TM 11-380B

ROBERT B. DUDLEY

WAR DEPARTMENT

TECHNICAL MANUAL

•

CONVERTER M-209-B

20 September 1943

TECHNICAL MANUAL
No. 11-380B

WAR DEPARTMENT,
WASHINGTON, *20 September 1943.*

CONVERTER M-209-B

Order No. 36914-PHILA-43
Order No. 6919-PHILA-44

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

DESTRUCTION NOTICE

WHY — To prevent the enemy from using or salvaging this equipment for his benefit.

WHEN — When ordered by your commander, or when you are in immediate danger of capture.

HOW — 1. Smash—Use sledges, axes, hand-axes pick-axes, hammers, crowbars, heavy tools, etc.

2. Explosives—Use firearms, grenades, TNT, etc.

3. USE ANYTHING IMMEDIATELY AVAILABLE FOR DESTRUCTION OF THIS EQUIPMENT.

WHAT — 1. Smash—Open cover and lid and smash mechanism.

DESTROY EVERYTHING

CONVERTER M-209-B

SECTION I
DESCRIPTION

1. **Purpose and Distribution.**—*a*. Converter M-290-B is a cryptographic device issued by the Signal Corps for use by divisions and lower units, down to and including the company. It may also be used by higher units than a division or any others as may be designated by the Chief Signal Officer. Its purpose is to provide a safe and speedy means of cryptographing tactical messages by those who have had a minimum of training in cryptography.

b. The instructions can be applied to all cryptographic systems using Converter M-209-B. However, they may be modified by the publications issued with a particular system.

2. **Description.**—*a*. Converter M-209-B is a small, compact, hand-operated, tape-printing, mechanical device designed for rapid encipherment and decipher-

ment of tactical messages. When properly set and operated, it will encipher a plain text mesage of any length and automatically print the enciphered text on a paper tape in five-letter groups. It will also decipher a message that has been previously cryptographed by one of these devices, and print the plain text on a paper tape, with proper spacing between words. It is normally carried in a canvas case on a strap over the shoulder. The carrying strap may be attached underneath the machine for fastening it to the knee of the operator when used in the field or in a moving vehicle. A hand strap is also provided which may be attached to the left side of the machine. The case has compartments for carrying this technical manual, pencils, extra tape, message blanks, etc.

b. Converter M-209-B operates on the cryptographic principle of reciprocal substitution alphabets. The effect is that of sliding a normal-alphabet sequence against the same sequence reversed. A high degree of irregularity in the shifting of the alphabets with respect to each other is brought about by a train of gears, in which the number of teeth on the driving member is varied by the use of certain keying elements (paragraph 4).

c. Open the outer cover (18) of Converter M-209-B by pushing in on the knob (20) which is centrally located in the front. The following parts are visible:

(1) A series of six *key wheels* (37), bearing letters on their outer surfaces, which show through openings in the inner lid (26) of the unit.

(2) A large knurled knob at the left (8) attached to a metal *indicating disk* (7), bearing the letters of the alphabet in normal order. The indicating disk is associated with a *reproducing disk* (6) inside the unit. The reproducing disk bears the letters of the alphabet in reversed order. Only one letter at a time can be seen through the opening (10) in the cover.

(3) A small, knurled *paper feed knob* (11), is just behind the indicating disk. This knob can be turned only towards the rear of the machine. By turning it and its associated tape-advancing roller, the paper tape (12), on which the message is printed, is advanced when the converter is in operation.

(4) A cutting edge, for tearing off paper tape.

(5) A window (1), at the front left-hand corner of the inner lid (26), through which a letter counter (2) is seen.

(6) A knurled knob (33) on the right-hand side of the machine. This can be turned only by pushing in the button (25) at the back right-hand corner of the inner lid, and at the same time turning the knob. Then the key wheels are rotated as a unit, forward or backward, operating the letter counter.

(7) An encipher-decipher knob (9) just below the paper feed knob (11).

(8) A drive knob (32) at the right-hand side of the unit.

3. **Identification of Parts.**—Converter M-209-B consists of the following parts:

1. Letter counter window
2. Letter counter
3. Indicating index
4. Ink pad
5. Type wheel
6. Reproducing disk
7. Indicating disk
8. Setting knob
9. Encipher-decipher knob
10. Reading window
11. Paper feed knob
12. Paper tape
13. Paper pressure arm
14. Cover support
15. Ink pad container
16. Screw-driver
17. Oil can
18. Outer cover
19. Catch for inner lid
20. Cover catch button
21. Paper guard catch
22. Paper guard
23. Paper roll
24. Tweezers
25. Reset button
26. Inner lid

27. Number plate
28. Number ring
29. Drum bar
30. Drum bar lug
31. Inter-lock lever
32. Drive knob
33. Reset knob
34. Key wheel bench mark
35. Ineffective pin
36. Effective pin
37. Key wheels

The dimensions and weight of Converter M-209-B are as follows:

Height, 3½ inches
Width, 7½ inches
Depth, 4½ inches
Weight, 7.5 pounds

Packed for shipment in this country, the weight of the converter will be approximately 10 pounds, and it will displace about 0.37 cubic feet.

SECTION II
OPERATION

4. **Setting-Up the Keying Elements.**—*a. The internal keying elements.*—There are two internal keying elements. These are governed by a Cipher Key List similar to that described in paragraph 15.

(1) *Key wheel pins.*—Each of the six key wheels carries near its outer surface a number (equal to the number of letters on the key wheel) of equally-spaced pins which are somewhat longer than the thickness of the wheel. These pins can be pushed to the left or right by hand or by using a knife blade or other thin instrument such as the special screw-driver (16) which is found inside the outer cover of the converter. When pushed to the right, the pins are in a position to permit guide arms to move the drum bars (29). The drum bars, in turn, advance the type wheel through a train of

gears (paragraph 2*b*). This is called the *effective* position of the pins. Pushed to the left, the pins are in their *non-effective* position, namely, they are in such a position that the guide arms are prevented from moving the drum bars. When pins are pushed to the right, their left ends must be flush with the left-hand side of the key wheel, and when pushed to the left their right ends must be flush with the right-hand side of the key wheel. *Intermediate positions will give faulty results when enciphering or deciphering.* When the pins on all the wheels are *all* in either their effective or non-effective positions, the resulting encipherment with be monoalphabetic. This must be avoided. From 40 to 60 per cent of the pins should be in their effective positions.

