MECCANO CONSTRUCTORS GUIDE

by B. N. Love **Part 12**

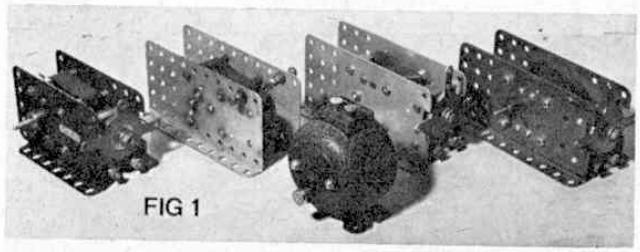
ELECTRICAL CIRCUITS FOR MOTORS AND LIGHTS

SO MANY TYPES of electric motor have been available to the Meccano enthusiast over the years that he may well be confused at times as to what is required in the way of power supplies and, as the number of transformers and controllers is equally profuse, a short explanation of general requirements may help to clarify the matter. Essentially, two types of Meccano motor are available to the constructor, one being known as a " universal " type and the other as a D.C. type. For a period of some 40 years or more, Meccano Ltd. produced the first type in large quantities and in several patterns, a selection of which are shown in Fig. 1. These are all known as ' side plate ' motors with the exception of the spherical enclosed motor which is affectionately known as a ' cricket ball " type.

All these motors are of the " Universal " type, which means that they may be very conveniently run, *via a suitable transformer*, from Alternating Current (A.C.) as supplied to houses in most parts of the world, or from Direct Current (D.C.) as supplied by a battery or transformer/rectifier.

Alternating Current is constantly changing direction 50 times per second in most European countries and 60 times per second in the U.S.A. Since an A.C. motor consists basically of an electro-magnetic armature driven by repulsion and attraction from an electro-magnetic set of field coils, the change of direction of current, being the same at any instant of time for both the armature and the field coils, means that the magnetic relationship between the two parts of the motor is constant, in terms of direction of rotation. D.C. motors for model driving, on the other hand, commonly have permanent magnet yokes acting in place of field coils, which means that the field of such a motor is not reversible. If such a motor had an armature supplied with alternating current it would try to start and reverse 50 times per second which would result in a complete cancellation of rotation—not to mention a probable burned-out armature! The D.C. motor has several advantages however, since it is only necessary to supply current to the armature.

With modern development of nickel alloy permanent magnets, motor fields can be very dense and very compact with long life characteristics—a failing in early D.C. motors for model driving. Hence, a battery, fitted with a switch which will change over the feed wire contacts will operate a D.C. motor in either direction and has the great advantage of portability making the model independent of trailing power supply leads.



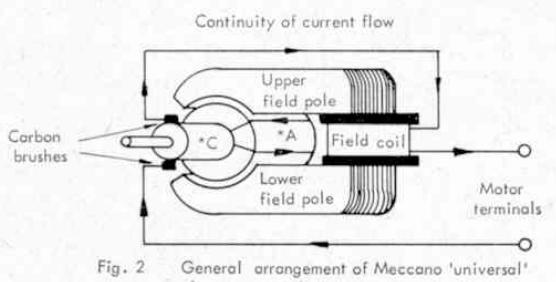


Fig. 2 General arrangement of Meccano 'universal' electric motor showing 'series' wound arrangement for Field coil and armature. *C - commutator *A - armature

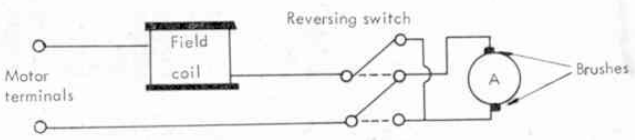


Fig. 2 b. Reverse switching arrangement common to Meccano 6 volt, 15 volt and 20 volt 'universal' (A.C. / D.C.) motors.

