McKENZIE & HOLLAND 1873 PATENT FRAMES

by Andrew Waugh (Amended)

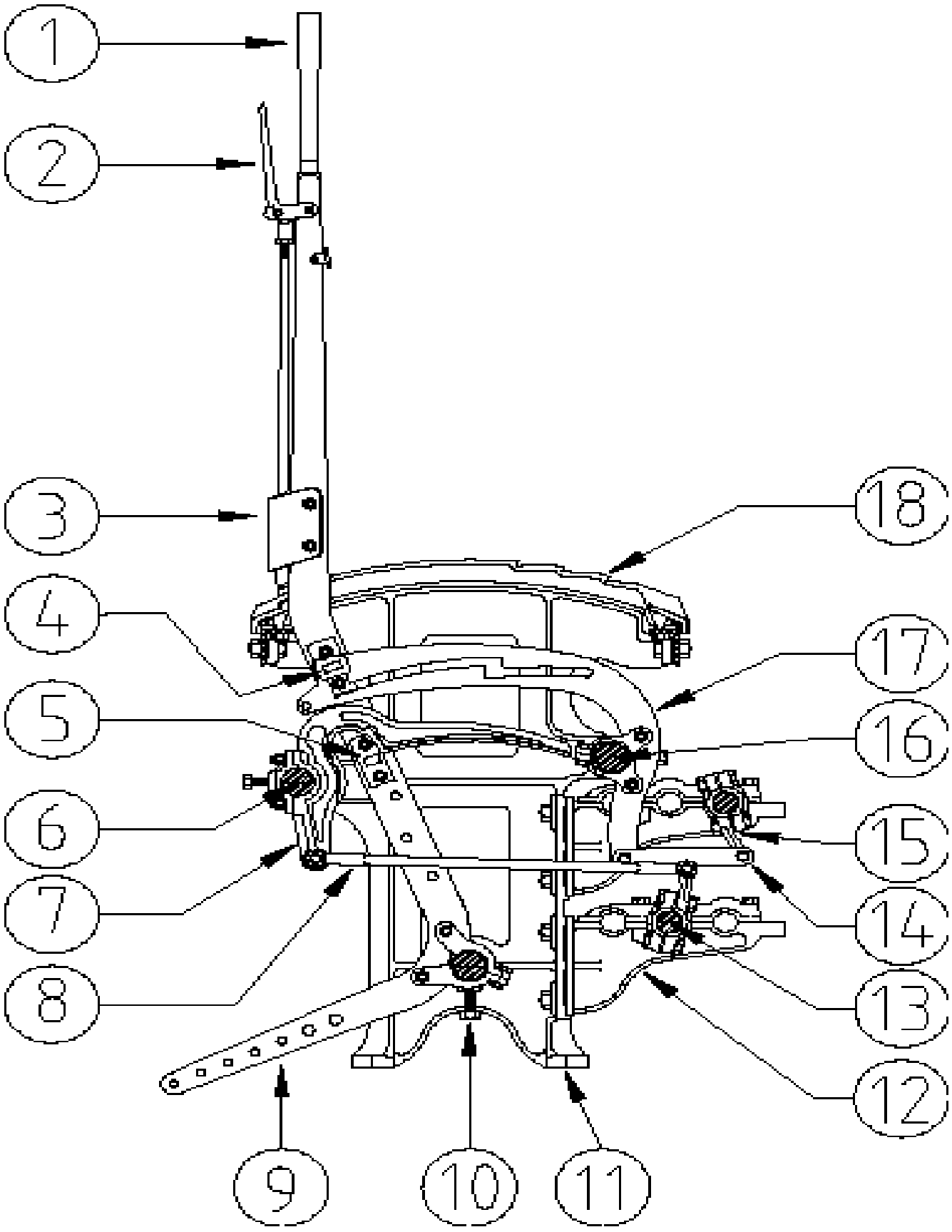
Highley Signal Box was first fitted with a McKenzie & Holland 1873 patent frame, manufactured in Worcester. Approximately 1905 the frame was refitted with Great Western Railway tappet locking with 5¼" slides which was unusual. The following article was written in regard to the Australian Railways but describes the type of frame that Highley Signal Box once had.