(2) *Drum bar lugs.*—There are 27 drum bars (29), arranged about a central shaft, forming a sort of basket or cage at the back of the machine. Each of these drum bars is equipped with two movable lugs, either of which causes the drum bar to move to the left when pushed by a guide arm which, in turn, is permitted to operate by an effective pin on one of the key wheels. Each drum bar has eight holes. The two movable lugs may be located in any of the holes by using

the special screw-driver (16). Two of the holes are marked with a zero, and the others from 1 to 6, on the scale at the back of the machine. When a drum bar lug is in the zero position, it is not put into use at all, although the drum bar to which it is attached may still be moved if the other lug is not in a zero position too. When a lug is in any one of the positions 1 to 6, inclusive, the drum bar to which it is attached will be actuated by the corresponding key wheel whenever one of its effective pins permits one of the drum bar activating guide arms to be depressed. When moving the lugs into their prescribed positions, push them slightly toward the front of the machine with the aid of the notched screw-driver, to disengage them from the hole in the drum bar. Be sure that the lugs snap into the desired positions, as lugs slightly out of proper adjustment will not only produce faulty text but also may jam the machine. In order to facilitate proper lug settings and checking, place the left-hand lugs only in positions 1, 2, 3, and left zero, while the right-hand lugs are used in positions 4, 5, 6, and right zero.

b. The external keying element.—This element of the key refers to the initial alignment of the six key wheels according to a series of letters chosen at random

by the operator, and appearing in the message as the message indicator (paragraph 14). To set the key wheels to their initial positions, as indicated by the letters of the message indicator, proceed as follows:

(1) Test the drive knob (32) to be sure that it is in a locked position. It automatically assumes this position at the end of each operating cycle, that is, after a letter has been printed on the tape and the drive knob is returned to its initial position. *THE DRIVE KNOB CAN'T BE MOVED AGAIN UNTIL AFTER THE INDICATING DISK IS MOVED.* The drive knob must remain in the locked position until all adjustments have been made.

(2) The letter counter must be set to zero. This is done by turning the knob (33) while the button (25) is depressed. There are two reasons for this step. First, you can be sure that in encipherment the first character printed will be the initial letter of a 5-letter group, so that the cryptographic text will be grouped correctly in 5's when the message has been completed. Second, the counter will show the exact number of letters enciphered or deciphered, which will be of value in checking.

(3) Now set the key wheels to the letters of the message indicator by turning each key wheel individually until the desired letter is aligned on the white *bench mark* (34) across the slots through which the key wheels protrude. Since the wheels turn in only one direction, be careful not to turn the desired letter beyond the bench mark. Use the flat end of the tweezers for turning the key wheels. *Don't use eraser tips for this purpose.*

5. **Encipherment.**—With the internal keying elements of the machine adjusted as directed in Signal Operation Instructions and according to instructions contained in paragraph 4*a*, select a message indicator and adjust key wheels (paragraph 14). To encipher a message proceed as follows:

a. Turn the encipher-decipher knob (9) so that the letter C is upward. This sets the machine for enciphering.

b. Advance the paper tape so as to leave about 6 inches of space before the first letter is printed. This space may be used for the insertion, by hand, of the address, signature, and message number and indicator.

c. The letters of the text are located on the indicating disk and brought, one after another, to register with the bench mark (3) by turning the indicating disk knob. *After each adjustment, remove the fingers from the indicating disk knob and turn the drive knob through a complete cycle.* The cipher text will be printed and automatically spaced in 5-letter groups on the paper tape (12). If the letter Z on the indicating disk is used as a space sign after each word, the message, on decipherment, will automatically be spaced into correct word lengths of the original plain-text. *If a desired letter on the indicating disk is already in register with the bench mark, you must move the indicating disk slightly and return the letter to registration before the drive knob can be moved.* After the message has been enciphered, advance the tape by turning the knob (11) until the printing moves out at least six inches beyond the cutting edge, and tear off the tape.

d. If authorized, write the address, writer's message number, date of message, and any other necessary transmitting data at the head of the tape. Follow this by the system and message indicators (as two 5-letter groups). At the end of the tape, repeat the message

and system indicators (in that order) and add the time of signature. The tape may be handed in that form to the transmitting operator, or it may be pasted on a message blank.

6. **Decipherment.**—With the internal keying elements adjusted for encipherment (paragraph 5), to decipher a message, proceed as follows:

a. Turn the encipher-decipher knob so that the letter D is upward. This sets the machine for deciphering.

b. Set the letter counter to zero.

c. Set the key wheels to the message indicator (the second group of the message proper). Check these letters against the second appearance of the indicator at the end of the cryptogram.

d. Operate the machine as in encipherment, bringing the successive letters of the cipher text to the bench mark, by turning the indicating disk. *Disregard the spaces between the 5-letter groups of the cipher text.* Copy the plain-text on the tape upon a message blank, or paste the tape directly on the blank for delivery to the addressee.

7. **Automatic Spacing and the Letter Z.**—In encipherment, the cryptographic text is automatically printed in 5-letter groups (subparagraph 5*c*). In this process, if the letter Z is enciphered as the space sign between successive words, on decipherment the plain-text will be automatically reproduced in its original word lengths. This is possible only by eliminating Z as one of the letters of the alphabet. If a word containing the letter Z occurs in the plain-text of a message to be enciphered, for example, the word ORGANIZED, on decipherment the text will be reproduced as ORGANI ED. The missing letter can of course be supplied by the context.

