# Whys and Wherefores

*Looking Behind the Scenes to Learn How the Character of an Engine is Developed from Certain Essential Considerations—A New Series*

THERE is a feature of the Morris Ten engine which is not present for the reason one might expect. The crankshaft, which is remarkable for the large size of its journals and crank pins, is provided with counterbalance weights. To many of us the sight of a crank balance weight recalls early single-cylinder engines and the need of making them run smoothly enough to permit one to continue to sit on the saddle of a motor cycle—which is not meant as a jibe at the expense of the excellent motor cycles of to-day. But the balance weights on the four-throw crankshaft of the Morris Ten are not put there to damp vibration as such. They are put in to balance as far as possible the inertia forces set up in each throw by its individual piston and connecting rod, for if these are not balanced they impose a heavy load on the crankshaft journals and bearings. The balance weights are used to increase journal bearing life.

### The Starting Point

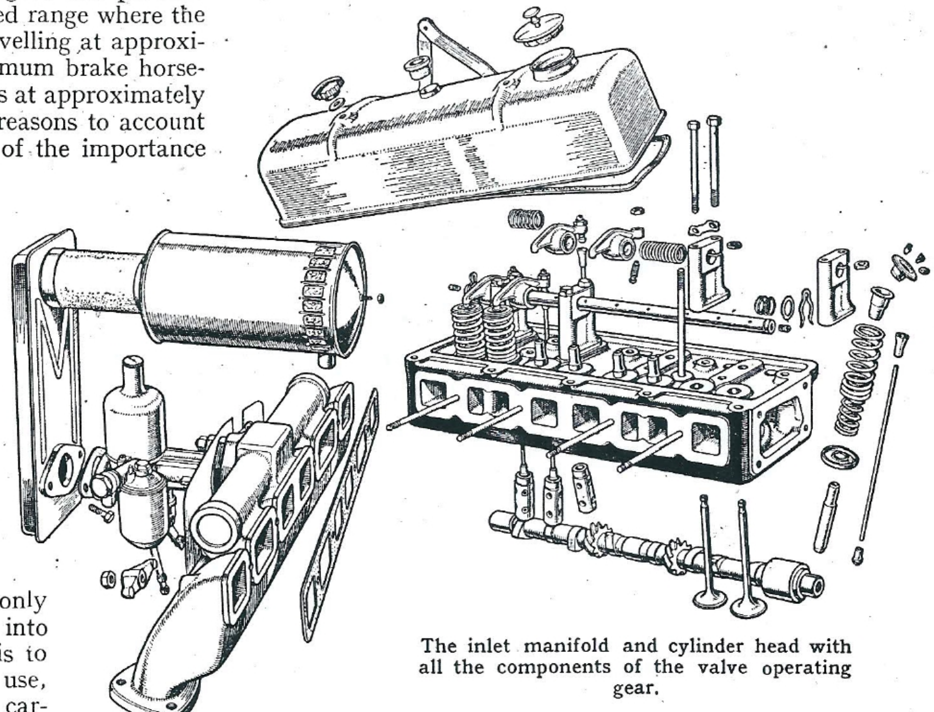
During the conversations which I had with the Morris Engines engineering staff, I could not resist the temptation to ask what was the starting point in laying out a new design. The answer was extremely interesting—the starting point is the inlet valve. It is accepted that a correctly designed engine, not supercharged, will produce its highest torque at a point in its speed range where the gas flow through the inlet valve is travelling at approximately 135ft. per second. The maximum brake horsepower is delivered when this gas flow is at approximately 240ft. per second. There are many reasons to account for this state of affairs, but in view of the importance of these two gas velocities it is a fact that the design of the inlet valve and throat is the keynote of the engine. Different cams, timing, carburettors, ignition, and so forth will have very little effect on the characteristics of the engine if the keynote is correctly struck.

It will be noticed that the Morris Ten has an inlet valve of larger size than the exhaust. The reason for this, put very broadly, is that it is much more difficult to get mixture into the cylinder than it is to get exhaust gas out of it. For one thing, there is only atmospheric pressure to push the gas into the cylinder. The word "suction" is to my mind a most misleading term to use, especially in all matters relating to carburation, for suction at the most only implies the creation of a vacuum. A vacuum cannot do any more than let air flow in to fill it up, and air is normally at atmospheric pressure. On the other side of the story, exhaust gases are under a considerable residual pressure left from the expansion stroke, and are literally burning to get out of the cylinder. Also, they are being pushed from behind by the rising pistons. Hence, the exhaust valve may be quite a little smaller than the inlet. Indeed, there are schools of thought which believe that most exhaust valves are larger than they need be.

