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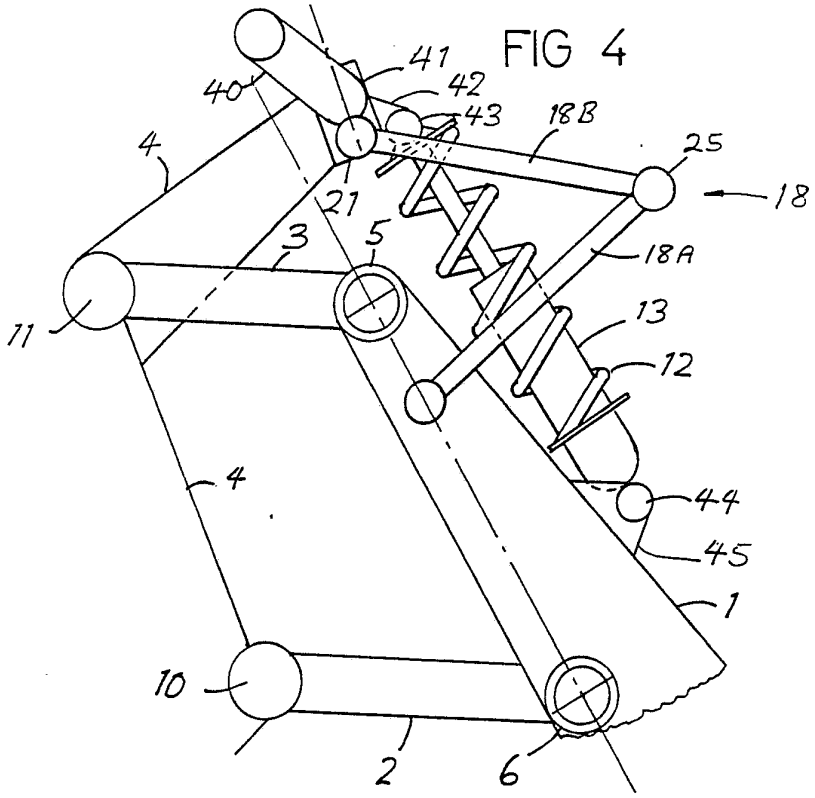
(54) Vehicle suspension assembly for single steerable front wheel

(57) A motorcycle has the front forks coupled to the chassis by upper and lower wishbone links 3,2. The open ends of the wishbones are to the rear and are pivotally coupled to the frame to allow upward and downward suspension movement. The front ends of the wishbones are coupled to the front forks by universal joints 5,6 which allow upward and downward suspension movement and also steering movement. The handlebars 40 are pivotally mounted on the chassis and are coupled to the front forks by a first steering wishbone link 18B pivotally coupled to the handlebars and by a second steering wishbone link 18A pivotally coupled to the front forks. The two steering wishbone links project from the handlebars and the front forks and are pivotally coupled together at their distal ends. Resilient suspension means 12 are coupled between the front forks and the handlebars, rather than the chassis.

FIG 4



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The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1982.

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FIG.1.

