Back to basics – Points Part 2 of 2

The following is an edited version of an article originally published in IRSE News. It is published in the PWI Journal with the kind permission and co-operation of the IRSE. This article provides an insight into points, ie a pair of switch rails fitted with Point Operating Equipment. It is taken from the latest in a series of “Back to basics” articles by the Institution of Railway Signalling Engineer’s (IRSE). This article is aimed particularly at helping people preparing to take Module A of the IRSE’s Exam, but it will also be helpful to those people who are new to the rail industry. The article is in two parts, the first of which was published in the previous issue of the PWI Journal.

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Part one of this article, (see PWI Journal October 2022), looked at the fundamentals of points and point operation, including how points are moved, detected and locked. This second part explores some of the additional features and functions associated with points. These are not universal, and the details vary, so it is worthwhile investigating whether and how they are applied on railways with which you are familiar.

ELECTRICAL POWER FOR MOVING POINTS

Many point operating mechanisms use relatively low voltages, typically 120V, although voltages as low as 24V may also be encountered. Usually these are DC machines, although some use AC, particularly in DC traction areas for immunity purposes. They may have a peak current requirement of as much as 12A when the points begin to move and at the completion of the movement.

Where points are powered directly from the interlocking, the high current requirement constrains the maximum distance to the points, dependent upon the size of cable used, to avoid excessive voltage drop. To overcome this limitation, points may alternatively obtain their power from a local trackside source, with low power relay or solid-state control circuits connecting the interlocking to the power source, to switch the power on and off as required. Sometimes the power is derived from the traction supply, which can be problematic if the voltage fluctuates depending upon the presence or absence of trains in the vicinity.

In some countries, higher voltages, (up to 400V AC, sometimes three-phase), are used to power the operating mechanisms, which enable the points to be powered directly from the interlocking at much greater distances.

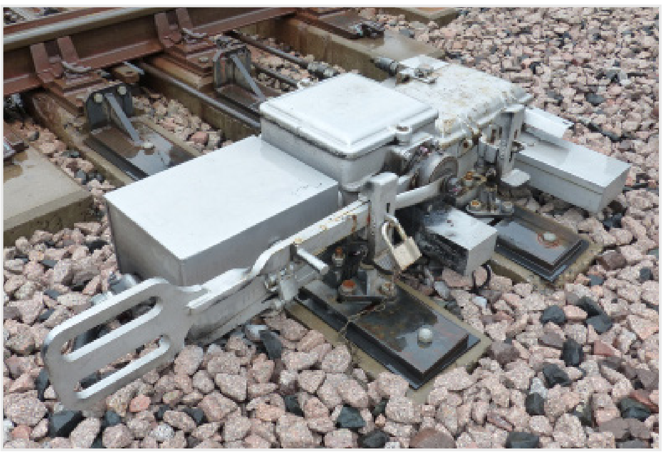

Figure 1: A point machine with integral levers for manual operation and for switching between auto and manual (Photo Francis How).

Other features of point operating include:

- They are often required to be AC immune, to avoid the possibility of electromagnetic induction causing the motor to turn, (even slightly), in AC electrified areas.
- They usually have some sort of clutch or cut-out so that in the event of the mechanism being unable to complete the point movement, (eg due to obstruction), the mechanism and the power supply do not suffer damage by continuing to operate.
- The design of the clutch or cut-out, and of the internal circuits of the operating mechanism, are such that if the points are prevented from completing their movement, the signaller can call the points back to their original position.

MOVING POWER-OPERATED POINTS UNDER FAILURE CONDITIONS

There must be a means of operating points manually if it is not possible to move them under power. Point operating mechanisms are therefore designed so that they can be operated using a rotary handle or a lever to emulate the operation of the electric motor, (albeit slowly), or in the case of hydraulically operated mechanisms, to pump the hydraulic fluid. In some cases the lever is permanently attached to the point operating mechanism and padlocked to prevent misuse, (see figure 1). In other cases the handle is inserted into the machine, which disconnects the electrical supply so that power operation cannot inadvertently re-start (which, apart from anything else, could cause injury to the operator). The handle is kept securely in a trackside cabinet or off-site, to avoid the risk of an unauthorised person attempting to operate the machine with potentially catastrophic results.

TIME OF OPERATION

The faster that points can be moved, the more quickly a route can be set, and on busy railways this can have a measurable impact on capacity. Time of operation of points is therefore a factor for consideration. Typically, a point machine can move a set of points in ~3-5 seconds, although mechanisms on long turnouts may take longer. Some operate more quickly – not much more than 1-2 seconds. Of course, there are other timing factors that need to be considered in determining the total time of operation, including the time that elapses between the signaller initiating the setting of a route over a set of points and the point operating mechanism being powered by the interlocking.