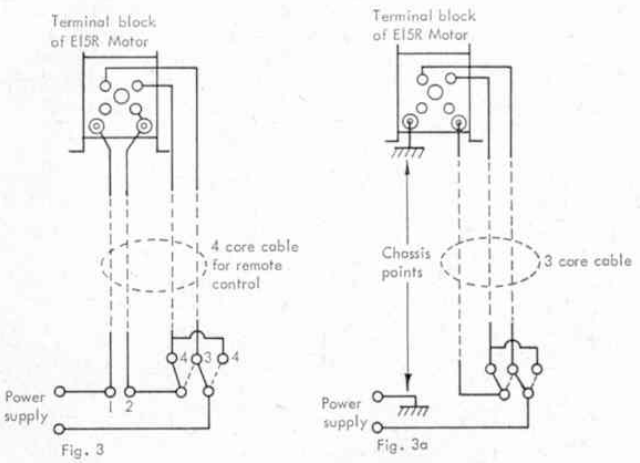


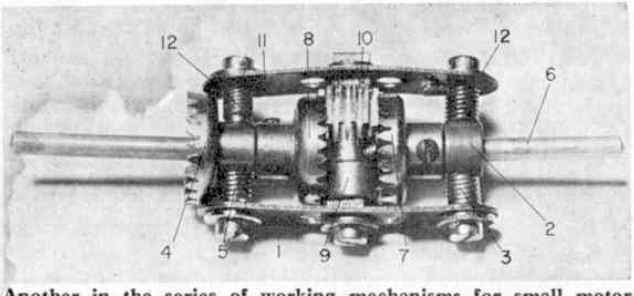
Fig. 3 Fig. 3a

Alternate methods of wiring the E15R and similar Meccano 'universal' motors for reversing by remote control. Fig. 3 - 4 core system. Fig 3a - 3 core system with one lead 'earthed' to chassis model. A Double Pole, Double Throw change-over switch is required for the remote reversing.

Early Meccano motors were intended to be operated from lead-acid accumulators as their current demands and low efficiency made dry battery operation unsatisfactory and very expensive. Four-volt motors were quite common in the early 20's to suit the accumulator but low voltage means high current consumption for the power required. By the late 20's the voltage rating had been increased to 6 volts and attempts made to drive Meccano motors from house mains. Few districts in U.K. were on A.C. supplies and one Meccano motor was manufactured to run from 110 volts, this being supplied from the then 220 volt D.C. domestic supply

AMONG THE MODEL BUILDERS

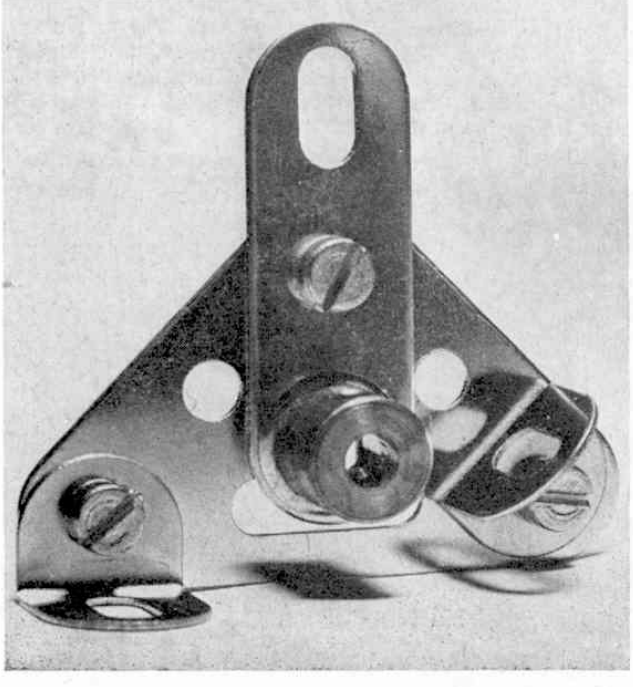
with 'Spanner'



Another in the series of working mechanisms for small motor vehicles is this " baby " Differential designed by Mr. James Grady of Dundee, Scotland.

" BABY " DIFFERENTIAL

James Grady of Dundee (the man, you may remember, who specialises in useful mechanisms for smaller motor vehicles using 1 in. Pulleys with Motor Tyres as wheels) has been designing again—and with his usual success. This time he has come up with the very neat, yet fully-working " baby " Differential illustrated in the accompanying photograph.



