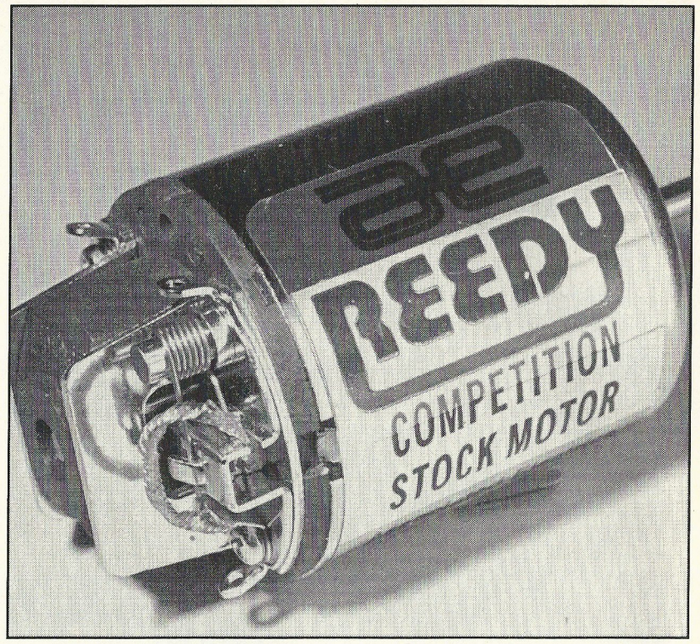


THE POWER GAME

Everything you've ever needed to know about RC electric motors, by Pete Winton.

Whatever your age, it is never too late to learn something new. This Model Cars Racing Special will hopefully contain new information which helps you to learn more about some aspects of electric car racing—in this case motors—and thus broaden your enjoyment of the sport. This comprehensive guide to motor preparation, care, and maintenance is divided into step by step sections which will enable the reader to get the most out of their existing equipment, and provide some guide to purchase of new equipment. Before we start, "I wanna tell you a story"!! Some of you may have heard of, or remember, a great racing driver from Sweden called Ronnie Peterson. Ronnie was one of the great natural drivers and was killed in the late seventies after a startline shunt at the Italian Grand Prix, Monza. During the mid-seventies he drove for the *BMW* Junior Team in America, piloting a '320 Turbo'. On one occasion he was partnered by Englishman David Hobbs at Watkins Glen. Hobbs was keen to make a good impression on the legendary young Swede, and offered Peterson the first practice session to set-up the car. Peterson politely declined, saying that he would not be a regular at every race due to his Formula 1 commitments —whatever set-up Hobbs chose would be fine by him.

Hobbs sweated hard in a fledgling car to get it right, and in the first timed practice set what he felt was a good time. Petersen climbed into the car he had tested only once and after a short acclimatisation session, slammed round in a time around four seconds faster than Hobbs. Hobbs' reaction is not recorded, his lasting impression was of a man who knew more about car control than Hobbs would in a lifetime!

The moral of the story is that, however fast you think your competitors are, it is highly unlikely that the speed of their motor is the only reason you have been beaten. It is more than likely that driving ability has made up for that difference in lap times. The most important factor in choosing motors for electric car racing—circuit or off-road—is that you, the driver, can make the best possible use of all the power a given motor can produce. We shall return to this point later in the article—more than once!!

How it works

Were it not for the genius of Michael Faraday in discovering a use for electro-magnetic induction, it is difficult to imagine what the world would be like today. Faraday did not 'invent' electricity, it was already available in the form of crude lead/acid batteries. Faraday discovered that if a permanent magnet was moved inside a coil of wire, electricity was produced. This only happened when the magnet moved, and he found a relationship between the rate (or speed) of movement and the electrical energy produced. Similarly, he wound copper wire round a soft iron rod and found that when the wire was connected to a battery, the soft iron rod behaved like a permanent magnet.

All electric motors used in circuit and off-road R.C. cars follow that basic principle—including those used in the servo for steering the car. The copper wire wound round the soft iron core in the middle of a motor is energised by electric current passed from the drive battery. This turns that into an electro-magnetic 'pole' which is the same as the pole of the permanent magnet in that side of the can. Since like poles repel, the 'pole' is pushed away. This is translated into rotary motion.

In order for the same 'pole' to be repelled by the magnet on the opposite side of the cam, we reverse the current which, on flowing in the opposite direction, changes the 'pole' from and to –, and is again repelled. Current reversal is achieved through a commutator. The accompanying diagrams illustrate the principle much better. It is not necessary to understand in detail how the motor works, but it must be noted that the strength of the permanent magnets and the action of current reversal are significant factors in motor performance at a practical level.

How it really works!!

At this point some of you may have got lost and be on the verge of turning the page. DON'T. We have disposed of the only technical part of this article at the outset, from here on its practical advice all the way. To get the best from a motor (to get it to 'work' for you) is a matter of good care, preparation and correct selection of gear ratio. For a motor to work well it must be installed properly in the car, be securely connected electrically to the speed controller, and have a clean commutator with good brush contact. That is how motors really work in electric race cars, and those points must be followed by every racer from club beginner to National Champion. Irrespective of the theory, one ignores these basic points at ones peril.

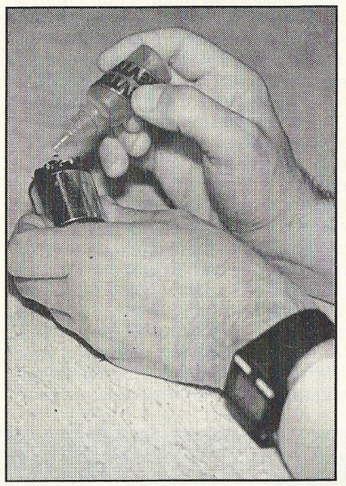
Motor terminology

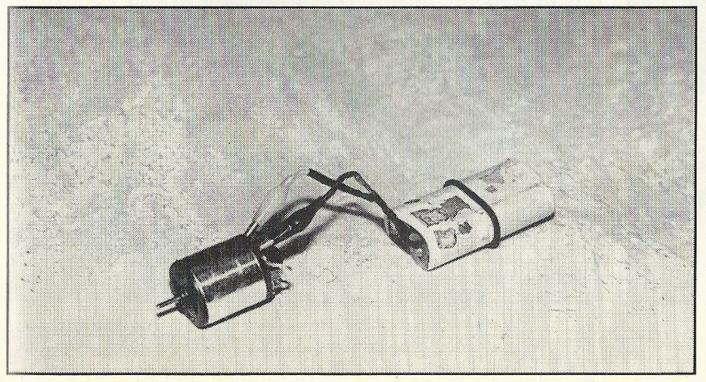
Whatever the label on a motor says (*Parma, Demon, Reedy, Twister, MG, Trinity* etc etc) there are two basic types. One is fully enclosed allowing no ready access to any parts and is termed the 'Igorashi' type. These were very common in the seventies and early eighties, and are still used extensively in Japanese 1:10th off-road car kits. Primarily designed as low cost motors for use in portable appliances, these motors are reliable and durable. Their demise in most club racing activities is due mainly to the lack of adjustments available for timing (more of which anon) and lack of access for cleaning and maintenance.

