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(54) **HIGH EFFICIENCY VEHICLE**

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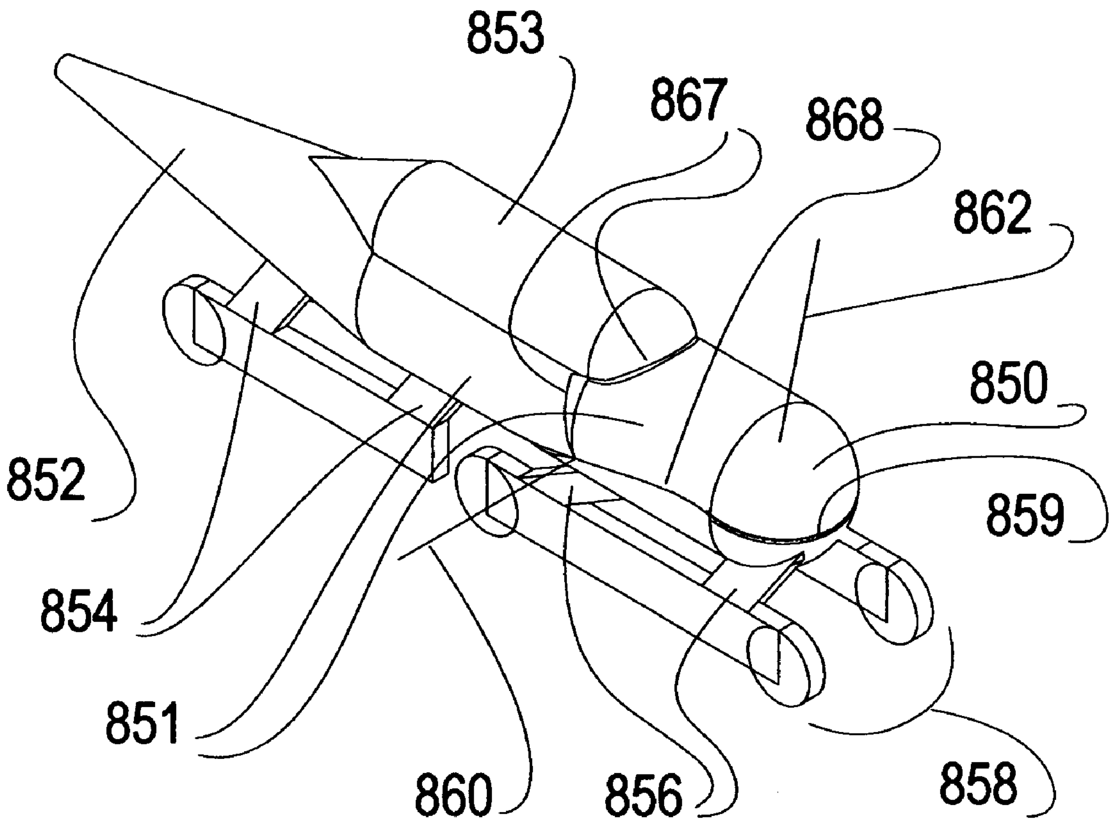
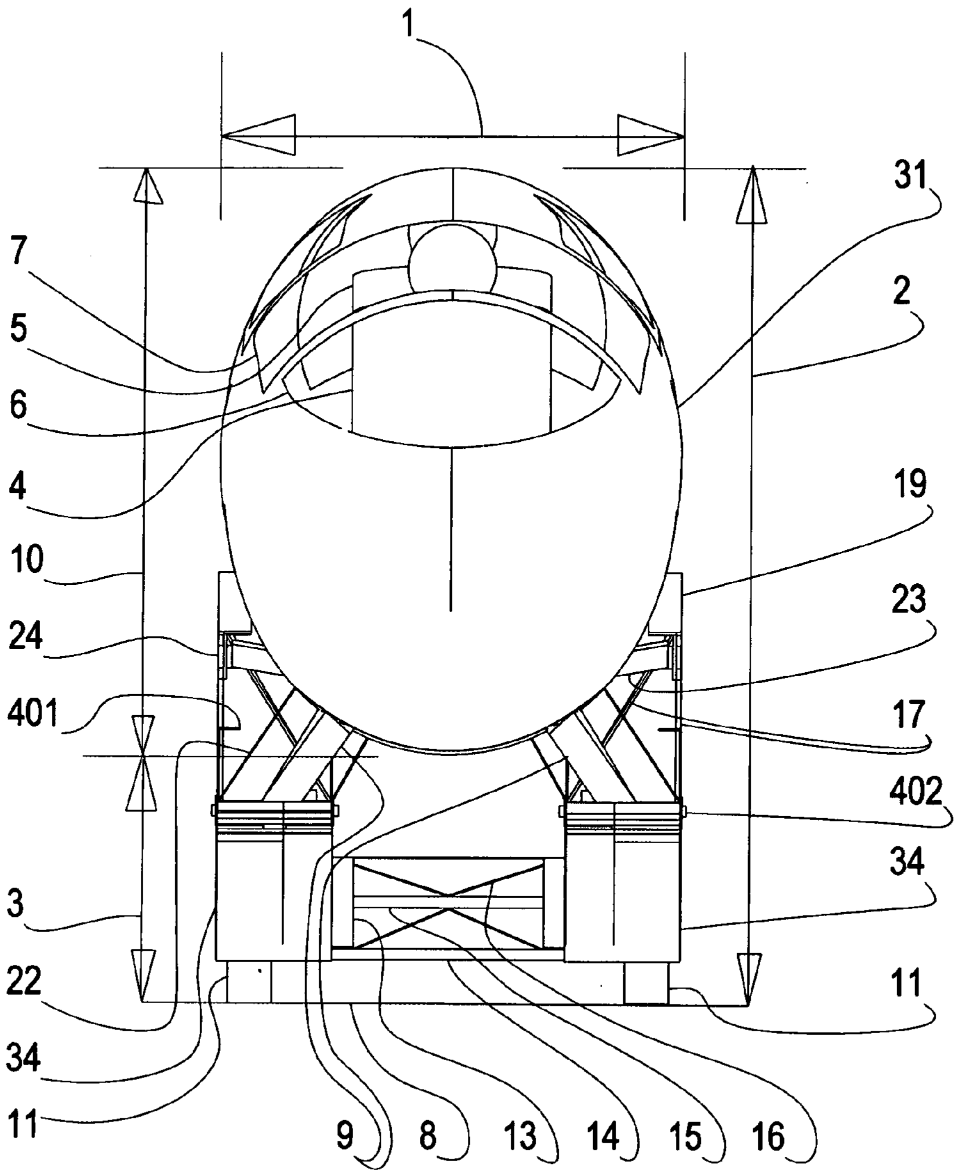
(57) **ABSTRACT**

Here invented are efficient road vehicles having special aerodynamic shapes, with stabilizing devices that enable aerodynamic efficiency. An embodiment is a articulated vehicle that is tall and narrow. It includes a carriage part that encloses a driver and passenger riding in tandem. This car is only wide enough for persons seated in single file, so it has very low projected frontal area compared with typical cars. Further, the narrow width makes a body shaped like an airship practical, where that shape is characterized by a very low drag coefficient in free flow conditions. Since this body is elevated on struts to enable such free flow aerodynamic conditions, the drag coefficient of the airship is made applicable to this road vehicle. Because this car has both low frontal area and low drag coefficient it will require minimal energy for high speed operation.





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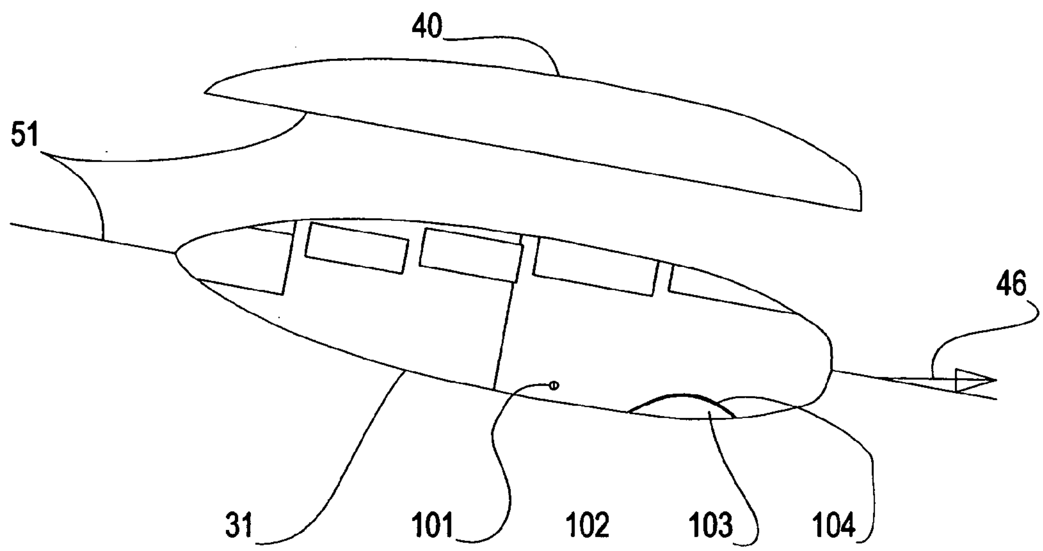

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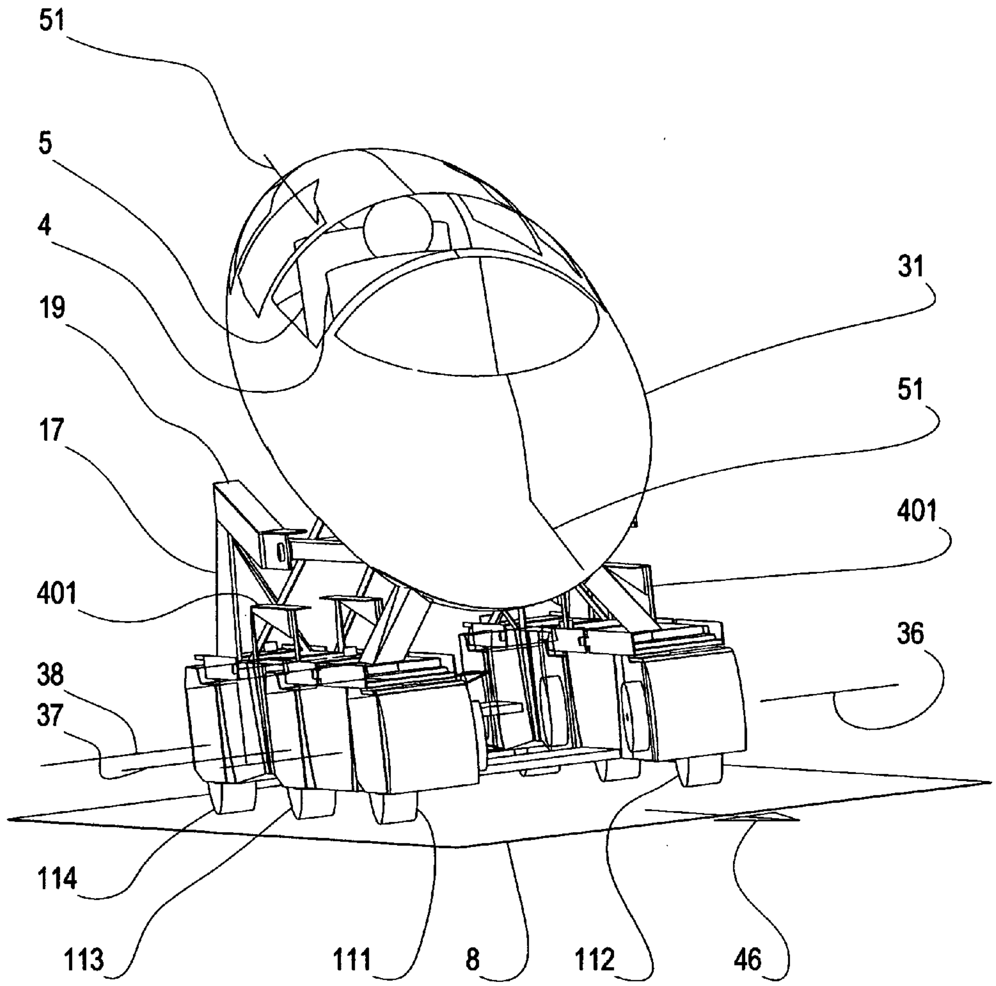

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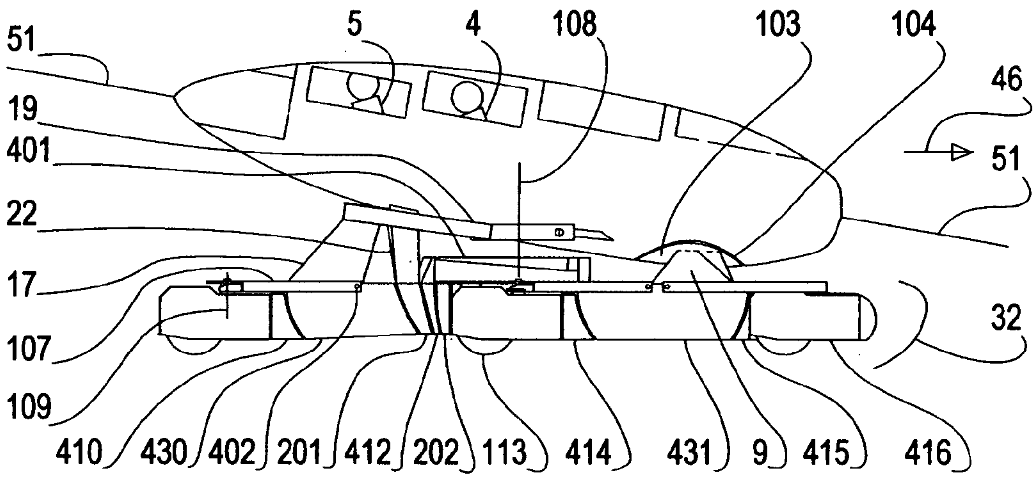
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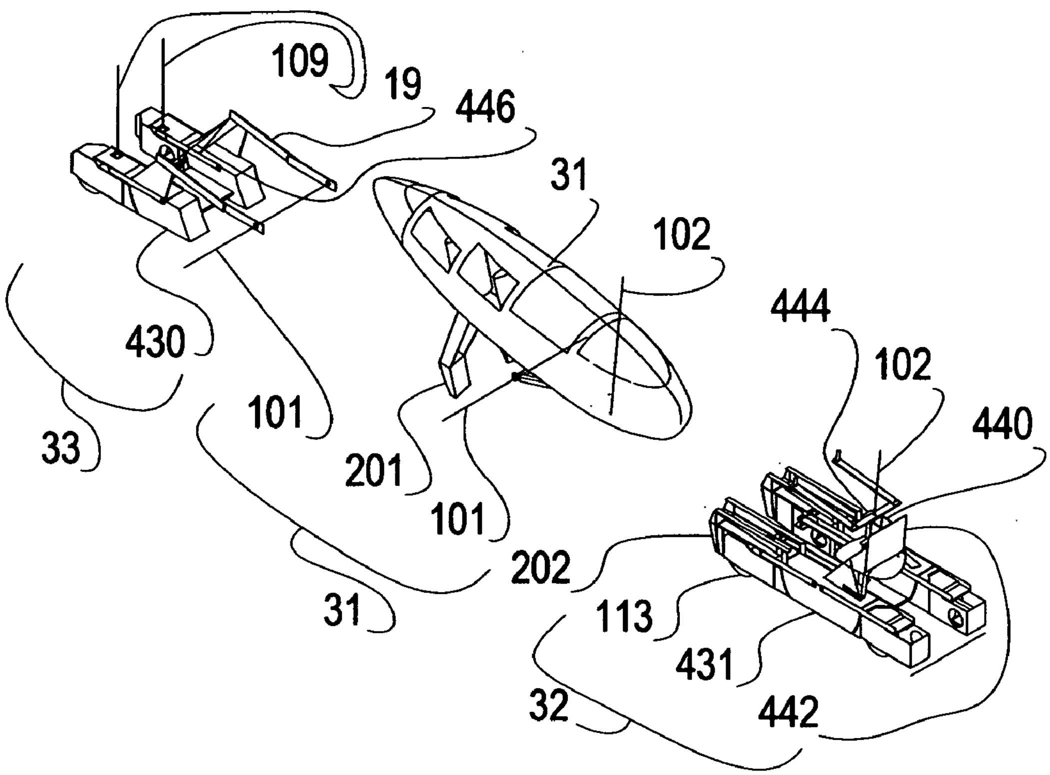
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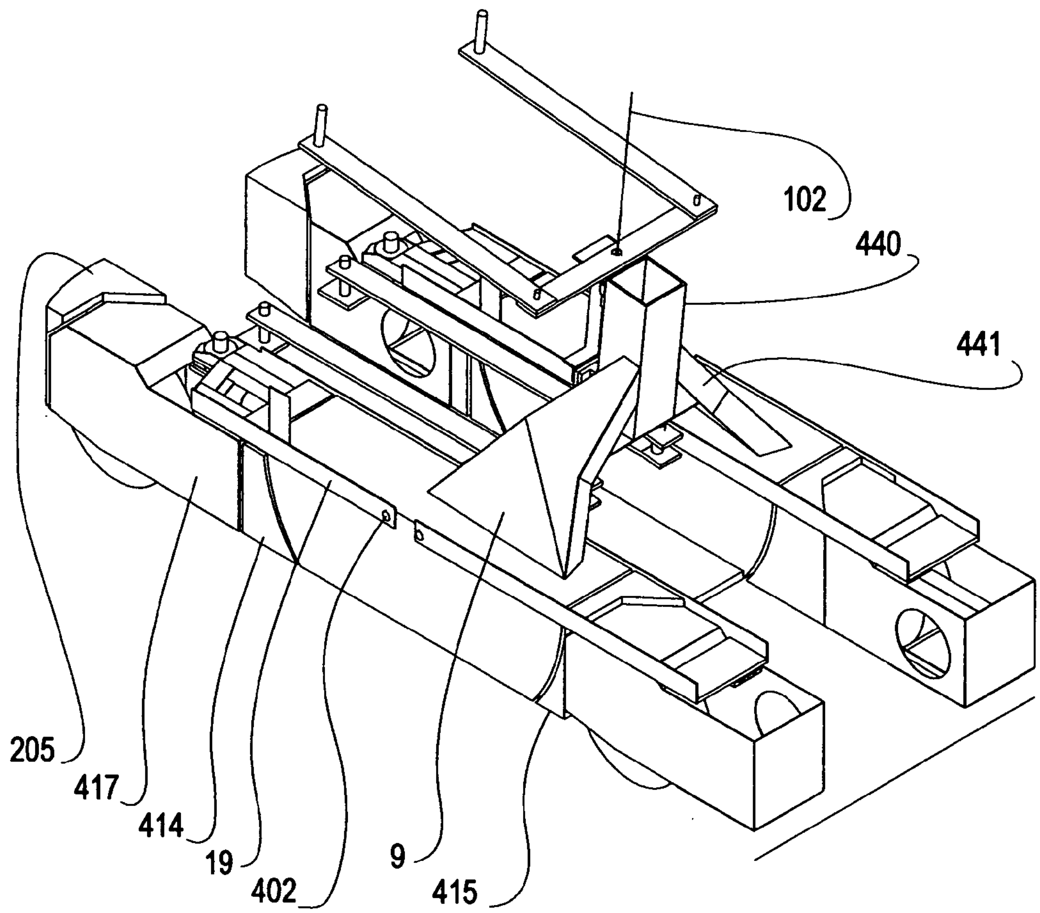
FIGURE 5



