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TOP SECRET-T

Chapter III. Description and Characteristics of Bombe and Checking Machine

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CHAPTER III. - DESCRIPTION AND CHARACTERISTICS OF BOMBE AND CHECKING MACHINE.

GENERAL DESCRIPTION.

The Bombe (figs. 44 and 45) made by the British Tabulating Machine Company Ltd. is a portable electro-mechanical device for the rapid decoding of enigma machine messages. It contains the equivalent of the wheels and "uncle walters" of 36 enigma machines and is motor driven. There are four current inputs and three stecker boards. The bombe operates on 220 volts direct current which in the case of U S A bay is obtained from a mercury arc rectifier connected to the 220 volt alternating current mains. It is a self contained unit only requiring connection to a power line.

WEIGHT.

The bombe weighs approximately one ton.

POWER CONSUMPTION.

The total consumption of the bombe is about 10 amperes. Its supply leads are fused on both sides of the line with 12 ampere fuses. The motor is a Thomson Houston Shunt Wound Direct Current 220 Volt Motor rated at 0.75 horsepower and drawing 3.8 amperes when running at 800 rpm or 3.42 amperes at 1000 rpm.

OPERATING SPEED.

The bombe is designed to operate at a speed of 64 carries per minute (64 steps of the drums of the middle row per minute). Each step of the middle row follows a complete revolution of the fast drums (top row) providing the "carry" circuit is operative.

INSTALLATION AND PREPARATION FOR USE.

The following procedure is necessary to install the bombe and make it ready for use. The machine is put in position and the current supply leads connected to the power mains. The Motor and Control power switches should be in the OFF position when this is done. The bombe is inspected for general condition to detect any breakage or damage that may have occurred during shipment. The machine shall be completely lubricated. All adjustments of the drive and carry mechanisms and of the relays are inspected. The "hot spot" on the control cam is blocked out so that the bombe will not latch up at setting ZZZ and then the machine is run for 24 hours to wear in all the moving parts.

RELOCATION OF MOTOR AND CONTROL SWITCHES.

When the bombe is received from the factory the Motor and Control power switches are located at the bottom on the right hand end of the machine. These are relocated to a position adjacent to the Start and Stop switches as shown on figure 44.

RUNNING TEST MENUS.

In order to prove the proper functioning of the bombe it is necessary to set up test menus and run them to get the expected right stops. These test menus are shown in figures 46 to 50 inclusive. The first step in setting up the machine for these menus is to attach the wheels in the proper wheel order as indicated at the top of the menu.

ATTACHING DRUMS.

The drums to be used are specified in the wheel order assignment. For instance in figure 46, test menu no.1 calls for wheels 3 2 4. This means that no.3 drums shall be used for the top or fast drums, no.2 shall be used for the intermediate, and no.4 shall be used for the bottom or slow drum. By referring to the table of drum color codes on page 9, it will be found that the no.3 drums are green, no. 2 maroon and no. 4 are yellow.

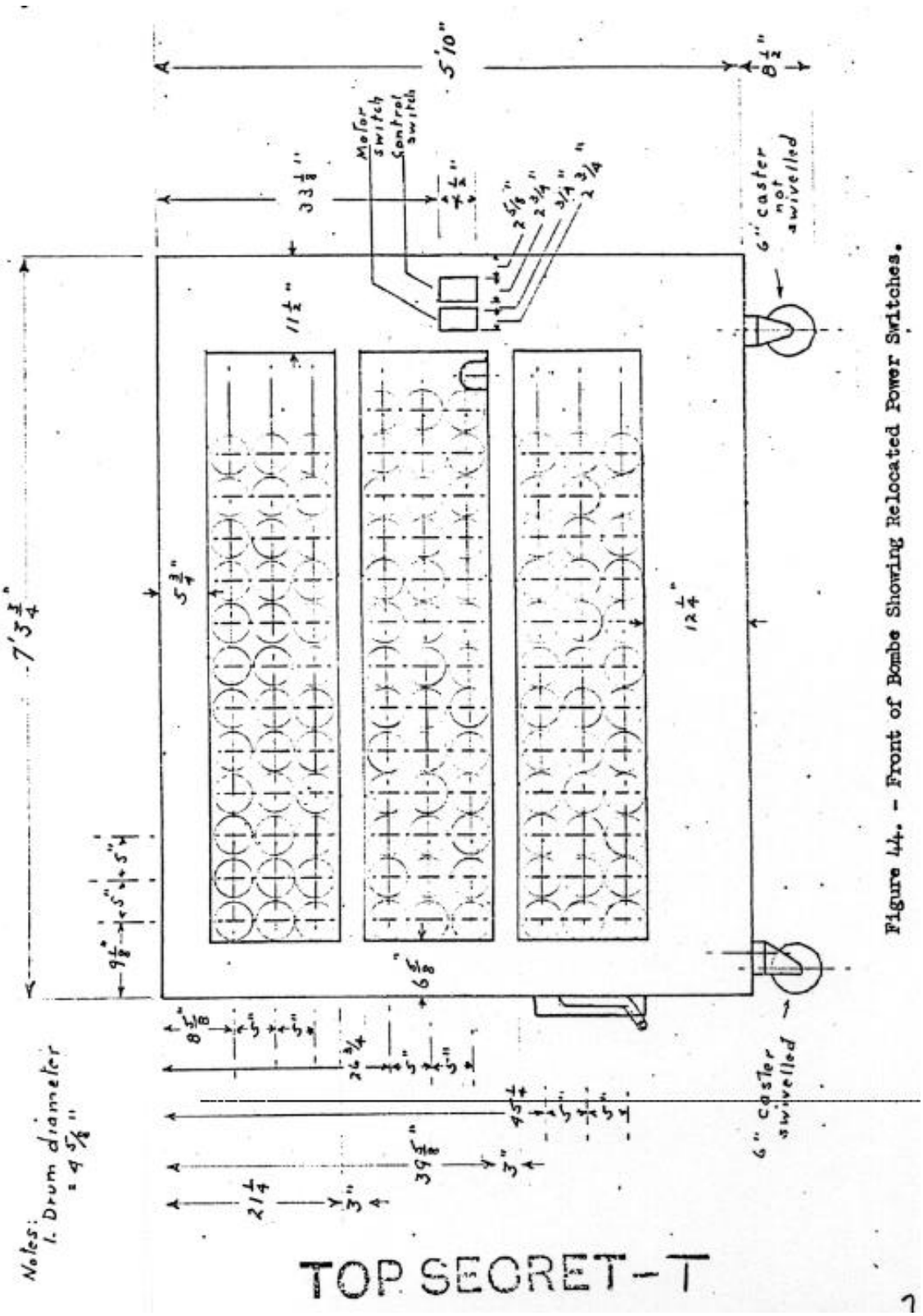


Figure 44. - Front of Bombe Showing Relocated Power Switches.

