# 2 Active Components for Non-bogie Stock

## 2.1 Introduction

On a model railway, wagons have to fulfil two functions.

- to look like the prototype and
- to behave like the prototype.

This section concerns the choice and arrangement of those components which make the vehicle perform on the track. The cosmetic parts are dealt with in Part 4, Section 4.

The principles outlined are cross-standard and apply to all non-powered vehicles.

## 2.2 Wagon Component Parts

The 4-wheeled wagon is the simplest railway vehicle and most probably the first which any modeller makes for himself. In basic model form it comprises four distinct parts.

1. Body: being the basic floor with solebars and framing but can also include the sides, end and roof of the vehicle.
2. Running gear: wheels, bearings and suspension units.
3. Draw gear: the means to connect adjacent vehicles.
4. Buffers: the components which absorb shocks when trains are being pushed.

These four component parts must be made in such a way as to carry out their functions in an efficient and reliable way and to give good running qualities while cosmetically conforming to the appearance of the prototype. Detailing may be as basic or as complete as the builder desires, as it is only cosmetic.

## 2.3 Bodies

In the prototype, vehicles have two distinct assemblies, the underframe and the body.

The underframe comprises all of the components that are required for the vehicle to run on the railway. The main frames could be made from wood or metal or a combination of the two and carried all the active components, wheels, buffers, couplings and brakes. The body is the part that carries the load, or passengers, and can be quite flimsy on its own. Bodies had many different forms while underframes were very similar and, as railways developed, came to be standardised under the control of the Railway Clearance House.

In model form it is often the body that has the rigidity and it is normal practice for modellers to build the body first and then fix the underframe and its components to it, the reverse of the prototype in the steam age! However, modern practice is now increasingly rejecting the separate underframe for monocoque construction.

In model making, the wagon or coach body can be made from any suitable material. Its main functions, other than looking like the prototype, are to locate the active components in the correct relative positions and to enable the model to behave in a prototypical manner on the track. The body itself must have sufficient strength and rigidity to withstand the considerable forces and shock loading which it will be subjected to when running on a layout. Materials, which have been found to be suitable, are wood, card, metals, sheet plastic, injection moulded plastics and some polyurethane resins. In some cases the materials used do not have sufficient strength in themselves and it is essential that reinforcement of the key areas of drawbars and buffer mountings is incorporated in the model. These particular areas are dealt with in the appropriate sections.

## 2.4 Running Gear

Running gear is defined as the wheels, axles and suspension units. It is these units that turn a model into a vehicle which will or will not perform as its prototype. It is assumed that the modeller will have decided upon his track and wheel standards, both of which have a major bearing on the way in which wagons perform on the track, before building begins. Model four-wheeled vehicles can be built on simple plain un-sprung bearings or on various types of moving suspension of differing complexity. While moving suspensions add complexity, they improve running and where they are designed such that each wheel is always in contact with the rail-head and carries a substantially equal proportion of the total weight, dirt is rarely found on the treads. On large exhibition and display layouts this factor could, by itself, justify their use.

### 2.4.1 Rigid suspension

As described in the introduction, early wagons ran on wheels carried in simple bearings. In model form this is also the most common practice. Wheels of the appropriate form mounted on an axle make one unit. The wheels must be fixed at the correct back-to-back dimension as defined by the standards adopted and should run truly with no perceptible wobble or eccentricity. The axles are carried in bearings, usually outside the wheels, by cast metal or moulded plastic axleguards. These axleguards represent the prototype components of the W irons, axleboxes and springs and are available in a wide range of types to suit the model being built. The axles may run in the axleguard itself or in a bearing fitted into the axleguard. These bearings are normally brass bushes though some modellers use hard nylon or PTFE plastic, which can give free running and do not need lubrication.

In using plain bearings there are 5 conditions that must be met to achieve the best running.

1. The axles must be parallel to each other.
2. The wheels must be in line with each other
3. There must be minimum end float in the axles
4. Wheels must turn easily.
5. All four wheels must touch the ground when on a flat surface.

