Meccano Constructors Guide

by B. N. Love

Part 2 – Pulleys, sprockets and gears

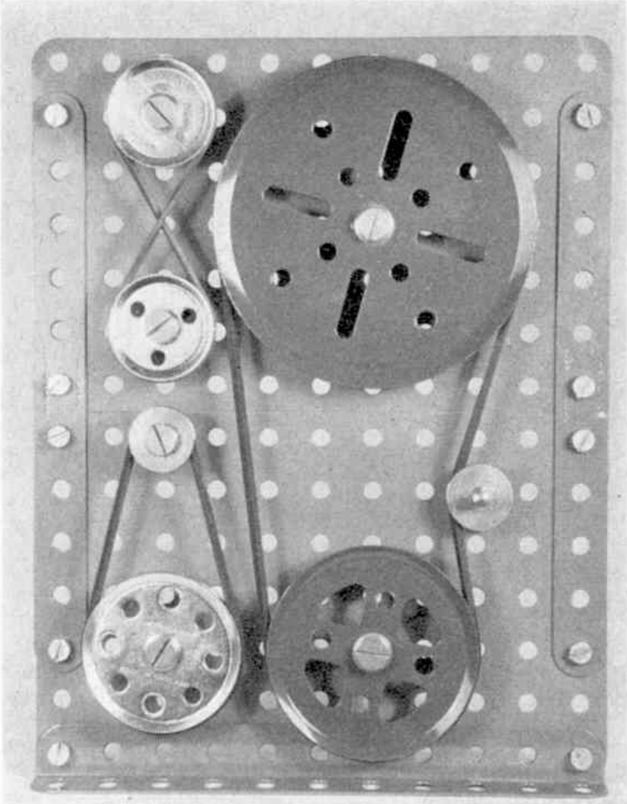


FIG 1

ACTION MODELS invariably have the greatest attraction for Meccano enthusiasts of all ages and this chapter deals with some of the aspects of putting Meccano models in motion.

Wheels and axles were among the earliest components in the system and a simple range of gears and sprocket wheels followed shortly after the inception of "Mechanics Made Easy", the forerunner of Meccano, more than half a century ago. The family of Pulleys illustrated in Fig. 1, vary very little from their original design and give a range of diameters from ½ in. to 3 in. When used with an equally wide range of Meccano rubber Driving Bands, a large number of pulley ratios are obtainable. Both the ½ in. and 1 in. Pulley are available with or without boss but where no boss is fitted, the Pulley is described as "loose" and is used principally as a guide pulley in cord hoisting mechanisms or for making up multi-sheave pulley blocks.

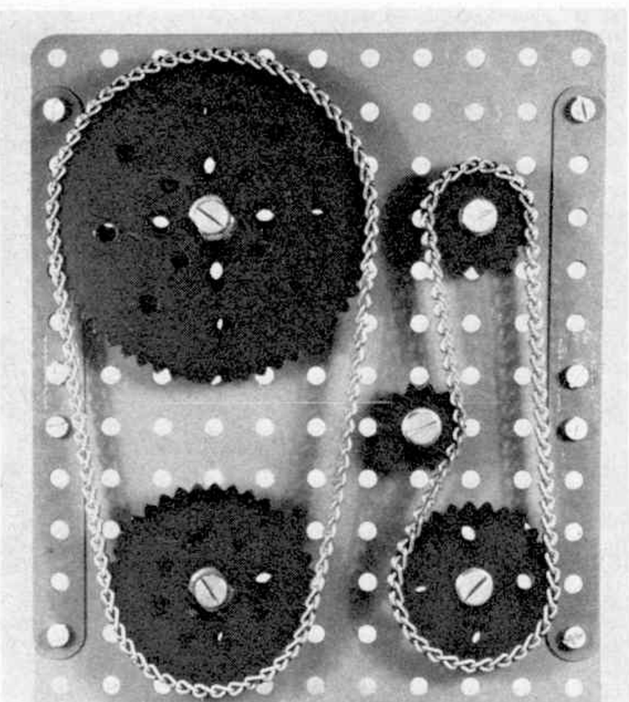


FIG 3

Considerable power may be transmitted by Meccano Pulley drives which may be reinforced by using a system of twin Pulleys and double Driving Bands. An example of this is shown in Fig. 3, where Pulleys are successfully used in conjunction with a gear-box to transmit motion to a sophisticated model of a self-programming Fairground model. There is plenty of scope, both in simple and more advanced models for the use of pulley drives and the rubber Driving Bands give excellent latitude in tensioning and positioning of their respective Pulley Wheels. These Bands are manufactured in "light" and "heavy" gauge to suit individual power requirements.

