‘A superb explanatory device’

The MONIAC, an early hydraulic analog computer

Anna Corkhill

Since 1953, the University of Melbourne has owned a rare machine: a hydraulic analog computer capable of explaining the economy and performing complex economic calculations. It is generally known as the MONIAC (which stands for ‘MOnetary National Income Analog Computer’), though it has also been called the ‘Financephalograph’, the ‘National Income Monetary Flow Demonstrator’ and simply the ‘Phillips Machine’, after its inventor, Bill Phillips. The machine, one of approximately 12 ever created, was purchased by the Department of Economics in 1953, at the request of Professor Wilfred Prest, who had seen a MONIAC demonstration on a study tour of the United Kingdom in 1952–53. Prest decided that funds available from the unoccupied Ritchie Chair in Economics would be most appropriately spent on this fascinating new piece of technology. It arrived in Melbourne in 1954, cost £995 (£1,300 including freight) and was installed in the south-west corner of the Old Commerce Building. In 1963 the MONIAC was damaged while in transit to the new Economics and Commerce Building (now Arts West), after which it was placed in a basement storage area. It remained hidden until the 1990s, when it was rediscovered, partially restored and given a position in a simple display case on level 1 of the Economics and Commerce Building. The machine has recently been moved to the entrance of the new Giblin Eunson Business, Economics and Education Library in the ICT Building, 111 Barry Street.

Though a reasonably accurate computational device, the MONIAC’s key aim was to demonstrate Keynesian economic models in a clear, visual way. As a pedagogical aid, it used coloured water to represent money flowing through the economy, and showed the relationships between various aspects of the economy such as income, taxes, government spending and investment. It could be calibrated to represent different national economies, and recorded the output of its calculations on graph paper at the top of the machine, with pens powered by a 1 RPM (revolutions per minute) motor. Unlike most computers, which hide their mechanics behind a plastic or metal casing, the workings of the MONIAC are on display, because its very purpose was to simplify complex economic equations and demonstrate their results in a dynamic, colourful show.

The MONIAC comprises a series of clear acrylic tanks connected by rubber tubing and powered by a mechanical pump. (In the prototype, the pump’s motor was recycled from a World War II Lancaster bomber, but the university’s MONIAC was commercially made.) It is approximately two metres high and one metre wide, with a metal backing enclosing the machine’s pump and connecting tubing. The machine has three main water tanks, representing taxes and government spending, savings and investment, and import–export. The ‘active balances’ tank at the bottom represents the total stock of currency and bank credit in the economy at any given time. When in operation, water was injected into the ‘active balances’ tank, pumped up to the top of the machine as income, and allowed to flow downwards as expenditure (separated into consumption spending and domestic spending), with controlled amounts of water being siphoned off to enter the tanks representing taxes and government spending, savings and investment, and import–export. The flow was modified by leakages (savings, taxes and imports) and injections (investment, government expenditure and export receipts). Nine simultaneous economic equations (adjustable ‘functions’) were run to produce the flow of the MONIAC demonstrations.

MONIAC machine (Monetary National Income Analog Computer), designed by A.W.H. Phillips, manufactured by Air Trainers Ltd, Aylesbury, Buckinghamshire, England, c. 1953, metal, rubber, acrylic, and mixed media, height approx. 2 metres. Purchased 1953, Department of Economics, Faculty of Economics and Commerce, University of Melbourne

Each equation regulated a set of macro-economic relationships: income and taxation, income and government expenditure, income and consumption, interest rates and investment, domestic expenditure and imports, domestic expenditure and exports, exchange rates and imports, and exchange rates and exports.[1] These adjustable functions were represented by acrylic schedules clipped onto the machine. The two output graphs, one on each side of the machine, recorded (at the rate of two minutes per year) the resulting gross national product and the effect of the variables on the rate of interest and on imports and exports.[2] The machine's functions and the water levels in each section were controlled by delicate mechanical sensors consisting of vaned water wheels.[3] Each function was linked mechanically by valves and floats. The national economy as demonstrated by the machine could be 'shocked', that is, affected by a sudden change such as an altered tax rate or change in investment spending. If no shocks were introduced, the income flow would settle at an equilibrium where injections were set equal to leaks. Cochineal dye was used to colour the water a deep crimson, making it more visually distinctive and easier to 'read'.

