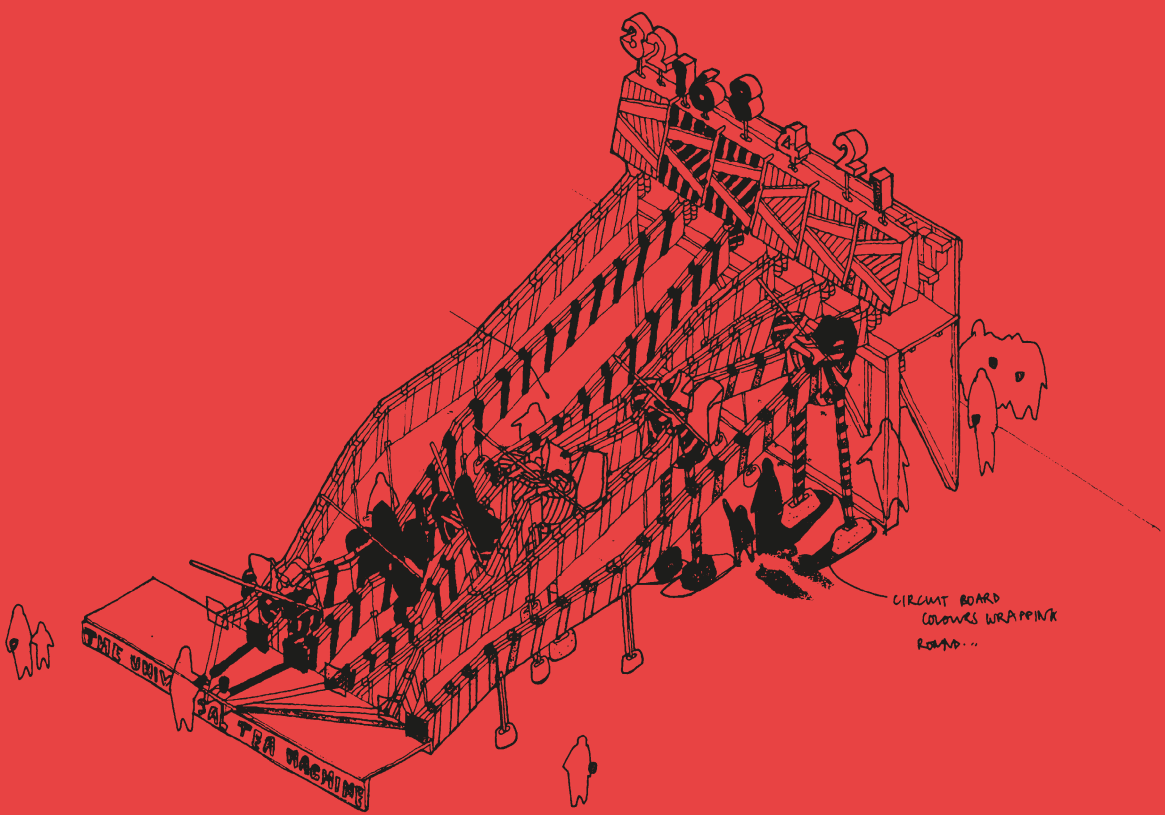
Universal Tea Machine



by Smout Allen

Project Details

Practice:	Smout Allen
Designers:	Mark Smout and Laura Allen Mark Smout and Laura Allen contributed equally to this project through their joint practice, Smout Allen.
Title:	Universal Tea Machine
Output type:	Design
Function:	Public architectural installation
Location:	Victoria Park, Hackney, London
Client:	Mayor of London, Greater London Authority
Practical completion:	July 2012
Dates:	27 July – 12 August 2012
Budget:	£115,000
Size:	12m × 5m × 3.5m
Collaborators:	Design: Luke Pearson and Saundra Youkhana (You & Pea); concept: Iain Borden (UCL); fabrication and design installation: Nick Westby (Westby Jones) and Oliver Palmer
Support:	The Greater London Authority; the Bartlett School of Architecture, UCL


16
8
4
2
1


SUGAR

Statement about the Research Content and Process

Description

Built as part of London's Olympic and Paralympic celebrations, the Universal Tea Machine is a pavilion-sized 'adding computer' that celebrates the British appetite for trade, technological innovation and tea. It reflects London's long and deeply held love affair with tea. From the London Tea Auctions held at East India House, through the construction of some of the world's largest dockyard infrastructure for its import and export, tea has not only been a British cultural phenomenon but also an important catalyst for the finance and trading that today comprise much of modern London.

It also pays homage to the late English mathematician Alan Turing's 'universal Turing machine'. Turing's highly influential role in the development of computer science was also celebrated in the 'Alan Turning Year 2012' to mark the centenary of his birth.

Questions

1. **How can an interactive architectural installation engage adults and children in playful approaches to Britishness?**
2. **How can calculation and computing principles (binary computation) be visualised in a large-scale urban game?**

1 ***(previous page)*** **The Universal Tea Machine, installed in the BT Live site for the London 2012 celebrations**

Methods

1. **Investigations into binary computation as the foundation of computing.**
2. **Prototyping of the game elements.**
3. **Digital fabrication methods and on-site fabrication.**
4. **Testing the game playing.**

Dissemination

There were 193,000 visitors to the project site during its two-week installation. The project was reviewed by UK and international architectural and design press, including: *Architecture Today, BD Online, Design Exchange, The Independent, Edible Geography, The Village Voice* and *Tree Hugger*.

Statement of Significance

One of the winners of the Greater London Authority's Wonder competition for architectural installations to celebrate the London 2012 Olympics and Paralympics.

Introduction

Built as part of London's Olympic and Paralympic celebrations, the Universal Tea Machine is a pavilion-sized 'adding computer' that celebrates the British appetite for trade, technological innovation and tea. It reflects London's long and deeply held love affair with tea. From the London Tea Auctions held at East India House, through the construction of some of the world's largest dockyard infrastructure for its import and export, tea has not only been a British cultural phenomenon but also an important catalyst for the finance and trading that today comprise much of modern London.

