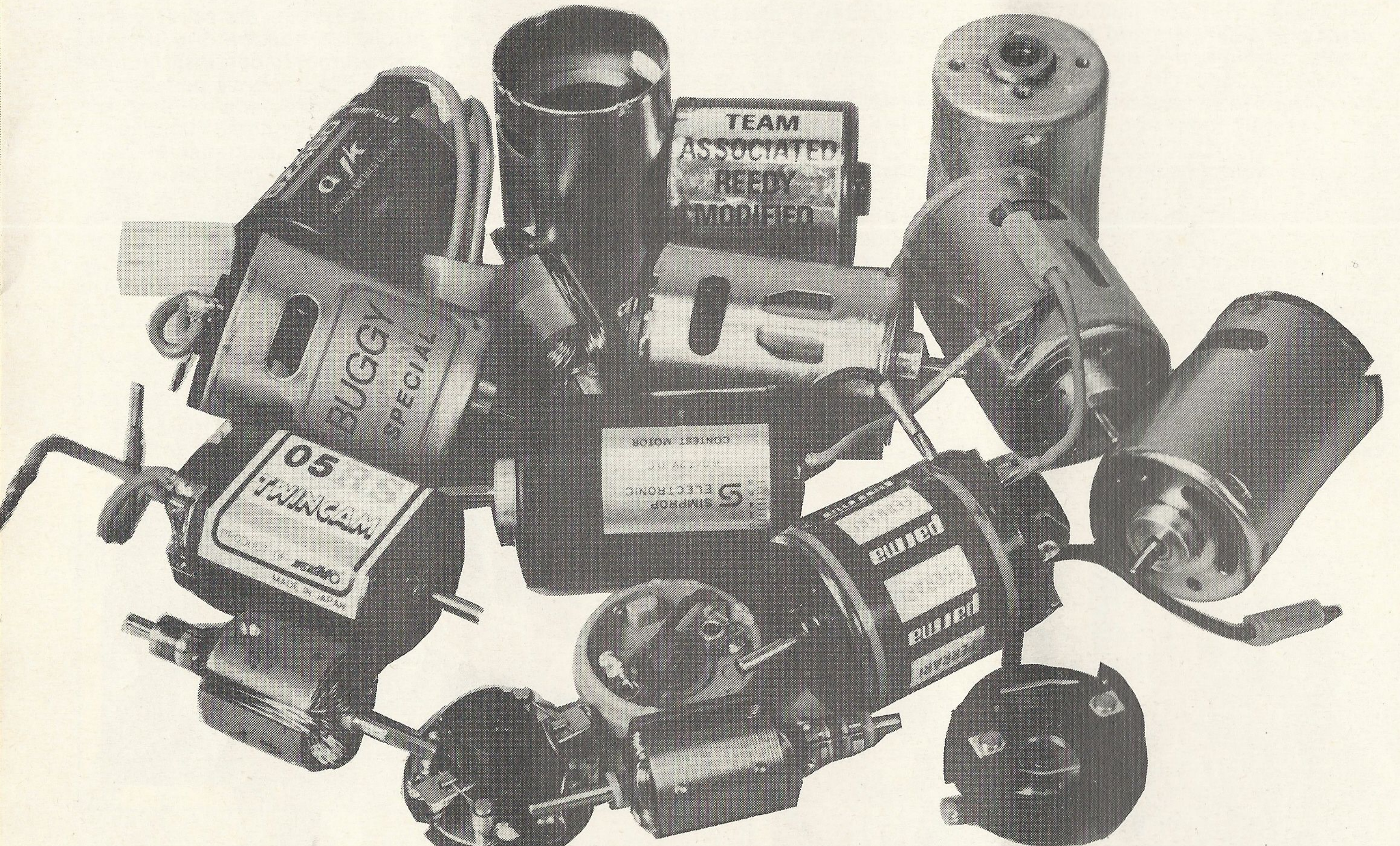

Motor Torque

ALTHOUGH THE MAJORITY of this feature is concerned with maintaining and preparing electric motors for use with R/C cars it would seem wise to spend a little time explaining just how an electric motor works.

For R/C car applications although different motors are used they all follow the same principles of operation and have main components as shown in **Fig. 1**.

These are (a) Permanent magnet
(b) Electromagnet/armature.
(c) Commutator and brush assembly.

