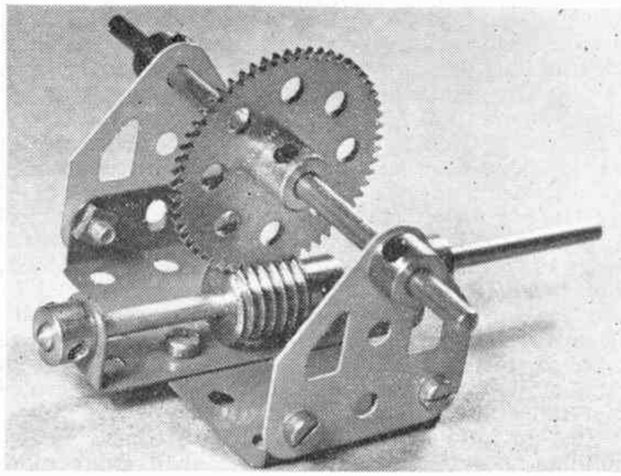
copy. "I believe the whole idea of the exercise", says Gerald, "Is to find out how we can work out the shapes of a pattern, and then copy it". It is done, he goes on to say, "More or less on the same lines as the assembly line in a factory," and he adds that "I must admit all this is a jolly good idea to see how patient one is when confronted with the various patterns."

The "Meccano Section" is only a small part of the excellent work done down at the Blind Rehabilitation Centre in Torquay, but it was sufficient to show Gerald Hutton that he could still enjoy his old hobby. The accompanying pictures prove how successful he has been and, in addition to the models shown, he has built numerous others from the old-style Instructions Manuals containing written building instructions. How does he do it?—By copying the instructions in Braille and working out mental illustrations to go with them. That's genuine skill!

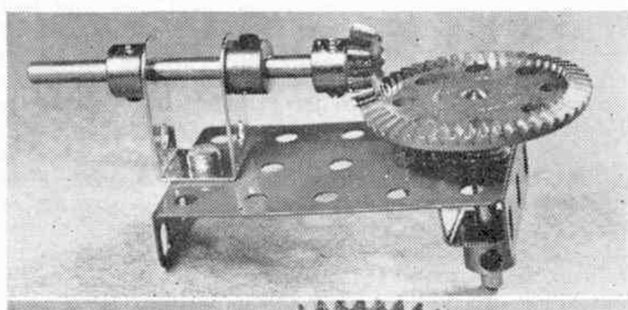
DRIVE ON

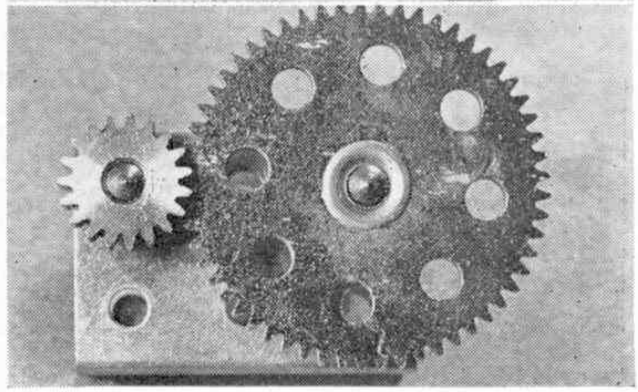
Spanner looks at the methods and linkages used in the driving of Meccano models



The Meccano Worm Gear No. 32 has a rating of 1, therefore, when it is meshed with a Gear, you immediately have a ratio as high as the number of teeth on the Gear. Here, we see a Worm meshing with a 57-teeth Gear to result in a 57 : 1 ratio.

Below, top, a positive method of obtaining a right-angled drive is to use bevel gearing. Here we have a Meccano Bevel Gear 30a (16-teeth) meshing with Gear 30c (48-teeth) to give such a drive and, at the same time, a gear ratio of 3 : 1. Next, a gear ratio of 3 : 1 obtained by meshing a ½ in. Pinion (19-teeth) No. 26 with a 57-teeth Gear, No. 27a. These are two of the most frequently used gears in the Meccano system.





WHENEVER I feature working models in the M.M. I describe, almost in passing, how they are driven: X is connected to Y; this Pinion meshes with that Gear, and so on—stark building instructions, all, without any theory to explain why it is done. This is as it should be in constructional articles, but it's worth pausing here to take a general look at the various methods of driving or, more correctly, the various methods of transmitting drive in Meccano models. "Transmitting" is the operative word because, as far as Meccano is concerned, there are only two actual drive sources—manual and motor.

