Nº1 SHOP
TECHNICAL FORUM

Insulated Efficiency

Having described his method of making high-efficiency worm drives (MRJ No. 42), SID STUBBS explains some straightforward methods for building high-efficiency chassis to put them in:

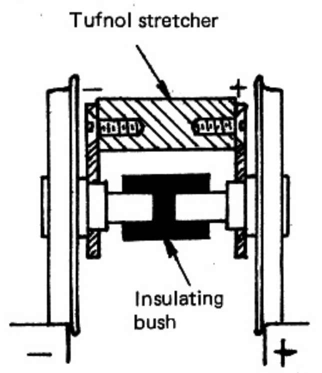
When two-rail arrived in a big way after World War II, it presented quite a few electrical problems. One of these was that of insulating the locomotive wheels one side from the other and of getting the current off the wheels to the motor.There have been many solutions to this problem but, to my mind, the simplest was, and still is, as shown in *Fig. 1*. We simply replace the metal frame stretchers with insulated ones projecting ½mm or so above the frames to prevent the latter touching the underside of the footplate, and cut the axles in the centre, forcing the half axles into a central insulating bush. The chassis uses metal wheels as before but we have now got rid of the nuisance of a collector. Current passes via the wheels, half axles and axleboxes to the frames and the two wires from the motor are connected to these.

The benefits are many. All wheels on both sides act as collectors (including bogie wheels and tender wheels as will be discussed later). There is no power-consuming friction due to collectors rubbing on the backs of the wheels, a very serious power loss in 4mm scale engines with spring-loaded pick-up plungers. There are no wiring and insulation problems as encountered in the fitting of such collectors. Plain metal wheels can be used — no bushing or cutting and Aralditing spokes. Metal brake shoes, sandpipes and so forth can be fitted with impunity; it doesn't matter if they do touch the wheels. Lastly, the loco body is electrically 'dead' — no shorts via buffers or couplings to other locos or vehicles of opposite polarity.

There are two disadvantages. Firstly, if outside cylinders mounted direct to the frames touch the footplate or valance, a short can occur. This I overcame by making such cylinders from insulating material such as Tufnol, metal-bushed for piston and valve rods. Where Walschaerts gear is involved, the expansion link is carried on a sub-frame which is insulated from the body by strips of insulation tape underneath the footplate and behind the expansion link girder frame attached to the valance but, of course, dummy.

The second disadvantage, manifest in *Fig. 1* is that the centre insulated bush is flexible and not very strong. Accordingly, I have, for forty years, made up the axles as *Fig. 2a*, using free-cutting mild steel and 'Carp' brand Tufnol for the bush. The Tufnol is forced into a thin steel tube and then bored right through true for the half axles. A small $^1/_{32}$in hole is drilled in the tube and bush to allow trapped air and Araldite to escape and the two half axles are forced in with a smear of Araldite and with a 20-thou punched-out disc of card between to prevent the half axles touching. These axles are very strong and simple to make. However, some folk like a parallel axle and, here, *Fig. 2b* shows the idea. I use $^7/_{32}$in free-cutting mild steel for 0 gauge and $^9/_{64}$in for 4mm. Now, since the centre bush is smaller, the half axles need to be stepped down. This feature obviates the need for the card spacer disc, the stepped length being made so as to avoid the ends touching when assembled. A groove is cut across the stepped ends into which the Araldite is forced on assembly and this forms a 'key' to help prevent the half axles turning relative to each other; surplus Araldite escapes via the small hole as before. A good force-fit is essential and the

Fig. 1



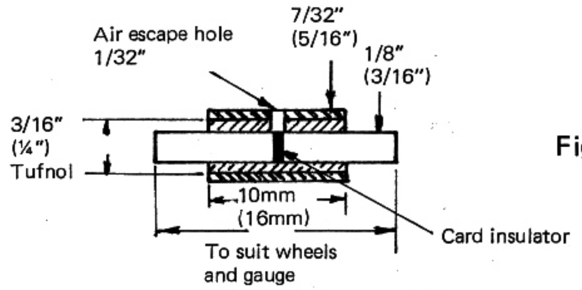
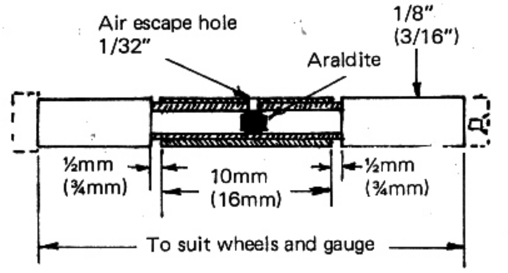


