Practical and Organisational Factors in the Development History of the Typex Cipher Machine and its Use at Bletchley Park

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Abstract

The Typex was Britain's main cipher machine during the Second World War. The best-described Typex models are the Mark II and the compact Marks III and VI. However, there remain gaps in the Typex 'family tree'. This paper reviews the development history of Typex and describes several previously unknown models of Typex based on documents produced by the British Signals Intelligence agency, the Government Code and Cypher School, a major user of Typex while based at Bletchley Park during the Second World War. Although these models were not brought into widespread service, the documentation sheds useful light on the design process. The design of successive models of Typex, and their adoption or rejection, had less to do with cryptographic considerations than the various mechanical and practical problems involved in designing a reliable cipher machine compatible with the communications systems used by the British state and armed forces.

1 Introduction

The Typex was Britain's main cipher machine during the Second World War, and therefore a significant machine in the history of cryptography. Useful articles have been published on its functioning, development, manufacturing and use by Louis Kruh and CA Deavours and Ralph Erskine.[1] However, the existing literature does not describe all Typex models or provide a full description of Typex development. The main reason for this is that records are extremely scant. Some of the gaps can be filled by papers produced by the British Signals Intelligence agency, the Government Code and Cypher School (GC&CS), a major user of Typex while based at Bletchley Park (BP) during the Second World War. These shed light on several previously unknown models of Typex, and additionally, by indicating why these were unsuccessful, on what made a successful cipher machine.

2 The Development of Typex

All wartime Typex machines were rotor-based cipher machines working on the same essential principle as the well-known Enigma machine. Indeed, the Typex scrambler was a near-copy of a commercial Enigma D (specifically machine A320, which had been purchased by GC&CS for evaluation in 1926)[2] with the addition of two stationary rotors (stators) positioned to the right of the stepping rotors. The rotors were given additional stepping notches, and eventually made reversible. From November 1941 a 'plugboard'

[1] Louis Kruh and CA Deavours, 'The Typex Cryptograph', *Cryptologia*, 7/2 (1983), 145-66; Ralph Erskine, 'The Development of Typex', *The Enigma Bulletin*, 2 (1997), 69-86; Ralph Erskine, 'The Admiralty and Cipher Machines During the Second World War: Not So Stupid After All', *Journal of Intelligence History*, 2/2 (2002), 49-68.

[2] Two machines, A320 and A323, were sold to Britain. A320 was analysed by Hugh Foss of GC&CS and it was almost certainly this machine which was lent to the Typex development team in 1934. A323 was probably purchased separately by the Royal Navy. See UK National Archives (TNA) HW 25/6, 'Early Correspondence Relating to the Enigma Cipher Machine'; HW 25/14, 'The Reciprocal Enigma'; AVIA 8/356, 'A 352: Recommendation for an award to Mr. E.W. Smith in connection with Type "X" Cypher Machines and Accessories', n.d.; Frode Weirud, 'Enigma D versus Zählwerk Enigma', https://www.cryptocellar.org/enigma/e-prod-history/enigma-d-vs-zaehlwerk-enigma.pdf [accessed December, 2024]; David Kenyon and Frode Weirud, 'Enigma G: The Counter Enigma', *Cryptologia*, 44/5 (2020). All subsequent archival references are to files at TNA unless otherwise stated.

Proceedings of the 8th International Conference on Historical Cryptology, pages 30-40
Poznań, Poland, 16-18 June, 2025

was added. This probably allowed the reflector wiring to be altered.[3] The Typex Mark 22, which incorporated both an Enigma-type entry plugboard and a pluggable reflector, did not appear until 1948.[4]

The idea of marrying up the Enigma scrambler with Creed teleprinter parts was first proposed by Wing Commander Oswyn G Lywood, then serving as chief signals officer at Royal Air Force (RAF) Coastal Command, in 1934. When the official Interdepartmental Committee on Cipher Machine Development declined to take the idea forward, Lywood assembled a team including Flight Lieutenant Coulson, responsible for code and cipher security in the RAF Signals Directorate, and a Mr EW Smith, foreman at the RAF wireless workshops at Kidbrooke, to develop the machine for the RAF.[5] Machines were manufactured by the Creed teleprinter company.[6] GC&CS, which had a remit for the security of British cipher systems, has been criticised for failing to contribute sufficiently to machine development,[7] but it did participate in the development of Typex by providing advice and testing prototypes and was regarded by the RAF as a major partner in the process.[8] The responsible officer at GC&CS was Deputy Head Edward Travis, who dealt with cryptographic matters.[9] Lywood later thanked Travis as 'in the early days of my Typex Development Committee when security principles were involved you were good enough to help us out by either attending yourself or sending a suitable representative'.[10]

