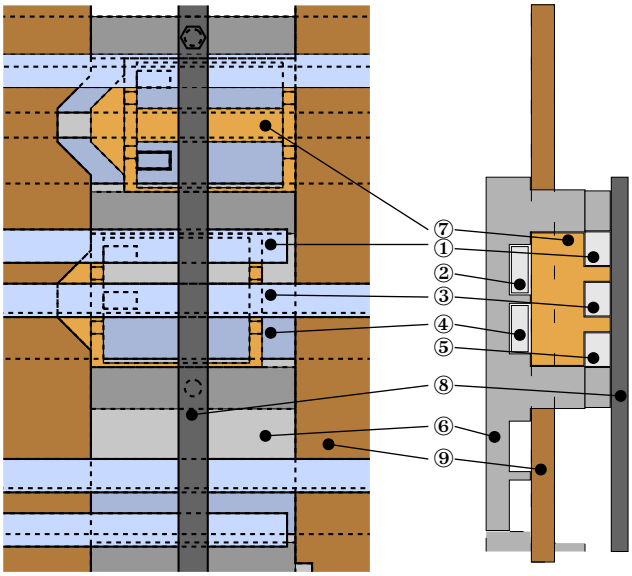
Something unusual

Background

I find things mechanical rather interesting and so I decided to try to display a complicated mechanism going through its motions. I have done an animated diagram of steam locomotive valve gear which shows the way steam is admitted to the cylinders with different 'cut-off' settings (see www.svrsig.org/ValveFwd.htm).

The challenge this time was to display the mechanical locking under a signal box as different levers were pulled. I had detailed information for quite a few signal boxes specifying exactly how the mechanical locking was laid out.



Left: *A section through a 5-bar locking tray has been marked up to show the bars, locking nibs and tappet. A lock of solid construction is fixed to a single bar whereas a hollow lock can be driven by several bars. On the left hand view, 'V'-shaped notches may be seen, cut into the tappets. A plate or a condition piece may be mounted on a tappet to engage with the upper half of a lock (or with a 'top thin' lock). Locking bars ① to ⑤, the tray (⑥), a sliding lock (⑦), strap (⑧) and tappet (⑨) are labelled.*

Data structure

Designing the data structure is a key step so that the information is arranged in a form that can be easily interrogated. I did this during a canal holiday in Ireland in 1999 and got it pretty close to the final arrangement.

Mechanical locking can be in various forms but I have concentrated on the Great Western 3-bar and 5-bar frames, as that is what we have on the Severn Valley Railway.

On the operating floor of the signal box is the top half of the lever frame with the levers protruding through a slot in the floor plates. Below this level, the movement of the levers is transmitted through a fishplate to a cam slide which imparts vertical motion to a tappet in two stages: firstly to prove the lever is not locked and then as the lever is fully travelled it releases other locking.

Draw data in memory

By using MakeDraw to generate the vector graphic image, the location in memory of each component is known. As it is generated the characteristics of each element is also known: a lock for example will sit in channel c%, to the right of tappet t% and bits are set to note whether it has a nib to the left or right or both and whether it drives a condition. This provides enough information to draw the detailed outline of the lock in the correct place, as shown on the dog chart. It also allows its interaction with tappets to be inferred.

The overall drawing is built up in layers so that the different components are drawn in turn starting with the locking tray, then in turn each group of items finishing with whatever is on top (top bars or straps). All of the components are then

```
File: Output2_Kr

00000000 : 44 72 61 77 C9 00 00 00  00 00 00 00 4D 61 6B 65 : DrawÉ.......Make
00000010 : 44 72 61 77 20 20 20 20  00 E7 FF FF 00 F3 FE FF : Draw    .çÿÿ.óþÿ
00000020 : 00 54 1A 00 1E 3A 0B 00  00 00 00 00 2C 00 00 00 : .T...:......,...
00000030 : 01 54 72 69 6E 69 74 79  2E 4D 65 64 69 75 6D 00 : .Trinity.Medium.
00000040 : 02 48 6F 6D 65 72 74 6F  6E 2E 4D 65 64 69 75 6D : .Homerton.Medium
00000050 : 00 00 00 00 06 00 00 00  60 8A 03 00 00 32 00 00 : ........`...2..
00000060 : 00 0E 07 00 1E 33 15 00  1E 3A 0B 00 20 20 20 20 : .....3...:..
