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E. S. D.

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RE.: SOLICITUD N° 01003854
FECHA SOLICITUD: Enero, 19, 2001
PATENTE: CAMION DE DESCARGA PARA OPERAR FUERA DE
AUTOPISTAS Y FUERA DE CARRETERA
SOLICITANTE: KREES CORPORATION

ASUNTO: PRESENTACIÓN PRIORIDADES

DILIA RODRIGUEZ D'ALEMAN, en mi condición de apoderada de la sociedad solicitante, en esta oportunidad y dando alcance a mi escrito de Abril 18 de 2.001, por el presente escrito me permito presentar:

- Copia certificada de la prioridad Estadounidense reivindicada N° 09/756,703 de Enero 10 de 2.001.
- Copia certificada de la prioridad Estadounidense reivindicada N° 09/758,844 de Enero 11 de 2.001.
- Traducción al Español de las mencionadas prioridades

Estas prioridades están siendo presentadas dentro del término de 16 meses de la presentación de la solicitud cuya prioridad se invoca.

Ruego a usted continuar con el presente trámite.

Señor Jefe,

DILIA RODRIGUEZ D'ALEMAN
LCD/sr
P-404

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PA 428985



THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE

United States Patent and Trademark Office

June 21, 2001

THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY FROM THE RECORDS OF THE UNITED STATES PATENT AND TRADEMARK OFFICE OF THOSE PAPERS OF THE BELOW IDENTIFIED PATENT APPLICATION THAT MET THE REQUIREMENTS TO BE GRANTED A FILING DATE UNDER 35 USC 111.

APPLICATION NUMBER: 09/758,844

FILING DATE: January 11, 2001



**By Authority of the
COMMISSIONER OF PATENTS AND TRADEMARKS**

H. L. Jackson

**H. L. JACKSON
Certifying Officer**

31-1201

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JC934 U.S. PTO
01/11/01

JC934 U.S. PTO
09/75844
01/11/01

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Docket No: 29038/38105B

PATENT APPLICATION TRANSMITTAL UNDER 37 C.F.R. 1.53

Box Patent Application
Commissioner for Patents
Washington, D.C. 20231

Sir:

Transmitted herewith for filing is the patent application of

Inventor(s): Edward S. Kress

Title: OFF-HIGHWAY OFF-ROAD DUMP TRUCK

1. Type of Application

- ☒ This is a new application for a
 - ☒ utility patent.
 - ☐ design patent.

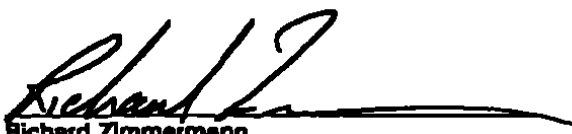
☒ This is a continuation-in-part application of a prior application filed via hand delivery on January 10, 2001 (Attorney Docket No. 29038/38105A).

2. Application Papers Enclosed

- 1 Title Page
- 38 Pages of Specification (excluding Claims, Abstract, Drawings & Sequence Listing)
- 2 Page(s) of Claims
- 1 Page(s) of Abstract
- 13 Sheet(s) of Drawings (Figs.1 to 12)
 - ☐ Formal
 - ☒ Informal
- 0 Page(s) of Sequence Listing

CERTIFICATION UNDER 37 CFR 1.10

I hereby certify that this Patent Application Transmittal and the documents referred to as enclosed therewith are being deposited with the United States Postal Service on January 11, 2001, in an envelope addressed to the Commissioner for Patents, Washington, D.C. 20231 utilizing the "Express Mail Post Office to Addressee" service of the United States Postal Service under Mailing Label No. EL564457715US.


Richard Zimmermann

09758844, 011101

3. Declaration or Oath

- ☐ Enclosed
- ☐ Executed by (check all applicable boxes)
- ☐ Inventor(s)
 - ☐ Legal representative of inventor(s)
(37 CFR 1.42 or 1.43)
 - ☐ Joint inventor or person showing a proprietary interest on
behalf of inventor who refused to sign or cannot be
reached
 - ☐ The petition required by 37 CFR 1.47 and the
statement required by 37 CFR 1.47 are enclosed.
See Item 5D below for fee.
- ☒ Not enclosed - the undersigned attorney or agent is authorized to file this
application on behalf of the applicant(s). An executed declaration will
follow.

4. Small Entity Status

- ☒ Applicant claims small entity status. See 37 CFR 1.27.
- ☐ A small entity statement is(are) attached.

5. Additional Papers Enclosed

- ☐ Preliminary Amendment
- ☐ Information Disclosure Statement
- ☐ Declaration of Biological Deposit
- ☐ Computer readable copy of sequence listing containing nucleotide and/or
amino acid sequence
- ☐ Microfiche computer program
- ☐ Associate Power of Attorney
- ☐ Verified translation of a non-English patent application
- ☐ An assignment of the invention
- ☐ Request and Certification Under 35 U.S.C. 122(b)(2)(B)(i)
- ☒ Return receipt postcard
- ☐ Other

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KAC
[Signature]

6. Priority Applications Under 35 USC 119

Certified copies of applications from which priority under 35 USC 119 is claimed are listed below and

- ☐ are attached.
☐ will follow.

COUNTRY	APPLICATION NO.	FILED

7. Filing Fee Calculation (37 CFR 1.16)

A. ☒ Utility Application

CLAIMS AS FILED - INCLUDING PRELIMINARY AMENDMENT (IF ANY)						
			SMALL ENTITY		OTHER THAN A SMALL ENTITY	
	NO. FILED	NO. EXTRA	RATE	FEE	RATE	FEE
BASIC FEE				\$355.00		\$710.00
TOTAL	1 - 20	= 0	X 9 =	\$	X 18 =	\$
INDEP.	1 - 3	= 0	X 40 =	\$	X 80 =	\$
☐ First Presentation of Multiple Dependent Claim			+ 135 =	\$	+ 270 =	\$
Filing Fee:				\$355.00	OR	\$

B. ☐ Design Application (\$160.00/\$320.00) Filing Fee: \$ _____

C. ☐ Plant Application (\$245.00/\$490.00) Filing Fee: \$ _____

D. Other Fees

- ☐ Recording Assignment [Fee -- \$40.00 per assignment] \$ _____
- ☐ Petition fee for filing by other than all the inventors or person on behalf of the inventor where inventor refused to sign or cannot be reached [Fee -- \$130.00] \$ _____
- ☐ Other \$ _____

Total Fees Enclosed \$355.00

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101110-440005/60

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8. Method of Payment of Fees

- ☒ Enclosed check in the amount of: \$355.00
- ☐ Charge Deposit Account No. 13-2855 in the amount of: \$ _____
A copy of this Transmittal is enclosed.
- ☐ Not enclosed

9. Deposit Account and Refund Authorization

The Commissioner is hereby authorized to charge any deficiency in the amount enclosed or any additional fees which may be required during the pendency of this application under 37 CFR 1.16 or 37 CFR 1.17 or under other applicable rules (except payment of issue fees), to Deposit Account No. 13-2855. A copy of this Transmittal is enclosed.

Please refund any overpayment to Marshall, O'Toole, Gerstein, Murray & Borun at the address below.

10. Correspondence Address

Customer No.: 04743

Respectfully submitted,

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Bryan J. Lempla
Reg. No: 39,748

January 11, 2001

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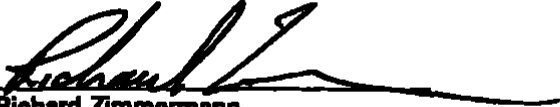
Attorney docket: 29038/36105B

SOLE INVENTOR

"EXPRESS MAIL" mailing label No.
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Date of Deposit: January 11, 2001

I hereby certify that this paper (or fee) is being
deposited with the United States Postal
Service "EXPRESS MAIL POST OFFICE TO
ADDRESSEE" service under 37 CFR §1.10 on
the date indicated above and is addressed to:
Commissioner for Patents, Washington, D.C.
20231


Richard Zimmermann

**APPLICATION FOR
UNITED STATES LETTERS PATENT**

S P E C I F I C A T I O N

TO ALL WHOM IT MAY CONCERN:

Be it known that I, EDWARD S. KRESS a citizen of the United
States of America, residing at 16600 W. Brimfield Jubilee Road, Brimfield
61517, and in the State of Illinois have invented a new and useful OFF-
HIGHWAY OFF- ROAD DUMP TRUCK, of which the following is a
specification.

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OFF-HIGHWAY OFF-ROAD DUMP TRUCK

FIELD OF THE INVENTION

The present invention relates generally to dump trucks, and more particularly to a fixed frame dump truck.

BACKGROUND OF THE INVENTION

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5 As technology becomes available, it is important to use the technology
in the most efficient manner possible. Almost one-half century ago,
components with better reliability and greater capacities became available for
off-highway trucks. By using these components in the optimum configuration,
what was believed to be the off-highway truck of the future was configured.
10 Specifically, rather than having multiple engines, transmissions, axles, and
tires for larger trucks, the number of engines and transmissions were reduced
to one each, axles to two, and tires to six. Importantly, oleo-pneumatic
suspensions were introduced at that time. These changes resulted in a
compact, short wheelbase, light weight, but robust truck with improved
15 maneuverability and ride characteristics. Today, the industry still considers
this configuration to be ideal for now and for the foreseeable future.

 Traditionally, fixed frame trucks use mechanical drive components
which require the engine to be mechanically linked to a transmission, the
transmission to be mechanically linked to the differential in the rear axle, the
20 differential to then be mechanically linked to a planetary drive, and the
planetary drive to be mechanically linked to the rear rims and tires. The rear

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tires in turn provide the driving force at the ground to move the truck. This method is used in virtually all highway passenger cars and trucks, and is used in most off-highway trucks up to around 200 tons. Off-highway trucks have now increased in capacity to 360 tons. About half of those trucks use mechanical drive components. The remaining half use electrical drive components.

In the last few years, larger trucks (300 tons and over) have reverted from Direct Current (DC) motors to a new technology that can effectively control the speed and torque of Alternating Current (AC) motors. Mechanical drive systems supply power over a wide speed range. DC systems supply power over a narrow speed range. AC systems can supply power over a wider speed range than DC systems, but not as wide a range as mechanical drive systems. However, because of their excellent reliability and simplicity, AC systems are an excellent choice.

The electrical drive vehicles now offered in the industry have the same location for the engine and alternator as a mechanical drive truck has for the engine and transmission. Two electric motors are normally located in the center of the rear axle in place of the mechanical drive differential and deliver power directly into the rear wheels through gear reducers. These prior art trucks still use the traditional two axle, six tire configuration having a single rear axle with two sets of dual tires for driving the truck. The front two tires are not driven and only steer the truck. They cannot steer sharply because the

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29038/36105A

frame that supports the engine and front suspension limit the turn capability.

The configuration of the two axle, six tire trucks after almost fifty years of refinement is at the practical limit in size and efficiency.

Thirty years ago an oleo-pneumatic strut was developed for off-
5 highway trucks which supported two tires, one on each side of the strut,
through two connected spindles positioned one on each side of the strut.
Among the many apparent advantages of this arrangement is the feature of tire
separation. Dual tires which are on virtually all rear axles of this conventional
construction are spaced very close together. Heat build up with these large,
10 closely spaced tires is very serious. Radiant heat is transferred from one tire to
another, limiting the performance of the tires and consequently the
performance of the truck. With the tires on both sides of the strut, the spacing
of the tires is about six times that of a conventional dual tire configuration.
This additional spacing effectively eliminates this radiant heat problem.

15 In the past there have been two trucks built with common oscillating
spindles. One spindle is located on the front, non-driving, steering axle with a
strut between the tires. The other spindle is located on a rear, non-steering,
drive axle with a motor between the tires driving the tires through a
differential planetary gear set. In theory, oscillating spindles will allow the
20 load to be equal on both tires. However, in practice this is only the case on a
flat road with tires of equal diameter. Both of these prior art trucks require the
pivot point of the oscillation to be well above the surface of the road. On

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uneven ground, the higher tire of the pair, of course, moves up. However, the higher tire must also move out as the lower tire moves in. This movement shifts weight to the lower tire.

When turning, side or lateral forces are generated. Because the pivot point is located well above the ground, these side forces will shift additional weight to the outside tire. These lateral forces will either add or subtract to the load on the tire. The net result can put more load from the two sources on the lower tire and a side or lateral load on both tires.

On ground or roads that are fairly even, and when the truck is not turning fast, this is not typically a problem. However, when the ground becomes very uneven and/or when the truck is going fast around a corner, two undesirable conditions exist. First because there is structure between the tires on all of these vehicles, the spindle oscillation must be limited. A serious structural problem exists for all components when the spindle is at the limit of its oscillation. High vertical loads are imposed on the lower tire and high side loads are imposed on both tires. Side loads are the most damaging causing significant premature wear to drive components, bearings, structure, and the like. Second, when one tire blows out, very serious dynamic forces are generated on all structures and on the remaining tire.

With non-oscillating spindles, the only load increase between the tires occurs when an uneven ground surface deflects one tire more than the other. When a tire blows out with the non-oscillating spindle nothing serious takes

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place. The strut is substantial in design to easily handle the full load on one tire. The bearings, if designed for 500,000 miles, will last for 50,000 miles under such conditions. Hopefully, the failed tire can be replaced within that length of time. Tire loading is only slightly greater between the tires of a strut with non-oscillating spindles on severely uneven surfaces than with dual tires on a conventional truck that encounter the same uneven surface.

Also, with a non-oscillating spindle the tire can be placed close to the strut. With an oscillating spindle, the tires must be spaced from the strut far enough to allow for the oscillation. This additional distance aggravates forces on the tire and forces generated when the oscillating spindle hits the oscillation limiting structure. In addition, the stability base of a non-oscillating spindle is at the outside tire. The stability base of an oscillating spindle is at the pivot point between the tires. Although this is much better than the stability base at the rear axle of conventional trucks it is not as good as either the front axle on conventional trucks or the non-oscillating spindle. In conclusion, there is no benefit to an oscillating spindle, only serious functional problems along with higher manufacturing and operating cost.

In recent years it was realized that there was a need for trucks to travel on unprepared surfaces, or off the road. As a result, an all terrain articulated, all wheel drive truck was developed, articulated slightly forward of the center of the truck. A drive line through the point of articulation powers the rear axle. Such trucks have become a standard in the construction industry, with

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their all-wheel drive mobility in soft off road conditions. In addition, all farmers know less fuel is used when the front tractor tires are driven. They pull when driven, when not driven they push. However, the industry generally has limited the capacity of these units to only 40 tons. This is only one-ninth the capacity of the larger two axle trucks. The Russians, and an American truck manufacturing company, recognized the need to provide a large capacity all wheel drive truck. They have both developed a larger version of this articulated truck, but they did not make an impact on the industry. These trucks are no longer built because they lacked maneuverability, were too heavy, were unstable, and were costly to produce and operate. In addition, the configurations of these articulation trucks are fundamentally wrong. When cornering, weight shifts forward and to the side as the vehicle turns. To counteract these forces, the front outside tire should either stay in place or effectively move to the outside of the curve. With these articulated trucks, the front outside tire swings inward, the opposite of what is required, thereby reducing their stability.

These small all terrain articulated trucks are generally considered lighter duty than the standard fixed frame off-highway truck. Surprisingly, since they are lightly constructed, they have very poor payload to empty weight (P/W) ratios which are in the range of 1.05/1 to 1.2/1.

An empty truck must always travel in both directions, the payload in one, between the loading point and unloading point. To evaluate the cost of

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moving the truck versus the entire payload, the factor of $2(W/P)$, defined in greater detail herein, can be used.

The articulated truck with a P/W ratio of 1.12 will require \$1.78 to move the truck for every \$1.00 it takes to move the payload. The majority of current off-highway truck designs have a payload to weight ratio between 1.4 and 1.6. With P/W of 1.5, for every dollar to move the payload, it takes \$1.33 to move the truck.

Conventional fixed frame trucks use limited stroke, non-compensated suspension which requires tires and structural members to absorb imposed dynamic and torsional stresses. This, in turn, requires the structural members to be heavy and, due to their configuration, prone to have areas of high stress concentrations.

In addition, there are other problems associated with many of these existing trucks. Conventional trucks have dual rear tires mounted on the same hub requiring both tires to turn at the same speed causing the dual tires to scrub when turning because each tire is a different distance from the point about which the truck turns. This requires each tire to rotate at a different rate which the tires cannot do because they are mounted on the same hub. These dual tires must also be precisely matched in size because they do rotate on the same hub. Otherwise there will be abnormal wear on the smaller tire because it must turn faster since it has a smaller radius. There is obviously less load on the smaller tire. The tire with the heavier load will not slip, so the smaller tire

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with less load must slip and will wear. The smaller tire will also wear faster and faster as it gets smaller over time. Also, with dual tires, the outer tire and rim must be removed to replace or access the inner tire.

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BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a lower, front isometric view of a dump truck constructed in accordance with the teachings of the invention.

FIG. 2A is an upper, forward isometric view of the dump truck of FIG. 1 with the body up and the tires in a straight forward orientation.

FIG. 2B is an upper, forward isometric view of the dump truck of FIG. 1 with the body up and the tires at maximum turn.

FIG. 3 is a view similar to FIG. 2, but with the tires parallel at 90 degrees and the body dumping to the side relative to the direction of truck movement.

FIG. 4 is a rear view of the truck of FIG. 1.

FIG. 5 is a top view of the truck of FIG. 1 with the dump body shown only in phantom.

FIG. 6 is a side view in partial cross section of a strut module of the truck of FIG. 1.

FIG. 7 is an upper rear isometric view of one strut module of the truck shown in FIG. 1 and with one wheel removed.

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FIG. 8A is an upper forward isometric view of the strut module with a motor and brake cooling air intake, motor controllers, motor controller radiator fan, fan motor, and braking grids.

FIG. 8B is an enlarged view of a portion of FIG. 8A taken from circle detail 8B.

FIG. 9 is a cross section from the top through the center of the lower strut, motor, and spindle showing air flow paths and components of the module assembly.

FIG. 10 shows the routing for all lines in position from a main suspension section of the truck to a movable and rotatable portion of the truck.

FIG. 10A shows all of the lines of FIG. 9 with all other structure removed.

FIG. 10B shows the routing of the ground wire, temperature sensor and motor speed indicators shown in FIG. 8.

FIG. 10C shows the routing of the hydraulic lines for brakes and hydraulic motors of FIG. 8.

FIG. 10D shows the routing position of the various lines where a strut module is oriented in a nominal straight ahead orientation.

FIG. 10E shows the routing position of the various lines where a strut module is turned to a large angle of rotation.

FIGS. 11A - 11F are each a schematic illustration of a possible steering mode of the truck of FIG. 1.

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FIG. 12 is a forward, upper isometric view of another example of a truck constructed according to the teachings of the present invention wherein only the front wheels are steerable.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Examples of a dump truck constructed according to the teachings of the present invention are shown and described herein. While the disclosed dump trucks can be used for on-pavement applications, they are particularly well suited for off-highway applications and even more so for off road applications. The disclosed trucks improve productivity, reduce cost, and have the ability to operate economically in the most adverse conditions. This allows a mine to operate more economically benefitting from more than just the reduced hauling costs. At least some tires are mounted independently, eliminating tire scrub when turning. Because the tires can be independently mounted and driven, these tires need not be precisely matched in size. The steering capability of the truck permits access to both the inner or the outer tire without removing the other tire of the set. By turning the tires well beyond 90 degrees as is permitted by the truck disclosed herein, all tires are easily accessible when appropriately turned and can be independently replaced either by removing or not removing the rim. The unique or novel truck configurations solve the previously discussed problems of conventional trucks

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and have many other features and advantages that will become apparent upon reviewing the description below.

FIGS. 1-5, 8A, 8B, and 11A-11F show one example of a truck constructed according to the teachings of the invention. FIG. 12 shows another example of a truck. FIGS. 6, 7, 9, and 10-10F show one example of a strut module according to the teachings of the present invention that is particularly useful on the trucks described herein.

Referring now to the drawings, FIGS. 1-5 generally illustrate a truck (20) constructed according to the teachings of the invention. The truck (20) has a frame (22) with a center section (24) defining a longitudinal axis "A" of the truck. The frame (22) also has a forward transverse section (26) and a rear transverse section (28) connected with the center section and arranged generally perpendicular to the center section, whereby the frame (22) has an I-shaped configuration in plan view. The transverse sections each define strut supports for the truck (20), as defined in greater detail below.

The frame (22) is supported above a ground surface in this example on a number of wheel and tire assemblies (30). The wheel and tire assemblies are each mounted to one of a front or rear strut module (32F) and (32R), respectively, (simply (32) hereinafter if not referring to the forward or reverse modules specifically), described in greater detail below. The modules (32F) and (32R) are in turn mounted depending from the opposed ends of the forward and rear transverse frame sections (26) and (28), respectively. In the

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present example, each of four strut module (32) carries a pair of wheel and tire assemblies(30), thus totaling eight. Each of the eight wheel and tire assemblies (30) has one tire (34) mounted on a wheel rim (36) for rotation about a portion of the respective strut module (32).

5 The truck (20) also has a dump body (38) pivotally mounted to a top portion of the frame (22). The dump body (38) is adapted to carry contents when in a lowered position (FIG. 1) and can be raised at a forward end (40) (FIG. 2) for dumping the contents. A rear end (42) of the dump body (38) has a pair of pivot structures (44) depending from its bottom surface (46). These pivot structures (44) are coupled to pivot structures (45) depending from the rear transverse frame section (28) on equidistant opposite sides of the frame center section (24).

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15 To dump contents from the dump body (38), in one example the truck (20) has a single extendable cylinder (48) pivotally coupled at trunnions (50) to a forward part of the frame (22) along the center axis "A". In this example, the trunnions (50) are carried centrally on a front facing surface (52) of the forward transverse frame section (26). The trunnions (50) are positioned forward of the end of the frame center section (24) and forward of the front wheel and tire assemblies (30), outside the turning or rotation envelope of the tires (34) generated by the rotation of the strut modules. The dump cylinder (48) has a second end pivotally coupled to the underside or bottom surface (46) of the dump body (38) nearer the forward end (40). When extended, the

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dump cylinder (48) raises the forward end (40) of the dump body (38) as shown in FIG. 2. Certain benefits are achieved by this configuration and are described in greater detail below when describing the operation of the various features and characteristics of the truck (20).

5 When loading the dump body (38) and transporting the contents, the dump body (38) rests on the top surfaces (56) and (58), respectively, of the transverse frame sections (26) and (28). This allows the body (38) and the frame (22) to work as one unit, each strengthening and supporting the other. There is effectively no load or bending moment on the frame sections (24),
10 (26) and (28) of the truck (20) that are imposed by the dump body (38) itself or by the load or contents in the body (38).

 The truck (20) also generally has a cab (60) that typically houses the controls for operating the truck (20). The cab (60) also typically houses suitable conveniences for the truck operator, though not shown, such as one or
15 more seats, windows, environmental controls, doors, audio and communication devices, and the like. The cab (60) in the present example is positioned at one end of the frame (22) near the forward transverse frame section (26), and is supported by the frame (22) in an elevated position. The cab (60) can be located on either side of the truck (20) or in the middle above
20 the axis "A". In this example, the cab (60) is positioned somewhat forward of the front wheel and tire assemblies (30) and below or beneath the forward end (40) of the dump body (38). This position increases the visibility for the

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operator and will allow the operator to see the front wheel and tire assemblies (30) at all times, if necessary.

The central section (24) of the frame (22) interconnects the forward and rear transverse sections (26) and (28), and hence, the front strut or suspension modules (32F) to the rear strut modules (32R). The central frame section (24) in the present example contains one or more power modules (66) which can have radiators (61), engines (62), alternators (64), one or more fuel tanks (68) (such as for engine fuel), one or more hydraulic fluid tanks (70) (such as for brake fluid or other hydraulically actuated system fluid), as well as other auxiliary truck components.

It is very important that the load is dumped as quickly as possible to assure the maximum productivity of the truck (20). The high pressure oil to tip the dump body (38) enters through a rod end (47) of the multistage dump cylinder (48). The rod end (47) is connected near the front of the body (40).

This is a very long distance from the hydraulic pumps on the engine (62). Large enough pumps and hydraulic lines needed to dump the load in a reasonable time would be impractical. Therefore, one or more hydraulic accumulators (72) are mounted to the underside (46) of the dump body (38) in close proximity to the dump cylinder (48) to assist in quickly lifting the dump body (38) and its contents. The accumulators (72) in this example are connected through two large dump valves (74) to assure adequate flow to the rod end of the dump cylinder (48) near the forward end of the center section

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(24) of the frame (22). An additional hydraulic tank (76) is in close proximity to the dump valves (74) to quickly receive oil from the dump cylinder (48) as the body (38) is lowered to the frame (22).

