(12) UK Patent Application (19) GB (11) 2 121 364 A

(21) Application No **8310385**
(22) Date of filing **18 Apr 1983**
(30) Priority data
(31) **8212059**
(32) **26 Apr 1982**
(33) **United Kingdom (GB)**
(43) Application published
21 Dec 1983
(51) **INT CL³**
B62K 25/04
(52) Domestic classification
B7E CS
(56) Documents cited
GBA 2021496
(58) Field of search
B7E
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(54) **Motorcycle suspension**

(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 are pivotally mounted on the chassis and are coupled to the front forks by a first steering wishbone link 23 pivotally coupled to the handlebars and by a second steering wishbone link 24 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.

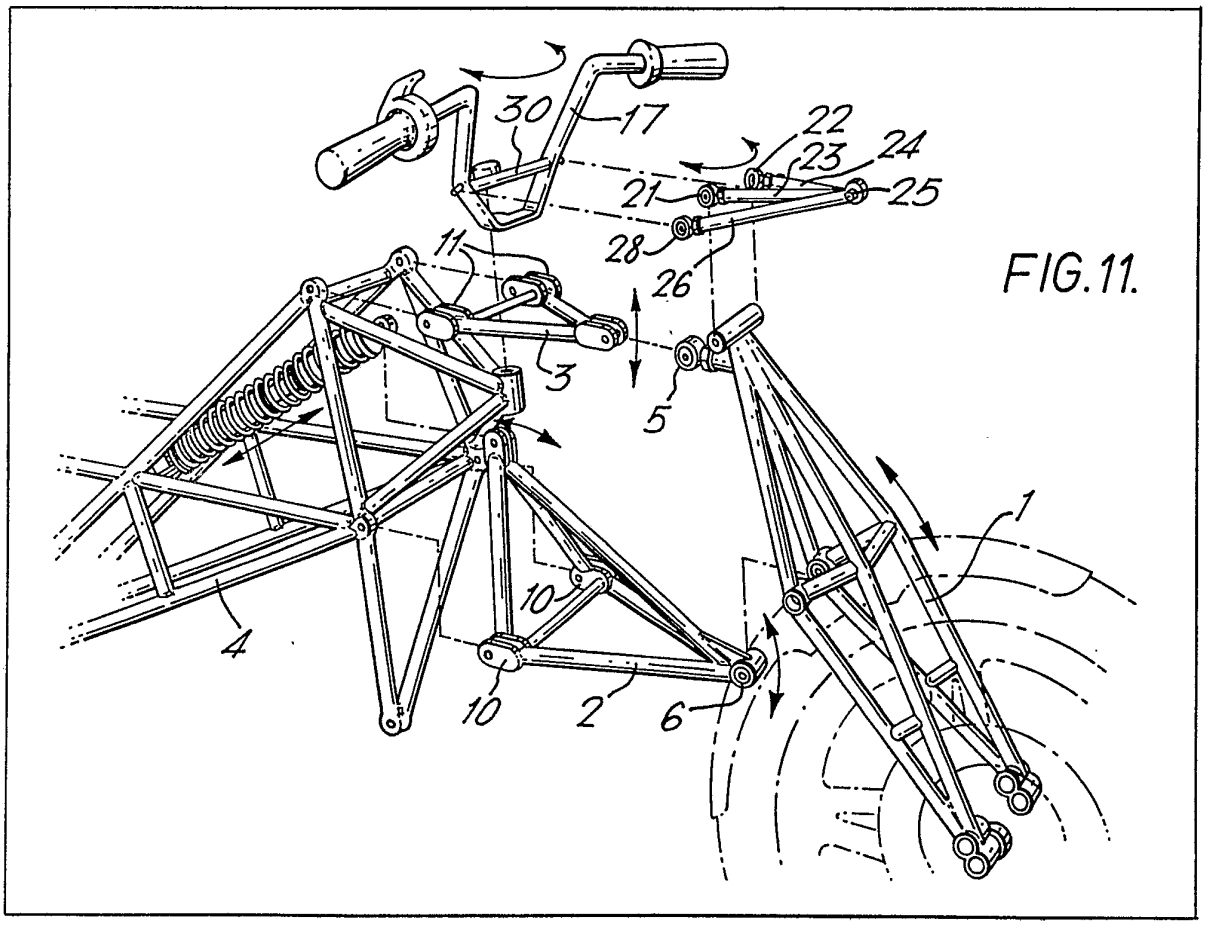

FIG.11.

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The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

FIG.1.

