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"A Trailing Arm Suspension Assembly"

This invention relates to a leading or trailing arm suspension assembly in particular for armoured vehicles.

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In wheeled armoured vehicles the space claim of the suspension system is a critical factor when seeking to maximise the usable interior volume of the vehicle. Typically a wheel well incorporating the suspension system and wheel is built into the vehicle and this intrudes into the interior space of the vehicle reducing the interior volume and causing an obstruction. The suspension assembly is mounted on the side wall of the hull between the wheel and the hull side wall. Further, in conventional suspension systems spring mounts, bump and rebound stops and control arms are typically mounted on the hull of the vehicle as separate elements thus requiring accurate positioning of these locations on the hull to maintain the correct relationship of the various suspension elements to each other. This presents problems in the manufacture of such vehicles.

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The present invention is directed towards overcoming these problems.

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It is an object of the present invention to provide a suspension system which greatly reduces the intrusion of the suspension elements into the armoured hull thus maximising usable internal space in the vehicle.

Statements of Invention

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According to the invention there is provided a modular suspension assembly for an armoured vehicle, including:

a support frame,

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a pair of suspension units mounted on the support frame, namely a leading arm suspension unit and a trailing arm suspension unit,

each suspension unit including a suspension arm having an outer end and an

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inner end,

said outer end having means for connection to a wheel or track support,

5 said inner end being pivotally mounted on the support frame and connected to a spring means on the support frame which opposes pivotal movement of the suspension arm away from a neutral position,

the suspension arms being pivotal in a common vertical plane,

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the support frame having mounting means for securing the support frame to a bottom of a vehicle hull upon which the modular suspension assembly is to be mounted.

15 In a particularly preferred embodiment the assembly forms a module having a sealed support housing within which the spring and lever arm are mounted, the lever arm being connected to the suspension arm by a pivot shaft which projects through an associated opening in a side wall of the housing, a seal being mounted in said opening about the shaft to seal between the housing and the shaft.

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In another embodiment the housing has means for reacting bump and rebound forces within the housing.

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In a further embodiment the lever arm has a rebound stop which is engagable against an inner side wall of the housing.

In another embodiment a bearing is mounted between the spring means and an inner side wall of the housing to transmit bump forces to the housing.

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In a particularly preferred embodiment the suspension assembly includes a pair of in-line suspension arms, namely a forward suspension arm and a rearward suspension arm, the spring means for the arms being supported in a horizontal juxtaposed position. Preferably the spring means and the lever arms associated with each of the suspension arms are mounted in a common housing.

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Various other embodiments are as described in the claims given at the end of this patent specification.

5 The invention will be more clearly understood by the following description of some embodiments thereof given by way of example only, with reference to the accompanying drawings, in which;

10 Fig. 1 is a perspective view of a trailing arm suspension assembly according to the invention;

Fig. 2 is an end elevational view of the assembly;

Fig. 3 is a sectional elevational view taken along the line III-III of Fig. 2;

15 Fig. 4 is a plan view of the assembly;

Fig. 5 is a sectional view taken along the line V-V of Fig. 4;

20 Fig. 6 is a sectional view taken along the line VI-VI of Fig. 4;

Fig. 7 is an elevational view of the assembly;

Fig. 8 is a sectional view taken along the line VIII-VIII of Fig. 7;

25 Figs. 9 to 11 are detail sectional views of portion of the assembly;

Fig. 12 is an elevation view of the assembly carrying a pair of wheels;

30 Fig. 13 is an end elevational view showing a pair of the assemblies in position for connection to a vehicle body;

Fig. 14 is a plan view of the pair of assemblies shown in Fig. 13;

Fig. 15 is a detail plan view of portion of the assembly;

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Fig. 16 is a perspective view showing a vehicle layout incorporating the suspension assembly of the invention; and

5 Figs. 17 to 33 show suspension assemblies according to various different embodiments of the invention.

Referring to the drawings there is illustrated a trailing arm suspension assembly according to the invention indicated generally by the reference numeral 1. The assembly 1 is in this case in the form of a two wheel station module. It will be appreciated however that a single wheel station module could alternatively be provided. A pair of suspension arms, namely a forward suspension arm 2 and a rear suspension arm 3 are pivotally mounted on a housing 4 containing spring means 5, 6 associated with each of the arms 2, 3 respectively. Each suspension arm 2, 3 has an outer end 8 upon which are mounted wheel hub assemblies 9. In the illustrated embodiment the wheel hubs 9 are non-steering. It will be appreciated however that in other embodiments means may be provided for steering the hubs 9. An inner end 10 of each suspension arm 2, 3 is connected by a pivot shaft 11 with an associated lever arm 12 mounted within the housing 4. An upper end of the lever arm 12 is connected to a spring element which in this case comprises a hydrostrut 14 which extends between the lever arm 12 and a side wall of the housing 4.

