Percy Ludgate

The modest accountant from Dublin Percy Ludgate (1883-1922) is a very interesting figure in the world of calculating machines. Starting some time about 1903 to work on his hobby (calculating machines) nightly, until the small hours, and initially completely independently from Charles Babbage, he managed to design an extremely interesting and original universal calculating machine. As Brian Randell wrote "One must wonder just how much more he might have achieved, if he had had but a modest fraction of the resources, available to Babbage (to say nothing of Aiken!), and had no succumbed to pneumonia at such a tragically early age."

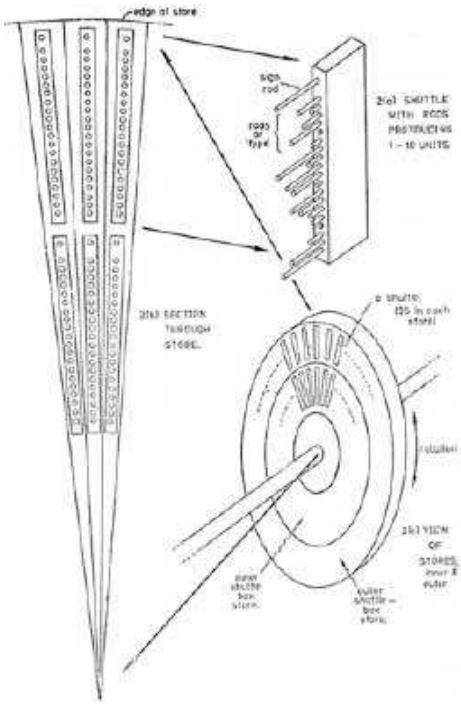
Percy Edwin Ludgate was born on 2nd of August 1883 in Skibbereen, County Cork, Ireland, in the family of Michael and Mary Ludgate. He was the youngest of four children, all boys, Thomas, Frederick, Alfred and Percy. His father Michael served in the army. It is believed that Percy attended North Strand Parish School, then studied accountancy at Rathmines College of Commerce, Dublin, and was awarded a gold medal by the Corporation of Accountants on the occasion of his final examination. Ludgate worked as an auditor until his death, with the firm of *Kevans and Son* in Dublin. Percy never married and was described by his contemporaries as a "very gentle, a modest simple man" who "possessed the characteristics one usually associates with genius, and he was so regarded by his colleagues on the staff...". In the period 1914-1918 Ludgate worked for a committee, set up by the War Office, to provide supply for the cavalry divisions of the army and was much prized for the major role, that he played. In the summer of 1922 Ludgate was on holiday to Lucerne, Switzerland, but shortly after his return developed pneumonia, and died on 16th of October, 1922.

There are only two sources of information for Ludgate's machine—the initial description of his *analytical machine* in *Scientific Proceedings of the Royal Dublin Society* of April, 1909 (Communicated by Professor A. W. Conway) (see the description) and a short description by C. V. Boys in the July 1909 number of *Nature*.

These two publications must have been noticed by the scientific society in Britain, because Ludgate was appointed to write the article (*Automatic calculating machines*) in the book *Napier tercentenary celebration: Handbook of the exhibition of Napier relics and of books, instruments, and devices for facilitating calculation* from 1914. No records have been found however on any attempts to patent his machine, or to obtain financial backing for its construction from the government.

The analytical engine of Ludgate has three main components: store, arithmetic unit and

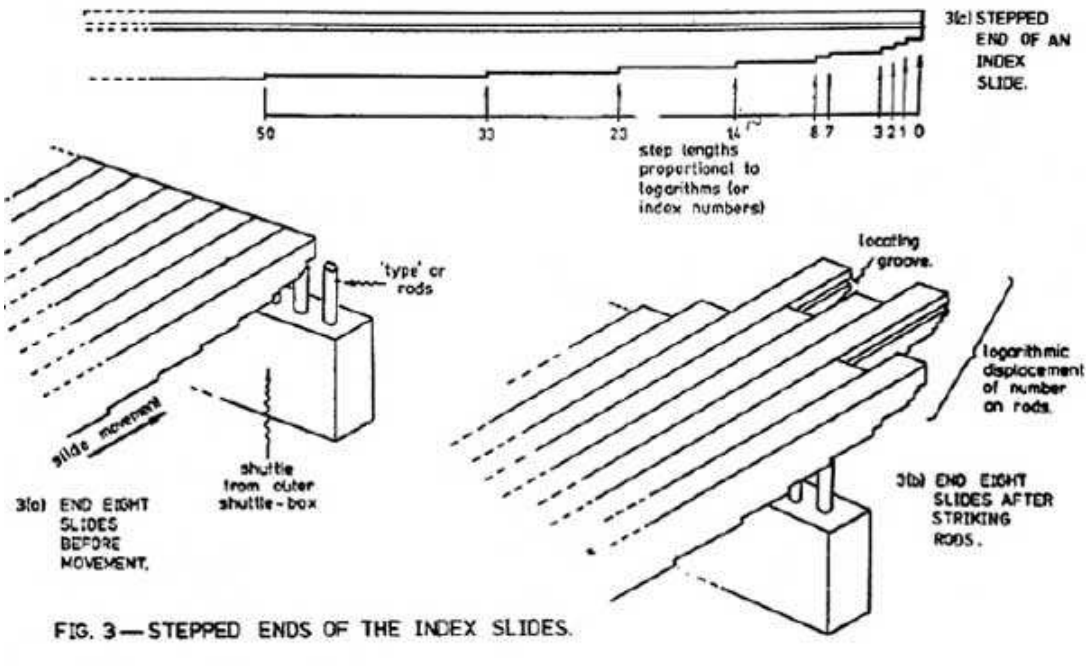
sequencing mechanism.