Prior to 1912 the standard interlocking frame on the Victorian Railways (Australia) was the McKenzie and Holland No 5/5A/6/6A Pattern Frames. These four variants, collectively known as the 1873 Patent frames, were all identical in operation, and differed only in minor constructional details. From 1912 the VR switched to a Cam and Tappet frame for new installations, but there was never a policy to replace the older frames, nor were they relocked with tappet locking. Seven are still in service, including the 196 lever Spencer Street No 1 Box.

The 1873 Patent frames appeared at a pivotal point in the development of mechanical interlocking. Stevens had patented tappet locking in 1870 and the other two main manufactures had to come up with a workable alternative. McKenzie and Holland refined their 1866 design to come up with the 1873 patent design, just beating Saxby and Farmer who did not come up with a design that wore well until 1874.

The operation of an 1873 Patent frame is hard to describe without copious illustrations, but the recent abolition of Newport A gave the opportunity to take a series of photos of the frame while it lay in the grass at Newport.

The design is sometimes known as the `Hook, Cam & Soldier', which is quite descriptive. The actual locking is carried out by large cast iron locks which `hook' lock studs fitted to the levers. Operation of the lock is by means of cams, rocking shafts, and soldiers.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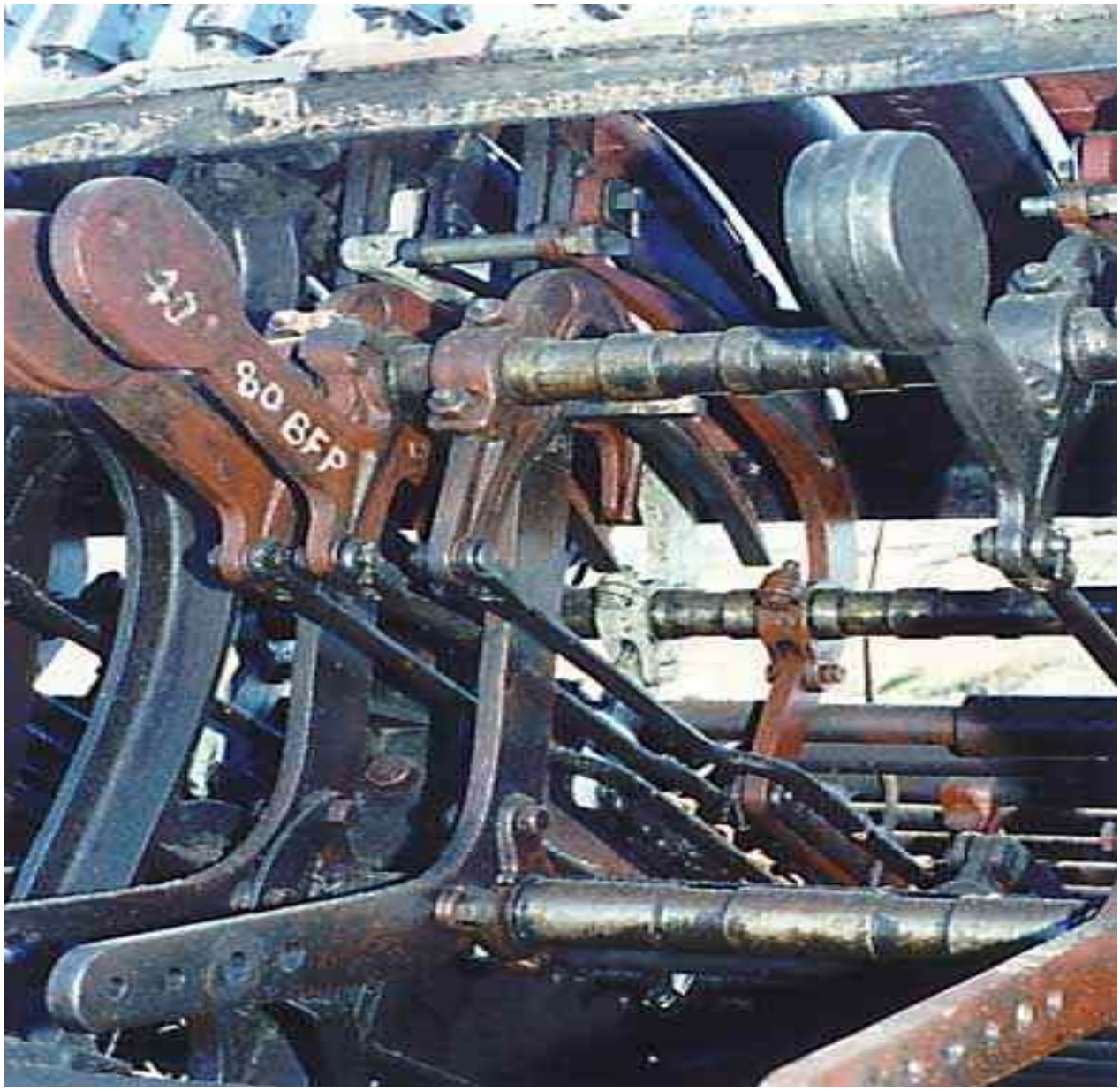
The operation of the locking can be followed from this transverse view. The locking is driven indirectly from the movement of the lever (1) by means of a cam (17). Movement of the cam has two phases. The first occurs during the initial movement of the lever. Attached to the lever just below the floor-plate is a cam stud (4) which operates in a slot in the cam. As the lever is moved from the normal position, the cam stud forces the cam upwards, rotating it clockwise around the cam shaft (16). During this movement the tail of the cam moves forwards 1 1/8" which operates the interlocking. The second movement of the cam occurs as the lever approaches the first reverse notch. The cam stud again lifts the cam and the cam tail again moves forward a second 1 1/8" to operate the locking for a second time. This first movement of the cam locks any conflicting levers and the second movement releases levers for subsequent operation. The lever can be placed in any of three reverse notches. Further movement beyond the first reverse notch does not affect the locking, but gives a greater travel to the lever tail.

