(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
15 October 2020 (15.10.2020)

WIPO | PCT

(10) International Publication Number
WO 2020/206543 A1

(51) International Patent Classification:
B62D 7/18 (2006.01) *B60B 27/04* (2006.01)

(21) International Application Number:
PCT/CA2020/050469

(22) International Filing Date:
09 April 2020 (09.04.2020)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
3040098 11 April 2019 (11.04.2019) CA
62/832,588 11 April 2019 (11.04.2019) US

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,

WO 2020/206543 A1

(54) Title: DIRECT DRIVE LONG TRAVEL STEERING KNUCKLE

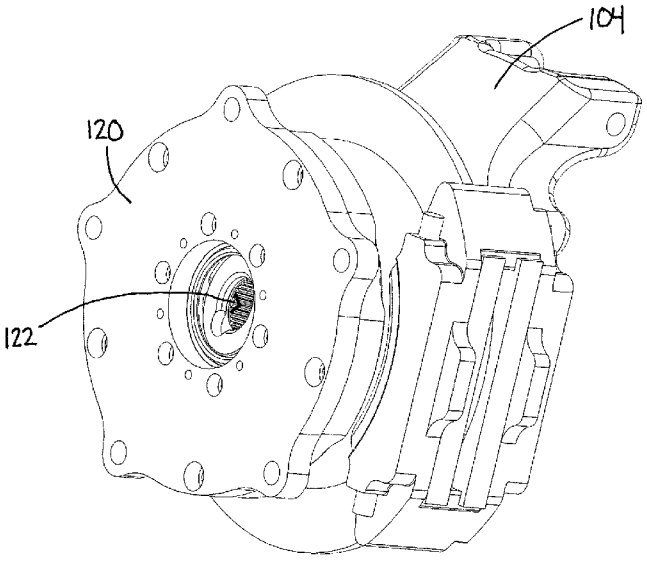


Fig. 7

(57) Abstract: A direct drive long travel steering knuckle, the knuckle having a hub with an expanded cavity, wherein such cavity houses an articulated joint, adapted to receive the outermost end of a mid axle shaft, wherein such mid axle shaft is lengthened to extend from a differential of the vehicle through the hub cavity. The expanded hub cavity accommodates an extended range of motion of the axle shaft and accordingly, the articulating hub provides for increased vertical range of motion of the vehicle's wheels, especially when used in conjunction with an active controlling suspension system.

[Continued on next page]

TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*
— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*

DIRECT DRIVE LONG TRAVEL STEERING KNUCKLE

FIELD

This disclosure relates to a steering knuckle, specifically a steering knuckle having a wheel hub with an expanded internal cavity adapted to accommodate a lengthened mid axle shaft so as to increase axle articulation to improve the range of motion for a vehicle's wheels.

BACKGROUND

In both industry and leisure applications, it is often desirable to traverse rough terrain in a wheeled vehicle, such as a truck or in other forms of utility vehicles.

Conventional vehicle suspension and drivetrain systems may not typically be capable of traversing such terrain, as climbing the vehicle over large obstacles such as fallen trees or boulders, combined with the uneven nature of the ground itself including ruts and ditches often requires more ground clearance than may be conventionally provided. For example, when travelling either up, down or transversely across a slope, adequate ground clearance is required so as to prevent the vehicle from becoming immobilized on the rough terrain. Wheel travel is also important for performance.

The drivetrain, which comprises a group of components including the differential, universal joints, and the axle assembly comprising, drive shafts, constant velocity joints (CV joints), axle shafts, and stub shafts, in addition to a vehicle's control arms, limit suspension travel and a vehicle's ground clearance.

It is thus desirable to increase a vehicle's ground clearance and wheel travel without increasing the width of the vehicle, so as to allow crossing of particularly rough terrain presenting large obstacles, such as fallen trees or boulders, for example in confined spaces between insurmountable obstacles

Providing for increased vertical range of motion of a vehicles' wheels allows increased ground clearance and increased performance over rough terrain, especially when used in conjunction with an active controlling suspension system, without increased vehicle width, which allows the vehicle's tires to remain in contact with the ground in more rugged conditions.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates a perspective view of a conventional drivetrain assembly.

Figure 2 illustrates a perspective view of a conventional wheel hub.

Figure 3A illustrates, in plan view, a steering wheel hub according to an embodiment of the present disclosure.

Figure 3B is a left side elevation view of the steering wheel hub of Figure 3A.

Figure 3C is a front elevation view of the steering wheel hub of Figure 3A.

Figure 3D is, in perspective view, the steering wheel hub of Figure 3A.

Figure 3E is the section view along line A-A in Figure 3A.

Figure 4 illustrates a perspective view of the steering wheel hub embodiment of Figure 3.

Figure 5 is a top view of a drivetrain and wheel assembly according to an embodiment of the present disclosure.

Figure 6 is an isometric view of a steering wheel hub according to an embodiment of the present disclosure.

Figure 7 is a reverse view of the steering wheel hub embodiment of Figure 7.

Figure 8A is a top view of a steering wheel hub assembly according to the present disclosure.

Figure 8B is a sectional view along line 8-8 in Figure 8A illustrating one example of the range of articulation of a mid-axle shaft extending through the steering wheel hub cavity.

Figure 9A is a top view of a drivetrain and wheel assembly according to an embodiment of the present disclosure.

Figure 9B is a section view of Figure 9A sectioned along line A-A in Figure 9A.

Figure 10A is a top view of a drivetrain and wheel assembly according to an embodiment of the present disclosure wherein the wheel assembly is travelling in a downward direction.

Figure 10B is a section view of Figure 10A sectioned along line B-B in Figure 10A.

Figure 11A is a top view of a drivetrain and wheel assembly according to an embodiment of the present disclosure wherein the wheel assembly is travelling in an upward direction.

Figure 11B is a section view of Figure 11A sectioned along line C-C in Figure 11A.

Figure 12 is a plan view illustrating the assembly of Figure 9A with the steering mechanism engaged to turn the wheels.

Figure 13 is a front view of the assembly of Figure 12.

SUMMARY

A direct drive long travel steering knuckle, having a wheel hub, adapted to increase the range of motion of a vehicle's wheels on a driven axle that also steers. The steering hub includes a hollow rigid body having opposite inner and outer ends and having a cavity extending therebetween. The size and shape of the cavity defines and limits a sweep angle. The sweep angle is the angular range of motion of

an extended length mid axle shaft which is pivotally mounted in the outermost end of the steering hub cavity. The extended length mid axle shaft thus replaces the conventional stub shaft in a wheel hub. The direct drive long travel steering knuckle accommodates an extended length mid axle shaft without increasing the track axle width. The angular range of motion of the extended length mid axle shaft is primarily constrained by the internal dimensions of the hub cavity and the size of the opening into the cavity on its innermost end; that is, the end closest to the differential.

Thus an articulated joint is mountable in the outer end of the steering hub. The articulated joint mounts to the outermost end of mid axle shaft extending from the differential. The mid axle shaft extends through the cavity opening in the inner end of the hub and through the cavity in the hub to the outer end of the cavity. The mid axle shaft is rotatable through substantially the entire sweep angle. According to wheel size, tire size, type of joints and amount of steering required, in one aspect of the present disclosure, the increased vertical range of travel of the wheel may be in the range of about 19 - 24 inches or more, for example 36 inches of travel.

The steering hub cavity may for example be substantially frusto-conical or cylindrically shaped. The opening in to the inner end of the cavity has a diameter sufficient to allow the desired vertical range of motion of the mid axle shaft. The size of the opening is completely dependent on, and scalable to accommodate, the size of the tires, wheels, axles, joints, amount of wheel travel and steering required. The sweep angle of the cavity may for example be in the range of 25-30 or more degrees about the articulating joint. It will be appreciated by a person skilled in the art that the sweep angle S may vary depending on the size of the cavity and wheel,and how much suspension travel and steering is required.