The first four are relatively easy to achieve if normal care in setting out and assembly is taken. The last condition is quite difficult to obtain and maintain in practice. Even in 'rigid' wagons on the prototype there was some flexibility in the body and wheels would be forced onto the rail by the weight of the wagon. In model form, bodies tend to be rigid and even quite large additions of weight do not cause the wheels to follow irregularities in the track. Heavy wagons do not have the same tendency to bounce at irregularities in the track but this is because of the greater inertia of the mass. Heavy wagons reduce the load a locomotive may pull and, while on small layouts this may be of little consequence, could make a vast difference in larger layouts with lengthy trains.

When building a wagon from a kit, care in following the manufacturers instructions is normally sufficient to produce a free running vehicle. However care in ensuring that the 5 conditions above are met will pay dividends on the track.

In scratch building, the modeller has to control all five requirements himself. Careful setting-out of the basic dimensions and drawing guidelines for axle centres with try-square and ruler is essential. Wheels and axles can be positioned in line with the drawn lines and checked by eye. A small straight edge laid between the backs of the wheels can show if the wheels are in line. (See Part 2, Section 5.3).

End float and free running are closely linked and normally if one condition is met the other follows, this is particularly the case where pin pointed axles are used as they require no end float. If using plain bearings judicious use of washers between the bearing and the wheel boss can limit end play. Plain bearings will require regular lubrication and, depending on use, may need the bearings cleaned out and re-oiled. Some oils have a tendency to dry out or attract dust, which forms a 'gummy' substance that impedes free rotation. PTFE plastic bearings that do not need any lubrication can be substituted for the brass ones normally supplied.

The most difficult condition to meet is number 5. An accepted method of assembly of rigid vehicles is to fix the axleguards to the vehicle floor and to leave the glue or solvent to set with the model sitting on its wheels on a dead flat surface; a piece of plate glass being the ideal flat surface to use. Before leaving the glue to set overnight a careful check that all wheel flanges touch the glass must be made. This method has been used since the dawn of railway modelling and works most of the time. However over time the body may begin level but as solvents and glues dry out stresses may be set up which cause the floor to warp.

### 2.4.2 Loose wheel bearings

Some modellers leave some slop in the journals to permit the axle a little leeway to drop under its own weight. On dead flat track the wagons weight is carried equally on the four wheels but if a dip in one rail is encountered then the wheel follows it. The wagon is, however, now only carried on 3 wheels and can rock. The situation is similar to a 4-legged stool on uneven ground, which in effect rocks on opposite legs. This method of suspension can contribute to better running but is not as effective as compensation.

### 2.4.3 Compensated suspension

In using compensated suspension all 5 conditions given above still apply, but one set of wheels is permitted some rocking movement across the wagon floor thus permitting the wheels to follow the irregularities of the track. This arrangement in effect gives a 'three point suspension' reminiscent of the milkmaids 3-legged stool which

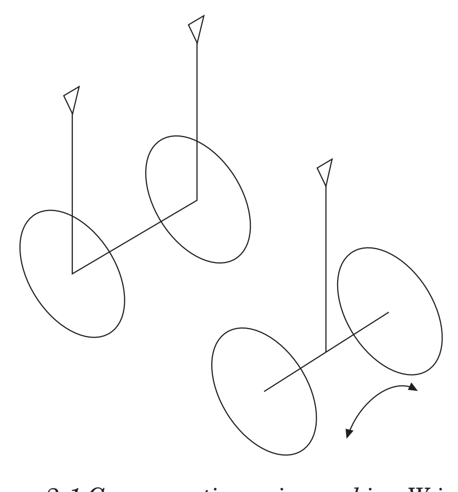

*Figure 2-1 Compensation using rocking W-irons*

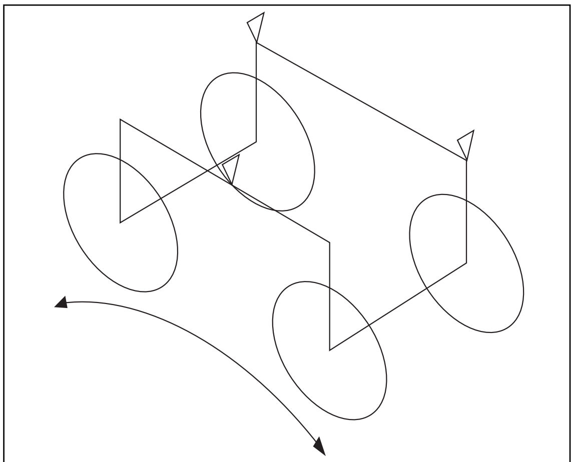

*Figure 2-2 Compensation using rocking solebars*

always gives a stable seat! Because one wheelset can 'float' relative to the other, any distortion of the vehicle body has no effect on the ability of the wheels to contact the flat surface and more consistent running performance can be ensured. There are two main types of compensation