In 1982, these motors were superceded by the 'Yokomo' type now universally used in all club racing where competitors buy motors not supplied with the kit. The 'Yokomo' is characterised by its shorter metal cam and 'exposed' brushgear. There are many different designs of this motor, but all are referred to by the term 'Yokomo'. This article deals almost exclusively with the 'Yokomo' motor, but reference to the 'Igarashi' type is made where appropriate, since many people run these in cars when starting out in the sport.

Let's look at the basic parts which go to make up a motor. When assembled, the motor has two distinct features. The motor can is the metal part to which the label is normally attached. The can is normally blanked off at one end to enclose a bearing from which protrudes a shaft. This is the main shaft of the motor to which is attached the soft iron core, copper windings, and commutator. It runs the whole length of the motor. The 10-15mm of shaft protruding is used to attach the pinion gear, and often has a flat ground on it. The place where the shaft protrudes is called the can end—simple eh?

At the other end of the motor is a plastic moulding (metal types are used) which carries two metal plates. These are secured to the plastic by a small screw, and a large rivet which sticks up in the form of a post. These plates, one each side of the centreline of the motor, are bent to form a channel. These plates are known as the brush holders because . . . they hold the brushes. The small screw holds a tag to which is spot welded a small piece of copper wire or braid. This wire is embedded in a sintered copper 'block' which goes into the brush holder. The copper block is called the brush. The brush is pushed down the holder and held against the commutator by a small tension spring pivoted on the rivet post. The spring is called the brush spring, and the post is called the spring post. The copper braid which goes from the back of the brush to the tag is called the shunt, the plastic moulding to which the brush holders are attached is called the endbell and at the extreme end of the endbell is a bearing which holds the other end of the shaft we see protruding from the can. If a motor is to hand, pick it up and identify all the parts we have referred to and compare it with the diagrams. Two major items in the motor, cam and endbell, are visible from the outside. The third major component is inside the motor. This is called the armature—don't pull your motor apart yet! There are several parts to the armature. The stack is the soft iron core which has three separate slots. Each slot is filled with wire—the windings, and a complete wound 'slot' is called a pole. All 'Yokomo' motors have three pole armatures. The copper coloured drum on one end of the armature is called the commutator. The commutator (or com) has three segments which are insulated from each other, and the windings are connected to each segment in a certain way to energise each pole separately. A commutator normally has one segment for each pole on the motor.





Opposite page: The latest in technology from Mike Reedy—brush holders with built in heatsinks. Above left: Adding Revtech drops to a motor. Left: The motor connected to a 4 cell pack being run-in.

Motor selection

Some are lucky enough to be able to choose motors by buying one from a good model shop. Others have their motors selected for them—it comes with the kit. If you are starting racing and the kit you have bought includes a motor then use that one. During the time you are learning to drive car damage is a distinct possibility, so save any spare cash for that, don't go and buy a faster motor until you can drive your car for at least one third of a race without making a serious mistake. Like David Hobbs, driver skill counts more than motor power at this stage.

Most car clubs run to one or other of the British Radio Car Association (BRCA) rules—standard or modified. Standard motors are made to a specification laid down in BRCA rules. 1:10th off-road motors are 27 turns of 22 gauge wire (27 is the number of turns of wire on each pole, 23 gauge is the wire thickness) and 1:12th circuit standard motors are 35 turns of 23 gauge. These motors are sealed units which cannot be opened, and prices are limited by BRCA rules. All motors supplied in car kits conform to BRCA standard class rules. A separate section on standard motors will follow.

Modified motors must use all the normal 'Yokomo' components (armature, endbell, can etc) but can be wound with any choice of wire thickness and number of turns. Modified motors make up the bulk of club racing in my experience, and are the motors used for National Championship races. The word modified should be regarded as indicating a more expensive motor built to a higher quality than standard motors. Modified motors have a system of removing the endbell from the can allowing access to the armature. Modifieds can be rebuilt to 'as new' condition which extends their life considerably. This consistent extended life makes them a better bet long term than standard motors, despite the extra expense of purchase.

The time will come when buying a new motor is on the cards. You have saved your pocket money, washed all the neighbours cars, and sold the cat—what do you buy? If a standard motor is needed, then take a look at what is being used successfully at your club, go down to your local model shop and buy one the same. Whether you choose *Demon, Parma, MG, Twister, SRM, Kyosho* etc, etc, there is an equal chance of getting a very good motor for £15.00—it's that simple.

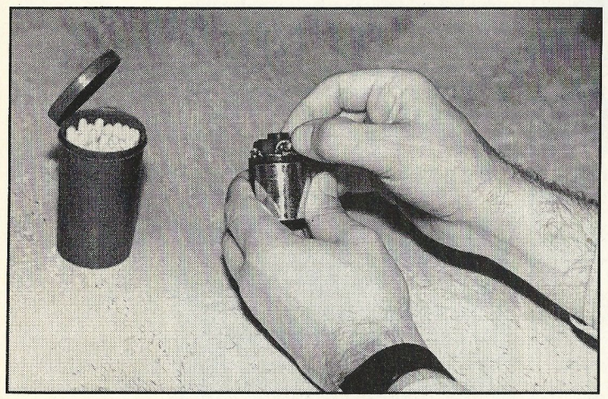
Buying a modified is slightly different. First decide what you want the motor for. If it is to improve on current performance then the choice is wide, but if you are looking for another motor to add to your stable then obviously you need to choose something specific. For the person looking to speed up a standard kit car, but who is concerned about too much speed, go for no more than a 21 turn double, or even a 23 turn double. (Double refers to the number of wires wound simultaneously around the armature pole, in this case two. A triple uses three wires, a quad four, a single one. All standard motors are singles). Anything from 23 down to 21 turn doubles will give good usable performance. The less turns a motor has, the faster (or hotter) it will be. Check the motor chart column on suggested gear ratios. If a motor is suggested to run on 10:1, that means for every 10 times the motor goes round, the wheel goes round once. You will need to buy a new motor pinion gear to change the gear ratio on your car. Be quite clear that you cannot run a modified motor on the gear ratio supplied with the kit and expect it to work—IT WILL NOT. You will destroy the motor, or your *Ni-cad* batteries, very quickly unless you have selected the correct recommended gear ratio for the motor you have bought.