One convenient location for additional accumulators (72), to help power the dump cylinder (48), the steering cylinders (132), and the constant leveling of the struts (100), is inside the center section (24) of the frame (22). High pressure gas cylinders (78), normally nitrogen gas, can be located in this center section (24) to store the energy to power the accumulators throughout the truck (20). Alternatively, these gas cylinders (78) and accumulators (72) can be mounted virtually anywhere on the truck as desired. As the load increases on the truck, the gas in chambers (98) and (99) in the strut (100) compresses (See FIG. 6 and the description below) and oil from the accumulators (72) then flows into chamber (97) keeping the truck height constant in both the loaded and unloaded condition.

The configuration and arrangement of the I-shaped frame (22) and dump body (38) produces a decreased empty weight of the truck (20) as compared to prior known truck configurations. The frame (22) and body (38) configuration also yields the added benefit of having space for two additional tires (34) on each side on the front suspension modules (32F) of the truck as compared to only one tire per side on conventional truck designs. The configuration of the strut modules (32), described in greater detail below, also permits mounting the two additional tires (34) and rims (36) on the forward

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end of the truck at only a minimal increase in cost and weight. The additional cost and weight is only due to the other wheel and tire assembly (30). Due to the available space created by the truck (20) configuration, a second power module (66) can also be easily attached to the frame (22) vastly increasing the productivity of the truck (20). The close proximity of each tire to the strut is important to help reduce the overall width of the truck. The turning envelope of the tires on a strut is accommodated by the ample space beneath and between the frame components. The turning envelope of one strut must, however, clear the envelope of an adjacent strut to permit the large strut rotation angles

The frame (22) and body (38) configuration also conveniently allow for a wheelbase 50% longer than conventional trucks. As a result of the significantly longer wheelbase, the weight shift between axles is minimized while operating the truck (20). Less weight shift reduces both static and dynamic loads on the frame (22) and body structure (38). Less weight shift also reduces the load on the front tires (34) while cornering. It is an important feature that on the front of the truck (20) there are four tires (34), two on each side, to absorb the side forces and forward weight shift when turning.

Referring now to FIG. 6, a strut module (32) is generally shown in partial cross section with the outside wheel and tire assembly (30) removed. Each strut module (32), however, includes the two tires (34) in this example mounted on the respective rims (36) which are in turn carried on opposite

sides of the strut (100). In the present example, the two spindles (142) are fixed to the strut rod (110) and do not oscillate.

Though described in greater detail below, each module (32) generally has a hydraulic strut assembly (100) which is attached above the tires (34) to a respective end of one of the transverse frame sections (26) or (28). One strut assembly (100) depends from each of the four corners of the truck (20). Each strut assembly (100) has a fixed strut housing (102) secured to and depending from its respective frame section (26) or (28). Each strut housing (102) defines a strut axis "S" shown generally vertical in the present example when in the normal ride position. A steer tube (104) in the present example is arranged co-axially with and received over each strut housing (102) and is adapted for rotational movement relative to the respective housing (102). A steering link (106) is affixed near the upper end of each steer tube (104) and defines a plane generally perpendicular to the strut (100) axis "S". As shown best in FIG. 5, each steering link (106) defines a pair of generally opposed steer arms (108) and (109). The steer arms (108) and (109) are manipulated as described below to independently steer each of the strut modules (32).

Each strut assembly (100) also has a cylinder rod (110) telescopically received within the housing (102) that is slidable relative to the housing (102). The cylinder rod (110) is positioned at about its midpoint in vertical travel range relative to the housing (102) when in the normal ride position so that it can extend from the housing or retract into the housing as needed when

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traveling over varying terrain. A spindle housing (112) is affixed on the bottom end of the cylinder rod (110) and has a cylindrical wall portion (114) that surrounds the exterior surface of the steer tube (104) at its lower end. The spindle housing (112) can move vertically with the cylinder rod (110) and relative to the steer tube (104). The cylinder rod (110) and housing (102) operate as a conventional hydraulic strut (100) to cushion the load. Thus, the spindle housing (112) can move vertically relative to the respective frame section (26) or (28) for shock absorption.

A scissors link (120) has a first link arm (122) pivotally coupled at a first pivot joint (124) defined by a first bracket (125) affixed to the steer tube (104). The scissors link (120) also has a second link arm (126) pivotally coupled at a second pivot joint (128) defined by a second bracket (129) affixed to the spindle housing (112). The outer ends of the first (122) and second (126) link arms are coupled to one another at a third pivot joint (130). The pivot joints (124), (128) and (130) of the scissors link (120) permit the spindle housing (112) to move freely relative to the steer tube (104) and strut housing (102) along the strut axis "S". Each component of the scissors link (130), however, is sturdily designed to prevent relative rotation between the steer tube (104) and spindle housing (112). Thus, as the steer tube (104) is rotated about the strut axis "S" by movement of the steering link (106) as described below, the spindle housing (112) is also rotated to turn the wheel and tire assemblies (30).

As shown in FIGS. 2 and 5, each strut module (32) is steered independently by a pair of extendible hydraulic steer cylinders (132) and (133) each having one end pivotally connected to a respective one of the steer arms (108) and (109) of the steering link (106). The opposite ends of the steer cylinders (132) and (133) are pivotally coupled to bracket portions of the frame (22). Each steer cylinder (132) and (133) has an extendible rod (134) controlled by a steer cylinder control valve (131). A pressure indicator on each control valve (131) can be utilized via a computer (not shown) to coordinate steer cylinder pressure with wheel motor torque, as necessary.

Appropriate extension and retraction of the steer cylinders (132) and (133) of a particular strut module (32) will rotate the respective steer tube (104) about the strut housing (102) relative to the axis "S" to turn the spindle housing (112), and hence, the wheel and tire assemblies (30). In one example, the tires (34) and wheels (36) of a particular module (32) can be steered more than 90 degrees, such as about 110 degrees or more in each direction, as shown in FIG. 2, from a nominal or rest position, as shown in FIG. 5.

Referring to FIG. 9, each wheel and tire assembly (30) can be independently driven by a discrete motor (140) that is internally mounted inside a spindle (142) supporting each wheel rim (36). Each motor (140) is preferably an independently controlled electric AC drive motor (140). The motor (140) which derives its power from high speed must be combined with a speed reducer (139) to obtain high torque to produce the draw-bar required to

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propel a truck (20) of this type through soft ground and up steep hills. The truck (20) having high torque and the independent all wheel drive capability will give unique utility for the mining and construction industries. As shown in FIG. 9, each spindle (142) carries one motor (140) internally and supports two bearings (136) which, in turn, support a hub (144), which supports the speed reducer (139), a rim (36), and preferably one of the tires (34). Each spindle housing (112) has two spindles (142), one on each side connected to a central structure containing a tapered hole which accepts the strut rod (110). Each motor (140) drives only one of the two wheel and tire assemblies (30) of each strut module (32) and, therefore, each tire (34) can be driven independently, as necessary. The spindle (42) and hub(44) each support a section of a wheel brake (138), which, when actuated, restricts relative motion of the hub and spindle.

Each strut module (32) also has an air cooling system for the AC drive motor (140) utilizing air circulated through the spindle housing (112) and spindles (142). One example of the cooling system for each strut module (32) is shown in FIGS. 7-9 and simply described herein. Contained in the module (32) is an air inlet (145) positioned between the respective pair of tires (34) and, preferably, even with the top surface of the tires (34). This air inlet duct (146) contains a motor (147) which drives a fan (148) forcing cooling air through an air cleaner (149) into the spindle housing (112) through an air inlet (150) into an inlet air chamber (151) divided by plate (152) to separate the

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inlet air from the outlet air. Air then enters the motor (140) through holes (153) in the non drive end of the motor (140), then through holes (154) through the stator and holes (155) through the rotor. The air leaves the motor (140) through holes (156) in the motor housing (160). The air then travels back over the motor (140) through the gap (157) defined by the inside diameter of the spindle (142) and the outer diameter of the motor (140). The air then enters the outlet air chamber passing the plate (152) which separates the incoming air from the out going air. The air then exits the spindle housing through a hole (159).

In one example, the air that exits hole (159) after cooling the motor (140) passes through an exhaust duct (168). The exhaust duct (168) has one end coupled to the outlet opening (159) and an opposite end defining an exhaust opening (170) positioned between the respective tires (34) of the strut module (32) and again, preferably, even with the top surface of the tires (34). The air will flow from the outlet opening (159) through the exhaust duct (168) and exit the exhaust outlet (170). The position of the outlet (170) prevents the warm exhaust air from heating the inner surface of the tires (34).

In a further example, the exhaust duct (168) can effectively become an oil cooler for a wet disc brake system (138). High volumes of air must be used to keep the motor (140) cool, therefore, the air leaving the motor (140) will be much cooler than the hot cooling oil leaving the brakes (138). The air can be circulated over the tubes (165) carrying the oil from the brakes (138) to the

pumps (167), and back to the brakes (138) through the exhaust duct (168) oil cooler, cooling the oil and the brakes as required. The pumps (167) are driven by a motor (166) whose energy source can be high pressure oil from the accumulator (72) system that can be available on the truck. The inlet fan motor (147) of the air inlet duct (146) can also receive its supply power from the same accumulator line (190) shown in FIG. 10D. In summary, the disclosed strut construction allows the fan motor (147) and fan to circulate cooling air to the traction motors (140) and the oil cooled disc brakes (138).

In one example, the inlet air duct (146) can be affixed at the inlet opening (150) to the front of the spindle housing (112). The exhaust duct (168) can be affixed at the outlet opening (159) to the rear of the spindle housing (112). The exhaust duct (168) passes through the upper scissors link bracket (125) affixed to the steer tube (104) and is free to move up and down with the spindle housing (112) free of the steer tube (104). As shown in FIG. 10, the various hydraulic lines (172) for the fan motor (147) and the hydraulic lines for the parking (192) and service brakes (194) will be routed outside the scissors link (120).

Each strut module (32) is therefore composed of the strut (100), the various steering components, the spindle housing (112) and spindles (142), the wheel drive motors (140), speed reducers (139), the two brakes (138), and the cooling systems for the motors and the brakes. Also included in each strut module (32) are two hubs (144), two rims (36) and two tires (34). Each strut

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module (32) further includes the air flow cooling system, hydraulic and electric power cables, hydraulic lines to the brakes, and the motors to drive the cooling fan and the wet disc brake cooling oil pump. The strut module (32) construction and the frame (22) construction of the truck (20) produces a number advantages and benefits that are not available with conventional trucks of any size.

In one example, the steering link (106) and the two steer arms (108) and (109) are fixed to the steer tube (104) above the highest point of the tires (34) when the strut (100) is collapsed. With each of the steering cylinders (132) and (133) properly spaced and with adequate length of stroke, rotational angles well beyond 90 degrees can be attainable. In operation, each pair of the hydraulic steering cylinders (132) and (133) can turn the respective strut module (32) well above 110 degrees in each direction, for example, to achieve many different turning patterns for the truck (20) as exemplified in FIGS. 2 and 11A-11F. The wheels are always turned about a given common turning focal point unless when the vehicle is moving in a straight line.

By aligning the tires (34) of each strut module (32) as needed depending on the length and width of the truck (20) wheel base as shown in FIGS. 2 and 11E, the truck (20) can rotate about its center point while requiring only 45%, or less than half, of the turning area or radius of conventional trucks. The tires (34) can also be turned to any position while remaining parallel to one another as shown in FIGS. 11A- 11C. Thus , the

truck (20) can be driven in a straight line and yet the body (38) and frame (22) can be oriented at virtually any angle relative to the longitudinal axis "A" of the truck. In addition, as shown in FIGS. 11D and 11F, any two strut modules (32) can be steered independent of the other two strut modules (32) and independent of each other to steer the truck (20) relative to any side or end, not just from the front end as with conventional trucks. Many benefits can be achieved by such steering flexibility. In addition, because each tire (34) on each strut module (32) is independently driven by its own motor (140), the two tires (34) on a module (32) can be driven at slightly different speeds, eliminating tire scrubbing when turning.

The truck (20) need be no wider and no higher than a conventional truck, and yet can carry approximately twice the load and can weigh only slightly more than a conventional truck when empty. Conventional off-highway trucks must ride on relatively good, smooth surfaces in order to travel efficiently, such as on prepared mine roads. The truck (20) can travel efficiently on less than ideal surfaces and can travel up steeper grades because of its all wheel drive characteristics. These factors can significantly reduce the cost of hauling material and also can significantly contribute to reducing the cost of operating an entire mine.

In one example, the steering cylinders (132) and (133) can contain a linear displacement transducer to determine the axial position of each extended steer cylinder rod (134) to further determine the angle of the axis of

the tires (34). An onboard computer (not shown) of the truck (20) can track this angle for each module (32) and will signal the appropriate controller of the other steering cylinders for the other modules (32). In this way, the rotated position about the strut axis "S" can be controlled. For example, all tires (34) can be controlled to either roll on parallel wheel axis' to move the truck (20) in a straight line, as shown in FIGS. 11A-11C. Alternatively, the wheel axis' can be controlled so that they all intersect at a common point to provide a desired and proper radius as shown in FIGS. 11D- 11F.

The modules (32) can be dynamically steered independently to maintain the common intersection point while turning and straightening the truck (20). This intersection point can be determined and controlled by a computer (not shown). The angle of the tires can be controlled in conjunction with linear displacement transducers (201) (see FIG. 12) integral with the steer cylinders (132) and (133). All tire (34) distances from this common intersection turning point will be known at all times, allowing the relative tire speeds to be controlled by the independent motor controllers (179). The tires (34) will then pull evenly, eliminating tire scrubbing while turning or traveling in a linear path.

As noted above, in one example, the intersection point can be moved to a position equal distance between the front and back modules (32F) and (32R), respectively, and to a point at the center of the truck (20) as shown in FIGS. 2 and 11E. In this steered configuration, the truck (20) can rotate about itself.

Thus, the truck (20) can be turned around without moving forward or backing up in and within a very tight space. This is not possible with a conventional truck.

In another example exemplified in FIGS. 11A and 11C and as shown schematically in FIG. 3, the truck (20) can be positioned to dump contents from the body (38) either parallel to the truck axis "A" or perpendicular to the axis "A", as desired, or at some other angle as desired. This again can be done in very tight spaces without backing up the truck (20). This is done by rotating all strut modules (32) at the same rate so they remain along parallel wheel rotation axis' "W" as shown in FIGS. 11A-C. The tires (34) will always be going in a straight line but the truck body (38) will be rotating relative to the direction of travel. The truck (20) need not be backed up to alter the dump body (38) orientation relative to the dump point. Instead, the tires (34) can maintain the direction of travel as the dump body (38) rotates into position to dump the contents. This feature is particularly useful where the truck (20) must be positioned in a tight space to dump into a hopper or be positioned to dump over a bank. In summary, when at the loading shovel or at the dumping point, the truck (20) can move directly into position, and then drive away easily, reducing the time required to maneuver the truck (20) into and out of position for loading or dumping. Thus, the truck (20) effectively is both rear dump and a side dump truck.

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Many in the mining industry have recognized the need for a side dump truck. A mining executive in the 1960's stated to the effect that, "[t]he Lord must question our intelligence because we unnecessarily back up to dump a truck in the mines each year an equivalent distance equal to many times around the moon." He could have doubled that distance if he realized that in many instances, a truck must also be backed up to the loading shovel as well, thus essentially doubling the backing distance. The backing distance for both loading and unloading can be eliminated utilizing the truck according to the teachings of the invention. Also, the significant crew effort required for backing these extremely large vehicles is also eliminated. In addition, when at the loading shovel or the dumping point, the truck 20 can move directly into position, and then drive away easily, reducing the time required to maneuver the truck into and out of position for loading or dumping.

With all the rotation generated by the strut (100) when steering and the up and down motion of the strut (100) on uneven ground and poor roads, the routing of the electric cables (184) and (186) and the various hydraulics lines becomes very important. Slip rings for electric cables are very undesirable and swivel joints for hydraulic lines are impractical. This invention solves these serious problems.

An enclosed chamber (174) is mounted forward of both the forward and rear transverse frame sections (26) and (28). Each is placed above the steer cylinders (132) and (133) and steer arms (108) and (109). Above each

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enclosed chamber (174), conveniently placed, is the respective AC traction motor control box (179). Through the rear section of this enclosed chamber (174), the steer tube (104) of the strut module (32) is placed. From the motor control box (179) through the enclosed chamber (174), in this example, are 12 electric power cables (175), one ground wire (184), and one hose containing small sensor and control wires (182). From the accumulators (72), four hydraulic lines (188-194) enter the chamber. One line (192) is for the parking brake, one line (194) is for the service brake, and one is a high pressure accumulator oil line (190) to power both the fan motor (147) and the motor (166) to power the brake pumps (167) that circulate the brake cooling oil. There is also one low pressure oil line (188) to return oil from these motor two motors (147) and (166). Two small valves (198) and (200) are also provided, one for controlling the fan motor speed as required and the other for controlling the braking pump motor speed as required.

In this example, these power cables (184), (186) and hoses (188-194) are routed directly to the required component in the lower unsprung components of the strut module (32). These cables (184), (186) and hoses (188-194), in this example, are clamped at one end to the enclosed chamber (174). They are all effectively the same length and are stacked three high and held together appropriately to stay in the same vertical plane and to minimize sag. They are in turn supported in a manner to prevent wear between the lower cables (184), (186) and hoses (188-194) and the floor of the enclosed chamber

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(174). Three of these stacks are loosely connected side by side. They are clamped to the steer tube (104) and are routed around the steer tube (104) down through the steer arm (108) and down over the steer tube (104) and looped appropriately to accommodate the full stroke of the strut (100). The scissors link (106) can help support the bundle as needed. Inside the enclosed chamber (174), nine wires and hoses are routed in two loops (197A and 197B) and looped appropriately to accommodate the rotation of the steer tube (104). Nine wires and hoses are routed in the tow loops (197A and 197B) opposite to each other. It would be possible to stack nine or all eighteen of these wires and hoses vertically, but this would increase the height of the truck (20) and the center of gravity of the truck (20) unnecessarily which is undesirable

The efficiency of a large hauling truck (which relates to the cost of moving the payload) is proportional to the payload weight (P) relative to the empty vehicle weight (EVW). This is referred to as the payload to weight ratio P/EVW . In an effort to relate this to actual cost of moving a payload, one can multiply EVW times two, add the payload P, then divide this entire amount by the payload P:

$$(EVW*2+P)/P,$$

where this equation accounts for the fact that the vehicle moves in both directions to and from the loading point, whereas the payload moves in only one direction to the dumping point. This equation describes the amount of

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work the truck must do to complete one haulage cycle. Assuming that the payload is one or, $P = 1$, the above equation becomes:

$$(2/P/W+1)/1.$$

This equation can be simplified to $2/(P/W)$. For P/W of 2.0, for every dollar it takes to move the payload, it takes \$1 to move the truck. With P/W of 1.5, for every dollar to move the payload, it takes \$1.33 to move the truck. The majority of current off-highway truck designs have a payload to weight ratio between 1.4 and 1.6. The disclosed truck according to the teachings of the invention allows P/W ratios of over 2.3, resulting in less than 87 cents to move the truck for ever dollar required to move the payload.

A conventional truck with a two axle and short wheelbase configuration has four tires on the back and only two on the front. Although successful by present industry standards, it is not ideal due to variations in the center of gravity of the load (weight shifts forward when going down hill), and the dynamics of cornering. Under these conditions, front tires can experience high static and dynamic overloads. If a tire fails under these overload conditions, loss of control of the truck can easily result. The disclosed truck (20) can have a 60% longer wheelbase than some competitive trucks and will in turn use four tires (34) on the front axle. This configuration significantly reduces stress on the front tires (34) when under these adverse conditions. Additionally, if one tire (34) on a module (32) should fail, the remaining tire (34) can maintain control of the truck (20).

Another very important factor in the intrinsic value of a vehicle is its performance capability, which relates to the horsepower available to move a unit of material. There are two factors that can be used to compare vehicle performance and productivity. They are Horsepower (HP) per Gross Vehicle Weight (GVW) which is HP/GVW , and the horsepower that is moving the payload (PL), namely, $HP \times PL/GVW$ which is referred to as payload horsepower. With plenty of open space beneath the frame (22) of the truck (20) and with space between the strut modules (32F) and (32R), two of the largest conventional truck engines can be easily mounted to significantly increase the performance characteristics of the truck (20). The frame (22) and strut module (32) arrangement also provides unparalleled access to the power modules (66) for servicing and/or replacement. Payload horsepower of the disclosed truck (20) is approximately 2.4 times greater than the largest most productive conventional truck on the market today.

The major components for evaluating vehicle stability dependent upon the height of the center of gravity (CG) and the stability base (SB), or, in actuality, the square of the stability base (SB^2). In most vehicles today, the stability base of the front axle is at the center of the front tires. This arrangement is good for stability, but bad for frame stresses and front tire loading. The stability of the rear axle is the point where the rear suspension effectively reacts at the center line of the rear axle. On most conventional trucks, the stability base between the front and rear axles is normally 5 times

greater on the front axle. When this result is squared, the result is that the single front outside tire on the curve on conventional trucks effectively absorbs virtually all cornering side forces as well as the forward weight shift forces generated by cornering. The body is basically held from tipping over by the pins in the rear of the truck that the body pivots about when dumping and very slightly by the narrow frame. This conventional truck arrangement imposes high torsional stress on the narrow frame and overloads (during a turn) the single outside front tire to an extremely high degree. The disclosed truck (20) distributes the cornering forces equally to the four tires on side of the truck (20) that is on the outside of the curve. The long wheelbase minimizes the forward weight shift generated by cornering. This minimized weight shift is absorbed by two tires (34) rather than one tire on conventional trucks. This is one of the very important features of this invention is that under all similar operating conditions the tires (34) will be under less stress not only reducing tire (34) cost but will allow the truck (20) to perform well at higher speeds and greater loads.

When dumping, conventional trucks locate their dump cylinders somewhere between the two axles requiring the cylinders to lift the entire weight of the body and the load. This load is transmitted directly into the frame. This location of the cylinders thus puts maximum stress on the frame. In the disclosed truck of this invention (20), the dump cylinder (48) is mounted to the frame (22) between the front strut modules (32F). Thus, the dump

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cylinder (48) is required to exert a force one half the weight of the body (38) and load. The other half of this weight is supported by the pivot pins (43) in the rear of the truck (20). The load is transmitted directly in to the strut modules (32F), and not between the front and rear modules (32R) along the truck axis "A". This arrangement effectively eliminates bending stresses in the frame and reduces stress in the body (38) also allowing the frame (22) to be much more robust but lighter than frames of conventional trucks. FIG. 2 shows accumulators (72) that will help to greatly reduce the time required to dump the truck (20). The accumulators (72) are closely mounted to the dump cylinder (48) to improve the flow characteristics of the oil from the accumulators (72) to the dump cylinder (48). This arrangement allows the truck (20) to dump and return the body (38) in less than one half the time it takes to dump and return the body on conventional trucks dumping loads almost twice as large.

All conventional trucks must stop, change direction, and back up to a bank or a hopper to dump the load. However, this is dangerous for at least two reasons. First, the driver must be very attentive or he will back over the bank or into an object. Second, inertia force generated from the truck's weight as the brakes are applied to stop at the edge of a bank can, on occasion, cause the bank to collapse.

This stopping, reversing, turning, backing up and stopping again is not only hard on the truck but is time consuming. This conventional procedure

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also takes place every time the truck backs under a shovel to get loaded and backs to a dumping site to unload. The disclosed truck (20) eliminates this unproductive, unsafe and wasteful maneuver completely at both ends of the haul cycle.

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The disclosed dump truck (20) allows greater capacities, higher efficiencies, and improved maneuverability. In addition, all tires (34) can be driven and steered independently, allowing for superior mobility under poor hauling conditions. The disclosed truck (20) is a very rugged, very heavy duty and yet a very light weight truck relative to its capacity with remarkable performance features under the most adverse conditions. The disclosed truck (20) is a major step forward, not only in truck carrying capacity, but in every characteristic that the earth moving industry needs to both increase production and to reduce cost of moving material. Importantly, the disclosed truck can thus reduce the cost of operating a mine, construction site, or the like.

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FIG. 12 shows another example of a (truck) according to the teachings of the invention. The disclosed truck (300) has only front strut modules (32F) as described above. The front wheel and tire assemblies (30) can be independently steered, as described previously, through large steering angles of 110 degrees or more. The front wheel and tire assemblies (30) are also driven independently by discrete motors as described above. However, the rear wheel and tire assemblies (302) are not steerable. They remain in a straight forward orientation as shown. The truck (300) steers similar to

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conventional cars and trucks except for benefits achieved by the front strut
modules (32F). The rear wheel and tire assemblies (302) can be mounted two,
per truck with one per side, four per truck with two per side, or more as
needed. The rear wheel and tire assemblies (302) can be mounted on
5 conventional, non-driven axles so that the wheels are free spinning, thus
eliminating rear wheel tire scrubbing while turning. The rear wheel and tire
assemblies (302) can alternatively be mounted on rear strut modules (304R)
that are essentially the same as described above for modules (32R), except that
they do not turn. Each wheel and tire assembly can be driven independently
10 by its own discrete motor as described above to avoid scrubbing when turning.