Each pivot shaft 11 passes through an opening in a side wall of the housing 4. A seal is mounted in said opening about the shaft 11 to seal between the housing 4 and the shaft 11.

25 The lever arm 12 is provided with an resilient rebound stop 16 at an upper end of the lever arm 12. This rebound stop 16 is engagable against an associated striking plate 17 on an inside face of a side wall of the housing 4. A bearing 18 is mounted between the upper end of the lever arm 12 and an inner end 19 of the hydrostrut 14. A second bearing 20 is mounted between an outer end 21 of the hydrostrut 14 and an inner side wall of the housing 4 to transmit bump forces to the housing 4.

30 It will be noted that a pivot axis X about which each suspension arm 2, 3 rotates lies beneath the line of action Y of the hydrostrut 14 spring means.

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It will also be noted that the pivot shaft 11, lever arm 12 and hydrostrut assemblies associated with each of the suspension arms 2, 3 are mounted side by side which provides a compact configuration. The hydrostruts 14 are supported in a substantially horizontal orientation.

In the illustrated embodiment the spring element is a hydrostrut 14 but in alternative embodiments various other spring media such as coil spring, rubber or any suitable elastic medium may be used. The mechanical rebound stop 16 reacts all the rebound forces directly on the housing 4 and likewise all the suspension bump forces are reacted directly into the housing 4 through the second bearing 20 mounted between the hydrostrut 14 and the housing 4. Both of the bearings 18, 20 allow pivoting movement at each end of the hydrostrut 14.

It will be noted that the complete assembly of moving parts are contained within the housing 4 and so are protected from dust, mud and mechanical impact. As the suspension and its force reaction elements are completely contained within the housing 4 the requirement for machining of the vehicle hull or accurate location of individual elements of a suspension system of the hull is eliminated.

Horizontal mounting flanges are provided on the housing 4 comprising an inner mounting flange 30 and an outer mounting flange 31. The outer mounting flange 31 has a central pivot hole 32 on either side of which mounting slots 33 are provided. These mounting slots 33 are somewhat elongated and are for reception of undersize mounting bolts for attachment of the assembly 1 to an underside of a vehicle allowing some adjustment in a horizontal plane. The inner mounting flange 30 has a number of mounting slots 34 which are elongated and arranged on a radius relative to the pivot hole 32. Thus the pivot hole 32 can be engaged with a spigot or pivot pin on the underside of the vehicle and the whole assembly can be pivoted about the pivot pin swinging about a vertical axis through the pivot pin for correct alignment of the assembly 1 on the vehicle body. Once in alignment mounting bolts engage through the slots 33, 34 to securely bolt the assembly 1 in position on the vehicle body.

It will be appreciated that the invention provides a suspension assembly of compact

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construction which can be mounted to an underside of the vehicle to minimise or eliminate intrusion into the interior volume of the vehicle. The modular assemblies are easy to fit and align on the vehicle body and require only one mounting point on the armoured hull. All of the interconnected moving elements and bearings are contained within a sealed housing. Also, all the bump and rebound forces are reacted within the assembly. While the inclusion of bump stops and rebound stops within the housing is desirable it is envisaged that in some configurations these may be omitted from the housing if desired. It is advantageous that the front suspension arm 2 rises between the inner end 10 and outer end 8. When the vehicle hits a bump the front leading arm with wheel will rise and move rearwards relieving the loads.

It will be noted also that the compact arrangement of the assembly 1 allows clearance for delivery of a drive shaft to the hub assemblies 9 if required.

With the twin suspension arm arrangement illustrated the suspension has zero net average torque applied to the hull mounting because the suspension arms produce opposite and on average equal torques.

Regarding the provision of a drive for the wheels this can be done in a number of different ways. For example a drive train may be fed through the suspension arm. Alternatively an electric motor could be provided in the hub and cabling and a cooling system delivered through the suspension arm through the electric motor.

Figs. 16 to 33 show various other embodiments of the invention and parts similar to those described previously are assigned the same reference numerals in these drawings.

Referring to Fig. 16 there is shown a vehicle 50 incorporating two of the suspension assemblies 1 described previously. In this layout the platform is an eight by eight wheeled configuration with conventional Ackerman type steering on the front four wheels 52 which in this case are located by a double wishbone suspension 53. Two pairs of rear wheels 55 are mounted on a hull 56 of the vehicle 50 by means of the suspension assemblies 1 which are bolted to the bottom of the hull 56.

