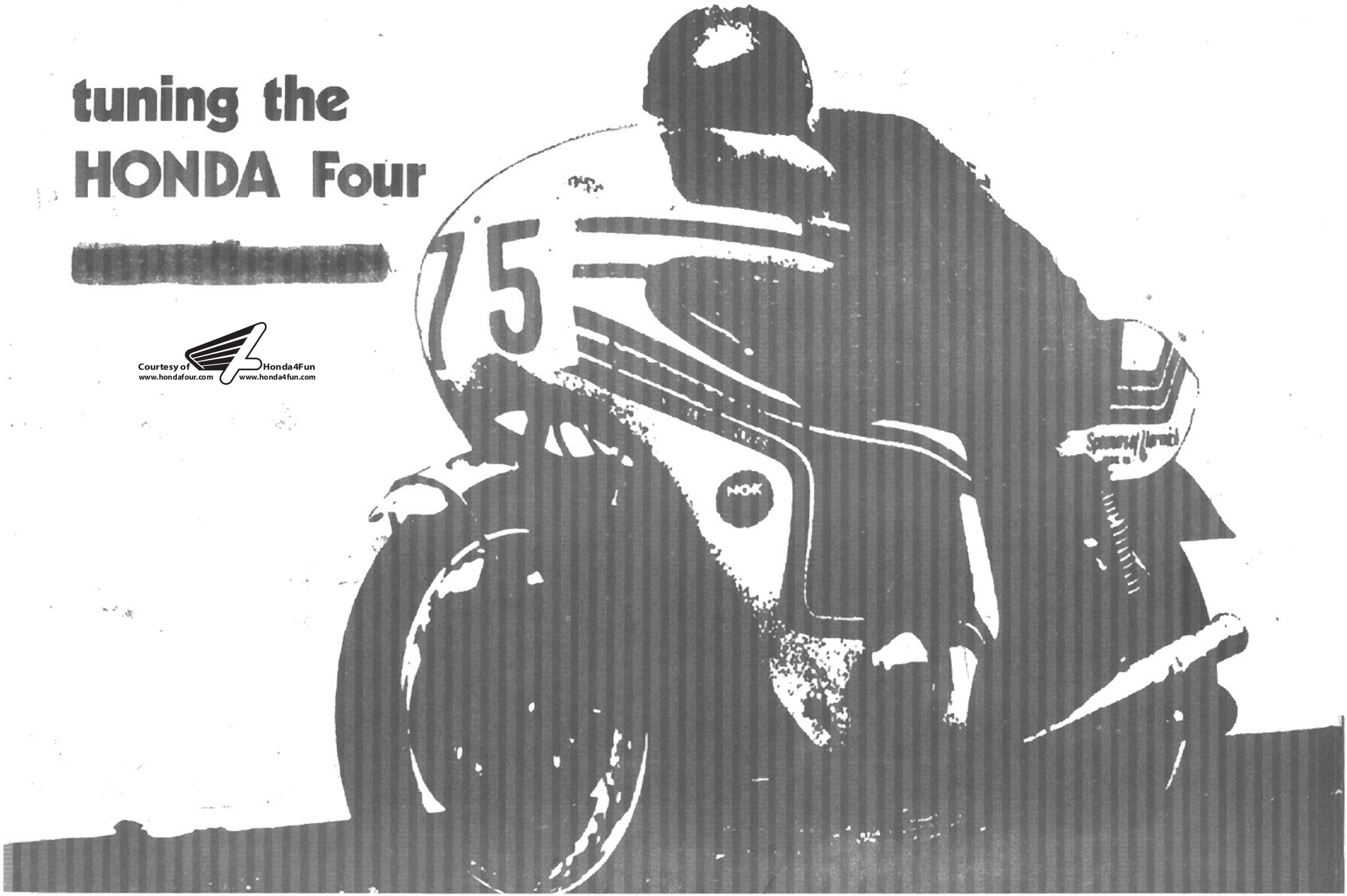
tuning the HONDA Four



This book aims to show how to improve the perrormance of Honda Four motorcycles for road racing. In addition, each chapter shows what tuning can be carried out without making a bike unsuitable for road use.

