Editing and completing the index

After all this work, the index itself looks like a regular print index, with time codes instead of page numbers. Editing, proofing, and submitting works much like a print index. During the editing stage of the Zoo Project, a lot of the name issues are resolved, and indexing finalized.

Summary

Most of the work on video projects goes into making sure the time codes will be good for the eventual purposes of the project, and that the codes make sense for the users and their devices. The other demanding part is translating the spoken words to text entries, correcting spellings, and adding clarifying detail for the text and the index. Working with a researcher or editor helps simplify this research phase. Once these decisions and research are finished, though, the indexing is straightforward.

Acknowledgment

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The peripheral and central indexes at Bletchley Park during the Second World War

Eric L. Nelson

Indexing played an important role at Bletchley Park, the central site for Allied codebreaking during the Second World War. Much of the work done there remains shrouded in secrecy, but information about how multiple indexes were created and used there is emerging.

Brief mention of an 'Index' at Bletchley Park (BP) is made in a number of publications, with little detail provided. As it turns out there were at least 16 peripheral indexes, kept by various Huts and Blocks, as well as a mechanized Central Index into which all peripheral indexes fed their intelligence. By the end of the war, there were millions of coded punch cards in the Central Index, with more than a dozen tabulating machines conducting queries on them. Writing in The Indexer 18 years ago, Wallis and Lavell suspected 'that there were several different indexes in the "back rooms"' of Second World War Bletchley Park (2000: 31). As it turns out, they were correct. As this article will reveal, BP was home to at least 15 handwritten indexes, and one that was typed and distributed. There was also a most secret, mechanized, 'state of the art' Central Index which used British Tabulating Machine Company (BTM) and International Business Machines Corporation (IBM) tabulators.[1]

The contribution of indexing to the success of BP cannot be overstated. As an example of the difference it can make, suppose you are an Air Advisor in Hut 3 who was just handed a raw decrypt which reads:

140KL GA3ZU 50413 0N030 430EV ON210 0XXXX

Using your knowledge of German, you interpret the message thus:

140,000 Liters GA3 to 50 41 30 N – 03 04 30 E by 2100

You walk across the hall and ask the index librarian if she has cards on 'GA3', and '50 41 30 N – 03 04 30 E.' Indeed she does:[2]

- The card titled 'GA3' indicates this is a high-grade aviation fuel.
- The card titled '50 41 30 N – 03 04 30 E' shows:
  - This is the Lille/Nord airfield in France.
  - It has been used by the Luftwaffe for the last 95 days.
  - A report to Luftwaffe high command, decrypted 18 hours ago, reports 62 of 74 Heinkel He 111 medium bombers are operational.
  - A message decrypted three hours ago reports 12 trucks bearing 'B1ELZA/SNIB' are en route to these coordinates. A side note indicates B1ELZA is the name of incendiary bomb casings, and SNIB are steel-nosed incendiary bombs.

As this example demonstrates, a two-minute visit to the Index can provide invaluable information that should be

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Figure 1 Hut 3 at Bletchley Park.

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included as part of processing a decrypt. Commenting on the value of indexed information BP codebreaker Peter Calvocoressi noted, 'The Index, which is an enlarged human memory, is key, absolutely key' (UK Channel 4, 1999). BP-codebreaker Lord Asa Briggs adds, '[W]e all depended on easy access to meticulous indexing, [which is] an essential component in all code-breaking' (2012: 19).

The peripheral indexes

Handwritten indexes are known to have been kept in Huts 3, 4, 6, 7, 8, and Block F. With one exception, it appears they were kept on 5" x 9" cards (Calvocoressi, 1980: 62). Index librarians were mainly young women, recruited from the wealthy and educated upper middle class. They tended to be 'enthusiastic, cheerful and quick-witted.' Many spoke German and had spent time in Germany, so they had firsthand knowledge of the 'growing ugliness of the [Nazi] regime' (McKay, 2013: 61). As an example, Sarah Baring was an index librarian in the Naval Section of Hut 4. In 1937, when she was 17 years old, her parents sent her to Munich to learn German and further her education. While there, she regularly saw Hitler, Goering, and Goebbels in the Charlton Tea Rooms. 'We would choose a table as close as possible and stare at them in obvious distaste … it gave us … a good opportunity to observe them' (2000: 2).