It also pays homage to the late English mathematician Alan Turing's 'universal Turing machine'. Turing's highly influential role in the development of computer science was also celebrated in the 'Alan Turning Year 2012' to mark the centenary of his birth. [fig.1]

Aims and Objectives

1. The installation aimed to playfully represent two distinctive elements of London's cultural and financial life: tea culture and trade, and the invention of the 'universal Turing machine'.
2. The installation aimed to engage visitors through game playing approaches found in traditional playground games and fairground attractions.

Questions

1. How can an interactive architectural installation engage adults and children in playful approaches to Britishness?
2. How can calculation and computing principles (binary computation) be visualised in a large-scale urban game?

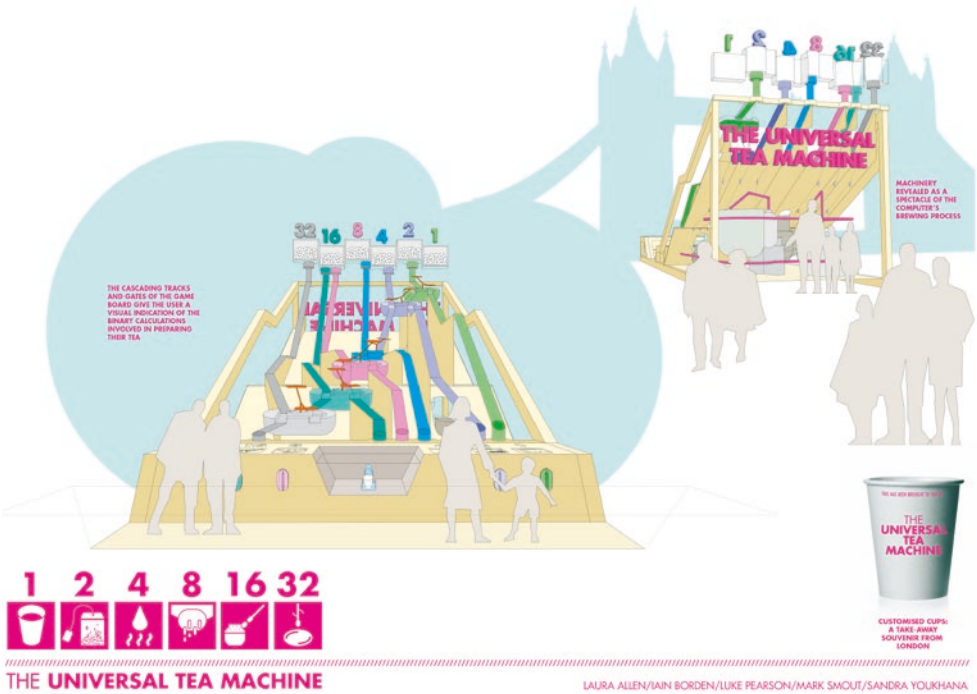
Context

Mayor of London's 'Wonder' projects

The Universal Tea Machine is a winning design in the Greater London Authority's competition for temporary architecture installations to coincide with the 2012 Olympics and Paralympics in London. The project responded to the brief for 'interactive installations on an urban scale' that would engage the public in an interpretation of aspects of city life and its history. The project was initially conceived with various public sites on the Southbank in mind but, owing to planning and installation security constraints, it was ultimately sited in the BT Live site in Victoria Park for the duration of the summer games. There were 193,000 visitors to the site over the two weeks of installation.

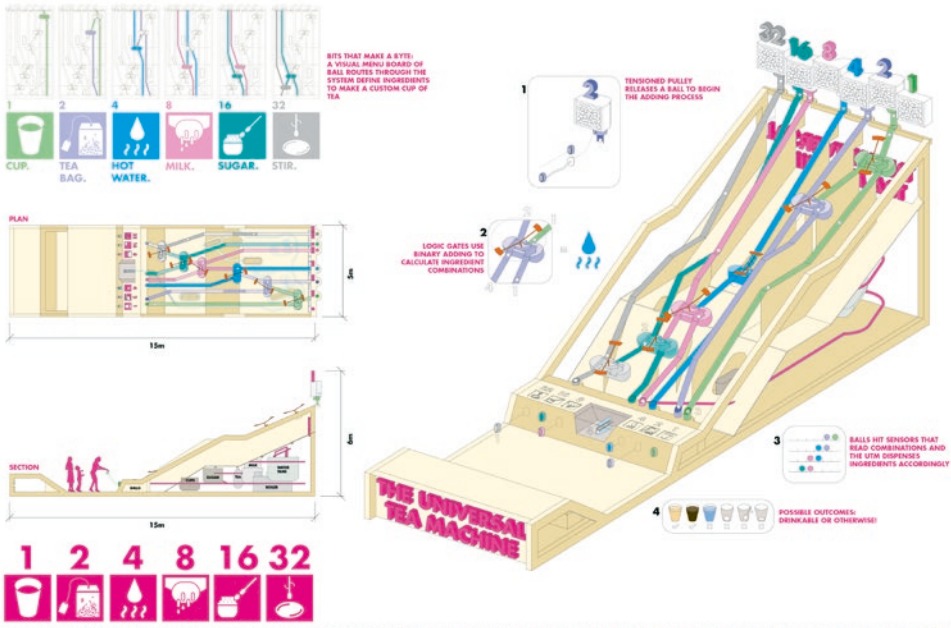
Tea

According to the UK Tea Council, some 165 million cups of tea are consumed in Britain every single day. Tea is a great symbol of the integration of diverse cultures into British society and daily life. It also remains inextricably linked with the idea of ritual, whether as a quick dunk of the bag in a local café or the complex choreographies of a tea party. The Universal Tea Machine reveals the importance of tea through public interaction and spectacle, not only by celebrating the ceremony of tea, but also by using the founding principles of computation in order to understand the composite parts of the great British 'cuppa'.