Frederick Roland Emett, *The Financephalograph Position*, published in *Punch*, 15 April 1953. Reproduced with permission from Punch Ltd

At the University of Melbourne, the MONIAC was mostly used to demonstrate macro-economic theory to honours classes and on open days to entice prospective students. Unfortunately, it was prone to leak if its demonstrator failed to adequately control the economy, and many demonstrations ended suddenly due to flooded tutorial rooms. It was described at the time as having 'the potentialities of a recalcitrant student'.[4]

The MONIAC was invented and constructed by economist Alban William Housego ('Bill') Phillips (1914–1975), in consultation with Walter Newlyn and James Meade from Leeds University and the London School of Economics (LSE). Phillips was born in New Zealand and grew up on a dairy farm. He moved to Australia shortly after finishing school and worked in various jobs including as a crocodile hunter and cinema manager, before settling in England and studying electrical engineering. Shortly after the outbreak of World War II he joined the Royal Air Force and was posted to Singapore, escaping to Java when Singapore was captured by Japan. He became a prisoner of war in Java when it too was captured by Japanese forces. He became well known at the camp for building a secret radio and an immersion element (run from camp lighting) to make hot drinks. When the war ended, Phillips was awarded a New Zealand forces scholarship to study abroad and chose the LSE, where he majored in sociology. He was not an excellent student of sociology, a fact that he attributed to his heavy cigarette-smoking habit, which prevented him from concentrating for the long stretches of time required for examinations. He did, however, take some subjects in economics, which interested him much more than sociology; even so, he was just a 'pass' student.

In 1949 Phillips conceived an idea for a machine to demonstrate and perform calculations 'on the workings of the macro-economy—the broad relationships between income, employment, interest rates and other economic variables'.[5] He wanted a straightforward, visual method of demonstrating economic theories and, in particular, making clear the complexities of multiple simultaneous equations. Phillips discussed the idea with Walter Newlyn, a junior academic at Leeds University who had studied with Phillips at the LSE, and proceeded to build a prototype (with Newlyn's assistance) over one summer in a garage in Croydon. Newlyn persuaded the head of department at Leeds to advance £100 towards building the prototype. Newlyn helped as a craftsman's mate—sanding and gluing together pieces of acrylic and supplementing Phillips' economic knowledge.[6] The finished machine was demonstrated on 29 November 1949 before a distinguished audience at Professor Robbins' seminar. In the process of demonstrating the MONIAC and its functions, Phillips delivered a comprehensive lecture on the economic theories of Keynes and Robertson (in his heavy New Zealand accent), whilst pacing back and forth, chain-smoking. The demonstration was a rousing success and greatly impressed the audience, many of whom had come expecting a fiasco.[7] Over the next few years, MONIACs were purchased by the universities of Manchester, Oxford and Cambridge, as well as Roosevelt College at Harvard. Non-university buyers included Ford Motors and the Reserve Bank of Guatemala. In August 1950, Phillips published an article in the journal *Economica*, which greatly increased his recognition as an economist and creator of the MONIAC.[8] He was appointed as assistant lecturer at the LSE in October 1950, his publication and invention compensating for his

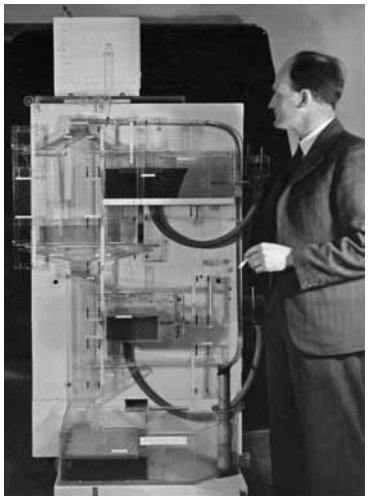
poor marks. He became a full lecturer in 1951, finished his PhD thesis, 'Dynamic models in economics', in 1953, became a reader in 1954 and Tooke Professor of Economic Science and Statistics in 1958. That year Phillips also visited the University of Melbourne on a study-leave tour.[9]

During the early 1950s Phillips' machine received some attention in the press, with an article published in the American magazine *Fortune* in 1952 and a satirical article, 'The Financephalograph position', and cartoon (illustrated right) appearing in British *Punch* in 1953. The *Fortune* article was somewhat of an advertorial, indicating that a machine could be purchased for US$4,300 and explaining that it might be of use in 'demonstrating fiscal problems before congressional committees, etc'.[10] Similarly, *Punch* predicted a wide use for the MONIAC, albeit slightly mockingly, advocating that every town, city and village should have one, for calculating 'the subtle impact of a slump in the second-hand ship market, the slightest hint of a boom in soap, emery-wheels or white fish'.[11]

Despite the excitement in economic circles and various publications, the machine did not become a popular mass-produced item. Simultaneous developments in electronic—rather than analog—computers quickly surpassed the range, detail and accuracy of the MONIAC. But the MONIAC was unique in its visual aspect and as a teaching aid, despite its limited scope. Unfortunately it was relatively expensive to produce, cumbersome to ship and difficult to maintain. Its demonstrators needed not only advanced economic knowledge but also specific technical skills. Due to the difficulty in running the machine without leaking and the maintenance required to keep it operational, only two of the approximately five surviving MONIACs are still being used for demonstration purposes.

Bill Phillips went on to publish an influential economic theory called the 'Phillips Curve', which describes the relationship between unemployment and inflation and is well known by all those who have studied economics at university level. He continued to carry out maintenance on the two MONIACs owned by the LSE, but MONIACs abroad, such as the one in Melbourne, fell more quickly into disrepair. The University of Melbourne's machine is in a stable and relatively complete condition, retaining most of its original parts.

