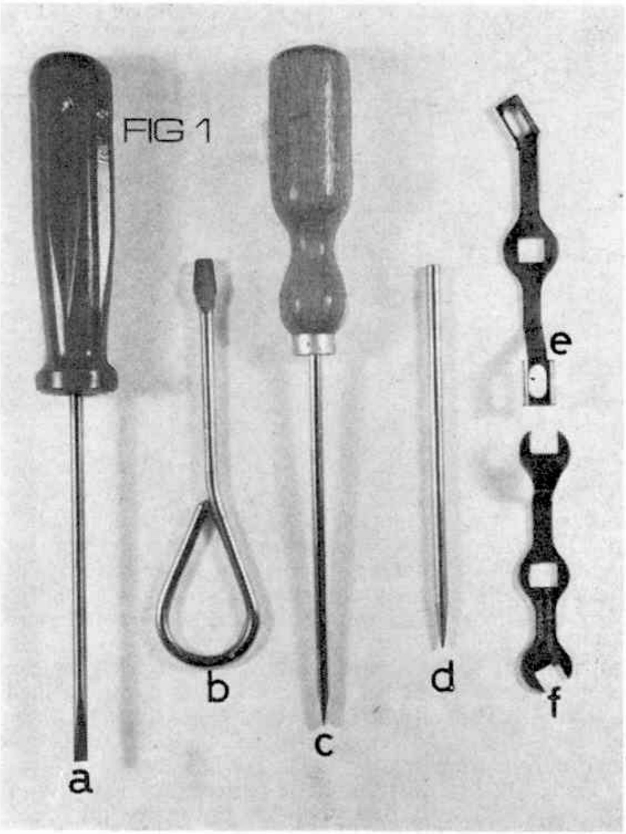
Meccano Constructors Guide

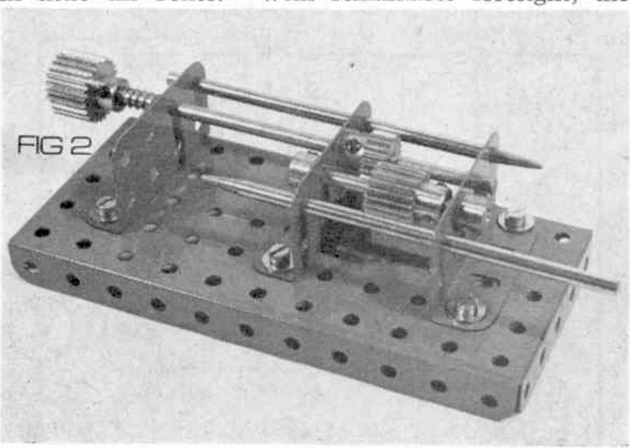
A new series dealing with gadgets and mechanisms that will be useful to Meccano modellers



By B. N. Love

Part 1—Basic Construction

THERE IS no doubt that Meccano Parts make up the most versatile and comprehensive construction system in the world and one which has maintained its lead in a competitive field ever since its inception by Frank Hornby in 1901, when he marketed his first comparatively crude " Mechanics Made Easy " outfits in little tin boxes. With remarkable foresight, the creator of Meccano adopted a standardisation of parts and perforations on which the system has developed over a period of three generations. The greatest appeal in using Meccano stems from the fact that no special tools are required to construct even the most complex and advanced models, the basic items being a screwdriver and a spanner. However, even in the use of simple tools, there is a right and a wrong way of employing them and this opening article of what will be a twelve-part series, gives some hints and guidance for the benefit of all who enjoy this wonderful hobby the world over.



Nuts and Bolts, Part Nos'. 37a and 37b respectively, are the basic fasteners for the whole system and these are manufactured literally by the million in the high speed ultra-modern machines in the Meccano factory at Liverpool and they follow a standard Whitworth pattern of 5/32 in. diameter. They are well made and very strong and, provided that they are not abused, they will continue to serve the constructor, model

Fig. 1 shows the basic Meccano model-building tools: a. is the Super Tool Set Screwdriver; b. is the standard Screwdriver; c. is the long, wooden-handled Screwdriver; d. is the Drift; e is the Box Spanner; f. is the standard Spanner. Fig. 2 shows the Drift at work—aligning holes.

after model for a lifetime. Two simple rules will help both in the long life of the Bolts and the correct construction by making sure that there is always a clean entry for the Bolt in the holes of the Meccano Parts which are being secured together and that the Bolt rotates freely as it is tightened. Any tendency for the Bolt to jam or the Nut to stick on the thread should immediately be checked for cross threading arising from careless application of the Nut. Make sure that the Screwdriver blade has a clean square end which is a snug fit into the slot of the Bolt and never sharpen the blade to a cutting edge. This is very dangerous to the person and wreaks havoc with the carefully machined slots in the boltheads.

One of the most useful additional tools for the Meccano constructor is the Drift which is shown with the other basic tools in Fig. 1. This is Part No. 36c and is manufactured to have a full tolerance on its diameter but is shaped to a blunt point at one end which allows the builder to insert the Drift into an assembly of Strips or Plates to align all of the holes prior to bolting up the pieces to make sure that Axle Rods or further Bolts may be inserted cleanly. Fig. 2 shows some of the applications of the Drift and if this is fitted with a Spring Clip or a Collar, the Drift will remain in place when the model is turned to one side and is almost as good as having a third hand.

