INTRODUCTION

This leaflet describes the range of Protofour rolling stock components and their use in rolling stock construction, or in the conversion of stock originally built for other 4mm scale systems. These instructions will be extended from time to time as new items of equipment are introduced into the Protofour range.

Generally speaking, both hand-built and commercial vehicle bodies are produced correctly to scale, and only the running gear and suspension are incorrectly proportioned. The fitting of correctly proportioned Protofour running gear and accessories therefore produces complete scale models.

Protofour rolling stock components have been produced to enable both original construction and conversions to be carried out using identical parts. All components have been designed to provide ease of installation, compatibility with other Protofour parts, faultless running, and authentic appearance. When correctly handled and maintained, they will give long and reliable service.

ABBREVIATIONS

The following abbreviations are used in the text :

∅	Diameter	ED	Equivalent Diameter
mm	Millimetres	CSU	Compensated Suspension Unit
'	Feet	C & W	Carriage & Wagon
"	Inches	B & T	Bogie & Tender
RCH	Railway Clearing House	BB	Back to Back

MAINTENANCE

Each Protofour component is manufactured from the most suitable material. However, as all materials have their limitations, the following precautions should be taken by the modeller to prevent inadvertent damage or deterioration.

Steel

This material is used for wheel tyres and other components where strength and resistance to wear is required. It gives superior running, collects less dirt than other materials and additionally presents an authentic appearance. As steel is susceptible to rusting, it is usually supplied with a chemically treated surface which helps to minimise rusting. However, the following measures should be taken :

1. Store steel parts in a container together with VPI (Banrust or similar) paper, or cover the layout with sheets of VPI paper and plastic foil to enclose the airspace when not in use. This prevents the formation of water which causes initial rusting.
2. Wipe steel surfaces with a lightly oiled rag at maintenance intervals. Where wheel treads are concerned, the application of a light coating of Electrolube will protect these while assisting the passage of electrical current between the rail and the wheels.
3. If rust forms, it may be removed with the use of a glass-fibre brush, and the surface re-oiled.
4. Where it is impossible to prevent excessive moisture from reaching the layout, nickel-plated wheels are obtainable. However, these do not run quite so well as the steel variety.
5. The protective coating on steel tyres may also be removed with a glass-fibre brush.

Plastic

This almost universal medium is used in certain forms for mouldings. These are subject to the usual limitations.

1. Do not use plastic solvents - carbon tetrachloride, trichlorethylene, etc., - to clean plastic parts. They will deform, or the plastic structure will be damaged and weakened.
2. Do not use paints containing plastic solvents on plastic parts. The surface of the material may take on a 'crackle' finish.
3. Do not use certain synthetic oils on plastic parts. These contain solvents which soften the material. (Check the label on the oil container).
4. Do not use excessive heat near plastic components. Soldering operations should not be carried out on or near plastic material.

Brass and other Non-Ferrous Metals

These are used in many different forms. Brass is often blackened, in which case, scratching will remove the coating, revealing shiny metal underneath. This feature is useful when preparing for soldering; the use of the glass-fibre brush will provide clean metal without damage to the surface details.

Solder paint and cored solder wire are the two most convenient forms of solder for the modeller. The former is particularly suitable for fine work since it is easy to add just the right amount, so avoiding the difficult task of removing excess solder. However, solder paint should not be used on tinplate and on other metals where the corrosive action of the flux creates problems. Solder joints should normally be cleaned of residual flux to prevent interaction between the flux and the metal. This is most important when fine parts are 'sweated' together, as eventually the metal could be eaten away through corrosion.

Tolerances

Protofour parts are produced to exacting standards and should be treated with reasonable care. Wheel sets should be checked by means of the BB gauge before placing them in service, and at maintenance intervals thereafter. Whenever running difficulties occur, always check the BB setting of the wheel sets before seeking the cause elsewhere.

Vehicles, owing to their portable nature, are usually the first casualties from rough handling and the condition of their running gear should be checked regularly for signs of deterioration. Apart from the BB gauge check, wheel wobble may be detected by spinning the wheels in their bearings. The wheel pair may be removed from the vehicle and rolled gently on a mirror surface to detect whether the wobble is caused by a single wheel or by a bent axle. Generally, the wobble may be rectified by the modeller but a wheel pair on a bent axle will have to be replaced.

Lubrication

Protofour wheels are intended to run 'dry' in the bearings. Oil applied to bearings will eventually reach the track, and so interfere with the passage of current from rail to wheels. If desired, a soft pencil rotated in the point of the cone will be found to give bearings a dry lubricant effect.

Fitting of Wheels

The fitting of wheels to axles, and wheel pairs on axle to vehicles, should be carried out using a standard technique. Always apply fitting forces to the wheel boss, never to the wheel rim. Always hold wheel pairs by the axle, never by the rim. This avoids the accidental application of excessive force to the wheel rim and prevents distortion of, or damage to, the wheel centre.

C & W wheels are supplied as pairs on axle, as the axle is almost invariably used with outside bearings. However, separate wheels and axles are available if desired; no responsibility can be accepted for the performance of C & W wheels which have been mounted by the modeller.

B & T wheels are provided either ready-mounted or as separate units. They are made with a slightly less tight fitting on the axle and should be locked at their final settings using a locking compound such as 'Locktite'.

Locomotive driving wheels are of similar construction to the C & W and B & T types with the addition of a tapered metal bush incorporated in the wheel boss. This bush fits on to the end of the driving axle, which is machined with a matching taper. This enables the wheel to be press fitted to the axle until, at the correct BB setting, it is locked in place and runs true. At a position of semi-tightness, the quartering of one wheel against the other may be carried out precisely and without difficulty, and the settings preserved by pressing the wheel to BB gauge. The wheels may be removed from the axles by drifting out the axles with a centre punch, without danger of damage to, or distortion of, the centres.

CARRIAGE & WAGON WHEELS

Standard Settings

Axle Length — 26.0mm over points
Axle Diameter — 1.8mm

Axles

The standard C & W axle (Fig. 1) is made from hardened and polished steel, chemically treated. Standard points are provided at the ends which are designed to run in the standard coned bearings.

Pointed ends have been selected as they give very good running characteristics, and the frictional losses are so small that gravity shunting of vehicles may be carried out. Also, the conversion of assembled vehicles is easier, as the 26.0mm axle can be inserted into fixed axleguards.

Both axle and bearing are designed to fit directly into the Protofour W-iron Unit.

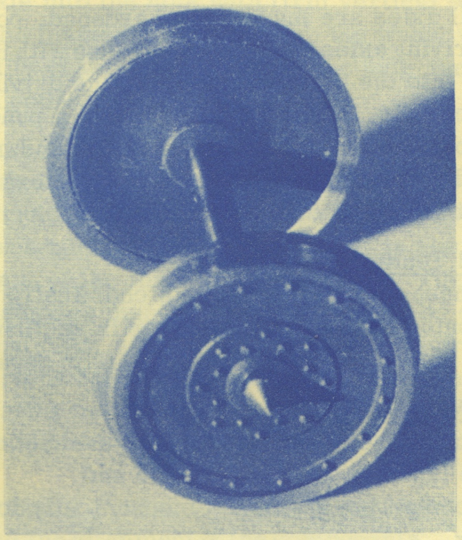


Fig. 1. Protofour Mansell wheel showing pointed axle ends.

Wheels

These consist of a steel tyre to a standard C & W contour, fitted to a moulded centre. (Figs: 1 & 2). The steel tyre is chemically treated for partial rust protection and for appearance, and the centre, of non-hygroscopic plastic material, contains full prototypical detail. The wheel treads will polish in service just as in the prototype; the process may be accelerated by rubbing the tread with a glass-fibre brush.

The wheels are normally supplied ready-mounted on axle, but they may be obtained separately if desired.

Use of C & W Wheels

Until very recent times, wagon wheels were almost universally of 3' 1½" ø and carriage of 3' 7½" ø, or 3' 6" ø. Protofour wheels have been produced as a range to 3' 1½" or 3' 7½" ED, using centres as appropriate.

