United States Patent

Andriussi

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[54] **SAFETY RAIL FOR ROADS AND MOTORWAYS**

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[21] Appl. No.: **42,970**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 710,005, March 4, 1968.

[52] **U.S. Cl.** **256/13.1,** 52/725, 52/731, 256/59

[51] **Int. Cl.** **E01f 15/00**

[58] **Field of Search** 256/13.1, 1, 65, 59; 52/724, 52/725, 731; 94/1.5

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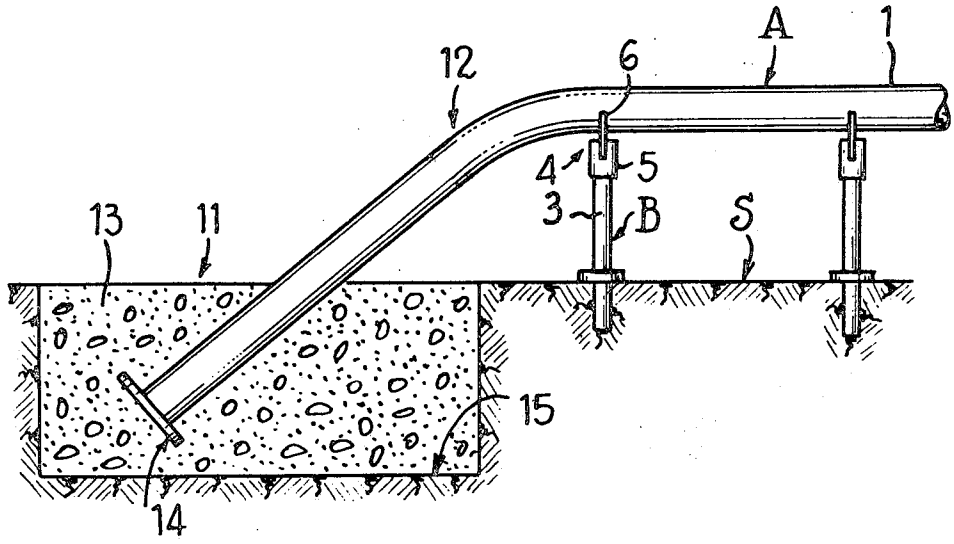
Primary Examiner—Dennis L. Taylor

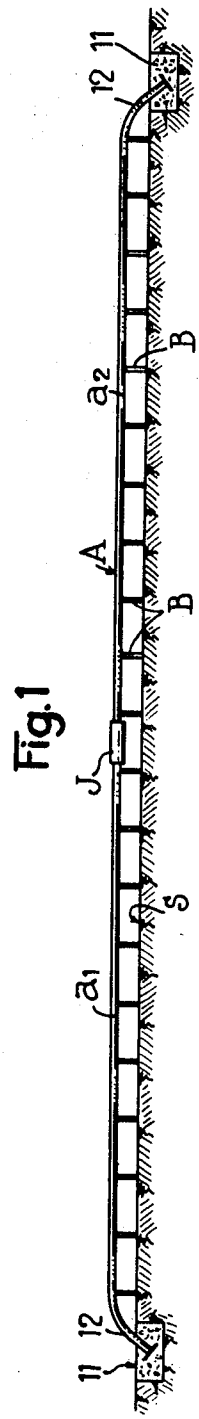
Attorney—Albert M. Zalkind, Leon R. Horne and Jacob Shuster