8. **Checking and Correcting Errors.**—*a.* If, in the course of decipherment, you wish to go back and check or correct a word, you can do so by proceeding as follows: Note the position of the last letter or letters which are correct, counting from the first cipher letter. For example, go back to the beginning of the 25th group in the message. The 1st letter of that group is $(24 \times 5) + 1 = 121$st letter. Since the counter showed zero at the beginning of decipherment and is now at, for example, 129, reset the key wheels to the position they occupied after the encipherment of the 120th

letter. Depress the button (25), and revolve reset knob (33) until the stroke counter reads 120. The machine is now ready to decipher the 121st letter of the message, that is, the first letter of the 25th group. Do the same thing if you have been disturbed and have lost your place in the message you are deciphering.

b. If you wish to go back to correct or change a word, when enciphering, proceed as in paragraph 8*a*. Much more care must be taken to find the numerical position of the letter or letters to be corrected, since you must refer to the plain-text, count the letters in each word, and also count the spaces between words if Z was used to separate them in encipherment.

9. **Analysis and Correction of Garbles.**—*a*. Garbled texts may result from faulty operation of a cryptographic device, from errors made in transmission, or from mistakes made by either the enciphering or deciphering operator. Often the garble may be so slight that the reading of the text will be only a little hindered, but it may be so serious that the text will be unreadable. It is important when operating Converter M-209-B to be able to recognize the types of garbles and their causes, and make the proper corrections whenever

possible. You should always make an attempt to decipher before returning the message to the originator for reencipherment.

b. There are five common causes of garbled text when using the Converter M-209-B:

(1) *A key wheel pin out of place.*—When making the initial settings of the machine, one pin on the key wheels which should have been in an effective position may have been placed in an ineffective position, or vice versa. This will cause garbled text. A single-letter error will appear periodically in the text, always at the same interval from the preceding error. Locate the misplaced pin in the following way:

Count the number of letters, including spaces, from any one of the garbled letters to the next one. This number determines the wheel on which the incorrect pin setting is located; for example, if the count is 17, the incorrect pin will be found on wheel number 6 (numbering from left to right) because this wheel contains only 17 pins. (Table 1, Page 36). If the count is 19, the incorrect pin will be found on wheel number 5; if 21, on wheel number 4; if 23, on wheel number

3; if 25, on wheel number 2; if 26, on wheel number 1. A misplaced pin on wheel number 6 will produce a garble similar to the following:

NOW IS *L*HE TIME FOR ALL *X*OOD MEN

Now turn the letter counter back to one less than the number of the letter in error. In this example it would be turned back to 7. By counting in a clockwise direction, as E, F, G, H, etc., from the key wheel letter which is lined on the bench mark, the incorrect pin, which governed the activating arm upon the printing of the garbled letter, may be found. Count back 11 letters, beginning with the letter lined on the bench mark, for wheel number 6; 12 for wheel number 5; 13 for wheel number 4; 14 for wheel number 3; 15 for wheel number 2; 16 for wheel number 1. Change the pin and re-decipher the message to check its correctness.

(2) *Drum bar lug out of place.*—Garbles ranging from fairly readable text to a mere jumble of letters can be caused by a misplaced lug on any one of the drum bars. An error where only one lug on a bar is effective when both lugs should be, may be recognized by the non-periodic appearance of single-letter errors and group errors. It might appear as:

NO*V* IS TH*D* TIME FOR A*K*L GOOD*Y*MEN

Note that the garbled letter is always the letter which immediately precedes the correct letter in alphabet. V precedes W, D precedes E, etc. When two lugs are effective on a single bar and only one should be, there is a similar, non-periodic appearance of single errors and groups of errors. In this case, however, the garbled letter is always the letter which just follows the correct letter in the alphabet. An example might be:

NO*X* IS THE*AUIMF* FOR*AAML HOOE* MEN

In the case where both lugs on any bar are placed in zero positions when one should be effective, or when a lug is made effective in the wrong column, the result will be unreadable text. Correction of any of the lug errors is difficult unless the cipher key list is available for a complete check. By determining which of the types of lug errors is causing the trouble, use the trial and error method of locating the misplaced lug.

(3) *Incorrect setting of the indicator.*—This mistake can be made by the enciphering operator if he fails to copy down the correct message indicator of the cipher key indicator; by the transmitting agency if reception

is poor; or by the deciphering operator if he made an inaccurate setting. In any case, it will produce unreadable text. Correction can be made only by referring to the right indicators.

(4) *Transmission errors.*—The frequency of garbles in such a case will depend upon the transmitting and receiving operators and upon the quality of the communication at the time of transmission. Usually, the correct meaning is evident from the context of the message, unless letters or groups are omitted or repeated twice.

(5) *Omissions or repetitions.*—The deciphering operator may find Converter M-209-B producing clear, readable text up to a certain point, after which nothing but garble follows. The cause is either the omission of letters of groups, or the repetition of letters or groups. To determine exactly which of these is producing the garble, he must make several checks. First, examine the cryptographed text for the repetition of a group or groups, which do not necessarily appear as identical groups side by side, but may appear as:

QHKLV NCR*QH KLV*OP

Turn back the counter to the number preceding the number of the letter (N in the above example), this time omitting the repeated letters. Second, if a group is not repeated, examine the length of each group to determine whether there may be one or more which are shorter or longer than five letters. If shorter, a letter or letters has been left out in transmission and the letter-counter must be turned up the necessary number of times to compensate for the omission before proceeding. If longer, a letter or letters has been added and must be omitted. Third, the fault may be on the part of the deciphering operator because of carelessness or interruption. Turn back to the last letter of clear text and proceed again with the deciphering from that point. Fourth, the most difficult of this type of error to locate is the omission of a group or groups by the transmitting agency. If none of the previous errors is found, assume that one group has been omitted and set the letter counter up five points before proceeding. Next, try ten points, and even fifteen, until clear text is produced.