When calculating pulley ratios, the diameters of the various Meccano Pulleys may be taken as an approximate guide so that a 1 in. Pulley driving a 2 in. Pulley will give a step down ratio of 2 : 1, but the belt drives in general have the disadvantage of stretching which can, in turn, cause slipping or "creeping" of the driving belt. Ratios must therefore be considered to be approximate.

Fig. 1. The basic gauge of Meccano Pulley Wheels. The ½ in. Pulley without boss acts as a "jockey" pulley to increase belt tension. The twisted belt provides a reverse drive.
Fig. 3. The basic range of Meccano Sprocket Wheels.

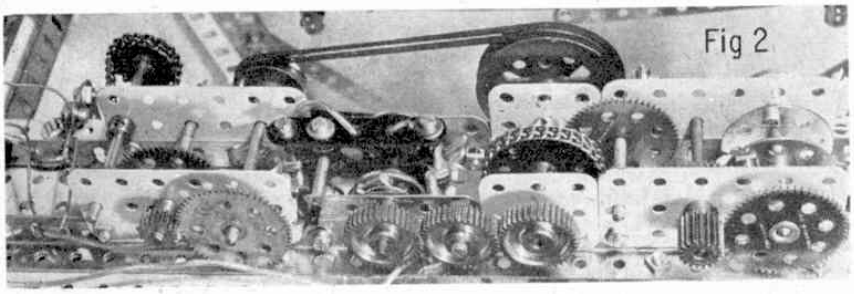
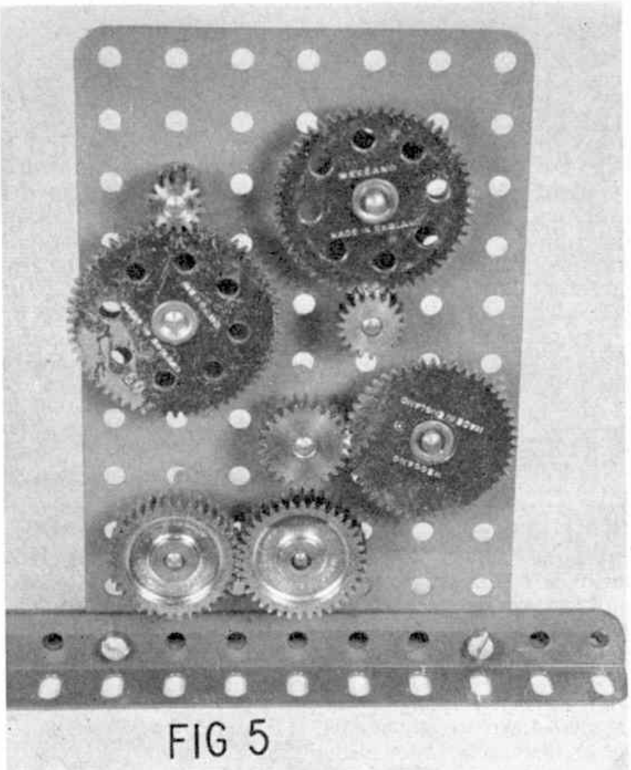
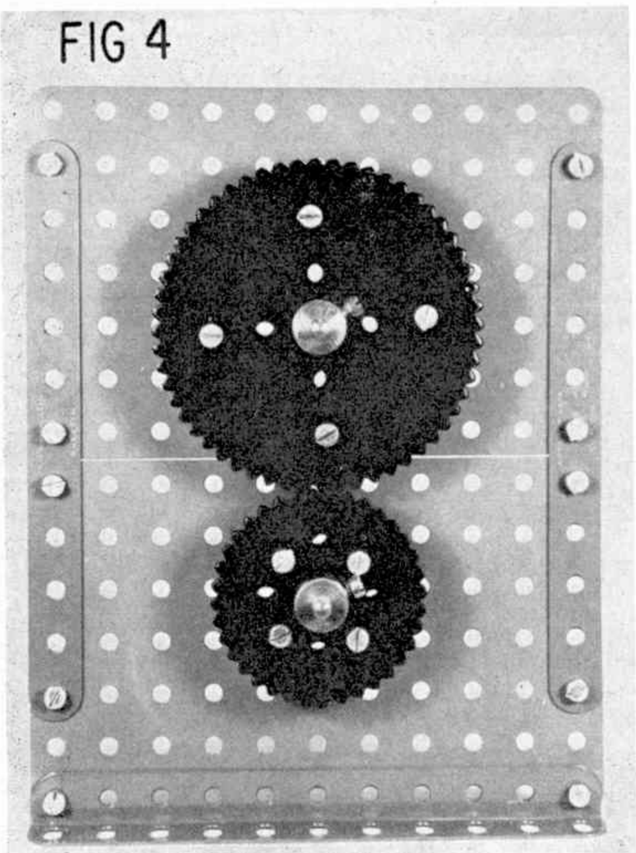


