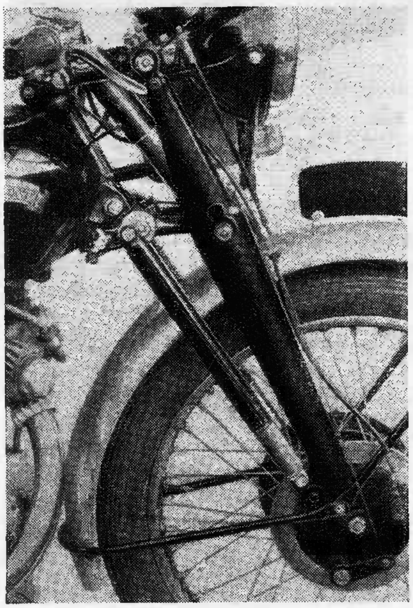
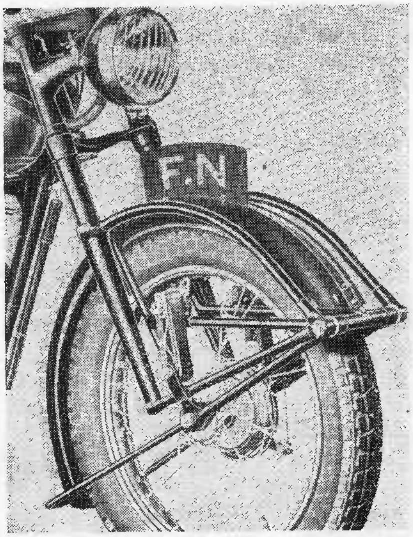
MOTORCYCLE ENGINEERING—4

Front Suspension in Practice

PHIL IRVING Pursues His Analysis of Current Front-end Design



How to do it: an eccentric on the lower rear spindle provided quick trail adjustment on the Vincent "Girdraulic" fork—an Irving brain-child. Forged links were employed.



Built for Belgian pavé, the long-trailing-link 1949 F.N. fork is extremely complicated.

EVEN on an apparently smooth surface, some effort is involved in holding a straight course or in turning a corner, and to withstand this there must be as much torsional rigidity as possible between the handlebars and the wheel. If there is any mechanical slackness the wheel can be deflected out of the true path even if the bars are held steady; but if there is a general lack of stiffness, due to twisting of the components, accurate steering control may be impossible, especially when the machine has to be taken quickly through a swervy section with successive bends to right and left.

You can get an idea of the torsional strength of any fork by grasping the wheel between your knees and then trying to turn the bars. A well-designed girder fork will be almost immovable; the very best of the telescopics will be almost as good, though the poorest examples will not only twist several degrees but may even stay twisted when the bars are released! Bottom-link forks can be quite good in this respect, especially if the fork-tubes are of large diameter and very firmly fixed to the top cross-members, as they are, for instance, in the experimental Reynolds design illustrated; but equivalent stiffness is not so easy to obtain with the Earles type without an excessive weight penalty, because of the more complicated and longer path along which the forces are transmitted.

Undesirable deflection will also occur if there is any deficiency in lateral rigidity. If the tyre receives a sideways blow (and even an oblique blow has a sideways component) it will then be deflected out of its true position, and front and back wheels will momentarily be out of track. The back wheel may either try to swing back into line, by which time the front wheel has sprung back again, or it may try to come round still farther. In either event, the rider is not, for the moment, in 100% control, and he may be in severe trouble on a succession of bumps, as when crossing a set of tram-lines at an angle.

Improving the Girder

Girder forks can be very bad offenders in this respect, especially if the links and spindles are of small section and poorly attached to each other. Being so high up, any flexure of the rectangles formed by the two pairs of links and their spindles is greatly magnified at ground level, although this movement can be reduced almost to nothing by using integral forged links, as on the Rudge and Vincent "Girdraulic" designs.

Telescopic forks are intrinsically poor also, because one slider can move up while the other moves down, not only permitting the tyre to go out of track but allowing considerable tilt to the wheel as well. This action is resisted only by the rigidity of the axle and its attachment to the sliders, and again it can be seen that in the more successful designs this point has received attention. Greatly increased rigidity could be obtained by a stiff bridge connecting the sliders at their upper ends, though this is rarely done; it is surprising, however, that wider use is not made of large-diameter, hollow spindles rather like the one which Eric Oliver fitted on his Norton sidecar outfit.

