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(54) **FUEL TANK FOR A RAIL VEHICLE**

KRAFTSTOFFTANK FÜR EIN SCHIENENFAHRZEUG

RESERVOIR DE CARBURANT POUR VEHICULE FERROVIAIRE

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US-A- 4 703 771**

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Description

[0001] The present invention relates to rail vehicles and more particularly to the design and construction of fuel tanks for incorporation in such vehicles. It also relates to a method of balancing a rail vehicle by the appropriate arrangement of a fuel tank.

[0002] Rail vehicles frequently incorporate fuel tanks within their design. Diesel and diesel/electric powered trains require substantial reserves of fuel for their propulsion. Diesel or in certain circumstances heating oil is also used for heating of passenger compartments. This may be stored in a separate tank or may be drawn from the same source as the fuel for propulsion. The quantities of fuel used and its weight can be significant to the extent that the location of the fuel tanks can affect the balance and centre of gravity of the train itself.

[0003] A railway vehicle with two fuel tanks is disclosed in DE 20113898 U (D1). The first fuel tank appears to be located symmetrically with respect to a vehicle. The second tank is indicated to one side of the vehicle. This is however a separate tank provided with a pump to deliver fuel from the main tank. The lowest point of the two tanks is located in the symmetrical portion of the tank.

[0004] On integrated passenger trains without a separate locomotive, fuel tanks are commonly situated in the underfloor region beneath the passenger compartments. This area is limited in space due to the constraints imposed by the floor height, the outer train profile limits and the ground clearance. Such a fuel tank is disclosed according to the content of DE 19719920 A which illustrates how a fuel tank can be located to maximize the available space.

[0005] A problem with such designs is the location of the sump from where the fuel is drawn off. When stationary on a cambered section of track or when negotiating an extended incline it is important that the fuel feed pipe remains immersed to avoid the passage of air. This requires further adaptation of the design of the tank to ensure an effective sump or alternatively limits the lowest level to which fuel may be drawn, resulting in excess dead volume in the fuel tank. Attempts to avoid this problem tend to reduce the overall volume of the fuel tank. One such arrangement is disclosed in US3854416 A, which uses a pair of elongated, symmetrically arranged tanks linked together by a thin feed tank located at a central sump. Such an arrangement increases stability in preventing sloshing of fuel from one side of the train to the other but is limited in overall capacity since the region between the tanks is not utilized for fuel storage.

[0006] Particularly in modern low-floor carriages where the floor is only 600 mm above the level of the rails, the height available for installation of the fuel tank may be as little as 200 - 250 mm. Current low-profile fuel tanks seek to maximise utilisation of this space while minimising extra weight and subject to the constraints of clearance requirements for track mounted objects.

[0007] An additional problem encountered in design-

ing and manufacturing a rail carriage is the need to ensure that the weight of the carriage is equally distributed between the left and right side wheels. If the centre of gravity of the carriage is not on the centreline, uneven wear of the wheels can ensue. An out of balance rail vehicle is also extremely dangerous from the point of derailment risk. For this reason the maximum tolerated difference in wheel loading is generally in the order of a few percent (maximum 5%) and any large out-of-balance items, such as toilets with associated clean and wastewater reservoirs, require compensation by locating other items such as batteries, electrical systems etc. on the opposing side of the train. Under certain circumstances, insufficient balancing components are available and ballast may be required, adding to the overall weight of the carriage.

[0008] The Itino™ train as manufactured by Bombardier Transportation uses a fuel tank of symmetric cross section which is asymmetrically located. This provides a balancing mass at the expense of a loss of fuel tank capacity. Additionally, the balancing mass decreases steadily as the fuel is consumed and its effectiveness is thus reduced.

[0009] There is therefore a need for a fuel tank for a rail vehicle which not only maximises the available space in the underfloor region but also reduces dead weight of fuel which cannot effectively be used. There is also a need for a fuel tank which provides compensation for out of balance loading on the rail vehicle without increasing the overall weight of the vehicle.

[0010] According to the present invention there is provided a rail vehicle including an out-of-balance mass located to one side of a centreline of the vehicle and a fuel tank located in the underfloor region of the rail vehicle, the tank comprising: a first portion arranged substantially symmetrically to the centreline of the rail vehicle; a second portion arranged asymmetrically to the centreline of the rail vehicle to the other side of the centreline and serving to receive a balancing mass of fluid; and a sump located in the asymmetric portion at a distance from the centreline and forming the lowest portion of the tank.

[0011] In order that the balancing effect of such a fuel tank is significant it is desirable that the volume of the second asymmetric portion be a substantial part of the whole volume of the fuel tank, accordingly, it is desirable that the volume of the asymmetric portion exceeds 5% of the total capacity of the tank, more preferably the volume of the asymmetric portion may exceed 10% of the total capacity of the tank and ideally the volume of the asymmetric portion exceeds 25% of the total capacity of the tank. The precise volume of the asymmetric portion is in general chosen to match the out of balance mass present in the rail vehicle.

[0012] According to another aspect, the present invention provides a method of balancing an out-of balance mass located to one side of a centreline of a rail vehicle by use of a reserve fuel tank, the method comprising: providing a tank in the underfloor region of the rail vehicle,

the tank having an asymmetric reserve portion; locating the tank such that the asymmetric reserve portion is located to the other side of the centreline; and filling the tank with fluid whereby the mass of fluid in the asymmetric reserve portion of the tank serves to balance the out-of-balance mass during normal driving conditions.

[0013] Further aspects and advantages of the present invention are embodied in the dependent claims.