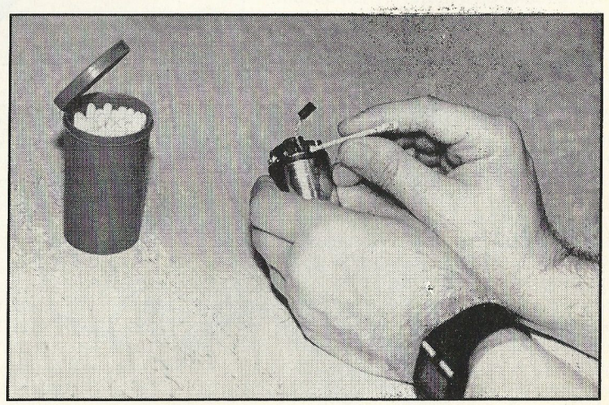
For seasoned or skilled club racers, the fastest motor you are likely to be able to use properly is around a 17 double, 16 triple or 18 quad. Motors hotter than this are for very skilled drivers, which is not to say the rest of us can't use them, but that the higher power may not result in more laps for most of us—back to Mr. Hobbs and Mr. Peterson! The other point to make is that a well set-up 19 double will outperform a badly set-up 17 double every time. If it helps at all, my pit box contains a 23 double, 19 single, and 19 double—I have been short of straight line speed sometimes, but never been short of all-round performance.

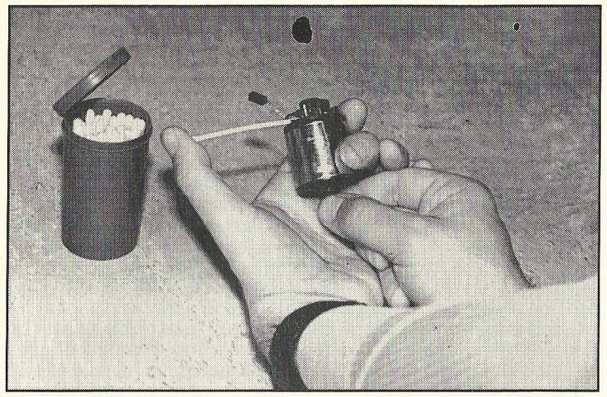
Running-in—please pass

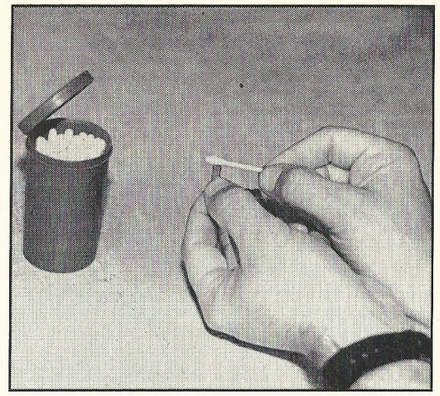
Like all things mechanical, a running-in period helps to prolong the life of the motor. The object of running-in an electric motor is to wear the brushes to the shape of the commutator. When new, brushes will be in contact with the com on only a very small part of their surface area. When one switches on something electrical there is occasionally a spark. The spark occurs when electricity tries to jump across very small air gaps. This sparking wears away the contacts, which is why we replace the 'points' in a real car distributor. New motors spark quite a lot, this wears brushes and generates heat—neither desirable.

There are three ways to bed in new motors (standard or modified)—the best way, the acceptable way, and the wrong way. The wrong way is to put the motor in the car on the suggested ratio and hammer round the track using brakes and acceleration at will. The acceptable way is to put the motor in the car on a much higher ratio than suggested and drive round the track using gentle acceleration, no brakes at all, and most importantly—no reverse.









Bottom far left. Unhook springs then carefully remove hood. Bottom right: Soak cotton bud in spray and clean down brush holder until it reaches the com. Above left: Apply light pressure on the cotton bud and rotate armature. Right: Remove brush and clean with cotton bud twice.

Let's assume you have purchased a 29 double suggested to run on 10:1. By consulting the gear ratio chart for your car, it is determined that a ratio of 13:60 (13 tooth motor pinion, 60 tooth spur gear) will give the desired ratio approximately 10:1. (on a *PB* 'Maxima' this is 10.19.1 for example). Take the motor out of the packet and examine it carefully. Make sure all the parts are correctly fitted, and everything looks in place. If in doubt, take it back to the shop. NEVER MAKE ANY ADJUSTMENTS TO A NEW MOTOR BEFORE YOU HAVE RUN IT AT LEAST THREE TIMES. Solder on some suitable connectors to the wires supplied, or to the tags on the brush holders (red is live, black or blue negative). If a motor has no suppressors, fit two ceramic capacitors to the motor from each brush holder to the can. NEVER RUN A MOTOR WITHOUT SUPPRESSORS—IT IS ILLEGAL AND CAUSES INTERFERENCE ON YOUR RADIO CONTROL EQUIPMENT.

Put a very small drop of light oil (say 3 in 1) in each bearing. Now fit the motor into the car, but not using the 13 tooth pinion of the suggested ratio. Fit a pinion one tooth smaller, in this case a 12 tooth. Make all usual preparations for a race, and put the car on the track. Accelerate gently, and then drive your race carefully. Never accelerate hard, apply power gently, and never use the brakes, let the car slow down for the turns of its own accord. Never use reverse, if the car is stuck ask a marshal to move it by hand. As the race progresses start to accelerate more quickly, say after half the race is complete. Always use top speed from the start, but now gradually increase the speed of acceleration. As the race nears its close start to accelerate harder and harder, until on the last two laps or so you are driving normally, but with no brakes or reverse. After doing your turn at marshalling take the car back down to the pits and remove the motor. The motor will be hot, but not so hot it can't be held in the hand. Turn the shaft by hand, it should be free moving, just as it came from the packet. The reason for avoiding the use of brakes and reverse is that it causes excessive sparking between the brush and the commutator. At this early stage in a motor's life that will cause damage to the com.

This running-in race will bed in the brushes. Remember to drive the car at top speed where possible, but to accelerate gently at first, harder later, and avoid the brakes and reverse.

Now fit the pinion which gives the recommended ratio for the motor, and drive the second race just as you wish, but still avoiding reverse wherever possible. You will now want to check the race duration (did the cells go flat?) and then adjust the gear ratio accordingly. After your third race, an inspection and cleaning of the brushes/commutator will be needed, that will be dealt with later.

The best way to run-in brushes to my mind requires some investment in equipment. You will need some *Rev-Tec* BCD drops *(SRM Racing)*, some motor cleaning spray (*Reedy, Parma, Demon* etc—check the motor spray section before buying) and a four cell battery pack. Use only four of a normal six cell pack or—like me—four cells from a pack which was overcharged!! Put four drops of BCD down each brush holder, connect the motor correctly to the four cell pack, and leave it to run for about 20-25 minutes. After this time, with the motor still running, squirt three or four short bursts of spray directly into the commutator, allowing the excess to spill onto an old rag—the dining room carpet is not an old rag! Leave the motor to run for another two or three minutes until the spray dries out. There may be quite a bit of sparking during running-in and spraying, but because we are using low voltage (four cells) it causes no harm. Now put a smal drop of oil in each bearing—DON'T FORGET.

Once run-in on the bench, the motor can be fitted with suppressors and leads. The motor can be put straight onto the recommended gear ratio. There is a section on motor gearing containing more information.

