CHAPTER 6.

THE IGNITION SYSTEM.

For both two-stroke and four-stroke, the need for an ignition system is universal and the operating principles of both types of system are the same.
Only the components used to do the job vary in design.

All types of system need to use a coil, either readily identifiable as the cylindrical component supplying high voltage to the distributor via the centrally situated H.T. cable, or less obvious as an integrated part of the magneto or mag-flywheel of the motorcycle.

The coil consists of two windings and an iron core that can be magnetised.
Current is fed into the primary winding and then interrupted.
When this interruption takes place, a high voltage is induced in the secondary winding which discharges itself at the spark plug. The length of build up time or dwell directly influences the energy of the high voltage discharge.

The method of feeding current to the primary winding can either be from a battery, which is part of a continuously re-charging electrical system as used on a car, or it can be supplied direct from a generator that is integral with the magneto or flywheel.

Interruption of the primary current is a switching operation, which was carried out mechanically by a contact-breaker in older vehicles, now electronically, using digitally managed transistors.
At this stage, some method of ignition timing variation is also introduced to advance the spark as engine rpm increases.
This is also the stage at which we must start giving some thought to modification.

Why is ignition advance necessary?

Although the compressed mixture is highly inflammable as previously discussed, it is not explosive and therefore has to undergo a burning process that takes time, albeit only one or two milliseconds.
The burn time must be taken into consideration in order to produce maximum combustion pressure just at the right time - as the piston is starting to descend.
If it occurs too early it is resisting the natural motion of the moving parts and will set up alarmingly high stresses in piston, con-rod and crankshaft.
If it occurs too late, then potential driving force on the piston is wasted.

So, ignition advance is necessary to compensate for the "burn time" between the point at which the spark occurs, and point of maximum pressure build-up.
This burn time varies according to engine design characteristics, as explained on the section on combustion, and, measured, in crankshaft degrees, is a fair guide to the combustion efficiency of the combined power producing components.
Examples of these variations can be seen in the table below, which compares the various ignition advance requirements of standard engines with those required in modified engines.

The 850 Mini at the top of the list needs 42 degs of advance.
The 1270 Mini, with its big bore, ports and valves, yet with the same port layout, but with a high compression ratio, takes a sharp upward jump in efficiency with combustion improving slightly more than breathing, thus allowing for maximum advance to drop slightly. (Fig. 93)

The super efficient Ford 1600BDA four valve, produced its maximum power of more than 85Kw/Litre using only 32degs of advance, due largely to its compact pent-roof combustion chamber layout.

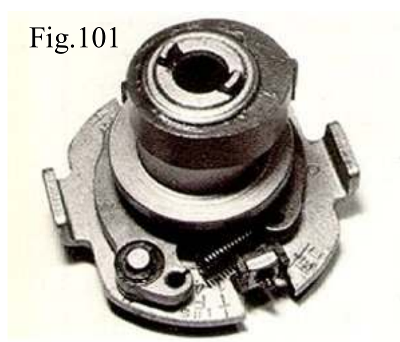
Make	Standard			Modified	
	Max.Adv. Degrees	RPM	Static Adv.	Total Adv.	RPM
850 Mini	42	3500	10	42	4000
1000 Mini	32	4900	10	38	4500
1275 Mini GT	30	4000	5	36	4500
1275 Mini S	27	7000	2	30	5000
875 Imp	31	5200	10	40	4500
875 Imp Sport	37	6000	12	40	5000
998 Imp	31	5000	10	46	5000
Avenger	32	4500	12	34	3500
Avenger GT	30	3000	10	38	4800
Ford Cross Flow					
Escort 1300GT	28	4700	10	36	5200
Mexico 1600	30	4000	8	34	4000
Ford OHC					
Escort 1600BDA	25	4000	10	32	5000
Escort RS2000	28	4500	8	36	3500
Ford P/rod					
3.0 V6	35	4400	10	38	3000
Jaguar 3.8/4.2	36	5400	8	40	3200
Rover 3.5 V8	30	4800	10	32	3000
Opel/Vauxhall 2.3	32	3800	10	38	4000
Kawasaki 900/1000	40	3000	10	40	3000
Honda 750/1000	36	6000	10	40	3500
Norton 750 twin	34	5000	5	38	3000
Tri/BSA twins	36	4500	10	40	3000

The columns under the heading "modified", are based on an average tuning stage, about Stage 2, comprising multiple carbs, a compression ratio between 9.5:1 and 10:1, valve timing with more than 70 degs. of overlap, oversize ports and valves and multi-branch exhaust manifold.
Each application will require individual adjustment but these are reasonable starting points.

Two-stroke engines will require little or no change from standard, because their near perfect, compact combustion chamber shape means that almost no flame-spread time increase takes place with modification.