[0014] Embodiments of the present invention will now be described, by way of example only, having reference to the accompanying figures, in which:

Figure 1 is a cross sectional view across a low-floor rail vehicle;

Figure 2 is a similar cross sectional view to Figure 1 indicating the displacement of the centre of gravity of the vehicle due to asymmetric construction;

Figure 3 is a similar cross sectional view to Figure 1 indicating the theoretical maximum fuel tank capacity;

Figure 4 is a similar cross sectional view to Figure 1 indicating the actual maximum fuel tank capacity for a tank of symmetrical configuration;

Figure 5 is a similar cross sectional view to Figure 1 with the fuel tank positioned off-centre;

Figure 6 is a similar cross sectional view to Figure 1 with an asymmetric fuel tank according to one aspect of the present invention;

Figure 7 is a similar cross sectional view to Figure 6 indicating the increase in capacity achieved;

Figure 8 is a cross sectional view of an alternative fuel tank construction according to the present invention; and

Figure 9 is a cross sectional view of a preferred construction of an underfloor fuel tank.

[0015] A rail vehicle 1 having a low-floor construction is shown in cross-section in Figure 1 indicating body 2, floor 4 and wheels 6. For the avoidance of doubt, the cross-section is a transverse section taken across the carriage and all further references to cross-section are to be interpreted according to this definition.

[0016] The rail vehicle 1 has a centre of gravity 8 symmetrically located between the two wheels 6. The floor 4 is located a height h above the level of the rails 10. For low-floor constructions the height h may be around 600 mm. For high-floor constructions h may typically be between 1.000 mm and 1200 mm.

[0017] Figure 2 illustrates how the construction of the rail vehicle 1 may lead to a shift in the centre of gravity

8. A constructional unit 20, such as a toilet cubicle having a centre of gravity 22 is located to one side of the rail vehicle 1. This causes a lateral shift in the centre of gravity of the rail vehicle 1 to a point 8' resulting in an unequal loading of the wheels 6 whereby the force R_R on the right wheel is greater than the force R_L on the left wheel. An imbalance in wheel loading can lead to uneven wheel wear and must be avoided.

[0018] Figure 3 illustrates a fuel tank 30 located beneath the floor 4 of the rail vehicle 1. The theoretical maximum area available for installation of the fuel tank is delimited by the floor 4, the outer train profile 32 and the required ground clearance. The actual maximum volume which can be occupied effectively is however illustrated by the fuel tank 40 of Figure 4 which has a central sump 42 to ensure continuous immersion of the fuel feed pipe (not shown) by which fuel in the tank may be drawn off. On either side of the sump 42, the lower surface 44 of the fuel tank 40 is slanted upwards to avoid dead volume within the fuel tank 40. The angle of slant is determined by the maximum angle of camber encountered by the rail vehicle such that should it be kept stationary on a cambered section, fuel will always remain in the sump. Additionally, the true ground clearance profile is illustrated by the broken line 46 having recess 48. The recess 48 indicates the need for increased clearance along the centreline of the track to allow for track mounted devices.

[0019] This tank cross section is extremely advantageous in reducing the overall weight of the fuel tank, compared with the corresponding large volume substantially rectangular tank cross section which includes substantial dead volume. Typical values for track camber may be as much as 1 in 10 or 10% and the lower surface 44 of the tank will ideally be sloped sideways at approximately this gradient too. The lower surface 44 may also ideally be sloped in the longitudinal direction at a value corresponding to the maximum incline encountered. Typical values for incline are lower than camber and may be approximately 15 in 1000 or 1.5%.

[0020] In Figure 5, a fuel tank 50 having a centre of gravity 51 is placed off-centre with respect to the centreline of the rail vehicle 1. Such an arrangement is known from the Itino™ train as manufactured by Bombardier Transportation and can provide a balancing mass to compensate for other out of balance masses such as toilet constructions, batteries and service equipment. The construction according to Figure 5 however results in a loss of volume indicated by the shaded area 53. Since typically, in low-floor constructions fuel tank capacity is critical, any loss in volume is to be avoided. Additionally, since the fuel tank 50 is itself symmetrical in construction, as it empties, the effect on the centre of gravity varies and the balancing effect reduces in linear fashion from full to empty.

[0021] A fuel tank 60 according to the present invention is illustrated in Figure 6. The fuel tank 60 is located in the same underfloor space as in the previous figures but is provided with a sump 62 located to one side of the cen-

treline of the rail vehicle 1. The significance of such an arrangement is twofold. Firstly, since the sump 62 is located to one side of the recess 68, it can be situated lower than a corresponding centrally located sump, increasing the capacity of the fuel tank. Secondly, the asymmetry introduced by the location of the sump 62, causes the centre of gravity 61 of the fuel tank to be shifted with respect to the centreline of the rail vehicle 1. As the fuel is used and the level in the fuel tank 60 drops, the centre of gravity of the tank will move in the direction of the sump 62, maintaining the desired balancing effect. Again, the angle of slant of the lower surface 64 of the fuel tank 60 corresponds to the maximum track camber to ensure that the sump 62 remains at the lowest point under all conditions.

[0022] According to Figure 7, the fuel tank 60 of Figure 6 is compared with the fuel tank 40 of Figure 4. The increase in capacity of the tank is illustrated by the shaded area 72. Figure 7 also clearly illustrates how the fuel tank 60 may be considered as comprising a symmetrical portion corresponding substantially to the fuel tank 40 and an asymmetric portion corresponding to the shaded area 72. The symmetrical portion by definition plays no role in the balance of the train (to the extent that the train is not tilted or negotiating a curve). Of significance to the invention however, the asymmetric portion has a centre of gravity 71 which is located at a distance d from the centre line of the rail vehicle and can thus exercise a substantial balancing force to compensate for other out of balance items. Furthermore, the location of portion 72 adjacent to the sump 62 ensures that it is part of the last portion of fuel to be used and thus the balancing effect is maintained substantially constant while the bulk of the fuel is used.