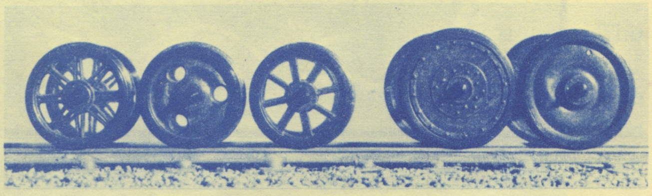


Fig. 2. Initial range of Protofour C & W wheels. (see text)

3' 1½" x 8 open spokes (Fig. 2a). These wheels were used for the great majority of Private Owner wagons from the turn of the century until the second world war, and they also appeared on some company-owned vehicles.

3' 1½" x 8 solid spokes (Fig. 2c). This was a standard wheel form for early vehicles, and for most company vehicles in the pre-grouping era. It was also used for heavy vehicles such as tank wagons, and it has survived to BR times, being used on the standard Cattle Van.

3' 1½" x 3-hole disc (Fig. 2b). This wheel was used in increasing numbers for all wagons from early in the century until, in 1938, it became a standard P.O. wagon wheel. It is now a standard BR wheel.

3' 7½" Mansell (Fig: 1 & 2d). This wheel was made from a steel tyre shrunk on to a disc formed by teak segments and held by cast iron plates. It was almost universally used on passenger stock in the pre-grouping period.

3' 7½" steel disc (Fig. 2e). This type of wheel was in use from early in the century and became a standard LMS and GW wheel, (LNE and SR using mainly 3' 6" types). BR also standardised a similar wheel to 3' 6" ø.

LOCOMOTIVE DRIVING WHEELS & AXLES: BOGIE & TENDER WHEELS & AXLES

Standard Settings

Standard driving axle	—	22.75mm x 3.17mm (1/8") ø
Industrial driving axle	—	22.75mm x 2.2mm ø
Crankpin bore	—	0.9mm ø
B & T axle (inside bearings)	—	22.4mm x 2.2mm ø
B & T axle (outside bearings)	—	26.0mm x 2.2mm ø

Axles

All axles are made from hardened, polished and chemically treated steel.

Driving axles are intended for use with inside bearings, and are parallel with tapered ends. These tapers fit into the tapered inserts of the driving wheels. The axle ends are centre-popped for authentic appearance (Fig. 3) and serve to locate a punch when the latter is used to release a wheel.

Bogie and Tender axles are to a standard diameter of 2.2mm and are obtainable for either 'inside' or 'outside' bearings. The former pattern has flush ends and centre-pops; the latter standard points identical to those of the C & W axles.

Bogie and Tender Wheels (Fig. 3)

These are formed from a chemically treated or, alternatively, nickel-plated steel tyre to locomotive contour - somewhat heavier in section than the C & W tyre - which is fitted to a moulded plastic centre. The wheels are supplied either separately or ready-fitted to the axle.

Driving Wheels (Fig. 3)

These are similar to the B & T wheels, except that the centres contain a tapered brass insert to match the taper on the driving axle end.

Locomotive tyres are mechanically locked to the centres, so that the latter have minimal compression.

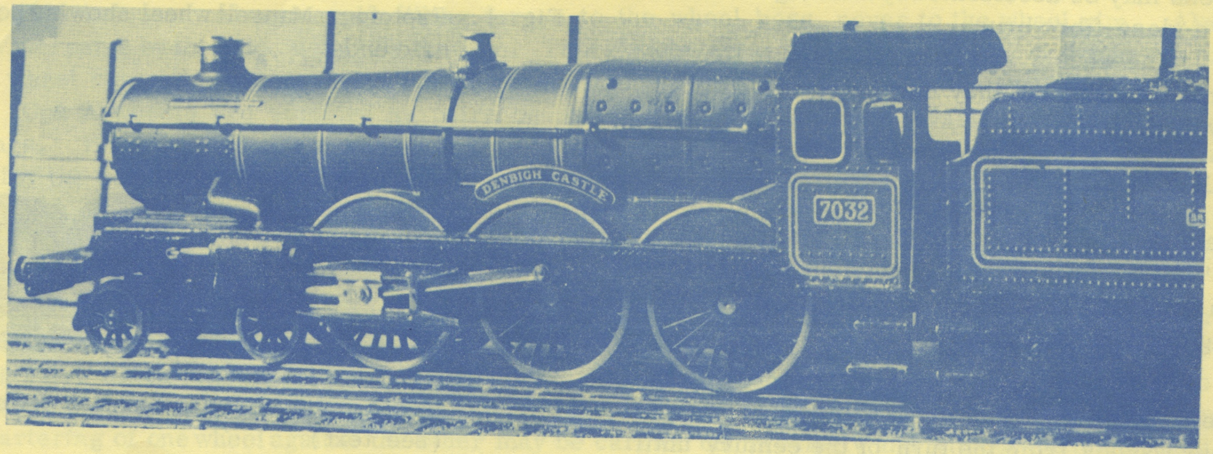


Fig. 3. A Hornby-Dublo 'Castle' fitted with Protofour driving and bogie wheels.

Where tyres are used for electrical pickup, the treads should be cleaned using a glass-fibre brush to remove the chemical coating, which does not conduct electricity as efficiently as plain steel or nickel.

Driving wheels of 3' 11" diameter or less are fitted with a smaller tapered insert to be used with the industrial locomotive axle. This enables the smaller bosses of these wheels to be correctly represented without losing the advantages of the metal-to-metal fitting of wheel to axle. The same industrial axle/insert type is used for Diesel wheels.

Although the centres of driving wheels contain as much detail as possible, they do not incorporate balance weights. The latter vary in size and position from axle to axle, as well as between locomotive types.

Wherever possible, wheel centres are moulded from data taken from existing prototypes, and spokes are moulded with correct flare and taper. Each wheel is based on a specific prototype design and so incorporates the crank boss found on that type. (It would not be economically feasible to represent every type of wheel relating to a certain diameter). Crank bosses are pre-drilled to accept Protofour crank pins with a firm fit.

Assembly of Bogie and Tender Wheels

B & T wheels may be purchased ready-mounted on axles. However, in the majority of conversions the wheels will be purchased separately and assembled on the chassis.

The B & T wheels are a firm press fit on the axles. When fitting, pressure must be applied only to the wheel boss, and great care must be taken to ensure that axle and wheel are held in proper alignment.

ALWAYS USE THE BB GAUGE TO DETERMINE WHEEL SETTING DURING ASSEMBLY. Check that spokes are correctly aligned between both wheels of a pair.

The axle may (in most cases) be introduced into the wheel using hand pressure by placing the wheel face down on a firm, flat surface and forcing the axle into the hole with firm vertical pressure. Owing to the close fit of the wheel boss on the axle, and the method of production, the wheel will automatically align itself on the axle. To avoid the possibility of wheels moving on the axle they may be locked using a locking compound such as 'Torqseal' or 'Loctite'.

Assembly of Locomotive Driving Wheels

Driving wheels should be fitted with crank pins before commencing assembly. (see below)

The bore of the insert and the taper of the axle should both be cleaned carefully to remove any particles of dirt or dust which might otherwise affect the true running of the wheel. It is also possible for some axles or inserts to have burrs formed as the result of the machining process. These should be removed very carefully with a fine file. Under no circumstances must the taper surfaces be damaged.

Always ensure that driving wheels and axles are matched, as axles and inserts are produced in batches, and there may be small variations between the various batch deliveries. To check that wheels and axle are a matched pair, carefully clean the taper surfaces and mount the wheels finger-tight on the axles . If the components are correctly matched the axle ends should be recessed at least 0.5 - 1mm in the brass inserts.

An ideal tool for wheel assembly is an old micrometer, which will give a carefully graduated pressure on the centre of the wheel boss, while maintaining the alignment of the components. Similarly, mounting wheels between lathe centres, a machine vise, or even the use of modified G-cramps, will give similar effect. The pressure surface must be sufficiently large to cover the insert, yet small enough to avoid the crankpin. Always take time for this operation, and carry out each stage carefully and deliberately.

Mount both wheels finger-tight on the axle ends. Check which wheel has the axle end nearest to the face of the boss and remove the OTHER wheel from the axle.