Baring offers insight into the use, and usefulness, of manual indexes.

> On watch people appeared … at the windowed hatch outside the room and would ask, usually in a tearing hurry, if we had a card indicating the movements of a certain ship, place or personnel and go away satisfied when we found the information. I soon realized the true magnitude of a cross-reference Index and how it helped to put pieces together like a jig-saw puzzle by interpretation and analysis.
>
> (Baring, 2000: 69–70)

The known peripheral indexes are discussed below.

Abbreviations and Equivalents (A&E) Index[3]

This index was created and maintained by Trevor Jones of Hut 3. Regularly updated copies were provided to the principal watch rooms at BP, and later to government ministries. By the end of the war, the index contained 10,000 abbreviations and acronyms, and 16,000 equivalents (Brunt, 2006: 132–3). As noted by Brunt, 'The Germans used [abbreviations] freely owing to the way that Enigma operated and the security requirements that message lengths be severely restricted' (2006: 131). For example, 'Fschm.Spr' is the abbreviation for Fallschirmspringer (parachute jumper) (US Army, 1943: 60).

Abbreviations Index

Naval Section VI, in Hut 4, kept this index. The principal source of information was captured documents (Brunt, 2006: 141–2). It appears to be similar to the A&E Index, and was probably duplicative in many respects. It is known that Hut 4 exchanged indexes with Trevor Jones, and supplied copies to a few other interested parties (Brunt, 2006: 142).

Air Index

Calvocoressi describes the Air Index thus, '[It was the] central repository of what Ultra knew about the Luftwaffe. Its importance cannot be exaggerated' (1980: 61).The Air Index was set up by Squadron Leader Reggie Cullingham in 1941 (Welchman, 1982: 224). Before the war Cullingham worked for *Kelly's Directory* (Lewin, 1978: 121), which undoubtedly imbued him with excellent indexing skills. The Air Index was located in a long narrow room which opened into The Watch[4] (Calvocoressi, 1980: 63, see also 54–8). Watch members consulted the Air Index as they translated and interpreted decrypted Luftwaffe messages. The head of the Air Index was given a copy of every message that passed through The Watch. Red chalk was used to mark key words and phrases to be indexed (Calvocoressi, 1980: 62). Using data from the index, one of the team members, Christine Brooke-Rose, maintained a huge wall chart showing every German unit and its location (Smith, 2015: 129). The Air Index was staffed entirely by women, many of whom had a master's degree (Calvocoressi, 1980: 62).

Army Index

The Army Index was colocated with the Air Index in Hut 3, in a room across the corridor (Calvocoressi, 1980: 63). The function was similar, the key difference being that the Army Index was focused on the non-naval German military.

Authorities, Geographical and Personnel Index

This contained the location of naval organizations, with details on their personnel. It was kept in Hut 4 (Brunt, 2006: 143).

Captured Documents Index

This was maintained by Naval Section VI in Hut 4. By the end of the war about 10,000 German and 4,300 Italian captured documents had been indexed here (Brunt, 2006: 144–5).

Cross-Reference Index

This may also have been known as the Naval Index. In a television interview broadcast in 1999, Sarah Baring described this Hut 4 index, 'I worked in the Cross-Reference Index, one of the most valuable reference libraries at BP. A very extraordinary form of intelligence' (UK Channel 4, 1999). In the same broadcast, Peter Calvocoressi added, 'That is intelligence you very rarely get. The top chap saying "my plan of battle is the extermination of the following countries in the next six weeks or whatever." It's putting together lots and lots of little bits and pieces.' By the end of the war this index filled three large rooms (Smith, 2015, p. 75).[5]

Enemy Officer Personnel Index

This index tracked individual naval officers, their ranks and assignments, and their qualifications. It was kept in Hut 4 (Brunt, 2006: 143).

Equipment and Manufacturers and General Technicalities Index

Information in this index included equipment counts, and information on firms supplying the German navy. It was kept in Hut 4. As Brunt notes, 'Sometimes the nature of the firms provided the only clues to the meanings [of naval] messages' (2006: 143).

Equivalents Index

This index provided equivalent words in English for words in German, Italian, Spanish and French. It was kept in Hut 4 (Brunt, 2006: 140–1).