According to one aspect of the present disclosure, a direct drive long travel steering knuckle kit may be provided which includes at least one of the extended length mid axle shafts adapted to extend from the vehicle differential, through the hub cavity, so as to terminate at the articulating joint on the

outermost end of the hub. Without the normal outer stub axle, the drive axle attaches to the wheel further towards outside of the vehicle, but the steering, ball joints and suspension parts can only attach on the inside of the tire. So for the axle to move up and down with the suspension and move forward and back when steering, (because the pivot point outer CV / unjointed is moved further out) the axle needs clearance for this movement to occur, creating the need for a hollow steering knuckle.

DETAILED DESCRIPTION

The direct drive long travel steering knuckle 104 of the present disclosure provides for improved range of motion of a vehicle's wheels so as to improve off-road performance.

A vehicle's drivetrain is a series of parts that work in conjunction to transmit power produced by the vehicle's engine to the vehicle's wheels. In the prior art, as seen in Figure 1, stub shafts 18 are components of the drivetrain. Stub shafts 18 are mounted in the wheel hub 10, along the wheel axis of rotation. The innermost ends of the stub shafts 18 are mounted to constant velocity (CV) joints 22, or other articulating joint (collectively referred herein as "CV joint"). CV joints 22 and 24 are mounted at the ends of mid axle shafts 20, CV joints 24 couple mid axle shafts 20 to the vehicle's differential 26.

Each stub shaft 18 is rigidly connected to its corresponding steering hub 10 and bearing assembly. Conventional wheel hubs 10 do not allow angular movement of the stub shaft 18 other than the rotational movement about the wheel axis of rotation which transmits the rotation of the mid axle shaft 20 to the wheel. As seen in Figure 2, the hub cavity 12 of a conventional wheel hub 10 is relatively narrow for a smug fit over the corresponding stub shaft 18. The stub shaft 18 and the narrow hub cavity 12 are two limiting factors with respect to increasing axle shaft vertical articulation and corresponding vertical range of motion of the wheel they are connected to, the others being joint angle and vehicle width.

In the present disclosure, the stub shaft 18 is eliminated from the vehicle's drivetrain, and conventional axle shafts 20 are replaced with extended length axle shafts 118. The steering hub cavity 102 is widened so as to increase the internal diameter of the cavity, as seen in Figures 3 and 4, having a cavity diameter indicated as dimension D in Figure 3B. An increase in vertical range of wheel travel is achieved by increasing the vertical angular range of motion and the length of mid axle shaft 118 relative to the vehicle's differential 116. By eliminating the stub shaft 18, and lengthening the mid axle shaft 118 by a roughly equivalent length, an extended range of vertical motion of the steering hub 100, and thereby the vertical motion of wheel 124, is obtained. A lengthened mid axle shaft 118 and its corresponding angular range of motion is accommodated by widening the internal cavity 102 of the steering hub 100 so as to increase its diameter D, thereby providing an extended angular range of motion corresponding to sweep angle S. The direct drive long travel steering knuckle accommodates a lengthened mid axle shaft without increasing the track axle width. Lengthened axle shaft 118 as illustrated in Figure 5, extends completely through the hub 100 to an articulated joint 122 mounted in the hub's 100 outermost end wall 105. In some embodiments of the present disclosure, the hub cavity 102 may for example be frusto-conical or cylindrically shaped.

The direct drive long travel steering knuckle 104 houses a wheel hub. The wheel hub is a hollow rigid body having inner and outer ends 103, 105 respectively. The hub cavity 102 extends between ends 103, 105 and includes a sweep angle S, shown between the dotted lines in Figure 3E from outer end 105 to inner end 103. The sweep angle S defines an angular space approximating a cone between the two ends 103, 105 across which the axle shaft 118 is free to pivot on joint 122. As seen in Figure 8, sweep angle S may be approximately 30 degrees or more, which provides the increased vertical range of motion of the wheel 124 as compared to a conventional vertical range of motion. The sweep angle S may vary, depending on the size of the cavity 102 and wheel 124. Further, the range of motion of the wheel 124 is further dependent on the length of the mid axle shaft.

The outer end 105 of steering hub 100 is proximate to the vehicle's wheel mounting plate 120. The inner end 103 of steering hub 100 is proximate to steering knuckle 104. Articulated joint 122 is mounted in outer end 105, as illustrated in Figure 6, and is adapted to receive the outermost end of the corresponding axle shaft 118. The articulated joint 122 may, for example, without intending to be limited, be a CV joint. Joint 122 connects the axle shaft 118 to the vehicle's corresponding wheel 124 via wheel mounting plate 120 and in the manner of a CV joint, allows the axle shaft 118 to transmit power to the wheel 124 at a variable angle, at a constant rotational speed, while accommodating the motion of a vehicle's suspension system. The outer end 105 of the steering hub 100 body mounts conventionally to the wheel mounting plate 120.

The dimensions, sweep angle and ranges of motion are provided by way of example in this description and the accompanying Figures, and are not intended to be limiting.

Control arms 110, 112 are components of the vehicle's suspension system that also play a role in ground clearance. Control arms 110, 112 allow the wheels 124 to travel up and down in a controlled manner; while preventing forward and rearward movement. In the present disclosure, as illustrated in Figure 4, the steering hub 100 is connected to steering knuckle 104, which in turn is connected to upper 110 and lower control arms 112 via upper 106 and lower ball joints 108. The steering knuckle 104 connects to the wheel's suspension system via the control arms 110, 112 and attaches to steering components 111 via knuckle arm 109. The inner ends of the control arms 110, 112 extend inwardly, towards the center of the vehicle frame from respectively, the upper and lower ends of the steering knuckle 104. The control arms 110, 112 connect the wheel steering hub 100 and knuckle 104 to the frame of the vehicle or to a frame extension 114 under the vehicle frame. Control arms 110, 112 may be A-arms.

As illustrated in Figures 9A – 11B, the front wheel control arms 110, 112 facilitate the up and down movement of the wheel 124 (shown in dotted outline). As seen in Figure 10B, as the wheel 124 travels downward in direction B so as to increase vertical distance R, the control arms 110, 112 and axle shaft 118 rotate downwardly in direction B', so as to accommodate the downward movement of the wheel 124 in direction B. Similarly, as seen in Figure 11B, as the wheel 124 travels upward in direction A so as to decrease height R, the control arms 110, 112 rotate upward in direction A', so as to accommodate the upward movement of the wheel in direction A. Steering rotation of hubs 100 is provided by steering linkage 111.

For the front wheels, in order to accommodate the increased vertical range of motion of the upper and lower control arms 110, 112 , a vehicle frame extension 114 may be provided which mounts up underneath the vehicle frame and sub-frame supporting the engine and differential 116. The frame extension 114, once mounted underneath the engine and frame of the vehicle, extends downwardly there from so as to support the inside ends of the lower control arm 112. Thus, preferably the frame extension 114 has control arm bushings for the mating of the frame extension 114 to the innermost ends of the upper 110 and lower control arms 112. The upper 110 and lower control arm 112 bushings are separated vertically on the frame extension 114.

The frame extension 114 is symmetric about the center line of the vehicle, and accommodates left and right pairs of control arms 110, 112 for the corresponding left and right wheels 124.

A rear frame extension 114 structure may be provided at the rear of the vehicle frame, again mounted up under the frame, but otherwise providing the same function as provided by the frame extension 114 in the front. The description of the use of a frame, or frame extension, and control arms such as A- arms is not intended to be limiting but rather illustrative, as other systems such as McPherson strut would also work.

In a preferred embodiment of the present disclosure, the increased vertical range of motion of the wheel steering hub 100 on the outermost ends of the control arms 110, 112 may provide extra vertical travel in the range of, for example, 24 or more inches for a typical truck arrangement, for example, a typical half-ton pick-up truck. The extra vertical range of motion provided will vary depending on a vehicle's width, wheel size, sweep angle S, and length of the mid axle shaft 118.

WHAT IS CLAIMED IS:

1. A direct drive long travel steering knuckle for a vehicle, the direct drive long travel steering knuckle comprising:

a wheel hub, the wheel hub comprising:

a hollow rigid body having opposite inner and outer ends and having a cavity extending therebetween, said cavity including a sweep angle, from the outer end, and

wherein the inner end includes an opening into the cavity, and wherein an articulated joint is mountable in the outer end and is adapted to receive therein an outermost end of a mid shaft extending from a differential of the vehicle and through the opening in the inner end and through the cavity to the outer end so as to be rotatable about the articulated joint through substantially the sweep angle.