The Earles type can be very rigid laterally because, despite the length of the side tubes, they can be joined by a short tube of large diameter without serious increase in unsprung weight; the wheel-guiding mechanism can, in fact, be almost a replica of the forks used at the rear end. But short trailing links, without resorting to a cumbersome arrangement, are of necessity independent.

Short Leading Links

Short leading links are usually also independent, and in both cases the pair of links plus the axle constitute, in effect, a single-throw crank which can twist or bend if the axle is weak or the links are not virtually in one piece with it. The right way to secure adequate rigidity would be by splining or keying a large-diameter axle to which the mating links would be held tightly by pinch-bolts; but the more usual system is merely to rely on friction, which is probably sufficient for solo work if the attachment is really firm.

A good, but long discarded form of construction is to join both links by a secondary fork, roughly parallel to the main blades and, if desired, with the springs or only a single spring located at the top of this fork. This was the basis of the Harley-Davidson design and many others, but it involves extra load-carrying bearings, and, by increasing the unsprung weight, partly nullifies the bottom-link type's chief virtue, minimum unsprung weight.

Another method—used, for example, on the Greeves and racing Honda forks—is to join the links by a loop-tube passing round the rear of the tyre; but, while acceptable on a competition model, this oscillating member is somewhat of an embarrassment when a touring mudguard is used.

The action of the fork under heavy front braking is most important. Adverse disturbances can be set up, partly by the transference of weight to the front end which then occurs, and partly by local forces and deflections within the fork mechanism. If the line of action of the axle is rearwardly inclined, as with telescopics or sloping trailing links, the fork springs will compress considerably, and the machine will also "throw back" immediately it comes to rest. Girder forks can be designed to remain substantially level; though, should the layout of the links be incorrect, a fearful vertical shudder can develop if the front brake happens to be applied when the forks are almost fully extended.

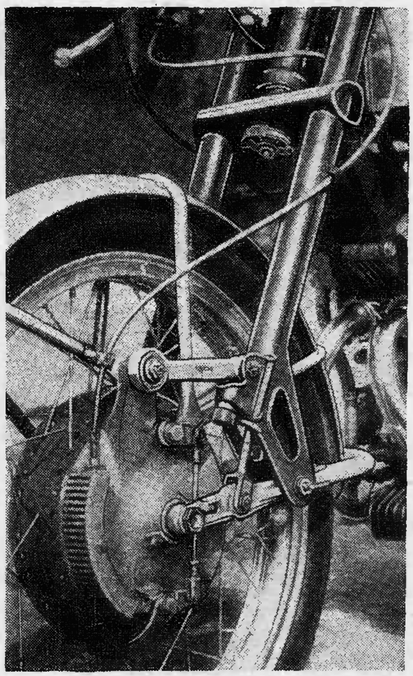
With leading links, the forks tend to depress under the increased load; but if the brake torque-reaction is resisted simply by bolting the brake-plate to one link, the upward reaction may be greater than the downward load on the link and the model may try to stand on tip-toe, so to speak. This undesirable state of affairs can be minimized by lengthening the links, and it hardly exists at all in the Earles type. But a better method is to float the brake-plate on the axle and resist the torque by another pin-jointed link; by correctly laying-out the various angles and lengths, an absolutely level ride can be obtained. Even then, the local forces involved may be in the region of 400 or 500 lb. and deflections may be caused by these very high loads which will tend to make the model veer to one side—an effect which is best obviated by using dual brakes, whatever type of fork is employed. It is noticeable that this symmetrical system has gained a lot of ground recently amongst racing machines.