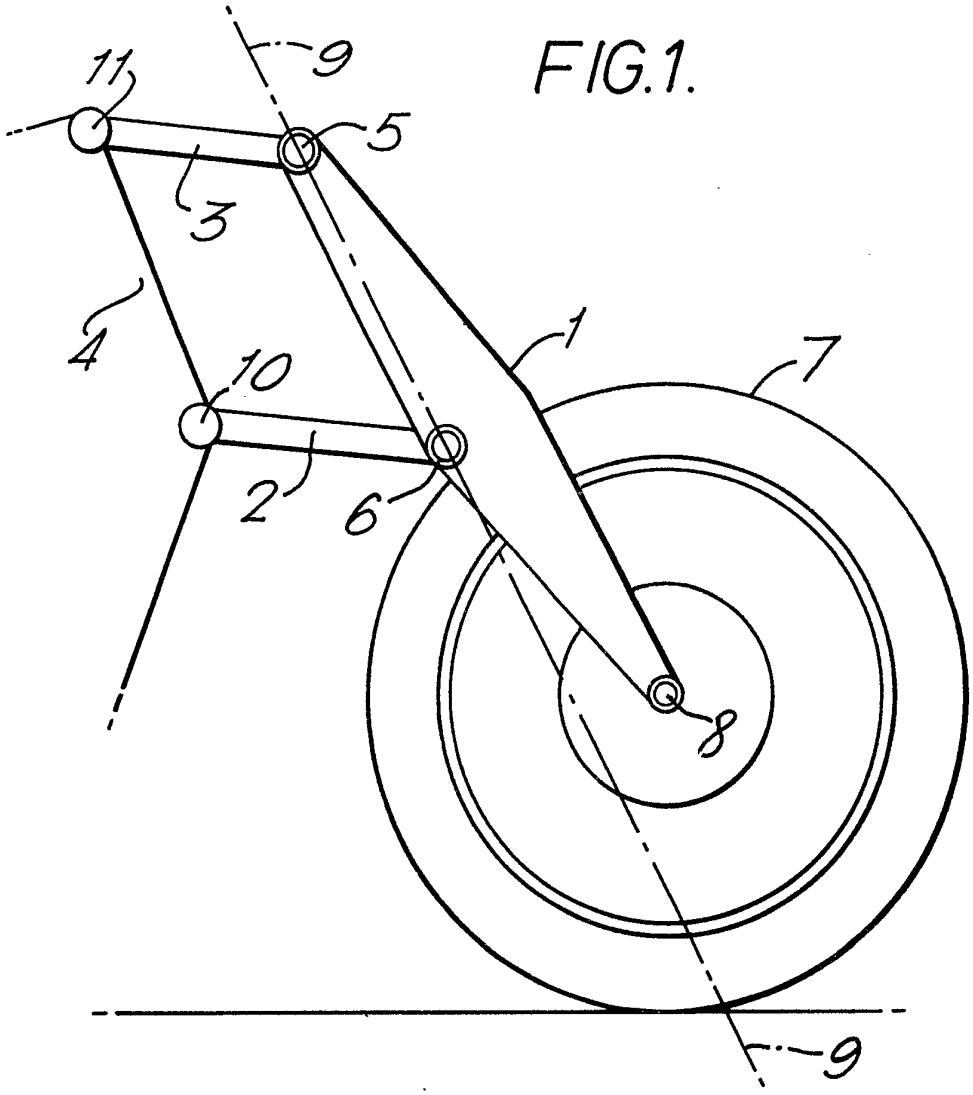
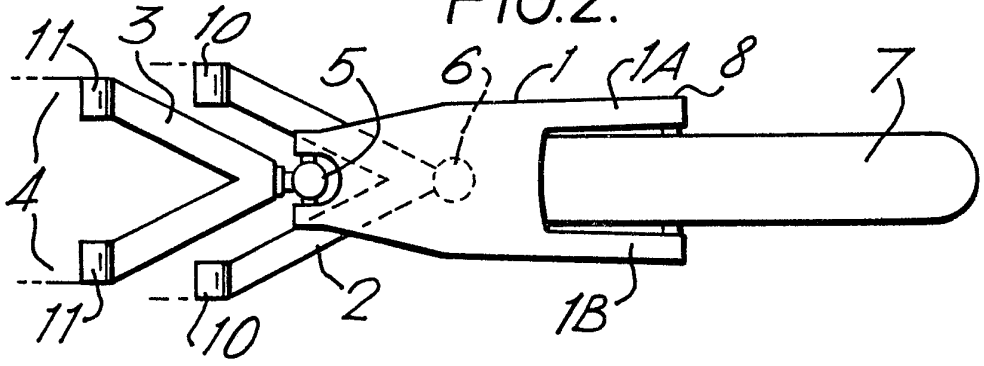


FIG.2.