TRAILABLE POINTS

Whilst the locking of points is without doubt an important safety feature, it does have a drawback. If a train passes through the points in the trailing direction without authority, with the points set and locked in the opposite position, it is almost inevitable that the operating mechanism and rods will be damaged, and quite possibly

Figure 2: A set of points fitted with a back-drive on the left-hand side. The bracket connected to the sleeper at the intermediate stretcher bar position supports the rodding run by way of a rodding roller wheel (Photo John Alexander).

the rails as well. This is known as a “run-through”. In extreme situations the locking mechanism may be so effective that the wheel flanges on the closed side are forced up and over the switch rail, derailing the train.

To deal with this situation, on some railways the points and their operating mechanisms are designed to be trailable. If a run-through occurs, the sideways pressure of the wheels on the inside of the open switch rail causes the points to unlock, and the closed switch rail is thereby released so that it can open sufficiently for the wheel flanges to pass through. For this to happen, each switch blade is separately driven from the operating mechanism and there are no stretcher bars, (and sometimes no point lock). Trailable points may also be ‘resettable’, meaning they can be restored to normal operation after a run-through without attendance on-site, or ‘non-resettable’ meaning that on-site intervention is required.

Trailable points are also provided on some tram networks and other low-speed railways, not to cater for run-throughs but for legitimate operating movements. These points are “passive” – there is no operating mechanism or lock, and they are spring-loaded or fitted with a non-powered hydraulic piston so that in the absence of a train they always lie in one position, (normal or reverse, as required for the situation). If a train passes over the points in the trailing direction which is opposite to the natural lie of the points, the wheel flanges will push the switches to the required position. After all the wheels have passed over, the mechanism will return the points to their natural position. This arrangement can, for example, be useful on simple passing loops on single lines where it saves the cost of providing point operating mechanisms. The downside is that speed restrictions must be applied over the points to minimise the risk of derailment, (as well as reducing wear and tear), which is particularly important when making facing movements because there is no Facing Point Lock (FPL).

Finally, it should be noted that hand-operated points, which are used in sidings and are operated by a lever adjacent to the points, are often also trailable in the sense that a train can legitimately move over them in the trailing direction and they move to allow the wheel flanges through. Hand operated points are also used on lower density/rural railways in some countries where it is not economic to provide power-operated points. In these cases, the points are often locked to prevent misuse and are non-trailable.

SUPPLEMENTARY OPERATING MECHANISMS

So far it has been implicitly assumed that if the operating mechanism moves the switch tips to the correct position, all the rest of each switch rail will move as well, maintaining the correct track gauge throughout the points for the route set. This however is not necessarily the case, as the length and weight of the switch rail is considerable. The rail weight is typically 60kg/m and the longest points, found on high-speed lines, (where the diverging route speed may be 200km/h or more), can be 150m or more in length from switch tip to common crossing – although of course the switch rails themselves are shorter than this.

It is usual therefore, even on points with relatively low diverging route speeds, to fit one or more “back-drives”, (also known as supplementary drives). Most commonly these take the form of an assembly of cranks and rodding which connect the switch tips to a position further along the length of the switch, (see figure 2).

When the point operating mechanism moves the switch tips, the motion is transmitted via the cranks and rodding so that the whole length of the switch rail moves in unison. The cranks and rodding must be adjusted correctly, because the amount of lateral motion required part-way down the length of the switch is less than at the tips. Sometimes a supplementary detector is fitted further along the switch rails to check that the rails are in the correct position, the contacts of which form part of the detection circuit, (see figure 3).

Back drives composed of rodding and cranks are still commonplace although they can be difficult to maintain. Alternatives introduced include a torsion bar mounted along the track, or supplementary hydraulic rams.

On long turnouts a single point operating mechanism may not have sufficient power to move the whole switch or, even if it does, the switches may bend along their length rather than fully move to the

