



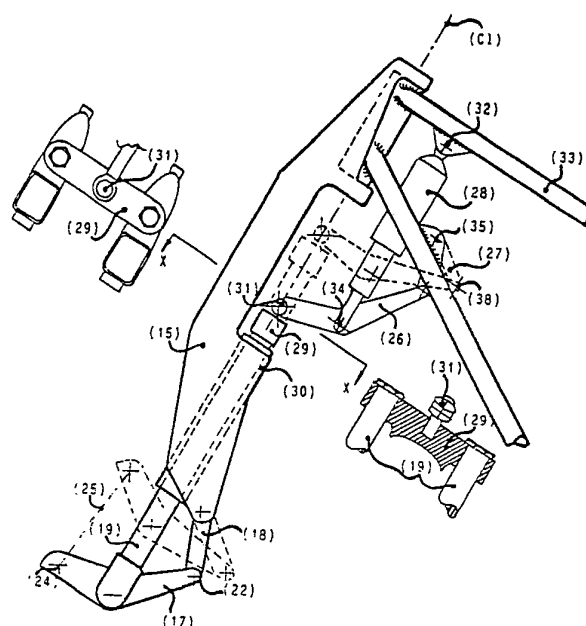
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(54) Title: IMPROVEMENTS TO MOTORCYCLE FRONT SUSPENSION

(57) Abstract

A front suspension system for a motorcycle has a steerable front fork comprising two substantially parallel legs (15) each carrying an articulated suspension mechanism comprising a link (17) supporting the front wheel at a first end (24). A second end (22) of the link (17) is pivotally connected to the fork leg (15) by restraining means (18) allowing translationnal movement of the second end (22) in response to movement at the first end (24). A telescopic element (19) is pivotally connected (20) between the ends (24, 22) of the link (17) and is slidable axially in bearing means fixed in or adjacent the fork leg (15). The articulated mechanisms are joined by interconnecting means (29) to oppose relative movement therebetween. Resilient suspension means (1) are operatively connected to the articulated mechanisms to oppose relative movement between the front fork and the articulated mechanisms in response to load applied in use to the motorcycle.



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IMPROVEMENTS TO MOTORCYCLE FRONT SUSPENSION

From UK application 8221493/PCT00179, motorcycles are known with suspension for the front and rear wheel, the front being carried on a steerable front fork rotatably mounted about an inclined steering axis, said fork comprising substantially parallel legs, with each leg carrying at its lower end a suspension means that minimises the variations in steering 'trail' or castor-effect that machine pitching is known to cause.

Pitching is defined as the change in the angle of the steering axis to a line drawn between, and tangential to, the wheels at points adjacent to the respective contact patches of the front and rear tyres on the road surface. Independant movement of the front and rear wheels by differential extension and compression of the suspension as may be caused by weight-transfer during acceleration and braking, or uneven road surfaces, will cause this angle to change, which in turn is known to cause the trail or castor-effect of the vehicle steering geometry to vary.

The means disclosed as per Fig.1, comprises a pair of substantially parallel legs(15), each leg carrying at its base a link(17) supporting the wheel at a first end(24), and a second end(22) being pivotally connected(21) to the fork leg by restraining means(18) allowing translational movement of the second end in response to movement at the first, and being pivotally connected between these two ends at a point(20) displaced in a substantially vertical plane from a line joining the two ends to a telescopic element(19) sliding axially in or adjacent to, and substantially in the same axis as the fork legs, such that the resultant suspension motion(25) at the wheel spindle minimizes the said 'trail' variations.

No resilient suspension means is provided in the claims of 8221493, but the specification suggests that this would be provided by way of conventional spring(1) and hydraulic damper(2) units incorporated in each leg and acting between the telescopic member and the fork leg as per Fig.1, or alternatively introduced between a point adjacent to the wheel spindle on each link, and a point above this on the respective fork leg.

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Further disclosed in 8221493 is a means for reducing or eliminating the effects of weight transference during braking, said means being the rigid mounting of the brake caliper of a disc-brake assembly on to the suspension link so that upon
5 braking forces are generated to oppose or eliminate the effects of weight transference, or alternatively the mounting of the brake caliper rotatably about the spindle of the wheel, and the pivotal connection of the brake caliper to the fork leg being such that said opposition of forces occurs.

10 OBJECTS OF THE PRESENT INVENTION.

An object of the present invention is to unite the suspension mechanisms in each fork leg so as to ensure they operate simultaneously to prevent any twisting or bending of the wheel spindle.

15 A further object is to reduce the moment of inertia of the fork assembly in the side-to-side 'steering' mode by arranging for the resilient suspension medium to be by a single spring/damper unit or similar means, mounted on or close to the steering axis of the fork; or alternatively to minimise the moment of steering
20 inertia, by arranging for the mass of the resilient medium to be removed from the fork entirely by housing the said suspension medium within or on the frame or chassis of the motorcycle, and be operatively connected to the suspension mechanism.

A further object is that the lever ratio of movement between the
25 wheel and the resilient suspension medium progressively reduces with suspension travel in a manner as to provide initially very compliant suspension characteristics that become progressively firmer with wheel excursion.

A further object is that where the suspension medium is mounted
30 on the chassis of the motorcycle, the operative connection between the suspension medium and the suspension mechanism is such that steering movement and suspension movement are separate and independent; alternatively to arrange such a joint so that movement of the fork rotatably about the steering axis interacts
35 with the vehicle suspension to augment or modify the vehicle steering characteristics, according to the requirements of the particular case.

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A further object is to minimise the effective 'unsprung' inertia of the moving parts of the suspension, including any such ancilliaries that are commonly fixed to the front suspension such as the mudguard.

- 5 A further object is to provide a methods of mounting the brake caliper of the front disc brake assembly so that the opposition of forces thereby generated on braking can be altered to suit particular circumstances, or alternatively can be devised so that the effect of the brake-reaction forces is less pronounced
10 at the begining of wheel excursion than towards full compression, or vice-versa.

- A further object is to provide methods of arranging the geometry of the front suspension components to produce different wheel motions, such as for example a motion devised to minimise
15 'trail' variations under conditions where the front and rear wheel suspension travel is assumed to be substantially equal and simultaneous; or for example where the wheelbase of the vehicle is required to be maintained substantially constant regardless of front and rear suspension travel; or to compensate for
20 different road conditions or vehicle pay-loads as for example may occur when carrying a passenger or luggage.

- a further object is to arrange that changes in the front fork geometry or suspension characteristics can be carried out readily to maintain or modify the over-all suspension and/or
25 steering parameters of the vehicle according to particular circumstances.

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DESCRIPTION OF EMBODIMENTS

In the embodiment illustrated Fig.2, a motorcycle has a steering column fixed or integral with the chassis, and set at a predetermined angle. Rotatably mounted on bearings running on this steering column is a front wheel carrying fork assembly comprising a pair of parallel fork legs united by yokes provided either side of the steering column, the legs incorporating in the base of each an articulated suspension means. The telescopic elements (19) of the suspension means in each leg are united where they protrude from their respective bearings by a rigid bridge piece (29) which is bolted, clamped, splined or otherwise firmly mounted to the top of the said elements, so that there can be no differential axial movement between them. The fork legs (15) are so shaped, relieved or pierced locally as to provide working clearance for the axial movement of the bridge piece.

The assembly as a whole therefore exhibits an improved integrity of motion, and thus reduces any tendency for the wheel spindle to twist or bend, or for the wheel to tilt out of alignment.

In an alternative embodiment Fig.3, the bridge piece is replaced or augmented by an inverted 'U' shaped stay (41) disposed substantially parallel to the fork legs, and pivotally mounted on the suspension link (17) at its lower ends adjacent to the wheel spindle mountings. At the upper end the stay carries a pivotal mounting (42) to a nominally horizontal locating link (26) designed to maintain the substantially parallel position of the stay with respect to the fork legs, the other end of the said link being pivotally mounted (35) at a convenient point on the upper part of the fork legs.

In a further development illustrated Fig.4, the link(26) is pivotally mounted on the upper parts of the telescopic elements or upon the bridge piece(29) previously described. This arrangement is advantageous where a requirement exists to minimise the angular displacement of the locating link. Because both the suspension link and the telescopic elements move respectively to the fork legs in response to wheel movement, it will be apparent that the locating link will not move through such a large angle as is the case where it is pivoted from the fork leg.

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- In another embodiment also illustrated by a dotted line in Fig.4, the suspension links may be united by a rigid extension (45) arranged to pass around the wheel. This extension is best formed adjacent to the end nearest the restraining means (22) -
5 as opposed to an extension of that end nearest the wheel mounting - as this part of the suspension system does not move appreciably in response to wheel excursion and therefore the additional mass of the extension would not add significantly to the 'unsprung' inertia of the suspension system as a whole.
- 10 Any or all of the methods described above may be used singly or in combination with the object of ensuring that the suspension mechanisms in each leg operate simultaneously to obviate bending or misalignment.

- As previously described 21493 suggests that the resilient
15 suspension medium would normally be provided by a pair of conventional coil spring / hydraulic damper units. These would either be housed within the fork legs as per Fig.1 and act independently upon their respective telescopic elements, or alternatively as per Fig.2, be mounted adjacent to the fork legs
20 and act between upper an mounting point on each leg(32), and a lower mounting point(34) provided on the suspension link adjacent to the wheel spindle.

- Such arrangements have the disadvantage that it is necessary to duplicate the suspension means for each leg. This in turn
25 requires that the characteristics of the resilient suspension means are matched closely in respect of spring rates and damping qualities. In motorcycle suspensions the mis-matching of pairs of springs and dampers is known to cause bending loads on the wheel spindle, and consequent tilting and mis-alignment of the
30 wheel.

Additionally the weight of the springs and damper mechanisms adds to the side-to-side rotatable 'steering' inertia of the fork, particularly as by definition these suspension units are carried at some radius from the steering axis.