2. The direct drive long travel steering knuckle of claim 1 wherein the cavity is substantially frusto-conically shaped.

3. The direct drive long travel steering knuckle of claim 1 wherein the cavity is substantially cylindrical.

4. A direct drive long travel steering knuckle kit for a vehicle comprising the steering knuckle of claim 1, and further including at least one mid axle shaft adapted to extend from the vehicle differential through said cavity to couple to the articulated joint.

5. The direct drive long travel steering knuckle of claim 1 wherein the increased vertical range of travel is substantially at least 24 inches.

6. The direct drive long travel steering knuckle of claim 1 wherein said opening has a diameter of substantially at least 6 inches.

7. The direct drive long travel steering knuckle of claim 1 wherein said sweep angle is substantially in the range of at least 25 degrees.

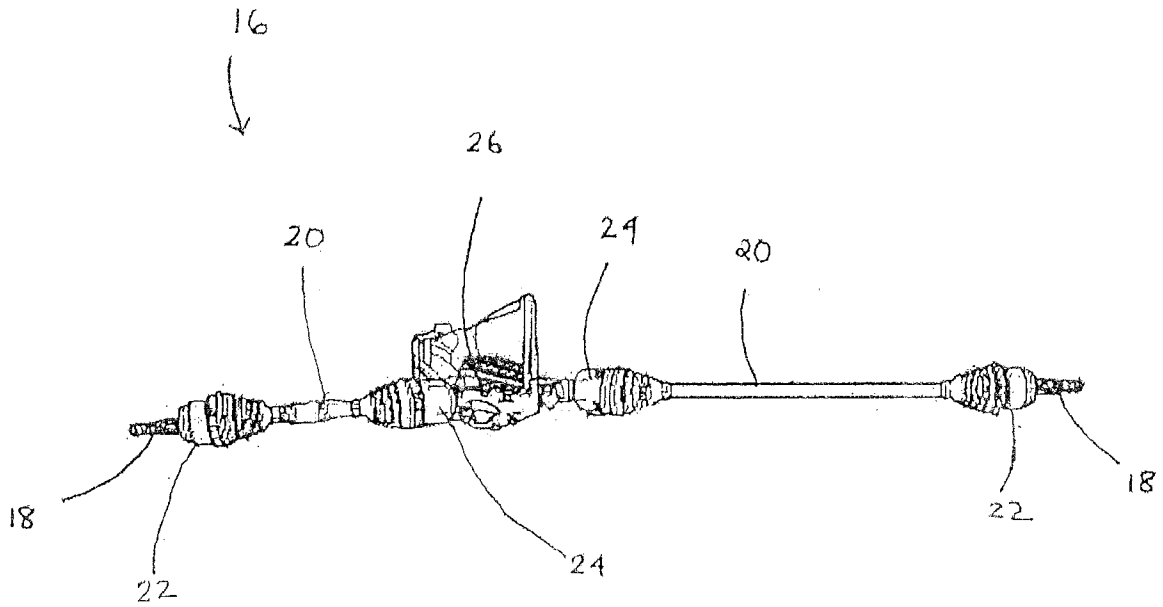


FIG. 1
(PRIOR ART)

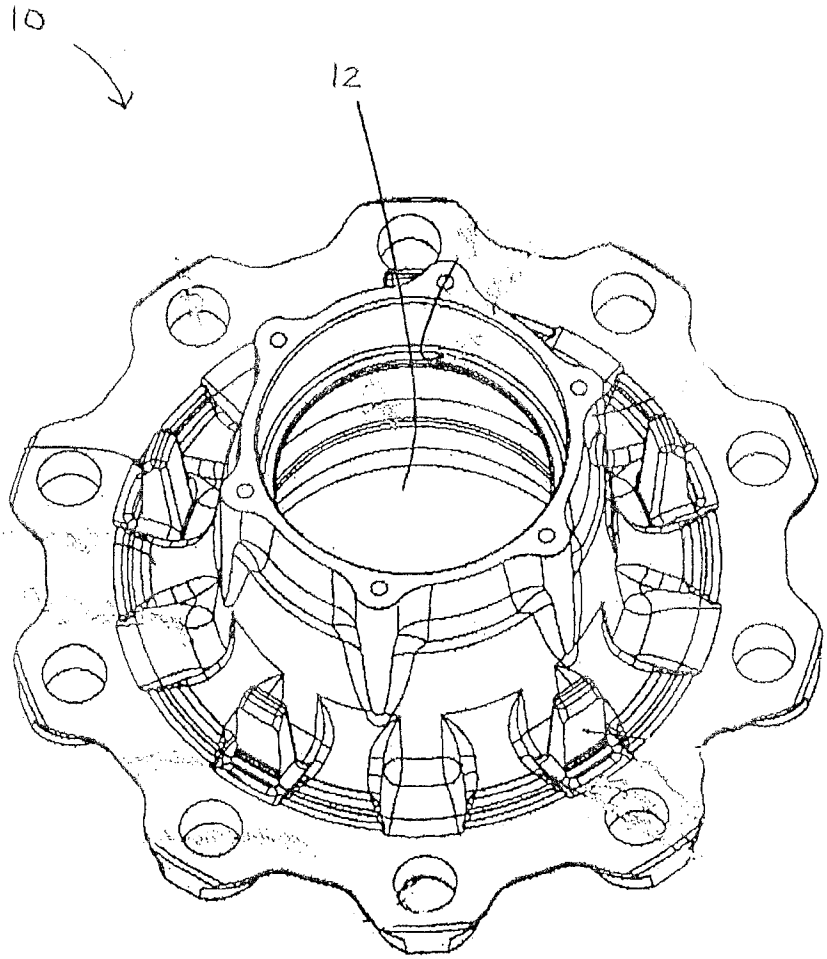


FIG. 2
(Prior Art)

