The Alchymical Analyser: Illustration of Theoretical Computing Concepts via Instructional Art Objects

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ABSTRACT
The Alchymical Analyser (Fig. 1) is an instructional art object whose purpose is to simulate the alchemical process. The user of the Analyser is invited to engage in a game in which the goal is to correctly complete a series of computations. The participant is directed through the process via pictograms illustrating the associations between the symbols present on the dial interface. (not shown on this prototype) By completing the game, the participant is endowed with a greater sense of the logical architecture behind the computations as well as their relationship to the physical architecture of the machine itself**.** This paper describes the theory, construction, operation, and applications.

Fig. 1. The Alchymical Analyser

INTRODUCTION
Digital technology can be found in a wide range of applications, from supercomputers to tennis shoes. We live in an age of digital ubiquity. Despite the pervasiveness of this technology, it is not uncommon to hear one refer to this technology as 'magical', even though it is scientifically based. A factor contributing to this myth stems from the fact that one cannot see the operation of a computer as one would that of something more mechanical in nature. Another myth about computing is that it is a recent technology. Without some knowledge of computing history, it is difficult to imagine an early device that could perform mathematical calculations, yet devices constructed for this purpose have been employed for centuries, e.g., the abacus and more recently, Babbage's difference engine. The Laboratory for Artistic Research and Development has endeavored to develop a modern computing device that utilizes the alchemical process as the machine's 'magical' quality and resolves this quality by tethering it to the operation of the machine, thereby illustrating the mechanics behind the 'magic.'

ALCHEMY AND AUTOMATA
The art or science of alchemy is deeply rooted in the history of human civilization and is still practiced to some degree in this modern age. Western alchemy, as opposed to those forms practiced in other cultures, is based on the work of the Greek philosopher, Aristotle. He purports that the material world is born of a primal matter, or Prima Materia. This primal matter exists as one of the four elements (Fire, Air, Water, or Earth) when impressed upon by two of the four material qualities (Cold, Hot, Humid, or Dry). All matter consists of varying quantities of these four elements. The alchemical process involves the manipulation of these material qualities of matter with the ultimate goal of obtaining the Prima Materia, or 'Philosopher's Stone'. This product, the union of all material qualities, possesses the ability to transmute base metals to precious ones [1].

Although technological evolution has shifted the scientific paradigm, alchemy can still be viewed from a scientific rather than a 'magical' viewpoint. On the other hand, the 'magic' produced by modern science could even be referred to as 'modern alchemy' [2]. Alchemy's goal-oriented study of material qualities bears no difference from the modus operandi of modern science. Most importantly, alchemy and modern science share a common language of signs and symbols. Being that mathematics is a system to

manipulate symbols, it is ideally suited to represent the alchemical process. A mathematical machine can be created to perform this process. This theoretical machine is referred to as an automaton. An automaton is characterized by the manner in which it performs a procedure: for any automaton there is a group of inputs to which it reacts, and a group of outputs which it produces, the relation between these being determined by the structure, or architecture of the automaton [3]. This architecture is composed of a finite set of states defined by qualities of being, e.g., a light bulb is in the ON state as it has the quality of being ON. An automaton is illustrated as a state diagram in which the states of the machine are represented as circles and the transitions between them as arrows. An automaton always begins its procedure in an initial state (denoted as q_0) and ends in a set of final states (represented by two inscribed circles). The interpretation of an automaton in relation to the alchemical process is as follows (Fig. 2): The machine is in its beginning, or start state at q_0. The first input (**d**ry, **h**ot, **h**umid, or **c**old) changes the state of the machine to that of q_{1x}, where x corresponds to that input. The second input (**d**ry, **h**ot, **m**oist, or **c**old) then places the machine in its final state, q_{2x}, where x corresponds to the element (**F**ire, **A**ir **W**ater, or **E**arth) possessing those two qualities. (To insure clarity, the quality **h**umid is represented as **f**luid in the state diagram.)

