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Item Description: This is a draft manuscript of a lengthy report compiled by the RAF Bomber Command Operational Research Section, probably some time in 1945. The report was authored by Dr. Basil Dickins, a rising star in the field of physics who served as Section head during the war. Using a thematic approach it explores in excellent detail the challenges inherent in strategic bombing, making it a valuable source for both historians of air power and those studying Europe in the Second World War.

Keywords: Bomber Command; Operational Research; Operations; Technique; Bombing; Navigation

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APPENDIX No. 4

HOLLERITH MACHINERY

Hollerith Card

1. These are rectangular pieces of cardboard with one corner removed, being of three different sizes - 38, 45 and 80 column. All can be punched out in any of 12 positions vertically and this can be repeated in any column. The 80 column card, approximately $7\frac{3}{8}$" x $3\frac{1}{4}$", was used for O.R.S. work.

Punch

2. This machine consists essentially of a carriage, punch keys and punch knives, one for each position, and operates on the typewriter system. On a card being fed into the machine and a punch key depressed a corresponding rectangular hole is punched out in the appropriate column. As the key is released the carriage moves over so that the next column is immediately under the punch knives. There are two more keys on the machine, one a space key which spaces without punching and the other, the release key, allows the carriage to run to its full extent. By holding down the space key the carriage is stopped from moving and thus overpunching can be produced. Two keys may not be depressed at the same time, except in the case of the X and Y (or 11 and 12) keys, either of which may be depressed simultaneously with one of the 0-9 keys (this is to facilitate alphabet punching - see Appendix 5, Form No. 2).

Verifier

3. Mechanical: A mechanical verifier has a similar appearance to a punch, the only difference being that instead of sharp knives it has blunt blades. The verifier operator has both the cards and documents in the same order as they were punched. Each card is fed into the machine and the operator strikes the keys corresponding to the information on the document. Providing the punch blade finds a corresponding hole in the card the machine will space, but if no such hole exists the machine ceases to space. In this case, however, the blade does not pierce the card. The operator then ensures that the card and the document do in fact disagree before destroying the card. The defect of this machine is that it is not possible to check double punching accurately. As two keys cannot be depressed simultaneously, the space key must be held down whilst each hole is checked individually. It is possible at slow speeds to feel

/whether

whether the two holes are punched but at rapid speeds no check is possible as, on releasing the space key after verifying the column, the card will be spaced automatically.

4. Electrical: The operators procedure is exactly the same as that for the mechanical verifier. Instead of punch blades, brushes, one for each hole, make electrical contact with a brass roller and the card is passed between the brushes and the roller. If a hole is sensed, i.e. the brush passes through the hole, one side of a relay is energised. Providing the other side of the relay is simultaneously energised by the depression of the key, the card is allowed to space, but if only one side of the relay is energised, which happens if the key depressed does not correspond with the hole sensed, the machine does not space. When checking double punching, all the keys corresponding to the holes in the card must be depressed. The original type electrical verifier, however, passed a card providing that at least all the keys corresponding to holes punched were depressed. Thus, although this machine was more accurate than a mechanical verifier, 100 per cent accuracy could not be guaranteed on double punched columns. As the work done by O.R.S. involved considerable quantities of double punching the British Tabulating Machine Co. agreed to make a special machine incorporating new features whereby only the depression of the corresponding keys to holes punched would cause the machine to space.

Punch Room Organisation

5. Information about Punch Room organisation is contained at Encl. 14A on BC/52183/ORS., Vol.I and full details concerning normal punching speeds which depend on the number of columns punched are given therein. It was not possible, however, in O.R.S. work to maintain a speed greater than a half to three quarters of those given. Verifying is slightly faster than punching.

Counter/Sorter

6. The counter/sorter is designed for the purpose of counting the holes punched on a given column of the card, and also registering the number of cards not punched in the column. It will simultaneously sort the cards into one of thirteen pockets, twelve of which correspond to the twelve positions of punching and the thirteenth to the cards not punched on the column.

7. The counting mechanism is equipped with fifteen adding counters of five digit capacity each of which is only capable of adding unity for each punching in the appropriate position. 12 counters correspond to the 12 punching positions

/of

of the cards, 1 is for unpunched cards i.e. rejects, 1 counter is for subtotals and the remaining 1 is capable of accumulating the grand total.

8. A selecting device enables all cards punched with any individual hole to be sorted out whilst the remainder are passed into the reject pocket.

9. A card being sorted on an overpunched column is put into the pocket corresponding to the first hole sensed but it sets up a figure 1 in each of the counters corresponding to the holes punched.

10. The rate of feed is 360-400 cards per minute whether sorting or counting, which may be performed separately or simultaneously.

Tabulator

11. There are many different types of this machine with varying functions. A brief description, however, of the Senior Rolling Total Tabulator which was the particular machine used is given below.

12. The tabulator has two main functions - Listing and Tabulating. In listing, each card is read and the information obtained (Alphabetical as well as numerical) is printed by means of print banks. In tabulating, totals which have accumulated in counters from information on the card are printed when required.

13. Before being passed through this machine, the cards have usually been sorted into groups in some numerical sequence. The tabulator can be made to perform various functions whenever the group changes and it is thus possible to obtain totals at the end of each group. It is possible before printing, to transfer totals positively or negatively from one counter to another and after printing to zeroise them. The Tabulator can distinguish three types of change, Major, Intermediate and Minor; it is not necessary to perform the same functions at all three types although at each change of the same type the same functions will always be performed.

14. It is possible to put information from the card onto one of a number of counters or print banks according to some designation on the cards, and negative totals can be printed in their complementary form, if required.