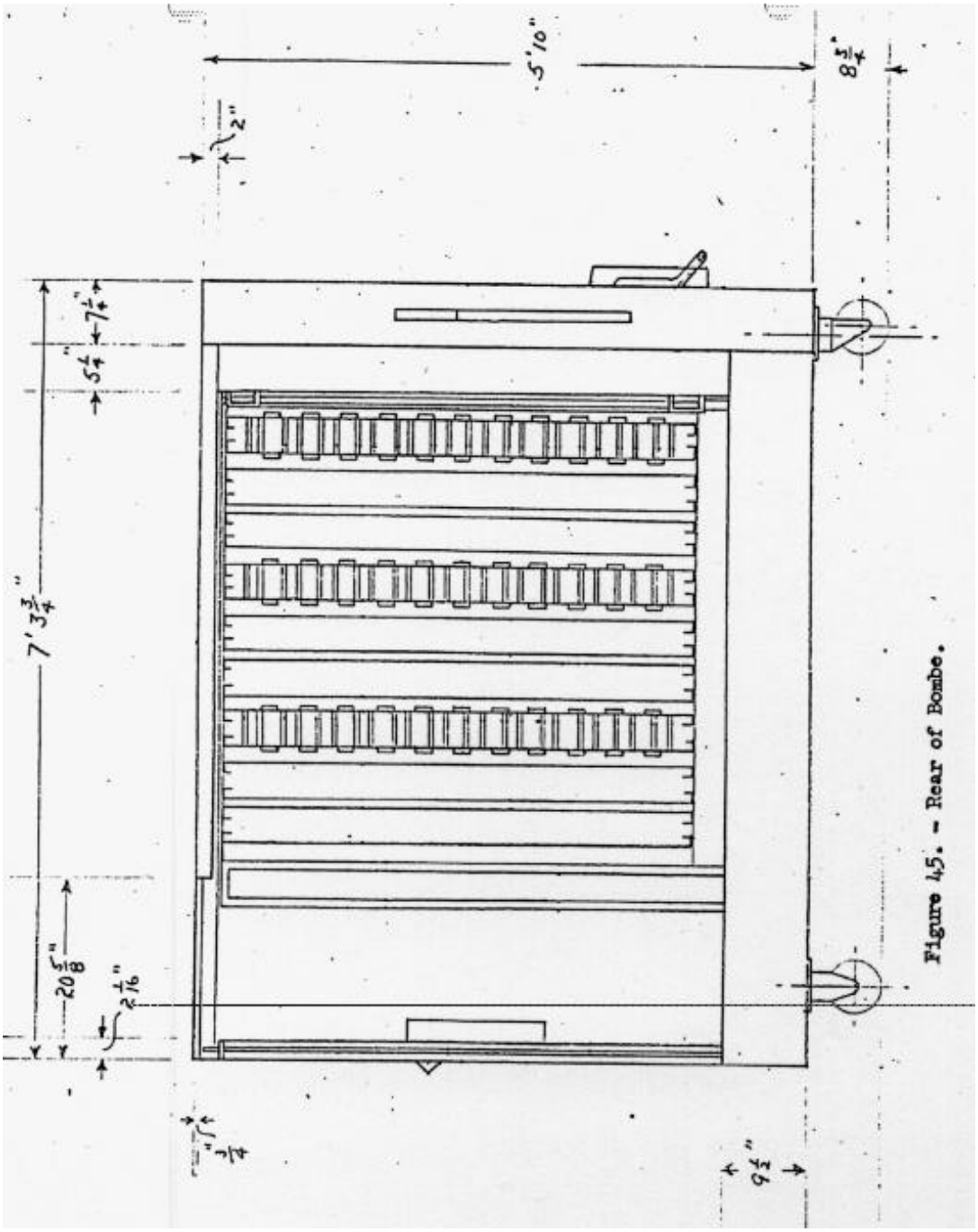


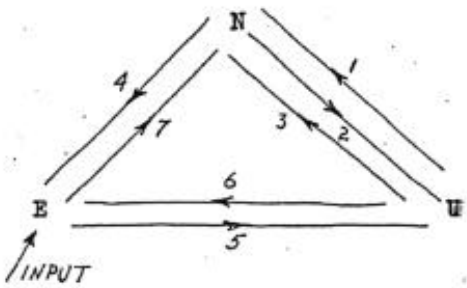
Figure 45. - Rear of Bombe.

TEST MENUS.

NOTE: Wheel orders and wheel settings are read from top to bottom.

MENU I.

Wheels 3 2 4

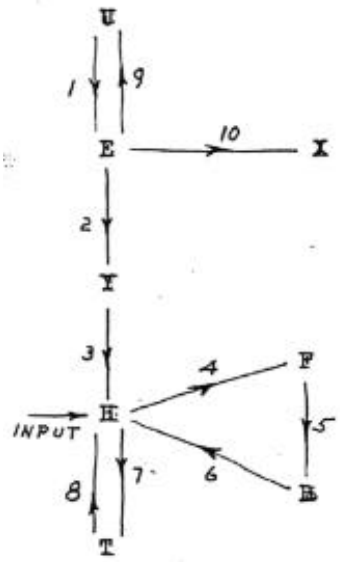


1	Z Z S	U (2 out, 3 in) 1 in (5 out,6in)
2	Z Z Z	N (1 out, 2 in)(3 out,4 in) 7 out
3	Z A X	E (4 out,5 in)(6 out,7 in)input
4	Z A S	
5	Z A Y	Current entry at "a"
6	Z Z W	
7	Z A V	

One Stop Only B U O : L

MENU II.

Wheels 4 3 2

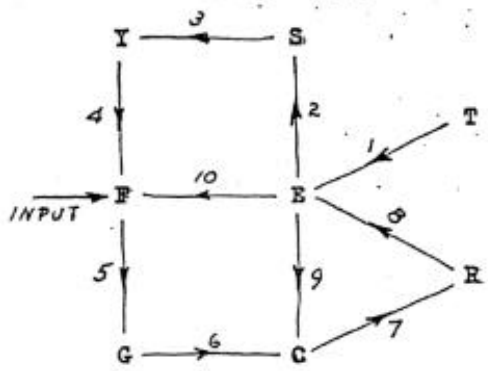


1	E K R	U 1 in, 9 in.
2	R T N	E (1 out,2 in)(9 out,10 in)
3	S A O	Y (2 " ,3 ")
4	E K P	H (3 " ,4 ")(6 out,7 in),8 out,input
5	R T I	F (4 " ,5 ")
6	R T Q	B (5 " ,6 ")
7	S A T	T (7 " ,8 ")
8	S A S	X 10 out.
9	R T R	
10	R T J	Current entry at "e"

Stops F J W : F
A O T : H
F A L : N
F V D : J

MENU III.

Wheels 1 5 3



1	Z A P	
2	Z Z J	
3	Z A J	
4	Z Z P	
5	Z Z N	
6	Z A N	
7	Z Z K	
8	Z A G	
9	Z Z O	
10	Z Z R	

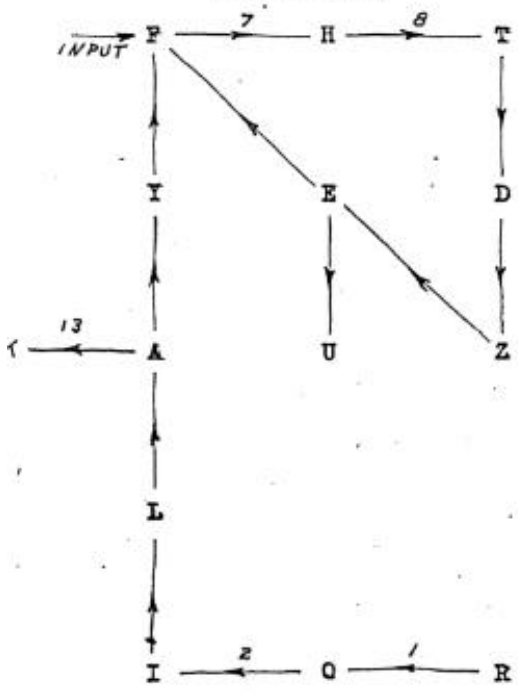
T 1 in.
E (1 out,2 in)(8 out,9 in)10 in.
S (2 out,3 in)
Y (3 " ,4 ")
F (4 " ,5 ") 10 out,input
G (5 " ,6 ")
C (6 " ,7 "), 9 out
R (7 " ,8 ")

Current entry at "a"

Stops A F Y : K
C B W : U @
Q D N : I @
K F M : B @
N Y B : J @
Z M A : I

MENU IV.