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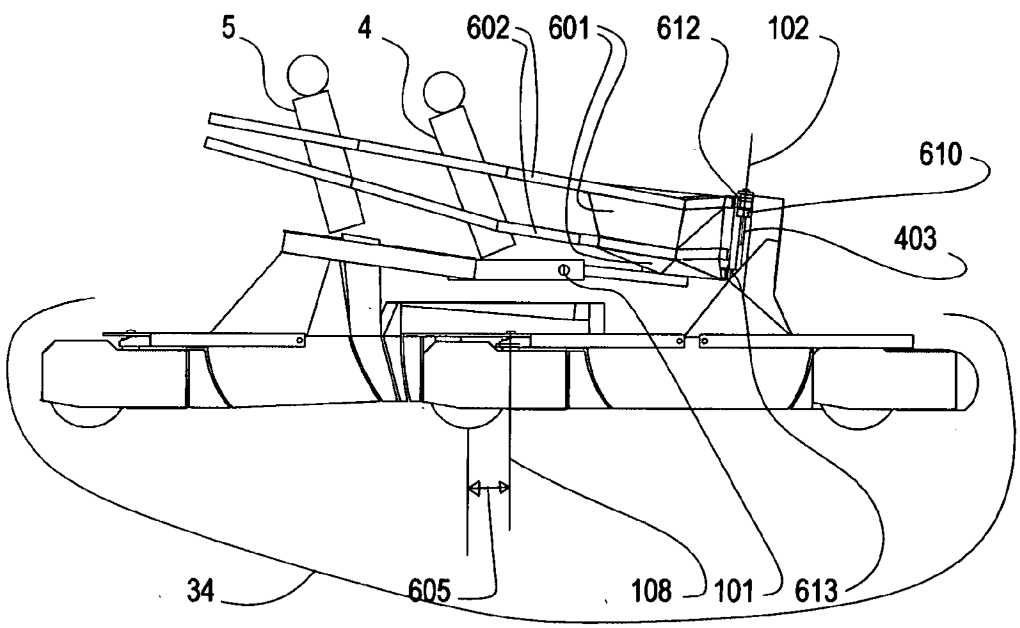

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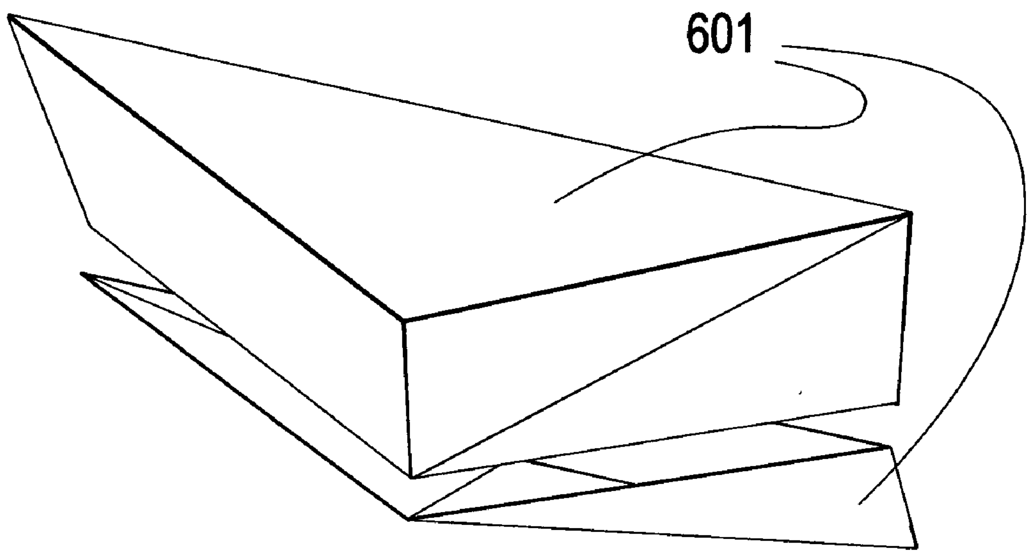

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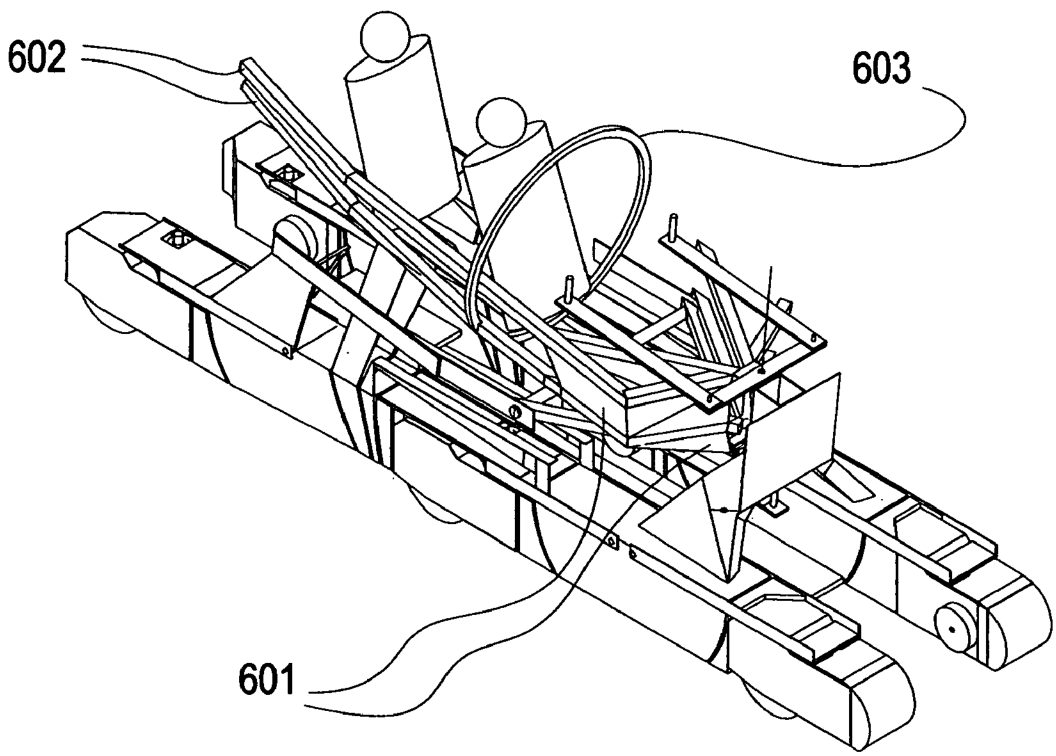

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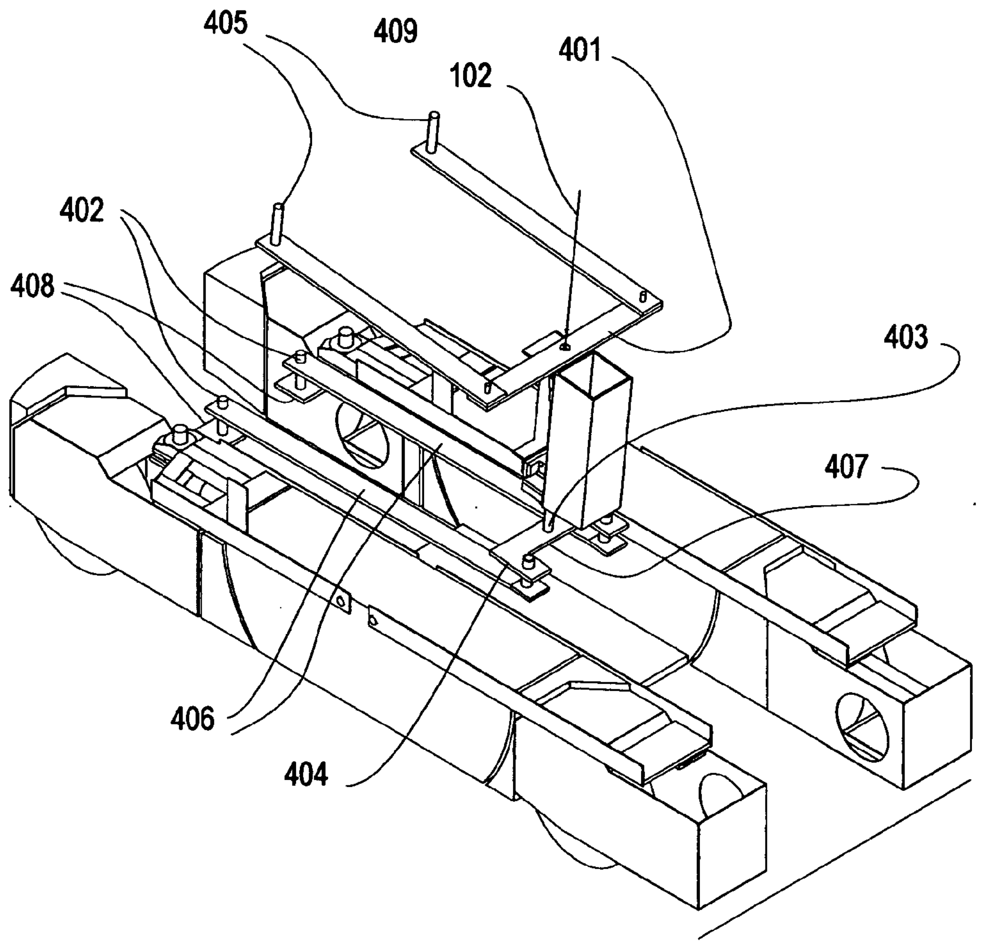

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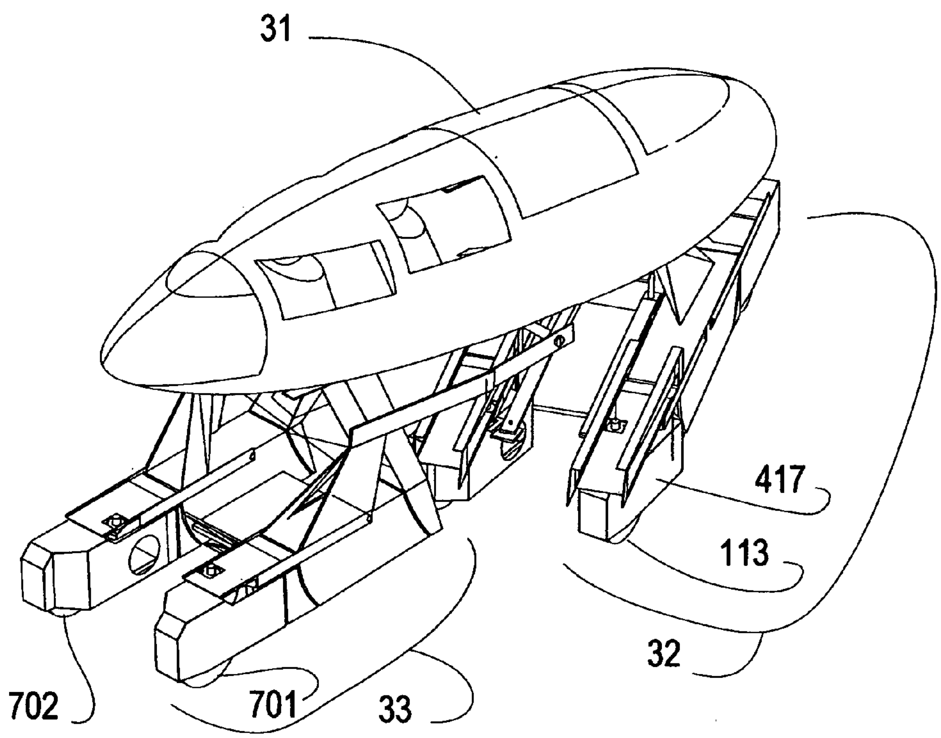

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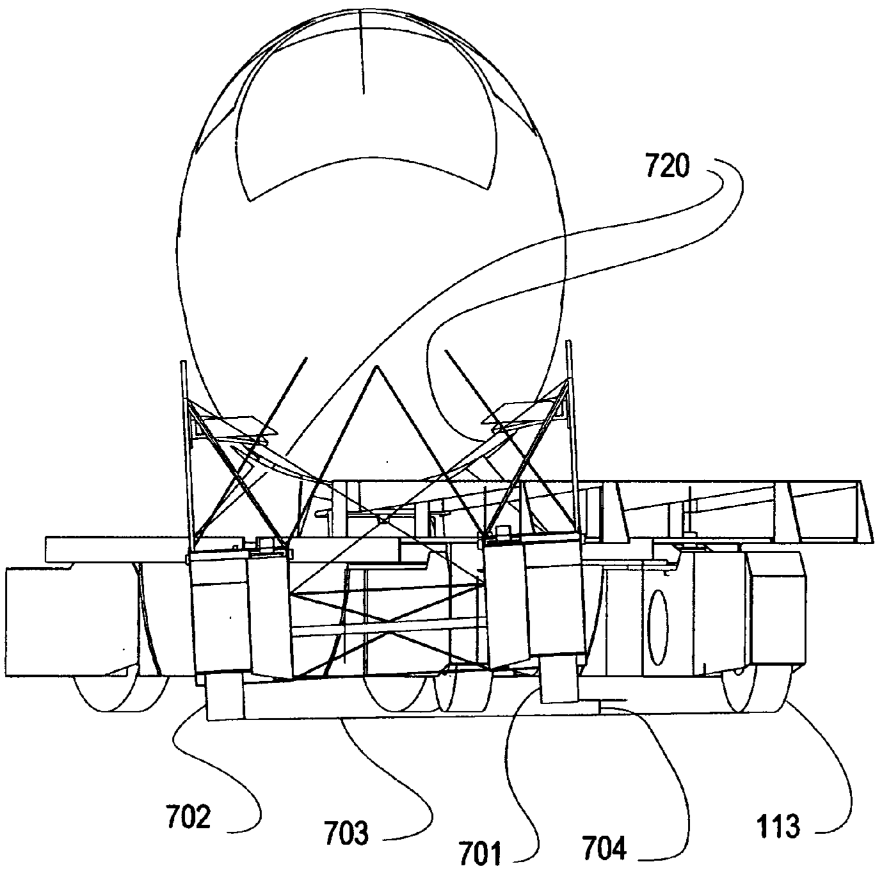

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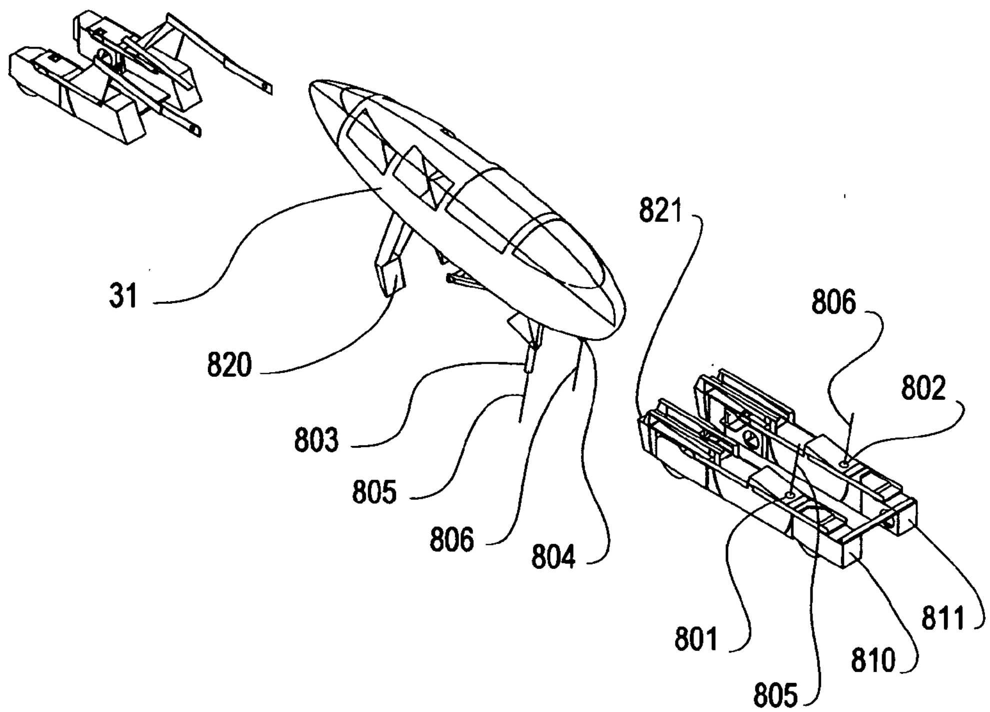

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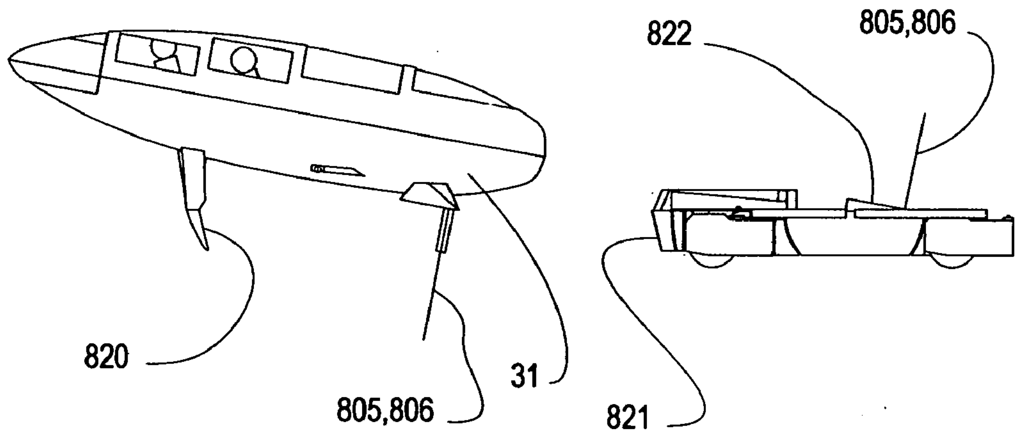