Fig. 2a



Remove ends shown dotted after turning

Fig. 2b

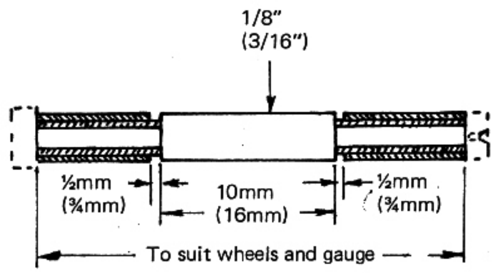


Fig. 2c

In 2b and 2c, stepped parts of axles are 0.067" (0.116"). Tufnol bush is 0.102" (0.157"). Bores of Tufnol bush and steel sleeve are .001" less than these figures to provide a good force fit.

Where two dimensions are shown, that in brackets is for 7mm scale, the other for 4mm.

axles are obviously not as strong in torque as the first type but they have proved perfectly adequate in service and I have made a fair number to date. The assembled axle is rather longer than needed and a centre is drilled in one half axle. Each one is then chucked true in a collet, held by about $1/16$in–$3/32$in length and the other end runs on the lathe tailstock centre. They are then machined down to $3/16$in (0 gauge) or $1/8$in (4mm) and finally cut to length.

Another method is as shown in *Fig. 2c* where the axle is solid but stepped down at each end and a steel bush with Tufnol sleeve within is forced on each end. Again, they are machined parallel and to size after assembly. This method permits the axle centre to embody cranks and electrics for working inside motion whilst still permitting current pick-up via the wheels.

Obviously, all the foregoing calls for a lathe and so is really mostly of use to the more serious modeller who possesses such a tool or knows a friend who does. Could we hope that someone in the trade will take up the idea?

MAXIMUM EFFICIENCY

Start by making a pair of coupling rods, drilling the crankpin holes with the two pieces of blank metal clamped together to ensure identical centres. I cut and file mine from mild steel and, since I spring my wheels, six coupled and over rods are articulated, again doing all the drilling as a pair to ensure identical centres. A useful tip here is to make up hardened filing bushes from silver steel, the size of the big ends, which are bolted each side of the rod by a bolt through the crankpin hole (make such holes to one of the BA sizes). The bushes are hardened after machining by threading on a wire, heating to cherry red and quenching in water. You can then file the bosses down to the bush diameter, leaving the oil cap bosses projecting, of course. See *Fig. 3*.

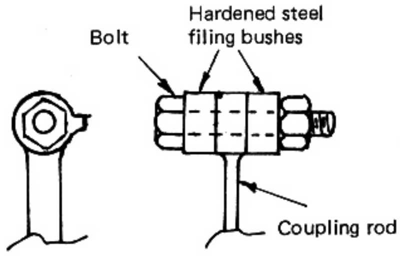


Fig. 3

Having got the rods, mark out and cut out the frames, again as a pair clamped or sweated together. Also, at this stage, drill the holes for the screws holding the frames to the stretchers and also for the dowel pins and other holes for brake hanger fastenings, etc. Mark out the position of the driving axle centres and drill *one hole only* to the same size as the coupling rod crankpin hole. Locate a coupling rod by a push-fit spigot in this hole, line up the coupling rod parallel with the frames and drill the other axle holes off it. Having got these holes which are, of course, at precisely the same centres as the coupling rods, you can now open them out to take the axle bushes. If you are careful and use a coning bit in each hole to start with, you should not lose centres when the larger drill goes through, but I do, in fact, employ a flat-ended drill bit with a pilot the size of the crank-pin hole. This bit is easily made from silver steel, hardened.

Having preserved the centres of axles and coupling rods, we may as well mention the same dodge for driving wheel crank throws. Mark out one wheel and drill the crank hole, then locate each of the remaining wheels in turn against this first one using a push-fit piece of axle steel through the bores and drill all the other crank holes using the first one as a jig.

If the driving wheels are to be sprung, it is not necessary to cut out the metal below the axle bush holes to form horns, and the holes in these (to accommodate the split pins to retain the axle bushes) should also be drilled at this stage. Finally, saw and file out the frames as a pair.

