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SECOND NOTE ON POSSIBLE DEVELOPMENTS

19.9.41

Since the first note was written quite a lot of progress has been made and we are nearer to a definite decision on future plans. The Super Test Plate has not been altered, and I propose to call this machine the "Quagga". Keene is getting ahead with the designs and has not yet discovered any insuperable difficulties. Turing has pointed out that various tables can be produced which will enable us to calculate the best method of using a Quagga for any particular problem. Aitken has pointed out that, for dealing with hand menus which involve rather too much work in the D.R. and M.R., it would be very useful to have a one bank Jumbo which could be used in combination with a Quagga. I am now quite convinced that we need a one bank machine, and propose to call it a "Baby Jumbo". Thanks to a suggestion from Lawn the Super Jumbo "B" has been completely superseded by a 676 relay machine working on a different principle, which I propose to call the "Mammoth". Finally, I now think that all future Jumbos should use Keene's "cast iron" scheme.

Our problems fall into two classes :- "Full range" problems, in which we have to try 17,576 positions per wheel order, and "Short range" problems in which we only have to try a few positions.

Short range problems are at present dealt with by hand, and extremely weak menus can sometimes be used. The main difficulty is apt to be the large amount of time required; we hope to be able to reduce this by using Baby Jumbo and the Quagga, and so to increase the number of problems of this type that can be tackled. Full range problems need bombes and strong menus. The menus have to be strong enough to reduce the running time and the time required for testing to reasonable proportions. We hope to reduce the minimum strength of menu that is required by producing improved bombes and by using the Quagga for testing.

When Jumbo was designed, we expected to want to run weak menus on a limited range, so the machine had to be able to deal with any kind of grouping. In theory Jumbo will deal with any menus, however weak, and will not fail to record the correct story, but of course the running time becomes prohibitive when a weak menu is run on the full range. In fact, Jumbo is a machine which takes no risks, but the limited range jobs, which we expected to run, no longer exist, and the performance of Jumbo on the type of menu that the time factor allows us to run on the full range could be considerably improved by allowing the machine to take certain very slight risks.

We have already considered the possibility of making a menu runnable by taking the risk of assuming either that a certain number of letters of the menu are self-steckered (diagonal selection) or that some letter of one chain is steckered to some letter of another chain (subsidiary chain control). I now think that it would in many cases be far more profitable to take the risk of assuming that in the correct position there is a 25/1 grouping on the main chain.(This means that all stecker of a letter of the main chain other than the correct stecker form one group, any one member of the group implying all the others). In some cases it may be reasonable to assume that there is also a 25/1 grouping on a subsidiary chain in the correct position.

The double input method had not been discovered when Jumbo was designed, so the machine suffers from the serious disadvantage of not being able to record the significant letter on the subsidiary chain. This will, I hope, be rectified on the second Jumbo, but it seems a pity not to do more. When in a double input job we have one straight on each input it would be a great advantage to be able to do a more complete test by comparing the stecker implied by both straights whether they are connected or not, and this will I think be possible on a modified Jumbo as well as on a Mammoth, if we are prepared to assume a 25/1 grouping on both chains.

As the Baby Jumbo will be used for short range problems, it cannot make use of 25/1 assumptions and must work on the same principle as the existing Jumbo. It might be profitable to fit Baby Jumbo with a device suggested by Lawn, which would give simultaneous chain control while the bombe is running.

The Super Jumbo “B” had the disadvantage that it could only be used with a definite self stecker assumption. This is overcome in the Mammoth by using a different principle for testing. On any bombe a choice of current entry line is equivalent to a stecker assumption, which may either be used directly, by examining the implied stecker, or indirectly, by examining stecker that are not implied The indirect method is used on existing bombes for detecting straights because it does not involve relays going up for every position of the bombe, but the direct method is used on Jumbo for testing straights. On Super Jumbo “B” it was proposed to use the direct method, with current entry on a self stecker; this would have meant that a number of relays would go up in every position of the bombe, which is too much to ask of any relays. The Mammoth works on the indirect method, which does not put too heavy a strain on the relays and enables us to run menus without a self stecker assumption when we want to do so.

I will now discuss in some detail the Mammoth, the 25/1 Jumbo, and the Baby Jumbo as I picture them at the moment. I expect they can be improved still further.

The Mammoth.

There are three diagonal boards and 676 differential relays forming a relay board of 26 rows and columns. The positive ends of the primary coils of the relays are connected to the corresponding points of the second diagonal board. The positive ends of the secondary coils of therelays are connected to the corresponding points of the third diagonal board. The negative ends of all primary and secondary coils are connected to the negative side of the main circuit through resistances. A relay goes up when current passes through one coil but not through the other.