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In an embodiment of the present invention shown in Fig.5, a single spring/damper unit is employed, with consequent advantages. In this embodiment the suspension medium(28) is mounted below the steering column of the motorcycle. The upper
5 end of the suspension unit is mounted upon a fixing (32) on the lower yoke that unites the fork legs. The lower end of the unit bears upon and is fixed by a mounting(34) to the bridge piece (29) that unites the two telescopic elements. Thus when the telescopic elements slide axially in response to wheel movement,
10 the bridge piece also moves to act upon the suspension unit. The characteristic features of this embodiment are that the suspension unit rotates with the fork on steering movement, that the telescopic elements are arranged parallel to the steering axis, and that they are substantially in the same plane so that
15 any displacement laterally of the point upon which the suspension unit works from a line joining the centre of the telescopic elements can be accommodated. If the telescopic elements are not parallel to the steering axis, the upper and lower mounting points for the suspension units must permit the angular
20 displacement of the suspension unit that will occur on operating.

Because of space limitations the location of the suspension means under the steering column may not be possible. In an alternative embodiment the steering column, lower yoke and steering bearing are proportioned to admit the suspension unit
25 within or partly within the column, and the upper end of the unit would therefore be fixed to a mounting provided on the underside of the top yoke that unites the fork legs. The internal dimensions of the steering column will similarly require proportioning to give sufficient working clearance to
30 provide for angular displacement of the suspension unit if required.

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A further embodiment of the present invention is represented in Fig.6, when the location of the suspension unit under or within the steering column is not required or possible. In this example the suspension medium (28) is carried forward but close to the steering column, and acted upon by a link (26) pivotally mounted at one end to a bracket(35) on the fork legs, and connected to the bridge-piece by another link (36). This second link provides a means for accomodating the differences in motion between the link and bridge piece. The link pivots about its mounting(35) so describes an arcuate path at point (37), whilst the bridge piece motion is straight line - although not necessarily parallel with the steering axis or in the same plane. An alternative arrangement is illustrated in Fig.7, where the link (26) acts directly upon a pivot(31) provided on the bridge-piece, and the translational motion of the link is absorbed by a restraining means (27) attached by a pivot (35) to the fork legs.

A further embodiment refers to Fig.3, previously described. In this an inverted 'U' stay (41) is provided pivotally mounted at its base to the suspension links, and at its upper end via a locating link(26). In this embodiment the suspension medium would be mounted at its lower end on a pivot(34) provided on the link, and a mounting point(32) upon a bracket attached to the fork legs or yokes. Alternatively the suspension medium can be acted upon by a link as arranged in Fig.4, where the link(26) is pivoted at one end upon the bridge piece(29), and at the other to the upper part of the 'U' stay. In this embodiment the upper mounting point(32) for the suspension unit is similarly upon a bracket attached to the fork legs, the lower(34) on the link(26).

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With reference to Fig.5 previously discussed, a further embodiment will be apparent in which advantageously the mass of the suspension medium has been removed from the side-to-side steering inertia of the fork. This is accomplished by locating
5 the single spring/damper unit or other resilient means on the motorcycle chassis itself, and providing an operative connection to transmit the wheel movement to the resilient means, and further allow the fork to remain rotatably mounted for steering purposes.

10 Thus in the example illustrated the upper mounting point(32) for the suspension medium(28) would be fixed non-rotatably to the motorcycle chassis, or to the inner surface of the steering column. The lower mounting point(34) on the bridge piece would be a rotatable coupling or joint permitting movement of the fork
15 side-to-side to effect steering. Alternatively the component parts of the suspension unit can be so proportioned and constructed as to provide the bearing and supporting means of the steering column, whilst still functioning as a suspension medium. In this way the mass of the suspension medium will be
20 largely removed from the side-to-side steering inertia of the fork.

In this embodiment, whilst the telescopic elements(19) within each leg slide axially parallel to the steering axis, and substantially in the same plane, no additional linkage or means
25 for absorbing translational movement will be required, and minor differences may be accommodated by pivotal or flexible mounting of the suspension unit.

Other embodiments wherein the suspension medium is mounted non-rotatably on the chassis of the motorcycle are illustrated
30 as examples in Figures 8 to 11. In all these the principle remains that the resilient means is mounted upon the chassis of the motorcycle, that the motion of the wheel is conveyed to the resilient medium via a connective means that accommodates any translational motion, and that the fork is free to turn for
35 steering.

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In the embodiments illustrated in Figs. 8 through 11, the telescopic elements(19) are arranged to be coincident with the plane of the steering axis, and the joint (31) provided in the centre of the bridge piece(29) thus to lie on the steering axis
5 regardless of the axial position of the telescopic elements.

In Figs 8 & 9 a link(26) operates on a suspension medium(28) fixed non-rotatably on the chassis at point(32) via a mounting point(34) and is connected to the said joint(31), and being pivotally connected to the chassis via a restraining means(27)
10 at a point(38) to a pivot or bracket(35). The restraining means absorbs the translational motion occurring between the linear motion of the telescopic elements, and the arcuate motion of the link operating on the suspension medium.

Alternatively as per Figs. 10 & 11 the translational motion is
15 absorbed by a link(36) mounted upon the joint(31), and connected pivotally at a point(37) to a link(26) pivotally mounted on the chassis at a point(35) operating via a mounting point(34) on a suspension medium(28) fixed non-rotatably on the chassis at point(32) via a mounting point(34).

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In this manner the side-to-side movement of the fork to effect steering has no influence on the suspension, and vice-versa. The joint lying in the centre of the bridge-piece may be of the ball & socket 'universal' variety, or divided into the two components necessary for its function - namely a coupling able to transmit the suspension loads in the axis of the steering column whilst permitting rotational movement of the fork, and a coupling to accommodate the angular displacement of the linkage that will occur with the axial movement of the bridge-piece on suspension travel, and transmit the suspension loads to the resilient means. This second element does not have to lie directly on the steering axis, but convenience may indicate that this is the preferred location.

A variant of this embodiment is possible to confer an additional advantageous feature. As is known from 21493 the steering geometry termed 'trail' influences the auto-stability of motorcycles by making the front wheel self-aligning, and it is the variation of this important dimension under pitching conditions that 21493 seeks to overcome.

However, in particular cases it is thought that large 'trail' dimensions necessary to achieve a satisfactory degree of stability at high speeds can contribute to the setting up of high frequency 'flutter' oscillations at lower speeds. Similarly it is known that excessive 'trail' can introduce heaviness or lack of response into the steering at lower speeds. Moreover it is known that motorcycles designed for accurate steering at low speeds such as off-road 'Trials' machines have comparatively small 'trail' dimensions, and this lack of sufficient self-aligning tendency in the front wheel leads to unduly light and unpredictable steering qualities at higher speeds. The embodiment illustrated in Fig.12 seeks to overcome this problem by arranging for the suspension system to introduce an additional self-aligning force to the front wheel over and above the designed 'trail'.

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In the example illustrated the 'universal' joint (31) transmitting suspension movement from the bridge-piece to the resilient medium is displaced along the vehicle centre-line away from the steering axis by a dimension ('A'). Should the front wheel of the vehicle be displaced away from the straight-ahead position the joint will be angularly displaced. The side elevation Fig.13 of the suspension link arrangement illustrates that this angular movement of the joint is resisted by the resultant of the loads within the linkage, which will thus tend to return the wheel to the straight-ahead position.

The self-aligning force generated is proportional to the angular deflection of the wheel, and the resultant force operating on the joint arising from the linkage and resilient medium. By arranging - consistent with the other objects of the present invention - for the resultant forces to be at a minimum for the first portion of the suspension travel, it is possible to ensure that the normal low-speed steering of the machine remains unaffected by the additional self-aligning property thus introduced. In this context it is assumed that major excursions of suspension are most likely to occur under conditions of high dynamic loads at higher speeds, or under circumstances where the wheel is violently deflected by an obstacle.

In this respect it is important to recognise that motorcycles exhibit two distinct modes of steering. At low speeds considerable side-to-side movement of the front wheel is exercised by the rider via the handlebars to manoeuvre and balance the machine. At higher speeds however it is known that the steering characteristics change, such that the wheel does not move appreciably away from the straight-ahead position to negotiate bends or curves, rather that the rider applies a force or couple to the handlebars which is transmitted via the fork to the wheel where gyroscopic precession translates the force through approximately 90 degrees to bank the machine over in order to steer.

Thus it would only be inadvertantly that the fork would be moved rotatably to any appreciable extent at higher speeds, and under these conditions the dynamic loads applied to the suspension system will be greater than at low speeds, and thus the suspension travel and resultant force generated within the linkage will be greater.

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Fig.14, illustrates another advantageous feature of the present invention. In this example the movement of the wheel is plotted at the wheel spindle (24) as it follows the path (25) and is linked schematically by the telescopic element (19) with the
5 corresponding bridge piece (29). The motion at the wheel spindle is measured at equal 20mm increments over a total excursion of 160mm, whilst the bridge piece only moves a total of 105mm. Thus the effective inertia of the bridge piece, and of any ancilliary such as the mudguard mounted upon it will be
10 reduced by the ratio of the difference between these distances - ie 34%, compared with the known method of mounting the front mudguard by brackets or stays to a point on or close to the wheel spindle. Further the mounting of the mudguard in such a manner overcomes the principal objections to an alternative
15 known method of mudguard mounting, in which this is fixed to the underside of the steering column. Such a mounting position - whilst removing the mass of the component from the 'unsprung' weight of the vehicle - is not placed efficiently to catch spray or road debris because the tyre surface will rarely be near the
20 mudguard except when the suspension is fully compressed.

Fig.14 also illustrates the differential of movement between the wheel spindle and the suspension medium as this is compressed. In this example the wheel spindle moves 160mm, whilst the suspension is compressed by 72mm. The effective reduction in
25 inertia of the suspension medium arising from the example linkage illustrated is thus 55%.

Alterations in the geometry of the suspension means disclosed in 21493 will effect the ratio of wheel movement to telescopic element motion, and therefore - consistent with the other
30 objects of the invention - it is possible to select a set of dimensions that will achieve the desired reduction in inertia for the bridge piece and mudguard. Similarly, the length, shape and disposition of the links transmitting the suspension motion from the bridge piece to the suspension medium can be chosen to
35 achieve the desired reduction in inertia for this component, consistent with the other objects of the present invention.

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- Fig.15 illustrates a further beneficial feature of the present invention. In this by means of a graph a line is drawn from the incremental movements of the wheel as plotted at point (24), and the suspension medium at point (34). Wheel movement is plotted
5 along the horizontal axis, suspension on the vertical axis. The resultant line is distinctly curved, illustrating that compression of the suspension medium at the beginning of suspension travel is comparatively less than at subsequent points by virtue of the changing lever-ratio of the mechanism.
- 10 This effect known as 'rising rate' is known to improve the over-all compliance of the suspension system, in that the lower effective spring-rate at the beginning of suspension travel permits the absorption of minor road irregularities, whilst the increasing stiffness of the springing thereafter prevents the
15 suspension 'bottoming out', or becoming used up over rougher surfaces.