Once the motor has been run-in, then normal use will require cleaning and checking of the motor to ensure all is well. The importance of running-in a new motor is paramount, it materially affects the overall life and performance of the motor. Time spent on careful running-in will be handsomely repaid in the future.

Motor installation and usage

With your motor now run-in and ready to race, there are a number of Do's and Dont's which need to be observed for maximum performance. The first Do is always fit at least two suppressors to your motor. Suppressors are small capacitors which reduce sparking between the brush and the commutator. This sparking causes electrical signals to be transmitted which interfere with radios, televisions, etc and that is illegal. Equally important is that they cause interference on your radio control equipment which will eventually damage the receiver or speed controller—or both. Always use ceramic type capacitors which are obtainable from *SRM, Laser, Intronics, Parma, Demon,* and all good model shops. See the picture sequence for fitting details.

When the motor is installed in the car, ensure that the pinion and spur gear mesh correctly. There must always be a small gap between the gear teeth, and they must rotate freely without binding. The motor screws must hold the motor firmly in place, but do not overtighten the screws. The pressure easily exerted on the short arm of an Allen key or small screwdriver is sufficient. Drivers of cars with motors mounted in a plastic gearbox should be especially careful. Modified motors generate a lot of heat and this can allow distortion of the plastic which leads to the motor coming loose. In general do not use motors with less than 23/22 turns in plastic gearboxes, in my experience this is asking for trouble.

Motor wires leading to the speed controller must be soldered to the tags on the brush holder. For conve-

nience one may choose to fit a plug in the motor leads to make removal easier. Always use a 'toolproof' connector (*Tamiya* or Mate 'N Lock) to prevent accidental connection of the motor in reverse—it's been done!! Use substantial motor leads. Silicon insulated leads (*Parma, Demon, MG, SRM,*) are the best. The extra expense is amply repaid in reliability and long service life. Never leave any motor lead wiring exposed. The wires must be fully insulated from the motor to the speed controller. If bare wires touch considerable damage can be caused.

With the motor correctly installed,

There are as many different ways to clean a motor as there are racers

the major causes of damage are heat and dirt. Heat is generated by poor gearboxes and bearings which have excessive friction, and by running the motor on the wrong gear ratio. Dirt is a serious problem in outdoor racing, less so indoors.

The number one mistake made by racers is wrong gear ratio selection. Standard motors have a lot of torque, but not much power. Torque is the ability to overcome inertia, that is to get a weight on the move. Power is the ability to convert the available energy into movement, that is to keep the weight moving. Standard motors get weight moving, and gear ratios around 6.1/2 to 7 to 1 (6.5:1, 7:1) are common. Modified motors have more power and less torque in general, so they need a higher numerical ratio (say 10:1 or 11:1). Modifieds are faster because they can develop more speed (revolutions per minute) and reach that speed quicker.

Because indoor scales (a 1:12th circuit cars) are lighter, and race for longer, the penalty for overgearing is less heavy. Normally the car will be quite fast, but will not last the race as the cells go flat. Outdoor scales (1:10th off-road, 1:10th circuit) use heavier cars which, in muddy conditions, get heavier as they race. The penalty for overgearing can be horrendous; high commutator wear, high brush wear, even desoldering of motor leads. This heat distorts the commutator, reduces the power of the magnets, and lowers motor performance.

One must select the correct gear ratio for each different motor—I cannot over-emphasise this vital factor. Modified motors used in standard kits without changing gear ratio will be badly damaged—expect no sympathy from any model shop if this happens.

Gear ratio selection must also suit track and conditions. On a tight club circuit you will need a higher numerical ratio than for a fast track with long straights and easy turns. When racing outdoors in the wet the car can gain an extra 15% in weight very quickly. If one has chosen a 21 double wind, and the recommended ratio is, say, 9:1 the first task is to select the correct pinion and spur gear to achieve this ratio. Don't be afraid to start a 10:1 and work down, but for optimum performance have gears available for 10:1, 9.5:1, and 9:1. If the car easily lasts the race on 10:1, change to 9.5:1. The object is to finish the race, it is useless to use 9:1 and be very fast only to lose the race on the last lap by going flat.

Wrong gear ratio selection is the major cause for excessive heat. Some motors may last a full race distance but still be too hot to hold in the hand afterwards. Motors in 1:10th off-road cars get very hot, but if they are so hot the motor wires come off, you have got it wrong. Select the right gear ratio and this will not be a problem.

Dirt is not really a problem for indoor racers, but outdoors it can do damage. Whenever possible use a motor boot to protect the endbell unless your car has an all enveloping undertray ('Cat, Maxima' etc). If conditions are dry and dusty, always use a boot.

Motor care and cleaning

Always remove the motor after every race and check that it runs freely without any notchiness in the bearings. There are as many different ways to clean a motor as there are racers, but this advice comes from fifteen years spent in slot-racing, electric boats, and electric cars. The methods are cost effective and simple and have paid dividends in long useful life for all my motors. You will need a box of cotton buds (for those important little places!) a tin of motor spray (see item on sprays) and a bottle of BCD drops by *Rev-Tech (SRM Racing).*

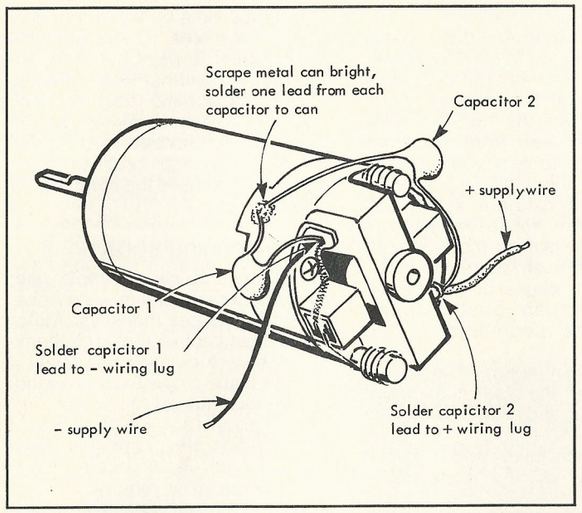
After every race clean the face of the brushes and the commutator. This removes any dirt or oil build-up and prolongs brush life whilst keeping peak performance. Unhook the brush spring from the clip on top of the brush holder, swing it around until the short arm clears the brush holder, and lift it off the post. Put enough spray on the cotton bud for it to be completely soaked. Remove the brush from the holder. Push the cotton bud down the holder until it touches the commutator. Rotate the motor back and forth several times. Remove the bud, it will be black on the end. Wipe the side of the bud across the face of the brush. Soak another bud in spray and repeat for the other brush and holder. It may be necessary to clean the commutator a third or fourth time to remove all dirt. Replace the brushes and springs. After every meeting a more thorough method is needed. Put four or five drops of BCD down each brush and connect to a four cell pack. Leave running for 15 minutes. Whilst the motor is still running, squirt three or four short bursts of spray into the commutator. Leave the motor to run for another few minutes, then disconnect. Again, repeat the cotton bud procedure. The commutator should now be back to its original copper colour. Put one small drop of light oil in the endbell bearing, the motor spray may have removed existing oil.