Press the axle to the point where the axle end is about to appear flush with the wheel boss. The single wheel on its axle is then mounted in the chassis, together with bearings and spacers as necessary. The fitting of a suitable gear wheel onto the selected drive axle can be carried out at this stage. The second wheel is then mounted on the axle taper and pressed until it is finger-tight. In this configuration correct quartering is obtained (see below) and the wheel finally pressed to its correct position on the axle using the BB gauge to determine the setting.

Driving wheels may be removed from the axle by SUPPORTING THE REAR FACE OF THE BOSS and tapping the axle out using a drift or a spring-loaded centre punch.

Balance weights and other detail have to be added to the wheels by the modeller. They may be formed from thin plastic sheet, or moulded to the spokes using a substance such as Devcon padding. Do not use plastic solvents as an adhesive which may distort the spokes, or any adhesives containing solvents, e.g., Evostik, etc.

Quartering of Driving Wheels

The majority of locomotives were fitted with cranks set at 90 degrees to each other. For models, in which internal cranks are rarely fitted, a 90 degree setting is necessary for proper transmission of the drive between wheel pairs.

IT IS ESSENTIAL TO CHECK THE CORRECT BORING OF THE COUPLING RODS BEFORE FITTING THEM TO THE WHEELS. This is done by placing the rod over the axle centres of the side on which it is to be fitted (there may be slight errors of bearing settings in the chassis) and locating one bore over the centre-pop mark in the axle end. The other centre-pop marks should be visible exactly in the centres of the remaining bores. If they are not, the bores will need reworking to ensure free running. Repeat for the second side.

With the wheels on one side of the chassis locked in position, the coupling rod is attached to the crank pins on the fitted wheels. Using the spokes as a guide, the second set of lightly-fitted wheels is adjusted so that the cranks lie at 90 degrees to the first set. This may be done by setting the first coupling rod in the uppermost position with cranks vertical, while aligning the second set with the cranks horizontal. Normally, the right-hand wheel cranks of a locomotive are set 90 degrees ahead of the left-hand wheel cranks. It is not essential to achieve an exact 90 degree setting, but it IS essential that each wheel pair shall have the same angular displacement of the cranks as the other sets.

When the second coupling rod has been fitted, the chassis is placed on a flat surface - such as a mirror - and tested for free running. If there is binding, the wheels will skid on the mirror surface, and the source of the binding must be located and the fault corrected. It is advisable to tackle this operation by confirming the alignment of one wheel set's cranks at 90 degrees, and to use this set as a 'master', carrying out the fine adjustment of the other wheels without disturbing the setting of the master set.

Place one coupling rod at the 'top dead centre' position, and examine the opposite wheels for the correct alignment of the spokes. If all spokes do not take up exactly the same angle, correct the 'odd' wheel by gently turning it on the axle and try again on the mirror. When all wheels are correctly aligned and the chassis is running sweetly, use the press tool, lathe or micrometer, and BB gauge, to set the second group of wheels to gauge. This will automatically lock the settings.

If despite correct quartering, there is still binding of the rods, the fault may be caused by a crankpin set at an incorrect distance on the boss, giving a greater or lesser 'throw' than its fellows. This condition may be found by setting the cranks for one coupling rod horizontally, leaving the main driving wheel crankpin assembled, and removing the crankpin nut and bearing from one pin of a driven wheel. Using an eyeglass, it is possible to check whether the crankpin screw lies centrally in the coupling rod bore, or towards one side. If the screw is not central, the rod bore must be enlarged to accommodate this displacement. When corrected, the bearing and locknut are replaced, and if running is still not free, check and correct each driven bearing pin in turn.

Selection of Locomotive Wheel Diameters

Prototype wheel diameters could be reduced through tyre wear and recontouring to 2½" below the nominal value. In the model it is therefore permissible to use a wheel of 2½" ED less than nominal value without departing, to any appreciable extent, from faithfulness to prototype. This means, for example, that a prototype with 5'8" ø wheels could be represented in model form using 5'6" ED wheels.

The range of driving and B & T wheels in the Protofour range is given in the current price list.

CARRIAGE & WAGON WHEEL SUSPENSIONS

Standard Settings

CSU outside faces	— 24.0mm
Standard coned bearing	— 2.0mm x 3.0mm ø x 2.75mm length
Spacing between solebar inside faces	— 24.1mm (min) — 25.0mm

Dimensions and Clearances

In prototype vehicles, the major dimensions of wheels, bearings, axleguard settings and underframes were more or less standard. Dimensions were based on the centre-to-centre distance between the axle bearing journals, which was always 6'6". As the springs were situated directly above the axlebox bearings, and the solebars of the vehicle directly above the springs, the centreline spacing of the solebars was also 6'6". Timber solebars for wagons were usually 5" wide, so the dimension between inside faces came to 6'1". The W-irons were usually ¾" thick, and with 1/8" washers or plates between the guards and the solebars, the centrelines of the W-irons would be the logical figure of 6'0" apart.

Wagons with steel channel underframes had solebars the width of the channel flange, which was usually 3" and, in this case, the between-faces spacing of solebars was 6'3". To achieve the standard W-iron setting of 6'0" the W-irons of these vehicles were joggled inwards 1". 1923 RCH timber-framed wagons used solebars of 5" thickness but offset, so that they also adopted the joggled W-iron as standard for both timber and steel underframe wagons.

Similar dimensions applied to carriage bogies, the springs being mounted on the flange of the beam forming the bogie side frame. Carriages mounted on bogies generally had solebars spaced at 7'0" between faces to afford clearance for the swing of the wheel sets. Carriages fitted with fixed axleguards had solebar spacings similar to wagons, the additional sideplay on the centre wheel sets of 6-wheeled generally being provided by additional play in the axlebox grooves.

All suspensions on prototype vehicles are generously sprung, and it is both logical and intelligent practice to allow the wheels on model vehicles to follow track irregularities in a similar manner.

Protofour Standard Suspension

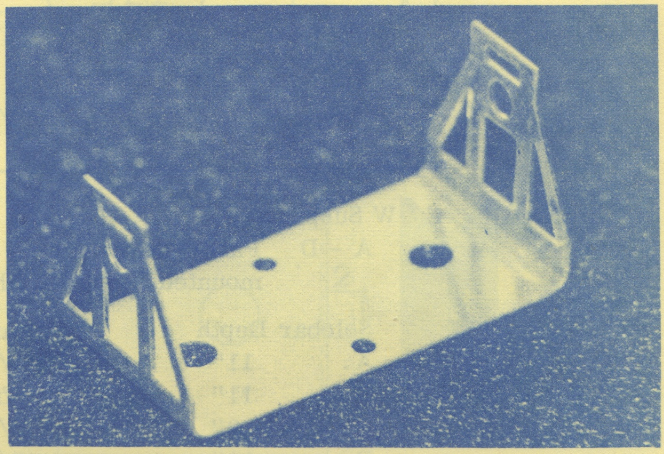
One of the difficulties in building or converting scale vehicles has always been the simultaneous provision of scale W-iron thickness and correctly adjusted wheel suspension. The best running of wheel sets is obtained through the use of a pointed end axle, and the Protofour C & W axle has been standardised at 1.8mm ø and 26.0mm (scale 6'6") length over points. The axle point is designed to run in a coned brass bearing, the latter having a flange to limit its travel in a 2.0mm hole.

A scale W-iron unit (Fig. 4) has been produced to retain the wheel sets and bearings at the correct settings. This consists of a pair of scale metal W-irons which form the arms of a U-shaped unit. The unit will accept wheels up to 3'7" diameter. The completed unit may be attached to the vehicle through two fixing holes of 1.3mm diameter located on the centreline of the bridge of the unit.

The bearings are fitted to the axleguards (Fig. 5) by placing the 2.0mm ø holes of the latter over clearance holes in a hard, smooth working surface. The bearings are introduced from the inside face and pressed home until restrained by the flange. The press fit ensures that no other fixing is required and the hard surface prevents any distortion of the axleguard during the operation. Bearings may also be secured with epoxy resin adhesive. Alternatively, they may be lightly soldered in place, but solder paint should NOT be used as this leads to corrosion of the W-iron unit.