- Alterations to the dimensions of the components of the articulated suspension means can enhance or reduce this
20 rising-rate effect, particularly the length or disposition of the restraining means. Similarly the length, shape and disposition of the linkage transmitting the bridge-piece or 'U' stay motion to the suspension medium can enhance or reduce this 'rising rate' effect.

The examples illustrated in Fig.16 demonstrate the difference in 'rising rate' characteristics between two outwardly similar constructions. The restraining means in this instance is a roller and track mechanism as disclosed in 21493. In the drawings the incremental movement of the wheel spindle is plotted at regular intervals, and the corresponding movement at the bridge-piece at the universal joint, and at the suspension unit mounting point on the upper link. A graph - Fig.17, is plotted with wheel movement on the horizontal axis, bridge-piece movement on the left hand vertical axis, and suspension medium compression on the right hand vertical axis. The solid lines indicate the effective lever-ratio of the system at these two points, measured against wheel movement for a construction ('A' Fig.16) in which the restraining means (31) for the wheel-carrying link (17), are disposed in order to enhance this rising - rate effect. The broken lines indicate the rising - rate effect of the construction ('B' Fig.16) in which the restraining means only are disposed differently. As can be seen there is a marked difference between the respective solid and broken lines for the two examples. Similar and complementary effects can be achieved by altering the dimensions, shape and disposition of the other suspension components hereby described, to enhance or reduce the rising-rate characteristics of the suspension.

A further development shown in Fig.18 illustrates another beneficial feature of the present invention. In this the wheel-carrying link (17) is arranged in two parts hinged one upon the other and with an adjusting device ('Xi') provided between the two to alter the angles enclosed within points 24, 20 & 22. Thus in this construction the dimensions between 24 & 20, and between 20 & 22 remain constant, whilst the dimension between 24 & 22 can be lengthened or forshortened. Reducing the dimension between 24 & 22 will increase the vertical displacement of point 20 from a line joining points 24 & 22. Increasing the dimension between 24 & 22 will reduce the vertical displacement until a condition is reached where the points 24, 20 & 22 are in line. Further adjustment would produce a vertical displacement in the other direction, and points 24 & 22 would become closer. Further adjustment (Xii) may be provided within the restraining means(18) to augment or replace the adjustment means previously described.

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Other embodiments of this variable geometry principle are possible, by for example arranging for the adjustment to lengthen or shorten the distance between 20 & 22, or between 20 & 24. Nor need the adjustment be provided by the hinging of two components, but could for example be accomplished by means of locating points 20, 22 & 24 on eccentric mounts, whereby all three dimensions referred to could be lengthened or shortened individually or in combination. Alternatively substitute components of the desired dimensions may be used to provide the required effect.

In Fig.18 the motion of the wheel spindle at point 24 is drawn for three representative geometries achieved by the means discussed. In the first - the solid line (25i) is a shallow curve so that a mean-line drawn through it would intersect with the steering axis at some point above the wheel spindle. Such a line is characteristic of wheel motions calculated to minimise 'trail' variations under pitching conditions. The dotted line (25ii) is a shallow curve so that a mean-line drawn through it will be substantially parallel with the steering axis. Such a motion will minimise 'trail' variations under conditions where machine 'pitching' is not assumed to occur, ie the front and rear suspension of the vehicle move equally and simultaneously. The broken line (25iii) is a shallow curve midway between the two other examples, as may be used in a vehicle where neither 'trail' variation arising from machine pitching or through simultaneous and equal movement is deemed to have over-riding importance, and a compromise is made between the two conditions.

Such a vehicle could for example use a brake linkage as disclosed in 21493 or as hereinafter described, to limit the effects of weight-transference on the front suspension, Such brake arrangements are known as 'anti-dive', and can reduce the degree of machine pitching that would otherwise occur, and thus would limit the trail variations that occur under braking conditions.

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Improvements in an anti-dive brake linkage are now described. In 21493 a brake arrangement is disclosed whereby a disc-brake caliper is rigidly mounted onto the wheel-carrying suspension link. Such a construction has the disadvantage that where
5 considerable lengths of suspension travel are required - for example in excess of 120mm, and where a requirement also exists to keep the physical dimensions of the wheel link comparatively small - for example less than 200mm, the angular displacement of the wheel-carrying link will be such that the anti-dive effect
10 will be excessive, or cause the front end of the motorcycle to actually rise on braking.

A similar problem exists in respect to the other anti-dive brake arrangement disclosed in 21493. In this the brake caliper is rotatably mounted about the wheel spindle, and connected to the
15 fork leg by a tie-rod or torque arm. Once again considerable lengths of suspension movement and a requirement to keep the pivotal interconnection between the brake caliper and torque arm within say the diameter of the wheel may give rise to excessive anti-dive effects, so that the smooth operation of the
20 suspension is affected, or that the front of the machine rises on braking.

The embodiments now described overcome these problems by re-locating the linkage between the moving parts of the suspension means in order to reduce the angular displacement of
25 a rotatably mounted disc-brake caliper. In the drawing Fig.19, a disc brake caliper is mounted on a bracket or carrier (27) that is rotatably mounted concentric with the wheel spindle (24) and grips on operation a disc brake (28). A torque arm (29) is pivotally mounted between a lower extension of the telescopic
30 element (19) at a point (31), and the disc brake caliper mounting bracket at a point (30).

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By examination of the change in the relationship of these points with suspension travel, where the wheel spindle moves between points (24) and (24i), it will be seen that the angular displacement of the brake carrier (*'B') is far less than that of the wheel carrying link (*'W'). Moreover this difference in angular displacement can be enhanced or reduced by altering the distance between - respectively points (20) and (31), and points (24) and (30), or by shortening one with respect to the other. A ready means of adjusting the anti-dive effect can therefore be provided by arranging for a series of mounting holes, slots or other adjustment feature in either the disc-brake carrier or the telescopic element, or both. The torque arm can also have a screw arrangement in order to maintain or modify the relationship between the points. The torque arm (29) has screwed ends permitting the lengthening or shortening of the distance between points (30) and (31).

A further embodiment is illustrated schematically in drawing, Fig.20. In this example the wheel travel would possibly be in excess of 200mm as is common with certain rough-terrain motorcycles such as are used in competition 'Moto-Cross'. With this type of motorcycle it is often considered important to provide a brake linkage that permits a certain amount of 'pitching', in order to maintain the special steering characteristics particular to that type of motorcycle. A reduced degree of 'anti-dive' may therefore be specified. The means by which this may be achieved will now be described with reference to the drawing.

A brake caliper is mounted on a carrier(27) mounted rotatably concentric with a wheel spindle (24).A torque arm (29) is pivotally mounted at one end to the brake caliper carrier at point (30), and at the other end at point (31) to an extension of the restraining means(18) linking the fork leg (15) to the wheel carrying link(17).

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Because the restraining link describes an arc (22-22i) on suspension excursion to absorb the translational motion of the wheel-carrying link at point(22), it will be apparent that by suitable proportioning of the components the difference in the angular displacement of the brake caliper consequent on this movement and on the movement of the wheel spindle can be reduced or eliminated. Under these circumstances the resultant of the loads may not cause any anti-dive effect at all, even though providing a firm torque anchorage to absorb the braking loads themselves. The linkage can be adjusted in a similar manner to that previously described for the other embodiment by providing alternative mounting points, slots or screw adjusters.

A third brake mounting position can be discussed with reference to Figs.3 & 4 previously described. In these embodiments a 'U' shaped stay(41) is arranged to convey the motion at the wheel spindle along a path substantially parallel to the axis of the fork legs. By appropriately dimensioning this stay to resist the loads, it can provide a convenient mounting agency for the disc brake caliper. Alterations in the dimension between the lower pivotal mounting points for the 'U' stay and the wheel spindle(24) will provide a measure of control over the degree of 'anti-dive' produced by this construction.

All three embodiments can be re-arranged so that the brake calipers lie in different positions, and the linkage as described is equally applicable to motorcycles with drum-type brakes.

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CLAIMS

- 1) A front suspension system for a motorcycle having a front wheel, a rear wheel and a chassis between them, wherein is mounted rotatably a steerable front fork comprising two substantially parallel legs carrying an articulated suspension
5 mechanism in each leg, said suspension mechanism comprising a link supporting the front wheel at a first end, and a second end being pivotally connected to the fork leg by restraining means allowing translational movement of the second end in response to movement at the first, and being pivotally connected between
10 these two ends a telescopic element sliding axially in bearing means fixed in or adjacent to the fork leg, wherein said articulated mechanisms are joined by interconnective means one with the other in order to oppose relative movement between the two, and wherein is provided resilient suspension means
15 operatively connected to the articulated mechanisms in order to oppose relative movement between the front fork and the said mechanisms in response to a load applied to said motorcycle.
- 2) A front suspension system as to claim 1) wherein an interconnective means between the articulated mechanisms of each
20 leg is a rigid extension of the wheel carrying links passing around the wheel and uniting the said links.
- 3) A front suspension system as to claim 1) wherein an interconnective means between the articulated mechanisms of each leg is a bridge piece mounted upon the upper portions of the
25 telescopic elements.
- 4) A front suspension system as to claim 1) wherein an interconnective means between the articulated mechanisms of each leg is an inverted 'U' stay pivotally mounted upon the suspension links at its base on each leg adjacent to the wheel
30 spindle, and wherein a locating means is provided at its upper end connected to the stay in a manner characterised in that the said 'U' stay remains substantially parallel with the fork legs during suspension movement.

