SPIDERS

SPIDER NUMBER 3 =JUMBO

3

TERMINOLOGY

Spider 3 has 36 enigmas, each of which has an input and an output consisting of two sets of 26 terminals. There are three DIAGONAL BOARDS. Each diagonal board consists of 26 rows of terminals which are called row A, row B, ..., row Z. Each row of the board consists of 26 terminals or POINTS, which will be denoted by small letters. Thus Pd denotes the d point of row P. There are also three STECKER BOARDS each containing 351 *(361 ?)* points corresponding to the possible stecker, and each stecker board is associated with a diagonal board. Every point of a diagonal board corresponds to a stecker and is connected to the point of the associated stecker board which represents that stecker. Thus the terminals Pd and Dp both correspond to the stecker P/D and are connected to the same point of the stecker board.

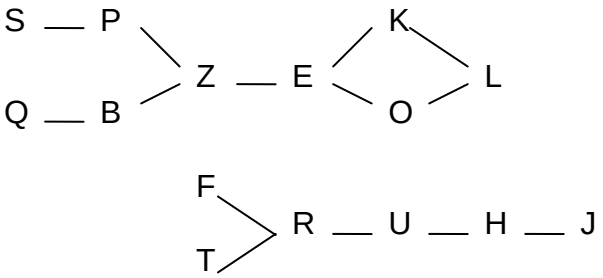
The spider has four INPUTS, which must not be confused with the enigma inputs. Each spider input is a set of 26 terminals or LINES. When the spider is in action the main current enters the spider at one of the lines of an input, and this line is known as the CURRENT ENTRY LINE. (The current entry line must not be confused with the spider input.) Each input is associated with a set of 26 switches, which control the current entry line , and with a set of 26 sensing relays, whose action can cause the spider to stop. The wiring will be described later. Three of the four inputs are also associated with sets of 26 SEARCHING RELAYS which control the current entry switches. The fourth input is only needed for “double input” jobs, as will be explained later.

When the spider is in use on a normal job the inputs and outputs of a number of the enigmas are connected to certain rows of one of the diagonal boards according to a “menu” and one of the spider inputs is connected to a suitably chosen row of this diagonal board, the expression INPUT AT K meaning that the spider input is connected to row K of the diagonal board. This configuration is known as a BANK and it is possible to run three banks at a time. In the account that follows only one bank will be considered.

The alphabets of the wheels of the 36 enigmas are adjusted to German ZZZ ringstellung. In addition to these wheels there is a set of three RECORDING WHEELS which move with the enigmas and are used to record the German ringstellung corresponding to any position of the spider.

STANDARD PROCEDURE

A MENU is composed of one or more webs, such as



and an input is chosen in the first web, say at E. For any particular ringstellung the assumption of a stecker for E, say E/Y, leads to at least one stecker for all the letters of the first web and may lead to stecker for the letters of the second web. The chance of obtaining a contradiction depends on the lengths and number of closures of the webs. Any contradiction on the first web, i.e. two stecker for one of the letters of the first web, leads immediately to two stecker for every letter of the first web. Thus, with a reasonably long first

web, it is highly probable that a stecker for E which involves a contradiction on the first web will cause this web to “fill up”, that is to say it will lead to all stecker of all letters of the web. A contradiction on the second web will tend to make the second web fill up, and this tends to give contradictions on the first web. A contradiction which is off both webs does not lead to further contradictions.

In any position of the spider the points of the diagonal board which are connected to a line of the input, say Ey, are exactly those which correspond to the stecker that can be deduced from the assumption E/Y by means of the webs of the menu. We are looking for a ringstellung such that some stecker of E does not lead to contradictory stecker, so the spider is looking for a position in which the diagonal board points connected to some line of the input are such that no two of them belong to the same row. In such a position the stecker involved are said to constitute a STORY.

The spider input is said to be FULL when each line is connected to every other line. When the input is not full we say that GROUPING occurs because the lines of the input are divided into a number (greater than one) of groups, each line of a group being connected to all other lines of that group, but to no other lines of the input. When a line of the input, say Ex, is not connected to any other line of the input, we say that there is a STRAIGHT on Ex. By far the commonest type of grouping is that in which there is one straight and the remaining lines form a single connected group. Any other form of grouping is known as BOXING.

