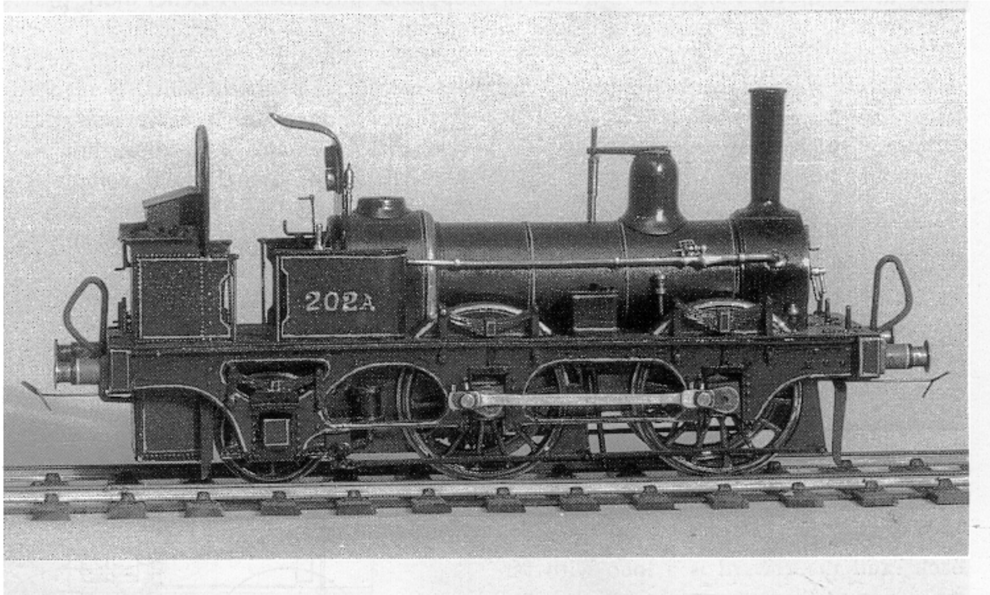


MIDLAND No. 202 in EM

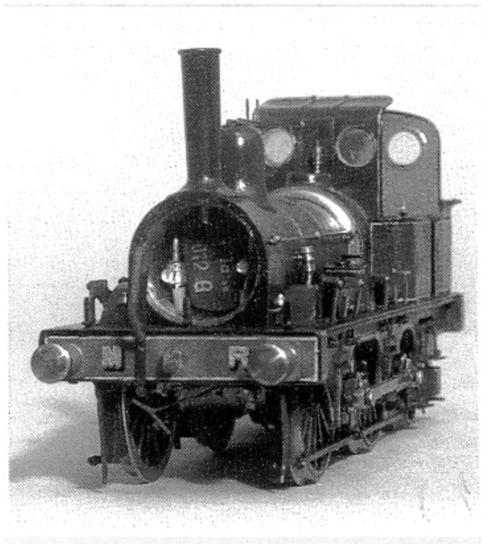
SID STUBBS describes a remarkable little engine which presented a number of problems in 4mm scale. Here's how real engineering resolved them:

The prototype of this model was a little-known 0–4–2 well tank of which the Midland Railway possessed three. They started life as diminutive 2–2–2 well tanks purchased in 1850 from William Fairbairn & Son Ltd by the 'Little' North Western Railway which ran from Skipton to Lancaster. This line was worked by the Midland from 1852, vested in the Midland in 1859 and purchased by them in 1871. Mathew Kirtley, the Midland Locomotive Superintendent, rebuilt the three engines in the 1860s in the form modelled. They were numbered 200 to 202 inclusive and No. 202 was recorded by the late E. L. Ahrons as working local passenger traffic on London's Gunnersbury–Cricklewood service in the 1880s. She was scrapped about 1898 so she didn't do too badly. It is believed that at some time she was on the duplicate list as 202A and my model is numbered accordingly.