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- 5) A front suspension system as to claim 4) wherein the locating means is a linkage pivotally connected between the 'U' stay and the fork legs.
- 6) A front suspension system as to claims 3) and 5) wherein the
5 said locating means is pivotally connected between the 'U' stay and the bridge piece.
- 7) A front suspension system as to any one of the preceeding claims characterised in that the resilient suspension means is housed within the steering column of the motorcycle.
- 10 8) A front suspension system as to any one of the preceeding claims characterised in that the resilient suspension means operatively connected to the articulated mechanisms is fixed to the front fork of the motorcycle so as to turn with the fork on steering.
- 15 9) A front suspension system as to any one of the preceeding claims 1) to 7) characterised in that the resilient suspension means operatively connected to the articulated mechanisms is fixed to the chassis of the motorcycle so as not to turn with the fork on steering.
- 20 10) A front suspension system as to any one of the preceeding claims in which the resilient suspension means is operatively connected to the articulated mechanisms via the interconnective means whereby suspension loads are transmitted via the said interconnective means.
- 25 11) A front suspension system as to claim 9) and 10) in which the operative connection acts by way of a rotatable joint set on the said interconnective means.
- 12) A front suspension system as to claim 11) wherein the
30 rotatable joint is arranged to lie on the steering axis of motorcycle during suspension excursion.

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13) A front suspension system as to claim 11) wherein the rotatable joint is arranged to lie a specified distance from the steering axis of the motorcycle, displaced along the longitudinal axis of the motorcycle, such that on rotatable
5 movement of the fork the rotatable joint will be displaced away from the longitudinal axis of the motorcycle.

14) A front suspension system as to any one of the preceeding claims in which the operative connection is a linkage.

15) A front suspension system as to claim 14) in which the
10 linkage is arranged to produce a reducing lever-ratio with suspension excursion as measured between the resilient suspension means and the wheel spindle.

16) a front suspension system as to claim 13) in which the connective means is arranged so that over a portion of the
15 suspension excursion a resultant force is produced acting upon the rotatable joint in such a way as to tend to maintain the alignment of the front wheel along the longitudinal axis of the motorcycle.

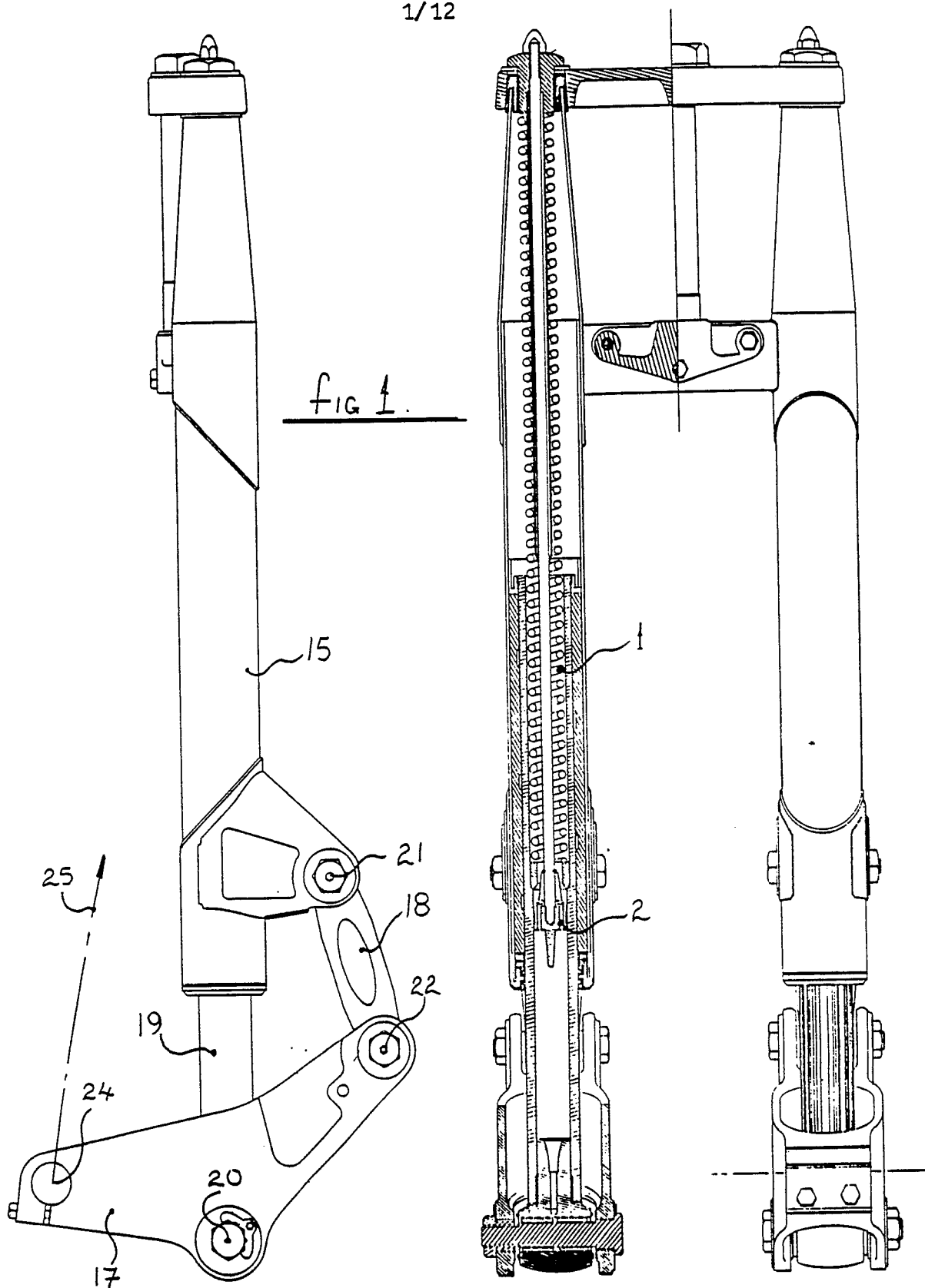
17) A front suspension system as to any one of the preceeding
20 claims wherein a mudguard or other such ancillary is carried upon the interconnective means.

18) A front suspension system as to any one of the preceeding claims in which a brake caliper or similar braking apparatus is carried on a mounting rotatably mounted concentric with the
25 front wheel spindle, and pivotally connected by a torque arm to the telescopic element of the articulated mechanism, or an extension thereof, such that application of the brake apparatus produces a force opposing suspension movement.

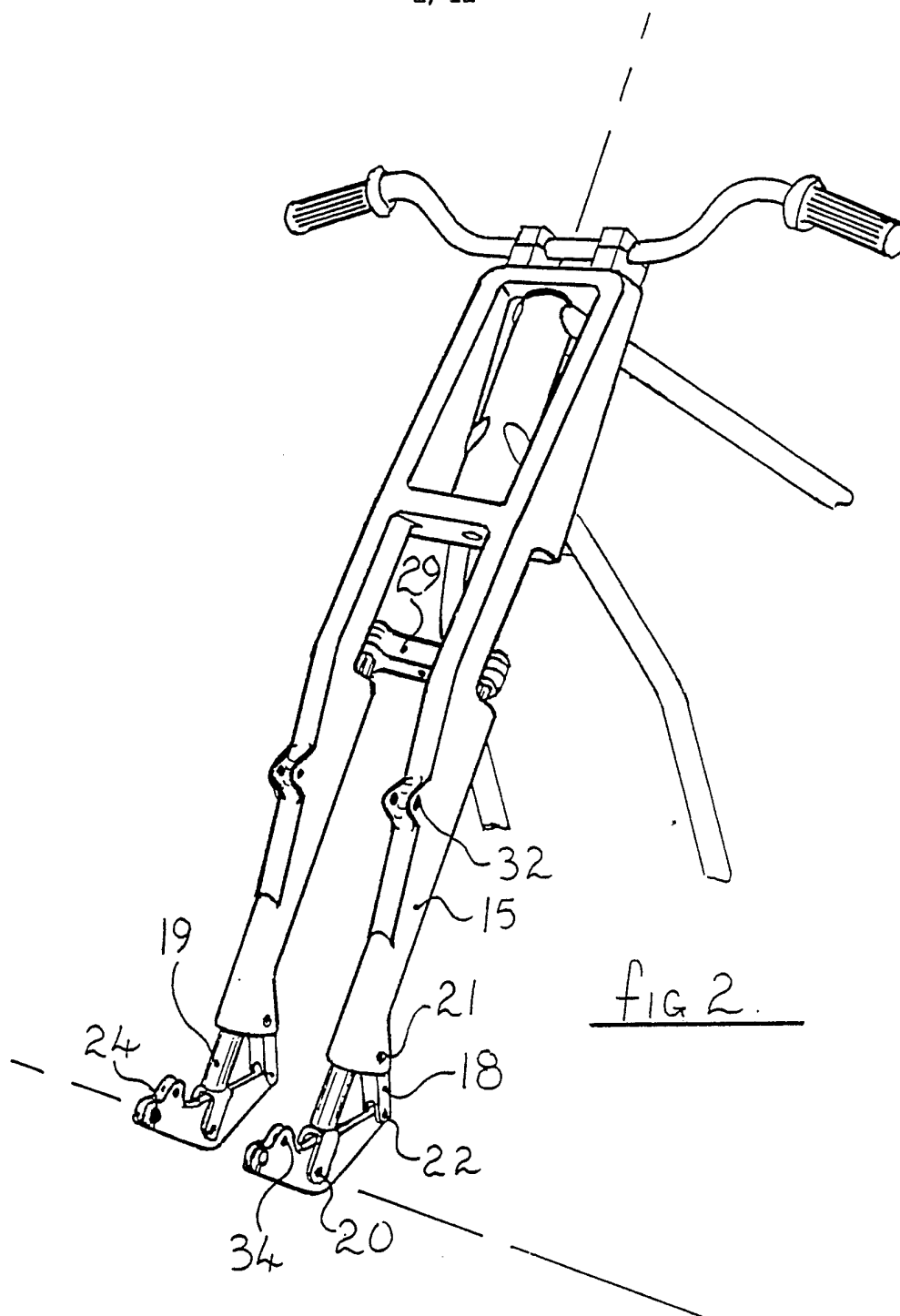
19) A front suspension system as to any one of claims 1) to 17)
30 wherein a brake caliper or similar braking apparatus is carried on a mounting rotatably mounted concentric with the front wheel spindle, and pivotally connected by a torque arm to the restraining means linking the fork leg to the articulated mechanism, or an extension thereof.