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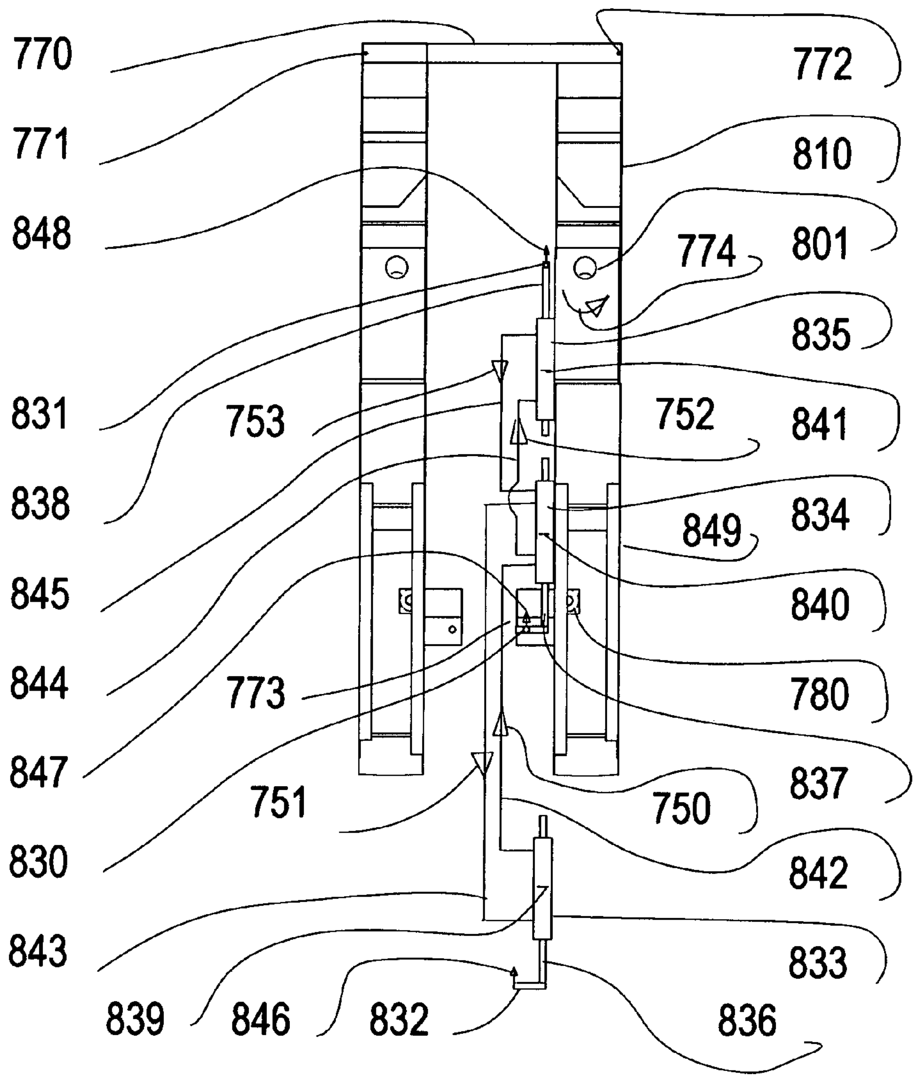
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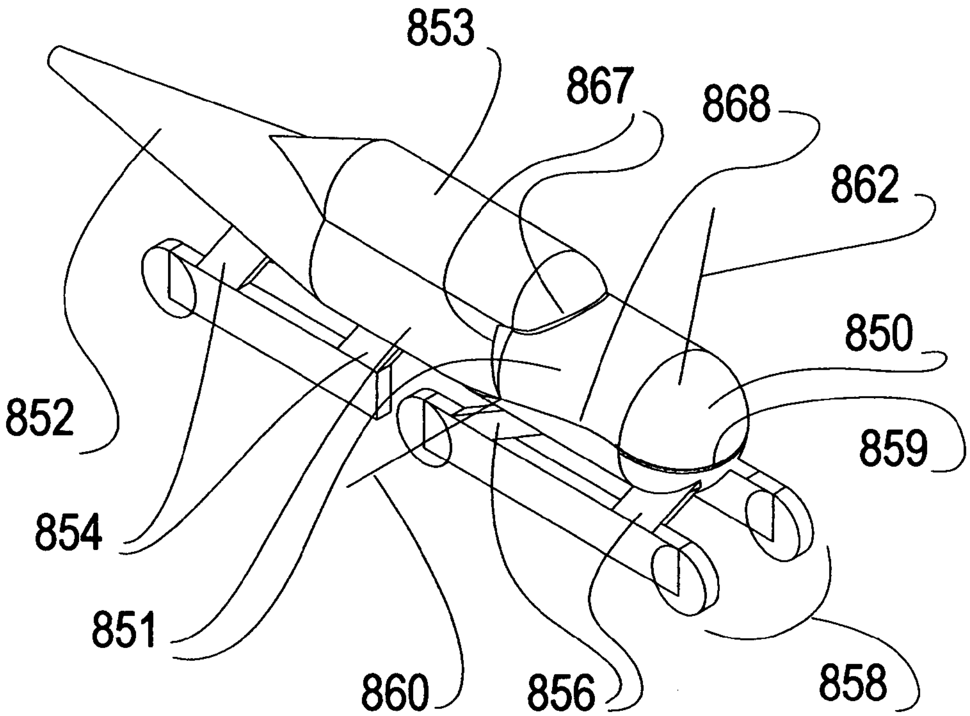
FIGURE 15



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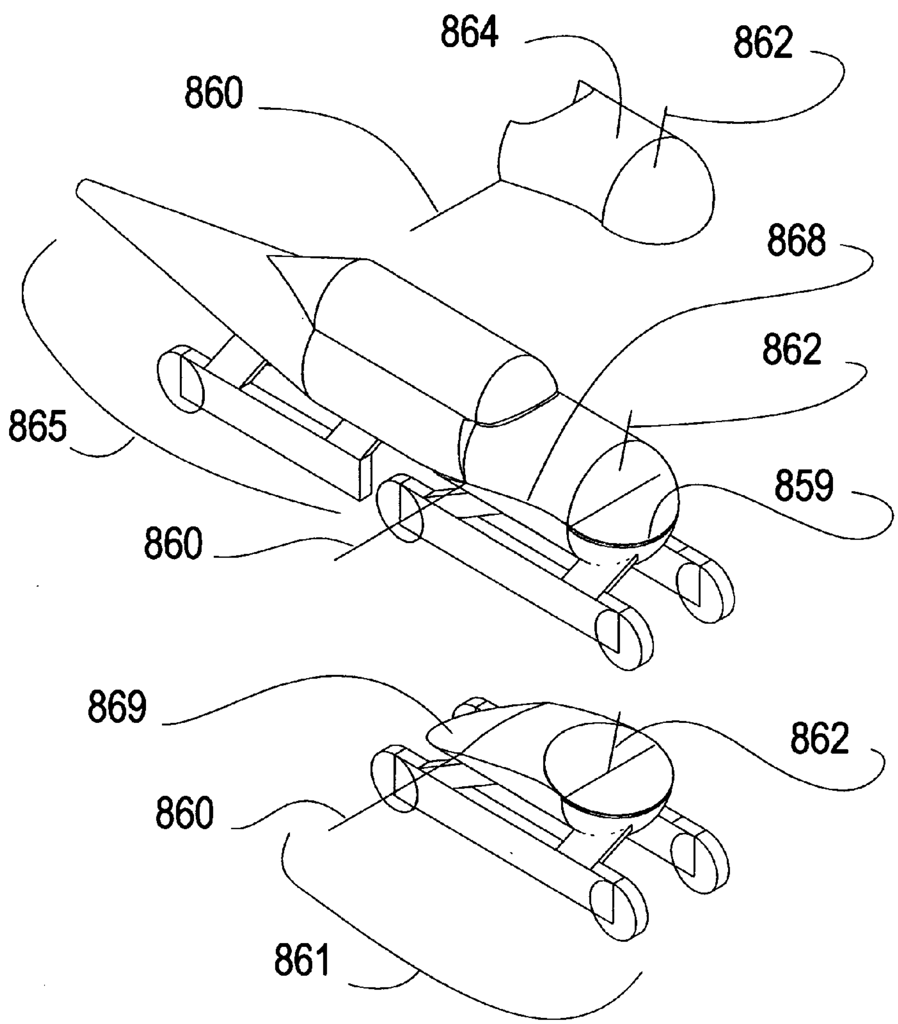

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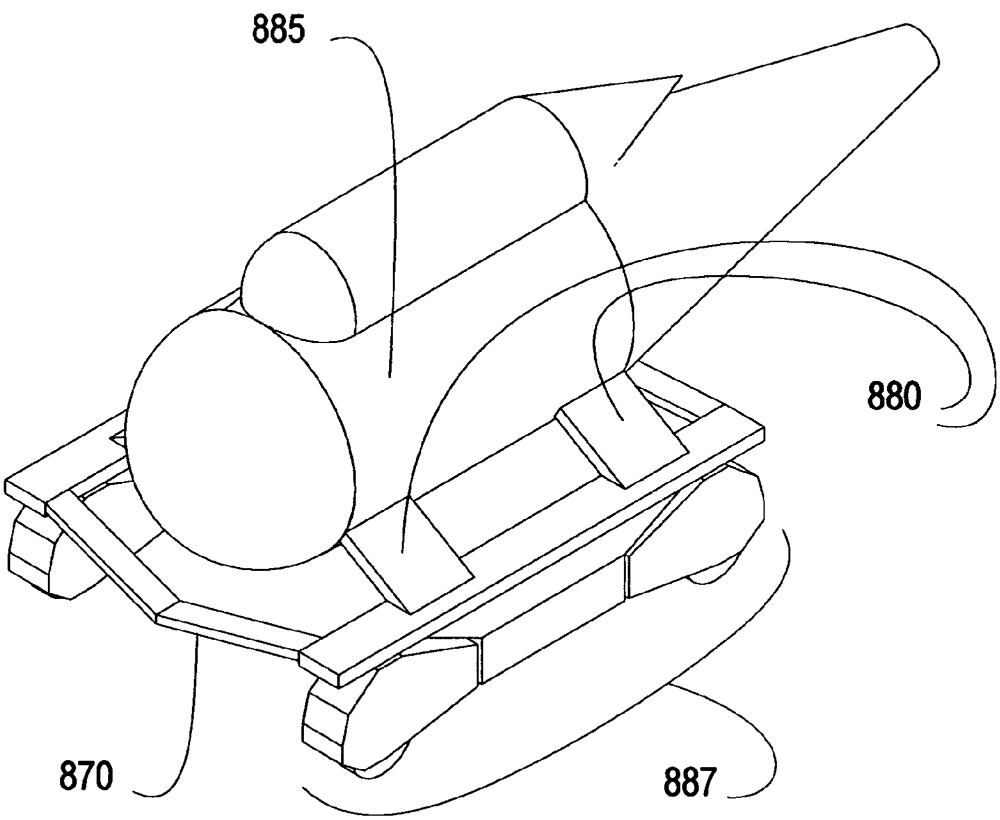

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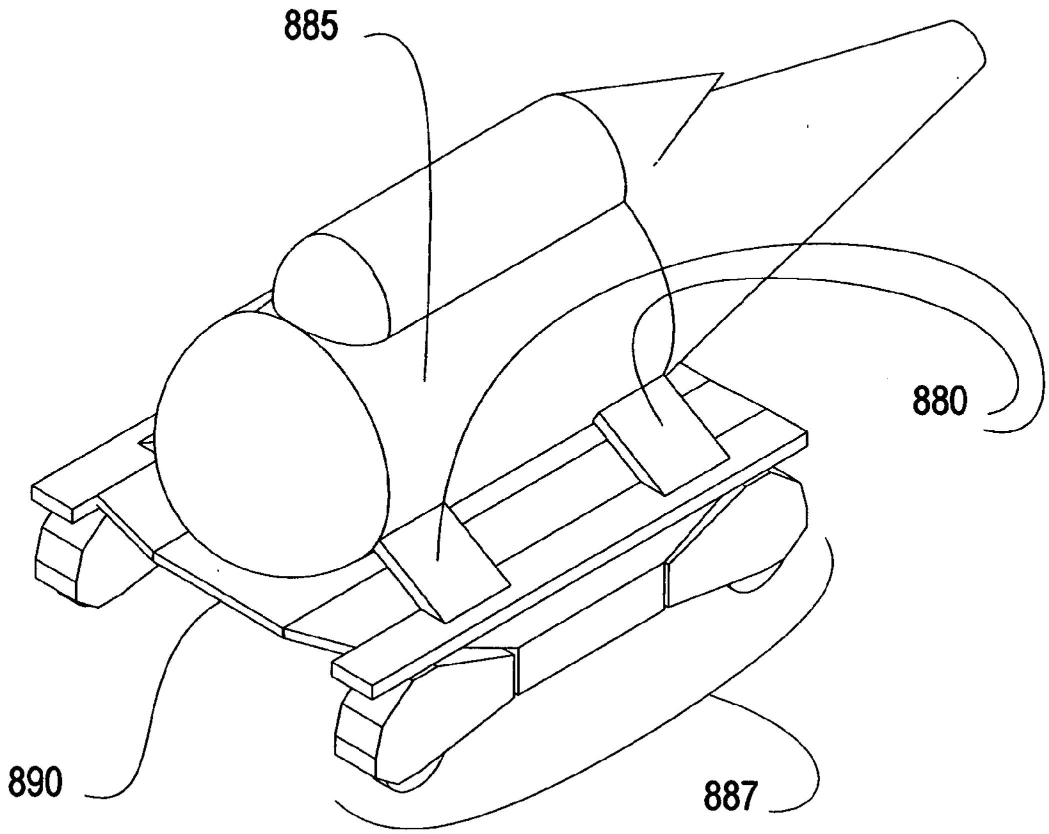

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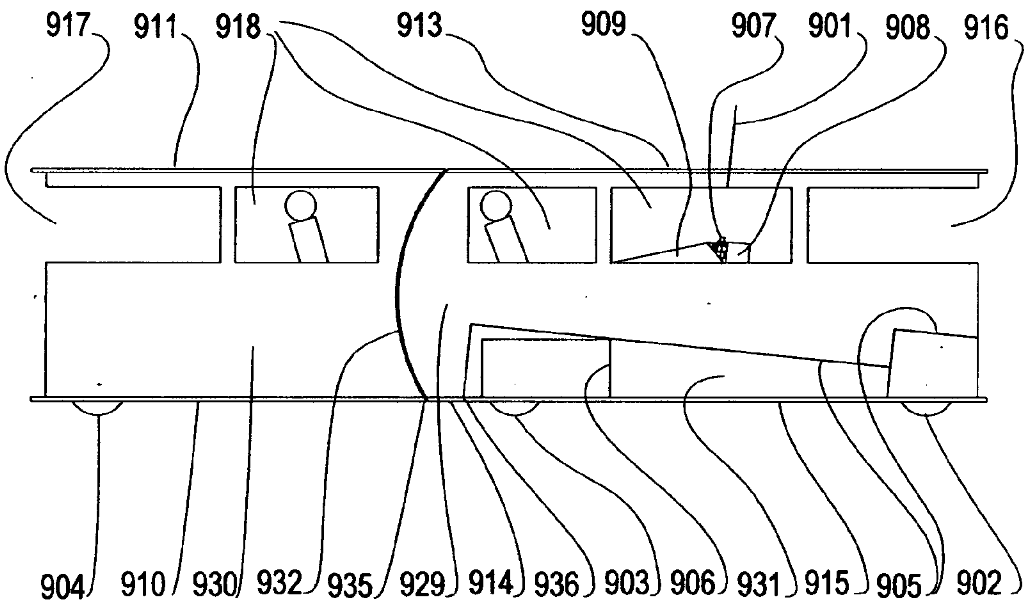
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FIGURE 20

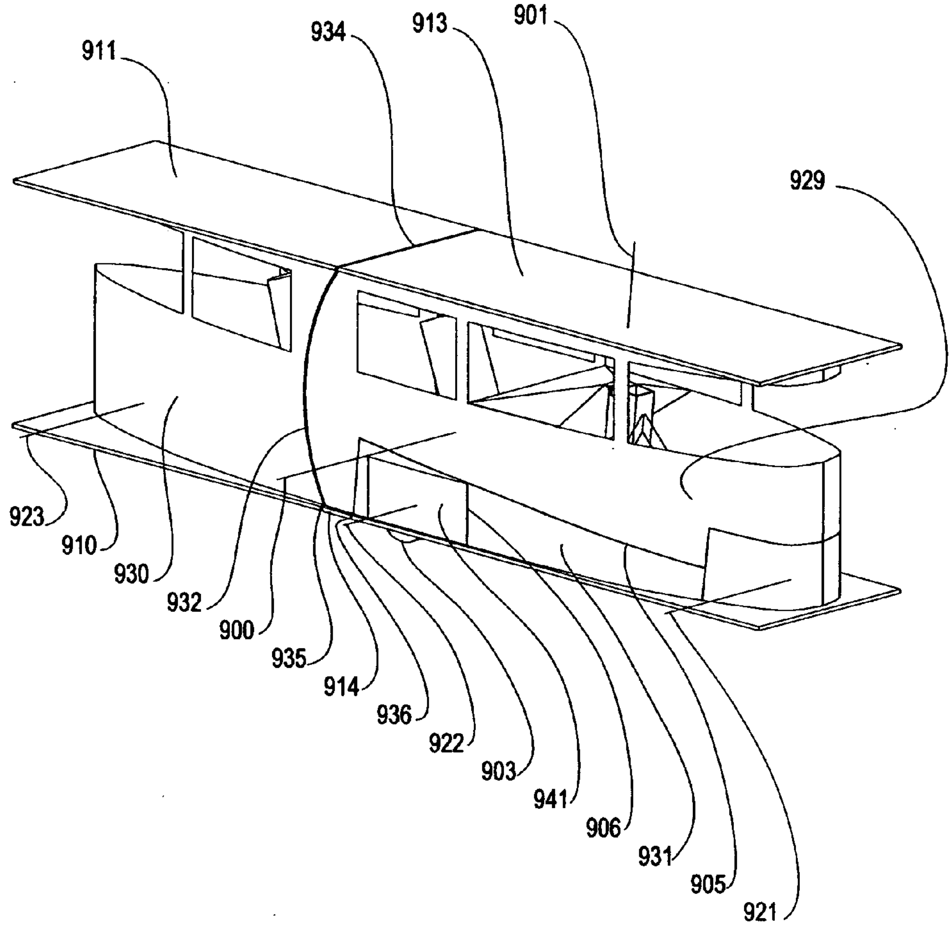
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FIGURE 21

