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Modelling Oil Reservoirs:Analog Computing at British Petroleum

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Abstract

During the early 1960s an analog computer was installed at British Petroleum (BP) to model the hydrodynamics of oil fields. The computer was custom built but influenced by similar machines developed for the American companies Carter Oil and Sun Oil.

Why did BP choose to install an analog computer at this time? Did they perceive analog as complementary or inferior to digital? To explain why a seemingly backward technology was still being installed during the 1960s, we need to differentiate between a user perspective and an application perspective. Coming from an application perspective, I suggest that the BP engineers focused mainly on the suitability and simplicity of analog rather than the modern, progressive, but expensive technology of digital.

This article investigates the history of reservoir modelling by analog computer, the American machines that inspired the BP machine and the engineering culture that procured it.

Keywords: K.2 History of Computing, Oil Reservoir Analyzers, Analog Computers, Electrolytic Tank Analogs, British Petroleum, EMI Electronics

Introduction

'Oilfield Studies by Computer' announced an article in *The Times* on the 23rd November 1962. Documenting the installation of an analog computer at the British Petroleum (BP) research centre, the article described how the computer would provide the means to model an oil reservoir 'in electrical form'.[1]

For many industries, the period 1950–1960 saw an increasing dependence on computational support to manage commercial activities and the petroleum industry was no exception. In particular, BP was one of the first British companies to purchase a large digital computer when its English Electric DEUCE was installed in 1956. This computer had originally been purchased to manage refinery related calculations but was used extensively to solve Operational Research (OR) problems.[2]

Within this context of extensive digital computer use and investment, it is interesting that in November 1962, an analog computer (or analyzer) was

[1] Anon (Nov 23, 1962).

[2] Bamberg (2000) pages 398–399.

installed to aid the work of BP's Exploration Research Division, the research group associated with BP's exploration department. Typically, analog computers have been considered by historians to be a predecessor technology to digital, the implication being that an analog would have not been purchased once a company became committed to digital. The purchase of the BP analyzer questions the validity of understanding analog as a predecessor technology.[3]

The computer allowed reservoir engineers to simulate an oil field reservoir through the creation of an electrical analog, or model, which could then be studied in a laboratory setting. Through exploring the effects that various oil production strategies had on this model, the computer could be used to predict the optimum operating conditions of an oil well. It was manufactured by EMI Electronics Ltd to the custom specification of BP engineers and installed at their Sunbury Research Centre.

Based in particular on the research and development of two American Oil Companies: Carter Oil and Sun Oil, the computer was the first installation of its kind in the UK.[4] For the engineers who prepared the specification, analog computing was not a technology 'on the way out', but rather a technique that was still being developed and explored; distinct, and yet complementary to digital computing. This article introduces the history of applying analog computing principles to reservoir modelling, firstly by looking at the early reservoir analyzers invented in American research centers and then by focusing on the story of the BP analyzer.

Despite their use of analog computing, the engineers at BP did not engage with the *Analog/Digital debate*, the ongoing rhetoric of technological quality and suitability that created two cultures of computation.[5] Located within an industrial setting, the BP engineers identified analog techniques because other (American) companies were deriving useful results from them.

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[3] As well as providing support to BP, the exploration research group offered consultancy services. It was for this work that the reservoir analyzer was found to be most useful.

[4] BP (1961a).

[5] This is discussed extensively by Small (2001).

Reservoir modelling and the business process: Motivations for modelling the effects of oil production

The business process of oil exploration revolves around a cycle of licensing concessions on areas of land or seabed (often referred to as *license blocks*) and exploring them for oil. If a reservoir is discovered then suitable techniques need to be applied to extract (produce) the oil.

Since a bad choice of production strategy can render large volumes of crude oil unobtainable, predicting the long-term effects of a production strategy was important. During the early twentieth century, oil companies became increasingly aware of this and initiated research programs to mathematically model reservoir behaviour. Because of the complexity of the relationships involved, analytical methods were not practical. Instead, reservoir engineers created an analog model, a physical system with analogous behaviour to the reservoir.