Wheels 2 4 3



1	Z A B	
2	Z Z B	
3	Z Z K	
4	Z Z L	
5	Z Z E	
6	Z Z H(Z Z R)	
7	Z Z N	
8	Z Z F	
9	Z Z M	
10	Z Z G	
11	Z A A	
12	Z Z A	
13	Z Z I	
14	Z Z J	

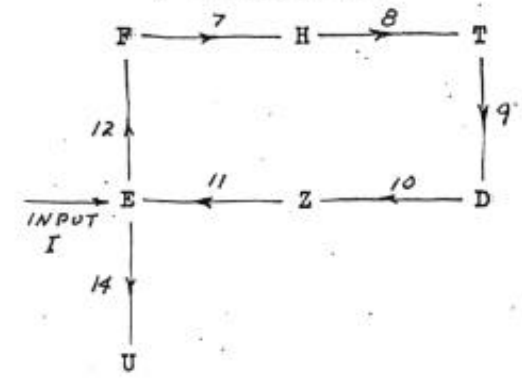
R 1 in.
O (1 out,2 in)
I (2 " ,3 ")
L (3 " ,4 ")
A (4 " ,5 ")
K 13 out
Y (5 out,6 in)
F (6 out,7 in)12 out,input
H (7 " ,8 ")
T (8 " ,9 ")
D (9 " ,10 ")
Z (10 " ,11 ")
E (11 " ,12 ") 14 in
U 14 out

current entry at "i"

Stops D G T : I
L F T : F

MENU IVA. DOUBLE INPUT JOB.

Wheels 2 4 3



Same menu as IV except that:

6 Z Z R instead of Z Z H

F 7 in,12 out.
E (11out, 12 in) 14 in,input I
R 1 in,6 out.
A (4 out,5 in) 13 in,input II.

Current entry at "a" on I
"c" on II.

Stops B S T : W (W)
D G T : B (Y)
E U P : C (N)

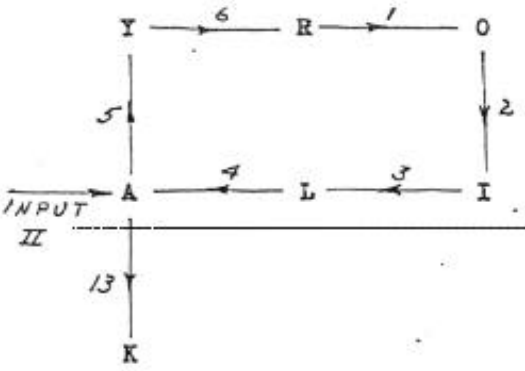
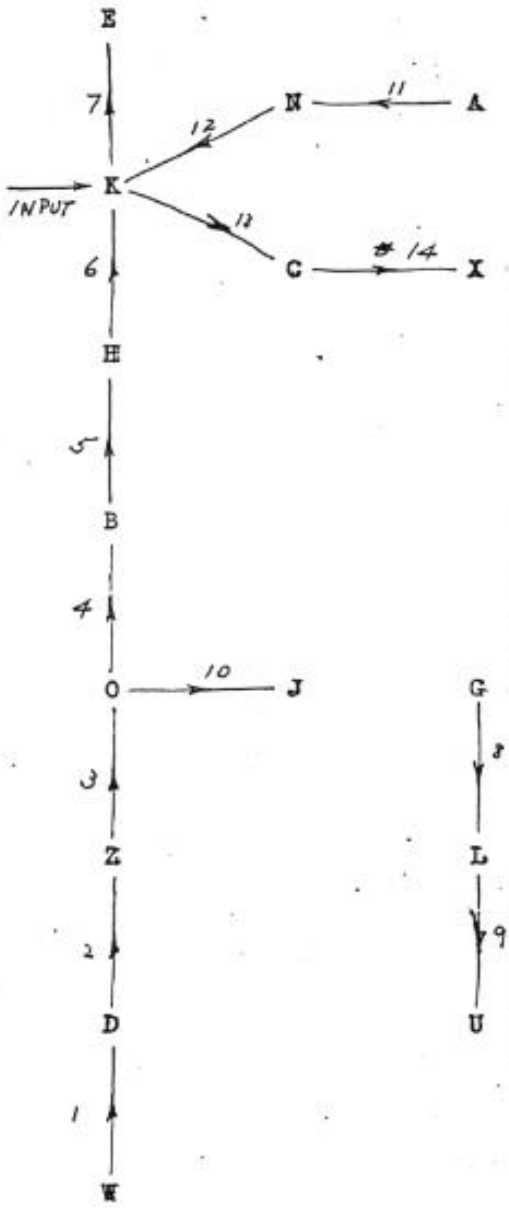


Figure 48. - Test Menu IVA.

MENU V.

Wheels 1 4 5



1	V X W	W	1 in.
2	O K M	D	(1 out, 2 in)
3	A M E	Z	(2 " , 3 ")
4	F M Q	O	(3 " , 4 ") 10 in
5	O K N	B	(4 " , 5 ")
6	O T O	H	(5 " , 6 ")
7	Y X V	K	(6 " , 7 "), (12 out
8	O T P		13 in), input
9	A M G	C	(13 out, 14 in)
10	O T N (O L N)	N	(11 out, 12 in)
11	O K O	L	(8 out, 9 in)
12	F M R	G	8 in.
13	A M F	A	11 in.
14	Y X X (Y X V)	J	10 out.
		U	9 out.
		E	7 out.
		X	14 out.

Current entry at "z".

Stops with wheels 10 & 14 set at O T N, Y X X

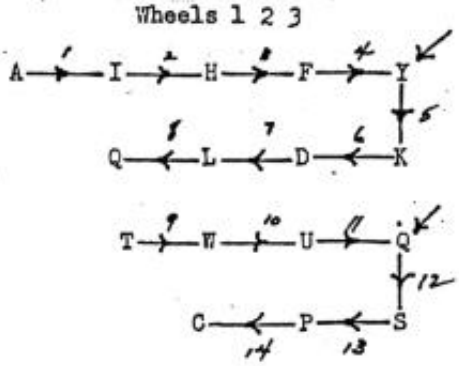
	D E Z : M	M E S : Y	A P E : R
	R W X : Y	Z X R : Y	U Q B : M
G	B O X : G	C O R : R	J I B : S
	G R W : R	C A R : T	D E B : Q
8	N P U : F	V A L : K	C M A : R
	V C U : Y	F C J : U	G A A : R
	U S S : Y	R P G : L	

L Stops with wheels set at O L N, Y X V

	V C U : Y	D G N : Q	I X J : P
9	P B T : V	E A N : P	F C J : U
	Z Z R : R	~~E P M : I~~	~~U G H : S~~
	Z X R : Y @	W K L : P	K A C : T
U	C O R : R	W I L : R	O F A : K
	K F R : Y	W Z J : P	G A A : R

MENU VI.