FIG 3

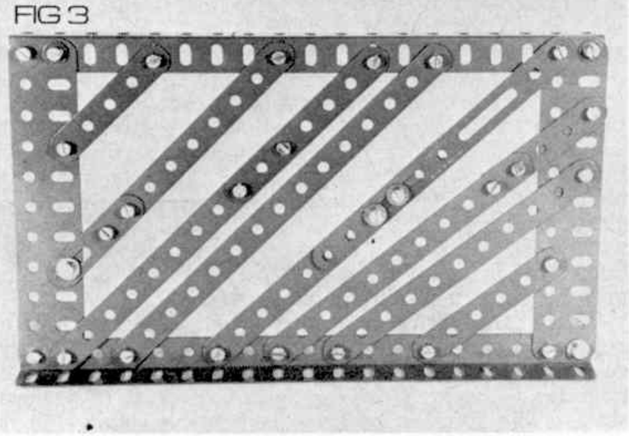


Fig. 3. A demonstration assembly showing how elongated holes in Slotted Strips and other parts enable diagonally-mounted Strips to span inexact distances between anchoring points.

In the simpler models, journals for Axle Rods are quite commonly formed by the holes in Perforated Strips or Plates and two points of support are adequate in such cases. However, where an Axle Rod has to pass through three or more holes in a line, such as often happens in the case of gearboxes, etc., the Drift is invaluable for making sure that all holes are properly aligned. Again, where greater precision or long running operation is required, journals may be provided by Double Arm Cranks, Part No. 62b, or by Bush Wheels, Part No. 24 or 24a, bolted to the Plates or Strips forming the side members of the mechanism. Because Bush Wheels have a peened over lip where the boss is joined, they may be stood off from their respective mountings by inserting a packing Washer on the securing Bolts, as shown in Fig. 5, and then correctly aligned with the Drift which should pass quite cleanly and without binding through both bosses forming a pair of journals.

Meccano Washers themselves, Part No. 38, are a most useful if not essential part of the serious constructor's kit as they serve several uses. They may be employed as packing in many applications; they may be placed under the head of a Bolt to protect the enamelled surfaces of Meccano Plates, etc., and to give extra grip from the Bolt in mechanisms subject to vibration. Their most common use, however, is that of providing a smooth running bearing face between the boss of a Gear or Wheel etc., and the journal carrying the Axle Rod. Lubrication of all journals with a tiny spot of light machine oil will assist the smooth running of any model but, if overdone, the process becomes messy and can attract enough dust or fluff to defeat its own object.

If a model is chosen from one of the Meccano construction manuals, the parts list should be checked against available parts and these should be set aside where they are handy and ready for immediate use so that handling or raking over the parts is reduced to a minimum. Bolts and Nuts may be screwed up finger-tight for the early stages of construction until the builder is satisfied that his model is 'coming up

FIG 4

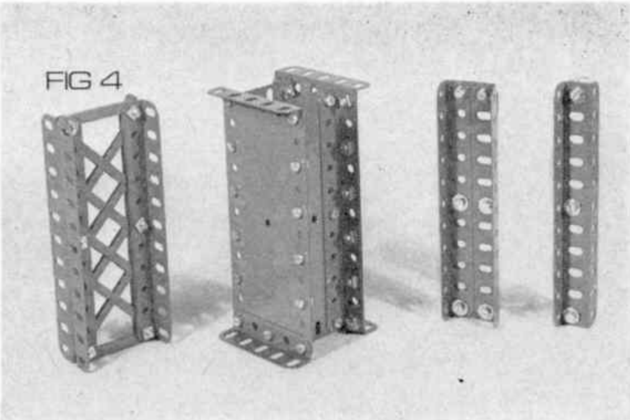
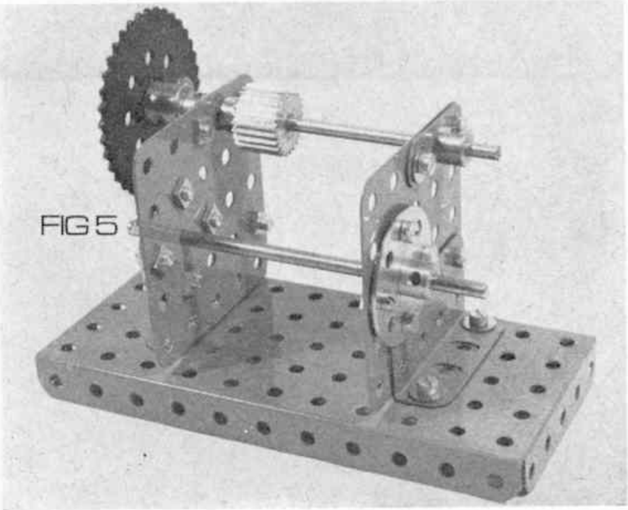


Fig. 4. Some of the many different types of composite girders that can be built up using basic Meccano parts. Just about every type of girder in existence can be reproduced in this way.

Fig. 5. While the simplest bearings for Meccano Rods are supplied by the holes in Strips and Plates, etc., a stronger, more efficient bearing is supplied by the boss of a suitable part bolted to the Strip or Plate. This picture shows a Double Arm Crank and a Bush Wheel being used in this way.