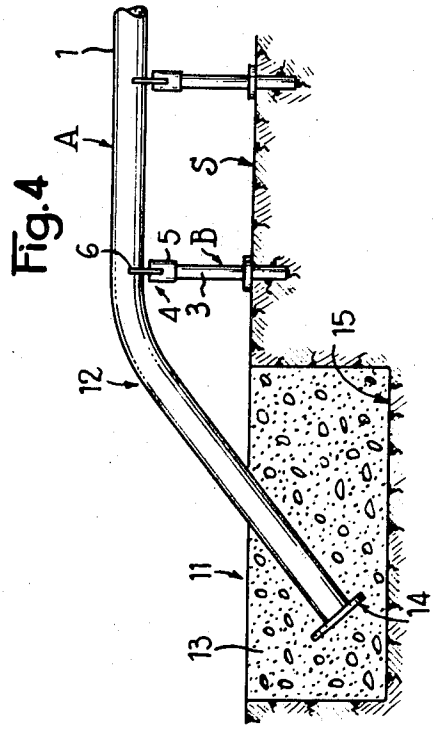
[57] **ABSTRACT**

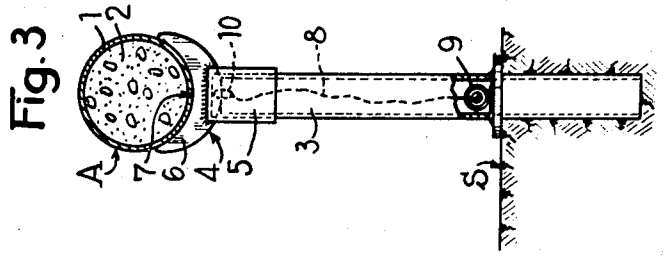
Safety rail for roads and motorways comprising in combination at least one element which has a great effective length without a break and a large linear mass and an undeformable section having a relatively large modulus of inertia and is capable of deforming plastically to a great extent, and supports on which said element rests horizontally with no appreciable mechanical attachment thereto and which substantially unaffect the homogeneity of said fundamentally active element.

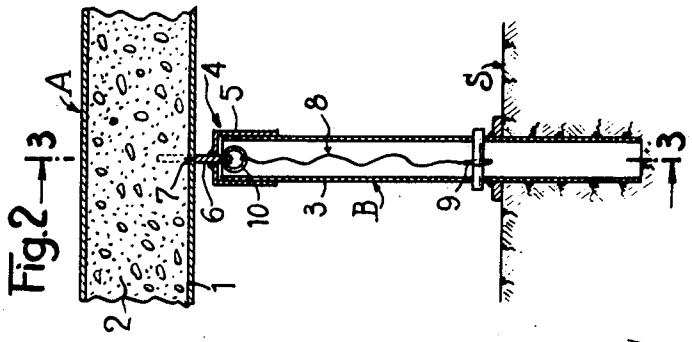
13 Claims, 11 Drawing Figures




Fig.1
11
12
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a2
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J
S
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Fig.4
1
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Fig.3
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Fig.2
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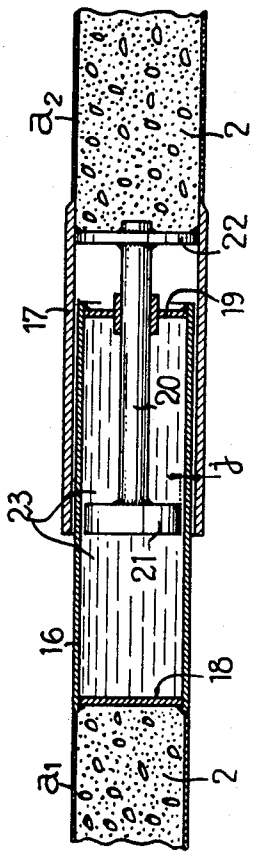