The Typex Mark I (as it was retrospectively designated) was a large online printing machine which 'enables cyphering to be done direct on to a telegraph line or a perforator for use on a wireless circuit giving a printed copy of both cypher and plain language version for filing'.[11] Pressure of time and funds ensured that 'every effort was made to utilise existing standard telegraph equipment', resulting in a 'somewhat bulky and immobile' apparatus. The machine incorporated two standard commercial teleprinters which 'extend on either side of a scrambler assembly comprising keyboard and drums, and are connected to it by multi-core cables'.[12] No machines or photographs are known to survive, but the arrangement was presumably similar to that of other cipher machines incorporating two electric typewriters and enciphering apparatus mounted to a desk, such as the Kryha *Elektrik* or the well-known US analogue of the Japanese 'Purple' machine. If it was desired to send messages by wireless, the cipher teleprinter could be replaced by a perforator which punched the message into Morse tape.[13] The teleprinter assembly completely replaced the Enigma lampboard; there was no remaining lampboard output.[14] Given the size and complexity of the Mark I, mass production was out of the question and only 29 were produced;[15] these had been installed at Air Ministry and headquarters of RAF Commands by the middle of

[3] ADM 1/27186, 'Review of the Security of Naval Codes and Cyphers', 32; AIR 10/4051, 'Type X Machine Mark VI'. No wartime reference to a Typex with entry plugboard has been found; wartime manuals and 1945 American cryptanalytic reports describe machines with only a pluggable reflector. See the reports at https://cryptocellar.org/rotor/typex/index.html [accessed April 2025].

[4] NK O'Neill and KJ Hughes, *History of CBNRC*, vol. V, https://luxexumbra.blogspot.com/2019/08/history-of-cbnrc.html [accessed April, 2025], paras. 20.7 and 20.15. The Mark 22 'was in fact a Mark II with modified scrambler unit'; later 'the security of Mark 22 was greatly enhanced by the addition of a cross-over plugboard.' The Mark 22 is mentioned in a 1947 British document: see NSA Friedman Collection, A2435939, 'Modifications to Improve the Security of the Combined Cipher Machine', 29/10/47, https://www.nsa.gov/Portals/75/documents/news-features/declassified-documents/friedman-documents/patent-equipment/FOLDER_120/41772139081122.pdf [accessed April 2025]. There was also the Mark 23, which could be converted into the Combined Cipher Machine (CCM).

[5] An additional member of the design team, Sergeant (later Flying Officer) Albert Phillip Lemmon, is mentioned for the first time in relation to the Mark II.

[6] Erskine, 'The Development of Typex', 70-2; Erskine, 'The Admiralty and Cipher Machines, 50-1.

[7] John Ferris, *Behind the Enigma: The Authorised History of GCHQ* (London: Bloomsbury, 2020), 102-4.

[8] AVIA 8/356, memorandum no. 22, 14/05/38.

[9] AG Denniston, 'The Government Code and Cypher School Between the Wars', *Intelligence and National Security*, 1/1 (1986), 53.

[10] HW 62/1, Lywood to Travis, 19/08/43.

[11] AVIA 8/356, memorandum no. 11, 29/12/37.

[12] AVIA 8/356, 'A403: Recommendation of Awards in respect of the development of the Type X Mark II Cypher Machine', n.d.

[13] I.e. using the Wheatstone system, rather than Baudot-Murray teleprinter code.

[14] AVIA 8/356, 'A 352: Recommendation for an award to Mr. E.W. Smith in connection with Type "X" Cypher Machines and Accessories', n.d. However, a lampboard-type device known as a 'shadowgraph' was provided for emergency use.

[15] AVIA 8/356, memorandum no. 68, 12/09/41.