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MODELS COVERED

CB350 Four	bore/stroke - 47/50 five speed wet sump lubrication 34 b.h.p. at 8000
CB400 Four	bore/stroke - 51/50 six speed wet sump lubrication 37 b.h.p. at 8500
CB500 Four	bore/stroke - 56/50.6 wet sump lubrication five speed 50 b.h.p. at 9000
CB550 Four	bore/stroke - 58.5/50.6 five speed wet sump lubrication 50 b.h p. at 8000
CB750 Four	bore/stroke - 61/63 five speed dry sump lubrication 67 b.h.p. at 8500

Chapter 1 - Racing a Honda Four

The road Honda fours were not the instant success on the racetrack that many of us had anticipated. They tended to be heavier and bulkier than other race machinery and they produced nothing like the huge amounts of power of the 'works' fours of Hailwood's days. And this is not surprising - Honda designed these bikes for luxury touring, not for racing; and as usual Honda made the bike just right for its intended purpose.

The road four engines have remarkably little in common with the earlier racers. They have plain bearing cranks instead of pressed up roller bearing ones, and are only single overhead cam. So before you decide to tune your bike for racing, and try to take on allcomers, make sure your bike stands a chance in the class you have in mind:-

350 open Very few 350 fours are available in this country and there is no way that you will beat the Yamaha TZ350s on a road four. You would need a very special motor in a light chassis - very expensive , and even then not a proven proposition. Only limited tuning parts are available for 350 fours.

350 production One or two clubs run a 350 production class offering a good opportunity for the 350 four. You'll be up against Yamaha RD350s which are very quick. But the 500 four is successful in production events, so why not the 350?

500 open A few 500 fours in special frame kits compete in the 500 cc events, again bettered by TZ350s. A far better idea is to compete in the ' 4-strokes only ' races that are becoming popular with many clubs. A well prepared Honda is a match for Seeleys and Manxes.

500 production This is by far the most successful class for Honda fours. The mild tuning allowable in production racing releases enough power for the 400 or 500 fours to keep up with the opposition and the easy starting and steady handling give the Honda the edge.

Unlimited open Here the opposition really does get stiff - Yamaha TZ750s , Suzuki RG500s etc. and few Hondas can keep up. But,since Honda's involvement in endurance racing it has become clear that the full potential of the fours is astounding'. Make no mistake the new 'works" Hondas are very special and painstakingly prepared.

It is now a serious proposition to build a 750 four for open slass racing with big bore kit, twin cam head tuning goodies and, just as important , the know-how now available.

Unlimited production Recently big-bore production Hondas have scored successes at all levels of competition. Personally, I can't see how a big-bore Honda can possibly be legal - but I don't make the rules.

Many tuning parts and mods. outlined in these pages are suitable for production racing bikes, but at all times you must check to see if you are breaking general production or homologation rules.

The more power you extract from an engine, the more load there will be on all internal components. Get hold of a workshop manual, strip your engine and check that all parts are well within the manufacturers tolerances.

Crankshaft The Honda four crankshaft does not look very special. But it is special - the average plain bearing crank like the one in most saloon cars, could not stand the 11,000 revs plus that many racers torture their cranks with. Partly, the cranks are special in their design and partly in their very tight tolerances. These tolerances are measured in microns (thousandths of millimetre) and if you have any more than a little wear, you're in trouble. Some bearing wear can be taken up by fitting a different grade of shell - this is not recommended by Honda and it is advisable to put this work in the hands of a specialist who is prepared to guarantee his work.

Replacement shells are ordered by quoting the various letters and numbers on the crankcases, crankshaft and con rods. These numbers are stamped on by Hondas after very accurate measurements have been taken.

Cam chain and tensioner If the cam chain breaks the damage can be expensive, let alone the expense and frustration of lost racing. So replace these components very regularly indeed.