[0023] The volume of the asymmetric portion 72 may be chosen according to the mass of the out-of-balance object for which it is desired to compensate. Typically, the volume of the asymmetric portion exceeds 5% of the total volume of the fuel tank 60. Preferably, the volume of the asymmetric portion exceeds 10% of the total volume of the fuel tank 60. Ideally, the volume of the asymmetric portion even exceeds 25% of the total volume of the fuel tank 60. For a fuel tank having a total capacity of 2000L this would ensure balancing masses of 100 kg, 200 kg and 500 kg respectively.

[0024] In considering the balance of the fuel tank, the effect of the centre of gravity on the balance of the rail vehicle may be determined in various ways. The fuel tank itself has a mass and consequently a centre of gravity. This mass is both constant and fixed with respect to the rail vehicle and its effect on the balance can be easily determined. For the asymmetrically shaped construction of Figure 6, the fuel tank 60 will have an asymmetric centre of gravity 61 relative to the centre line of the train. Further discussion will be directed only to the effects of the fuel. Similarly, when full, the fuel contained within the fuel tank 60 will have a centre of gravity located at or near the point 61. As the fuel is used however, and the level

in the fuel tank drops, the position of its centre of gravity will change. In the design of Figure 6, the centre of gravity of the fuel will move to the left away from the centreline and downwards. As it does so, the mass of the fuel decreases and its moment about the centreline of the rail vehicle, calculated as the product of the mass of fuel and the distance of its centre of gravity from the centreline, decreases too until when only the last drops of fuel are left, the centre of gravity of these remaining drops is located in the sump itself.

[0025] An alternative and simpler way of considering the balance is to work from the axis of symmetry. For any shape of fuel tank, the volume contained may be divided into a symmetric part, defined as that volume which is symmetric with respect to the centreline of the train and an asymmetric part which is effectively out of balance although it may be effectively balancing other items of the rail vehicle. As fuel is used and the level in the fuel tank falls (the situation on a level track being considered) any fuel which is used from the symmetric volume is used symmetrically and causes no change in the centre of gravity. The fuel in the asymmetric portion has its centre of gravity as illustrated by point 71 in Figure 7. Only when this latter fuel is used does the mass of the out of balance fuel change and its effect on the balance of the rail vehicle is reduced. The centre of gravity 71 of the out of balance fuel will drop and may also move with respect to the centreline of the train depending on the cross section of this volume.

[0026] This effect is illustrated more clearly in Figure 8 which shows an alternative design of asymmetric fuel tank 80 without (substantially) sloping lower surfaces. The fuel tank 80 has a symmetrical section 82 having a centre of gravity 83 and an asymmetric section 84 having a centre of gravity 85 located a distance d from the centreline of the rail vehicle. Initially fuel is used from the section 82 until only the asymmetric section 84 remains. During this period which may represent the majority of running time, the balancing effect of the mass of fuel in the asymmetric section 84 remains constant. Only once the level begins to drop within this section does the centre of gravity 85 start to move. Since the asymmetric section 84 is itself symmetrical about its centre of gravity 85, the distance d will remain constant as the last fuel is used up. This asymmetric section 84 may effectively be considered as the reserve section of the tank which under normal conditions is not used up and can thus provide a constant balancing force to compensate for other out of balance items on the rail vehicle.

[0027] Various other shapes and configurations may also be considered which fall within the scope of the present invention. The angle of slant of the lower surfaces of the tank may be reduced or omitted completely, producing a stepped configuration as in Figure 8 which may be suitable for use where track camber is not significant. The slant of the lower surfaces may also be omitted in those cases where the volume of the sump itself is sufficient to supply fuel during the maximum duration in

which the rail vehicle could remain stationary on a camber.

[0028] As mentioned above, the exact outer profile of the fuel tank may be dictated by other factors such as the underfloor profile, the ground clearance profile, fuel tank fixation brackets and other service items located in the underfloor region. Figure 9 illustrates a fuel tank 90 similar in design to Figure 6 indicating the effective increase in volume 92 over a symmetrical design and the presence of additional design constraints such as recess 95 for receiving e.g. ducting, pipes or other components. Furthermore, it should be noted that the present invention relates to the transverse cross-section of the fuel tank and there may be variations in this cross-section along the longitudinal direction.

[0029] The fuel tank may be formed as an integral construction. Alternatively, for existing designs, the additional volume e.g. 72 in Figure 7 or 84 in Figure 8 could be formed as a separate unit, connected to the existing tank as an "add on" unit with fluid communication via perforations through the interfacing surface or via additional fuel pipes. Similarly, the additional volume could be completely physically separate from the existing volume whereby two separate tanks ensue, a first substantially symmetrically located main tank and an asymmetrically located reserve tank. Through the use of appropriate fluid connections including e.g. one-way valves it may be ensured that the reserve tank remains full until it is required, even in the presence of adverse track camber.

Claims

1. A rail vehicle (1) including an out-of-balance mass located to one side of a centreline of the vehicle and a fuel tank (60, 80, 90) located in the underfloor region of the rail vehicle, the tank comprising: a first portion arranged substantially symmetrically to the centreline of the rail vehicle; a second portion arranged asymmetrically to the centreline of the rail vehicle to the other side of the centreline and serving to receive a balancing mass of fuel; and a sump (62) located in the asymmetric portion at a distance from the centreline and forming the lowest portion of the tank.
2. The rail vehicle according to claim 1 in which the volume of the asymmetric portion exceeds 5% of the total capacity of the tank.
3. The rail vehicle according to claim 2 in which the volume of the asymmetric portion exceeds 10% of the total capacity of the tank.
4. The rail vehicle according to claim 3 in which the volume of the asymmetric portion exceeds 25% of the total capacity of the tank.