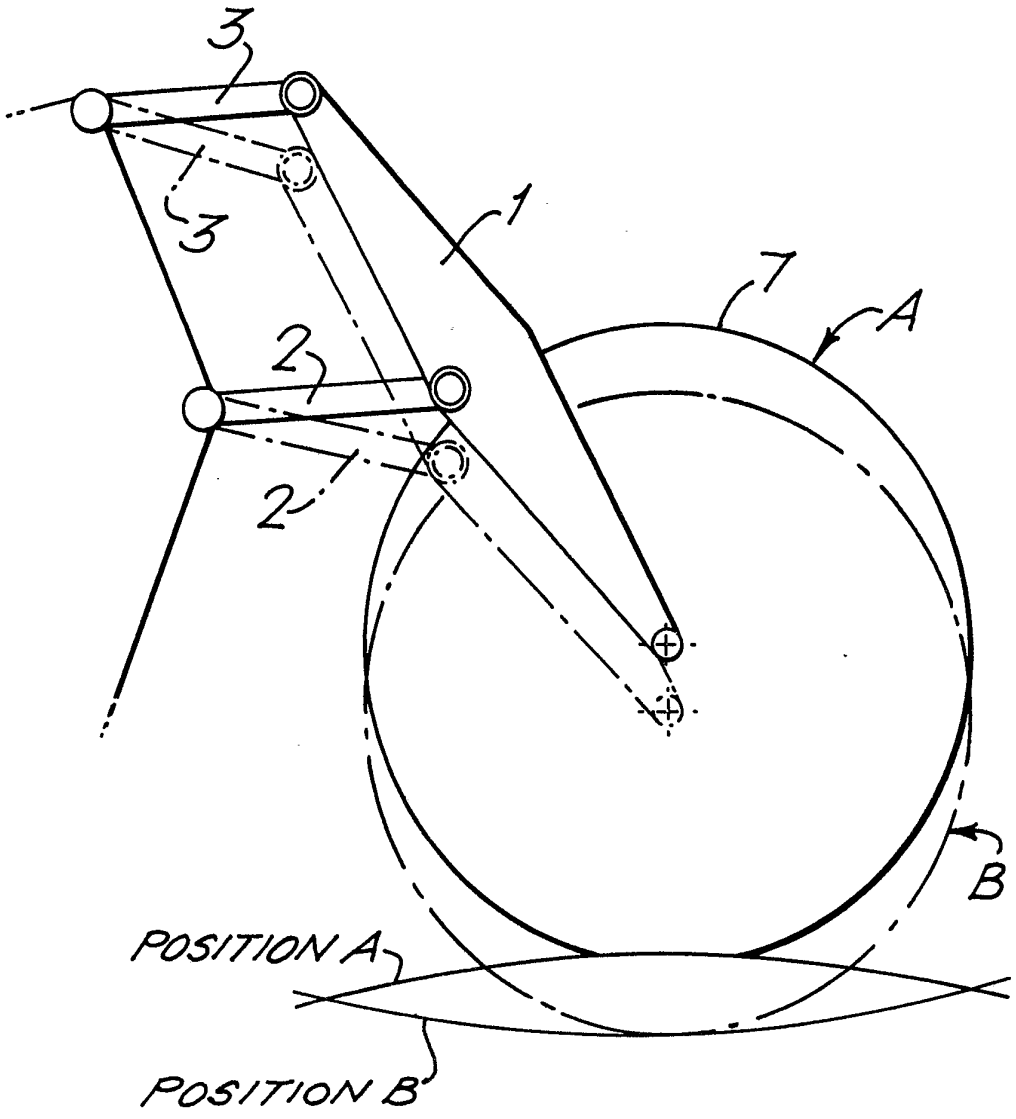


FIG.3.