FIG 5



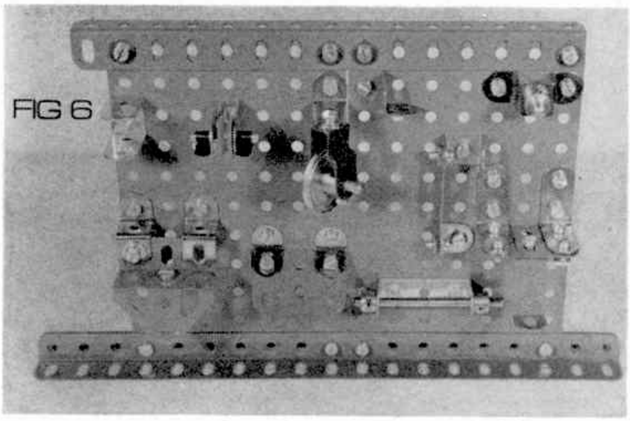


Fig. 6. Some of the many brackets included in the Meccano system with a few examples of the innumerable uses to which they are put.

square '. At this stage, the Nuts should be held quite firmly with the Spanner and the Bolts screwed home firmly with the Screwdriver. Should a really tight grip be required, necessitating a final turn of the Spanner, a Washer should be placed under the Nut to prevent its edges from scoring a circle in the enamel on the Meccano Parts. This enamel is hard wearing but will not stand up to abuses of this kind. On the other hand, a little care in handling and storing the parts can be rewarded with a lifetime of service from your Meccano Outfit.

Every Meccano Manual carries an illustrated list of Meccano Parts, many of which have specialised applications and some of these will be dealt with in a later chapter. Basically, the correct use of Strips, Angle Girders, Plates, Wheels and Axle Rods are most important. Strips are intended principally to act as bracing units or tie rods where they are primarily in tension, i.e. being stretched, but the shorter varieties will carry considerable loads, especially when several thicknesses are combined by means of Nuts and Bolts. Some of the uses of Strips are shown in Fig. 3.

It is a well known engineering principle that the strength of structures relies in many cases on triangulation, it being a fact that a triangle is not readily pushed out of shape, and the range of Perforated Strips is ideal for this purpose. There are occasions, however, particularly where a right-angled structure is required, when the Perforated Strip selected will just not reach across the necessary diagonal and when, in addition, the simple process of bolting on an extra length of Strip is equally unsuccessful. There are two methods available to the constructor to overcome this difficulty. A large range of Meccano Parts, such as Angle Girders, Flat Girders and Flexible Plates, are provided with elongated holes which give considerable latitude in adjusting diagonal constructions, but where this does still not give sufficient scope, special parts known as Slotted Strips, may be used as shown in Fig. 3. Slotted Strips are made in two lengths, Part No. 55, 5½ in. long, and Part No. 55a, 2 in. long, and the slots in these special Strips are also put to good use in models where a sliding Axle Rod mechanism is employed.

Angle Girders combine some of the uses of the Perforated Strip with a part which will stand both compression and tension and this makes any Girder an ideal element in a framework where great strength is required. Laid flat, any strip metal will bend or sag but turned up like a knife edge, it then becomes very rigid in a vertical direction. A Girder always presents at least one of its sections in opposition to its load and will therefore stand up not only to compression and tension but also to bending forces as well. A simple framework of Meccano Angle Girders can be assembled quite quickly to take the weight of a man without showing any signs of stress or damage, although it is not really recommended that the beginner with a small outfit attempts such a venture at the outset! Fig. 4 shows how various forms of girders may be constructed from basic parts.

There are many occasions when the attachment points for various parts of a structure are not directly accessible and for this reason, the Meccano system includes a comprehensive range of brackets in various sizes. The simplest of these is Part No. 12 which is the ½ × ½ in. Angle Bracket having two holes, one of which is slotted so that a useful range of adjustment is available. A simple development of this part is the Double Bracket, Part No. 11 and this is really extended throughout the entire range of the Double Angle Strips which run from 1½ in. up to 5½ in. with fixing lugs of various lengths, also, in some cases. Fig. 6 shows a number of Meccano Brackets and some of the applications for which they are designed. In each case they simulate standard engineering practice, but whereas a welding or riveting process is frequently used in steel structures, the Meccano constructor must rely upon the Nuts and Bolts. It is therefore very important that they are all very securely tightened in any model which is subject to motion or vibration or substantial weight and, again, the use of Washers for extra grip under Boltheads is very strongly recommended. Meccano brackets perform two principle functions, one being to connect Plates, Strips, etc., at various angles and the other to provide simple bearings or journals for Axle Rods. Some of the brackets have

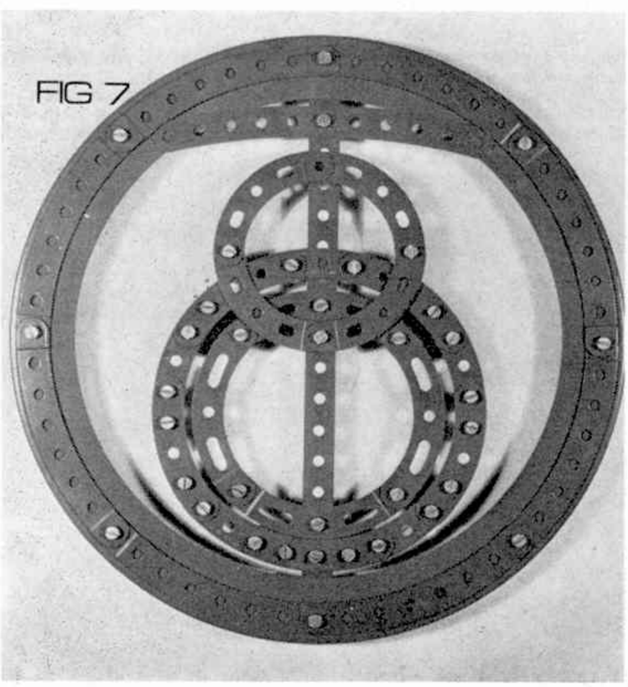
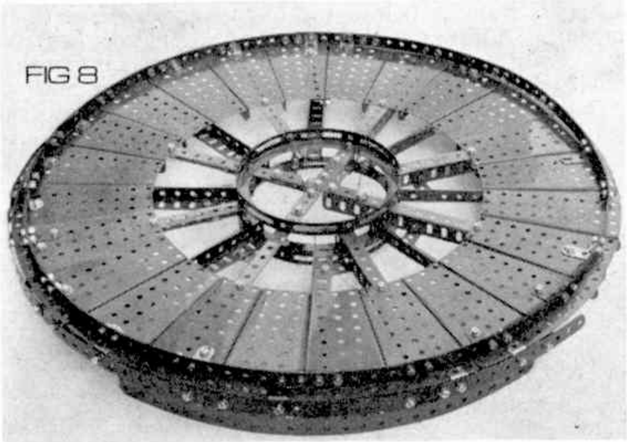


