUSB connectors come loose, connection seems poor for moving parts

Ethernet Data
Ethernet Power

RJ45 connections are fairly secure

Power Socket that wont come loose

Phone connector for sensor data

WIFI

Screw clamp connectors

Power bus

Plastic insulation electrical conduit

Wiring Harness Concerns

Dependant on microcontroller
Dependant on servos
Dependant on sensing

Qwiic Cable - 500mm
In stock PRT-14429
$1.95

Qwiic JST Connector - SMD 4-pin
In stock PRT-14417 In Fritzing Library
$0.50

Colloquy of Mobiles Replica

Design Development: Software

Colloquy of Mobiles Replica

Design Development: Prototype / Model Algorithm

Build prototypes of responsive environment components recreating Colloquy of Mobiles behaviors and interactions to address the following issues.

Recreate Colloquy of Mobiles system code from synthesized documents

- Scenario
- Flowchart
- Algorithm
- Hardware Selection and Libraries for Sensing and Actuation

Colloquy of Mobiles Replica

Design Development: Prototype / Model Algorithm

...

Male Description

1. The Male mobile has two 'drives', **0** and **P** (associated with orange and puce colored light)
2. The Male drive state is indicated visually by an upper display**, A**.
3. The Male's main goal is to satisfy (or reduce) the 0 and P 'drives' which normally build up over time.
4. The Male can do so, in the case of 0, by projecting an intense beam of orange light from its central part, **B**, in such a way that it falls upon receptors in its upper part; **C**;
5. In the case of P satisfaction the Male must project an intense beam of puce light from B in such a way that it falls on receptors in the lower part, **D**.
6. In order to achieve this goal it must elicit the co-operation of a Female who, unlike the Male, is provided with a vertically positionable reflector capable of taking the beam from B and reflecting it back either to **D** or **C**.
7. **D** and **C** are free-moving members loosely coupled to the main mobile body.

Males engage in motion that:

1. Rotates the bar linkage, **Z**
2. Rotates itself about its point of suspension.

The Male Drive States Are:

1. 'upper limit ≥ drive **0** > drive **P** ≥ lower limit'	which induces an **0** satisfaction search;
2. 'upper limit ≥ drive **P** > drive **0** ≥ lower limit'	which induces a **P** satisfaction search;
3. '(lower limit > drive **0**) and (lower limit > drive **P**)'	the male is satisfied and indifferent;
4. '(drive **0** > upper limit) and (drive **P** > upper limit)'	which induces a search for either **0** or **P** satisfaction.

Colloquy of Mobiles Replica

Design Development: Prototype / Model Algorithm

...

Male Scenario: Male **I** has drive **0** greater than drive **P** and has not found a female to help it. In this case…

1. Male **I** sends out an intermittent directional visual signal which serves to identify it as 'male **I**' and its desire as '**0** satisfaction'.
2. Male **I** moves according to (I) and (2) above (unless (Male **I**) is blocked by Male **II**) seeking a co-operative and receptive female (the females are normally in rotational motion, seeking males)
3. Should the directional signal fall on the receptor **a** of a female who is willing to co-operate, she produces an identifying sound in synchrony with the intermittent light signal.
4. Male **I** detects the correlation between the female and his light signal and stops his motion (unless he is prevented from doing so by male **II**).
5. Male **I** triggers off an autonomous energetic event which consists in shining an intense orange light, for at least a minimum interval, in the direction of the located female.
6. The immediate result is an increase in the Male **I 0** drive.
7. Male **I** anticipates subsequent reinforcement (which he will achieve if the female behaves appropriately and if the free moving part, **C**, is appropriately positioned during at least some of this behavior).
8. Reinforcement, which substantially reduces the **0** drive, is obtained if the **0** goal is satisfied; that is, if orange light falls on the receptor in **C**.
9. Supposing reinforcement occurs, Male **I** emits an identifying sound signal which is received by the co-operating female; the autonomous energetic event is prolonged and the **0** drive is decreased.
10. The co-operative encounter terminates after a short time if reinforcement does not occur, or if it is externally disrupted.
11. Otherwise, it continues until the drive state of Male **I** is modified so that he aims for a different goal.