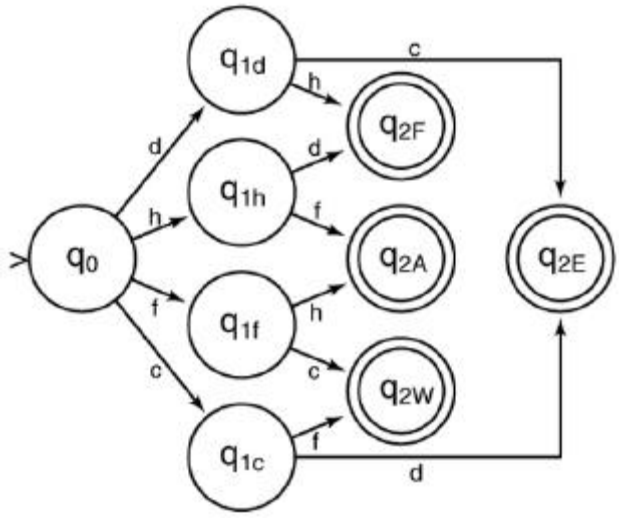

Fig. 2. The finite state automaton for a sample alchemical process

THE ALCHYMICAL ANALYSER

The physical embodiment of this finite state automaton is the Alchymical Analyser, whose purpose is to simulate the alchemical process. It consists of a telephone dial interface (Fig. 3.1) to a relay-based logic unit whose output is viewed on a lighted display. (Please refer to the schematic at the end of the paper.) The physical form of the device follows its function, its aesthetic presence providing clues as to its operational logic. The utilization of electromechanical components such as relays provide the user with positive feedback in the forms of sound and motion as calculations are performed, strengthening the relationship between theory and operation. The lighted display also provides visual feedback as results of the computations are shown. The user is invited to engage in a game whose goal is to obtain the 'Philosopher's Stone'. This is accomplished by the correct completion of four calculations involving the pairing of material qualities. The participant is provided with an 'instruction book' consisting of a series of pictograms, not unlike those appearing in antiquated alchemy texts. The first pictogram (Fig. 3.2) is an adapted Venn diagram that serves to illustrate the relationships between the symbols present on the dial interface, the states of the machine corresponding to those inputs, and the relationship between these states and the goal of the game [4].

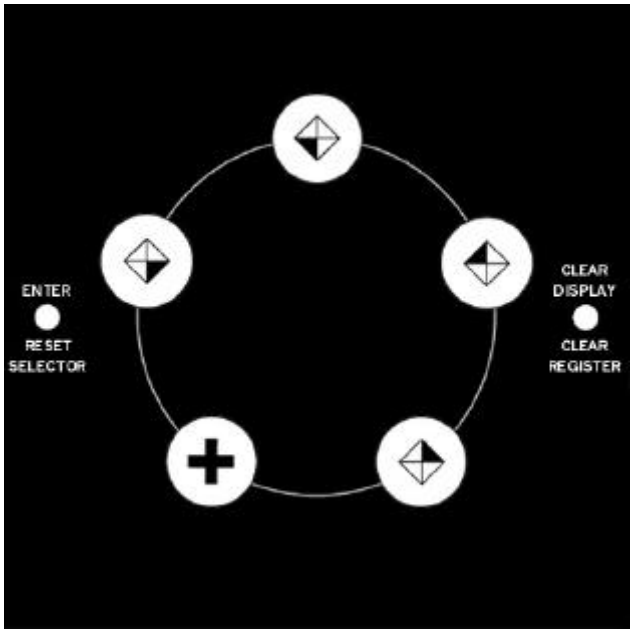

Fig 3.1. Schematic of the Dial Interface

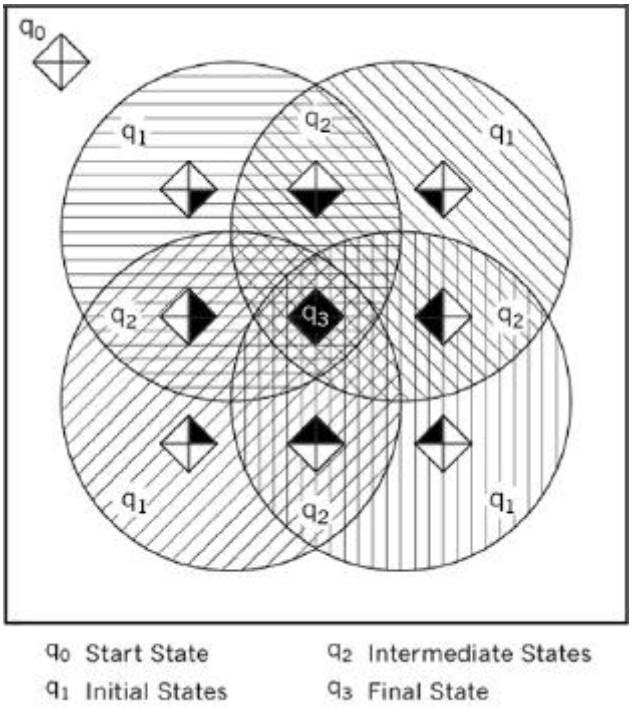

Fig. 3.2. Adapted Diagram

(The state designations present in Fig. 3.2 are relative only to Fig. 2 and do not appear in the 'instruction book'.) The second pictogram shows a sample operation, illustrating the format of the expressions to be entered (Fig. 3.3).