The main application of a reservoir analyzer was predicting the pressure changes in a reservoir due to the effects of 'water influx'. Most oil reservoirs are surrounded by porous water-bearing rocks known as the aquifer. Since this exerts hydraulic pressure on the reservoir, variations in aquifer pressure affect the production-rate.[6] As a dynamic model, the reservoir analyzer became an important tool to assist in the decision making processes associated with production management. Such decisions were not only important for obtaining the maximum output of a reservoir, but also assisted with the conservation of natural resources.[7]

Reservoir modelling and analog computation : the Carter and Sun Machines

Analog computers function by manipulating a physical analogy or model rather than solving a problem through the manipulation of a numerical or symbolic representation. The first use of the term dates from the early 1940s but the technology has a rich history that predates the attribution of its name.[8] For example, Bromley (1990) begins his account of analog comput-

[6] Craft and Hawkins (1959) page 205.

[7] In their company periodical, Carter Oil asserted that their analyzer could '[forecast] the production future of an oil field in the interest of conservation'. (May 1946 issue of *The Link*).

[8] Atanasoff (1984) and Mindell (2002) page 387.

ing with the Antikythera mechanism of antiquity and also identifies mechanical tide-predicting machines as important early analog computers. Mindell (2002) describes analog technology from the perspective of automatic controllers such as gun directors and autopilots.

The post-1950s analog computer industry is rarely discussed by computer historians, the technology usually being understood as superseded by the digital computer. However, some scholars have noted that although the technology had been relegated to small niches, there was a significant analog computing industry during this period. In *Between Human and Machine*, Mindell observed that the transition from analog to digital was 'neither instant, obvious, nor complete'.[9]

The first application of analog computing principles to oil reservoir calculations is attributed to William A. Bruce, a researcher for the Oklahoma-based company Carter Oil. His invention of an 'analyzer for subterranean fluid reservoirs' in 1942 showed that the dynamics of an underground oil reservoir could be represented by electrical circuits. Bruce had trained as a physicist, receiving in 1938 a PhD from the University of Washington for his X-Ray scattering studies of Zinc crystals. He joined Carter shortly after completing this research.[10]

In line with his training as a materials physicist, an early project that Bruce was involved in at Carter was investigating the effects of Arc Welding on the 40ft cylindrical tubes used to encase oil wells.[11] However, during the following years, Bruce turned his attention away from materials and began developing the reservoir analyzer, modelling an oilfield's aquifer region using a network of resistors and capacitors. In 1945 Bruce applied for a patent to cover his analyzer design and this was followed by two associated applications: one a refined model of the well and the second a tool for data input.[12]

Bruce did not initially make reference to analog, analogy or computer. Throughout his 1945 patent application the circuit was described as an 'electrical counterpart of a reservoir'.[13] Later reservoir analyzers would refer to electrical analogies and so position them within the analog computing field.

[9] Mindell (2002) page 10.

[10] There is only three months between the last publication associating him with Washington and the first to acknowledge Carter. Compare Jauncey and Bruce (1938) and Severinghaus (1939).

[11] Bruce (1939).

[12] Bruce (1947, 1949).

[13] Bruce (1947), column 2.

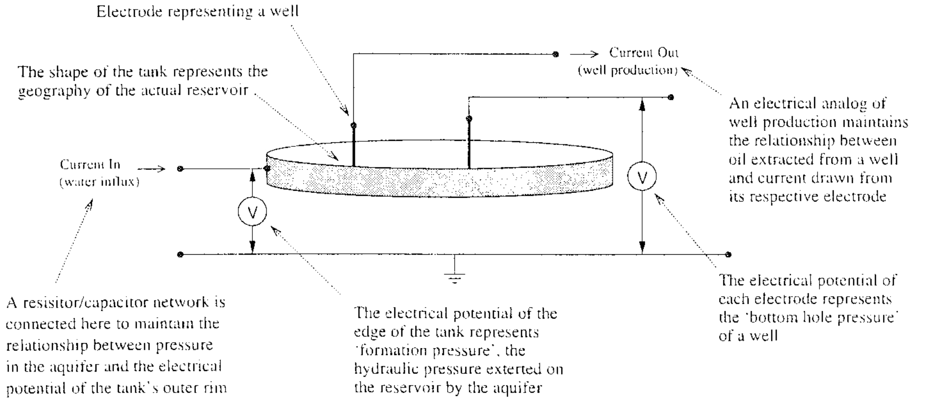

Figure 1: The basic features of Bruce's model, interpreted from his 1947 patent. The reservoir is modelled with an electrolytic tank, with electrodes representing wells. Current flow into the tank is controlled by a model of the aquifer. The flow of current out of a given electrode is proportional to the production flow of the corresponding well.