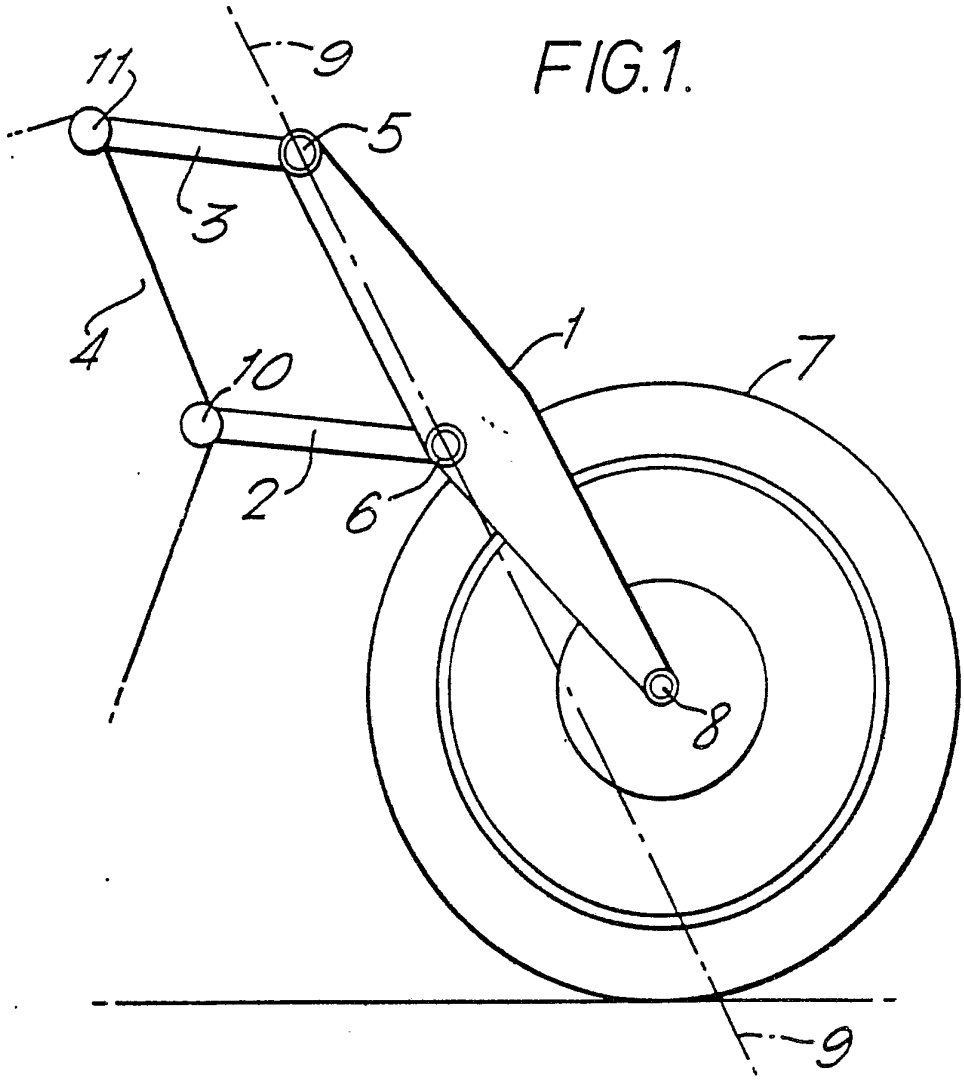
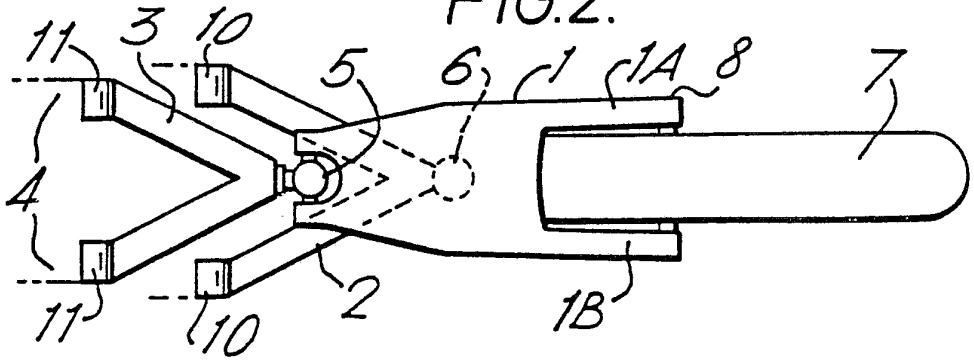


FIG.2.