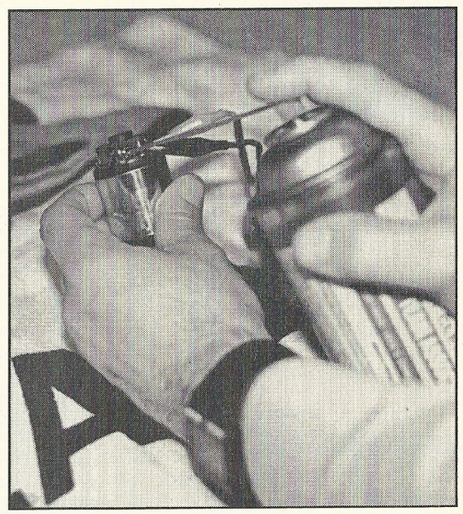
After every two or three meetings, or if the meeting has been wet, it is advisable to dismantle the motor and clean out the can and endbell. Remove the springs and brushes from the holder. Undo the two screws on the endbell which are between the brush holders. Remove the endbell and look into it. One of

Many motors returned to me for repair and rebuild show common damage from misuse of these sticks

the spacer washers from the armature may have stuck to the bearing. Get it out with a small screwdriver or tweezers, and place aside. Hold the commutator and pull the armature out carefully. Again, look into the endbell and remove any spacer washers which may have stuck to the endbell bearing. Place armature and washer/s aside, remember to put the washers aside so it is obvious to which end of the motor they belong.

Clean the can with an old rag wrapped around a finger, if it is really bad use a small paint brush dipped in motor spray to loosen the dirt first, then wipe around with the rag. Use the small brush to remove dirt and copper dust from the endbell. Refit any loose washers to the can end of the armature, and slide it back down the can and into the bearing. Make sure the washers don't fall off, either by holding the armature up, or





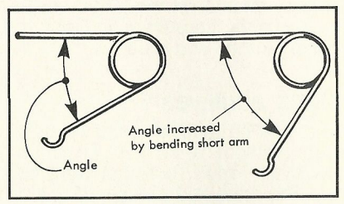
Right: Spray motor cleaner down the brush holder, whilst turning armature—it's not easy!

smearing them with a small drop of oil to 'hold' them onto the stack. Refit the loose washers to the commutator end of the armature shaft and replace the endbell by lining up the cutouts in the retaining ring and endbell. Rotate the endbell until the two scribed marks line up. Tighten the screws gently until firm, don't overtighten.

Use the cotton bud procedure finally and the motor is ready for use. That is the do's—now don'ts. Again, these are the result of experience, so the choice is yours. Commutator cleaning sticks, especially the glass fibre strand type, are not recommended. The copper commutator is soft and easily worn by the glass fibre. Many motors returned to me for repair and rebuild show common damage from misuse of these sticks. The BCD drops method of cleaning is quite sufficient, and eventually it will be impossible to get a bright shiny com without a retrue. Don't let the brushes get more than $\frac{1}{3}$ worn. After this the natural lubricant in the brush has been exhausted, and wear rates increase rapidly. Don't clean the face of the brushes with anything other than the cotton bud. Again, abrasives such as the glass fibre stick will break up the soft surface and cause excessive sparking which accelerates wear. Don't immerse motors in any liquid whilst they are running. This flushes the oil out of the bearings, but not the dirt. Once dry and reoiled, the dirt quickly gets into the bearing tracks and ruins them.

Motor timing

Motors with removable endbells permit the endbell to be rotated relative to the can. This alters the angular



position at which current is passed to the commutator relative to the position of the armature pole in the magnet field. If the endbell is rotated anti-clockwise the motor will have more speed (revs per minute) and draw more current. It is permissible to increase the motor timing up to 3mm from the setting supplied, but the gear ratio must be watched, you may need a numerically higher ratio. This is a complicated facet of motor performance. Mark the position of the endbell with a scribed line. Undo the endbell screws 1 to $1\frac{1}{2}$ turns. Rotate the endbell anti-clockwise about 2mm. Retighten the screws. The motor will be slightly faster. Increasing the timing in this way makes sparking at the brushes more likely, and increases commutator/brush wear. The precise point at which the timing should be is difficult to determine as it depends so much on the individual motor type and wind. In general, up to 2mm will give some useful performance gain, beyond that any gain is offset by high commutator and brush wear. In my experience top drivers rarely adjust motor timing, and when they do sophisticated equipment is used to find the ideal setting—and then the motor is left untouched. Up to 2mm is OK, beyond that is asking for trouble.

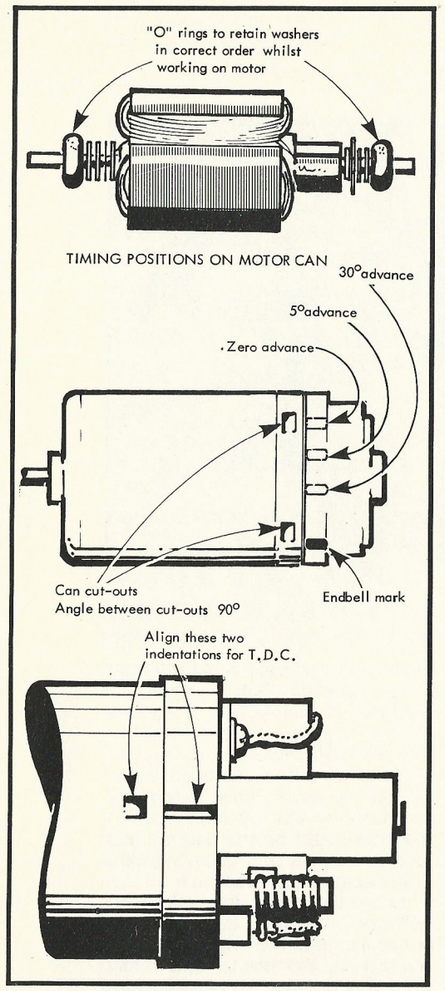
Motor rebuilds

Looking at the assembled motor, identify the major items. Before taking the motor apart, an indelible mark must be made on the cam/endbell joint so that we can reassemble the motor exactly as it was.

Where the plastic (normally) endbell meets the metal cam, choose a convenient point to mark or scribe a line across the plastic and metal. Mark only one line, and make sure it will not be rubbed off or dissolved by cleaners. Personally I always scribe the line with a sharp blade which cuts into the metal and plastic—no mistakes later with this method!

Remove the brush springs and place aside. Carefully withdraw the brushes completely from the holder and leave them 'hanging' by the braid. Undo the endbell screws and gently remove the endbell. A tip here is to only undo the screws $\frac{2}{3}$ turns, rotate the endbell until the keep plate lines up with the cutouts in the cam, and withdraw the whole assembly. If you're unsure how this works, take the screws right out first time and see how the keep plate works, I'm sure you will then see what I mean. Whichever method is used, make sure the keep plate is removed from the cam.