Modelling hydraulic pressures with electricity: the Bruce Analyzer

Bruce's analyzer consisted of two sections, one an electrical analog of the reservoir and the other an electrical analog of the aquifer. The reservoir was modelled by a tank with a conductive edge containing a low conductivity electrolyte (see Figure 1). By representing the water drive into a reservoir as a source of electrical power, the analyzer enabled an analogy to be drawn between hydraulic pressures in the reservoir (and the surrounding rocks), and electrical potentials in the electrolyte (and the surrounding circuits). In an actual reservoir, water influx is caused by hydraulic pressures from its adjacent aquifer; on the analyzer, the electrical potential of the reservoir's outer rim was determined by the output voltage of a resistor/capacitor network modelling the aquifer (See Table 1).

To simulate a given oil field, the user would first create an initial model based on geographical data and then refine it by 'playing through' past measurements of reservoir data, usually drawn from observations over a minimum of two to three years. The required reservoir behaviour was engineered, or programmed, so that at any point in the run-time, current drawn from the

Actual Reservoir (hydraulic system)	Reservoir Analyzer (electrical analog)
Hydraulic capacitance of aquifer	Electrical capacitance of aquifer analog
Hydraulic permeability of aquifer	Electrical resistance of aquifer analog
Aquifer pressure	Electrical potential of the tank's edge
Reservoir pressure (at a given point)	Electrolyte potential (at a given point)
Well bottom-hole pressure	Electrode potential
Oil production	Current drawn from electrode

Table 1: The analogy between reservoir and analyzer

model was proportional to the oil extracted from the actual reservoir. Measurements of electrode potentials taken during a run-time were compared to the records of well bottom-hole pressures observed in the field, any differences being used to improve the model. This process was known as historic matching.

Following from the work of Bruce at Carter, a number of other US companies invested in analog computer research and development. The patent records show that other significant players were the Sun Oil Company, the Texas Company and Union Oil. The improvements made by these companies in their patents often related to the analyzer's user interface, providing, for example, the facility to manipulate the model dynamically in real-time.

Incorporating repetitive operation: the Sun Analyzer

Between 1949 and 1953, Sun Oil filed six patent applications for technologies relating to reservoir analyzers, three of which were assigned to Omar L. Patterson. It is in this work that we can see the developing association between the reservoir analyzer and analog computation, two of the patents were entitled *Analog Computer or Analyzer*[14]

The Sun analyzers differed from those of Carter Oil by their use of repetitive operation (or rep-op), a technique that was proving popular in mainstream analog computing. A repetitive operation analog computer, as opposed to a 'single shot' analog computer employed faster time-scaling techniques and allowed a user to immediately see the effects of altering the parameters of a model.

Bruce's analyzer was a single shot computer and although time was scaled

[14]Patterson (1955, 1958).

so that the model progressed much faster than the actual reservoir, analyzer-time still moved slowly enough to allow the user to make measurements and directly observe trends. With a single shot computer, the bulk of analysis was performed off-line. This involved comparing the analyzer plots with trends observed in the field. In contrast, rep-op computers provided a technology for on-line analysis.

With repetitive operation, the Sun analyzer designed by Patterson increased the time-scaling so that fifty years were represented by an analyzer run-time of two milliseconds. While this allowed the historic matching to be completed on-line, the downside of the increased speed was that it became impossible for a user to make measurements without the aid of special hardware. Many general purpose rep-op computers solved this problem by replacing paper plots with the dynamic graphical output of an oscilloscope. However, Patterson used the different technique of 'pulse marking'. This involved using a synchronising circuit to trigger measurements and provided a means for 'a stroboscopic view of a recurrent phenomenon' to be captured. Patterson's analyzer used a roaming probe to make such observations and this made the recording circuits simpler than in the Bruce analyzer.[15]

Demand side: the need for a BP analog computer and the decision to re-design

The origins of the BP installation date back to a memorandum circulated to the members of the Exploration Research Advisory Committee in December 1956. This committee met quarterly and provided a link between the research personnel of BP's Exploration Research Division and M. H. Lowson, the division's technical manager.