Fig. 7. When bolted together, the various Meccano Curved Strips will make up complete rings of different diameters, as this picture clearly shows. The rings are seen here attached to a 9¾ in. Flanged Ring to give an idea of size.

elongated holes and they provide for adjustments previously mentioned.

A development of the Perforated Strip is the Curved Strip and there are no less than five different Curved Strips in the Meccano system, ranging from 2½ in. to 5½ in. length and having curvatures varying in radius from 1⅜ in. to 10 in. Three of these are 'stepped' curves which means that the end of each strip is cranked slightly to allow the adjacent strip to bed into it without changing the overall level of a completed circle. Fig. 7 shows the range of Curved Strips arranged as complete circles with the exception of the 10 in. radius Strip which is shown as a separate item at the top of the display. The decorative value of the Curved Strip is evident from the illustration but they may be used structurally of course to form flywheels and formers for cylinders. Part No. 90, the 2½ in. Curved Strip is of interest to clockmakers as it forms a circle having 30 holes and makes a wheel for a 30-peg escapement in conjunction with a pendulum of royal length. The slotted holes in two of the Curved Strips, 89a and 90a add to the versatility of their use. All radii are measured from hole centres.

Fig. 8. The one non-rectangular flanged plate in the Meccano range is the Flanged Sector Plate, Part No. 54. Designed as a small sector of a large circle, twenty-four Plates are required to make up the complete circle.



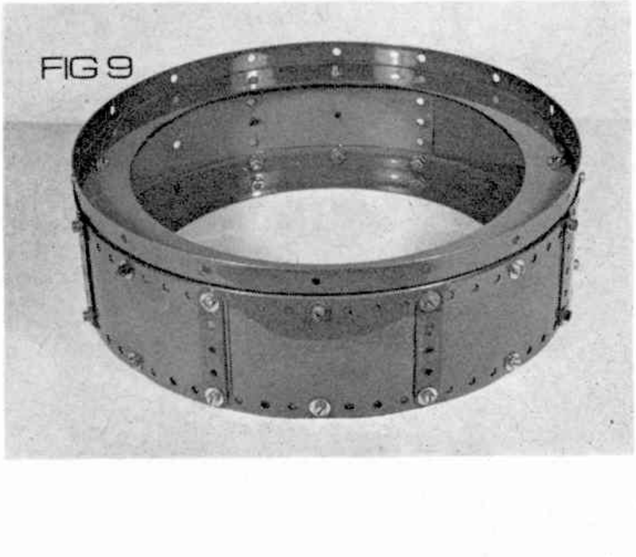
While Strips and Girders form the 'skeleton' of general Meccano structures, Flat Plates and Flanged Plates complement the construction by serving as bases and supplying extra rigidity and large perforated areas for the purposes of providing journals for mechanisms, anchoring points for brackets and Girders and standard spacing for gear meshing, etc. Examples are illustrated in Figs. 2, 5 and 6.

Flanged Plates are produced with flanges to give the same sort of edge rigidity as is found in Angle Girders. They are made in a similar gauge of steel to that used for Perforated Strips up to 5½ in. in length and provide adequate strength for virtually all requirements. Flat Plates are made in a thicker gauge to give them rigidity in a flat plane and they range in size from 1½ in. square up to 5½ × 3½ in. In each case they are fully perforated at standard half inch spacing. Although the majority of the Plates mentioned are of rectangular form, the Sector Plate, Part No. 54 is an exception since it was originally designed to form a sector of quite a large circular platform. This is illustrated in Fig. 8 which shows a complete circle of Sector Plates forming the base for a Giant Dragline. It is interesting to note that this circle is 20 in. in diameter and the outer curved edge formed by the Sector Plates is the same as that formed by the largest Curved Strip which is of 10 in. radius.

The versatility of the Meccano system was considerably extended some 36 years ago when Flexible Plates were introduced—originally in cardboard and fibre, but these being quickly superceded by thin-gauge flexible steel plates which have remained in the system ever since. They are available with a width of 2½ in. and with lengths varying from 1½ in. to 12½ in. Their general applications for filling in large areas on the surface of models and for providing curved surfaces are well known to the Meccano constructor, but their application extends beyond this. They may, for example, be used as very strong webs for large girders (see Fig. 4) by employing several thicknesses of Flexible Plates and, as they are all made with elongated holes at their ends, they allow a considerable amount of latitude in adjustment. They will also make up into cylinders, over a very wide range of diameters and a further advantage in using Flexible Plates is that, when they are formed into cylinders, they possess very rigid properties in the line of the axis of the cylinder. That is to say, if a cylinder is made from Flexible Plates bolted to the flanges of a pair of Circular Girders (Part No. 143), it forms a very strong drum which will form a very stable base for constructions of towers, etc. capable of supporting considerable loads. This follows the well-known mechanical property of sheet metal bent to circular or corrugated forms, Fig. 9 illustrating the use of Flexible Plates for this purpose.