The store (see the nearby conjectural drawing of the store from D. Riches, 1973) used a "shuttle" for each variable. Each shuttle acted as a carrier for a set of protruding metal rods, there being one rod for the sign, and for each of the 20 decimal digits, comprising a number. The current value of each digit of the number currently stored in the shuttle was represented by the lateral position of the corresponding rod, i.e. by the length of rod protruding from the shuttle. The shuttles were to be held in "two coaxial cylindrical shuttle-boxes". A particular number could be brought to the arithmetic unit by rotating the appropriate shuttle box through an appropriate angle. There was also to be provision for tables of constants, represented by sets of holes, of depth from one to nine units, drilled into the surface of one or more special cylinders. This method would appear to have considerable advantages over that used by Babbage (i.e. columns of toothed disks, each capable of being connected by a train of gear wheels to the arithmetic unit. Ludgate mentions a further advantage, i.e. "that the shuttles are quite independent of the machine, so that new shuttles, representing new variables can be introduced at any time".

The arithmetic unit is a *direct* or *partial product* multiplying machine. In Ludgate's machine however is used a logarithmic method of multiplication. Each digit of one operand is translated into the corresponding *index number* (or *Irish logarithm*). This set of index numbers is then added to the index number form of one of the digits of the other operand. The additions are performed concurrently by simple concatenation of lateral displacements. Then a reverse translation is performed to obtain the set of two-digit partial products. The set of partial products so obtained for each digit in the second operand are then accumulated using a *mill*, which is presumably a fairly conventional set of coaxial toothed wheels, incorporating a carrying mechanism. Ludgate claims, that he designed his own version of the *anticipating carriage* od Babbage, i.e. mechanism for assimilation, in a single step, of all the carry digits, produced during the addition of two numbers.

Ludgate was equally unconventional in his scheme for division, which is based upon a table of reciprocals of the integers 100-999, and a rapidly convergent series for $(1+x)^{-1}$, where $|x|<10^{-3}$. The calculation of the series was controlled by what we would now call a built-in subroutine.



The arithmetic unit of Ludgate's machine (conjectural drawing from D. Riches, 1973)

The sequencing mechanism of Ludgate was to be controlled by a perforated paper tape, termed a *formula paper*, on which row of perforations defined a complete instruction. Each instruction specified two operands, the type of arithmetic operation to be performed, and the location (or pairs of locations) which was to receive the result. Thus the mechanism of Ludgate is much simpler that Babbage's, and all that was necessary was to arrange for the appropriate angle of rotation of the shuttle-box, containing the shuttle representing the required variable. Ludgate clearly agreed with Babbage as to the fundamental importance of conditional branching, although he doesn't indicate how it was to be done—presumably, following Babbage, he intended that mechanism that read the formula paper could be directed to skip a specified number of rows, either forwards or backwards.

Another feature of the sequencing mechanism was the provision of built-in subroutines. The operation code for division, e. g. caused control to pass temporarily to a sequence of instructions represented by rows of perforations on a permanent *dividing cylinder*. Another cylinder provided a logarithm subroutine, and Ludgate mentions the possibility of indefinite expansion of the set of such auxiliary cylinders.

Literature

1) B. Randell, "Ludgate's analytical machine of 1909", The Computer Journal, Volume 14, Issue 3
2) P. E. Ludgate, "On a Proposed Analytical Machine", Scientific Proceedings, Royal Dublin Society, Volume 12 Issue 9, April 1909
3) "A New Analytical Engine", Nature, Volume 81, 1 July 1909

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