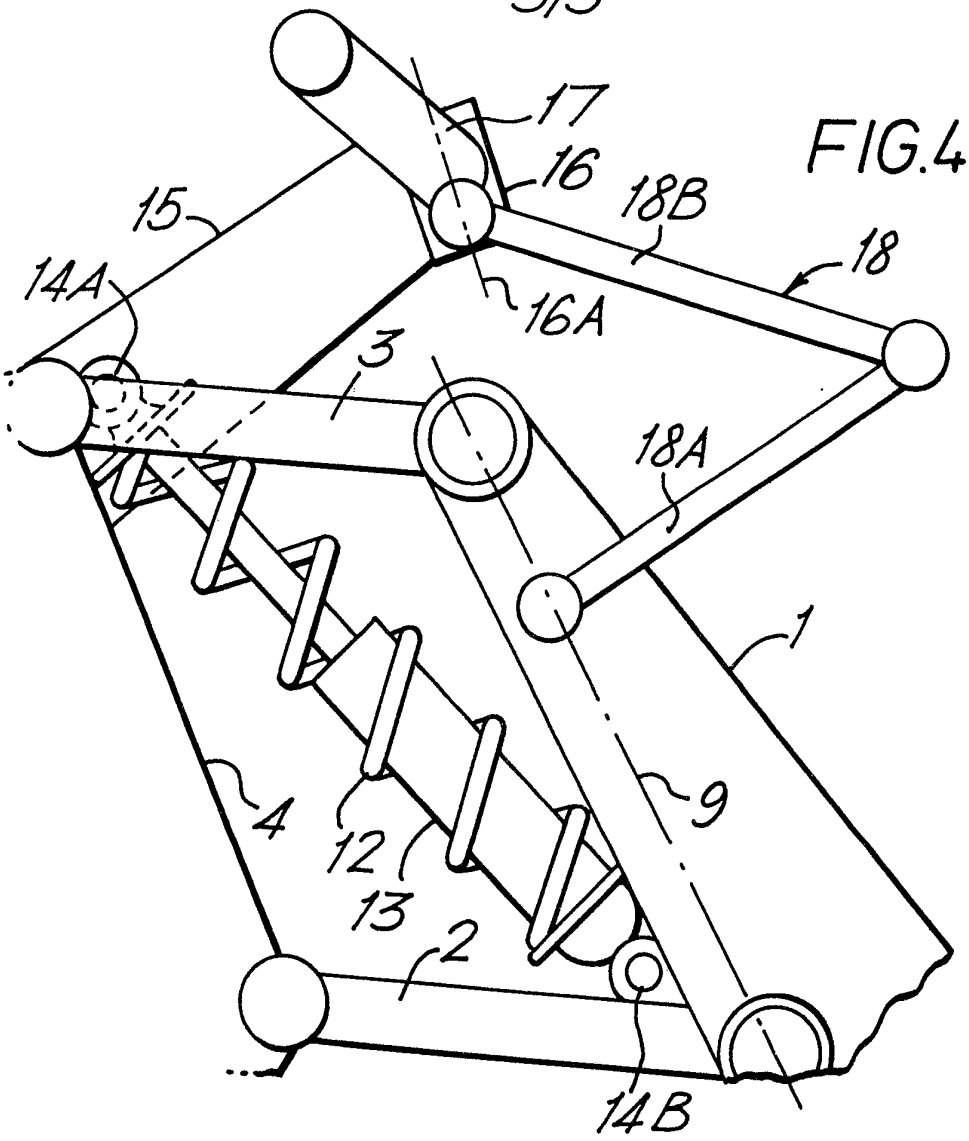


FIG.4.

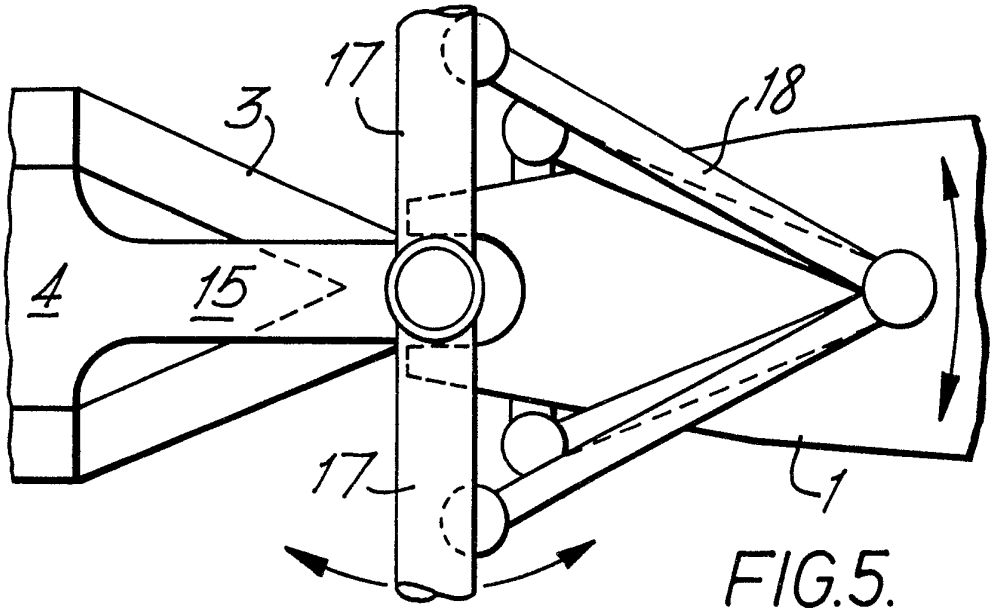


FIG.5.

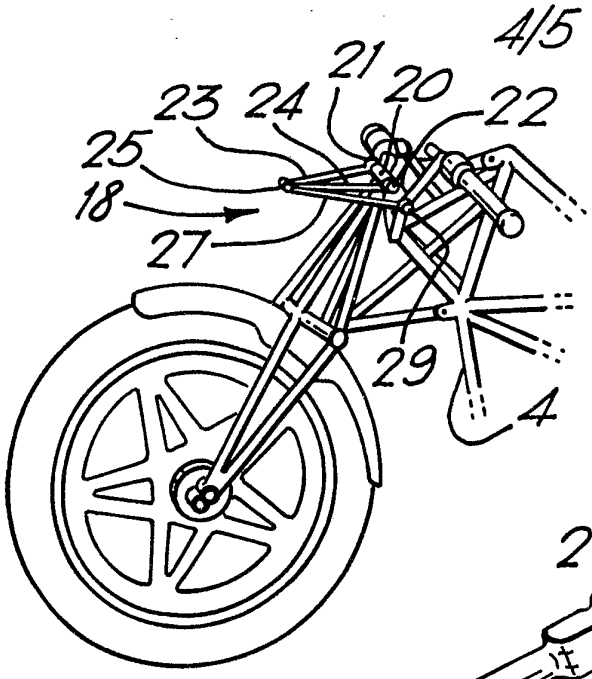


FIG.6.