Triangulation has already been mentioned in connection with mechanical rigidity and this is catered for in the Meccano system by a range of Triangular Plates as well as formations of Perforated Strips. These Plates fall into two categories, i.e. rigid and flexible, and the largest in the first category is Part No. 76, 2½ in. Triangular Plate. This is very useful as a journal plate or centre plate and its slotted holes permit meshing of gears in non-standard spacing. Part No. 77 is the 1 in. Triangular Plate which is useful for supplying a mid-point anchorage or journal at half standard spacing because of its equilateral form. Other triangular forms of rigid parts are found in the Trunnions, Part Nos, 126 and 126a, Corner Brackets, Part Nos. 133 and 133a.

Fig. 9. The main use of Meccano Flexible Plates is to fill in large open areas of a model, but they can also be used in the construction of special drums which, when completed, will take tremendous weights. One such drum is shown in this picture.



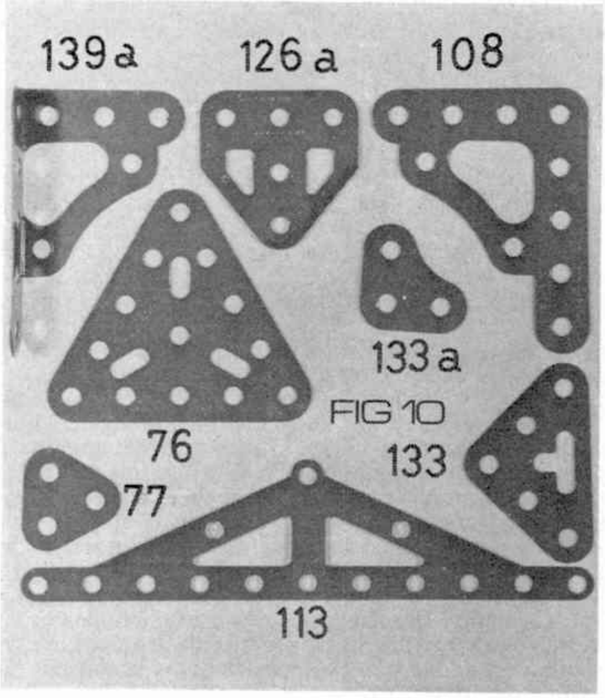
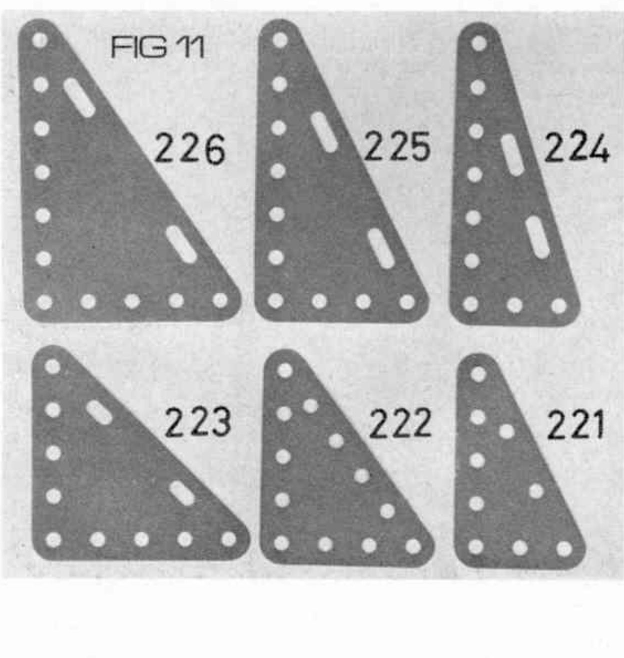


Fig. 10 and Fig. 11 show examples of the many types of triangular-shaped parts contained in the Meccano system. Because of their shape, triangular parts will withstand a great deal of pressure.

Corner Gusset, Part No. 108, Flanged Brackets, Part Nos. 139 and 139a and the Girder Frame, Part No. 113. The above are illustrated in Fig. 10.

As a complement to the Flexible Plates, a series of Triangular Flexible Plates was introduced into the system in the 1950's which extended the versatility of the system still further. Used in single layers, the Triangular Flexible Plates are principally used for filling appropriate shapes as a surface covering but if several thicknesses are bolted together and used in conjunction with Angle Girders they provide extremely strong corner structures. Again, by overlapping a pair of Triangular Plates, after reversing one of them, a rectangular plate is formed and as there are six different sizes available, an extension of the range of rectangular Flexible Plates is immediately available.



Some of the Triangular Flexible Plates have slots to facilitate adjustments and these are illustrated in Fig. 11.

Actually, a type of Flexible Plate was in use in the Meccano system almost sixty years ago and is still with us to-day. This is the Braced Girder which has featured extensively in Meccano models and structures since their first appearances in the early Manuals of Instructions and the Meccano Magazine. It has both structural and decorative properties and is shown in Fig. 4 as the bracing web of a deep ' H ' girder, where several Braced Girders (reversed to give the ' crossover ' appearance) are used.