Looking into the endbell one should see the bearing at the far end, and possibly a lot of black or gold dust. Look at the brushes where they contact the commutator. To avoid renewal, brushes should be nicely curved, square to the axis, and reasonably shiny. If they are black on



one edge, pitted, or worn at an angle—replace.

Before cleaning, remove any armature spacer washers stuck to the bearing.

Clean the endbell thoroughly in *Ronsonol* (or similar) lighter petrol to remove all dirt and dust. When reusing the brushes, take care not to knock them about or damage them, if this happens they need to be replaced. Don't worry too much about the ball bearing at this stage. Place the clean endbell aside.

Before removing the armature from the cam (what do you mean you already have!) look at the commutator. The commutator should be reasonably clean and unmarked. If it is very black and covered with sticky black grease then clean it with a cloth and some lighter petrol.

This should restore some clean surface but if this fails a remachining (trueing) operation will help—but all is not lost!

Now remove the spacing washers, and the large nylon or fibre 'oil flinger'. Holding the commutator, remove the armature from the cam. Take the spacing washers off the cam end of the armature and place aside in a separate pile to the others removed so far—check that none have 'stuck' to the bearing in the cam. Clean out the can in lighter petrol, making sure that any small bits of metal are removed from the magnets.

Wash the armature in lighter petrol, taking care not to damage the commutator which is made of soft copper. Dry the armature completely. The major cause of lost performance is brush dust trapped between the segments of the commutator.

Using a thin sharp blade, very carefully insert the blade in each slot near the wires, and draw it away from the stack.

Do not touch the sides of the slot or the face of the commutator segments.

Repeat for each slot and wash the commutator in lighter petrol.

Motor re-assembly is the reverse of dismantling. Make sure that the spacer washers are replaced exactly as they cdame off the armature. Fit new brushes if required, and refit the motor springs and brushes.

Motor additives

No piece on motors would be complete without a section on motor additives—and I wish that were not so. The use and abuse of motor additives could fill a novel. My best advice to the average club competitor is don't use additives. However, you all see the top boys doing it, so I had better tell you how and why simply because you can then get it right. Let it be clear that if you get it wrong, motor performance will drop rapidly and the only cure is a com true and new brushes.

There are three popular motor additives: 'BCD drops' by *Rev-Tech (SRM Racing)* 'Power Plus' by *Trinity (Schumacher)* and 'Reedy-in-a-can' *(SRM, Longshaws, Demon).* 'Power Plus' and 'Reedy' are best applied about five minutes before you race. Put three or four small drops of Power Plus, one or two bursts of Reedy, down each brush holder, and turn the motor over 20 or so times to work the liquid in. Rev-Tech is best applied at least 30 minutes before racing by putting two or three drops down each brush holder and turning the motor over 20 or so times.

Additives attempt to get between the brush face and the commutator to lubricate and close air gaps. However, the additive makes the brush face soft, and as the brush wears and spark, the additive combines with the carbon to leave heavy deposits in the slots between the commutator segments. These deposits cause current to pass between one segment and another which impairs the electromagnetic field in each pole and reduces motor performance. If one chooses to use additives then change brushes more frequently, and have the commutator trued more often.

Motor cleaning sprays

Motor sprays follow a simple rule, you get what you pay for—pay peanuts and you get monkeys. Motor sprays must contain the right chemicals otherwise damage will result. I shall not name those to be avoided, but do recommend those by *Parma—Associated/Reedy—Race prep—Demon.* Never spray at bodyshells or foam motor boats. Never spray directly at anyone. Avoid skin contact whenever possible. Motor sprays are toxic and can harm people, they are designed for cleaning motors.

Use the motor spray on the cotton buds or a rag to remove dirt and grease from inside and outside the motor. Use the spray as shown to remove BCD drops after running on the four cell pack to bed-in brushes or clean the commutator. About three or four short bursts of spray directed straight at the commutator using the tube supplied with be adequate. Hold the motor 'endbell down' to avoid the spray washing through the can.

Non-toxic sprays are coming soon, I have tried one called 'Dans R/C Stuff' which is as good as those mentioned above.

Always put one small drop of oil in each bearing after using motor spray. I mean small. Never re-oil the endbell bearing regularly, oil will leak onto the commutator with disastrous results.

Brush springs

The important aspect of brush springs is that they apply equal tension to each brush. Check this by holding one next to the other and looking at the angle between the short and long arms.

The angle should be equal on both springs. If it is not hold the long arm in a pair of pliers and gently push on the coil to reduce or increase the angle. Some motors are supplied with springs which have an angle of about 70°, others are almost 180°.

The larger the angle, the more pressure the spring exerts on the brush, and the more current will be passed to the motor. This is true up to a point, beyond that point excessive spring pressure will only add to friction losses (and thus generate more heat) for no return in better performance. It is roughly true that for tracks requiring lots of acceleration a higher spring pressure helps, and for long tracks with fast turns a lighter spring pressure reduces friction and helps the motor to turn faster. However, the difference is marginal for 1:10th cars, and needs to be used with care in 1:12th.

As a general hint, I use springs with an angle of at least 90° on all modifieds for 1:12th, but not much more. For 1/10th 90° to 120° is a good compromise. On standard motors always use the spring angle supplied with the motor, but conduct experiments to see if more or less spring angle (and hence pressure) helps. Try to carry spare sets of springs—if one continually bends the long arm it will weaken and break. All springs currently available are good for use in all 'Yokomo' motors.

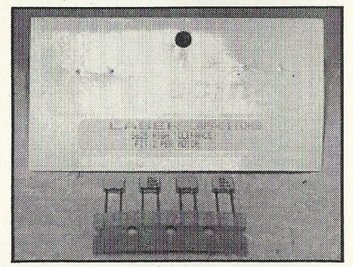
Motor brushes

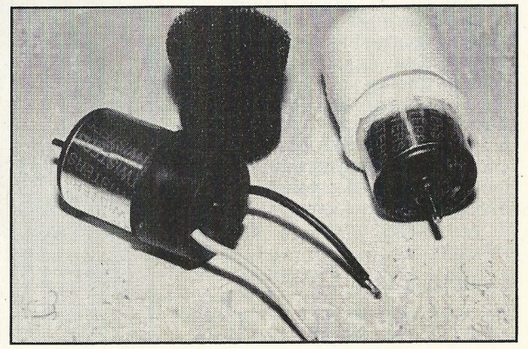
Had this been written six months ago this section would have been easy. However, recent developments in brushes have made life a little complicated, and with more development to come I can only suggest that you keep your eyes on Model Cars magazine for updates.

The motor brush is the vital link in the motor equation since it is the humble brush which passes—or doesn't as the case may be—all the current from the speed controller to the commutator. If the brush is worn, dirty or incorrectly fitted then the motor will not perform. On acceleration the brush must pass up to 60 or 70 amps momentarily, and on average through a race about 10-15 amps in off road, and about 8-10 amps in 1:12th circuit. A single bar electric fire uses about 4-5 amps continuously and although it uses wire specifically designed to emit heat, you have some idea of the task involved.

