The hunt for Ireland's early (1909!) computer pioneer

or

The Power of Persistence!

Brian Randell

Newcastle – 29 June 2020

An Unexpected Discovery in 1970

Percy Ludgate (1883-1922)

'I have myself designed an analytical machine, on different lines from Babbage's, to work with 192 variables of 20 figures each. A short account of it appeared in the *Scientific Proceedings, Royal Dublin Society*, April 1909. Complete descriptive drawings of the machine exist, as well as a description in manuscript, but I have not been able to take any steps to have it constructed.'

[Ludgate 1914]

The Hunt Resumes!

"Randell's 1971 and 1982 papers revealed Ludgate and resurrected him from obscurity, but nothing new has been published on him since then. Prof.J.G.Byrne collected an original offprint of Ludgate's 1909 paper for what became the John Gabriel Byrne Computer Science Collection in the Department of Computer Science, Trinity College Dublin, and in 1991 instigated a prize in memory of Ludgate. The Collection now holds copies of all the known literature and records relating to Ludgate and, prompted by the cataloguing of this collection since 2017, the authors have further investigated his life and work."

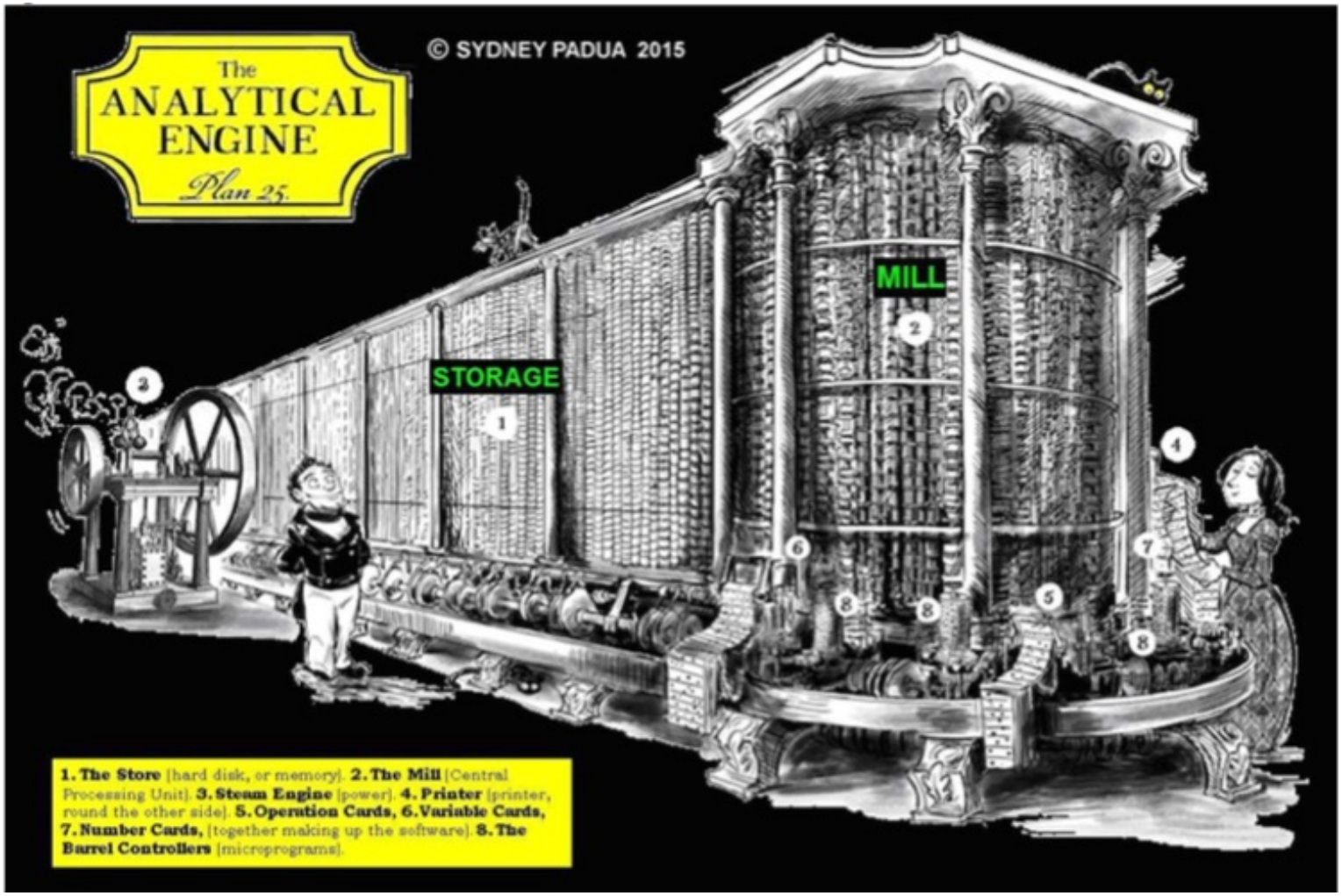
This investigation is led by Dr. Brian Coghlan, who is in charge of the Byrne Collection.