Consider a menu in which the letters of the main chain are A, B, C, ..., H, and suppose that we are prepared to assume a 25/1 grouping on the main chain in the correct position. The menu, which may include a number of subsidiary chains, is plugged to the first diagonal board in the usual way. The rows A, B, C, ..., H of the first diagonal board are plugged to the corresponding rows of the second diagonal board. The rows A, B, C, ..., H of the third diagonal board are plugged to the positive side of the main circuit. The current entry will be at some point of the first diagonal board. Thus the only relays which can operate are those which are either in one of the rows A, B, C, ...,H, or in one of the columns A, B, C, ...,H, of the relay board. One of these relays will be up if it is not

connected to the current entry point, i.e. if the stecker represented by the relay is not implied by the stecker represented by the current entry point.

Suppose first that we have an ordinary input, with 26 associated sensing relays, which is plugged to the B row of the first diagonal board, and suppose that the current entry is on the a line. Whenever the input is full, all relays of the relay board are down. When there is a straight on some line of the input other than the a line, say on the k line, and when the grouping on the input is 25/1, all relays of the relay board will be down except those corresponding to the stecker of A, B, C, ..., H which are implied by B/K. When there is a straight on the current entry line all the operative relays on the relay board will be up except those corresponding to the stecker implied by B/A. If there were two or more straights on the input, at least two relays in each of the rows A, B, C, ...H of the relay board would be up, and the machine could not tell which relays corresponded to which straight.

Thus, if we assume a 25 / 1 grouping and also assume that B is not steckered to A, the correct story will be detected by arranging that the machine will stop when :-

1) Some input relay is up.

2) Not more than one relay is up in any row of the relay board.

The machine will not stop for any straight which involves a contradiction of the form A / Y, C / Y, when Y does not occur on the main chain. in fact the machine will only stop for a story, and, when a stop has occurred, the story can be recorded by means of the relays which are up on the relay board.

If there is a subsidiary chain involving the letters P, Q, R, ..., U, this chain will help to fill the input, but will not help to throw out a story by a contradiction of the form A / Y, P / Y, because the relays P / Y and Y / P of the relay board are not operative. Suppose that we use a second input, plugged to the P row of the first diagonal board, and plug rows P, Q, R, ..., U of the second and third diagonal boards to the corresponding rows of the first diagonal board and the positive side of the main circuit respectively. The relays of the relay board corresponding to all stecker of P, Q, R, ..., U will then be operative. The current entry can still be on the a line of the B input, and there need be no current entry line on the P input. Suppose that the machine will only stop when :-

1) Some relay is up on each input.

2) Not more than one relay is up in any row of the relay board.

Suppose that the correct stecker of B and P are M and N. Then in the correct position there will be straights on the lines Bm and Pn and the implied stecker relays on the relay board will be up. Unfortunately, a second straight on the subsidiary chain would make other relays in rows P, Q, R, ..., U of the relay board go up, which would prevent the machine from stopping. Consequently we cannot use the machine in this way unless we are prepared to assume a 25 / 1 grouping on the subsidiary chain as well as on the main chain. On the other hand the method is extremely powerful in cases in which it is reasonable to make this assumption.

When a subsidiary chain is reasonably strong but not strong enough to justify a 25 / 1 assumption, we can reduce the number of stops by insisting that some relay of the P

input must be up without plugging up the rows P, Q, R, ..., U of the second and third diagonal boards.

For dealing with weak menus we can also make use of definite self stecker assumptions. For example, suppose that we are prepared to assume a 25 / 1 grouping on the main chain but not on the subsidiary chain. We can make the assumption P / P by putting current in at all lines of the P input except the p line and having no current entry on the B input. When this is done it is of course safe to plug rows A, B, C, ..., H and P,Q, R, ..., U of the diagonal boards, so we shall be testing on both chains. If P / P fails we try Q / Q, R / R ...

The Mammoth has two obvious snags. In an ordinary job, when only one current entry line is used, a straight on the current entry line would cause a large number of relays to go up, and this may well be serious for electrical reasons. Also, when a menu contains a number of weak subsidiary chains, the Mammoth will fail to discard some stories which could be discarded by an examination of the implied stecker of the letters of the subsidiary chains. The first snag could be overcome by always using at least two current entry lines, e.g. Ba and Bc, but both snags can be removed, if we are prepared to introduce the following further complications.

I believe it is possible to arrange the wiring of the input sensing relays so that :-

1) The machine will only stop when one and only one of the input relays is up.

2) When the machine has stopped, the current entry line is automatically switched to the line corresponding to the one relay that went up.

Consider first a menu with one main chain, on which we are prepared to assume 25 / 1 grouping, and a number of subsidiary chains. The rows of the second and third diagonal boards corresponding to the letters of the main chains are plugged as before. The rows of the first diagonal board which correspond to the letters of the subsidiary chain are plugged to the corresponding rows of the second diagonal board through the points of 26 way relays, whose contacts are only made when the machine has stopped. Finally, it is arranged that, when the machine stops, the connection between the positive side of the main circuit and the third diagonal board is broken.