A Meccano illustrated price list shows Part Nos. listed up to 234f but so many parts of a similar type are listed as a,b,c,d,e, etc., that there are well over 250 parts in the system. The objects of this first part of the series for Meccano Constructors has been to review the basic parts with which the builder should acquaint himself before tackling the more ambitious models. A fuller development of the system will be dealt with in these pages over the next 11 months, during which time a number of topics will be covered in subsequent articles. Part II next month will deal extensively with gearing and transmission in general and will be fully illustrated, as will be the rest of the articles throughout the series.

New Book for Dinky Toy Collectors

Price 5/-

All serious Dinky Toy collectors, worthy of the name, will have heard of the book " History of British Dinky Toys 1934-64 " by Cecil Gibson. The book is invaluable to collectors, and is limited only in that it deals exclusively with what can be described as " ground vehicles "—cars, lorries, buses, etc. This is perfectly understandable considering the number of models which fall under the heading, but it does mean that the growing band of die-cast aircraft collectors as well as the old waterline ship series collectors do not have anything like the same detailed information to draw on as the vehicle collectors. I should say, " did not ", because the aircraft men are now well and truly catered for with the publication of a 16-page foolscap-size, stereotyped booklet entitled " The Dimmock-Jackson Checklist of Dinky Toys Aircraft ".

Produced by Alan Dimmock and Leslie Jackson, this booklet contains a wealth of information on every known Dinky aircraft save the two latest examples which were released after the booklet had been finished. It identifies each model, gives its year of introduction and a concise description of its salient features. A great deal of effort must have gone into the preparation of the booklet which is being made available at its cost price of 5/-. It is produced purely as a service to collectors and is entirely non-profit-making: hence the low price. It can be obtained from either Mr. A Dimmock, 2 Wynter Road, Southampton, SO2 5NY or Mr. L. Jackson, 369 Lower Broughton Road, Salford 7, Lancs M7 9HR, and it's well worth the price.

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Part 2 – Pulleys, sprockets and gears

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.

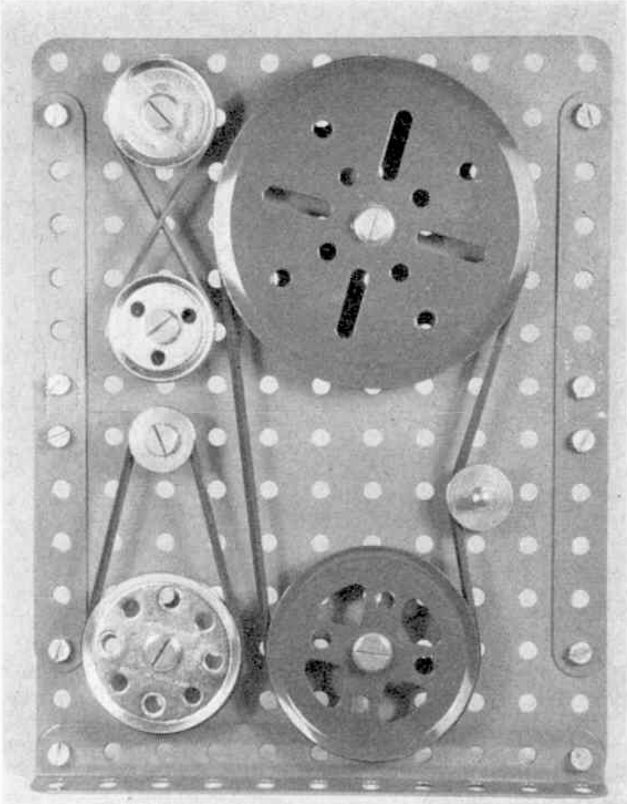


FIG 1

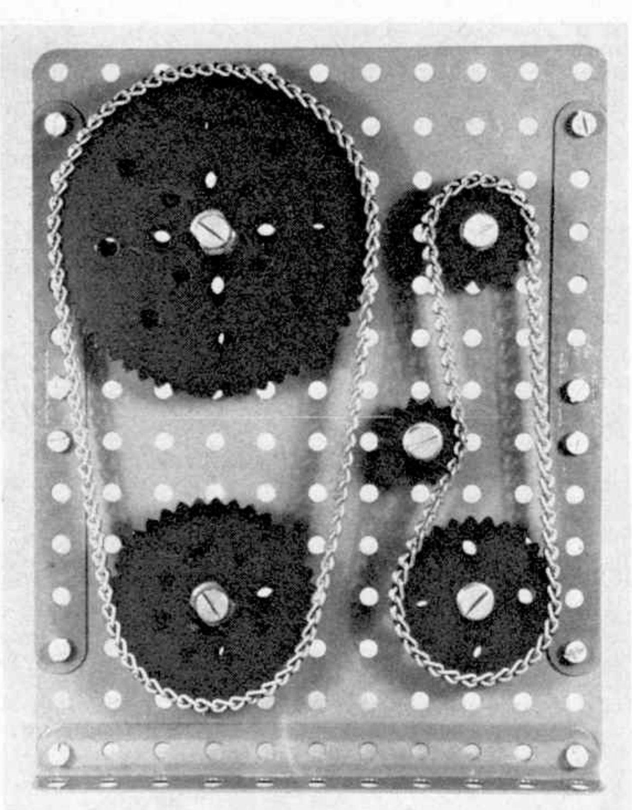


FIG 3

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.