Two Challenges

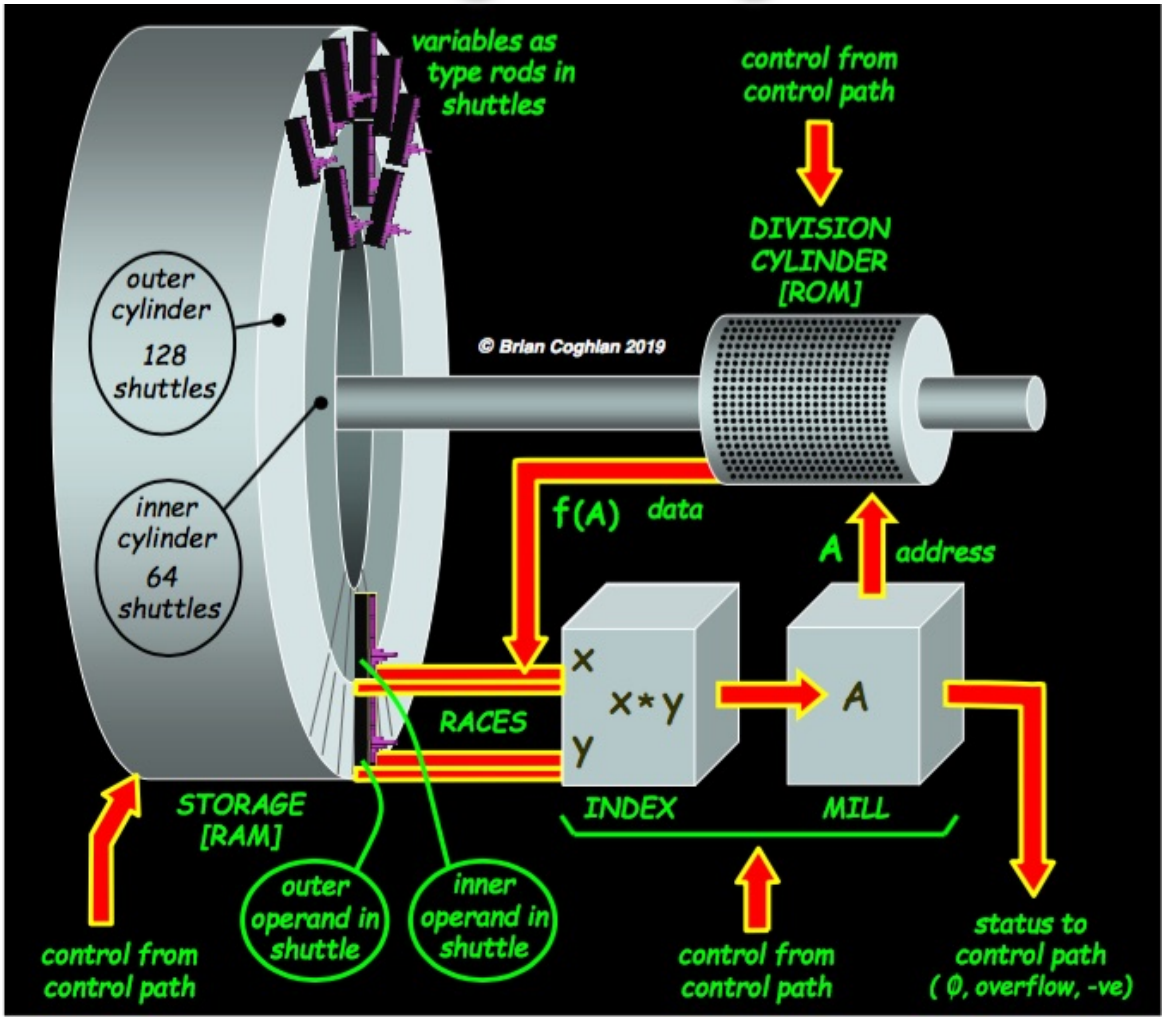
Is there any chance that Ludgate's drawings and documents still exist and can be found?

Are any relatives (perhaps descended from his parents) alive or their possessions findable - and if so are any documents, photos or memories of Percy Ludgate?

Babbage's Analytical Engine – 1834



Conjectural Drawing of Ludgate's Machine 1909



In contrast to Babbage's huge machine, this would have been the size of a bar fridge.

“Irish” Logarithms

Ludgate introduced a brand new concept, that he called an “Index”, to do multiplication based on what are now called Irish Logarithms. The core of his machine did not just do additions; it did multiply-accumulation (MAC), i.e. multiply followed by add to any previous result in the Mill.

For two operands Z_J and Z_K, Ludgate’s index numbers ensure

$$Z_Y = Z_{J*K} = Z_J + Z_K.$$

Some example indexes are

$$Z_1 = 0,\ Z_2 = 1,\ Z_3 = 7,\ Z_5 = 23,\ Z_{15\ (3*5)} = 30.$$

Ludgate's Tables

Decimal operand	Simple index	Ordinal number
0	50	9
1	0	0
2	1	1
3	7	4
4	2	2
5	23	7
6	8	5
7	33	8
8	3	3
9	14	6

Partial product	Composite index	Partial product	Composite index	Partial product	Composite index
1	0	15	30	36	16
2	1	16	4	40	26
3	7	18	15	42	41
4	2	20	25	45	37
5	23	21	40	48	11
6	8	24	10	49	66
7	33	25	46	54	22
8	3	27	21	56	36
9	14	28	35	63	47
10	24	30	31	64	6
12	9	32	5	72	17
14	34	35	56	81	28

Table 2 *Ludgate's logarithmic simple and complex indexes (reproduced from Ludgate 1909 Table 1 and 2)*

(Simple indexes form a non-monotonic function of the decimal operands, but a monotonic function of the "ordinals".)

