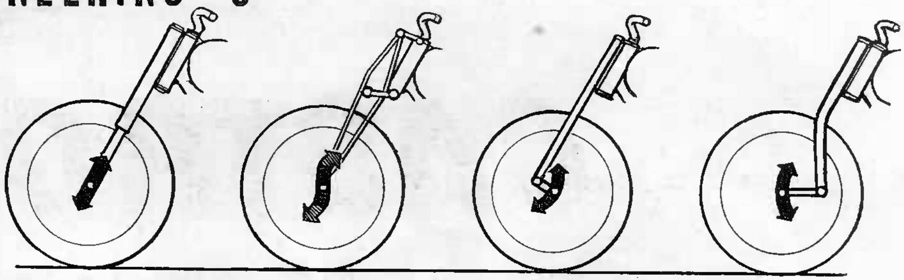
MOTORCYCLE ENGINEERING—3

PHIL IRVING

Discusses



Front Suspension in Practice

Safety and Comfort Depend Upon Well-designed Springing: Factors Which Have to be Taken into Account in Selecting a System (Part 1)

FROM the very earliest days of the motorcycle, front fork design has been in a fluid state. Apart from the plain, unsprung variety, which was inherited from the velocipedes of the period, almost all the types which are in use today were tried, even in the crudest possible way, about 50 years ago—as anyone who visits the Montagu Motor Museum can verify for himself.

However, at no time did any particular design-style attain universal adoption, in the way that the beam-axle did on four-wheelers, though there were periods when a single type was predominant, largely as a result of its success in racing. Thus for a number of years the so-called "girder" or "parallel-link" fork in various guises held the field, though there were many who did not think it was the best form. The situation changed very rapidly after the telescopic fork commenced to win races regularly, and in a few years this almost completely ousted the girder type on English machines, while even American designers who for long had remained faithful to the bottom-link variety—leading in the Harley-Davidson example, trailing in the Indian—were shaken in their allegiance and changed to other types.

The same state of flux exists both in England and on the Continent today. It is not unusual to find one factory using dissimilar designs on its various models, while experimental machines, utilizing yet other designs, are continually making their appearance. It may be instructive to examine the pros and cons of the known variants to see why all this chopping and changing has taken place.

In general, all fork designs now used fall into one of four groups: at the top of this page is a diagram showing each of these four types, (a) telescopic, (b) girder, (c) trailing link and (d) leading link, the path of each axle being indicated by the heavy lines and arrows. The angle and shape of these paths affects the suspension in ways which will be described later. There are two variations of group d; the long-link commonly referred to as the Earles type, and the short-link, the main difference being that in the former the links are united by a cross-member behind the wheel which contains a pivot bearing and in the latter they are usually separate.

The principles underlying the way in which a solo machine is endowed with auto-stability have already been described and the importance of correctly apportioning the rake of the head and the trail of the front wheel outlined. When a sidecar is fitted the whole vehicle possesses a two-dimensional wheelbase, and auto-stability is no longer required, in fact a steering geometry which is best for two wheels is by no means ideal for three. There is bound to be a certain amount of side-drag from the third wheel and air-resistance from the body both of which try to swing the machine around to the sidecar side, which, for the purposes of this exercise, we will assume to be always on the left. This drag is resisted by the front tyre, but as the point of tyre contact lies behind the steering axis, the wheel will turn to the left and the outfit will run round in a circle unless it is held on a straight course; the greater the trail, the more pronounced the effect will be. Likewise, extreme rake is a disadvantage, because as soon as the wheel is turned the front of the frame drops and quite a lot of effort is required to centralize the wheel again, as naturally a portion of the sidecar weight has to be raised as well as that of the machine. Rigging the outfit with a considerable "lean-out" of the frame cancels out the effect of trail to an extent which will enable the outfit to run straight on a flat road, but it