The only other model I have ever seen was a 7mm scale version built, I believe, in the early 'fifties, by the late R. E. Lacy and he confessed, at that time, that he hadn't been able to find a motor small enough to go in. He was so kind as to let me have a print of his own drawing but as this has faded badly with time, I have made the drawing reproduced herewith. I resolved to build a 4mm EM version and initially commenced to make my own motor. The problem with a well tank is that there are no side tanks to hide the motor or to disguise a cut-away boiler or firebox. Almost invariably, the motor must be cylindrical to fit within the boiler. In this case, the boiler is 3ft 3in outside diameter, or 13mm in 4mm scale, thus calling for a cylindrical motor of about 12mm diameter – less than half an inch, and no commercial motor of that size was available 30 years ago.

However, in due course, the Faulhaber 1219, 12 volts, 0126 motor came along and this proved the answer. Such a small motor is limited in power and undue frictional losses in the gearing and running gear cannot be tolerated. Accordingly, the worm is 1/8in diameter, two-start, 28 threads per inch, cut in the lathe, case-hardened and highly polished. It is forced onto a 1mm diameter hardened steel shaft which runs in phosphor-bronze bushes, and the domed end of the shaft bears against a 1/32in steel ball as a thrust bearing at one end. Two hardened and lapped steel washers are located between the worm and bush at the other end with three 1/32in steel balls between, spaced out in a drilled bronze washer to form the front thrust bearing. The phosphor-bronze worm wheel has 45 teeth and is cut as a plain helical gear, not 'throated' as worm wheels usually are because this can cause friction if there is any side play or the pair are not carefully meshed. The worm wheel is mounted with a 25-tooth steel pinion on a common phosphor-bronze bush free-running on a 1/32in diameter pin in a suitable intermediate gear carrier bracket mounted on the Tufnol frame spacer and the pinion meshes with a 50-tooth brass gear set-screwed on the driving axle. The intermediate gear bracket has an elongated fixing screw-hole to permit horizontal sliding for correct meshing of the 25 and 50-tooth gears and a suitable shim beneath adjusts the mesh of the worm and worm wheel. The overall gear ratio is 45:1, this high figure being necessary as the small motor runs at high speed and also because the higher the torque multiplication, the better. All gears were hobbed in the lathe (see MRJ No. 42, 'High efficiency worm drives').

The worm and bearings are fitted in a brass 'cartridge', ¼in diameter set-screwed within a ¼in bore within the boiler which is turned from solid brass. Suitable slots are milled into the boiler and cartridge to allow access to the wormwheel to mesh with the worm. Coupling the motor and the worm shaft is an 11½mm diameter coupling comprising two pins in the wormshaft flange engaging two free-fit



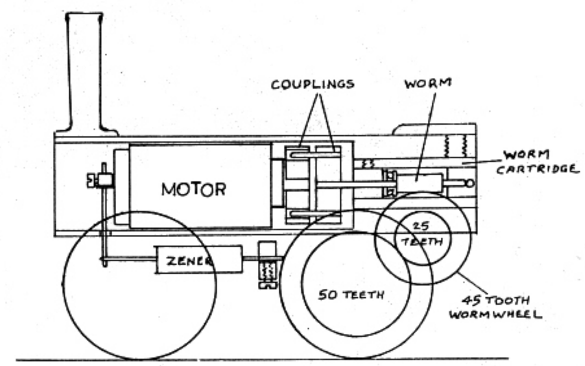
Photos: PHILIP HALL

holes in the motor flange, both halves of the coupling being as large as possible to give some flywheel effect to prevent jack-rabbit starting and stopping. The remainder of the boiler is bored out to 12mm diameter to accommodate the motor which is a slide fit.