Index of Differences

This was a product of tabulating machine processing. As BP codebreaker Edward Simpson notes, '[W]e relied heavily on the Freebornery to provide us with Indexes of Differences and of Good Groups' (2011a: 134). Differencing is a mathematical process used to develop possible additives used in mathematically based encryption.[6] Simpson adds, 'this was a big job done for us by the Freebornery' (2011b: 403). ('Freebornery', the system used for constructing the Central Index, is discussed below.)

Index of Good Groups

This was also a product of tabulating machine processing. Good groups are bits of enciphered text for which the mathematical decipherment key is known, groups which appear in a mathematically based codebook (Simpson, 2011a: 132).

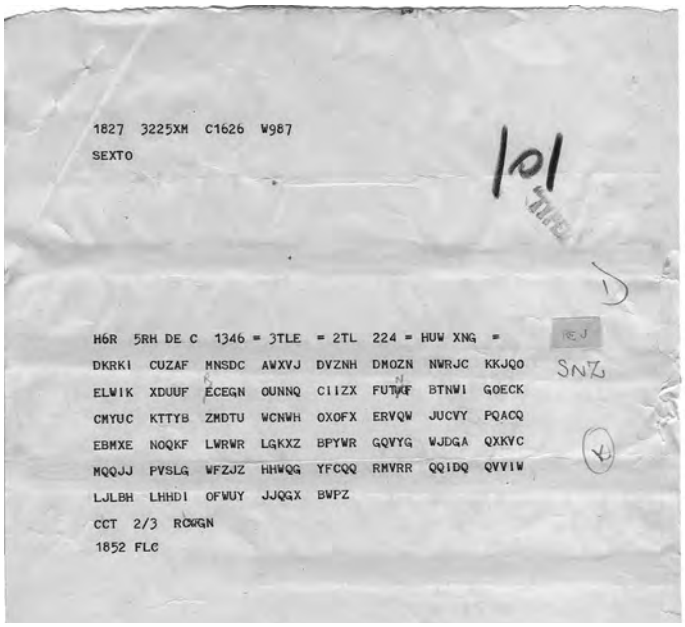

Figure 2 A typical Bletchley Park intercept sheet.
US Air Force (2008). Image in the public domain.

Good groups were used in tabulating machine production, to generate the Index of Differences.

Japanese Call Sign Index

Little is known of this index, other than its name, which seems to be sufficiently self-descriptive. It was kept in Block F, and does not seem to have been treated as very important. As Mary Wisbey noted, 'The first job I had to do was extremely boring … [the Japanese Air Section's] call-sign index was terribly behind …. It took quite a long time … to bring it up to date' (Smith, 2015: 235).

NS VI Index, aka Library

This was an index of captured naval documents. It was compiled by Valerie Travis, daughter of Commander Edward Travis, under the direction of Geoffrey Tandy, for Naval Section VI in Hut 4 (Brunt, 2006: 140, 144–5, 147).

Oberkommando der Kriegsmarine Index

Data used in this index was obtained from captured documents, and was used to determine the duties of specific German military components. It was kept in Hut 4 (Brunt, 2006: 143–4).

Waiting Index

This was a collection of worksheets that described unsolved problems or unknown words, or words lacking an English language equivalent. There were separate sections for German, Italian, Japanese, and other languages as needed. It was kept in Hut 4 (Brunt, 2006: 142). These were meant to be perused as new information became available, in order to see if a problem could be resolved.