00000070 : 20 20 20 20 20 20 20 20  06 00 00 00 C0 03 00 00 :          ....À...

00055B20 : 00 00 00 00 06 00 00 00  04 02 00 00 80 B5 05 00 : ............€µ..
00055B30 : 00 25 05 00 80 DB 05 00  80 74 05 00 4C 6F 63 6B : .%..€Û..€t..Lock
00055B40 : 20 33 20 20 20 20 20 20  02 00 00 00 78 00 00 00 :  3      ....x...

00055CC0 : 02 00 00 00 68 00 00 00  80 B6 05 00 00 6C 05 00 : ....h...€¶...l..
00055CD0 : 80 BD 05 00 80 74 05 00  FF FF FF FF 00 00 00 00 : €½..€t..ÿÿÿÿ....
00055CE0 : 00 02 00 00 00 00 00 00  02 00 00 00 80 B6 05 00 : ............€¶..
00055CF0 : 00 6C 05 00 08 00 00 00  80 B6 05 00 80 74 05 00 : .l......€¶..€t..
00055D00 : 08 00 00 00 80 BD 05 00  80 74 05 00 02 00 00 00 : ....€½..€t......
00055D10 : 80 B6 05 00 00 70 05 00  08 00 00 00 00 BC 05 00 : €¶...p.......¼..
00055D20 : 00 70 05 00 00 00 00 00  06 00 00 00 10 02 00 00 : .p..............

00094820 : 89 E7 19 00 89 10 01 00  05 00 00 00 00 00 00 00 : ç.............
00094830 :

Diagram is at &54 (length=&038A60)
ddLock%(3)=&55B24 (length=&0204)
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The Draw file data for the dog chart for Kidderminster. When drawing lock number 3 the paths (object type 2) in that group are rendered using Draw_Stroke and Draw_Fill with a transformation matrix adjusted to apply a translation which corresponds to the lock movement.

drawn again as unfilled shapes with a dotted outline. Hidden lines thus appear dotted but solid lines are unaffected.

In the diagrammatic view only thin locks that sit on top of another lock are filled: this ensures that the outline of the lock underneath is shown as dotted where hidden. By convention conditions (which sit under the tappet on a 3-bar frame) are drawn in solid outline.

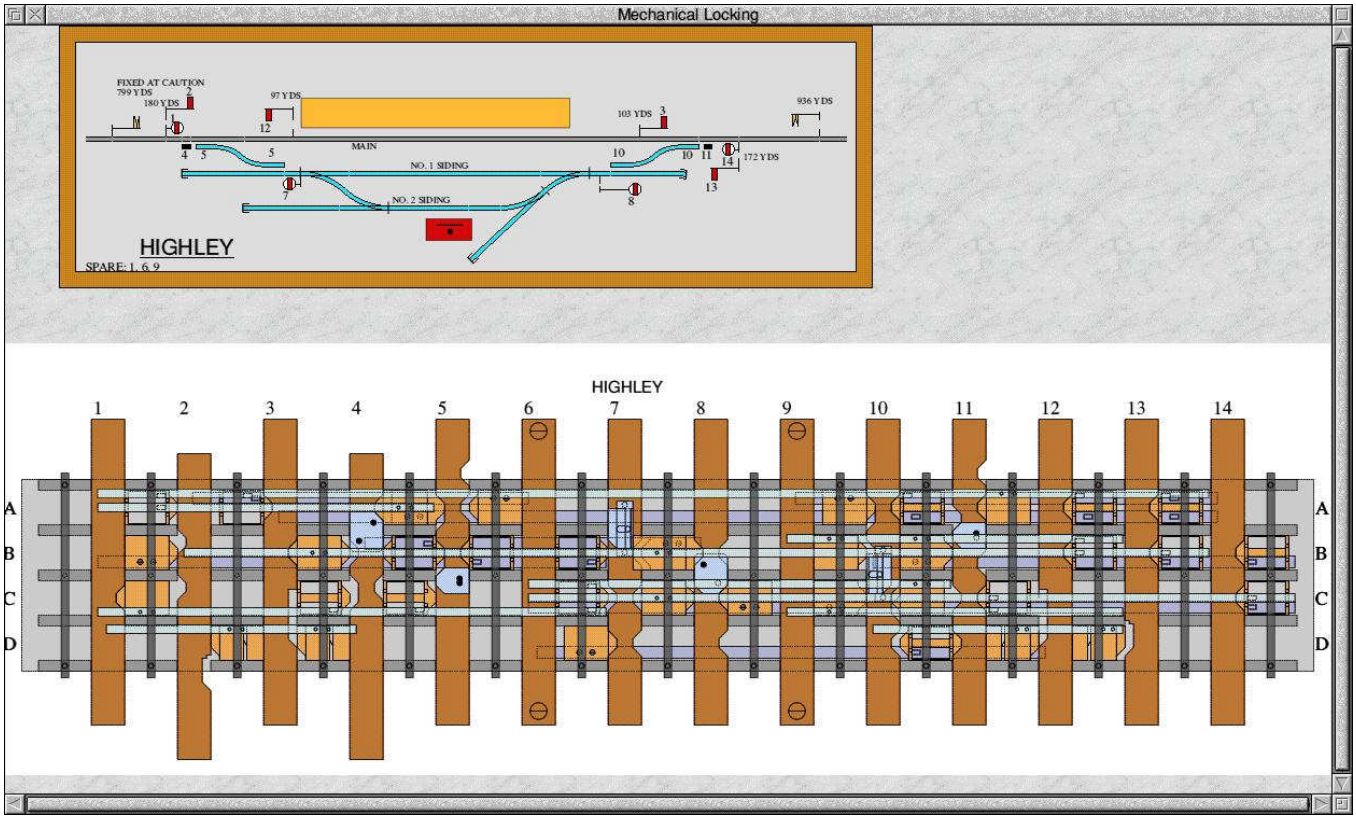
A further feature is provided to facilitate modifications: when making a modification to mechanical locking it is conventional to provide a 'before' and 'after' view with items to be removed from the former shown in green and items to be added in the latter shown in red. The location of items within the Draw file that might need to be coloured are written to a file with the pointers to their colour (black) and line width. Another programme that lists the components to be coloured can then be run to colour and/or thicken the relevant lines.

```
1570 : REM Bar B2 (starts at 4)
1580 : DATA "Bar 2,(4),2,0"
1590 : DATA "Stud on bar 2,4,2,0"
1600 : DATA "Lock,7,2,0,type=135"