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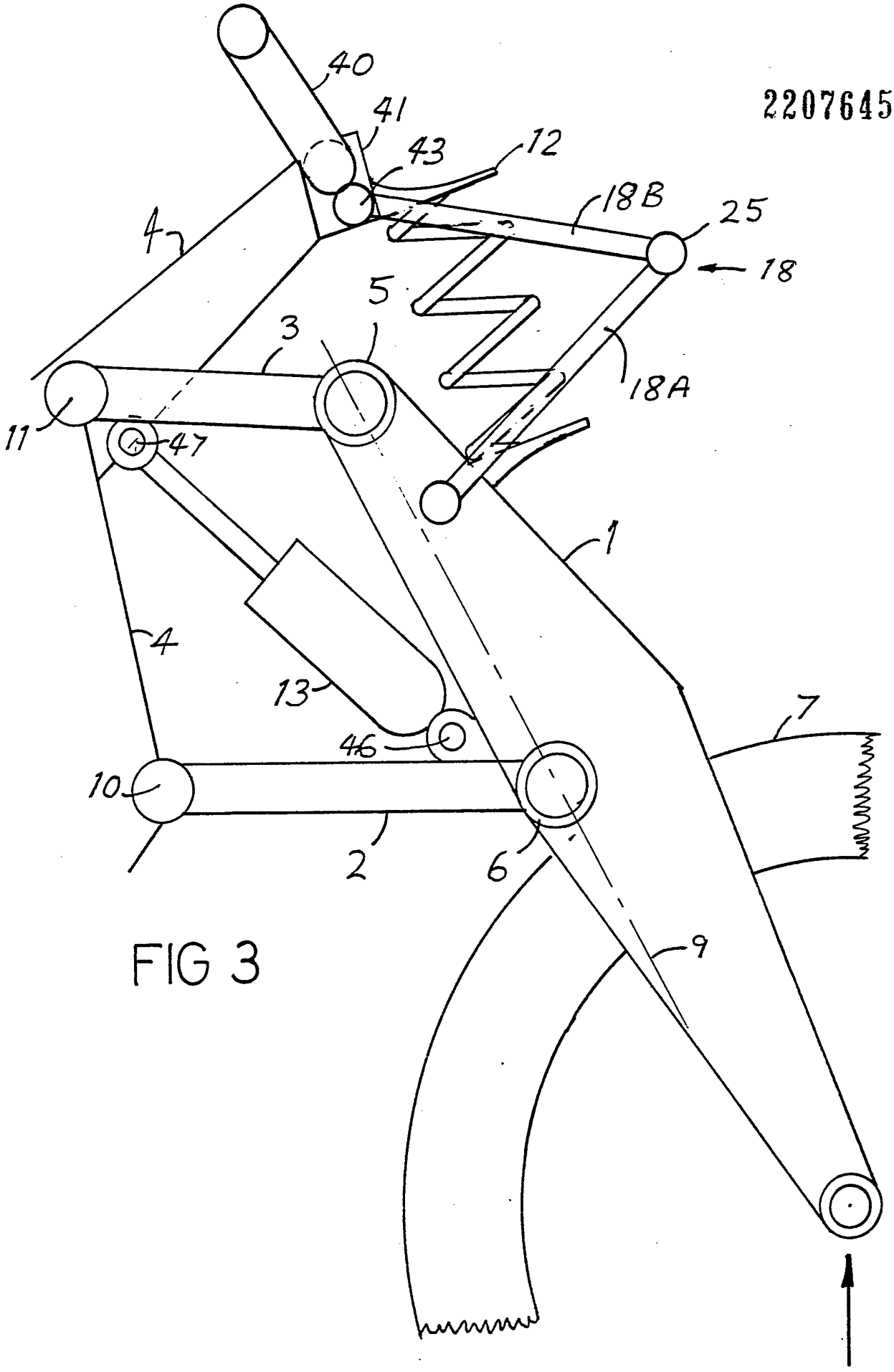

