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UNDERGROUND HIGH-SPEED TRANSPORTATION SYSTEM

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ABSTRACT OF THE DISCLOSURE

A high-speed underground transportation system. An underground tube has a train of cars running through it, each car having thereon at least two sets of legs. Each set of legs has three legs positioned symmetrically around and radiating from an axis coaxial with the axis of the tube. A frame unit connects the legs, and driving wheels are provided on the extreme ends of two of the legs. A freely rotatable wheel is provided on the extreme end of the third leg. The two driving wheels engage the wall of the tube, and driving motors coupled to the wheels for driving the car along the wall. The wheel on the third leg holds the car in position within the tube.

BACKGROUND OF THE INVENTION

The present invention deals with an underground, high-speed transportation system. As the tendency towards the concentration of the population in large cities where space for residence is limited increases, satellite towns and suburbs are being formed. It has been proven that even in peace time, motor car transportation cannot solve the resultant traffic congestion, but, instead, tends to increase it. To cope with the congestion of commuters traveling from their outlying homes to their jobs in the city, a super-high-speed transportation system is being sought.

Meanwhile, the development of a hydrogen bomb carried by missiles is being rapidly made in certain countries and protective measures against such bombs in any emergency have to be considered realistically. One of these realistic measures is the centralization of towns far away from the metropolis. For this consideration to be practical, the speed of transportation from the satellite town to the metropolis must be increased to the extent that the distance between them can be covered a twice the average speed of 200 kph. per hour, which the New Tokaido Line in Japan is presently capable of achieving, namely 400 kph per hour for the transportation system of the future. If this increased speed is achieved for commuter trains, families left in the satellite towns may be relatively free from the dangers resulting from a Hydrogen bomb being dropped on the metropolis where the commuters work.

It is said that 350 kms. per hour is the maximum speed possible on a conventional railway system using wheels and rails. Even if this maximum is increased in the future, any system above the ground can not be free from exposure to the effects of Hydrogen bombs and total destruction. As to air transportation, even with future progress in its carrying capacity, the same thing can be said as is said regarding a railway system with respect to the risk of exposure to Hydrogen bomb damages.

Such being the cases regarding ground and air transportation, it remains to say that an underground transportation system, installed deep underground, is the only one which is fully protected against the effects of a Hydrogen bomb. However, present conventional, underground railways are being operated at very modest speeds 70 kms. per hour maximum due to inherent mechanical difficulties. These are comparable with surface railways and are nothing more than local slow trains in tunnels.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide an underground transportation system capable of operating at high speeds.

It is another object of the present invention to provide an underground high speed transportation system which is freed from the limitations described above for a conventional underground railway system employing wheels and rails.

These objects are achieved by an underground transportation system which is enclosed in a circular tube constructed deep under ground beyond even the reach of the effect of Hydrogen bombs of the future. Said tube has a monocoque structure capable of withstanding both external and internal pressure exerted on the shell. The internal pressure is caused by driving and supporting legs of the cars radiating from a pinion in the car frame, said pinion being co-axial with the center of the tube. A rail is not used for directing the train, since only one train at a time moves through each section, the train being guided by the direction of the tube itself. The driving and supporting legs are fitted with air filled tires which are driven by means of electric power taken from an overhead electrical system, so that the system is practically noiseless, increased noise being the principal factor preventing an increase of speed in the conventional underground railways using wheels and rails. As the tube is located deep underground the temperature in the tube remains constant and even in severe cold regions such as high latitude regions of Siberia or Canada, transportation is easily maintained year around without being affected by severe weather. With the recent advance of technology in tunnel excavating machinery, tube construction can be rapidly carried out. Especially in the vicinity of a metropolis, much time and money are required for purchasing land for rail lines or airfields for air transportation before starting construction. Most of these difficulties can be overcome by using a deep tunnel system. The time required to complete an underground tube near a metropolis may therefore be favorably compared with conventional transportation systems relying on ground or air, thus offsetting the increased cost of tunnel excavation.