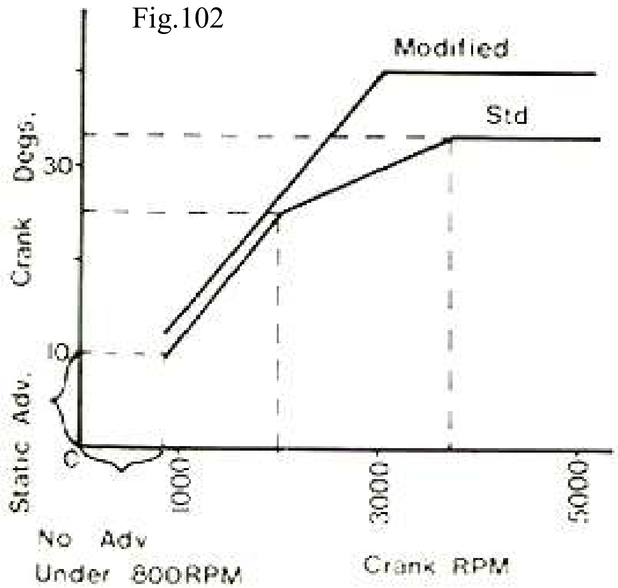
Fig.100

Fig.101



Advance curves can be altered by modifying the springs and stops that control motion of the centrifugal weights, usually situated behind or under the contact-breaker housing (Figs. 100, 101). Typical curves of standard and modified form are shown in Fig. 103.

Fig.102



Electronic Ignition.

Although it had done a good job for many years, the mechanical contact-breaker system was, at best, an inaccurate and unreliable method of triggering the spark, and was at the end of it's life in the 1980's.

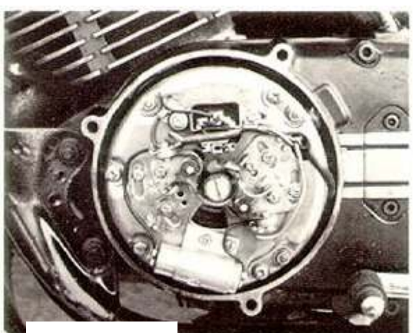


Fig.103

It was at its worst when running direct on the crankshaft, as used on many early motorcycles (Fig. 103), and subjected to the lateral movement and vibrations that are part of the crankshafts natural oscillation.
Stroboscopic observation and accurate timing checks at high speeds showed these systems to be far worse than the conventional car distributor.

Fig.104

Digital electronic ignition switching has now been with us for many years, either as standard equipment (Fig. 104), or as a retro-fit kit (Fig. 105), proving to be both reliable and accurate.
All transistorised systems work on the same basic principles, although they may vary in detail.

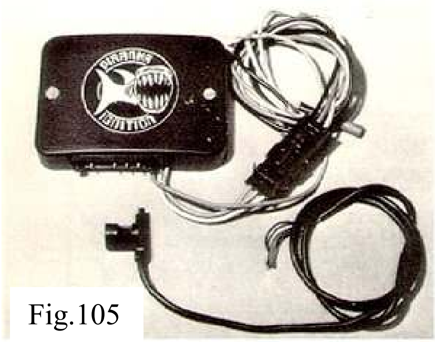


Fig.105

Initial triggering is carried out as a result of either a magnetic, inductive, or optical signal starting a series of transistor switching functions, which finish up breaking up the primary coil circuit.

Apart from having the obvious advantage of no mechanical coupling, other than the rotor drive, the extremely high switching time means that the coil has a much longer dwell period in which to recover, and consequently delivers higher H.T. voltage and energy.

Additional benefits of electronic triggering allow the amplified switching signal to be boosted by a transformer or capacitor, to increase the primary voltage delivered to the coil, resulting in even higher spark energy and consequently better combustion.

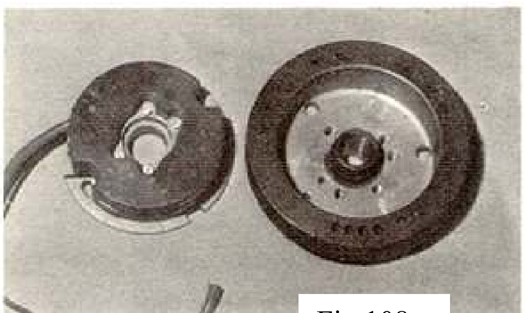


Fig.108

Ideal small two-stroke ignition comes from the electronic flywheel (Fig. 108), and even lawn mower engine ignition systems have now evolved into "solid state” technology, combining power generator, transistor switching and electronic advance control, into one neat solid state pack.

Although we said earlier how undesirable it is to have contact-breaker mechanisms running direct on the crank-shaft, the true ignition relationship is between crank and spark-plug, therefore the ideal triggering point should be at the crank.

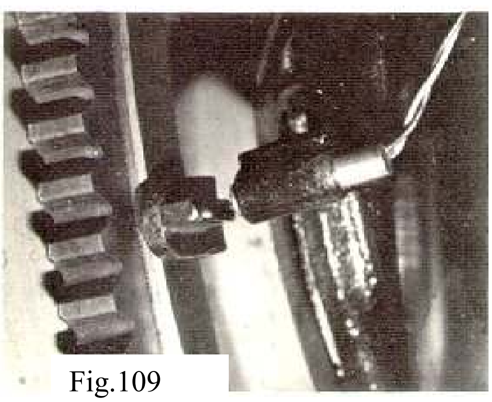


Fig.109

The ideal way of doing this is to trigger the ignition signal at the flywheel rim.(Fig.109)
Obviously, the bigger the radius from the crank centre at which we can situate the trigger, then the higher the degree of accuracy.