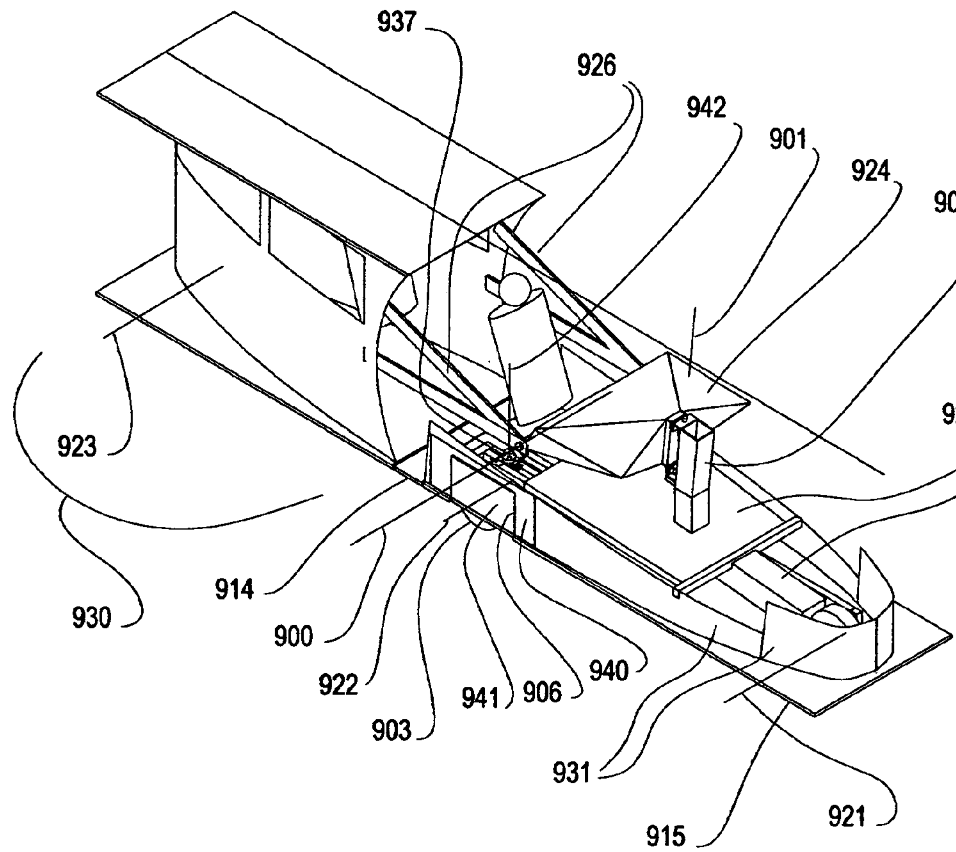
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FIGURE 22

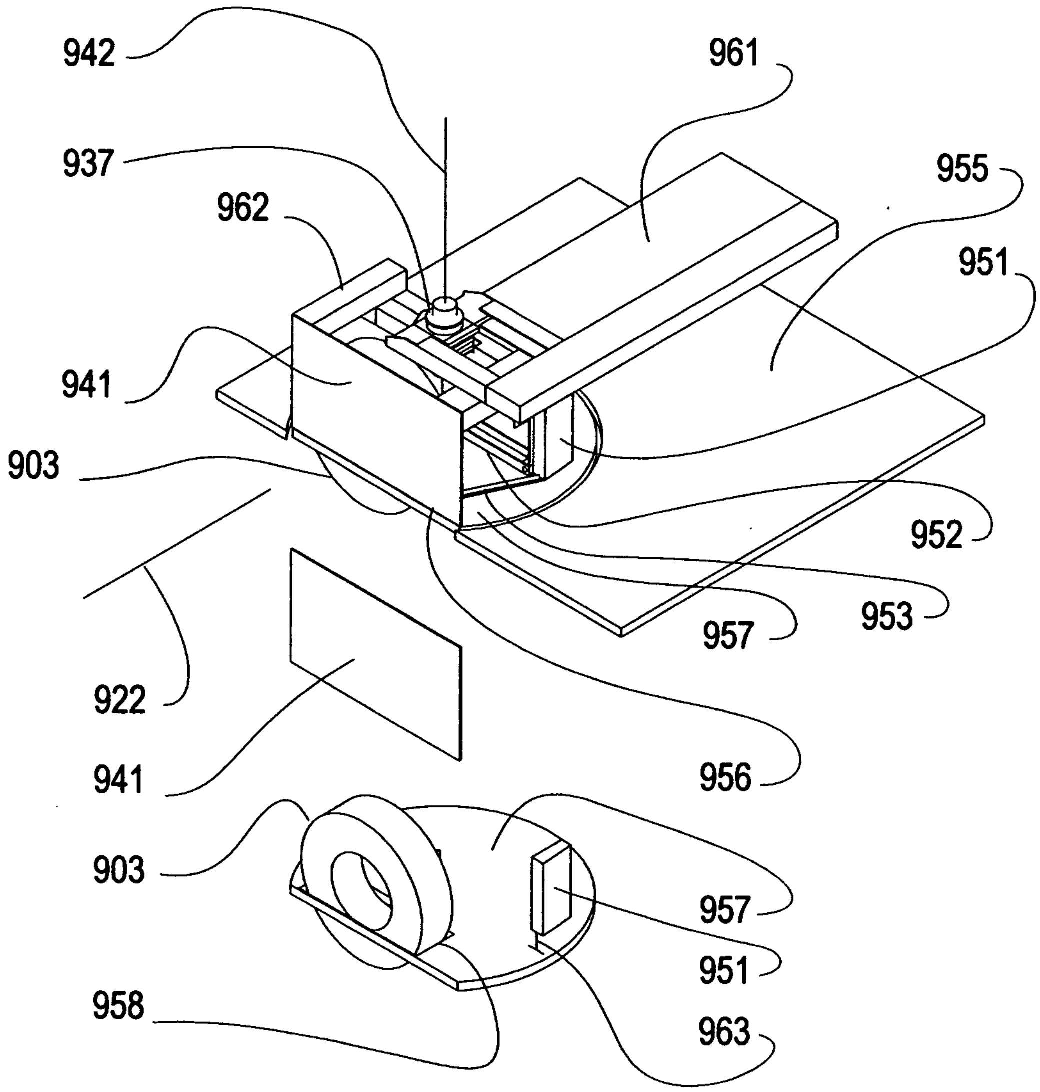
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FIGURE 23

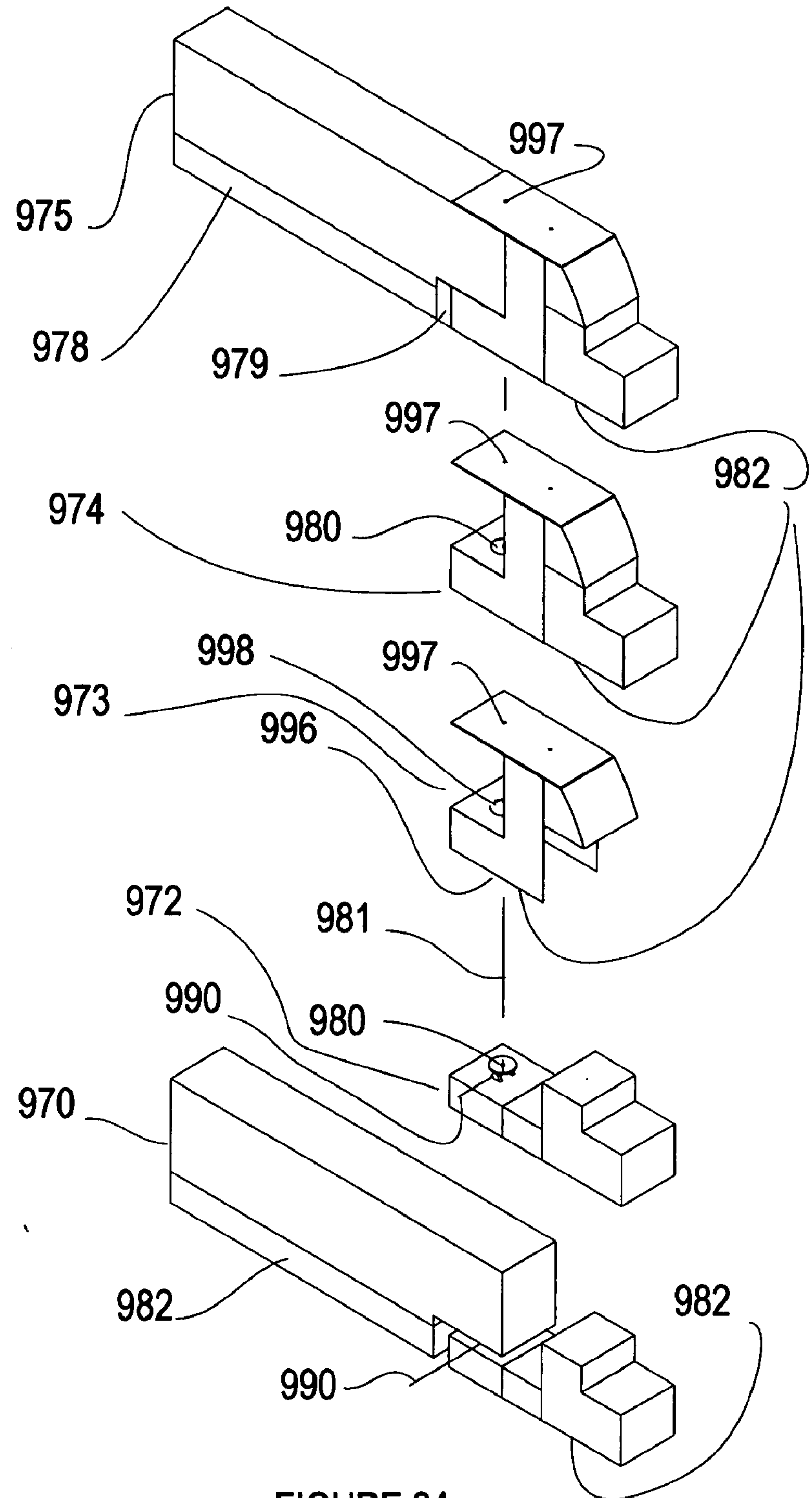
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FIGURE 24

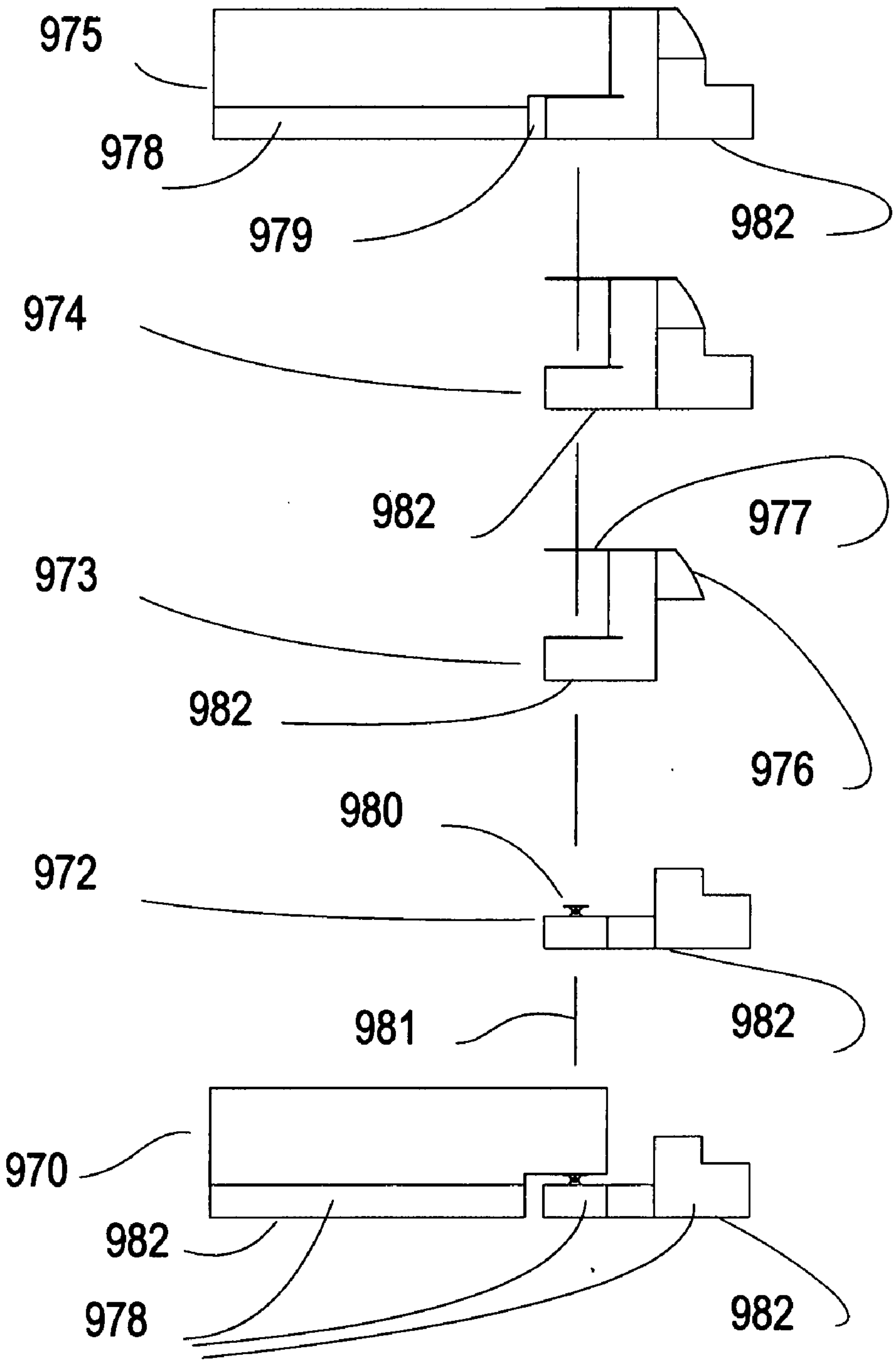
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FIGURE 25

HIGH EFFICIENCY VEHICLE

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] This present invention relates to motor vehicles.

[0004] 2. Description of the Prior Art

[0005] Aerodynamic efficiency is a high priority in design of air vehicles. In design of automobiles it ranks below a list of requirement that conflict with efficiency, some of which are rarely questioned. Such are requirements for two front seats, ease of implementation, and fashion conformity. When energy is inexpensive and inexhaustible, such requirements are not a problem. Technological innovations, for example electric drive systems capable of regenerative braking, are interesting curiosities. Adequate motivation for significant innovation is lacking and key decision makers need have no understanding of innovative possibilities. Thus, when the energy equation is significantly changed, the world wide motor vehicle industry is ill equipped to adapt effectively. In such a world, minor improvements pass for important progress. Useful principles, if not completely forgotten, are poorly understood.

[0006] A basic concept in aerodynamics is that of drag coefficient. At any given speed the actual drag force is proportional to the product of projected frontal area and the drag coefficient value. While the drag coefficient value is a function of Reynolds number, for vehicle sizes and speeds of interest that drag coefficient value is reasonably constant. An effort to reduce the width of cars by eliminating the right front seat, as in Bullis, application Ser. No. 11/064,301, Feb. 23, 2005 accomplished a significant reduction in projected frontal area. Further aerodynamic drag force reduction depends on reduction of drag coefficient.

[0007] The ideal airship shape is available from the history of aerodynamic research. Prior to developing the modern airplane wing shape, Prandtl and his students at his Gottingen University laboratory in Germany, with cooperating American researchers, studied the aerodynamics of airships. Such vehicles were of great interest in 1906, their use continuing through WWII. A typical airship shape was developed that was roughly a cylinder with tapered ends, this being a body of revolution about an axis aligned with the flight direction. Prandtl showed that drag force due to accelerative effects could be almost eliminated by a refined taper function. Only a small viscous drag then remains. Wind tunnel test results are available that can be scaled to dimensions appropriate for the automobile. In spite of this background, very little of this technology has been used in the design of road vehicle.

[0008] It appears that a large impediment to progress in this regard is the nearly universal requirement for seating arrangements that include, at least, two front seats. Therefore, to enclose two adults seated in such front seats in a body of revolution requires that such a body be about six feet in diameter. Thus, the attempt in the 1930 era to utilize the airship resulted in a car known as the Dymaxion. This example is said to have achieved improved gas mileage for its day, but nothing like what might be expected for a body of revolution somewhat similar to the ideal airship known to Prandtl. A significant difference was that it was not significantly elevated above the ground. Given that stability of this vehicle was a concern, that limitation seems inescapable.

[0009] The kind of thinking ingrained in the process of automobile design is illustrated in a Mercedes Benz press release that discusses development of an automobile based on a nearly ideal aerodynamic body form. They utilized the shape of an unusual looking fish known as the box-fish known for low hydrodynamic drag. The initial test model was shaped like that fish and wind tunnel tests showed it to be subject to extremely low air drag. It is not noted in the release, but having width approximately equal to height means that this functions much like a body of revolution. They do discuss the effect of testing at a significant separation distance from the ground, such that free flow aerodynamic conditions are maintained. While they measured extremely low drag in free flow conditions, when more realistic conditions were represented, by testing in proximity to the ground, they suffered a 50% penalty in drag coefficient. They further indicate that adding other features necessary for a realistic car, as well as the provision for operation close to the ground, causes a degradation of drag resistance of more than 200% relative to the ideal body test results in free flow conditions. Such features included wheel wells that provide for wheel steering and suspension devices. The inability of these experts to achieve better results can be attributed to their ground rule, as stated by the press release, that the vehicle width required for seating two persons was six feet. Apparently, a single wide car is inconceivable, at least for major production auto makers. Thus, they are barred from realization of the accumulating advantages of such an arrangement, where a reduction in projected frontal area, closer adherence to the ideal shape, and practicality of elevating such a shape are realizable measures to improve efficiency. The wide form naturally leads to a flat bottomed form which further exacerbates the degradation in drag coefficient caused by proximity to the ground. While this development effort achieved a significant improvement in aerodynamic efficiency, it came far short of the level of performance originally suggested by the box-fish ideal shape. This development process thus illustrates the requirements and assumptions that are a basic part of the present day automotive design process.

[0010] A practical rule for achieving an approximation of free flow conditions can be postulated based on a ground separation requirement related to the frontal projected area, where this rule stipulates an elevation sufficient for achieving a significant practical performance advantage. For bodies of revolution and for rectangular shapes having width greater than height, an approximate elevation standard is one half of the square root of the projected frontal area. Applying this rule to a six foot wide body of revolution car, where two people can ride side-by-side, leads to an overall car height of over eight feet. This would obviously not appeal to car designers.

[0011] It might be supposed that a narrow car would have been considered by the Mercedes-Benz project team that worked on the box fish shape, were a practical way to stabilize such a car available. The previous invention that might have been useful in this concept work, Bullis, application Ser. No. 11/064,301, Feb. 23, 2005, was not available at that time.

[0012] Faced with these realities, the nearly universal choice has been to give up on the ideal body form and any attempt at elevation. In fact, most designs go in the opposite direction. Efforts to make cars economical usually result in a very low vehicle body height that is spaced as close as possible to the ground. The designs usually direct air flow over, and to the sides of, the car. At least this ends up with low and wide car that is naturally stable. The obvious drawback of significantly uncomfortable seating and unpleasant height of eye has never been widely accepted by car buyers. The automotive industry has, thus, failed to show a development path capable of addressing present fuel efficiency concerns.

[0013] An exception is suggested by a developmental vehicle called the Aptera, which appears to the published description to be a very lightweight vehicle, probably less than a large motorcycle; with an extremely wide wheel base, apparently about as wide as that of a large truck. This is reported to be an aerodynamic shape designed by an optimizing, finite element computer code, where the coefficient of drag seems to be nearly ideal. Inspection of the published information seems to show a ground clearance that allows some increase of air flow under the vehicle, compared to typical cars. This ground clearance, together with the body shape, appears to be working to minimize ground surface effect, whether or not this was an intention of the designers or a determination made by the optimizing computer code. The vehicle is still very low overall, and this appears to be at the expense of rider comfort, where two adults are said to be riding side by side, with very little headroom. Since there is no provision for stabilization beyond weight in the vehicle body and the wide wheel base, it is important that the overall height be as low as possible. Given that it carries two adults side by side, this vehicle is a remarkable achievement in aerodynamic design. It shows the potential for shape refinement of the finite element method.