5. The rail vehicle according to any preceding claim in which the lower surfaces of the tank slant sideways and upwards from the sump at an inclination of approximately 10%.
6. The rail vehicle according to any preceding claim wherein the tank has a generally triangular cross section, the base being aligned with the floor of the rail vehicle, the sump being located at the apex of the triangle.
7. The rail vehicle according to any of claims 1 to 5 in which the lower surface of the tank has a stepped configuration.
8. The rail vehicle according to any of claims 1 to 7 in which the second asymmetric portion of the tank is formed as a separate component.
9. The rail vehicle according to claim 8 in which the interior of the second asymmetric portion of the tank communicates with the interior of the first portion.
10. The rail vehicle according to any of claims 1 to 9 in which the lower surface of the tank slopes upwards from the sump in a longitudinal direction at an inclination of approximately 1%.
11. The rail vehicle according to any of claims 1 to 10 in which the tank has a height of less than 300 mm.
12. A method of balancing an out-of-balance mass located to one side of a centreline of a rail vehicle, the method comprising: providing a tank in the underfloor region of the rail vehicle, the tank having an asymmetric reserve portion; locating the tank such that the asymmetric reserve portion is located to the other side of the centreline; and filling the tank with fluid whereby the mass of fluid in the asymmetric reserve portion of the tank serves to balance the out-of-balance mass.
13. The method of claim 12 wherein the rail vehicle is according to any of claims 1 to 11.
14. The method according to claim 12 or claim 13, further comprising using the fluid during operation of the vehicle whereby the centre of gravity of the tank moves away from the centreline of the rail vehicle as the volume of fluid in the tank reduces such that the moment of force of the centre of gravity of the fluid about the centre of gravity of the vehicle remains substantially constant.

Patentansprüche

1. Schienenfahrzeug (1) mit einer unausgewuchteten

- Masse, die sich auf einer Seite von einer Mittellinie des Fahrzeugs befindet, und einem Kraftstoffbehälter (60, 80, 90), der sich im Unterbodenbereich des Schienenfahrzeugs befindet, wobei der Behälter Folgendes umfasst: einen ersten Teil, der im Wesentlichen symmetrisch mit der Mittellinie des Schienenfahrzeugs angeordnet ist; einen zweiten Teil, der asymmetrisch zur Mittellinie des Schienenfahrzeugs auf der anderen Seite von der Mittellinie angeordnet ist und zum Erhalten einer ausgleichenden Kraftstoffmasse dient; und eine im asymmetrischen Teil in einer Entfernung von der Mittellinie befindliche und den untersten Teil des Behälters bildende Wanne (62).
2. Schienenfahrzeug nach Anspruch 1, bei dem das Volumen des asymmetrischen Teils 5 % des gesamten Fassungsvermögens des Behälters überschreitet.
 3. Schienenfahrzeug nach Anspruch 2, bei dem das Volumen des asymmetrischen Teils 10 % des gesamten Fassungsvermögens des Behälters überschreitet.
 4. Schienenfahrzeug nach Anspruch 3, bei dem das Volumen des asymmetrischen Teils 25 % des gesamten Fassungsvermögens des Behälters überschreitet.
 5. Schienenfahrzeug nach einem der vorhergehenden Ansprüche, bei dem die unteren Oberflächen des Behälters mit einer Neigung von etwa 10 % seitlich und aufwärts von der Wanne abgeschrägt sind.
 6. Schienenfahrzeug nach einem der vorhergehenden Ansprüche, bei dem der Behälter einen allgemein dreieckigen Querschnitt aufweist, wobei die Basis auf den Boden des Schienenfahrzeugs ausgerichtet ist, wobei sich die Wanne an der Spitze des Dreiecks befindet.
 7. Schienenfahrzeug nach einem der Ansprüche 1 bis 5, bei dem die untere Oberfläche des Behälters eine gestufte Konfiguration aufweist.
 8. Schienenfahrzeug nach einem der Ansprüche 1 bis 7, bei dem der zweite asymmetrische Teil des Behälters als eine separate Komponente ausgebildet ist.
 9. Schienenfahrzeug nach Anspruch 8, bei dem das Innere des zweiten asymmetrischen Teils des Behälters mit dem Inneren des ersten Teils in Verbindung steht.
 10. Schienenfahrzeug nach einem der Ansprüche 1 bis 9, bei dem die untere Oberfläche des Behälters mit einer Neigung von etwa 1 % von der Wanne in einer Längsrichtung schräg ansteigt.
 11. Schienenfahrzeug nach einem der Ansprüche 1 bis 10, bei dem der Behälter eine Höhe von weniger als 300 mm aufweist.
 12. Verfahren zum Ausgleichen einer unausgewuchteten Masse, die sich auf einer Seite von einer Mittellinie eines Schienenfahrzeugs befindet, wobei das Verfahren Folgendes aufweist: Bereitstellen eines Behälters im Unterbodenbereich des Schienenfahrzeugs, wobei der Behälter einen asymmetrischen Reserveteil aufweist; Anordnen des Behälters so, dass der asymmetrische Reserveteil sich auf der anderen Seite von der Mittellinie befindet; und Füllen des Behälters mit Fluid, wodurch die Fluidmasse im asymmetrischen Reserveteil des Behälters zum Ausgleichen der unausgewuchteten Masse dient.
 13. Verfahren nach Anspruch 12, bei dem das Schienenfahrzeug gemäß einem der Ansprüche 1 bis 11 ist.
 14. Verfahren nach Anspruch 12 oder Anspruch 13, das ferner das Verwenden des Fluids während des Betriebs des Fahrzeugs umfasst, wodurch der Schwerpunkt des Behälters sich von der Mittellinie des Schienenfahrzeugs weg bewegt, während sich das Fluidvolumen im Behälter verringert derart, dass das Kraftmoment des Schwerpunkts des Fluids um den Schwerpunkt des Fahrzeugs im Wesentlichen konstant bleibt.