Now the frames can be separated and fitted to the insulated stretchers. I find it simplest to take a strip of 'Carp' brand Tufnol of the correct width to go between the frames and to clamp the frames squarely each side of this strip with ½mm of strip standing proud above the frames and then to drill through each side into the Tufnol for the frame screws and dowels. Use 8 BA countersunk screws for 7mm scale, 10 BA for 4mm scale, and make the dowels $1/16$in dia steel in both cases. Cutting the Tufnol strip to width does present a problem. Milling is one obvious way if your lathe has a vertical slide. Personally I use a four-jaw chuck, clamp the strip across that and face to width as a turning job. With care, you can file the strip, finishing by draw-filing to get it as square and flat as possible. Final rubbing on emery cloth on a sheet of glass will assist.

Fig. 4 shows a typical frame assembly. If you have used the Tufnol strip method of spacing, you will now need to cut away such of the strip as required to permit space for the gears, motor

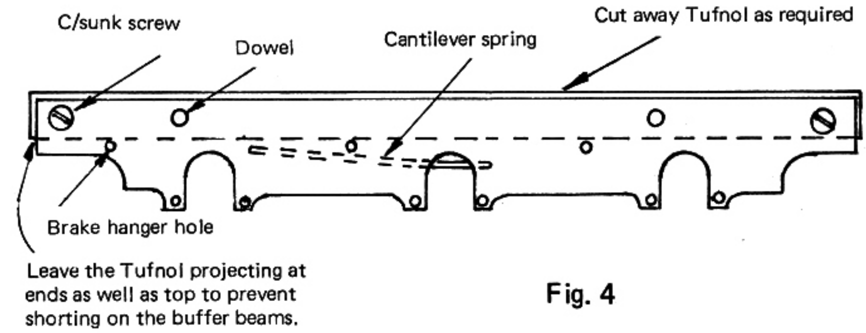
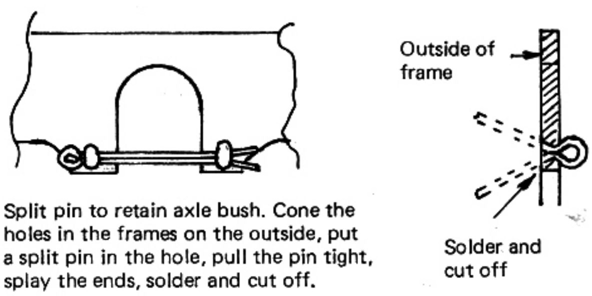


Fig. 4



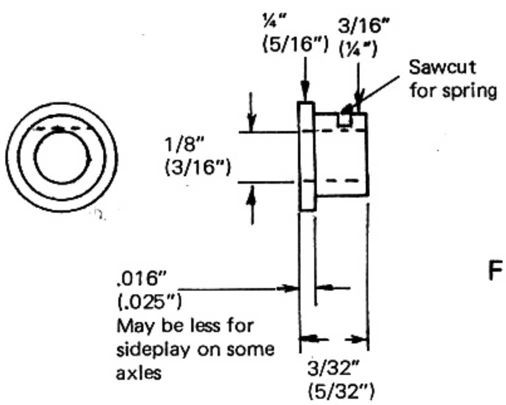
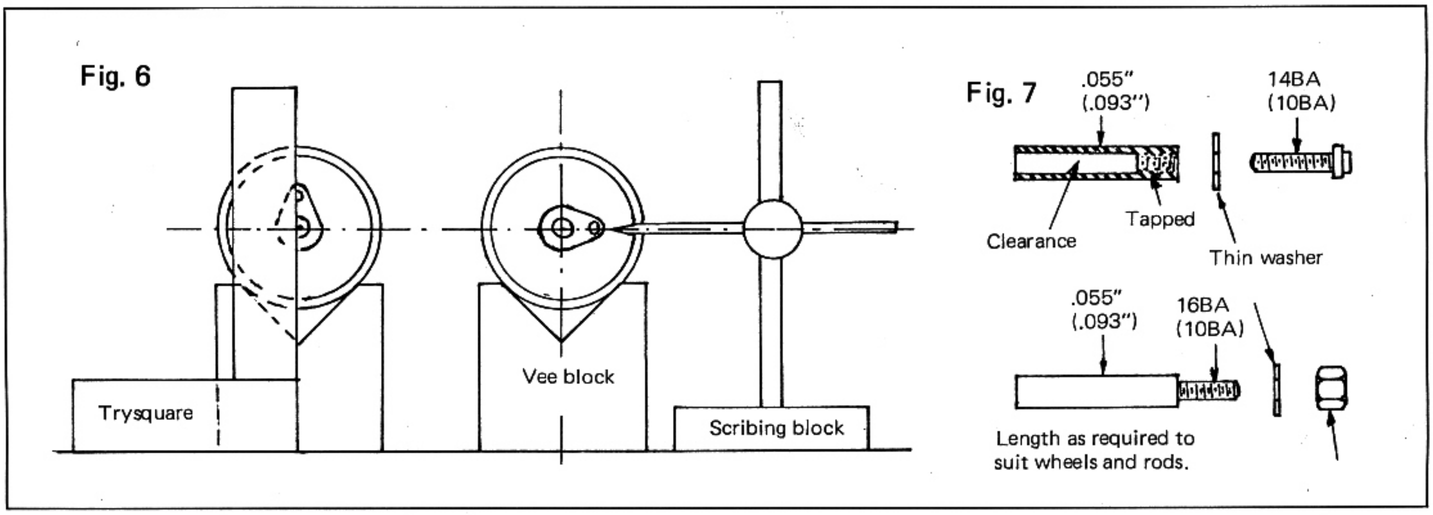