Fig. 2. Pulleys, sprockets and gear wheels in combination to operate an accurate programming mechanism. Fig. 4. Meccano Sprocket Wheels paired-up to give direct meshing as heavy duty spur gears. Fig. 5. Range of pinions and gear wheels giving four different ratios ranging from 1 : 1 to 4 : 1.

Where it is important that a mechanism must have its various movements running in step, or "synchronised", the role of the pulley drive may be taken over by Meccano Sprocket Wheels and Sprocket Chain. Since the Sprocket Wheels are cut with similar tooth forms and are available in directly related ratios, it is a simple matter to employ them for driving widely separated shafts with a guarantee of accurate timing. Fig. 3 shows the basic range of Sprocket Wheels available, but it is important to remember, here, that, while the diameters of the parts can be used as a *guide* in calculating Sprocket ratios, the *exact* ratios can only be determined by the number of teeth each part has. For example, the diameter system indicates that a 1 in. Sprocket driving a 3 in. Sprocket results in a ratio of 3 : 1, whereas, the exact ratio is 56 : 18 or slightly more than 3 : 1. Generally speaking, therefore, diameters are more a guide to the spacing of shaft centres, while teeth numbers enable ratios to be calculated accurately.

It is not generally realised by Constructors that Part No. 168b, Ball Thrust Race Toothed Disc, 4 in. dia. is also a useful sprocket wheel when bolted to a Bush Wheel or similar centre. Furthermore it has the peculiar number of 73 teeth. By arranging for this Toothed Disc to be engaged by a rotary shaft carrying a Fork Piece radially mounted, the 73-toothed Disc can be advanced one tooth at a time. If, in turn, its own shaft drives a 5 : 1 reduction ratio, an overall ratio of $73 \times 5 = 365$ is obtained. This should be of great interest to clock builders, being a very simple method of recording a complete year's calendar movements !





A further unorthodox feature of the Meccano Sprocket system is that Sprocket Wheels may be directly engaged as coarse-toothed gears and, by bolting them in pairs, a substantial area of tooth meshing surface is obtained together with rugged drive properties and an excellent reproduction of "period" gearing reminiscent of the days of the great engineers Matthew Boulton and James Watt in the early Industrial Revolution. Fig. 4 shows an example of such an arrangement. As all Sprocket Wheels of $1\frac{1}{2}$ in. diameter or greater are perforated with radial holes, they serve very well as hub centres for heavy rotating structures and as the 2 in. and 3 in. Sprockets have heavy duty brass bosses they are capable of supporting very stout structures.

For a high degree of precision and an infinite range of ratios the Gear Wheels and Pinions in the Meccano system may be employed with the utmost confidence.