FIG 3

FIG 4

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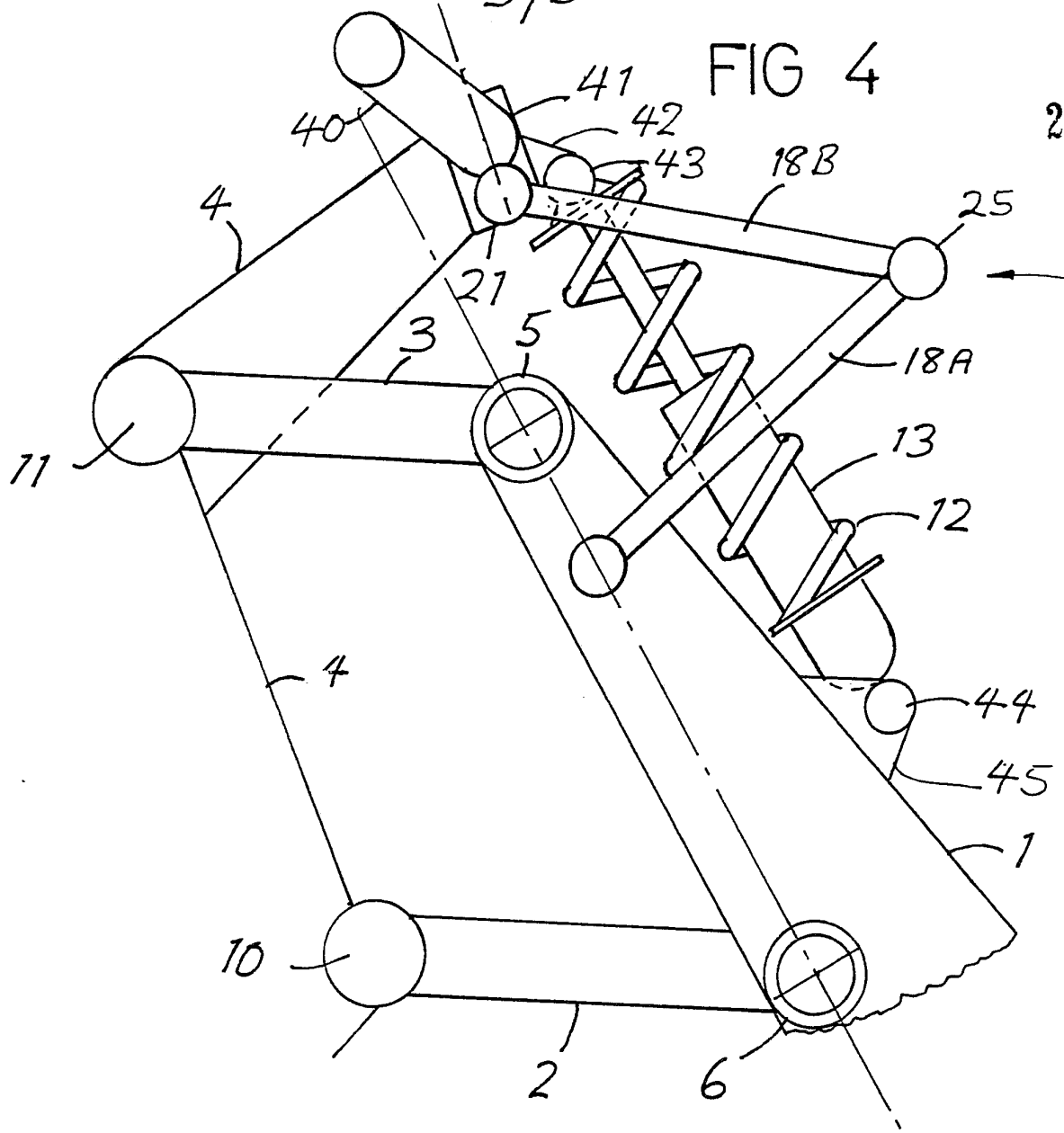