1. Rocking W-iron, Figure 2-1
2. Rocking Solebar, Figure 2-2

The rocking W-iron is the most commonly used and usually consists of an etched cradle that carries the W-irons, bearings and wheelset. The cradle is held in a bearing at its mid point and is allowed a small amount of rock each side, about 0.5mm is sufficient. Cosmetic springs and axleboxes to the prototype pattern are fitted with provision made to permit the bearing to move. The cosmetic springs are usually fixed to the solebars and the axle box to the w-iron with a slot in the top of the latter to accommodate the spring buckle, though other arrangements are possible.

An alternative to this type, and most useful when converting existing models to compensation, is to use an internal bearing cradle which fits between the wheels. The protruding axle ends are trimmed flush with the face of the wheels and the wheelset mounted inside purely dummy prototype W-irons and springs etc. Conversion is made easy if a miniature slitting disc is used to cut off the axle ends of one wheelset without removing the fixed axleguards and disturbing the cosmetic parts of the model.

Care must be taken when fitting the brake gear to both the above types to ensure that the shoes do not hinder movement or cause a short circuit should they inadvertently touch the wheel tread or flange.

The rocking Solebar is useful where there is no flat floor on which to fit the rocking cradle of the W-iron type. Types ideal for this system include tank and hopper wagons.

In use, the wagon solebars are assembled with axleguards and wheel bearings as normal, but only one solebar is fixed to the buffer beams. The other solebar is pivoted at its midpoint and permitted some lateral rocking movement; about 0.5mm up and down at the ends is sufficient. This permits the '3-legged stool' effect and lets the wheels follow the track. Brake gear can be fixed to the solebar and shoes can be close to the wheels which, as they all move together, permits prototypical appearance without the risk of short circuits.

### 2.4.4 Springing

Wheels may be mounted in axleboxes sliding in W-irons just like the prototype and there are commercial systems available to enable this.

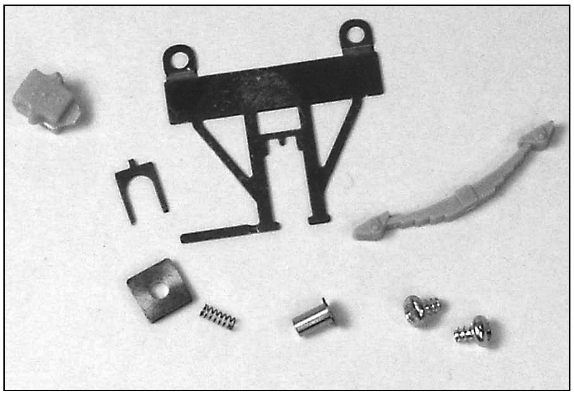

*Photo 2-1 Components for sprung wagon axleboxes by Slater's*

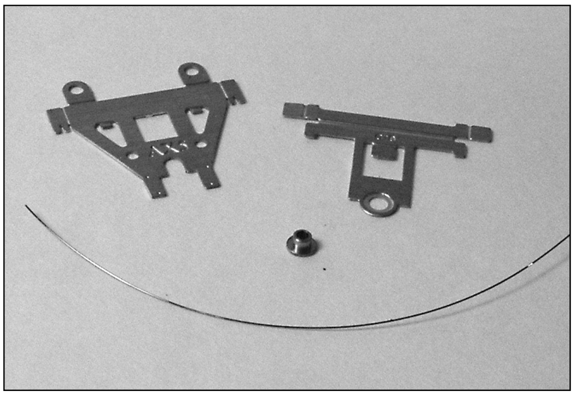

*Photo 2-2 Components for sprung wagon axleboxes by Exactoscale*

(Photos 2.1 and 2.2). The axleboxes are controlled either by miniature coil springs hidden behind the dummy leaf springs or by wire 'leaf' springs in a similar position. Springing systems work extremely well and tests reported in the model press indicate that vehicles fitted with springs perform better than other suspension methods. The five conditions above still need to be rigidly adhered to but there are two further considerations that require attention.