Revendications

1. Véhicule ferroviaire (1) incluant une masse déséquilibrée située d'un côté d'une ligne médiane du véhicule et un réservoir d'essence (60, 80, 90) situé dans la région sous-plancher du véhicule ferroviaire, le réservoir comprenant : une première portion agencée sensiblement de manière symétrique par rapport à la ligne médiane du véhicule ferroviaire; une seconde portion agencée de manière asymétrique par rapport à la ligne médiane du véhicule ferroviaire vers l'autre côté de la ligne médiane et servant à recevoir une masse d'équilibrage du carburant ; et un carter d'huile (62) situé dans la portion asymétrique à une certaine distance de la ligne médiane et formant la portion la plus basse du réservoir.
2. Véhicule ferroviaire selon la revendication 1, dans lequel le volume de la portion asymétrique dépasse 5 % de la capacité totale du réservoir.
3. Véhicule ferroviaire selon la revendication 2, dans lequel le volume de la portion asymétrique dépasse

10 % de la capacité totale du réservoir.

conque des revendications 1 à 11.

4. Véhicule ferroviaire selon la revendication 3, dans lequel le volume de la portion asymétrique dépasse 25 % de la capacité totale du réservoir. 5
5. Véhicule ferroviaire selon l'une quelconque des revendications précédentes, dans lequel les surfaces inférieures du réservoir sont en pente vers les côtés et vers le haut par rapport au carter d'huile selon une inclinaison d'approximativement 10 %. 10
6. Véhicule ferroviaire selon l'une quelconque des revendications précédentes, dans lequel le réservoir a une section en coupe transversale généralement triangulaire, la base étant alignée avec le plancher du véhicule ferroviaire, le carter d'huile étant situé au niveau du sommet du triangle. 15
7. Véhicule ferroviaire selon l'une quelconque des revendications 1 à 5, dans lequel la surface inférieure du réservoir présente une configuration étagée. 20
8. Véhicule ferroviaire selon l'une quelconque des revendications 1 à 7, dans lequel la seconde portion asymétrique du réservoir est réalisée sous la forme d'un composant séparé. 25
9. Véhicule ferroviaire selon la revendication 8, dans lequel l'intérieur de la seconde portion asymétrique du réservoir communique avec l'intérieur de la première portion. 30
10. Véhicule ferroviaire selon l'une quelconque des revendications 1 à 9, dans lequel la surface inférieure du réservoir est en pente vers le haut par rapport au carter d'huile dans une direction longitudinale selon une inclinaison d'approximativement 1 %. 35
11. Véhicule ferroviaire selon l'une quelconque des revendications 1 à 10, dans lequel le réservoir a une hauteur inférieure à 300 mm. 40
12. Procédé d'équilibrage d'une masse déséquilibrée située d'un côté d'une ligne médiane d'un véhicule ferroviaire, le procédé comprenant les étapes consistant à : prévoir un réservoir dans la région sous-plancher du véhicule ferroviaire, le réservoir ayant une portion de réserve asymétrique ; disposer le réservoir de telle sorte que la portion de réserve asymétrique est située vers l'autre côté de la ligne médiane ; et remplir le réservoir de fluide, moyennant quoi la masse de fluide dans la portion de réserve asymétrique du réservoir sert à équilibrer la masse déséquilibrée. 45
50
55
13. Procédé selon la revendication 12, dans lequel le véhicule ferroviaire est un véhicule selon l'une quel-

14. Procédé selon la revendication 12 ou 13, comprenant en outre l'utilisation du fluide pendant le fonctionnement du véhicule, moyennant quoi le centre de gravité du réservoir s'écarte de la ligne médiane du véhicule ferroviaire au fur et à mesure que le volume de fluide dans le réservoir se réduit, de telle sorte que le moment de force du centre de gravité du fluide autour du centre de gravité du véhicule reste sensiblement constant.