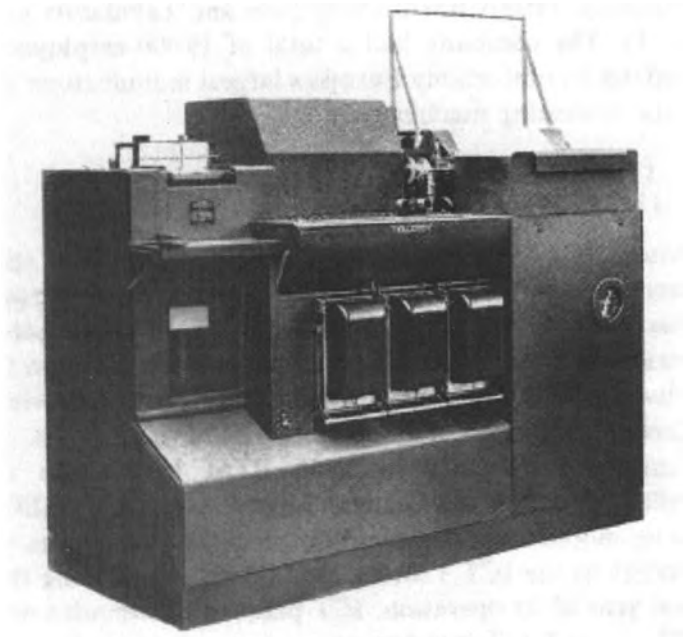

Figure 3 BTM Rolling Total Tabulator

Source: Unknown. Believed to be in the public domain.

The Central Index (CI)

The Central Index (CI), also called the Intelligence Index, was established in Hut 7 but later moved to Block C (CCHT, 2017). Simpson describes it as a 'massive Hollerith installation … serving the whole of Bletchley Park' (2011a: 134). A similar installation existed in America, according to BP codebreaker, designer and supervisor Gordon Welchman (1982: 182). The head of the Central Index was Frederic Freeborn, who before the war was the director of the British Tabulating Machine (BTM) Company's factory in Lechworth, which is where Hollerith machines were produced (Smith, 1998: 87) under licence from IBM (Grace's Guide, 2018: 1–2). This work was also carried out at four BP outstations (Smith, 2011: 109–10), undoubtedly made possible by the fact that punch card data can be transmitted over telephone lines (US GSA, 1965: 62).

Conveyer belts, pneumatic tubes, and messengers delivered intelligence from the peripheral indexes (Smith, 2011: 109–10)[7] and other sources[8] to Block C once the Central Index was moved there (Whelan, 1990s: 13; CCHT, 2017: 2). Intelligence was coded onto punch cards. Each card can be programmed with 80 lines of data. At the height of the war 2 million cards were punched each week (Whelan, 1990s: 26).[9] Therefore, at a minimum, there would have been dozens of millions of coded cards by the war's end.

Tabulating machines searched, sorted, and carried out other processes on decks of punch cards in a manner not dissimilar to how search engines operate today. As Perry and Casey note,

> 'A punch card file, properly coded, can be searched mechanically according to any of the categories for which it is coded, or any combination of categories … [These can also be used for] studying relationships between factors. A well-organized punched-card file can serve as an effective tool for evaluating the significance of recorded data …
>
> (Perry and Casey, 1952: 449–50)

Smith adds, 'The Hollerith tabulating machines … made the initial searches … of the Enigma traffic for features that might assist the codebreakers …' (2011: 109). And as Greenberg notes, the tabulating machine process was 'an early search engine' (2014: 80). Cherry Lavell, who operated Colossus and Hollerith machines after the war, adds, 'A room full of tabulators printing made a pretty horrendous racket' (personal correspondence, 2018).

Ronald Whelan was one of the three BTM employees sent to BP to start the Central Index. The lead was Frederic Freeborn, and Whelan was his chief deputy. Whelan's brother Norman was the third BTM employee. The operation was soon called the 'Freebornery' by its BP 'customers.'

Whelan describes the types of machines used in the Central Index, adding that innovative modifications were made in order to increase work range and simplify or combine operating procedures; but '[d]etails of these changes were not made known to BTM' (1990s: 3). The choice to withhold knowledge from their employer (BTM) must have been difficult for Freeborn and the Whelan brothers, but doing so makes sense when we consider that tabulating machines were also in use in Germany, where among other things they were used by the SS to identify and track Jews (USHMM, 2017). In the Freebornery, there were at least six types of machines in use.