**Movement**. The sliding axlebox must be able to move smoothly up and down the guide. A good test is if the box will slide under its own weight when the wagon is upturned. Care must be taken if painting the units as they are easily gummed up, a better colouring method is to chemically blacken the units before assembly.

**Weighting**. For spring suspension to work properly the vehicle must ride on the springs ('live' springing) such that when pressed down the body will compress the springs further and when lifted slightly the wheels will still remain in contact with the rail. A total movement of about 1mm is more than sufficient to cope with the most irregular track faults. Experimentation has determined that about 65 grams (2.5 ounces) per axle is a good figure to aim for but some whitemetal wagons weigh considerably more than this so stronger springs need to be fitted.

**Note:** Some modellers use a combination of the loose wheel bearing mentioned above and a light spring that pushes the wheel down into dips. This is known as a 'dead' spring as opposed to the 'live' spring method and does improve the running as it goes some way towards equalising the load carried by each wheel.

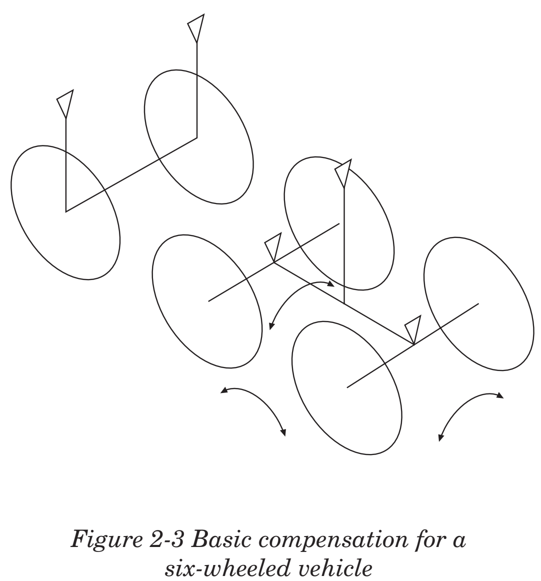

*Figure 2-3 Basic compensation for a six-wheeled vehicle*

### 2.4.5 Special cases – 6 or multi-wheeled rigid vehicles.

Short wheelbase 6- or 8-wheeled wagons, eg brake vans, may be built rigid or sprung but with a little side play allowed in the centre axles to permit the vehicle to round curves. It is best for these centre axles to run in plain bearings. It may be advantageous to use inside bearings for these wheels and to permit a little upward play to prevent rocking on this axle if a hump is to be negotiated. If sprung, the centre axle springs should be softer than those at the outer ends.

Where compensation is used one outer W-iron/axle assembly may be fixed to the wagon floor. The other two axles units are mounted on a sub frame to give three-point suspension. This sub frame is further pivoted at its mid point to give a three-point suspension to the body (Figure 2-3).

Long wheelbase 6-wheeled vehicles. This type of underframe is mainly found on coaching stock and a few specialised goods wagons. The prototype used two basic methods to introduce flexibility. The simplest being to permit some side play on the centre axle. This was normally done by using longer hanging links on the springs and giving the axlebox some lateral play in the w-irons. A more complex method was the Cleminson system, which linked all axles together and made the outer ones 'steer' into curves under the influence of the centre axle. This system gave a better ride to vehicles and permitted quite sharp curves to be negotiated.

In models, where the curvature is usually much sharper than prototype, the rigid system is very unreliable and severe compromises have to be taken with appearance to get enough side play on the centre axle. The length of wheelbase, often 18' or more, causes problems at track irregularities where any vehicle rock can be magnified to the point where the flange will climb onto the railhead causing derailment. To obtain the best running of 6-wheelers some type of flexible running gear is advised.