Colloquy of Mobiles Replica

Design Development: Prototype / Model Algorithm

...

Female Description:

1. A Female has an **0** drive and a **P** drive.
2. Unless both drives are satisfied (when she becomes inert) the Female rotates and searches for a Male.
3. According to her drive state, she is receptive to males offering **0** or **P** cooperation or to both.

Colloquy of Mobiles Replica

Design Development: Prototype / Model Algorithm

...

Female Variables

Name	Type		Description
μ	*number*		female drive variable
$\Delta\mu$	*NA*		not used
$d\mu$	*number*		increment for increasing female drive during search
$\delta\mu$	*number*		increment for lowering female drive during reinforcement
y	*number*		[lower] limit on variable μ
M_A	*enum*	UNKNOWN/DOWN/UP	memory for orange
M_B	*enum*	UNKNOWN/DOWN/UP	memory for puce
F	*boolean*		reinforcement variable, evaluated by the male
t	*NA*		not used
Δt	*number*		fixed delay, sleep for a duration

Colloquy of Mobiles Replica

Design Development: Prototype / Model Algorithm

...

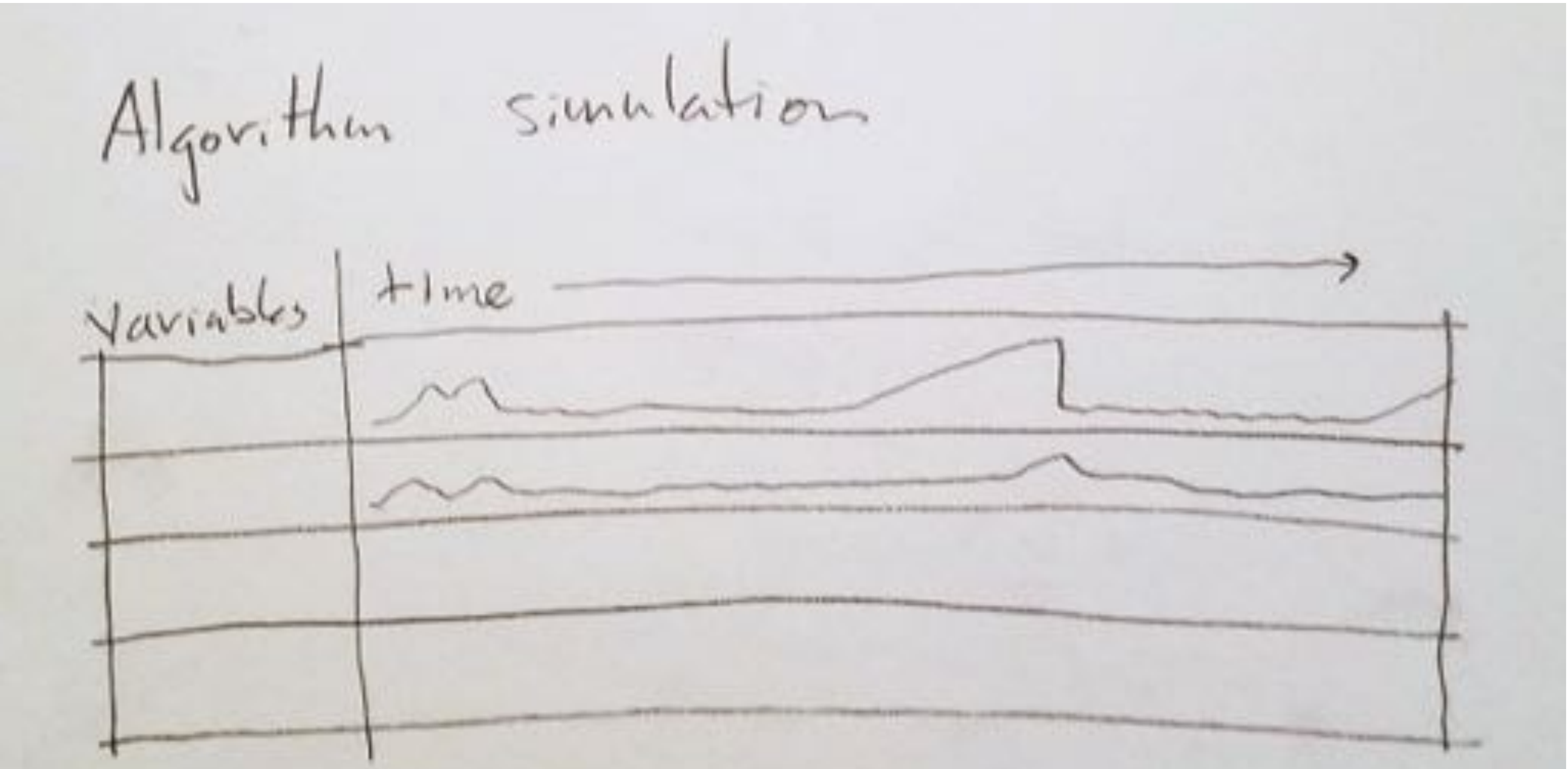
Female Scenario: Suppose that she is looking for **0** cooperation and suppose she encountered Male **I** in the state already described