Fig. 5



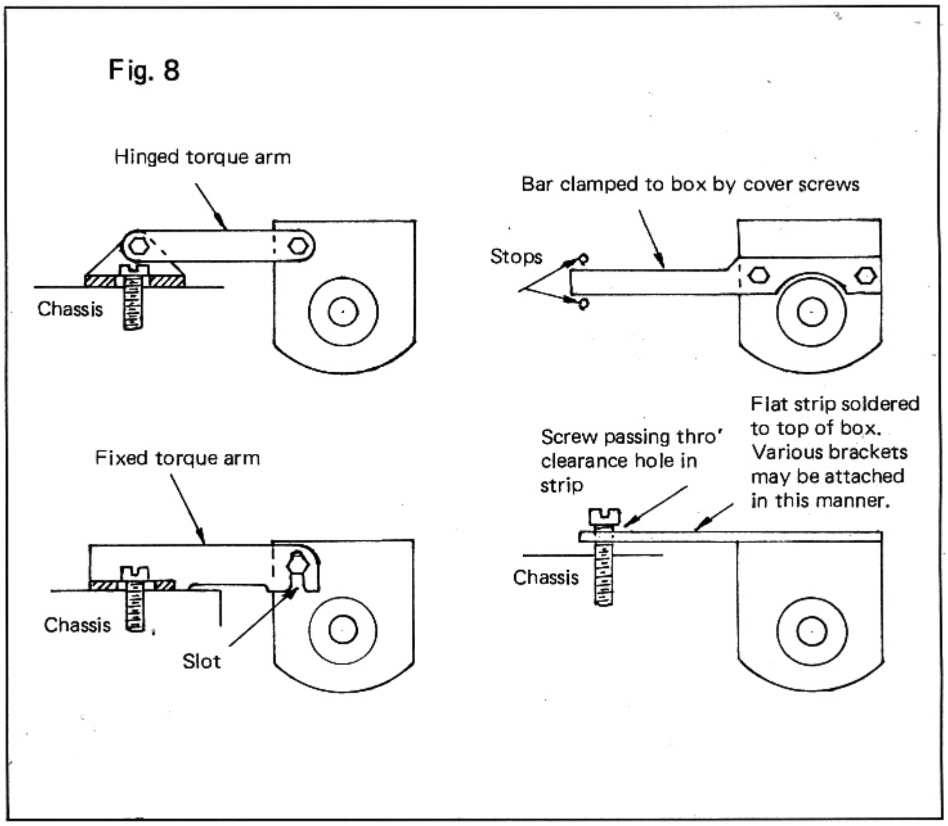
or just the normal 'space between the frames beneath the boiler'. It is advisable to make a sketch of this cutting before you actually start to make the frames so that the screws and dowels do not find themselves located in the parts cut away.

If the axles are to be sprung, beware of overdoing the amount of movement. I never let it exceed the flange depth because this can permit the flange to ride up and derail; I personally never make use of equalisation. The aim is to permit the chassis to sit down solid on a level track, the springing only being intended to press the wheel down into any slight irregularity. For axleboxes, I use round flanged bushes of phosphor-bronze as in *Fig. 5*. The springs are cantilever spring steel wires, 27 SWG for 4mm scale, 23 SWG for 7mm scale. They are soldered behind the frames as shown in *Fig. 4* and bear on the projecting bodies of the axle bushes. A sawcut in each bush, nearly breaking into the bore and located just behind the frame when the bush is in position, allows the spring wire to lay in the sawcut and prevent the bush turning. The springs are bent down after soldering to give sufficient downward thrust, generally with regard to the final weight of the finished loco.