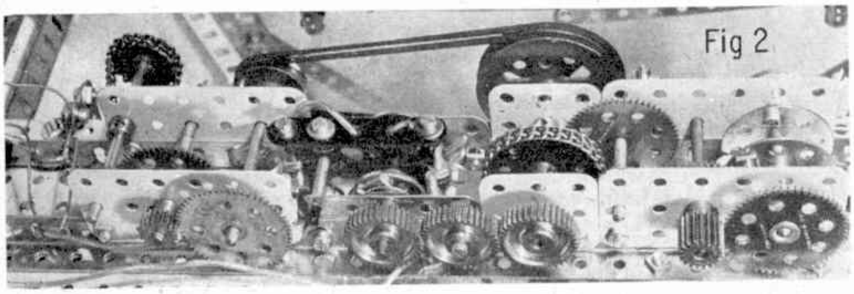
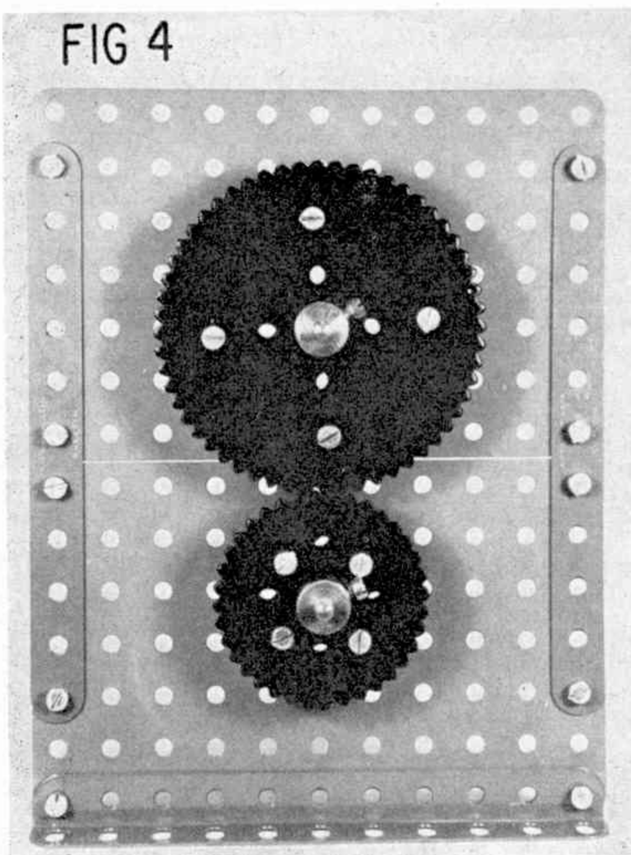
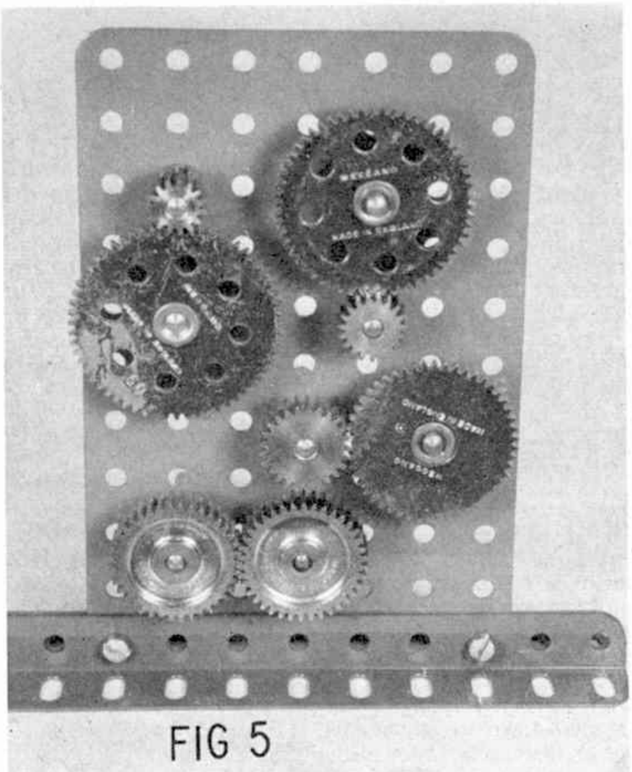


Fig. 2. Pulleys, sprockets and gear wheels in combination to operate an accurate programming mechanism. **Fig. 4.** Meccano Sprocket Wheels paired-up to give direct meshing as heavy duty spur gears. **Fig. 5.** Range of pinions and gear wheels giving four different ratios ranging from 1 : 1 to 4 : 1.

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 1½ 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.