1937 and officially superseded non-machine systems from 17 August that year.[16]

By the end of 1937, Lywood was already working on a simpler offline printing machine intended for use at lower headquarters. The Typex Mark II, which would become the most common variant, appeared in 1938. From a modern perspective, descriptions of the Mark II as simple, cheap and portable appear surprising: compared to its wartime competitors it was notably expensive to manufacture, a hassle to maintain due to its complex mechanics, and not readily man-portable, weighing 55kg.[17] However, compared to the essentially immobile Mark I machines, it was a great improvement. The two models were cryptographically identical but the keyboard, scrambler mechanism and printers all saw major redesign.[18] The Mark II incorporated two printers, which provided a plaintext and ciphertext copy of the message on a paper strip. However it was 'not capable of working direct to line', unless connected to existing Mark I teleprinter and perforator equipment.[19]

The most common other versions were the Mark III and Mark VI.[20] Each largely duplicated the functions of the Mark II in a more compact form, and could be driven electrically or by hand. They also lacked online functionality.[21]

A truly portable version of Typex which output to a lampboard also appeared, in the form of the Mark IA. This very closely replicated the form of

Figure 1: Part of the Cypher Office at Bletchley Park, with Mark II Typex machines in use. Alfred Sidney White, the head of the section, is standing, right (© Crown Copyright, reproduced with the permission of GCHQ under delegated authority from the Keeper of Public Records).

[16] AVIA 8/356, memorandum no. 11, 29/12/37; AVIA 8/356, 'A 352: Recommendation for an award to Mr. E.W. Smith in connection with Type "X" Cypher Machines and Accessories', n.d.
[17] Erskine, 'The Development of Typex', 72.
[18] AVIA 8/356, memorandum no. 54, 06/11/40; AVIA 8/356, memorandum no. 37, 25/09/39.
[19] AVIA 8/356, 'A 403: Recommendation of Awards in respect of the development of the Type X Mark II Cypher Machine', n.d.
[20] For production figures see Erskine, 'The Development of Typex', 72-3 and Erskine, 'The Admiralty and Cipher Machines', 52-3.
[21] Erskine, 'The Development of Typex', 74 and 86 fig. 5; FO 850/134, 'Maintenance of Typex Machines Marks IB, II, III and VI by Code and Cypher Personnel'.

Enigma, down to the wooden box with lid. The Mark IB added a front rail which could be operated with the non-typing hand to help drive the rotors, which was very difficult to do with the keys alone.[22] Little is known about the intended or actual role of the Mark IA/B. One IB machine was supplied to GC&CS, and 20 more were requested in October 1942,[23] but there is no indication that it was produced in numbers rivalling the printing models.

Other models of Typex represented attempts to improve the machine's suitability for large-scale communications, and in particular combine the online functionality of the Mark I with the size and relative portability of the Mark II. Several of these feature in correspondence relating to communications of the Government Code and Cypher School (GC&CS) based at Bletchley Park (BP).

3 The Use of Typex at Bletchley Park

The best-known application of Typex at BP is the use of adapted machines to 'decode' Enigma traffic. However, a more important use was in communications. Hut 6, the section which decrypted German army and air force Enigma traffic, had at most 42 Enigma-Typex machines.[24] Hut 8, which handled a smaller amount of naval Enigma traffic, probably had fewer than this. However, the Cypher Office, which dealt with all encipherment and decipherment required for GC&CS communications, had at least 60-70 Mark II Typexes.[25] By 1945 some 450 staff were processing around 500,000 groups of traffic per day using at least 23 different cipher keys;[26] it was purportedly 'the largest Typex office in the world and GC&CS experience became vastly greater than anyone else's'.[27]

The Cypher Office was a civilian section mostly employing women in their twenties. Many were 'directed' (effectively conscripted) from the local area and few were educated beyond Junior School Certificate level. There were persistent problems with high sickness rates and staff turnover (seen as indicators of poor morale) due to poor working conditions, low pay and the drudgery of the work. Most staff were unaware their work related to Signals Intelligence.[28]

Most traffic handled by the Cypher Office comprised encrypted enemy messages intercepted at overseas Y Stations (radio intercept stations). These were sent to BP via a high-speed Morse network operated by 26 (Signals) Group RAF – commanded by Lywood, who eventually reached the rank of Air Vice-Marshal. At BP messages were received in the 'Auto Room', an RAF-staffed section located adjacent to the Cypher Office in Block E (it also handled return traffic to the Y Stations).[29] Stations working to BP could be

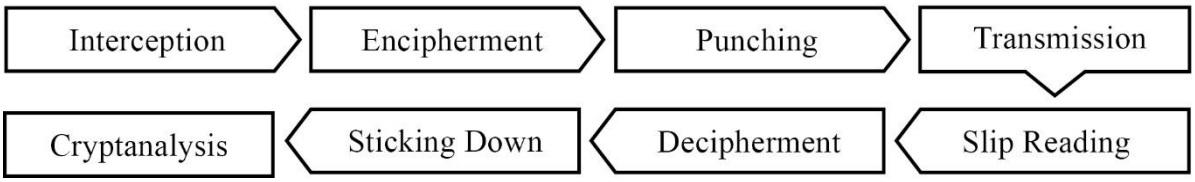

Figure 2: Processes involved in the transmission of intercepted messages to Bletchley Park by high-speed Morse.