[0014] There have been some attempts to produce a narrow car with seating width for only one person. The Stanley Steamer race car of 1885 was for a single person and it was built with some meaningful consideration of aerodynamic performance. However, its open cockpit and exposed driver prevented most of the intended low drag effect. The cycle cars of the 1910 era were also narrow, but aerodynamic shape was not a significant part of these designs. Cars were produced in the 1950 era with single wide seating, such as the Messerschmitt, which also was very carefully shaped for aerodynamic effect, but this also was very low to the ground. Designing a car with an elevated body on a conventional wheel base would require addition of significant, low placed weight to achieve a stable vehicle. However, gas mileage goals have always tended to encourage car designs that were light weight, especially where the usual propulsion machinery had no capability to recapture kinetic energy by use of regenerative braking. Rolling resistance due to friction in tires and drive train apparatus further discourages heavy vehicles. Consequently, there could be little incentive in the past to create a car having an elevated body.

[0015] A high and narrow vehicle, where persons were seated singly or in tandem, was discussed in Bullis, application Ser. No. 11/064,301, Feb. 23, 2005 (hereby incorporated by reference). That invention focused on providing a method of stabilizing such a vehicle using an articulated vehicle arrangement that was a two frame system, having a stabilizer part that was connected to a carriage part with a two axis articulated joint. A streamlined version was also included in this disclosure. A body is said to be streamlined where that body has a controlled contour where stream line convergence is fairly rapid and stream line divergence is very gradual, where a stream line is an imaginary line which is, at the instant of observation, tangent to the velocity vector at every point through which it passes. However, in this arrangement it was necessary for the stabilizer rear wheels to pass under the carriage part and the necessary clearance for this was increased by the need for carriage pitch hinging action. This meant a trade-off had to be made between overall vehicle height and a desire for an uninterrupted aerodynamic carriage surface. It was also necessary for the forward part of the carriage to allow clearance for pitching. This limited shaping possibilities. Further, this disclosure did not provide for an aerodynamic carriage entity that operated independently of the stabilizer part. Neither did it provide for an aerodynamically integrated carriage and stabilizer. Also, this prior disclosure showed the streamlined version as vertically elongated, with its lowest point raised above the ground only high enough to give reasonable clearance of uneven surfaces, with no provision for air flow under the vehicle.

[0016] While general vehicle shaping can potentially provide very useful results, failure to attend to details can almost void such benefits. An example of such detail is the wheel well configuration used. In all the years of industry history, only very limited attempts have been made to fix this known cause of automobile and truck inefficiency. Similarly, only sporadic attempts have been made to make the under body surface smooth. Large gaps in semi-trucks between the tractor and trailer have been given some attention, though this stops short of changes to the basic form of the tractor or the trailer. A variety of devices have been discussed to reduce the blunt rear end effect of the semi-truck, and this is the largest cause of truck drag. The problem here is, at least partly, due to legal limitations on truck length. A serious look at the importance of such laws is appropriate; change in these laws could enable light weight fairing systems that would greatly cut the use of energy by the trucking industry.

[0017] With these limitations, the degree of aerodynamic refinement represented in that prior disclosure was not clearly superior to that of conventional automobiles. Thus the fuel economy improvement was based only on the greatly reduced width. Almost doubling of gas mileage was expected. Although widespread public acceptance of this breakthrough requires rearrangement of the way people sit in cars, this expected improvement in gas mileage is expected to strongly motivate such changes.

[0018] However, there remains strong motivation for even further improvement. It is reasonable to expect that the entire world population will increasingly insist on participating in a life style that includes the ability to move about quickly, safely, and comfortably. As life styles are transformed, energy conservation, pollution, and global warming problems will be exacerbated. A major part of the solution to these problems could be a large reduction in the amount of energy needed for transportation. While it is well known that public transportation holds promise in that regard, it is clear that most people prefer distributed living that tends to be inconsistent with practical public transportation systems. It is here assumed that a solution that preserves the fast personal car, with its associated time efficiency and flexibility, will be much more readily accepted.

SUMMARY OF THE INVENTION

[0019] Here disclosed are efficient road vehicles having special aerodynamic shapes, with stabilizing devices that enable aerodynamic efficiency. An embodiment is car that is tall and narrow. It includes a carriage part that encloses a driver and passenger riding in tandem. This car is only wide enough for persons seated in single file, so it has very low projected frontal area compared with typical cars. Further, the narrow width means that a body shaped like an airship can be used. That shape is characterized by a very low drag coefficient in free flow conditions. Since this body can be elevated on struts to enable such free flow aerodynamic conditions, the drag coefficient of the airship is made applicable to this road vehicle. Thus achieved is a car having both low frontal area and low drag coefficient that will require minimal energy for high speed operation.

[0020] The struts connect to low profile wheel trains on each side of the vehicle, such that the carriage and wheel trains act as isolated aerodynamic entities. The wheel trains are horizontal columns that include equipment and wheels, enclosed with fairing surfaces and made aerodynamically smooth with special fairing devices. Together these parts also form a special stabilization system that is essential for road operation of this narrow car.

[0021] The stabilizing system structure includes a front wheel axle, a control wheel axle, and a rear wheel axle and a mechanism that keeps at least one wheel from each axle in contact with the road. Control wheels are mounted to individually pivot on their vertical axes, where a linkage enables pivot control of the control wheels by a driver. When the control wheels are pivoted, forward motion of the narrow vehicle then causes the control wheels to shift laterally toward the outside of a turn, whereby a control wheel, now extended to the side, sets a stabilizing stance. The control wheels are linked to the front wheels, such that their lateral shift causes the front wheels to change their travel direction to follow a turning path. The carriage is then guided along the turning path by the front wheels, with the rear wheels tracking on the road surface to hold the carriage toward the inside of the turn.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] FIG. **1** Frontal view of an elevated airship held on struts for free flow operation.

[0023] FIG. **2** Formation of airship as a body of revolution defined by a revolved curve.

[0024] FIG. **3** Dynamic view of elevated airship showing three axles and wheels on roadway.

[0025] FIG. **4** Three frame vehicle with parts detailed.

[0026] FIG. **5** Separated frames of three frame vehicle.

[0027] FIG. **6** Structure and functional details of control frame from three frame vehicle.

[0028] FIG. **7** Articulated joint between internal carriage structure and control frame structure.

[0029] FIG. **8** Brace to assure rigidity of control frame and connection to carriage shell.

[0030] FIG. **9** Three frame vehicle with carriage shell removed.

[0031] FIG. **10** Control frame including steering linkage, with extension into carriage space.

[0032] FIG. **11** Three frame vehicle in turning operation.

[0033] FIG. **12** Stabilizing and tilting effects of three frame articulated stabilization system.

[0034] FIG. **13** Dual control frame system as a variation of three frame system.

[0035] FIG. **14** Carriage frame separate from dual control frames.

[0036] FIG. **15** Hydraulic control linkage illustrated in relation to dual control frames.

[0037] FIG. **16** Two frame articulated vehicle, with struts and in line wheel system.

[0038] FIG. **17** Frames of two frame vehicle related, with fairing on two axis joint structure.

[0039] FIG. **18** Narrow aerodynamic body of revolution on widely spaced wheel trains.

[0040] FIG. **19** High efficiency pickup truck.

[0041] FIG. **20** Vertical airfoil body providing free airflow by lateral air flow pattern control.

[0042] FIG. **21** Details of three frame vehicle integrated with vertical airfoil body.

[0043] FIG. **22** Three frame airfoil vehicle with outer surface of linking frame removed.

[0044] FIG. **23** Wheel well fairing apparatus.

[0045] FIG. **24** Fairing apparatus related to a two axis articulated vehicle that is a semi-truck.

[0046] FIG. **25** Fairing apparatus in semi-truck in perspective to show fairing shape.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT AND VARIATIONS

[0047] The preferred embodiment offers a way to greatly reduce the amount of fuel needed for personal road transportation. For the most part, this fuel comes from burning hydrocarbons, whether they are oil derived or coal. While there are potential efficiency advantages, use of electrical energy does not significantly change this, since use of energy in this form only means that the fuel is burned at some distant site. Thus, the appropriate objective is to simply reduce the amount of energy needed. It should also be framed in terms of reducing the amount of energy needed to transport one person a distance of one mile. It must also satisfy the need for rapid transportation, given that time sitting in a car is a negative measure of effectiveness in transportation.

[0048] The present invention is designed to greatly cut energy usage and it is particularly effective for high speed automotive operation. While commercial acceptance will depend on people changing the way they drive and ride in cars, incentives promised by this new vehicle type include continuation of the high speed mobility to which people are accustomed, where that life style is threatened by energy shortages, pollution, and global warming issues. Furthermore, the driver is provided with a commanding view of the road, enabling superior driving compared to other possible efficient vehicles. Improvements in safety and comfort are also envisioned. Still further, more cars can move on the road and more can be parked in a given sized parking lot. Inexpensive construction is also planned. A profound world-wide impact is envisioned.

[0049] The embodiment design adapts airship research to the automotive field. Special stabilization features are incorporated to produce a practical car that is free of most of the air drag force that is a major cause of automobile inefficiency. This new car has both a very low air drag coefficient and a low projected frontal area. Because the force caused by air drag, at any given speed, is proportional to a product of that projected frontal area and that drag coefficient, the resulting air drag force is less than a fourth that of the typical car. Although this is most important at highway speeds, with other efficiency measures such as electric wheel drive that eliminates much of the typical drive train machinery, hybrid propulsion system with regenerative braking, and low friction loss tires, overall gas mileage up to about 200 miles per gallon is expected.

[0050] This new car is a stabilized, narrow vehicle that is just wide enough to seat large adults in single file. This alone accomplishes a reduction of projected frontal area to about half that of a typical car. Further, that narrow seating arrangement makes it practical to enclose the seated adults in an aerodynamic body shape known to have a very low drag coefficient. Such an ideal body is approximately a body of revolution, or a shape that produces a radially symmetric air flow pattern around it, like that produced by a body of revolution. The body of revolution has a body axis that is a fixed line length that is about the same as the vehicle length. This axis is approximately aligned with the vehicle straight travel direction. The body of revolution is constructed by revolving a curve constructed on a plane, where that curve connects to both ends of the body axis. Where the curve is highly optimized for aerodynamic purposes, this produces a highly optimized body shape.

[0051] Finally, the narrow form makes it feasible to support this body shape in an elevated position, thus providing free flow aerodynamic conditions that make its very low drag coefficient effective in a road vehicle. Not only can the body of revolution be implemented in a well known, ideal airship shape, but the radially symmetric air flow pattern better enables spreading to the sides compared to flat bottomed shapes, so the required elevation is reduced. Even though the elevation is minimized, the vehicle is still unusually tall and narrow. Stabilizing such a car requires more than conventional automotive methods.

[0052] Airship research carried out in the 1920 era provides a high performance aerodynamic body shape that is here used as a carriage to enclose persons riding in the automobile. Wind tunnel tests were carried out in those years producing air drag force measurement data that can be used to design this high efficiency automobile. This data is especially complete for the Akron-Zeppelin shape, even including drag force data for the model at a variety of pitch angles. For vehicle speeds of interest the drag coefficient can be reasonably estimated from this data for scaled models of this shape.

[0053] However, the wind tunnel tests were arranged to provide numbers applicable to high altitude flight. While such numbers are applicable for airship operation, ground operation involves a flat surface that disturbs free flow aerodynamic conditions. The effective drag coefficient is substantially increased. Thus, it is important to allow as much room under the carriage for air flow, relative to the carriage, as possible. Although an ideal height is greater than would be possible, an effective approximation to free flow conditions at a highway speed is expected for an elevation equal to half the square root of the projected frontal area. The preferred embodiment is held slightly higher than this rule dictates. This rule is only very rough guidance, which is not intended to be a limitation. It is anticipated that shape refinement will enable tuning of the highway speed that is ideal and extending somewhat the most effective speed range. Obviously, the elevated, nearly ideal body will represent an unusual looking, tall and narrow vehicle.

[0054] This shape is well suited for enclosing large people sitting in single file and providing adequate viewing angles, especially when pitched down about ten degrees.

[0055] Having arranged for the carriage to have extremely low air drag, the air drag of the lower frames including the wheels becomes significant. An arrangement that provides additional stability, while optimizing the aerodynamic shape of the lower frames, arranges lower frame structural parts, heavy equipment, and wheels in low profile, thin horizontal columns. This is an ideal location for vehicle weight, and it is particularly well suited for holding electrical batteries. Flat motors fit within these columns. These stabilizing effects are important to counter cross wind effects and tilted road surfaces, since these are concerns not dealt with by the stabilizing measures involved in turning. Each such column is enclosed in a covering surface that produces a smooth surfaced, elongated aerodynamic unit that operates like a train. Such a wheel train operates as a unit on each side of the vehicle, and an air flow passage is enabled between the trains. Because each wheel train includes parts from the front frame and parts from the rear frame, it operates as an aerodynamic unit for straight line travel, but is interrupted for turning and other flexing actions. Consequently, fairings are needed to smooth over the gaps that must be present to allow such action.

[0056] Special fairing devices have been discovered that are able to make the aerodynamic surfaces nearly perfect. This is an inter-axis fairing concept that enables continuous surfaces to be maintained for straight line travel. Such continuous surfaces would be broken for a variety of flexing and pivoting actions, but they would be reestablished for the shape that mostly prevails in straight road operation. This inter-axis fairing system involves a part that is held between two axes and provides conformal surfaces to parts that hinge on those two axes.

[0057] Compared to flat surfaces, the generally cylindrical shape of the carriage provides a significantly reduced drag coefficient in regard to lateral air flow, thus significantly reducing cross wind force effects. This is more of an issue where the axis of the carriage is held with at a small downward pitch angle relative to the horizontal to enhance viewing and headroom. While this increases the height of the carriage at the rear, thereby increasing the lever arm of cross wind force, this can be tolerated because of the low drag coefficient for a cylindrical form.

[0058] FIG. **1** shows a frontal view of an elevated airship form of the carriage **31** part of the vehicle. Forward details are emphasized. The width **1** and overall height **2** of this tall and narrow vehicle are indicated. The height extent of the carriage alone **10** is measured as the height of the projected frontal area of the carriage alone. Elevation **3** above the road surface **8** is also shown. Place holders for a driver **4** and a passenger **5** are shown riding in tandem, as viewed through lower front window **6** and upper front window **7**. Struts **9** attach to wheel trains **34** to hold the carriage **31** well above the road surface. The low profile wheel trains **34** are seen in frontal view, with front wheels **11** that are mostly enclosed in the wheel trains **34**, protruding sufficiently to operate on the road surface **8**. One of six electric motors **13** can be seen in proximity to the left front wheel **11**. The airfoil shaped, front cross beam **14** is a thin horizontal panel that spans between the wheel trains **34**, and provides frame rigidity. Another horizontal panel **15**, also to be shaped as an airfoil, can be seen here, even though it is near the rear of the vehicle. Other details pointed out include pitch hinging mechanism **24**, straps **16** to hold the vehicle rigid, tracking frame attachment arms **19**, airfoils supporting a fairing shell, tracking frame structure **17** utilizing airfoils shapes, brace and fairing **23** for pitch hinging mechanism, another fairing shell support **401**, and a hinge pin **402** that connects the individual wheel suspension mechanisms to the wheel train **34** structure.

[0059] The key performance feature, low aerodynamic drag force, is determined by the projected frontal area, which is the outline area of the carriage **31** as shown in this view, in combination with the very low drag coefficient of the airship body form.

[0060] FIG. **2** shows the Akron-Zeppelin defining curve **40** spanning an axis line **51**. When revolved about that axis line **51**, this defining curve produces the carriage shape. With appropriate scaling to the automotive purpose, and addition of windows and other details, it becomes the carriage **31** part of the vehicle. The vehicle travels to the right in this illustration for forward travel **46**. This is then set at a fixed pitch angle **45**; a minor variation that helps with headroom. This carriage part of the vehicle is shown as an isolated part here, but the relationship of it to the remainder of the vehicle keys on the pitch hinging axis **101** and the yaw hinging axis **102**. The entire carriage body is a rigid unit except for a cut out surface **103** that is fixed to one side of the yaw hinging mechanism, while the carriage **31** is fixed to the other side of that mechanism. A very small gap **104** is shown that is a very small interruption in the otherwise smooth surface of the airship shaped body, except when an actual vehicle turning operation is under way.

[0061] FIG. **3** illustrates the front axle **36**, the middle axle **37**, and the rear axle **38**, with the forward travel direction indicated by the arrow **46**. The three frame system is defined by these axles, with the front axle **36** and the middle axle **37** being part of the control frame, and the rear axle **37** being part of the tracking frame. FIG. **5** is a clearer picture of these parts, with the control frame **32** and the tracking frame **33** shown separated. The carriage frame **31** is the body of revolution form **31** first shown in FIG. **2**. Six wheels can now be seen in relation to the roadway plane **8**. The two front wheels **111**,**112** guide the final turning action of the vehicle. These wheels are fixed on the front axle such that wheels and axle change direction as a unit. The right control wheel **113** and the right rear wheel **114** are pointed out here. Note that the axles are the center lines of wheel rotation for straight line travel, but when wheels pivot in turning action this is not the case. Attachment structures **17**,**19** are part of the tracking frame.

[0062] FIG. **4** shows a side view where stabilizing system parts can be more clearly pointed out. Driver place holder **4** and passenger place holder **5**, body of revolution axis **51**, and travel direction indicator **46** orient the view. The side view of the struts **9** shows how these connect between the carriage and the structure below. At the top, the struts **9** attach through a cutout **103** from the carriage body shell, to internal structure of the carriage to be shown later. The cutout provides a small gap **104** that provides an aerodynamic smooth body of revolution when the vehicle is traveling straight.

[0063] The structure below that the struts **9** attach to, on the side that can be seen, is part of the right side wheel train. From the pitch hinging mechanism **24** shown in FIG. **1**, a bent horizontal arm **19** and other structure connects to wheel train structure toward the rear of the vehicle. Each wheel enclosure is connected to a horizontal pivot axis by a suspension arm, as shown by arm **107** and horizontal pivot axis **402**. The middle wheels are control wheels, with the right side control wheel **113** here visible. The middle wheels are mounted at the middle axle **37** such that they are allowed to pivot about a vertical pivot axis **108**. Other details include the tracking frame attachment structure arm **401**, fairing support airfoils **22**, tracking frame structure airfoils **22**, tracking wheel suspension arm **17**, hinging at pin **402**, and a rear wheel pivot axis **109** that enables rear wheel steering as a backing aid.