Wheels 1 2 3

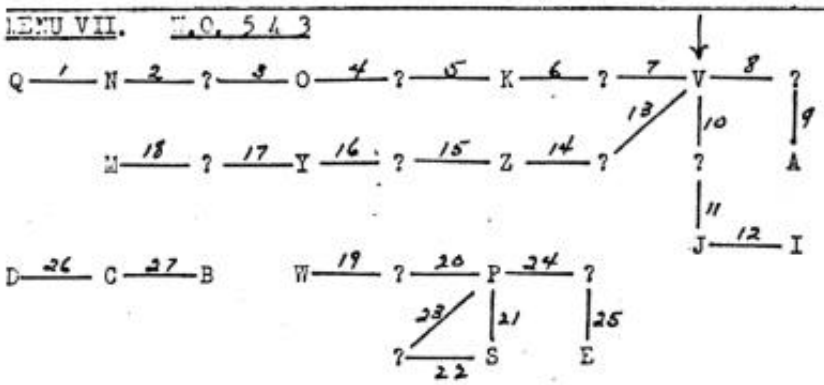


1	Z Z A	A 1 in
2	Z Z D	I (1 out, 2 in)
3	Z A D	H (2 " 3 ")
4	Z A I	F (3 " 4 ")
5	Z Z B	Y (4 " 5 ") Input I
6	Z Z O	K (5 " 6 ")
7	Z Z K	D (6 " 7 ")
8	Z A F	L (7 " 8 ")
9	Z A D	G 8 out
10	Z Z R	T 9 in
11	Z A J	W (9 out, 10 in)
12	Z A E	U (10 " 11 ")
13	Z A Y	O (11 " 12 ") Input II
14	Z A K	S 12 " 13 ")
		P (13 " 14 ")
		C 14 out

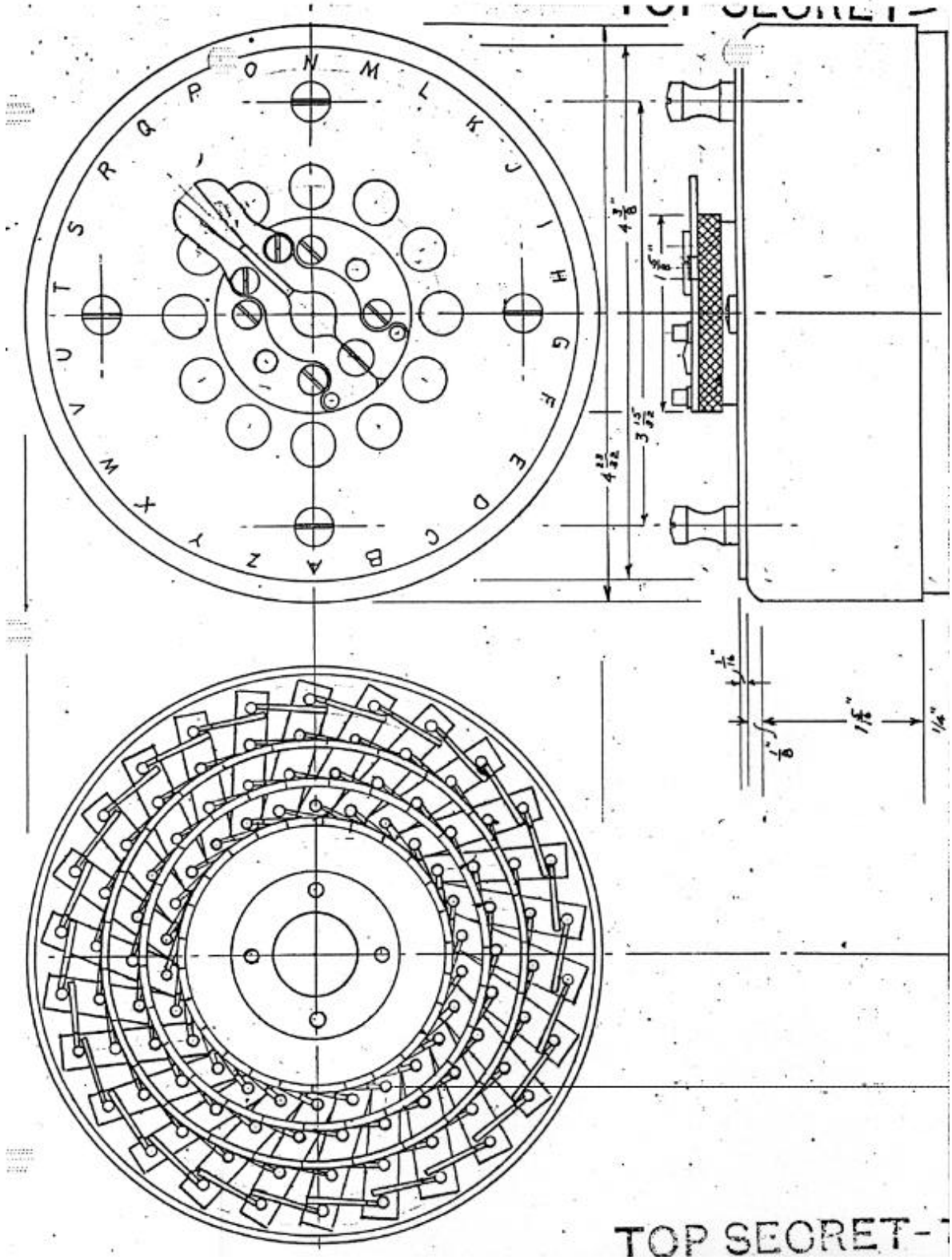
Stops ✓Aux. CHain

E V Z : E (R)	X T U : E (G)	A A N : V (O)	R I G : Z (N & R)
L V Y : G (M)	V Q Q : G (E)	B T N : Z (J)	H C F : B (L)
G T W : E (B)	B O P : B (Z)	D C N : B (B)	L X E : J (X)
R P W : J (V)	F K P : N (V)	K E K : Y (E & M)	S H C : B (O)
G X V : Y (J)	M V O : G (E)	I E K : J (F)	
B E V : J (M)	F K O : Y (T)	T O J : Y (X)	

MENU VII. M.O. 5 4 3



1 AG P	15 E N N	Stops: C K Y : H
2 E N F	16 E M Q	U R V : C
3 E M I	17 EN G	B V Q : J
4 E N H	18 E M J	Z D Q : R
5 E M K	19 E N R	I C P : U
6 E N L	20 E M U	R F M : X
7 E M O	21 C I R	P O L : R
8 E N K	22 E M L	Q A L : L
9 E M N	23 E N I	U R J : G
10 E N M	24 E M R	X B F : G
11 E M P	25 E N Q	J Q E : L
12 C I Q	26 C I P	U B E : H
13 E M T	27 A G N	D Y C : V
14 E N Q		F T B : L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The drums are mounted on a shaft extending through a commutator mounted flush in the face of the bombe. 2 sets of keys are fitted to each shaft, passing through it and extending beyond for about a sixteenth of an inch on either side. As the drum is pushed onto the shaft the first set of keys encountered consists or two pins, one behind the other which fit into a keyway inside the drum and position the drum with respect to the shaft in the direction of rotation. The second set of keys consists of one pin, at right angles to the first set,which rides on a shoulder inside the drum and determines the extent to which the drum may be pushed onto the shaft.

The drums are locked in place by the latch mechanism on the face of the drum which engages a circumferential groove near the end of the shaft. After the drum has been attached to its shaft the combination of drum and shaft may be set to any desired starting position because of a ratchet mechanism interposed between the shaft and its drive mechanism. The setting is prescribed by the menu, as for instance test menu 1 previously mentioned specifies that the drums of the first enigma shall be set at Z Z S. This means that the drums of one enigma (one fast drum with its associated intermediate and slow drums) selected as enigma no.1 shall have its fast drum set at Z, its intermediate at Z and its slow at S. The fast drum is rotated until Z on its dial is set against the pointer attached to the face of the bombe etc.

PLUGGING-UP BOMBE.

The connections indicated on the menu are made by a patching arrangement of plugs and cords. The plug consists of a rubber plastic shell 4 1/4 inches long 1 inch deep and 1 1/2 inches wide from which protrude 26 flat prongs 3/8 inch long and 1/4 inch wide. These prongs are assembled in pairs with insulating separators. The bottom of the plug is indicated by metal strip inserted in the plug shell.