BRIEF DESCRIPTION OF THE DRAWING

Other objects and advantages of this invention will appear from the following description of preferred embodiments taken in connection with the accompanying drawings in which:

FIG. 1 is a transverse sectional view showing the general arrangement of the driving setup, with an outline of the passenger car positioned in a circular tube buried deep in the ground;

FIG. 2 is a sectional view, showing the driving setup, taken along line II in FIG. 1;

FIG. 3 is a view similar to FIG. 1 showing another embodiment of the present invention;

FIG. 4 is a detail view showing a weight carrying wheel attached to the intermediate frame structure of the car with a partial outline of the passenger car;

FIG. 5 is a longitudinal sectional view showing the general arrangement of the train;

FIG. 6 is a transverse sectional view showing the general arrangement at a station in accordance with the present invention;
FIG. 7 is a transverse sectional view showing a switching junction for several tubes; FIG. 8A is a plan view showing the switching junction arranged to switch a train to a side tube; FIG. 8B is a plan view similar to that of FIG. 8A showing the switching junction arranged to connect the tube to the straight principal tube; FIG. 9 is a view similar to FIG. 1 showing the general arrangement of a driving unit having special driving wheels; FIG. 10 is a sectional view showing the special driving wheel mechanism of FIG. 9; FIG. 11 is a view similar to FIG. 1 showing a driving unit with a ceiling effect mechanism and the corresponding special construction of the internal surface of the tube; FIG. 12 is a detail view showing a gyrostabilizer housed above a weight carrying wheel similar to that shown in FIG. 3; and FIG. 13 is a view showing the general arrangement of a train of this invention having a gyrostabilizer for the car and a ceiling effect mechanism for the driving unit added to the embodiment shown in FIG. 5.

**DESCRIPTION OF THE PREFERRED EMBODIMENTS**

According to this invention, a passenger or cargo loaded train consisting of separate cars and capable of transporting two thousand people at a time or the equivalent amount of cargo is run in a circular tube made from such materials as concrete or steel, which can withstand the high pressure from the earth at a deep depth, at high speeds of between 400 and 600 kph. per hour. This monocoque structure is able to withstand the weight of the loaded cars supported by radiating legs which are in contact with the internal surface of the tube. Each of the cars is supported by two or three units positioned along according to its length. Said driving units are centrally and rotatably pinned in a frame in the principal body of the car. Each driving unit has four radially extending legs in a vertical frame with air filled wheels at their ends. Said wheels are in close contact with the internal surface of the tube. Three of the extending legs with air filled tires at their ends are equally spaced circumferentially around the internal surface of the tube, two driving wheels contacting the inner surface of the tube at points on a horizontal straight line spaced above the bottom of the tube, and the remaining leg being a ceiling leg contacting the tube at the highest point on the inner circumference of the tube. The fourth leg, also having an air filled tire at its end, principally carries the weight of this unit and part of the load due to the car proper. If the car is long and heavy, load-carrying wheels are provided underneath the car. Thus, the driving unit has rotational freedom of its own in a transverse vertical plane about the pinion in the car frame and the three radial legs are cushioned by a unified hydraulic control system so that the pressure on the tube can be equally maintained. The wheels on the two horizontally aligned legs are driving wheels driven by electric motors. The power for these motors is taken from overhead mains by means of rigid, extending electric collectors positioned on the carriage near the ceiling leg. Thus, conventional rails are not used in this invention. The direction of the train coincides with that of the tube.