The memorandum identified the agenda for their next meeting which was to be a discussion of a report from Dr J Birks, a member of the Exploration Research Division who had just returned from a two month tour of research centers in the United States. Birks' report documented various applications of computers in exploration research, and outlined their potential benefit to BP. In particular, He drew attention to the use of 'reservoir analysers', analog computers that could 'predict future changes in reservoir pressure with production'.[16] Birks recorded that there were two main types of analyzer in

[15] Patterson (1955).
[16] Birks (1956).

use, the 'Bruce or Carter analyzer' and the 'Sun analyzer':

> The Bruce analyser is generally used for large reservoir units such as Kirkuk, Burgan and the Aramco fields where there is a considerable amount of core analysis and fluid data available and where plenty of time can be devoted to building up and adjusting a large scale electrical model of the reservoir and aquifer. The Sun analyser is best used for small reservoirs or ones which can be treated as a few units since it is much easier to use and gives a visual display of the pressure decline curve.
>
> (Birks, 1956)

Birks concluded his discussion by recommending that BP should purchase 'a Sun type analogue computer for the use of the reservoir engineering group'.[17] He also recommended that a small digital computer be purchased. Both machines were approved when the advisory committee met to discuss the report, but it was recommended that a reservoir engineer be trained on the Sun analyzer and that this training should inform the choice between purchasing a Bruce or a Sun analyzer.[18]

During the following year, a detailed investigation was undertaken to select between the two American machines. The study was done by both Birks and another member of the Exploration Research team, Dr K R Keep. They considered the particular strengths and weaknesses of the Sun and Bruce analyzers and their relative suitability for BP's particular work. In 1958 Keep prepared a report of their findings.

Keep's report, was circulated to the members Exploration Research Advisory Committee. In it he outlined the need for the analog computer and provided a technical specification. The original plan of purchasing one of the American analyzers was abandoned due to them not being 'flexible enough' for the group's consulting work.[19]

The report described the Sun machine as having 'serious limitations', but Keep was impressed with its other characteristics: 'the chief advantage of the Sun type is that it has a fast repetition rate and uses some excellent electronic techniques which are worth using in any future analogues.'[20] Although the Bruce analyzer met some of the requirements, it was deficient in a number

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[17] Birks (1956).
[18] BP (1958).
[19] Keep (1958).
[20] Keep (1958).

of respects. In order for the purchase of the analyzer to be worthwhile, BP would need a custom design.

> In view of the limitations of the existing types of analogue, it was considered that any future instrument should combine the advantages of previous models and at the same time attempt to reduce the disadvantages to a minimum. The suggested specification therefore combines the fast, repetitive techniques of the Sun analyser with the areal representation of the Carter-type. For this purpose, about 40 condenser and 70 resistance units would be required to simulate an oil pool subdivided into 10 layers and 4 areas.
>
> (BP, 1958, page 2)

Unlike the American research groups who developed their own analyzers in-house, BP would commission a third party to do the design work. The committee approved a six month 'development study contract' with EMI Electronics costing £4,000. This would be followed up with the purchase of a computer for around £40,000.[21]

Supply side: EMI Electronics and the EMIAC

It is interesting that the Exploration Committee did not consider other electronic manufacturers before deciding that EMI Electronics should manage the development of the analog computer. It was not due to a lack of many more-established manufacturers offering commercial analog computers, but because BP did not want to purchase an off-the-shelf product, preferring a custom-built machine.

EMI Electronics was a subsidiary of the entertainment company *Electrical and Musical Industries* (EMI) and was formed around 1957 to bring together EMI's various interests in electronic goods.[22] EMI was a regular supplier of bespoke-hardware to BP, and had recently completed a development contract for an instrument to investigate rock formations.[23] Since BP wanted to design the analog computer within a similar business process, it made sense to use a company who they knew could produce a successful custom product.

[21] BP (1958).

[22] Anon (1959) and Hamilton (1997) page 82. EMI were pioneers in a number of electronic products including medical scanners and domestic television.

[23] EMI (1961).