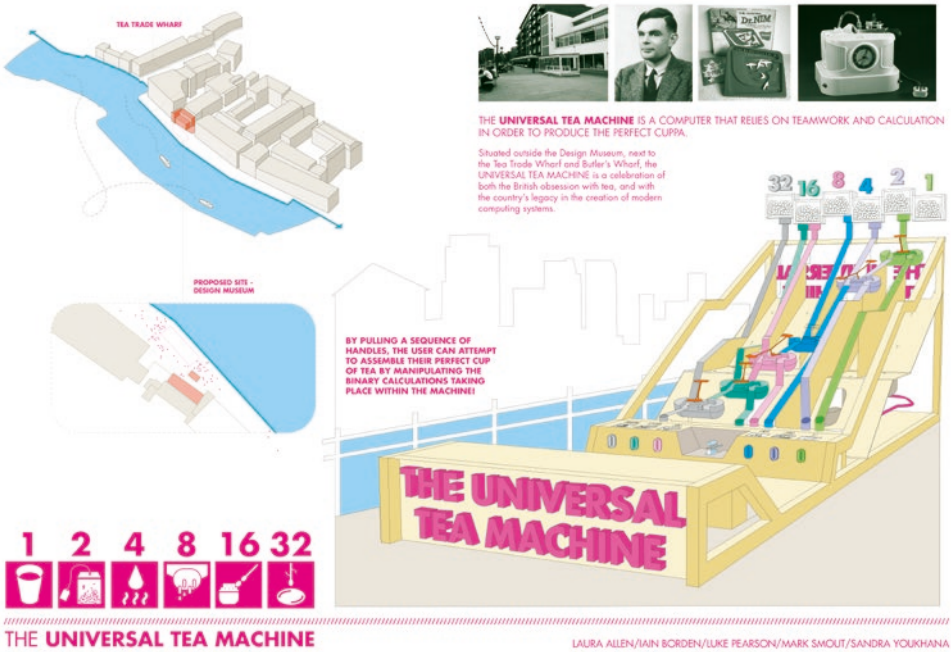


2a

2
Competition submission boards


BITS THAT MAKE A BYTE:
A VISUAL MENU BOARD OF BALL ROUTES THROUGH THE SYSTEM DEFINE INGREDIENTS TO MAKE A CUSTOM CUP OF TEA
1 2 4 8 16 32
CUP. TEA BAG. HOT WATER. MILK. SUGAR. STIR.
PLAN
15m
SECTION
15m
1 TENSIONED PULLEY RELEASES A BALL TO BEGIN THE ADDING PROCESS
2 LOGIC GATES USE BINARY ADDING TO CALCULATE INGREDIENT COMBINATIONS
3 BALLS HIT SENSORS THAT READ COMBINATIONS AND THE UTM DISPENSES INGREDIENTS ACCORDINGLY
4 POSSIBLE OUTCOMES: DRINKABLE OR OTHERWISE!
32 16 8 4 2 1
THE UNIVERSAL TEA MACHINE
1 2 4 8 16 32
THE UNIVERSAL TEA MACHINE
LAURA ALLEN/IAIN BORDEN/LUKE PEARSON/MARK SMOUT/SANDRA YOUKHANA

2b


TEA TRADE WHARF
PROPOSED SITE - DESIGN MUSEUM
THE UNIVERSAL TEA MACHINE IS A COMPUTER THAT RELIES ON TEAMWORK AND CALCULATION IN ORDER TO PRODUCE THE PERFECT CUPPA.
Situated outside the Design Museum, next to the Tea Trade Wharf and Butler's Wharf, the UNIVERSAL TEA MACHINE is a celebration of both the British obsession with tea, and with the country's legacy in the creation of modern computing systems.
BY PULLING A SEQUENCE OF HANDLES, THE USER CAN ATTEMPT TO ASSEMBLE THEIR PERFECT CUP OF TEA BY MANIPULATING THE BINARY CALCULATIONS TAKING PLACE WITHIN THE MACHINE!
32 16 8 4 2 1
THE UNIVERSAL TEA MACHINE
1 2 4 8 16 32
THE UNIVERSAL TEA MACHINE
LAURA ALLEN/IAIN BORDEN/LUKE PEARSON/MARK SMOUT/SANDRA YOUKHANA

2c

The open underbelly of the Universal Tea Machine discloses the ingredients and machinery which conjure up the cup of tea in whichever way desired. This reveals the mystery of objects such as the famous bedside 'Teasmade', a well-known British invention, creating its very own spectacle of the tea-making process.

Logic and calculation

The Universal Tea Machine produces a display of calculation, as one of the fundamental logics of trading and computation. In this way it registers London's significant history of trade over many centuries, developing from small shops cradled within winding medieval streets, to the trading infrastructure of Victorian docks spread across the east of the city, and through to the capital's position today as one of the world's great centres of finance. In addition, Britain's rich history in the development of computation and the calculations has constantly pushed it to the forefront of trade and commerce. This history includes pioneers in computing, such as Charles Babbage and Alan Turing, whose world-leading research allowed the conception of the rapid interflows of data and trade which are essential components of present-day finance and commerce in London and global markets. [fig. 2]