Though comically described by some as a 'Heath Robinson' or 'Rube Goldberg' style contraption,[12] the MONIAC has significance in the history of computing, the history of economic modelling and the history of the university-level teaching of economics. The MONIAC's place in the continuum of computer development, however, is relatively minor. As a hydraulic analog computer, it could not compete with concurrent developments in electronic computing and did not build upon the



Professor A.W.H. (Bill) Phillips and the prototype MONIAC, which he first demonstrated at a London School of Economics seminar in 1949. IMAGELIBRARY/6, reproduced with permission from the Library of the London School of Economics and Political Science

developments of previous computers such as the ENIAC in the United States.[13] The machine's computations ran at an accuracy of a reported +/- 2 per cent to +/- 4 per cent,[14] and as such it was more an indicative than a definitive device. Its ability to run complex calculations as a recorded output meant that the MONIAC *was* a computer, not simply a visual aid, but its computational ability did not exceed that which could be solved mathematically. Rather, it encouraged understanding of complex ideas, gave a feel for macro-economic behaviour and presented visual results that made such concepts accessible without advanced mathematical knowledge.[15] In this way, it could demonstrate the economic theories of the time to both students and professional economists.

The MONIAC has been noted for presenting a 'physical worldview'[16] and is also representative of the focus of post-World-War-II scholarship on invention and the application of theories from various disciplines to real-world situations.[17] Though considered a remarkable combination of electrical, mechanical, manual, liquid and plastic control, and deserving of a place in the history of quantitative computer control mechanisms,[18] it is historically most significant for its contribution to economic modelling and the pedagogical demonstration of economic theory.[19] Melbourne's MONIAC, a treasured member of the Department of Economics, represents this university's continuing encouragement of new ways of thinking and progressive technologies, as well as its long involvement in the discipline of economics.

Anna Corkhill recently completed a Master of Art Curatorship at the University of Melbourne. She spends half her time as a Curatorial Assistant at the State Library of Victoria and the other half as a Heritage Databases Officer at the Victorian Parliamentary Library.

The MONIAC can be seen during the opening hours of the Giblin Eunson Library. See http://library.unimelb.edu.au/hours/branches/giblin_eunson_library for details.

1 *MONIAC* (brochure), Wellington: COMPAQ and the New Zealand Institute of Economic Research, c. 1990–95.
2 'The Moniac: Economics in thirty fascinating minutes', *Fortune*, March 1952, p. 101.
3 Reza Moghadam and Colin Carter, 'The restoration of the Phillips Machine: Pumping up the economy', *Economic Affairs*, October–November 1989, p. 25.
4 'News and notes', *Economic Record*, vol. 30, May 1954, p. 86.
5 Tim Ng and Matthew Wright, 'Introducing MONIAC: An early and innovative economic model', *Reserve Bank of New Zealand Bulletin*, vol. 70, no. 4, December 2007, p. 46.
6 Chris Bissell, 'The Moniac, a hydromechanical analog computer of the 1950s', *IEEE Control Systems Magazine*, February 2007, p. 70.
7 *MONIAC* (brochure).
8 A. William Phillips, 'Mechanical models in economic dynamics', *Economica*, vol. 17, no. 67, August 1950, pp. 283–305.
9 Joe Isaac, 'The 1950s: Adjustment and consolidation', in Ross Williams (ed.), *Balanced growth: A history of the Department of Economics, University of Melbourne*, North Melbourne: Australian Scholarly Publishing, 2009, p. 94.
10 'The Moniac: Economics in thirty fascinating minutes'.
11 J.B. Boothroyd, 'The Financephalograph position', *Punch*, 15 April 1953, p. 456.
12 Heath Robinson (1872–1944) was an English cartoonist known for drawing elaborate, imaginary machine inventions that performed relatively simple tasks. Rube Goldberg (1883–1970), an American cartoonist, drew similar imaginary inventions, which performed simple operations in long, convoluted ways.
13 ENIAC or 'Electronic Numerical Integrator and Computer', built in the mid-1940s at the University of Pennsylvania, was an early electronic computer (Ng and Wright, 'Introducing MONIAC', p. 46).
14 Bissell, 'The Moniac', p. 49.
15 Bissell, 'The Moniac', pp. 72–3.
16 David Vines, 'The Phillips Machine as a "progressive" model', in Robert Leeson (ed.), *A.W.H. Phillips: Collected works in contemporary perspective*, Cambridge University Press, 2000, p. 40.
17 Adam Curtis, *From Keynes to chaos* (video recording), LBBC Television Service, 1992.
18 R.M. Goodwin, 'A superb explanatory device', in Leeson (ed.), *A.W.H. Phillips*, p. 119.
19 Doron Swade, 'The Phillips Machine and the history of computing', in Leeson (ed.), *A.W.H. Phillips*, p. 125. The University of Melbourne has been in correspondence with Doron Swade regarding the future and display of its MONIAC.