The jack consists of an element 3 1/2 inches long, 1 1/2 inches deep and 1 inch wide mounted between uprights of 1 1/4 inch by 1 1/4 inch angle iron. The angle iron is notched to receive guide prongs on the side of the plug which position the plug with respect to the contacts of the jack. The springs of the jack lay in a vertical plane and like the plug are assembled in pairs. They are positioned and shaped to receive the prongs of the plug and may be described as female prongs. These jacks are mounted in columns on the rear of the bombe. Counting from the left as one faces the rear of the bombe, the first, fourth and seventh columns contain the jacks connected to the diagonal board. The second, fifth and eighth columns contain the jacks serving the commons. The eighth column also contains the input jacks. The third, sixth and ninth columns contain the jacks connected to the enigmas. These latter jacks are associated in pairs, one jack of which serves the input end and the other the output end of its enigma.

Assuming that test menu no. I is the menu to be plugged up the first step in the procedure is to tie as many enigmas together by "commoning" (or "coupling") jacks as is possible. This jack is a unit 5 inches long, 2 1/8 inches deep and 2 1/8 inches wide and consists of a jack element, described above, in a special mounting on the rear of which is mounted a double ended set of plug prongs extending in a vertical direction instead of in the horizontal direction of a normal plug. This jack is inserted between the "OUT" jack of a lower numbered enigma and the "IN" jack of a higher numbered enigma be tied together. In the case of this menu 6 such jacks would be inserted. Once inserted the jack is held in place by means of a latching mechanism on the jack which grips extension plates on the angle iron of the column. The two ends of the enigmas are thereby electrically connected lead for lead and brought out to an auxiliary jack.

The next step in plugging up the bombe is to plug the enigmas to the "common" jacks. The top set of "common" jacks is selected to connect to the "input" because of its accessibility to the INPUT jacks. A patch is made from the "comnoning" jack tying enigmas 4 and 5 to the bottom jack of this set of "commons". Similarly the junction of enigmas 6 and 7 is patched to the next to the bottom jack of this set of "commons". The junctions of enigmas 1 and 2, and 3 and 4 are then patched to the second set of commons. In addition the outer end of enigma 7 is patched to this set of commons.

Again the junction of enigmas 2 and 3, and 5 and 6 are patched to the third set of "commons". The inner end of enigma 1 is also brought to this set. Now returning to the top set of commons a patch is made to letter E of the diagonal board and another patch to INPUT CHAIN I jack. In a similar manner letter N on the diagonal board to the third set of "commons".

SETTING SWITCHES + (CHAIN, SEARCHING, CARRY, INPUT).

After the drums have been attached and the plugging finished, the next step is to set the switches controlling the chain to be used, the letter at which searching is to be done, and the type of input, single or double. These switches art located in a panel 26 1/2 inches high and 8 1/2 inches wide on the right hard end of the bombe as seen from the front. There are four columns of toggle switches. At the top of the first column is a switch labelled "CHAIN 1, OFF-ON". There are similar switches at the top of each of the other columns for chains 2 and 3. In each column below the chain switch are 26 searching switches labelled and reading downwards from Z to A. At the bottom of the second column is the CARRY OFF-ON switch. On the 30 point machine there is a DOUBLE INPUT, OFF - ON switch at the bottom of the fourth column. At the bottom of the third column is the CARRY HOME, OFF - ON switch. On the older 39 point bombe the setting of the machine for the type of input is accomplished by the insertion of a single or double input plugboard. The receptacle for this plugboard is located on the left hand end of the machine as seen from the front.

In the description above of setting up the bombe for "Test Menu No.1" the menu was only set up on 7 enigmas connected to the input of CHAIN 1. Hence CHAIN 1 switch is operated to the ON position and all other CHAIN switches to the OFF position. It is specified in "TEST MENU NO.1" that the current entry shall be at "A". The "A" searching switch in the first column is therefore operated and all the other searching switches in all the columns are restored to the OFF position. This menu is of the single input type, so the DOUBLE INPUT switch remains in the OFF position. If the bombe happens to be the old 39 point type, the SINGLE INPUT plugboard is inserted in the machine. The CARRY and CARRY HOME switches must be OFF. Operate the MOTOR and CONTROL switches. (The MOTOR switch is at the left and the CONTROL switch is at the right as you face the bombe). Depress the START key. (The START key is at the right as you face the bombe). Operate the CARRY switch when the bombe has attained its normal running speed.

BOMBE RUNNING AND SENSING - ELECTRICAL CONTROL CIRCUIT.

The bombe as it is running is essentially a mechanical mechanism operating under the control of an electrical relay circuit. This relay circuit consists of 34 control relays, 2 high speed relays and 4 sets of 26 sensing relays each for the detection of the straight or OC which indicates a possible solution, 26 stop relays for controlling the stopping of the bombe at a proper place to indicate the straight, 2 clutch magnets for controlling the driving mechanism, 2 sets of dual carry magnets for each of the three banks, 7 multi relays for closing the circuits to the indicating unit coils sets of 26 indicating unit coils, a heavy duty coil for opening the sensing circuit when The operator is verifying the indicated stop, 6 circuit breakers for making and breaking the sensing circuit with sufficient margin to prevent it being made or broken on the commentators associated with the drums, and 11 cams and contacts for controlling the time of making and breaking of the control circuits. The circuit is shown in a block diagram on page 70.

A round core relay with the spring pile-up mounted above the core is used for the control relays and stop relays. The armature is hinged at the front of the relay and acts as a lever to push the moving spring upward away from the coil. The relay is of moderately heavy construction. It is designed to operate in .007 - .008 seconds and is known as the standard general purpose International Business Machines Corp. or British Tabulating Machine Co. Ltd. relay. The two high speed relays are of the telegraph sounder type with two round spool magnets mounted vertically with respect to the base. The spring pile-up is also mounted vertically and is

