MOTORCYCLE ENGINEERING—33

Ignition Factors

Effects of combustion lag: The two-plug system

By PHIL IRVING

BEFORE an engine can run, it must, of course, start. For it to do this, the mixture-strength in the little space occupied by the plug-points—or, more precisely, *between* the plug-points, which may be only .018 in. apart—must be within the limits of 16 : 1 and 12 : 1 by weight if petrol is the fuel, or about 8 : 1 if alcohol is used. This applies to the amount of fuel present *in the form of vapour;* droplets, however small, do not count, and it is easy to see that at the low speeds of starting the mixture is hardly likely to be homogeneous, but is more likely to be of varying consistency, with some areas too weak to ignite and some too rich, or merely containing wet fuel in suspension.

As only a portion of petrol will vaporize at ordinary temperature, it is necessary to provide a temporary surplus for cold starting, and modern petrols are blended to suit the prevailing weather conditions so that starting is not much of a problem. If, however, a flooded engine does not start at once, it will be reluctant to do so at all, because the previously unvaporized fractions have been given time to vaporize and the mixture then becomes too rich to maintain combustion, even if the spark does manage to initiate it.

The necessity to provide an ignitable mixture at the plug-points remains paramount at all other speeds, and it may well be that the condition does not exist at some point in the speed range because of the pressure of pockets of residual spent gas.

This is particularly likely to occur in two-strokes, which depend upon the direction of the stream of gas from the transfer ports to scavenge the upper end of the cylinder. Even a small dilution of a correct mixture with spent gas may cause either a complete misfire or an unsuspected lag in the commencement of combustion which may have a great effect in reducing power at, say, 9,000 r.p.m., when the time available for the whole process is less than one-thousandth of a second. Sometimes a seemingly trivial change in position of the plug will result in an appreciable gain in power because the points have been moved into an area more favourable for combustion.

The same effect has often been observed in four-stroke engines, in which, generally speaking, the plug is best placed at the apex of the angle made by the offset inlet and exhaust ports, rather than in the space between them.

One difficulty associated with excessively domed pistons, especially in small bores, is that the plug is severely masked by the dome just when combustion is occurring; the bonfire lights up all right, but immediately afterwards the spread of flame is severely hampered by the rising piston-crown and power is lost. An endeavour to cure this may be made by using an amount of advance so great that the combustion is well under way before the piston intrudes itself, but this is only an expedient and may well yield little increase of power because the advance is really too great; in other words, the second error introduced does not completely cancel out the effects of the first. A better idea is to make a local flat or depression in the crown adjacent to the plug, or to use an asymmetrical crown.

In view of the frantically small time available, it appears at first sight that a second plug could not fail to be an advantage in obtaining complete and rapid combustion, and would also be better from the viewpoint of reliability. Some years ago, almost all English racing factories swung over to two-plug heads, stuck to them for a couple of years, and then went back to one.

When all the secrecy had cleared away and notes were compared, the general opinion seemed to be that power in the medium-speed range (and consequently the acceleration) was improved, but there was little or no gain at top revs. From the reliability aspect there was no gain at all, because the amount of advance required for

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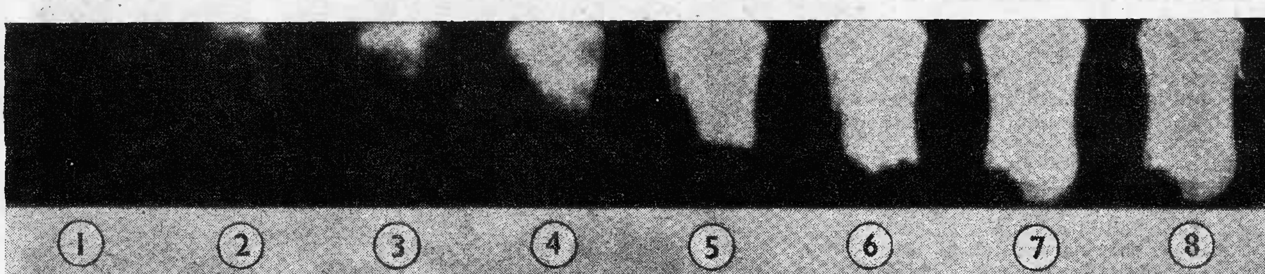
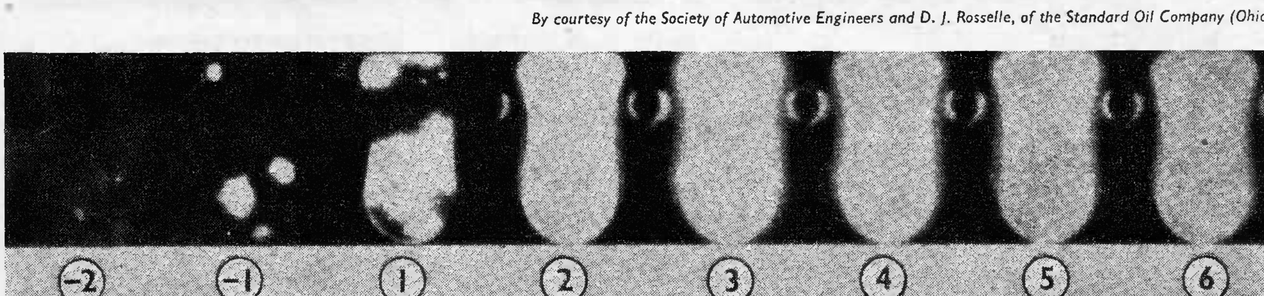


