STEWART ENGINEERING

***THE* SUNBEAM SPECIALISTS**

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The Pros and Cons of Flexible Mountings for Motor Cycle Power Units

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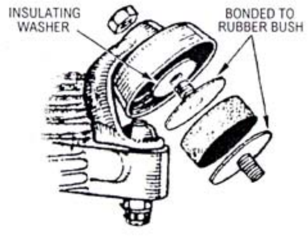
(from The Motor Cycle, 7 August 1952)



Details of the front engine mounting of the S7 Sunbeam twin.

In his article, `Unbalance of the Piston Engine' *(The Motor Cycle* for April 10), "Ubique" pointed out that the normal types of motor cycle engine cannot be perfectly balanced, no matter how much care is exercised in the design and development work, and in the erection of each unit. All such engines suffer from vibration to a greater or lesser extent. Subsequently, the Editor drew attention to the prevalence of vibration with modern motor cycles, and asked a question which many of his readers must have echoed: is rubber-mounting of the power-unit the solution?

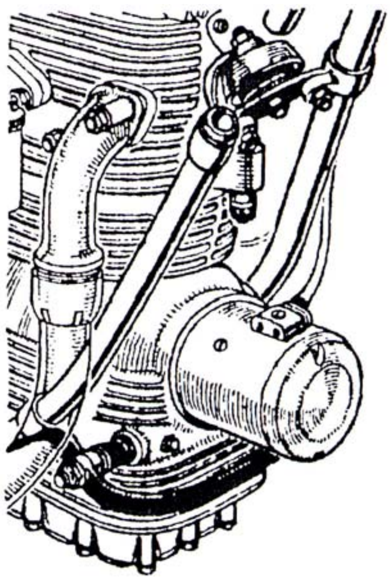
Rubber as a means of absorbing vibration is known and accepted throughout the engineering world, and its multitudinous applications range from supporting delicate instruments to the mounting of motor-bus bodies and diesel-generator sets. Rubber in the bearers of automobile engines is now commonplace, and is largely responsible for the remote feel of the average car engine of today. The use of rubber for this purpose is not intended to cover up bad vibrational characteristics resulting from indifferent balancing, but to eliminate - or at least render negligible - the transmission of unavoidable vibration.

Most motor cycles have what is commonly called a `vibration period' within the usable range of engine speed. Some machines have more than one period. A period is usually a narrow range of revolutions in which the engine feels rougher than it does at other speeds. It may not generally be known that this is not really an engine phenomenon, but is due to the engine's vibration frequency getting into step with the natural frequency of vibrations of some other part of the machine, such as the frame (which may have several natural frequencies) or handlebar. This coincidence of frequencies causes the part concerned to resonate, or vibrate in sympathy, thus giving the effect of increased vibration from the engine.

NATURAL FREQUENCY

The engine vibration is there throughout the speed range; its magnitude depends on that of the out-of-balance forces, and its frequency on the engine speed. With a rigid mounting and reasonable balance characteristics, much of the vibration is normally absorbed in the surrounding structure and it may only become noticeable when resonance occurs.

This effect has often been noticed on changing an engine from one frame to another of different design (and hence different natural frequencies), when the period occurs at a different engine speed. Also, as "Torrens" has mentioned on occasions, alteration of the natural frequency of the handlebar can work wonders if the handlebar vibrates badly at a frequently used speed. It may not be possible to push the natural frequency outside the engine speed range, but it can usually be `moved' to a less critical part of the speed range.
Various attempts at using rubber as an anti-vibration mounting for handlebars have not always been successful, and all have been dropped. They sometimes ~4 suffered from two drawbacks: first, they caused a deterioration on handling qualities owing to the interposition of `jelly' between rider and front wheel,



Right: Sunbeam S7 forward engine mounting and steadying *snubbers.*

and secondly, they aimed at removing a symptom instead of attacking the disease at its source. Vibration at footrests, saddle, or petrol tank can be as uncomfortable as dithering handlebars. Only by effectively insulating the engine unit from the rest of the machine can the sympathetic vibrations be reduced or eliminated. Rubber is the obvious and most suitable material for a resilient mounting of this kind.

There are two methods of mounting an engine in rubber - fully flexible or semi-flexible. In the former, the location of the bearers and the degree of resilience allow sufficient freedom for the absorption of vibration and torque reaction impulses. With the semi-flexible, the amount of movement is restricted and the degree of insulation correspondingly reduced, for it is not intended to provide complete isolation of vibration, but to reduce the intensity of its transmission.