There are two distinct methods in use which

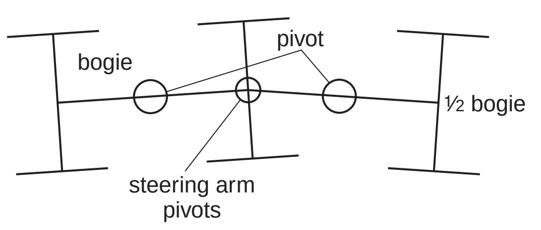


*Figure 2-4 Bogie and a half compensation*

give good running qualities:-

The simplest method, that most often used by kit makers, is the bogie & a half method shown in Figure 2-4. This is a compromise on the prototype as it does not place the wheel sets in the best attitude to the rail but can work quite well. In this method two adjacent axles are arranged as a bogie, usually with inside bearings which can be rigid, compensated or sprung, The bogie is pivoted at its midpoint between the two axles and the third axle is carried in a half bogie or pony truck which is pivoted between the wheel and its inner end which is linked to the main bogie.

True Cleminson suspension (Figure 2-5) requires more complicated setting up but has the advantage of always presenting the wheels at the best angle to the rails and equalising end throw, which is important where vehicles are propelled round sharp curves. In this method the centre axle can slide across the vehicle taking with it its suspension units. The outer axles are carried in pivoting units which have steering bars linked to the centre axle. As the centre axle moves, the outer wheels steer into the curve.

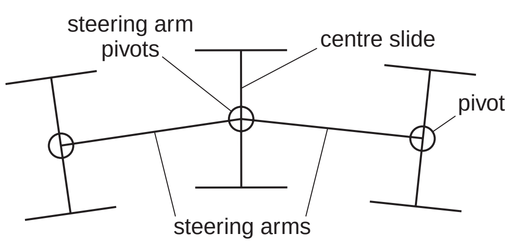


*Figure 2-5 Cleminson guide system*

## 2.5 Draw Gear

Vehicles must be coupled up to make trains; the most common method used in the prototype is the simple hook and chain. In model form this method can be replicated exactly and has the virtue of being simple and cheap.

In the prototype, the hook is mounted in a slot in the centre of the headstock (buffer beam) of the vehicle and is often retained by a continuous drawbar and spring to the coupling at the other end of the vehicle. The drawbar and hooks thus put a compressive force on the wagon underframe and when the wagon is pulled along it is, in effect, being pushed by the its rear coupling. This is done to prevent the vehicle frame having to take tensile forces that could pull the frame apart!

In the model form a simplified version is generally used which puts the pull on to the leading end of the wagon and and places the stress at that end. The hook can be rigidly fixed into the headstock with glue or given some movement under the control of a spring. If the vehicle is built from strong enough materials there are few problems. Glued whitemetal kits or some plastics have less inherent strength and can be pulled apart especially if subjected to heavy shock loading which can be the case if marshalled at the head of heavy trains. In these circumstances it is best to replicate the prototype and to use stress-relieving wire, incorporating a spring if wished, linking the couplings at each end of the wagon (Figure 2-6).

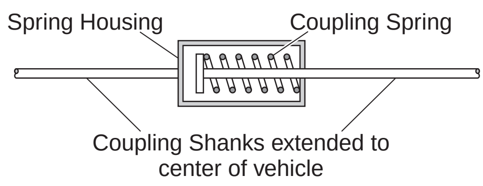


*Figure 2-6 Central coupling spring system*

Modern practice has seen the increasing use of semi-automatic and automatic couplings on freight stock. Some companies have used a knuckle type coupling on coaching stock for many years. These couplings are often used to make up block trains that still have provision for the hook and link coupling at the outer ends of each rake. The modeller can replicate these simply by following the prototype methods.

### 2.5.1 Autocouplings

There are a number of different types of automatic couplings on the market. None of these are prototypical but are used to permit more convenient or realistic operation of models, usually without the intervention of the human hand. Most couplings are fixed under the buffer beam though some use a hook running in the prototype slot. Care must be taken in fitting autocouplings as most have fairly limited tolerances if they are to be reliable. It is also important to take into consideration the structural strength of the fixings.