The motion of the cam plate is transferred up and down the frame by means of rocking shafts (13). Frames can contain two layers of rocking shaft brackets, as shown in the diagram. Two cam links (14) connect the cam tail to a soldier (15) clamped to a rocking shaft. As the cam is lifted by the lever, the soldier rotates the rocking shaft.

The interlocking is performed by cast iron locks (7) which rotate on a lock shaft (6) mounted on the rear of the frame. The tails of the locks are connected by lock rods (8) to soldiers clamped to the rocking shafts.

As the rocking shaft rotates, the movement is transferred to the cast iron locks which rotated on the lock shaft to lock or release levers by means of a lock stud (5) mounted on the lever.

There are several different types of cast iron lock. The one illustrated in the diagram is the main lock. This is used to lock a lever normal when another lever is operated. As the Main Lock rotates around the lock shaft, the heel of the lock drops in front of the lock stud preventing the lever from being moved from the normal position.



A shot from the rear of the frame showing the complete under-floor gear for one lever. Crossing the photo from left to right can be seen the lock shaft (top), the cam shaft (middle), and the lever shaft (bottom). A number of rocking shafts can be seen immediately above the lever shaft. The lever shaft is turned down every 5 inches for a lever, but the cam shaft and lock shafts are turned down twice every 5 inches. This allows two cams or two locks between each lever. The cam tail and lock tails are in the same vertical plane, so where there is a cam and a lock on the same side of the shaft (as for this lever), the lock rod must be set to clear the cam tail. The set can be clearly seen in this photo. Victorian frames were normally arranged for a vertical lead-out and the lever tail projected out the back of the frame. A variety of lengths of lever tails were used in Rocker frames. Short tails were cheaper to fabricate, but gave limited travel and were mostly used for points or FPLs

A close up of the previous photo showing the relationship between the levers, cams, and locks. At the top of the photo can be seen a cam, with the two rises in the cam slot clearly visible, with the cam stud in its normal position at the top of the first rise. The cam is prevented from jumping off the cam stud by a large square washer and split pin. (The horizontal pin bolted to the rear extension of the cam drove an electric lock mounted above floor level.) Under the cam can be seen a Main lock, mounted on the lock shaft which runs from right to left across the photo. The lock stud can be seen between the heel of the main lock and the lock shaft. If the main lock dropped down, the lock stud would be trapped behind the heel of the main lock, holding the lever normal. On the other hand, if the lever was reversed the lock stud would pass underneath the curved lower edge of the main lock and prevent the main lock from rotating, hence locking the levers that drive the main lock.