10. **Defective Operation.**—*a.* Although Converter M-209-B is ruggedly constructed, it must be handled

with care to assure satisfactory operation. Avoid too much speed in moving the drive knob. A steady, moderate, smooth operation will give the best results.

b. *Fully* complete each operating cycle before trying to set the indicating disk to the next letter. The indicating disk must be moved before trying to move the drive knob after a preceding complete cycle, even if it happens to be set at the desired letter. Also, be sure that the reset knob (33) at the right of the machine is in a locked position. It will click slightly when the key wheels, if rotated together, come in alignment with the white bench mark and the letter-counter registers. Note that the knob (33) operates an inter-lock lever (31) (See Fig. 2). This inter-lock lever allows the reset knob (33) to be operated only when the drum bar cage is in its starting position (also its final position on completion of the operating cycle). If the reset knob has not clicked into position the cage will be locked, the lever (31) catching a notch in the number ring (28). If the key wheels have been turned individually, be sure that each wheel has clicked into position with the desired letter registering with the white bench mark. If the wheel is not quite in position, there may be a mistake in the first text letter. All the parts are

interlocked in a way in which they will operate correctly, but if you don't complete a movement, or if one of the parts is left in an intermediate or incorrect position and you try to move the drive knob, the operating mechanism is likely to jam. *If this happens, never use force in trying to correct the trouble.* First, try to locate the cause of the jamming. If it can't be traced back to such faults as incomplete movements or faulty position of the operating parts, it may have been caused by too much speed in moving the drive knob. To clear a jam caused by too much speed, open the inner lid of the machine and rock the drum bar cage back and forth, until the movement can be completed by turning the drive knob.

c. Incorrect positioning of the lugs on the drum bars is another cause of jamming. Each drum bar, if activated, should move out the same distance to the left of the drum as other active bars. Failure to move out properly is caused by a lug not being in proper position. To relieve a jam due to this cause, locate the improperly-positioned lug (usually pressing against the end of one of the drum bar guide arms) and move it to the proper position, using the special screw-driver.

d. Complete every necessary movement; make sure that operating members are accurately positioned and are not in intermediate positions. This is the most important safeguard against faulty operation, either mechanical or cryptographic.

SECTION III
CIPHER KEYS AND KEY LISTS

11. Cryptographic Systems.—A cryptographic system consists of:

(1) Converter M-209-B.

(2) TM-11-380B, Technical Manual for Converter M-209-B.

(3) *Cipher Key List,* issued periodically, giving instructions governing the arrangement of the keying elements for the system. These lists are usually included in the Signal Operation Instructions of a using organization, but may also be found in system publications. Instructions for the preparation of Cipher Key Lists will be found in paragraph 15.

12. Necessity for Keys and Changes.—*a.* In order that you may communicate with other operators of Converter M-209-B, it is necessary to make the initial

settings of the units identical, and that the progress from these initial settings be absolutely identical. Do this by setting the elements of the cryptographic mechanism to positions and adjustments according to a *cipher key* used with a set of *keying elements* (paragraph 13).

b. Converter M-209-B possesses a high degree of cryptographic security, but it is not invulnerable to solution, especially if a large volume of messages are enciphered by means of any one arrangement of the keying elements. To provide maximum security a daily change should be made in the keying elements referred to as the *internal keying elements, while* **the *external keying element* should be different for each message.** The method of determining or indicating the changes in the arrangement of the keying elements must be agreed upon in advance, and thoroughly understood by all who are to use the machine.

13. **Keying Elements.**—There are three keying elements for Converter M-209-B. These are divided into two groups:

a. The external keying element.—This element of the key is the one selected by the operator himself, and

will be different for every message enciphered. It refers to the initial alignment of the six key wheels (37) as indicated by a series of letters which are lined up from left to right along the white bench mark (34). This series of letters, in one form or another, will appear in the message as the message indicator (paragraph 14).

b. The internal keying elements.—These elements are two in number, and they are to be changed only as directed by the signal or communication officer of the unit concerned. They refer to:

(1) The number of effective pins (36) in each of the six key wheels.

(2) The positions of the movable lugs (30) on the drum bars (29) (Paragraph 4).

14. **Indicators.**—Every cryptogram enciphered with Converter M-209-B has both a *system indicator* and a *message indicator*. The system indicator will be found in a publication describing the particular system involved, or will be provided for in Signal Operation Instructions. It will appear in the message immediately following the writer's number group, if any. It will also appear at the end of the message before the

writer's time, if any. The message indicator is selected by the operator himself, and determines for each message the initial positions of the six key wheels. It will appear in the message immediately after the first appearance and immediately before the second appearance of the system indicator. In choosing a message indicator, the operator writes down a random selection of five letters, subject to the limitations of the letters actually present on the key wheels. The first of these five letters governs the setting of the first two wheels, counting from left to right. Any letter from A to Z (except W) can be used as the first letter of the indicator. For the second letter, governing wheel number 3, the choice ranges from A to X (omitting W). For wheel number 4 (third letter) any letter from A to U may be selected. For wheel number 5 (fourth letter) select any letter from A to S. For wheel number 6 (fifth letter) any letter from A to Q. An example of such a message indicator would be HILQD and the wheels would be adjusted so that the letters HHILQD would be lined up along the bench mark. Additional security may be obtained by enciphering the message indicator according to the instructions contained in the correct Cipher Key List.

15. Preparation of Cipher Key Lists.—*a.* In order that Signal Operation Instructions may indicate in an absolutely clear and unambiguous manner the arrangement of the internal keying elements, it is essential that definite forms and procedures be followed in preparing the Cipher Key Lists.

b. To prepare a table of pin settings which will have a favorable randomizing effect on the shifting of the alphabets proceed as follows:

(1) Prepare a chart of the key wheels by listing in alphabetical order, starting with A, the letters appearing on the face of each wheel: the first wheel, A to Z, the second wheel A to Z (omitting W), the third wheel A to X (omitting W), the fourth wheel A to U, the fifth wheel A to S, and the sixth wheel A to Q.