## 2.6 Buffers

Wagons get pushed as well as pulled so the buffers must take the strain. In early days the buffers were merely extensions to the wagon frame and were subjected to considerable shock forces. If wagons were struck while sitting on a curve it is

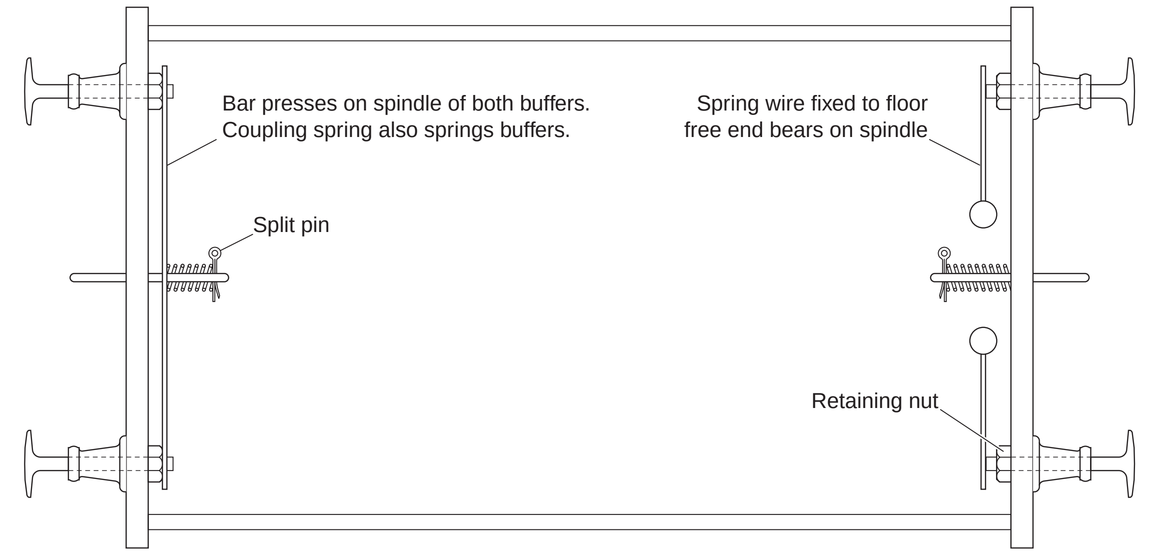


*Figure 2-7 The two methods of arranging springing for buffers*

obvious that only the inner buffers would be taking the stress which would tend to twist or rack the frame. In an attempt to reduce some of the shock effects, firstly padding and then sprung spindles and heads were introduced. In model form the buffers must perform the same task as their prototype equivalent but, as the forces are much less and are compressive, it is acceptable to use unsprung or 'dumb' buffers. Many kit manufacturers supply cast or moulded buffers, which are quite suitable, though vulnerable to breakage especially where heavy shunting takes place!

If using three-link couplings, dumb buffers may cause clearance problems when coupling up on curves and can cause unacceptable side forces when running round sharp curves. It may be found that sprung buffers not only work better in model form but add an additional prototypical dimension. Buffer head sizes were standardised to a great extent but there were many types of buffer guide, often with quite typical company features which the modeller will want to replicate. In model form the guide may be fixed permanently to the buffer beam and the head and spindle sprung. There are three main types of springing which can be used in models.

- **An equalising bar** which also uses the coupling spring to act as the buffer spring. This method is very easy to install but care must be taken in selecting the tension of the spring. Too stiff and the buffers will not compress, too soft and the coupling will pull too far out its slot!
- **A leaf type** spring behind the buffer beam. In this type one end of the spring is fixed to the floor or frame and the free end bears lightly against the end of the spindle. By varying the length of spring, which is usually a springy wire, or the stiffness of the material, the buffer may be given a stiffness appropriate to the model.
- **Self contained.** In this method the buffer body contains a small compression spring, which gives the required control. Care must be taken in selecting the spring rate used; in the writer's experience many of the springs supplied through the trade are far too stiff. A good rule of thumb to test for correct stiffness is that the buffers should be seen to compress slightly when only one wagon is being propelled.

In all sprung buffer applications care should be taken to ensure that spindles can move smoothly, a light oil sparingly used can help to keep them working. It is also important to ensure that at each end of the vehicles the springs are evenly matched and take an equal share of the load.

### 2.6.1 Sprung buffers and autocouplings

Some autocouplers, eg Alex Jackson & Lincs, only pull and require the buffers to carry out the pushing function. It is imperative in these cases to ensure that the tolerances are adhered to if satisfactory operation is to be obtained. When using couplers which push as well as pull it may be a requirement to prevent the buffers protruding too far as contact between buffers may prevent full operation of the coupler, especially a problem on curves. Modellers are advised to consider the implications before committing to a coupler type.