EMI decided to develop the reservoir analyzer around the technology of their commercial analog computer, the EMIAC II.[24] Other important uses of the EMIAC included missile research work at De Havilland Propellers, Whitworth Gloster and the Australian Government Aircraft Factory and aircraft control research at Hobson Ltd. Educational applications of the computer included engineering calculations at Oxford University, Cranfield and Witwatersrand University of Johannesburg.[25]

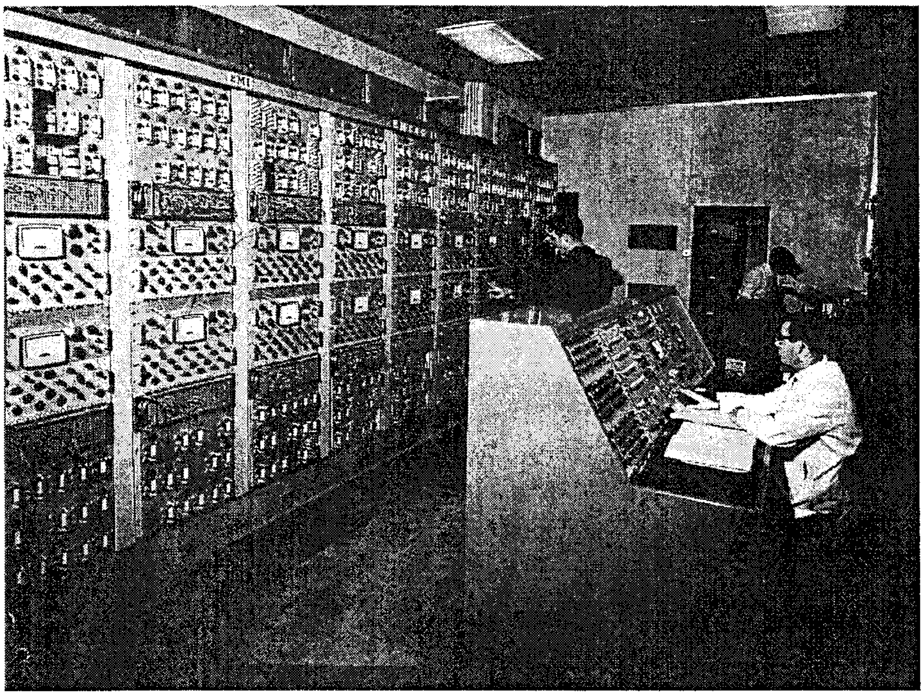

Figure 2: The EMIAC II installed at Sunbury. EMI designed extra hardware specific to the reservoir modelling problem which is controlled via the console. (BP Archive: reference EMIAC II 7331_1) ©BP plc

The EMIAC was like other analog computers of the period in that it had a modular design. While the basic computer was a single module consisting

[24]The name EMIAC was an acronym for *EMI Analogue Computer*; the company's offering in digital computing was named the EMIDEC. In EMI's pre-1962 trade literature the name appears as 'EMIAC II' and later as 'EMIac II'.

[25]See EMI (1959, 1962a,b, 1963b, 1965).

of 18 computing components, extra modules could be connected to allow more complex problems to be solved. Within each module the selection of computing components installed was fully configurable. Each component was encased in a removable tray, or 'C Box' which could be swapped with relative ease and allowed the computer to be customized for a particular problem.[26] To implement BP's requirements, EMI assembled 18 EMIAC II rack mounted modules providing 324 C Box locations (see Figure 2).

BP and the analog/digital debate

Small (2001) refers to an 'analogue/digital debate' and attributed its apparent emergence to the effects that the parallel alternative technologies of analog and digital had in polarizing the computer community into two camps. While acknowledging that these classifications were sometimes hazy, he also describes conflict between the two communities related to their members' status.

> The analogue computer community ... were keen to refute – even ridicule – the claims of the digital 'men'. Though commercial competition helped fuel the analogue/digital debate, with the benefit of hindsight we can conclude that status was one of the underlying issues in the debate. At issue was the relative status of developers and users of electronic analogue computer equipment *vis-à-vis* the digital computer community of developers and users.
>
> (Small, 2001)

We have to ask ourselves whether or not the analog/digital debate actually existed, or whether it is merely a product of back-projecting a more current understanding of analog and digital. Were there really two cultures, and if so were they both cultures of computation? Were the two groups actually in opposition, or were their technical and commercial offerings complimentary to each other?