(2) Prepare a set of 156 lettered cards or counters, 78 of which are marked R and the remainder L. Shuffle the cards or counters thoroughly and draw out one at a time, marking with a dash the position of the pins successively, starting with A on wheel number 1, in accordance with the letter drawn. If R, make a dash to the right of the letter; if L, make a dash to the left. (Table 1, page 36). This procedure insures a perfectly

random assortment in which from 40 to 60 per cent of the pins are in the effective position.

c. To prepare a table of favorable settings for the drum bar lugs, proceed as follows in the order given:

(1) Mark off six columns of ¼-inch cross-section paper and number the columns from 1 to 6. These numbers denote the effective positions for lug settings. Number the rows of the form from 1 to 27, starting at the top. These numbers denote the drum bars in the order in which they become effective during an operating cycle of the machine.

(2) Select at random six numbers, subject to the following limitations:

(*a*) Their sum must not be less than 28 nor more than 39.

(*b*) Of the six numbers selected, at least two, and not more than four, must be even; a set of five even numbers and one odd number (or five odd numbers and one even number) must never be chosen.

(*c*) The six numbers must be well scattered from 1 to 13, inclusive.

(*d*) The same set of six numbers must not be used a second time as long as other sets are available.

(3) Rearrange the numbers so that they will appear in random order.

(4) Subtract 27 (the number of bars on the drum) from the total of the six numbers. The condition is described as overlap when the two lugs (paragraph 4*a*(2)) on the same bar are placed in effective positions.

(5) Distribute the overlaps among the numbers according to the following rules:

(*a*) Most of the six numbers (that is, drum columns) must be involved.

(*b*) Overlaps should involve both columns which are side by side and columns which are separated.

(*c*) Many small overlaps should be used in preference to one large overlap.

(6) The numbers must be so selected and the overlaps so placed that a number or the sum of certain numbers will yield all the values from 1 to 27, inclusive. The numbers 1 and 2 must always be chosen, otherwise all numbers from 1 to 27 inclusive cannot be obtained.

It must be remembered that the result of two effective lugs on the same drum bar is 1. As an example of this latter point, in table 2 there are three effective lugs in column 6 and one effective lug in column 3, giving a total of 4. But two of the effective lugs are on one bar, yielding a result of only 3. Therefore the proper total for columns 3 and 6 is 3 (2 plus 1) and not 4.

(7) The effective lugs are now entered on the prepared chart, lugs in the same column being placed on successive drum bars as far as possible.

d. After the tables of settings for both the key wheel pins and the drum bar lugs are prepared, it is desirable to provide a means by which operators of the machine can check the accuracy of their settings. This is done by adjusting the machine according to the charts and enciphering the letter A twenty-six times, starting with the key wheels aligned on the letters AAAAAA. The twenty-six cipher equivalents are included with the two tables as a check, so that, after his adjustments have been made, the operator of a machine may test his accuracy by enciphering twenty-six A's himself, with the key wheels set initially at AAAAAA. Any deviation from the 26-letter check indicates that an error was made in the settings and a recheck of the

entire adjustment must be made. The 26-letter check should be derived for, and included with, every pair of keying tables issued. It will be given in the Cipher Key List merely as a sequence of letters such as the following:

26-letter check

T K H R X C U Y T K N O I K R J N T A D T A I V P M

e. An example of the form in which the two tables referred to in subparagraphs 15*b* and 15*c* will appear in the Cipher Key Lists is shown in Tables 1 and 2 on pp. 36-37. In Table 1, "A—" indicates that the pin designated by the letter A on the key wheel is to be pushed to the right, while "—A" indicates that the pin designated by the letter A is to be placed in the left position. In Table 2 it is indicated that the left-hand lug on bar number 1 (see number ring (28)) is in the number 3 position, and the right-hand lug is in number 6 position. The right-hand lug on bar number 2 is in number 6 position, but the left-hand lug not being shown is in the zero or non-effective position, etc. The zero positions are not shown on the table—a lug not in one of the numbered positions is in a zero position. These positions are determined by reference to the number plate (27) at the rear of the drum bar cage.

TABLE 1—*Position of Key Wheel Pins*
Period of (date) to (date)

No. 1 (26)	*No. 2* (25)	*No. 3* (23)	*No. 4* (21)	*No. 5* (19)	*No. 6* (17)
A—	—A	A—	—A	—A	A—
B—	—B	B—	—B	B—	B—
—C	—C	—C	C—	—C	—C
D—	D—	—D	—D	D—	D—
—E	E—	—E	E—	E—	—E
—F	—F	—F	F—	F—	—F
—G	G—	G—	—G	—G	—G
H—	—H	H—	H—	H—	H—
I—	I—	—I	I—	I—	—I
—J	J—	J—	—J	—J	—J
K—	K—	—K	—K	—K	K—
—L	L—	L—	—L	—L	—L
M—	—M	M—	M—	M—	—M
N—	—N	N—	N—	N—	N—
—O	O—	—O	—O	—O	O—
—P	—P	—P	P—	P—	—P
—Q	—Q	—Q	—Q	—Q	Q—
—R	R—	R—	—R	—R	
S—	S—	S—	S—	S—	
T—	—T	T—	T—		
—U	U—	U—	U—		
V—	—V	V—			
W—	X—	X—			
—X	—Y				
—Y	—Z				
—Z					

TABLE 2—*Position of Drum Bar Lugs*
Period of (date) to (date)

	1	2	3	4	5	6
1			X			X
2						X
3	X					X
4	X				X	
5				X	X	
6				X		
7				X		
8				X		
9				X		
1Ø		X				
11		X				
12		X				
13		X				
14		X				
15		X				
16		X				
17		X				
18		X				
19		X				
20		X			X	
21		X			X	
22					X	
23					X	
24					X	
25					X	
26					X	
27					X	

Steps numbered as in paragraph 15*c*.