[0064] The wheel train is a combination of wheels and motors in enclosures, battery compartments, and fairing devices. The right side wheel train **34** show here has an involved set of fairings that make it a smooth aerodynamic unit for forward travel, yet allow various actions needed for road operations. A rear fairing shell **410** enables smooth action of the rear suspension device in relation to a rear battery compartment **430**. This rear fairing shell **410** is attached to the rear suspension arm **17**. Its front and back surfaces enable rear wheel turning and suspension action, yet maintain aerodynamic smoothness. Note that the fairing shells here discussed are not actually blocks as shown, and that only the external surfaces actually exist. A pitch action fairing shell **201** is held by the supports **22** in fixed relationship to the carriage frame such that pitch hinging action is allowed for uneven road surfaces, but returns the wheel trains to a smooth aerodynamic condition for level road conditions. A yaw action fairing shell **412** acts similarly in turning operations. Its rear surface mates approximately, with very small gap, with the front surface of the pitch fairing shell **201** when the wheel train is in a straight condition. The front surface of the yaw action fairing shell **412** similarly mates with the control wheel rear fairing shell **202**, allowing the suspension device for that wheel to act. The yaw action fairing shell **412** is held rigidly to the control frame structure by the support arm **401**. The control wheel enclosure is shaped at the rear to mate well with the control wheel rear fairing shell **202**. Other fairing shells **414**,**415** function with respect to battery box **431**, similarly to functioning of the rear fairing shell **410**. The front wheel enclosure **416** is the only one of six that is identified.

[0065] FIG. **5** shows the three frames of the vehicle separated for viewing clarity. Each individual frame operates as a rigid structure with the exception of control wheel **39** pivoting action and small angle flexing necessary for individual wheel spring suspension devices. Rear wheels are also fixed to enable pivoting about vertical axes **109** to facilitate an important secondary function of backing the vehicle. The control frame **32** connects to the carriage frame **31** through the yaw hinging axis **102** and the tracking frame **33** connects to that carriage frame **31** through the pitch hinging axis **101**. This arrangement enables a nearly ideal airship form without significant interruptions of the ideal surface. The gap **104**, visible in FIG. **4**, becomes a significant surface interruption only during turns, since it closes to a very small surface gap when straight line travel resumes. The wheel train parts are separated for viewing clarity here also, but when the frames are joined through the hinging axes, the wheel trains also form horizontal columns having smooth surfaces that are minimally interrupted for straight line travel of the vehicle. Fairing mechanisms needed for this action include a filler block **201** shown here as a solid, shaped block. Actual implementation of this block is anticipated to not actually fill the block, but only maintain the outer surfaces that become part of the outer wheel train fairing surfaces.

[0066] FIG. **5** also shows a brace **442** that helps hold the post **440** that, in turn, supports bearings that maintain a fixed orientation of the near vertical yaw axis **102** with respect to the control frame, thus controlling the carriage frame **31** orientation. Only yaw hinging is enabled by this arrangement;

neither pitch hinging nor roll hinging are allowed. This serves to enable a clean body of revolution as the carriage **31** and to provide stabilization of the relatively high vehicle. Bracing **446** of the tracking frame keeps it an approximately rigid structure. The pitch hinging relationship about the pitch axis **101** between the tracking frame **33** and the carriage frame **31** similarly enables only relative pitch hinging. Thus, the carriage is controlled to hold toward the inside of a turn.

[0067] FIG. **6** shows further detail of the control frame, particularly the structural tie in **441** of the struts **9**. It also continues the discussion of the fairings in the wheel train system. Shaping of a wheel enclosure **417** is accomplished by a block **205** that is fixed to that adjacent wheel enclosure, where the block provides a surface at its rear side that mates with the forward surface of the following block **202** seen in FIG. **5**. Another filler bock **206** functions similarly, allowing angular motion of the suspension arm **306** about its hinging pin **307**.

[0068] FIG. **7** shows the tie in to the carriage internal structure **602**. Here the view of the internal structure **602** is enabled by removing of the outer carriage body surface. Viewing orientation is provided by the driver place holder **10** and the passenger place holder **604**. The carriage internal structure **602** is made rigid by the box beams shown as well as the unit body effect of the outer carriage shell. The carriage internal structure also includes a rigid tie in **620** to the pitch hinging axis **101**. The key bracing structures **601** prevent roll motion between the pitch hinging axis **101** and the yaw hinging axis **102** and also help make the body framing rigid. The yaw hinging mechanism is centered on the near vertical shaft **403** that turns freely relative to the carriage structure **602** and, hence, the carriage **31**. Bearings **612**,**613** fixed on the carriage structure enable this relative motion. The shaft **403** also turns freely relative to the control frame **32**, with bearings **610**,**611** enabling this motion. The shaft **403** is a strong cylinder capable of carrying significant roll angle torque and pitch angle torque from the control frame **32** to the carriage **31**, such that relative roll motion and relative pitch motion are blocked. However, the shaft **403** also is part of the turning linkage, to be discussed next. That pitch hinging action enables relative pitch angle variation between the carriage **31** and the tracking frame **33**. The tracking frame also provides roll control of the carriage **31** by blocking relative roll motion between the carriage and the tracking frame **33**. The vertical pivoting axis **108** of the control wheel **39** is shown offset from the road contact point for that control wheel **39**. This offset is a caster effect arrangement. Caster offset **605** is also shown here.

[0069] FIG. **7** also clearly identifies one of the low profile wheel trains **34** that extend the full length of the vehicle. Each of these encloses three wheels on each side, along with batteries, significant structure and electric motors fitted with chain drive and sprockets on the motors and wheel drums.

[0070] FIG. **8** shows bracing that relates to FIG. **7**. This bracing ties the carriage internal structure **602** and the structural connection **620** to the pitch hinging axis **101** mechanism together and locks these to the yaw hinging axis **102** mechanism. These are formed of metal panels welded into rigid structures. This is a representative way to achieve the intended rigidity.

[0071] FIG. **9** shows the method of fixing the carriage internal structure **602** in relation to the carriage **31**. Only one side of the internal structure **602** is shown. The framing hoop **603** shown is one of multiple such hoops that form the body of revolution shape that gives the intended aerodynamic performance. Such frames tie in to the unit body of the carriage shell.

[0072] FIG. **10** illustrates the steering linkage between the driver and the control wheels. Parts shown here operate in respect to the control frame structure, although handles **405** link to a driver who is generally fixed relative to the carriage **31**. Control arms **409** pivotally link to cross arm **401** which is fixed on a near vertical shaft **403** that carries torque to the lower cross arm **407** that is also fixed on that vertical shaft **403**. The lower cross arm **407** is similarly, pivotally linked to lower control arms **406** that are pivotally linked to lever arms **408** that are positioned to enable forcing control wheels such as the visible wheel **39** to pivot. The lower cross arm **407** is shaped with an offset **404** to slightly vary the angle between the two control wheels for larger turning angles.

[0073] Turning action is illustrated in FIG. **11**. A left turn operation is shown underway. The control wheels, as demonstrated by the visible, right side control wheel **113**, are shown having pivoted relative to the control frame **32** and forward motion has caused that control frame **32** to turn to move along a turning path. The carriage **31** allows that turning action by the control frame **32**, though it is prevented from immediately changing direction by the tracking frame **33**. However, because the front wheels are rigidly linked to the control wheel position, and that control wheel position has been forced laterally toward the outside of the turn by the pivot action and forward travel of the control wheels, the carriage is then forced to turn to follow the travel of the front wheels. Because at least one of the rear wheels **701**, **702** maintains good road contact, the tracking frame **33** and the carriage **31** follow the yaw axis like a trailer follows a trailer hitch on a car. The tracking frame **33** holds the carriage **31** toward the inside of the turn, which is on the left in this illustration. The control wheel **113**, which is on the right in this illustration, is well positioned on the right side. Because it is significantly extended toward the outside of the turn, it acts on a lever arm, creating a roll torque that counters the radial acceleration effect of the turning carriage **31**.

[0074] The right control wheel **113** is mostly within an enclosure **417** that pivots to force pivoting of the right control wheel **113**.

[0075] The tracking frame **33** does not provide vertical support for the carriage **31** because of the pitch hinging axis **101**. Therefore, the control wheels must be positioned sufficiently rearward, relative to the weight distribution throughout the vehicle, so that the carriage **31** does not tip over backwards. The pitch hinging axis **101** must also be appropriately positioned relative to this need.

[0076] Aside from action that stabilizes the vehicle, the steering system itself is a dynamic control system, where the control input is the steering angle set by the driver. The turning of the control frame **32** is a response that continues until that control frame is oriented to match that set steering angle. At that point the control wheel **113** is in a straightened pivot angle, and the control frame **32** adheres to a straight path. An issue arises with such a system, where the control frame **32** has significant mass that can lead to dynamic instability. As the control frame swings to its straight position, it is possible that an overshoot will occur that the driver will find difficult to control. The caster offset **605** of the control wheel cannot be large, otherwise it will difficult for the driver to prevent that overshoot. Reducing the caster effect offset gives the driver a stronger control effect. Spring action in the steering linkage can also contribute to instability of the steering system.

[0077] Tilt effect due to a tilted yaw hinging axis **102** can be seen in FIG. **12** where the right rear wheel **701** can be seen to be higher **704**, relative to a horizontal line **703**, than the left rear wheel **702** during the left turn according to the example of the previous figure. This lifting is made visible by keeping the individual wheel suspension actions inoperative, such that there is full rigidity in the vehicle, except for the yaw hinging, the pitch hinging, and the control wheel pivoting actions. The lifting of that right rear wheel **701** is a visible indication of the vehicle tilt that affects the carriage **31** tilt as well. Driver and passenger comfort in turning is enhanced by this tilt which is toward the inside of the turn of this example. Bracing cables **720** show the effect of these in making the tracking frame rigid. Note that in actual operation, the suspension devices at each wheel will seek a balance such that the right rear wheel **701** does not actually lift as shown.

[0078] A further detail is that the front wheels are positioned somewhat forward of the near vertical yaw axis such that a variety of possible driving conditions can be dealt with. This was included in response to a concern for excessively banked turns where the vehicle speed was not sufficient to prevent roll over to the inside of the turn. This concern is addressed by appropriate placement of the front wheels relative to the yaw hinging pivot point so as to cause them to extend in a direction opposite that of the control wheels.

[0079] A further stabilizing effect is provided by wheel trains that include wheels and heavy equipment, enclosed in horizontal columns. These are held separate from the carriage. The weight distribution inherent in the wheel train arrangement provides favorable mechanical dynamic effects, stabilizing against transient side forces especially well.

Alternate Embodiments

[0080] The combination of an airship form of body of revolution that is elevated above the road surface to enable free flow aerodynamics and an articulated stabilization system, where the articulated system enabled both overall height and separation between the vehicle and the ground, has been detailed as the preferred embodiment. Various combinations of high efficiency bodies, means of enabling free flow aerodynamic conditions, and stabilizing base systems are alternative embodiments of the high efficiency vehicle.

[0081] One such alternative combination involves a four frame articulated stabilization system. It is similar to the preferred embodiment except that front frame is divided into two parts, one on the right and one on the left. Flexibly attached to each front frame is a single front wheel and a single control wheel that is behind that front wheel. Preferably, the control wheels are about in the middle of the vehicle. The wheels operate in a turn as before, with control wheels pivoting, extending to the outside of the turn to give a stabilizing stance, and forcing the front wheels to turn. Two yaw hinging axes are now involved, with these individually tilted outward so that when the control wheels extend outward they are force slightly downward. Each yaw hinging axis is now attached to a strut which is rigidly fixed to the carriage body. This eliminates any need to interrupt the carriage surface to allow hinging movement. A lateral stabilizing bar connects pivotally to each of the lower front frames such that orientation of these is coordinated appropriately. This includes provision for the front wheels to be at a slightly different angle in turning, the difference increasing with turning angle increase. By making the attachment points forward of, and laterally to the outside of, the yaw hinging axes, this can be accomplished.

[0082] This alternative is shown in FIG. **13**, where dual control frames **810**, **811** are shown instead of the single control frame previously discussed. Here there are two yaw hinging axes **805**, **806**, with outer bearing systems **801**, **802** and inner shafts **803**, **804** that fit within the outer bearing systems **810**, **811**. The dual control frames **810**, **811** would be free to hinge independently of each other except for a control bar **812** that holds them at the correct relative angle for a given turning radius. FIG. **14** shows this same configuration from a perspective that shows that there is now no interruption in the ideal aerodynamic carriage body **31**, in contrast to the arrangement shown in FIG. **2**, where a cutout **103** fixed to the struts **9** necessitates a gap **104**. FIG. **14** also shows the fairings **820**, **821** that are now differently shaped to accommodate the separated yaw hinging axes **805**, **806** that are now the rotation centers that define the fairing surface shapes.

[0083] FIG. **15** shows the control frames in plan view where the appropriate steering control linkage for this form is indicated. Although a mechanical linkage, somewhat more complicated than that in the preferred embodiment, is possible, a hydraulic system is envisioned. Such is detailed here in a schematic form. The three frame system of the preferred embodiment can use similar hydraulic technology to help minimize equipment under that elevated body. Details are provided only for the right side the left side operates similarly. Three hydraulic cylinders **833**, **834**, **835** are shown, where steering control by a driver is enabled through a handle **832** that forces motion of a shaft **836** that drives a piston in the controlling cylinder **833**, driving a piston that is initially midway as indicated **839**. The controlling cylinder **833** is mounted to the carriage structure. A control wheel actuator cylinder **834** mounted on the right control frame and shaft **837** control the right side control wheel, being pivotally attached **830** to a lever **773** that is mounted on the right side control wheel enclosure **839**. A bearing arrangement **837** enables that enclosure **839** to pivot relative to the right control frame. A sensing cylinder **835** with shaft **838** is pivotally linked **831** to the carriage body **31** above shown in FIG. **14**. The sensing cylinder **835** is also mounted on the right control frame. Hydraulic lines **842**, **843**, **844**, **845** connect cylinder compartments, defined by the cylinders and the piston positions **839**, **840**, **841** as shown.

[0084] Operation responds to initial displacement **846**, moving fluid in the directions indicated **750**, and **751** to activate the actuator cylinder **840** to force movement **847** that rotates the control wheel enclosure **839**. Forward travel then forces rotation **774** of the right control frame, that rotation being centered on the right yaw axis mechanism **801**. This forces the right front wheel enclosure **810** to pivot about that right yaw axis, and inherently also forces a direction change for that right front wheel. Although the left side acts similarly, a control bar **770** attached on each side **771**, **772** forces coordination that is appropriate. Attachment points **771**, **772** are set such that the right and left frames deviate from parallelism for larger turning angles. A sensing shaft **838** displacement that is a function of the rotation angle **774** then drives fluid in the directions **752**, **753** indicated. The fluid is thus returned to and taken out of the actuator cylinder **834**. This flow continues until the actuator cylinder **834** is returned to the neutral position and the control wheel enclosure **839** is straight with the right control frame, and the control frame now travels in a straight line. This is a control system operation where the actuator cylinder apparatus **840** operates to force matching of the command displacement **846** and the response displacement **848**. This is a rudimentary description of a system that is envisioned as a much more sophisticated apparatus.

[0085] A further alternative vehicle combination is much like that above, except the front and rear wheels are arranged much like a typical automobile. However, the yaw hinging action is retained, where the control wheels are pivotally mounted on control arms that extend as before. However, the carriage, the main lower structure, and struts are a rigid unit, so the articulating action is only that of the control arms. These control arms are linked to the front wheels so that they cause these front wheels to turn, just like before. As before, the front wheels extend in a direction opposite that of the control wheels, depending on the front wheel position relative to the pivot point. This alternative exemplifies the range of possible variations of the preferred embodiment.

[0086] Another example of an elevated aerodynamic body relies on a two frame stabilization system as shown in FIG. **16** and FIG. **17**. Visible in FIG. **16** is a body shape that is a generalized body of revolution formed of a sphere **850**, cylinder **851**, and cone **852** in a combination that is less optimized than the airship shape. A canopy **853** is attached for viewing, without otherwise enlarging the body. Struts **856** attach structure supported on two forward wheels to a lower forward body part that is part of the sphere **850** and cylinder **851**. Rearward struts **854** attach structure supported by a rear wheel to the cone part **852** and the rear part of the cylinder **851**. The cylinder **851** has parts that are linked by a hinging mechanism that enables relative hinging of these parts about the pitch axis **860**. This necessitates body joints **867** that are made as smooth as possible by surfaces that roughly slide parallel with each other. The rearward body section is rigidly attached to the rear struts **854**. The forward body is split into upper and lower parts that are divided at other body joints **868**, **859**. These upper and lower parts are also linked by a hinging mechanism that enables them to rotate with respect to each other about the near vertical yaw axis **862**. The surface of the forward spherical part is well maintained during yaw hinging action by the forward joint arrangement **859**. However, in a turning operation the forward cylinder surface is seriously broken at the continuation rearward **868** of that joint **859**, but the ideal shape is approximately restored when that yaw hinging angle goes to zero for straight forward travel of the vehicle. The lower body part is rigidly attached to the forward wheels by the forward struts **856**. Because of the yaw hinging arrangement the vehicle can turn corners and because of the pitch hinging arrangement the wheels maintain adequate contact with the road surface, even if it is not completely flat.

[0087] FIG. **17** clarifies the two main frames **861**, **865** of this example vehicle. The control frame **861** is shown separately, as well as in the connected arrangement. The control frame **861** illustration shows the yaw hinging axis **862** coming from the center of a flat disc. This disc is suggestive of the fifth wheel device used to connect the tractor to the trailer of a semi-truck, except the pitch hinging axis **860** is here significantly offset from the yaw hinging axis **862**. The structural link between the hinging mechanisms at these axes **860**, **862** is enclosed in the body surface part **864** that acts as a fairing to maintain the desired aerodynamic shape. It is important to making this fairing **864** apparatus effective that mating surfaces between body parts act with regard to only one axis of rotation. Thus gaps **859**, **868** are only large enough to allow for slight structural flexing and manufacturing tolerances. The gaps **867** shown in FIG. **16** are less ideal due to curvature effects, but the rule is still applicable.

[0088] In contrast, FIG. **17** shows a significant surface that is shaped to provide an interface between the rear frame **865** and the control frame **861**, where relative motion between these frames is about two axes. While this interface enables pitch hinging and yaw hinging between these two frames, there is a significant notch that remains, even for the straight line travel condition. This demonstrates the difficulty with constructing a fairing device that spans a two axis joint.

[0089] In the two frame stabilization system, the steering action is like that of the preferred embodiment. However, it is more critical with the two frame arrangement that the weight of the rear frame causes a downward force at the pitch axis and that this force point is set forward of the rear wheels of the control frame **861**. This makes it necessary to arrange the two axis interface as described above, except that if the carriage part is sufficiently elevated the clearance issue can be avoided. This leads to a greater vehicle height for this two frame arrangement and additional vehicle weight is then needed to counter the more severe effect of cross wind force.

[0090] In another application where wheel base width is not tightly limited, a highly efficient, elevated aerodynamic vehicle can be implemented more simply, relying on the stabilizing properties of the wheel train system alone. FIG. **18** illustrates this alternate apparatus. A simpler aerodynamic body **885** is now possible. While it is envisioned here as a sphere, cone, cylinder combination it is anticipated that the ideal airship would be superior. As with the preferred embodiment, the single wide seating arrangement is key to making this a highly efficient aerodynamic vehicle. Other possible body shapes are also envisioned, such including the box fish shape or specially refined shapes that are possibilities arising from computer optimization. Note that the struts **880** are shown as rectangular shapes, this is only for drawing simplicity, and actual implementation will benefit from airfoil shapes. Computer optimization of the body will ultimately provide a unified design that includes strut effects as part of the body system. These expectations are relevant to the preferred embodiment implementation as well.