The **permanent magnet**, fitted to the inside of the motor case, is usually manufactured from a ceramic material 'loaded' with magnetic material. The actual constituents of this ceramic 'mix' influences both the power of the magnet and the price! As a simple 'rule of thumb' the more powerful the permanent magnet the more powerful the motor. Some magnets have some

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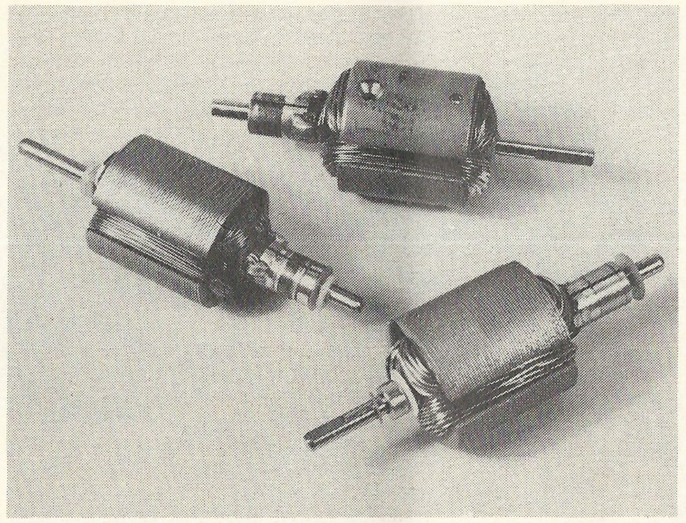
pretty exotic ingredients and this partially accounts for their exotic prices!

The **armature** consists of a coil (or coils) of wire, wound round a soft iron former or core. When an electric current flows through any piece of wire it creates a magnetic field. The more current (the lower the resistance of the winding) the stronger this field becomes. We have a number of loops or windings on our armature (a) to restrict the current to sensible proportions (it's no good having a super powerful field if its going to flatten our batteries in 30 secs!) and (b) together with the shape of the soft iron core, to get the optimum 'shape' of magnetic field. Soft iron is used as this does not form a permanent magnet and as we will see later it is important for our electromagnet to be able to change its pattern rapidly.

When current flows through a loop of wire it produces a North and South pole **(Fig. 2a)** if you reverse the current flow (swap the battery leads) these poles reverse **(Fig. 2b).** If you suspend this loop between the poles of a permanent magnet without a battery connected . . . nothing will happen because the wire is made of copper and is not affected by the magnetic field of the permanent magnet. But . . . now connect the battery into the wire loop and our electromagnet forms its North and South poles and the loop will now rotate betwen the poles of the permanent magnet **(Fig. 3b)**. *Like poles repell, Unlike poles attract*. If we could



Above: armatures taken from three electric motors of the type used in R/C car applications. Note the three coils or poles and commutator. The centre armature has been drilled into to remove material for perfect balancing.