In his covering letter to me, Mr. Grady writes, " In designing this mechanism, I deliberately refrained from using any expensive parts such as Couplings, etc., as my aim was to make it as cheaply as possible to catch the youngsters. Why should the boys with the big Sets get all the fun ? ! " Why, indeed, Mr. Grady !

Construction of the mechanism has been made possible by the new-design 2 in. Strips with the additional hole in the centre. Secured by a Nut in the centre hole of one of these new 2 in. Strips 1 is a $1\frac{1}{8}$ in. Bolt, a Washer between the head of the Bolt and the Strip. One end of the Strip is then secured to a Collar 2 by a $\frac{3}{8}$ in. Bolt, but is spaced from it by a Cord Anchoring Spring 3 on the shank of the Bolt, a Washer also being carried between the bolthead and the Strip. At its other end, the Strip is secured to the boss of a $\frac{3}{4}$ in. Contrate Wheel 4, again being spaced from it by a Cord Anchoring Spring 5 and carrying a Washer under the bolthead.

Now journalled, free, in the Collar is a $1\frac{1}{2}$ in. Rod 6, on the inside end of which a second $\frac{3}{4}$ in. Contrate Wheel 7 is fixed. Another $\frac{3}{4}$ in. Contrate Wheel 8, is in turn, fixed on the inside end of a 2 in. Rod journalled, free, in the boss of Contrate 4. Mounted, free, on the $1\frac{1}{8}$ in. Bolt between Contrates 7 and 8 is a Collar 9 and a $\frac{7}{16}$ in. Pinion 10, after which a second 2 in. Strip 11 is lock-nutted on the lower end of the Bolt. The Pinion, of course, meshes with the Contrates.

To finish the Unit off, the ends of Strip 11, like Strip 1, are secured to Collar 2 and the boss of Contrate Wheel 4 by $\frac{3}{8}$ in. Bolts, Cord Anchoring Springs 12 again being used as spacers, and Washers again being carried, one under the head of each Bolt. A certain amount of careful adjustment may be required before the mechanism will operate freely, and it will be necessary to curve the 2 in. Strips slightly, but I can assure readers that Mr. Grady's sample unit illustrated worked extremely well, indeed.

PARTS REQUIRED

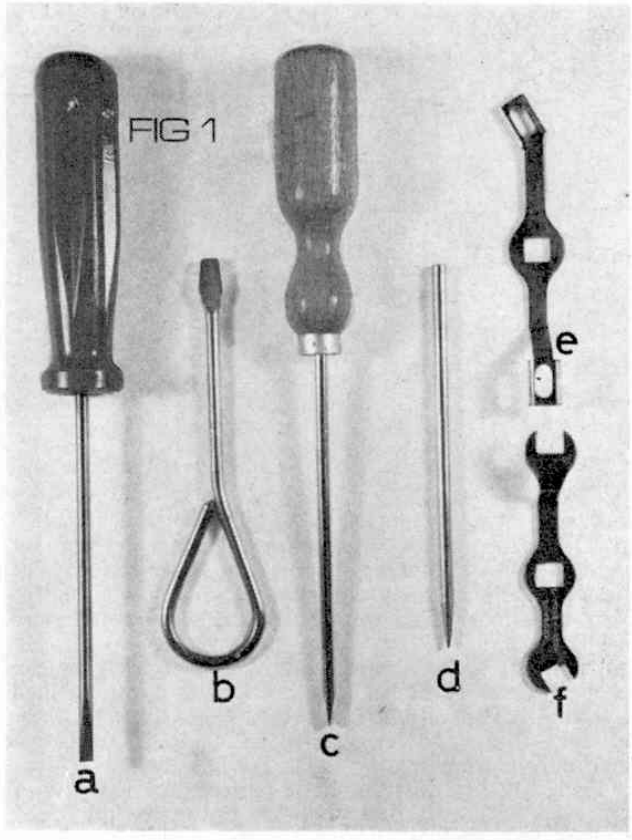
2—6	1—26c	3—37a	1—59
1—17	3—29	8—38	4—111c
1—18a			1—111d

For the Mathematically-minded

In lighter vein, Mr. Bob Hauton of Lincoln—another well-known member of Meccano modelling circles—has supplied me with an idea for a Meccano

