Note by Eachus

RESISTANCE METHOD OF MAMMOTH SENSING

(The scheme is described for us with a standard three wheel bombe, but it is applicable to a four wheel machine)

It is suggested that Mammoth testing may be done with relatively little additional equipment if we depend on the sensing relays of the bombe for the detection of straights. For the present purpose it is enough to remember that when the bombe reaches a position in which a straight occurs, one of these relays closes a circuit which results in the bombe stopping. The function of the additional equipment will be to break this circuit in most cases when the straight contains a "legal contradiction". Testing will be done in columns composed of points of main-chain rows, and only those stecker required by the main-chain straight will enter into the testing.

Suppose that a new board, to be called a "resistor board", 26 x 26, analagous to the diagonal board, but without diagonal wiring, is constructed. Let points of main-chain rows of the resistor-board be connected to the corresponding points of the diagonal board, and let the other points of the resistor board be earthed. Suppose the point of the diagonal board usually called the "input point" be kept a earth potential, without altering the sensing circuit. (That is, use the negative side of the supply for input). On the diagonal board, points of main-chain rows and columns will be earthed (via the enigmas, to the "input point") unless they are points of the straight. On the new board, with the connections mentioned, every point will be earthed, unless it is in a main-chain row, and is also a point of the straight. The testing apparatus must determine whether or not there are two points in some column not earthed – that is, if some letter is steckered to two different main-chain letters.

We proceed as follows:

To each point of the resistor board, connect on the right a resistance of value R, and common these by columns. (These common connections will be called "test leads" for the respective columns). To each resistor board point of main chain rows, connect on the left a resistance of value N, and let all these resistors be connected to the potential source which supplies the sensing relays.

We now find that the test-lead for a column not containing a point of the straight to be connected only to earth, and is therefore at earth potential. If a column contains one point of the straight, the electrical paths through the wiring of that column is that of diagram 1. If there are two points of the straight in a column, we have the situation of diagram 2. Recalling that all points of the straight are connected to one another via the enigmas, and that one relay will be connected to the straight, it is seen that the various column-circuits combine to diagram 3.

Computation shows that the potential of a test lead will be $^1/_{26}$ that of the straight if there is one point of the straight in the column, and $^1/_{13}$ that of the straight if there are two points of the straight in the column.

If there are ‘a’ columns with one point of the straight, and ‘b’ with two, if the relay resistance is 5000 ohms, N = 5000 K and R = 5000 L, then the resistance from the high voltage to the straight is

$$\frac{5000K}{a+2b+K}$$

and the resistance from the straight to earth is:

$$\frac{26x5000L}{25a+48b}$$

If the input voltage is 200, the potential of the straight will be:

$$\frac{26(a+2b+K)L}{(26L+24K)(a+2b)+(26L+a)K}\ x200$$

If K = 5 and L = 40, the straight-potential will be about 185 volts, and is nearly independent of ‘a’ and ‘b’. There is a residual voltage of 15 across the relay corresponding to the straight.

The problem, then, is to break the stop-circuit if some test lead reaches a potential of 14 volts, but to avoid breaking it if no test lead gets above 7 volts. Let each test lead be wired to the grid of a valve, and let the plate circuits of these twenty six valves be put in parallel with one another, and in series with the coil of a relay. Let the valves be biased so as to give essentially no current for a grid-potential of 7 volts, but relay-operating current for a 14 volt grid potential. Let the relay be of the normally-closed type, and put the relay contacts in series with the stop-circuit. Thus operation of the relay will prevent the stopping of the bombe.

There remains one problem, to assure the bombe stopping if the straight is on the input line. In this case, all the test leads rise to a potential far above 14 volts, and we may make use of this by a twenty-seventh valve and a second relay. Take one test lead to the grid of the valve, bias the valve to operate the relay at, say, 30 volts, and wire the new relay to short-circuit the contacts of the first one. An alternative procedure for this is to make the twenty seventh grid pluggable, plug it to the test lead of an on-chain column, and bias the valve to operate the relay at 14 volts.