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- 20) A front suspension system as to any one of claims 4) to 17) wherein a brake caliper or similar apparatus is mounted upon or linked to the inverted 'U' stay.
- 21) A front suspension system as to any of the preceeding claims
- 5 in which the articulated mechanism is configured to produce wheel spindle motions such that a mean line drawn through the resultant motion can be vertical or inclined so that the said mean line intersects the steering axis of the motorcycle above the wheel spindle or any motion in between said vertical or
- 10 inclined motion.
- 22) A front suspension system as to any one of the preceeding claims in which the articulated mechanism is configured to produce a reducing lever-ratio as measured between the wheel spindle and telescopic element.
- 15 23) A front suspension system as to any one of the preceeding claims in which any alteration, or all of them, to the geometry of the suspension and brake components, and their respective mounting positions as hereinbefore described to achieve different suspension, wheel movements and/or braking
- 20 characteristics is readily attainable.
- 24) Any novel feature or novel combination of features hereinbefore described and/or shown in the accompanying drawings.



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fig 3.

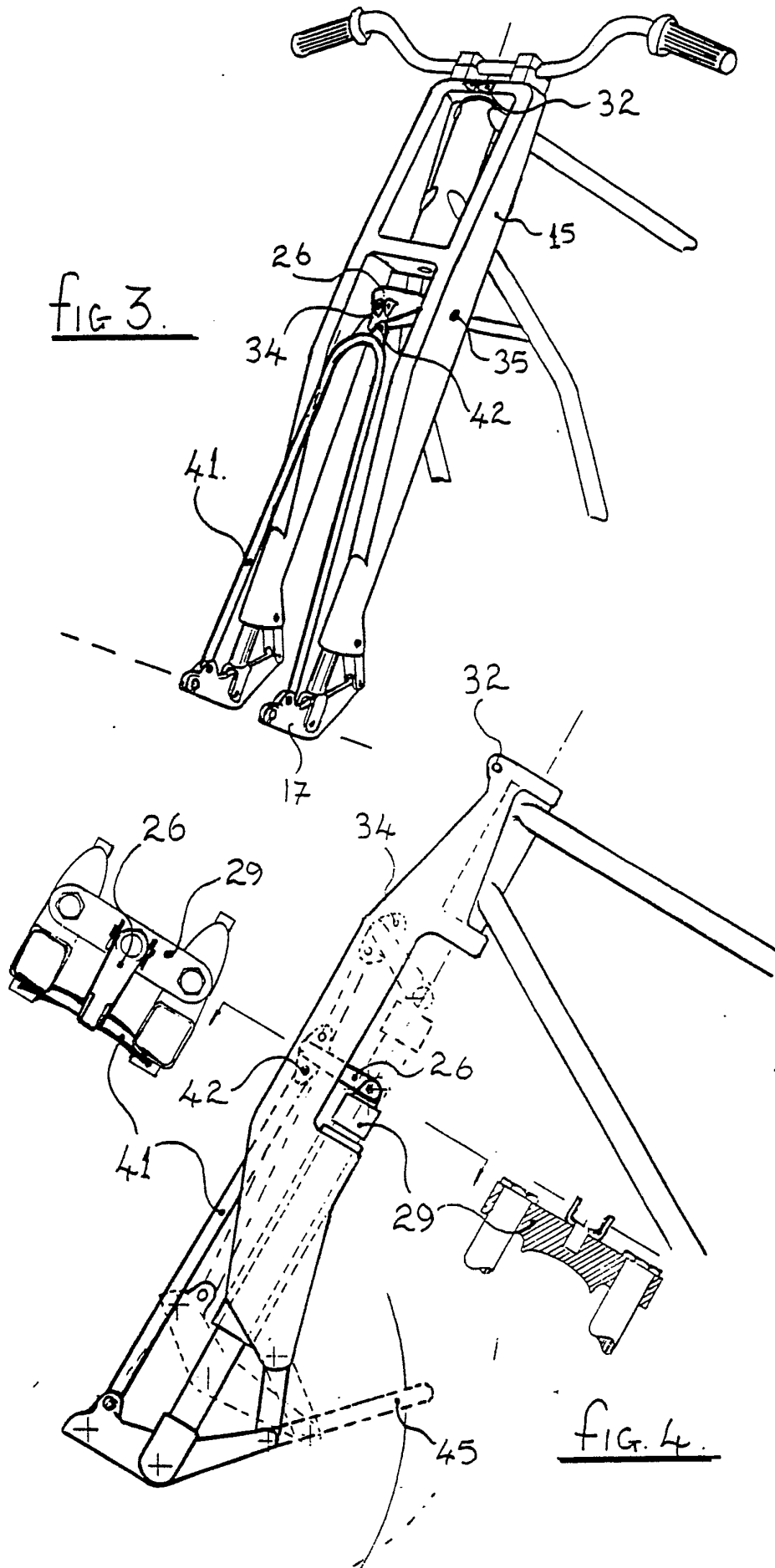
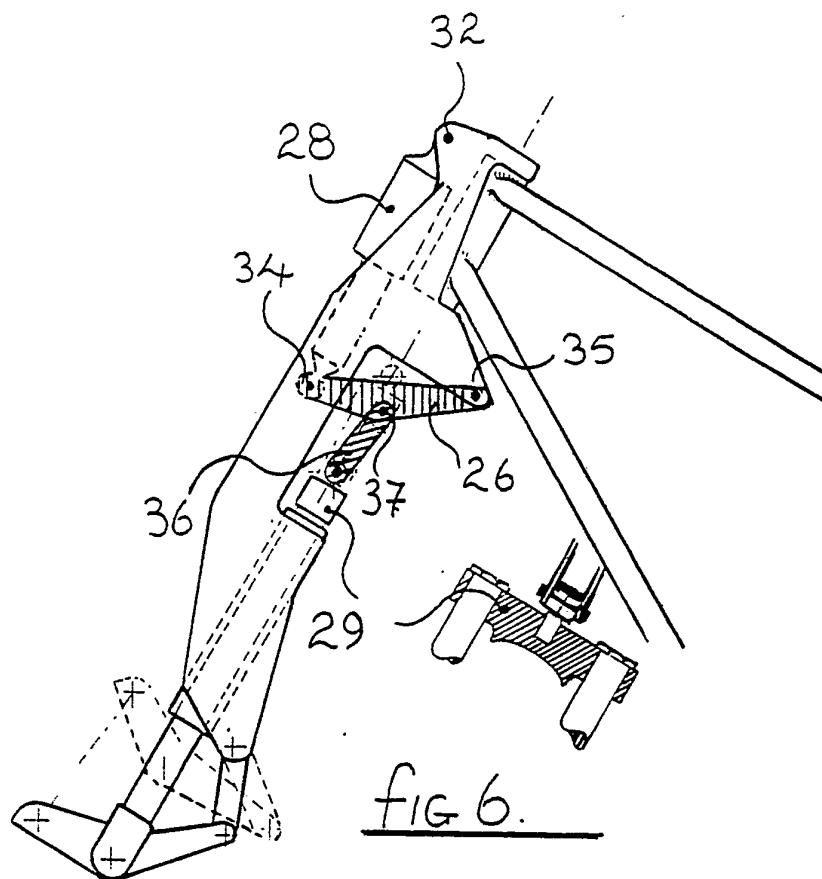
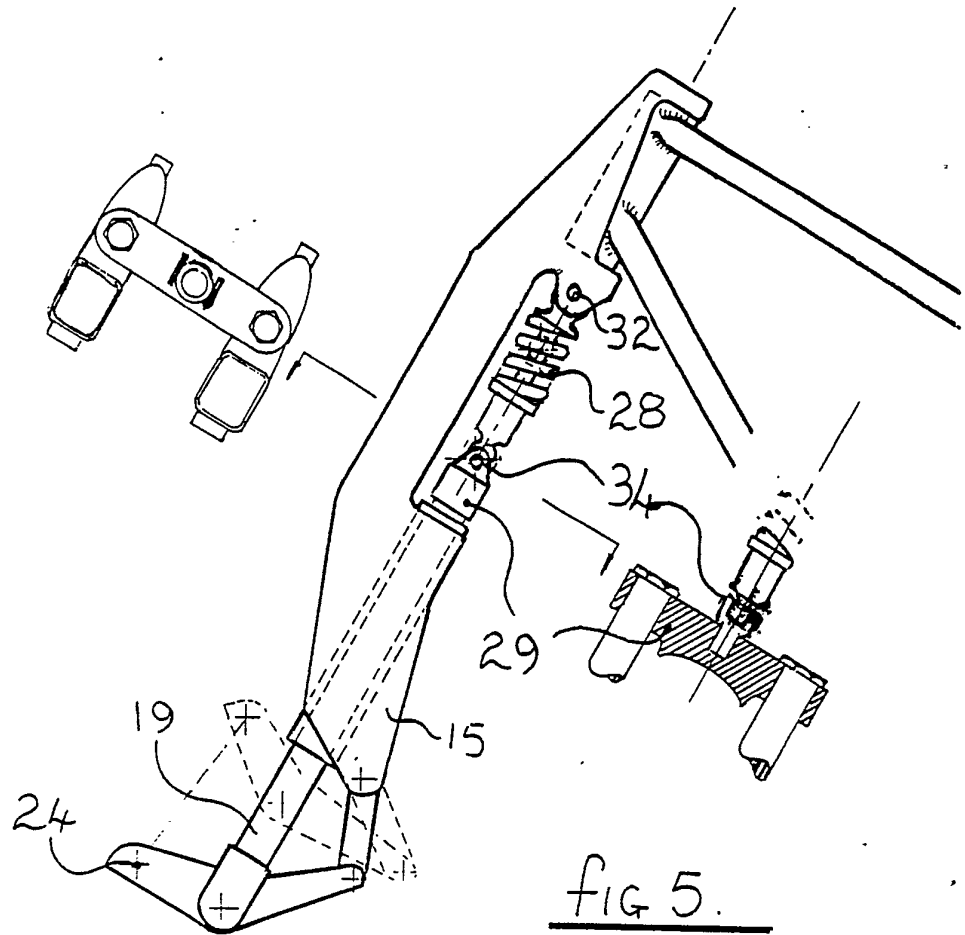
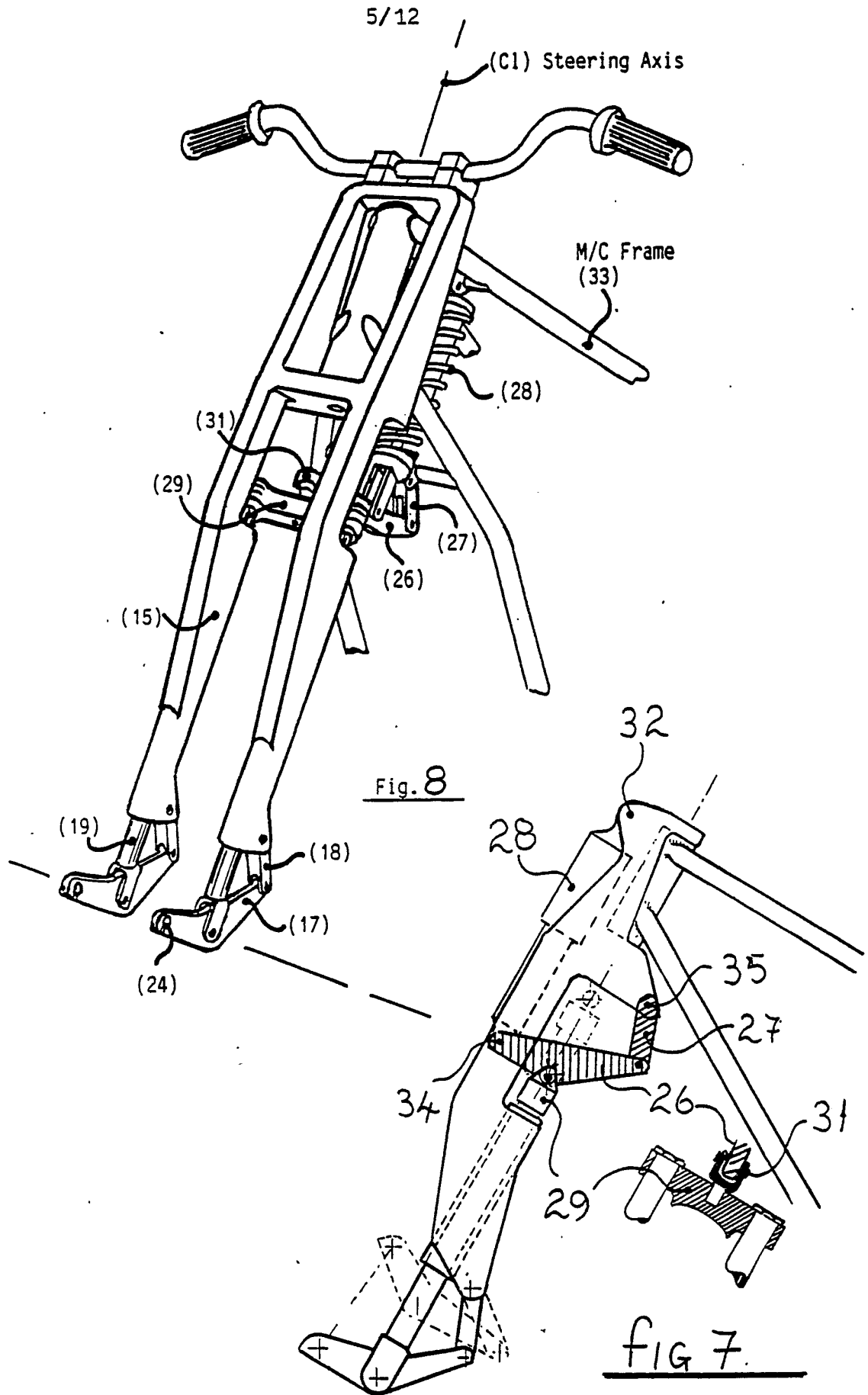