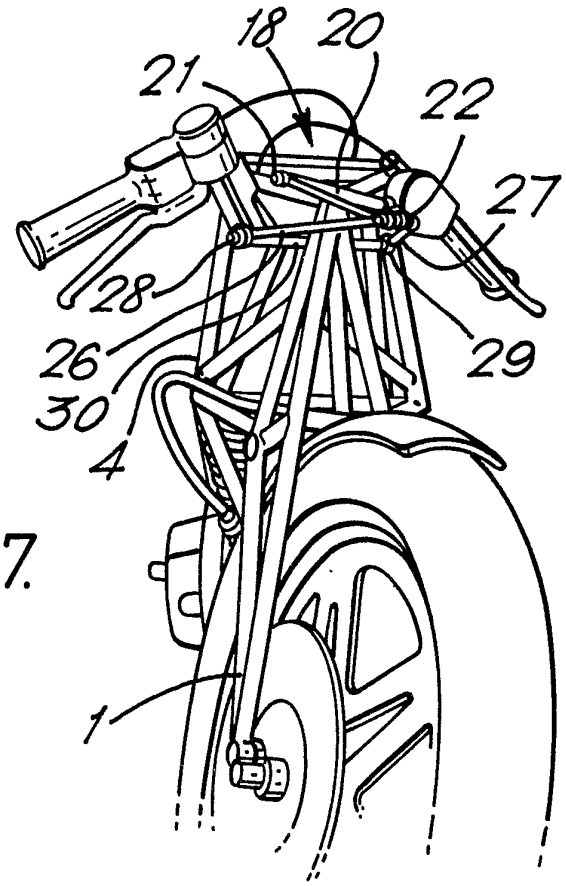


FIG.7.

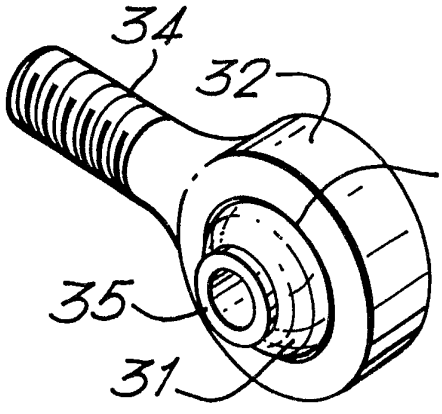
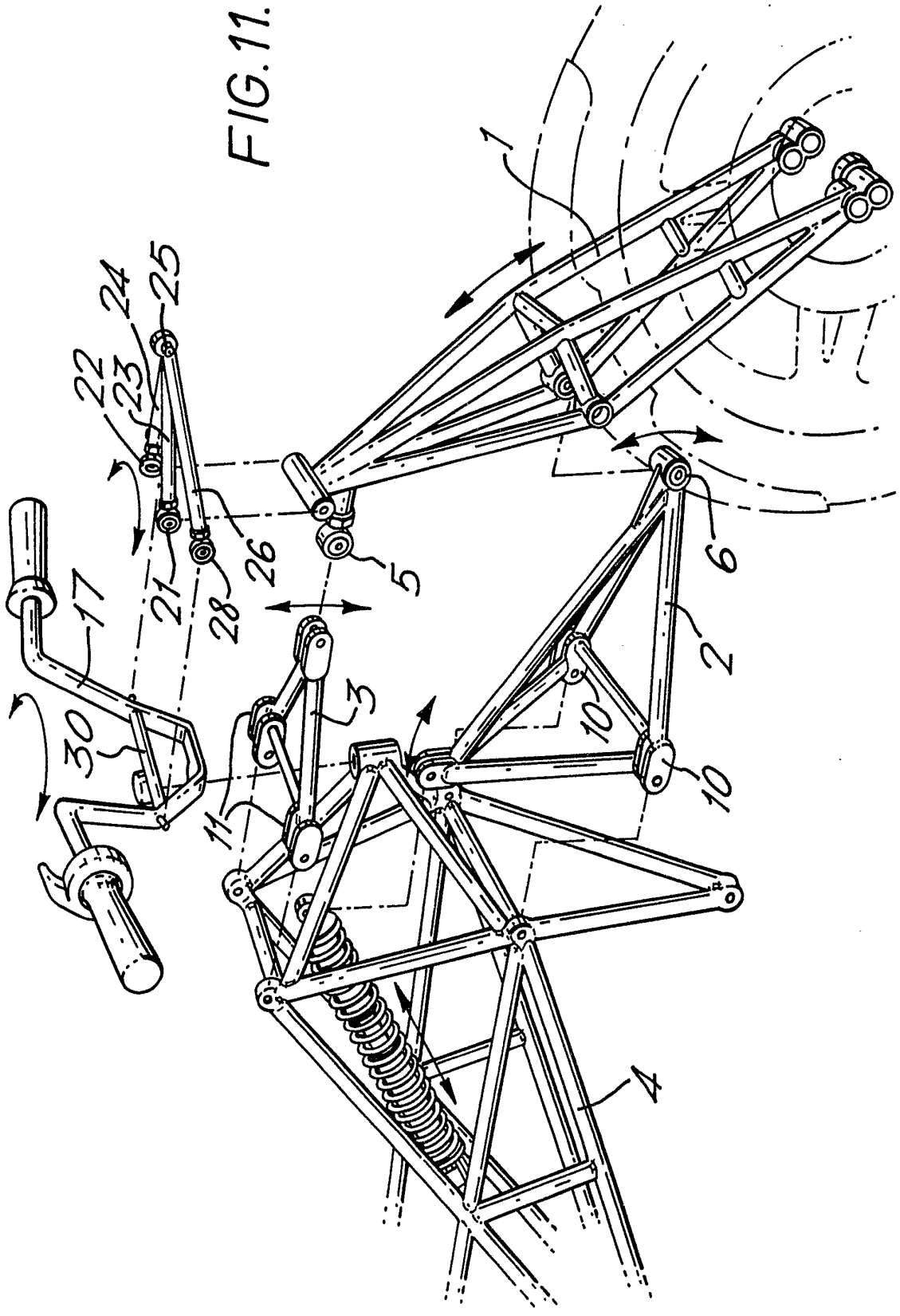