Referring now to FIGS. 1–5, driving wheels 10 and 11 free wheel 12 and a load carrying wheels 13 are in close contact with the internal surface 14 of the wall of a tube 1 which is circular and is buried deep in the earth 0. Wheels 10, 11 and 12 are fixed to the ends of legs 3, 4 and 5 and these legs extend outwardly from the bearing case of a center axle 8 which in turn is housed in a pair of bearing cases 9 constituting part of the car proper. Said three legs 3, 4 and 5 are equally, radially spaced about the center axle 8 which is positioned within the tube 1 such that its center is made to coincide substantially with the axis of the tube 1. By so positioning the center axle 8, the wheels 10, 11 and 12 can move freely along the surface 14 of the wall. These legs, 3, 4 and 5 are rigidly fixed to a frame unit 15. Legs 3, 4 and 5 have a common construction which allows the wheels 10, 11 and 12 to be moved radially either towards or away from the center axle 8 by means of a unified hydraulic control system consisting of a plunger oil chamber 20A and connecting lines 20 connected to cylinder chambers 3a, 4a and 5a. As a result of this construction, the pressure exerted by the three wheels 10, 11 and 12 on the wall surface 14 of the tube can be uniformly increased or decreased in accordance with the speed of the train. The driving wheels 10 and 11 are driven by electric motors 16 on the ends of legs 3 and 4. A load-carrying wheel 13 is positioned at the end of a short leg 6 which is firmly fixed to the frame 15 of the unit and which is circumferentially positioned midway along the wall surface 14 between the two driving wheels 10 and 11. A conventional disc brake system is provided on each of the four wheels 10, 11, 12 and 13. In addition, the braking power of the driving wheels 10 and 11 and of the free wheel 12 can be increased, when the occasion requires, by increasing the oil pressure in the oil control chamber 20A. The frame unit 15, including the wheels 10, 11, 12 and 13, can easily be removed from the car proper, as required, for inspection and repair. Electrical power is taken from outside sources and picked up through power collectors 17 which can be attached to the frame units 15 or an intermediate body frame (FIG. 5) near the top thereof. The electric power collectors 17 are rigidly constructed and appropriate pressure is maintained between them and the overhead main lines 18 by means of elastic cushion 17a. Frame units 15 are provided at the front and rear of each car 7 and, if necessary, also in the middle. In addition to load carrying wheels 13, independent load carrying wheels 13' are attached by means of short legs 6' to an intermediate body frame 15' at intermediate parts of the car 7, as shown in FIG. 4, in order to bear the principal carrying load of the car 7.

In the case of a train having several cars connected together, it is important that the passengers and guards be able to move between adjacent cars or compartments. For this purpose, a modified frame unit, as shown in FIG. 3, is used. Instead of having a center axle 8 from which the legs 3, 4 and 5 radiate, a circular bearing case 8' is provided. The inner ends of the radiating legs 3', 4' and 5' are positioned on saddle bearings 21, each having a curved surface which follows the circumference of the circular body structure 8' in such a manner that frame unit 15 function in a manner similar to the basic frame unit having a center axle, as shown in FIG. 1. Through opening ABCD one can freely move from one compartment to another throughout the entire train.

Referring now to FIGS. 9 and 10, although at high speed, a straight tunnel is most desirable, sometime curving of the tunnel is unavoidable. When the carriage enters a curve, the center of gravity tends to rise in order to balance the centrifugal force created by the rotation of the carriage. Likewise, the driving wheels 10 and 11 tend to move up along the wall surface 14 of the tube. The wheels 10 and 11 connect to the legs 3, 4, 5 and are able to negotiate large radius curves by a sidewise deformation of the air filled tires. This maneuvering is limited when the curve has a small radius. For such circumstances, the end part of each leg 3 and 4 as in two parts 3b and 3c as shown in FIG. 10. The stem portion 3b housed in the telescopic upper part of the bed 2b can be magnetically fixed to stem part 3c when current is caused to flow in the windings 27 and 29 surrounding the parts 3a and 3b of the stem. Means 35, such as a spring, are provided to restore the stem path to their normal position after the curve has been navigated and the car re-enters a straight course. In operation, when entering a
curve, the stem parts 3b and 3c are demagnetized so as to be set free, and when the curve has been navigated and the car is returned to its normal position, the stems are magnetized and firmly fixed to each other in order to be ready for high speeds on the straight course.