fig. 4.





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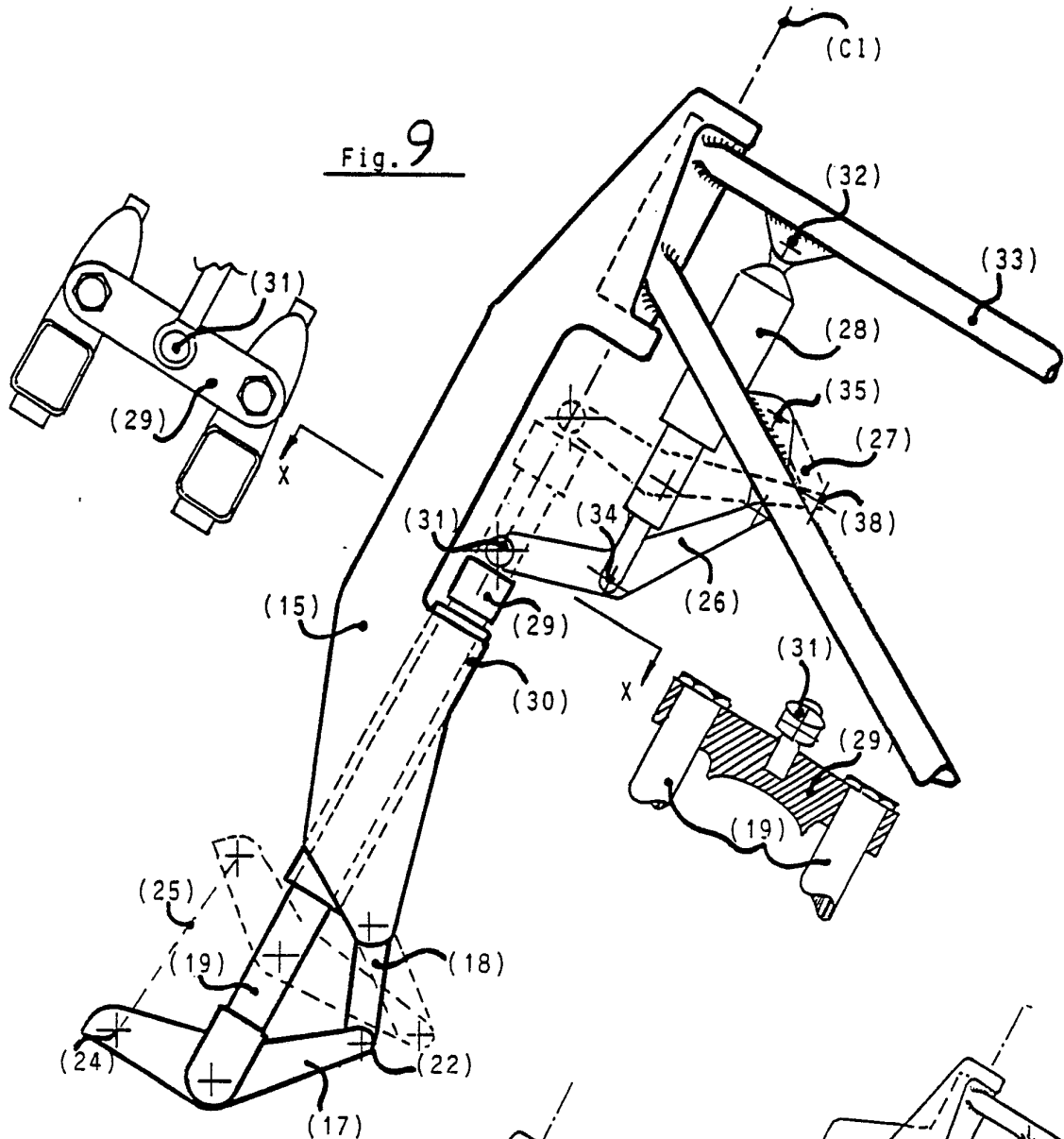