Fit the wheel set into the unit (Fig. 5) by inserting one end of the unit into the bearing. Carefully spring out the opposite W-iron and press the other pinpoint into place in its bearing. Check the play in the axle and spin the wheels. The play should be just sufficient to give free running without binding. If the axles bind, or if the axle is too sloppy, remove the wheels and carefully bend the W-iron until satisfactory running is obtained.

Clasp-type brake gear may, if desired, be added to the unit, as it will then hold its clearances from the wheels permanently.



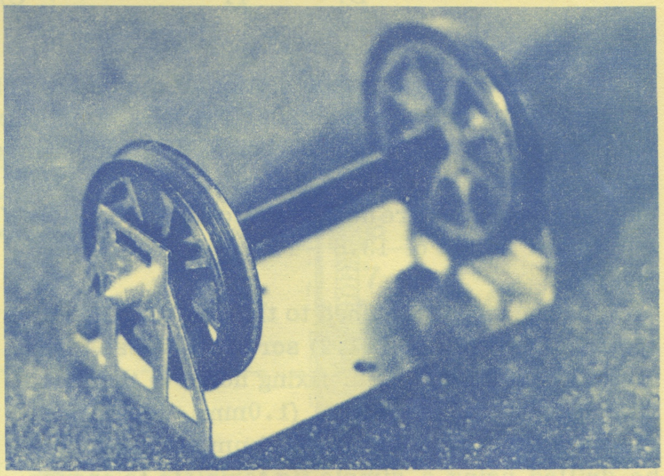


Fig. 4 (top). Protofour W-iron unit.
Fig. 5 (above). W-iron unit fitted with bearings and wheel set, (CSU).

Compensated Suspension

Figure 6 illustrates the differences in clearance between the floor and the bridge of the unit when used in vehicles of different solebar, wheel diameter and buffer mounting settings. The buffers must always be positioned 3'5" - 3'6" scale height above the rail top surface. These variations require a form of packing in almost all cases. Various methods can be used to provide the packing and to allow compensation, some of which also result in considerable reduction of noise transmission.

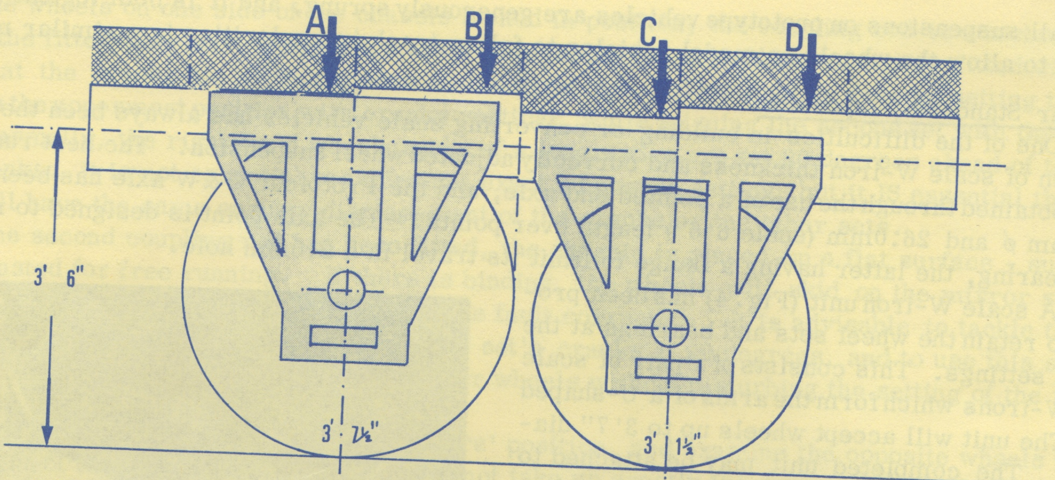


Fig. 6. C & W Suspension.

A - D Packing thickness. These values assume that the vehicle floor is mounted flush with the top of the solebars.

	Solebar Depth	Solebar/Buffer	Wheel Dia.	Packing
A.	11"	C/line	3'7½" (14.5mm)	—
B.	11"	Offset	3'7½" (14.5mm)	0.3mm
C.	9"	C/line	3'1½" (12.5mm)	1.0mm
D.	11"	C/line	3'1½" (12.5mm)	1.5mm

Method 'A'

To achieve a proper setting of the buffer height, and to provide a means of controlling the flexing of the W-iron units in the underframe, a strip packing is used. This is made from a strip of rubber 4mm x 1mm x 10mm, slotted at the ends to locate around the fixing screws attaching the unit to the vehicle floor. To enable the use of a single type of packing, with standard resilience characteristics, the W-iron unit may be bent where necessary to form a shallow Vee in the bridge, to match the 1mm rubber thickness to a buffer height of 13.8 - 14mm in the finished vehicle.

The unit is attached to the vehicle floor by means of two 12 BA (M1.2) screws. These form a close fit in the 1.3mm fixing holes in the unit. Two tapping holes, No. 61 (1.0mm), located on the vehicle centreline and 9.0mm apart, should be drilled using a simple jig template to ensure their accurate location. Otherwise, the axle of the unit may lie askew the frame, with consequent detriment to the running. The holes are lightly tapped 12 BA or M1.2. The rubber packing is placed in position, the unit located over the holes and the 12 BA (M1.2) screws inserted and driven home until they reach the bridge of the un it.

Each screw is then very carefully adjusted until :

a) The unit just nestles against the packing.
b) There is flexing of the suspension without noticeable looseness of the unit.
c) The unit sits upright in relation to the solebars.