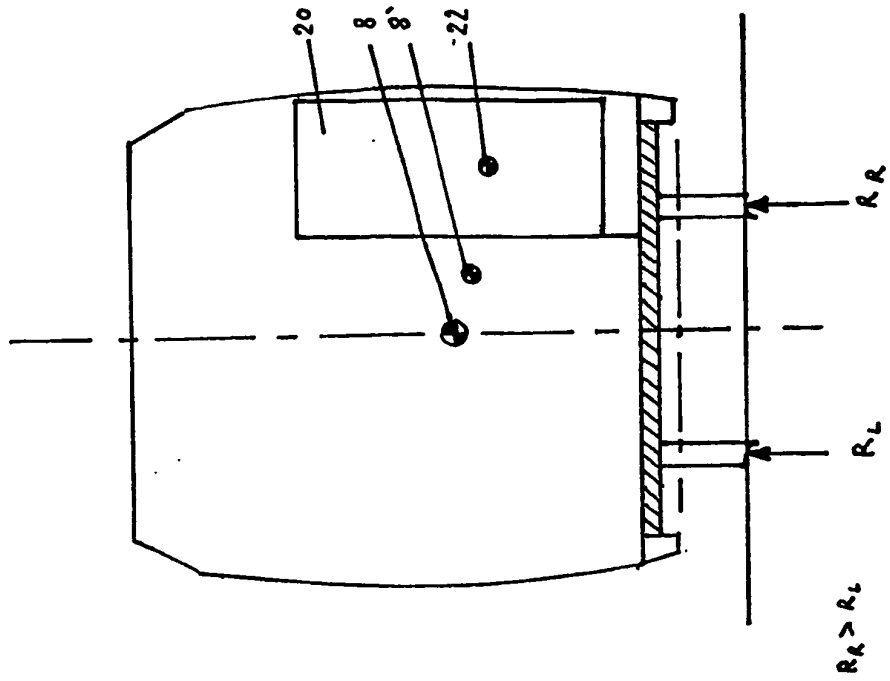


Fig. 2

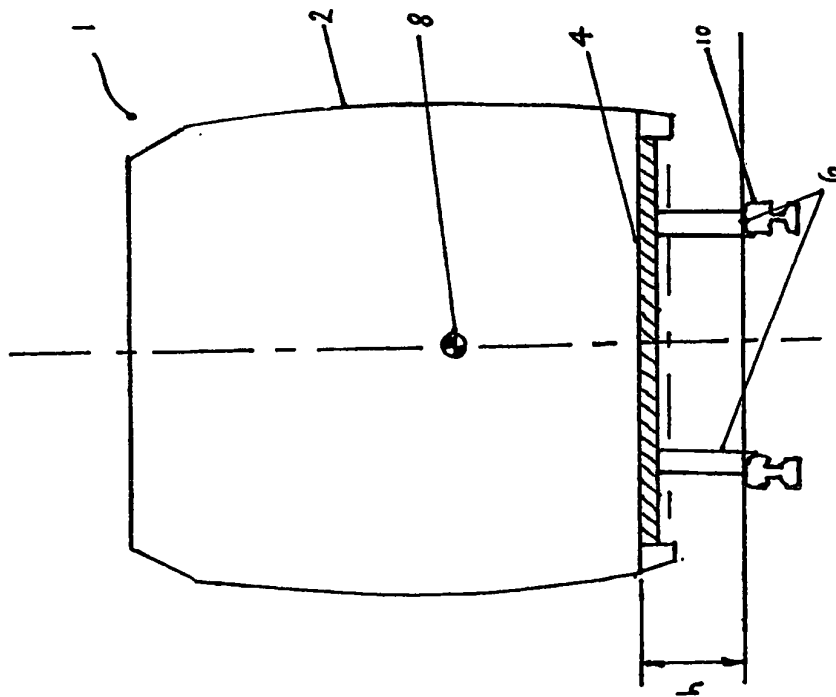


Fig. 1

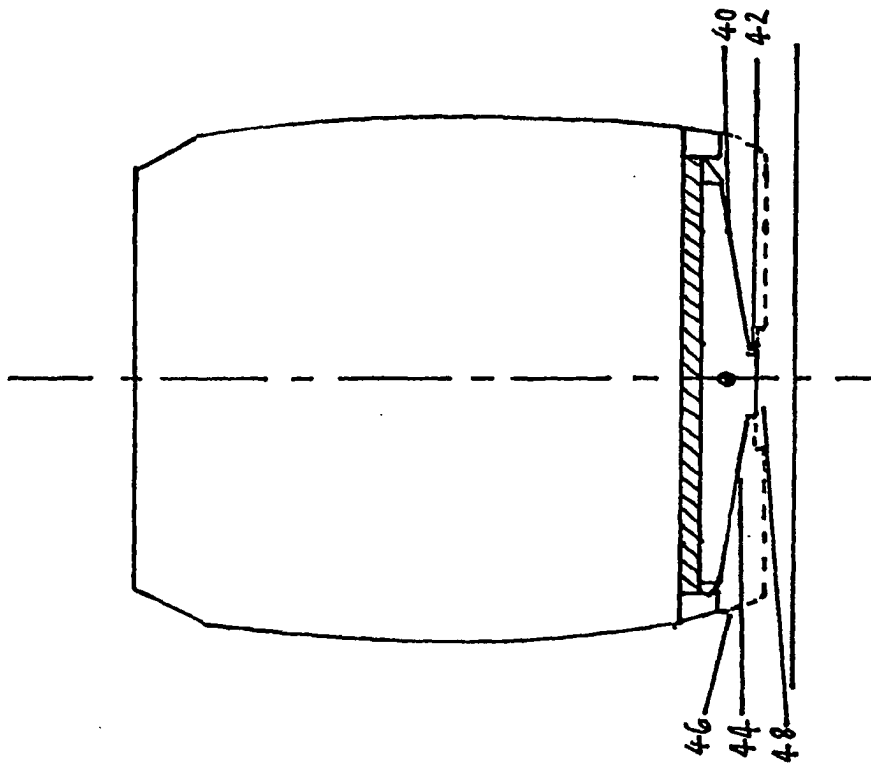


Fig. 3

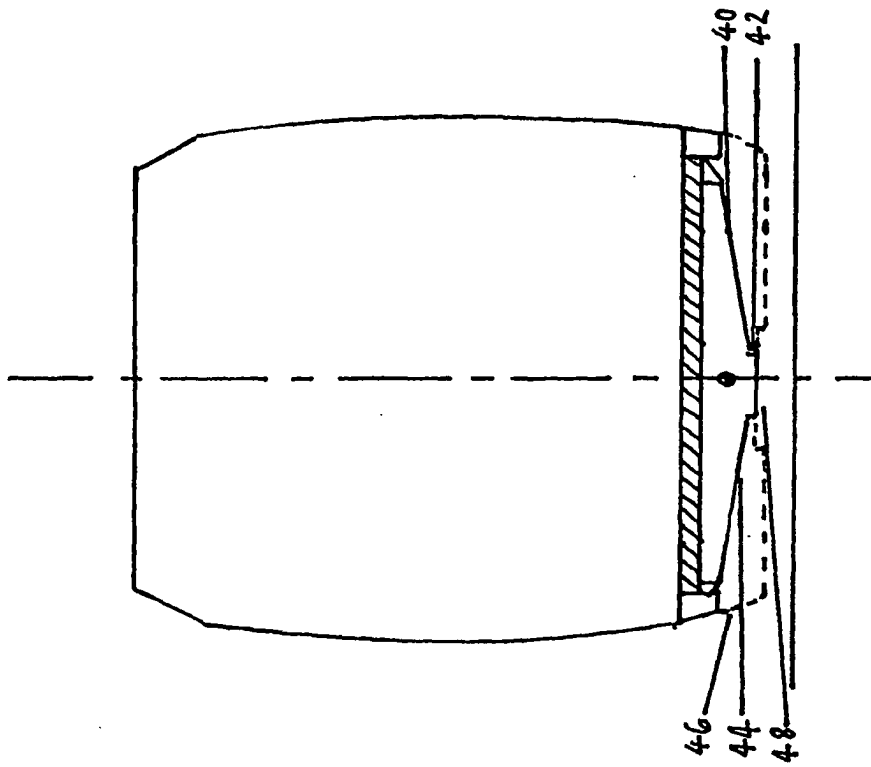