The bushes are retained as shown in *Fig. 4* using 3/64in or 1/16in steel split pins for 7mm scale, 1/32in split pins for 4mm scale. In some cases, a single long wire can be threaded along each frame through the split pins without being visible from the side, and the ends are then bent down to prevent the wire coming adrift. Removing both wires then permits all wheels to be dropped.

If a gearbox such as that described in MRJ No. 42 is to be used, fit it before the wheels are forced on, filing a slight flat on the axle for the setscrew to bite on. Also, don't forget the axle bushes.

To quarter driving wheels, the method shown in *Fig. 6* is used. One wheel is forced on each axle giving about .0005in force-fit. The other end of the axle has been very slightly tapered over the last 1–2mm using fine emery with the axle in the lathe so that the wheel can push on part way but still be rotated on the axle. The wheelset is then supported on a vee-block (or a decent bit of brass channel) on a flat surface (lathe bed, glass, etc) and a try-square is used to get one crankpin vertical above the axle. A fine dimple in the axle end helps in sighting truly central. The other wheel is then adjusted by rotation and a scribing block used to get the crankpin and axle centre dead horizontal. Sounds complicated, but it's easier than you may think and they use basically the same method on the real railway; when all wheels are set up in this way, and before you press the second wheel home, fit all the axles in the chassis and try on the coupling rods. If any slight adjustment is needed, it can be made at this stage. When the wheels run without binding, press all the loose wheels home to correct back-to-back.



I don't like crankpins with screwed ends fitting into tapped holes in the wheels. The tapping can 'wander' and thus lose correct crank throw. Instead, I use a crankpin forced into a drilled hole. *Fig. 7* shows two alternative designs.

If using a worm gear box as described in MRJ No. 42, it will be necessary to prevent it turning round the axle. *Fig. 8* shows some ideas for achieving this. Where a torque arm engages the screw which does duty as a setscrew for the loose bearing of the worm shaft, and as a torque arm screw, it is a good idea to make the hole in the bracket (for the screw bolting the bracket to the chassis) in the form of a slot. This permits the bracket and torque arm to be moved longitudinally to tilt the shaft of the worm to line up with the motor shaft. A cardan shaft drive is then used between the motor and gearbox. This permits the gearbox axle to be sprung as the other axles. The cardan shaft and couplings are shown in *Fig. 9*.

There are, nowadays, a number of decent motors on the market, generally of the can variety. My own preference is for a 'coreless' motor — Portescap, Falhauber or Maxon — of 16mm dia × 24mm for 4mm, or 22mm dia × 30mm for 7mm. There is no reason why larger motors should not be used and, since various ones come on the surplus market from time to time, I use these when suitable.

Fig. 10 shows a method of mounting on a chassis. Another idea is to 'stick' them on the chassis on a bed of bath sealant which, being flexible, can also lower vibration and noise levels. Motors can be mounted on the loco chassis or, if there is not enough space here, in the tender with a cardan shaft via the firebox.

To my mind, a flywheel is a must, either mounted on the motor or the worm shaft and as large and heavy as space will permit. I cast lead ones using a mould machined in hardwood or Tufnol as *Fig. 11*. For 7mm, the brass spigot which protrudes through the mould is ⅜in dia, for 4mm ¼in dia. The cast lead holds tight to the spigot which then forms a chucking spigot for turning and boring the flywheel. If you wish to be very sure, tin the spigot with solder before casting or saw a few grooves for the lead to grip. The cardan shaft coupling, bored for the motor, is forced into the brass bore of the flywheel and, since the ball joint of the cardan shaft will lie within the flywheel, the latter is recessed out a little way where the slot of the coupling lies so that the driving pin of the ball joint does not foul. Two 10 BA tapped holes are situated at 180°, passing through the brass centre and steel coupling within the flywheel with recesses to clear the setscrew heads within the lead body. Such flywheels can, of course, be machined from brass but they are not so effective as lead.