Fig.5

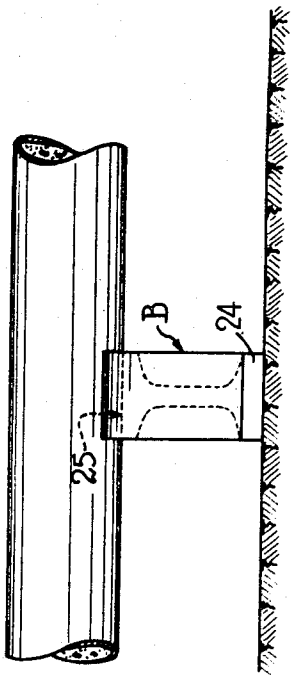


Fig.6

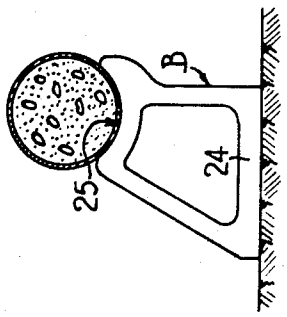


Fig.7

Fig.8

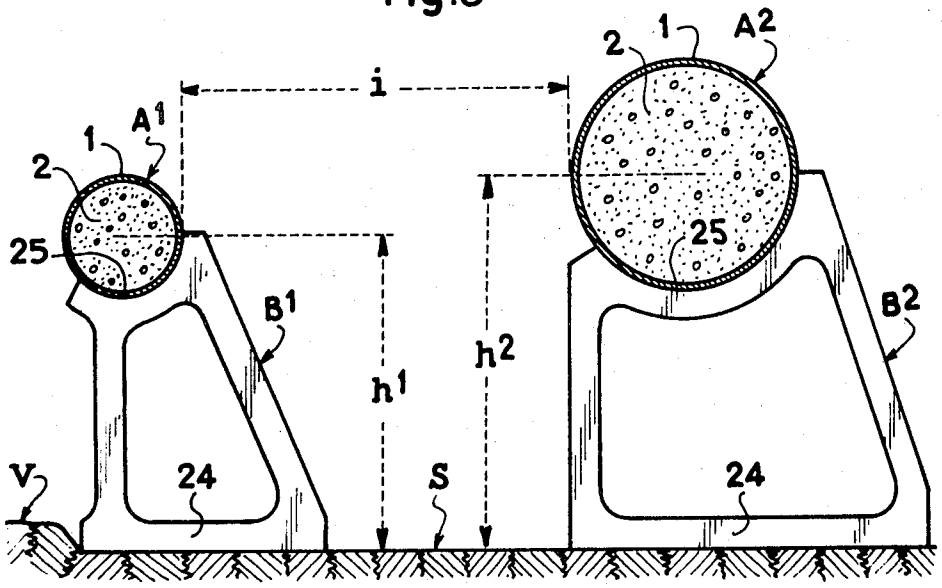


Fig.9

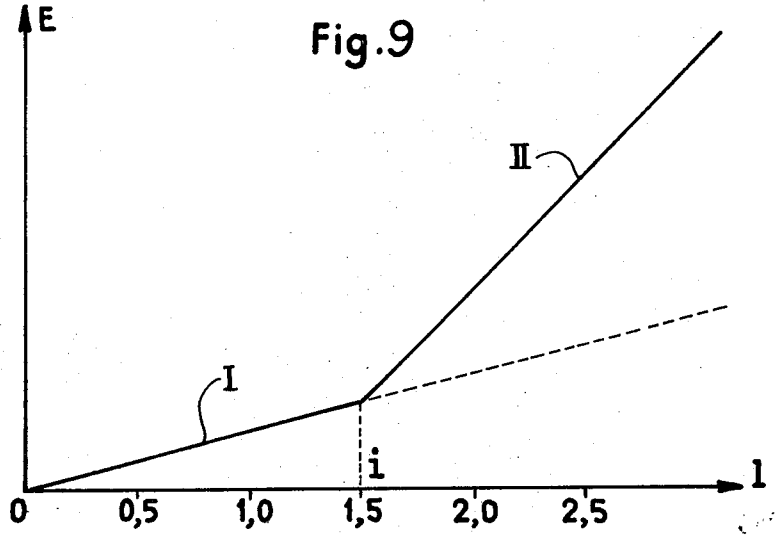


Fig.10

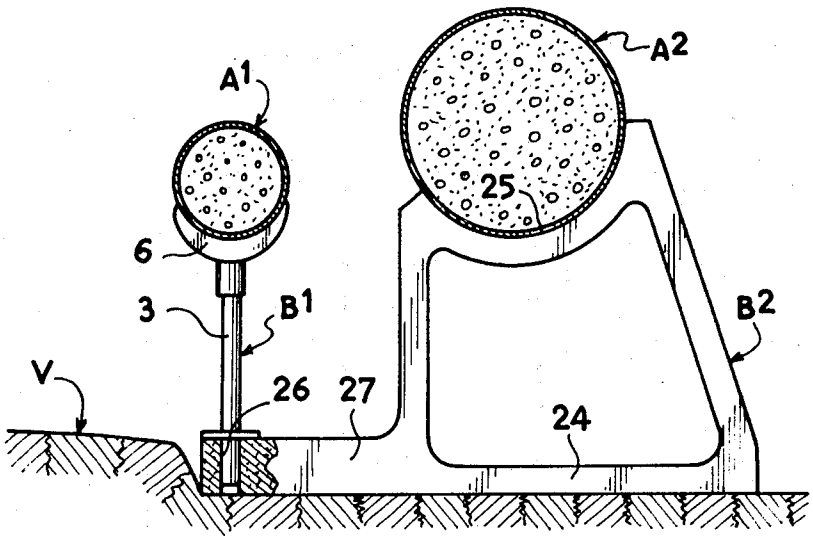
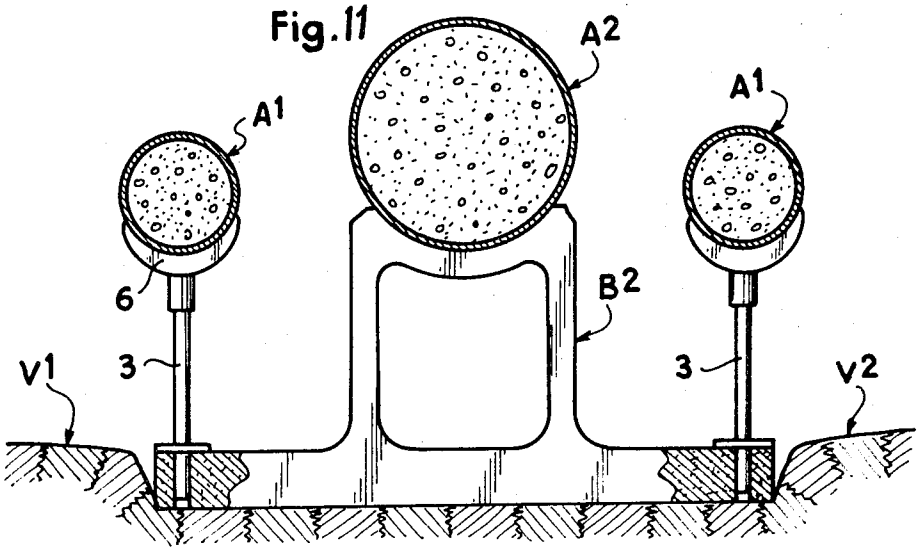


Fig.11



SAFETY RAIL FOR ROADS AND MOTORWAYS

This application is a continuation-in-part of my application Ser. No. 710,005, filed Mar. 4, 1968.

The present invention relates to safety rails for roads and motorways for increasing the safety of the vehicles and passengers when these vehicles are in difficulty and tend to leave the road and also for dividing, in the case of motorways having separate ways, the two ways by preventing the passage of vehicles from one way to the other.

These rails or barriers have heretofore usually been constructed of section elements having a U-section or like section, obtained by folding galvanized sheet steel, and mounted on posts embedded in the ground.

The elements currently in use have a serious defect due to their very principle. These section elements have a relatively small mass and a low moment of inertia. Consequently, the posts must be very strong since it is they which constitute the main stopping means.

Moreover, the stiffness of known rails varies to a very large extent, depending on whether the impact of a vehicle occurs in the region of a support (firmly embedded post) or in the center of the span between posts.

Further, at the point of impact, the section element is crushed and the moment of inertia is considerably reduced which results in pocketing which very suddenly stops the vehicle.

The object of the invention is to provide an improved safety rail based on fundamentally different principles so as to roughly progressively arrest the vehicle and afford the occupents greater safety.

Three main parameters define the behavior of a safety rail of the "inertia" type, that is of the type having ground supports which have no appreciable effect on the deformation of the rail itself:

1. The linear mass which governs the dynamic operation and any exchange of energy between the vehicle and rail.

2. The moment of inertia which governs the stiffness of the rail.

3. The modulus of inertia which governs the threshold of plastic deformation beyond which the energy is absorbed without elastic restoration of energy.

Many tests carried out seem to show that the optimum linear mass is between 100 and 150 kg per meter of rail length. For this linear mass, it is believed that the modulus of inertia should be between 100 and 150 cm^3 to avoid fracture of the rail while affording a low plastic deformation threshold.