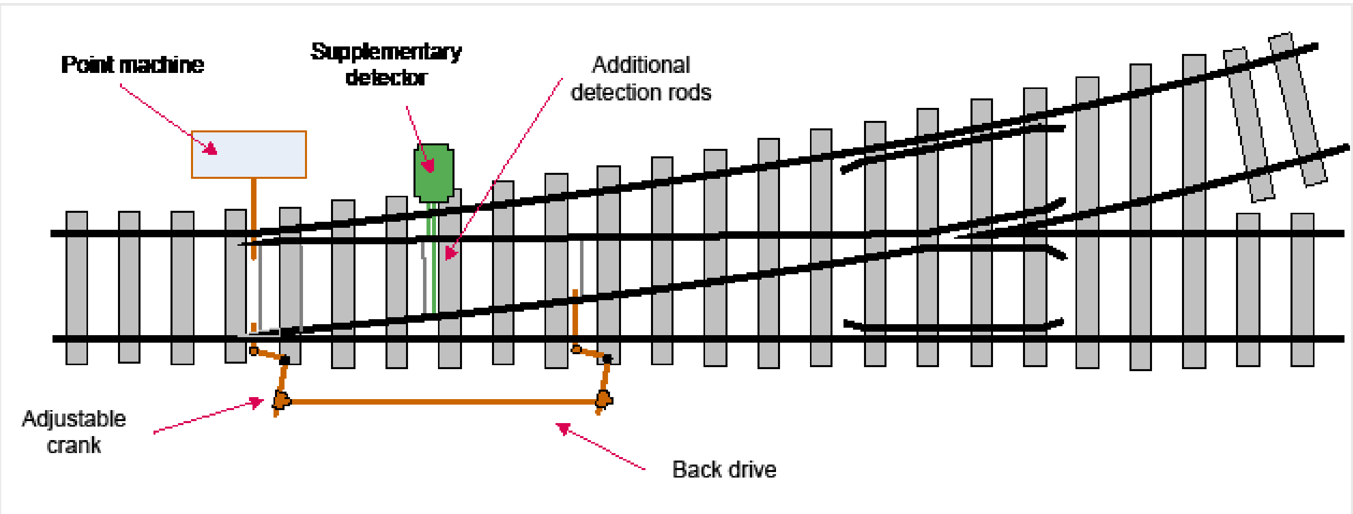

Figure 3: A set of points with a back-drive and supplementary detector. Sometimes the back-drive is located between the switch rails. Note that this drawing is intentionally not to scale, in order to illustrate the back-drive and connector more clearly (Diagram Andy Knight).

required position. To overcome these problems, supplementary point operating mechanisms, (also known as auxiliary actuators), are located part-way along the switch rail, (see figure 4). These are controlled from the interlocking and move at the same time as the operating mechanism at the switch tips. In some cases these supplementary mechanisms may include a lock to help hold the switch rails in position throughout their length.

Long turnouts are also usually equipped with supplementary detection, which may be integral with the supplementary operating mechanisms where provided. The electrical contacts for these supplementary detectors form part of the overall points detection so far as the interlocking is concerned. However, sometimes the status of each detector is separately indicated, (either locally on site or back at the interlocking), to make it easier when fault-finding.

SWING NOSE CROSSINGS

The greater the length of a set of points, the smaller the angle between the rails where they meet at the common crossing and the longer the gap over which the wheels pass without having a rail to guide or support them, (see figure 5).

On very long points this gap would become unacceptably large, and the crossing nose would be too slender to support the wheels. This clearly has safety implications. To overcome this problem, a "swing nose" is used.

In a swing nose crossing, the crossing nose, (labelled in figure 5), moves sideways to close the gap for whichever route is set. It has its own operating mechanism to do this, working in synchronism

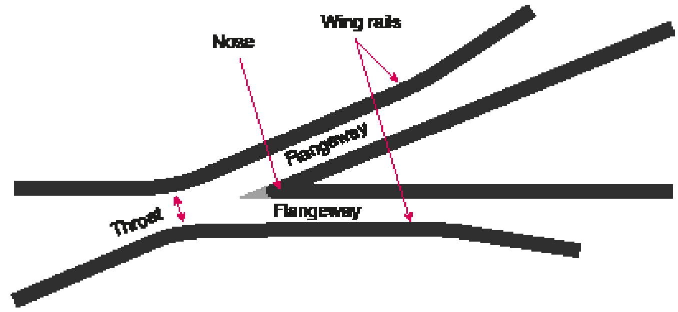

Figure 5: The common crossing (frog) of a set of points, showing the component parts.

Figure 4: (Above left) Multiple operating mechanisms in use on a high-speed turnout. In this example there is just one machine driving the points (to the left of the switch tips), and the power from it is transmitted hydraulically to several setting and locking mechanisms along the length of the switch rails (Photo Francis How).

Figure 6: A swing nose crossing. Photo Wikimedia/Dzelzceļnieks, CC-SA4 licence

Figure 7: A fixed diamond crossing. A train on either track can only go straight on, not diverge (Photo Network Rail).

with the other operating mechanism(s) under the control of the interlocking. Detection of the position of the nose forms part of the overall points detection circuit. A swing nose crossing is shown in figure 6.