[22] Ibid.
[23] HW 62/1, 'Typex Machines for GC&CS', 28/01/43.
[24] HW 43/72, 'History of Hut 6, vol. 3', 21.
[25] HW 14/85, 'Report on E Operations at the GC and CS by WF Friedman', 12/08/43, 106; HW 62/3, memorandum, 18/05/45.
[26] HW 14/145, GC&CS weekly admin returns; HW 62/3, 'Cipher Office: Total Incoming Groups Handled in Each Setting', n.d. but 03/45.
[27] HW 50/50, 'Memorandum by Mr de Grey', 29-30. Earlier in the war, the limited capacity of the Cypher Office was a serious bottleneck in the intelligence-production process: in January 1942 a backlog of over one million groups of intercepted traffic was destroyed as there were not sufficient staff or machines to de-Typex it. See HW 43/2, 'History of British Sigint, 1914-1945; volume II', 528.
[28] HW 64/67, 'Staff Matters'; HW 64/62, 'Welfare'.
[29] RAF Signals Museum, 'The Signals War: A Brief History of No. 26 Group RAF', 15-16; HW 50/50, 'Memorandum by Mr de Grey', 27-8; HW 64/63, 'RAF Personnel at Bletchley Park'. BP was identified to subscribers as 'Church Green'. This was the name of the camp which housed the headquarters of 372 Wireless Unit, which had operational control of the Auto Room and administered most RAF staff at BP, who were accommodated at the camp. It also ran the receiving station at Stoke Hammond (near Bletchley) and transmitting station at Greatworth (Northamptonshire) linked to the Auto Room.

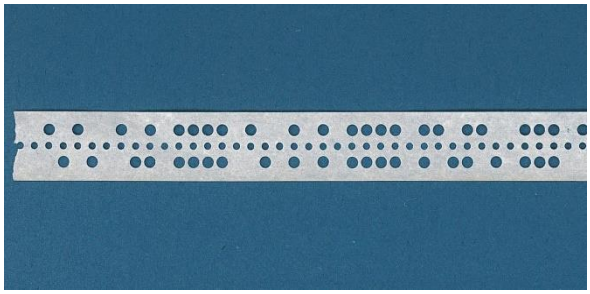

Figure 3: Morse tape (Bletchley Park Trust (BPT)).

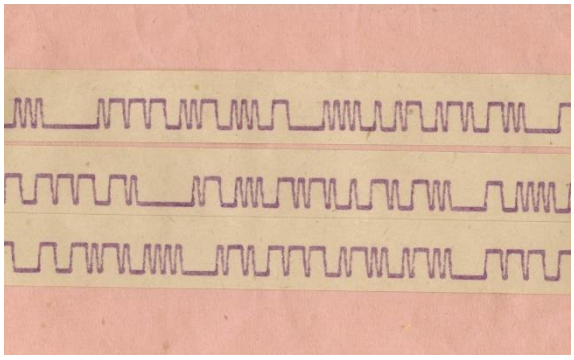

Figure 4: Morse slip (BPT).