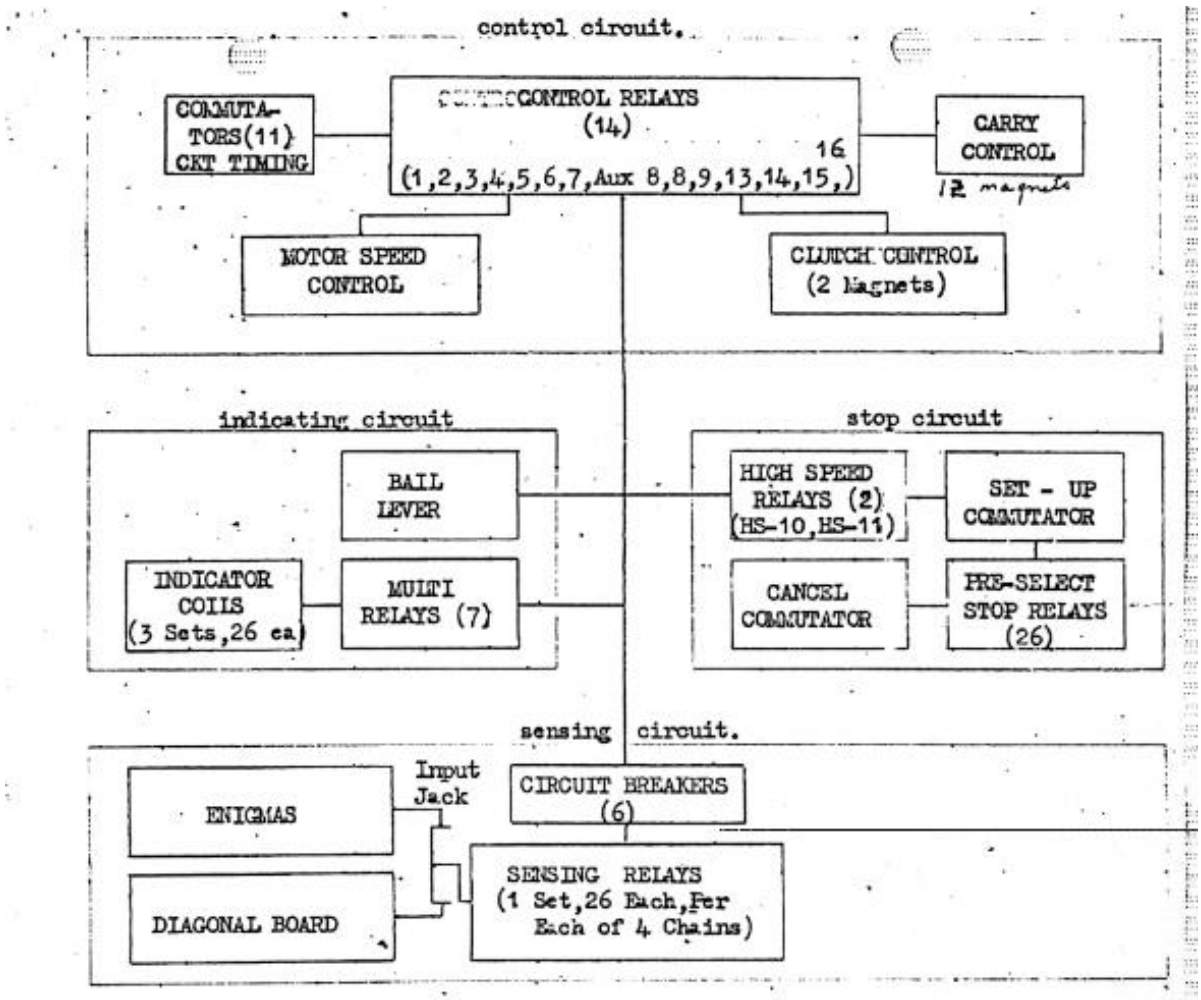

Fig. Block Diagram,Electrical Circuit of Bombe.

actuated by a long armature mounted in a fashion similar to a telegraph sounder bar. The armature lies in a plane parallel to the base and is attracted by the spool magnets. It is fixed at the end nearest the spools and attached at the other end to the moving springs of the pile-up. The so-called Siemens relay is used for the sensing relay. This relay is somewhat similar to the HS-10 and HS-11 relays but much smaller. It consists of two independent armatures each actuated by a spool magnet. The magnet spool windings are connected in series. The spools are mounted vertically with respect to the base. The springs are mounted in cantilever arrangement with the free end extending over and slightly beyond the spool magnet. The relay is of relatively light construction and is designed to operate in a minimum of .002 seconds. The two clutch magnets are connected in series and attract or release a clutch arm. This clutch arm when attracted permits a dog to engage a ratchet transmitting power from the motor to the driven mechanism. When released the clutch arm seizes the spider carrying the dog and stops the driven mechanism at the proper point. There are two sets of Carry magnets per bank of enigmas or a total of 12 magnets. One set engages the mechanism which advances the "intermediate" drums, while the other controls the advance of the "slow" drums. Each set consists of a pair of magnets connected in series and all the magnets controlling the same type of magnets for all banks are connected in series. Thus each time the C-3

cam closes its contacts, all "intermediate" drums on the bombe are advanced and each time a "hot spot" on the back of the "indicator intermediate" drum makes contact all "slow" drums advance.

The seven multi relays are of a rugged multiple contact type, each relay carrying 12 sets of transfer contacts and measuring 4 3/4 inches long, 4 3/8 inches high and 2 3/8 inches wide. The mounting of the core and the armature action resembles somewhat the "standard general purpose" relay. The horizontally mounted core attracts an L-shaped armature which, by virtue of being hinges at the front end of the relay, pushes an auxiliary armature upward. This auxiliary armature is hinged at the rear of the relay and operates the moving springs of the 12 sets of contacts through a large insulating stud mounted on the front end of this auxiliary armature. This relay is designed to operate in .012 to .020 seconds and release in .006 to .012 seconds.

The 3 sets of 26 indicating unit coils each are mounted in an assembly known as the No. 513 80 column International Business Machine Corporation Comparing Unit. Two or the columns are not used. These are the 27th and 54th columns. The energizing of one of those magnets functions a linkage which causes a pointer to give an indication on a horizontal scale. A bail lever with one pair of "make" contacts and one set of "break" contacts is also part of the indicating unit. The bail lever is operated to test the indication to insure that it is not faulty. The "make" contact operates a relay which breaks the "sensing" circuit and requires the "sensing" relay to reoperate when the lever is released. The "break" contact opens the clutch magnet circuit while the lever is operated.

The "heavy duty" relay is of identical construction with the multi relays except that it has only two sets of "break" contacts instead of 12 sets of contacts. The circuit breakers consist of heavy duty normally closed contacts which are opened at carefully timed intervals to insure that the "sensing circuit" is broken at these circuit breakers instead of at the commutators associated with the enigma drums. These contacts are actuated by a gear shaped plastic cam on which rides a roller attached to a pivoted arm carrying one of the pair of contacts. The pivoted arm is held against the toothed cam by a flat spring.

The cams for controlling the time of closing the electrical circuits resemble the circuit breakers except that the contacts are of lighter construction and the method of actuating the moving contact is slightly different. In this case one end of the moving spring is fixed and the other end rides on the surface of a cam whose contour varies from a low spot gradually to a high point and then abruptly drops to the low point. The contacts function as either "make" or "break" contacts dependent on which of the pair of springs bears on the cam.

The control commutator is made up of a disc of insulating material 1 1/2 inches in diameter and 3/8 inches thick, 2/3 or whose periphery is encased in a metal tire on which ride two spring contacts. The commutator merely serves to close a circuit between the springs while they ride on the metal tire.

MECHANISM OF BOMBE.

A mechanism consisting of drive motor, belt drive, clutch, cams (both electrical and mechanical), index wheel, circuit breakers, commutators, carry elements and drums provide the moving parts of the bombe, exclusive of the relays, and operate under control of the electrical circuit just described. The motor is a Thomson Houston Shunt Wound Direct Current 220 Volt Motor rated at 0.75 horsepower and drawing 3.8 amperes when running at 800 rpm or 3.42 amperes at 1000 rpm. The belt drive utilizes an ordinary V belt running from a pulley of 2 inch diameter on the motor to a pulley of 6 inch diameter on the clutch. The clutch is of the pawl and ratchet type, and is magnetically controlled. The power is supplied through a shaft connected by belt drive to the motor. The driving ratchet is pinned to this shaft, and when the pawl is engaged, transmits power through the driving pawl arm to the main gearing which drives the vertical drive shaft. Each pair of gears uses one fiber gear in this main gearing with the intent that in case of some mechanical bind throughout the mechanism the teeth on the fiber gear will