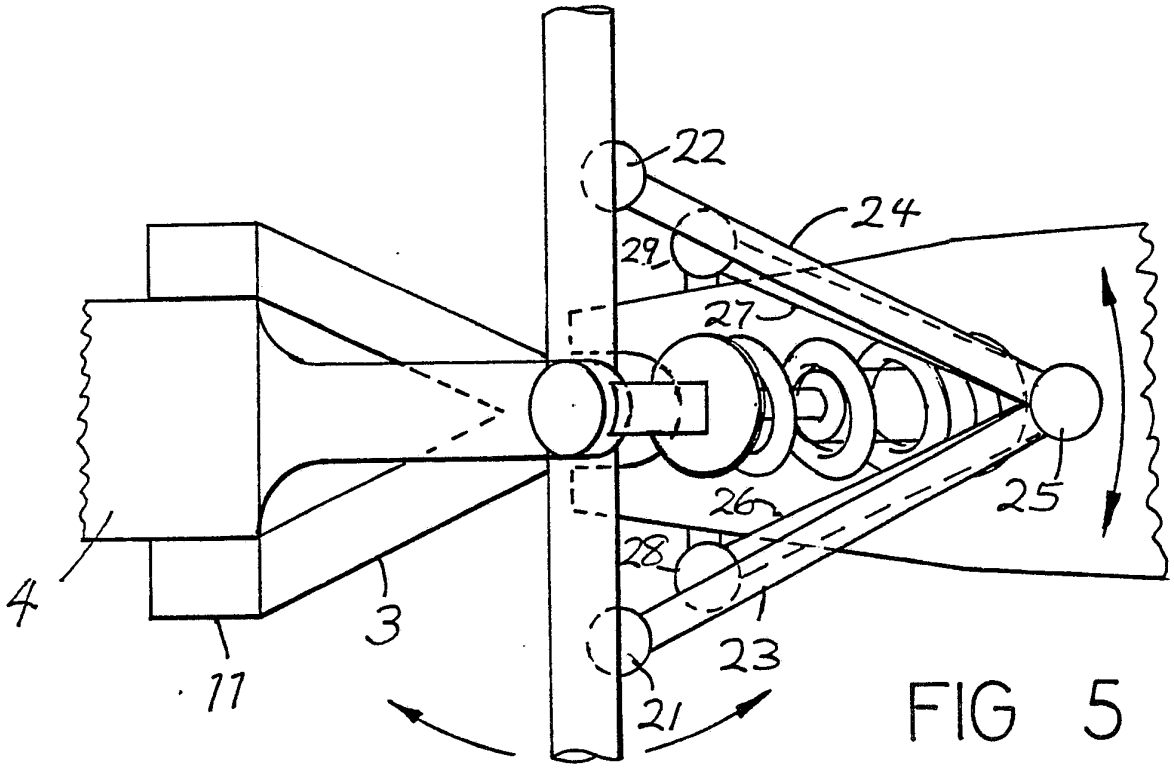

FIG 5

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VEHICLE SUSPENSION ASSEMBLY

The present invention relates to a vehicle suspension assembly, and is concerned with a front suspension assembly for a vehicle having a single, steered, front wheel, particularly but not exclusively for a two wheeled motorcycle.

The present invention is an improvement in the suspension assembly disclosed in my previous British Patent Number GB2121364B.

Although the sliding telescopic front forks of the modern motorcycle have been almost universally accepted, there remain disadvantages connected with them including relatively high friction where sliding seals are involved in the upward and downwards suspension travel, flexing of the tubular forms in cornering and when accommodating undulating surfaces, and change of wheelbase of the cycle during compression and expansion in suspension movements. The handling of a two-wheeled vehicle during cornering and absorption of suspension shocks depends crucially upon the inter-relationship of steering angle, suspension movement, wheelbase and so on, and it is an object of the present invention to provide a novel front suspension assembly particularly suited to two-wheeled motorcycles, and providing improved handling qualities, structural strength, and

weight saving, compared with previously known suspension systems.

Although the novel system disclosed in our prior patent mentioned above provides a basic principle which overcomes these difficulties, the positioning of the spring and damping units in our prior patent still gives rise to friction and stiction in some joints. It is an object of the present invention to improve the arrangements for springing and damping, for certain uses such as road work and off-road riding.

According to the present invention there is provided a front suspension assembly for a vehicle having a single, steered, front wheel, the assembly comprising a chassis of the vehicle, a front sub-frame for mounting the front wheel of the vehicle, upper and lower suspension links coupling the front sub-frame to the chassis of the vehicle, forward and rearward pivotal couplings for coupling the suspension links to the front sub-frame and to the chassis respectively and for allowing upward and downward suspension movement of the sub-frame relative to the chassis by pivotal movement of the suspension links, the forward pivotal couplings being universal couplings allowing steering movement of the front sub-frame about a steering axis as well as allowing the said pivotal movements for upward and downward suspension movement of the front sub-

frame, steering means pivotally mounted on the chassis for applying steering movement to the front sub-frame, a pivotal steering linkage coupling the steering means to the front sub-frame, and resilient suspension means to accommodate the said upward and downward suspension movement of the front sub-frame relative to the chassis, the resilient suspension means being coupled between the front sub-frame and the steering means.

Conveniently the resilient suspension means may comprise a conventional suspension spring, or an air suspension unit, a rubber suspension unit, or an hydraulic active suspension unit.

Normally there will be provided also damping means to provide a damping effect on the said upward and downward suspension movement of the front sub-frame relative to the chassis, and preferably the damping means is also coupled between the front sub-frame and the steering means. In other arrangements, however, the damping means may be coupled, for example, between the lower suspension link, and the chassis of the vehicle.

In a preferred form of the present invention, the said steering linkage comprises a first steering link projecting from the steering member and pivotally linked at its proximal end to the steering means, and a second steering link projecting from the front sub-frame and pivotally linked at its proximal end to the front sub-

frame, the first and second steering links being pivotally coupled to each other at their distal ends, the first steering link comprising a wishbone link having two diverging arms rigidly fixed relative to each other and positioned with the open end of the wishbone pivotally connected to the steering means, the first steering link being connected to the steering means by two spaced apart universal couplings positioned one at each end of the spaced apart ends of the first wishbone arms, the second steering link comprising a further wishbone link having two diverging arms rigidly fixed relative to each other and positioned with the open end of the wishbone pivotally connected to the front sub-frame, the second steering link being connected to the front sub-frame by two further spaced apart universal couplings positioned one at each end of the spaced apart ends of the second wishbone arms, the two wishbone links being coupled to each other by a single universal coupling at the said distal ends of the wishbone links.