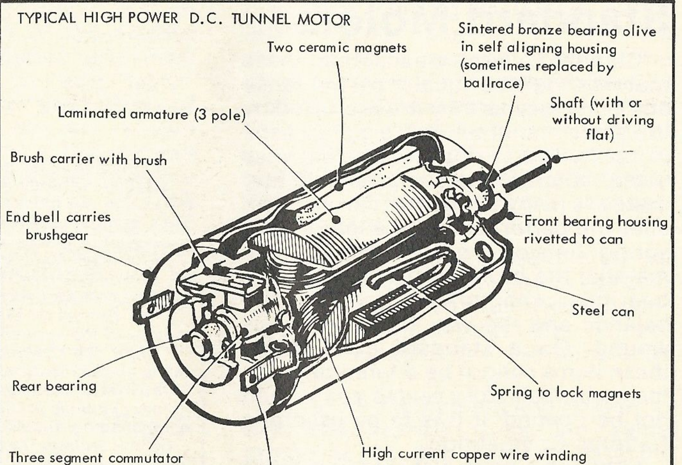


Fig. 1

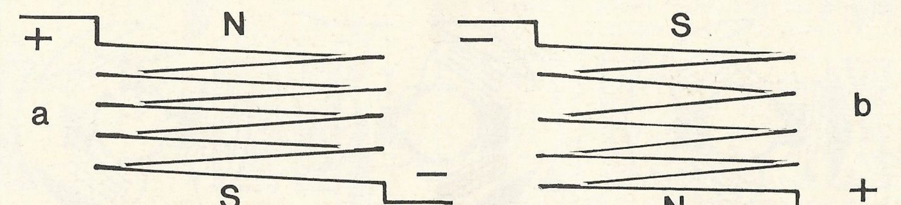


Fig. 2

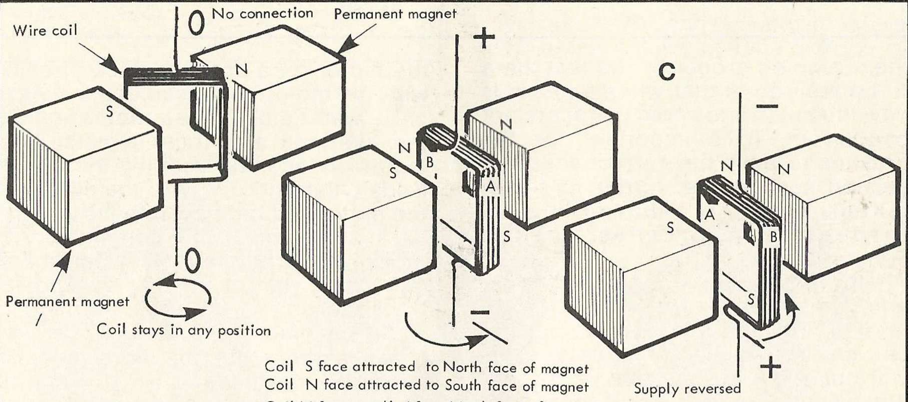


Fig. 3

now reverse the current flow the loop of wire will again change its position, rotating so that the new North pole is facing the South pole of the p.m.

We now have two problems, (1) how to reverse the current flow so that the armature will rotate continuously and (2) how to ensure in which direction the armature will rotate.

Current reversal is performed by the **commutator** which in our motor is drum shaped and mounted directly onto the armature spindle. Both commutator and armature revolve together.

However, before moving onto the finer details of commutation we must establish that our motor features an armature fitted with *three* wire coils. These three wire coils are all connected to the commutator in series. When energised with electrical current they will become electromagnetic and produce North and South poles. Of course with three coils we have three *poles* and this is very important to give smooth and reliable motor operation.

Back to the commutator. The conducting face of this is divided into copper segments with gaps in between. The number of segments involved is governed by the number of coils on the armature (in this case three). Electrical current is passed through the commutator and onto the armature via two 'brushes' either side of the motor case **(Fig. 4)**. These 'brushes' rub on the side of the commutator and are of sufficient width to bridge the gaps between the copper segments and will do so alternately as the commutator rotates.

Now we come to the reason why. When a brush bridges a commutator gap it bypasses the corresponding armature coil whilst energising the other two, these then become north and south poles (according to the current flow) and magnetism induces

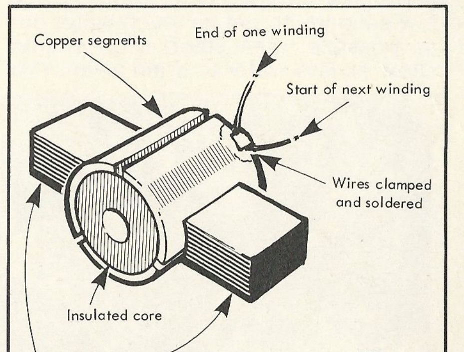


Fig. 4

rotation **(Fig. 5)**. As the commutator (and armature) revolves the other brush bridges a gap and the same situation as above is produced. However, because the brush is connected to the *opposite* terminal of the power supply, the current flow is reversed, which in turn changes the polarity of the other two coils so that rotation continues **(Fig. 6)**.

Remember, all this happens at very high speeds and depending on the quality of the motor components can vary between 10,000 to 30,000 rotations per minute.

Motor Maintenance

Here in the UK two classes of racing for electric powered R/C cars are run, 'Standard and Modified'. These terms describe the motor being used, although both types are virtually the same regarding operation and components. Whether a motor is modified or standard greatly affects the price of the complete unit. 'Standard' types can sell for under £10.00 whilst the 'Modified' variety can cost anything up to £35.00.

Standard Motors

'Standard class' means that these motors should be equal in performance and efficiency as they are produced by the same manufacturer, e.g., Igorashi. In reality this is not the case because these motors are mass produced and there are many things that can vary and alter the performance of a motor. The spring tension on the brushes, the material the brushes are made of, the bearings, magnetic strength, the balance and the way the armature is wound. On a standard class motor these items cannot be altered because the motor is factory sealed and should not be opened, if it is to be used in a National Competition.