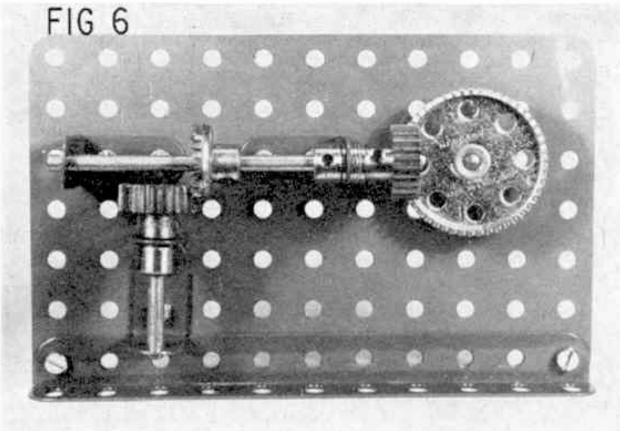


FIG 6

Fig. 5 shows a few simple arrangements of Gears with standard spacing in ratios suitable for general model building. These are calculated in each case by noting the *numbers of teeth* (not diameters) and making a fraction from the two numbers obtained from any meshing pair. If the arrangement is used to obtain increased speed (with resulting reduced power, or "torque"), it is known as a step-up ratio, one example of which is a 50-teeth Gear Wheel driving a 25-teeth Pinion, the step-up ratio being 50/25 or 1 :2. If the Pinion drives the Geer Wheel, a step-down or reduction ratio (with increased torque) is obtained, in which case the ratio would be 2 : 1.

As the Constructor advances in his model building techniques, gear ratios will become more important and if an accurate timing device is required in a particular mechanism, a sound knowledge of the required ratios is essential. It is a common error among novice builders using gear drives for the first time to *add* gear ratios when there are several rotating shafts in a gear-box. This is wrong, of course, as the action of one gear ratio driving a second or third, is to *multiply* the ratios in step up arrangements and to *divide* them in step-down arrangements. Referring back to Fig. 2 as an example, the pulley shaft carries a 19-teeth Pinion meshing with a 57-teeth Gear to give a first stage reduction of 3 :1. Next, a 25-teeth Pinion passes on the drive to a 50-teeth Gear Wheel, giving a second stage reduction of 2 : 1 and, finally, a long-faced 19-teeth Pinion transmits the drive to a 57-teeth Gear Wheel giving a third stage reduction of 3 : 1. Putting these three ratios in combination we now get $3 \times 2 \times 3 = 18$ so that the whole gear train in this case gives a reduction ratio of 18 : 1.

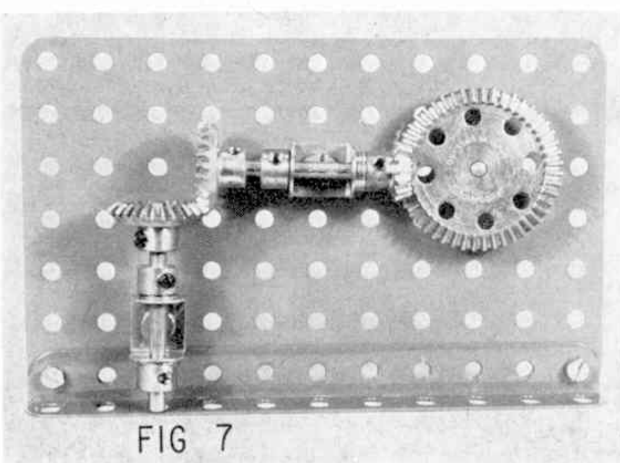


FIG 7

The gear arangements shown in Fig. 5 are all mounted on shafts set in bearings which are spaced 1 in. apart and provide ratios from 1 : 1 down to 4 : 1. Gear diameters are quoted on the official parts list and, generally speaking, if the diameters of a pair of meshing gears are added and then divided by 2, the centre distance of the driving shafts is obtained. However, in the case of the Pinion, Part No. 26c, and the Gear Wheel, Part No. 27d, which combine at 1 in. spacing to give a ratio of 4 : 1, the sum of the diameters is $2\frac{1}{16}$ in. and when this is halved, the result is $1\frac{1}{32}$ in., but the discrepancy is not sufficient to effect the smooth meshing of these two gears at 1 in. spacing. Larger ratios are obtainable directly by meshing the 19-teeth Pinion with the $2\frac{1}{2}$ in. or $3\frac{1}{2}$ in. Gear Wheel, when ratios of 5 : 1 and 7 : 1 respectively are obtained.