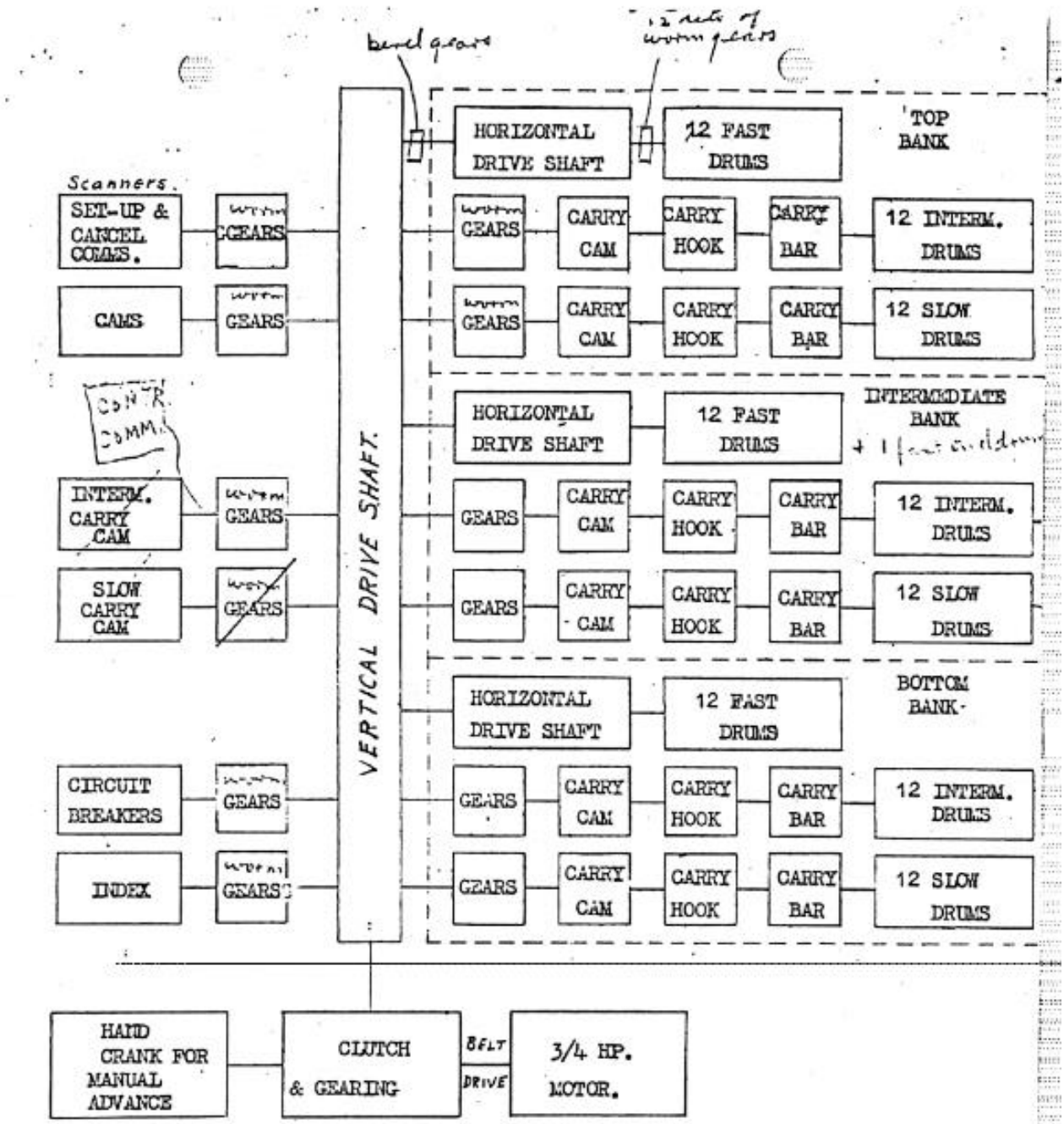

Fig. BOX DIAGRAM FOR MECHANICAL LINKAGE.

give way first, thus protecting the rest of the mechanism against damage. A hand crank is connected to this main gearing to provide a means of advancing the mechanism by hard in cases of making adjustments or repairs.

The vertical drive shaft runs in ball bearings and is supported on the lower main drive bevel gear. Three bevel metal to metal gear sets transmit power from this vertical shaft to the horizontal drive shafts driving the fast drums. All other gearing working off the vertical shaft is of the worm gear type.

The horizontal drive shafts are supported in ball bearings and drive the fast drums through 12 sets of worm drives on each shaft with an additional worm drive on the middle shaft to drive the indicator drum.

The carry cams for the intermediate and slow drums of each shaft are continuously

operated through gearing so designed that when the carry mechanism is effective the intermediate drums are advanced one position for each revolution of the fast drums; and similarly the slow drums are advanced one position for each revolution of the intermediate drums.

When the carry magnets are energized the carry hooks are engaged with the carry cams and cause the carry bars to be pulled horizontally to an extreme position and then restored to the normal position. The carry hook is attached to and hinged on the carry bar. This reciprocating action of the carry bar is translated into a rotary motion of the drum by means of a pawl and ratchet, which also serves to move the drum one position. The shafts for 12 drums are advanced with each stroke of the carry bar.

The scanners, Set-up and Cancel commutators, are driven through worm gearing from the vertical drive shaft. The bearings for these gears are simple bearings mounted in the vertical guard plate. These bearings are adequate since there is no great torque transmitted through these gears. The commutators consist of insulating discs in which are set 4 concentric rings of 26 contacts each. A brush arm with 4 brushes sweeps over the contacts on each commutator. A time relation is established between the sweep arms of the 2 commutators by adjusting them so that the brushes of the Cancel commutator make a given set of terminals before the brushes of the Set-up commutator makes it's corresponding set of terminals.

Eleven electrical cams mounted on one shaft are also driven through worm gearing from the main shaft also. These cams serve both to open and close electrical circuits at definite intervals with respect to the index. There are two types of cams, - "make" cams and "break" cams. The "make" cam closes at a definite point, remains closed for a period determined by the cam contour and then opens at some point within limits depending upon the tension of the springs. For instance cam 6 is a "make" cam and closes precisely at 30 1/2 and opens at about 17 1/2 to 18. The "break" cam opens at a definite point, remains open for a period determined by the cam contour and then closes at some point within limits. Thus cam 7 is a "break" cam and opens precisely at 26 1/2 and closes at about i3 1/2 to 14. The cam is made of fiber with a contour of the logarithmic spiral type and the determination of whether it is to be a "make" or "break" cam is dependent upon which one of its pair of springs rides on the cam.

The indicating drums and the electrical carry cams are driven by the same horizontal drive shaft and carry bars that drive the regular drums of the intermediate bank.

The control cam is a ceramic type cam with a metal tire encasing 2/3 of its periphery and is driven through gearing from the vertical drive shaft. Two brushes bear on its surface and form a closed circuit when resting on the metal tire.

Six circuit breakers on a horizontal shaft are driven through gearing from the vertical drive shaft. These breakers consist of a fixed contact and a moveable contact each. The moveable contact is mounted on an arm pivoted in the middle with the contact on one end and the other having a roller. The roller rides under spring tension on a plastic cam whose periphery has a series of 26 cupped indentations. Two of these breakers are used to close the circuit which supplies current to the sensing circuit at exactly 1/4 of a position before the index point. The remaining four are designed to break the circuit at exactly 1/4 position after the index point. With these adjustments the current flowing in the sensing circuit is made and broken on these circuit breakers and not at the commutators or relays.

The bombe is equipped with an index to provide a reference against which all timing adjustments are made. The index is a dial over which sweeps an indicator driven through gearing from the vertical drive shaft. One complete revolution of the pointer covers one sensing cycle and one carry cycle. The complete revolution is divided into 30 equal positions, 26 of which are devoted to the sensing cycle and 4 to the carry cycle.

THE CHECKING MACHINE. GENERAL DESCRIPTION.

The checking machine could be considered as an enigma machine as it has the components to perform encoding and decoding. However its construction does not facilitate encoding of text. The parts used are similar to those used in bombe construction. The checking machine is so arranged as to facilitate the testing of bombe solutions for their cryptographic worthiness. The checking machine has positions for four wheels, or drums, so that it can be used for any type of enigma work; Army, Navy or Air Force, and is built by the British Tabulating Machine Company Ltd. of Letchworth England.

INSTALLATION AND PREPARATION FOR USE. As received from the factory the machine is mounted on a wooden stand so constructed as to store the eight drums within easy reach of the operator. Drum separation cleats on the shelves are removed as it was found that their presence caused drum clip springs to become damaged.