Although I have just said that these motors cannot be altered they can be run in properly and looked after to keep them running properly. The first thing to be realised is that when a motor is new the brush and commutator are not bedded in, it is important for the brushes to have the correct shape or section so that the current is transmitted smoothly and efficiently through the brushes to the commutator.

Right: two types of endbell currently in use on our electric motors. Left: the ubiquitous Mabuchi 540 endbell features phosphour-bronze brushes soldered onto leaf springs on the inside of the endbell. Right: the Yokomo style endbell features brushes which slide into channels in the endbell being retained by coil springs. This method allows access to the commutator for cleaning etc.

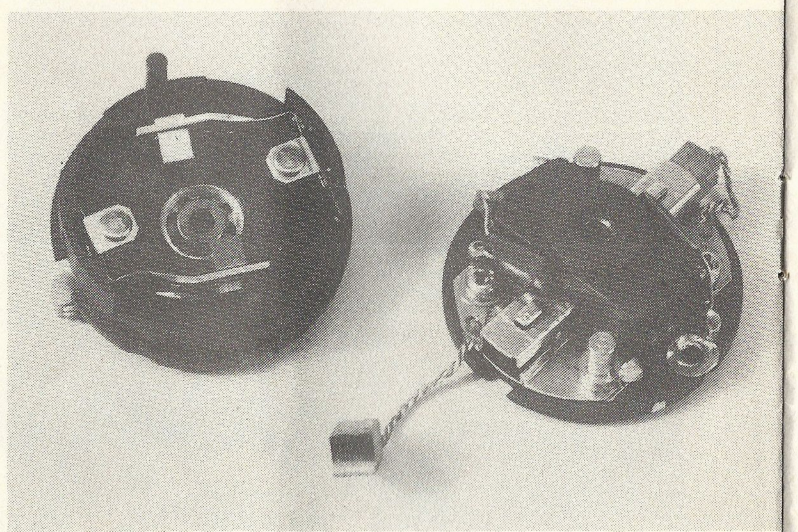
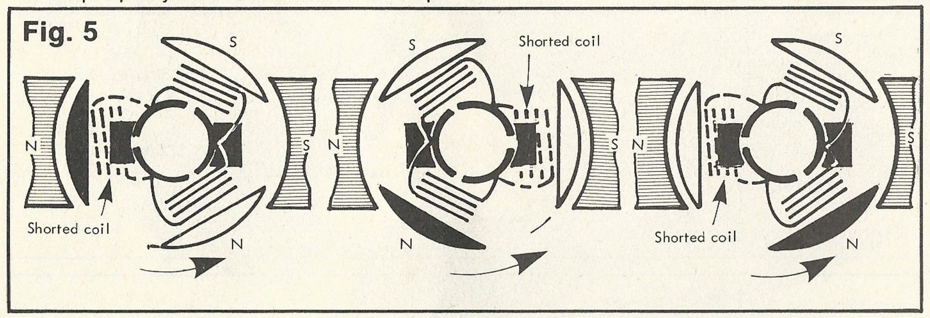


Fig. 5



If the motor is put straight into the car and run under load, the brushes will wear into shape and deposit a lot of carbon around the commutator. This will not allow a good flow of current and can also distort the commutator due to heat build up.

The most common way of running-in a motor is to run the motor off load for approximately two hours at reduced voltage, this is done in 5-10 minute sessions or until the motor becomes warm and then allowed to cool down before running again. The first six runs should be set at 2.4 volts, then three runs of 4.8 volts and finally three runs at 7.2 volts, remembering to keep the motor cool and the bearings well oiled. The reason I use these voltages is that you can charge an old six-cell Ni-Cad pack and use this as the power source by tapping of the first two cells for the first voltage, the other four for the second and the full pack for the final runs. The motor can now be fitted into the car and raced.