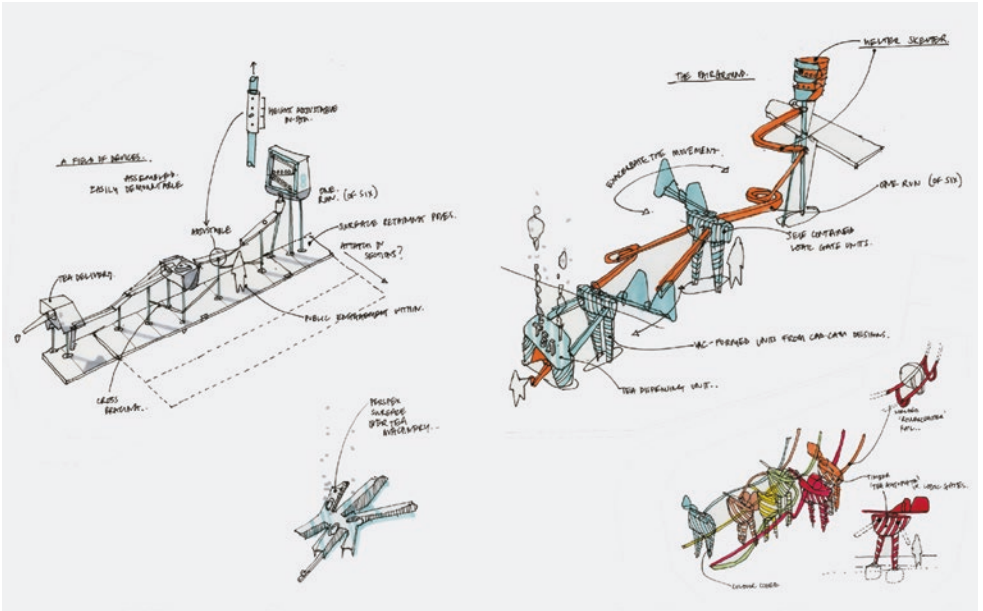
Methods

Investigations into binary computation as the foundation of computing

The project is a representation of a simple principle of computation, and evokes the educational possibilities of play and public engagement. A demonstration of binary calculation can be achieved by modelling a binary marble adding machine where marbles replace electrical current and gravity replaces voltage. The principles of the system can be made at a large scale and this helps the visibility of the demonstration.

We explored how logic, or 'flip-flop', gates (circuits in which two stable states can be achieved to store information) can provide a visual representation of the two-base binary form.

The system operates, or change occurs in the system, when a signal is applied to one or more of the control inputs to generate one or two outputs. These gates are therefore 'basic storage elements' in a sequential system (or logic). They are fundamental building blocks of electronic digital systems used in computing, as well as many other systems. [fig. 3 & 4]



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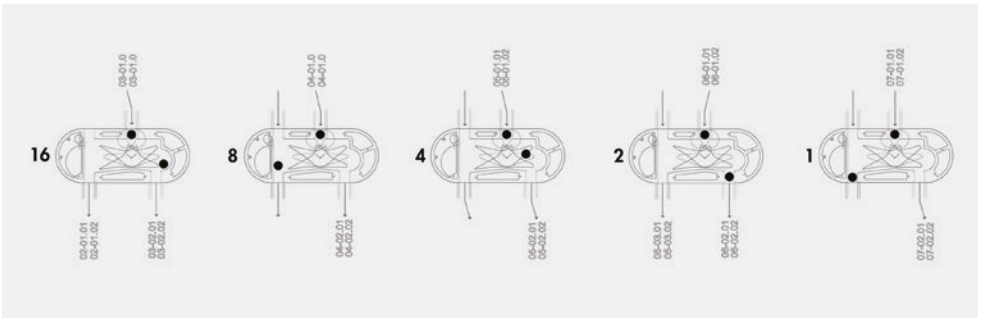
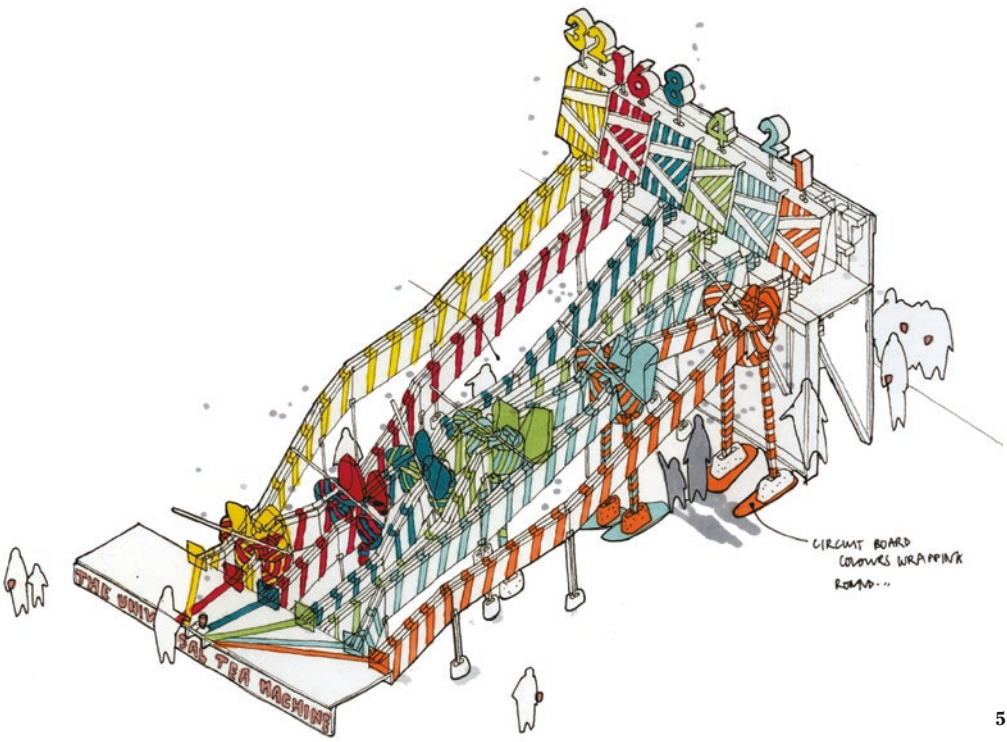