1610 : DATA "Fixed stud on bar 2,7,2,0"
```

An example from the programme 'AdjColHY' that picks out the items on bar B2 and colours them red.

Application 'Locking'

The application concentrates on a view of the mechanical locking, as it would appear under the signal box operating floor. A locking tray supports the movement of the tappets, spaced at the same spacing as the lever to lever separation on the operating floor. It also supports the moving locks and bars in separate channels.



The screen shot above shows a display of the mechanical locking at Highley (as it is planned to be in Nov 2024) as levers 4 and 2 are pulled to admit an Up train into the platform. To move the tappets just requires a mouse click. In fact any individual component can be moved by a mouse click over it - if it is free to move.

The 3-bar frames were introduced in 1904 and were arranged so that the tappet travel (1¾") was equal to the channel spacing - i.e. a port cut in the tappet would line up with the channel below when the lever was reversed. Some frames converted to 3-bar locking had a smaller tappet travel but still used standard locking trays. Lever spacings were either 4" or 5¼".

Bewdley South is an example of a non-standard design: tappet travel (1 7/16") was less than channel spacing (1 15/16").

The 5-bar frame introduced in c.1926 was an improvement and allowed five locking bars in each channel. The channel spacing (2 5/8") was greater than that in the 3-bar frames so that a port cut in one channel would not move far enough to affect the locking in the channel below. The standard 5-bar frames had levers spaced 4" apart but special locking trays were built to suit 5" and 5¼" lever spacing for frames converted to 5-bar locking and again with increased channel separation to suit converted frames where the tappet travel was greater than normal. Examples of this are Highley (5" lever spacing), Newbury East Junction (5¼" lever spacing) and St Austell (5¼" lever spacing with non-standard tappet travel).

Other idiosyncracies also had to be catered for: unnumbered spaces in the centre of a frame (example Oxford Engine Shed), extra locking for added levers or gate wheels at the left hand end (numbered 'A' and 'B' or '0', examples Colthrop Siding and Bewdley South).

On 3-bar frames narrow ports were used where locks were added but the locking in the channel below was not to be affected (example Bewdley North, Oxford Station South).