Some hints

- Use a high quality jointing compound (like Hylomar or Wellseal) to stop head gasket weeping
- Replace all engine and gearbox seals regularly or they may fail
- Make sure that you have the clutch plates round the right way or they'll slip
- Do not overtighten the rockerbox retaining screws

Chapter 3 - Principles of tuning

There are two major aspects of engine tuning : improved cylinder filling and higher revs. At all times bear in mind the problems of ' over-tuning ' ; narrow power band, too narrow for the ratios available, power band at too high revs for reliability, overstressing of crankshaft and con rods etc.

Camshafts The camshaft has the most dramatic effect on performance of any component as it determines the basic power characteristics of the engine. Of course the cam won't work in isolation and must be matched to an exhaust system 'tuned' to the same revs.
On the other hand it is sometimes possible to 'detune' an engine fitted with too 'hairy' a cam, by matching it to an exhaust of a lower (not too low) rev range.
Choose the cam to suit the use and revs of your bike (see Chapter 5).

Compression ratio Increasing the compression ratio will give increased power throughout the rev range. The limits of this improvement are : 1, the very damaging 'pinking' if the compression ratio is too high and 2, the extra load on engine components, most important the crank.

Gas flow Improvements in gas flow have two effects on performance. 1, the better gas flow allows more mixture into the cylinder each engine rev and therefore, more power and 2, the faster flow allows the engine to breath at higher revs, rather like a 'hairier" camshaft, with increased b.h.p. at high revs.

Valves The standard valves are perfectly O.K. for all states of tune. The only time you will need bigger valves is when the port size is increased until a decent valve seating cannot be obtained. Lighten the valves by turning metal out of the heads where the original screwdriver slots are machined.

Valve springs Again, the standard springs are good enough for the extra revs of racing. If you fit a full race camshaft, different springs may be specified; always fit these or you will wreck the camshaft.

Porting improvements This is one area where the work is much better left to a specialist. Not because porting mods are difficult but because Honda heads are expensive. One mistake could cost dear.

There are mods. that are safe to carry out, though:

1. Smooth out the ports, removing roughness and casting marks. Don't polish the port walls
2. Remove the bottom portion of the valve guides where they protrude into the ports.
3. Reduce in height, and knife-edge, the ridge that runs along the top of the inlet port toward the guide.

Experts in Honda head porting are Dixon's, SS Performance and Gordon Russell.

Larger ports *The Honda heads only lend themselves to* modest increase in port size. If you are planning vast performance changes, you will find it necessary to fit a special head such as the Piper one.

Chapter 5 - Camshafts

Choosing your cam There are three basic types of cam profile produced for Honda fours: standard, the original Honda fitment

road/track, performance cams designed to fit with minimum alterations

full race, cams designed to produce maximum power from a four, within the limits of maximum revs and other constructional restraints of the basic engine.

In general, you wont go wrong if you fit the camshaft recommended by the camshaft manufacturer for the type of racing or road use that you require.

But life isn't that simple; a lot of bikes go surprisingly well with standard cams, the extra power being derived from other forms of tuning, such as gas flow, compression ratio,etc. And, many road bikes are successfully run on race cams; the worst features of very narrow power band being suppressed by the stock exhaust system. For racing the narrowness of power band that you can tolerate is determined by the closeness of the gear ratios, and time wasted with too many gear changes.

Fitting a performance camshaft. Performance camshafts differ from standard ones in the amount of lift (not a lot with Hondas) and the duration of valve opening time. Therefore the valves are going to behave in a different way to before. Always make sure that:

1. The valve to piston clearance never becomes less than .070 in. Increase clearance by deepening the valve pockets.in the pistons
2. The valve springs never become less than .050 in from coil bound at full lift. Special springs are available for cams with appreciably more lift
3. The cam manufacturer's recommendation for the modification of other components is carried out.