1. On receipt of his intermittent directional signal, the Female puts his name 'Male **I**' and his intention '**0** satisfaction' into a short-term memory.
2. The Female emits the correlated sound which the Male can recognize
3. The Female expects to receive the 'energetic' beam of orange light.
4. If this does fall on her vertical reflector, **b**, she stops her rotational motion and starts a search, using this reflector, to position the beam on some part of Male **I** that will give rise to a reinforcement signal.
5. The Female's goal is to obtain the conjunction of orange light on her reflector and the reinforcement signal from Male **I**.
6. Female goal achievement reduces her **0** drive.
7. Female likelihood of achieving this goal in the rather short time allowed for an unreinforced encounter, depends upon the vertical reflector search strategy and this in turn depends upon her previous experience (upon what she has learned and placed in a long term 'memory').
8. In ignorance of males, her vertical strategy is a haphazard search reflecting the beam up and down.
9. However, if she has previously learned that reinforcement for **0** light comes from reflecting it upwards (in fact on to **C** of Male **I**), then her strategy becomes a limited upwards search.
10. A similar comment applies to **P** experience.
11. Further, not all males are necessarily the same; some may like **0** light on **D** and **P** light on **C**; she can learn that trick also.
12. In any case, the vertical search strategy terminates after a short time (and the rotational search is resumed) if a reinforcement signal is not received from the male.
13. If a signal is received, the vertical search is prolonged possibly until the female drive state has been modified.