Both layouts share the disadvantage that the engine is no longer able to stiffen the frame, which, therefore, could not be of the diamond pattern. In a cradle frame, the engine is not specifically a structural member, but since the engine is normally rigidly attached to the frame at three or more points, it does form a useful brace. If the frame had to rely entirely on its own rigidity it might have to be slightly more robust. Thus, with a rubber engine mounting, an increase in weight might be necessary unless more costly materials or sections were employed.

Where shaft final drive is used, neither type of mounting should present much difficulty, since the universal joints and splined coupling should be able to accommodate as much relative movement as even a fully flexible mounting would require. A possible exception is the big 'single', with which the forces involved would necessitate a fairly large travel for their absorption.

If transmission is by means of chain, the picture is very different, because a chain (if it is to function efficiently and to give good service) requires accurate alignment of sprockets to be maintained, and the minimum of centre-distance variation. The relative movement with the semi-flexible mounting could probably be kept sufficiently small to reduce the hardships endured by the chain to within reasonable limits. Even so, it would seem preferable to adopt unit or semi-unit construction of engine and gearbox, thereby avoiding trouble with the high-speed, short-centre primary drive.

SEMI-FLEXIBLE MOUNTING

It appears highly unlikely, however, that, owing to the amount of movement required, chain transmission could prove satisfactory with a fully flexible mounting. Since the axis of oscillation under torque reaction is that of the least moment of inertia of the engine unit, it is, in theory, possible to eliminate variation in drive centres from this cause by locating the sprocket on this axis, but to do so would certainly introduce complications. Also, the out-ofbalance forces, being of quite a different nature, would still cause excessive movement of the sprocket.

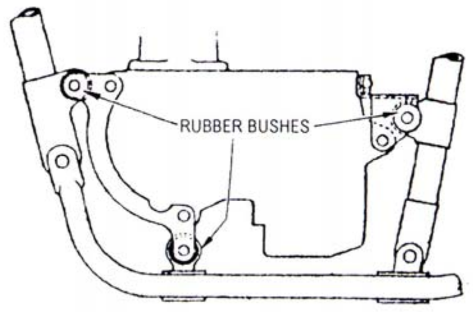
Sine the fully flexible mounting appears to be limited in its application to machines with shaft final drive, what are the prospects for the semi-flexible type, which should be capable of incorporation with shaft or chain? No great amount of experimental work has been done thereon, so the information available is rather limited, but expert opinion is that such mountings could not be a general cure for vibration troubles. The reason is that, at best, the semi-flexible mounting can be no more than a compromise - and compromises rarely achieve anything like the full advantages of either extreme.

While the semi-flexible mounting could, in a particular case, effect an improvement by 'de-tuning' an otherwise troublesome vibration, it might prove, in another instance, to be more unsatisfactory than the rigid mounting it supplants. The energy of the vibration must be absorbed somewhere, and with a rigid mounting this is done to a considerable extent by the frame. if the engine is flexibly mounted, the amplitude of the vibration is governed by its mass relative to the reciprocating weight, and the degree of balance of the latter.

The fully flexible mounting absorbs the whole of such movement so that there is, in effect, no vibration to transmit. In unfavourable circumstances, a semi-flexible mounting might give rise to nearly as much movement as the fully flexible one while transmitting forces as large as, or larger than, the rigid mounting. It might be thought that such a mounting should come into its own in the lightweight field, since the forces to be dealt with would be small. However, it is far from certain that a worthwhile improvement in the vibrational characteristics would result, as was found by a well-known manufacturer of small-capacity machines. This firm experimented with an engine-gear unit mounted on concentric rubber sleeve bearings. Three mounting points for the unit were provided in a normal cradle frame.

Tests revealed that the improvement in smoothness of running in comparison with the standard mounting was so small as to be hardly noticeable, and the results did not warrant the added complication and expense.

It is at this point that the knowledgeable reader asks, "What about the LE Velocette? It has semi-flexible mounting and is probably the smoothest motorcycle yet made." He is right on both counts, but it should be borne in mind that the flat-twin engine is one of the better motorcycle layouts from the balance aspect; only a rocking couple mars its tranquillity. With the small dimensions and low reciprocating weights on this engine, the couples are very modest, as are the torque reaction impulses.