fig 10

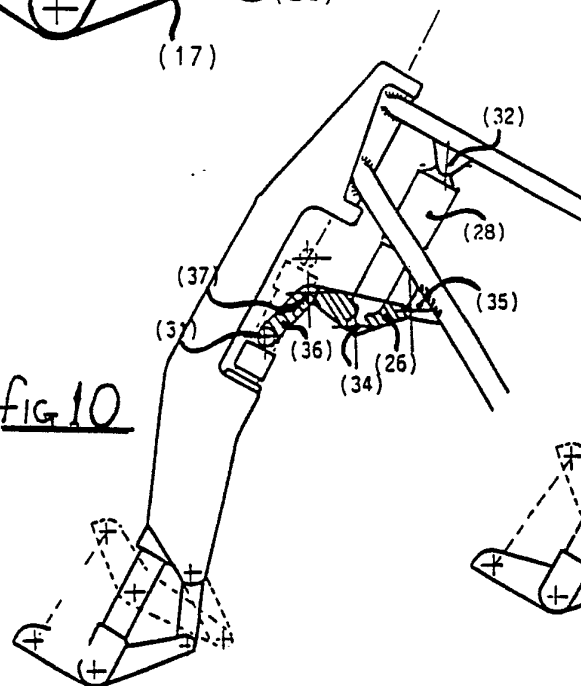
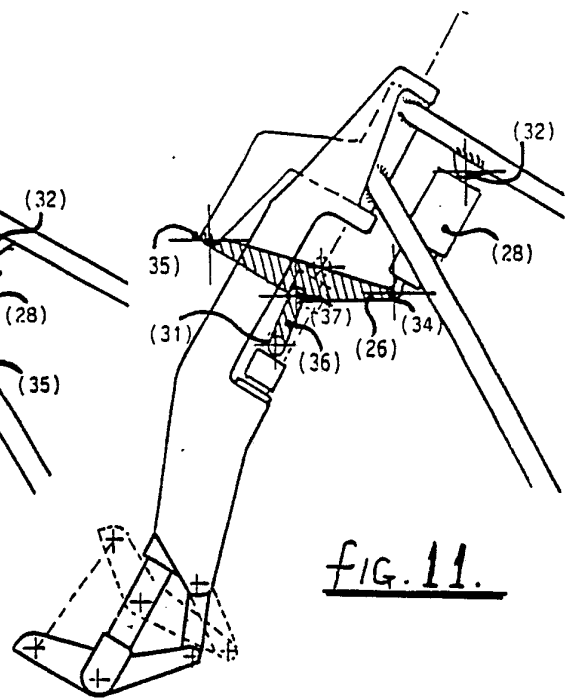
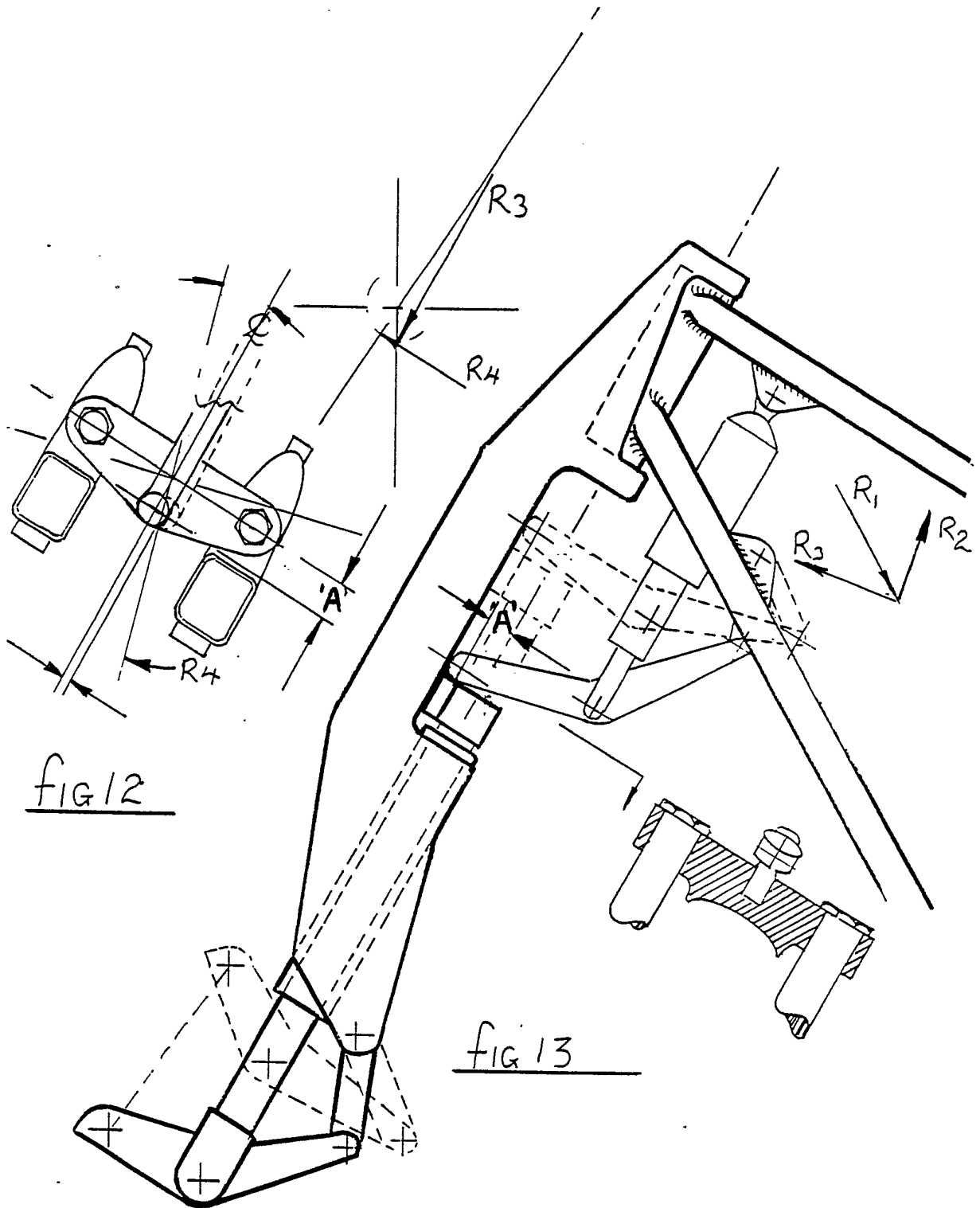
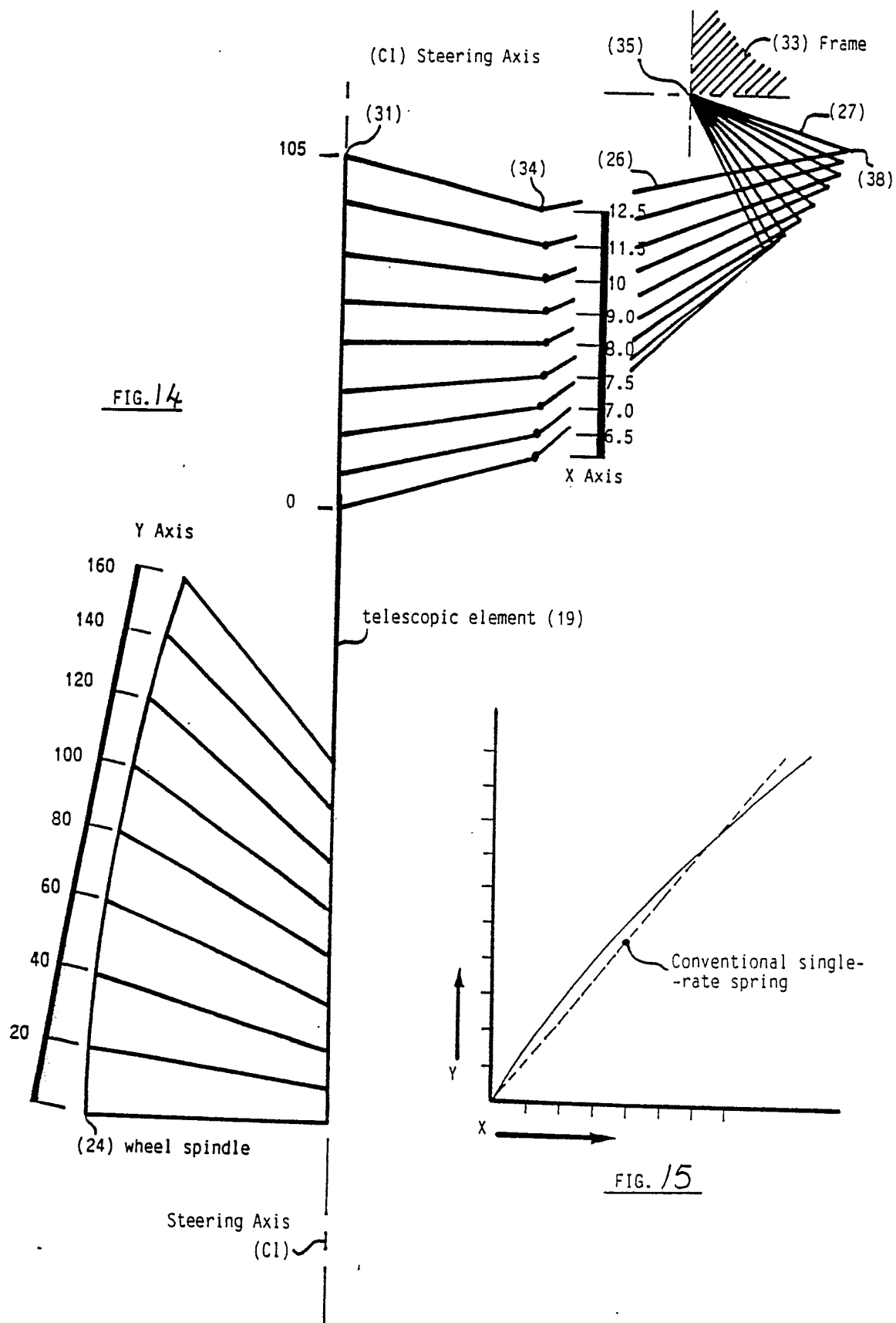


fig. 11.