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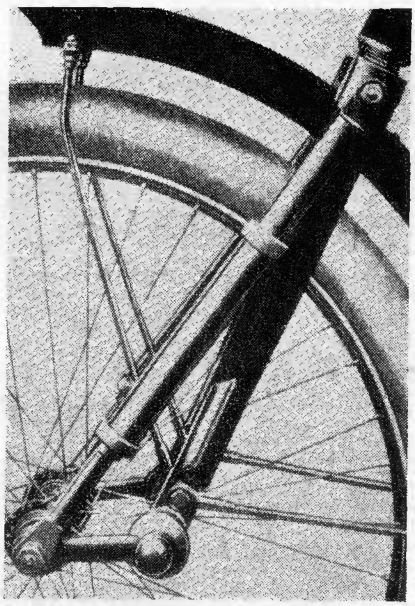
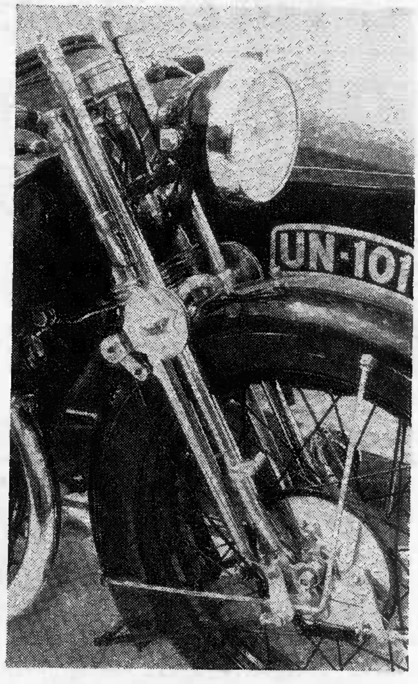


A pioneer combination of telescopic and leading link design — the 1909 NSU.



Typical American practice—the Harley-Davidson bottom-link type as used on certain British Brough Superior models.

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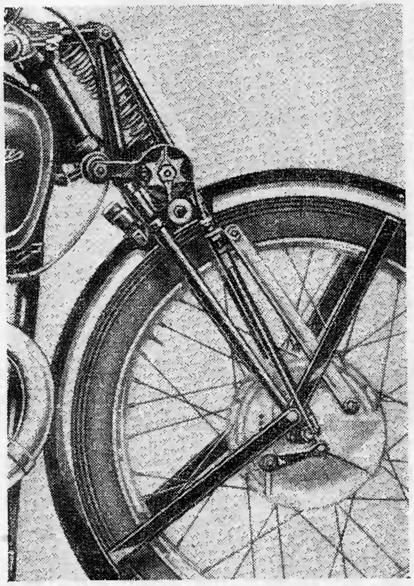


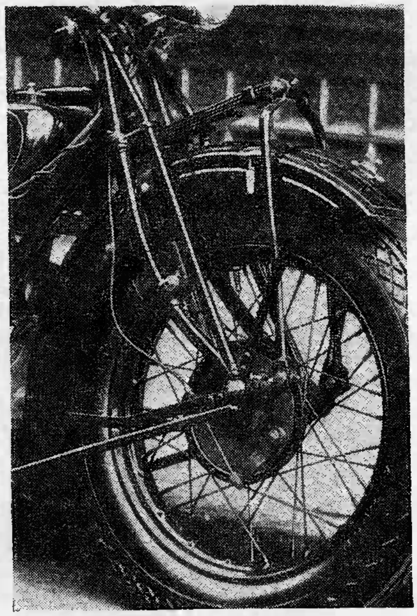
A famous girder pattern, used by Velocettes for both racing and touring models with great success.

will still want to run down the slope of a cambered road, either towards or away from the chair if the trail is excessive. For that reason, forks for dual-purpose models should have some means of altering the trail quickly and easily, and those designed especially for sidecar use, which would probably only be pure racing machines, should have the head angle much steeper than usual; somewhere about 15°, with the trail reduced to 1 inch or less, will give effortless steering on smooth surfaces. On rough surfaces, or if sand or mud is being negotiated, the actual point of contact with rocks or the wall of soil ahead of the tyre may be so far forward of the column axis that the trail, if only slightly positive, will become, in effect, considerably negative and a lot of work may then be required to hold the wheel on a straight course; so for adverse conditions it does not pay to reduce the trail too much.

In any case, sidecar or solo, the rake and trail must both vary continuously when the machine is traversing bumps; to quote an example: If the forks on a 52-in. wheelbase frame are compressed 3 in., the head angle steepens in relation to the ground by about 4°—and if at the same time the rear wheel is off the ground, or is at the limit of its rebound travel on the rear springs, the head will steepen by another 4°. Conversely, if the front forks are extended and the rear suspension compressed, the head will lie back by a total of 8°—so that it may, under extreme conditions, vary from its designed static position by plus or minus 8°, though only rarely will it alter by more than plus or minus 5°.