For the purposes of this article, the drive source is not important. What we are interested in is how the drive is taken from the source to the point where it is applied, and what happens to the power on the way. Generally speaking there are four basic types of drive—direct, belt, chain and gear. Of these, the last three are closely related to the final output power as well as the speed of the drive system, as we shall see.

Direct drive

First, however, let us look at the direct drive system which is certainly the most simple in operation, at the same time being the most limited in use. Direct drive is where the output shaft of the drive source, or an extension of the output shaft, serves also as the final drive for the operation being carried out. Assume, for example, that you have a simple crane in which the hook cord winding drum is provided by a Rod coupled direct to the output shaft of a Motor. This is direct drive as also are the manual winding operations in the Mobile Crane featured on page 498 of this issue. Here, the power source is the operator, the final output shaft being the Crank Handle or jib control Rod, as the case may be. The drive is therefore direct from the operator to the Rod or Handle.

Belt drive

If direct drive is limited in use, however, perhaps the most frequently used drive method—particularly in smaller models—is the belt system. This, one of the oldest forms of drive transmission, is where a Pulley on the output shaft of the power source is connected to another Pulley on a second shaft by an "endless" belt, usually represented in Meccano models by a rubber Driving Band or a length of Cord with its ends joined. Immediately a minimum of two Pulleys have been introduced into the system it becomes possible to vary its final output power and speed by using Pulleys of different diameters. Imagine for instance, that the power source is a Meccano Motor and a ½ in. Pulley, Part No. 23a, on its output shaft is connected to, a 2 in. Pulley, No. 20a, on the final shaft of the system. The circumference of the 2 in. Pulley is four times greater than the circumference of the ½ in. Pulley, therefore the ½ in. Pulley will need to revolve four times in order to turn the 2 in. Pulley through one revolution. This results in a step-down reduction ratio of 4 : 1 between the Motor output shaft and the final drive shaft. If, on the other hand, the positions of the Pulleys were reversed, then the resulting effect would be a step-up ratio of 1 : 4 causing the final drive shaft to revolve four times faster than the output shaft of the Motor. A step-up ratio is fairly unusual in Meccano model-building, however, for reasons we shall study more closely when we look at gear drives.

Chain drive

While a belt drive is suitable for small or at least uncomplicated models, it has the disadvantage of possible "slip" between the belt and the Pulleys. Consequently it cannot be fully relied on to give a positive and accurate drive when the ratio to be produced is of critical importance—and this is where chain drive is invaluable. Meccano Sprocket Wheels and Chain serve the same purpose as the Pulley and belt system with the one important difference that, if mounted correctly, there is no slip between the Chain and the Sprockets. It therefore follows that the Sprocket on one Rod can be used to drive the Sprocket on another Rod at a definite rate.

Included in the Meccano system are five Sprocket Wheels, numbered 95, 95a, 95b, 96 and 96a, all of different diameters and all with a different quantity of teeth ranging from 56 down to 14. By using a combination of Sprocket sizes suitable step-up or step-down ratios can be obtained, the particular ratio being determined by the number of teeth on the Sprockets. For example, Part No. 96, with 18 teeth, connected to Part No. 95, with 36 teeth, would give a ratio of 2 : 1.

Turning to the Sprocket Chain, itself, this is numbered 94 and is supplied in 40 in. lengths with six links to the inch. When the required length for a particular job has been measured off, it can be easily separated by gently prising open the ends of one of the links with the blade of a screwdriver until the adjacent link can be slipped out. After rejoining, the ends of the opened link are carefully bent back again, care being taken to ensure that they do not grip the next link too tightly. The Chain should be passed around the Sprockets with the turned-over ends of the links facing outwards away from the Sprockets, as this will result in smoother running. Note that, in place, the chain must not be completely taut, but should have a very small amount of "play" in it to keep friction to a minimum.

Gear drive

We come now to gearing which is by far the most interesting and accurate method of transmitting drive in Meccano. First, however, let us take a look at the basic types of gears in general use today, of which there are five—spur, contrate, bevel, helical and worm. Of these, perhaps the most common are spur gears, used to transmit drive from one shaft to another running parallel to it. The Meccano range of spur gears includes Pinions numbered 25, 25a, 25b, 26, 26a, 26b, and 26c, plus Gear Wheels 27, 27a, 27b, 27c, 27d and 31. Remember though, that as far as working-out ratios is concerned, Pinions 25, 25a and 25b can really only be counted as one gear, all having a similar diameter and number of teeth. In fact, the only difference between them is their width or "face", the same thing applying to Pinions 26, 26a and 26b.