Colloquy of Mobiles Replica

Design Development: Prototype / Model Algorithm

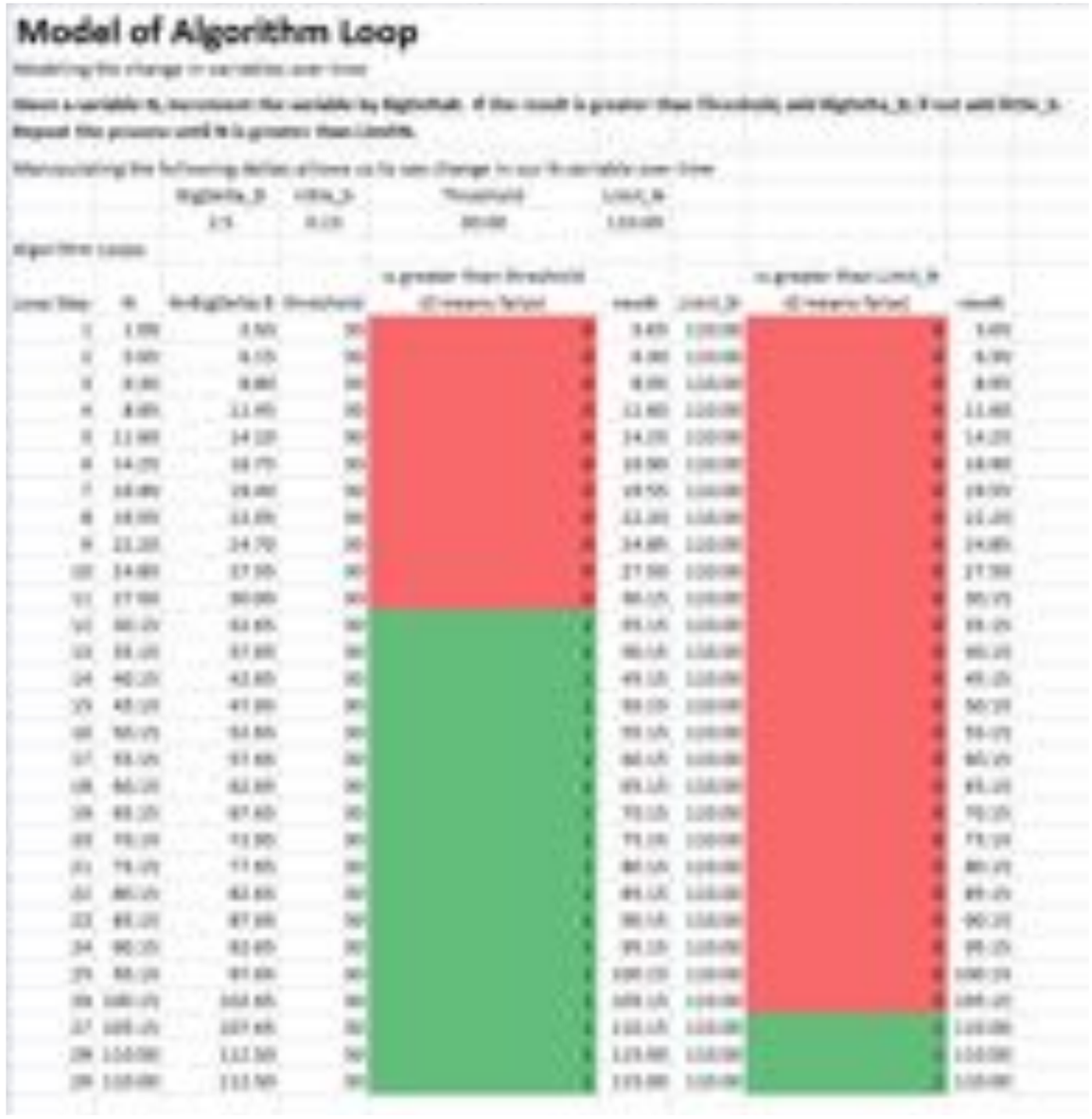
…



Colloquy of Mobiles Replica

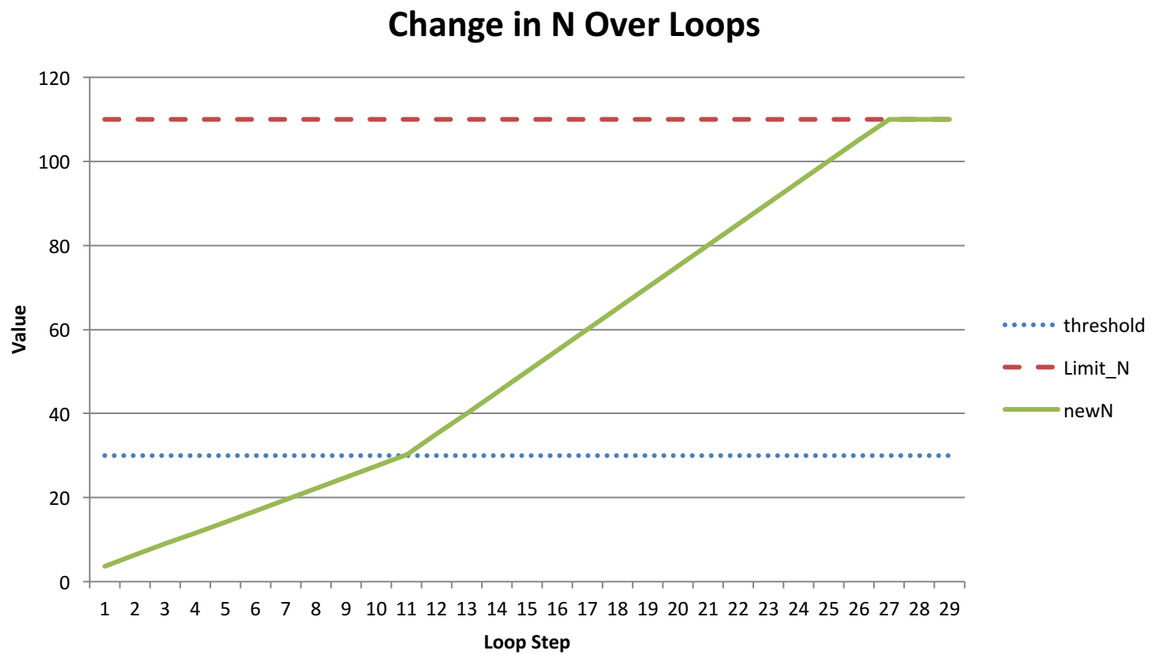
Design Development: Prototype / Model Algorithm