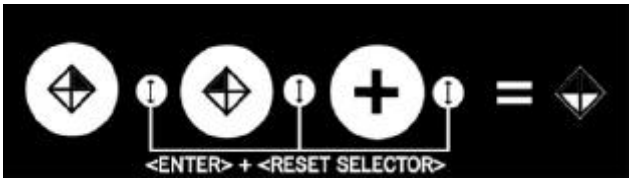

Fig. 3.3. Sample Operation

The third pictogram shows the display in its final state, depicting the goal of the work (Fig. 3.4).

Fig. 3.4. The display at machine final state

TECHNICAL OVERVIEW

(Please refer to Fig. 4.) The dial interface consists of a Western Electric telephone dial with five positions: four positions correspond to the possible inputs (material qualities) and one to the operator. Two Western Electric momentary toggle switches flank the dial and serve to perform the functions of entering the input into the hold register, resetting the line selector, clearing the hold register in the logic unit, and resetting the display. The logic unit consists of a Western Electric line selector whose contacts are linked to four dual-latch relays, acting as hold registers. Each latch relay is wired in series with one other, forming four AND gates. The combination of the relays is in accordance with the alchemical model, effectively enabling two material qualities to be added with one of the four elements as a resultant. When the participant dials a symbol corresponding to a quality, the line selector advances its position, closing a circuit to its corresponding latch relay in the hold register. Upon pressing <ENTER>, the latch is activated and the input is displayed. The line selector is then <RESET>. This procedure is repeated. The user then dials the operator and presses <ENTER>. Upon doing so, the circuit from the latch relays to the display is closed, displaying the result. This procedure is repeated four times, effectively lighting all positions on the display. The participant has then completed the game. The line selector, hold register and display are then cleared, returning the machine to its initial state.

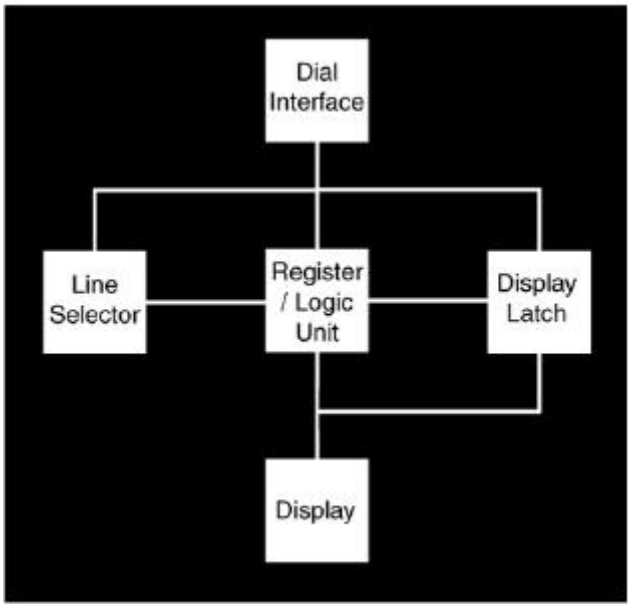

Fig. 4. Functional Diagram of the Analyser

DISCUSSION

The Alchymical Analyser is an instructive art object. It effectively ties together the historical and theoretical bases of computing as well as the relationship between the procedural structures of both modern science and alchemy. It is suited to gallery as well as museum environments and may also be used as an educational tool in the classroom. To date, the prototype has been displayed in an art gallery, where the users were given a personal tutorial on its operation, theory and design. Feedback from the user group was positive. All admitted to gaining a greater understanding of the concepts involved. In observing the users' interactions with the Analyser, it has become apparent that further consideration must be given to the interface. The choice of the telephone dial is based on the user's assumed familiarity with the rotary telephone, yet the users continue to approach the machine as if it were foreign. They appear hesitant for fear of 'breaking the machine' or 'doing something wrong'. It is therefore necessary to make the interface more 'natural'. One possible solution is to represent the material qualities as physical objects placed on pedestals. In order to perform a calculation, one must rearrange the objects, doing so until the correct permutation is achieved. The lighted display could still serve as the output, but elements such as sound and motion are to be considered as additional possibilities. The issues raised by the Alchemical Analyser are to be explored in future endeavors. The ultimate goal of the Analyser is to suggest new manners in which information can be expressed effectively. In a technological age where information exchange is becoming increasingly pervasive and dense, the organization of this information into a meaningful structure is of the utmost importance. The poetic arrangement of media can not only communicate to but also enable the participant to experience the information at hand. We experience our environment via our sensorim, and the careful orchestration of the senses by mediating technologies can make the difference between seeing and understanding.

CONCLUSION

The laboratory expects that the Alchymical Analyser will suggest new directions in the aesthetic evolution of art as well as in the design of teaching aids. Through the union of old and new technologies, novel devices can be constructed to demystify the current technological environment.

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