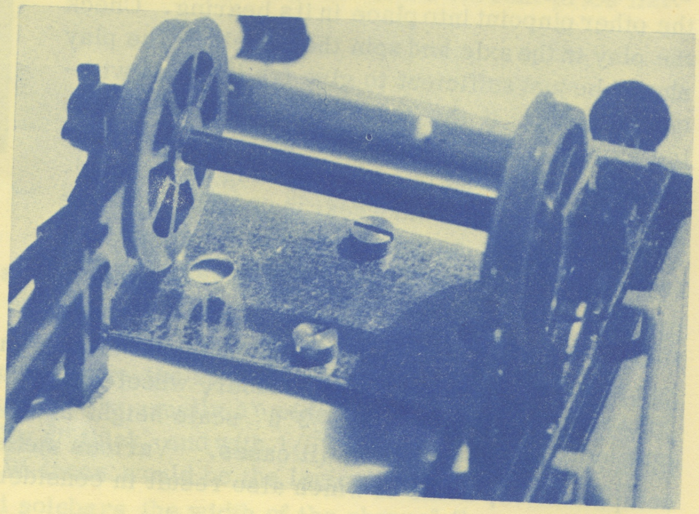


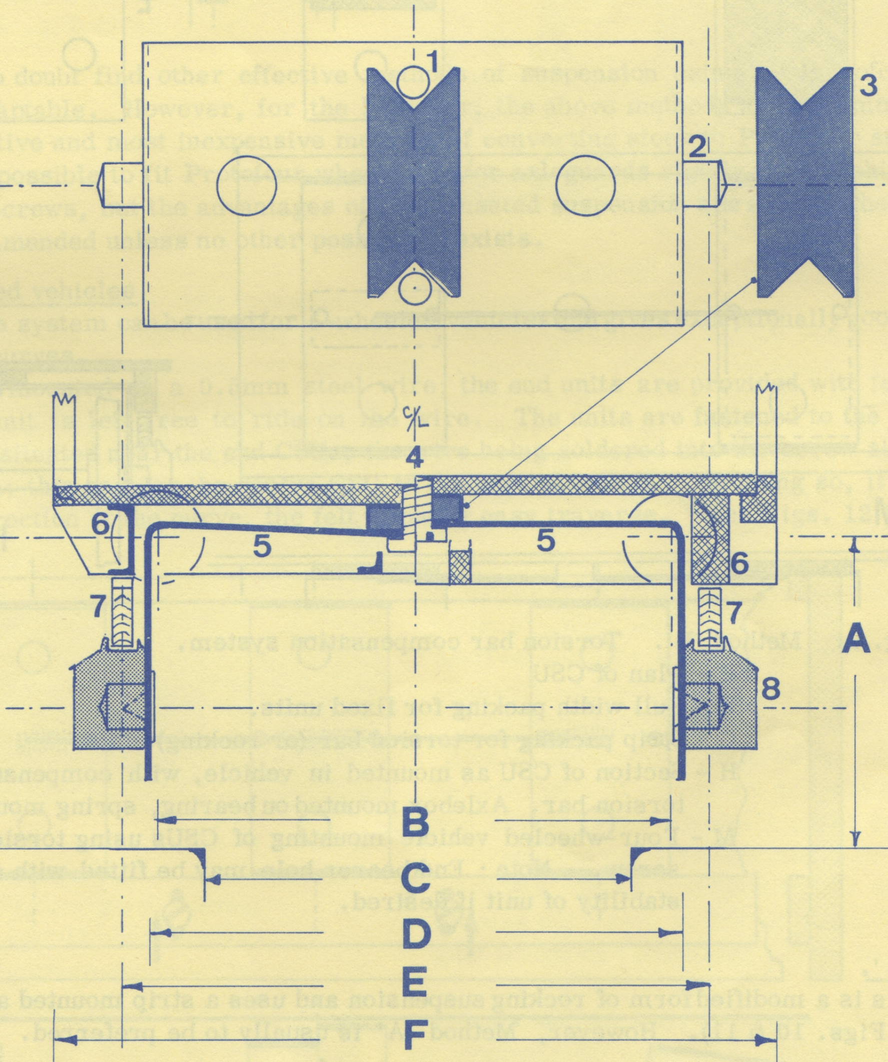
Fig. 7. CSU mounted in a typical wagon. Method 'A'.

When these characteristics have been achieved, the screws should be locked at their settings by means of locking compound, and the projecting screw shaft above floor level removed and rendered flush with the floor surface.

Fig. 8. Mounting of Protofour compensated suspension units (CSU) in standard wagon underframes.

Key to Diagram :

1 - CSU mounting holes for 12 BA screws or standard track rivets.
2 - Standard bearing mounted in CSU.
3 - Rubber packing strip.
4 - 12 BA mounting screws in vehicle floor.
5 - Bridge of CSU. Left-hand : Steel underframe and adjusted bridge.
Right-hand: Timber underframe, straight bridge.
6 - Steel and timber solebars.
7 - Spring.
8 - Axlebox.



Dimensions :

A - Standard buffer centreline to rail top	3' 5"
B - Buffer centres	5' $8\frac{1}{2}$"
C - Track gauge	4' $8\frac{1}{2}$"
D - Axleguard centres	6' 0"
E - Axle journals, solebar centres	6' 6"
F - Overall width of body, standard RCH wagon	8' 0"

Method 'B'.

Another possibility is the mounting of the CSUs on a 0.5mm steel wire which operates as a torsion bar suspension. The wire is attached to the slot of a screw mounted on the vehicle centreline. One unit is fixed with suitable packing while the other is allowed to rock; a narrower packing strip being provided in this case. (See Fig. 9 below).

The mounting of the CSUs on the wire is best carried out in a simple jig, and a fairly heavy soldering iron will be required to make the solder flow easily.

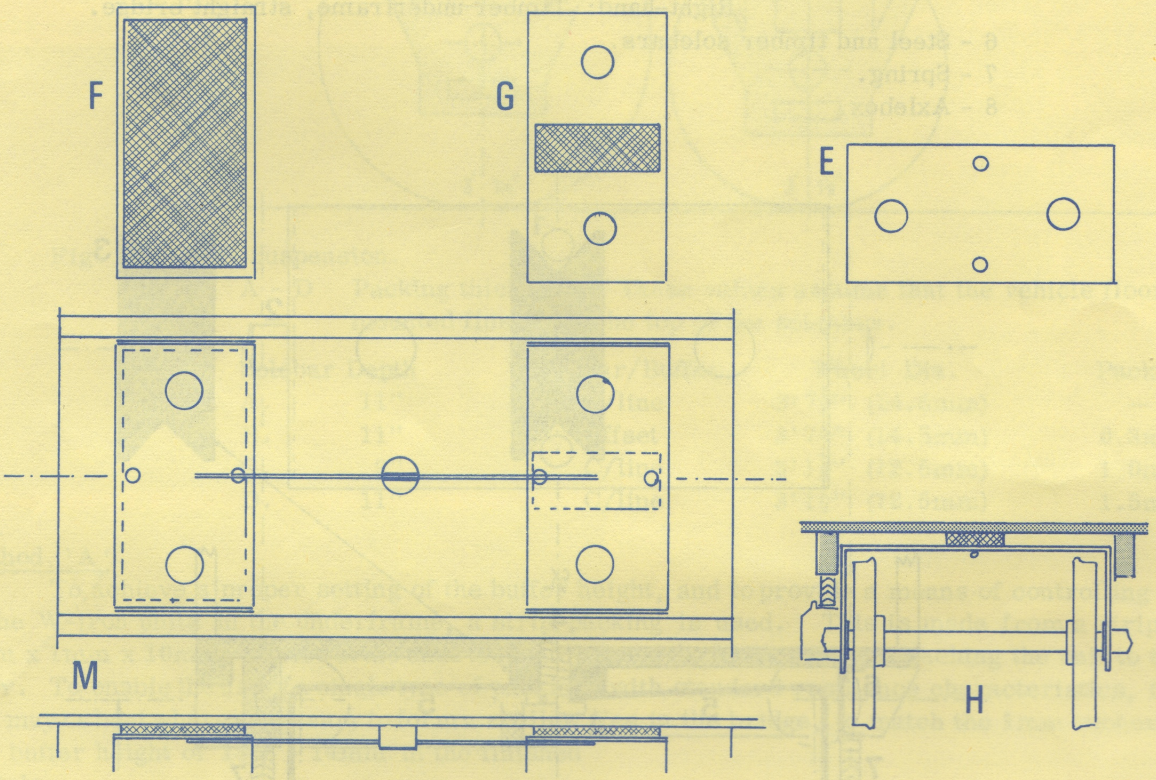


Fig. 9. Method 'B'. Torsion bar compensation system.

E - Plan of CSU
F - Full width packing for fixed units.
G - Strip packing for torsion bar (or rocking) units.
H - Section of CSU as mounted in vehicle, with compensation system and torsion bar. Axlebox mounted on bearing, spring mounted on solebar.
M - Four-wheeled vehicle mounting of CSUs using torsion bar and single screw. Note : End bearer hole may be fitted with a pin to increase stability of unit if desired.

Method 'C'.

This is a modified form of rocking suspension and uses a strip mounted along the vehicle centreline, (see Figs. 10 & 11). However, Method 'A' is usually to be preferred.

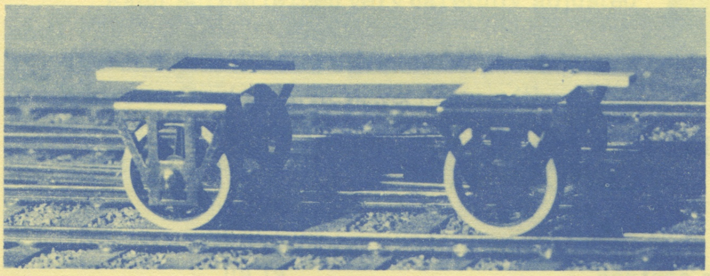


Fig. 10. CSUs mounted on a centre-line packing strip.