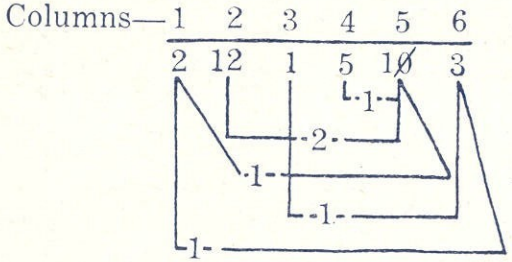
(1) See box, table 2.

(2) Numbers chosen at random: 1, 2, 3, 5, 1Ø, 12.

(3) Numbers are transposed: 2, 12, 1, 5, 1Ø, 3.

(4) 27 is subtracted from their total to find number of overlaps: $2 + 12 + 1 + 5 + 1Ø + 3 = 33 - 27 = 6$.

(5) Overlaps are distributed:



(*a*) All of the six numbers are involved.

(*b*) Column 1 is overlapped with Columns 5 and 6 (columns separated).

Column 2 is overlapped with Column 5 (columns separated).

Column 3 is overlapped with Column 6 (columns separated).

Column 4 is overlapped with Column 5 (columns side by side).

(*c*) Small overlaps are used in preference to one large one.

(6) Notice that from the numbers, or combinations of them, it is possible to obtain all values from 1 to 27 inclusive.

(7) Effective lugs are marked on the chart prepared in Step 1. (Table 2).

SECTION IV
MAINTENANCE

16. **Paper Tape Supply.**—To insert a fresh tape into the feed mechanism, release the hinged guard (22) which holds the paper in place and allow it to tilt forward against the inner lid. Remove the empty spool and place a new roll of tape over the pin so that it will unroll in a counter-clockwise (to the left) direction. Pass the end of the tape through the slot in the guard. Bring it forward and insert it in the tape slot just above the encipher-decipher knob (9). Push the tape through the tape channel until it appears at the top, making certain that the paper passes under the two small springs immediately behind the type wheel (5). Then pass it between the tape-advancing rollers while pressing downward on the paper pressure arm (13).

17. **Inking Pad.**—Extra inking pads are kept in one of the small metal containers held by spring clips in

the outer cover of the machine. To insert a fresh pad, open the inner lid (26), remove the old pad by means of the tweezers, and insert a new one in its place. The life of a pad can be prolonged by turning it end for end.

18. **Type Wheel.**—After considerable use the type wheel (5) may become caked with ink and will produce indistinct characters. Clean the type as on a typewriter, with type cleaner and a typewriter brush.

19. **Oiling.**—Where oil holes are provided for lubricating bearings a drop of oil should be inserted occasionally from the container in the cover. Except as regards the left end of the drum, which should be kept well oiled, all other points where friction occurs should be oiled only sparingly from time to time. *Avoid excessive oiling.*

20. **Exhausted Paper or Ink Supply.**—If the printing becomes illegible or fails to function due to exhaustion of the paper tape reserve or ink supply, the cipher text or clear text can be read off the letters on the reproducing disk (6) when these appear in the aperture (10) *after* each manipulation of the operating lever.

21. **Repairs.**—If defective or worn parts cause trouble don't attempt to make repairs, except those of a very minor nature such as replacement of a broken or disconnected spring. Return the machine to the depot so that it may be repaired by trained personnel, or replaced with a serviceable unit.

[A.G. 300.7 (15 September 1943).]

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:

J. A. ULIO,
Major General,
The Adjutant General.

DISTRIBUTION: X

(For explanation of symbols see FM 21-6)