Meccano Constructors Guide

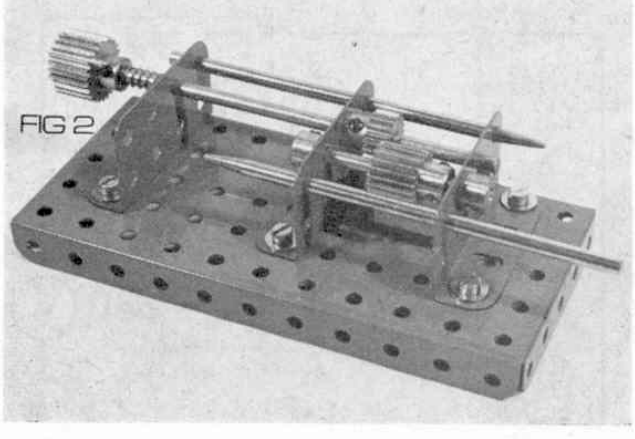
A new series dealing with gadgets and mechanisms that will be useful to Meccano modellers



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.

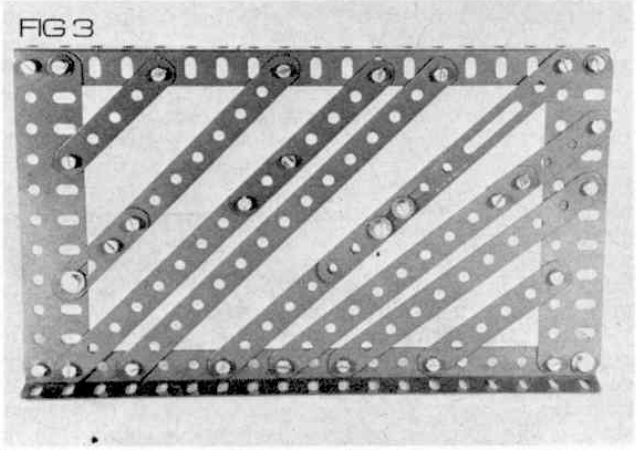


Fig. 3. A demonstration assembly showing how elongated holes in Slotted Strips and other parts enable diagonally-mounted Strips to span inexact distances between anchoring points.

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

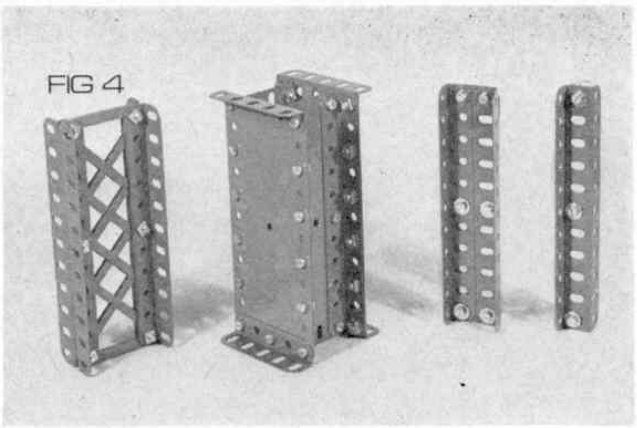


Fig. 4. Some of the many different types of composite girders that can be built up using basic Meccano parts. Just about every type of girder in existence can be reproduced in this way.

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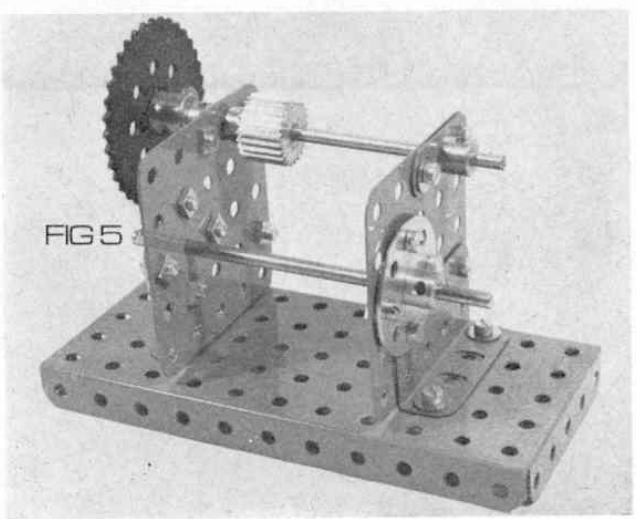