Referring to Figs. 11–13, the latter ensuring stability of the car 7 and of the frame unit 15 is an important part of this invention. For low speed trains, around 400 km./hour, a gyroscopic stabilizer 41 (FIG. 12) is installed for this purpose in the lower part of the carriage above the load carrying leg or legs 6. However, for trains intended to travel at higher speeds, another means is provided to stabilize the frame unit 15 and to prevent said frame unit 15 from starting to vibrate. From the upper portion of the frame unit 15 on both sides of the carriage 7, air jet streams, produced in a mechanism comprising a motor 39 and an impeller 40, are directed against specially made baffles 37 on the wall surface 14 of the tube to produce a ceiling effect stabilizing action. This ceiling effect, in contrast to the ground effect used for other purposes, effectively can stabilize the frame unit 15. The pressure of the air jet streams can be increased for increased stability, as the occasion requires. For a curved bed of the tube, this baffle 37 can be shifted up or down depending on the direction of the turn and the speed of the train at the curve in order that the curve can be effectively negotiated.

Referring to FIG. 6, an opening is cut in the tube 1 along a platform, to provide a station at which passengers may board or depart from the train. As can be seen from the drawing, wheels 10, 11, 12 and 13 remain in contact with the wall surface of the tube at the station. Switching the car 7 of a train smoothly from the main tube 22, 23 to a side tube 23 is a very important operation in operating a train system of this kind. According to this invention, this is effectively solved in the manner shown in FIGS. 7 and 8. Straight tube portion 24 and curved tube portion 25 of sufficient length are rigidly connected together and adapted to move sideways on wheels running on parallel rails, at the switching junction. This arrangement is provided in a specially designed underground structure, as shown in FIG. 7. FIG. 8a shows the tube portion 25 positioned to divert a train coming from the main tube 22 to the side tube 23; FIG. 8b shows the normal operating position of the tube where the train continues on in the main tube 22.

Referring, finally, to FIGS. 5 and 13, a train, according to this invention, can be formed of a plurality of cars capable of travelling at high speeds, thanks to the method of taking the power from an outside source instead of using the system. The latter is apt to create an additional, objectionable rush of air in the tube, thus prejudicing the operation of a subsequent train.

The present invention avoids the drawbacks of the familiar rail transportation system used in the past as a means of transportation at speeds as high as those achieved by this invention. Slipping of the wheels on the rail or a snake motion between the wheels and rails in the case of a conventional two rail system are considered two of the obstacles in the use at speeds beyond 350 kmps. per hour. Further, any rail installed above ground is affected by the temperature of the surroundings due to solar heat reflecting directly on it. Together with the use of an automatic traffic control system relying on the use of regionally unconnected rails, this solar heat influence prevents the use of a single long rail constituting a single unit throughout its total distance. At high speeds, the gaps between joining rails create a noise and vibration. Those riding on the New Tokaido Line in Japan experience these, though the benefits accruing from rapid transportation for a distance of 510 kms. is apt to obscure these discomforts. This solar effect on a monorail system on an elevated superstructure is more aggravated than for a ground railway. According to this invention, such gaps are avoided regardless of the distance, and therefore no discomfort of this sort is experienced at high speeds. If the car carries a big load which cannot be borne by driving units alone, lead bearing legs having wheels with air filled tires at their ends are provided at intervals along the carriage.

When the speed is increased, the ceiling effect system used in connection with the driving units effectively controls the vibration of the driving unit along the circumference of the tube. At the same time, the gyro stabilizer installed in the bottom of the car keeps down the rolling effect of the car proper.

Electric current can be supplied from external sources, including an underground atomic power station, by means of electric lines fixed on the internal surface of the tube. A conventional pantograph system is not used as this is not effective for high speed use. Regarding air resistance in the train tube, if necessary the whole tube can be pressurized at low pressure and the compartments for the operators and the passengers can be pressure controlled for comfort.