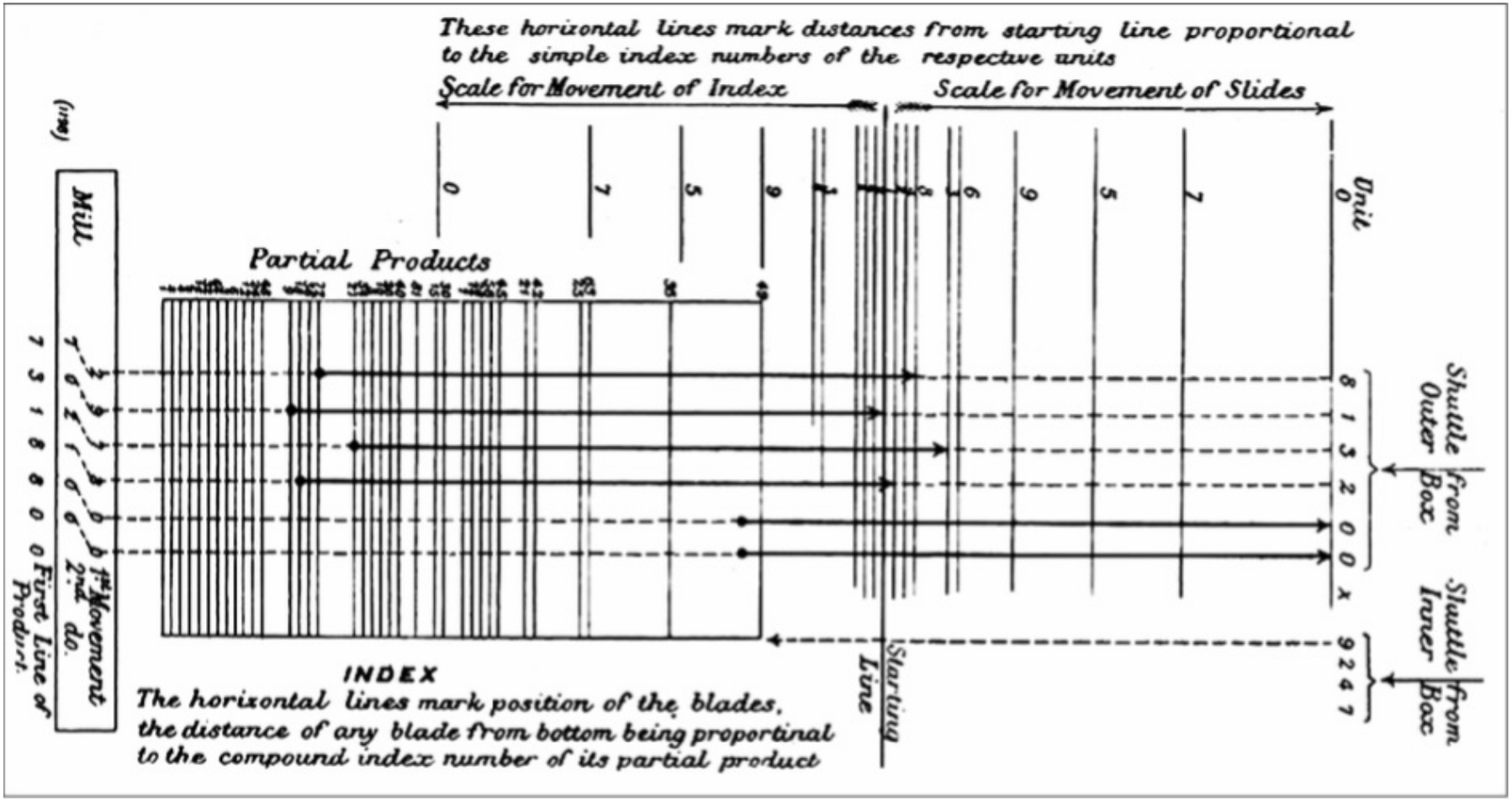
Ludgate's Machine

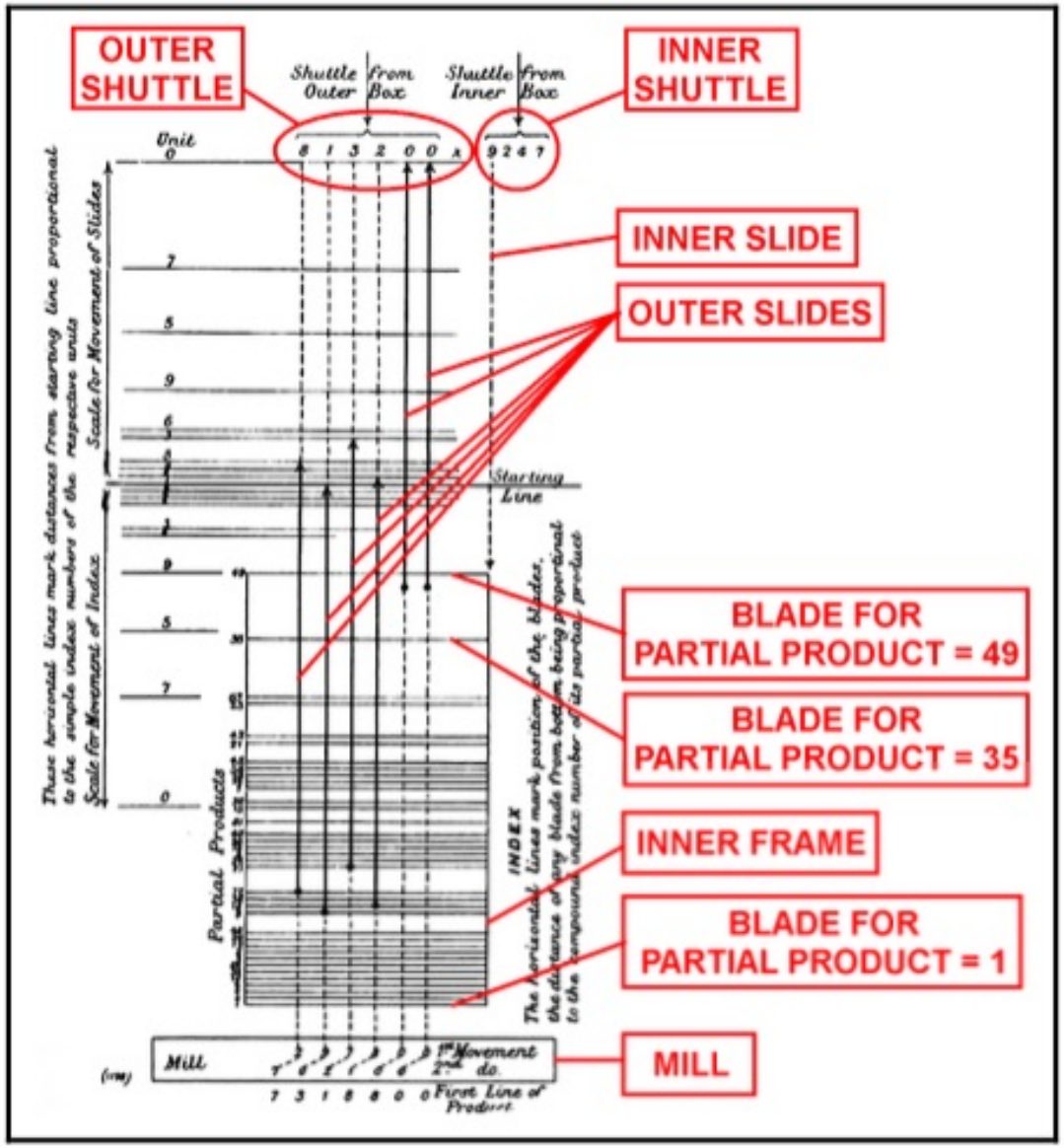
The chance of finding Ludgate's drawings was remote, but the search was nevertheless intense and protracted. Family wills and papers were sought, libraries and archives scoured, and attempts made to find paperwork related to his career, and to his submission of his 1909 Royal Dublin Society paper, and his paper for the 1914 Napier Tercentenary Celebration.

Just before Christmas 2019 an account of his work was discovered by Ralf Buelow in the little-known magazine *The English Mechanic and World of Science* (Sep. 1909), which turned out to a copy of one in the equally obscure magazine *Engineering* (August 1909).

Both these included a drawing representing Ludgate's Index! This surely must have been provided by Ludgate himself!