Lastly, with the two aforementioned parameters thus defined, it is considered that it is with an inertia of about 2,000 cm^4 that a suitable rail stiffness is obtained, this having been confirmed by moderate deceleration values and only slight damage to the vehicle striking the rail.

The judicious association of a steel case or tube and concrete as filling material enabled the suitable values of these three parameters to be simultaneously determined.

For example, with a steel tube diameter of 250 mm and a wall thickness of 1.5 mm filled with concrete, there is obtained :

Linear mass : 132 kg/meter

Moment of inertia : 2,031 cm^4

Modulus of inertia : 121 cm^3

Note that, without the concrete filling, the tube alone gives :

Linear mass : 10 kg/meter

Moment of inertia : 920 cm^4

Modulus of inertia : 73 cm^3.

THe latter values, which greatly differ from the former relating to the composite element comprising the tube and the concrete filling, reveal the fundamentally important effect of the filling.

This rail comprises in combination at least one element which has a great effective length without a break and a large linear mass and an undeformable section having a relatively large modulus of inertia and is capable of deforming plastically to a great extent, and supports on which said element rests horizontally with no appreciable mechanical attachment thereto and which supports substantially unaffect the homogeneity of said fundamentally active element.

Preferably, said element has a linear mass of at least 100 kg/m and a modulus of inertia of at least 100 cc and is capable of undergoing a deformation corresponding to a flexion of at least 2 m per 100 m of length.

The main advantages of this safety rail are the following :

The high unit mall of the longitudinal element permits transferring the kinetic energy of the moving vehicle to this element which is slightly displaced at low speed with the result that the vehicle is braked rapidly instead of being arrested suddenly.

The absence of a solution of continuity or break in the element, associated with great freedom relative to the supports, ensures continuity in the effect, irrespective of the position of the point of impact.

As the supports merely serve to position the assembly, they can have a judiciously chosen fragility so as to oppose no appreciable resistance to the vehicle.

The transverse deformation of the supported element occurs well beyond the elastic deformation thereof owing to the fact that the inertia of the section is practically constant. Indeed, it is in the plastic deformation range that the energy can be absorbed without being restored.

Further features and advantages of the invention will be apparent from the ensuing description with reference to the accompanying drawings :

In the drawings:

FIG. 1 is an elevational view of a section of an installed safety rail;

FIG. 2 is a longitudinal sectional view of a part of the longitudinal element of great length and a support therefor;

FIG. 3 is a sectional view taken along line 3—3 of FIG. 2;

FIG. 4 is a detail view of the anchoring of one of the ends of the longitudinal element;

FIG. 5 is a longitudinal sectional view of an expansion joint between two sections of longitudinal element;

FIG. 6 is a partial elevational view of a modification of the rail according to the invention;

FIG. 7 is an elevational view of one of the supports of said modification;

FIG. 8 is a diagrammatic vertical cross-sectional view of a composite rail having two elements according to the invention;

FIG. 9 is a graph which shows, as a function of lengths l of deformations in meters, plotted as abscissae, the energy absorbed, plotted as ordinates;

FIG. 10 is a view similar to FIG. 8 of a modification, and

FIG. 11 shows, under the same conditions, a composite asymmetrical rail having three elements.

In the embodiments shown in FIGS. 1–5, the safety rail comprises a main element A of great length and supports B on which the element A bears roughly horizontally and parallel to the ground S.

The main heavy element A is substantially continuous without an effective solution of continuity or break. In fact, this element consists of two sections a^1 and a^2 interconnected by an expansion joint J which enables these sections to undergo relative movements while it ensures the continuity of the general characteristics of the element. This joint J, the details of which will be referred to hereinafter, allows a relative movement between the two sections a^1 and a^2 for very slow movements due to expansions but it has a practically absolute rigidity in the event of a brief stress such as that produced by an impact.

Each section a^1 or a^2 of the main element A consists of a tubular metal case 1 filled with a filling 2 adapted to increase its mass and improve the conservation of the section. This filling can be of, for example, sand, earth or concrete. The element A can have a length of several hundreds of meters, for example 200–300 m.