Electrical feed to the motor is by two nickel silver spring wires mounted in the chassis and projecting upwards through holes in the smokebox floor. These engage terminals soldered onto the two solder tags at the end of the motor and serve also to prevent the motor turning or sliding within the boiler. 16BA pinch screws in the terminals ensure good electrical contact. After running in, the efficiency of the gearing proved such as to permit the driving wheels to 'drive back' and the reward is a loco with far more power than its weight can handle. *Fig. 1* shows the complete arrangement.

My layout runs on 24 volts, so using a 12 volt motor could be risky and, indeed, the loco speed would be far higher than it should be. Accordingly, two opposed 8 volt Zener diodes were fitted, one in each motor lead, set to conduct in opposite directions. A Zener diode passes current freely in one direction but blocks it in the other direction until the 'Zener' voltage, in this case 8 volts, is reached. It then conducts freely in reverse whilst the voltage remains 8 or above but only the balance of actual track voltage less 8 volts is passed to the motor, so at 24 volts the motor receives 16 volts and this seems okay. The use of two opposed Zeners is necessary so that one or other is acting whichever way the current flows and thus the loco can be reversed by reversing polarity in the normal manner. *Fig. 2* shows the circuit. 5 watt diodes ref IN5344B are employed. Being rated at 5 watts, they will pass 5 ÷ 8 amps ≏ 0.60 amps without overload and since the loco

Fig. 1. Drive arrangements



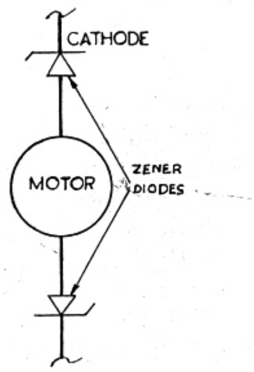
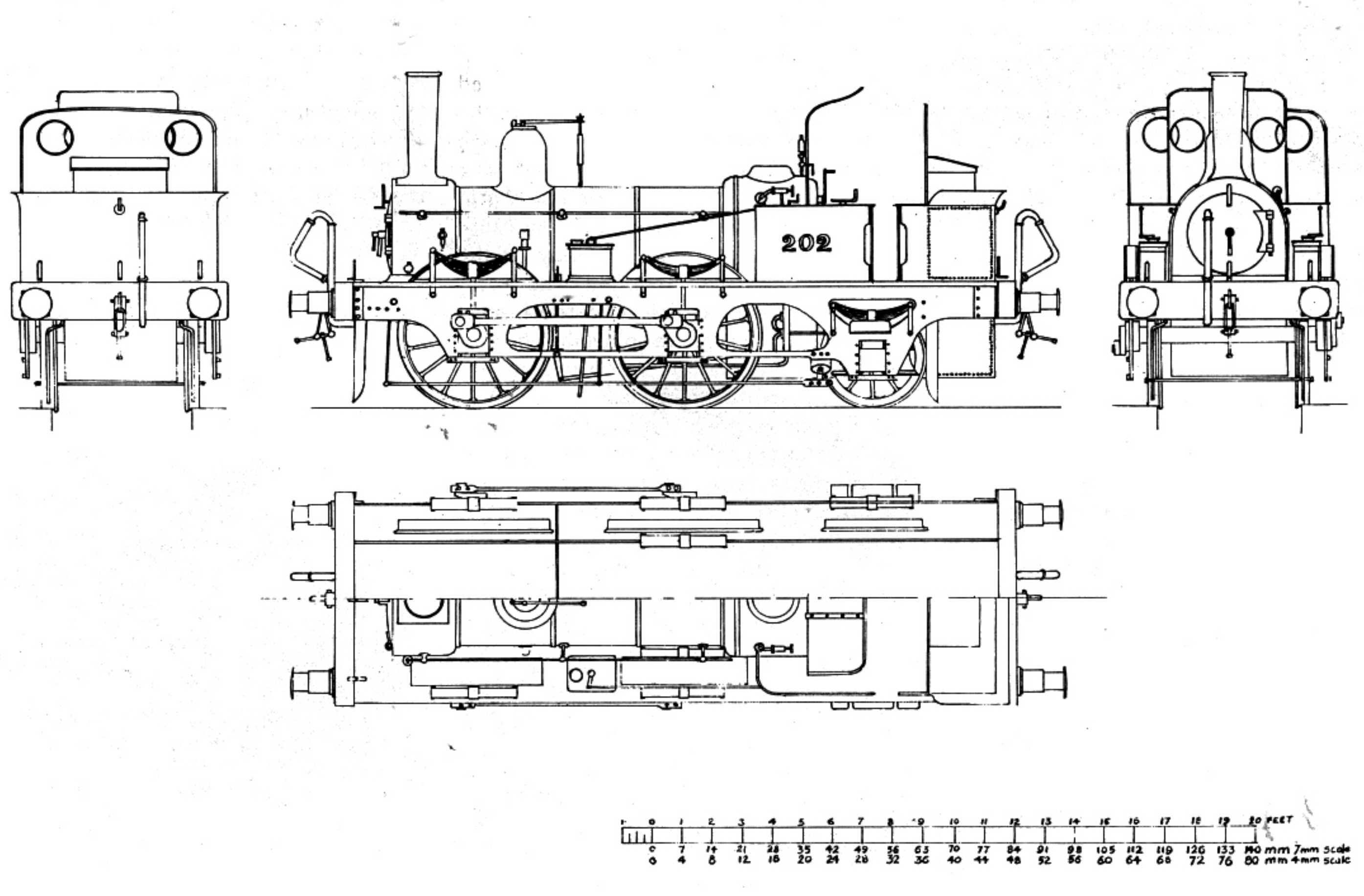