A shot taken when the frame had been partially dismantled showing a lever in the first reverse notch. The cam has operated through the two rises, and it can be seen that in this position the back quarter of the cam stud is supporting the cam, preventing it from dropping. The lever could be worked to any of the three reverse notches, the cam stud travelling in the final section of the cam slot but without moving the cam.

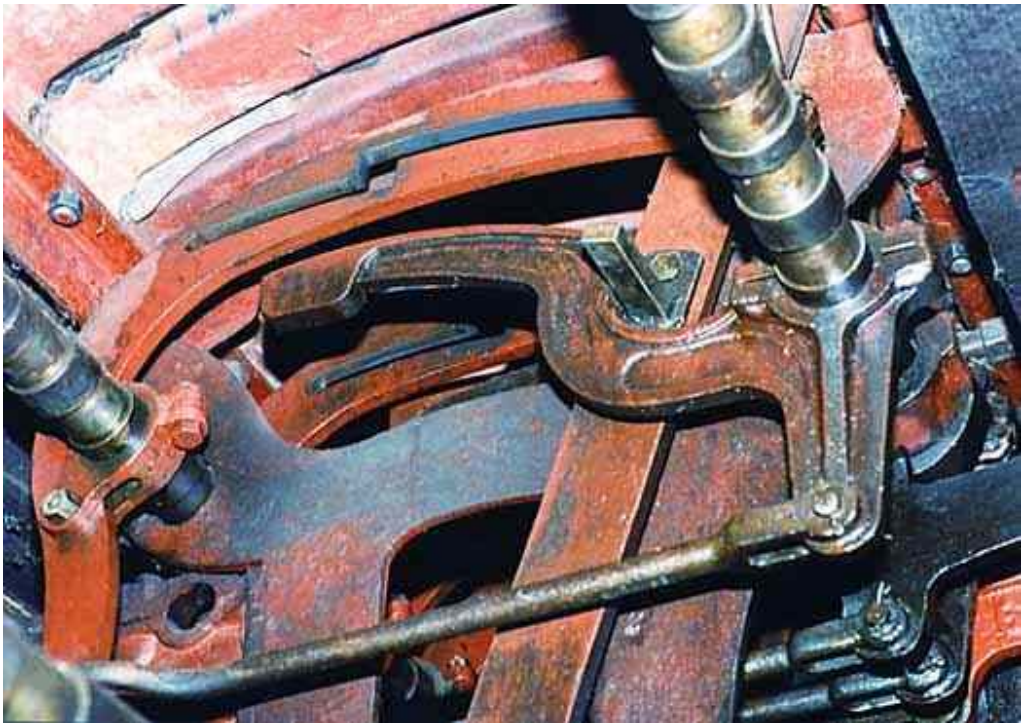
A view looking down `through the floor' onto the top rocking shafts. The soldiers can be seen clamped to the shafts, with the cam links and lock rods visible running vertically towards the top of the photo. The cams are connected via cam links (the closely spaced parallel bars which can be seen in the middle and to the left of the photo) to soldiers clamped upon the rockers shafts. Other soldiers on the shafts drive lock rods (the thicker rods to the right) which operate the locks. One point to notice is the relative sparsely of soldiers. This photo was taken near the middle of the frame where most of the levers are point and FPL levers. In 1873 patent frames the rocking shafts were generally driven by the point and FPL levers and the locks were applied to the signal levers. The middle of the frame consequently had few soldiers.

A detail shot of the soldiers clamped to two rocking shafts. The lower shaft has the drive from a cam; the cam links are the two flat parallel mild steel bars (1 ½" by 5/16"), one placed each side of the soldier head. The upper rocking shaft has a drive from a cam at left, and locks on the two adjacent levers. Lock rods are solid ¾" wrought iron rods with a forged eye to connect to the soldier head. Each lock rod is different, and must be made to order by a blacksmith.