An Amazing Find





An Analysis of the Drawing

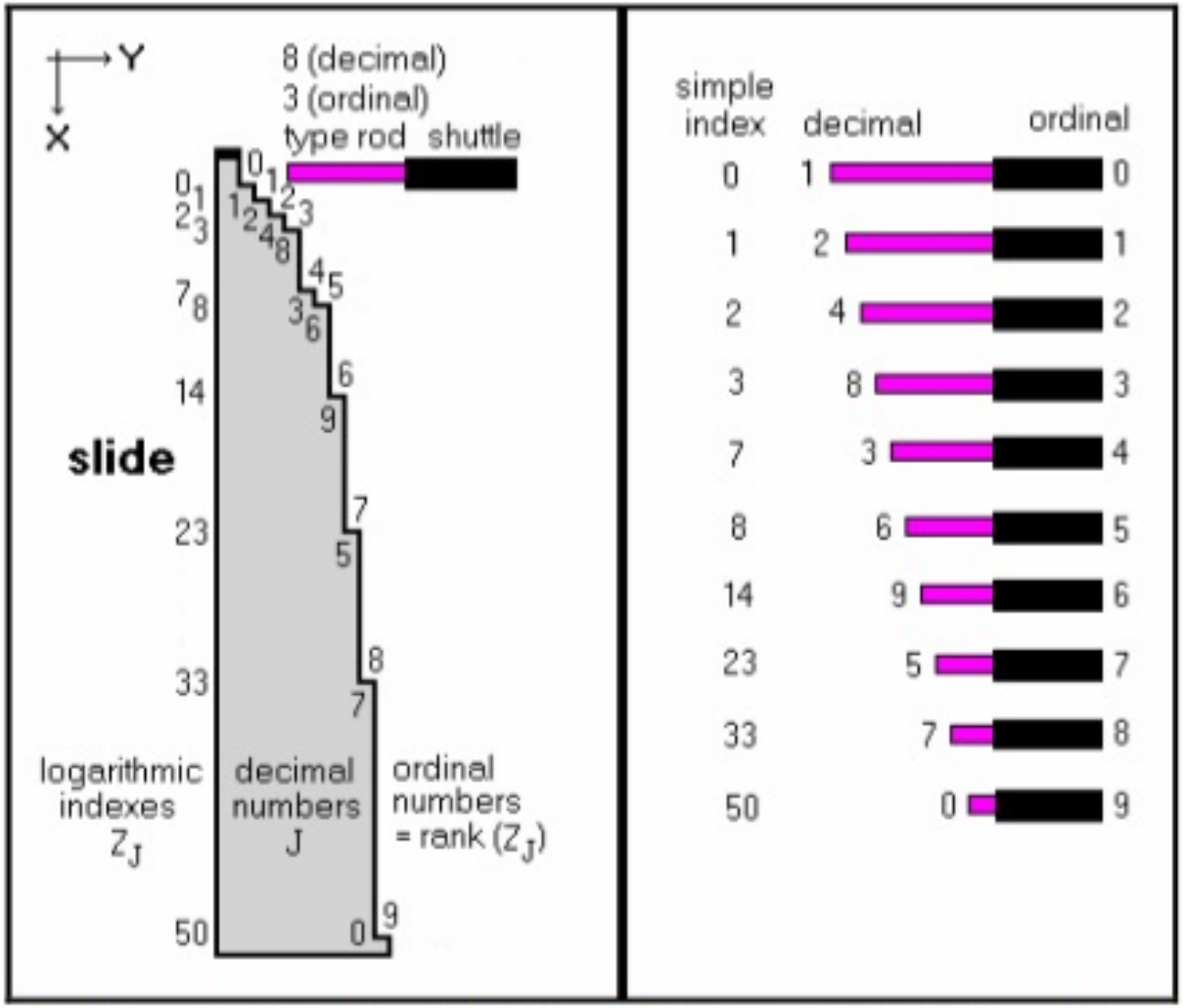


Figure 5 *(left) Ludgate's logarithmic slide, (right) shuttle rod extensions for simple indexes, decimal and ordinal values*

A "Slide" for converting ordinals to logarithms and a set of digits in shuttles

What we've added to our understanding

	Base operation is **multiply-accumulate (MAC)** not addition
	Multiply is done with **Irish Logarithms** by **INDEX**
	Long **multiply starts at left digit** of multiplier
¥	Numbers must be **fixed-point**
	Multiply-accumulate result **units first, then tens** by **MILL**
¥	Timing implies **pipelining** tens carryadds
¥	Instruction set: **ADD, SUBTRACT, MULTIPLY, DIVIDE, STORE, CONDITIONAL BRANCH**
	Two-operand addressing for load
¥	**Two-operand addressing for store**
	Fast for 1909: ADD / SUB 3 sec, MUL 10 sec, DIV 90 sec, LOG 120 sec
¥	Storage of 192 variables implies **(64 inner + 128 outer) shuttles** equi-spaced
¥	Hence storage size implies **binary storage addressing**
	Numbers stored via **rod for sign & every digit** protruding 1–10 units
	Data input / output via **punched number-paper** (or upper keyboard)
	Program input / output via **punched formula-paper** (or lower keyboard), one instruction per row
¥	**Manual preemption**
	Small size: estimated by Ludgate as 0.5m H x 0.7m L x 0.6m W

Some Still Unsolved Questions
Ludgate's Analytical Machine

How storage cylinders were rotated	Any internal dimensions
How a shuttle was moved	Any internal timing
How the INDEX mechanism worked	Almost everything about program control
How the MILL mechanism worked	Almost everything about input & output

Table 3 *Sample of known unknowns of Percy Ludgate's analytical engine*

And of course, all the other drawings remain to be found!