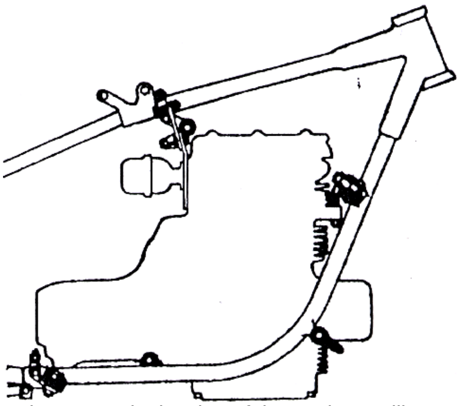


Layout of an experimental semi-flexible engine mounting.

Consequently, the 200cc twin-cylinder Velocette is an inherently smooth engine; it is, therefore, not altogether surprising to learn that the primary function of the rubber mounting in this design is not to absorb vibration, but to minimise the amount of noise transmitted to the sheet steel of the frame. This insulation is effected by interposing rubber grommets between the engine unit and frame at front and rear and, in addition, rubber washers are employed to prevent metallic contact with the mounting bolts.

'FLOATING-POWER' PRINCIPLE

The mounting employed on the Sunbeam S7 and S8 models is of the fully flexible pattern and is arranged on the original Chrysler 'floating-power' principle. This system entails two main supports, one high up at the front of the engine and the other underneath the gearbox. The two supports lie on the axis of least moment of inertia. When the engine is idling or running under light load, it floats entirely on these supports, but increased lateral resistance to torque reaction is provided when required by two pairs of rubber snubbers. One pair is carried on the front down-tubes, and the other above and behind the cylinder head, equidistant from the axis of oscillation.


Diagrammatic drawing of the engine resilient Mountings of the Sunbeam twin

So far, only primary unbalance and torque reaction have been considered *vis-a-vis* the resilient engine mounting, but there are other possible sources of vibration. Unbalanced secondary forces, though not so troublesome as the primaries, can be of appreciable magnitude, particularly if, in the interests of compactness, the con-rod is short. "Ubique" explained that the frequency of the secondaries is twice per revolution, or double that of the primaries, and their direction is vertical. Hence the whole nature of secondary forces is different, so that a flexible mounting designed purely with the primary forces in mind could conceivably result in some unpleasantness from the secondaries. In the Sunbeam layout, these secondary vibrations are dealt with by an additional friction damper incorporated in the upper snubber mounting.

The crankshaft also comes into the picture since, like any other shaft, it has a natural frequency of torsional vibration. Where this coincides with the frequency of the applied impulses (in this case, the power strokes of the engine), torsional resonance will be set up in the shaft.

Since the average motorcycle crankshaft assembly is short and stiff, its natural frequency is very high, and is well outside the range of engine speed which can be reached. Even four-cylinder, in-line engines of normal size are rarely troubled by a crankshaft period, though it is possible that a small straight-four capable of high r.p.m. might be affected. In straight sixes and eights in the automobile world, the point has to be watched, and torsional vibration dampers are sometimes found to be necessary.

Torsional resonance in the transmission can also occur, but this is usually taken care of by some form of cushdrive and is rarely troublesome.

CASE FOR THE MULTI

So, I think, we may draw these conclusions. From the vibrational aspect, there is a strong theoretical case for multi-cylinder engines on account of the reduction in the magnitude of the out-of-balance forces produced in a given size of engine. The lower the amplitude of vibration, the more easily it can be absorbed, either in the surrounding structure or in a rubber mounting. To ensure a satisfactory degree of isolation of the vibration and of torque reaction impulses, a fully flexible mounting is necessary.

The unit-construction, shaft-drive layout is, in general, a satisfactory proposition for a fully flexible mounting; the possible exception is the large single-cylinder engine. However, such a mounting is not suitable for use with chain drive.

The semi-flexible mounting, while more generally applicable, is certainly not a panacea for vibration troubles, though it may be valuable in particular instances. Where a rigid engine mounting is used, there seems to be scope for closer co-ordination between engine and frame design (this to include appendages such as the handlebar) to ensure that so-called 'periods' occur, as far as possible, at less important parts of the engine-speed range. The more extensive use of rubber in the mounting of various parts of a machine with rigid engine mounting could prove helpful in eliminating sympathetic vibration.