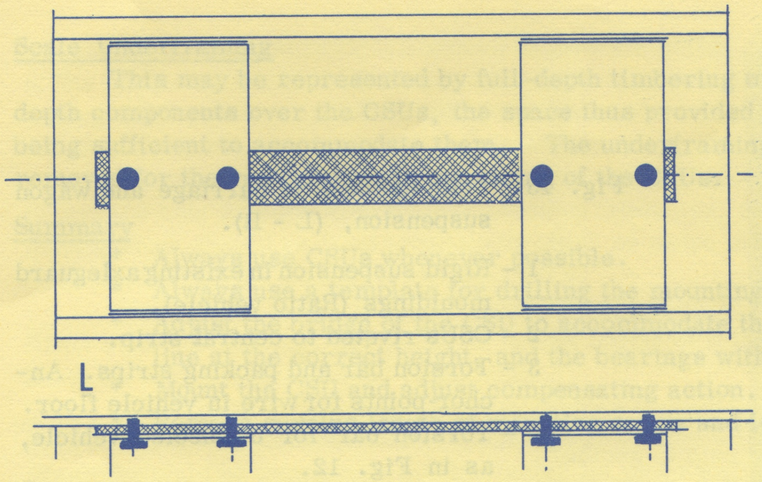


Fig. 11. Four-wheeled vehicle mounting of CSUs using a solid packing and rivets.

Modellers will no doubt find other effective methods of suspension using the Protofour units, which are extremely adaptable. However, for the beginner, the above methods are recommended as the simplest, most effective and most inexpensive methods of converting stock to Protofour standards.

It is, of course, possible to fit Protofour wheels and/or axleguards rigidly to the vehicle, using track rivets in place of screws, but the advantages of compensated suspension are so overwhelming that this method is not recommended unless no other possibility exists.

Suspensions for 6-wheeled vehicles

A Cleminson-type system can be used for 6-wheeled vehicles and gives exceptionally good running, even over small radius curves.

Three CSUs are mounted on a 0.5mm steel wire; the end units are provided with felt packing strips, and the centre unit is left free to ride on the wire. The units are fastened to the vehicle by means of 10 BA screws situated near the end CSUs, the wire being soldered into the screw slots. The screws are able to turn; this enables the centre CSU to displace sideways. In doing so, it traverses the end CSUs into the direction of the curve, the felt allowing easy traverse. (see Figs. 12 & 13-4).

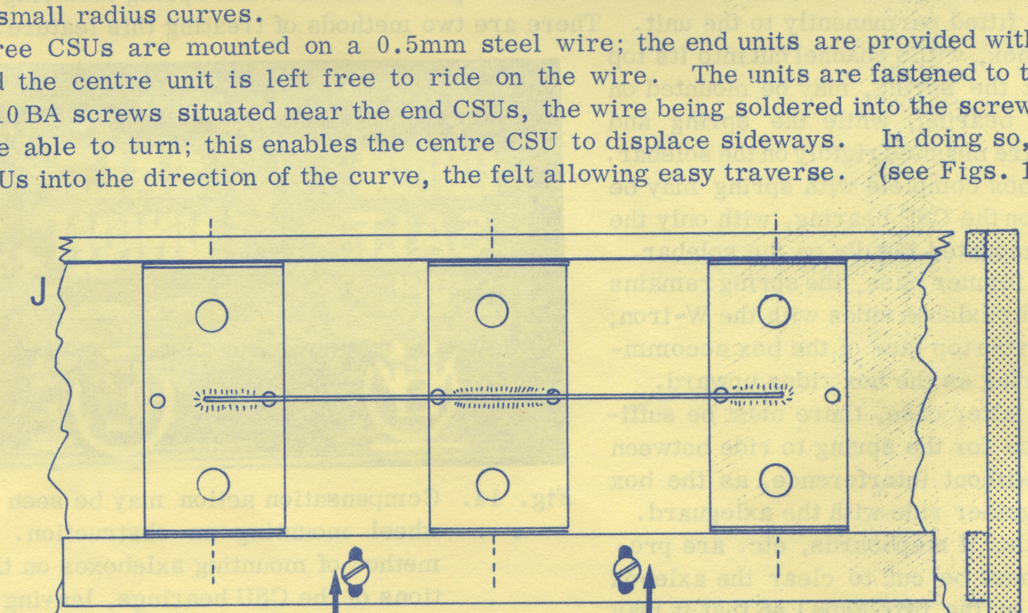


Fig. 12. (top) Jig for assembly of CSUs on torsion bar wire.
(above) Six-wheeled suspension using torsion bar and twin screw heads.

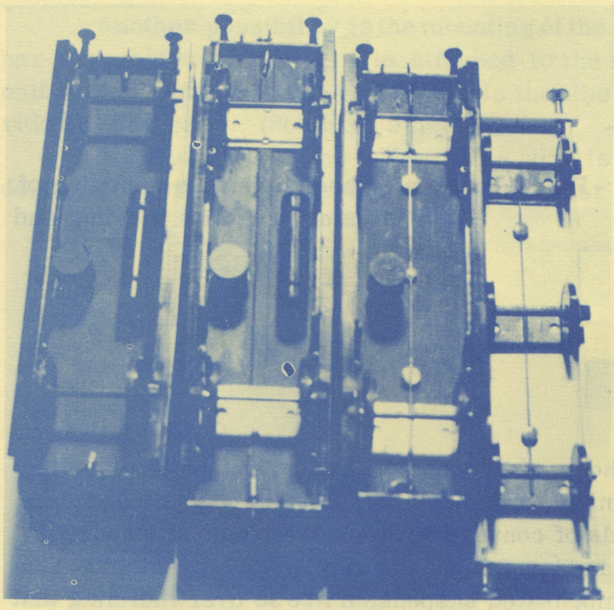


Fig. 13. Four methods of carriage and wagon suspension, (L - R).

1 - Rigid suspension in existing axleguard mouldings (Ratio vehicle).
2 - CSUs riveted to central strip.
3 - Torsion bar and packing strips. Anchor points for wire in vehicle floor.
4 - Torsion bar for 6-wheeled vehicle, as in Fig. 12.

<u>Treatment of Axleboxes and Springs</u>

The bearing of the Protofour Compensated Suspension Unit (CSU) projects from the outside face of the W-iron and may be used as a key to locate a correct pattern axlebox and spring moulding or casting which may be fitted permanently to the unit. There are two methods of treating this feature.

1. The axlebox, with a channel cut into its top to accept the spring, may be mounted on the CSU bearing, while the spring and hangers are mounted rigidly on the solebar.
2. The axlebox complete with spring may be mounted on the CSU bearing, with only the hangers mounted rigidly on the solebar.

In the former case, the spring remains fixed, while the axlebox rides with the W-iron; the channel on the top face of the box accommodates the spring as the box rides upward.

In the latter case, there must be sufficient clearance for the spring to ride between the hangers without interference, as the box and spring together ride with the axleguard.

Note that if stepboards, etc. are provided, they must be cut to clear the axlebox (as they are on the prototype) so that it may ride freely.

Moulded axleboxes and springs, based on prototype designs, are under development as a future part of the Protofour range of components.

Fig. 14. Compensation action may be seen by the LH wheel mounting an obstruction. Note the method of mounting axleboxes on the projections of the CSU bearings, leaving clearance for the compensating action between the spring and axlebox mouldings.

<u>Weighting</u>

As mentioned already, compensation action is dependent upon weighting. A vehicle must be sufficiently heavy to take advantage of the resilience of the rubber pads or the torsion wire and so cause the CSUs to flex, and it must also prevent the wheels from 'bouncing' at rail irregularities. On the other hand, too much weight will cause increased friction at the coned bearings, and may even splay them outwards owing to the force on the coning. A minimal weight for a typical 4-wheel vehicle would appear to be 1 oz, but the actual values depend upon the conditions of the layout and the personal preferences of the operator.

The fitting of weights to most vehicles is a comparatively simple operation, but in single-plank open wagons, for example, some ingenuity will be needed.

Most cast metal kits are too heavy and must be reduced in weight by the replacement of certain items, such as roofs and floors, by lighter material.

Scale Underframing

This may be represented by full-depth timbering or section in the middle of the vehicle and half-depth components over the CSUs, the space thus provided between the floor and the half-depth timbering being sufficient to accommodate them. The underframing should be fitted in such a way that it may be removed for the replacement or servicing of the CSUs.

Summary

* Always use CSUs whenever possible.
* Always use a template for drilling the mounting holes in the vehicle precisely.
* Adjust the bridge of the CSU to accommodate the rubber strip packing with the buffer centre-line at the correct height, and the bearings with virtually no play on the axle.
* Mount the CSU and adjust compensating action.
* Remove surplus length of mounting screw and lock the settings.