The stecker plugboard mounted on a clip on the side of the machine stand is not necessary to the testing of the bombe solutions and so is removed and the lip cut off. The circuit through this plugboard is then wired straight through without
crossovers. This step was found to be of value in making the checking machine so that it required less repair time.

In order to preserve color coding on the drums each shell is knurled and the knurl filled with paint. The normal point on the shell, marked with a simple pin point as it comes from the factory, is replaced by a screw head for permanence and ease in use. The machine operates from regular 50 cycle 220 volt supply mains and consumes a negligible amount of current.

DESCRIPTION OF DRUMS. Checking machine drums are similar in construction to the bombe drum. They differ in two respects; the ringstellung and the brush construction. The ringstellung in the checking drum is variable whereas it is fixed on the bombe drum. Provided with a ball bearing positioning device in the hub the ringstellung comes to rest with a letter exactly opposite the normal (screw) point. The checking drum brush is made from phosphor bronze in the shape of a leaf spring and having a small upturned U at the end. The phosphor bronze material gives constant springiness necessary for positive contact with the commutator in the operation of the drum. The U portion at the end of the brush contacts the brass segments of the drum commutator. This upturned U at the tip of the brush allows the checking drum to be turned in either direction without damaging the brush.

DESCRIPTION OF PARTS. The principal parts used in a checking machine are as follows:

1. ON * OFF Switch.
2. Step-down transformer
3. 26 Letter keys (one for each letter of the alphabet)
4. Associated with the keys are twenty-six corresponding lamps each lighting a letter of the alphabet.
5. Drums and drum commutator mountings.
6. The U/W (unclewalter) turn around plug and socket.

The ON - OFF switch needs no explanation. The purpose of the step down transformer is to reduce the input volts of 220 to 75 for the lamps. The letter keys are actually a transfer switch. When the key is in the normal position; i.e. -not operated, a circuit is completed through the associated lamp. When the key is operated the associated lamp circuit is broken and battery potential is placed on the drum combination. The provision for breaking the lamp, circuit is necessary due to the fact that the German enigma machine can encode no letter as itself. The U/W plug provides the current "turn round" point as does the identically named part in the German enigma machine. There are two types of U/W plugs; one which is wired straight without crossovers and which corresponds in conjunction with the fourth drum to the "B" U/W in use at the end of hostilities. The other type of plug is the eel plug (also used in the bombe on certain cases) and which is made pluggable so as to correspond with the pluggable U/W (unkewaaltz) introduced by the Germans in July 1944.

DESCRIPTION OF THE CHECKING MACHINE CIRCUIT. The circuit of this machine is very simple. Basically there is only one circuit type and this is operated 26 times once for each letter in the alphabet.

Considering the transformer as a battery and a starting point the current for let us say the A key is traced as follows: when the A key is depressed potential is placed on the stecker board section (now replaced with straight wiring) thence to the first or right hand commutator and drum. As the commutators are connected together in sequence from right to left the circuit passes through the four drums in the haphazard drum wiring to the U/W where the current is turned to go through the drums again, this time from left to right and along a different haphazard wiring set up to return to the first commutator at any of the 25 remaining letters or commutator segments. Let us suppose this letter is Z; the circuit now goes from the right hand
circuit and lighting the Z lamp. This Z is now interpreted as the stecker of the letter at the other end of the link being tested.

MANNER OF OPERATION. The operation of the checking is fully described in all its phases on pages 12 to 23 inclusive.

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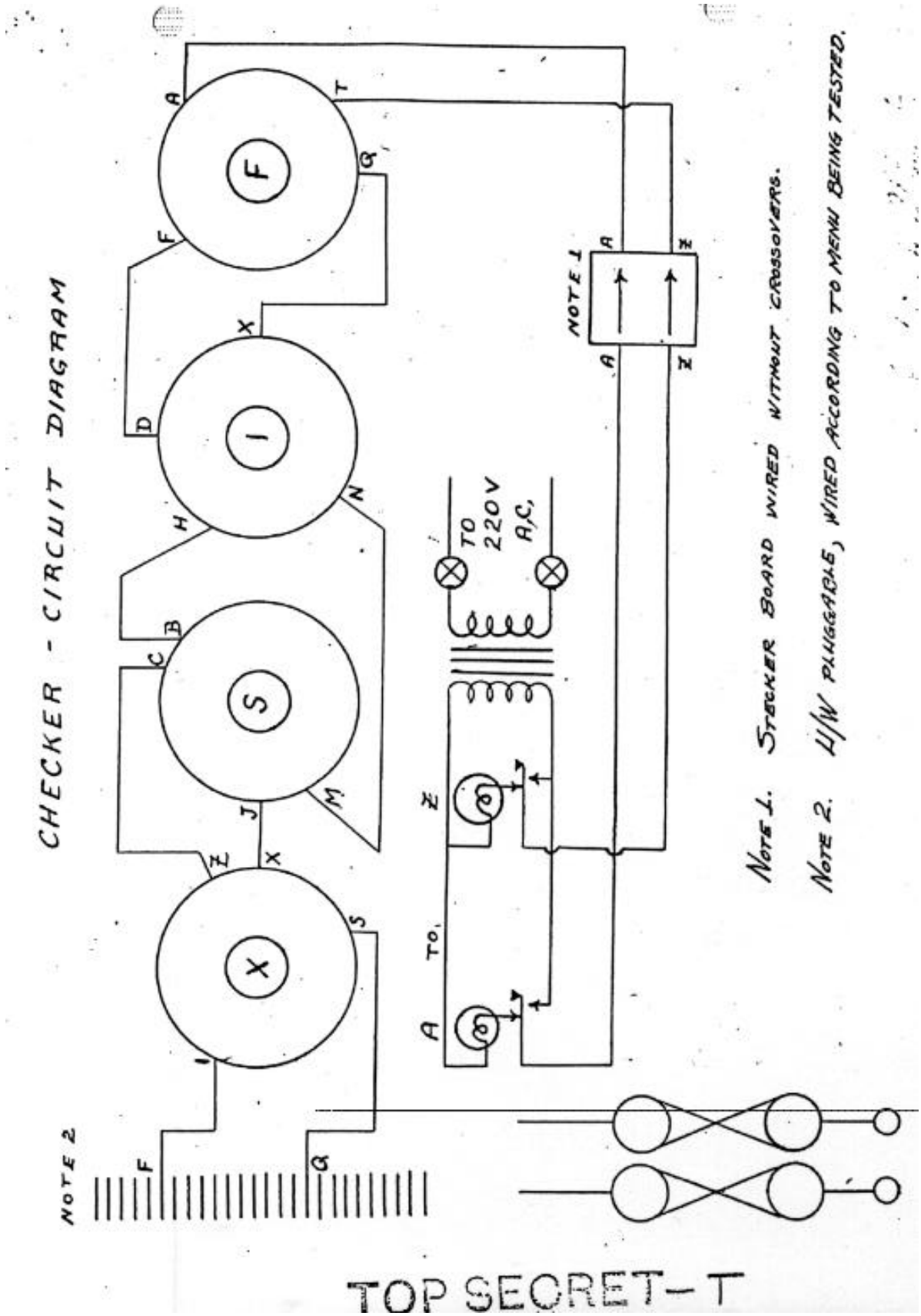
CHECKER - CIRCUIT DIAGRAM
F
I
S
X
NOTE 1
TO 220V A.C.
TO
NOTE 2
NOTE 1. STECKER BOARD WIRED WITHOUT CROSSOVERS.
NOTE 2. U/W PLUGGABLE, WIRED ACCORDING TO MENU BEING TESTED.
TOP SECRET-T