Swing nose crossings are sometimes also used on turnouts that are not particularly long but where the axle loads are heavy, to minimise damage and noise.

OTHER SWITCH AND CROSSING LAYOUTS

So far consideration has been given to points which permit a train in the facing direction to take one of two routes. These can, of course, be used in combination to create more complex junctions, a simple example being a linking track, (crossover), between two parallel lines.

However, sometimes there is insufficient space to accommodate the points required for all the movements that the operators require. Most commonly this occurs in the vicinity of large stations, particularly terminal stations. In such circumstances various options are available to the permanent way engineer, including:

- Fixed diamond crossings – which have no moving parts.
- Switch diamonds – sometimes known as movable elbows or movable angles. These are functionally equivalent to a fixed diamond crossover but have moving parts.
- Slip switches – sometimes known as double switches, puzzle switches or compound switches. They are further delineated according to the position of the switch tips - where the tips are within the diamond crossing they are referred to as either 'inside' or 'internal' slips, and where the tips are outside the crossing they are referred to as either 'outside' or 'external' slips.

Examples of these are shown in figures 7, 8 and 9. Other point configurations can be found in various parts of the world, including Y-shaped junctions where both routes are curved, and three-way junctions where there are three routes in the facing direction.

TRACK CIRCUIT INSULATION IN POINTS

One of the difficulties associated with equipment such as point rods, soleplates and stretcher bars is that they provide an electrical path between the rails, so that a track circuit through the points would show permanently occupied. To address this problem all these components are designed with insulators. An alternative, of course, is to use axle counters, although most points are provided with insulators as standard, regardless of the means of train detection.

THE EFFECTS OF TEMPERATURE ON POINTS

Variations in weather, and in particular temperature, can have a significant impact on points, in various ways. Firstly, changes in temperatures can cause the switch rails to vary in length. In the UK, for instance, it is not uncommon to have 10-15 degrees Celsius change in air temperature during the course of a day, plus another ~20 degrees variation in the rail temperature caused by sunlight on the rails.

The effect is to move the tapered end of the switch rails forward and back by ~10-15mm, with the additional complication of seasonal changes shifting the mean. Other countries are likely to experience even greater variations. The changing length of the switch rails can cause difficulties in maintaining the correct adjustment of the locking and detection mechanisms.

A second problem is snow, which can cause an obstruction between the stock and switch rails, preventing the points from fully moving to the required position. Originally the only solution was to send people out to clear the snow. Later, gas -powered switch heaters were fitted to the outsides of the stock rails, or heated oil was pumped through pipes integral with the chairs supporting the rails to melt the snow. Nowadays most switch heaters are electrically powered.

Another temperature-related problem affects the rodding that is used to move manually operated points, (see Part One of this article, in particular figures 5 and 6). Thermal expansion and contraction of the rodding can make it impossible to move the points or, potentially, move them slightly without any action by the signaller! To overcome this problem, an arrangement of cranks called a "compensator" is fitted at intervals in the rodding run, which adjusts as the rodding varies in length so as to prevent the points becoming inoperable.

POINTS FOR AVOIDING COLLISIONS

Throughout this article there has been an emphasis on the need for safety, primarily to avoid derailments on points. Therefore, it may seem strange that the very last types of points to mention are ones which are intended to derail or sidetrack trains and vehicles! These are known as trap points and catch points, although they can also

Figure 8: (Left) A switch diamond crossing. A train on either track can only go straight on, not diverge. The (obtuse) crossings are fitted with two pairs of switch rails, back-to-back, which are moved in synchronism to provide a continuous rail head for the train movement (Photo Wikimedia/Falk2, CC-SA4 licence).

be referred to as run-off points and derailers. Naming conventions vary across different railway administrations, and the phrases 'trap points' and 'catch points' are often used interchangeably, although historically there is a difference.

Trap points are typically provided at the exits of sidings and passing loops, where the track joins a main line, (see figure 10). Unless a route is set for a train into or out of the siding or loop, the trap points are set so that if a train or vehicle inadvertently passes the trap points, it is likely to quickly and safely come to a stand, rather than passing onto the main line where a collision could occur with another train. The trap points are usually operated in synchronism with the corresponding points in the main line.

Trap points take various forms. In figure 10, the points have a short length of track beyond them to guide the overrunning vehicles away from the main line, (these are called 'safety points' in some countries). Sometimes a sand-drag and buffer stop or a train arrestor is provided to bring vehicles to a halt as soon as possible. Careful site-specific consideration is needed at the design stage, involving both signal and permanent way engineers, as well as operators, to ensure that the train will stop without causing too much damage.