The truck (300) would be less expensive than the truck (20), and yet
provide nearly all the benefits. The truck (300) would not be able to be driven
parallel to its own axis but the high turning angle of the front strut modules
(32F) will permit turning of the vehicle about the rear wheel contact point.
15 The turning radius would still be less than double the length of the truck.
Other alternative embodiments can include front strut modules that turn as
described above but do not drive the front wheels. The rear wheels in this
embodiment can be driven as described above but not turned. The
independent drive motor of each driven wheels can be controlled as above to
20 eliminate tire scrubbing.

The foregoing detailed description has been given for clearness of
understanding only and no unnecessary limitations should be understood

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therefrom, as modifications would be obvious to those of ordinary skill in the
art.

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What is Claimed is:

1. A truck comprising:

a frame having a forward end and a rearward end;

at least two rear wheels coupled to a portion of the frame and
supporting the rearward end of the frame;

a forward strut support coupled to the frame near the forward end;

at least first and second strut modules, the first and second strut
modules coupled to the forward strut support, wherein each of the strut
modules includes;

a strut assembly oriented having an upper end, a lower end, and
a strut axis, the strut assembly having a strut housing affixed at the upper end
to part of the truck frame concentric with the strut axis and having a steer tube
arranged to rotate about the strut axis relative to the strut housing;

a spindle assembly having a pair of oppositely disposed
spindles extending from a spindle housing and defining a wheel rotation axis,
the spindle assembly being carried at the lower end of the strut assembly for
co-rotation with the steer tube about the strut axis, the spindle assembly
constructed for damped movement along the strut axis relative to the truck
frame;

a pair of wheel and tire assemblies, one each supported by a
respective one of the spindles for rotation about the wheel rotation axis;

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a pair of drive motors, one each associated with each of the
spindles for drivingly rotating the respective wheel and tire assembly about the
wheel rotation axis;

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a steering mechanism adapted to rotate the steer tube and
spindle assembly relative to the strut housing of each strut module independent
of the other strut modules; and

an air cooling system constructed and arranged to pass ambient
air at least through part of the motors to dissipate heat from each motor.

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OFF-HIGHWAY OFF-ROAD DUMP TRUCK

ABSTRACT

5 A normally off-highway off-road dump truck is disclosed. The truck
has a frame with a forward end and a rearward end. The rearward end of the
frame is supported by at least two wheels coupled to part of the frame. The
truck also has a forward strut support coupled to the frame near the forward
end. The truck has at least first and second strut modules coupled to the
forward strut support. The first and second strut modules each have an
independent steering mechanism and at least one wheel and tire assembly.
Each of the first and second strut modules also has a motor for driving the
respective at least one wheel and tire assembly independent of the wheel and
tire assembly of the other strut module.

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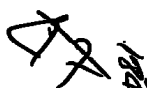


FIG. 1

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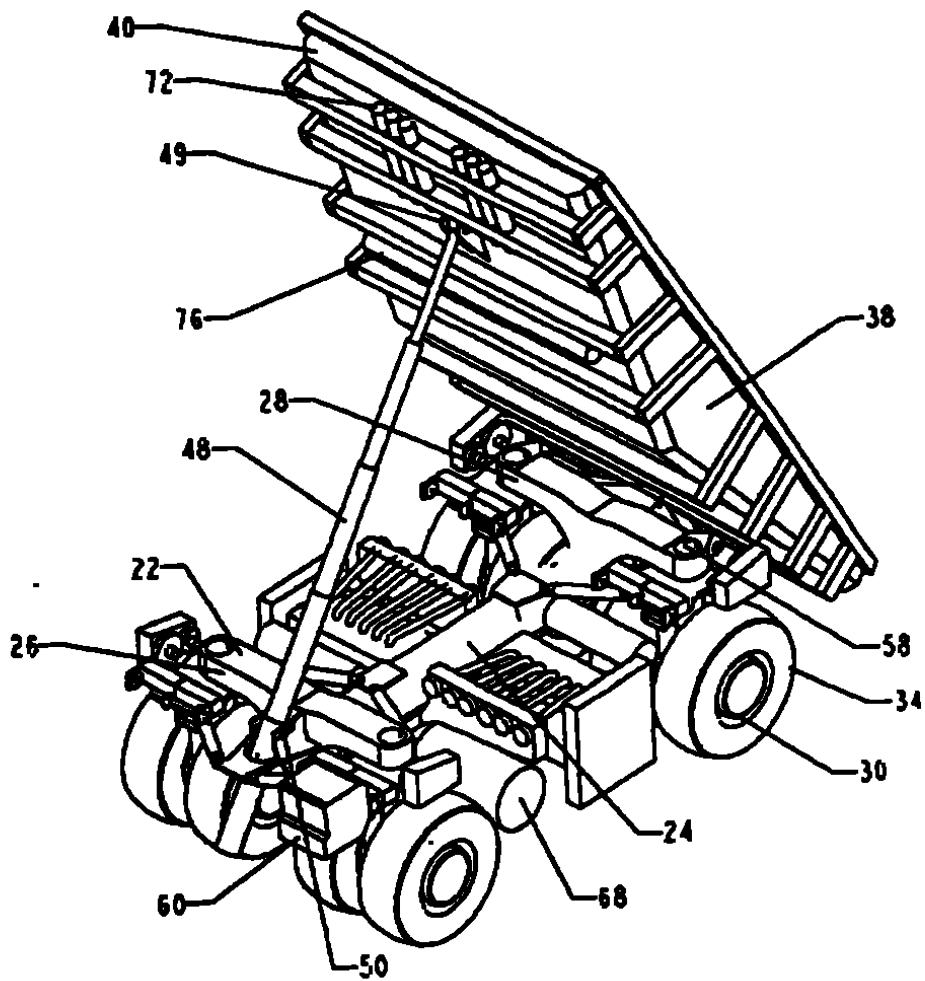


FIG. 2A

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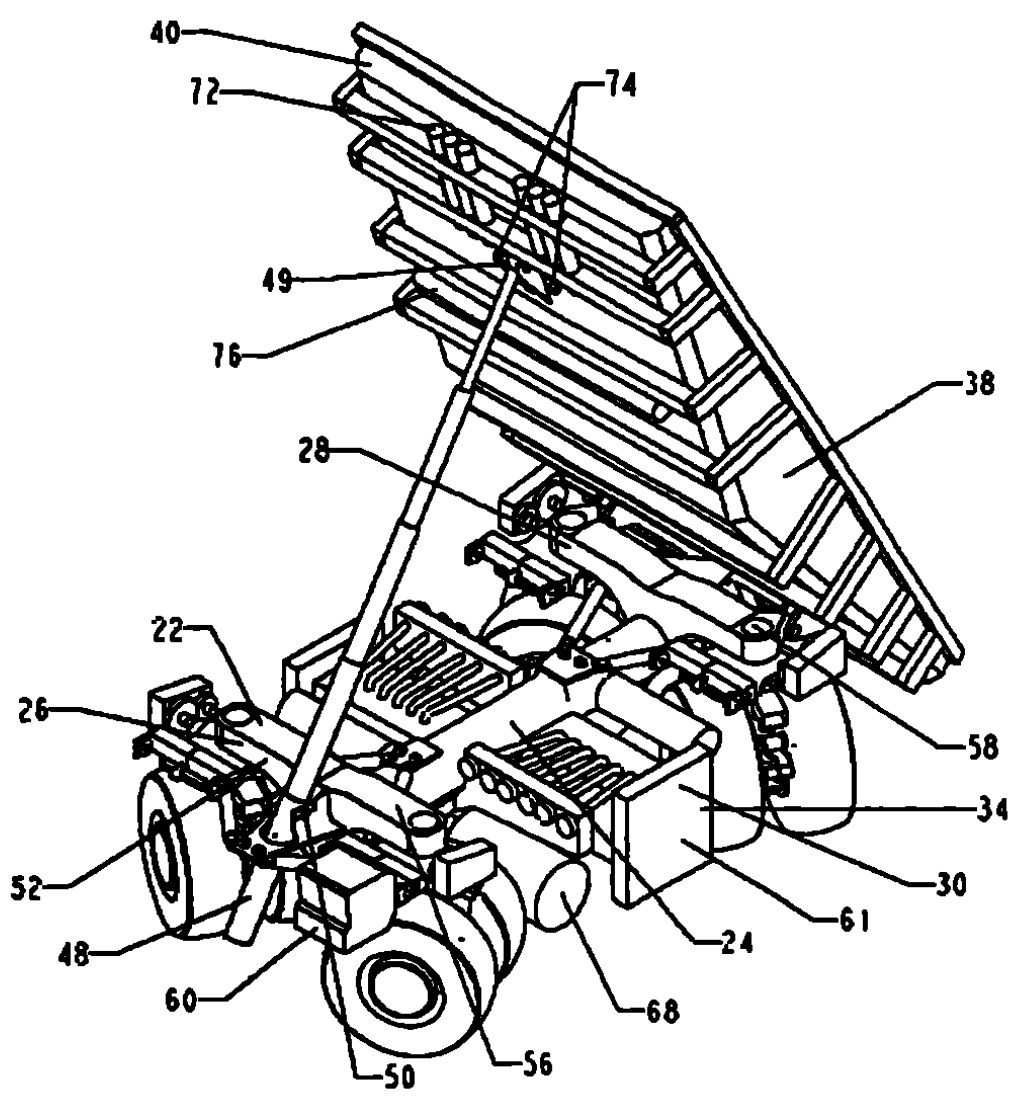


FIG. 2B

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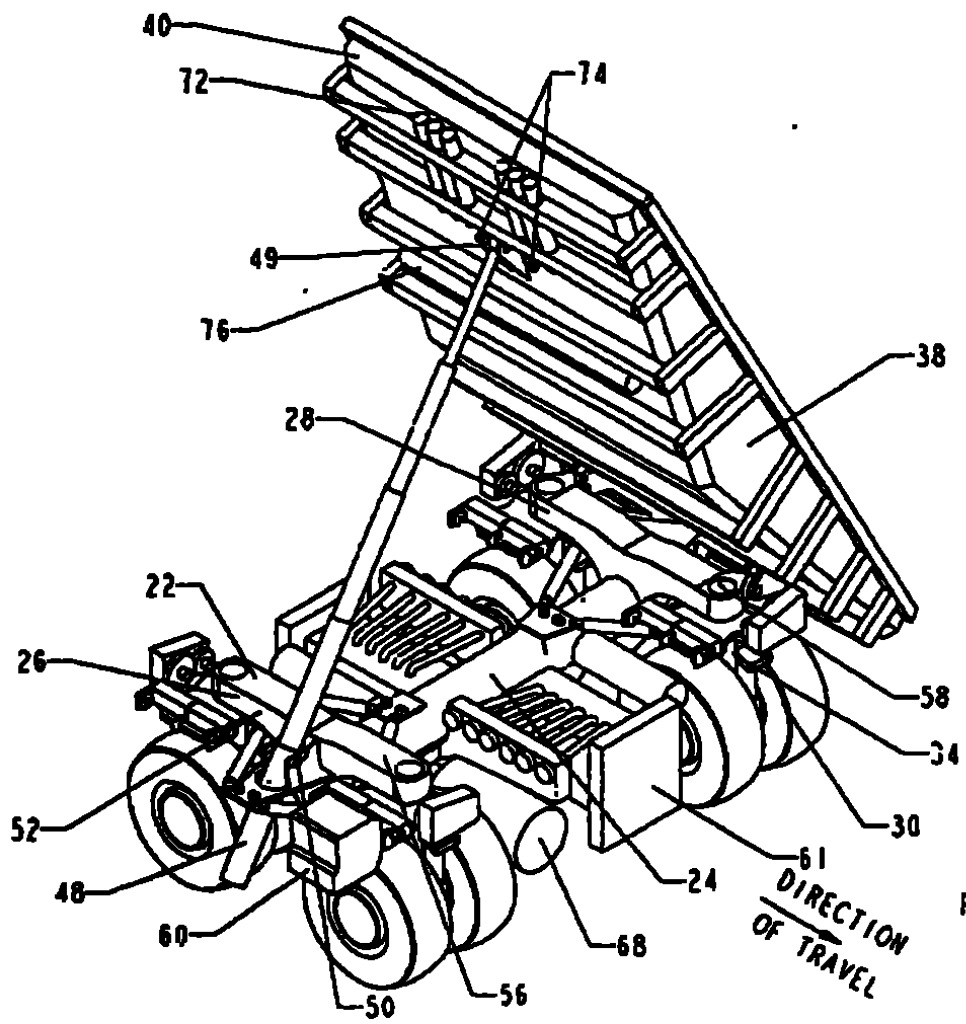


FIG. 3

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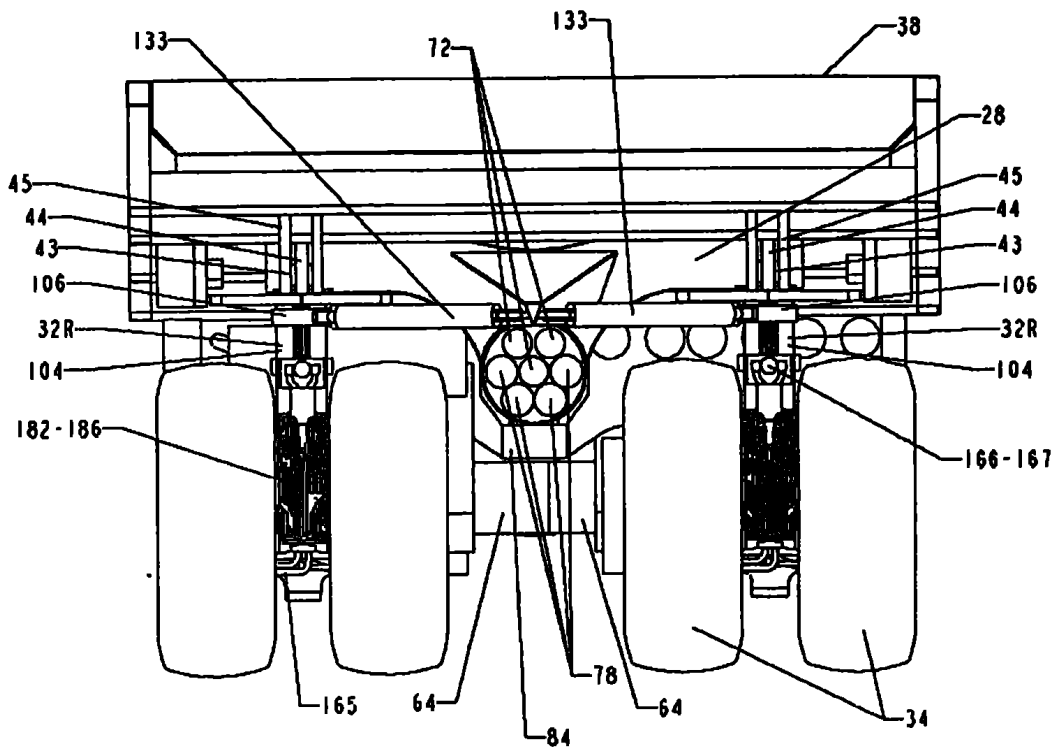


FIG. 4

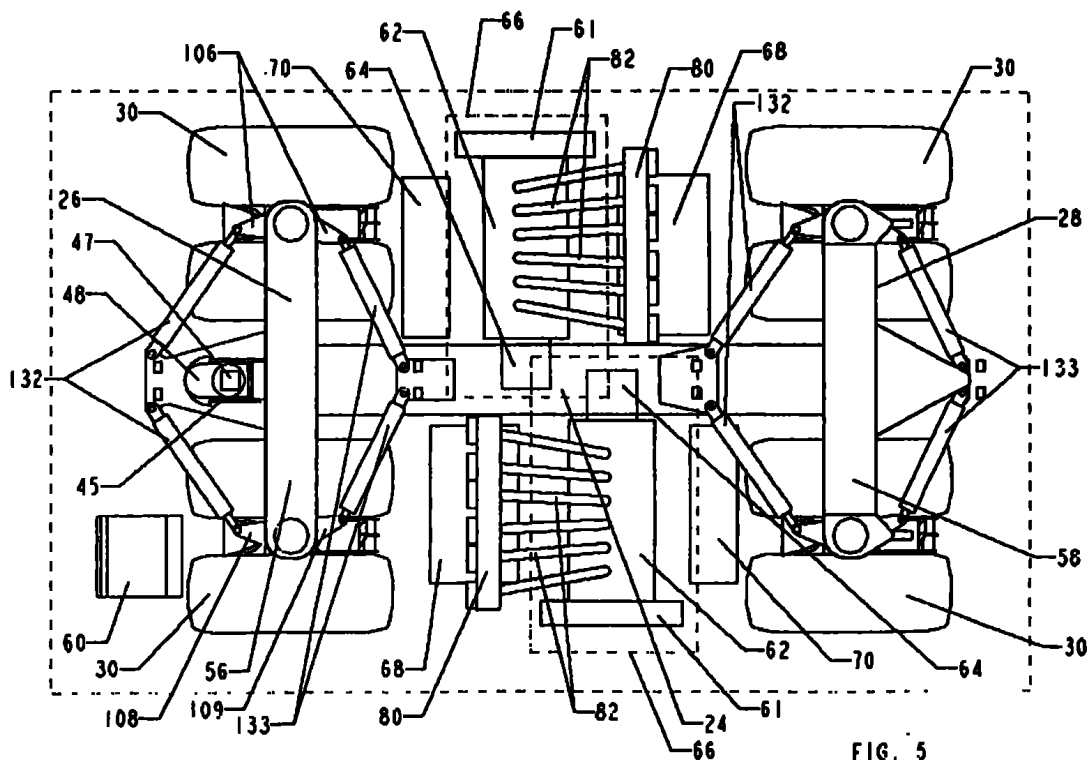
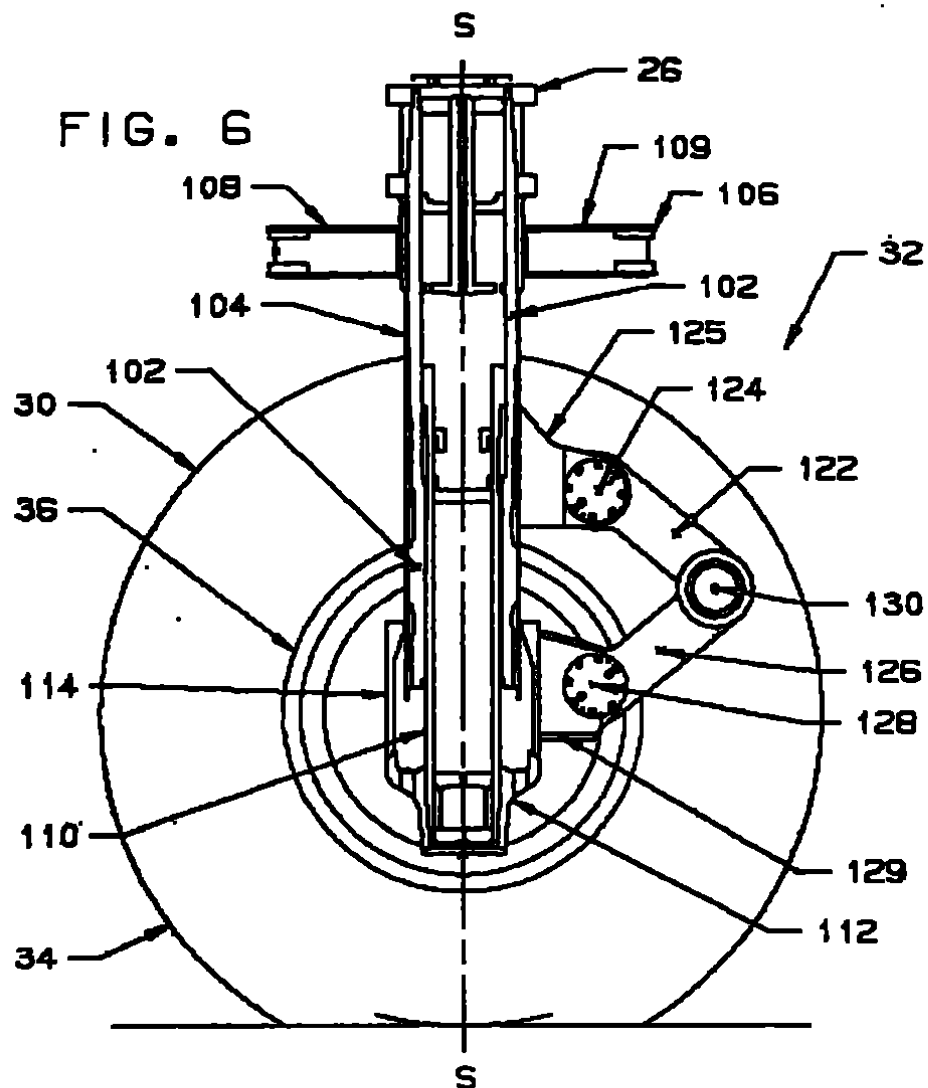


FIG. 5

Handwritten signature or initials.