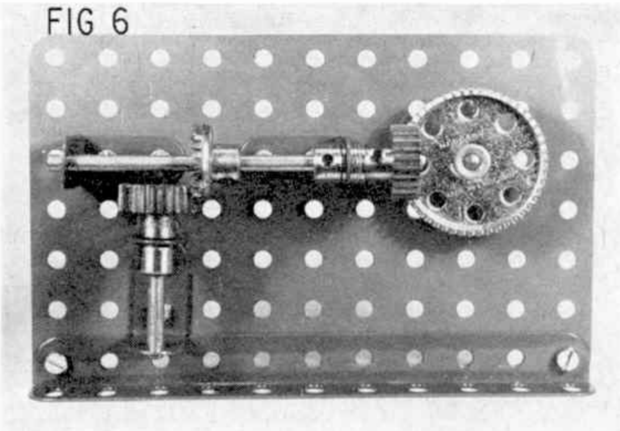
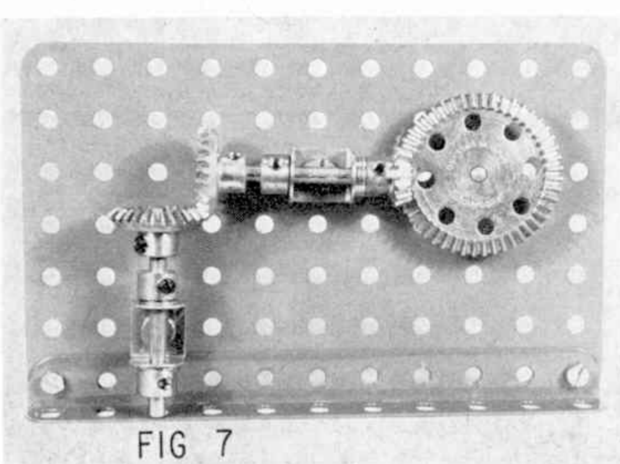


Fig. 5 shows a few simple arrangements of Gears with standard spacing in ratios suitable for general model building. These are calculated in each case by noting the *numbers of teeth* (not diameters) and making a fraction from the two numbers obtained from any meshing pair. If the arrangement is used 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.

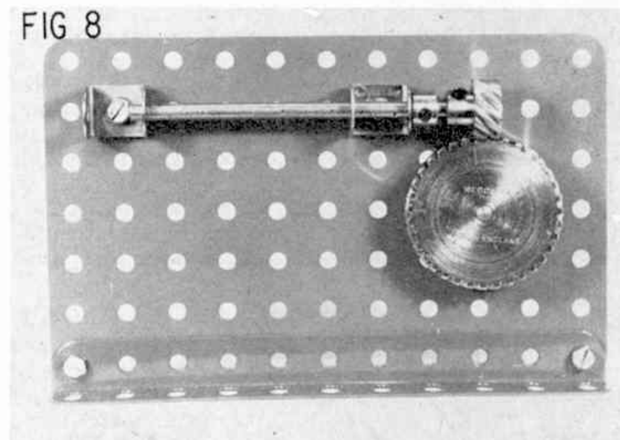
As the Constructor advances in his model building techniques, gear ratios will become more important and if an accurate timing device is required in a particular mechanism, a sound knowledge of the required ratios is essential. It is a common error among novice builders using gear drives for the first 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.



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 illu-



strated 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.

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 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.

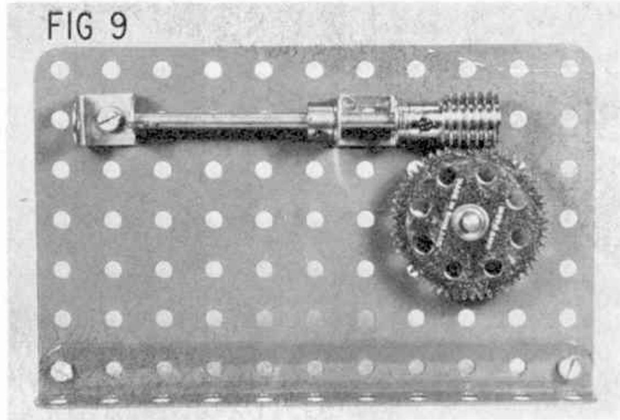


Fig. 9. A Worm drive, considered to be the final development of a helical drive.

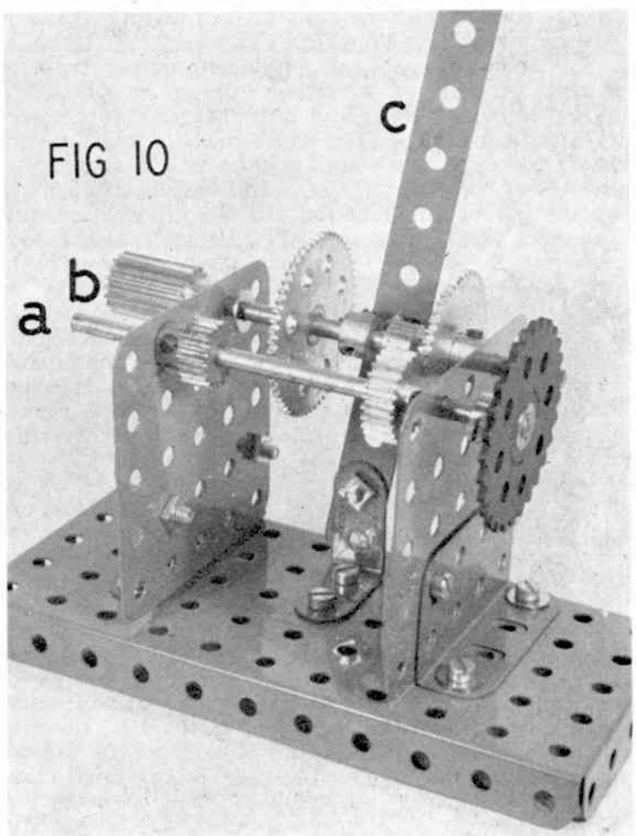


Fig. 10. A simple form of two-speed change-over gearbox. The input shaft (a) receives the drive via its Sprocket Wheel which is then passed on to either of the two Gear Wheels on the output shaft (b) by means of the gear shift lever (c) which is pivotted by a lock-nutted Bolt to the 1 × 1 in. Angle Bracket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