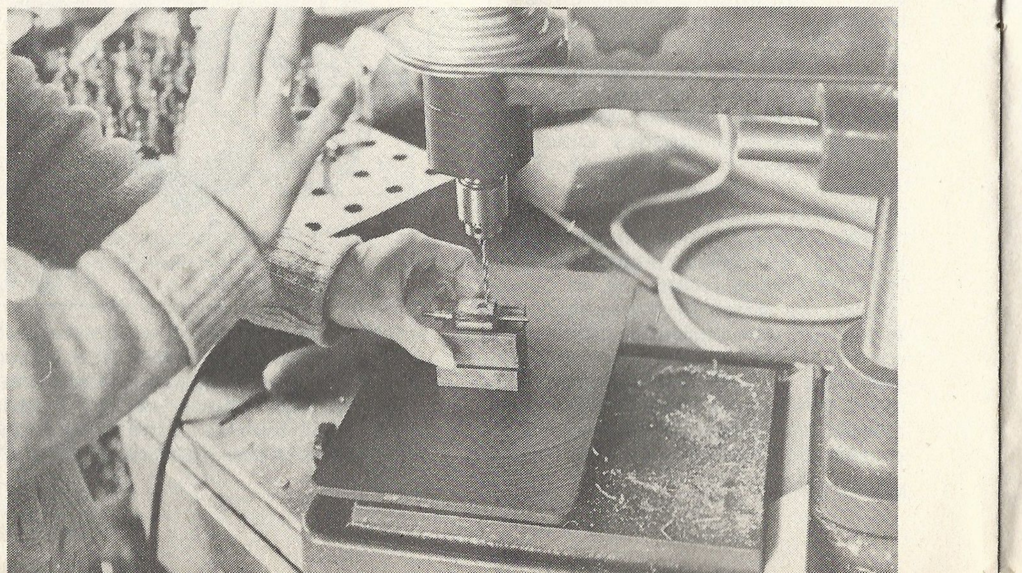
There is now a different method of running-in motors which is far quicker, and requires only *15 seconds* to accomplish fully. This involves running the motor on a charged pack of cells with the motor immersed under water.

To 'water dip' the new motor first oil the bearings and then immerse the motor under water keeping the motor leads clear and dry, you then remove the motor and connect it to the battery pack and immediately re-immerse it, moving it slightly to keep water in the can. The motor will slow down fractionally and you will notice the water becoming slightly dirty. **Do not leave in the water for more than 20 seconds maximum.** 15 seconds is normally enough to run the motor in fully. Remove the motor from the water and shake it whilst it is still running for a few seconds to get as much water out as possible, then stand it on end to allow excess water to drain away. You can then re-oil the bearings and fit to your car. With luck you will now have a good motor.

Standard motors although they cannot be opened can still be maintained and cared for. It does not hurt to drop a little oil on the bearings just before you go out to race. The best lubricant I have found is a light oil such as *WD40* or *M.G. Products'* 'Motor Lube'. After the motor has been used for a few meetings it should also be cleaned. This can be done in a variety of ways. One method is to spray an electrical contact cleaner through the motor fixing holes whilst the motor is running, **do not use cleaner that contains lubricant as this can get on the commutator and brushes,** then allow the fluid and dirt to flow out of these holes. The motor bearings should then be oiled and re-used.

Another method I have just started to used is to drop a few drops of *M.G. Products'* 'Mr. Cool', commutator fluid into the can at the start of the meeting as this seems to keep the motor clean and makes for less general cleaning.

With the new *Yokomo* standard motors coming on to the market it is far easier to keep these clean and running properly, however, it is unwise to 'water-dip' these motors as the brushes are very soft and will wear too quickly, it is better to run them in with the low voltage method. Because the brush gear on a *Yokomo* is exposed and thus easier to work on. The brushes can be removed and the slider cleaned and kept free of dirt. The commutator can be cleaned by using cotton buds or lint-free cloth dipped in 'Mr. Cool' or an electrical contact cleaner, remember to make sure no fluff is left on the commutator. Lastly use a thin knife blade and clean any loose dirt from between the copper segments taking care not to damage the edges.

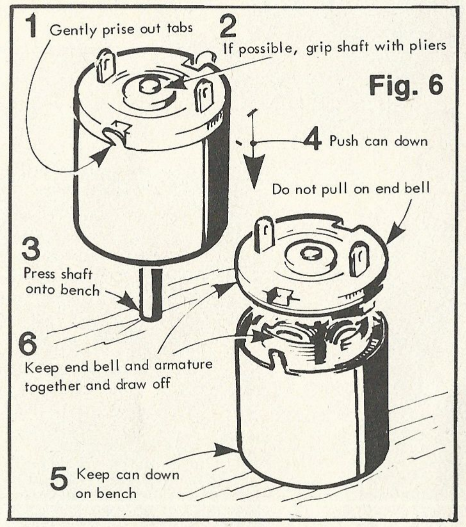


One common problem that has been encountered with the standard class *Yokomo* motors is a noticeable loss of power when put under load. It was found that in some cases the brushes were not moving freely in their slides thus causing inefficient contact with the commutator. This was rectified by removing the brushes and rubbing them very lightly on fine 'wet-or-dry' emery paper to allow them to slide and make proper contact with the commutator. **Do not remove too much material.** The other advantage with *Yokomo* motors is that the brushes can be replaced. However, I have not yet seen actual *Yokomo* brushes for sale although *Ripmax* are selling spares for the *Kyosho* 'Le-Mans' motors and these are the same type. The first thing to remember if you are going to strip the motor is that it is an expensive item so take care of it.