[0091] In this alternative, the wheel base is fixed, much like that in conventional automobiles. Thus, articulation is not a part of this version. Stabilizing properties of the wheel train arrangement were found to be so substantial as to enable a simpler embodiment of the high efficiency vehicle, where the narrow part of the automobile is only the carriage. By simply spreading the simpler wheel trains **887** to widen the wheel base, adequate stabilization can be achieved without need for the complication of the articulated stabilization system. This is now a four wheel system, where turning only requires pivoting of the front two wheels as with typical cars. Now, simplified wheel trains can be implemented, where each wheel train includes only two wheels with heavy equipment between these two wheels. Fairings similarly provide a smooth aerodynamic surface for straight line travel, but these are simplified because they are only needed to enable the pivoting for turning of the front wheels and flexing due to spring suspension of wheels. Now there are two thin struts on each side of the vehicle that serve to elevate the carriage with simpler structural requirements. Not only does the wheel train system provide roll stabilization for steady state forces, it is a weight distribution arrangement that maximizes moment of inertia about the longitudinal axis, thereby limiting the effect of transient forces. A brace between **870** the wheel trains provides structural advantages that put less stress on the struts **880**.

[0092] FIG. **19** shows a pickup truck version of the above alternative. Here a large flat panel **890**, of airfoil shape, spans between the wheel trains and similarly helps structurally brace the vehicle. This panel also enables a load carrying function, as with a pickup truck, except the load is carried under the vehicle. Though somewhat degraded if a load is carried, aerodynamic efficiency of this embodiment is also exceptional. While this second embodiment with a wider, fixed wheel base lacks the compact qualities of a truly narrow car, it is a less expensive, but still very efficient aerodynamic alternative.

[0093] Another alternative to the preferred embodiment is a system that utilizes the height advantage and ideal surface arrangements inherent in the three frame articulated stabilization system, but does not strive for a large separation distance between the aerodynamic body and the ground. Rather, it strives to control air flow so that air only flows laterally to pass by the vehicle body. This arrangement also minimizes the effect of the road surface, such that this body shape also operates under approximately free flow conditions. Thus, even though the approach is different than that represented by the preferred embodiment, it is also a narrow car having a highly efficient aerodynamic shape, and this shape is made effective by an arrangement that enables free flow aerodynamic conditions.

[0094] This alternative system implements an aerodynamic shape that is patterned after an airfoil, where that airfoil is shaped only for minimum drag and not for lift. It is only a short segment of such an airfoil. This alternate is illustrated in FIG. **20** and FIG. **21**. The side view of FIG. **20** shows the wheel positions and the perspective of FIG. **21** shows the airfoil shape. This body is oriented like a wing on its end, where one end is very close to the ground. The articulation system works as in the preferred embodiment, but no struts are needed to elevate the body. FIG. **20** shows outer surfaces of the three frames in this vehicle that include a control frame **931**, a linking frame **929**, and a tracking frame **930**. The view of FIG. **22** shows an exposed view of the control frame **931** and the tracking frame **930**. Only the small bottom panel **914** of the linking frame is shown here. The carriage function that encloses driver and passengers, spans between the linking frame and the tracking frame.

[0095] Details shown in FIG. **20** include single front wheel **902**, right middle wheel **903**, and single rear wheel **904**. Flat top panel **911**, **913**, and flat bottom panel **910**, **914**, **915** are segmented to extend between vehicle frames, yet function as single surfaces for straight travel over smooth surfaces. A front window **916**, a rear window **917**, and middle windows **918** enable operation by a driver and a view for a passenger, seated in single file. Internal structure **909** of the linking frame **929** can be seen attaching through yaw hinging joint mechanism **907** to control frame post **908** that is a rigid structural part of the control frame **931**. Slight gaps in the airfoil surface **905** and the bottom panel **936** enable yaw hinging action about the yaw axis **901**. A gap in the side **932** enables pitch hinging action as do panel gaps, top and bottom, as represented by a gap in the bottom panel **935**. A slight wheel pivoting gap **906** interrupts the airfoil side surface for control wheel **903** pivoting during a turning operation.

[0096] In FIG. **21** the three axles are pointed out; such include front axle **921**, middle axle **922** and rear axle **923**. Though not limited to such, the rear wheel **904** has a fixed rotational axis aligned with its axle. Control wheels, as shown by the right control wheel **903**, pivot such that their rotational axes are not necessarily so aligned. The front wheel **902** also pivots as part of the turning action. It can be said that the whole front axle pivots in this operation.

[0097] The top panel is shown with its segments **911**, **913** separated by a small gap **934**. A small fairing panel **941** is shown that pivots with the right control wheel **903** to break the airfoil side surface for that pivoting action at small gap **906**.

[0098] FIG. **22** shows a panel **940** that is approximately flush with the airfoil surface that serves as a frame for action of the pivoting panel **941**.

[0099] Also in FIG. **22** the frame connections can be seen. The linking frame **929**, as represented by some of its internal structure **909**, is connected through the yaw hinging axis **901** mechanism to control frame **931** structural post **908** that is fixed to control frame internal structure **925**. The linking frame **929** is also connected to the tracking frame **930** through the pitch hinging axis **900** mechanism. The linking frame **929** outer surface and a fairing surface on the control frame **931** together form a single airfoil shape for straight line travel, as does the fairing surface on the tracking frame **930** and the linking frame **929** outer surface. The yaw hinging joint between the middle frame and the control frame enables the control frame to turn, relative to the linking frame, thus turning the front wheel **902**. As with the preferred embodiment, the control frame **931** is caused to turn by control wheels that are middle wheels of the vehicle, and these similarly extend laterally to the outside of the turn to give a stabilizing stance. Only a small gap **905**, seen in FIG. **20**, is needed to allow the control frame **931** fairing surface to turn relative to the linking frame **929** exterior surface.

[0100] FIG. **22** also shows the tracking frame **930** structural parts **926** that connect that frame to the pitch hinging axis **900** mechanism. The pitch hinging axis **900** mechanism operates to enable the tracking frame **930** to remain grounded for a reasonable range of conditions, thus controlling the heading angle of the carriage body. The tracking frame enclosure is separated from the middle frame surface by a small gap, only large enough to enable pitch hinging of the tracking frame part of the carriage relative to the part of the carriage that does not pitch. This gap is shaped by the intersection of a hollow cylinder centered on the pitch hinging axis and the general airfoil surface. This cylinder defines the boundary between the middle frame and the tracking frame, though the inner space is only minimally affected to the degree necessary to allow for relative motion across the gap. At least one of the tracking frame wheels must maintain firm ground contact to make the stabilization system effective.

[0101] Wing tip vortices were an issue in early wing design, also addressed by Prandtl, where it was shown that these were a significant cause of drag. An arrangement in a wind tunnel, where the wing extended from wall to wall of the wind tunnel, showed that air flow so constrained did not develop such vortices. The nearly flat panel, horizontal, on the top of the above described vehicle, functions somewhat like one wind tunnel wall, and a similar panel on the bottom of the vehicle similarly acts like the opposite wind tunnel wall. An old, aircraft carrier based plane, the E2-B, used an arrangement having a similar effect, on its relatively short wings. Not an insignificant benefit of the top flat panel is a second purpose, where it functions as a sunshade. The bottom panel action is more significant. Because it is made parallel to the road surface such that there is no cause for vertical acceleration of air flow and air stream lines run parallel to both the panel and the road surface, the only air drag on the vehicle underside is the result of viscous drag effects that create a relatively thin boundary layer. Wheels force an obvious exception to this idealization, but this is problem is minimized by mostly eliminating the usual wheel wells that enable wheel pivoting and operation of suspension systems.

[0102] This is done with a wheel shell system, where the shell is a conceptual shape like a barrel, where that barrel encloses most of the wheel, as well as electric drive equipment and the suspension system. Pivoting of this wheel arrangement involves pivoting of this conceptual barrel and the enclosed contents. The barrel defines a cut away part of the airfoil outer surface. The bottom disc of this barrel is flush with the lower panel, but is cut free of the barrel such that it can move vertically as the spring suspended wheel moves vertically. The outside surface of this barrel is modified in shape, roughly flattened, to give a surface that conforms to the air foil surface shape when the vehicle is traveling straight. The bottom disc is also modified with a roughly straight edge that conforms to the airfoil outer surface, and therefore also conforms to the flattened barrel side surface. A cutout in the bottom panel is needed that matches the mostly circular shape of the disc. Thus, for operation on smooth roads, a nearly continuous bottom planar surface is maintained. In actual implementation, the only barrel surfaces that are actually needed are the bottom disc and the flattened side part of the barrel. The bottom disc is fixed to the horizontal wheel axis so it moves with the lower end of the suspension apparatus and the flattened side surface is fixed to the structure where the upper end of the suspension apparatus is attached. A cutout is obviously required to allow the wheel to penetrate the modified bottom disc, but this needs only to be large enough to enable simple rotation of that wheel, since the disc and the wheel both move up and down together and pivot together.

[0103] FIG. **23** shows the wheel shell arrangement including its fairing surfaces that maintain smooth aerodynamic surfaces. The pivoting panel **941** is attached by structure **962** and brace **953** to pivoting wheel structure **951**. Because the conceptual barrel centered on the pivot axis **942** cuts a plane parallel to the side of the airfoil to define the panel **941**, and the side window **940** seen in FIG. **22**, the panel **941** will be flush with that side window **940** when it is not pivoted, yet a small gap enables it to pivot. By mounting this panel to the pivoting part of the wheel structure only, and not on the suspension arm that gives the wheel freedom to move up and down, the panel **941** to window **940** interface is nearly perfect. A disc **957**, that is also cut out by the conceptual barrel, now from the bottom flat panel, moves up and down as needed for operation of the suspension system, shown here as a hinged arm **953**. Clearance **963** between the pivoting structural part **951** and the disc **957** is needed to enable this up and down movement. A gap **956** is needed to allow the disc **957** to move up and down and pivot as well, while the side panel **941** only pivots. The pivot bearing **937** enables the pivoting action of the structure below, represented by parts **951**, **962**, **953**, relative to the structure above **961** that is part of the control frame internal structure. This control frame structure serves as the link between the lateral position of the control wheel **903** and the pivot angle of the front wheel **902** of the vehicle. This fairing arrangement has been here described in respect to the airfoil body example that is a highly efficient body. It has importance in relation to more general automobile applications, where wheel wells are responsible for much of the inefficiency of these automobiles.

[0104] The above described airfoil shaped version has larger vulnerability to cross wind aerodynamic forces than the elevated body of revolution form. A simple solution to this is to add more weight to counter this effect.

[0105] Large trucks are also of great interest relative to aerodynamic efficiency. An airfoil shape is envisioned for greatly improving aerodynamics. An important part of this is a fairing arrangement similar to fairings that have been extensively discussed here. An interim apparatus is here described, where applicability to existing vehicles and existing designs is intended. FIG. **24** and FIG. **25** show how a basic semi-truck can be fitted with a nearly ideal fairing apparatus. The basic truck **970**, shown without wheels, is the starting point. Enclosing panels **978** enclose much of the rear wheels and under body space down to a base line **982** that extends forward at a height that is as low as practical. The pitch axis **990** of the articulating joint enables relative angular motion between the tractor **972** and the trailer part, necessitating a special apparatus that is here provided. The top plate disc, of the joint apparatus **980**, hinges about this pitch axis **990** on a hinging mechanism below. The provided fairing **973** has a cutout **998**. A pivot connection is provided for by a hole **997** centered on the yaw axis **981** as shown at the top of the fairing assembly **973**. In the combination of tractor and fairing **974**, this cutout **998** fits around the top plate disc **980**, and the fairing is rigidly attached to that top plate disc **980**. When the full system **975** is put together, the trailer attaches as before to the articulating joint, and is supported by the top plate disc of the joint apparatus **980**. The fairing apparatus is stabilized relative to the trailer body by a pivoting connection through the fairing top hole **997**. The system is completed with a thin panel **979** fixed to the trailer body to close out that lower gap. This panel and the fairing apparatus side panels allow free rotation of the trailer about the yaw axis **981**, but when the truck is traveling straight, trailer body to fairing gaps are effectively closed aerodynamically. The side panels of the fairing apparatus similarly allow relative pitch hinging between the tractor and the fairing apparatus. The side panels of the fairing apparatus **973** are fitted to slide relative to the side panels of the tractor **972**. The curved front surface **976** of the fairing apparatus **973** have a shape defined by a surface of a cylinder having a center aligned with the pitch axis **990**. This front surface **976** meets the tractor cabin upper front edge such that pitch hinging action will cause it to open a gap, close that gap, or extend slightly over the front of the tractor cabin. A similarly shaped surface attached to the tractor can be used to make this a sliding joint, where it need not extend too low. Use of flexible material to further treat gaps is expected for aerodynamic purposes and to control vibration and rattling effects.

[0106] It seems possible that trucks will eventually be built in the shape of the vehicle shown in FIG. **21**. The interface line between the tractor and the fairing will then be somewhat like the interface **905** of that example. However, rather than the rotational joint of that example, the truck tractor to fairing joint would be a sliding joint with sufficient overlap to enable such relative motions. The fairing apparatus would then be adapted to serve as the cabin for the driver.

RAMIFICATIONS

[0107] The articulated vehicle wheel system disclosed in Bullis, application Ser. No. 11/064,301, Feb. 23, 2005, eliminated dependence on a low center of gravity and a wide wheel base to stabilize vehicles with a two frame vehicle connected with an articulating joint. The present invention discloses a three frame system, and variations, where a first frame is connected to a second frame with an articulating joint, and the second frame is connected to a third frame with an articulating joint. Both inventions relied on articulating joint action that held the vehicle parts fixed in roll angle relative to any other part. This enabled prevention of vehicle roll over by the wheel system operation. In this operation, the control wheel pivots in response to driver action. Then it extends on the outside of the turn at the same time as it forces the front wheels of the vehicle to turn. Thus, the stabilizing action is coordinated with the turning action. Variations of this are possible, including linking the control wheel extension mechanism to a rear wheel as well, or instead of, the front wheel. In any case, it makes a tall and narrow vehicle possible.

[0108] However, not only does a higher center of gravity enable a tall and narrow vehicle, it also enables an elevated vehicle, where the carriage body is elevated above the ground giving substantial ground clearance. It is now clear that this ground clearance is important for other purposes that go beyond the need to clear obstacles or uneven places on the road. The preferred embodiment earlier discussed is an example. Another is a military vehicle giving protection from explosive devices in a roadway, where soldiers are carried at a height that significantly separates them from the source of explosion and the height allows for armor structure between soldiers and that source. That armor can be wedge shaped to provide a blast splitting effect. A further benefit of the elevation capability is that thin struts can be used to separate the carriage from the lower, supporting structures, such that shapes can be utilized that operate independently.

[0109] Operation of the wheel system is enabled by the articulating action of the vehicle. This articulating action is needed to assure that essential wheels remain in contact with the ground. Because it requires hinging between vehicle parts, there is a present design issue that clearance must be maintained as these parts hinge on each other. This affects the detailed shaping of the vehicle frames, as well as the layout of the carriage interior and the positioning of other equipment. A fortunate benefit of elevating the carriage is that it eases design of the system where the control wheels must pass under the carriage as they operate to provide the stabilizing and turning actions. Because of these considerations, a variety of articulating arrangements have been examined. They are significantly different in structure, but all enable the underlying wheel action.

[0110] Thus there have been a series of configurations leading from the initial streamlined form disclosed in Bullis, application Ser. No. 11/064,301, Feb. 23, 2005 to the present preferred embodiment and alternatives. This development sequence illustrates the intended broad scope of the invention.

[0111] Early on, an elevated body of revolution was selected, with the expectation that an electric car was within the range of possibility, where good aerodynamics would directly impact the operating range of such a car on a single charge. A simplified shape was first used that was convenient to draw in three dimensions, which is a combination of a sphere, a cylinder, and a cone on a common axis, with the sphere being the leading part as the vehicle travels forward. Work progressed with this shape as the carriage part of the vehicle, in conformance with that earlier disclosure. Rear wheels were individually attached to that carriage. The stabilizer part included struts that connected between the stabilizer structure and the two axis, articulating joint. The offset joint structure was attached to a part of the carriage, which had to be split from the following part of the carriage to allow hinging action. This split was an aerodynamic setback. Providing clearance for the control wheels under the carriage was made more difficult by the pitch hinging action, and an aerodynamically undesirable notch in the bottom of the carriage was needed. It was then found that the wheels on each side could be aligned with electrical equipment, including heavy batteries, in a low profile, horizontal column. This was called a wheel train to suggest its similarities to a streamlined railroad train. To realize the full effect of the wheel train, the three wheels on each side needed to be included, so the need for a smooth joint with a surface fairing device was noted. In the course of this work a fairing apparatus was developed that provided greatly improved aerodynamic body shape possibilities. This fairing device is mounted to the structure of the two axis joint, such that it simplifies interfaces across either joint axis. While this fitted the need for the offset two axis joint system, it has application to semi-truck systems, where the fifth wheel is a two axis joint, though the axes are not offset.

[0112] With these complications, benefits of a simpler device were considered. Such a simpler vehicle could depend on the stabilizing effect of heavy wheel trains spread to give a wheel base width like a typical car, now with only two wheels structurally held in a fixed relationship. The strut concept and the streamlined aerodynamic carriage would be the same, except there would not be a need for the split or the notch in the carriage body. The penalty would be that it would no longer be a narrow car. However, it would still be very useful, especially in less populated areas. A bracing panel between the struts was included for structural reasons, but it then was seen as an opportunity for service as a pickup truck.

[0113] It was then discovered that the carriage body and the offset joint structural could be a single structural frame, thus eliminating the split in the carriage body. Furthermore, because the pitching action was eliminated between parts of the carriage, the notch could also be eliminated. This makes possible a much greater shape integrity for the nearly ideal aerodynamic forms. Now the airship shape is a very attractive form. The airfoil shape, like a wing on end, is nearly as good, and the aerodynamic flow requirements may be more easily satisfied.

[0114] Then the airship research historical records were found. Analysis of the test results for the airships showed that these shapes represented an important building block, where aerodynamic drag could be meaningfully predicted. Further study then supported the idea that an achievable separation distance between the airship-shaped carriage would enable aerodynamic drag performance reasonably close to results obtained by scaling the airship measurements.

[0115] Another variation was then considered. Previously the yaw axis joint mechanism was within the carriage and the struts were rigidly fixed to the lower structure of the control frame. However, a double control frame was then found to be possible, where the struts were rigidly attached to the carriage and a yaw hinging axis was implemented at the lower end of the struts, within the wheel trains. The wheel trains now act independently in response to their respective control wheels. They also do not need to be both a part of a rigid control frame unit. However, there is a need for these dual control frames to be coordinated to protect against misalignment and to make the direction angles of the respective front wheels fix at slightly different angles to prevent lateral sliding in a turn.