Supposing that current enters the spider on the y line of the input. Then, if E/Y is a true stecker, there must be a straight on Ey when the spider is in the correct position, so that the current does not reach any other line of the input. If on the other hand some other letter, say G, is the true stecker of E, there must be a straight on Eg, so the current which enters on the y line does not reach the g line of the input. In fact in the correct position there must be a straight, so the input is not full, and grouping must occur. But every case of grouping does not necessarily imply a straight, and a straight does not always imply a story because a straight may involve contradictions off the first web.

The number of positions in which grouping occurs depends on the size of the webs and on the number of closures. When the webs are large enough the occurrence of boxing is most unlikely but with the smaller webs that will become workable on Spider 3 cases of boxing will undoubtedly arise, and must be taken into account. However, with webs of any reasonable size, the input will still be full in the vast majority of positions of the spider, and this fact enables us to save a considerable amount of time by dividing the spider’s work into four stages, as follows.

<u>Stage 1</u>

The current entry is on a fixed line of the input, usually the a-line. The sensing relays detect any position in which the input is not full, i.e. any position in which grouping occurs, by the fact that in these positions at least one line of the input is not energised. When a grouping position is detected, the middle wheel carry is put out of action and the fast wheels perform one revolution and stop in the exact position. This is known to Tab as PRESELECTED STOPPING.

<u>Stage 2</u>

When the spider has stopped, the searching relays change the current entry to each line of the input in turn and any line on which there is a straight is detected by the fact that when the current enters at this line no other line is energised. This scanning process is necessitated by the possibility of boxing, so the process itself has come to be known to Tab as the “boxing” process. If no straight is found, as will happen in the case of a 24/2 boxing, the spider is automatically restarted. When a straight occurs a typewriter records the bank involved, the German ringstellung, and the SIGNIFICANT LETTER, i.e. the line of the input on which the straight is found.