FIG. 6



0000000000000000

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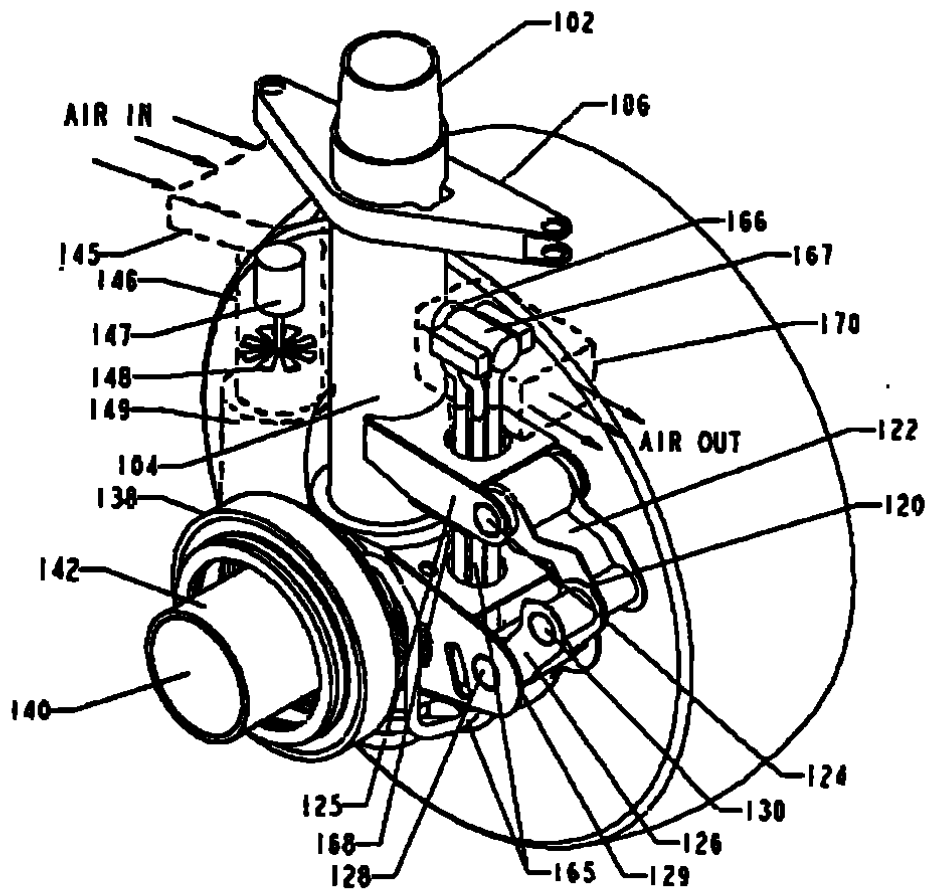


FIG. 7

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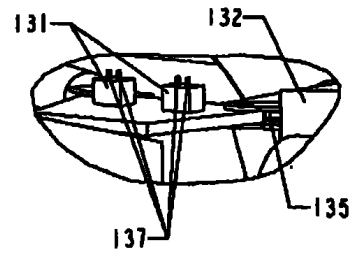
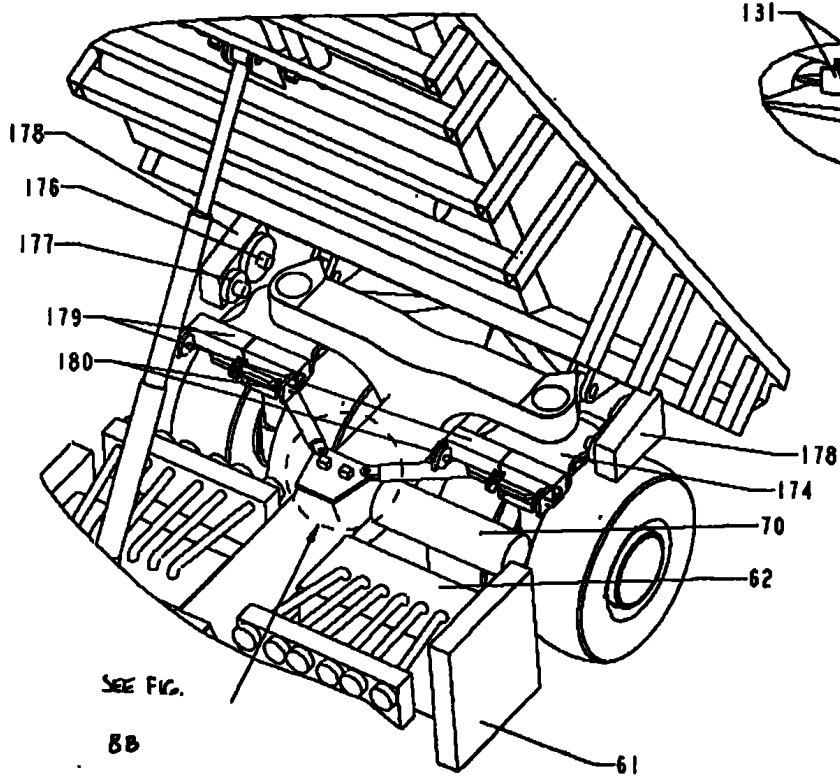
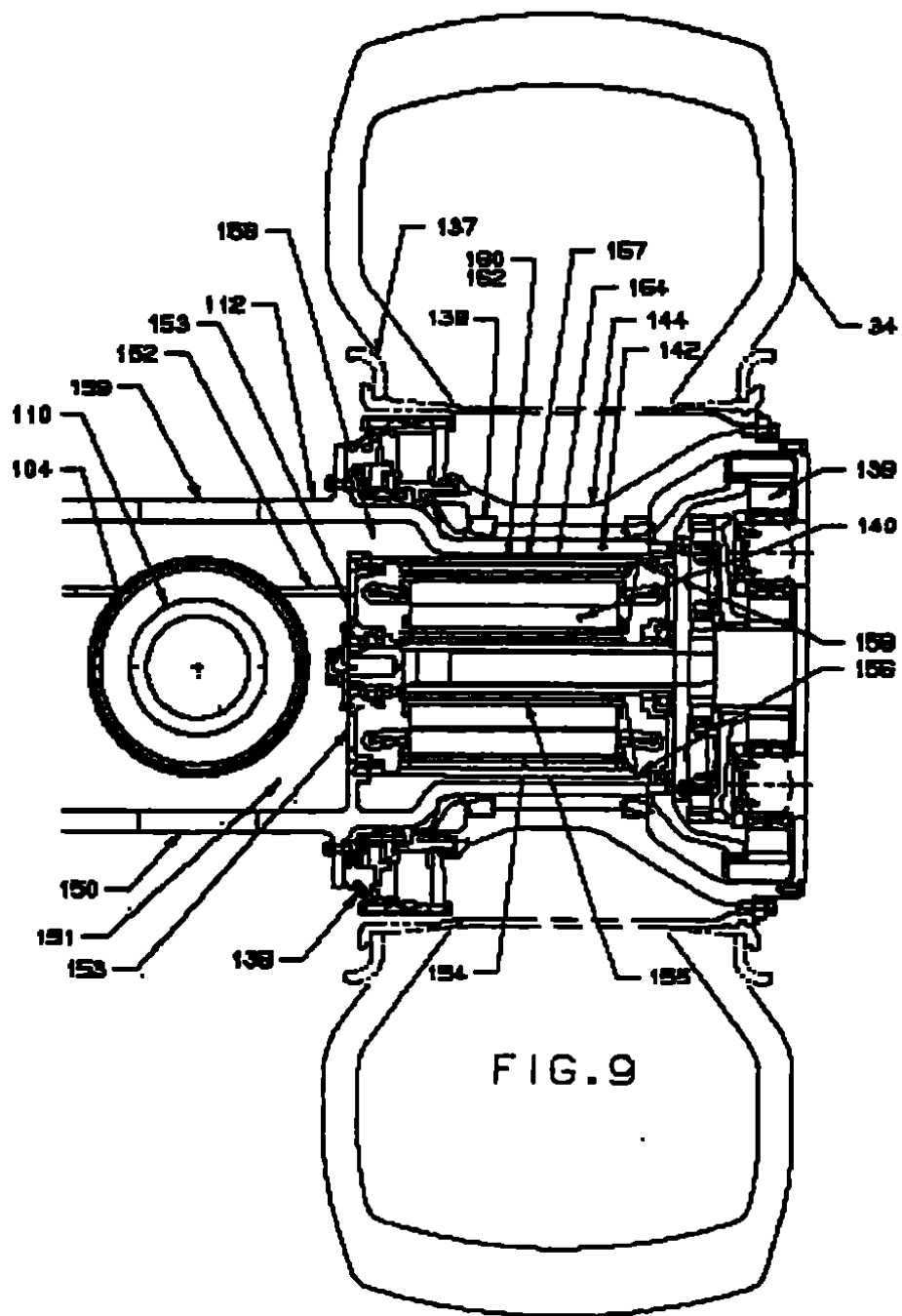


FIG. 8B

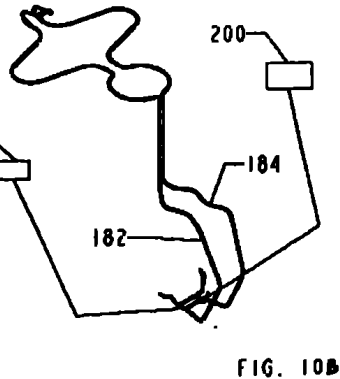
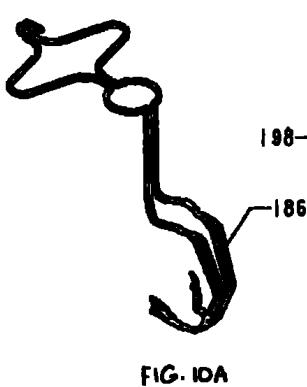
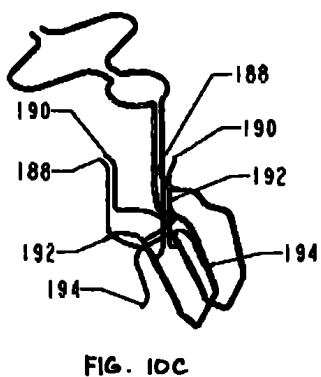
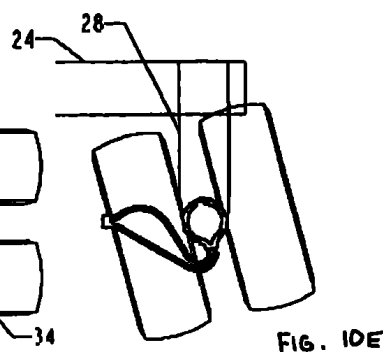
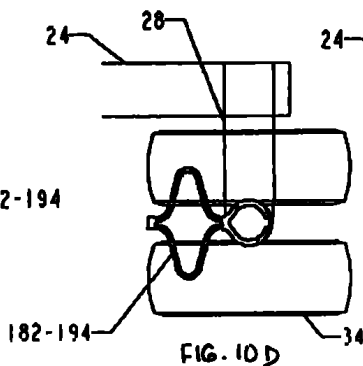
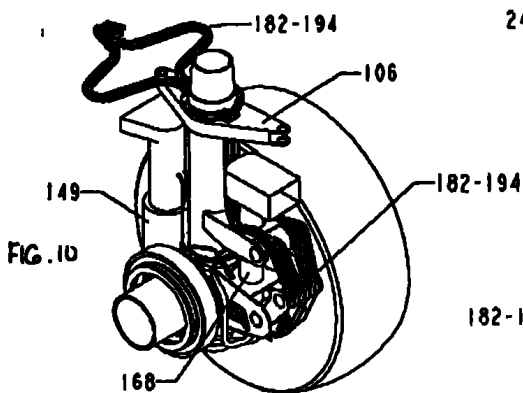
FIG. 8A

Spd

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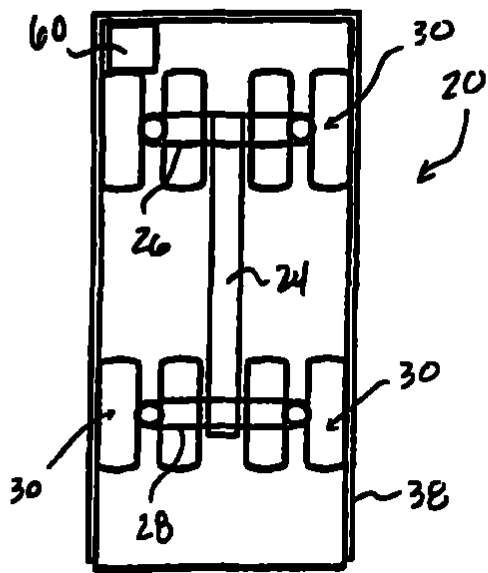


FIG. 11A

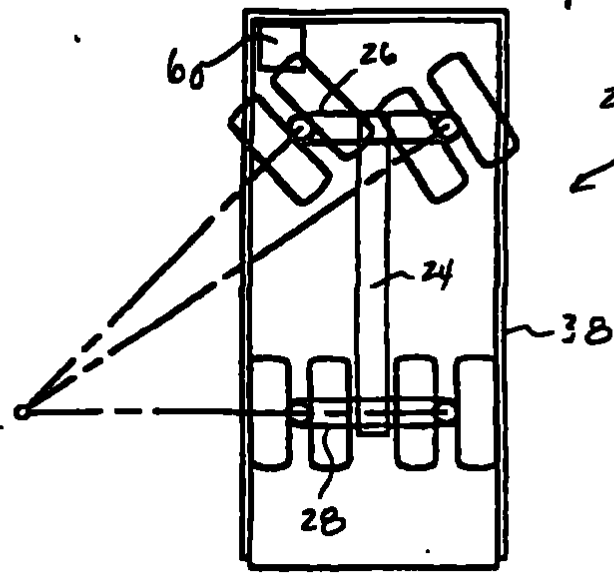


FIG. 11D

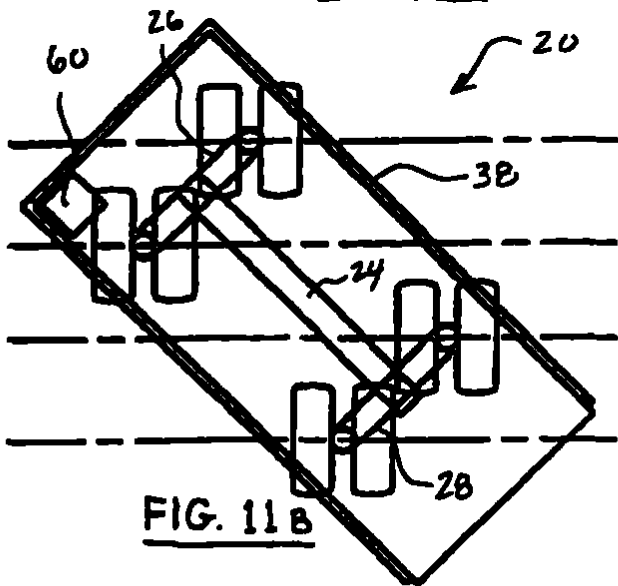


FIG. 11B

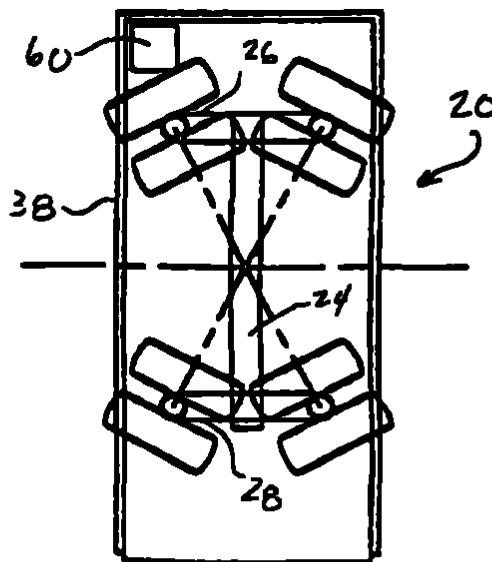


FIG. 11E

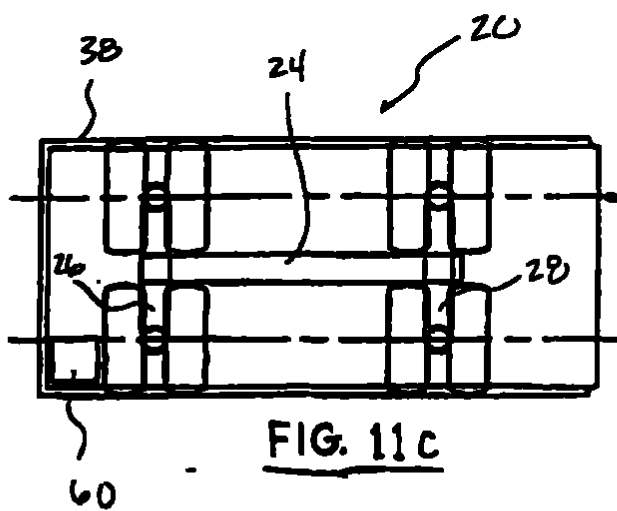


FIG. 11C

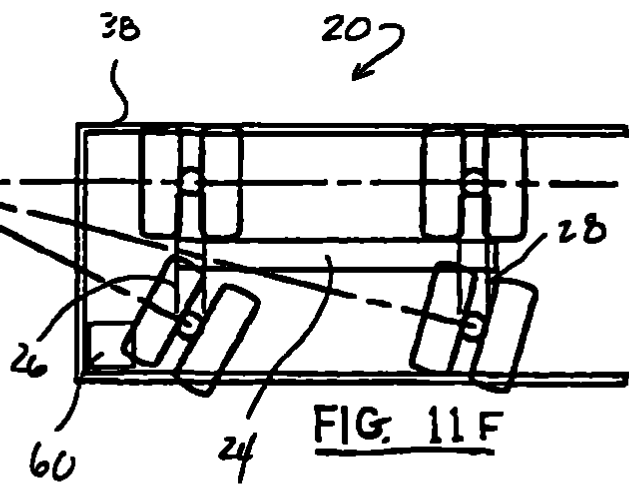


FIG. 11F

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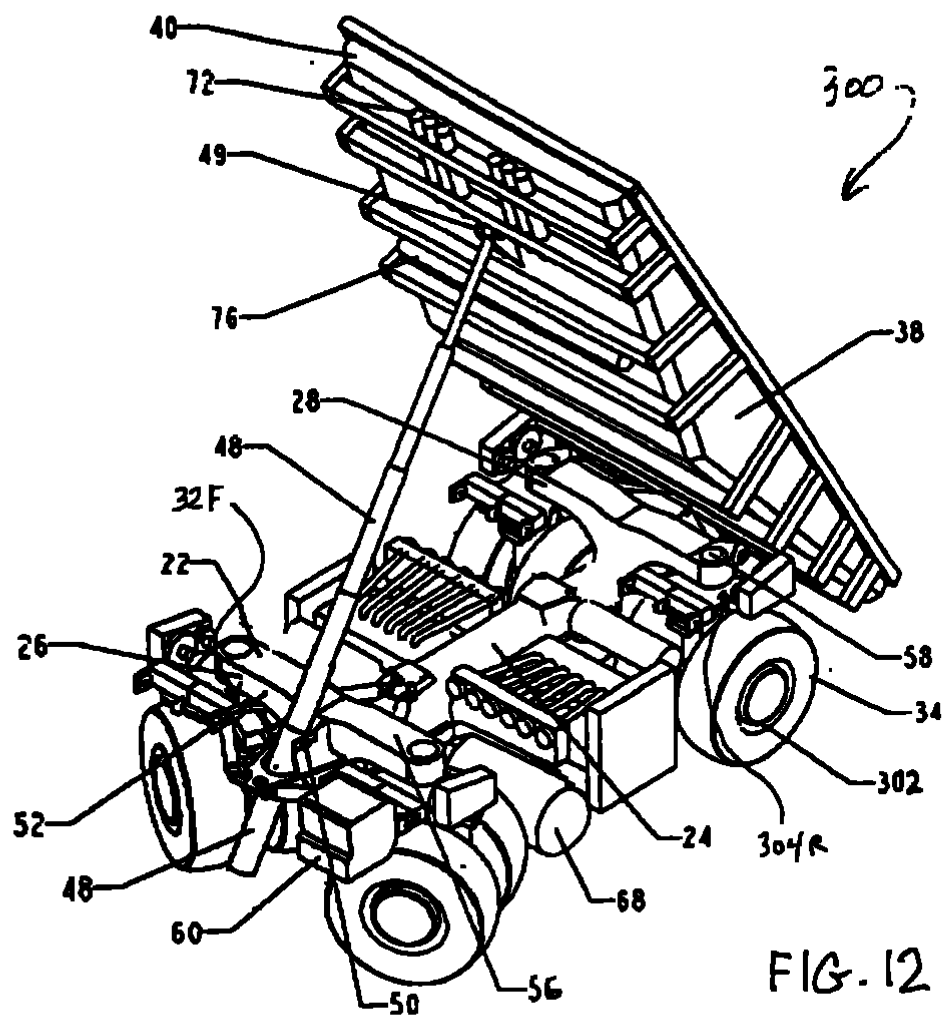


FIG. 12

05758844-011101

ESTADOS UNIDOS DE AMÉRICA

A QUIEN INTERESE

DEPARTAMENTO DE COMERCIO DE ESTADOS UNIDOS

Oficina de Patentes y Marcas de Estados Unidos

21 de junio de 2001

EL PRESENTE TIENE COMO OBJETO CERTIFICAR QUE LOS ANEXOS AL PRESENTE INSTRUMENTO SON UNA FIEL COPIA DE LOS REGISTROS QUE REPOSAN EN LA OFICINA DE PATENTES Y MARCAS DE ESTADOS UNIDOS DE LOS DOCUMENTOS CORRESPONDIENTES A LA SOLICITUD DE PATENTE QUE APARECE A CONTINUACIÓN, Y QU ELLOS CUMPLEN CON LOS REQUERIMIENTOS EXIGIDOS PARA QUE SE LES CONFIERA UNA FECHA DE RADICACIÓN SEGÚN EL CÓDIGO 35 USC 111.

NÚMERO DE SOLICITUD : 09/758,844

FECHA DE RADICACIÓN: enero 11 de 2001

Autorizado por el COMISIONADO DE PATENTES Y MARCAS

(Firmado) H.L. JACKSON /Funcionario de Certificaciones

128
194

SOLICITUD DE PATENTE

EN LA OFICINA DE PATENTES Y MARCAS DE LOS ESTADOS UNIDOS

Expediente No.: 29038/36105B

SOLICITUD DE PATENTE TRANSMITIBLE BAJO 37 C.F.R. 1.53

**Casilla para Solicitud de Patente
Comisionado para Patentes
Washington, D.C. 20231**

Señor:

Adjunto se trasmite para registro la solicitud de patente de el (los)

Inventor (es) : Edward S. Krees

Titulada : CAMIÓN DE DESCARGA PARA OPERAR FUERA DE
AUTOPISTAS Y FUERA DE CARRETERAS

1. Tipo de Solicitud

☒ Esta es una solicitud nueva para un
☒ Modelo de utilidad.

☐ Diseño industrial.

☒ Esta es una solicitud de continuación en parte de una solicitud anterior
Presentada en enero 10 de 2001 (Expediente de Abogado No.29038/36105 A).

2. Documentos Incluidos en la Solicitud

1 Página con el Título
38 Páginas de Especificaciones(reivindicaciones, Resumen,
Dibujos & Listado de Secuencia).
2 Página(s) de Reivindicaciones
1 Página(s) de Resumen
13 Hoja(s) de Dibujos (Figuras 1 a 12)

☐ Formal

☒ Informal

0 Página(s) de Listado de Secuencia

CERTIFICACIÓN BAJO 37 CFR 1.10

Por medio de la presente certifico que esta Solicitud de Patente Transmisible y los documentos adjuntos referidos con ella, están siendo depositados en el Servicio Postal de los Estados Unidos en enero 11 de 2001, en un sobre dirigido al Comisionado para Patentes, Washington, D.C. 20231, a través de la "Oficina de Correo Expreso al Destinatario", un servicio del Servicio Postal de los Estados Unidos, bajo el número EL584457715U6.

(Firmado) Richard Zimmermann

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65

3. Declaración o Juramento

☐

Adjunto

☐

Llevada a cabo por (revise todas las posibilidades)

☐

Inventor(es)

☐

Representante Legal del Inventor(es)
(37 CFR 1.42 o 1.43)

☐

Co-Inventor o persona que expresa interés en la propiedad a favor del inventor quien se rehúsa a firmar o no puede ser encontrado

☐

Se adjuntan la petición requerida bajo 37 CFR 1.47 y la declaración requerida bajo 37 CFR 1.47. Ver el numeral 5D abajo para la tasa.

☒

No se adjunta-el agente o el abogado abajo firmante esta autorizado para presentar esta solicitud en representación del solicitante(s). Se presentara una declaración cumpliendo con las formalidades.

4. Estatus de Pequeña Entidad

☒

El solicitante reclama el estatus de pequeña entidad. Ver 37 CFR 1.27

☐

Se adjunta declaración(es) de pequeña entidad.

5. Documentos Adicionales Adjuntos

☐

Corrección Preliminar

☐

Exposición de la Descripción de la Información

☐

Declaración de Depósito Biológico

☐

Copia legible de computador de listado de secuencia, conteniendo la secuencia de nucleótidos y/o de amino ácidos

☐

Microficha de programa de computador

☐

Poder de Oficina Asociada de Abogados

☐

Traducción oficial de solicitud de patente que no venga en inglés

☐

Cesión de la Invención

☐

Solicitud y Certificación según 35 U.S.C. 122(b)(2)(B)(i)

☒

Sello postal prepago para retornar a vuelta de correo

☐

Otros

6. Solicitud de Prioridad según 35 USC 119

Copias certificadas de las solicitudes a partir de las cuales se reclama prioridad según 35 USC 119, se enlistan abajo y

- ☐ se adjuntan
- ☐ se enviarán

PAIS	SOLICITUD No.	PRESENTADA

7. Cálculo de las Tasas de Presentación (37 CFR 1.16)

A. ☒ Solicitud de Modelo de Utilidad

REIVINDICACIONES PRESENTADAS-INCLUYENDO CORRECCIÓN PRELIMINAR (SI LA HAY)						
			PEQUEÑA ENTIDAD		OTRA DISTINTA A PEQUEÑA ENTIDAD	
	No. PRE-SENTADO	CANTIDAD EXTRA	TARIFA	TASA	TARIFA	TASA
TASA BASICA				\$355.00		\$ 710.00
TOTAL	1 - 20	= 0	X 9=	\$	X18=	\$
INDEPEN	1 - 3	= 0	X40=	\$	X80=	\$
☐ Primera Presentación de Múltiples Reivindicaciones Dependientes			+135=	\$	+270=	\$
Tasa de Presentación:				\$355.00	0	\$

B. ☐ Solicitud de Designación (\$100.00/\$330.00) Tasa Presentación: \$_____

C. ☐ Solicitud de Plana (\$245.00/\$400.00) Tasa Presentación: \$_____

D. Otras Tasas

- ☐ Designación de Registro [Tasa-\$40.00 por designación] \$_____
- ☐ Tasa de peritaje para presentación por otros diferentes a todos los inventores o persona en representación de el inventor cuando el inventor se rehuse a firmar o no pueda ser encontrado [Tasa-\$130.00] \$_____
- ☐ Otros \$_____

Total Tasas Adjuntas \$ 355.00

197
251
60

8. Método para el Pago de las Tasas

- ☒ Cheque adjunto por la suma de: \$ 355.00
- ☐ Cargo a la Cuenta de Ahorros No. 13-2855, por la suma de: \$ _____
Se adjunta copia del trámite
- ☐ No se adjunta

9. Depósito en Cuenta y Autorización de Reembolso

Por medio de la presente se autoriza al Comisionado para cargar la diferencia por menor valor pagado a lo estipulado o cualquier tasa adicional que se requiera durante el trámite restante de esta solicitud, según 37 CFR 1.16 ó 37 CFR 1.17 o según otras normas aplicables (excepto el pago de tasas de publicación), a la Cuenta de Ahorros No. 13-2855. Se adjunta una copia de este trámite.