If you use a *Yokomo* in a buggy always fit a rubber boot to stop dirt reaching the commutator and brush gear.

Modified motors

Why is a modified motor quicker than a standard motor? Mainly because it has been manufactured to closer tolerances than its standard class equivalent. Nevertheless, another way of increasing the power output is to increase the current used by the motor and the simplest way of doing this is to reduce the number of wire turns on the armature. This has the effect of lowering the resistance of the wire coils and increasing the current passed through the winding which in turn increases the power of the electro magnetic field produced and thus causes the motor to turn faster. However, the major producers of modified motors do not just remove wire from the armature but instead completely rewind the armature with a different number of turns or use another gauge of wire. Using this method, motors can be produced to meet very fine specifications such as different race durations and gearing ratios.



Another limiting factor on motor efficiency is whether or not the armature is in balance or not. If the armature stack is unbalanced vibration will be caused and subsequently lessen the power output. Various methods of armature balancing are carried out and generally involve either the addition or removal of material from strategic points of the armature core.

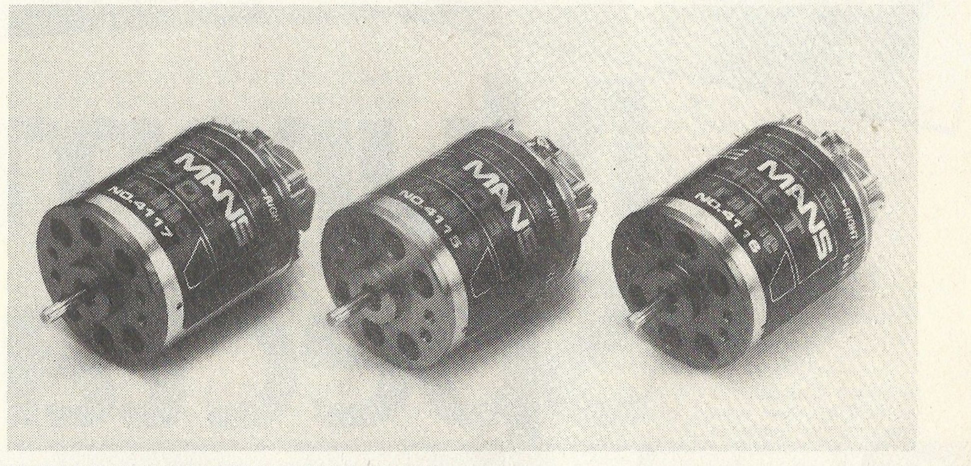
The commutator should also be perfectly cylindrical or 'comm trued' to allow full brush contact. Adding ball-races into the motor can for the armature spindles will also aid overall efficiency.

As far as maintaining and preparing modified motors goes the same principles as set out for standard motors applies. Having said that, most modified motors will already have some running-in time on the clock. However, when removing the endbell of any modified motor a few simple guidelines should be observed.

When removing the endbell of an Igorashi or Mabuchi motor the first thing to do is mark across the join between can and endbell. This is so that upon reassembly you can get the motor rotating the right way and set to its standard timing. Do not just pull the endbell off the motor.

To remove the end bell and armature remove the screws or tape fixing it to the can. When this is done, grip the armature shaft where it comes out of the end bell and place the other end of the armature on a bench then push the can clear; this will remove the end bell and armature as one unit **(Fig. 7)**.

Take note of the spacing washers so that you can replace them in the right order. Now hold the brushes away from the commutator and remove the end bell. You can now clean the armature, bearings and the can. If you find that the motor is losing power and the commutator appears to be pitted and grooved *M.G. Products* offer a very good motor rebuild service that is not that expensive and can increase the life of the motor.



Across left: material being removed from a motor armature for balancing. Above right: Kyosho of Japan produce these three Yokomo style, 'Le-Mans' motors. Competitive in both price and performance. Right: Mike Reedy of Associated, USA produces a wide range of re-worked motors for both Standard and Modified class racing.