All of the foregoing gears are known as "spur" gears and are of simple tooth form meshing together on parallel shafts.

To effect a change of direction in gearing requires the use of gears which have their teeth turned at an appropriate angle. The simplest form of such a gear in the Meccano system is the Contrate Wheel illustrated in Fig. 6. Two sizes are available, namely the $\frac{3}{4}$ in. diameter 25-teeth and the $1\frac{1}{2}$ in. diameter 50-teeth Contrate Wheels. When meshed with 25-teeth Pinions as shown, they provide 1 : 1 and 1 : 2 ratios respectively. They can, of course, be meshed with other Pinion sizes to provide other ratios, calculation again being done simply by comparing teeth numbers.

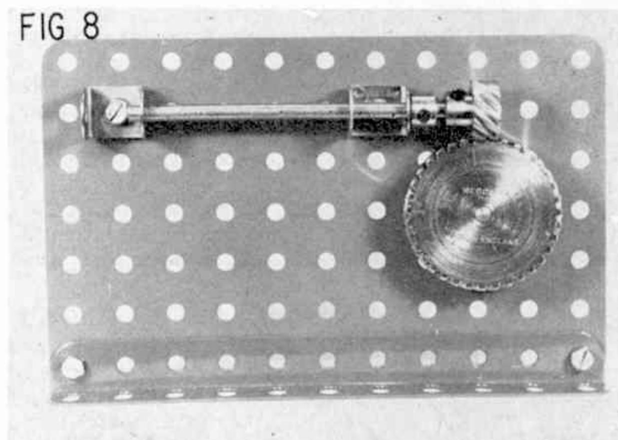


FIG 8

A development of the contrate is the bevel gear and this is also available in the Meccano system following standard engineering practice. Bevel Gears give a much stronger and quieter drive than Contrate Wheels owing to the careful formation and meshing of the teeth to provide a drive at right-angles. They are assisted in their performance by the fairly wide surface contact of teeth provided. One pair of Bevel Gears, Part No.'s 30a and 30c are designed to be used as a matched pair as the teeth angle of the larger gear have cut to complement that of the smaller. As they have 16 teeth and 48 teeth respectively, they provide a 3 : 1 ratio Part No. 30, the $\frac{7}{8}$ in. Bevel Gear has 26 teeth cut at an angle of 45° and is used with a second Bevel Gear of the same size to provide a strong right-angle drive with a 1 : 1 ratio. These are illustrated in Fig. 7.

Fig. 6 Contrate drive giving two changes of direction and 2 : 1 gear reduction. Fig. 7. Bevel gearing giving two changes of direction and 3 : 1 reduction. Fig. 8. Helical drive giving right angle change of direction with axles mounted in different places.

Perhaps the most interesting Meccano gears are the pair of Helical Gears, Part No.'s 211a and 211b. Motion through Helical Gears is transmitted by a cross-sliding action and the teeth are cut with a twisted curve so that the faces of a meshing pair are at right-angles. Accurate location of shafts driven by Helical Gears is essential if smooth action is to be obtained, but when properly set up and lightly lubricated, they provide a very smooth chatter-free and almost silent drive. Although designed as a matched pair, the smaller of the Helicals can be meshed with one of its own kind to give a 1 : 1 ratio, but some adjustment in standard spacing between the right-angle shafts is necessary to achieve this. When the normal pair, 211a and 211b are used, the ratio is approximately 1 : 3 although, in practice, they do not give an exact whole number ratio, counting the teeth. A helical drive is shown in Fig. 8.