Although a coil of tempered steel wire looks a simple thing, as a matter of fact its design for a particular purpose is an exceedingly complex matter. Especially is this so in the case of a valve spring, which is expected to stand up to a minimum test of 10 million reversals.

### Valve Spring "Surging"

One of many impediments to the long life of a valve spring is the effect of what is called surging. When an impulse is imparted by the cam to the valve spring, a disturbance of the coils is initiated which travels along the length of the spring in the form of a wave. This wave is reflected from each end of the spring in turn. If an impact is given to the spring by the cam at the precise instant that a wave is being reflected from the same end, the result is cumulative and induces a greater surge. This explains why synchronous speeds of vibration occur. Engine speeds which are sub-multiples of the natural spring frequency are synchronous speeds.



The inlet manifold and cylinder head with all the components of the valve operating gear.

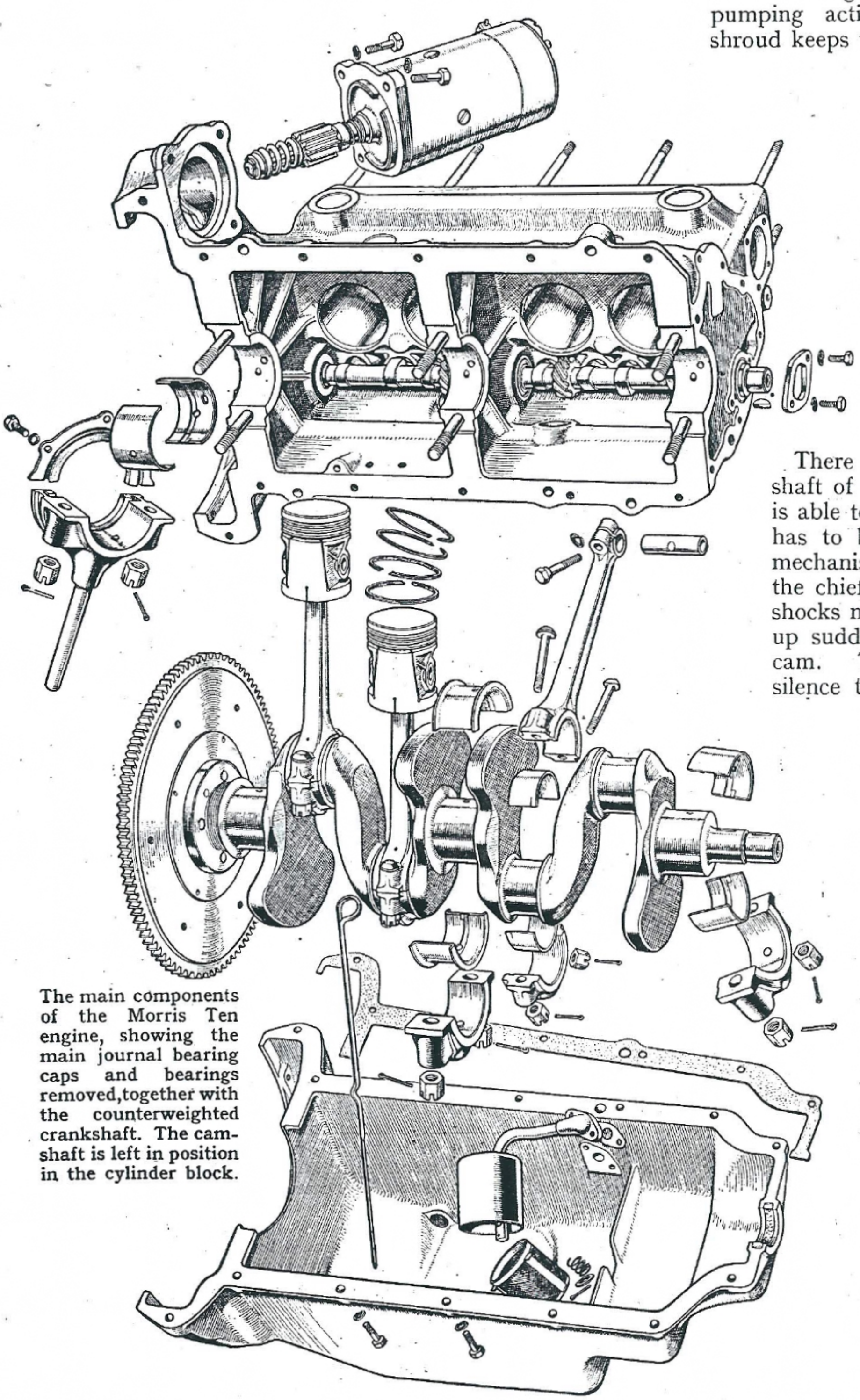
It is easy to realise that surging, if unchecked, can produce some very high stresses in the material of the spring. Examination of a valve spring of the Morris Ten engine will show one of the several methods which are used to keep surging under control. It will be seen that the pitch of the coils is not constant, those at the end remote from the lift being closer together. The