The tube 1 can be advantageously of ordinary steel having a minimum wall thickness of the order of 1.5 mm, the minimum diameter being 250 mm. The filling material can have a density of the order of 2.5. Under these conditions, the element A has a linear mass at least equal to 100 kg/m and preferably between 100 and 500 kg/m and a modulus of inertia of at least 100 cc and it is capable of assuming an elastic flexion of at least 2 m per 100 m of length.

The supports B are each constructed of a post 3 surmounted by a support cradle 4. The post 3 is driven into the ground and for example consists of a small-section tube which has for function to support the element A at a suitable height but is capable of moving aside by folding upon passage of a vehicle without any substantial retarding effect. The support cradle 4 surmounts the post 3 and its shape is designed to maintain, upon application of small transverse forces, the element A which merely bears on the cradle with no mechanical attachment thereto. The cradle 4 is not fixed to the post 3. It comprises a sleeve or 5 capping the post and a crescent-shaped vertical wall 6 welded thereto and having a concave upper edge 7. Upon impact, this cradle 4 can therefore leave the post 3 to which it is connected by a tie 8 (cable or chain) which is slack at rest and is connected to the post at 9 and to the cradle at 10. This tie retains the cradle after it has left the post and thus avoids a projection thereof which could be dangerous. The supports B can have such length that the axis of the tube A is at least about 500 mm from the ground.

The element A is anchored in the ground at 11 at each end (FIGS. 1 and 2).

Adjacent each anchoring the element A is bent at 12 and extends into a block 13 of concrete in which it terminates in a sole plate 14 (FIG. 4) intended to complete the connection of the element A to the block 13. The latter consists of a mass of concrete poured on the site into a pit 15. This ensures correct operation of the device under impacts which might occur in the vicinity of one of the ends of the section of road thus equipped. For example, the minimum volume of the concrete 13 is 2 m^3

FIG. 5 relates to an expansion joint J provided on the element A between the upstream section a^1 and downstream section a^2.

Two annular metal sleeves 16 and 17 having a thickness substantially greater than that of said sections a^1 and a^2 of the main element A (so as to compensate for the absence of the filling material) are respectively fixed by a continuous weld to these sections.

The sleeve 17 has an inside diameter slightly greater than the outside diameter of the sleeve 16 so as to be capable of being engaged thereon. The sleeve 16 is closed at the upstream end by a wall 18 which limits the zone filled with the material 2. Another wall 19 is fixed by a continuous weld to the downstream end of the sleeve 16 and it comprises an aperture for the passage of a sliding rod 20. A piston 21 is fixed to the end of the rod 20 inside the sleeve 16 and there is a diametral clearance between the piston and the sleeve. At the downstream end the rod 19 is fixed to another wall 22 which limits the zone filled with the material 2 in the section a^2.

The assembly is arranged as shown. The sleeve 16 is previously provided with a disc 18 and welded to the end of section a^1. The piston 21 and rod 19 are engaged in this sleeve, the disc 19 is slipped onto the rod 20 and welded to the sleeve 16 and then the disc 22 is welded to the rod 20. Thereafter, the sleeve 17 is engaged on the sleeve 16 and the sleeve 16 is first welded to the disc 22 and then to the section a^2.

The space defined by the sleeve 16 and the walls 18 and 19 is divided into two chambers by the piston 21. These chambers are filled with a product 23 having a very high viscosity (for example grease, mastic or silicone). It will be clear that the assembly comprising elements 16, 20, 21 and 23 constitutes a structure operable as a dashpot. Thus, in course of very slow relative longitudinal movements between the sections a^1 and a^2 resulting from expansions or contractions, the material 23 is transferred between the two chambers separated by the piston 21 owing to the clearance between the latter and the sleeve 16.

For very brief stresses, the high viscosity of the material 23 creates considerable losses of force so that the relative displacement between the sections a^1 and a^2 is negligible, even in respect of considerable forces.

It is obvious that the diametral clearance between the piston 21 and the sleeve 17 must be determined to suit the material 23 employed.

Upon impact, the expansion joint thus designed ensures the homogeneous continuity of the main element A formed by the sections a^1 and a^2 interconnected by this joint J; the engagement of the sleeve 17 on the sleeve 16 ensuring the transverse connection and the rigidity of the device comprising the piston 21 and the material 23 ensuring the longitudinal connection.