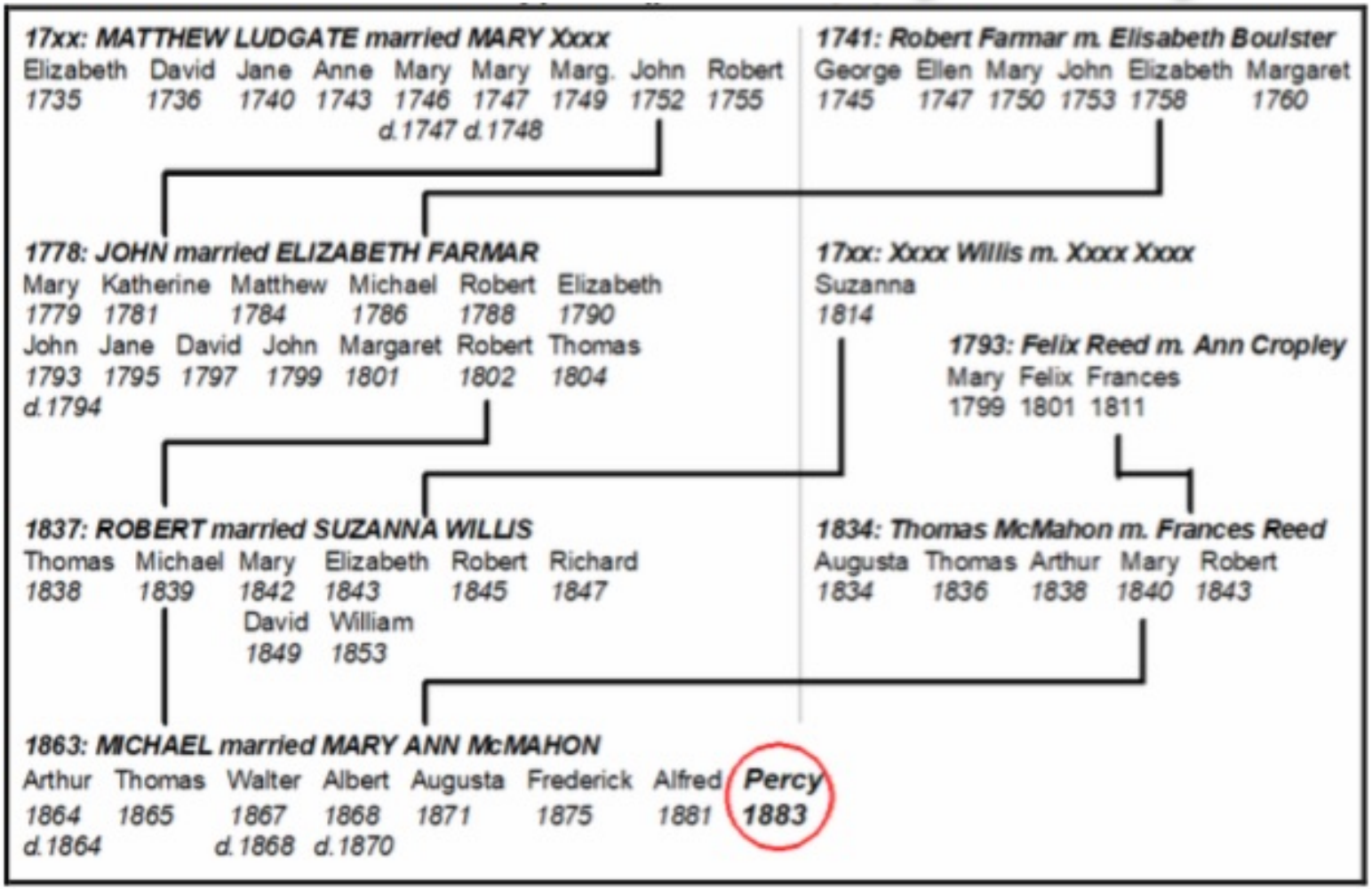
Percy Ludgate's Family – 1

In 1971 an Irish archivist told me : "by all normal criteria, it was clear that he had never existed".

Eventually, the Librarian of the Royal Dublin Society called all the Ludgates in the Dublin phone book, and found one niece, a Miss Violet Ludgate. This led to my finding details of Percy Ludgate and his parents, and establishing that she was their only living descendant.

This time some serious genealogists managed to find lots more about Percy's ancestors.

Percy's Ancestors – almost all identified only recently



Percy Ludgate's Family – 2

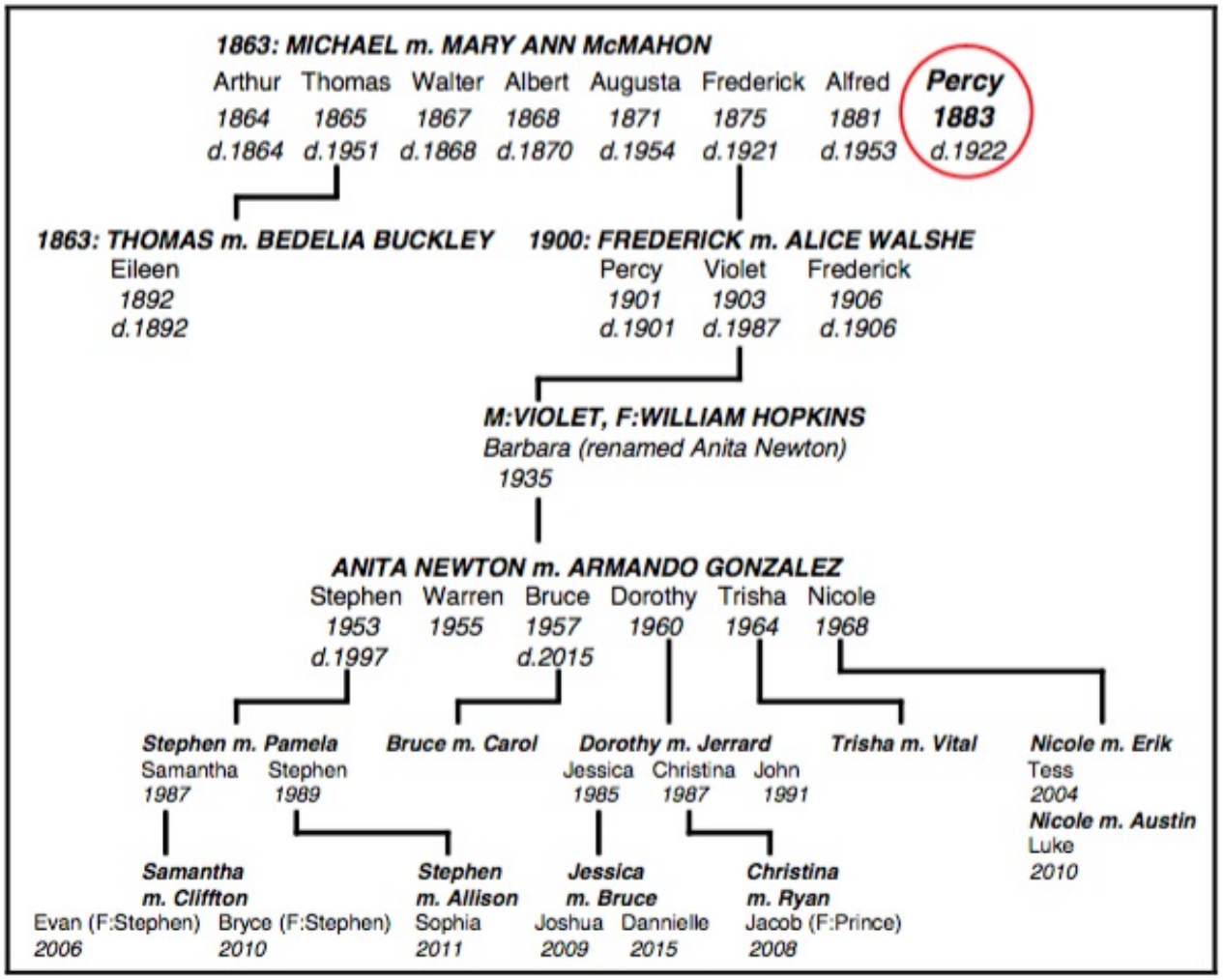
Violet Ludgate – my only source of family information about Percy Ludgate, had died, never having married, in 1987.