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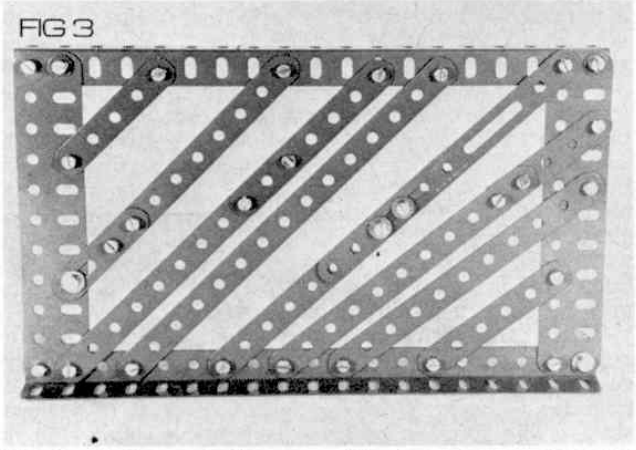

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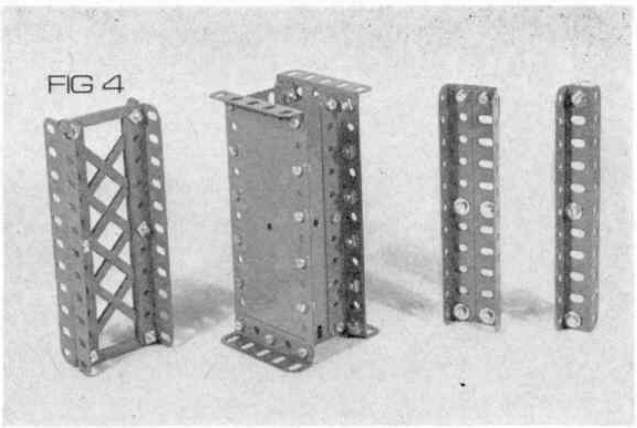

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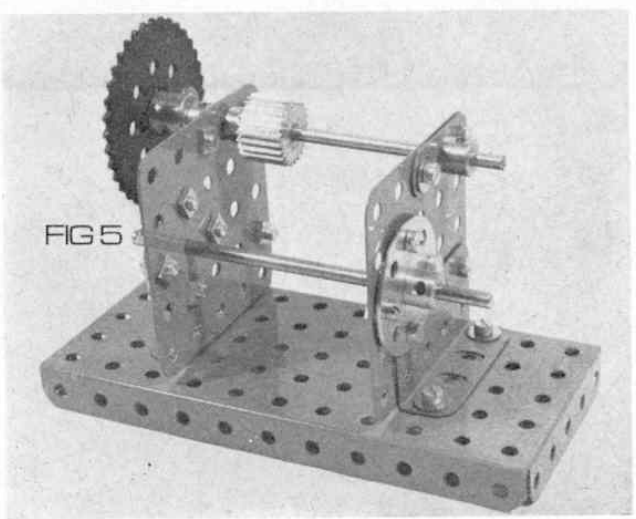


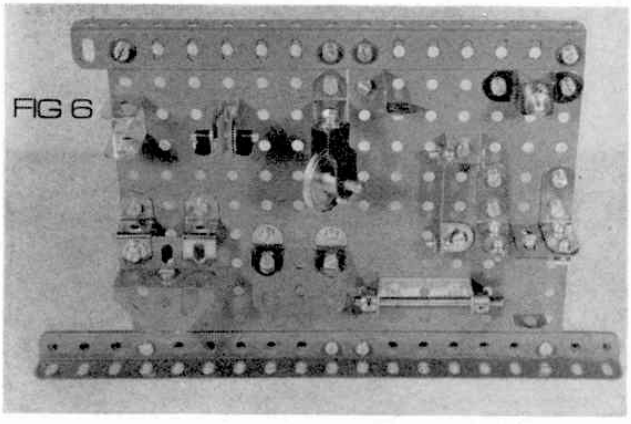


Fig. 6. Some of the many brackets included in the Meccano system with a few examples of the innumerable uses to which they are put.