The debate certainly existed on some level within the computer community and Small identified that people involved with computers became either

[26] For example, if a user required more integrators than normal, C Boxes containing other components could be removed and replaced by integrator components. A full range of boxes incorporating all the common analog computing components were available. The computer featured removable patch panels so that problems could be 'patched up' away from the computer. For a detailed technical description of the EMIAC see EMI (1963a).

'analogue or digital men.' There is no doubt that there were a number of vocal groups who pursued promoting one class of computing over the other, the question is how far this debate extended and whether it was appropriate for other end-users like BP to engage with the discussion.

We can conceive that the debate appeared quite different from alternative perspectives and in particular we can identify both an application and research outlook. From the research outlook, we can consider those involved in computer research and development. Take for example Mauchly and other researchers at the Moore school, digital computing pioneers who articulated and understood a clear distinction between the two types of computers.[27] To develop the language with which to communicate about the emerging technology of computers, it was necessary for pioneers to identify classifications and types between different machines, approaches and representations. While those with a *research outlook* were debating the merits of these two distinct computing technologies, the engineers at BP had an *application outlook* where different computers were evaluated in terms of their practical and observed suitability rather than a theoretic suitability derived from their internal design, architecture or data representation.

In 1946, Jay Forrester decided to use a digital rather than an analog computer as the central technology of Project Whirlwind, a general-purpose flight simulator. This is one of the first examples of a turning point from analog to digital and Forrester went on to construct a powerful real-time digital computer.[28] However, this again is an example drawn from the world of research rather than of application[29] and although Forrester can be credited with the foresight that general purpose digital computers were far more powerful and versatile tools, his design choice was only possible because of quite exceptional funding. Project Whirlwind proved that digital computers could be constructed to work in real-time and so take on tasks that analog computers had previously been used for. However, affordable digital alter-

[27]One of our earliest examples of a separation of computation into two classes exists in communication between Mauchly and Atanasoff. See Mauchly (1984) and Mauchly (1941). That the distinction emerged from the digital community is entirely understandable; a new technology had emerged and needed to be associated and yet also distinguished from other computing technologies.

[28]Campbell-Kelly and Aspray (1996) pages 143–145.

[29]Although Whirlwind began as a military project with a definite purpose, the project exceeded both its allocation of time and funding taking on a far more research based approach to real-time computing. It was important that such projects existed, but BP's computer requirement was not so 'cutting-edge'.

natives to analog computing were much slower in coming to the application community. For those without the deep budgets of a defence contract, analog computers were the tool of choice well into the early 1970s. For BP, when comparing affordable computers, digital machines were just not fast enough:

> [Mr Docksey] queried, however, whether a digital computor [sic] could not be used for these studies but later agreed with Dr Birks that there was a strong case for the analogue approach, the studies being both awkward and time-consuming when carried out on the large digital computor which would be required.
>
> (BP, 1958)

Another significant aspect of the analog/digital debate was the differing approaches of the engineer and the scientist. While scientists yearned for the general purpose applicability of digital, engineers preferred the 'did the job' applicability of analog. Special purpose tools were acceptable in an industrial setting but general purpose tools were the preference of the academic environment.

As an engineer, Birks understood the technology in terms of the problem. The language of his proposals did not presuppose that digital was better than analog, neither did it represent a view that analog was always more appropriate than digital. This is best illustrated by the fact that alongside his proposal for the analog computer, he drew attention to the importance of acquiring access to a digital computer. For Birks, a digital computer was a priority since the machine could be used 'for any type of numerical calculation and not only for petroleum engineering problems.'[30] However, this was not driven by perceived superiority. The analog computer was less of a priority because its immediate use was for external consultancy. Here we see once again that Birks saw straight through the analog/digital divide to the business operations that the machines supported. The digital was required because it would immediately help the group with current work, the analog was required because it would significantly extend the group's skills-base in the long term.

The BP engineers were aware of the generality of digital computing and knew that many of the problems could be solved on digital machines but that this would come with extra expense and size, and be time consuming in operation:

[30]BP (1957).