FIG.10.

FIG.11.



SPECIFICATION

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 majority of two wheeled motorcycles manufactured at present have telescopic front forks in which the front wheel is positioned between parallel tubular members each having a telescopic joint with appropriate springs and dampers, so that upward and downward suspension travel is provided by the tubular members sliding into and out of each other at the telescopic joints. At their upper ends the front forks are fixedly mounted together at a steering head assembly which is coupled to the main chassis at a main head bearing which allows steering movement about a steering axis inclined to both the horizontal and the vertical. A previously used form of front suspension, known as the girder system, had the front forks coupled to the steering head assembly by a pivotal parallelogram linkage allowing upward and downward suspension travel against a spring, but again steering was achieved by a separate steering head bearing allowing steering movement about the steering axis to be inclined the vertical and the horizontal. In another form of motorised two wheeled vehicle, the motor-scooter, the front wheel is commonly suspended from one side only by a single pivoted arm is coupled to an upright leading through the steering head to the handle bars. Again the suspension movement by pivoting of the arm mounting for the wheel against a spring, is separated from the steering movement about the main steering axis.

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 downward suspension travel, flexing of the tubular forks in cornering and when accommodating undulating surfaces, and change of wheel base of the cycle during compression and expansion in suspension movement. 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, wheel base 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.

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 front 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 inclined to the horizontal as well as allowing the said pivotal movements for upward and downward suspension movement of the front sub-frame, a steering member pivotally mounted on the chassis for applying steering movement to the front sub-frame, and a pivotal steering linkage coupling the steering member to the front sub-frame, the steering linkage comprising a first steering link projecting from the steering member and pivotally linked at its proximal end to the steering member, 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.

Preferably 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.

Preferably the first steering link projects forwardly from the steering member, and the second steering link projects forwardly from the front sub-frame.

Also preferably the first steering link comprises a wishbone link with the open end of the wishbone connected to the steering member, and the second steering link comprises a wishbone link with the open end of the wishbone connected to 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 member comprises part of a handle bar assembly.

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 other 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. Coveniently each of the said upper and lower suspension links comprise 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 consist of a single universal joint accommodating upward and downward suspension travel of the front sub-frame by 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.

In accordance with one particularly preferred form of the invention there is provided a motorcycle front suspension assembly comprising a motorcycle chassis, a front fork sub-frame comprising a pair of front forks for mounting the front wheel of the motorcycle upper and lower suspension links for coupling the front sub-frame to the chassis of the motorcycle each of the upper and lower suspension links comprising a wishbone with the open end of the wishbone to the rear, forward and rearward pivotal couplings for coupling the suspension wishbone links to the front sub-frame and to the chassis respectively and for allowing upward and downward suspension movement of the front sub-frame relative to the chassis by pivotal movement of the suspension links, forward pivotal couplings of each suspension wishbone link being universal couplings allowing steering movement of the front sub-frame about a steering axis inclined to the horizontal, as well as allowing the said pivotal movements for upward and downward suspension movement of the front sub-frame, a handlebar assembly pivotally mounted on the chassis (and including a steering member) for applying steering movement to the front sub-frame, and a pivotal steering linkage coupling the handlebar assembly to the front fork sub-frame, the steering linkage being symmetrical about a longitudinal centre line of the vehicle, when viewed from above with the front sub-frame centrally aligned, the steering linkage comprising a first steering link in the form of a wishbone projecting forwardly from the handlebar assembly with the open end of the wishbone pivotally linked to the handlebar assembly, and a second steering link in the form of a wishbone projecting forwardly from the front fork sub-frame with the open end of the wishbone pivotally linked to the front fork sub-frame, the first and second steering wishbone links being pivotally coupled to each other at their forwardly projecting distal ends.

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 in 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 coupling. 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°.

Conveniently the steering force applied to the front sub-frame is applied by handle bars mounted on the main chassis and pivoted thereto by 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. In such an arrangement, the handle bars are coupled to the front sub-frame on which the front wheel is mounted, by means of a pivotal linkage such that turning movement of the handle bars produces a desired turning movement of the front sub-frame. 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 known as a "Rose" joint, in which a ball is partially encased in a housing such as to give access to the ball on two opposed sides of the housing, with one input to the joint being secured to the housing and the other input to the joint being secured to the ball through openings in the said two opposed sides of the housing.