Preferably the said steering linkage is symetrical about a longitudinal centre line of the vehicle, when viewed from above with the front sub-frame centrally aligned.

Preferably the first steering link projects forwardly from the steering member, and the second

steering link projects forwardly from the front sub-frame.

In some arrangements the proximal end of the first steering link is connected to the steering member at a higher level than the proximal end of the second steering link which is connected to the front sub-frame.

In other arrangements the proximal end of the first steering link is connected to the steering member at a lower level than the proximal end of the second steering link which is connected to the front sub-frame.

In preferred arrangements the steering means includes a conventional handle bar.

Conveniently the said front sub-frame consists of a pair of front forks positioned one on either side of the front wheel with the axle of the front wheel mounted across the lower ends of the front forks. However in some other preferred arrangements the front sub-frame may comprise a single sided mounting for the front wheel.

Preferably the said rearward pivotal couplings comprise bearings allowing pivoting about a horizontal axis only, to accommodate the upward and downward suspension travel of the front sub-frame. Conveniently each of the said upper and lower suspension links comprises a wishbone linkage with the open portion of the wishbone to the rear and with a bearing at each of

the two rear ends of the wishbone allowing pivotal movement of the wishbone about a single horizontal axis common to the two rear bearings of the wishbone. In such a case, preferably the front pivotal coupling of each wishbone consists of a single universal joint accommodating upward and downward suspension travel of the front sub-frame by a pivotal movement about a horizontal axis of the universal joint, and accommodating steering movement of the front sub-frame by pivotal movement about the said steering axis.

It is a particular feature of the present invention, at least in preferred forms thereof, that the said universal couplings which allow both suspension movement and steering movement, are positioned outside the circumference of the front wheel of the vehicle.

As with known suspension systems for motorcycles, the angles chosen between the various components of the suspension assembly will be modified according to the handling requirements of a particular situation. However it is preferred that the lower forward pivotal coupling is positioned in front of the upper forward pivotal coupling, and that the lower rearward pivotal coupling is positioned to the fore of the upper rearward pivotal coupling. It is also preferred that the upper forward pivotal coupling is positioned to the fore of the lower rearward pivotal couplings. Preferably the

steering axis, that is to say the axis passing through the two universal pivotal couplings about which the steering movement takes place, passes through a point of contact of the front wheel with the ground, and makes an angle, known as the steering head angle, with the vertical of approximately 27 degrees.

Conveniently the steering force applied to the front sub-frame is applied by handle-bars mounted on the main chassis and pivoted thereto by ball or roller bearings allowing steering movement of the handle-bars about an axis inclined to the vertical and to the horizontal, and conveniently inclined at an angle similar to the said steering axis. It is to be appreciated that the handle-bars will not be mounted directly on the front sub-frame, since the front sub-frame will be subject to upward and downward suspension travel in response to undulating surfaces.

Preferably each universal joint comprises a ball-type universal joint, of the kind used generally in car suspension assemblies. The present invention provides particular advantage with regard to the loads being borne by the universal joints of the suspension system. In my previous patent mentioned above, it was proposed to locate the resilient suspension unit between the lower wishbone link and the chassis of the vehicle. This resulted in the main suspension load of the front

wheel being transmitted through the ball joint of the lower wishbone link. Although this is acceptable, and may even be preferable, in some applications such as racing, the arrangement can produce excessive wear of the lower front universal joint. The arrangement proposed in the present invention has the advantage that the main suspension load of the front wheel does not pass through either the upper or lower front universal joint of the two suspension links, but instead passes directly from the front sub-frame through the steering bearings of the said steering means. Since the steering bearings are required to rotate only about a single axis (and are not required to provide universal pivoting), the strains of the main load of the front wheel can more easily be accommodated within the steering bearings .

Although the present invention has particular application to two-wheeled motorcycles, it is to be appreciated that it may equally well be used in, for example, a three-wheeled vehicle having two rear wheels and a single steered front wheel. In such a case the steering movement required may be applied to the front sub-frame by handle-bars or by a steering wheel mounted on the main chassis.

Advantages which may be obtained, at least in preferred embodiments of the present invention, include a relatively small change in wheelbase during suspension

travel of the front wheel, low frictional losses during suspension travel and steering movement, and a light rigid structure which gives less flexing during cornering and travel over undulating ground, than can be obtained with conventional systems.