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

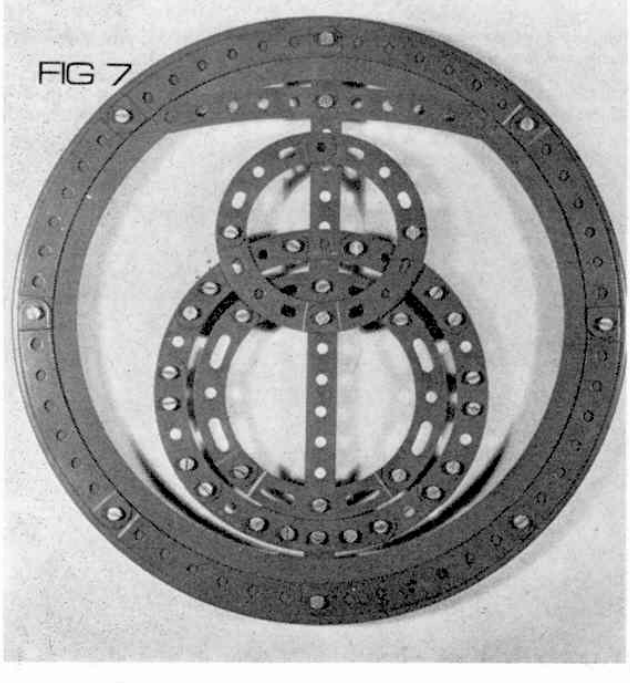
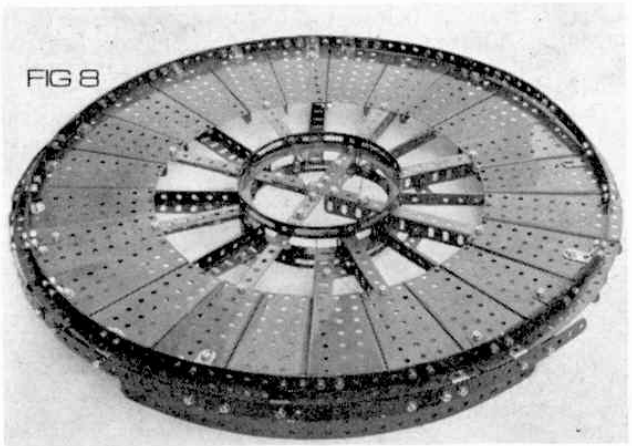


Fig. 7. When bolted together, the various Meccano Curved Strips will make up complete rings of different diameters, as this picture clearly shows. The rings are seen here attached to a 9⅞ in. Flanged Ring to give an idea of size.

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

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.



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.

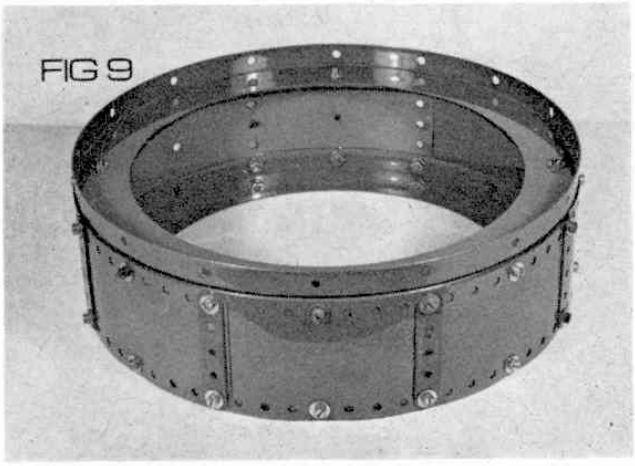
While Strips and Girders form the 'skeleton' of general Meccano structures, Flat Plates and Flanged Plates complement the construction by serving as bases and supplying extra rigidity and large perforated areas for the purposes of providing journals for mechanisms, anchoring points for brackets and Girders 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.