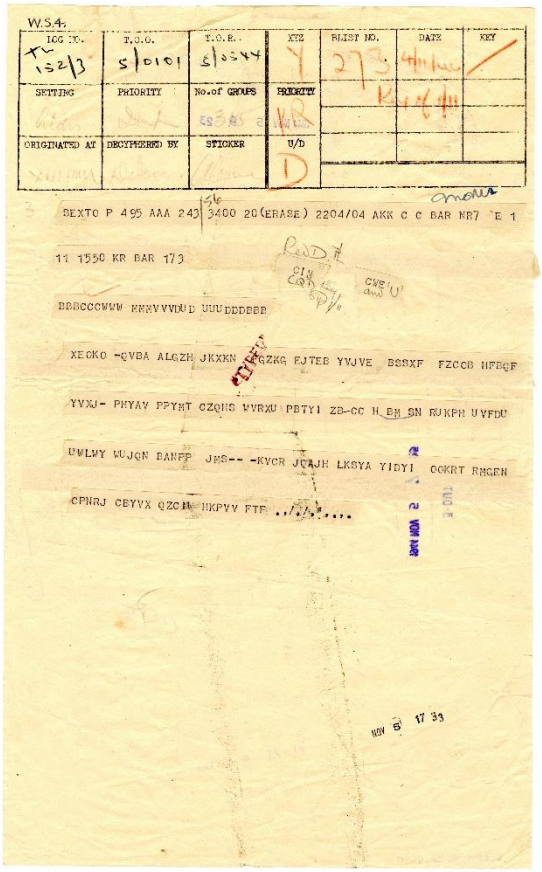

Figure 5: De-Typexed intercept as passed on from the Cypher Office for cryptanalysis (BPT BLEPK:0020.5.128; © Crown Copyright, reproduced with the permission of GCHQ under delegated authority from the Keeper of Public Records).

fixed wireless stations, or mobile stations such as RAF 'Heavy Mobile Units' (HMUs), Army Type M or R Special Wireless Sections and 'Golden Arrow' wireless units.[30] Intercepts were enciphered on Typex (i.e. overlaying the enemy encipherment with an additional layer of British encipherment) before transmission. In March 1943 out of a total requirement of 861 machines throughout the services, 105 were needed by the Y Services for this purpose.[31] On arrival messages had to be deciphered (or 'de-Typexed') in the Cypher Office, restoring the original, singly-enciphered message, before they could be passed to the cryptanalysts. An additional function of the Cypher Office was to encrypt Ultra intelligence before its transmission to Allied commanders in the field.[32]

The process of sending by high-speed Morse was fairly cumbersome (see Figure 2). At the sending end, after encipherment, messages were punched onto Morse (Wheatstone) tape using a perforator (Fig. 3). When the tape was fed through a reader ('autohead') the message was transmitted. At the receiving end, the message was reproduced as a line on tape by an 'undulator'; this was known as 'Morse slip' (Fig. 4). Personnel skilled in 'slip reading' were required to type up the message into readable (albeit still enciphered) text ready for de-Typexing. De-Typexing also involved multiple steps, as the 'plaintext' (singly-enciphered) output tape had to be 'stuck down' onto sheets for practical handling by the cryptanalysts and checked for errors (Fig. 5). Though the whole system could handle vastly more traffic than

[30] HW 43/72, 'History of Hut 6, vol. 2', 49-50; 'The Signals War, 15-16; WO 219/5319, 'Notes on Wireless Interception ("Y") Organisation in the Field', 21/11/43; 'The Golden Arrow Group 1944 to 1945', https://www.goldbeach.org.uk/yservice/Golden%20Arrow.htm [accessed January 2025]; Bletchley Park Trust, material relating to Alan Foot.

[31] HW 62/1, Saunders to Travis, 06/03/43.

[32] Most Ultra was disseminated by cable or via a special MI6 radio station at Windy Ridge near Bletchley, but some went via the Auto Room.

manual encipherment and transmission, a considerable number of personnel were required.

GC&CS therefore explored ways to increase the efficiency of its communications. Some solutions related to organisation and training. The workload and output of individual staff were carefully monitored to identify problems, while maintenance schedules were optimised to minimise the amount of time machines were out of order, and Typex rotors were kept ready made-up to reduce time spent changing settings.[33] Cypher Office staff were given five weeks' training in slip reading so they could de-Typex traffic direct from Morse slip, eliminating the typing-up stage which was normally done in the Auto Room.[34] Solutions were also sought in new machinery.

4 Improved Typex Models

Because of its printed output the Typex was already a much more suitable machine for large-scale communications than Enigma, but some improved models were tested at or designed in consultation with GC&CS. That none of these saw widespread use had to do with organisational factors and the fact that their advanced features did not necessarily lead to improvements in relation to the most important concern: maximising the traffic that could be carried on communications links.

4.1 Typex Mark IV

One attempt to combine the features of the Mark I and Mark II was the Mark IV. This probably involved incorporating the Typex scrambler into the Creed Model 7 teleprinter to create an online teleprinter cipher machine.[35] Development was abandoned for unknown reasons, though it is reasonable to speculate this had to do with technical difficulties, as this was the fate of several other attempts to combine cipher machines with existing typewriters or teleprinters.[36]

4.2 Typex Mark V

The Mark V, known as the 'Teletypex', was a more successful execution of the same concept. It was tested by the War Office on behalf of GC&CS in early 1943, and described as 'quite practicable' on cable links. However, landline links were usually treated as secure so there was little demand for a machine for this purpose. An alternative application was on radio-teleprinter (radio-teletype) links, but here 'the technical irregularities of the average circuit tried was to render the teletypex [sic] Mark V quite ineffective as a method of handling traffic'. There were several serious issues. As soon as a letter was missed due to interference the rotors of the machines at each end of the link got out of step and the rest of the message was unintelligible. The fact the machine did not transmit letters in groups and did not create a record of the message as transmitted – since 'to do so would have caused considerable further increase in the complexity, size, and weight of the apparatus' – made it difficult to correct mistakes.