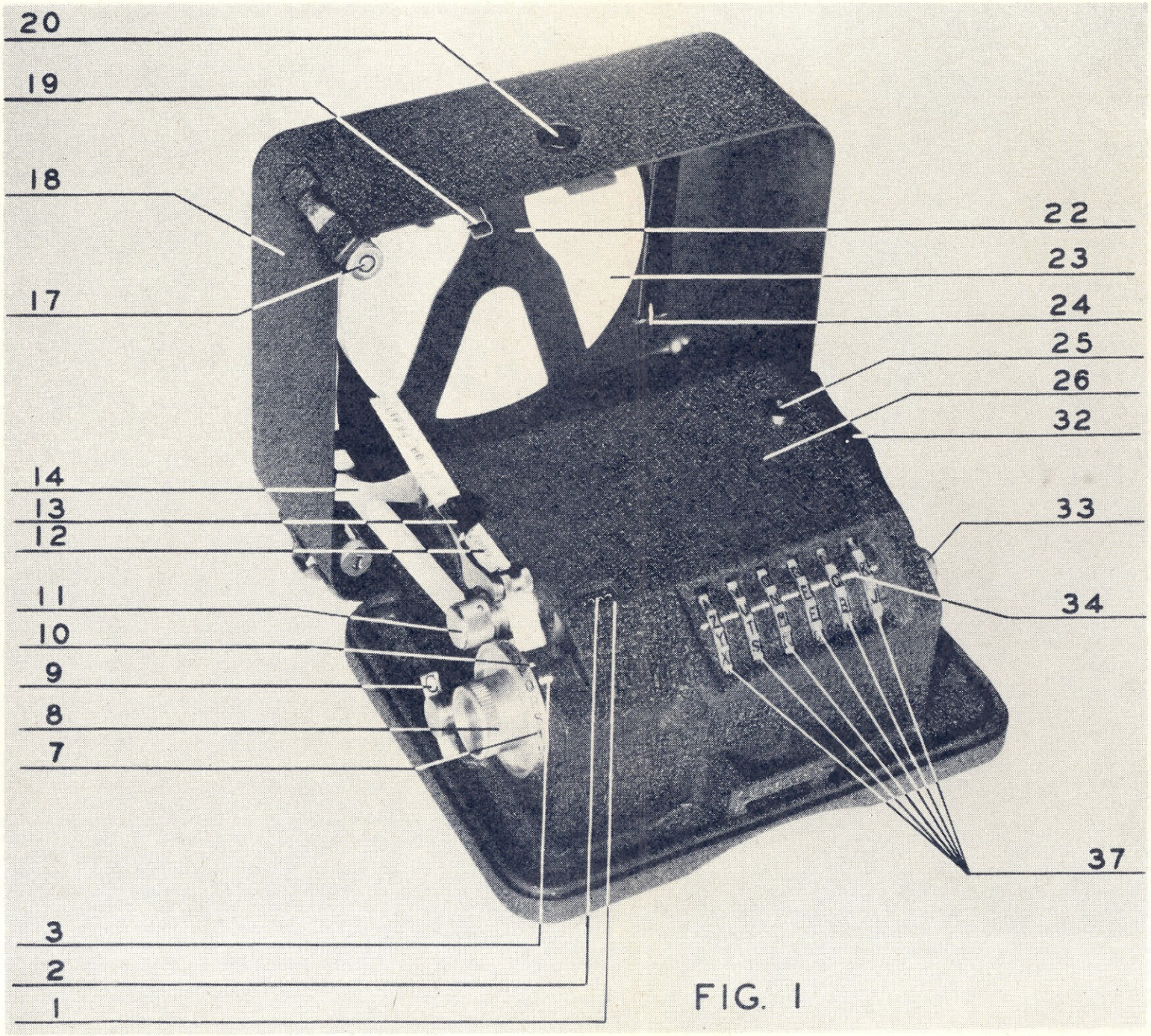


FIG. 1—*Converter M-209-B, Top View with Cover Raised*

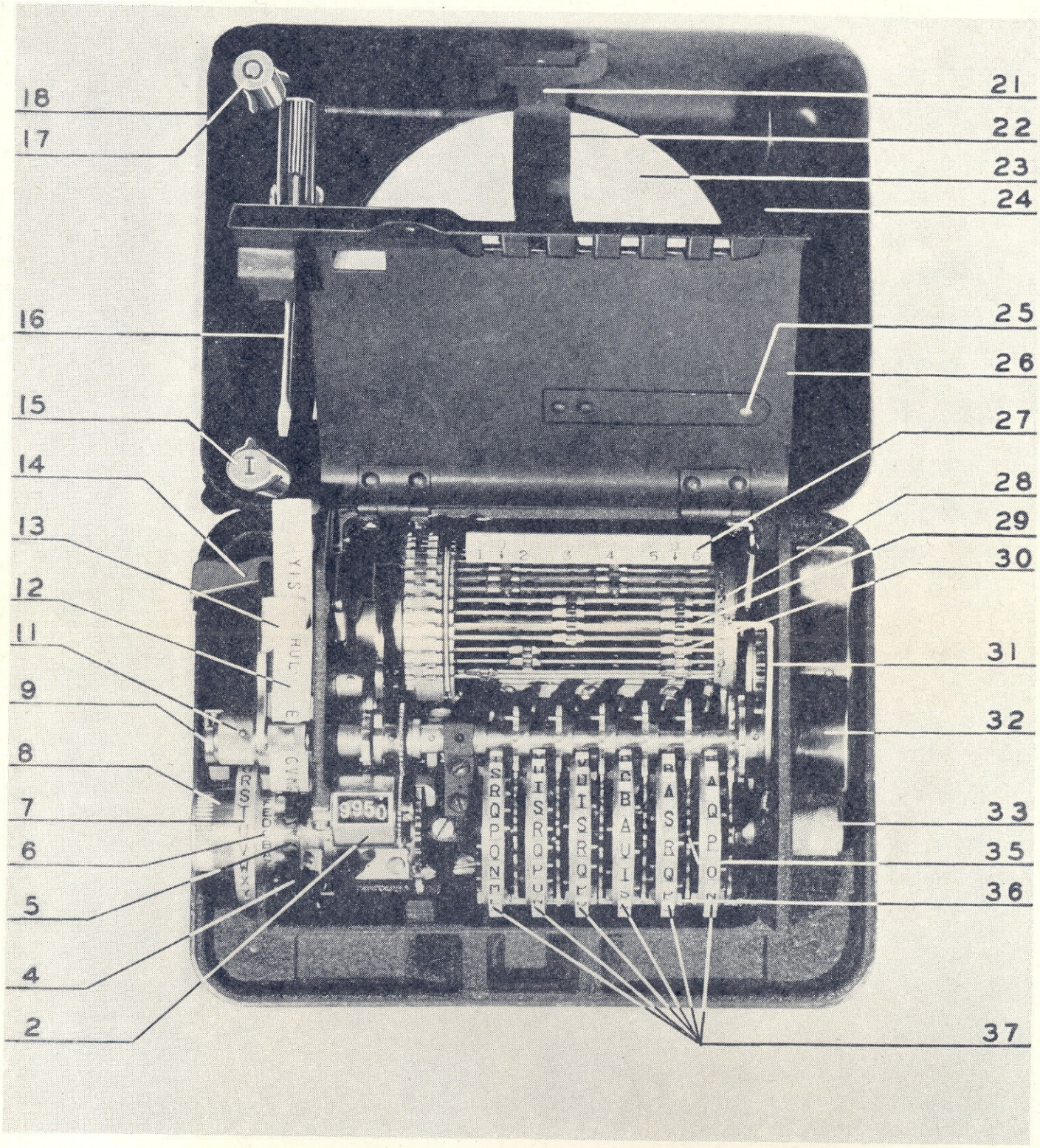


FIG. 2—*Converter M-209-B, Top View with Cover and Lid Raised*

SECTION V

SUPPLEMENTARY DATA

22. Table of Replaceable Parts, Converter M-209-B.—

Total Quan. in Equip.	Ref. Symb.	Sig. Corps Stock No.	NAME OF PART AND DESCRIPTION	Mfr. Code	Contr's. Dwg. or Part No.
4		6E1009A/F5	Foot, base, rubber, Mfr. No. 1322	AI	R2
4		6E1009A/S10	Screw, base, rubber foot		R4
6		6E1009A/S15	Screw, sideplate, right-hand (Special)		R17
..		6E1009A/S15	Screw, sideplate, left-hand (Same as R17)		R26
1	26, 25, 34	6E1009A/L10	Lid		XMR32
6		6E1009A/S16	Screw, lid hinge, left-hand (Special)		R38
8		6E1009A/S11	Screw, lid hinge, right-hand (Special)		R38A
8		6E1009A/W5	Lock washer, lid hinge (#6 Split-Kantlink $\frac{1}{32}$x x$\frac{1}{32}$) (Special)	GK	R39
1	18, 20, 22	6E1009A/C25	Cover Assembly		MR55
..		6E1009A/S16	Screw, cover hinge (Same as R38)		R60
1	14	6E1009A/S80	Support, cover		MR63
1		6E1009A/S50	Spring, cover support, Mfr. No. R65	H	R65
1		6E1009A/S7	Screw, cover support (Special)		R66
1		6E1009A/L1	Latch plate, cover		R92
4		6E1009A/S6	Screw, cover latch plate (Special)		R92A
1		6E1009A/S13	Screw, set, keywheel shaft (Special)		R117
2		6E1009A/S9	Screw, end, keywheel shaft (Special)		R118
1	33	6E1009A/K10	Knob, keywheel reset		R132
1		6E1009A/S58	Spring, keywheel feed pawl		R136
..		6E1009A/S11	Screw, keywheel feed arm bracket (Same as R38A)		R141
..		6E1009A/S6	Screw, intermediate gear shaft bearing (Same as R92A)		R173
1		6E1009A/S55	Spring, intermediate gear release arm		R195
1	32	6E1009A/K9	Knob, drive (operating lever)		XMR230
1		6E1009A/C17	Cotter, drive knob		R232
1	5,6,7,8	6E1009A/T8	Type wheel, complete—Metal (or Plastic)		MR240 or XMR240
1		6E1009A/B15	Bracket, ink pad arm		MR264
..		6E1009A/S11	Screw, ink pad arm bracket (Same as R141)		R265
..		6E1009A/W5	Lock washer, ink pad arm bracket (Same as R39)		R265A
1		6E1009A/H3	Hammer, print arm		R277
1		6E1009A/R10	Rubber, print arm hammer		R278
1		6E1009A/S5	Screw, print arm hammer (Special)		R279