Special ports or conditions were cut for levers which provided releases mid-

Rendering a graphic to screen

Vector graphic data (in the form of a Draw file) has the advantage of being scalable without loss of quality as it is only rasterised (converted to bit map data) when plotting it to the screen. It also allows bit map data to be rendered whatever its resolution or colour depth, although zooming in would become pixellated at sufficient magnification.

The data are arranged so that the first item in the data is either a group object containing a vector graphic representation of the box diagram or a sprite (bit map) object of the box diagram. If a box diagram is included this means that an efficient routine 'DrawFile_Render' can be used to render the box diagram (which is in a fixed position and does not change) specifying the end of the data to be rendered as the end of that object (i.e. where the other objects start) and ignoring the remainer of the Draw data.

A transformation matrix is used to convert the Draw coordinates of an item, which are expressed in 1/46080 of an inch to pixels on screen.

The vector graphic data representing the mechanical locking is in known positions in memory, each item contained within a group object, and the technique here is to render each group object individually (using Draw_Stroke and Draw_Fill for path objects) adjusting the transformation matrix for each in turn to take account of its position, zoom level and movement as the locks, bars and tappets move.

To draw the screen initially and after movement has ceased, the standard method using Wimp_ForceRedraw, Wimp_RedrawWindow and Wimp_GetRectangle was adopted which blanks the area covered by the window and asks the application to redraw various rectangles that need updating (either the whole window or, where it is partially covered, several rectangles making up the areas that are visible).

During movement a different technique is used: only those objects known to be moving are redrawn and no areas are blanked. This uses Wimp_UpdateWindow in place of Wimp_RedrawWindow and only items that are moving are actually redrawn. Once the movement is complete, the whole image is redrawn (using Wimp_RedrawWindow), again rendering each component individually with its position adjusted correctly. This ensures that any filled object that moves has the hidden (dotted) lines behind it redrawn correctly.

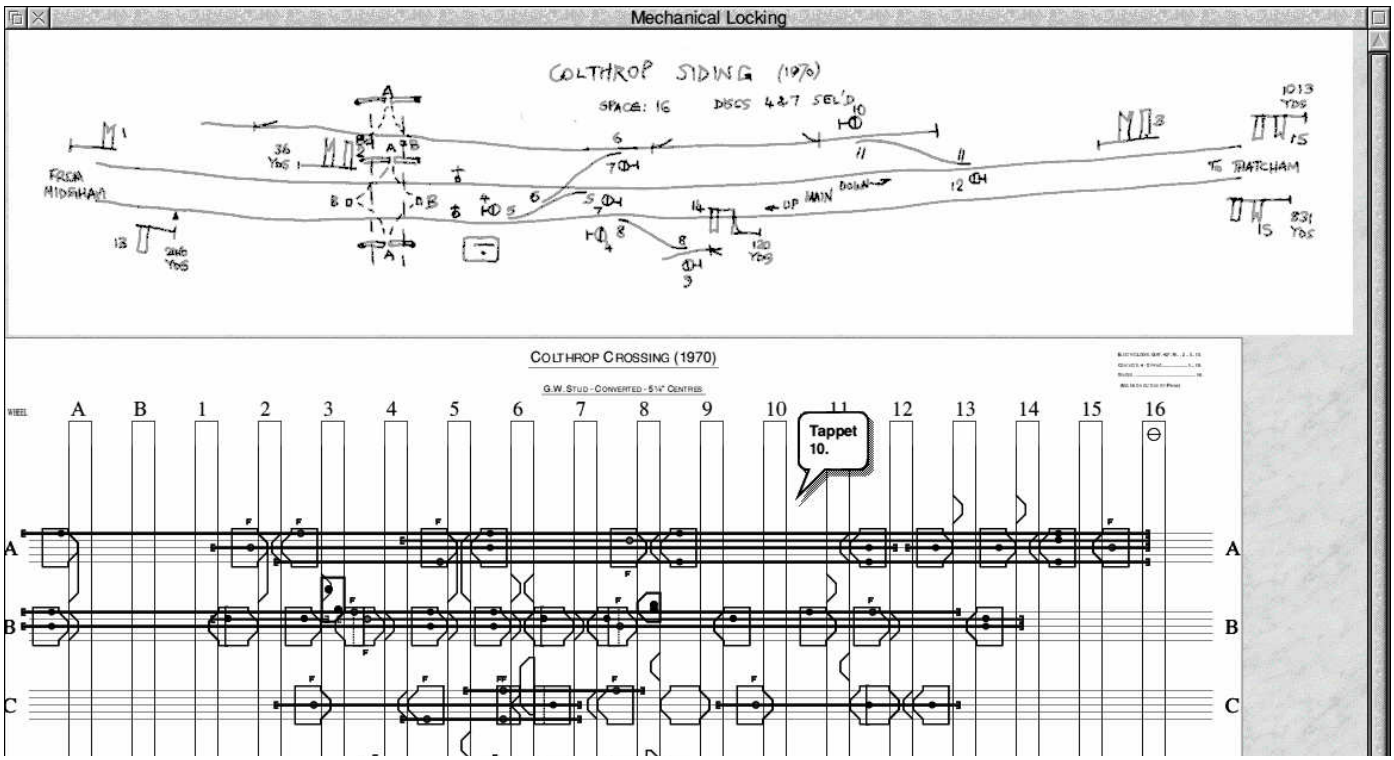
The original intention was simply to animate the diagrammatic view (the 'dog chart') which has the advantage that there are very few filled paths (only thin locks sitting above another lock, to ensure the hidden lines appear correctly). The technique proved to work fairly well for the visual image of the actual locking although what is visible through the ports cut in the tappets only reappears when movement is complete.