4

3
Design sketch by Luke Pearson showing alternative design for the gates, magazine and teasmade

4
Technical drawings showing gate and rocker design



5

5
Design sketch by Luke Pearson showing alternative design for the gates, magazine and teasmade

Prototyping of the game elements

Scaled and full-size prototypes were made of all the Universal Tea Machine's mechanical components – the logic gates and ball delivery magazines. These tested the performance of the computation elements and the function and reliability of the system. The input runs were tested for the necessary angle of inclination to produce the correct speed for ball travel without inducing bounce and voiding the calculation. The teasmade components were also prototyped to ensure that correct timing and ingredient delivery could be ensured. [fig. 5]

a. Ball delivery system

Five magazines which hold 15 balls are positioned at the back and top of the machine and can deliver the balls individually into each of the input runs. The balls are launched with sufficient momentum down gravity-fed runs to enable them to tip the balance of the rocker in the flip-flop gates. [fig. 6]

b. Input runs

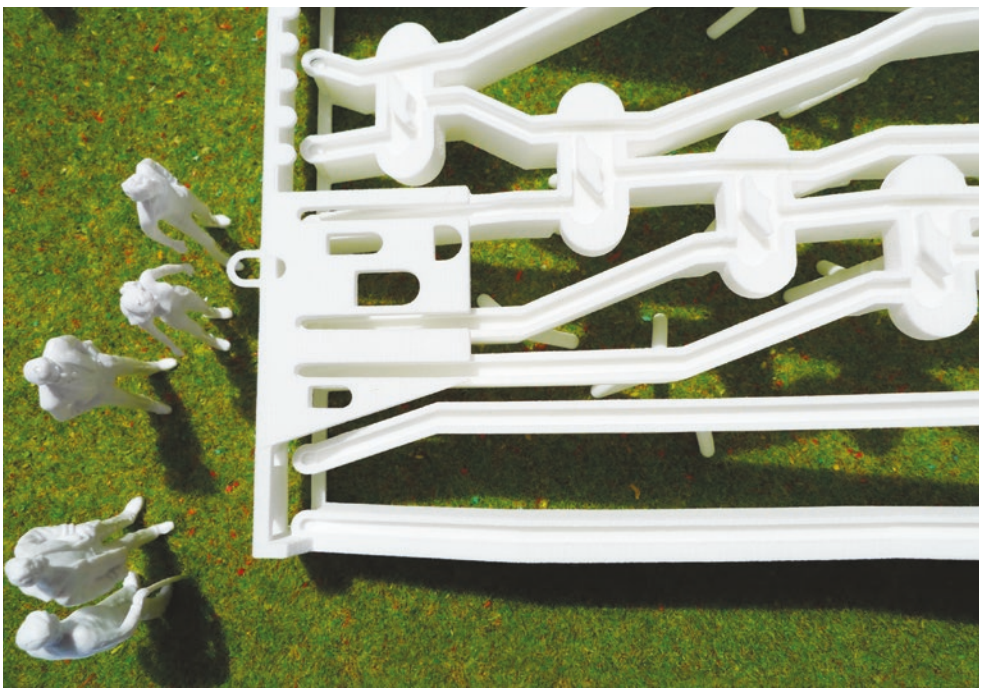
The input runs, constructed as box beams, span 12 metres from the rear structure (which holds the ball delivery magazines) to the calculating desk and teasmade. The runs are inclined to gravity-feed into the input gates and cranked in plan to elaborate the journey of the ball. Five runs, numbered 1, 2, 4, 8, 16, each correspond with a flip-flop gate to compute the addition. [fig. 7]

c. Logic gates

Five 'flip-flop' gates with rocking switches receive the adding balls and provide the sequential logic of the installation. These were designed so the player can read the progress of the cumulative sum. Metal flags on each gate assist this process by reading the result of the addition. [fig. 8]