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 wheel base 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 diagrammatic side and plan views respectively of a front suspension assembly embodying the present invention;

Figure 3 is a diagrammatic side view of the

suspension assembly of Figure 1, illustrating two deflected positions of the front wheel;

Figures 4 and 5 are diagrammatic side and plan views respectively showing details of the suspension system shown generally in Figure 1, and illustrating one form of springing system and steering arrangement;

Figures 6 and 7 show diagrammatic perspective views from the side and front respectively of a modified embodiment of the invention, and illustrate an alternative steering arrangement;

Figure 10 is a diagrammatic perspective view of a ball-type universal joint particularly suited for use in embodiments of the present invention, and

Figure 11 shows an exploded view of the arrangement shown in Figures 6 and 7.

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. In preferred forms of the invention, as shown in the Figures, the universal joints 5 and 6 are both positioned outside the circumference of the front wheel 7, and it is also preferred that the steering axis 9 passes through a point of contact of the wheel 7 with the ground. Conveniently the angle of the steering axis 9 with the vertical, the steering head angle, is in the region of 27°.

It will be appreciated from the Figures and the description that the assembly allows upward and downward suspension movement of the wheel 7 with the front sub-frame 1 relative to the chassis 4 by pivotal movement of the suspension links 2 and 3 about horizontal axes passing through the bearings 10 and 11 and the universal joints 5 and 6. It will also be appreciated that the arrangement allows steering movement of the front wheel 7 with the front sub-frame 1 by pivotal movement of the sub-frame 1 about the steering axis 9 passing through the universal joints 5 and 6. Thus the universal joints 5 and 6 allow rotary steering movement about the steering axis 9 in addition to allowing the said pivotal movements for upward and downward suspension travel of the front wheel.

The functions of a front suspension system of a motorcycle are threefold, namely to carry the weight of the front end of the motorcycle (including the braking load), to provide for steering of the motorcycle, and to allow suspension travel (i.e. 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 motorcycle, there is shown in Figure 4 a unit comprising a spring 12 and damper 13 which is coupled at its upper end to the main chassis 4 by a bearing 14A which allows pivotal movement about a horizontal axis, and is coupled at its lower end to the forward end of the lower wishbone 2 by a further bearing 14B which again allows pivotal movement about a horizontal axis. The weight of the machine is thus transferred to the front wheel by way of the spring and damper unit 12, 13. It will be appreciated that the bearings 14A and 14B only need to allow pivoting about horizontal axes, since the steering movement of the sub-frame 1 is accommodated by the universal joints 5 and 6 which are positioned foward of the spring and damper mountings 14A and 14B. The spring and damper arrangement shown is convenient, but numerous other arrangements will be clear to one skilled in the art, for examples the spring and damper unit 12, 13 could be positioned more to the rear within the main chassis 4 and could be coupled at its lower rearward end to the chassis and at its forward upper end to a rearward extension of the upper wishbone 3.

Considering next the second function of allowing steering of the vehicle, the steering effort will be applied usually in the case of a motorcycle by conventional handle bars. However it will not be appropriate to mount the handle bars directly on the front sub-frame 1 as is normally the case, because in the case of the present embodiment, the front sub-frame 1 will rise and fall relative to the main chassis 4 during suspension travel. As shown in Figure 4, the handle bars 17 may therefore be mounted on an extension 15 of the chassis 4, and the handle bars 17 are mounted on a bearing 16 for pivotal movement about an axis inclined to both the horizontal and the vertical and indicated at 16A. This may be parallel to the steering axis 9 or, as shown, may be slightly inclined thereto. Thus the handle bars 17 may be turned from side to side about the bearing 16 relative to the chassis 4. The steering movement is transferred to the front sub-frame 1 by way of a pivoted steering linkage 18 which is coupled to the front sub-frame 1 at 18A, and is coupled to the handle bars 17 at 18B.

Thus in the steering arrangement of Figures 4 and 5, handle bar motion is transferred to steering motion of the front fork 1 by a symmetrical pivotal linkage 18.

In a modified form of steering arrangement shown in Figures 6 and 7, the front forks 1 are pivotally linked to the handle bars 17 by a pivotal linkage again indicated at 18, which is independent of mounting on the main frame 4. In the arrangement of Figures 6 and 7 a cross-member 20 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 a wishbone and are coupled at their outer ends to the universal joints 21 and 22 respectively. At the front end of the wishbone, the rods 23 and 24 are coupled by a further universal joint 25 to further lower wishbone comprising rods 26 and 27 which are coupled in turn to respective universal joints 28 and 29 mounted at the ends of a further cross-member 30. The cross-member 30 constitutes part of the handle bar assembly 17, the handle bars 17 being mounted on the main frame 4 by steering bearings similar to the bearings 16 set out in Figure 4.

Thus by the arrangement shown in Figures 6 and 7, the handle bars 17 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, to the cross-member 20 which is fixed relative to the front forks 1. 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.