Mention was made of pick-up from bogie and tender wheels. *Fig. 12* shows how, by making a bogie as a small insulated chassis just like that of the loco, one can arrange cantilever spring wires soldered to the main chassis to rub on two metal plates on top of the bogie, connected to the bogie side frames and thus to spring the bogie and to collect the current and feed it to the main frames. If one makes the tender chassis as the loco chassis and leaves the outside frames as dummies, wires, disguised as water feed pipes, can pass from tender to loco frames so that the tender wheels also act as collectors. These wires can be simply detachable using press studs or tube-and-pin plugs so that the tender can be disconnected. Where motors are in the tender, driving the gearbox in the loco via a cardan shaft, the current is then fed to the motor from the tender frames.

It is my practice to refrain from springing the rear axle of tenders. This ensures the tender's 'squareness' on the track. The leading and centre axles are, however, sprung to keep the

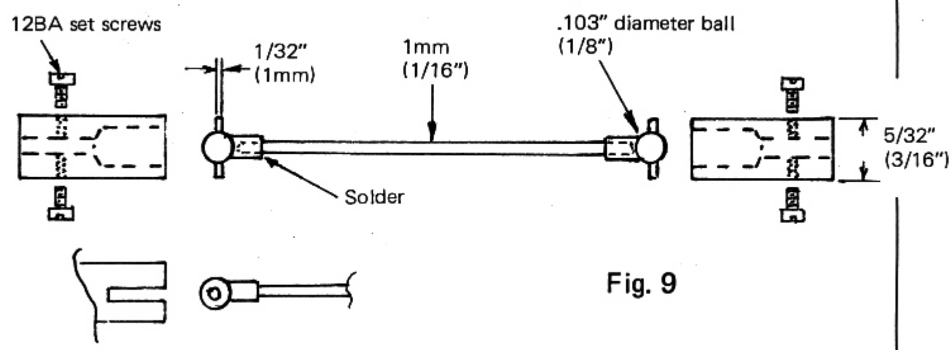
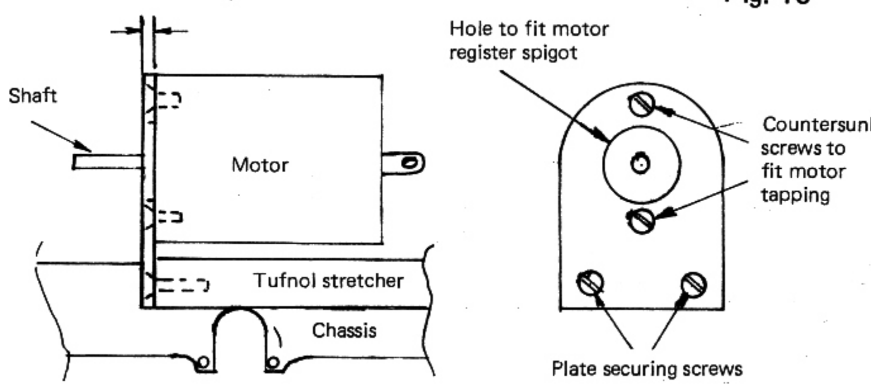
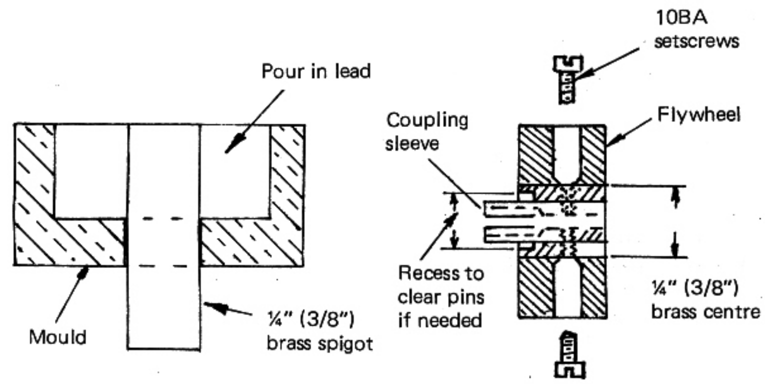


Fig. 9



The motor mounting plate may be cranked to throw the motor at an angle to the horizontal.

Fig. 10



Moulds for 7mm are usually 1¼" dia x ½" deep. For 4mm 1" dia x 3/8" deep. This allows about 1/16" machining all round.