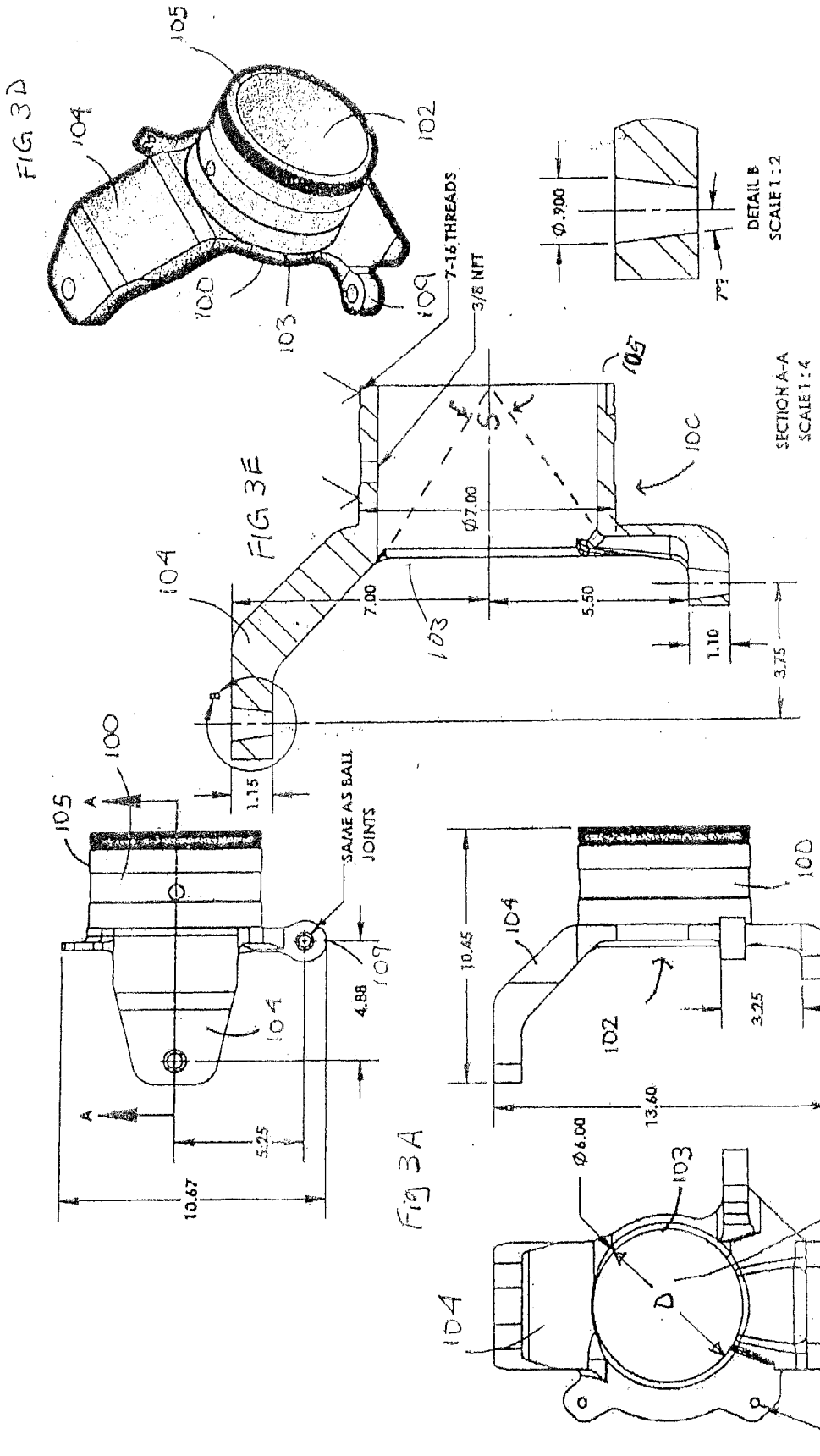


FIG 3D
105
104
102
100
103
109
FIG 3E
7-16 THREADS
3/8 NPT
105
104
100C
Ø7.00
7.00
5.50
1.10
3.75
103
1.15
SECTION A-A
SCALE 1:4
Ø.900
DETAIL B
SCALE 1:2
FIG 3A
105
100
A
SAME AS BALL JOINTS
109
4.88
104
A
5.25
10.67
FIG 3C
10.45
104
100
102
3.25
13.60
FIG 3B
Ø6.00
103
102
104
2X Ø .33 THRU
3/8-24 UNF-THRU