Bevel gears (represented in Meccano by Parts 30, 30a and 30c), contrate gears (represented by Parts 28 and 29), helical gears (Parts 211a and 211b) and worm gears (Part 32) all serve a similar purpose in that they are used to drive shafts positioned at right-angles to each other. Here the similarity ends, however. A Contrate is usually meshed with a Pinion, whereas Bevel Gears, like Helical Gears, can only be used together. Alternatively, a Contrate will mesh with a Pinion and a pair of Bevels with each other only when the Rods on which they are mounted are at right-angles to each other in the same plane. Helical Gears, on the other hand, will only mesh when the supporting Rods pass one at right-angles to the other in a different plane, this also applying to the Worm which will mesh both with Pinions and Gear Wheels.

Differences aside, it is gearing which really makes it possible to accurately increase or decrease the final output speed of a mechanism. If, say, a ½ in. Pinion with 19 teeth on one shaft is meshed with a 57-teeth Gear on a second shaft, a 3 : 1 reduction ratio will result, the second shaft revolving at one-third the speed of the first shaft. If the positions of the gears are reversed a step-up ratio of 1 : 3 results causing the second shaft to revolve three times as fast as the first shaft. As with Sprocket and Chain drive the ratio of any two meshing spur, bevel, contrate or helical gears is discovered by dividing the number of teeth on the smaller gear into the number of teeth on the larger.

If, in the above example, the speed reduction was insufficient for the job on hand, a second stage could be added. Suppose, in addition to the Gear, another ½ in. Pinion was mounted on the second shaft and meshed with a second 57-teeth Gear on a third Rod. A further 3 : 1 reduction would result between the second and third shafts therefore the overall reduction between the first and third shafts would be 9 : 1, a figure obtained by multiplying the two 3 : 1 ratios together. If a similar third stage were added, the overall ratio would be 27 : 1, thus: $3 \times 3 \times 3 = 27$. This type of arrangement employing more than a single stage (two gears) is known as a compound gear train.

So far we have been looking at gears in relation to speed but it is a matter of mechanical fact that a gear train also has a direct effect on power, the increase or decrease in power being inversely proportional to the increase or decrease in speed. To give an example, if a 3 : 1 reduction-ratio gear train, such as our first example above, was coupled to a Motor, the speed of the second shaft would be one-third that of the Motor

At right, top. An example of chain drive using Meccano Sprocket Wheels 95 (36 teeth) and 96 (18 teeth) connected by Sprocket Chain 94. A ratio of 2 : 1 results. Next, an example of a 3-stage compound gear train which gives the enormous reduction ratio of 2793 : 1 between the input shaft A and the output shaft B. The input shaft must revolve 2,793 times to turn the output shaft once, but the power at the output shaft is 2,793 times greater than at the input shaft.

output shaft, but the power output of the second shaft would be three times greater than the Motor shaft. In mechanical terms, for a reduction ratio of 3 : 1, the power ratio is 1 : 3 and this direct reversal always applies, no matter what the ratio.

By the same token, of course, if a step-up ratio of 1 : 3 is coupled to a Motor, the power ratio will be 3 : 1, meaning that the power output of the second shaft will be one-third that of the Motor shaft. For this reason, step-up ratios are rarely used in Meccano model-building, where the object of gearing is almost always to obtain increased power by "stepping-down." In many cases, in fact, the amount of reduction required is so great that, if ordinary Pinions and Gears were used, a multi-stage gearbox would be necessary—and this is where the Meccano Worm Gear comes in handy! This has a rating of 1, therefore, when it is meshed with a Gear, you immediately have a reduction ratio as high as the number of teeth on the Gear. If meshed with the popular 57-teeth Gear, for instance, the resulting ratio is 57 : 1 and with this sort of figure to start with you can soon increase the ratio enormously in very few stages.