Fig. 11

Fig. 12

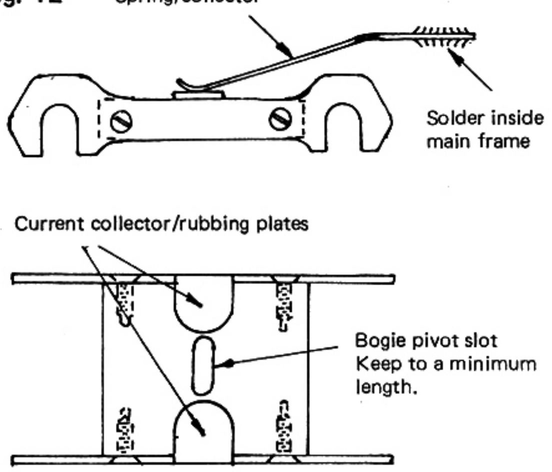
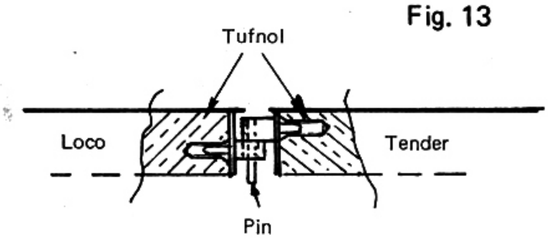


Fig. 13



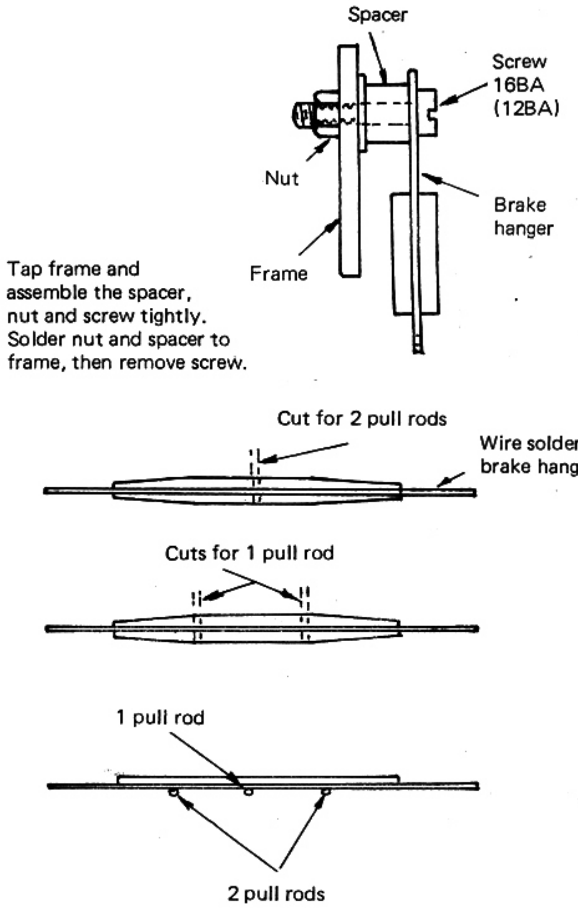
By careful filing of the loco drag link, the tender hook can be made to sit down thereon with both footplates level. If the shanks of the drag link and hook are extended behind the beams and soldered, they can also act as spigots to hold the Tufnol chassis top in place so that only one chassis bolt is required at the opposite end.

wheels in contact with the track but the horn slots are machined about ½mm above the normal level so that they are clear of the axle bushes. The front of the tender is then supported on the loco drag link as *Fig. 13*. Thus, part of the weight of the tender, plus motor and flywheel, if therein, is carried on the loco and, indeed, in some cases, extra lead weight is added to the tender. This is particularly valuable in 4-4-0 locos when getting weight on the rear drivers is a problem. It is vital on single driver locos where every ounce counts. Such models call for a boiler full of lead and very careful balancing to bring the centre of gravity over the driving axle. In the case of 'singles' alone, I sit the loco down hard on the leading and trailing bogie or carrier wheels and allow the driving axle a lot of sprung travel above and below the normal datum because the driving wheels must grip the track hard, even in hollows, but the locos must not rock over bumps.

Brakes are fitted by a screw into the frame, supplemented by a nut behind if the frame is not really thick enough for tapping. In this way, brakes can be taken off as an assembly if need be. Brake pull rods outside the wheels are just soldered to pins protruding from the brake hangers. Where the pull rods are inside between the wheels, insulated brake stretchers are made from thin copper-clad circuit board. *Fig. 14* shows the idea. Having soldered a cross wire to the stretcher to engage the hangers, it is cut down to the insulating board in two places for one pull rod or in the centre for two pull rods. The pull rods are then soldered in place. As stated, the entire assembly can be removed by withdrawing the brake hanger screws, and the insulated stretchers prevent a short circuit across the frames.