stroke (examples Arley and Hampton Loade). This allows the lever to be pulled part way to lock the route and release the locking which prevents signals in opposing directions from being cleared and when fully reverse locks the frame and electrically connects the adjoining boxes in 'long section' working. This allows the box to be switched in and out.

Special ports were cut to offer sequential (non-reciprocal) locking (example Highley).

The principle, however, is very simple: notches are cut into the tappet to allow locks to slide sideways. In a particular channel, locks are connected by locking bars and thus lock or release other tappets.

I decided to animate both a view of the diagrammatic arrangement of the locking (called a 'dog chart') as well as a view of



A hand-drawn diagram is a little less elegant but this shows Colthrop Siding as it was in 1970. In a task that appeared to be set for a trainee, a relock to current standards was undertaken in 1971 (also included) but this appeared to have the effect of accelerating the demise of the sidings, points 11 being removed in July 1971 and the remainder of the connections by April 1973.

the actual locking as it would appear visually. A picture, as they say, is worth a thousand words and the screenshots illustrate the actual locking and dog chart.

Once I had a vector graphic representation of the diagram (called a 'dog chart') it was relatively simple to animate it. If I rendered each part in turn, I could displace each item by a different amount to represent its movement. The complication was working out which items were free to move and which other items would move as a result.

Better still, during the movement I could redraw only those items that were moving. Turning off vector anti-aliasing also gave a better result.

Once the basic data structure is determined and the means of drawing an individual piece of locking is worked out, quite large signal boxes can be given the same treatment however complex the locking might be.

Description of locations

The locations that have been included complete with a layout diagram are described below:

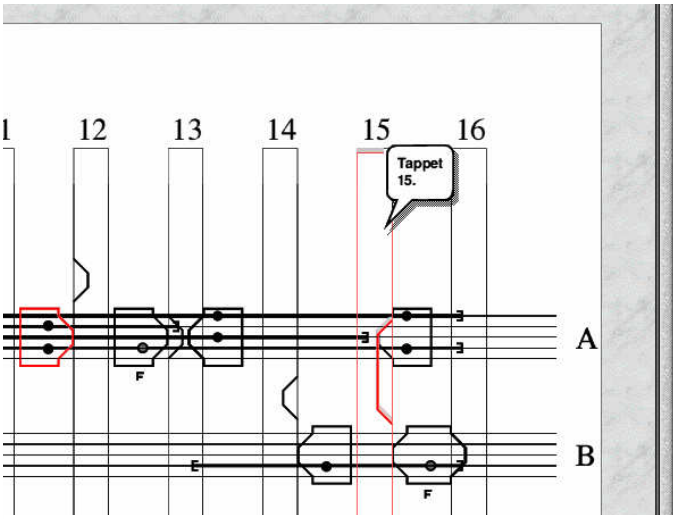
0. Test1 : **Test**

Some exotic forms of conditional locking are shown, along with the locking table. It does not represent any actual layout. Frame: 12 levers VT5.

11. ActYd : **Acton Yard**

Jan 1967, box diagram included. Most of the layout controlled by Acton panel had been transferred by now to Old Oak Common panel. The signalling and controls for the Goods Lines were not transferred to Old Oak Common though, and these were controlled by Acton Yard and a new box at Acton West - the connections to and from the Main and Relief Lines were controlled both from the panel and the relevant box using electrical releases and slots.