Embodiments of the invention will now be described by way of example with reference to the accompanying drawings in which:-

Figures 1 and 2 are diagramatic side and plan views respectively of a front suspension assembly embodying the present invention;

Figure 3 is a diagramatic side view of one form of springing and damping arrangement for the suspension system of Figures 1 and 2, embodying the invention,

Figures 4 and 5 are diagramatic side and plan views respectively of an alternative, preferred, form of springing and damping arrangement, embodying the invention.

Referring firstly to Figures 1 and 2, a front suspension assembly for a vehicle having a single steered front wheel, especially a two-wheeled motorcycle, has a front sub-frame 1, comprising front forks 1A and 1B, for mounting a front wheel 7 on an axle 8. The front sub-frame 1 is coupled to the main chassis 4 of the vehicle by upper and lower suspension links consisting of wishbones 3 and 2. The wishbones 3 and 2

are linked to the chassis by rear pivotal couplings formed by two pairs of bearings 11 and 10 respectively which allow pivotal movement of the wishbones 3 and 2 about horizontal axes. The wishbones 3 and 2 are coupled to the front sub-frame 1 by two universal joints 5 and 6 which allow pivotal movement both about horizontal axes corresponding to the horizontal movement at the bearings 10 and 11, and also allow pivotal steering movement about a steering axis 9 which passes through the universal joints 5 and 6 and is shown in broken line in Figure 1.

The functions of a front suspension system of a motorcycle are threefold, namely to carry weight of the front end of the motorcycle (including the braking load), to provide for steering of the motorcycle, and to allow suspension travel (ie upward and downward movement of the front wheel) in order to cope with travel over uneven surfaces.

Considering firstly the function of carrying the weight of the front end of the motor cycle, there is shown in Figure 4 a unit comprising a spring 12 and a damper 13 which is coupled at its upper end to the steering head assembly which consists of a conventional handlebar 40, a pivoting member 41 which pivots on ball or tapered roller bearings and is thereby linked to the main frame 4. The steering bearings are of a type known

in engineering as frictionless bearings. The spring and damper unit 12, 13 is coupled to a protruding mount 42 by a damper pivot 43 which allows pivoting about a horizontal axis only. Similarly at the lower end, the springing and damping unit 12, 13 is mounted by a damper pivot 44 to a projecting mount 45 projecting forwardly from the front sub-frame 1.

The weight of the machine is thus transferred to the front wheel by way of the spring and damper unit 12 13, through the frictionless bearings of the pivot member 41.

Considering next the steering function of allowing steering of the vehicle, the steering effort will applied in conventional manner through the handlebars 40, and the handlebar motion is transferred to steering motion of the front fork 1 by a symetrical pivotal linkage 18. A cross member is mounted at the head of the front forks 1 and carries universal joints 21 and 22 at the ends thereof. Two rods 23 and 24 are rigidly connected together to form the wishbone 18B and are coupled at their outer ends to the universal joints 21 and 22 respectively. At the front end of the wishbone 18B, the rods 23 and 24 are coupled by a further universal joint 25 to the further lower wishbone 18A comprising rods 26 and 27 which are coupled in turn to

respective universal joints 28 and 29 mounted on either side of the front assembly 1.

Thus by the arrangement shown in figures 4 and 5, the handlebars 40 may be turned relative to the frame 4 on steering bearings, and this motion is transferred to the forks 1 through the rods 26 and 27, and 23 and 24. Suspension movement of the front forks 1 relative to the main frame 4 is accommodated by pivoting of the rods 26, 27, 23 and 24 about their respective universal joints 21, 22, 25, 28 and 29. (It is to be noted that in some forms the joints 21, 22, 28 and 29 may be universal joints, but in other applications they may be joints capable of rotation only about one axis.)

In Figure 3, there is shown an alternative arrangement to that shown in Figure 4. In the embodiment of Figure 3, the damping unit 13 is positioned differently, although the spring 12 remains positioned between the front fork 1 and the steering assembly 41. The damping unit 13 is coupled between a pivot 46 mounted on the lower wishbone 2, and a pivot 47 mounted on the main frame 4. Because the loads passing through the damper 13 are very much less than those passing through the main spring 12, the relocation of the damper 13 in the position shown in Figure 3, imposes little additional load on the main suspension universal joint 6. In some applications the damping

position shown in Figure 3 may be preferable, and still allows retention of the main advantage of the invention, achieved by positioning the spring 12 between the front fork 1 and the steering head assembly 41.