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Fig. 17 shows four rear wheels 55 which are driven by conventional prop shafts 56 connecting the hubs 9 directly to differentials 57 which are mounted mid ships underneath the inner armour floor of the vehicle. The driveline is fitted with traction control, CTI, lockup and ABS.

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Referring to Fig. 18 an in-arm drive arrangement. The drive is carried from a single differential to a splitter box integrated to the suspension module from which it is carried through the suspension arm journal by a shaft and down the suspension arm 2, 3 by a precision high performance inverted tooth chain drive indicated generally by the reference numeral 60.

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Figs. 19 and 20 show various electric drive arrangements for use with the suspension assemblies 1 an in-arm driveline with a single differential per four wheel bogie lends itself very well to the incorporation of electric drive with either a single motor 63 as illustrated in Fig. 19, two motors 64 as illustrated in Fig. 20 or four motors.

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Referring now to Figs. 21 to 23 an arrangement of the suspension assembly for a tracked vehicle is shown, indicated generally by the reference numeral 60. In this suspension assembly 60 a rocking beam 61 is mounted at an outer end of each suspension arm 2, 3. A centre 62 of each rocking beam 61 is pivotally mounted on the suspension arm 2, 3 by a pivot pin 64 for pivotal movement about a horizontal pivot axis. Bushings 65 at each end of the rocking beam 61 receive pivot shafts 66 carrying pairs of wheels 67 for engaging and supporting a track 68 on the vehicle 69.

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Referring now to Figs. 24 to 30 there is shown another variation in this case for a hybridised track/wheel design. This is similar to the suspension assembly 60 described with reference to Figs. 21 to 23. In this case however there is additionally a wheel support hub 70 mounted co-axially with the pivot pins of the rocking beams 61. The wheel hubs 70 carry wheels 71 as shown in Figs. 26 and 27 which extend below the track 68. The track wheels 67 are sized so that the track 68 is some distance above the ground contact point of the road wheels 71. All road wheels 71 are fitted with in-hub motors and directional control is by skid steering. When the vehicle 75 is operating on firm ground it functions as a wheeled vehicle with all the advantages in here and in this – high speed, strategic mobility, low running costs. When the vehicle

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- enters soft ground, which exceeds the floatation capacity of the tyres, it sinks until the tracks 68 take up the load. With suitable control algorithms for control of the motors the track drive will be automatically engaged when the load and drag on the track is sensed. Road wheel drive will be maintained and the tractive effort will be optimally distributed between the tracks and the wheels to maximise mobility in all terrains. Because the road wheels are not required to provide the floatation and soft terrain capability normally required of off-road wheeled vehicles smaller, lighter wheels and tyres may be used reducing the weight and space (especially with) claim of the wheels. Similarly, as the tracks are not required to operate on hard, broken terrain to the same extent as those on a conventional tracked vehicle would be the track structure and weight can be significantly reduced compared to a normal track. Also, since the wheels do contribute significantly to floatation and traction in soft ground, the tracks may be narrower than would be required on a tracked vehicle.
- Referring now to Figs. 31 and 32 there is shown another suspension assembly indicated generally by the reference numeral 80. In this case the lever arm 12 is connected at its upper end to the hydrostrut 6 by means of a fork and trunnion connector indicated generally by the reference numeral 82. The other end of the hydrostrut 6 is mounted on the wall of the housing 4 by an elastomeric flexible mounting 84. The connector 82 is formed by laterally projecting trunnion pins 86 on the hydrostrut 6 which are rotatably journaled in associated bearing holes 87 in forked arms 88 at an upper end of the lever arm 12. This construction advantageously allows the length of the housing to be reduced providing a more compact modular construction for the suspension assembly 80.
- Referring now to Fig. 33 there is shown an arrangement whereby a pair of the suspension assemblies 1 are each mounted in a bogie arrangement for swivelling about a vertical axis on the underside of the vehicle hull. Each wheel 90 is pivotally mounted on the suspension arms 2, 3 at 91. A steering arm 92 mounted on the wheel sub axle is pivotally joined to a fixed point 93 by means of a drag link 94. When the bogies are rotated the wheels 90 are rotated relative to the bogies with the geometry suitably adjusted by the relative positioning of the steering arm 92 pivots and the drag link 94 anchorage points to give the required steering geometry.

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In another arrangement the drag link mounting point 93 may be provided with a means to alter its position such that no relative movement of the wheel 90 and bogie occurs.