At Coton (UK) in 1946, a heavily loaded freight train ran out of control on an incline and was derailed on a set of trap points, completely demolishing a signal box that was located beyond the

Figure 9: A double (internal) slip crossover, where a train approaching from any direction can either go straight on or take the diverging route. There are eight movable switch rails in this layout, all of which must be moved, detected and locked (Photo Shutterstock/ Leonid Andronov).

points. The destruction of the signal box caused another set of points to move, which sent 24 of the wagons into a siding where they collided with a locomotive. It might sound like a comedy of errors, but sadly the signalman on duty was killed.

In the example of figure 10, the function of the trap points is not to derail an overrunning train but to bring it to a stand on the rails. Where trap points are provided, this is the desirable option. Other types of trap point are also used, fitted with either one or two switch rails but no common crossing. These are intended to cause derailment – see figure 11. Again, the aim is to stop the train or vehicle as quickly as possible, clear of the running lines and the conflict point ahead. Occasionally, wide-to-gauge trap points are provided, where it would be unsafe to derail the train either to the left or the right.

However, this is a non-preferred way of stopping an over-running train as a derailment, even at slow speed, is very disruptive (there is a YouTube video showing this at Quorn on the Great Central Railway, a heritage railway in Britain: 46521 with TPO at Quorn Saturday 27th April 2013 ***https://youtu.be/Yr5EztEPJS8***).

The signal engineer refers to the use of points to prevent collisions when a train passes a signal at danger as "trapping protection". Trap points are an example of providing points specifically for this purpose but, where possible, points provided for other purposes,

Figure 10: Trap points at the end of a siding or loop line joining a main line. Photo Wikimedia/Falk2, CC-SA4 licence.

Figure 11: An example of a catch point that derails trains. Photo Network Rail.

(for example, as a crossover between two lines), are set by the interlocking to provide trapping protection so that an overrunning train passes onto a section of line that is hopefully clear of other trains, rather than into the path of another train. This interlocking feature is commonly known as flank protection.

When used in dark territory, (railway lines not controlled by signals but using train orders or track warrants to authorise movements), trap points are usually locally operated by hand with suitable locking arrangements to prevent misuse. They may be the responsibility of others rather than the signal engineer.

Trap points are still used at many locations on railways throughout the world, but catch points are rare on modern railways. They were provided on steep inclines in the days when railway vehicles were unbraked. If a train split in two as it ascended an incline, the back portion would run back down the gradient. The function of the catch points was to derail the vehicles as they ran back, to avoid the possibility of them running further downhill and colliding with another train. Catch points were generally not worked either by the signalman or the interlocking. As the train ascended the gradient it passed over the points in the trailing direction. The switch blades would be moved into the correct position by the wheels and return to the derail position after the train had passed. Self-evidently, unworked catch points were only installed on uni-directional lines!

Finally, although outside the scope of this article since they are not points, it is worth noting that derailers are widely used in North America and elsewhere, (including London Underground), as an alternative to trap points. They take various forms, usually a bolt-on to the running rail, (there is no movable switch rail). When set to derail, the mechanism forces the wheels up and over the running rail thereby derailing the vehicle(s). Derailers may be operated by a hand lever (often called a "switchstand" in North America), or by power, and they may be fitted with locks and detectors for integration into the signalling system.

CLOSING THOUGHTS

These two articles have explored the basics of points and point operation, and the role of signalling and the signal engineer in ensuring they work safely. More varieties of points exist than have been covered, not only for main line and metro railways, but also for rural and low density railways, tram railways, rack railways, dual gauge railways and more. However, the principles of safe operation are more or less the same.

If you are new to railway signalling or permanent way you are encouraged to ask your mentor or manager to arrange a visit to a set of points so that you can see for yourself what you have read about in these articles. However, as with any site visit, take care of yourself and others and obey all the safety rules – points are hazardous, and so are the trains that run over them.

A future article will look at the maintenance of points from a signal engineering point of view, including specifically the use of remote condition monitoring.

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About the author - Francis How has been a long-time member of the IRSE, throughout his distinguished career. First with British Rail/ Railtrack, with Atkins, and then as the technical director of the Railway Industry Association. He was a Thorrowgood scholar, (awarded to those who have excelled in the IRSE's exam) and served on IRSE Council for many years, becoming the President of the IRSE in 2012- 2013. He was appointed as the Chief Executive of the IRSE from 2015 to 2018, and led many of the improvements to the Institution. Francis is widely respected in the industry for his professionalism and extensive technical knowledge.

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