- BTM Rolling Total Tabulator with horizontal sorter. The sorting speed of this machine was 400 cards per minute, with output distributed into one of 13 pockets. Tabulation speed was 150 cards per minute, list speed 100 cards per minute (Whelan, 1990s: 4–6). See Figure 3.
- IBM 405 Tabulator. This was a true accounting machine with removable plug boards. It tabulated 150 cards per minute, or it could tabulate and print 80 cards per minute (Whelan, 1990s: 5; CUCHM, 2017). See Figure 4.
- Model 20 Punch and Verifier. This was a manual (that is, non-electric) machine used to punch holes in punch cards (i.e., coding them). Later, electric punch card machines were used. These had the added features of eliminating the requirement for insertion and ejection of individual cards, and also stacked the cards after punching (Whelan, 1990s: 2, 4). A few punch card machines were always kept near tabulators because, as Fierheller notes, 'Cards jammed in the machines from time to time. The resulting pieces of "confetti" had to be carefully reassembled and the card re-punched [before processing could continue]' (2014: 30).
- BTM Decimal Cross-Footing Multiplying Punch. This was a 'massive machine weighing perhaps as much as half a ton' (Whelan, 1990s: 11). These could add or subtract two or more numbers that were input, punching the result on the punch card (Pugh, 2009: 84). Output was 500–600 cards per hour. This machine was mainly used for analysis of code group and cipher group differencing (Whelan, 1990s: 11).
- Card reproducers. These were used to create exact copies

of cards.They could run 100 cards per minute through two feeds: the read unit and the punch unit. They also performed card reproducing and gang punching, which is putting the same information on multiple cards (Whelan, 1990s: 7).

- Card collators. Collators had two card feed units, and operated at 12,000 cycles per hour. They were used to merge two files of cards or to divide one file of cards into two files (Whelan, 1990s: 9–10).

Detachable plug boards were used to speed up processing by eliminating duplicative programming, something that was achieved by moving dozens of cables about (see Figure 5). Since there were many plug boards that were permanently wired, each for a particular job, they could be rapidly switched between processes. Whelan notes, 'Many were permanently plugged for repeated use' (1990s: 2–3). Time saved during war is essential. As Calvocoressi notes, 'The most useful intelligence needs to be both authentic and prompt' (1980: 4).

Tabulating machine searches followed the same logic used in programming today, using Boolean conditionals such as AND (find this AND that), NOT (find this NOT that), OR (find this OR that), etc. Though certain reports were run regularly, the majority of the queries were one-time customer requests. As Whelan describes, '[A] great deal of our effort was devoted to runs made on a once only basis …. We [also] had many processing tasks which were carried out on a … daily, weekly or monthly [basis]' (1990s: 3, 24).

Because space on a punch card is limited, abbreviations were undoubtedly used, thus necessitating an abbreviations dictionary (AD). The AD would be used both during card punching, and also when programming queries. The absence of an AD would quickly create chaos and inefficiency. For example, how would one abbreviate the word 'panzer'? At least seven logical abbreviations are possible, e.g.: pz, pn., pnz, panz, pzr, pnzr, or pan. Suppose a search was for 'pzr'. It would miss all of the intelligence associated with any of the other six abbreviations. Therefore, as Perry and Casey note, the use of a standardized punch card encoding method is essential (1952: 462–3) and the Central Index must have had an abbreviations dictionary. It would have made sense to have used Jones's A&E Index, though it is not known if this was done.

The organizing principles of indexing in the Central Index are as yet unknown; however, we can deduce there must have been a reference guide to the individual collections of punch cards, organized on unifying principles. Such a guide would be used to identify card decks that should be processed for a specific query, because it would not be possible to consult the millions of punch cards that existed. Such a reference guide is what Marden calls the collection of 'preliminary categor[ies]' (1965: 5), which Luhn calls a 'dictionary of notions' (1957: 313).

As an example, suppose an analyst at Whitehall wished to interrogate the Central Index on the topic of German rocketry, this being prompted by the onset of Doodlebug attacks. The reference guide might contain a category called 'German science'. However, suppose it consists of a million punch cards: it would be wasteful to query the entire body