# of Design

## No. I. THE MORRIS TEN ENGINE *(Continued)*

by

MONTAGUE TOMBS



**The main components of the Morris Ten engine, showing the main journal bearing caps and bearings removed, together with the counterweighted crankshaft. The camshaft is left in position in the cylinder block.**

surge wave is checked at this end by the close coils coming early into contact with one another, whereby their movement is shortened, and they are not overstressed. This description is skating more or less gracefully over the thin ice of a deep pool of technicalities, but it should help to explain matters.

Before leaving the subject of valves and springs, a note about oil control is desirable. Where the valve spring collet joins the valve stem a sealing washer of synthetic rubber is introduced, and the collet also carries a cylindrical shroud which just extends over the extremity of the valve guide. Overmuch oil is thus prevented from getting into the valve guide, whilst the slight pumping action caused by the movement of the shroud keeps the oil on the move.

On this engine the valves are disposed in a line overhead and at a slight angle. They are operated through push rods and rockers from a side camshaft. The tappets have a special interest. They are drum-shaped and hollow, the hollow centre being rather a work of foundry art since the holes in the sides are quite small. These tappets are of cast iron with chilled ends which produce a more effective wearing surface than case-hardened steel. The barrels are brought dead to size on that fascinating tool, the "centreless" grinder.

### Camshaft Design

There is a very interesting point about the camshaft of this engine. To make sure that a valve is able to sit right home on its seating a clearance has to be left between the stem, the operating mechanism and the cam. This clearance is usually the chief cause of a noisy valve gear, since light shocks may result from the clearance being taken up suddenly during the initial movement of the cam. To overcome this difficulty and achieve silence the cams of the Morris Ten are profiled with a slight ramp between zero diameter and the commencement of the flank of the cam which initiates the lift of the valve. This ramp is sufficiently high to take up the clearance, but it is also so graded that it first accelerates the tappet and then decelerates it so that the actual contact takes place at zero velocity.

Modern design of engines has been very much interwoven with the development of fuels, inasmuch as there has been a steady increase in octane value. Without going into details the octane rating may be described as the measure of the anti-knock properties. An improved octane value means, therefore, that the engine can be designed to run on a higher compression ratio without pinking. A higher compression produces a higher expansion pressure, whereby more power can be obtained from the same quantity of fuel. The combustion chamber, its shape and detail design also play a very important part in the matter. When a combustion chamber is full of highly compressed explosive mixture, and a flame is propagated by the spark of the

## WHYS AND WHEREFORES OF DESIGN (CONTINUED)

ignition, the front of the flame travels away from the ignition point towards the furthermost parts of the chamber. The gas already ignited by the spark expands rapidly, so that the remaining unburnt gas in front of the flame may, under certain circumstances, be raised to a pressure so great that it ignites spontaneously, or detonates, unless the shape of the combustion chamber is scientifically designed and equally well cooled.

In the Morris Ten engine, the combustion chamber shape is the result of much research to obtain a smooth flow through the valve ports. The combustion chamber is of a "lozenge" shape, with a lesser width than the cylinder bore, and a greater length, as the valve heads slightly overlap the top of the bore and cannot fall into the cylinder in the event of a spring or stem failure. The inlet valve, as already stated, is of larger diameter than the exhaust, and is arranged more directly above the bore.

Then the side of the combustion chamber in the direction of the inclination of the valves is not vertical, but sloping away, to give greater freedom to the inflow and outflow of the gases. Also, the roof of the chamber is not horizontal, but at right angles to the axis of the valve stems. The sparking plug enters the chamber through the sloping side wall, and is close to the exhaust valve. The ignition, and therefore the start of the flame front, take place in the hottest part of the combustion chamber, whereby the risk of detonation is considerably reduced.