CRANK PINS FOR LOCOMOTIVES

Standard Settings

Crankpin	—	14 BA countersunk
Wheel bore	—	0.9mm ø
Tubular bearing	—	1.0mm ø x 1.5mm flange
Bearing length	—	1.5mm, 2.5mm or 4.0mm
Spacer	—	1.0mm clearance
Washer	—	14 BA clearance
Locknut (circular or hexagonal)	—	14 BA

Crankpins

The crankpin forms the bearing surface which carries the coupling and connecting rods, and so transmits the drive from one pair of driving wheels to another.

It is essential, as in the prototype, that the model crankpins are as strong as possible, and also that they are correctly to scale in order to clear scale superstructures.

The Protofour crankpin system fulfils these requirements and is simply adapted to accommodate the various types and combinations of rods. Additionally, the tubular bearings may be removed from the wheel and replaced without disturbing the setting of the crankpin shaft or removing the wheel from the axle.

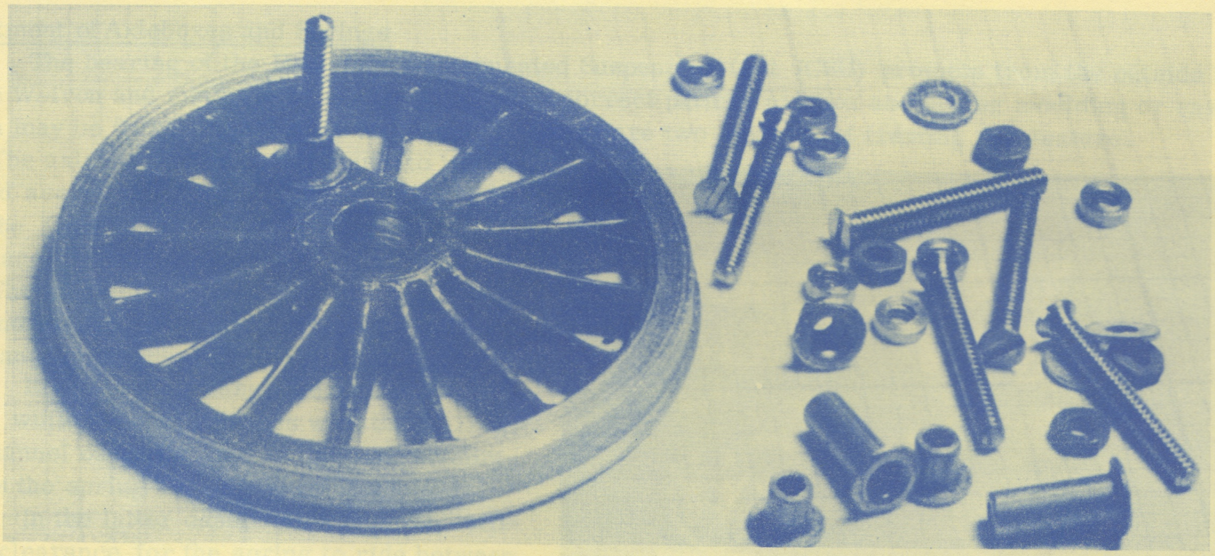


Fig. 15. Protofour crankpin components set out on 1mm squared graph paper for size comparison.

The 14 BA crankpin is inserted into the 0.9mm hole from the rear of the wheel, and as the hole is a slightly tight fit, the screw will tend to tap its own thread and so bed firmly when fully home. Check that the end of the screw thread is free from machine burrs before tapping, and care should be taken to avoid stripping the thread in the wheel boss by overtightening during this operation.

For normal coupling rods, the shaft of the screw projecting from the front face of the wheel is fitted successively with the tubular bearing (flange to the wheel face), the rod or rods (and their spacers if required), the washer, and the appropriate circular or hexagonal locknut. The bearing flange automatically ensures the correct spacing between the coupling rods and the face of the wheel boss.

In certain prototype situations, particularly where the coupling rod crankpin lies under the connecting rod, a special flush-faced crankpin locknut is used. This may be represented on the model by fitting the washer first, the rods, and the tubular bearing with the flange to the outside. The bearing is then held in place by means of locking compound.

As described under wheel quartering, it is essential to prove the coupling rods before fitting them to the crankpins. The quartering operation is then carried out, and the wheels finally pressed to correct BB setting.

Once wheels are fitted and the running is without binds or other difficulties, the crankpins may be finished off to give a prototypical appearance. The excess screw length is snipped from the pins, and the ends of the screws are stoned to give a smooth, flush appearance. To preserve the appearance of the locknuts, a piece of shim metal with a 1.0mm hole may be placed over the locknut and crankpin during this operation; alternatively, the operation completed, the locknut may be removed and replaced the other way round to show its original finish.

To reduce the long tubular bearings to the correct length, it will be found useful to drill a 1.0mm clearance hole in a metal plate of the correct thickness, and to insert the bearing from below. The projecting shaft should be filed away until, when no more metal is removed, the end of the bearing will be flush and flat to the washer.

If a return crank is to be fitted to the crankpin, it may either be drilled and tapped 14 BA, and fitted over the bearing, or soldered to the flange of a long bearing, which is then reduced to length and fitted as with the flush-faced crankpins.

The Protofour crankpin system enables a precise fitting of rods and motion, which ensures both good running and correct scale appearance. When all components are correctly fitted, the motorless chassis should be capable of moving under its own weight when placed on a slight slope.

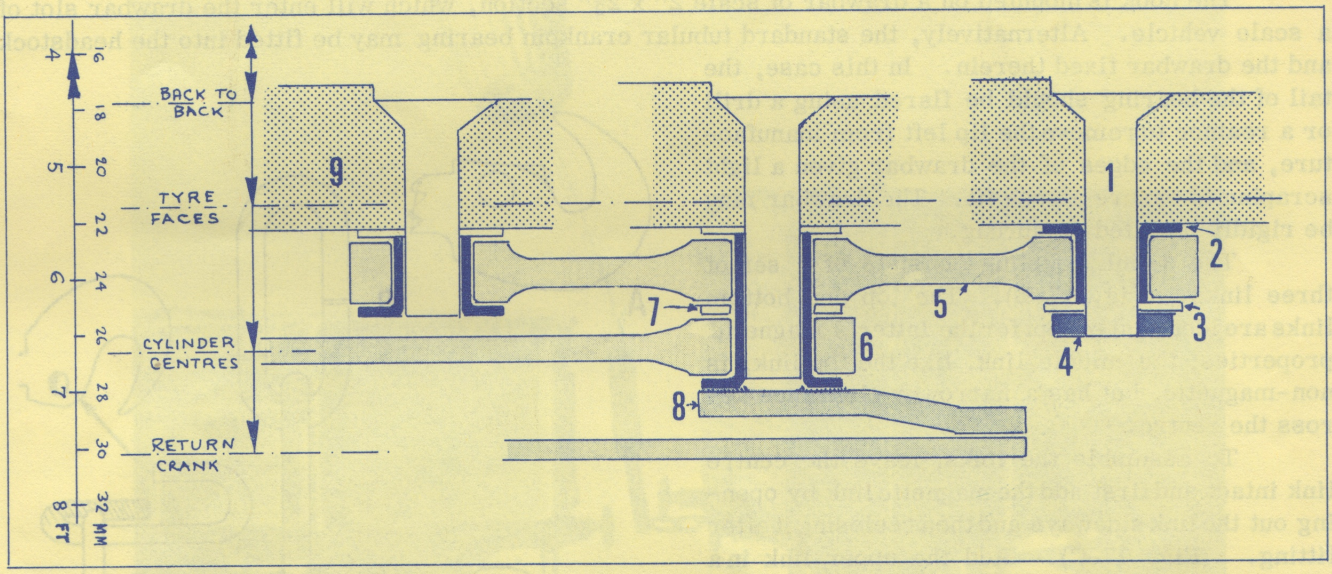


Fig. 16. Crankpin assembly.