Timing the camshaft. The original coarse timing arrangement for standard cams will not always be O·K· for performance cams. The only way to be sure is to attach a timing disc (there's one at the back of this book) to the crankshaft and record the actual timing figures of your cam. Typical timing figures are given in Table 1. Alterations in timing are achieved by elongating the holes in the camshaft sprocket so altering the relation

Chapter 6- - Compression ratio and pistons

There are three ways of increasing the compression ratio of your Honda : -

1. By fitting high compression pistons
2. By planing the cylinder head
3. By fitting longer con rods, available for some Hondas from Yoshimura distributors

High compression pistons All suppliers of tuning goodies can offer high compression pistons for popular models. These should fit your engine without modifications; deeper valve pockets already a feature.

Give preference to high compression pistons that bear genuine Honda casting marks - nobody knows Hondas like Honda. Also watch out for rings, some pistons use the original rings, some don't. Remember Honda rings are expensive and you may not want to discard your old ones.

If you have already raised the compression ratio by another means check the piston to valve clearance (no less than .o7o in) and make sure the pistons don't strike the head at full revs.

Planing the cylinder head. Very little metal can be planed from Honda four heads. A typical amount is .030 in giving a compression ratio increase of approx. 1:1 for all models except 750s (approx .75:1 increase).

Longer con rods A lot of people were very surprised to find that their very expensive aluminium con rods were 1mm longer than they should be. No they hadn't stretched, these rods were deliberately longer to raise the compression ratio. A very natty idea, but shouldn't somebody have been told. Again, check piston to valve and head clearances with these rods.

between the sprocket and the cam.

It is unlikely that you will achieve figures exactly the same as the manufacturer quotes.; always aim to 'split" the timing figures of the inlet cam either side of the manufacturer's figures. For example, it the manufacturer quotes 20^{o} and 50^{o} for inlet opening and closing, and you measure 21^{o} and 53^{o}, move the camshaft in relation to the sprocket until you can measure 19^{o} and 51^{o}.

Most performance cams work better with advanced ignition timing, again the manufacturer will specify. In general the increase is in the order of 10^{o}. As well as this , Honda racing cams dictate the use of larger main jets.

Table 1 Some typical cam profiles

	Inlet opens (BTDC)	Inlet closes (ABDC)	Exhaust opens (BBDC)	Exhaust closes (ATDC)
Standard (750)	5^{o}	30^{o}	35^{o}	5^{o}
Road/track (500)	20^{o}	50^{o}	50^{o}	18^{o}
Full race (500)	25^{o}	55^{o}	55^{o}	22^{o}

Into the unknown

The Honda that is capable of taking on TZ Yamahas will be revving to 15,000, will have a pressed-up crank and will require a special cam to get the engine to breath at these revs.

Chapter 9 - Lubrication

Oil — Always use 'R' or a mineral racing oil. If these prove to thick, use straight grades of engine oil such as Castrol CR130. I have found that multigrades will not survive racing in air cooled motorcycle engines.

If you are changing over to 'R', the complete engine must be stripped and every trace of mineral oil removed.

Oil coolers — Oil coolers are a really good idea for long distance racing, though a waste of time for six-lap scratches.

Fitting an oil cooler is a bit tricky on the wet sump models, you will need one of the special adaptor plates that fit behind the oil filter to provide the pickup points to the cooler. The 750s are much easier, being dry sump, all you have to do is tap in to the existing plumbing.

Chapter 10 - Big bore conversions

Big bore conversions provide the simplest method of increasing power, and are available for 500 and 750 motors. A big bore kit is essential for open class racing; the nearer you can get to 1000cc the better.

The manufacturer should have sorted out all the fitting problems; make sure he gives you detailed instructions. The most difficult job is machining out of the crankcase mouths to allow in the bigger cylinders.

Bigger carbs Any increase in performance of an engine should be matched to an increase in carburettor choke size. Of course you won't be able to do this on production racing machines - it just ain't legal.

As with all tuning don't overdo the carb size increase - if you have a bike in only a mild state of tune, use a carb only a little bigger than standard. Too big a carb will make the engine inflexible without any substantial gain at high revs.

There are two types of big carbs suited for tuned Hondas:

1. Keihin racing carbs - these are specially designed for the job are available in all the right sizes and are very expensive
2. Amal MkII concentrics - much cheaper , easy to tune and very compact.