The Weight Factor

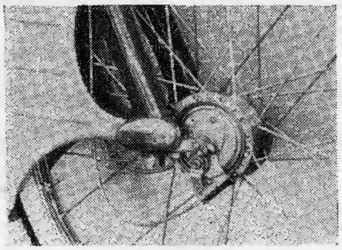
Given equal attention to detail design and choice of materials, there is not a lot of difference in total weight between any of the types for equivalent strength; but all the bottom-link varieties score over the girder and telescopic forms in *unsprung* weight. Under deflection, the main fork of a girder or the sliders of "teles" move at wheel speed, whereas only the active ends of the links move at wheel speed. Further, if the springs are attached at about the mid-points of a pair of short links, even their weight and that of the hydraulic damper mechanism is virtually 50% sprung, so the short-link varieties are potentially the best of all in this very important aspect. The Earles type is good also, but the springs move almost at wheel speed, and this type loses on the score of "pendulum effect"—that is to say, a big proportion of its weight is located behind the wheel and thus at a long distance from the steering column axis, whereas it is desirable to keep all the mass as close as possible to this axis for nicety of control.

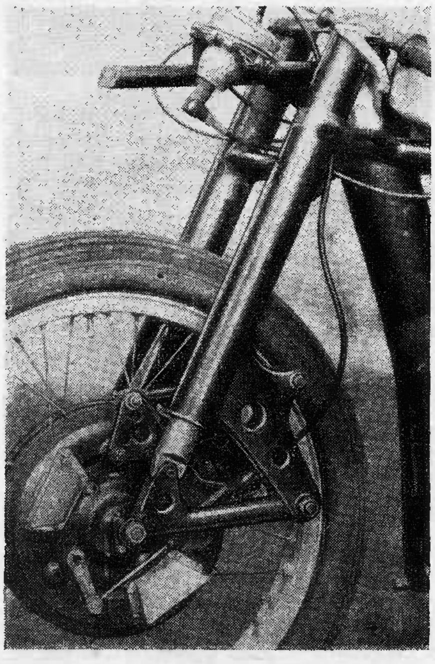
In a sidecar machine this is of less importance, and further it is easy to provide alternative pivot points in the Earles links to give a long trail for solo use and a short trail for sidecar work. Similar provision is also made in the Vincent "Girdraulic" fork by mounting the lower links on eccentric bushes. The simplicity of such an arrangement was one of the reasons why this type was chosen in preference to "teles," although it is not hard to devise a quick trail-adjustment on this form, either, as Royal Enfield and Panther have shown.

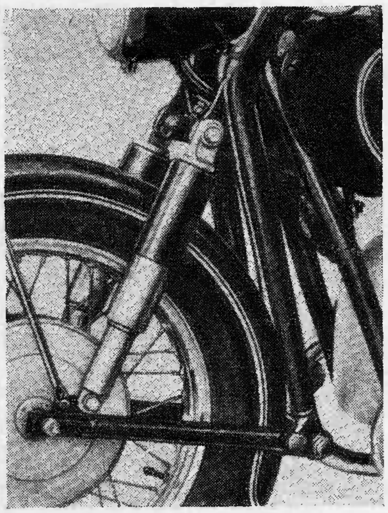
Telescopics come out top of the class on the score of neatness and a deceptive air of simplicity, while the trailing-link is probably the least tidy, although, by cunning use of pressings of tasteful design even this variety can be made quite attractive—as, for instance, on the Ariel "Leader." Taking all things into consideration, lateral rigidity of the wheel in the forks, torsional rigidity of the whole assembly, minimum unsprung weight, absence of "nose-diving" during braking, and neatness, the short-leading link type with floating brake-plates and springs enclosed in the main tubes is probably the best form though there still remains some difficulty with trail adjustment. The ideal solution here would be to construct the head in such a way that the column axis could be varied at will, and thereby alter the rake and the trail simultaneously to switch from solo to sidecar trim.



Torsional rigidity for the short leading link can be provided by a "hoop" passing round the rear of the wheel. On the Greeves roadster (above) it lies inside the mudguard; on the T.T. Honda (right) outside it. But individual links are sufficiently rigid for the NSU "Quickly" (below).







(Left) Low in weight, both sprung and unsprung, are the leading-link Reynolds forks on Geoff Duke's Junior Norton. (Above) Earles-type forks are fitted to all current B.M.W. roadsters.

Next week Phil Irving begins the most comprehensive survey of frame design yet written for a British journal.