> Dr Birks, commenting on Mr Lowson's observation regarding the need for a more advanced type of analogue, suggested that if the only purpose of a study was to predict pressure decline, there would be no need for an analogue. This could be done satisfactorily on a digital machine. However in the study of the effect of gas injection, particularly in a long oil column, the successive approximations performed by the digital computor [sic] would be time-consuming. Such a problem could be handled rapidly by an analogue...
>
> (BP, 1958)

Despite this, analog computing was not cheap. BP knew from the outset that the computer required would have an expensive cost of '[perhaps] several times that of those at present available'.[31] However, one of the engineers commented:

> The economies which can be effected by good reservoir computations make the differences in price insignificant. The primary concern should be whether a more advanced type of machine is required and if so, the aim should be to produce a good workable machine, size being relatively unimportant.
>
> (Docksey in BP, 1958)

In summary, BP needed a 'good workable machine' to give them an industrial advantage. A large expense was deemed recoverable and they simply opted for the technology that would best suit their needs. Analog techniques had already proved suitable in other oil companies so they chose to commission a custom machine based on these techniques.[32]

On a corporate level, analog/digital issues were not addressed by BP publicity; press releases relating to both types were used to strengthen the image of BP as a modern, technology enhanced company. BP appeared to be equally proud of both their digital and analog machines and this can be

[31] BP (1958).

[32] With relation to electrical supply calculations Tympas (1996) observed that network problems were first solved by office-style calculating machines, then by analog machines and finally by digital computers. These shifts of use, which he described as moving 'from digital to analog, and back' were due the shifting applicability of each technology over time. Oil reservoir calculation went through a similar development and BP's procurement is indicative of the superior applicability that analog technology boasted around 1960.

seen in the 1963 annual report where the reservoir analyzer and a new digital machine[33] were both announced and given equal prominence.

> On the computer side our effort was concentrated on preparing for the commissioning of the large [Ferranti] ATLAS computer which is coming into use in 1964.
>
> ...
>
> The exploration and production side of our business has been much helped by research, in particular from the installation of an analogue computer.
>
> (BP, 1963, page 31)

Compared to the costs of the ATLAS computer upward of £2.5 million, the expense of the reservoir analyser would have been negligible. There appears to have been no embarrassment associated with installing an analog computer, it was no different to any other tool. We see therefore that BP's industrial setting was open to both analog and digital technologies. A technology's ability to deliver results was the greater concern.

The utility of the BP analyzer

The computer was a state of the art piece of equipment and the first reservoir analyzer to be installed in the UK. It is interesting to explore to what extent it gave BP a commercial advantage and to understand why BP invested time and money into developing a computer superior to the American machines installed at Carter and Sun Oil.

Many factors contributed to the purchase of the analyzer, the original motivations came out of the quasi-academic culture of the exploration research team. They were not just seeking an off the shelf product but looking around to see what technology was being used elsewhere. However, the distinction between BP research and academic culture was the application perspective that prevented them from engaging first hand with the relative merits of analog and digital. The whole process of visiting American research centers, followed by suitability studies shows us a strong technical orientation. If the exploration research group had been more business oriented, they would

[33] This was actually owned by the University of London. BP provided a quarter of the funding and received an portion of computing time for five years. See BP (1961b).

never have critiqued the existing analyzers to the point where only a new design could be a viable procurement option.

The decision to purchase the analyzer required a long-term view of the groups activities, since the principle benefit related to the group's expanding consultancy skills rather than analysis of BP's own fields. Experience in reservoir simulation, would improve their competitiveness in external contracting.

> It was pointed out in the discussion that possession of such a computer would result in Kirklington Hall obtaining a wider experience of field problems; at the moment these problems are dealt with in their entirety by American companies.
>
> (BP, 1957)

It is clear that the analyzer was a highly desirable object, especially for Birks who gave the original impetus for the installation. In the context of the late 1950s, embracing computational support was an indicator of a business' modernity and wealth. For Birks and the rest of the research team, alongside the computer came the status of owning and using the only UK reservoir analyzer.