What happens when the charge burns : sequence photographs of combustion in a test engine with a quartz cylinder head. The spark—from a plug located out of the pictures to the top—occurs at Stage 1 in each case. Upper row shows normal combustion, with the flame front travelling smoothly and evenly across the chamber. Lower row shows pre-ignition occuring at several points before normal plug firing, so that much of the charge has been burned by the time the spark takes place. Result : power loss and knocking when the flame fronts collide.

By courtesy of the Society of Automotive Engineers and D. J. Rosselle, of the Standard Oil Company (Ohio).



IGNITION FACTORS

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two plugs was five or six degrees less than with one. If one failed, the engine still kept going, but at reduced power; the rider then had to choose whether he would lose the race through lack of speed, or lose it through stopping for a plug change which also entailed determining which plug was at fault.

If one discounts the reliability feature in view of modern improvements in plug technique, there may be grounds for resuscitating the scheme in large-bore high-compression engines, where the combustion chamber shape does not lend itself to efficient ignition from one spot, and also in ultra-high-speed engines of small bore, where the time element is so small that halving the distance through which the flame has to travel is likely to pay a dividend.

One snag, of course, is simply the mechanical one of finding room for the second plug so that it can easily be changed. Some designers have had to resort to the 10-mm. range of plugs in order to do this. Whilst these small plugs function quite well, they do not have quite the safety margin possessed by the usual 14-mm. types, owing to the restricted space in which the points and insulator have to be accommodated.

Firing both plugs at the correct instant in relation to each other is also a problem. It may be that optimum results are obtained with simultaneous firing, or that one plug should lead the other by one or two degrees because of their positions in the combustion chamber, but the advance will be less than that required with a single plug. If the spark at one plug for some reason occurs a little too soon, the spark at the other will not do anything much and the engine will then be running with single ignition at less than optimum advance, and consequently at reduced power.

One solution, if absolute synchronization is required, is to use a double-ended coil or magneto with no earth connection of the secondary coil (as in the Cooper-Lucas instrument). However, if a small phase difference is necessary two contact-breakers must be employed, irrespective of whether they operate coils or are built into magnetos, and the problem of setting them accurately except under test-bed conditions becomes acute.

This raises the question of coil v. magneto. Ignition-wise, the difference is that the coil gives its highest voltage at low speeds, and at high speeds eventually reaches a point, measured in sparks per minute, when the secondary voltage becomes too low and mis-firing sets in. The magneto, owing to the fact that it generates its own primary current which rises with speed, gives a higher voltage at high speeds, but this does not confer any real advantage over the coil, so long as the latter is being worked within its rated capacity.

Ordinary coils will deliver up to 18,000 sparks per minute, and are on the danger-line on a six-cylinder engine at 6,000 r.p.m. Hence the use of "sports" coils, rated at 21,000 sparks per minute. So it will be seen that even 15,000 r.p.m. on a two-stroke single can be handled quite easily. The main snag is that batteries are not always as reliable as they might be; but this bogy is far less of a nuisance than it used to be, and, all in all, coil ignition is probably better for both racing and touring.

He's on his way . . .

This is the last of the present Phil Irving series on "Motorcycle Engineering." But it's very far from being the last of Phil Irving. "Slide Rule," as thousands still know him, is now on his way back to this country from his native Australia—taking in at least one famous Italian factory en route. And he'll be here in time to give readers of "Motor Cycling" the finest technical coverage of the T.T. in motorcycling journalism. After which, there will be plenty of other subjects calling for a designer's-eye view. Earls Court, for instance . . . . WATCH FOR IRVING.