6

6
Prototyping the ball delivery system

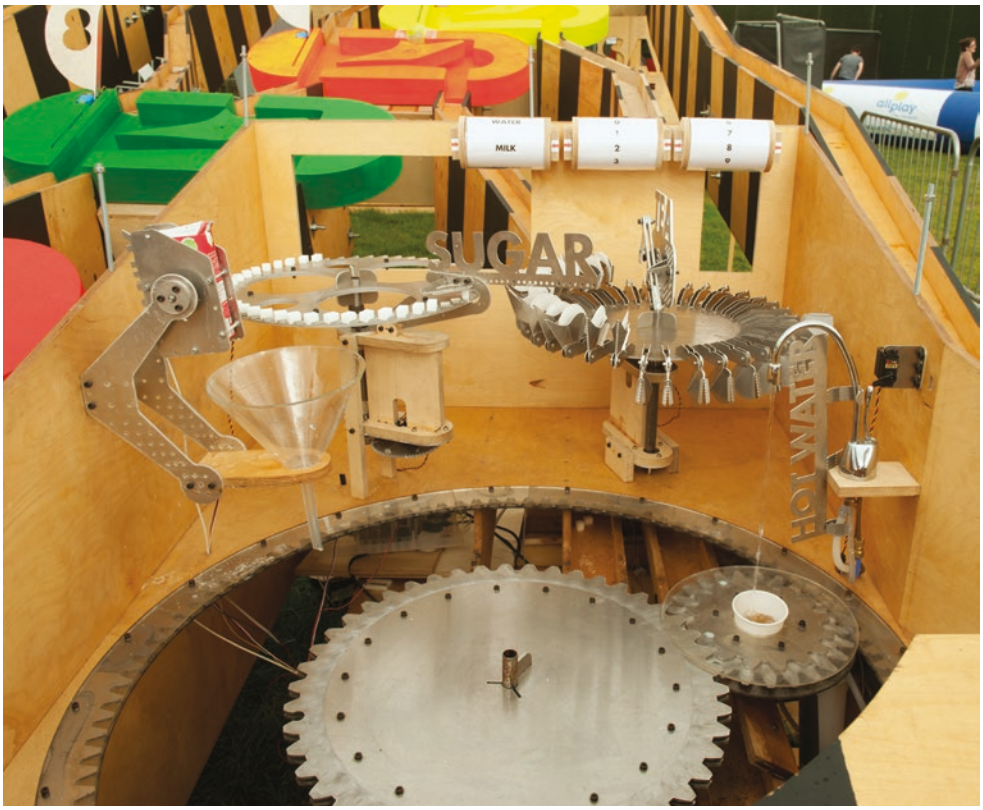


7

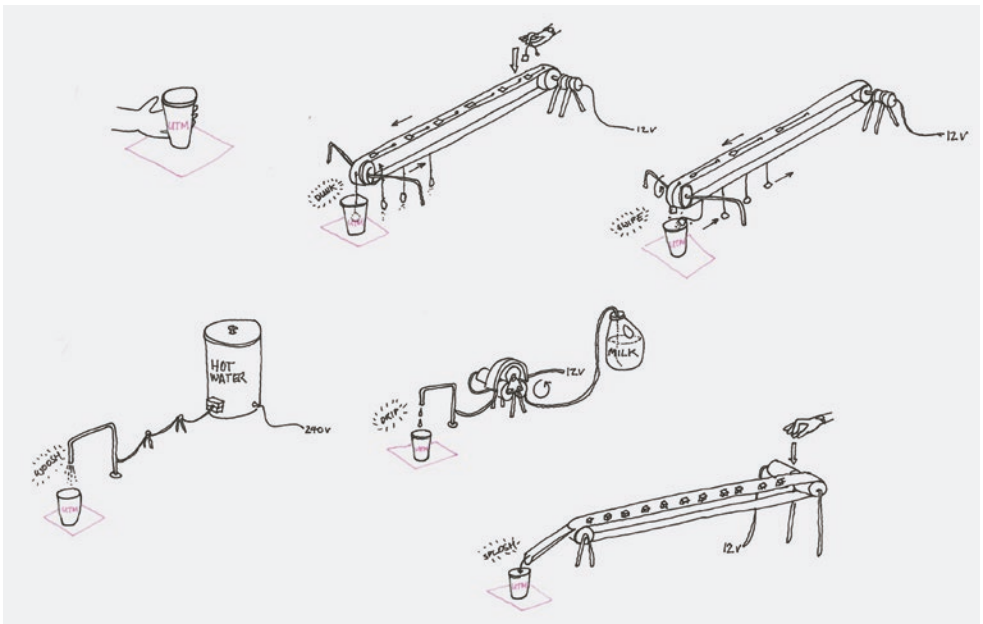
7
Competition model

8
The Universal Tea Machine is reminiscent of a fun fair or pinball game and the activity of calculating how to make tea becomes a spectacle

8


WATER
MILK
SUGAR
HOT WATER

9


12V
HOT WATER
240V
MILK
12V
12V
12V

10

d. The ‘teasmade’ kitchen

A cup of tea is produced by the addition of five ingredients: a cup, a teabag, milk, sugar and boiling water. The teasmade, designed and fabricated by Oliver Palmer, is series of Heath Robinson-like contraptions that separate the tea making into five mechanical activities, which surround a set of large cogs powered by servos linked to the binary calculator by an Arduino board that registers the activity of the logic gates. [fig. 9 & 10]

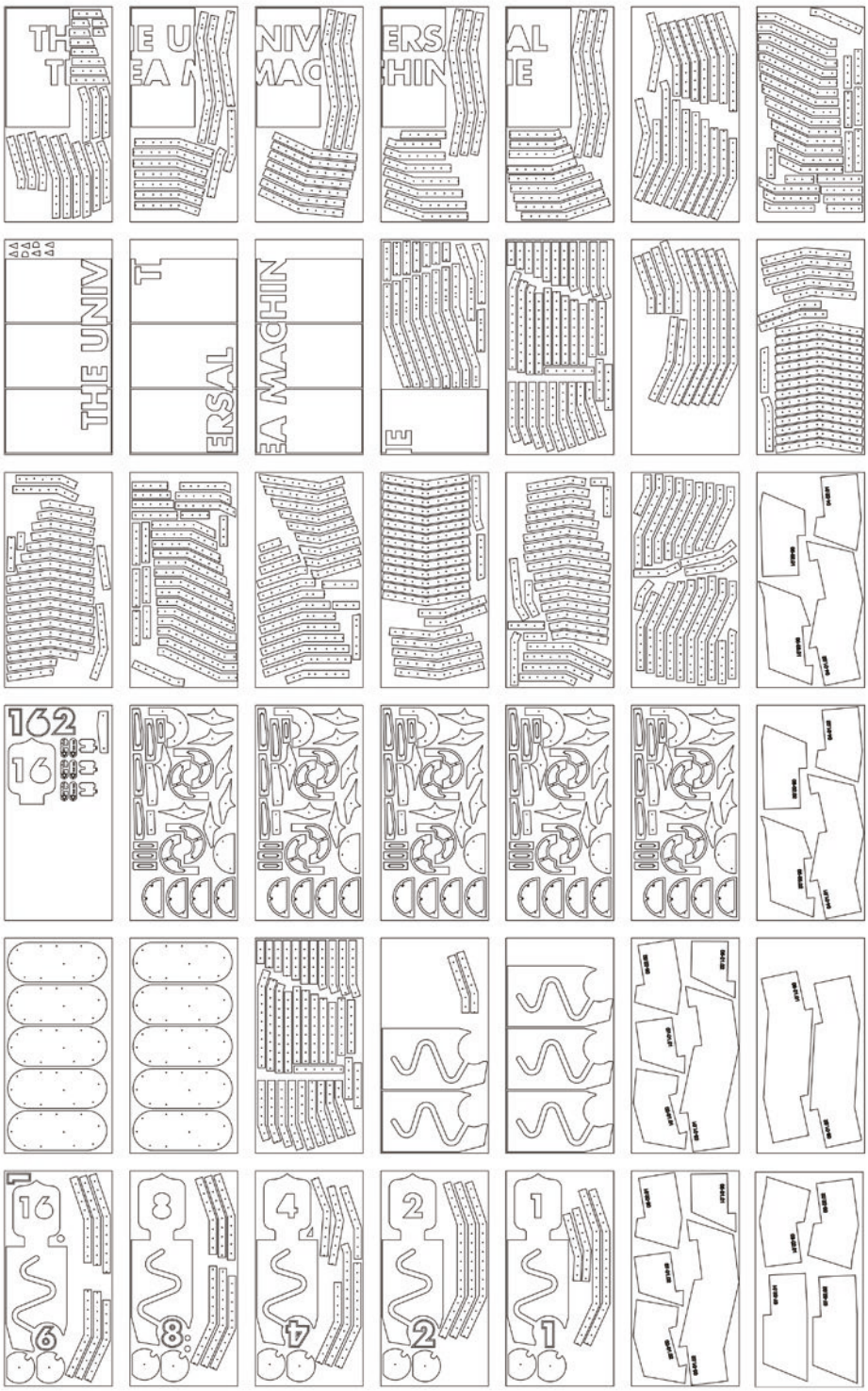
Digital fabrication methods and on-site fabrication