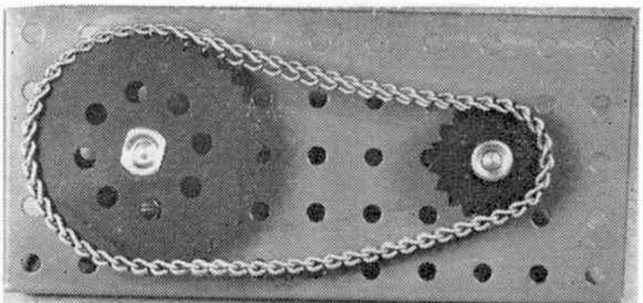
Let us take an imaginary case starting with 57 : 1 and including only two more additional stages using a ½ in. × 19-teeth Pinion meshing with a 3½ in. × 133-teeth Gear Wheel in each case. The ratio between each Pinion and Gear is 133 divided by 19 giving 7 : 1. To find the combined ratio of the three stages we multiply the three separate ratios together, thus: $57 \times 7 \times 7$. The final ratio, therefore is a staggering 2793 : 1! If you coupled the gear train to a Motor, the final shaft would turn very slowly, but just imagine the tremendous power it would have!

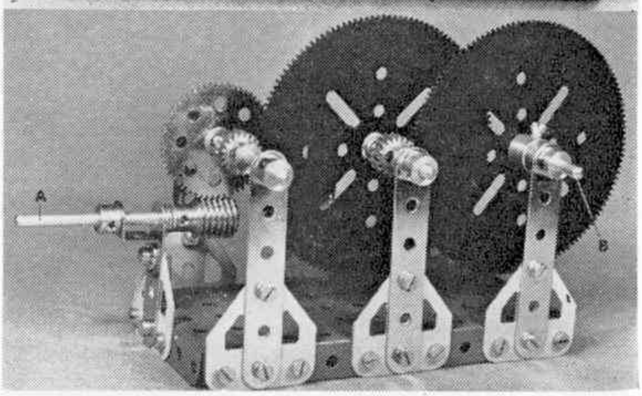
A few words now on things to look out for when fitting gearing to Meccano models. The most frequently used items in the range are the standard Pinions, numbered 25 to 26c, and the standard Gear Wheels, 27 to 27d. These of course have different diameters whereas

MECCANO GEARS AND SPROCKETS

Part No.	Description
25	3/4" diam. Pinion, 1/4" face, 25 teeth
25a	3/4" ,, ,, 1/2" ,, 25 ,,
25b	3/4" ,, ,, 3/4" ,, 25 ,,
26	1/2" ,, ,, 1/4" ,, 19 ,,
26a	1/2" ,, ,, 1/2" ,, 19 ,,
26b	1/2" ,, ,, 3/4" ,, 19 ,,
26c	7/16" ,, ,, 1/4" ,, 15 ,,
27	1 1/4" diam. Gear Wheel, 50 teeth
27a	1 1/2" ,, ,, ,, 57 ,,
27b	3 1/2" ,, ,, ,, 133 ,,
27c	2 1/2" ,, ,, ,, 95 ,,
27d	1 9/16" ,, ,, ,, 60 ,,
28	1 1/2" diam. Contrate Wheel, 50 teeth
29	3/4" ,, ,, ,, 25 ,,
30	7/8" diam. Bevel Gear, 26 teeth
30a	1/2" ,, ,, ,, 16 ,,
30c	1 1/2" ,, ,, ,, 48 ,,
31	1" ,, Gear Wheel, 1/4" face, 38 teeth
32	1/2" diam. Worm Gear
95	2" diam. Sprocket, Wheel, 36 teeth
95a	1 1/2" ,, ,, ,, 28 ,,
95b	3" ,, ,, ,, 56 ,,
96	1" ,, ,, ,, 18 ,,
96a	3/4" ,, ,, ,, 14 ,,
211a	1/2" ,, Helical Gear
211b	1 1/2" ,, ,, ,,

The Gears, Pinions and Sprocket Wheels contained in the Meccano system excluding No. 32 Worm Gear. See the list above for descriptions of the parts.





the holes in Meccano Strips and Plates, etc., are spaced regularly every half-inch. Consequently some parts when mounted in line will not mesh with others. The rule, therefore, is that *Pinions and Gears will only mesh if the combined diameters of any two Parts add up to the round inch or half-inch.* For example, a ¾ in. Pinion will mesh with a 1¼ in. Gear because their combined diameters add up to a round 2 in., but the same Pinion will not mesh with a 1½ in. Gear because the sum of their diameters is 2¼ in. In the same way, a ½ in. Pinion 26 will engage with a 2½ in. Gear 27c, but not with a 1¼ in. Gear 27. Note that the 7/16th in. Pinion No. 26c will mesh only with the 60-teeth Gear No. 27d, and vice versa.

Finally, all Meccano gears, excluding the Worm, are reversible meaning that they can be used either as the driving or the driven gear. The Worm, however, cannot be driven by another gear and therefore *must always be used as the driver in any gear mechanism.*