Under similar conditions, the trail is bound to decrease or increase according to the fall or rise of the rear end of the frame, though this effect is not very marked; a much more important factor is the alteration in trail and wheelbase introduced by the mechanism of the front suspension. With telescopic forks lying parallel to the steering-head the trail will remain approximately constant, though the wheelbase will alter; but if the axle is controlled by some form of linkage, so that it moves vertically, the trail will become less as it rises, though the wheelbase will then remain substantially constant. With yet other forms the axle may move in a circular or an S-shaped path, and both trail and wheelbase may alter.

Which principle is the best is hard to say. For many years the KTT Velocette, which was justly famed for its accurate steering, possessed girder forks with the linkage very carefully designed to give the wheel a straight-line vertical motion—that is



For many years Indians fitted this quarter-elliptic leaf-spring type of trailing-link fork to their big-twin machines.

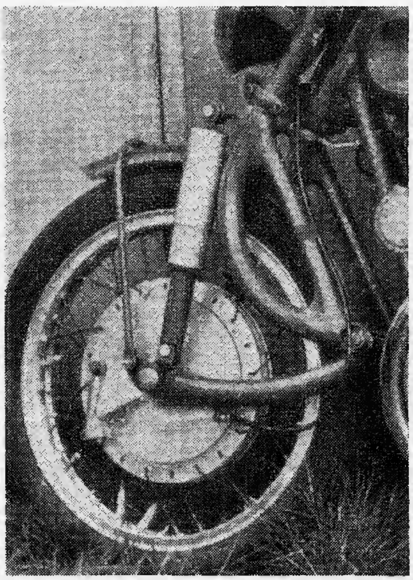
to say, on the "constant wheelbase" principle. The difficulty with girder forks is that straight-line axle motion can only be achieved by making the top and bottom links of differing lengths and with the spindle centres in the girders farther apart than those on the head assembly. Also the straight-line motion exists only for about 3 in. or so of travel; the axle will move sharply backwards at the extreme upper limit, and sharply forwards at the extreme down position, and an undesirably great alteration of the steering geometry will result unless the total movement is restricted to keep out of these disturbed regions.

A "Teles" Point

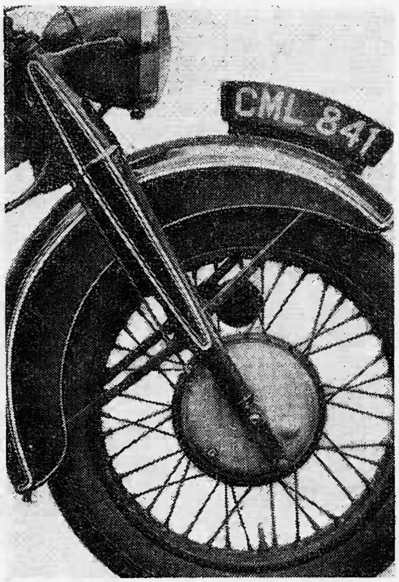
No such limitation applies to telescopic forks. A further argument sometimes advanced in their favour is that when the wheel passes over a bump it lags behind a little as it rises, and thus "rides" the obstruction more easily than if it could rise only vertically.

The axle motion of either leading-link or trailing-link forks is bound to follow a circular path, but the general direction of this arc can be varied by altering the position of the pivot in relation to the axle. Trailing links, in particular, can be made to exhibit the lagging effect on bumps by placing the pivot point well above the axle, which used to be a feature of the original Indian design.

Whatever one does must be in the nature of a compromise; but that the compromise can be successful is beyond dispute, for at one time or another specific examples of all the various forms have given good results. The failure of other designs to do so is most likely attributable to mechanical features which have not been able to cope with the stresses involved in steering on rough surfaces or under heavy braking.



Earles-type forks as employed on some of the earlier examples of racing M.V.-"fours."



An early pattern of telescopic fork standardized on production machines — the B.M.W.

Next week Phil Irving continues this subject, discoursing on fork action and styling.