The Universal Tea Machine is mainly constructed from CNC routed plywood fabricated into box beams, layered into solid junctions and built into panel enclosing structures. The performative elements of the logic gates and ball delivery system are also plywood with mechanical elements and electronic componentry. Due to site access and transport restrictions and manufacturing processes, the machine was designed to be partially constructed off-site in kit form and then assembled on-site.

The design and construction were a collaborative process where the team produced drawings and prototype models for testing and development, and for consultation with the Greater London Authority’s Wonder project delivery team. Nick Westby of Westby Jones was contracted to produce 3D digital fabrication drawings, and managed production, fabrication and site installation. Oliver Palmer was subcontracted to design and fabricate the teasmade, which uses an Arduino interface. [fig. 11–14]

9
The Universal Tea Machine showing the teasmade

10
Initial design sketches of the teasmade system


THE UNIV
ERSAL
EA MACHIN
IE
16
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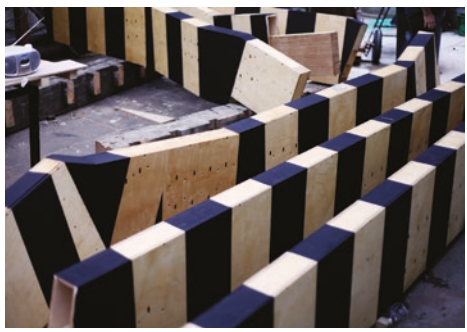


12h

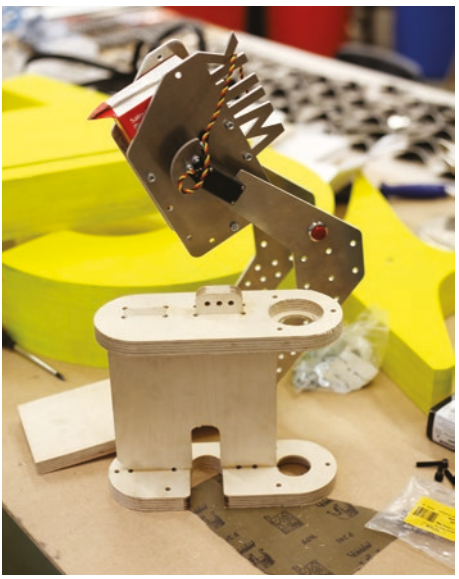
13

11 ***(previous page)***
Pattern drawings for CNC cutting

12 ***(previous page)***
Plywood kit parts being assembled for the input runs and beam joints

13
As on-site construction time was limited, the Universal Tea Machine was designed to be partially assembled and transported to the site.

14a



14b

14c

14
Prototyping the teasmade

15a

15b

15
Willing game players were assisted by a team of UCL students who guided their calculations and encouraged team participation.

Testing the game playing

a. Operation guidance

The aim of the Universal Tea Machine involved game playing, chance and mishap to produce a cup of tea and to invoke central components of London's vibrant cultural, trading and financial life. Game players were spurred on by group participation which naturally occurred when other observers of their game contributed advice to the player and became involved in the success or failure of each calculation. The audience were clearly enthralled by interaction with the machine, which rewarded collaboration and teamwork across ages. [fig. 15]

b. Game playing instructions

A digital random number generator gives the game player a series of five ascending numbers. The game player then attempts to produce each of the numbers in sequence with the Universal Tea Machine binary calculator. Each successful attempt allies to one of the components of a cup of tea – cup, milk, sugar, teabag and boiling water. Unsuccessful calculations and failure to follow instructions, however, run the risk of an 'imperfect' output – a cup containing milk minus a teabag, or sugar without a cup, etc.

At the front of the machine is the calculation table, which contains five large red buttons that each correspond to the 1, 2, 4, 8 and 16 input runs. The buttons trigger balls to be released from their magazines at the top of the run. As the balls are released in order to produce a calculation, they roll along the runs until they hit logic gates, where they come to rest on one side of the gate rocker. A ball remains in the gate until another ball is added to the run, reaches the gate, 'flops' the rocker switch and releases the first ball. If the correct calculation sequence has been performed, the corresponding ingredient for the cup of tea will be released. Therefore, through careful calculation and teamwork (and perhaps a degree of luck), a perfect cup of tea can be delivered straight to the hand of the operator. [fig. 16–18]