For long motor life and consistent performance it is best to regard motor brushes as consumable items. Serious club competitors should change brushes every two or three meetings at least—two if conditions were wet or dusty, three if conditions are good—or the equivalent of 8-12 races for a given motor if you use more than one motor at a meeting. Club members who are cost conscious could stretch this to four meetings or when the brushes are 1/3 worn. Before you see £ signs in front of the eyes, let's put that in perspective.

Below: SRM motor cooling plate. Centre: Capacitors which need to be placed on all motors. Bottom left: The equipment required to keep a motor in good running condition. Bottom right: Rubber or foam boots used to protect the business ends of motors.





Say you race every weekend ("I race every weekend Pete") and you travel only ten miles each way to get there in a family car. After four meetings you have done 80 miles or about 3 gallons of petrol, cost £5.25. You may have bought some spares, new tyres and even some new goodies for the model car. A new pair of motor brushes cost about £2.50, less then half the petrol money, and perhaps a fraction of other R/C car expenditure. Regular changing of brushes plus the occasional com true/rebuild adds up to "not a lot" in comparison with overall costs, yet it can prolong motor life three or four times.

The best advice is to replace brushes with original manufacturers equipment. However, I do not think any manufacturer, distributor, or model shop would argue that brushes sold under the *Parma* or *Associated* label are good and will suit any 'Yokomo' motor. There are two basic types of brush, those for standard motors, and those for modifieds.

Standard motor brushes are quite soft and have a bright copper colour with copper coloured shunts. Modified brushes are dark in colour and more commonly have silvered coloured shunts. Recent experiments with a new brush called the 'Ultra' by *Associated* have proved highly successful and these can be recommended for standard motors and 1:12th modifieds. The wear rate in 1:10th modified motors is not known so I suggest if you do try them in 1:10th watch the wear, you may end up changing them more frequently.

Motor performance can be improved by soldering brushes directly to the holders, or to the tag which must in turn be soldered to the brush holder. Use at least a 40 watt iron, and run solder across the edge of the screw onto the holder. Cut the shunt off the tag, and resolder to the tag. Most replacement brushes come without tags, and need to be

soldered on when replaced. There are a range of 'cut' brushes available. These have the width of the brush face reduced by machining. This prevents brush overlap and minimises sparking. They are worth trying in certain applications, but they are expensive. My general advice is that if you want to try cut brushes in a motor buy them, but don't file brushes yourself.

Many motors received for repair have brushes fitted which are filed by hand. This reduces the contact area which means that more current is passing through a smaller area. Although this reduces friction, it increases heat generated. At the highest competitive level skilled motor builders can, and do, cut brushes to achieve certain effects. In my time in the RC cars I have not been able to master this technique, and have obtained better results by keeping motors clean, adjusting gear ratios, or adjusting motor timing. I commend this approach to club racers as the more economic way of getting good performance.

Check the brush face carefully when it is cleaned after every race. If there are signs of deep score marks (light scoring is almost inevitable in outdoor racing) or pitting in the middle of the brush then dirt has got in and the brush should be changed. Always change brushes in pairs. These deep score marks may be present in the commutator as well, and a retrue is advisable. Brushes may become chipped on one edge, or have a dark black line. This is normal and unless severe can be ignored. Note also that the brush on the positive side of the motor always wears faster and worse than the brush on the negative side. When checking your wear and damage always look at the 'positive' brush more critically. Yes, you can swop brushes from positive to negative, but the saving is not great.

Brushes must slide freely in the holder. Another reason for removal and cleaning after every race is that the cotton bud pushed down the brush holder to touch the commutator also cleans dirt out of the holder. If there is any binding check for the cause and remove it. If brushes do not slide freely they will bind, and then motor performance drops rapidly. If for any reason the holder becomes distorted (when you drop the motor!!) it may be carefully straightened with a pair of long nosed pliers. If in doubt, return to a motor rebuilder.

Conclusions

Horsepower is not the be all and end all of R/C car performance. Choose your motors carefully and look after them well. It is better to buy two motors and spend a little more on care and maintenance than it is to buy three and have no money left for spray, cotton buds etc. I travel to quite a few meetings up and down the country, please do not be afraid to come and ask if I can be of help. Lastly, a list of Do's and Don'ts.

Do run in the new motor carefully on track or on bench
Do clean the brushes and commutator after every race with cotton bud soaked in spray.
Do clean the motor thoroughly by running on the four cell pack with *Rev-Tech* followed by careful cleaning with cloth and cotton bud, after every meeting.
Do fit capacitors to the motor
Do select the correct gear ratio for the motor and ensure good gear mesh and minimal drive train friction
Do regularly replace motor brushes
Do send you motor for rebuild every 20/30 runs—it pays off.
Do oil the bearings with one small drop after every meeting.
Do use motor additives sparingly or not at all
Don't use a new motor in a car at full power straight away
Don't immerse the motor in any liquid for cleaning, or forget to clean
Don't expect any sympathy if you forget to fit capacitors
Don't put a modified motor in a kit without changing gear ratio
Don't run a car with stiff gearboxes or dirty/seized bearings
Don't run brushes more than $\frac{1}{3}$ worn
Don't run a motor on and on and expect good performance
Don't oil bearings excessively, oil gets on the com and ruins brushes/commutator
Don't pour quantities of additive into a motor to make it faster, it will not. I am continually surprised by the number of people who spend large sums of money on motors, but never look after them. No one questions care and time taken to keep the gearbox, bearings, and suspension of a car in good condition. No one should question the need for motor care. Look after your motor, and it will look after you. Remember that you may have the fastest car on the track, but if you can't match the skill of your competitors, then you will be the loser. Far better to have a well set-up car powered by a motor you can handle and rely on.

Good luck — keep motoring!!