Considering next the third function of the front suspension, to allow upward and downward suspension travel, there is shown in Figure 3 a diagrammatic view of the front suspension showing the position of the wheel 7 in an upper position A when hitting a bump, and in position B for example when dropping into a pot-hole. This figure shows diagrammatically the two extreme positions that the front wheel may move to, and the consequent positions of the wishbones 2 and 3.

Referring now to Figure 10, there is shown a form of universal joint which is particularly suitable for use in embodiments of the present invention. The joint shown in Figure 10 is a ball-type universal joint of the kind known as a "Rose" joint. The joint comprises a ball 31 partially encased in a housing 32 which gives access to the ball on two opposed sides of the housing through openings of which one opening 33 is shown. One input to the ball joint is secured to the housing 32 by a threaded extension 34 and the other input to the joint is secured to the ball 31 by a bolt (not shown) secured to the ball 31 at a boss 35 protruding through the opening 33. A corresponding boss protrudes on the opposite side of the ball 31. The bearing surface of the housing 32 abutting the ball 31 is lined by a low friction material 36 such as Teflon.

It is to be noted that an attempt to mount the steering head of a conventional motorcycle by ball-type universal joints as shown would be unsuccessful because of the relatively high static friction experienced by such joints. If these joints were to be provided in place of the conventional tapered needle roller bearings in motorcycle the torque required to break the friction on the ball joints by movement of the handle bars would be considerable. The machine would have a tendency to continue in a straight line, and when a turning movement was applied to the handle bars, no steering would be achieved until the torque applied was sufficient to break the static friction on the balls, and thereafter a violent turn of the handle bars would be achieved. Similarly, correction after steering would be abrupt and uncontrollable.

The reason that the ball-type universal joint is successful in embodiments of the present invention is that the upward and downward suspension movement of the front forks continually moves the ball-type joints so that the static friction of the joints is continually being overcome by normal suspension movement as the vehicle moves along the road. Steering torque applied at the handle bars only needs to be sufficient to steer the vehicle, and is not required to overcome static friction, since this is being continually broken by normal suspension movement.

The embodiments of the invention shown and described allow a number of advantages over previously known front suspension systems for motorcycles. There is provided a mechanism for the accurate control of the front wheel of the motorcycle during its change in ride height, for example when riding over a bump, and during its steering, for example in turning a corner. The suspension assembly has very low frictional resistance to the free movement of the front wheel, and in practice provides a structure of great strength and low weight.

As can be seen from Figure 3, during travel of the front wheel from the lower position B to the upper position A there will be only a very small change in the wheel base of the vehicle.

As has been mentioned, use of universal joints and bearings gives lower friction loss in suspension travel than with conventional telescopic sliding front forks.

The assembly shown can be made to be much less flexible than conventional systems, giving better and safer rider control of the front wheel. The structure can also be made lighter and stronger than a conventional system.

In Figure 11 there is shown in exploded form the steering arrangement of Figures 6 and 7.

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 front sub-frame relative to the chassis by privotal movement of the suspension links, the forward pivotal couplings being universal couplings allowing steering movement of the front

sub-frame about a steering axis inclined to the horizontal, as well as allowing the said pivotal movements for upward and downward suspension movement of the front sub-frame,

a steering member pivotally mounted on the chassis for applying steering movement to the front sub-frame, and

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

the steering linkage comprising a first steering link projecting from the steering member and pivotally linked at its proximal end to the steering member, 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.

2. An assembly according to claim 1 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.

3. An assembly according to claim 1 or 2 in which the first steering link projects forwardly from the steering member, and the second steering link projects forwardly from the front sub-frame.

4. An assembly according to claim 1, 2 or 3 in which the first steering link comprises a wishbone link with the open end of the wishbone connected to the steering member, and the second steering link comprises a wishbone link with the open end of the wishbone connected to the front sub-frame.

5. An assembly according to any preceding claim in which 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.

6. An assembly according to any of claims 1 to 4 in which 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.

7. An assembly according to any preceding claim in which the steering member comprises part of a handle bar assembly.

8. 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.

9. 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.

10. 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.

11. An assembly according to claim 10 in which the front pivotal coupling of each wishbone consists of a single universal joint.

12. 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.

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

14. A motorcycle front suspension assembly comprising

a motorcycle chassis,

a front fork sub-frame comprising a pair of front forks for mounting the front wheel of the motorcycle

upper and lower suspension links for coupling the front sub-frame to the chassis of the motorcycle each of the upper and lower suspension links comprising a wishbone with the open end of the wishbone to the rear,

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

a handlebar assembly pivotally mounted on the chassis for applying steering movement to the front sub-frame, and

a pivotal steering linkage coupling the handlebar assembly to the front fork sub-frame, the steering linkage being symmetrical about a longitudinal centre line of the vehicle, when viewed from above with the front sub-frame centrally aligned,

the steering linkage comprising

a first steering link in the form of a wishbone projecting forwardly from the handlebar assembly with the open end of the wishbone pivotally linked to the handlebar assembly, and

a second steering link in the form of a wishbone projecting forwardly from the front fork sub-frame with the open end of the wishbone pivotally linked to the front fork sub-frame,

the first and second steering wishbone links being pivotally coupled to each other at their forwardly projecting distal ends.

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

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1983. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.