A bogie track rod 95 is provided between the bogies.

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The invention is not limited to the embodiments hereinbefore described which may be varied in both construction and detail within the scope of the appended claims.

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1. A modular suspension assembly for an armoured vehicle, including:
 - a support frame,
 - a pair of suspension units mounted on the support frame, namely a leading arm suspension unit and a trailing arm suspension unit,
 - each suspension unit including a suspension arm having an outer end and an inner end,
 - said outer end having means for connection to a wheel or track support,
 - said inner end being pivotally mounted on the support frame and connected to a spring means on the support frame which opposes pivotal movement of the suspension arm away from a neutral position,
 - the suspension arms being pivotal in a common vertical plane,
 - the support frame having mounting means for securing the support frame to a bottom of a vehicle hull upon which the modular suspension assembly is to be mounted.
2. A suspension assembly as claimed in claim 1 wherein the mounting means is adjustable to allow pivoting of the support frame about a vertical axis to facilitate correct alignment of the suspension arms on the vehicle hull.
3. A suspension assembly as claimed in claim 2 wherein the mounting means comprises a pair of spaced-apart horizontal mounting flanges on the support frame having vertical through holes for reception of associated mounting bolts to secure the mounting frame to the bottom of the vehicle hull.

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4. A suspension assembly as claimed in claim 3 wherein the through holes include a circular pivot hole in one flange for reception of a pivot pin and a plurality of elongate slots, a long axis of each slot lying on the circumference of a circle having its centre at the pivot hole.
5. A suspension assembly as claimed in claim 1 wherein a pivot axis about which each suspension arm rotates lies beneath the line of action of the spring means.
6. A suspension assembly as claimed in claim 1 wherein the spring means for the suspension arms are mounted on the support frame in a substantially horizontal side by side orientation.
7. A suspension assembly as claimed in claim 1 wherein the inner end of each suspension arm is connected to a lever arm which in turn acts on the spring means.
8. A suspension assembly as claimed in claim 7 wherein the support frame has a sealed housing within which the lever arms and spring means associated with the suspension arms are mounted, each lever arm being connected to the suspension arm by a pivot shaft which projects outwardly through a complementary opening in a side wall of the housing, a seal being mounted in said opening about the shaft to seal between the housing and the shaft.
9. A suspension assembly as claimed in claim 1 wherein each suspension arm inclines upwardly from the inner end to the outer end of the suspension arm.
10. A suspension assembly as claimed in claim 9 wherein the suspension arm of the leading arm suspension unit has its outer end located forwardly of its inner end, and the suspension arm of the trailing arm suspension unit has its outer end located rearwardly of its inner end.
11. A suspension assembly as claimed in claim 1 wherein means is provided at the outer end of each suspension arm for demountably securing a wheel or track support at said outer end.

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12. A suspension assembly as claimed in claim 1 wherein the spring means is a hydrostrut.
13. A suspension assembly as claimed in claim 12 wherein the inner end of each suspension arm is connected to a lever arm which in turn acts on the spring means, and swivel connectors are mounted at each end of the hydrostrut for connection between the hydrostrut and the support frame and the lever arm.
14. A suspension assembly as claimed in claim 13 wherein a fork and trunnion connector is provided between the lever arm and the hydrostrut
15. A suspension assembly as claimed in claim 13 or 14 wherein an elastomeric flexible mount is provided between the hydrostrut and the support frame.
16. A suspension assembly as claimed in claim 13 wherein swivel bearings are provided between each end of the hydrostrut and the support frame and the lever arm.
17. A suspension assembly as claimed in claim 1 wherein a rocking beam is mounted at an outer end of each suspension arm, a centre of the rocking beam being pivotally mounted on the suspension arm by a pivot pin extending between the beam and the suspension arm for pivotal movement about a horizontal pivot axis, a wheel or track support being mounted at each end of the rocking beam.
18. A suspension assembly as claimed in claim 17 wherein track supports are mounted at each end of the rocking beam and a wheel support is mounted co-axially with the pivot pin on the rocking beam or suspension arm.
19. A suspension assembly as claimed in claim 1 wherein the support frame forms a bogie with means for pivotally mounting the bogie on the bottom of the vehicle hull, the bogie having means for connection to a steering system of the vehicle for controlled pivoting of the bogie in response to a steering command from the steering system.

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20. A suspension assembly as claimed in claim 19 wherein steerable wheels are mounted at the outer ends of the suspension arms by swivel mounts, a steering arm of the swivel mount being connected by a drag link to a fixed mounting point to provide differential steering of the wheels in response to rotation of the bogie.