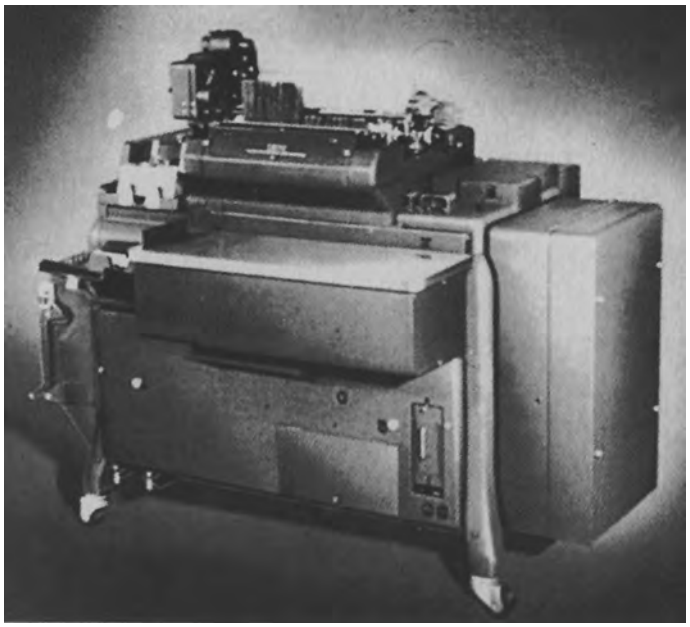

Figure 4 IBM Model 405 Tabulator

Used with permission, Underwood Books.

of scientific intelligence for what is actually a very narrow category of inquiry. Thus, subcategories of 'German science' would be looked to. One might be called 'Volatiles', perhaps with 8,000 punch cards. Using the Rolling Tabulator, this could be queried on 'Stoff' OR 'ethanol' OR 'hydrazin'. Cards with any of these would be sorted into a unique slot. Next, another subcategory called 'Scientist Names & Research' could be interrogated on the words 'Vergeltungswaffe' OR 'Rakete', sorting 'hits' into the another unique slot. In turn, the two sets of 'hits' could then be run through the 405 Tabulator, which would print their contents.[10] After that the cards would be returned to their parent decks, and the print out given to the requester. Alternatively, they might be transmitted to a teleprinter elsewhere.

Queries of the Central Index would first require meeting with an inquiry coder, who would have to understand what

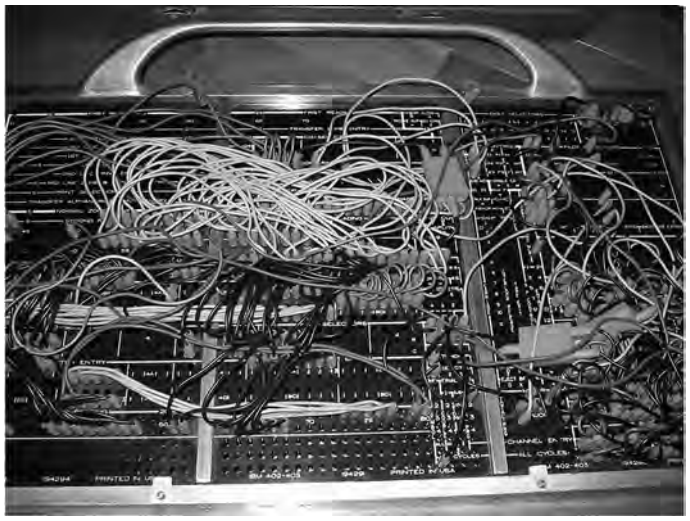

Figure 5 IBM Model 402 plugboard

Picture by Chris Shrigley (2003).
Used with permission.

was needed. The reference guide would be consulted to identify the subcategorical decks to be interrogated. After this a step-wise query process would be written, including which detachable plug boards would be used. A job length and resource-use estimate would be created and likely discussed with the duty lead, who would at the same time check the correctness of the proposed query process. Most likely, the lead would then assign a priority in the queue of waiting jobs, after which one waited until the job was run. Parsimony suggests use of the Central Index was therefore probably quite limited.

It is known the Freebornery continued its work after the war, under the leadership of Frederick Freeborn and the Whelan brothers. Perhaps at some point GCHQ will release details about how mechanized indexing carried on after the war.

Remaining mysteries

Many mysteries regarding how Bletchley Park operated remain to this day. Largely this is owing to restrictions on what can be said, as regulated by the Government Communications Headquarters (GCHQ). Those who worked at BP during the war and afterwards were required to sign the Official Secrets Act. This obligates them to remain silent about their work forever, unless authorized otherwise. Additionally, most of those who worked at BP are now gone from us. Even the youngest employees would now be in their 90s. What is known of still-shrouded aspects of BP work must be deduced from many sources, a form of sleuthing akin to Welchman's traffic analysis method (1982, chs 3–4). Scraps of information from disparate sources are assembled puzzle-like until a cogent story emerges.