The Mark V also contravened one of the essential principles of efficient telegraphic communication: keeping the link operating as close to maximum capacity as possible. In a conventional arrangement with separate teleprinter and cipher machines, a message that did not successfully decipher could be worked on separately while the link was kept busy with other traffic. With a combined machine, the valuable and expensive link to which it was connected had to sit idle while any corruptions were resolved; this could seriously reduce its capacity.[37]

In any case, Britain (unlike Germany, the USA and the Soviet Union) did not make significant use of radio-teleprinter, preferring high-speed Morse. Had the demand existed, the Mark V might have been improved to create a machine equivalent to the German SZ40/42 ('Tunny') and T-52 ('Sturgeon'), but in the event it does not appear to have been developed past the prototype stage.

[33] HW 50/50, 'Memorandum by Mr de Grey', 29.
[34] Ibid., 12; HW 14/67, Travis end of year report for 1942, 9.
[35] David Abrutat, 'The Story of TypeX', https://commsmuseum.co.uk/Typex/typex.htm [accessed January 2025].
[36] For example, the early printing models of Enigma and the O'Brien Cipher Typewriter.
[37] HW 62/1, 'Notes on the Teletypex Mark V', n.d. but March 1943; HW 62/1, Lycett to Travis, 23/03/43.

4.3 Typex Mark VII

It was recognised that a machine incorporating a Morse tape perforator and/or tape reader for processing high-speed Morse traffic would be far better suited to requirements. This led to several different projects, which are difficult to disentangle. Two different perforator models were under development by the RAF and Army by early 1943. Development of the RAF machine was begun partly at the instigation of Commander Malcolm Saunders, in charge of GC&CS communications between April 1942 and April 1943.[38] In early 1943 attachments were trialled which permitted both enciphering to Morse tape (using a perforator) or deciphering from tape (using a tape reader).[39] These features were ultimately incorporated into two different models.

The perforator model, designated the Mark VII, was tested by GC&CS in February 1944, but adoption was not recommended. The reasons were essentially organisational. At BP, cipher machines and radio links were operated by different sections (the Cypher Office and Auto Room). If Typex machines were placed in the Auto Room, this would leave two sections dealing with encipherment. There would be inevitable competition for mechanics and spare parts; it was impossible to employ experienced civilian operators in the Auto Room, and the RAF would struggle to find and train sufficient operators from scratch; and with responsibility divided it would be difficult to ensure prompt and reliable processing of traffic.

Alternatively, Mark VIIs could be placed with the existing Typex machines in the Cypher Office. Even though the Mark VII allowed rapid switching between punching plaintext and ciphertext, so that unenciphered message preambles could be typed before an enciphered message, this was incompatible with arrangements at BP: when sending messages, preambles would have to be prepared in the Auto Room, whose staff had the necessary knowledge of signalling arrangements, and joined to the correct ciphertexts produced in the Cypher Office. This was thought too likely to lead to errors.

Other options were to send the preambles at hand speed, which would significantly reduce the capacity of each link; or to prepare messages complete with preambles before they were passed on for encipherment and transmission, which would entail a major reorganisation of communications for which GC&CS had neither the staff, space nor appetite, especially since only a small number of Mark VII machines would initially be available. After consideration by the experts, none of these options was considered practical. It is possible the Mark VII saw service in Army or RAF signals centres where arrangements were simpler.[40]

4.4 Typex Mark IX

The tape reader model appeared as the Mark IX, 'a modified TYPEX machine operating in conjunction with a Morse Printer Head' to decrypt automatically from Morse tape. It was first mentioned in mid-1943 and was tested by GC&CS later in the year. The machine was mechanically reliable, but produced various procedural complications. For example, if the sending cipher operator made a mistake while using the Mark II, they would simply add an 'erasure signal' instructing the receiving operator to disregard the previous group. The Mark IX, however, required tapes without errors or corruptions. Erasures could not be cut out at the receiving station, because when tapes were rejoined this doubled their thickness and they would no longer fit through the Mark IX tape reader. This meant erasures had to be removed at the transmitting station. However, interference on the link could, naturally, reintroduce errors; during testing no more than 40 per cent of messages were received at BP with no errors (recording received messages on 'reperforated' tape was less reliable than using undulator slip). This meant 'any superiority of the Automatic Decoder is practically nullified by virtue of the difficulty experienced in producing a 100% [accurate] tape.'[41]