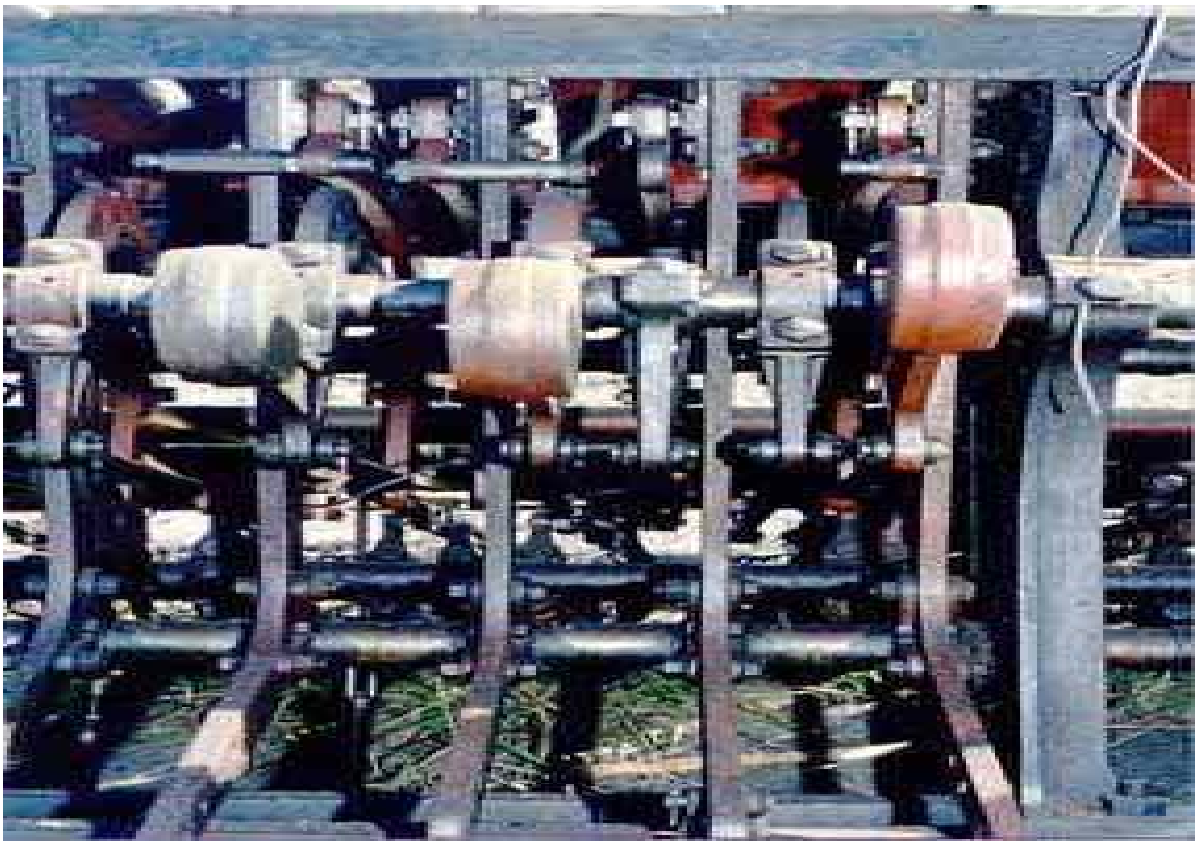
A close-up of a soldier and a slotted lock rod. A slotted lock rod was used when two (or more) rocking shafts drove one lock. This was common. In this case, two shafts drove a Main lock. When the soldier rotated (counter clockwise) the tail moved away from the camera and operated the lock rod. When the other soldier driving this lock rod rotated (not visible in this photo) the lock rod simply slid over the tail of this soldier.

A general view of the frame from Newport A from the rear showing the rocking shafts which transfer the motion of the levers up and down the frame. The number of rocking shafts on an 1873 Patent frame is limited (by the width of the box, if nothing else) and this was one of the major limitations to the complexity of the locking that could be applied to these frames and influenced interlocking practice. A variety of techniques were used to minimise the number of shafts used on a frame. For example, to avoid having to have opposing signals directly lock each other; FPL levers were normally used as `direction' levers, releasing the signals applying over the points when the FPL was in and the signals applying over the points in a trailing direction when the FPL was out. Rocking shafts provided when the frame was new often extended the full length of the frame, but rocking shafts provided during alterations were often as short as possible. Note that the weight of the rocking shafts has caused the frame to tip to the rear. In service it would be upright!