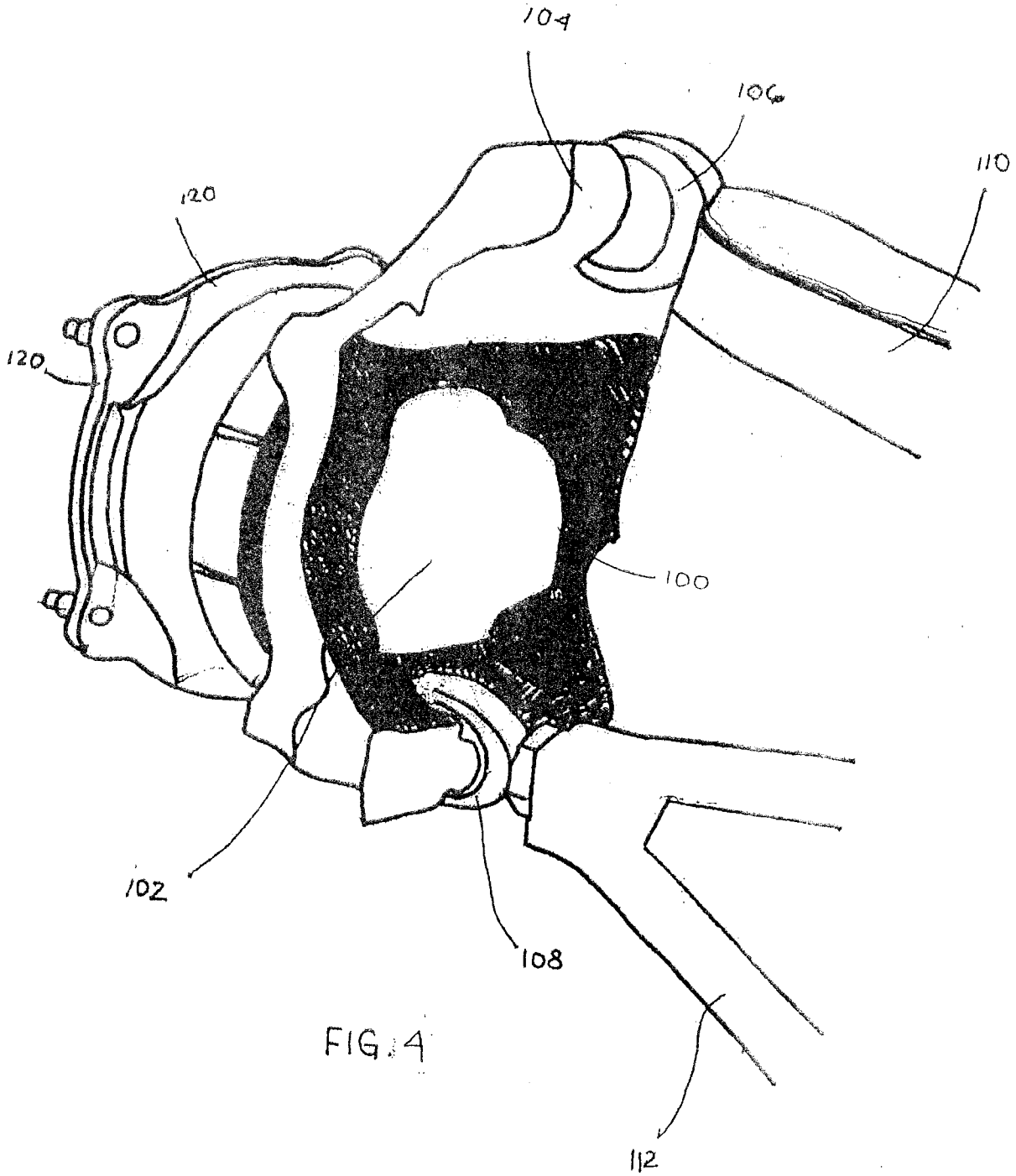


FIG. 4

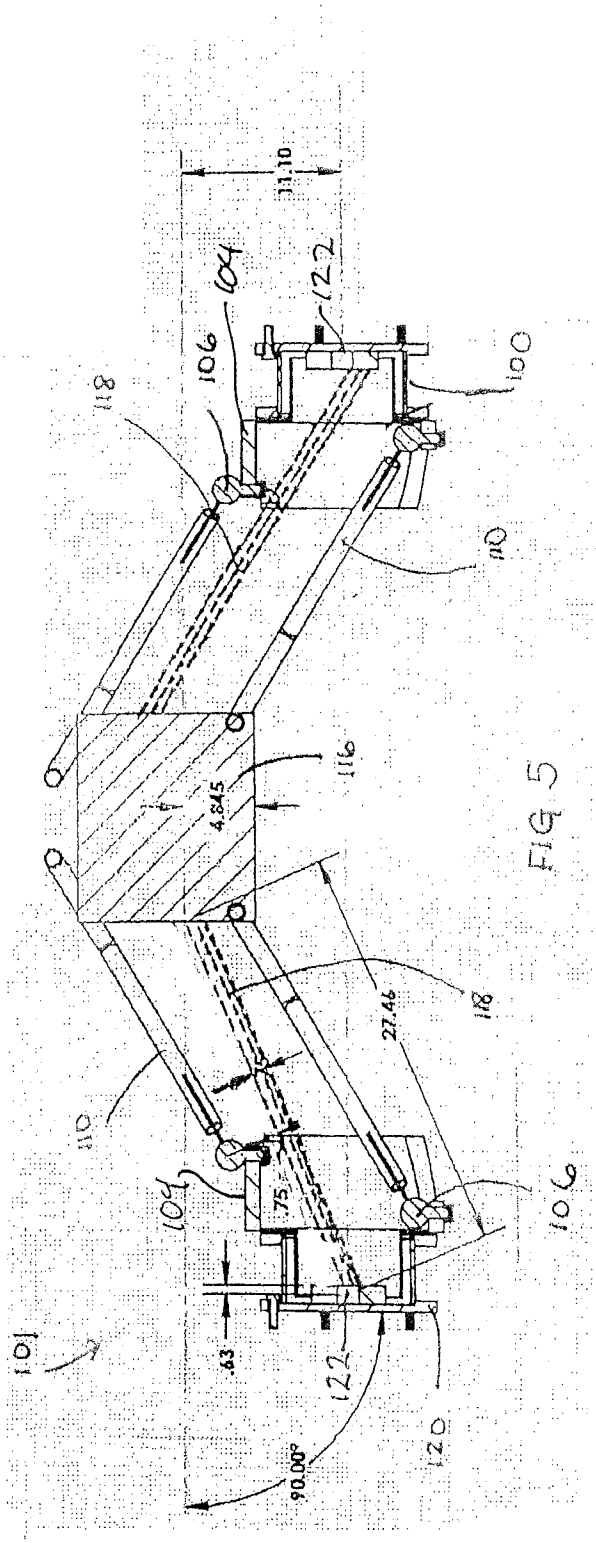
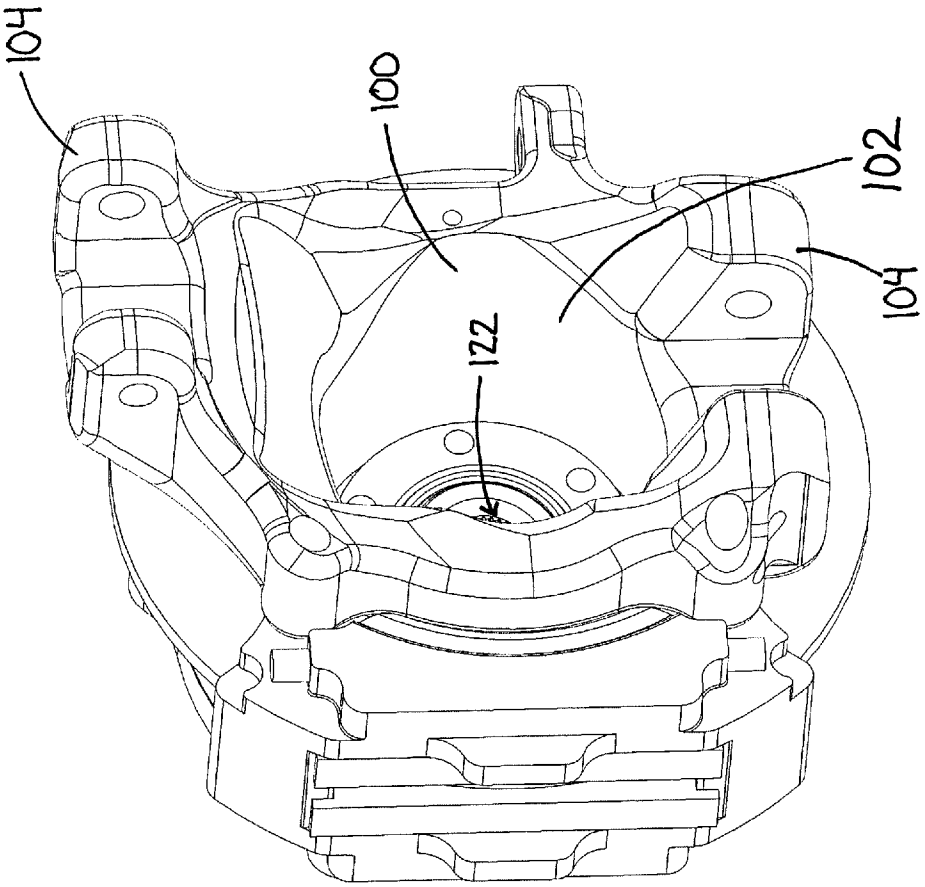

11.10
104
122
106
100
118
110
116
4.845
27.46
118
110
104
.75
.63
122
120
90.00°
101
106