1		6E1009A/W6	Washer, print arm (Special)		R280
2		6E1009A/S65	Spring, print arm		R281
1		6E1009A/B1	Ball, encipher-decipher detent, Mfr. No. 1/8", Grade #3	SKF	R297
1		6E1009A/S60	Spring, encipher-decipher detent		R298
1		6E1009A/S8	Screw, encipher-decipher detent (Special)		R299
..		6E1009A/S65	Spring, paper feed arm (Same as R281)		R303
1		6E1009A/S51	Spring, paper feed pawl		R307
1	11	6E1009A/S34	Shaft assembly, paper feed knob		MR313
1		6E1009A/K11	Cotter, paper feed knob		R315

All screws are ASME standard threads. The heads and finish make them special.
The word "Special" indicates part made for, or by, the contractor.

Total Quan. in Equip.	Ref. Symb.	Sig. Corps Stock No.	NAME OF PART AND DESCRIPTION	Mfr. Code	Contr's. Dwg. or Part No.
1		6E1009A/S64	Spring, paper pressure		R325
1	2	6E1009A/C20	Counter, Mfr. No. MR340	VR	MR340
..		6E1009A/S11	Screw, counter (Same as R38A)		R346
..		6E1009A/W5	Lock washer, counter (Same as R39)	GK	R347
1	24	6E1009A/T5	Tweezers, Mfr. No. Pr, Style Fig. 22312	WD	R350
1	16	6E1009A/S25	Screwdriver, Mfr. No. LCSR351	EP	R351
1	17	6E1009A/C2	Oil can, cover and dipstick		MR354-ASMO
1	15	6E1009A/C1	Ink can, MR358, ink pad with bushing MR357 and cover MR359		MR359-AS
2	23	4A2708	Paper roll (4″ roll standard ⅜″ tape)		R360
4		6E1009A/C12	Clip, message, Mfr. No. P1905-1	UH	R361
1		6E1009A/C5	Canvas carrying case, Mfr. No. 9220	WS	†Dwg. SC-6590-D R362
1		6E1009A/S75	Strap, hand, carrying (complete with snaps), Mfr. No. 9220	WS	†Dwg. SC-6590-D R364
1		6E1009/S10	Strap, shoulder, adjustable (25″-50″) (with snaps), Mfr. No. 9220	WS	R365
1		6D2103	Message Book M103, 4¾″ x 6⅜″ x ⅜″		†Dwg. SC-6590-D R366

†Indicates Signal Corps drawing.

INDEX OF MANUFACTURERS

Abbrev.	Name and Address
AI	Atlantic India Rubber Works, Inc. Chicago, Ill.
GK	George K. Garrett Co., Inc. Philadelphia, Pa.
H	M. D. Hubbard Spring Co. Pontiac, Mich.
SKF	S.K.F. Industries, Inc. Philadelphia, Pa.
VR	Veeder-Root, Inc. Hartford, Conn.
WD	William Dixon, Inc. Newark, N. J.
EP	Eversafe Products Co. New York City
UH	Union Hardware Co. Torrington, Conn.
WS	Wm. Stanley & Co., Inc. New York City