Fig. 4

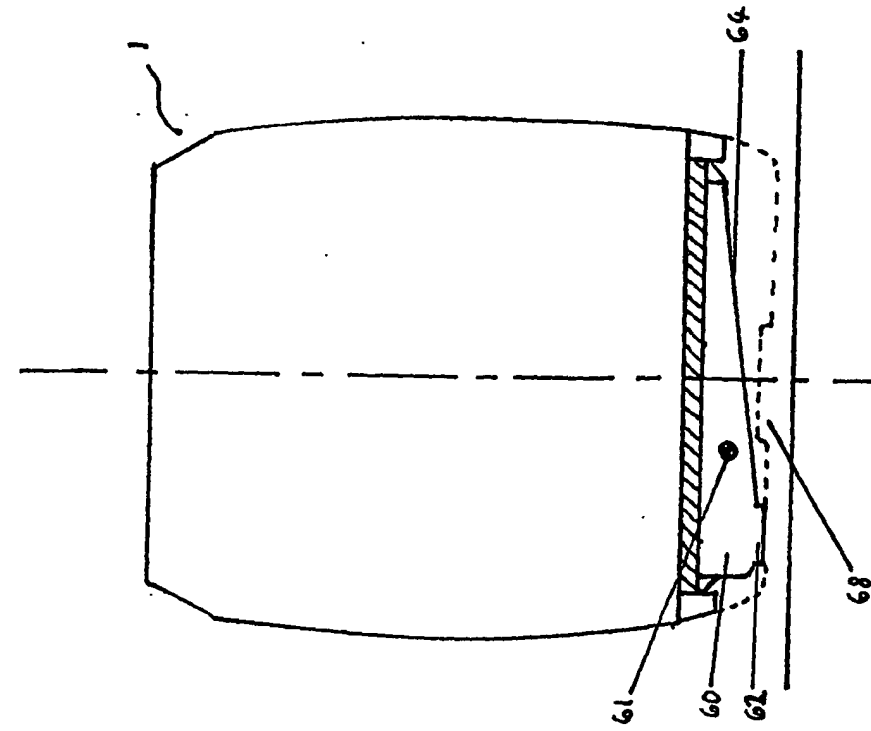


Fig. 5

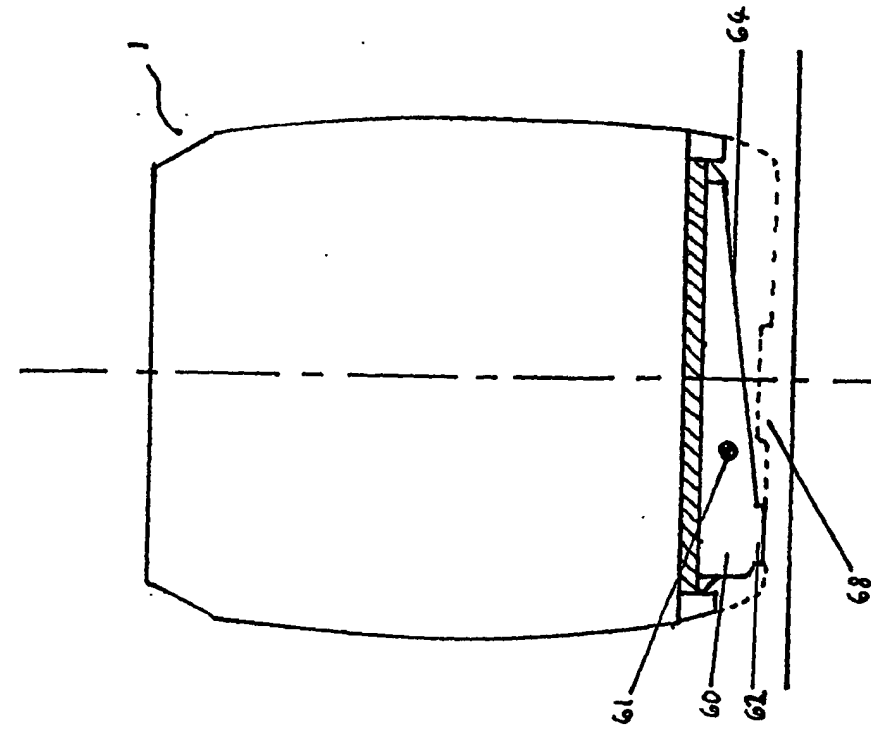


Fig. 6

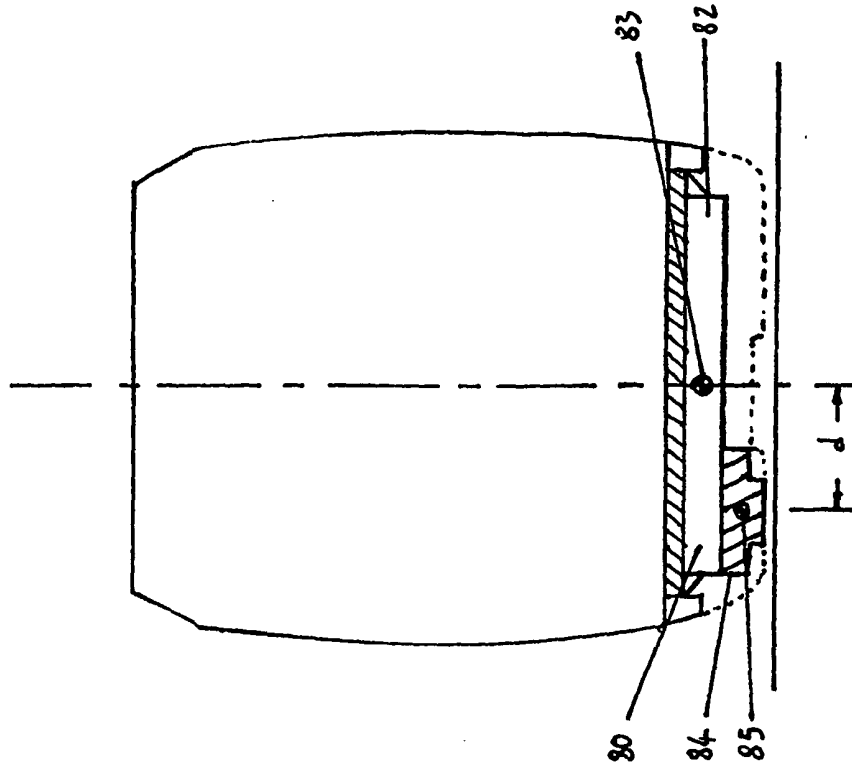


Fig. 8