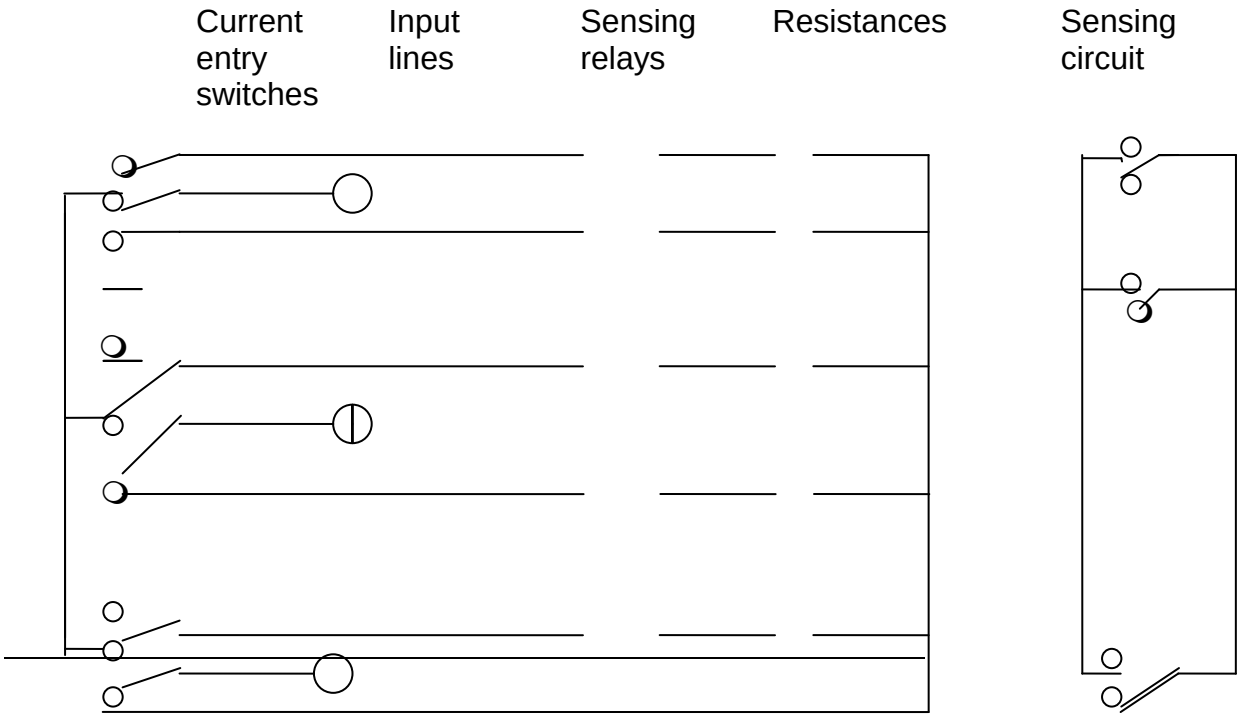
Stage 3

Each straight is tested for contradictions by the MACHINE GUN, so called because of the noise it makes. With current entry on the straight the machine gun examines each row of the diagonal board in turn and discards the straight if in any row two or more points are energised. In any stopping position there may of course be more than one straight to test, and these are tested in turn. The typing mentioned in Stage 2 is actually done while the machine gun is testing.

Stage 4

When a straight survives the machine gun test, the machine gun runs over the rows of the diagonal board again, and the stecker are typed. This second run is not made when a straight is discarded by the first run. When all the straights have been dealt with the spider is automatically restarted.

THE SENSING RELAYS



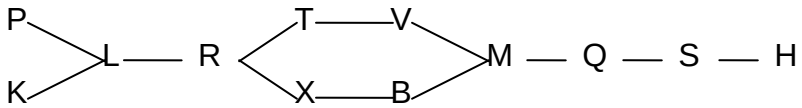
Each sensing relay has two windings, in opposite directions, and the relay is “up”, i.e. the relay switches operate, when current passes through one coil but not through the other. When current passes through both coils or through neither coil the switches do not operate, and the relay is in its normal or “down” position. The negative terminals of both coils are connected to the negative side of the main spider circuit, shown by the green line in the

diagram. Normally the positive end of the primary coil is connected to the positive side of the main circuit, shown by the red line, and the positive end of the secondary coil is connected to the corresponding line of the input. But a current entry switch breaks these two connections and connects the line of the input to the positive side of the main circuit. For example in the diagram the A current entry switch is on, so current enters the spider on the a-line of the input, and the A sensing relay is out of action and therefore down. If the input is full, all the lines of the input are connected to the positive side of the main circuit, so all the sensing relays are down. On the other hand if grouping occurs, at least one of the sensing relays is up. The sensing circuit, which detects grouping, is extremely simple. The positive and negative sides, shown by brown and violet lines in the diagram, are connected whenever one of the sensing relays is up.

When the spider is running, a make and break switch in the main circuit ensures that current only enters the enigmas when the wheel brushes are in contact. Whenever the positive and negative sides of the sensing circuit are connected the spider stops. Preselected stopping and boxing introduce other circuits and relays, which I have not shown in the diagram. The resistances in series with the coils of the sensing relays are to ensure that the same, current passes through the secondary coils regardless of the path through the spider, and to avoid back circuits.

It should be noticed that, with current entry on the a-line any straight is detected by the fact that the corresponding sensing relay goes up, unless there happens to be a straight on the a-line. In this case all the sensing relays other than the a-relay go up, and the existence of a second straight will not be detected unless the current entry line is changed, as is done automatically in Stage 2 by the searching relays which control the current entry switches.

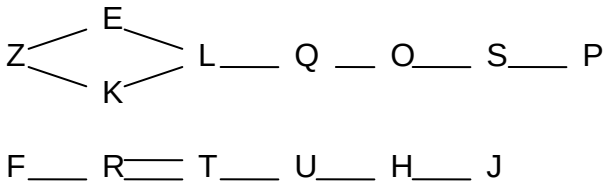
In the case of a long web such as



a suitable choice of the current entry line may help to reduce creepers. For instance, if the input is at L and the current entry line is the q-line, the current starts at two places on the web, and has a better chance of getting where it should.

DOUBLE INPUT FOR TWO WEBS

Consider the problem presented by two disconnected webs.



Two inputs are used, one on each web, say at Q and T. This means of course that one input is connected to the Q row of the diagonal board and the other to the T row. The current entry is on the t-line of the first input and on the q-line of the second input. These lines are actually connected through the diagonal board, but the double current entry is desirable for electrical reasons. The sensing circuits associated with the two inputs are connected in series, so that the spider only stops when grouping occurs on both inputs.

