# *The Atlas Computer Laboratory*

The National Institute for Research in Nuclear Science

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The development of the high-speed digital electronic computer is proving to be one of the major scientific achievements of modern times. It is now well known that Charles Babbage in 1820 realised the value of a machine which would perform a long series of calculations without human instructions, and he devoted most of his life to the attempt to build one; but the purely mechanical techniques of his day were unequal to the task and it was not until 1946, when electronic engineering was well advanced, that the first working digital computer was produced, in the form of the ENIAC, at the Moore School of Electrical Engineering, Philadelphia. This was designed and built with the specific aim of calculating shell trajectories for gunnery tables, but it was in fact a general purpose machine in the sense that it would carry out any calculation given the programme of steps to be followed and the initial data; further, it worked at about 1,000 times the speed of a human computer, giving a quite unprecedented increase in computational power. ENIAC started a long process of development, which is still going on and which has caused a great new industry to emerge —that of electronic data processing machines—and led to the production, as commercial ventures, of computers of up to 1,000 times the power of ENIAC, that is, of something like a million times the power of hand calculation.

It takes quite a time to see the implications of an increase in one's power to do some task by a factor of between 1,000 and 1,000,000; with computers this has happened within the past ten years, because machines were not in any sense generally available until the early 1950s, so it is not to be expected that we have yet fully appreciated their power. It is easy enough to realise that they have enormous value in, for example, engineering, in scientific technology and in commerce, where great quantities of arithmetic have to be done; but it was not at first obvious that the mere possibility of doing literally millions of arithmetical operations in a short time would make it necessary to take a fresh and critical look at the methods of formulation of many of the problems in applied mathematics, and to tackle difficult but fascinating mathematical problems such as the growth of rounding-error in repetitive numerical processes, or the relation between the true solution to a continuous problem and the computed solution to a discrete problem intended as an approximation. There is now a most voluminous international literature on, for example, matrix processes, ordinary and partial differential equations, multiple integration, methods of approximation to functions: essentially mathematical, but made relevant only by the existence of the high speed computer, without which the processes could never be carried out. Further, it has become clear that to think only in terms of numerical calculations is to take too narrow a view of the computer's powers. Considered in fine detail, the processes the machine uses in doing its arithmetic are logical operations on patterns of binary digits, sufficiently general and fundamental to be equally well suited to non-numerical operations on arbitrary symbols. Hence the possibility of using computers to attack problems such as pattern-recognition (a very wide field, which can include the reading of hand-written characters or of visual presentations of experimental observations, the study of the mechanism of learning and the analysis of linguistic or musical style), language-translation, the proving of theorems and formal mathematical manipulation. Here are many exceedingly difficult problems, important and challenging, on which there is still a great deal to be done.

Thus a large and fast electronic computer is a powerful instrument of great versatility—one can say that it has the universality of mathematics. The National Institute for Research in Nuclear Science placed an order in the autumn of 1961 for a machine of exceptional power, a Ferranti ATLAS, to be installed on the Chilton site during 1964. Like all the National Institute's equipment, it is intended as a national asset and will be available to research workers in all the universities without charge. There is no suggestion that its use shall be restricted to nuclear physics, even to physical science in general: physicists, psychologists and linguists will be equally welcome in the Laboratory. It will be available also to the Atomic Energy Authority's research laboratories at Harwell and Culham and to various Government research establishments—for example, the Meteorological Office is intending to use the machine for fundamental work on weather problems, and the Medical Research Council for work on the structure of proteins and viruses.

The basic idea for the design of the ATLAS originated in the Computing Machine Laboratory in the University of Manchester where, in fact, the first model is now (September, 1962) being assembled. It is not possible to make any simple statement of speed; the machine will add two munbers (48 binary digits—floating point) in under 2 $\mu$s, and multiply in under 5 $\mu$s. The logical design is such that a good deal of overlapping of operations is possible; and the average rate of obeying instructions is about 500,000 per second. A practical consequence is that a set of 100 linear algebraic equations in 100 unknowns can be solved in about 15 seconds. The machine has a unique feature, a 'fixed' store, made up of small ferrite rods in a wire mesh, whose contents cannot be altered by the programme and from which information can be read in as little as 0.3 $\mu$s; this is used to hold information needed by all programmes, such as basic constants, input/output routines, and routines for computing standard functions. There will be 8,192 words (each of 48 binary digits) of fixed store in the National Institute's machine, whose main specification is as follows:

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| Magnetic core store | 49,152 words (48 × 1,024) |
| Magnetic drum store | 98,304 words (96 × 1,024) |
| Magnetic tape store | (*a*) 16 Ampex TM.2 units |
| | (*b*) 2 I.B.M. 729 Mark IV |

Two line printers (600 lines per minute)
Two card readers and one card punch
Two paper tape readers, two punches
Two consoles

This will form the central equipment of the National Institute's ATLAS Computer Laboratory. It will be housed in a specially designed building located adjacent to the Rutherford High Energy Laboratory's main accelerator site and conveniently close to the Atomic Energy Research Establishment, and will provide accommodation for about 100 people. This will include about twenty small offices for visitors from universities and other research organisations, who may like to spend anything from a few days to several weeks in the Laboratory, developing a programme or carrying through a big computing project.

The building is to be completed by December, 1963, and the present expectation is that Ferranti will finish manufacture of the computer at about the same time and, after commissioning tests in the factory, will start installation at Harwell during the early part of 1964.

The general management of the Laboratory is in the hands of a committee set up by the National Institute, whose members are as follows:

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| *SIR WILLIAM PENNEY | (*Chairman*) |
| *DR. J. B. ADAMS | *Atomic Energy Authority* |
| DR. R. A. BUCKINGHAM | *University of London* |
| *SIR JOHN COCKCROFT | *University of Cambridge* |
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| DR. J. C. KENDREW | *University of Cambridge* |
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| DR. F. A. VICK | *Atomic Energy Authority* |
| DR. M. V. WILKES | *University of Cambridge* |

*Secretary:* DR. J. A. V. WILLIS (*Rutherford High Energy Laboratory*)

(*A member of the Governing Body of the Institute)

Like any other computing laboratory, the ATLAS Computer Laboratory will have a good deal of service work to do. Many people from the Rutherford Laboratory, the Atomic Energy Research Establishment and so on, will write their own programmes and will want only machine time and the services of operators and data-preparation staff: a large Operations Group is planned to ensure that this need is met—actually, the efficient running of so large and complex an installation poses quite difficult organisational problems. But many prospective users will want help in formulating their problems, in carrying through mathematical developments, in finding or adapting numerical processes and in writing their programmes, and the Laboratory will need mathematical staff at a wide range of levels to provide this help: it seems likely that there will be a need for quite a lot of fairly formal teaching of programming, of numerical techniques and of pure mathematics.

It is intended that the ATLAS Computer Laboratory shall play its part in exploring (and exploiting) the possible use of computers, and with this aim in view will offer research appointments to mathematicians, scientists and others who would like to work in the context of the machine. Appointments open to graduates and post-graduates will be in the Scientific Officer and Experimental Officer classes: a first or good second class university honours degree is normally required for entry to the Scientific Officer class, whose salary scales for the three main grades cover a span from £825 in the basic grade (£1,035 after two years' approved experience) to £2,695 at the maximum of the Principal Scientific Officer grade. Further details about terms and conditions affecting appointments may be obtained on application to the Personnel Officer, Building R.20, ATLAS Computer Laboratory, Chilton, Didcot, Berks.

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