FIG 5

Fig. 6



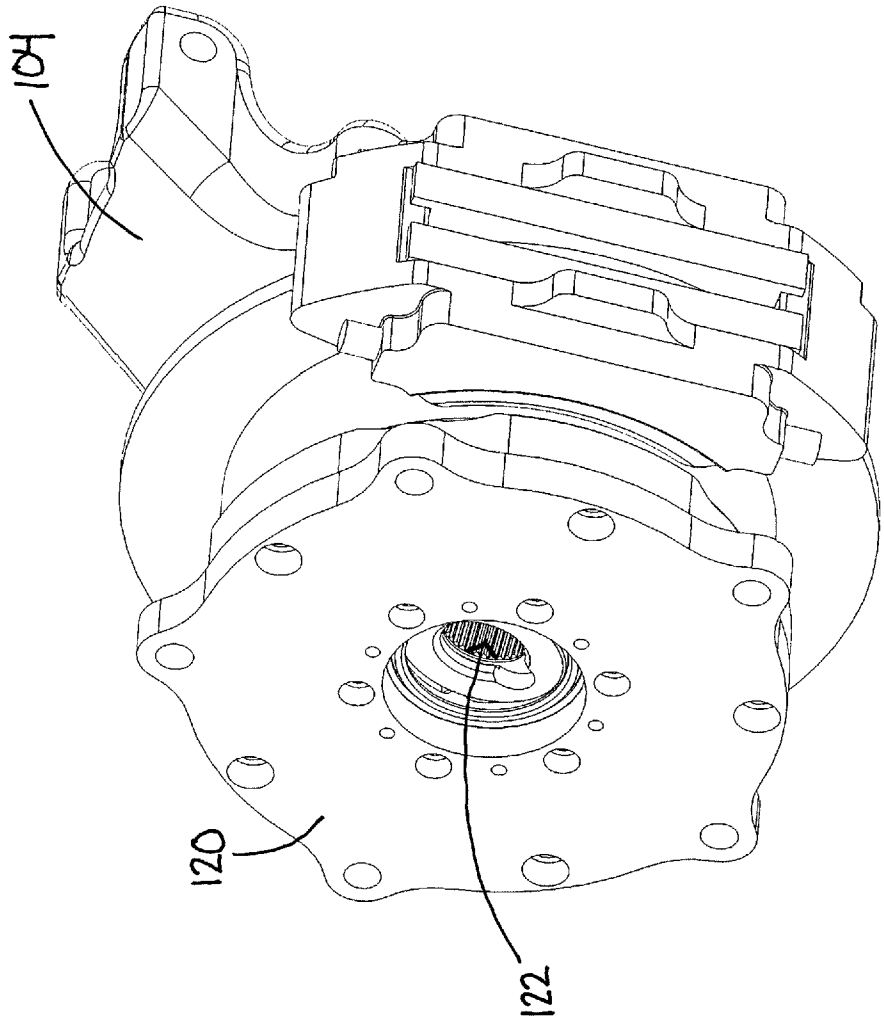


Fig. 7

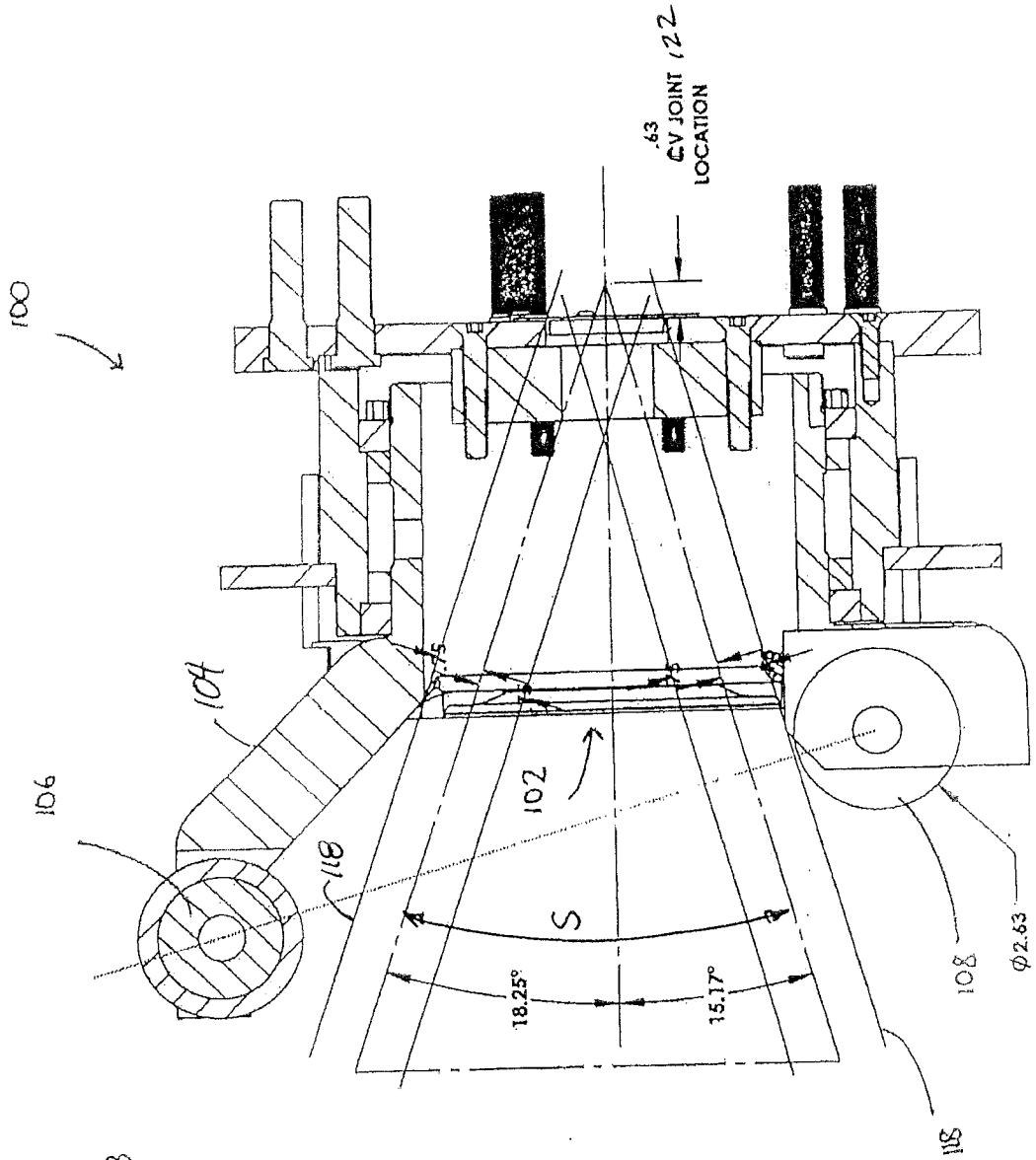

100
.63
CV JOINT 122
LOCATION
104
106
102
118
S
18.25°
15.17°
108
Φ2.63
118

FIG. 8B

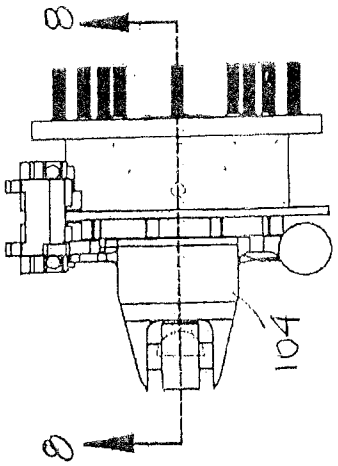

8
104
8

FIG 8A

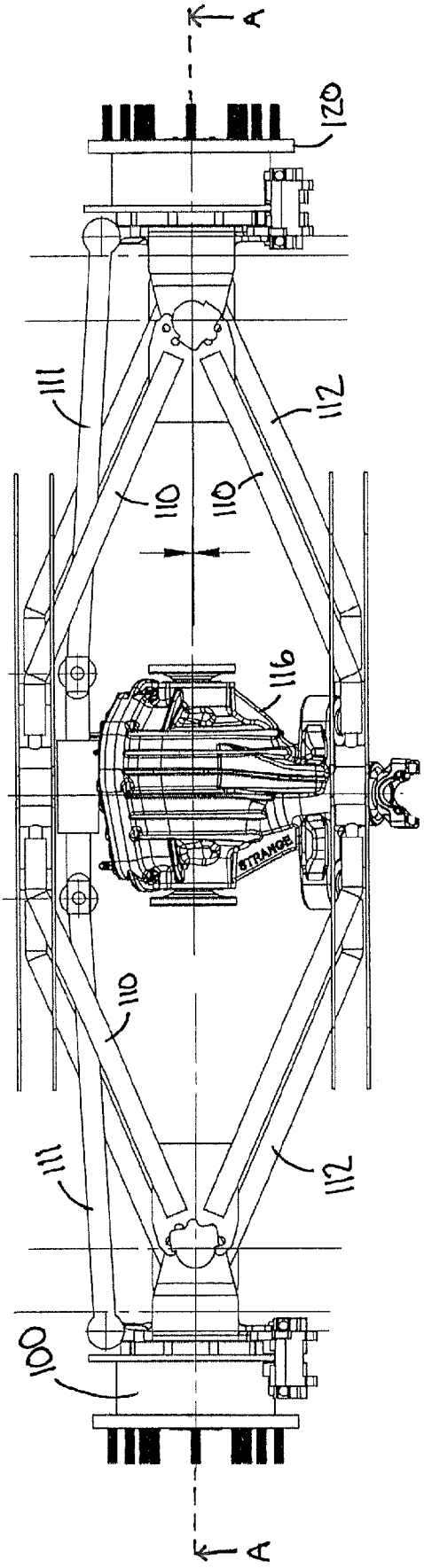


Fig. 9A

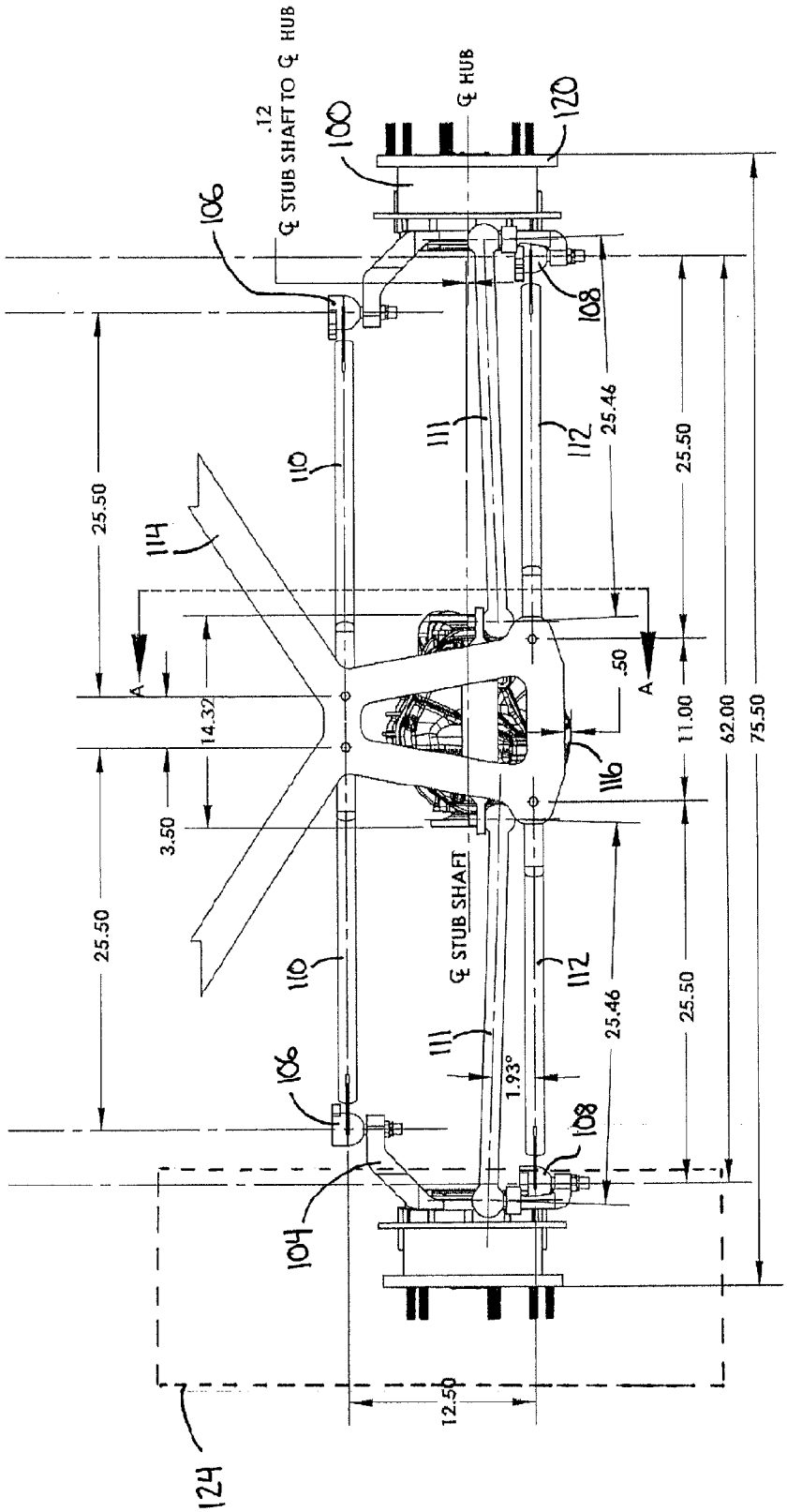

.12
℄ STUB SHAFT TO ℄ HUB
℄ HUB
100
120
106
108
111
112
25.46
25.50
110
114
25.50
A
A
.50
14.32
11.00
62.00
75.50
116
3.50
℄ STUB SHAFT
25.50
110
112
111
25.46
25.50
1.93°
106
108
104
12.50
124