Por favor, reembolsar cualquier sobrecosto a Marshall, O'Toole, Gerstein, Murray & Borun a la dirección que se menciona abajo.

10. Dirección para Correspondencia

Ciente No.: 04743

De ustedes respetuosamente,

MARSHALL, O'TOOLE, GERSTEIN,
MURRAY & BORUN
6300 Torre Sears
233 South Wacker Drive
Chicago, Illinois 60606-6402
(312) 474-6300
(312) 474-0448 (Telefaxímilo)

Por(Firmado): _____
Bryan J. Lemple
Registro No.: 39.746

Enero 11, 2001

Lo que se Reivindica es:

1. Un camión que comprende:

una armazón que tiene un extremo delantero y un extremo trasero;
por lo menos dos ruedas traseras acopladas a una porción del
armazón y soportando dicha sección posterior del mismo;

un soporte delantero de un apoyadero, acoplado al armazón, cerca de
su extremo delantero;

por lo menos un primero y segundo módulos de apoyaderos, donde el
primero y segundo módulos de apoyaderos están acoplados al soporte del
apoyadero delantero, y donde cada uno de los módulos de los apoyaderos
incluye:

un montaje de un apoyadero orientado, teniendo un extremo superior,
un extremo inferior, y un eje del apoyadero, teniendo el montaje del apoyadero
una caja protectora fijada al extremo superior en la parte concéntrica de la
estructura del camión con el eje del apoyadero y teniendo un tubo guía
dispuesto para rotar alrededor del eje del apoyadero con relación a la caja
protectora del apoyadero;

un montaje de eje teniendo un par de ejes dispuestos en forma
opuesta extendiéndose desde un eje de la caja protectora y definiendo unos
ejes de rotación de las ruedas, donde el montaje del eje es llevado al extremo
inferior del montaje del apoyadero para una rotación conjunta con el tubo guía,
alrededor del eje del apoyadero, donde el montaje del eje está construido para
amortiguar el movimiento a lo largo del eje del apoyadero, con relación a la
armazón del camión;

un par de ruedas y montaje de llantas, cada una soportada por su
respectivo eje de rotación, alrededor de los ejes de rotación de las llantas;

un par de motores de arrastre, cada uno asociado con cada uno de
los ejes para la rotación motriz de la respectiva rueda con su montaje de llanta,
alrededor de los ejes de rotación de las ruedas;

un mecanismo conductor adaptado para rotar el tubo guía y un
montaje de eje en relación con la caja protectora del apoyadero de cada
módulo independiente de apoyadero, de los otros módulos de apoyadero; y

un sistema de refrigeración por aire construido y dispuesto para
circular aire ambiente, al menos a través de la parte de los motores para disipar
el calor de cada motor.

P. 404 203
199 8

PA 428867



THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE

United States Patent and Trademark Office

June 21, 2001

THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY FROM THE RECORDS OF THE UNITED STATES PATENT AND TRADEMARK OFFICE OF THOSE PAPERS OF THE BELOW IDENTIFIED PATENT APPLICATION THAT MET THE REQUIREMENTS TO BE GRANTED A FILING DATE UNDER 35 USC 111.

APPLICATION NUMBER: 09/756,703

FILING DATE: January 10, 2001



By Authority of the
COMMISSIONER OF PATENTS AND TRADEMARKS

H. L. JACKSON
Certifying Officer

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264
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01/10/01
JCS23 U.S. PTO

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Docket No: 2903B/36105A

10/01/01
JCS23 U.S. PTO
01/10/01

PATENT APPLICATION TRANSMITTAL UNDER 37 C.F.R. 1.53

Box Patent Application
Commissioner for Patents
Washington, D.C. 20231

Sir:

Transmitted herewith for filing is the patent application of

Inventor(s): Edward S. Kress

Title: OFF-HIGHWAY OFF-ROAD DUMP TRUCK

1. Type of Application

- ☒ This is a new application for a utility patent.
- ☒ This application is related to co-pending U.S. provisional application Serial No. 60/177,147, filed on January 20, 2000.

2. Application Papers Enclosed

- 1 Title Page
- 34 Pages of Specification (excluding Claims, Abstract, Drawings & Sequence Listing)
- 2 Page(s) of Claims
- 1 Page(s) of Abstract
- 12 Sheet(s) of Drawings (Figs. 1 to 11)
- ☐ Formal
- ☒ Informal
- 0 Page(s) of Sequence Listing

CERTIFICATION UNDER 37 CFR 1.10

I hereby certify that this Patent Application Transmittal and the documents referred to as enclosed therewith are being hand delivered, in an envelope addressed to the Commissioner for Patents, Washington, D.C. 20231, on _____.

Hand delivered by

00756703-011001

201 205

3. Declaration or Oath

- ☐ Enclosed
 - ☐ Executed by (check all applicable boxes)
 - ☐ Inventor(s)
 - ☐ Legal representative of inventor(s)
(37 CFR 1.42 or 1.43)
 - ☐ Joint inventor or person showing a proprietary interest on behalf of inventor who refused to sign or cannot be reached
 - ☐ The petition required by 37 CFR 1.47 and the statement required by 37 CFR 1.47 are enclosed.
See Item 5D below for fee.
- ☒ Not enclosed - the undersigned attorney or agent is authorized to file this application on behalf of the applicant(s). An executed declaration will follow.

4. Small Entity Status

- ☒ Applicant claims small entity status. See 37 CFR 1.27.
- ☐ A small entity statement is(are) attached.

5. Additional Papers Enclosed

- ☐ Preliminary Amendment
- ☐ Information Disclosure Statement
- ☐ Declaration of Biological Deposit
- ☐ Computer readable copy of sequence listing containing nucleotide and/or amino acid sequence
- ☐ Microfiche computer program
- ☐ Associate Power of Attorney
- ☐ Verified translation of a non-English patent application
- ☐ An assignment of the invention
- ☐ Request and Certification Under 35 U.S.C. 122(b)(2)(B)(i)
- ☒ Return receipt postcard
- ☐ Other

09756703-011001

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6. Priority Applications Under 35 USC 119

Certified copies of applications from which priority under 35 USC 119 is claimed are listed below and

- ☐ are attached.
☐ will follow.

COUNTRY	APPLICATION NO.	FILED

7. Filing Fee Calculation (37 CFR 1.16)

A. ☒ Utility Application

CLAIMS AS FILED - INCLUDING PRELIMINARY AMENDMENT (IF ANY)						
			SMALL ENTITY		OTHER THAN A SMALL ENTITY	
	NO. FILED	NO. EXTRA	RATE	FEE	RATE	FEE
BASIC FEE				\$355.00		\$710.00
TOTAL	1 - 20	= 0	X 8 =	\$	X 18 =	\$
INDEP.	1 - 3	= 0	X 40 =	\$	X 80 =	\$
☐ First Presentation of Multiple Dependent Claim			+ 135 =	\$	+ 270 =	\$
Filing Fee:				\$355.00	OR	\$

B. ☐ Design Application (\$160.00/\$320.00) Filing Fee: \$ _____

C. ☐ Plant Application (\$245.00/\$490.00) Filing Fee: \$ _____

D. Other Fees

- ☐ Recording Assignment [Fee -- \$40.00 per assignment] \$ _____
- ☐ Petition fee for filing by other than all the inventors or person on behalf of the inventor where inventor refused to sign or cannot be reached [Fee -- \$130.00] \$ _____
- ☐ Other \$ _____

Total Fees Enclosed \$355.00

00755703-0110071

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X

8. Method of Payment of Fees

- ☒ Enclosed check in the amount of: \$355.00
☐ Charge Deposit Account No. 13-2856 in the amount of: \$_____
A copy of this Transmittal is enclosed.
☐ Not enclosed

9. Deposit Account and Refund Authorization

The Commissioner is hereby authorized to charge any deficiency in the amount enclosed or any additional fees which may be required during the pendency of this application under 37 CFR 1.16 or 37 CFR 1.17 or under other applicable rules (except payment of issue fees), to Deposit Account No. 13-2855. A copy of this Transmittal is enclosed.

Please refund any overpayment to Marshall, O'Toole, Gerstein, Murray & Borun at the address below.

10. Correspondence Address

Customer No.: 04743

Respectfully submitted,

MARSHALL, O'TOOLE, GERSTEIN,
MURRAY & BORUN
6300 Sears Tower
233 South Wacker Drive
Chicago, Illinois 60606-8402
(312) 474-6300
(312) 474-0448 (Telefacsimile)

By:

Bryan J. Lempis
Bryan J. Lempis
Reg. No: 39,746

January 9, 2001

10755773-011001

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H

Attorney docket: 29038/36105A

SOLE INVENTOR

Date of Deposit: _____
I hereby certify that this paper (or fee) is being deposited by hand delivery on the date indicated above and is addressed to: Commissioner for Patents, Washington, D.C. 20231.

Hand delivered by

○

1001003-011001

**APPLICATION FOR
UNITED STATES LETTERS PATENT**

S P E C I F I C A T I O N

○

TO ALL WHOM IT MAY CONCERN:

Be it known that I, EDWARD S. KRESS a citizen of the United States of America, residing at 16800 W. Brimfield Jubilee Road, Brimfield 61517, and in the State of Illinois have invented a new and useful OFF-HIGHWAY OFF- ROAD DUMP TRUCK, of which the following is a specification.

|

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OFF-HIGHWAY OFF-ROAD DUMP TRUCK

FIELD OF THE INVENTION

The present invention relates generally to dump trucks, and more particularly to a fixed frame dump truck.

BACKGROUND OF THE INVENTION

As technology becomes available, it is important to use the technology in the most efficient manner possible. Almost one-half century ago, components with better reliability and greater capacities became available for off-highway trucks. By using these components in the optimum configuration, what was believed to be the off-highway truck of the future was configured. Specifically, rather than having multiple engines, transmissions, axles, and tires for larger trucks, the number of engines and transmissions were reduced to one each, axles to two, and tires to six. Importantly, oleo-pneumatic suspensions were introduced at that time. These changes resulted in a compact, short wheelbase, light weight, but robust truck with improved maneuverability and ride characteristics. Today, the industry still considers this configuration to be ideal for now and for the foreseeable future.

Traditionally, fixed frame trucks use mechanical drive components which require the engine to be mechanically linked to a transmission, the transmission to be mechanically linked to the differential in the rear axle, the differential to then be mechanically linked to a planetary drive, and the planetary drive to be mechanically linked to the rear rims and tires. The rear

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206 7/10

tires in turn provide the driving force at the ground to move the truck. This method is used in virtually all highway passenger cars and trucks, and is used in most off-highway trucks up to around 200 tons. Off-highway trucks have now increased in capacity to 360 tons. About half of those trucks use mechanical drive components. The remaining half use electrical drive components.

In the last few years, larger trucks (300 tons and over) have reverted from Direct Current (DC) motors to a new technology that can effectively control the speed and torque of Alternating Current (AC) motors. Mechanical drive systems supply power over a wide speed range. DC systems supply power over a narrow speed range. AC systems can supply power over a wider speed range than DC systems, but not as wide a range as mechanical drive systems. However, because of their excellent reliability and simplicity, AC systems are an excellent choice.

The electrical drive vehicles now offered in the industry have the same location for the engine and alternator as a mechanical drive truck has for the engine and transmission. Two electric motors are normally located in the center of the rear axle in place of the mechanical drive differential and deliver power directly into the rear wheels through gear reducers. These prior art trucks still use the traditional two axle, six tire configuration having a single rear axle with two sets of dual tires for driving the truck. The front two tires are not driven and only steer the truck. They cannot steer sharply because the

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PATENT
29038/36105A

frame that supports the engine and front suspension limit the turn capability.

The configuration of the two axle, six tire trucks after almost fifty years of refinement is at the practical limit in size and efficiency.

Thirty years ago an oleo-pneumatic strut was developed for off-highway trucks which supported two tires, one on each side of the strut, through two connected spindles positioned one on each side of the strut. Among the many apparent advantages of this arrangement is the feature of tire separation. Dual tires which are on virtually all rear axles of this conventional construction are spaced very close together. Heat build up with these large, closely spaced tires is very serious. Radiant heat is transferred from one tire to another, limiting the performance of the tires and consequently the performance of the truck. With the tires on both sides of the strut, the spacing of the tires is about six times that of a conventional dual tire configuration. This additional spacing effectively eliminates this radiant heat problem.

In the past there have been two trucks built with common oscillating spindles. One spindle is located on the front, non-driving, steering axle with a strut between the tires. The other spindle is located on a rear, non-steering, drive axle with a motor between the tires driving the tires through a differential planetary gear set. In theory, oscillating spindles will allow the load to be equal on both tires. However, in practice this is only the case on a flat road with tires of equal diameter. Both of these prior art trucks require the pivot point of the oscillation to be well above the surface of the road. On

208 212

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uneven ground, the higher tire of the pair, of course, moves up. However, the higher tire must also move out as the lower tire moves in. This movement shifts weight to the lower tire.

5 When turning, side or lateral forces are generated. Because the pivot point is located well above the ground, these side forces will shift additional weight to the outside tire. These lateral forces will either add or subtract to the load on the tire. The net result can put more load from the two sources on the lower tire and a side or lateral load on both tires.

10 On ground or roads that are fairly even, and when the truck is not turning fast, this is not typically a problem. However, when the ground becomes very uneven and/or when the truck is going fast around a corner, two undesirable conditions exist. First because there is structure between the tires on all of these vehicles, the spindle oscillation must be limited. A serious structural problem exists for all components when the spindle is at the limit of
15 its oscillation. High vertical loads are imposed on the lower tire and high side loads are imposed on both tires. Side loads are the most damaging causing significant premature wear to drive components, bearings, structure, and the like. Second, when one tire blows out, very serious dynamic forces are generated on all structures and on the remaining tire.

20 With non-oscillating spindles, the only load increase between the tires occurs when an uneven ground surface deflects one tire more than the other. When a tire blows out with the non-oscillating spindle nothing serious takes

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place. The strut is substantial in design to easily handle the full load on one
tire. The bearings, if designed for 500,000 miles, will last for 50,000 miles
under such conditions. Hopefully, the failed tire can be replaced within that
length of time. Tire loading is only slightly greater between the tires of a strut
5 with non-oscillating spindles on severely uneven surfaces than with dual tires
on a conventional truck that encounter the same uneven surface.

Also, with a non-oscillating spindle the tire can be placed close to the
strut. With an oscillating spindle, the tires must be spaced from the strut far
enough to allow for the oscillation. This additional distance aggravates forces
10 on the tire and forces generated when the oscillating spindle hits the oscillation
limiting structure. In addition, the stability base of a non-oscillating spindle is
at the outside tire. The stability base of an oscillating spindle is at the pivot
point between the tires. Although this is much better than the stability base at
the rear axle of conventional trucks it is not as good as either the front axle on
15 conventional trucks or the non-oscillating spindle. In conclusion, there is no
benefit to an oscillating spindle, only serious functional problems along with
higher manufacturing and operating cost.

In recent years it was realized that there was a need for trucks to travel
on unprepared surfaces, or off the road. As a result, an all terrain articulated,
20 all wheel drive truck was developed, articulated slightly forward of the center
of the truck. A drive line through the point of articulation powers the rear
axle. Such trucks have become a standard in the construction industry, with

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their all-wheel drive mobility in soft off road conditions. In addition, all farmers know less fuel is used when the front tractor tires are driven. They pull when driven, when not driven they push. However, the industry generally has limited the capacity of these units to only 40 tons. This is only one-ninth the capacity of the larger two axle trucks. The Russians, and an American truck manufacturing company, recognized the need to provide a large capacity all wheel drive truck. They have both developed a larger version of this articulated truck, but they did not make an impact on the industry. These trucks are no longer built because they lacked maneuverability, were too heavy, were unstable, and were costly to produce and operate. In addition, the configurations of these articulation trucks are fundamentally wrong. When cornering, weight shifts forward and to the side as the vehicle turns. To counteract these forces, the front outside tire should either stay in place or effectively move to the outside of the curve. With these articulated trucks, the front outside tire swings inward, the opposite of what is required, thereby reducing their stability.

These small all terrain articulated trucks are generally considered lighter duty than the standard fixed frame off-highway truck. Surprisingly, since they are lightly constructed, they have very poor payload to empty weight (P/W) ratios which are in the range of 1.05/1 to 1.2/1.

An empty truck must always travel in both directions, the payload in one, between the loading point and unloading point. To evaluate the cost of

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moving the truck versus the entire payload, the factor of $2(W/P)$, defined in greater detail herein, can be used.

The articulated truck with a P/W ratio of 1.12 will require \$1.78 to move the truck for every \$1.00 it takes to move the payload. The majority of current off-highway truck designs have a payload to weight ratio between 1.4 and 1.6. With P/W of 1.5, for every dollar to move the payload, it takes \$1.33 to move the truck.

Conventional fixed frame trucks use limited stroke, non-compensated suspension which requires tires and structural members to absorb imposed dynamic and torsional stresses. This, in turn, requires the structural members to be heavy and, due to their configuration, prone to have areas of high stress concentrations.

In addition, there are other problems associated with many of these existing trucks. Conventional trucks have dual rear tires mounted on the same hub requiring both tires to turn at the same speed causing the dual tires to scrub when turning because each tire is a different distance from the point about which the truck turns. This requires each tire to rotate at a different rate which the tires cannot do because they are mounted on the same hub. These dual tires must also be precisely matched in size because they do rotate on the same hub. Otherwise there will be abnormal wear on the smaller tire because it must turn faster since it has a smaller radius. There is obviously less load on the smaller tire. The tire with the heavier load will not slip, so the smaller tire

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with less load must slip and will wear. The smaller tire will also wear faster and faster as it gets smaller over time. Also, with dual tires, the outer tire and rim must be removed to replace or access the inner tire.

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BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a lower, front isometric view of a dump truck constructed in accordance with the teachings of the invention.

FIG. 2A is an upper, forward isometric view of the dump truck of FIG. 1 with the body up and the tires in a straight forward orientation.

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FIG. 2B is an upper, forward isometric view of the dump truck of FIG. 1 with the body up and the tires at maximum turn.

FIG. 3 is a view similar to FIG. 2, but with the tires parallel at 90 degrees and the body dumping to the side relative to the direction of truck movement.

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FIG. 4 is a rear view of the truck of FIG. 1.

FIG. 5 is a top view of the truck of FIG. 1 with the dump body shown only in phantom.

FIG. 6 is a side view in partial cross section of a strut module of the truck of FIG. 1.

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FIG. 7 is an upper rear isometric view of one strut module of the truck shown in FIG. 1 and with one wheel removed.

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FIG. 8A is an upper forward isometric view of the strut module with a motor and brake cooling air intake, motor controllers, motor controller radiator fan, fan motor, and braking grids.

FIG. 8B is an enlarged view of a portion of FIG. 8A taken from circle detail 8B.

FIG. 9 is a cross section from the top through the center of the lower strut, motor, and spindle showing air flow paths and components of the module assembly.

FIG. 10 shows the routing for all lines in position from a main suspension section of the truck to a movable and rotatable portion of the truck.

FIG. 10A shows all of the lines of FIG. 9 with all other structure removed.

FIG. 10B shows the routing of the ground wire, temperature sensor and motor speed indicators shown in FIG. 8.

FIG. 10C shows the routing of the hydraulic lines for brakes and hydraulic motors of FIG. 8.

FIG. 10D shows the routing position of the various lines where a strut module is oriented in a nominal straight ahead orientation.

FIG. 10E shows the routing position of the various lines where a strut module is turned to a large angle of rotation.

FIGS. 11A - 11F are each a schematic illustration of a possible steering mode of the truck of FIG. 1.

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DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

An example of a dump truck constructed according to the teachings of the present invention is shown and described herein. While the disclosed dump truck can be used for on-pavement applications, it is particularly well suited for off-highway applications and even more so for off road applications. The disclosed truck improves productivity, reduces cost, and has the ability to operate economically in the most adverse conditions. This allows a mine to operate more economically benefitting from more than just the reduced hauling costs. Tires are mounted independently, eliminating tire scrub when turning. Because the tires are independently mounted and driven, the tires need not be precisely matched in size. The steering capability of the truck permits access to both the inner or the outer tire without removing the other tire of the set. By turning the tires well beyond 90 degrees as is permitted by the truck disclosed herein, all tires are easily accessible and can be independently replaced either by removing or not removing the rim. The unique or novel truck configuration solves the previously discussed problems of conventional trucks and has many other features and advantages that will become apparent upon reviewing the description below.

Referring now to the drawings, FIGS. 1-5 generally illustrate a truck (20) constructed according to the teachings of the invention. The truck (20) has a frame (22) with a center section (24) defining a longitudinal axis "A" of the truck. The frame (22) also has a forward transverse section (26) and a rear

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transverse section (28) connected with the center section and arranged generally perpendicular to the center section, whereby the frame (22) has an I-shaped configuration in plan view. The transverse sections each define strut supports for the truck (20), as defined in greater detail below.

5 The frame (22) is supported above a ground surface in this example on a number of wheel and tire assemblies (30). The wheel and tire assemblies are each mounted to one of a front or rear strut module (32F) and (32R), respectively, (simply (32) hereinafter if not referring to the forward or reverse modules specifically), described in greater detail below. The modules (32F) and (32R) are in turn mounted depending from the opposed ends of the forward and rear transverse frame sections (26) and (28), respectively. In the present example, each of four strut module (32) carries a pair of wheel and tire assemblies(30), thus totaling eight. Each of the eight wheel and tire assemblies (30) has one tire (34) mounted on a wheel rim (36) for rotation about a portion of the respective strut module (32).

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 The truck (20) also has a dump body (38) pivotally mounted to a top portion of the frame (22). The dump body (38) is adapted to carry contents when in a lowered position (FIG. 1) and can be raised at a forward end (40) (FIG. 2) for dumping the contents. A rear end (42) of the dump body (38) has a pair of pivot structures (44) depending from its bottom surface (46). These pivot structures (44) are coupled to pivot structures (45) depending from the

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rear transverse frame section (28) on equidistant opposite sides of the frame center section (24).

To dump contents from the dump body (38), in one example the truck (20) has a single extendable cylinder (48) pivotally coupled at trunnions (50) to a forward part of the frame (22) along the center axis "A". In this example, the trunnions (50) are carried centrally on a front facing surface (52) of the forward transverse frame section (26). The trunnions (50) are positioned forward of the end of the frame center section (24) and forward of the front wheel and tire assemblies (30), outside the turning or rotation envelope of the tires (34) generated by the rotation of the strut modules. The dump cylinder (48) has a second end pivotally coupled to the underside or bottom surface (46) of the dump body (38) nearer the forward end (40). When extended, the dump cylinder (48) raises the forward end (40) of the dump body (38) as shown in FIG. 2. Certain benefits are achieved by this configuration and are described in greater detail below when describing the operation of the various features and characteristics of the truck (20).

When loading the dump body (38) and transporting the contents, the dump body (38) rests on the top surfaces (56) and (58), respectively, of the transverse frame sections (26) and (28). This allows the body (38) and the frame (22) to work as one unit, each strengthening and supporting the other. There is effectively no load or bending moment on the frame sections (24),

(26) and (28) of the truck (20) that are imposed by the dump body (38) itself or by the load or contents in the body (38).

The truck (20) also generally has a cab (60) that typically houses the controls for operating the truck (20). The cab (60) also typically houses suitable conveniences for the truck operator, though not shown, such as one or more seats, windows, environmental controls, doors, audio and communication devices, and the like. The cab (60) in the present example is positioned at one end of the frame (22) near the forward transverse frame section (26), and is supported by the frame (22) in an elevated position. The cab (60) can be located on either side of the truck (20) or in the middle above the axis "A". In this example, the cab (60) is positioned somewhat forward of the front wheel and tire assemblies (30) and below or beneath the forward end (40) of the dump body (38). This position increases the visibility for the operator and will allow the operator to see the front wheel and tire assemblies (30) at all times, if necessary.

The central section (24) of the frame (22) interconnects the forward and rear transverse sections (26) and (28), and hence, the front strut or suspension modules (32F) to the rear strut modules (32R). The central frame section (24) in the present example contains one or more power modules (66) which can have radiators (61), engines (62), alternators (64), one or more fuel tanks (68) (such as for engine fuel), one or more hydraulic fluid tanks (70)

218 2/22
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(such as for brake fluid or other hydraulically actuated system fluid), as well as other auxiliary truck components.