FIGS. 6 and 7 show a modification in which the element A bears on concrete supports or bolsters B, such as those shown without being secured thereto. Each support B comprises a plane base 24 in contact with the

ground and a part-cylindrical concave upper face **25** conforming to a part of the shape of the element A. The support B has no point of attachment with the ground or with the longitudinal element A. Its sole function is to support the latter at the desired height above the ground. In the event of shock, it opposes only a small resistance to the vehicle which strikes thereagainst and can easily slide or tip over.

In both embodiments, after an impact, the element or elements A, B which are shifted can easily be put back into position. Finally, their installation merely by placing them on the ground requires no forming, driving or sinking work.

The rail according to the embodiments just described has a great capacity for deformation and its mass permits, as experiments have shown, a good range of adaptation, that is, good efficiency for stopping under good conditions vehicles of widely varying weights.

Nonetheless, the range of energies to be absorbed is so vast between a light vehicle travelling at average speed and a large vehicle or a heavy lorry or truck (for example, as compared with a vehicle of 600 kg travelling at 60 kph, a vehicle of 1,200 kg travelling at 180 kph corresponds to 18 times more kinetic energy and a heavy lorry of 15,000 kg travelling at 80 kph represents 45 times more energy) that it is obvious that a rail having a single effective element could only be a compromise.

Composite rails according to the invention which remedy this state of affairs will now be described.

These rails can indeed cover a very wide range of energy to be absorbed owing to the fact that they are composite and comprise in combination at least two absorbent elements which have different cross-sections and are parallel to each other and to the roadway and separated by a space which is as near to the average width of a touring car as the available space permits, the element having the smallest section being the nearest to the roadway.

As will be understood, this element having the smallest section will absorb the energy of average impacts due to touring cars whereas in respect of higher impacts due to heavy lorries or trucks, after the first element has been deformed to the extent of the space between the two elements, the second element having a larger mass and stiffness will in turn come into operation.

Thus, according to the embodiment shown in FIG. **8**, the composite rail is adapted to equip a road edge or an outer edge of a motorway whose adjacent roadway is located at V.

This rail comprises two absorbing elements A^1, A^2 which bear on separate supports B^1 and B^2.

The elements A^1 and A^2 are of the type described hereinbefore having a tubular case and a filling **2**, of great effective length without a break, a large linear mass and an undeformable section having a relatively high modulus of inertia, these elements being capable of undergoing a transverse plastic deformation to a large extent.

The element A^1 has a cross section which is smaller than that of the element A^2 and it therefore has a linear mass and a modulus of inertia which are less than those of the element A^2.

For example, the steel tube of the element A^1 can have a wall thickness of the order of 1.5 mm and a minimum outside diameter of 250 mm so that this element has, as mentioned in respect of the first embodiment, a linear mass equal to at least 100 kg/m and a modulus of inertia of at least 100 cc and it is capable of undergoing an elastic flexion of at least 2 mm per 100 m of length.

The larger element A^2 can comprise a tube having a thickness of the order of 3 mm and an outside diameter double that of the element A^1 which, for the same filling material, gives for the element A^2 a linear mass which is 4 times that of the element A^1 and a moment of inertia 16 times greater.

The element A^1 is placed at a height h^1 above the ground S which is less than the height h^2 of the element A^2. These heights correspond at least roughly to those of the most resistant parts respectively of a touring car and a heavy lorry or truck, namely about 0.70 m and 1.00 m.

This distance *i* between the two elements depends on the available space, but is as near as possible to the average width of a touring car, namely of the order of 1.5 m.

Each support B^1, B^2 can be one of the types described hereinbefore. In the presently described embodiment, they consist of concrete bolsters having a plane base **24** in contact with the ground and an upper part-cylindrical face **25** conforming to the shape of the corresponding element A^1 or A^2 and preferably rising higher on the side remote from the road V than on the side adjacent the latter.

With this composite rail, and as already mentioned, upon an average impact only the first element A^1 of the rail will be put under stress and the effect of the composite rail will be in every respect comparable to that of the single rail of the first two embodiments and the light or slow vehicles will be correctly deviated.