Switching of the train at a switching junction to a side tube is one of the important factors in a transportation system. According to this invention, this is easily provided for by providing a length of tube at the switching junction which can be moved sidewise in a specially constructed housing so that a train in a principal tube is diverted to a curved tube within the housing, and thus the train can be switched to a side tube.

What is claimed is:

1. A high speed underground transportation system comprising an underground tube, at least one car running in said underground tube, at least two sets of legs on said car, each set having three legs positioned symmetrically around and radiating from an axis coaxial with the axis of the tube, a frame unit connecting said legs, driving wheels on the extreme ends of two of said legs and a freely rotatable wheel on the extreme end of the third said leg, said two driving wheels lying on a horizontal line spaced above the bottom of the tube and below the middle of the tube and being in contact with the inner surface of the tube, and driving motors coupled to said driving wheels and driving said wheels for driving said car along said tube, wherein said legs are extensible and retractable and have an end part telescopically mounted in a main part, and said parts define between them a hydraulic chamber, and a hydraulic control system coupled to the hydraulic chambers for extending said end parts of said legs.

2. A high speed underground transportation system comprising an underground tube, at least one car running in said underground tube, at least two sets of legs on said car, each set having three legs positioned symmetrically around and radiating from an axis coaxial with the axis of the tube, a frame unit connecting said legs, driving wheels on the extreme ends of two of said legs and a freely rotatable wheel on the extreme end of the third said leg, said two driving wheels lying on a horizontal line spaced above the bottom of the tube and below the middle of the tube and being in contact with the inner surface of the tube, and driving motors coupled to said driving wheels and driving said wheels for driving said car along said tube, wherein said frame unit and legs are rotatably mounted on said car for rotation around said axis.

3. A high speed underground transportation system comprising an underground tube, at least one car running in said underground tube, at least two sets of legs on said car, each set having three legs positioned symmetrically around and radiating from an axis coaxial with the axis of the tube, a frame unit connecting said legs, driving wheels on the extreme ends of two of said legs and a freely rotatable wheel on the extreme end of the third said leg, said two driving wheels lying on a horizontal line spaced above the bottom of the tube and below the middle of the tube and being in contact with the inner surface of the tube, driving motors coupled to said driv-
7. Ing wheels and driving said wheels for driving said car along said tube, and gas jet producing means on said car and extending laterally of the car adjacent the upper part thereof and having means directing jets of gas upwardly from the ends of said means, and baffles running along the wall of the tube and having downwardly directed surfaces impinged by the jets of gas from the gas jet producing means, whereby the car is stabilized as it runs along the tube.

4. A high speed underground transportation system comprising an underground tube, at least one car running in said underground tube, at least two sets of legs on said car, each set having three legs positioned symmetrically around and radiating from an axis coaxial with the axis of the tube, a frame unit connecting said legs, driving wheels on the extreme ends of two of said legs, and a freely rotatable wheel on the extreme end of the third said leg, said two driving wheels lying on a horizontal line spaces above the bottom of the tube and below the middle of the tube and being in contact with the inner surface of the tube, and driving motors coupled to said driving wheels and driving said wheels for driving said car along said tube, wherein said legs have an outer stem portion on which said wheels are mounted and a separate inner stem portion on said legs, and magnetic means around the stem portions where they adjoin each other for magnetically connecting said stem portions when said magnetic means is actuated.

5. A transportation system as claimed in claim 2 in which said car has a pair of axial bearings thereon and said assembly of legs and frame unit has a central axle rotatably mounted in said bearings.

6. A transportation system as claimed in claim 2 in which said car has a circular member having a passage therethrough for passengers, said circular member being fixedly mounted on said car with the axis thereof coincident with said axis, and said legs being slidably mounted on the circumferential surface of said circular member.

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