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Op-20-G/ep

5 March 1945.

MEMORANDUM

From: Op-20-G-4-D-1.
To: Op-20-G-4.
Via: Op-20-G-4-D.

Subj: R5W Enigma Machine, Description of.

Enclosures: (A) Cryptanalytic Investigation of R5W.
(B) Technical Description of R5W.
(C) Wheel Wirings of R5W.
(D) Three Memoranda from Op-20-G-4-A.

1. Enclosures (A), (C), (D) originating at Op-20-G-4-A and enclosure (B) from Op-20-G-4-D-1 are forwarded as a file.

G. F. SMITH,
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Copy of instruction sheet supplied to M8 and M9 wheels topic.

25 April 1945

NOTES TO ACCOMPANY R5W WHEELS

1. General Description. The R5W Enigma uses 5 wheels, a fixed input sequence, a pluggable reflector and has enigma stepping on three wheels. The other two wheels, next to the input sequence, are settable by hand. A set of 14 wheels has been wired up for study of the properties of this machine.

2. M8 Wheels. Since the M8 basket is not big enough to accomodate five pairs of wheels and a reflector, the effect of either one or both of the non-moving wheels must be combined with the input sequence. Thus a non-reciprocal stecker plugboard is wired, combining the input sequence with some or all of the non-moving wheels. The wheels should be used in a basket with the old style or A benchmark. The screws for automatic stepping are set seven positions ahead of the actual turn positions.

3. M9 Wheels. The M9 wheels are wired so that their direction of rotation is opposite to that of the M8 wheels. A special attachment may be added to the M9 frame to accomodate the pluggable reflector, or the stecker strip may combine the fixed input sequence and one or more of the non-stepping wheels. The frame benchmark should be selected as A, or the stecker strip should be displaced one position and the frame benchmark at Z used.

4. Input Sequence. The input sequence on the R5W is the normal alphabet reversed, i.e., the input substitution is given by

Z Y X W U
↓ ↓ ↓ ↓ ↓
A B C D E etc.

and hence is reciprocal. However, when one or more of the non-moving wheels is added, the reciprocal property is generally destroyed. On M9 frames, for A benchmark, stecker strip should be placed so that Z is under the A or 1 light, and then A is under the Z or Ø light. If the Z benchmark on frame is desired, move stecker strip one position to left.

5. As a final check consult a paper model machine for doubtful cases.

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T O P S E C R E T
OP-20-G-4A/ac

1 March 1945.

INVESTIGATION OF R5W ENIGMA MACHINE

The following features of the R5W Enigma Machine are placed on record in accordance with the memoranda of date 26 February 1945. This report covers chiefly cryptographic features--an electrical and mechanical description is being prepared elsewhere. Briefly, the R5W Enigma is a five wheel enigma with a fixed stecker and a pluggable reflector. Only three of the five wheels step, and the stepping wheels have enigma motion.

1. Nature of Machine Keyboard. This can best be discussed in the mechanical description.

2. Provision For a Stecker. There is no provision for a stecker in the model examined. However, the two wheels next to the right contact plate do not step, and the combined action of the right contact plate and these two wheels can be considered as a non-reciprocal stecker.

3. Wiring of Right Contact Plate. The left face of the right contact plate has a set of 26 contacts. Beginning with A at the top and proceeding in a clockwise direction around this face, the contacts are wired to the letters, A, B, C, D, ---Z on the keyboard. The A level is the frame bench mark level, i.e. the level at which window settings are made.

4. Wheels and Cores. There are 7 wheels, numbered from 1 to 7, but all wheels appear to have the same cryptographic properties. Each wheel has a double set of contact studs on the right face, and another double set of contact studs on the inner or left face. These two sets of contacts are straight wired. Each wheel is provided with four notches on the left hand side of the core, with a full set of twenty six notches on the right hand side of the core. These four notches occur on all 7 wheels at the positions G, M, T, and Z. These notches are seven positions ahead of the window reading, so that steppings occurs between Z and A, F and G, M and N, and S and T, as read at the window. On the wheel is a movable ring bearing an alphabet which can be locked at any one of 26 positions. This ring alphabet runs in the reverse direction to the right contact plate wiring. Since the ring alphabet is movable, a standard position must be agreed upon when using the ring alphabet to specify positions on the wheel. The pole pin on the inner face of the wheel and the locking mechanism for the ring are on the same radius from the hub of the wheel, hence this position is uniquely determined, and

the ring may be locked in with A at this normal position. The notches which are on the wheel rather than on the ring are then specified from the ring alphabet in this normal or A position. This procedure was followed in the specification of notch positions already given.

The real cryptanalytic features are contained in the wirings of the 14 inner cores. These cores fit inside in the inner (and left) face of the wheels. The cores are marked with letters, A on one side and AR on the other side of the first core, B and BR on the second core, --- N and NR on the fourteenth core. The cores may be placed in the wheel with either the obverse or reverse side innermost, but since the cores have only one hole to fit over the pole pin of the wheel, no multiple positions are possible for a given face of the wheel. By convention, the sides of cores marked with a single letter (A, B, C---) will be called the obverse sides, and the sides marked by pairs of letters (AR, BR, CR,----) will be called the reverse side.

Photographs of the wheels and cores are included in the electrical and mechanical report.

The wiring of the fourteen cores is specified as follows: With the ring locked in at the normal or A position, letters on the ring are used to specify wiring contacts on the core. With the obverse face innermost, the obverse wiring specifications apply, for this the right hand face is the face marked with a single letter and the left hand face is the face marked with a pair of letters. The reverse wiring specifications are also given. These, of course, may be obtained from the former by the following substitutions: Let lower case letters refer to contacts for the obverse wiring specifications, and capital case letters refer to contacts for the reverse wiring specifications. Then the substitutions

a ⟷ A
b ⟷ Z
c ⟷ Y
d ⟷ X
e ⟷ W
n ⟷ N
z ⟷ B

can be used to convert obverse wiring specifications to reverse wiring specifications.

5. Reflector. The reflector is pluggable. The left contact plate leads to a Jones plug arrangement where the reciprocal pairs are plugged in.

6. Nature of the Stepping. Five wheels are placed in the machine. The two rightmost wheels do not step, and in connection with the right contact plate constitue a non-reciprocal stecker. The three left most wheels have enigma motion. On pressing a key, the wheels advance and then encipherment follows.

7. Bench Mark Levels. The contact on the right contact plate which corresponds to the window reading level is electrically connected to the A key on the typewriter board. Hence A is adopted as the frame bench mark level. By the previous agreement, section 4, Wheels and Cores, A is taken as the wheel bench mark. This is the position on the wheel of the pole pin or the ring locking unit.