Acton Yard is an example of a



An attempt to move tappet 15 (Down Home) shows (higlighted in red) that this is prevented by the locking between levers 12 (FPL for 11 points) and 15 implemented by bar A4 (bar 4 in channel A).

mechanical frame in which the mechanical locking principles have been applied to a layout where most of the main running signals are colour light and for some of these a single lever operates all of the available routes. Where there are many multi-routed signals, the conditional locking will become complicated and there are two trays, each of nine channels, to contain the locking. One lever has no less than ten conditions (lever 7) and several levers have six or more conditions attached to the tappet. Most of this is to provide signal to signal locking where the route may be set so that the signals read towards each other. Frame: 58 levers 4“ VT5.

5. Arley : **Arley**

As it is now but with mechanical sequential locking added (not yet fitted). Frame: 30 levers VT3.

14. BNorig : **Bewdley North**

Shown c.1956. This shows the layout inherited by the SVR in 1972-1974. Frame: 37 levers 4“ HT3.

6. BewdN : **Bewdley North**

Shown c. 2002, i.e. after levers had been shuffled to accommodate a new calling on arm, no. 34, but before the Up and Down distants became worked. Frame: 37 levers 4“ HT3.

10. BewdS : **Bewdley South**

Shown c.1995, the frame had been extended to accommodate lever 0 to work the Down Distant. Frame: 34 levers 4“ converted to VT3.

3. Bdgnth : **Bridgnorth**

Shown c.2000. Frame 30 levers 4“ VT3.

21. ColSg : **Colthrop Siding**

This is a draft plan dated 1971 showing the proposed situation to allow disc 12 to read to three routes. In fact disc 12 and associated connections were removed in mid 1971. The plan was not implemented. Frame: 18 levers 5¼“ Stud converted to VT5.

22. ColX : **Colthrop Crossing**

This box was renamed in 1999 as the sidings on the Down side had all been removed by 1973. It is shown as it was in 1970. Frame: 18 levers 5¼“ Stud converted to VT5.

45. ExeterE : **Exeter East**

Shown May 1943. Many connections and signals were controlled or slotted from Exeter Riverside box as shown on the box diagram. Frame: 52 levers 4“ VT3.

13. ExtrW : **Exeter West**

Shown in 1963. Changes had been made to allow passenger trains to depart from platform 4 to Exeter Central. The box has been recreated in The Railway Age at Crewe and you can see it in operation most weekends. A simulation of this box is available for RISC OS from !Store. Frame: 131 levers 4“ VT5.

1. Fowey : **Fowey Station**

Shown circa March 1936. The passenger service to St Blazey ceased c.1933 and changes were made in 1931 and 1936 accordingly. There is no provision for passenger trains terminating in the Up platform to depart from there but I am told that they did! Frame: 40

levers 4“ VT3.

9. HampL : **Hampton Loade**

Shown c.1999. One signal can only be pulled (no. 2) with the box switched out and the switching out lever (no. 8) has a special cam slide which moves the tappet in three stages. Frame: 16 levers VT5.

4. Highley : **Highley**

Shown as it is expected to be in Nov 2024. Changes to bring into use a disc reading into the Yard from the north end are included. A utility is provided to colour the new locking red. Frame: McKH 5“ converted to VT5.

2. Kidder : **Kidderminster Station**

Shown June 2024. This includes the changes made when Kidderminster Junction box closed and the connection with the main line was resignalled. New lever 55 is under construction. Frame: 62 levers 4“ VT5.

8. MorlJ : **Morlais Junction**

Previously Morlais South, shown in Nov 1965 just after FPL 14 was converted to track circuit locking (fouling bar 15 also removed) and sequential locking was added.

This box was unusual in that it could switch out with the route set either for the Main or Branch. Also there was a trailing double junction in the block section on the Up Main line. Frame 30 levers 4“ HT3.

43. NoWhJn : **Nowhere Junction**

A fictitious location showing some of the devices used to squeeze locking onto an existing frame. Frame: 3-bar.

30. OxfEShd : **Oxford Engine Shed**

Shown December 1930. This box was renamed Oxford Station North from 1944. Frame: 96 levers 4“ HT3.