### Filling the Cylinders

However carefully combustion chambers, valve ports and so on may be designed, all this work may be wasted if the cylinders do not get filled with (a) a full quota, (b) the same amount at the same temperature as the cylinder next door, and (c) an homogeneous and correctly proportioned mixture of atomised fuel-vapour and air. The carburettor is a worthy instrument which does its level best to supply exactly what is required. It is really a metering device, and for various reasons is liable to supply a stream of fuel vapour and air which may be a little different in composition in the centre from what it is close to the banks, so to speak. Apart from atomisation, it is one of the jobs of the hot-spot in the induction manifold to correct this stratification of the air-borne fuel. In the Morris Ten engine the hot-spot is so shaped and disposed that the heavier strata of the mixture play upon it more intensely than the lighter, and the atomisation is rendered more uniform thereby.

By no means the least interesting aspect of the design of the engine is to be found in the oil system, which is orthodox in one respect but unusual in another, namely, that a gear-type pump of unusually large capacity is used. The full output of this pump is not normally required or used, and a larger proportion than usual of its output is arranged to escape through the by-pass valve and return to the sump. But when an engine has been in service for a lengthy period and the bearings have worn a little, oil can escape from them more readily, and the pressure which should maintain the oil film between the shaft and the white metal of the bearing consequently drops. The output of the pump is sufficient to deal with any matter of this sort.

### Lubrication System

The actual circulation of the oil is arranged so that the pump draws its supply through a filter submerged in the sump and immediately passes the quantity required by the engine under pressure through a main-line filter. The surplus passes through the pump relief valve and returns to the sump. This filter is not made dismountable, but is intended to be used until fouled and then thrown away, a new one being put in its place. An additional release valve is provided which permits a direct supply to the engine if the filter becomes blocked.

From the pressure filter the oil is conducted to the main crankshaft bearings and the big-ends, whence a regulated supply is flung to the cylinder walls. Also, the oil is fed to the camshaft bearings, and the surplus from an end bearing is collected in a banjo oil-thrower ring and fed to the teeth of the chain sprockets of the distribution gear. A further gallery pipe feeds a metered supply of oil under pressure up to the rocker shaft and rocker ends of the valve gear.

In conclusion, I would like to remark that the excellent drawings by my colleague, John Ferguson, show an extraordinary amount of detail which the engineer will be able to follow out for himself. To describe everything in the engine would need a book on the subject, and I have confined myself to an attempt to portray some of the major issues in the minds of the designers.

*Next week: The Standard Independent Suspension.*

# Reducing the Number of Cylinders

*A Drastic Method of Cutting Down the Tax on Large Engines*

A MANCHESTER motor engineer has received a great deal of local publicity because he has cut down tax and consumption on an elderly American straight-eight by converting four of the cylinders into mere passengers. "Engineering mysteries under the bonnet" leads off one account, although it is rather less mysterious when later it suggests that no one would suspect that four of the pistons and con-rods were missing.

Quite a successful conversion of this sort by a London concern was described recently in *The Autocar*.

It is suggested that fours may be converted into twins and sixes into "Threes." But whereas a straight-eight may be tolerable with half its "pots" out of action, a four (or a six) similarly treated might be decidedly unpleasant in running. And some unexpected skipping-rope effects might occur in the crankshaft!

The engineer in question is Mr. Chas. Hampson, Grain Street, Deansgate, Manchester, and he claims that in the case of the eight-cylinder model consumption has been reduced from 13 to 24 m.p.g.; speed falling from 82 to 67-70 m.p.h. The tax is £3 1s. 11d. a quarter instead of £5 19s. 8d., and there is the expectation of insurance being reduced in proportion.

No special parts are required; only the application of time and mechanical skill. Hence, Mr. Hampson agrees there can be no patent about it at all, but that other traders or smart owners might copy the process. He considers the benefits great for big-car owners generally, and especially to commercial travellers with large consignments of goods. Of course, the fuel ration would be reduced if the final rating fell, as it usually would, below 20 h.p.

The system is equally applicable to c.v. engines, but some restraint on speed would have to be stressed on drivers and special care paid to the weight of loads.

Cost of conversion is estimated at £10 to £15.