Tuning carbs Whatever tuning you do, even if it only involves throwing away the air cleaner element and relieving the silencers, will involve carb rejetting. As a rough guide small throttle openings up to 1/8th are controlled by the pilot jet. Engine pickup with throttle openings 1/8th to 1/4 is controlled by the cutaway of the throttle slides. From 1/4 to 3/4 throttle the needle position determines the mixture and , of course. full throttle mixture is set by the main jet.

Always start your tuning from the top down - main jet first - and work your way down. The most accurate way of checking the mixture is by plug chops,- rapidly cutting the engine after a sustained run at the suspect throttle opening and checking the colour of the plugs.

Chapter 7 - The exhaust system

Theory The exhaust system is only right for a given engine, when, at a selected number of revs (usually, the middle of the useful rev range) the "slug" of gases released when the exhaust valve first opens travels the length of the exhaust system, gets reflected back, and the resultant "negative" pressure pulse reaches the cylinder with the cylinder at top dead centre. The formula for working this out involves the time it takes for the pulse to travel up and back the exhaust AND the length of time between exhaust valve opening and top dead centre at the specified engine speed

Length of exhaust times two = speed of gases (approx. 1500 ft/sec) X proportion of engine cycle EO to TDC X time of one engine rev

so:-

$$2 \times \text{length(ft)} = 1500\,(\text{ft/sec}) \times \frac{\text{EO(BBDC)} + 180}{360} \times \frac{1 \times 60\,(\text{sec/min})}{\text{A000 (revs)}}$$

no of

for example - if the exhaust opens (EO) at 50° BBDC and the selected engine revs are 10,000, the straight pipe exhaust length (L) is given by :

$$2L = 1500 \times \left(\frac{50+180}{360}\right) \times \frac{60}{10000}, \quad L = 2.875\text{ft}$$

Of course striaght pipes don't give maximum power; for this we need megaphones with shorter systems than for straights as the gas flow is slower. The actual speed depends on the 'fatness' of the megaphone - so too does the amount of the megaphone effect. For a wide power band use a shallow megaphone cone angle and a total length about 10% less than for straight pipe.

Four-into-1 exhausts Siamesed , four-into-1 exhausts are becoming popular for Hondas, not just because they work very well , but also because they work out cheaper than genuine Honda replacements. Typical dimensions are 34 inches from head to junction and 27 inch long megaphone.

The standard system. The standard ignition system is adequate up to the maximum revs that the crank is good for. But there are some sources of unreliability:

1. The points. Replace these regularly, and not only after the misfires - that's too late
2. The plug caps. Throw these away and fit good ones, preferably the Champion or NGK racing ones.

Electronic ignition. The Boyer electronic ignition is excellant, it is extremely reliable, maintains its timing indefinitely and is very easy to fit.
Lucas RITA ignition is also available for Honda fours but is not yet so well proven as the Boyer.

Self-generating ignition. 2-stroke racers often use the Krober self-generating electronic ignition systems which dispense with the battery and charging system as well as the points. I know of no such system for 4-strokes. If you want to lose the weight of the battery and the power consumption of the alternator, the only solution at present is the Yoshimura magneto.
When you remove the alternator to fit a Yoshi mag or a total-loss battery powered system, make sure you find an alternative method of securing crankcase oilway blanking plugs normally held in by the alternator casing.

Spark plugs. Honda four plugs are 12mm , long reach plugs. Champion and NGK produce a range of plugs suitable for fast road and racing uses:

NGK	CHAMPION (Gold Palladium)
D8ES	R-61G
D9ES	R-59G
D10ES	R-57G

Chapter 12 - Gears and gearing

There are two ways of altering the gearing of your Honda:

1. The overall gearing can be changed by selecting a combination of gearbox and rear wheel sprockets. Table 1 shows the final ratios available for commonly available sprockets
2. The intermediate gearing can only be changed by fitting a close ratio gear cluster available for certain models from Yoshimura

The overall gear ratio between engine and back wheel is determined by the combination of primary ratio (between crank and gearbox), intermediate ratios of the gears, and final ratio between gearbox and rear wheel sprockets. Table 2 shows primary and intermediate ratios for all models.