It is very important that the load is dumped as quickly as possible to assure the maximum productivity of the truck (20). The high pressure oil to tip the dump body (38) enters through a rod end (47) of the multistage dump cylinder (48). The rod end (47) is connected near the front of the body (40). This is a very long distance from the hydraulic pumps on the engine (62). Large enough pumps and hydraulic lines needed to dump the load in a reasonable time would be impractical. Therefore, one or more hydraulic accumulators (72) are mounted to the underside (46) of the dump body (38) in close proximity to the dump cylinder (48) to assist in quickly lifting the dump body (38) and its contents. The accumulators (72) in this example are connected through two large dump valves (74) to assure adequate flow to the rod end of the dump cylinder (48) near the forward end of the center section (24) of the frame (22). An additional hydraulic tank (76) is in close proximity to the dump valves (74) to quickly receive oil from the dump cylinder (48) as the body (38) is lowered to the frame (22).

One convenient location for additional accumulators (72), to help power the dump cylinder (48), the steering cylinders (132), and the constant leveling of the struts (100), is inside the center section (24) of the frame (22). High pressure gas cylinders (78), normally nitrogen gas, can be located in this center section (24) to store the energy to power the accumulators throughout

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the truck (20). Alternatively, these gas cylinders (78) and accumulators (72) can be mounted virtually anywhere on the truck as desired. As the load increases on the truck, the gas in chambers (98) and (99) in the strut (100) compresses (See FIG. 6 and the description below) and oil from the accumulators (72) then flows into chamber (97) keeping the truck height constant in both the loaded and unloaded condition.

The configuration and arrangement of the I-shaped frame (22) and dump body (38) produces a decreased empty weight of the truck (20) as compared to prior known truck configurations. The frame (22) and body (38) configuration also yields the added benefit of having space for two additional tires (34) on each side on the front suspension modules (32F) of the truck as compared to only one tire per side on conventional truck designs. The configuration of the strut modules (32), described in greater detail below, also permits mounting the two additional tires (34) and rims (36) on the forward end of the truck at only a minimal increase in cost and weight. The additional cost and weight is only due to the other wheel and tire assembly (30). Due to the available space created by the truck (20) configuration, a second power module (66) can also be easily attached to the frame (22) vastly increasing the productivity of the truck (20). The close proximity of each tire to the strut is important to help reduce the overall width of the truck. The turning envelope of the tires on a strut is accommodated by the ample space beneath and between the frame components. The turning envelope of one strut must,

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however, clear the envelope of an adjacent strut to permit the large strut rotation angles

The frame (22) and body (38) configuration also conveniently allow for a wheelbase 50% longer than conventional trucks. As a result of the significantly longer wheelbase, the weight shift between axles is minimized while operating the truck (20). Less weight shift reduces both static and dynamic loads on the frame (22) and body structure (38). Less weight shift also reduces the load on the front tires (34) while cornering. It is an important feature that on the front of the truck (20) there are four tires (34), two on each side, to absorb the side forces and forward weight shift when turning.

Referring now to FIG. 6, a strut module (32) is generally shown in partial cross section with the outside wheel and tire assembly (30) removed. Each strut module (32), however, includes the two tires (34) in this example mounted on the respective rims (36) which are in turn carried on opposite sides of the strut (100). In the present example, the two spindles (142) are fixed to the strut rod (110) and do not oscillate.

Though described in greater detail below, each module (32) generally has a hydraulic strut assembly (100) which is attached above the tires (34) to a respective end of one of the transverse frame sections (26) or (28). One strut assembly (100) depends from each of the four corners of the truck (20). Each strut assembly (100) has a fixed strut housing (102) secured to and depending from its respective frame section (26) or (28). Each strut housing (102)

defines a strut axis "S" shown generally vertical in the present example when in the normal ride position. A steer tube (104) in the present example is arranged co-axially with and received over each strut housing (102) and is adapted for rotational movement relative to the respective housing (102). A steering link (106) is affixed near the upper end of each steer tube (104) and defines a plane generally perpendicular to the strut (100) axis "S". As shown best in FIG. 5, each steering link (106) defines a pair of generally opposed steer arms (108) and (109). The steer arms (108) and (109) are manipulated as described below to independently steer each of the strut modules (32).

Each strut assembly (100) also has a cylinder rod (110) telescopically received within the housing (102) that is slidable relative to the housing (102). The cylinder rod (110) is positioned at about its midpoint in vertical travel range relative to the housing (102) when in the normal ride position so that it can extend from the housing or retract into the housing as needed when traveling over varying terrain. A spindle housing (112) is affixed on the bottom end of the cylinder rod (110) and has a cylindrical wall portion (114) that surrounds the exterior surface of the steer tube (104) at its lower end. The spindle housing (112) can move vertically with the cylinder rod (110) and relative to the steer tube (104). The cylinder rod (110) and housing (102) operate as a conventional hydraulic strut (100) to cushion the load. Thus, the spindle housing (112) can move vertically relative to the respective frame section (26) or (28) for shock absorption.

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5 A scissors link (120) has a first link arm (122) pivotally coupled at a first pivot joint (124) defined by a first bracket (125) affixed to the steer tube (104). The scissors link (120) also has a second link arm (126) pivotally coupled at a second pivot joint (128) defined by a second bracket (129) affixed to the spindle housing (112). The outer ends of the first (122) and second (126) link arms are coupled to one another at a third pivot joint (130). The pivot joints (124), (128) and (130) of the scissors link (120) permit the spindle housing (112) to move freely relative to the steer tube (104) and strut housing (102) along the strut axis "S". Each component of the scissors link (130), however, is sturdily designed to prevent relative rotation between the steer tube (104) and spindle housing (112). Thus, as the steer tube (104) is rotated about the strut axis "S" by movement of the steering link (106) as described below, the spindle housing (112) is also rotated to turn the wheel and tire assemblies (30).

15 As shown in FIGS. 2 and 5, each strut module (32) is steered independently by a pair of extendible hydraulic steer cylinders (132) and (133) each having one end pivotally connected to a respective one of the steer arms (108) and (109) of the steering link (106). The opposite ends of the steer cylinders (132) and (133) are pivotally coupled to bracket portions of the frame (22). Each steer cylinder (132) and (133) has an extendible rod (134) controlled by a steer cylinder control valve (131). A pressure indicator on

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each control valve (131) can be utilized via a computer (not shown) to coordinate steer cylinder pressure with wheel motor torque, as necessary.

Appropriate extension and retraction of the steer cylinders (132) and (133) of a particular strut module (32) will rotate the respective steer tube (104) about the strut housing (102) relative to the axis "S" to turn the spindle housing (112), and hence, the wheel and tire assemblies (30). In one example, the tires (34) and wheels (36) of a particular module (32) can be steered more than 90 degrees, such as about 110 degrees or more in each direction, as shown in FIG. 2, from a nominal or rest position, as shown in FIG. 5.

Referring to FIG. 9, each wheel and tire assembly (30) can be independently driven by a discrete motor (140) that is internally mounted inside a spindle (142) supporting each wheel rim (36). Each motor (140) is preferably an independently controlled electric AC drive motor (140). The motor (140) which derives its power from high speed must be combined with a speed reducer (139) to obtain high torque to produce the draw-bar required to propel a truck (20) of this type through soft ground and up steep hills. The truck (20) having high torque and the independent all wheel drive capability will give unique utility for the mining and construction industries. As shown in FIG. 9, each spindle (142) carries one motor (140) internally and supports two bearings (136) which, in turn, support a hub (144), which supports the speed reducer (139), a rim (36), and preferably one of the tires (34). Each spindle housing (112) has two spindles (142), one on each side connected to a

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central structure containing a tapered hole which accepts the strut rod (110).

Each motor (140) drives only one of the two wheel and tire assemblies (30) of each strut module (32) and, therefore, each tire (34) can be driven independently, as necessary. The spindle (42) and hub(44) each support a section of a wheel brake (138), which, when actuated, restricts relative motion of the hub and spindle.

Each strut module (32) also has an air cooling system for the AC drive motor (140) utilizing air circulated through the spindle housing (112) and spindles (142). One example of the cooling system for each strut module (32) is shown in FIGS. 7-9 and simply described herein. Contained in the module (32) is an air inlet (145) positioned between the respective pair of tires (34) and, preferably, even with the top surface of the tires (34). This air inlet duct (146) contains a motor (147) which drives a fan (148) forcing cooling air through an air cleaner (149) into the spindle housing (112) through an air inlet (150) into an inlet air chamber (151) divided by plate (152) to separate the inlet air from the outlet air. Air then enters the motor (140) through holes (153) in the non drive end of the motor (140), then through holes (154) through the stator and holes (155) through the rotor. The air leaves the motor (140) through holes (156) in the motor housing (160). The air then travels back over the motor (140) through the gap (157) defined by the inside diameter of the spindle (142) and the outer diameter of the motor (140). The air then enters the outlet air chamber passing the plate (152) which separates the incoming air

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from the out going air. The air then exits the spindle housing through a hole (159).

In one example, the air that exits hole (159) after cooling the motor (140) passes through an exhaust duct (168). The exhaust duct (168) has one end coupled to the outlet opening (159) and an opposite end defining an exhaust opening (170) positioned between the respective tires (34) of the strut module (32) and again, preferably, even with the top surface of the tires (34). The air will flow from the outlet opening (159) through the exhaust duct (168) and exit the exhaust outlet (170). The position of the outlet (170) prevents the warm exhaust air from heating the inner surface of the tires (34).

In a further example, the exhaust duct (168) can effectively become an oil cooler for a wet disc brake system (138). High volumes of air must be used to keep the motor (140) cool, therefore, the air leaving the motor (140) will be much cooler than the hot cooling oil leaving the brakes (138). The air can be circulated over the tubes (165) carrying the oil from the brakes (138) to the pumps (167), and back to the brakes (138) through the exhaust duct (168) oil cooler, cooling the oil and the brakes as required. The pumps (167) are driven by a motor (166) whose energy source can be high pressure oil from the accumulator (72) system that can be available on the truck. The inlet fan motor (147) of the air inlet duct (146) can also receive its supply power from the same accumulator line (190) shown in FIG. 10D. In summary, the

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disclosed strut construction allows the fan motor (147) and fan to circulate cooling air to the traction motors (140) and the oil cooled disc brakes (138).

In one example, the inlet air duct (146) can be affixed at the inlet opening (150) to the front of the spindle housing (112). The exhaust duct (168) can be affixed at the outlet opening (159) to the rear of the spindle housing (112). The exhaust duct (168) passes through the upper scissors link bracket (125) affixed to the steer tube (104) and is free to move up and down with the spindle housing (112) free of the steer tube (104). As shown in FIG. 10, the various hydraulic lines (172) for the fan motor (147) and the hydraulic lines for the parking (192) and service brakes (194) will be routed outside the scissors link (120).

Each strut module (32) is therefore composed of the strut (100), the various steering components, the spindle housing (112) and spindles (142), the wheel drive motors (140), speed reducers (139), the two brakes (138), and the cooling systems for the motors and the brakes. Also included in each strut module (32) are two hubs (144), two rims (36) and two tires (34). Each strut module (32) further includes the air flow cooling system, hydraulic and electric power cables, hydraulic lines to the brakes, and the motors to drive the cooling fan and the wet disc brake cooling oil pump. The strut module (32) construction and the frame (22) construction of the truck (20) produces a number advantages and benefits that are not available with conventional trucks of any size.

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In one example, the steering link (106) and the two steer arms (108) and (109) are fixed to the steer tube (104) above the highest point of the tires (34) when the strut (100) is collapsed. With each of the steering cylinders (132) and (133) properly spaced and with adequate length of stroke, rotational angles well beyond 90 degrees can be attainable. In operation, each pair of the hydraulic steering cylinders (132) and (133) can turn the respective strut module (32) well above 110 degrees in each direction, for example, to achieve many different turning patterns for the truck (20) as exemplified in FIGS. 2 and 11A-11F. The wheels are always turned about a given common turning focal point unless when the vehicle is moving in a straight line.

By aligning the tires (34) of each strut module (32) as needed depending on the length and width of the truck (20) wheel base as shown in FIGS. 2 and 11E, the truck (20) can rotate about its center point while requiring only 45%, or less than half, of the turning area or radius of conventional trucks. The tires (34) can also be turned to any position while remaining parallel to one another as shown in FIGS. 11A- 11C. Thus , the truck (20) can be driven in a straight line and yet the body (38) and frame (22) can be oriented at virtually any angle relative to the longitudinal axis "A" of the truck. In addition, as shown in FIGS. 11D and 11F, any two strut modules (32) can be steered independent of the other two strut modules (32) and independent of each other to steer the truck (20) relative to any side or end, not just from the front end as with conventional trucks. Many benefits can be

228 2/32
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achieved by such steering flexibility. In addition, because each tire (34) on each strut module (32) is independently driven by its own motor (140), the two tires (34) on a module (32) can be driven at slightly different speeds, eliminating tire scrubbing when turning.

5 The truck (20) need be no wider and no higher than a conventional truck, and yet can carry approximately twice the load and can weigh only slightly more than a conventional truck when empty. Conventional off-highway trucks must ride on relatively good, smooth surfaces in order to travel efficiently, such as on prepared mine roads. The truck (20) can travel
10 efficiently on less than ideal surfaces and can travel up steeper grades because of its all wheel drive characteristics. These factors can significantly reduce the cost of hauling material and also can significantly contribute to reducing the cost of operating an entire mine.

In one example, the steering cylinders (132) and (133) can contain a
15 linear displacement transducer to determine the axial position of each extended steer cylinder rod (134) to further determine the angle of the axis of the tires (34). An onboard computer (not shown) of the truck (20) can track this angle for each module (32) and will signal the appropriate controller of the other steering cylinders for the other modules (32). In this way, the rotated
20 position about the strut axis "S" can be controlled. For example, all tires (34) can be controlled to either roll on parallel wheel axis' to move the truck (20) in a straight line, as shown in FIGS. 11A-11C. Alternatively, the wheel axis' can

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229
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be controlled so that they all intersect at a common point to provide a desired and proper radius as shown in FIGS. 11D- 11F.

5 The modules (32) can be dynamically steered independently to maintain the common intersection point while turning and straightening the truck (20). This intersection point can be determined and controlled by a computer (not shown). The angle of the tires can be controlled in conjunction with linear displacement transducers (201) (see FIG. 12) integral with the steer cylinders (132) and (133). All tire (34) distances from this common intersection turning point will be known at all times, allowing the relative tire speeds to be controlled by the independent motor controllers (179). The tires (34) will then pull evenly, eliminating tire scrubbing while turning or traveling in a linear path.

10 As noted above, in one example, the intersection point can be moved to a position equal distance between the front and back modules (32F) and (32R), respectively, and to a point at the center of the truck (20) as shown in FIGS. 2 and 11E. In this steered configuration, the truck (20) can rotate about itself. Thus, the truck (20) can be turned around without moving forward or backing up in and within a very tight space. This is not possible with a conventional truck.

15 20 In another example exemplified in FIGS. 11A and 11C and as shown schematically in FIG. 3, the truck (20) can be positioned to dump contents from the body (38) either parallel to the truck axis "A" or perpendicular to the

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axis "A", as desired, or at some other angle as desired. This again can be done in very tight spaces without backing up the truck (20). This is done by rotating all strut modules (32) at the same rate so they remain along parallel wheel rotation axis "W" as shown in FIGS. 11A-C. The tires (34) will always be going in a straight line but the truck body (38) will be rotating relative to the direction of travel. The truck (20) need not be backed up to alter the dump body (38) orientation relative to the dump point. Instead, the tires (34) can maintain the direction of travel as the dump body (38) rotates into position to dump the contents. This feature is particularly useful where the truck (20) must be positioned in a tight space to dump into a hopper or be positioned to dump over a bank. In summary, when at the loading shovel or at the dumping point, the truck (20) can move directly into position, and then drive away easily, reducing the time required to maneuver the truck (20) into and out of position for loading or dumping. Thus, the truck (20) effectively is both rear dump and a side dump truck.

Many in the mining industry have recognized the need for a side dump truck. A mining executive in the 1960's stated to the effect that, "[t]he Lord must question our intelligence because we unnecessarily back up to dump a truck in the mines each year an equivalent distance equal to many times around the moon." He could have doubled that distance if he realized that in many instances, a truck must also be backed up to the loading shovel as well, thus essentially doubling the backing distance. The backing distance for both

loading and unloading can be eliminated utilizing the truck according to the teachings of the invention. Also, the significant crew effort required for backing these extremely large vehicles is also eliminated. In addition, when at the loading shovel or the dumping point, the truck 20 can move directly into position, and then drive away easily, reducing the time required to maneuver the truck into and out of position for loading or dumping.

With all the rotation generated by the strut (100) when steering and the up and down motion of the strut (100) on uneven ground and poor roads, the routing of the electric cables (184) and (186) and the various hydraulics lines becomes very important. Slip rings for electric cables are very undesirable and swivel joints for hydraulic lines are impractical. This invention solves these serious problems.

An enclosed chamber (174) is mounted forward of both the forward and rear transverse frame sections (26) and (28). Each is placed above the steer cylinders (132) and (133) and steer arms (108) and (109). Above each enclosed chamber (174), conveniently placed, is the respective AC traction motor control box (179). Through the rear section of this enclosed chamber (174), the steer tube (104) of the strut module (32) is placed. From the motor control box (179) through the enclosed chamber (174), in this example, are 12 electric power cables (175), one ground wire (184), and one hose containing small sensor and control wires (182). From the accumulators (72), four hydraulic lines (188-194) enter the chamber. One line (192) is for the parking

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PATENT
29038/36105A

brake, one line (194) is for the service brake, and one is a high pressure accumulator oil line (190) to power both the fan motor (147) and the motor (166) to power the brake pumps (167) that circulate the brake cooling oil. There is also one low pressure oil line (188) to return oil from these motor two
5 motors (147) and (166). Two small valves (198) and (200) are also provided, one for controlling the fan motor speed as required and the other for controlling the braking pump motor speed as required.

In this example, these power cables (184), (186) and hoses (188-194) are routed directly to the required component in the lower unsprung components of the strut module (32). These cables (184), (186) and hoses (188-194), in this example, are clamped at one end to the enclosed chamber (174). They are all effectively the same length and are stacked three high and held together appropriately to stay in the same vertical plane and to minimize sag. They are in turn supported in a manner to prevent wear between the lower
10 cables (184), (186) and hoses (188-194) and the floor of the enclosed chamber (174). Three of these stacks are loosely connected side by side. They are clamped to the steer tube (104) and are routed around the steer tube (104) down through the steer arm (108) and down over the steer tube (104) and looped appropriately to accommodate the full stroke of the strut (100). The
15 scissors link (106) can help support the bundle as needed. Inside the enclosed chamber (174), nine wires and hoses are routed in two loops (197A and 197B) and looped appropriately to accommodate the rotation of the steer tube (104).
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Nine wires and hoses are routed in the tow loops (197A and 197B) opposite to each other. It would be possible to stack nine or all eighteen of these wires and hoses vertically, but this would increase the height of the truck (20) and the center of gravity of the truck (20) unnecessarily which is undesirable

5 The efficiency of a large hauling truck (which relates to the cost of moving the payload) is proportional to the payload weight (P) relative to the empty vehicle weight (EVW). This is referred to as the payload to weight ratio P/EVW . In an effort to relate this to actual cost of moving a payload, one can multiply EVW times two, add the payload P, then divide this entire amount by the payload P:

$$(EVW*2+P)/P,$$

10 where this equation accounts for the fact that the vehicle moves in both directions to and from the loading point, whereas the payload moves in only one direction to the dumping point. This equation describes the amount of work the truck must do to complete one haulage cycle. Assuming that the payload is one or, $P = 1$, the above equation becomes:

$$(2/P/W+1)/1.$$

15 This equation can be simplified to $2/(P/W)$. For P/W of 2.0, for every dollar it takes to move the payload, it takes \$1 to move the truck. With P/W of 1.5, for every dollar to move the payload, it takes \$1.33 to move the truck. The majority of current off-highway truck designs have a payload to weight ratio between 1.4 and 1.6. The disclosed truck according to the teachings of the

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invention allows P/W ratios of over 2.3, resulting in less than 87 cents to move the truck for ever dollar required to move the payload.

A conventional truck with a two axle and short wheelbase configuration has four tires on the back and only two on the front. Although successful by present industry standards, it is not ideal due to variations in the center of gravity of the load (weight shifts forward when going down hill), and the dynamics of cornering. Under these conditions, front tires can experience high static and dynamic overloads. If a tire fails under these overload conditions, loss of control of the truck can easily result. The disclosed truck (20) can have a 60% longer wheelbase than some competitive trucks and will in turn use four tires (34) on the front axle. This configuration significantly reduces stress on the front tires (34) when under these adverse conditions. Additionally, if one tire (34) on a module (32) should fail, the remaining tire (34) can maintain control of the truck (20).

Another very important factor in the intrinsic value of a vehicle is its performance capability, which relates to the horsepower available to move a unit of material. There are two factors that can be used to compare vehicle performance and productivity. They are Horsepower (HP) per Gross Vehicle Weight (GVW) which is HP/GVW , and the horsepower that is moving the payload (PL), namely, $HP \times PL/GVW$ which is referred to as payload horsepower. With plenty of open space beneath the frame (22) of the truck (20) and with space between the strut modules (32F) and (32R), two of the

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largest conventional truck engines can be easily mounted to significantly increase the performance characteristics of the truck (20). The frame (22) and strut module (32) arrangement also provides unparalleled access to the power modules (66) for servicing and/or replacement. Payload horsepower of the disclosed truck (20) is approximately 2.4 times greater than the largest most productive conventional truck on the market today.

The major components for evaluating vehicle stability dependent upon the height of the center of gravity (CG) and the stability base (SB), or, in actuality, the square of the stability base (SB^2). In most vehicles today, the stability base of the front axle is at the center of the front tires. This arrangement is good for stability, but bad for frame stresses and front tire loading. The stability of the rear axle is the point where the rear suspension effectively reacts at the center line of the rear axle. On most conventional trucks, the stability base between the front and rear axles is normally 5 times greater on the front axle. When this result is squared, the result is that the single front outside tire on the curve on conventional trucks effectively absorbs virtually all cornering side forces as well as the forward weight shift forces generated by cornering. The body is basically held from tipping over by the pins in the rear of the truck that the body pivots about when dumping and very slightly by the narrow frame. This conventional truck arrangement imposes high torsional stress on the narrow frame and overloads (during a turn) the single outside front tire to an extremely high degree. The disclosed truck (20)

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distributes the cornering forces equally to the four tires on side of the truck (20) that is on the outside of the curve. The long wheelbase minimizes the forward weight shift generated by cornering. This minimized weight shift is absorbed by two tires (34) rather than one tire on conventional trucks. This is one of the very important features of this invention is that under all similar operating conditions the tires (34) will be under less stress not only reducing tire (34) cost but will allow the truck (20) to perform well at higher speeds and greater loads.

When dumping, conventional trucks locate their dump cylinders somewhere between the two axles requiring the cylinders to lift the entire weight of the body and the load. This load is transmitted directly into the frame. This location of the cylinders thus puts maximum stress on the frame. In the disclosed truck of this invention (20), the dump cylinder (48) is mounted to the frame (22) between the front strut modules (32F). Thus, the dump cylinder (48) is required to exert a force one half the weight of the body (38) and load. The other half of this weight is supported by the pivot pins (43) in the rear of the truck (20). The load is transmitted directly in to the strut modules (32F), and not between the front and rear modules (32R) along the truck axis "A". This arrangement effectively eliminates bending stresses in the frame and reduces stress in the body (38) also allowing the frame (22) to be much more robust but lighter than frames of conventional trucks. FIG. 2 shows accumulators (72) that will help to greatly reduce the time required to

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PATENT
29038/36105A

dump the truck (20). The are closely mounted to the dump cylinder (48) to improve the flow characteristics of the oil from the accumulators (72) to the dump cylinder (48). This arrangement allows the truck (20) to dump and return the body (38) in less than one half the time it takes to dump and return the body on conventional trucks dumping loads almost twice as large.

All conventional trucks must stop, change direction, and back up to a bank or a hopper to dump the load. However, this is dangerous for at least two reasons. First, the driver must be very attentive or he will back over the bank or into an object. Second, inertia force generated from the truck's weight as the brakes are applied to stop at the edge of a bank can, on occasion, cause the bank to collapse.

This stopping, reversing, turning, backing up and stopping again is not only hard on the truck but is time consuming. This conventional procedure also takes place every time the truck backs under a shovel to get loaded and backs to a dumping site to unload. The disclosed truck (20) eliminates this unproductive, unsafe and wasteful maneuver completely at both ends of the haul cycle.