...



Female Variables

Name	Type		Description
μ	*number*		female drive variable
$\Delta\mu$	*NA*		not used
$d\mu$	*number*		increment for increasing female drive during search
$\delta\mu$	*number*		increment for lowering female drive during reinforcement
y	*number*		[lower] limit on variable μ
M_A	*enum*	UNKNOWN/DOWN/UP	memory for orange
M_B	*enum*	UNKNOWN/DOWN/UP	memory for puce
F	*boolean*		reinforcement variable, evaluated by the male
t	*NA*		not used
Δt	*number*		fixed delay, sleep for a duration



Colloquy of Mobiles Replica

Design Development: Workspace for Prototype / Model

Colloquy of Mobiles Replica

Design Development: Prototype / Model

Prototyping Responsive Environment Elements: Workspace Layout

Colloquy of Mobiles Replica

Design Development: Prototype / Model

Prototyping Responsive Environment Elements: Workspace Layout

Colloquy of Mobiles Replica

Design Development: Prototype / Model

Prototyping Responsive Environment Elements: Workspace Layout

Colloquy of Mobiles Replica

Design Development: Prototype / Model

Prototyping Responsive Environment Elements: Workspace Layout

Colloquy of Mobiles Replica

Design Development: Prototype / Model

Prototyping Responsive Environment Elements: Workspace Layout

Colloquy of Mobiles Replica

Project Overview

Fabrication

Colloquy of Mobiles Replica

Project Overview

Fabrication

Coordination

Project Components

- Armature
- Mechanics
- Sensing
- Actuation
- Computation
- Communication
- Wiring Harness
- Software

Colloquy of Mobiles Replica

Project Overview

Fabrication

Execution

Project Components

- Armature
- Mechanics
- Sensing
- Actuation
- Computation
- Communication
- Wiring Harness
- Software

Colloquy of Mobiles Replica

Fabrication Resources

Resources available to supply fabrication tools, services, and expertise for building the Colloquy of Mobiles

CCS

- CNC
- Vacuum Forming
- Welding and Metalwork
- Glass Studio
- Fiberglass Vacuum Bagging
- 3D Printing
- Interaction Design Studio

Detroit

- Fabrication Shops

mHub

- CNC
- Vacuum Forming
- Welding and Metalwork
- Electronics Fabrication

IIT IDEA Shop

- Robotics Lab
- CNC
- 3D Printing

Colloquy of Mobiles Replica

Project Overview

Assembly / Installation

On Site Assembly

Project Components

- Armature
- Mechanics
- Sensing
- Actuation
- Computation
- Communication
- Wiring Harness
- Software

Colloquy of Mobiles Replica

Project Overview

Assembly / Installation

Colloquy of Mobiles Replica

Project Overview

Assembly / Installation

Testing / Punchlist

Project Components

- Armature
- Mechanics
- Sensing
- Actuation
- Computation
- Communication
- Wiring Harness
- Software

Colloquy of Mobiles Replica

Project Overview

CCS Exhibition

Colloquy of Mobiles Replica

Project Overview

Exhibition