For circuit racing gear the bike to reach maximum revs in top gear just before the braking point at the end of the longest straight. On the road , the engine will last longer if geared less revvy than for racing.

Table 1 - final gear ratios

Gearbox sprocket	Rear wheel sprocket..... 34	36	38	40	42	44
16	2.13	2.25	2.38	2.50	2.63	2.75
17	2.00	2.12	2.30	2.35	2.47	2.59
18	1.89	2.00	2.11	2.22	2.33	2.44

Table 2 - intermediate ratios

	350	400	500	550	750
Primary	3.423	3.442	2.000	3.062	1.708
1st	2.733	2.733	2.353	2.35	2.500
2nd	1.850	1.800	1.636	1.63	1.708
3rd	1.416	1.375	1.269	1.27	1.333
4th	1.148	1.111	1.036	1.03	1.097
5th	0.965	0.965	0.900	0.90	0.939
6th		0.866			

Front suspension Front springs of different poundage are not readily available - your best bet, if the standard ones don't suit is to fit springs of a bike of a different weight. The damping of the forks can be altered by the selection of fork oil. In ascending order of damping effect - TQF (car automatic transmission fluid), fork oil, Castrolite. 20-50 engine oil.
The S and W performance damping kit will improve the damping dramatically and is easily fitted to all models.

Rear suspension Japanese dampers have earned a bad name in this country, only providing light damping, and then wearing out rather fast. Use KONI or GIRLING units of the type recommended by these manufacturers for your model. Usually you will find the original spring poundages too hard, these being designed with a pillion in mind.

The frame The handling of a bike can be ruined if the frame is twisted or out of alignment in any way. These faults are not difficult to detect with a piece of string and a good eye. Basically, misalignment will show itself by making the wheels point in different directions - and that's not just front to back, but vertical misalignment as well. Front to back misalignment can be corrected by altering the setting of the chain tensioning adjusters on the rear wheel spindle. Vertical misalignment is a bit more tricky - remove small misalignment by heaving on a bar put through the wheel spindle slots in the swinging arm. But if the misalignment is severe then you've got a bent frame or swinging arm and the only cure is replacement.
Check the swinging arm bushes and the steering head races for wear - apart from that there's nothing to go wrong.

Improving the standard frame The standard road frame shows two weaknesses during racing:-

1. Swinging arm. The standard swinging arm flexes under severe acceleration and causes weaving.It is not easy to strengthen the original swingarm, better start from scratch. Build up from sturdy

box section, with gussetting that follows the line of the tyre section. Commercially made high performance swingarms are available for Hondas

2. The steering head stock. Bad handling both at speed and under braking can be caused by steering head flexure. A racing Honda is a fast, heavy machine, and the loads put on the steering head are phenomenal. The head should be braced with additional frame tubes that spread the load over as large a part of the frame as possible

Special frames There are two basic reasons for rejecting the standard frame - strength and weight - and these two may not go hand in hand. If you are racing an over-bored 750 producing over 100 b.h.p.with double front discs, then go for a strong frame with massive swingarm and well braced steering head. But if you have a 500 or smaller four, the greatest consideration will have to be weight. A lot of good frames are made for Hondas, such as Seeley, Rob North, Vendetta - but, in all cases discuss with the frame builder the type of use and the engine power that the frame will have to put up with.

Brakes Brakes are no problem for Honda fours. All models can be converted from single front disc to two, and this is even allowable for production racing. In addition Ferodo manufacture a range of performance pads for all models.

Converting to twin discs *This is easy for most models,* slightly difficult for 500s. 500s have different left and right fork sliders. If you fit two brake side legs, it works, but looks a little odd. Yoshimura legs solve this, but are a little dear. With other models, fitting double discs simply involves bolting on the extra components. In all cases the standard master cylinder will be spongy with two discs. To get the brake firm, fit the GOLD WING master cylinder.

The rear brake The standard rear brake is good enough for most machines and circuits. If you want the ultimate, fit the rear disc from an F1 750