Until Christmas 2018 it was thought that by 1953 Percy Ludgate's parents and siblings had died, and that there were no other descendants of his parents.

But then it was discovered that someone else had been looking for information about Violet, one of her descendants! It transpired she had given birth to a daughter, who was privately adopted and renamed, and brought up overseas.

This daughter had married and moved to America, and had numerous descendants, including seven grandchildren.

A Discovered Family



Thanks to the Grandchildren!

Figure 16 *Ludgate grave, before and after Sept. 2019*

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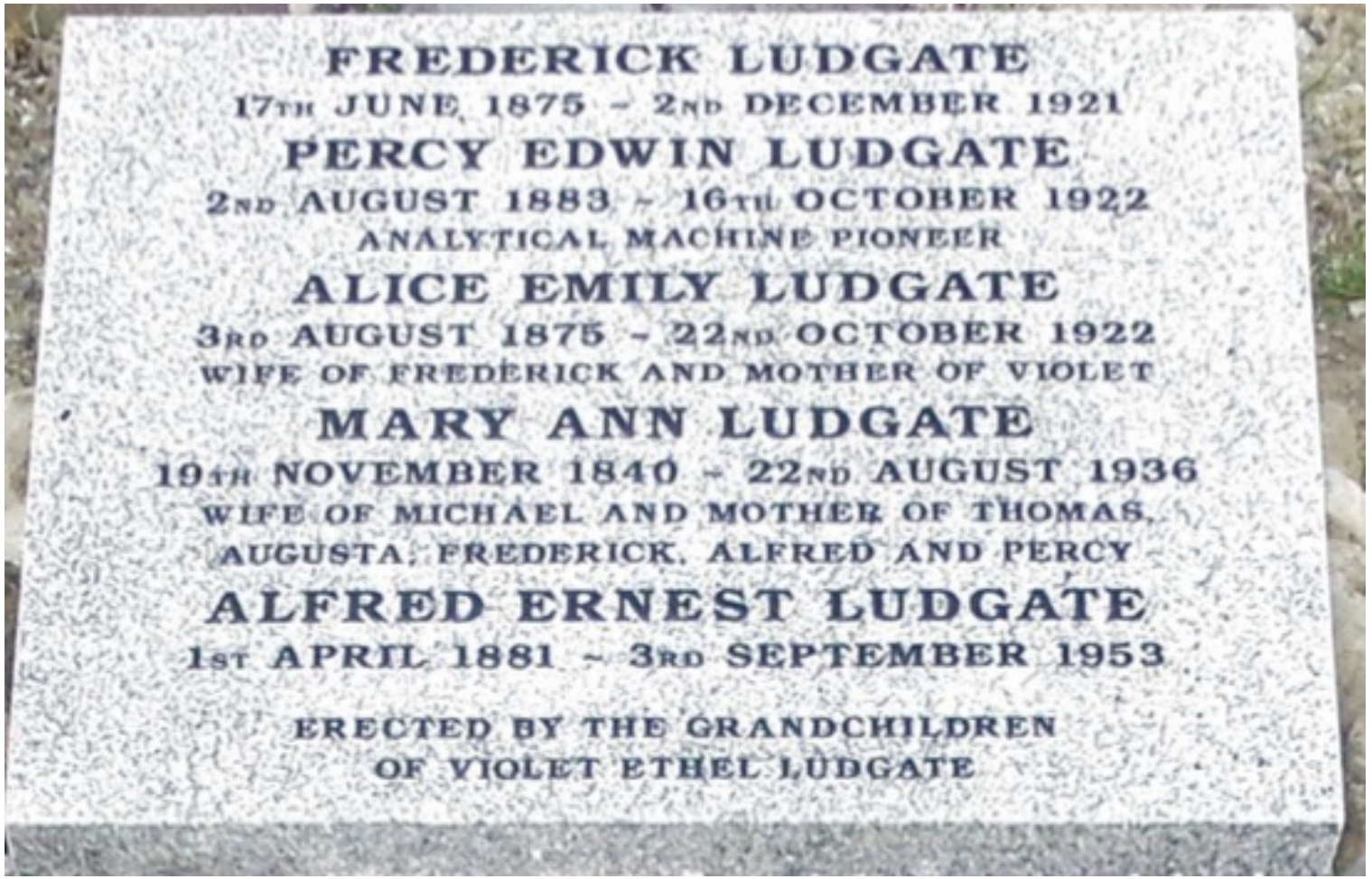
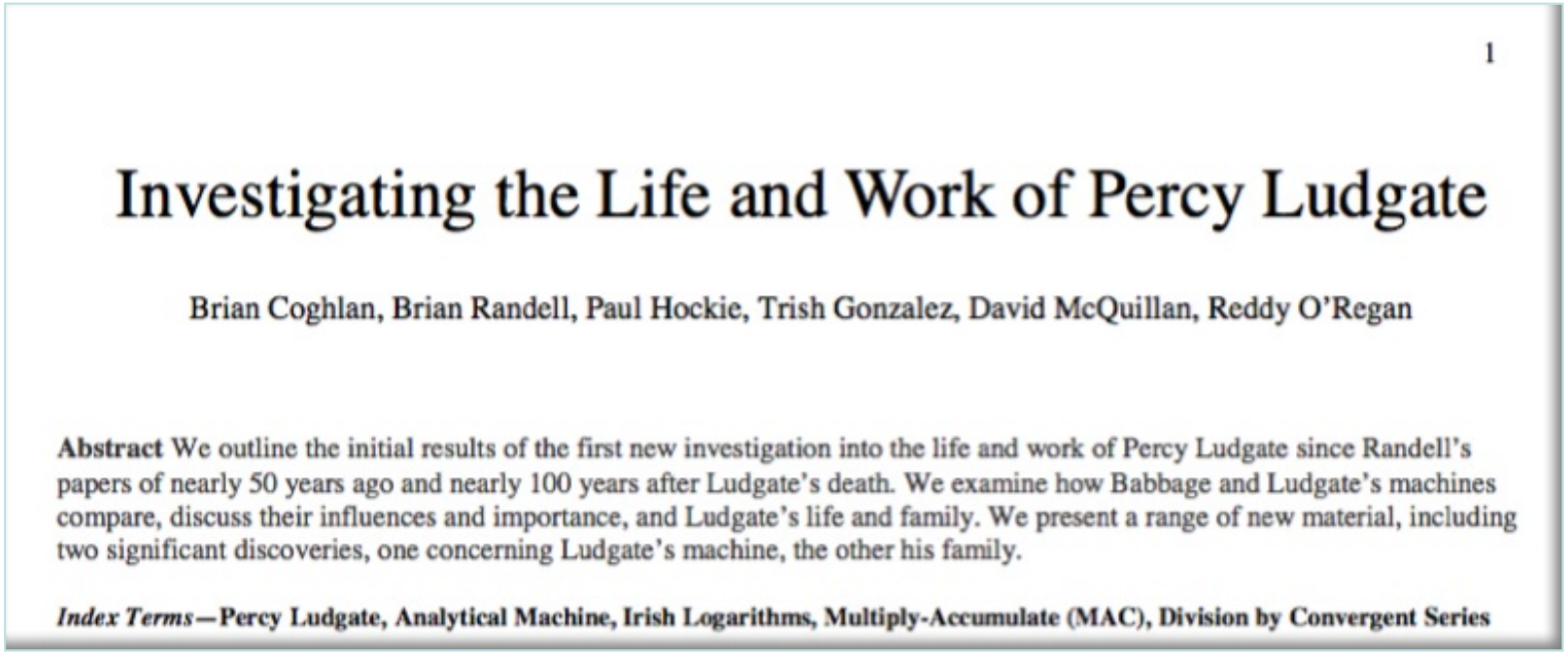
The New Memorial



Some Still Unsolved Questions About Percy Ludgate

Was he at North Strand National School?	Do Percy Ludgate's tax records exist?
Did he attend secondary school, and if so, where?	Do Prof.A.W.Conway's papers exist?
Which Corn Merchant did he join, and when?	Was he in poor health when he contracted pneumonia?
When did he start accountancy?	What ill health caused rejection by the Civil Service?
When did he join Kevans & Son?	Was there a relationship with Timothy Harrington MP?
Where is evidence of praise for his WW1 efforts?	Does his civil service file still exist in the UK?

The results to date – a 20-page draft paper



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Investigating the Life and Work of Percy Ludgate

Brian Coghlan, Brian Randell, Paul Hockie, Trish Gonzalez, David McQuillan, Reddy O'Regan

Abstract We outline the initial results of the first new investigation into the life and work of Percy Ludgate since Randell's papers of nearly 50 years ago and nearly 100 years after Ludgate's death. We examine how Babbage and Ludgate's machines compare, discuss their influences and importance, and Ludgate's life and family. We present a range of new material, including two significant discoveries, one concerning Ludgate's machine, the other his family.

***Index Terms*—Percy Ludgate, Analytical Machine, Irish Logarithms, Multiply-Accumulate (MAC), Division by Convergent Series**

A detailed technical report has also been prepared on attempts to deduce details of his machine by contextual analysis and to "re-imagine" its design.

However – the Main "Take-Away"

"The more I practice the luckier I get."

Arnold Palmer, the champion golfer