It makes sense that the handwritten, peripheral indexes of BP were maintained in parallel to the Central Index. In part this is because, as Baring describes, queries by translators were done quickly, in person, so that their products could be sent off without delay (2000: 69–70). Generally speaking, it appears that consulting the local card index in someone's Hut or Block would have been faster than going through the process required to interrogate the Central Index, if they even knew of it. The fact that so many writers speak of an index, singular tense, suggests they only knew of their own archive and not about any of the others.

Dedication

Elizabeth Wallis, co-author of The Indexer article that sparked this present work (Wallis and Lavell, 2000: 31), passed away very recently. Regretfully, she did not learn that her hunch about multiple indexes at Bletchley Park was spot-on. Very recently also, the author has enjoyed many delightful email exchanges with Cherry Lavell, who was pleased to learn the Wallis and Lavell hunch was found to be true. This article is dedicated in their honour.

Notes

1 Sometimes the BTM and IBM machines are called 'Hollerith machines', which is appropriate in a generic sense in that the BTM and IBM tabulating machines are the offspring of Hollerith machines. Users of these machines sometimes called them by their generic rather than given names.
2 Many accounts indicate all index librarians were female. No source says otherwise.
3 The actual name of this index is not known for certain.
4 The Watch was where decrypted messages were interpreted and analyzed. Sir Harry Hensley, a BP codebreaker, describes The Watch in Hut 3 as consisting of half a dozen watch keepers seated round a table, these being a mixture of civilian and military analysts. The duty officer was in an office immediately adjacent, and the index room was also close by. See Hinsley and Stripp (1993: 20). Some of the other huts had their own versions of a watch as well.
5 Unfortunately, the meaning of 'large' is not further described.
6 This is 'all the enciphered groups in a column had been enciphered by the same additive' (Simpson, 2011a: 133). The goal is to determine and then subtract out the additive used in a given column (2011a: 134). Differencing is the attack on a column of numbers (2011a: 134), and attempts to determine the additive value in common (Simpson, 2011b: 402). Essentially, 'The difference between two enciphered groups is the same as the difference between the codegroups underlying them, because the additive which they share cancels out' (2011b: 403). See Simpson for further details (2011b: 402–5).
8 Brunt (2006: 134–5) reports the Hut 3 index included information from non-Enigma sources as well, including captured documents, interrogations, other verbal sources, and information gotten through liaison.
9 Literally, 'they cross-referenced every piece of information passing through Bletchley.' Fierheller (2014: 25) reports a skilled punch card operator could process 200 to 300 punch cards per hour. Assuming a rate of 300 cards an hour, an 8-hour work day, and 6-day work week, the maximum output of a single punch card operator would be 14,400 cards per week. At 2 million cards processed per week, 139 punch card operators would be required. Whelan reports 60 punch card operators worked per 24-hour period (1990s: 3–4). Assuming an 8-hour work day, and shifts 7 days a week, the required punch card production rate would be nearly 600 cards per hour. Presently, this discrepancy cannot be explained.
10 Print-outs were on 'Interfold stationery' which printed 50 lines to the page (Whelan, 1990s: 5, 17).

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Unfortunately the author lives 8,381 kilometers from BP. Therefore, he is seeking collaborators who can visit BP to conduct research (research experience is not required). Please contact him at elnelson@ucdavis.edu*, with a cc to* phd@fastmail.com.

Structured data for online content: how indexers can help search engines

Alexandra Bell

Search engines are constantly crawling through a vast amount of online information. Most of this process is automated, but human assistance is still needed to tease out the meaning, context, and nuances that machines can miss. Alexandra Bell suggests that indexers could help search engines provide better results for users by applying structured data to online content.

Introduction

Indexers work diligently to interpret large volumes of information so that the valuable knowledge hiding within can be discovered. There is no larger volume of information than the internet, with the amount of information published online doubling every two years (Atlas, 2018). Search engines crawl online information relentlessly, becoming increasingly efficient at interpreting what that information is about and providing an accurate response for the vague queries that are entered into the search box. Speculation that algorithms developed by major search engines to interpret content and answer users' queries effectively will soon

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