16

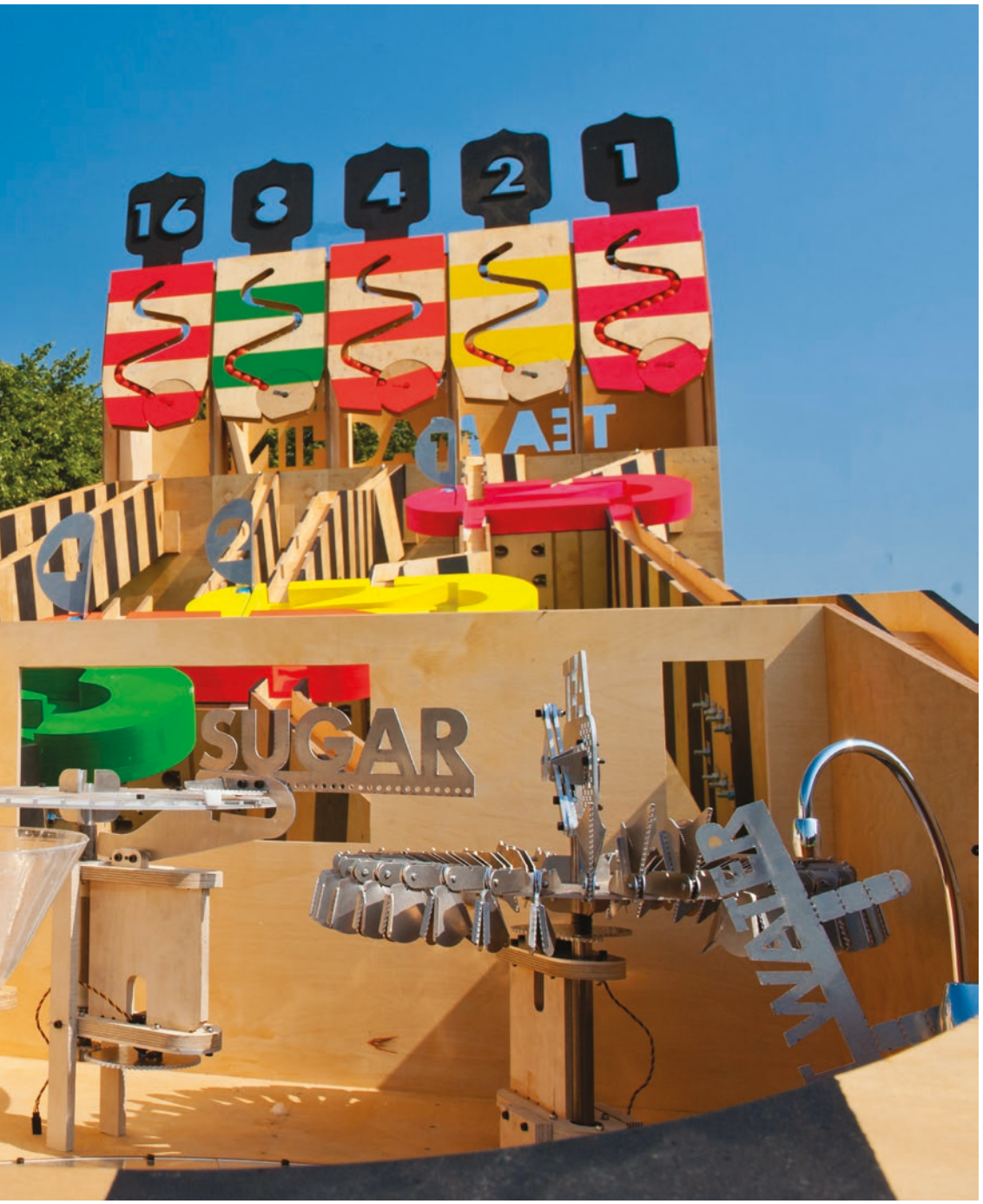
16
The calculation table

17

17
The teasmade showing cup delivery and the teabag dispenser

18
The random number generator initiates game play.

19
The Universal
Tea Machine



19

20

20
The Universal Tea Machine installed for the opening night of the London 2012 Olympic games. The red arrow fly past can be seen in the sky above.

c. A calculation example

Looking at the gates on the machine, you can see that there is both a ball held in the '4' and '1' gates, meaning that the current accumulated total is five.

A new target total is given for sugar – seven. To achieve this total, the operator releases a '2' ball, which rolls down the '2' run and rests in the '2' gate. The total is correct and sugar is dispensed.

Looking at the gates of the machine, you can now see that there are balls held in the '4', '2' and '1' gates, meaning the current accumulated total is seven.

A new target total is given for milk – eight. To achieve this, the operator releases a '1' ball, which rolls down the '1' run and dislodges the ball held in the '1' ball into the '2' gate, which in turn dislodges the ball held in the '2' gate into the '4' gate and knocks the ball held in the '4' gate into the '8' gate, where it remains. The total is correct and milk is dispensed.

Looking at the gates on the machine you can now see that there is only one ball held in the system and that is in the '8' gate, meaning that the current accumulated total is eight. [fig. 19 & 20]

Dissemination

A total of 193,000 people visited the project site during its two-week installation. The project was reviewed by UK and international architectural and design press including: *Architecture Today, BD Online, Design Exchange, The Independent, Edible Geography, The Village Voice* and *Tree Hugger.*

Related writings by others

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Nicola Twilley, 'The Universal Tea Machine: What do you get if you cross Alan Turing and the London Olympics?', *Edible Geography* (17 Jul 2012): www.ediblegeography.com/the-universal-tea-machine

p. 32
Tejal Rao, '3 good things: The Universal Tea Machine, sneaky pugs', *The Village Voice* (18 Jul 2012): http://blogs.villagevoice.com/forkintheroad/2012/07/universal_tea_machine_pugs.php

p. 33
Mark Wilding, 'Bartlett to unveil five architecture pavilions around London', *BD Online* (23 Jul 2012): www.bdonline.co.uk/news/bartlett-to-unveil-five-architecture-pavilions-around-london/5040099.article

pp. 34–35
Will Dean, 'The perfect cup of tea, get one whilst they're hot!', *The Independent* (2 Aug 2012): www.independent.co.uk/life-style/food-and-drink/features/will-deans-ideas-factory-the-perfect-cup-of-tea–get-one-while-theyre-hot-7999314.html

pp. 36–37
'Architectural installations pop up around London', *Design Exchange* (2 Aug 2012): www.demagazine.co.uk/architecture/architectural-installations-pop-up-around-london

p. 38
'A showcase of the Bartlett's teaching staff work', *Architecture Today* (4 Aug 2012): www.architecturetoday.co.uk/?p=24504

p. 39
Bonnie Alter, 'Pop-up architecture on the cheap – Just for the Olympics', *Tree Hugger* (8 Aug 2012): www.treehugger.com/urban-design/five-wonder-pavilions-olympics.html

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