With this arrangement the running of the machine is not altered, but, when a stop has been caused by a straight, the machine will come to rest with the relays of the relay board acting as single coil relays and with the current entry line on the straight. The operative relays will be those corresponding to all stecker of all letters of the menu, and the relays that are up will be those corresponding to all stecker directly implied by the straight. If the implied stecker of some letter of a subsidiary chain introduces a contradiction which did not show up in the indirect running test, this contradiction will show up now, and the machine will be automatically restarted. If there is still no contradiction, the story will be recorded.

This idea of following an indirect running test by a direct stationary test can also be applied to menus in which we are prepared to assume a 25 / 1 grouping on each of two chains, by using another special input. We should then be making use of the stecker of all

letters of both chains in the running test, while the implied stecker of letters of other subsidiary chains would be used in the stationary test.

Incidentally, it may be profitable to introduce diagonal selection on the Mammoth, but I think that subsidiary chain control has been superceded by the simultaneous testing of straights on two chains, which is one of the most striking features of the machine.

The 25 / 1 Jumbo.

Keene's "cast iron" wiring of an input has a similar effect to that of the special input for the Mammoth, but it is slightly more complicated. It ensures that the machine will stop either when one relay is up and the rest down or when one relay is down and the rest up, but in no other circumstances. It also ensures that, when a stop occurs, the current entry line is automatically switched to the isolated line of the input, so that a machine gun test can be made immediately, without the scanning process. If the cast iron method is used on a Jumbo, we shall only be able to use the machine when it is safe to assume a 25 / 1 grouping on the main chain of a menu, but this is not likely to rule out any menus that we should think of running as full range jobs on the present Jumbo.

When a menu contains two chains, on each of which we are prepared to assume a 25 / 1 grouping, we can use two cast iron inputs with one diagonal board and prevent the machine from stopping unless there is one straight on each chain. When the machine does stop the current entry will be switched to the straight on each input, so the machine gun test will test the two straights simultaneously, which is a great advantage.

Baby Jumbo.

I am not yet quite clear about this machine. The basic idea is that it should be similar to the existing Jumbo, but, as it will only have one bank, we may be able to introduce refinements which would be impossible on a three bank machine. The refinements that I have in mind are as follows

1) For short range jobs it would clearly be a great advantage if, once the menu is plugged up, we could set the bombe to any ringstellung either by pressing certain keys on three keyboards, or by three sets of 26 switches, or by setting three special wheels and then using a control switch.

2) For some jobs we might like to use auxilliary chain control, and if it is to be any use we must prevent the bombe from stopping for a straight that fails to get onto the subsidiary chain. This could be done by associating a differential relay with each point of the diagonal board which corresponds to a letter of the main chain being steckered to a letter of the subsidiary chain, and insisting that the machine shall not stop unless one of these relays is up. It seems likely that at most 60 relays would be needed for this purpose, but the plugging of the relays to the proper points of the diagonal board may be a lengthy process unless more relays are used, some of which will not be in action. The plugging could be done fairly easily, if six or seven rows of 26 relays were used.

3) Diagonal selection can also be introduced by having relays associated with the self stecker points of the diagonal board.

4) More use might be made of a subsidiary chain. On the present Jumbo system, when a double input job is being run, a stop can only take place if there is a relay up on the second input as well as on the first. When the machine has stopped, the first input is scanned. Current is put in at each line of the first input in turn, and a line on which there is a straight is detected by the fact that current entering on this line fails to reach any other line of the first input. A straight on the second input is lost at this stage unless it happens to be connected with a straight on the first input by a cross stecker between the two chains. We could arrange to scan the first input by putting the current in at every line but one, leaving out each line in turn. A straight on the first input, say on line q, would be detected by the fact that the q relay would go up when the current entry is on all lines but the q line. If there are also straights on the second input, say on the x and y lines, then the x and y relays of the second input will also be up, so these straights will not be lost. It may thus be possible to arrange that the machine gun will make successive tests, first with the current entry on the q line of the first input and on the x line of the second input, and then with current entry on the q line of the first input and on the y line of the second input.

5) It has been arranged that, on bombes 7,8, ..., the outer enigma wheels are the slow moving ones. This was done because in certain cases we may want to alter the menu slightly according to the position of the outer enigma wheels. For example we might want to arrange that, as the slow recording wheel moves from K to H, the middle wheel of the 10th enigma moves one place forward. It is of course possible to do this by hand, stopping the bombe when the middle and fast wheels have completed a 676 cycle and moving a particular middle wheel by hand, but this will be a slow process and will probably involve going round to the back of the machine to make sure that the adjustment has been made correctly. It would be a great advance in design if the alteration could be made automatically.