The disclosed dump truck (20) allows greater capacities, higher efficiencies, and improved maneuverability. In addition, all tires (34) can be driven and steered independently, allowing for superior mobility under poor hauling conditions. The disclosed truck (20) is a very rugged, very heavy duty and yet a very light weight truck relative to its capacity with remarkable

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PATENT
29038/36105A

performance features under the most adverse conditions. The disclosed truck
(20) is a major step forward, not only in truck carrying capacity, but in every
characteristic that the earth moving industry needs to both increase production
and to reduce cost of moving material. Importantly, the disclosed truck can
5 thus reduce the cost of operating a mine, construction site, or the like.

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What is Claimed is:

1. A truck comprising:

a frame;

5

a forward strut support coupled to the frame;

a rear strut support coupled to the frame;

first and second strut modules coupled to the forward strut support;

third and fourth strut modules coupled to the rear strut support,

wherein each of the strut modules includes;

10

a strut assembly oriented having an upper end, a lower end, and
a strut axis, the strut assembly having a strut housing affixed at the upper end
to part of the truck frame concentric with the strut axis and having a steer tube
arranged to rotate about the strut axis relative to the strut housing;

15

a spindle assembly having a pair of oppositely disposed
spindles extending from a spindle housing and defining a wheel rotation axis,
the spindle assembly being carried at the lower end of the strut assembly for
co-rotation with the steer tube about the strut axis, the spindle assembly
constructed for damped movement along the strut axis relative to the truck
frame;

20

a pair of wheel and tire assemblies, one each supported by a
respective one of the spindles for rotation about the wheel rotation axis;

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PATENT
29038/36105A

a pair of drive motors, one each associated with each of the
spindles for drivingly rotating the respective wheel and tire assembly about the
wheel rotation axis;

5 a steering mechanism adapted to rotate the steer tube and
spindle assembly relative to the strut housing of each strut module independent
of the others strut modules; and

an air cooling system constructed and arranged to pass ambient
air through at least part of the motors to dissipate heat from each motor.

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OFF-HIGHWAY OFF-ROAD DUMP TRUCK

ABSTRACT

5 A normally off-highway off-road dump truck is disclosed. The truck
has a frame with a central frame section, a forward strut support coupled to the
central frame section, and a rear strut support coupled to the central section.
The truck has first and second strut modules coupled to the forward strut
support and third and fourth strut modules coupled to the rear strut support.
10 Each of the strut modules is steerable and each of the strut modules includes at
least one tire mounted thereon. In one example, the strut modules are
steerable such that the truck can be driven in parallel to its longitudinal axis
and can also be driven substantially perpendicularly to its longitudinal axis. In
a further example, the truck is a dump truck with a dump body supported by
15 the frame that can be dumped regardless of the direction of travel of the truck
via the strut modules.

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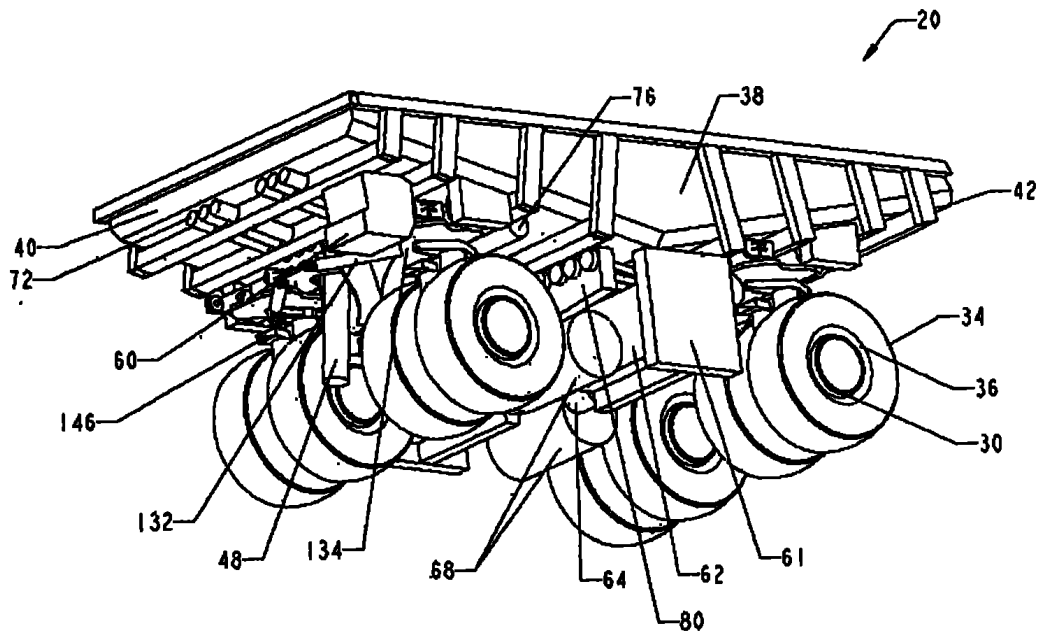


FIG. 1

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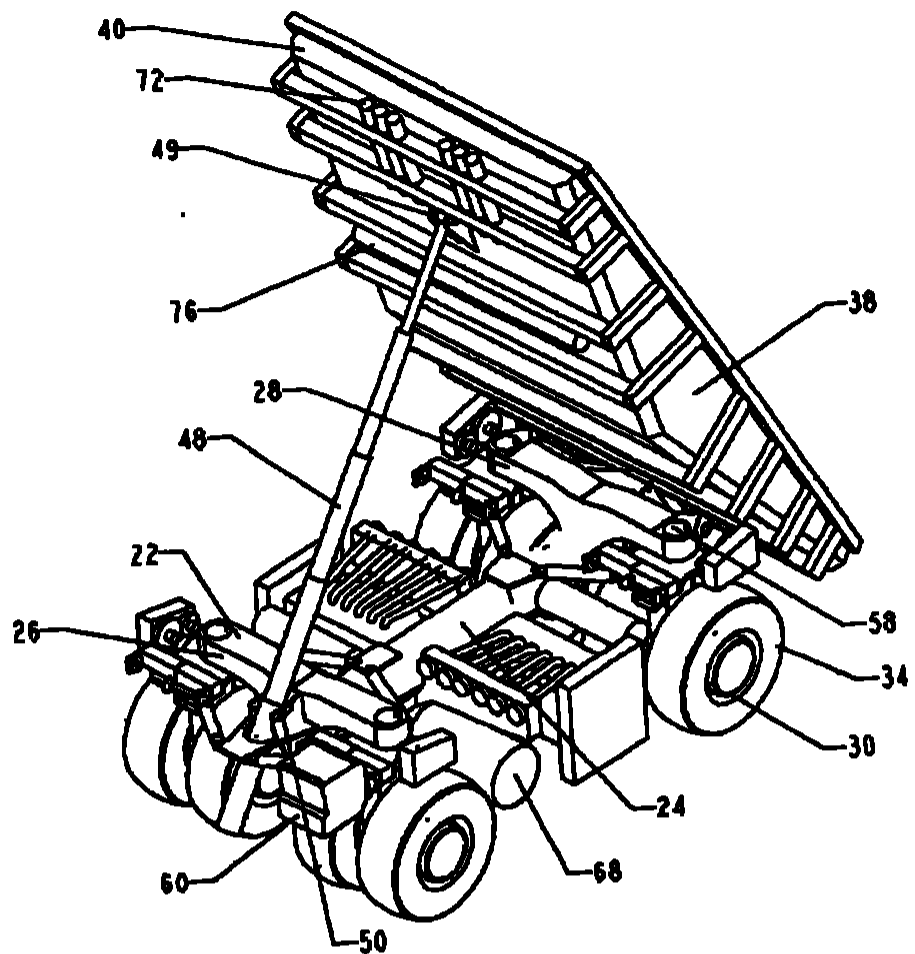


FIG. 2A

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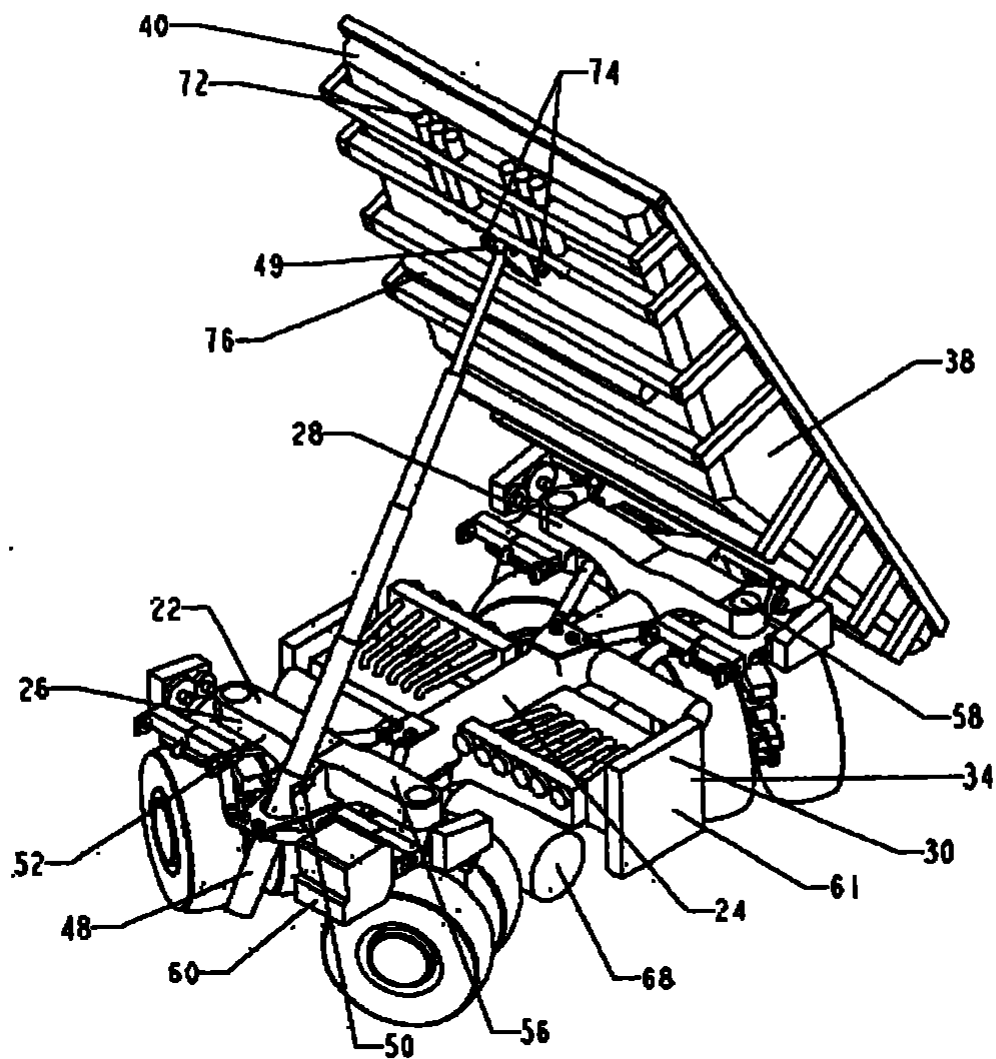


FIG. 2B

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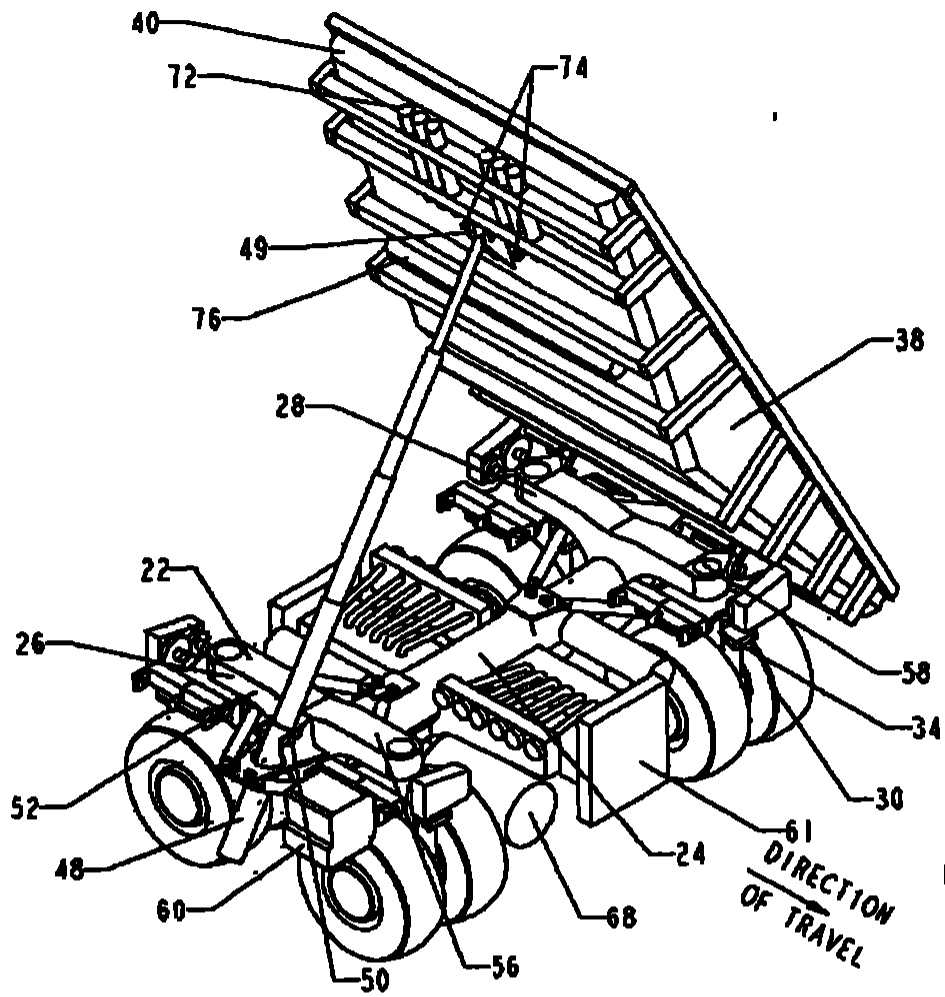


FIG. 3

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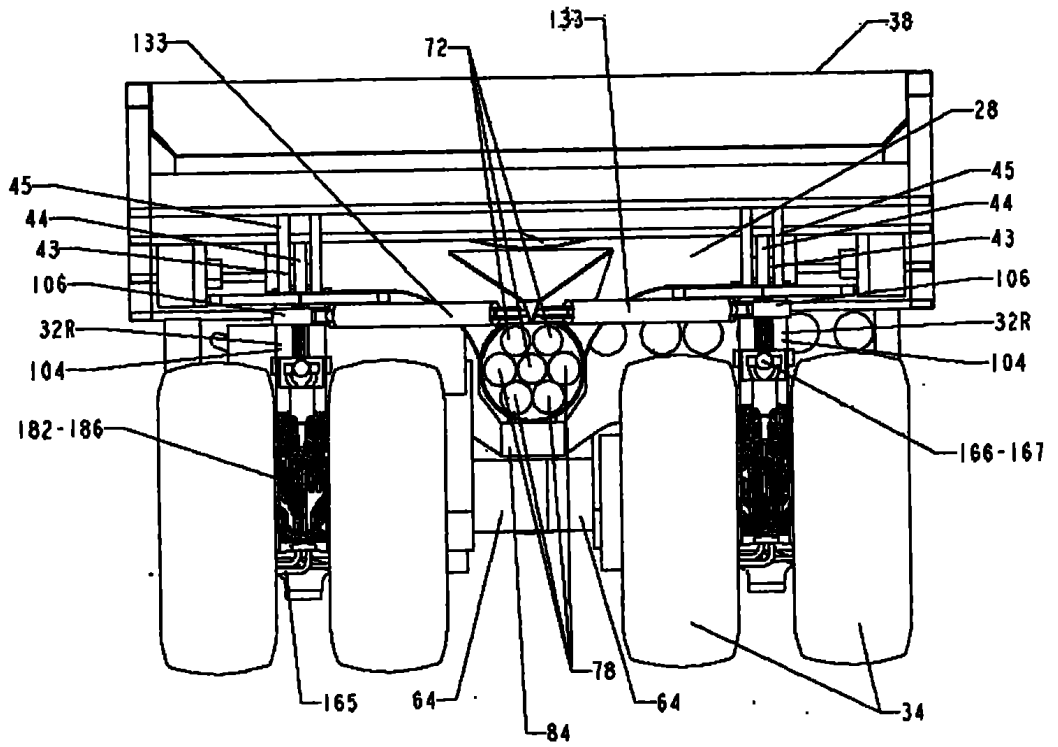


FIG. 4

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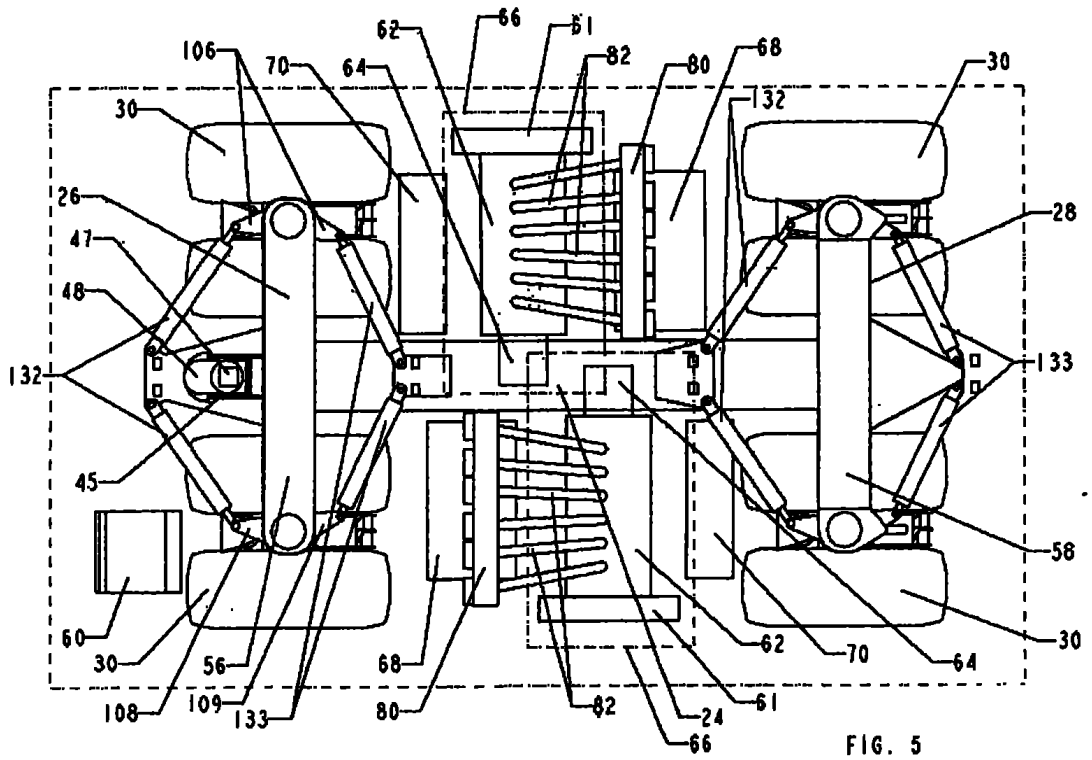
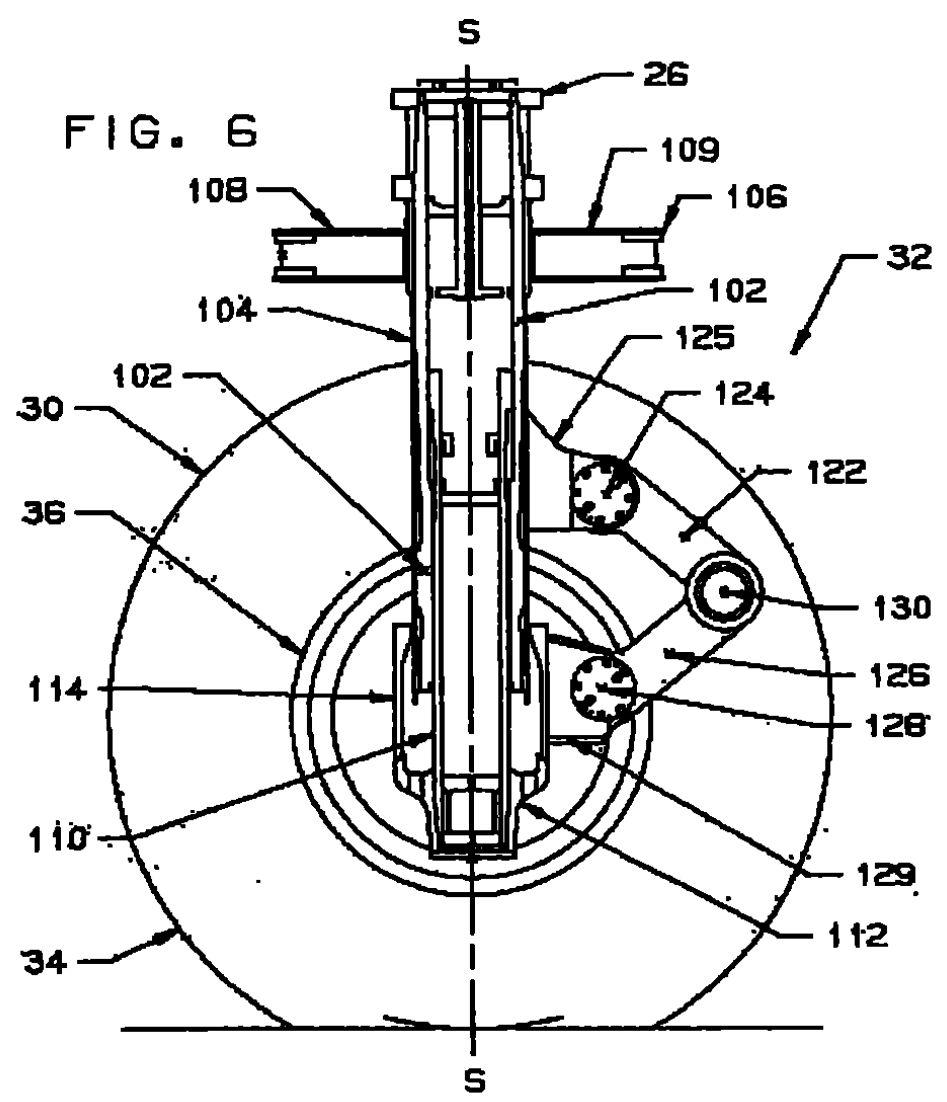


FIG. 5

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FIG. 6



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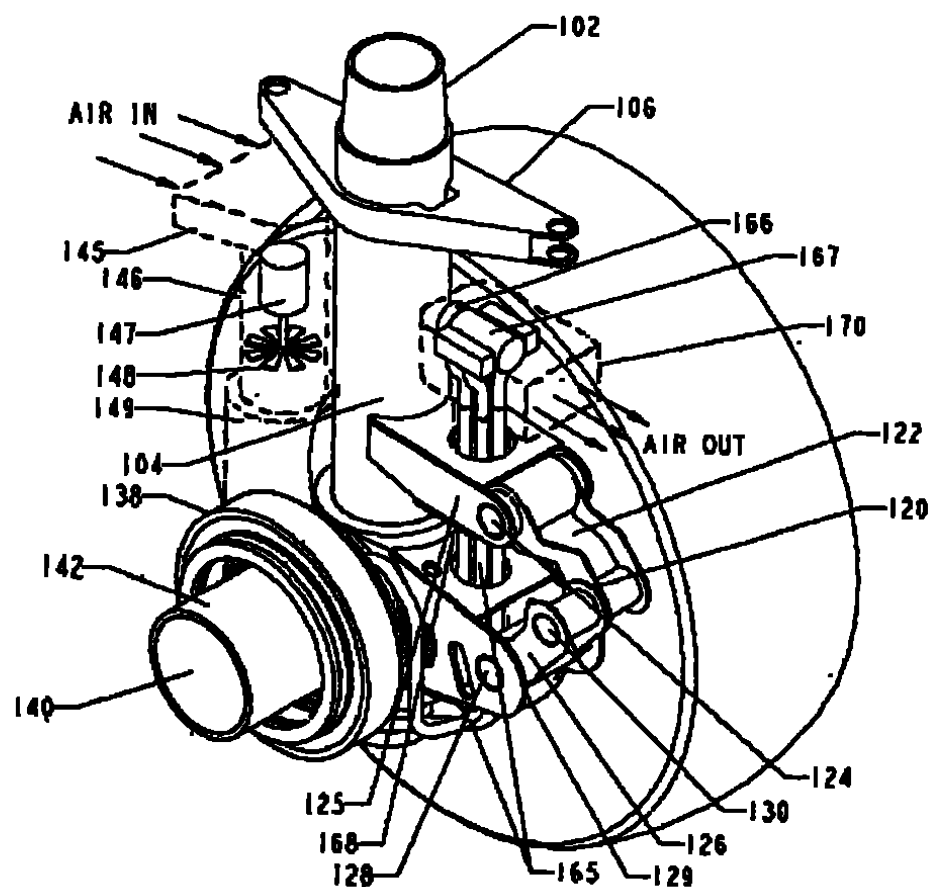