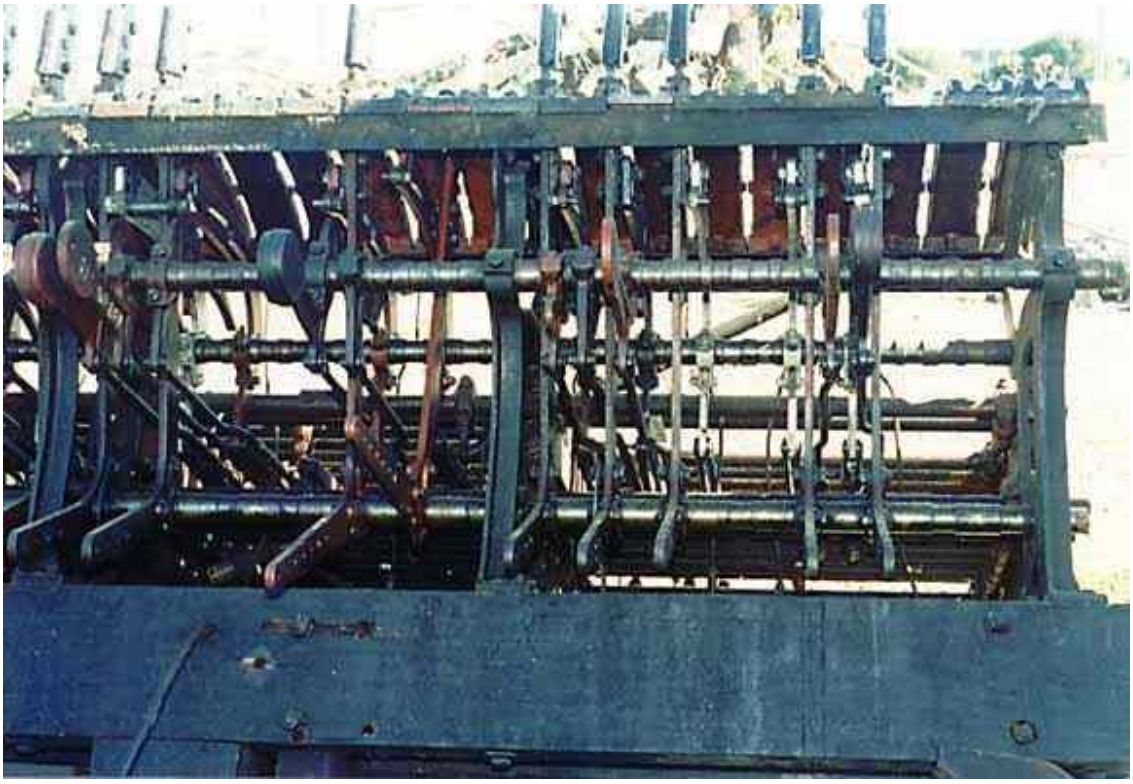
A view of the rocking shaft brackets from the left hand end of the frame. Two tiers of rocking shafts can be applied to a frame (known as the `top' and `bottom' rocking shafts). Thirty shafts could be fitted to the Newport A frame; 15 in the top bracket (which has 16 holes, but the first could not be used as it fouls the cam tails) and 15 in the bottom bracket.



Not from Newport A, this photo is included to show a different type of cast iron lock, a branch lock. When the branch lock is in its normal position (as shown here), the heel of the lock locks the lever normal. When operated, the heel drops from in front of the lock stud and releases the lever. When the lever is reversed, the curved tail of the branch lock prevents it from being lifted again, and so the lever(s) operating the branch lock are locked reverse. There were six basic types of lock, with several subtypes.



A square on view of the rear of the frame showing how locks and cams were fitted between levers. Two locks could be fitted between each lever. Thus, at most four different types of cast iron lock could be applied to one lever (two on each side), but this limited the number of locks which could be applied to adjacent levers. Four locks on a lever was very rare, a more typical number would be two: a main lock (locking the lever normal) and a branch lock (releasing the lever from normal). Two cams could also be applied between each lever, and this can be seen between the third and fourth levers from the right. The cast iron a frames supporting the interlocking frame also occupied space between the levers and restricted the locking on the levers adjacent to the frame.



Two bays of the frame from the rear. The basic support of the frame were the A frames. Older interlocking frames had frames every 7, 8, or 9 levers. The exact frame spacing depended on the length of the frame, and there was some tendency to have closer frame spacing in the middle of the frame. Frames reduced the locking capacity of the frame and added weight. Later frames appeared to standardise on 10 lever spacing's, but never longer than that. This photo also shows that these frames were not totally packed with metal; although it usually seems like it when the frame is in the box.