Available Electric Motors, Suppliers and Specifications

NAME		WIND	SUITABILITY	PRICE	SUPPLIER	COMMENTS
e.g. Cyclone		20 Double	1/10 4/2WD	£39.99	10:1 4WD 9:1 2WD	Suited to high traction surface
TWISTER	201	21 Double	2WD 1/10	£40.00	SRM	2WD World Champs TQ Motor
	202	19 Double	2WD 1/10	£40.00		2WD more punch, high grip, light gauge wire
	401	19 Double	4WD 1/10	£40.00		4WD smooth and fast all rounder, heavy gauge
	402	17 Double	4WD 1/10	£40.00		4WD extra acceleration
	501	16 Double	4WD 1/10	£40.00		4WD very fast, punchy, good nicads req'd
	501T	16 Triple	4WD 1/10	£40.00		4WD International winner, good all round
	701	15 Double	4WD 1/10 Titan	£40.00		4WD gear low—belt stretcher!
	702	14 Single	2WD 1/10 Titan	£40.00		2WD very fast, ratio critical, good with SCE's
	704	17 Triple	2WD/4WD 1/10 Titan	£40.00		2WD/4WD, very fast SCR motor
TWISTER	727	27 Double	1/12 circuit	£40.00	SRM	Smooth and fast
	747	27 Quad	1/12 circuit	£40.00		Punch and speed
	726	26 Double	1/12 circuit	£40.00		New short track motor
SCORCHER		27 Single	1/10 2WD/4WD	£15.00	SRM	BRCA standard motor, AYK type, 20° can advance
SCORCHER PLUS		27 Single	2WD/4WD	£15.00	SRM	BRCA standard motor, AYK type, 20° can advance and better mags
SCREAMER		27 Single	2WD/4WD 1/10	£15.00	SRM	BRCA standard motor, Yokomo type 16° advance 'Esprit'
TWISTER 802/804		27 Single	2WD/4WD 1/10	£15.00	SRM	BRCA standard motor, Blueprinted Yokomo 'Esprit' motor
		35 Single	1/12 circuit	£13.50		BRCA standard motor
		27 Single	1/10 2WD/4WD	£13.50		As above
22TR		27 Single	2WD	£15.00	SRM	Low cost graphite bearinged modified motor
19 TR		19 Single	2WD/4WD	£15.00	SRM	As above
		26 Double	1/12 circuit	£25.00		
		22 Double		£25.00		Popular all rounder
		21 Triple		£25.00		2WD performance motor
		20 Triple		£25.00		Powerful fast club motor
		20 Quad		£25.00		High efficiency race motor
		19 Double		£25.00		Medium size track fast motor
		18 Triple		£25.00		Medium track with long straight
		18 Quad		£25.00		High speed and torque motor
		17 Quad		£25.00		Medium torque high speed motor
		16 Double		£25.00		Fast torque motor for all tracks
		15 Double		£25.00		High speed high torque motor
		15 Triple		£25.00		High speed medium torque motor
		14 Quad		£25.00		Fastest track motor with efficiency
2002 Sprint		16 Single	1/10 4WD	£40.00	Lesro	Good all rounder
2003 Enduro		19 Double	1/10 4WD	£40.00	Lesro	Good in sticky conditions, suits hotshot
2004 Pure Gold		18 Double	1/10 2WD/4WD	£40.00	Lesro	Good on dusty/loose surfaces
2005 Oval		15 Double	1/10 4WD	£40.00	Lesro	Good on grippy surfaces
2006 Turbo Blast		20 Double	1/10 2WD/4WD	£29.96	Lesro	Machine wound motor, good club racing performer
2007 Drag		14 Double	1/10 2WD/4WD	£40.00	Lesro	Drag race motor, can last 5 mins on 4WD/2WD with low gearing
2008 Pavement Oval		16 Double	1/10 4WD	£40.00	Lesro	Good in 4WD with high grip
2009 Pavement Oval Jim Davis		15 Single	1/10 4WD	£40.00	Lesro	Good in 4WD with high grip and long straights
2010 Oval Blast		19 Double	1/10 2WD/4WD	£29.26	Lesro	Machine wound motor, slightly more torque than 2006
2011 Joel Johnson Signature		17 Triple	1/10 2WD	£40.00	Lesro	2WD Ifmar World Champions motor as used by Joel Johnson
2000 Stock Motor		28 Single	1/10 2WD/4WD	£5.00	Lesro	BRCA legal standard motor
1007 Double		23 Double	1/12 circuit	£40.00	Lesro	Small tracks, tight turns
1008 Triple		24 Triple	1/12 Circuit	£40.00	Lesro	Medium tracks, average corners
1009 Quad		24 Quad	1/12 circuit	£40.00	Lesro	Large tracks, fast corners
1011 Single		21 Single	1/12 circuit	£40.00	Lesro	Very small tracks, tight corners
14004 *		23 Double	1/12 circuit	£39.95	Parma	‡ 6 cell carpet
14007 *		24 Double	1/12 circuit	£39.95	Parma	‡ 6 cell ashphalt
14010		19 Double	1/10 2WD	£39.95	Parma	‡ Off-Road 6 cell
14013 *		20 Double	1/10 2WD	£39.95	Parma	‡ Off-Road 7 cell
14016 *		15 Quad	1/10 4WD	£39.95	Parma	‡ Off-Road 6 cell
14019 *		17 Quad	1/10 4WD	£39.95	Parma	‡ Off-Road 7 cell
14022		28 Single	1/10 4WD/2WD	£14.50	Parma	‡ BRCA legal standard motor
14023		27 Single	1/10 4WD/2WD	£14.50	Parma	‡ BRCA legal standard motor
14025		16 Double	1/10 4WD	£39.95	Parma	‡ Oval Motor
14028		15 Double	1/10 4WD	£39.95	Parma	‡ Drag Motor
Jerobee		35 single	1/12 circuit	£13.50	MG Model Products	BRCA legal standard motor
Brown Dot		27 Single	1/10 2WD/4WD	£15.00	MG Model Products	BRCA legal standard motor
Red Dot		18 Sing;e 20 Single 17 Double 19 Double	1/10 2WD/4WD	£15.00	MG Model Products	Same construction as Brown Dot but choice of wind—please specify
Red Dot 'Plus'		18 Single 20 Single 27 Single 17 Double 19 Double	1/10 2WD/4WD	£27.95	MG Model Products	New spec for 1988, includes ballraces and removable endbell
Magnum		From 15 Double to 26 quad	1/10 2WD/4WD and 1/12 circuit	£39.95	MG Model Products	Magnum armatures hand wound to order, also available from stock. Specify 2WD or 4WD. Special winds by arrangement
G610 Red Dot		17 Quad	1/10 4WD	£40.00	Schumacher	Associated/Reedy, very hot, very punchy
G611 Gold dot		19 Quad	1/10 4WD	£40.00	Schumacher	Associated/Reedy, Punch with speed
G612 Silver Dot		21 Double	1/10 2WD/4WD	£40.00	Schumacher	Associated/Reedy, smooth and fast
G613 Green dot		23 Quad	1/12 circuit	£40.00	Schumacher	Associated/Reedy, world wind—1/12 World Champion
G614 Red Heat		17 Turn	1/10	£29.50	Schumacher	'Esprit' Motor, ballraced etc, very hot, very punchy
G615 Gold Rush		19 Turn	1/10	£29.50	Schumacher	'Esprit' motor, ballraced etc, high speed with punch
G616 Quick Silver		21 Turn	1/10	£29.50	Schumacher	'Esprit' motor, ballraced etc, very fast and smooth
G600		35 single	1/12 circuit	£12.00	Schumacher	BRCA Standard Motor
G601		27 Single	1/10 2WD/4WD	£12.00	Schumacher	BRCA Standard Motor
G603				£12.00	Schumacher	Spirit 600 standard motor

* Note: Motors available in Yokomo, Cyclone, and 'K' construction styles (Yokomo part number shown)
‡ Helger Racing note that 'all motors are applicable to any form of racing'