Successful ordinariness

During the five years between the identification of the need and EMI's delivery, analog computing did not lose its applicability to reservoir engineering problems and in the 1963 annual report, BP presented the analog computer as a successful addition to their research establishment. Although there are few sources relating to the use of the computer after its installation, those that we have indicate that it was viewed as a profitable procurement. For example, during 1963 Gill requested extra staff for his Sunbury research team and this was in part due to their technical assistant being 'mostly concerned with the computer.' The use of the computer at that time included a contract modelling Iranian oil fields that was worth £20,000 annually, and Gill expected work of this kind to 'continue and increase in the next few years.'[34] Even with financing the machine running costs, the salary of one technical assistant and the occasional input of a reservoir engineer; an annual income

[34] Gill (1963) page 3.

of half the analyzer's value on one contract[35] indicates that the analyzer was indeed a successful purchase and that there was a market for BP's consultancy services.

We do not know when the computer was decommissioned but by 1975, most analog computer applications and installations had disappeared due to the faster speeds and lower costs of digital computers. Although purchasing an analog computer was a sensible choice in the early 1960s, by the late 1970s, the physical modelling techniques characteristic to analog computing had been replaced by symbolic mathematical modelling using digital computers. This had the result that reservoir engineering textbooks began to present the problem of reservoir simulation in terms of software simulation and mathematical models, instead of introducing the concepts of the hydraulic/electronic analogy behind the Bruce analyzer.[36] If BP followed the rest of industry in replacing analog with digital, then the computer would have had a working life of between five and ten years.

The BP story provides another example of an important application of analog computing to industrial problems. We have seen that it was commercially viable in 1958 for a global company to invest in an analog computer and that the engineers in our industrial setting were happy to accept a special-purpose or limited-purpose machine. Always driven by a need for accurate reservoir predictions, they did not seek the generality of digital computation or attempt to involve themselves in discussions over the long term effectiveness of analog technology.

When Bamberg (2000) wrote the history of BP for this period, he included a chapter on computer use within the company. However, in this chapter no reference to the EMIAC II was made. This is not surprising since the narrative was dominated by the development of OR methodologies and the use of digital computing in business management. Some historians might claim that this is an example of 'presentist' history – the ignorance of analog computer history in the light of digital computing and its dominance today. However this is not the case.

Firstly, Bamberg's excellent account is centrally about the company's business activities and the changes and developments in the management of global oil during the latter-half of the twentieth century.[37] Whereas the de-

[35]The budgeted price of the EMIAC II was £40,000.

[36]Compare Craft and Hawkins (1959) p 205-210 and Peaceman (1977) pp 1-2.

[37]See the review article by Pratt (2001). In fact, Pratt identified that this chapter 'stray[ed] from the thematic coherence' of the rest of the text.

velopment of OR did link with global business operations, a small research tool in Sunbury was more a *cog-in-the-machine* than a revolutionary aspect of the business process. Secondly, from the perspective of technical innovation at BP, our computer was of small historical significance. Built to a specification that re-used principles developed in American research, the EMIAC II installation was not a ground breaking machine, and neither was the research prepared using it particularly revolutionary.

What makes studying this computer interesting is what was earlier identified as the application perspective, the engineering culture that sought and used analog computational assistance. In a sense, the importance of this installation to the history of computing is its ordinariness, an attribute that manifests itself in the perceived unimportance of the computer in the grand trajectory of the business. In fact, the 'cog-in-the-wheel' metaphor identifies more than just the status of the analog computer, but can be taken as an illustration of the status of the personnel who worked around it. When Gill requested extra staff for the group he described the team as:

> ... a small but very active group working on a project which is elsewhere receiving a great deal of effort and attention. The group requires (and deserves) support in order to be able to make its own adequate contribution, and to gain and maintain a place for BP in the Petroleum Geochemistry field.
>
> In Geophysics and especially in seismic theoretical, field, and laboratory (model) work, we do not think the quantity and quality of the output receives wide or adequate recognition within the Company partly because of its specialised and mathematical, and also its long term nature.
>
> (Gill, 1963)

Exploration research played an important but often forgotten role in the large commercial activity of exploration, production and refining of oil. When a new analog computer was installed, the group achieved recognition by corporate level public relations, however, the analog computer quickly became forgotten as its use slipped into the quiet and ordinary activities of the Iranian research contracts. However, despite this lack of recognition the exploration researchers had specific work to deliver and to do this, they relied on the special purpose technology of the analog computer. Together, they did this well.

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Charles Care is a PhD student at the University of Warwick. His research area is the history of analog computing, focusing on applications and users of this technology. His thesis will situate this history within the broader context of the development of computer-based modelling techniques.

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