CLAIMS

1. A front suspension assembly for a vehicle having a single, steered, front wheel, the assembly comprising

a chassis of the vehicle,

a front sub-frame for mounting the front wheel of the vehicle,

upper and lower suspension links coupling the front sub-frame to the chassis of the vehicle,

forward and rearward pivotal couplings for coupling the suspension links to the front sub-frame and to the chassis respectively and for allowing upward and downward suspension movement of the sub-frame relative to the chassis by pivotal movement of the suspension links, the forward pivotal couplings being universal couplings allowing steering movement of the front sub-frame about a steering axis as well as allowing the said pivotal movements for upward and downward suspension movement of the front sub-frame,

steering means pivotally mounted on the chassis for applying steering movement to the front sub-frame,

a pivotal steering linkage coupling the steering means to the front sub-frame, and

resilient suspension means to accommodate the said upward and downward suspension movement of the front sub-

frame relative to the chassis, the resilient suspension means being coupled between the front sub-frame and the steering means.

2. An assembly according to claim 1 including damping means to provide a damping effect on the said upward and downward suspension movement of the front sub-frame relative to the chassis.

3. An assembly according to claim 2 in which the damping means is coupled between the front sub-frame and the steering means.

4. An assembly according to claim 2 in which the damping means is coupled between the lower suspension link, and the chassis of the vehicle.

5. An assembly according to any preceding claim in which the said steering linkage comprises a first steering link projecting from the steering member and pivotally linked at its proximal end to the steering means, and a second steering link projecting from the front sub-frame and pivotally linked at its proximal end to the front sub-frame, the first and second steering links being pivotally coupled to each other at their distal ends, the first steering link comprising a wishbone link having two diverging arms rigidly fixed relative to each other and positioned with the open end of the wishbone pivotally connected to the steering member, the first

steering link being connected to the steering means by two spaced apart universal couplings positioned one at each of the spaced apart ends of the first wishbone arms, the second steering link comprising a further wishbone link having two diverging arms rigidly fixed relative to each other and positioned with the open end of the wishbone pivotally connected to the front sub-frame, the second steering link being connected to the front sub-frame by two further spaced apart universal couplings positioned one at each of the spaced apart ends of the second wishbone arms, the two wishbone links being coupled to each other by a single universal coupling at the said distal ends of the wishbone links.

6. An assembly according to claim 5 in which the said steering linkage is symmetrical about a longitudinal centre line of the vehicle, when viewed from above with the front sub-frame centrally aligned.

7. An assembly according to any preceding claim in which the first steering link projects forwardly from the steering member, and the second steering link projects forwardly from the front sub-frame.

8. An assembly according to any preceding claim in which the proximal end of the first steering link is connected to the steering means at a higher level than

the proximal end of the second steering link which is connected to the front sub-frame.

9. An assembly according to any of claims 1 to 7 in which the proximal end of the first steering link is connected to the steering means at a lower level than the proximal end of the second steering link which is connected to the front sub-frame.

10. An assembly according to any preceding claim in which the steering means includes a conventional handle bar.

11. An assembly according to any preceding claim in which the said front sub-frame consists of a pair of front forks positioned one on either side of the front wheel with the axle of the front wheel mounted across the lower ends of the front forks.

12. An assembly according to any preceding claim in which the said rearward pivotal couplings of the upper and lower suspension links comprise bearings allowing pivoting about a horizontal axis only, to accommodate the upward and downward suspension travel of the front sub-frame.

13. An assembly according to any preceding claim in which each of the said upper and lower suspension links comprises a wishbone linkage with the open portion of

the wishbone to the rear and with a bearing at each of the two rear ends of the wishbone allowing pivotal movement of the wishbone about a single horizontal axis common to the two rear bearings of the wishbone.

14. An assembly according to claim 13 in which the front pivotal coupling of each wishbone consists of a single universal joint.

15. An assembly according to any preceding claim in which the said universal couplings which allow both suspension movement and steering movement are positioned outside the circumference of the front wheel of the vehicle.

16. An assembly according to any preceding claim in which the assembly forms a front suspension assembly for a motorcycle.

17. A vehicle front suspension assembly substantially as hereinbefore described with reference to any one or any combination of the accompanying drawings.

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