ELECTRONIC ENGINE MANAGEMENT.

Electronic control of the ignition system is automatically complemented by electronic control of the fuel system, either as an electronic carburettor, or as electronic fuel injection.
In order to meet the fuel and spark advance requirements to give perfect driveability as described in the section on carburetion, an engine management system must be able to read a couple of 3 dimensional maps correlating engine speed, load, air flow and burn efficiency, then supply the

correct size of fuel shot and adjust the ignition advance, to suit the precise demand on the engine at every revolution.

This function can only be accomplished by an on-board microcomputer that is constantly monitoring the engine requirements and controlling the ignition and fuel systems accordingly.

The Electronic Engine Control System (EECS as the Ford system was then designated), was a (then) powerful 16 bit microprocessor based electronic scanner/controller, continuously reading the data being fed to it from more than twenty transducers, sensing crank speed and load, throttle activity, induction air flow, air and water temperatures, atmospheric pressure and many other inputs.
These signals are digested and computed by the processor, which then outputs the ideal fuel and ignition setting at any given moment.

These types of system started to appear in the 1980's as standard equipment and electronic modification packs will need to be supplied as part of the tuning kit of the future.
In 1980, the Piper microprocessor development facility was already involved in developing high performance electronic packs with that day in view.

SPARK PLUGS - Selection and mixture checking.

Having made the choice of electronic system, the remainder of the ignition system will give great rewards for careful attention to detail.

The spark-plug handles the hot end of the ignition chain and should be selected and treated with care.

It functions by inducing the formation of a small mass of compressed air into electrified particles or "ions", thus exciting a spark to jump the gap between the central electrode and the earthed body of the plug.
Running temperature should lie between 400C and 955C. If spark plugs run colder than this, they will foul up and, if hotter, will overheat and cause pre-ignition.

It should be made clear at this point that, although plug colouring can be used to confirm that a correct mixture is being used, mixture itself should never influence plug choice.

Correct plug choice is influenced by the compression ratio, spark advance and power output of an individual engine design and can only finally be determined as a result of dynamometer tests.
If a plug is running too cold then it will probably be prone to "plug wetting" and failure at low speed/load conditions.
If it is running too hot, then it may promote high-speed detonation. It is often very difficult to make this choice without the appropriate test facilities, in which case it is safest to fall back on the advice of those with specialised experience, rather than have an overcooked plug nose drop through the middle of a piston.

Having made the right plug selection, the best way to check for correct mixture is as follows.
Selecting a road and a suitable time of day to ensure little or no road traffic, choose a long hill that will hold your top speed to, say, 60mph at full throttle.

Hold full throttle for as long as possible, then flick into neutral and switch off the ignition.

!! WARNING !! - Take care not to lock the steering!

Remove plugs and check visually, the side electrode should be faintly blue and the central insulator milk chocolate colour.

No soot or excessive white deposits should be visible.

If the plug is running too hot due to the mixture being too lean, the side electrode will be burned black and the insulator will be chalk white, so having ensured that it is the recommended grade, richen the mixture until the colour is O.K.

If the mixture is too rich, the plug will be matt black on the side electrode and around the rim with a dark brown to black colouring on the insulator.

If pre-ignition or detonation has occurred, fine silver beads will probably be seen around the insulator.

Spark intensity depends on good, sharp-edged electrodes and gaps as small as can be reasonably used.
Average gaps can be reduced to 0.5mm, but racing plugs will run as small as 0.4mm.

For highly tuned engines, H.T. leads should ideally be copper wire cored for minimum current resistance, with a heat resistant silicon rubber sleeve.
These are not however essential for lesser states of tune, and self-suppressed lead in **good condition** can often be adequate.

However, the real key to a successful ignition system is high voltage coupled with high spark energy, which depends on the correct selection and treatment of all the components involved.

Ignition advance requirement is a reliable pointer towards overall engine efficiency. If you only have the facility to set your ignition advance by trial and error, making small adjustments and monitoring performance changes, then the best setting will be an indication of how well you have tuned the rest of the engine.
If you require 50 degrees or more of advance, then there is something else wrong with the engine.

If the tuning advice in all the previous chapters has been followed, a good high performance engine should never require more than 40-45 degrees of full advance.

As ignition systems are developed to assist lean burn capability within the remaining life of the IC car engine, it is possible that combustion will be initiated by a system such as "Plasma Jet", a high-energy form of ignition, which ionises the compressed air in a cavity within the plug body and then shoots a jet of flame an inch or more into the combustion chamber, igniting a large area of the charge, resulting in faster flame-spread and a drastic reduction in ignition advance requirement.