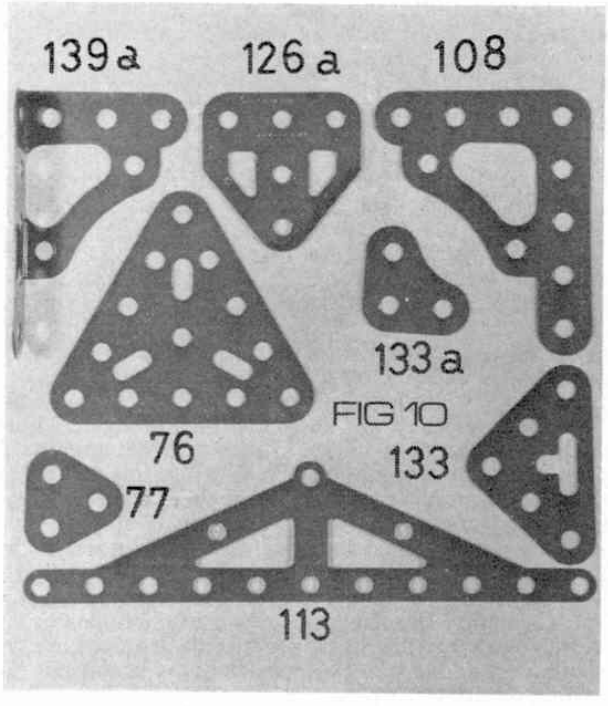
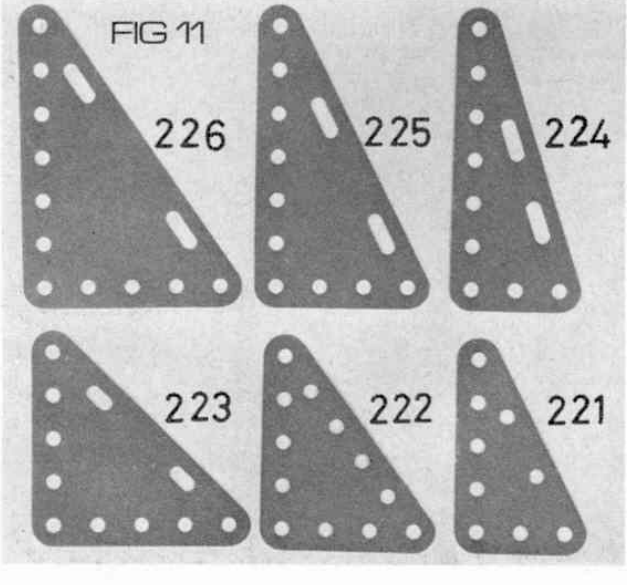


Fig. 10 and Fig. 11 show examples of the many types of triangular-shaped parts contained in the Meccano system. Because of their shape, triangular parts will withstand a great deal of pressure.

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/-

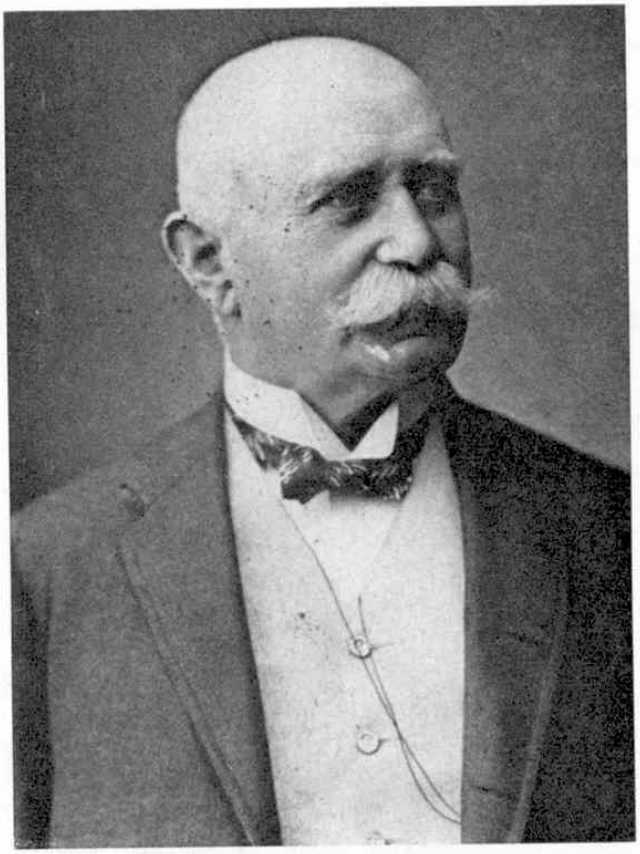
All serious Dinky Toy collectors, worthy of the name, will have heard of the book "History of British Dinky Toys 1934-64" by Cecil Gibson. The book is invaluable to collectors, and is limited only in that it deals exclusively with what can be described as "ground vehicles"—cars, lorries, buses, etc. 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.