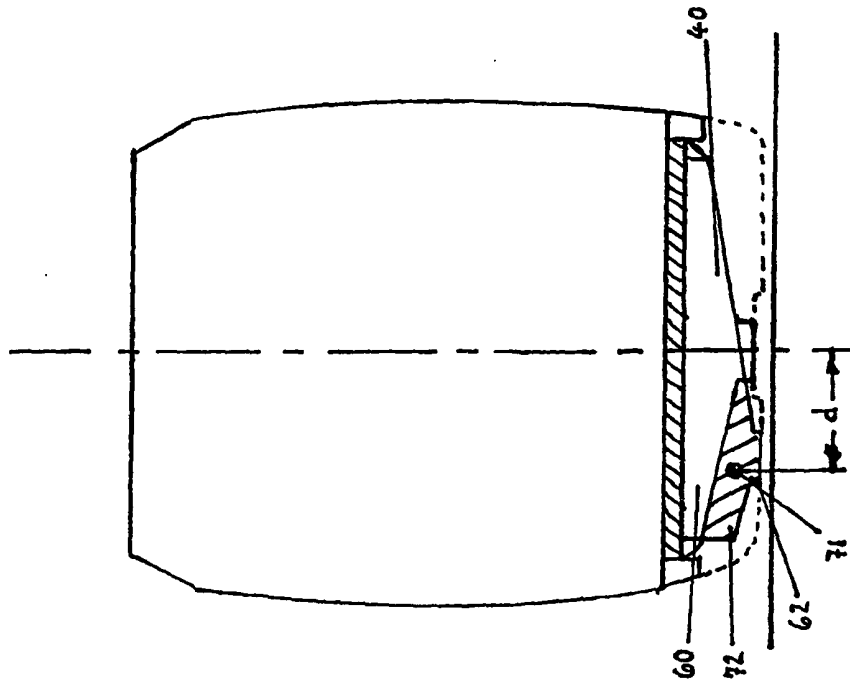


Fig. 7

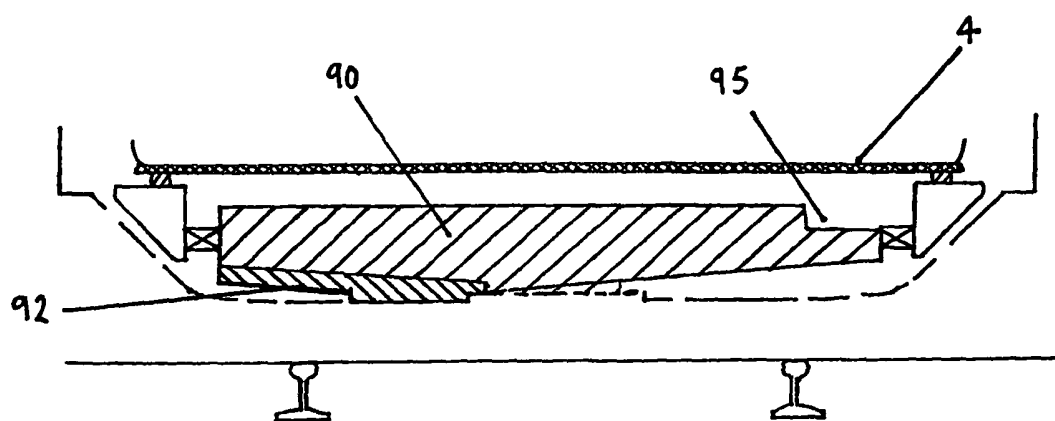


Fig 9

REFERENCES CITED IN THE DESCRIPTION

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