There were other problems. For collecting the statistics which were necessary to monitor efficiency, it was necessary to time-stamp messages; this was easy when dealing with typed

[38] HW 62/1, Saunders to Travis, 04/02/43.
[39] HW 62/1, 'Report by Mr Heil', 26/01/43; HW 62/1, Lywood to Travis, 17/02/43.
[40] HW 62/1, 'Report by Mr Heil', 26/01/43; HW 62/2, 'Typex Mark VII Machines', 20/02/44; HW 62/2, 'Typex Mark VII Machine', n.d. but 02/44; HW 62/2, 'Typex Mark VII Machines', 22/02/44.
[41] HW 62/1, 'Typex Mark IX Automatic Decoder', 10/12/43.

sheets, but harder when messages arrived as a thin and fragile paper tape. A specialist team decrypted message indicators (using indicator books) before messages were de-Typexed; again, it was unclear how to record the true indicator on the tape. The machine settings still had to be changed manually, so the increased speed of decryption could only be fully exploited where there was a need to process large volumes of traffic on the same cipher key, which was not usually the case at BP.

All these issues were rendered moot, however, by the fact that even under ideal conditions, the Mark IX proved to be no faster or more labour-efficient than the Mark II. A Mark IX, provided with a continuous supply of perfect tapes, processed 23,850 groups in 24 hours. Three experienced operators, each working an 8-hour shift on the Mark II, could process 24,000 groups, irrespective of any corruptions in the messages. Adoption was therefore not recommended.[42]

4.5 Typex Mark VIII

At approximately the same time, the Mark VIII was under development. Internet sources describe it as a Mark II incorporating a perforator but also capable of online use. Some photographs of uncertain provenance are also available.[43] The origins of this model are unclear. The Army had been working on its own high-speed Morse machine (also in collaboration with Creed). According to the sole documentary reference this machine, which had gone into production and was being considered for use by the RAF, 'differs from that produced by [the RAF at] Kidbrooke in that the whole of the operation, either in clear or in cypher is carried out from the Typex keyboard.'[44] This presumably meant it was an online machine, eliminating the need to feed the produced tape through a transmitter. Alternatively the Mark VIII may have been developed from the RAF perforator/tape reader attachments trialled in early 1943.[45]

Unfortunately, nothing else is known about the functions of the Mark VIII. If as described, it had obvious applications on high-speed Morse links. It appears to have been brought into service, as a manual was issued by the RAF.[46] However, the only other information about its use is a remark by Erskine that only 398 were ordered as late as 10 January 1945, which strongly implies it was not brought into widespread service before the end of the war.[47] The Mark VIII should be a subject of further research.

4.6 Unnamed Australian Typex

An online Morse machine was also under development in Australia in early 1943. The machine would encipher direct to line at typing speed. Decryption at the receiving end would be done manually, so there was no problem of synchronisation. However, any errors in encipherment would need to be corrected over the line – rather than being resolved before the message was transmitted – and this seemed to pose security risks, especially if it was necessary to re-encipher the same message on a different setting. GC&CS cryptanalyst Alan Turing was consulted on security aspects, but came to the surprising – if characteristically brusque – conclusion that 'This seems to be a communication problem rather than security, and therefore hardly my concern at all'. It is unclear whether the project came to fruition.[48]

4.7 Typex Mark IIA

By late 1944 an upgrade of the Mark II, designated the Mark IIA, was under development. The right-hand tape printer was replaced by a full page printer which could produce multiple copies of an enciphered message with automatic formatting. This was 'designed to fill the requirements of certain large and busy traffic centres handling signals which have to be dispatched over two or more different communication channels simultaneously' while 'obviating the delay and work of sticking up the tape and of typing out copies'. It was also possible to fit a standard Morse perforator to produce a perforated tape at the same time as the printed