FIG. 7

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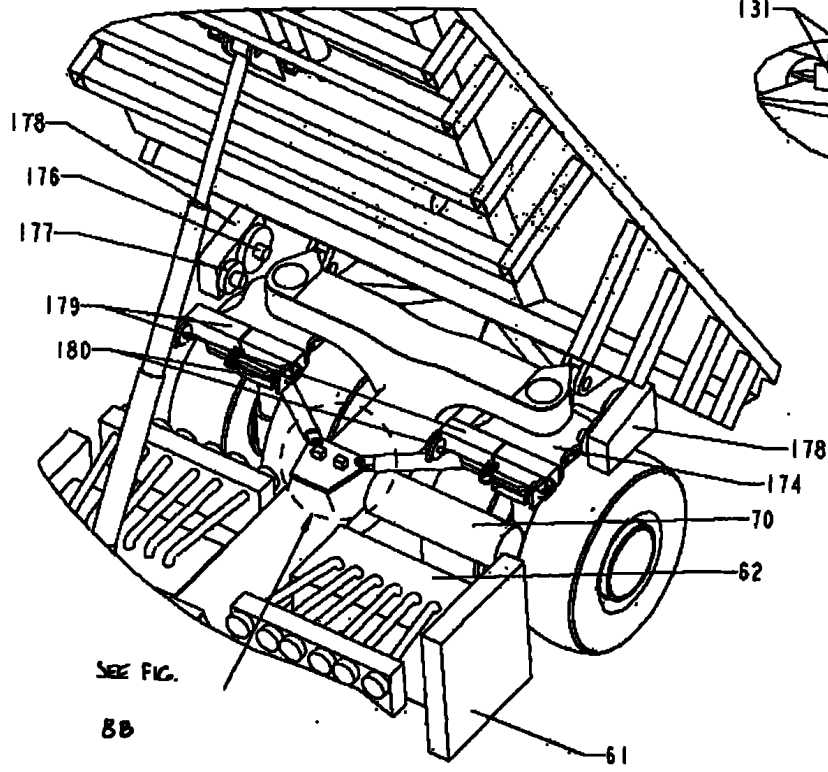


FIG. 8B

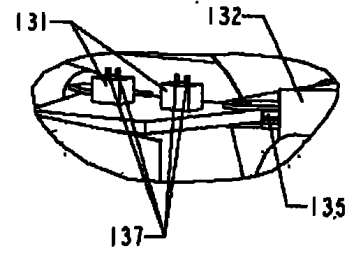


FIG. 8A

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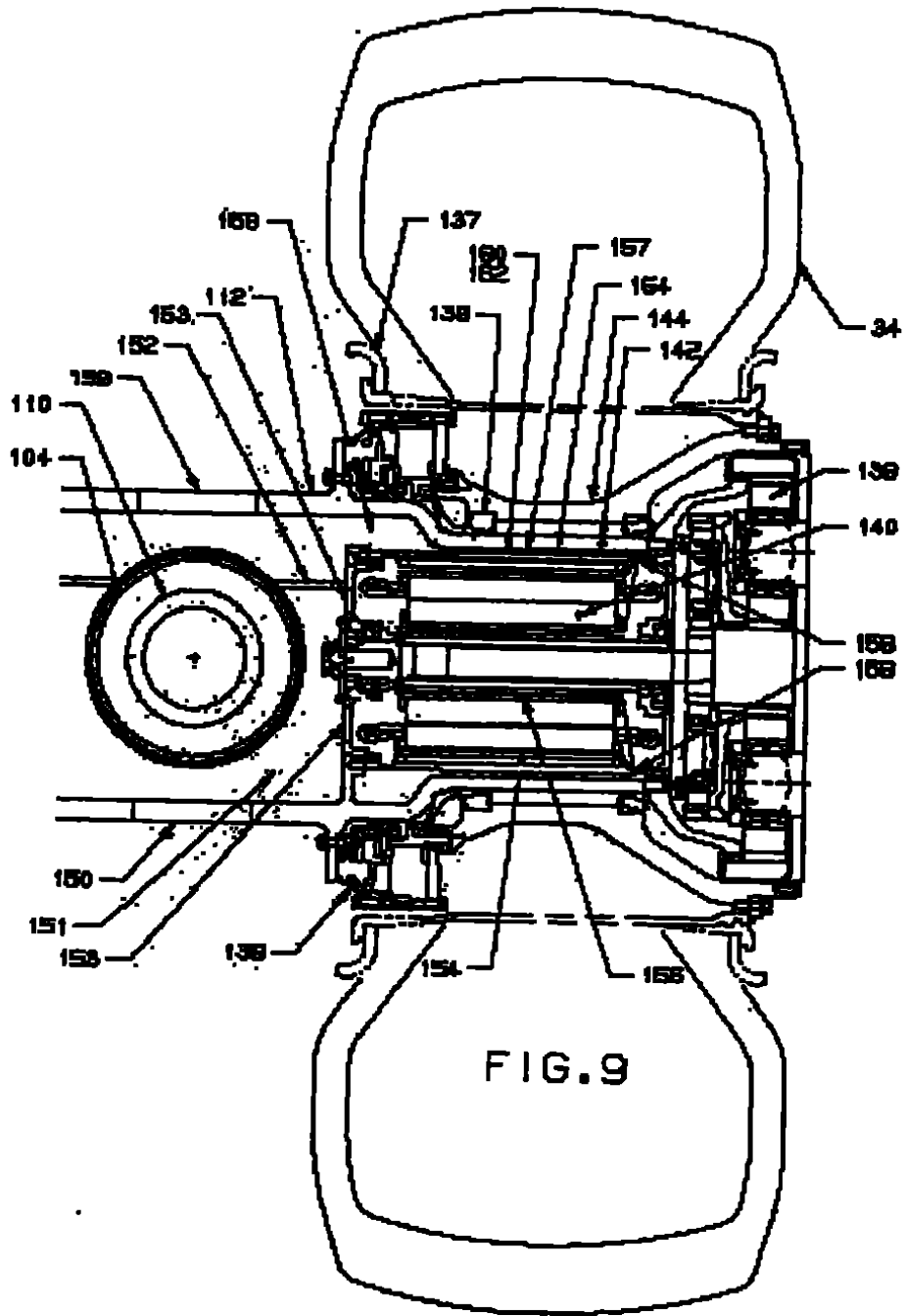


FIG. 9

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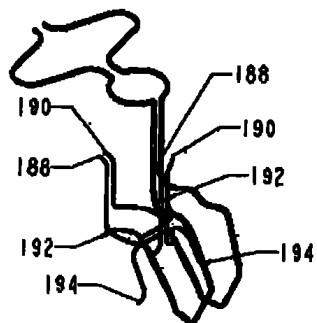
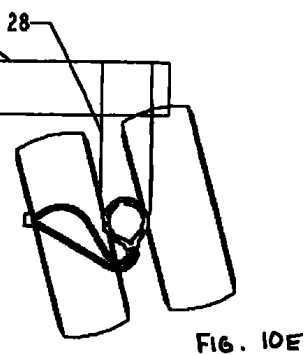
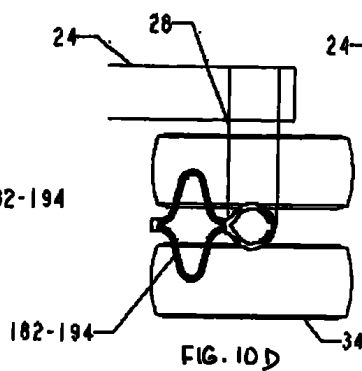
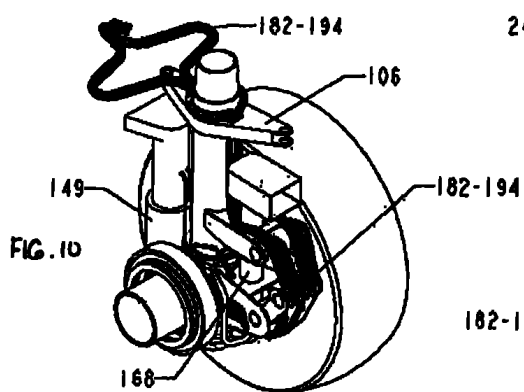


FIG. 10C

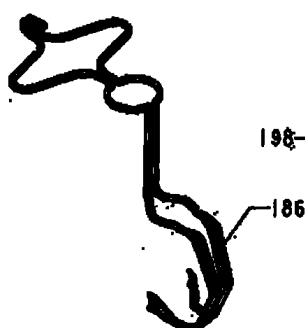


FIG. 10A

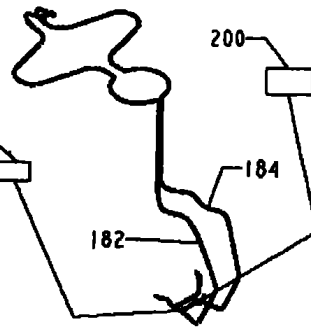


FIG. 10B

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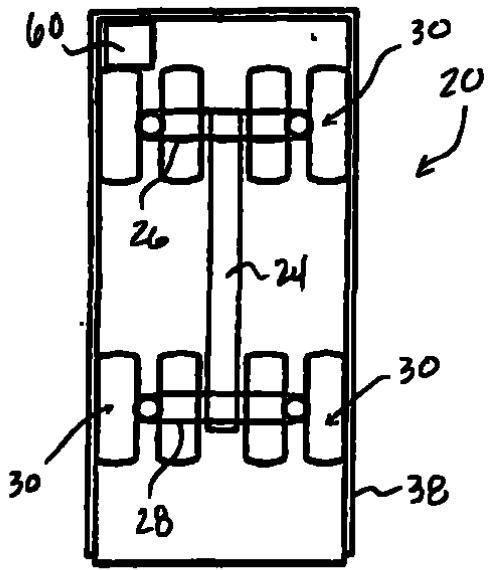


FIG. 11A

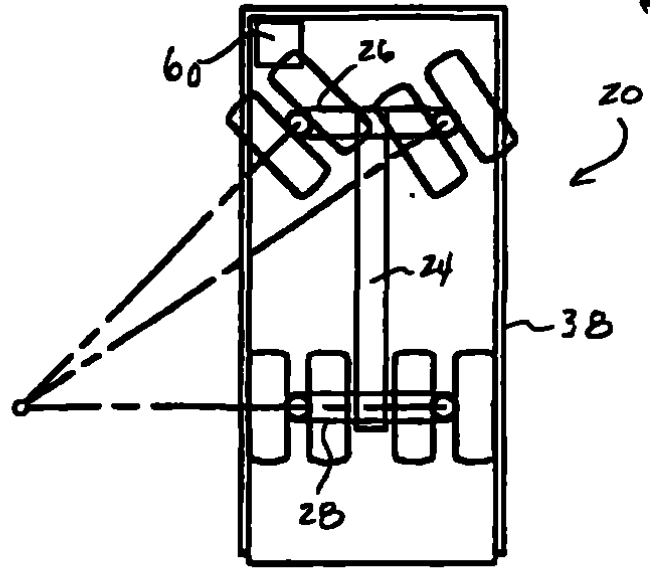


FIG. 11D

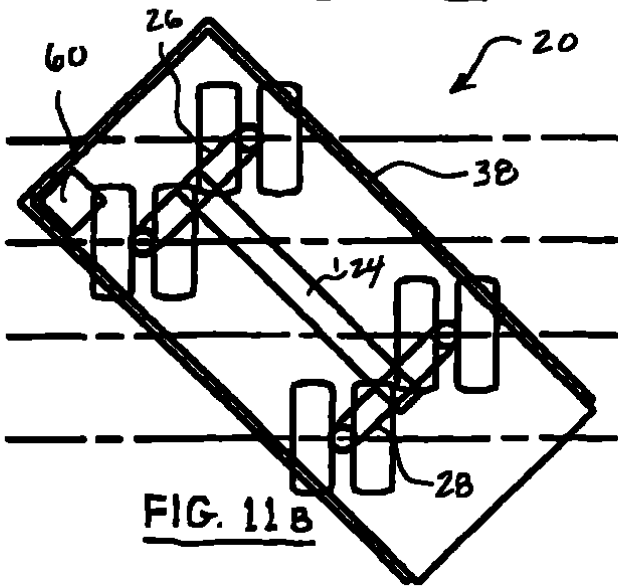


FIG. 11B

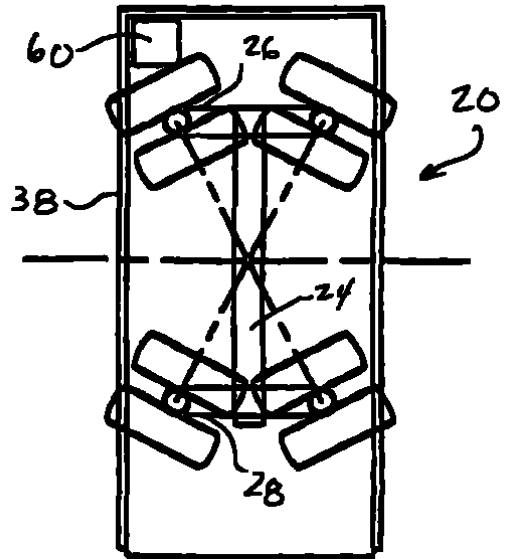


FIG. 11E

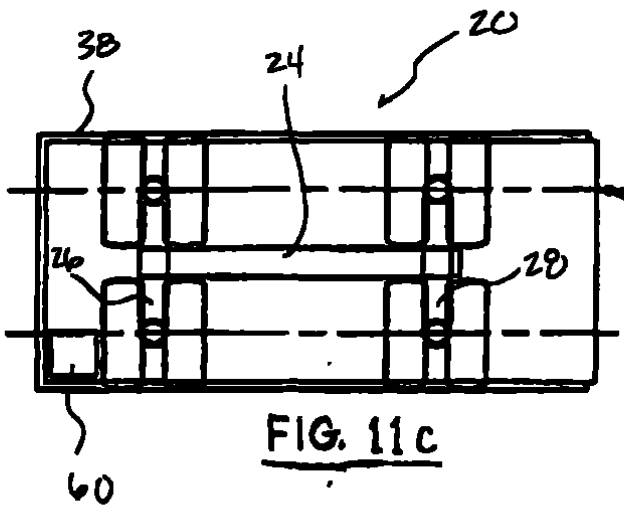


FIG. 11C

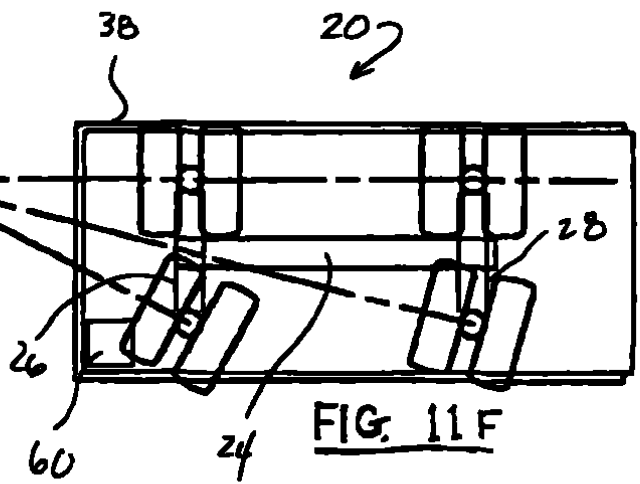


FIG. 11F

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ESTADOS UNIDOS DE AMÉRICA

A QUIEN INTERESE

DEPARTAMENTO DE COMERCIO DE ESTADOS UNIDOS

Oficina de Patentes y Marcas de Estados Unidos

21 de junio de 2001

EL PRESENTE TIENE COMO OBJETO CERTIFICAR QUE LOS ANEXOS AL PRESENTE INSTRUMENTO SON UNA FIEL COPIA DE LOS REGISTROS QUE REPOSAN EN LA OFICINA DE PATENTES Y MARCAS DE ESTADOS UNIDOS DE LOS DOCUMENTOS CORRESPONDIENTES A LA SOLICITUD DE PATENTE QUE APARECE A CONTINUACIÓN, Y QU ELLOS CUMPLEN CON LOS REQUERIMIENTOS EXIGIDOS PARA QUE SE LES CONFIERA UNA FECHA DE RADICACIÓN SEGÚN EL CÓDIGO 35 USC 111.

NÚMERO DE SOLICITUD : 09/758,703

FECHA DE RADICACIÓN: enero 10 de 2001

Autorizado por el COMISIONADO DE PATENTES Y MARCAS

(Firmado) H.L. JACKSON /Funcionario de Certificaciones

25 280
X

SOLICITUD DE PATENTE

EN LA OFICINA DE PATENTES Y MARCAS DE LOS ESTADOS UNIDOS

Expediente No.: 29038/36105B

SOLICITUD DE PATENTE TRANSMITIBLE BAJO 37 C.F.R. 1.53

**Casilla para Solicitud de Patente
Comisionado para Patentes
Washington, D.C. 20231**

Señor:

Adjunto se transmite para registro la solicitud de patente de el (los)

Inventor (es) : Edward S. Kres

**Titulada : CAMIÓN DE DESCARGA PARA OPERAR FUERA DE
AUTOPISTAS Y FUERA DE CARRETERAS**

1. Tipo de Solicitud

- ☒ Esta es una solicitud nueva para una patente de modelo de utilidad
- ☒ Esta solicitud está relacionada con otra solicitud provisional que se encuentra pendiente en los Estados Unidos Serie No.60/177,147, presentada en enero 20, 2000.

2. Documentos Incluidos en la Solicitud

- 1 Página con el Título
- 34 Páginas de Especificaciones(excluyendo las reivindicaciones, el Resumen, los Dibujos & Listado de Secuencia).
- 2 Página(s) de Reivindicaciones
- 1 Página(s) de Resumen
- 12 Hoja(s) de Dibujos (Figuras 1 a 11)

☐ Formal

☒ Informal

0 Página(s) de Listado de Secuencia

CERTIFICACIÓN BAJO 37 CFR 1.10

Por medio de la presente certifico que esta Solicitud de Patente Transmisible y los documentos adjuntos referidos con ella, están siendo entregados, en un sobre dirigido al Comisionado para Patentes, Washington, D.C. 20231, sobre _____.

Entregado por

256 261 174

3. Declaración o Juramento

- ☐ Adjunto
- ☐ Llevada a cabo por (revise todas las posibilidades)
- ☐ Inventor(es)
- ☐ Representante Legal del Inventor(es)
(37 CFR 1.42 o 1.43)
- ☐ Co-Inventor o persona que expresa interés en la propiedad a favor del Inventor quien se rehúsa a firmar o no puede ser encontrado
- ☐ Se adjuntan la petición requerida bajo 37 CFR 1.47 y la declaración requerida bajo 37 CFR 1.47. Ver el numeral 5D abajo para la tasa.
- ☒ No se adjunta-el agente o el abogado abajo firmante esta autorizado para presentar esta solicitud en representación del solicitante(s). Se presentara una declaración cumpliendo con las formalidades.

4. Estatus de Pequeña Entidad

- ☒ El solicitante reclama el estatus de pequeña entidad. Ver 37 CFR 1.27
- ☐ Se adjunta declaración(es) de pequeña entidad.

5. Documentos Adicionales Adjuntos

- ☐ Corrección Preliminar
- ☐ Exposición de la Descripción de la Información
- ☐ Declaración de Depósito Biológico
- ☐ Copia legible de computador de listado de secuencia, conteniendo la secuencia de nucleótidos y/o de amino ácidos
- ☐ Microficha de programa de computador
- ☐ Poder de Oficina Asociada de Abogados
- ☐ Traducción oficial de solicitud de patente que no venga en inglés
- ☐ Cesión de la invención
- ☐ Solicitud y Certificación según 35 U.S.C. 122(b)(2)(B)(i)
- ☒ Sello postal prepegado para retornar a vuelta de correo
- ☐ Otros

257 262

6. Solicitud de Prioridad según 35 USC 119

Copias certificadas de las solicitudes a partir de las cuales se reclama prioridad según 35 USC 119, se enlistan abajo y

- ☐ se adjuntan
☐ se enviarán

PAIS	SOLICITUD No.	PRESENTADA

7. Cálculo de las Tasas de Presentación (37 CFR 1.16)

- A. ☒ Solicitud de Modelo de Utilidad

REIVINDICACIONES PRESENTADAS-INCLUYENDO CORRECCIÓN PRELIMINAR (SI LA HAY)						
			PEQUEÑA ENTIDAD		OTRA DISTINTA A PEQUEÑA ENTIDAD	
	No. PRE-SENTADO	CANTIDAD EXTRA	TARIFA	TASA	TARIFA	TASA
TASA BASICA				\$355.00		\$ 710.00
TOTAL	1 - 20	= 0	X 9=	\$	X18=	\$
INDEPEN	1 - 3	= 0	X40=	\$	X80=	\$
☐ Primera Presentación de Múltiples Reivindicaciones Dependientes			+135=	\$	+270=	\$
Tasa de Presentación:				\$355.00	0	\$

- B. ☐ Solicitud de Designación (\$160.00/\$320.00) Tasa Presentación: \$ _____

- C. ☐ Solicitud de Planta (\$245.00/\$490.00) Tasa Presentación: \$ _____

D. Otras Tasas

- ☐ Designación de Registro [Tasa-\$40.00 por designación] \$ _____
- ☐ Tasa de petitorio para presentación por otros diferentes a todos los inventores o persona en representación de el inventor cuando el inventor se rehuse a firmar o no pueda ser encontrado [Tasa-\$130.00] \$ _____
- ☐ Otros \$ _____

Total Tasas Adjuntas \$ 355.00

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126

8. Método para el Pago de las Tasas

- ☒ Cheque adjunto por la suma de: \$ 355.00
- ☐ Cargo a la Cuenta de Ahorros No.13-2855, por la suma de: \$ _____
Se adjunta copia del trámite
- ☐ No se adjunta

9. Depósito en Cuenta y Autorización de Reembolso

Por medio de la presente se autoriza al Comisionado para cargar la diferencia por menor valor pagado a lo estipulado o cualquier tasa adicional que se requiera durante el trámite restante de esta solicitud, según 37 CFR 1.16 ó 37 CFR 1.17 o según otras normas aplicables (excepto el pago de tasas de publicación), a la Cuenta de Ahorros No.13-2855. Se adjunta una copia de este trámite.

Por favor, reembolsar cualquier sobrecosto a Marshall, O'Toole, Gerstein, Murray & Barun a la dirección que se menciona abajo.

10. Dirección para Correspondencia

Cliente No.: 04743

De ustedes respetuosamente,

MARSHALL, O'TOOLE, GERSTEIN,
MURRAY & BORUN
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Por(Firmado): _____
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Lo que se Reivindica es:

1. Un camión que comprende:

una armazón;
un soporte de apoyadero delantero, acoplado al armazón;
un soporte de apoyadero trasero, acoplado al armazón;
un primero y segundo módulos de apoyaderos, acoplados al soporte del apoyadero delantero;

un tercero y cuarto módulos de apoyaderos, acoplados al soporte del apoyadero trasero;

donde cada uno de los módulos de los apoyaderos incluye:

un montaje de un apoyadero orientado, teniendo un extremo superior, un extremo inferior, y un eje del apoyadero, teniendo el montaje del apoyadero una caja protectora fijada al extremo superior en la parte concéntrica de la estructura del camión con el eje del apoyadero y teniendo un tubo guía dispuesto para rotar alrededor del eje del apoyadero con relación a la caja protectora del apoyadero;

un montaje de eje teniendo un par de ejes dispuestos en forma opuesta extendiéndose desde un eje de la caja protectora y definiendo unos ejes de rotación de las ruedas, donde el montaje del eje es llevado al extremo inferior del montaje del apoyadero para una rotación conjunta con el tubo guía, alrededor del eje del apoyadero, donde el montaje del eje está construido para amortiguar el movimiento a lo largo del eje del apoyadero, con relación a la armazón del camión;

un par de ruedas y montaje de llantas, cada una soportada por su respectivo eje de rotación, alrededor de los ejes de rotación de las llantas;

un par de motores de arrastre, cada uno asociado con cada uno de los ejes para la rotación motriz de la respectiva rueda con su montaje de llanta, alrededor de los ejes de rotación de las ruedas;

un mecanismo conductor adaptado para rotar el tubo guía y un montaje de eje en relación con la caja protectora del apoyadero de cada módulo independiente de apoyadero, de los otros módulos de apoyadero; y

un sistema de refrigeración por aire construido y dispuesto para circular aire ambiente, al menos a través de la parte de los motores para disipar el calor de cada motor.