17. OxSN : **Oxford Station North**

Shown July 1956. Permanent space of four levers between nos. 40 and 41. Box diagram shows the position in May 1953. The principal changes between May 1953 and July 1956 (i.e. those not shown on the box diagram but included on the locking chart), are the provision of track circuits 12T, 16T and 57T in lieu of F.P.L. bars. This would have affected the locking on signals reading over the F.P.L. in the trailing direction (each way locks removed) and 12 leads 16 (mechanical locking removed and provided electrically). Frame: 96 levers 4“ converted to VT5 in 1942.

20. PenW : **Penwithers Junction**

January 1957. Frame 36 levers VT3.

12. RadyrJn : **Radyr Junction**

Shown December 1987 after changes had been made for passenger trains to reverse in the Up Main and the Relief Lines had been rationalised. Frame: 107 levers 4“ VT5.

15. ResE : **Resolven East**

Shown c.1950 just after signals 6 and 15 had been removed. Frame: 40 levers 4“ VT5.

44. RothJct : **Rotherwas Junction**

Shown July 1925 when the frame was shortened from 78 to 54 levers. Frame: 54 levers 4“ HT3.

42. RothJc : **Rotherwas Junction**

Shown June 1929. Lever 0 had been added to provide a working Down Main Distant extending the frame to 55 levers but shunting signals 23, 24, 35, 36, 37 and 49 were recovered and some replaced by stop lamps in September 1928 and levers 7, 23, 24, 25, 28, 35, 36, 37 and 49 had thus became spares. Frame: 55 levers 4“ HT3.

7. RothJ : **Rotherwas Junction**

Shown March 1957. Frame: 55 levers 4“ HT3.

19. StAus : **St Austell**

Shown April 1931. The box diagram shows the position at 1968. Although some small changes have been made to the layout at St Austell since 1932, the

interlocking has pretty much stayed the same from 1937 to 1968, with the exception of lever 43 - changed from an outer distant circa 1949 to provide access to the branch at Trenance Junction. Frame: 43 levers 5¼“ twist frame converted to VT5 in 1931.

41. StErth : **St Erth**

As at October 1941 with the box diagram recreated from the scheme plan showing alterations to be made in 1964 to make the junction into a single lead. Frame: 69 levers 4“ VT3.

Other locations are included but without a box diagram - these are earlier layouts at Acton Yard, Bordesley South in September 1935, Didcot East Junction in October 1958, Hinksey North in December 1946, Hinksey South in October 1941, Morris Cowley in June 1961 and February 1954, Newbury East Junction in February 1950, Newbury Racecourse in June 1963 and February 1965, Norton Fitzwarren, Oxford Station South in March 1943, Oxford South in August 1942, Par Station in April 1962, Pengam Junction in August 1951, Taplow in December 1946 and September 1955 and Tyseley North in October 1935.

The programme only shows mechanical locking - no attempt has been made to add electrical locking. A basic signal box diagram is included where possible, so that the individual tappets (or levers) have some meaning in terms of their function.

The application itself (!Locking) can be provided with all the information it needs to generate the animated locking for 48 signal boxes in a zip file of just 1.2Mbytes but, for convenience, it is provided with 26 boxes already processed along with diagrams of the layout, which requires a zip file of 19 Mbytes (which expands to 80 Mbytes on unpacking).

Interactive help (using !Help) and a StrongHelp manual are provided.

A signalbox simulation is available for both Windows and RISC OS that includes all forms of locking. This application (!SignalBox) is also available from !Store and an extensive train service for either Exeter West or Kidderminster is provided that will only run if it is signalled correctly.

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Downloadable software

Animated locking (RISC OS):
www.svrsig.org/Lock.zip (19Mbyte)
Signalbox simulation (RISC OS):
www.svrsig.org/software/SigBox.zip
Signalbox simulation (Windows):
www.svrsig.org/software/SignalBox.zip

URLs case sensitive.

RISC OS software also available via !Store, the App Store for RISC OS.

Chris Hall is a chartered mechanical engineer with a 29 year full time career in power stations and nuclear safety. This work included safety case preparation and oversight, moving to Oldbury power station in 1995 and to HQ in 2001. He retired in 2005 and has since indulged his hobbies including web design and computer programming and has worked for the last 30 years on a heritage railway as volunteer S&T technician and signalman. He is now 69 years old and has written a 60,000 word autobiography.