Fig. 9B

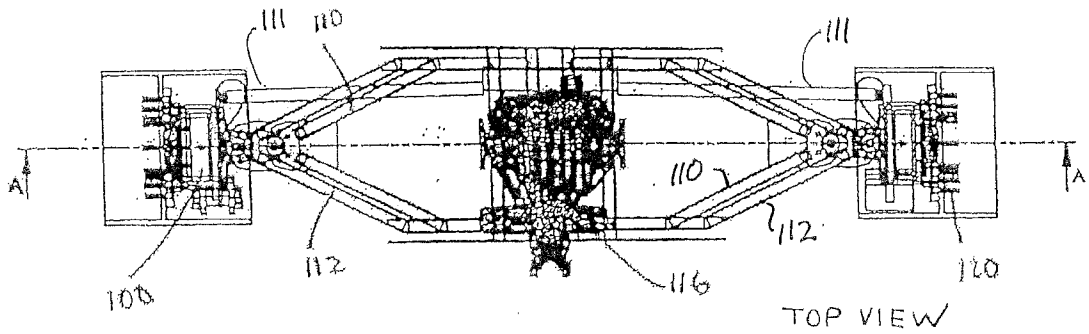

111
110
111
A
A
110
112
100
112
116
120
TOP VIEW

FIG. 9A

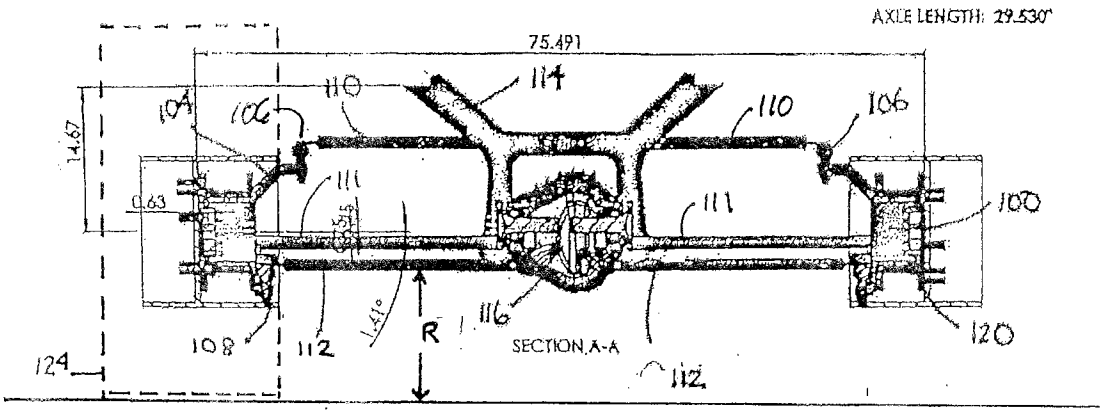

AXLE LENGTH: 29.530"
75.491
110
114
110
106
104
106
14.67
0.63
111
111
100
R
116
SECTION A-A
108
112
120
124
112

FIG. 9B

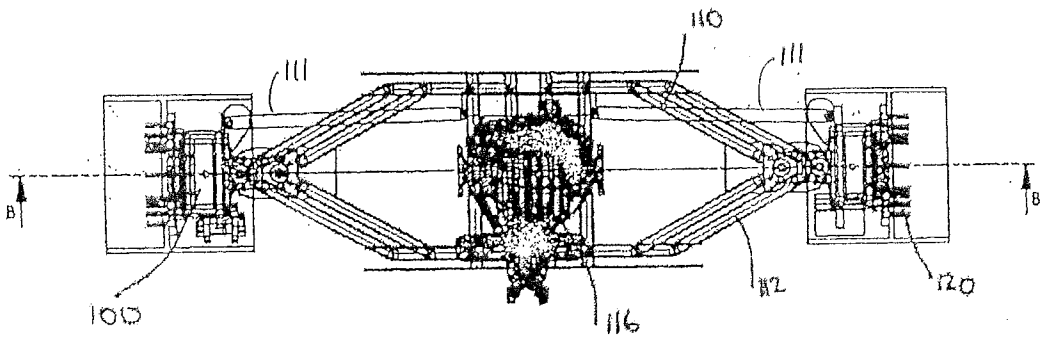


FIG 10A TOP VIEW

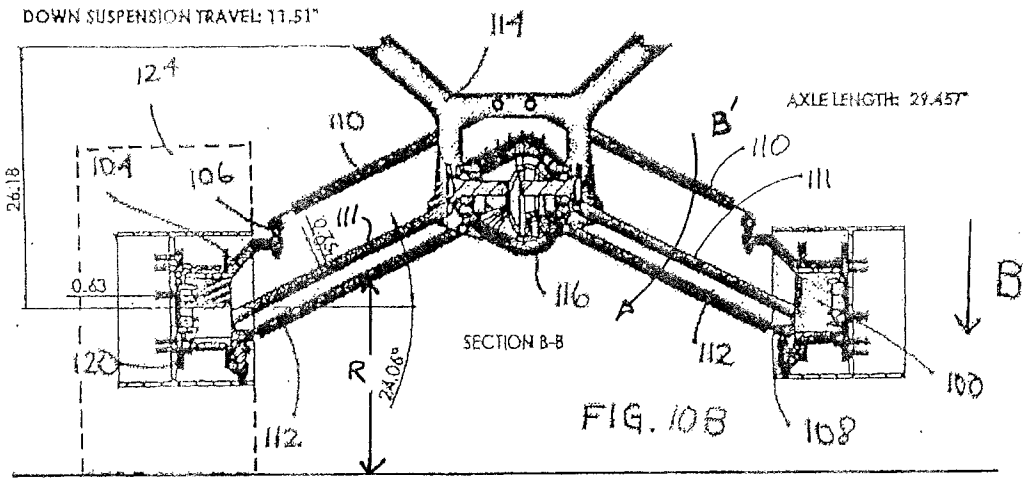


FIG. 10B

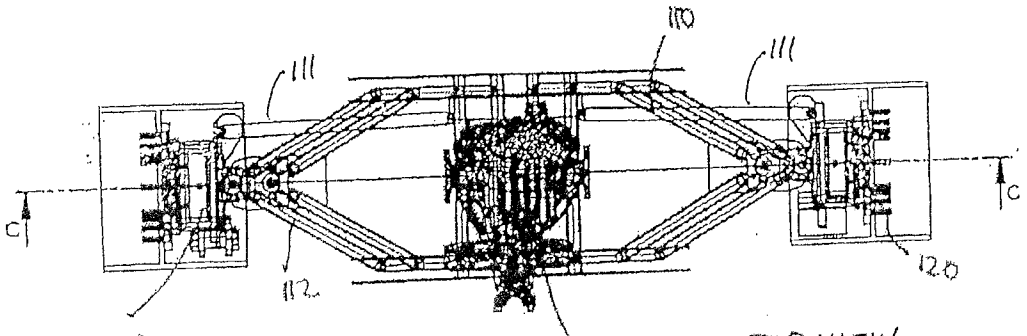


FIG 11 A

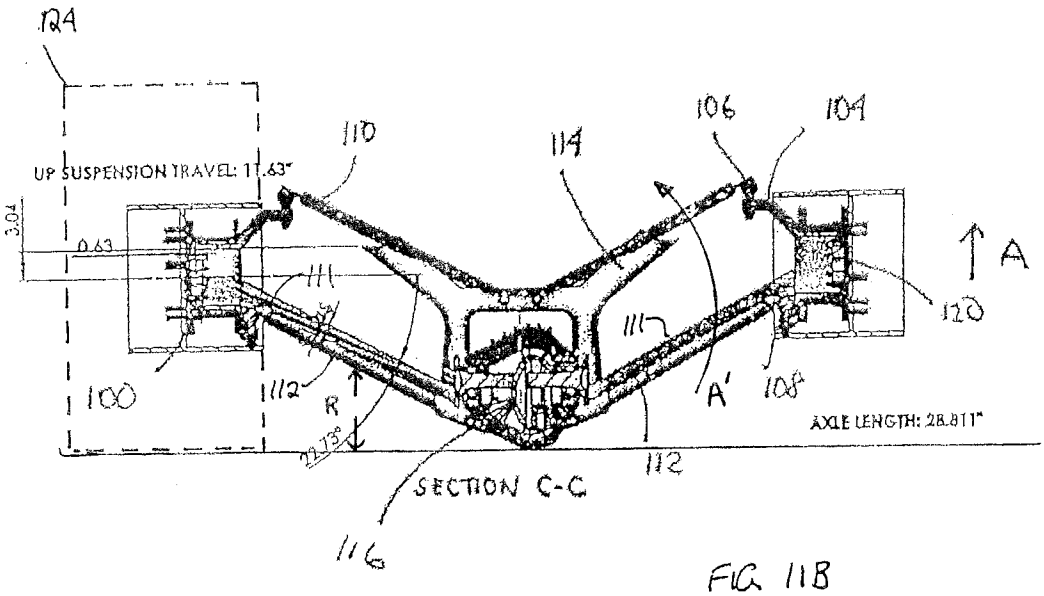


FIG 11B

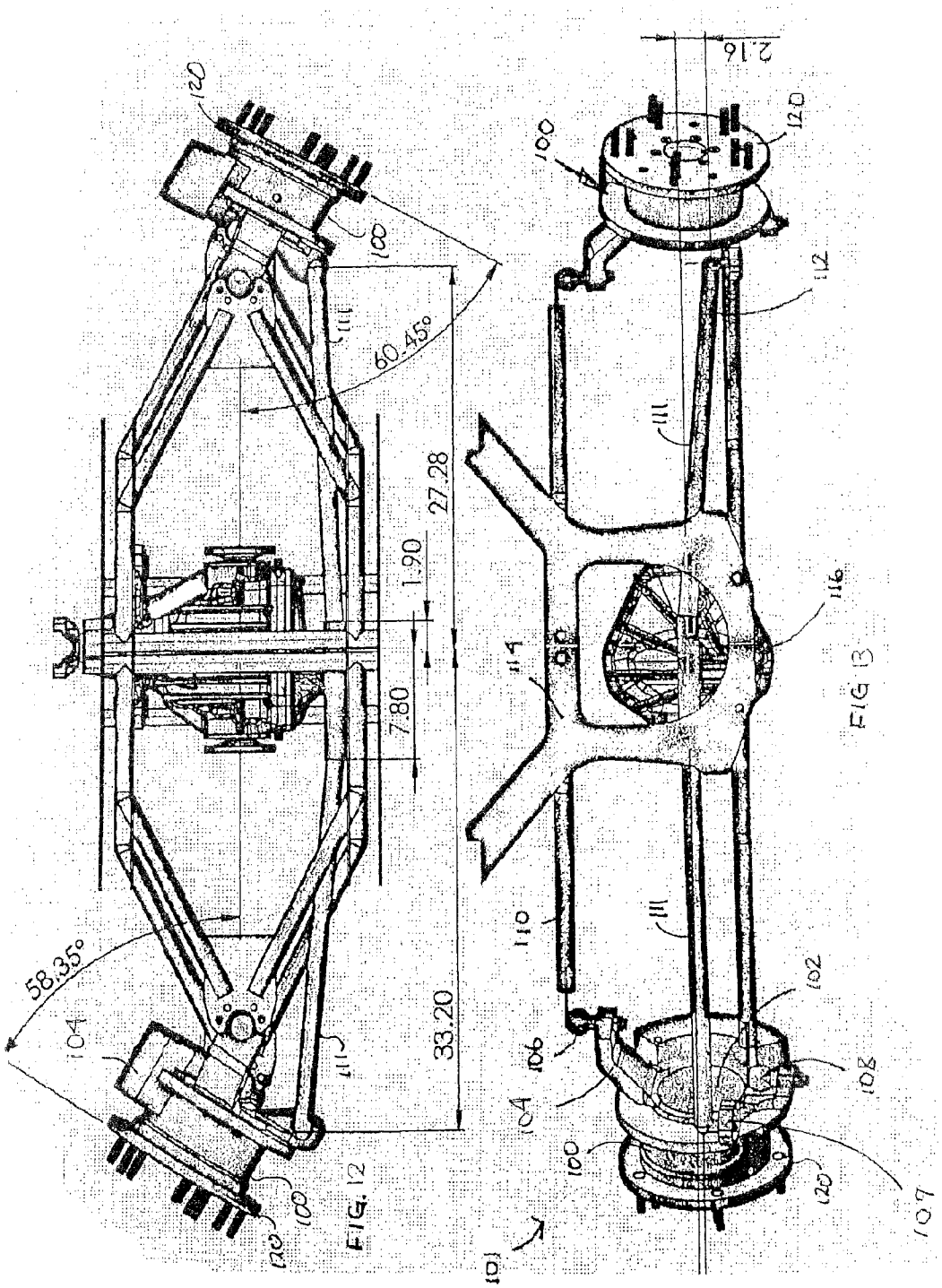

120
100
60.45°
27.28
1.90
7.80
33.20
58.35°
104
102
106
108
110
111
112
114
116
2.16

FIG. 12

FIG 13

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2020/050469

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***B62D 7/18*** (2006.01) , ***B60B 27/04*** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC: ***B62D*** (2006.01) , ***B60B*** (2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
none

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Intellect (Canadian Patent Database), Questel-Orbit (FamPat Database).
Keywords: wheel, angle, joint, hub, knuckle, steering, sweep and articulated.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR2530547, (Germain) 27 January 1984 (27-01-1984) *whole document*	1-7
X	US9527536, (Giesmann et al.) 27 December 2016 (27-12-2016) *whole document*	1-7
A	KR100999420, (Jong Sun) 9 December 2010 (09-12-2010) *whole document*	1-7

☐ Further documents are listed in the continuation of Box C.

☑ See patent family annex.

*	Special categories of cited documents:
"A"	document defining the general state of the art which is not considered to be of particular relevance
"D"	document cited by the applicant in the international application
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"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

Date of the actual completion of the international search 03 June 2020 (03-06-2020)	Date of mailing of the international search report 11 June 2020 (11-06-2020)
Name and mailing address of the ISA/CA Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 819-953-2476	Authorized officer Sorin Muntean (819) 639-7875

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CA2020/050469

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
FR2530547A1	27 January 1984 (27-01-1984)	FR2530547A1	27 January 1984 (27-01-1984)
	FR2530547B1	14 December 1984 (14-12-1984)	
	EP0099790A2	01 February 1984 (01-02-1984)	
	EP0099790A3	19 June 1985 (19-06-1985)	
	ES8403386A1	16 March 1984 (16-03-1984)	
US9527536B1	27 December 2016 (27-12-2016)	US9527536B1	27 December 2016 (27-12-2016)
	DE102016215719A1	02 March 2017 (02-03-2017)	
KR100999420B1	09 December 2010 (09-12-2010)	None	