Fig. 2.



The author, a renowned member of 'the Manchester School', at work in his modelling room.

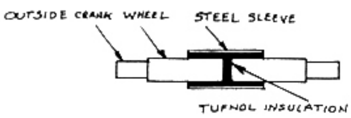
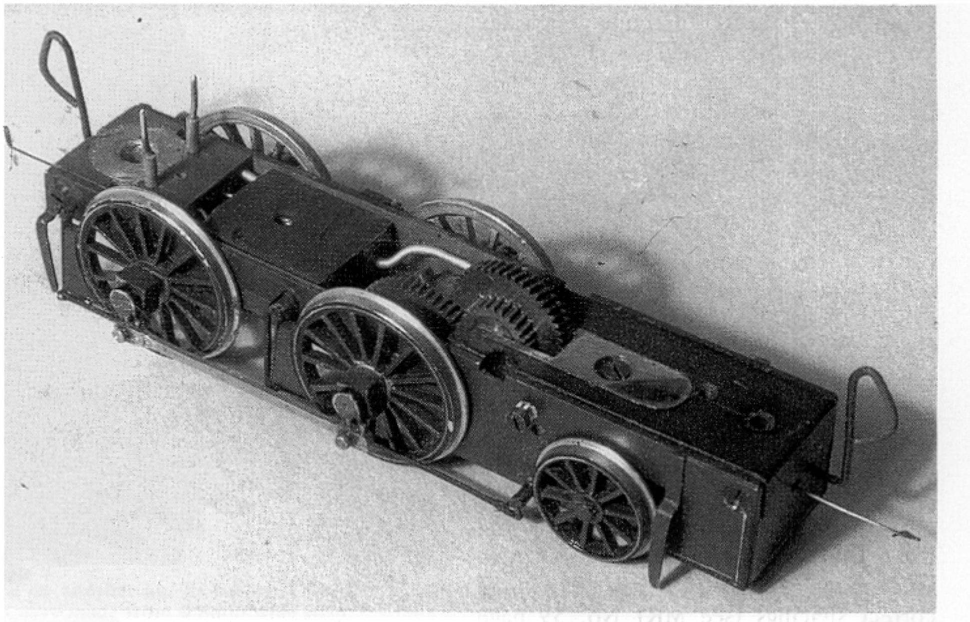