[42] HW 62/1, 'Note of Action', 24/06/43; HW 62/1, 'Type "X" Mark IX Service Trials', 08/12/43; HW 62/1, 'Typex Mark IX Automatic Decoder', 10/12/43.
[43] 'Typex: History/Development', https://www.jproc.ca/crypto/typex.html; 'Typex Mark VIII', https://cryptomuseum.com/crypto/uk/typex/index.htm#mk8; 'Typex', https://en.wikipedia.org/wiki/Typex [accessed January 2025].
[44] HW 62/1, 'Note of Action', 24/06/43.
[45] HW 62/1, 'Report by Mr Heil', 26/01/43; HW 62/1, Lywood to Travis, 17/02/43.
[46] AIR 20/1531, 'Security of RAF Signal Communications 1939-1944', 36.
[47] Erskine, 'The Development of Typex', 86 fig. 5.
[48] HW 62/1, Johnston to Turing, 20/01/43.

message sheets. It is unclear whether the machine went into production and there is no evidence it saw use on intelligence networks.[49]

4.8 Typex Mark X

The most advanced model of Typex, the Mark X, later named Mercury, was under early development by 1944-5. It appears to have been envisioned as a 'universal machine' for post-war general service traffic as well as use on radio teleprinter links.[50] The machine used a set of four control rotors to determine the movement of six ciphering rotors, similar to the principle of the American SIGABA (ECM Mark II). Prototypes were ready by 1948 and the machine saw service between approximately 1950 and 1963.[51]

5 Conclusion

The GC&CS records reveal four Typex models – Marks V, VII and IX, and an unnamed Australian prototype – which have not previously been described. Although some details remain uncertain, a largely complete list of Typex models can be presented for the first time (see Table 1).

Despite the amount of money and engineering ingenuity which must have gone into the development of Typex machines operating online or with perforated tape, none were adopted by GC&CS. Though less advanced, and necessitating more manual processing of traffic by staff, the earlier and simpler Mark II proved a more practical fit for the organisation at BP. The failure of more advanced models highlights how crucial it was that cipher machines, as well as being secure, were fully compatible with the communications system with which they were to be used. Theoretical improvements in efficiency and savings in time and (wo)manpower could evaporate when organisational arrangements and long-standing practices and procedures were taken into account.

It is notable that contemporary comments on the Typex make much more of the great increase in the efficiency of communications the machine permitted, due to the speed and accuracy it offered compared to manual systems, than its security. It was for those reasons, rather than its cryptographic strength, that the RAF Director of Signals predicted that 'general application of the Type X Mark II machine throughout the Services and Dominions will revolutionise secret telegraphic communications'.[52]

[49] FO 850/134, 'Typex Machines Mark IIA', 03/11/1944.
[50] HW 62/3, Lywood to Travis, 30/01/45.
[51] 'Mercury (Cipher Machine)', https://en.wikipedia.org/wiki/Mercury_(cipher_machine) [accessed January 2025].
[52] AVIA 8/356, memorandum no. 69, 12/09/41.

Mark	Year	Features	Adopted?
I	1937	Immobile online printing machine	Yes
IA/B	By 1943[53]	Portable glow-lamp machine	Yes
II	1938	Portable offline printing machine. Upgraded versions designated Mark 22 and Mark 23	Yes
IIA	1944[54]	Portable offline machine with full page printer	Unknown
III	By 1941[55]	Compact hand-operated offline machine	Yes
IV	Unknown	Adaptation of Creed Model 7 Teleprinter	No
V	1943	Online teleprinter machine	No
VI	By 1943[56]	Compact hand-operated offline machine	Yes
n/a	1943?	Unnamed Australian online machine	Unknown
VII	1944	Offline machine with perforator for enciphering to tape	Unknown
VIII	1943?	Online Morse perforator/tape reader machine	Yes
IX	1943	Offline machine with tape reader for deciphering from tape	No
X	1948	Online teleprinter machine	Yes

Table 1: Summary list of Typex models

[53] FO 850/134, 'Maintenance of Typex Machines Marks IB, II, III and VI by Code and Cypher Personnel' (Note the Mark IA/B is described alongside Mark VI).
[54] FO 850/134, 'Typex Machines Mark IIA', 03/11/1944.
[55] Erskine, 'The Admiralty and Cipher Machines', 52. The Mark III was under design by January 1940: see AVIA 8/355, 'Invention Relating to Drum Locking Device', 23/01/40.
[56] AIR 10/4051, 'Type X Machine Mark VI', 01/43; Erskine, 'The Development of Typex', 74.

Acknowledgements

The author would like to thank David Kenyon, Craig Heath, David Abrutat and the reviewers for their helpful comments and suggestions, and Annie Christie for assistance with graphics.

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