15. Three pluggable boards are used to set up the machine for any particular purpose and plugs providing electrical paths are joined from one socket to another on the board and thus considerable flexibility is provided.

16. The speeds of operation vary according to the type of machine and work but a rough average is given by 80 cards per minute listing and 150 cards per minute tabulating.

/Reproducer

Reproducer

17. The reproducer has two feeds and is capable of copying the information punched on a card in one feed onto the corresponding card in the other. A pluggable board affords flexibility and it is not necessary to copy the information given on a particular column onto the same column on the corresponding card. It is possible, therefore, to reduplicate a pack of cards identically or, alternatively, in a form in which the columns are interchanged. The machine, which operates at a speed of about 100 cards per minute, contains a self checking system whereby the information on the old cards is compared with that on the new ones, the machine ceasing to feed if disagreement is found.

18. It is also possible by using one feed of this machine to copy back information from one card to the following card (Gang-punching). Constant information on a series of cards can thus be mechanically produced.

19. Two additional features are present on this machine - Master Gang-punching and Summary Punching. Before using the Master Gang-punch technique, a series of Master cards, bearing information which is to be gang-punched onto a group of cards, are sorted in front of the groups of detail cards. The whole file of cards is passed through the Reproducer and the information is copied from each master card onto the following group of detail cards. For Summary punching the machine is connected to a Tabulator and at a Minor, Intermediate or Major change, the totals accumulated in the counters can be punched onto cards standing in the Reproducer.

Collator

20. The sorter is only capable of putting cards into sequence and, if it is required to merge together two packs of cards by means of the sorter, the same time is spent whether or not the two separate packs were already in the required sequence. The collator, however, has been designed to deal with this eventuality and is capable of merging together two files of cards both of which are in the same sequence (on not more than 16 columns).

21. After two groups of cards have been sorted, the machine can arrange them in any of the possible ways of associating two sequences of numbers. Many variations of this are possible and, for example, one or more cards in one file may correspond to a particular card in the other file and a card in one group may not have a corresponding card in the other. Two series of cards after

/collating

collating may be arranged into four groups as follows:-

(a) Cards from one file corresponding to those in the other.

(b) Cards from the other file corresponding to those in the first file.

(c) Cards from the first file without corresponding cards in the other file.

(d) Cards from the other file not corresponding to those in the first file.

Items (a) and (b) may be combined to give the corresponding cards from both sections merged into one pack.

22. Operations reverse to collating may also be performed and a file of cards may be separated into two components. Separation is generally brought about by extracting from a file of cards all those corresponding to specially prepared master set or all those corresponding to a particular card. In either case the master set or a pilot card will be presented in the other feed of the machine. The machine is only capable of reading numerical data and cannot distinguish X, Y or 0. punching but it is capable of checking that the cards in one feed are in ascending numerical sequence, ceasing to feed if this is not so.

23. Both feeds accept cards at the rate of 12,000 per hour; thus the output varies between 12 and 24,000 cards per hour dependant upon the frequency with which both feeds work simultaneously.

24. The machine is provided with a pluggable board by means of which it is possible to perform the many operations.

Multiplier

25. The machine is available for both decimal and sterling work. It obtains numerical data from two 'fields' (i.e. sections) on the card, up to 8 digits each, multiplies the two together and punches the answer on the same card. At the same time it will accumulate in a counter the totals of products on each card. With a crossfooting device, in addition to multiplication, the machine will add onto the product, one or two numbers obtained from other fields on the card. If an additional crossfooting device is also fitted, the scope of the calculations is further enlarged.

26. With this machine a master card technique similar to that used in gang punching with a Reproducer may also be used. The machine will punch on each detail card the product of a number already on it and a constant number taken from a Master card. When a new master card appears the chain is broken and the process is repeated with a new constant multiplier.

27. It is possible to correct any decimal figure to the nearest whole number either, as each card is punched, or, if using the master card technique, at the end of a particular group. A pluggable board is incorporated to give flexibility in obtaining the multiplier and multiplicand, in punching the product, and in determining the particular type of calculation to be performed. The speed of output varies according to the type of calculation and the number of digits involved, but a rough average is 1,000 cards per hour.

Interpreter

28. By means of this machine it is possible to print on the top of the card information punched on it; some specially adapted machines being capable of printing alphabetical information. Cards are normally interpreted when used for reference purposes or when it is required to extract particular cards by hand from a file. The rate of operation is 80 cards per minute, approximately.

APPENDIX No. 5

METHOD OF CODING FOR VARIOUS CARDS PRODUCED BY THE HOLLERITH SECTION

Form

1 - A Raid Report proforma, used for operations on nights subsequent to 18/19 November 1943.

2 - Method of coding cards for Raid Reports in the period 15/16 March 1944 to 29/30 April 1944. (Card No. 1).

3 - A Specimen Raid Report, coded on the system given in Form No. 2.

4 - Raid Report card for the period 1/2 May 1944 to 13/14 August 1944 (Card No. 2).

5 - Method of coding Raid Report card in the period 14/15 August 1944 to 30/31 October 1944. (Card No. 3).

6 - Raid Report card for 1/2 November 1944 to 14/15 March 1945. (Card No.4).

7 - The Raid Report card used for operations subsequent to 15/16 March 1945. (Card No. 5).

8 - Method of coding the card for aircraft intercepted by Enemy Aircraft.

9 - Coding for card punched for Damaged Aircraft.

10 - Card punched from Photographic Interpretation Plottings.

11 - Master Code for reports from returned Evaders.

12 - Master Code and type of cards originally punched for reports from returned Prisoners of War.

13 - Method of obtaining final cards for reports from returned Prisoners of War.

14 - Specimen List and Tabulation produced for analyses into the efficacy of each special equipment.