1 — 14 BA steel screw	4 — Locknut	7 — Spacer
2 — Tubular bearing	5 — Coupling rod	8 — Return crank
3 — Retaining collar	6 — Connecting rod	9 — Wheel boss

Measurements shown against the scale on the left are those taken from the equivalent position on the opposite side of the locomotive, i.e. — distance between centres.

BUFFING AND DRAWGEAR : MAGNETIC COUPLING

Standard Settings

Buffer spacing (5' 8½" equivalent)	—	22.83mm
Buffer length (headstock to face)	—	6.0mm (for all vehicles carrying standard 3-link couplings)
Length of coupling (inside)	—	10.2mm

Buffing Gear

Equipment for the assembly of sprung buffing gear is under development, and this section will be issued when the final design is released.

Scale Drawhook and 3-link Couplings

The Protofour drawhook scale is an exact representation of the prototypical hook and is cast in 'white metal'. (Fig. 17-A). Although apparently fragile, it will be found to have remarkable strength when used in its proper function.

The hook is mounted on a drawbar of scale 2" x 2½" section, which will enter the drawbar slot of a scale vehicle. Alternatively, the standard tubular crankpin bearing may be fitted into the headstock and the drawbar fixed therein. In this case, the tail of the bearing should be flared using a drill or a reamer to remove the lip left from manufacture, and the edges of the drawbar given a light scraping to ensure a snug fit. The drawbar may be rigidly mounted or sprung.

The 3-link coupling consists of a set of three links. (Fig. 17-B). The top and bottom links are identical except for the latter's magnetic properties; the middle link, like the top link, is non-magnetic, but has a narrower clearance across the centre.

To assemble the links, leave the centre link intact and first add the magnetic link by opening out the link sideways and then reclosing it after fitting. (Fig. 17-C). Add the upper link in a similar way, but leave the link open. Hold the drawhook in the inverted position and pass the open end of the top link through the hole. (Fig. 17-D). Close the top link. The coupling should hang vertically from the drawhook as the latter is rotated; if not, the top link should be worked in the hole until an easy fit is obtained.

Snipe-nosed pliers or stamp tweezers are ideal for manipulating the links during assembly, and if one's visual acuity is not what it might be, an eyeglass will ease the operation.

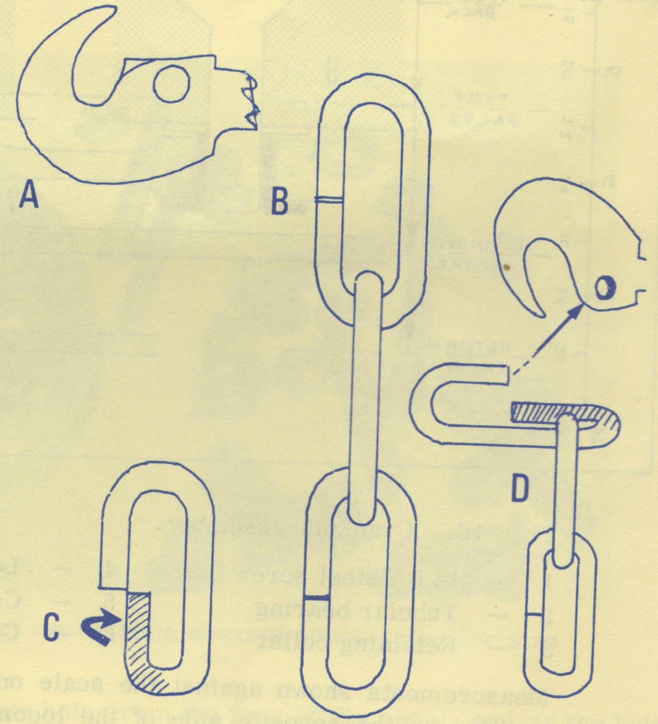


Fig. 17. Assembly of 3-link couplings.

Nevertheless, the fitting of 3-link couplings is an important contribution to the scale appearance of the vehicles, and the use of magnetic coupling adds a further dimension to the enjoyment of scale modelling.

Magnetic Shunters' Pole

This consists of a miniature stick magnet, mounted on a carrier wire. The unit is fitted to a penlite torch, which serves to provide both a holder and a means of illumination for the coupling operation. The shunters' pole is always held vertically downward during operations. (Fig. 18).

To couple :

* Shunt the wagons together.
* Lower the magnet alongside the appropriate link and allow the link to attach itself to the end of the magnet. (Note that in Fig. 18 the link is shown on the side of the magnet. This should be avoided as the coupling operation is much more difficult in this position).

* Lift the magnet so that the link extends ahead of the drawhook.
* Place the link over the adjoining drawhook and lower the magnet to attach the link to the hook.
* Continue the downward movement leaving the link in the hook and disengaging the magnet.
* Withdraw the magnet downwards, sideways, and then upwards.

To uncouple :

* Place the magnet vertically over the drawhook until the link jumps out of the hook and attaches itself to the magnet.
* Lift the link from the hook and bring the link downwards to its normal hanging position.
* Continue the downward movement until the link releases itself from the magnet.
* Withdraw the magnet downwards, sideways, and upwards.

Should the magnet accidentally pick up both end links during these operations, detach the links by moving the magnet downwards and sideways, and recommence the operation. Coupling and uncoupling is made much easier with the operating wrist resting on the baseboard or on the free hand.

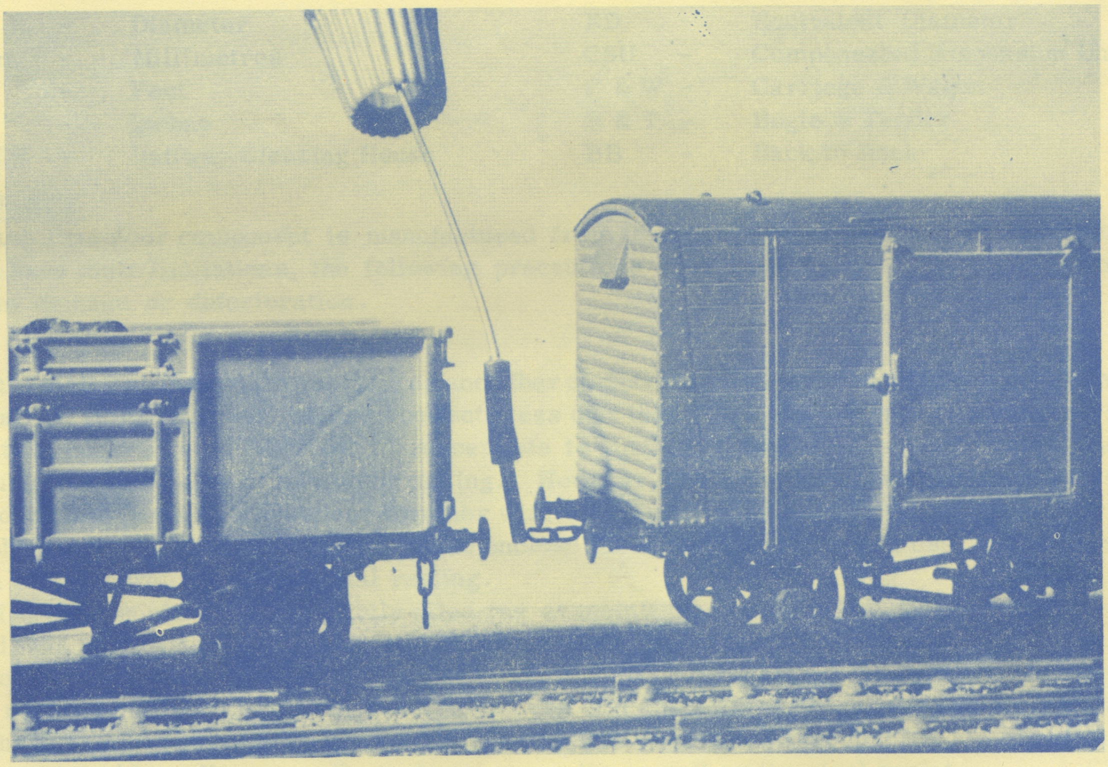


Fig. 18. Coupling with the magnetic shunters' pole.