When taken to its logical conclusion, a helical drive becomes the Worm and Pinion arrangement shown in Fig. 9. The Worm Wheel has a helix or "pitch" such that one revolution of the Worm will produce a movement in its driven Pinion equivalent to the distance of one tooth width. This makes gear ratios very simple to calculate since it is necessary to know only the number of teeth on the engaged Pinion or Gear Wheel. Hence, when meshing with the 3½ in. Gear Wheel, the worm will provide a reduction ratio of 133 : 1.

While the Meccano Helical Gears may be driven in either direction the Worm cannot be "back-driven", i.e. turned by the Gear Wheel with which it is meshed. This has some disadvantages but they are few and are outweighed by the advantage that a Worm drive provides its own brake so that, when employed in crane winding drums, etc., the moment power to the Worm shaft is stopped, the load will not be able to overdrive the worm because of the non-reversible nature of the Worm's helix.

Gear arrangements illustrated so far are simple ones, but when built into compound gear trains or gearboxes, they open up the Meccano system to its fullest extent, and the versatility of the Meccano system is limitless. Once the constructor has experimented with simple reduction gears in working models, gear changing and reverse mechanisms follow as a natural development. A very simple two-speed gearbox is illustrated in Fig. 10. The shaft receiving the drive from a hand wheel, clockwork or electric motor, etc., is known as the "input" shaft and the final shaft passing on the motion to the model movements is known as the "output" shaft. In Fig. 10 the input shaft (a) carries two Pinions of different sizes, while the output shaft (b) carries two different Gear Wheels to mesh with their resepctive Pinions, as required. A long-faced Pinion is secured to one end of the output shaft, which is free to slide in its bearings, being moved by a simple gear shift lever. It is important that one pair of gears is completely out of mesh before the second pair engages, or the mechanism will jam. The purpose of the outside Pinion is to provide a take-off point for additional gearing, its long face allowing the output shaft to slide through a distance adequate for gear changing.

It is sometimes convenient to use a similar arrangement for the simple purpose of reversing the drive from the output shaft. In this case, a 1 : 1 reverse drive can

Fig. 10. A simple form of two-speed change-over gearbox. The input shaft (a) receives the drive via its Sprocket Wheel which is then passed on to either of the two Gear Wheels on the output shaft (b) by means of the gear shift lever (c) which is pivotted by a lock-nutted Bolt to the 1 × 1 in. Angle Bracket and carries a Bolt engaging between the two central Collars on the output shaft.

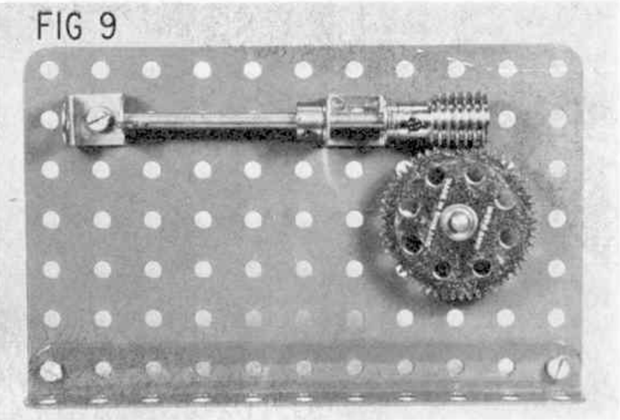


Fig. 9. A Worm drive, considered to be the final development of a helical drive.

be achieved by making one pair of gears from 1 in. Gear Wheels and inserting an intermediate gear known as an "idler" between a pair of Pinions at the other end of the gear change shaft. To keep the shaft spacing correct, three 19-teeth Pinions are used "in line", the centre Pinion being secured to the side plate of the gearbox by a 1 in. Bolt on which it is free to rotate or "idle". Its purpose is to pass on the rotation of the input shaft to the output shaft in the same direction, the reverse drive being effected by the pair of 1 in. Gear Wheels, when meshed at the other end of the shafts.

Next month, I will continue to explain the uses of Meccano Gears, and then combine the basic points outlined in the first two parts of this series and deal with crane structures.