If Q/T is a true stecker, in the correct position there will be a straight on Qt in the first input and a straight on Tq in the second input, these two straights being essentially the same. If Q is not steckered to T suppose that Q/X and T/Y are true stecker. Then there will be a straight on Qx in the first input and a straight on Ty in the second. Thus the spider will stop in the correct position. To save time stages 2, 3, and 4 will only be performed on the first input. Some stories may therefore give only the stecker of letters of the first web because the straight in question has failed to get onto the second web, but the fact that the spider has stopped indicates that grouping occurs on the second input, so that there is probably a straight on the second web, which can be found by hand methods.

The fourth input, with its current entry switches and sensing relays, will enable us to run two double input banks at a time.

PLUGBOARDS

The detachable plugboards used by Tab fit on to a board of 680 terminals, any two of which may be connected by inserting plugs at the back or outside of the plugboard. On Spider 3 these plugboards are use for four purposes.

1) The umkehrwaltz connections of the 36 enigmas are made by plugboards, so that a change of umkerhrwaltz can be made very quickly by interchanging plugboards.
2) The stecker boards are standard terminal boards, so that any particular set of stecker can be shorted by the insertion of a plugboard.
3) The wiring of the three recording wheels is taken out to a plugboard by means of which it will be possible to prevent the spider from stopping at certain prescribed ringstellung positions. This CUT OUT control will operate on all banks of the spider, and the setting of the enigma wheel alphabets to German instead of English ZZZ allows us to use the same plugboard for all wheel orders.
4) When for particular jobs it is necessary to make the current entry for Stage 1 at a line of the input other than the a-line , this can be done by means of a plugboard. This procedure is necessary because the current entry switches are operated by the searching relays.

THE STANDARD SPIDER

Some of the refinements introduced in Spider 3 are not needed for ordinary work, and some of them require more time in construction than we can spare at present. Accordingly it has been agreed that future spiders are to be constructed to a standard specification. However, when time permits or when it becomes necessary, these refinements can be added to any one of the standard spiders. The big saving in time of construction will come from the exclusion of the processes of boxing, machine gunning and tying, which reduces the procedure to Stage 1. The stecker board and the ringstellung cut out are also excluded, because they are only needed for special problems, but their inclusion on any particular spider will not cause serious delay. The connections between points of a diagonal board which represent the same stecker will be made direct. English ringstellung will be used on the standard machine, but an adjustment to German ringstellung must be made on any spider to which the ringstellung cut out is fitted. Another refinement that will probably be added to one or two of the spiders for naval work is a device to deal with the two alphabet

problem. The exact nature of this device has not yet been decided, but it will probably be based on the method now in use on the B.P. spider.

The specification of the standard spider is as follows :-

a) 36 enigmas with alphabets set to English ZZZ.
b) 3 recording discs with two alphabets in opposite directions.
c) 4 sets of sensing relays.
d) 4 sets of current entry switches connected with four inputs.
e) 3 diagonal boards.
f) preselected stopping.
g) significant letter indicators for the four sets of sensing relays.
h) Umkehrwaltz plugboards.

The outer and inner alphabets of the recording discs will show the ringstellung and wheel positions respectively. The expression “inner recording on P” means that at the beginning of a run the inner alphabet of the disc in question will be set at P, and that when a stop occurs the reading of the inner alphabet is recorded. Three distinct procedures are likely to be used .

1) Ringstellung recording, i.e. outer recording on Z for all three discs.

2) Enigma position recording :- If the initial position of a certain enigma is KBT, the position of this enigma at a stop is obtained by inner recording on K, B and T.

3) Mixed recording, i.e. position recording on the slow and medium discs and ringstellung recording on the fast disc.

In running the standard spider the input and current entry line are chosen with a view to reducing creepers. When a stop occurs readings will be taken from the recording discs and significant letter indicators. When a stop shows a straight on the current entry line and there is thought to be a danger of boxing, another current entry line must be tried before the spider is restarted to see if there is a straight on some other line of the input. To save time in operation the significant letter indicator and current entry switches will be near the recording wheels.

Double input jobs for two webs may be run as on spider 3, the four sets of sensing relays allowing two banks to be run at a time. When a stop occurs, significant letter readings will be taken on both inputs of each bank. If there is a straight on the current entry line, this line must be changed to see if there is another straight. For example suppose that on one bank the inputs are at Q and T, and that U is another letter of the second web. Normally the current entry lines are Qt and Tq, but if there is a straight on these lines the current entry on the second input should be suppressed and that on the first input changed to Qu to see if there is another straight on each input. When the webs are sufficiently long to make boxing extremely unlikely, this precaution may be considered unnecessary.