The main changes in wiring with change of menu are common to rows, and therefore may be made with multiple point plugs, a row at a time.

The left-hand resistors may be considered as serving a dual purpose. They serve to keep the potential of the straight high as a by-pass around the relay, and they should help to avoid “creepers” – that is, stops where no straight exists. Any long chain, earthed at one end and containing unbroken high initial brush resistance, will be connected at frequent intervals, through the left hand resistors, directly to the high voltage. Until the initial resistance is broken down the effect is to have the full potential across very short chains.

No change in principle is required to adapt this method to total electronic sensing. It would, in fact, require only one more valve for the detection of straights, without the sensing relays.

RESISTANCE METHOD OF MAMMOTH SENSING

The main-chain rows of the diagonal board are to be connected to the corresponding rows of the resistor board. In off-chain rows of the resistor board the input voltage is to be disconnected, and the points themselves earthed. (This may be accomplished by means of 52-point plugs. See diagram 1).

Suppose the tester to be connected, and the bombe running. When the bombe reaches a position in which there is no straight, all the diagonal board points of main-chain rows (and columns) are earthed, and so also are all resistor board points, either due to their connection with the diagonal board or due to the off-chain arrangement. All relays get current, and the bombe continues to the next position.

When the bombe reaches a position where there is a straight, not one on the in-put line, all main-chain points on the diagonal board except those of the straight will be earthed. Those on the straight will be connected to one another via the enigmas. On the resistor board, the circuit for one column is that of diagram 2 if there is one point of the straight in the column. If there are two such points in a column, the circuit becomes that of diagram 3. Calculation shows that in the first case the potential of the grid-lead is $^1/_{26}$ that of the straight, and in the second $^1/_{13}$ that of the straight.

The several column-circuits combine through the bombe and diagonal board with the relays as indicated in diagram 4.

If there are ‘a’ columns with one point of the straight and ‘b’ columns with two, if the relay resistance is 5000 ohms, ‘r’ = 5000 K, R = 5000 L, and the input voltage is 200 volts., the resistance from the high voltage to the straight is:

$$\frac{5000K}{a+2b+K}$$

And the resistance from the straight to the earth is:

$$\frac{26x5000L}{25a+48b}$$

The potential of the straight will then be:

$$\frac{26(a+2b+K)L}{(26L+24K)(a+2b)+(26L+a)K}\,x200$$

If K=5 and L=40, the straight-potential is about 185 volts., and is nearly independent of ‘a’ and ‘b’. There is a residual voltage of 15 across the relay corresponding to the straight.

The potential of the grid leads will be ‘o’, 7 volts. or 14 volts., according as there are none, one or two points of the straight in the column. The grids of the main set of valves should therefore be biased to give no current at 7 volts, but relay-operating current at 14 volts. (To fire at about 10 volts if thyrotrons are used. The plate supply may be steady for hard valves, but must be intermit for Thyrotrons.)

The effect of the relay is to open the stop-circuit, that is, to counteract the effect of the straight-sensing relays.

If a straight occurs on the input-line the potential of all grid leads will rise far above 14 volts. We will wire one of these leads to the grid of the twenty-seventh valve, and bias the latter to operate its relay at 50 volts. This relay is to counteract the effect of the one associated with the main set of valves. (Alternatively, if this grid is made pluggable, it may be biased to operate at 14 volts., and plugged to an on-chain column.) (If thyrotrons are used, the two relays may be combined to a single one of the differential type.)

It is hoped that a by-product of this scheme will be the elimination of "creeper" stops; that is, stops due to failure of the applied voltage to break down the initial resistance of a long series of brush contacts when no straight exists. Any long sequence earthed at one end and containing unbroken high initial resistance will be connected at frequent intervals, through the left hand resistors, directly to the high voltage. Until initial resistance is broken down, the effect is to have the full potential across very short chains.

This scheme requires modification in detail rather than in principle to be applicable to total electronic sensing.