GREAT ENGINEERS No. 23

COUNT FERDINAND VON ZEPPELIN (1838-1917)

by A. W. Neal



IT IS easy to see why, when man began to make determined efforts to fly, so much attention was paid to lighter-than-air vehicles. Aerodynamics were virtually unknown, for there was no real need for them. The balloon had been in existence for centuries and it appeared that this approach to getting about in the air would always be safer than heavier-than-air craft. Hot air as a lifting agent gave way to gas inflation, and from that point it was but a short step to the power-driven ship of the air. Then came a further step in advancement—the dirigible—the succeeding designs of which became larger and larger and more intricate. These enormous envelopes became known as 'Zeppelins', after their first builder Count Ferdinand von Zeppelin.

This German Count was born at Constance, Baden, in 1838. He was a soldier by profession, and he served in the Federal army during the American Civil War, and while in America he acquired a taste for ballooning. He saw active service in the Austrian War of 1866 and the France-Germany War of 1870. After he retired from the army he devoted himself to aeronautics.

His dream was an airship of unprecedented size by which the awaiting airways of the world could be opened up, and he set about raising funds to build it. On Lake Constance he constructed a vast floating hangar, which, by cables, always had its door end facing against the wind. In this, work on the ship was began in 1892, and two years later the first 'Zeppelin' was ready for trials. It took the form of a 420 feet long, 38 feet diameter, 24 sided prism with tapered ends. The 'Meccano-like' framework was of aluminium for lightness. It had 17 compartments, each containing a gas-bag. Over all was a linen and silk covering. Underneath the cigar-shaped hull were hung two cars carrying a 16 horse-power engine in each and accommodation for the crew. The first attempt to get the ship into the air was not at all successful, and some damage was suffered. But the second attempt was better and a speed of 20 miles per hour was reached. It became apparent that there were fundamental errors in design. The framework was not strong enough, the gas-bags were not tight and the engines under powered. One report states the ship was wrecked in landing. Five years later the Count had another ship completed, and this made two successful flights. Unfortunately it was completely destroyed by a windstorm in January, 1906. Following these and other set-backs the Count's faith in his dream began to wain, but his Government urged him to continue with his experiments. By the end of 1906 Zeppelin III took to the air, and from that time onward his ships made steady progress.

Zeppelin may have had at the back of his mind, although he did not say so, that the dirigible, in addition to purely commercial work, would figure in plans for war. Indeed, this did transpire. During the 1914-18 war the Germans used dirigibles for patrol work over the North Sea, and sent them on raids over France and Britain. They did much damage, but their morale effect was much greater. The defenders, however, worked out new techniques to combat this hazard. These leviathans of the skies proved to be vulnerable to incendiary shelling and attacks by aeroplanes, quite apart from adverse weather conditions. So, after learning the hard way, they were withdrawn from the war scene. By this time Zeppelin was dead.

After the 1914-18 war ended various leading countries took up building dirigibles, making many spectacular developments, flights and calamities. Their vulnerability to weather and other agencies was never overcome, so the wheel of fortune turned a complete circle and no more were made, and the heavier-than-air craft gained the ascendancy.

One sees in Zeppelin that great self-impelling urge that is inseparable from all inventors. It is hard to believe he was fifty-four before he finished his first design for a rigid airship. Fortunately he did not see the demise of this brain-child. He died at Charlottenburg on March 8, 1917, aged 79.