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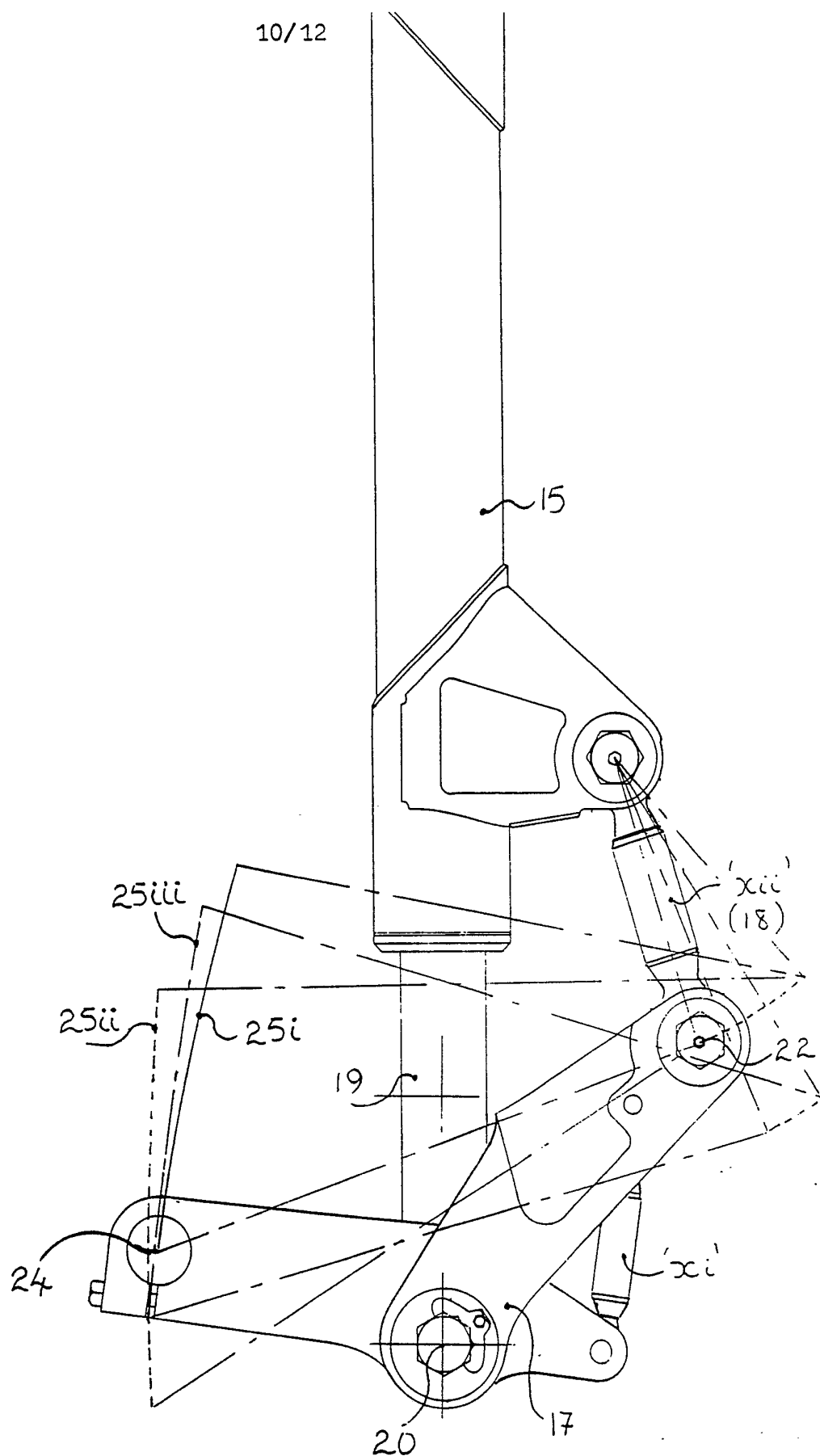
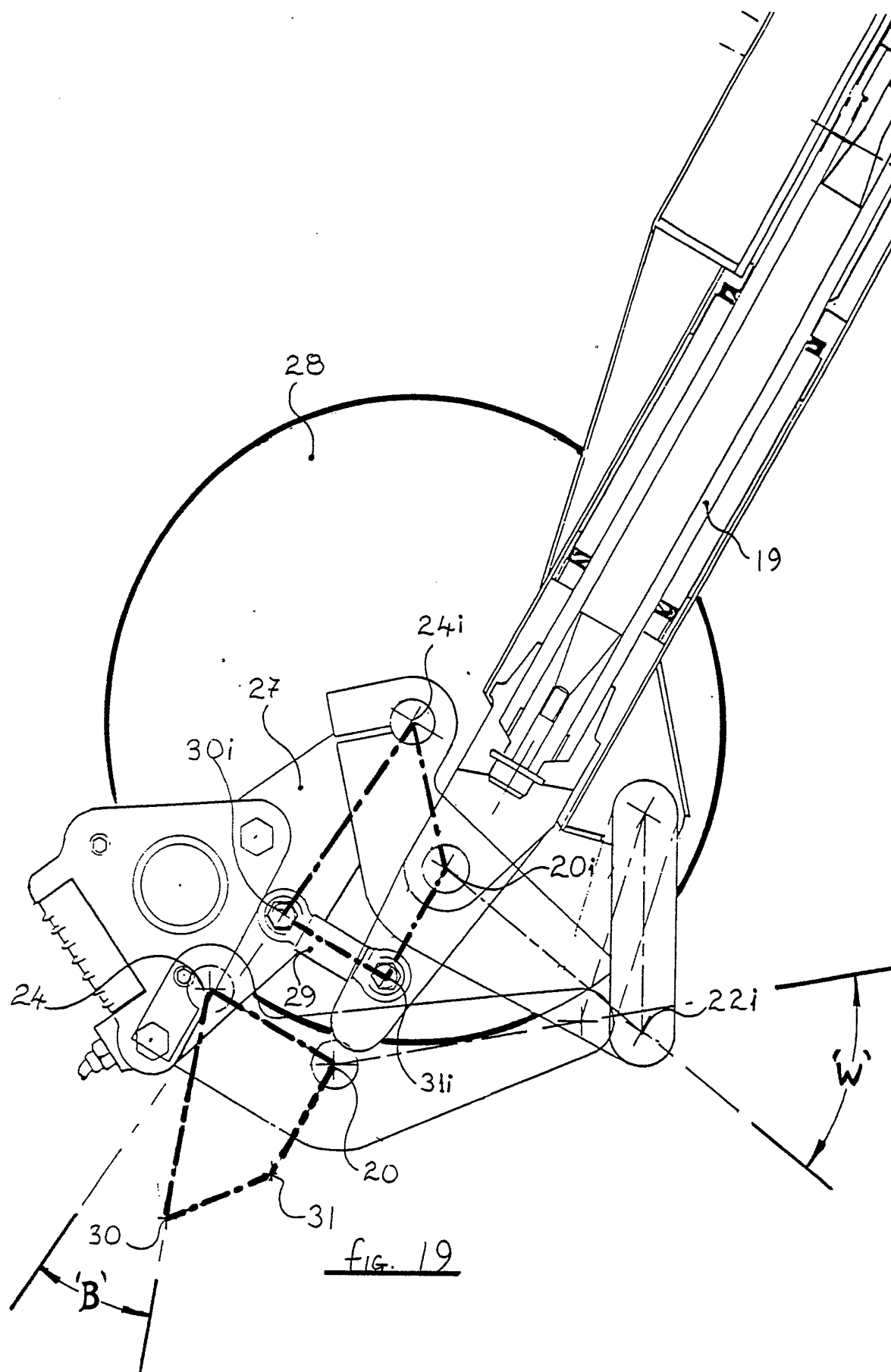
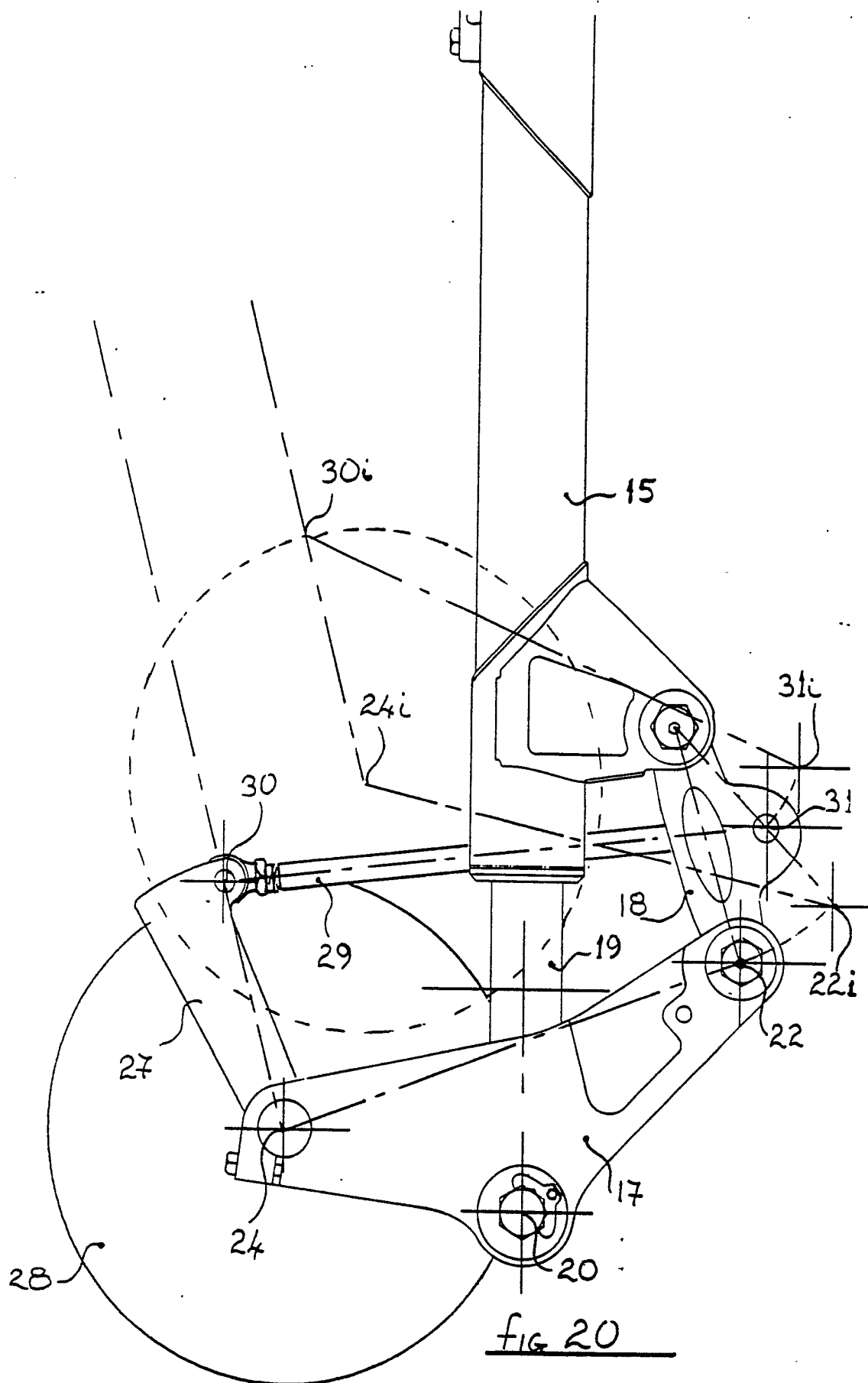


fig 18.





INTERNATIONAL SEARCH REPORT

International Application No. PCT/GB 85/00431

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶ According to International Patent Classification (IPC) or to both National Classification and IPC IPC ⁴ : B 62 K 25/08		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
IPC ⁴	B 62 K	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹		
Category ¹⁰	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
A	DE, C, 546631 (STANDARD FAHRZEUG FABRIK) 3 March 1932, see pages 1,2; figures --	1
A	GB, A, 1545403 (THE VICTORIA UNIVERSITY OF MANCHESTER) 10 May 1979, see figures 1-3; page 2, lines 34-130; page 3, lines 1-104 --	1
A	GB, A, 2147255 (RVT DESIGN & ENGINEERING) 9 May 1985, see figures 1-10; page 1; page 2, lines 1-58 --	1
A	FR, A, 2547549 (JANIN) 21 December 1984, see figures 1-5; page 3, lines 27-37; pages 4-7 --	1
A	US, A, 3954284 (RONAL F. PHILLIPS) 4 May 1976, see figures 1-4; column 1, lines 59-68; column 2; column 3, lines 1-9	1
¹⁰ Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search		Date of Mailing of this International Search Report
16th May 1986		13.06.86
International Searching Authority		Signature of Authorized Officer
EUROPEAN PATENT OFFICE		L. ROSSI

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON

INTERNATIONAL APPLICATION NO. PCT/GB 85/00431 (SA 10788)

This Annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 05/06/86

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE-C- 546631		None	
GB-A- 1545403	10/05/79	US-A- 4184695	22/01/80
GB-A- 2147255	09/05/85	GB-A,B 2106843	20/04/83
		JP-A- 58081879	17/05/83
FR-A- 2547549	21/12/84	None	
US-A- 3954284	04/05/76	None	

For more details about this annex :
see Official Journal of the European Patent Office, No. 12/82