[0116] Finally, because the very low drag now envisioned would be easily degraded by deviations from the ideal airship body, including any interface joint where even a small gap existed, further try was made to eliminate all such joints. Also, there was a space layout inefficiency caused by the intrusion of the yaw hinging mechanism into the carriage. It was found that by splitting the lower front frame of the three frame articulated vehicle, a dual yaw axis arrangement was possible. In this arrangement, the control wheels act the same way as before, except they independently link to the front wheels to cause independent front wheel turning. This version was more fully explained earlier, as an alternative embodiment.

[0117] Many refinements are envisioned. These include steadying bars, attached at the rear of the airship carriage, extending to the tracking frame. Such steadying bars would minimize bobbing and swaying at the rear of the airship carriage. Back wheel turning is also envisioned to aid in parking, reduce turning radius, and aid in general backing operation. Rolling resistance of tires is an ultimate issue, and it is known that large diameter tires offer some advantage. There is a need to keep the control wheels small such that the carriage body does not interfere with them. The inclined yaw hinging axis, now used to tilt the carriage in a turn, can be used to vary downward force on the control wheels, such that they are lightly loaded for straight line travel and more heavily loaded during a turning action. Because rolling resistance is roughly proportional to downward force of a load, it would be minimized for straight line travel. Also envisioned is a mechanism whereby a steady yaw hinging angle would be set as an offset that would result in straight line travel with front wheels extended to one side and control wheels extended to the opposite side. Also envisioned is tuning of the vehicle shapes somewhat like tuning of a sailboat shape to compensate for its fixed keel. Tuning also has a potential benefit in minimizing what remains of the roadway surface effect as far as distortion of the free flow aerodynamic pattern. It is known that airspeed close to an aerodynamic body is about that of the body, but tapers off as a function of separation distance. This tapering is very slow at low vehicle speeds, it more rapidly reverts to the surrounding environment air speed at higher vehicle speeds, and at yet higher vehicle speeds, it actually goes negative before reverting to the surrounding environment air speed. Because of this there is a potential opportunity for special shape tuning to set the taper function for the most useful speeds. Active tuning, where a shaping surface is adjusted as a function of speed, is a further possibility.

[0118] In a different approach to the aerodynamic body shaped as a body of revolution, with elevation of such a body to achieve free flow conditions, the validity of the airfoil as a very efficient body was also noted. Where such an airfoil is operated vertically to the ground, at least theoretically, it does not require elevation to establish free flow conditions, since air flow is only accelerated laterally. Since there is no large separation space needed, as required under the body of revolution, a larger inner space is possible. It is desirable that this body be as long as possible to best obtain a low drag coefficient. A rule of thumb is that it be six times the body width.

[0119] The use of wheel shells to eliminate the wheel well will be very important. It is notable that the wheel wells are a major source of air drag on conventional cars and trucks.

[0120] This description of the preferred embodiments, with alternates and variations has provided illustrations of the high efficiency, vehicle. As such it demonstrates a concept that is expected to have many variations. The appended claims should determine the scope of this invention, rather than the examples given.

I claim:

1. A vehicle for operation on a roadway, that includes

a carriage that is an enclosure to enclose objects to be transported, said carriage having an external shape designed to minimize aerodynamic drag force for operation in free flow aerodynamic operation, where said free flow aerodynamic operation is characterized by a free airflow pattern that would occur in absence of any external surface that affects airflow,

articulating linkage that connects a plurality of linked frames to enable relative hinging between frames about a yaw hinging axis and a pitch hinging axis while preventing relative hinging action between frames,

a stabilizing system that includes a three axle wheel arrangement having at least one wheel at each axle and includes means to maintain firm contact of at least one wheel at each axle with said roadway, where said stabilizing system includes means to enable a front wheel to pivot to change its travel direction, and a pivotal mounting that enables a middle wheel, that is a control wheel, to pivot to change its travel direction, where a first linkage is included that enables a driver to change travel direction of said control wheel, and a second linkage enables setting of travel direction of said front wheel according to degree of lateral extension of said control wheel, and a rear wheel that is mounted at a rearward position on said vehicle such that it is laterally fixed with respect to said carriage, and

where operation includes

a turning operation that is an action that simultaneously stabilizes and turns said narrow vehicle, where turning is in response to driver action that adjusts travel direction of said control wheel through action of said first linkage, such that forward motion causes said control wheel to extend laterally toward an outside of a turn, thus setting a stabilizing stance, while said control wheel acts, by extending, to set a turning travel direction of said front wheel through action of said second linkage, where said narrow carriage then follows said turning travel direction of said front wheel, with said rear wheel tracking to hold said narrow carriage toward an inside of said turn,

and an aerodynamic operation where displaced air approximately flows according to said free airflow pattern.

2. A vehicle according to claim **1**, where said carriage and said stabilizing system are integrated such that said external shape is maintained for straight line travel of said vehicle.

3. A vehicle according to claim **1**, where said free airflow pattern for aerodynamic operation of said narrow carriage includes substantial airflow displacement and a significant amount of displaced airflow passes under said narrow vehicle, and said narrow vehicle includes struts that connect between said narrow carriage and structure to which wheels are attached, where said struts hold said narrow carriage at a substantial height above said roadway, where said substantial height enables air flow under said carriage to approximate said free flow aerodynamic operation.

4. A vehicle according to claim **1**, where said free airflow pattern for aerodynamic operation of said narrow carriage includes substantial airflow displacement and a significant amount of displaced airflow passes under said narrow vehicle, and said narrow vehicle includes struts that connect between said narrow carriage and low profile wheel trains on each side of said vehicle, where said wheel trains are formed as aerodynamic entities that include wheels that are in line on each side with interspersed equipment and structure, where said wheel trains include aerodynamic fairing provisions that provide for approximately continuous outer surfaces, where said struts hold said narrow carriage at a substantial height above said roadway, where said substantial height enables air flow under said carriage to approximate said free flow aerodynamic operation.

5. A vehicle according to claim **1** where said carriage has a height and a width that are approximately equal.

6. A vehicle according to claim **1** where said narrow carriage has a height and a width, where said height is substantially greater than said width.

7. A vehicle according to claim **1** where said carriage is shaped similarly to an airship.

8. A vehicle according to claim **1**, where a seating arrangement is provided that is single wide, where said vehicle is not wider than necessary to provide such said seating arrangement.

9. A vehicle according to claim **1** where said carriage is a body of revolution having a longitudinal axis approximately aligned with travel direction of said vehicle.

10. A vehicle according to claim **1** where said carriage is a body of revolution having a longitudinal axis approximately aligned with travel direction of said vehicle, except said longitudinal axis is at a pitch angle where said vehicle is pitched at a downward angle.

11. A vehicle according to claim **1** where said narrow carriage is a tapered cylindrical shape that presents a low drag coefficient to high velocity cross winds.

12. A vehicle according to claim **1**, where said external shape minimizes airflow in a downward vertical direction, and said narrow vehicle has an approximately flat bottom such that air passing under said narrow vehicle is approximately the same as undisturbed surrounding air.

13. A vehicle according to claim **1**, where said external shape minimizes airflow in a downward vertical direction, and said narrow vehicle has an approximately flat bottom such that air passing under said narrow vehicle, and below a viscous effect boundary layer next to said flat bottom, is approximately the same as undisturbed surrounding air.

14. A vehicle according to claim **1**, and a hydraulic control system, where said first linkage is a hydraulic linkage where a driver actuated hydraulic control displacement causes said control wheel to pivot in a first direction to set said travel direction of said control wheel, where said lateral extension of said control wheel causes a hydraulic reaction displacement that causes said control wheel to pivot in a second direction that is opposite to said first direction, where said hydraulic control system acts to make a summation of said first direction and said second direction equal to zero.

15. A vehicle according to claim **1**, and a mechanical control system, where said first linkage is a mechanical linkage where a driver actuated control displacement causes said control wheel to pivot in a first direction to set said travel direction of said control wheel, where said lateral extension of said control wheel causes a reaction displacement that causes said control wheel to pivot in a second direction that is opposite to said first direction, where said mechanical control system acts to make a summation of said first direction and said second direction equal to zero.

16. A vehicle for operation on a roadway, that includes

an aerodynamic body having a shape that is designed to minimize aerodynamic drag force for operation in free flow aerodynamic conditions, where free flow aerodynamic conditions are characterized by a free flow airflow pattern that would occur for said aerodynamic body in absence of any surface that would affect said airflow pattern,

wheel apparatus to support said aerodynamic body and enable it to travel on said roadway,

a weight distribution providing a center of gravity that is sufficiently low to enable stable operation on said roadway,

where said vehicle is configured to enable roadway operation where an aerodynamic flow pattern approximates said free flow airflow pattern.

17. A vehicle according to claim **16** that is configured to function as a pickup truck.

18. A vehicle according to claim **16** that is configured to function as a pickup truck, where said aerodynamic body is a narrow body that provides a width that is no greater than needed to enable a single wide seating arrangement.

19. A vehicle according to claim **16**, where said aerodynamic body is configured for a single wide seating arrangement.

20. A vehicle according to claim **16**, where said aerodynamic body has a shape that is a body of revolution.

21. A vehicle according to claim **16**, where said aerodynamic body has a shape that is a body of revolution, and said vehicle is configured on struts that serve to elevate said aerodynamic body such that significant displaced air flows under said aerodynamic body to enable said aerodynamic airflow pattern that approximates said free flow airflow pattern.

22. A vehicle according to claim **16**, where said aerodynamic body has a shape approximately similar to that of an airship that operates similarly to the Akron-Zeppelin airship.

23. A vehicle according to claim **16**, where said aerodynamic body has an airfoil shape based on an aircraft wing shape that is configured for zero lift, where said airfoil shape is a section of such an aircraft wing arranged on end such that it extends vertically above said roadway.

24. A vehicle according to claim **16**, where said aerodynamic body has an airfoil shape based on an aircraft wing shape that is configured for zero lift, where said airfoil shape is a section of such an aircraft wing arranged on end such that it extends vertically above said roadway, where said vehicle is configured in a narrow form sufficient in width only to enable a single wide seating arrangement.

25. A vehicle according to claim **16**, where said aerodynamic body has an airfoil shape based on an aircraft wing shape that is configured for zero lift, where said airfoil shape is a section of such an aircraft wing arranged on end such that it extends vertically above said roadway, where said vehicle is configured to function as a semi-truck.

26. A vehicle according to claim **16**, where said aerodynamic body has an airfoil shape based on an aircraft wing shape that is configured for zero lift, where said airfoil shape is a section of such an aircraft wing arranged on end such that it extends vertically above said roadway, where said vehicle is configured to function as a semi-truck, where said semi-truck includes a two axis articulating joint that links a tractor part and a trailer part, and said semi-truck includes a fairing apparatus that provides smooth aerodynamic surfaces when said semi-truck is traveling in a straight line, but allows two axis articulating action of said semi-truck.

27. A vehicle according to claim **16**, where said aerodynamic body has an airfoil shape based on an aircraft wing shape that is configured for zero lift, where said airfoil shape is an airfoil section of such an aircraft wing arranged on end such that it extends vertically above said roadway, and horizontal and planar surfaces that cap said airfoil section at the top and the bottom, extending such that displaced air flows primarily laterally to pass along lateral sides of said airfoil section of said vehicle.

28. An articulated vehicle for road transportation purposes, that includes

an articulating stabilization system that includes a control frame, a tracking frame, and a linking frame, where articulating joints between frames block relative roll motion between frames, and a three axle wheel arrangement having at least one wheel at each axle, where a front axle and a middle axle are part of said control frame, and a rear axle is part of said tracking frame, and said control frame is connected through a near vertical yaw hinging axis to said linking frame, and said carriage is connected through a transverse and horizontal pitch hinging axis to said tracking frame, where said pitch hinging axis enables vertical motion of said tracking frame to enable a rear wheel to stay in firm contact with said roadway while allowing a middle wheel and a front wheel to maintain firm contact with said roadway, and where said yaw hinging axis enables a front wheel to pivot about said yaw hinging axis to change its travel direction, and a pivotal mounting enables a middle wheel, that is a control wheel, to pivot to change its travel direction, where a first linkage is included that provides a connection that enables a driver to change travel direction of said control wheel, and a second linkage provides a connection that enables lateral extension of said control wheel to determine travel direction of said front wheel,

where operations include

a turning operation that is a multiple action that simultaneously stabilizes and turns said vehicle, where turning is in response to a control action that adjusts travel direction of said control wheel through action of said first linkage, such that forward motion causes said control wheel to laterally extend toward an outside of a turn, thus setting a stabilizing stance, while said control wheel, by extending, acts to set a turning travel direction of said front wheel through action of said second linkage, where said linking frame then follows said turning travel direction of said front wheel, with said rear wheel tracking to hold said linking frame toward an inside of said turn.

29. An articulated vehicle according to claim **28** where said linking frame acts as a carriage that is an enclosure for subjects to be transported, where said subjects include a driver.

30. An articulated vehicle according to claim **28** where said linking frame acts as a carriage that is an enclosure for subjects to be transported, where said subjects include persons, where seating for said persons is only single file seating.

31. An articulated vehicle according to claim **28** where said linking frame acts as a carriage that is an aerodynamic body having a shape similar to that of an airship.

32. An articulated vehicle according to claim **28** where said linking frame acts as a carriage that is an aerodynamic body, where said carriage is held on struts attached to wheel structures such that said aerodynamic body is elevated to enable a free airflow pattern similar to that which would occur if there were no external surface that affects airflow.

33. An articulated vehicle according to claim **28** where said linking frame acts as a carriage that is an aerodynamic body, where said carriage is held on struts attached to wheel structures that are wheel trains where said wheel trains are formed as aerodynamic entities that include wheels that are in line on each side with interspersed equipment and structure, where said wheel trains include aerodynamic fairing provisions that provide for approximately continuous outer surfaces.

34. An articulated vehicle according to claim **28** where said linking frame acts as a carriage that is an aerodynamic body, where said carriage is held on struts attached to wheel structures that are wheel trains, where said wheel trains are formed as aerodynamic entities that include wheels that are in line on each side with interspersed equipment and structure that includes an electric drive system where batteries and electric motors, where said wheel trains are parallel, separated, horizontal.

35. An articulated vehicle according to claim **28** where said linking frame and said tracking frame support an enclosure that functions as a carriage that is an enclosure for subjects to be transported, where said carriage is shaped as an airfoil, like a section of an aircraft wing where that wing is on end so as to be vertically oriented, such that one end is close to the ground and one end reaches a top point of said carriage, with fairings that enable articulated vehicle operation such that airfoil shape of said carriage is disturbed during a turn but is restored for straight line travel.

36. An articulated vehicle according to claim **28**, and a hydraulic control system, where said first linkage is a hydraulic linkage where a driver actuated hydraulic control displacement causes said control wheel to pivot in a first direction to set said travel direction of said control wheel, where said lateral extension of said control wheel causes a hydraulic reaction displacement that causes said control wheel to pivot in a second direction that is opposite to said first direction, where said hydraulic control system acts to make a summation of said first direction and said second direction equal to zero.

37. An articulated vehicle according to claim **28**, and a mechanical control system, where said first linkage is a mechanical linkage where a driver actuated control displacement causes said control wheel to pivot in a first direction to set said travel direction of said control wheel, where said lateral extension of said control wheel causes a reaction displacement that causes said control wheel to pivot in a second direction that is opposite to said first direction, where said mechanical control system acts to make a summation of said first direction and said second direction equal to zero.

38. A vehicle for operation on a roadway, that includes

a carriage that is an enclosure having an external shape that minimizes aerodynamic drag force in free flow conditions, parallel, separated, wheel trains that are horizontal columns that are low profile arrangements of equipment and wheels, with supporting wheel train structure, and enclosures that are act as faired surfaces, allowing minimal protrusion of wheels to enable roadway contact, and to allow for typical uneven roadway surfaces, where said low profile arrangements minimize projected frontal area of said horizontal columns,

and struts that are structurally attached to said wheel train structure and said carriage so as to elevate said carriage to provide substantial separation space between said carriage and said roadway,

where operations include,

typical motor vehicle operation, where wide separation and low placed weight of wheel trains prevents rollover of said vehicle,

and aerodynamic operation where displaced air flows through said substantial separation space such that an overall pattern of airflow that approximates an airflow pattern that would occur were there no surfaces in proximity to affect air flow patterns, where said separation space thus minimizes aerodynamic drag force on said carriage.

39. A vehicle according to claim **38**, where said wheel trains minimize aerodynamic drag of wheels.

40. A vehicle according to claim **38**, where said carriage is a narrow carriage, having a width that is only wide enough for a single wide seating arrangement but is wide enough for safe and comfortable personal transportation.

41. A vehicle according to claim **38**, that includes an electric drive system where batteries and electric motors are enclosed in said wheel trains.

42. A vehicle according to claim **38**, where a horizontal airfoil connects between said wheel trains to enforce structural rigidity and serve also as a load carrying platform enabling operation of said vehicle as a pickup truck.

43. A vehicle that includes at least two frames that are connected with a two axis articulating joint, each frame having an external surface that conforms to a larger aerodynamic surface form, where said vehicle includes an aerodynamic fairing apparatus that provides a surface that spans between conforming external surfaces to form a larger aerodynamic surface according to said larger aerodynamic surface form, where said aerodynamic fairing apparatus allows flexibility needed for articulation between said two frames, where said fairing apparatus operates to reestablish said larger aerodynamic surface for straight line travel of said vehicle.

44. A vehicle according to claim **43**, where said vehicle is a conventional tractor-trailer arrangement known as a semi-truck.

45. An vehicle that includes a wheel in relation to a horizontal bottom panel and a vertical side panel, where said wheel travels approximately parallel to said vertical side panel, where a bottom panel cutout and a side panel cutout enable functions of said wheel that include pivoting about a vertical axis to turn and vertical motion to enable suspension device operation, where in absence of these cutouts these panels would meet at a right angle,

where said vehicle includes a fairing apparatus that provides a bottom fairing panel and a side fairing panel that fit flush in said cutouts to make said panels smooth and continuous surfaces for straight line travel of said vehicle, except for a small cutout in said bottom fairing panel that closely fits around a rotating said wheel such that such rotation is enabled,

where said fairing apparatus is an assembly that includes fairing apparatus structure that is mounted through a vertical axis bearing, centered on said vertical axis, to structure that is rigidly attached to a main frame of said vehicle, and where said fairing apparatus structure is rigidly attached to a horizontal axle that enables said rotation of said wheel,

where said fairing apparatus includes a disc shaped panel that is truncated at an outer edge, where said disc is defined with a center at said vertical axis, where said bottom panel cutout matches said disc, and where said disc is fixed to said horizontal axle such that it pivots with said wheel and moves up and down with said horizontal axle, where said disc acts as said bottom fairing panel,

where said fairing apparatus includes a rectangular shaped panel, where said side panel cutout matches said rectangular shaped panel, and where said rectangular shaped panel is fixed to said fairing apparatus structure such that it pivots with said wheel and does not move up and down with said horizontal axle, where said rectangular shaped panel acts as said side fairing panel.

46. A vehicle according to claim **45**, where said wheel protrudes through a closely fitting cutout in said disc such that said bottom panel is penetrated only to allow clearance for rotating of said wheel about its horizontal rotational axis.

47. A vehicle according to claim **45**, where said vehicle is a conventional road transportation truck and said fairing apparatus substantially eliminates air drag associated with wheel wells on said conventional road transportation truck.

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