Plastic-centred wheels which have a metal boss can be 'shorted' by making a fine sawcut

Fig. 14



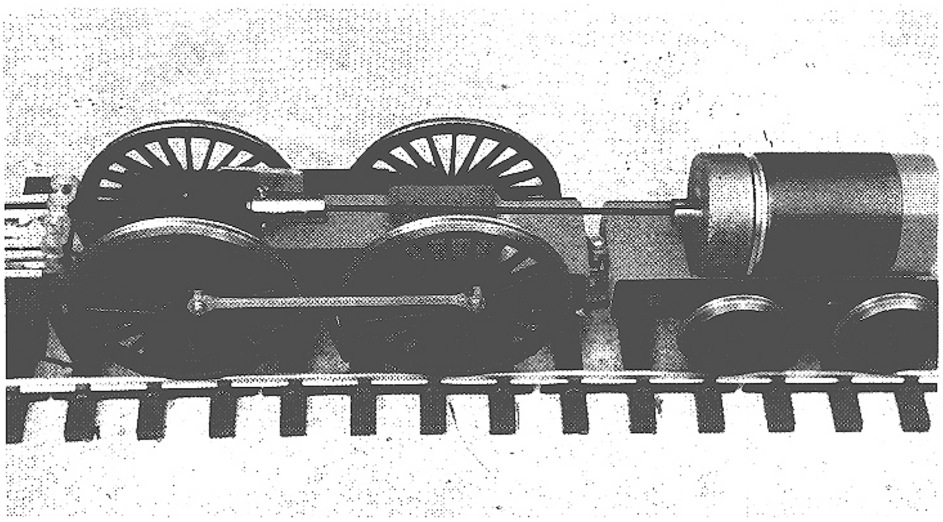
across the backs along opposite spokes, cutting about 0.01in into the flanges, spokes and centre boss and laying a length of 5 amp fuse wire in the sawcut. The wire is then soldered to flanges and the central boss, and trimmed off and cut away at the centre to clear the axle, finally filing the solder flat. Current can now pass to the axle as if the wheel was a metal one. Where there is no central metal boss, I bore out the plastic and press one in hard. I also bore out the squared centres of uninsulated Romford wheels and put in a bush which is then bored a force fit for plain ⅛in axles. It is possible to thread the ends of insulated axles of the type shown in *Fig. 2b* to accommodate threaded bogie and tender wheels and to tap 6 BA and square the axle ends for 0 gauge squared centre wheels, but getting the squared ends correctly set relative to each other is virtually impossible without proper equipment. Geoff Brown of Walsall Model Institute has, however, been agreeable to doing this for me on one or two occasions although how far his good nature would extend in this direction, I know not.

Tufnol is a material made by impregnating laminations of paper, fabric or glass fabric with various resins. In my experience, 'Carp' brand, made from Phenolic resin with fine weave fabric reinforcement, is an excellent material both from the point of view of strength and insulation. It machines well and can be tapped down to 10 BA (I have used 16 BA). A stamped, addressed envelope to Tufnol Ltd, P.O. Box 376, Wellhead Lane, Perry Bar, Birmingham, B42 2TB will bring you the address of your nearest stockist who will be able to supply whatever size you want and will cut strips to width as required. It is not cheap but price is relative when you are building a valuable model.

Finally, a photograph to illustrate the type of chassis I have described, an 0 gauge 4–4–0 tender loco with a large Maxon motor and flywheel in the tender. This one hauls 12 coaches before slipping and could obviously double that if weight were available. The boiler and firebox are full of lead, and lead is added to the tender. Both models will freewheel for several feet from full speed after the current is turned off, thanks to the flywheel.

In conclusion, I must acknowledge the great help and guidance which I have enjoyed over the last 50 years from many fine modellers, some no longer with us. I have picked their brains shamelessly and, in turn, offer, however inadequately, some of that wisdom to future generations.

Where I have indicated dimensions, these are generally as a guide, a few thou here or there or a change of design to suit a particular case will do no harm. It is, basically, the general principles of excellent design and operation that I wish to propound. If I have done that, I shall be content. Readers may well wish to raise comments and, if of sufficient importance, I will endeavour to deal with them in some future issue.



Drive details of 'O' gauge Aspinall 4–4–0. 28mm Maxon coreless motor and flywheel with cardan shaft drive to large wormgear unit.