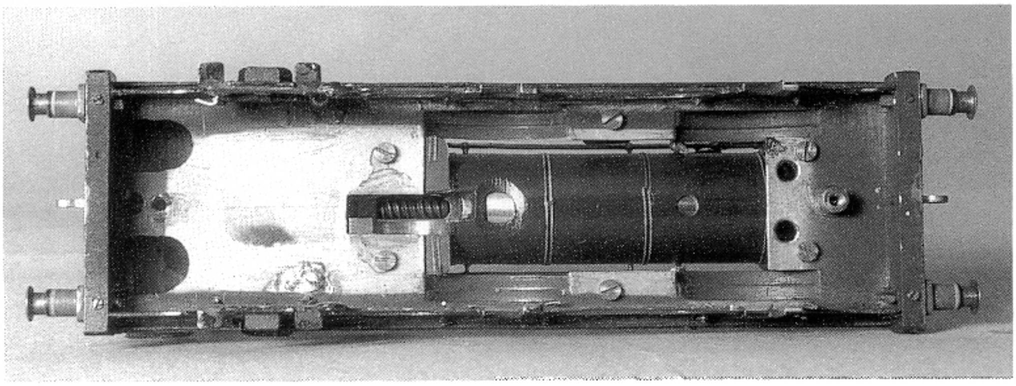
Fig. 3. Insulated axle

takes only about 0.10 amp, they are quite adequate. However, they are enclosed in a lead block between the frames which acts as a heat sink and provides a much needed bit of weight. Indeed, bits of lead are packed into all available places within the length of the coupled wheelbase but *not* in the well tank area so that the centre of gravity remains between the coupled wheels. Additionally, all wheels are sprung.

As to the general constructional details, the axles are of the split, insulated variety as in *Fig. 3* which means that



Gear arrangements in the chassis, shown here with motor removed.



current passes via the axle bushes to the inside frames, no collectors being required. The inside frames are insulated from each other and from the body by Tufnol stretchers which, being slightly proud above the frames, prevent them from contacting the body and shorting. There are two pairs of frames, outside and inside. Construction commenced with a pair of coupling rods drilled together to give identical centres. All four embryo frames were then clamped together and the coupled wheel centres drilled using a coupling rod as a jig, the frames then being opened out and slotted as required using these holes as a basis, thus ensuring that wheel and coupling rod centres are identical. The axles run in sprung bushes in the inside frames, Tufnol dummy hornblocks being furnished to engage the outside frames without short circuits through the metal body. These bushes are fitted onto the axles before the outside cranks are carefully quartered and pressed on. For a complete description of frame design, see my article in MRJ No. 56.

The wheels were turned from solid brass bar, holes drilled in the dividing head and the spokes sawn out with a fretsaw and filed to shape, afterwards being dull chrome plated to emulate steel (*Model Railway News* June/July 1959 for full details of method). Firebox and smokebox were milled and filed from solid brass and bored to receive the boiler before having their bases tapped and screwed to the footplate. Rivets are indented in the platework using a punch and suitably shaped die carried in a 'C' frame mounted in the lathe spindle, with the work held in a clamp in the toolpost to enable the rivets to be spaced by using the cross and top slide feedscrew dials to feed the plate beneath the punch at correct spacings (see MRJ No. 59 page 319). As much detail is incorporated as can reasonably be modelled in the space and with the necessary robustness, bearing in mind that this is no glass case non-runner. Details include cab fittings plus, normally, a crew in view of the open cab.

The engine will easily take a rake of three eight-wheel clerestory coaches or twelve wagons on a four foot radius 1-in-80 curve, and since this probably represents the limit of the real loco which only weighed 14 tons (a Brighton 'Terrier' weighs 22 tons and people think that's small), this performance must be accepted as satisfactory. A photo of the engine appears on page 83 of *Locomotive and Train Workings in the latter part of the Nineteenth Century* Vol. II by E. L. Ahrons.