On the other hand, for a greater impact corresponding to the shock of a heavy vehicle or a very rapid vehicle, the first element A^1 of the rail will be subjected to stress during the first moments of the shock and will bring about a beginning of a deviation and slowing down of the vehicle. If the deformation reaches, and then exceeds, the extent of the initial distance *i* between the two elements A^1 and A^2, the second element A^2 will in turn come into action and, owing to its larger mass and stiffness, will have a high deviating and slowing down effect which is added to that of the first element A^1.

In FIG. **9**, the straight line I represents the energy E absorbed by the element A^1 as a function of its deformation *l* in meters up to the value *i* of deformation corresponding to the distance between the two elements A^1 and A^2. The line II, following on the line I, represents the absorption of energy beyond the deformation *i* owing to the combined action of the two elements A^1 and A^2.

The choice of the relative dimensions of the two rails determines, as will be understood, the desired progressivity for the assembly and affords an additional factor in the adaptation compromise.

In the embodiment shown in FIG. **10**, the supports B^1 of the element A^1 consists of posts **3** similar to those shown in FIGS. **2** and **3**. Each post carries at the upper

end the element A^1 which bears on the crescent-shaped vertical wall **6** whereas, at the base, the post is driven into an aperture **26** provided in a lateral extension **27** of the base **24** of the support B^2. Preferably, the whole of this support (**24,27**) is lower than the road V and is practically buried so as to avoid a substantial projection above the horizontal plane containing the edge of this road.

FIG. **11** shows an arrangement for the center part of a motorway or of a road having two separate ways V^1 and V^2. Two lateral elements A^1 are provided for touring cars and the center element A^2 for heavy lorries or trucks. This very strong element A^2 affords additional safety against the passage of a vehicle from one roadway to the other.

The two elements A^1 are carried, as in the embodiment shown in FIG. **10**, by pairs of posts **3** driven into the base of the center support B^2.

Having now described my invention what I claim and desire to secure by Letters Patent is:

1. A safety rail structure for roads and motorways comprising in combination a continuous composite element comprising means defining a continuous tube of thin steel, said tube defining an inner cavity in which there is disposed solely a filling material comprising particles and substantially completely filling said cavity, and supports supported on the ground and on which said element rests in spaced relation to the ground, said tube having end portions of tube anchored in the ground and the element having an engagement with said supports which is such as to be sufficient to normally hold said element stationary relative to the ground and yet allow said element to readily disengage from said supports upon impact of a motor vehicle on said element.

2. A safety rail structure as claimed in claim **1**, wherein said element has a linear-mass of 100 kg/m–150 kg/m, a modulus of inertia of 100 cm^3–150 cm^3, said filling material being of concrete.

3. A safety rail structure as claimed in claim **1**, wherein said end portions are bent and extend obliquely into the ground where each end portion is anchored in a concrete block wholly embedded in the ground so as to leave no projection above ground level.

4. A safety rail structure as claimed in claim **3**, wherein said tube is substantially filled with said filling material in said bent end portions.

5. A safety rail structure for roads and motorways comprising in combination a continuous composite element comprising means defining a tube of metal, said tube defining a cavity extending throughout the length of said tube, said cavity containing exclusively a filling material comprising particles and substantially completely filling said cavity, and supports supported on the ground and on which said element rests in spaced relation to the ground, said element comprising two aligned sections and an expansion joint interconnecting said sections, said joint including a dashpot structure which is operative in a direction parallel to said sections and said joint being so adapted that the joint affords a transverse connection between the two sections whereas in the longitudinal direction the dashpot allows low relative longitudinal movements between the two sections but opposes rapid movements thereof liable to result from the impact of a vehicle on the element.

6. Safety rail structure as claimed in claim **5**, wherein said joint comprises two cylindrical tubular sleeves interengaged to be relatively slidable, one of said sleeves being fixed to one of said sections and having two end walls, a piston disposed inside said first sleeve with a radial clearance, said end walls defining with said piston two volumes on each side of said piston, a viscous product filling said volumes, and a piston rod connecting said piston to the other of said sections through one of said end walls, the other of said sleeves being fixed to said other of said sections.

7. A safety rail structure as claimed in claim **1**, wherein each support comprises a post capped by a cap carrying a transverse wall having a substantially crescent shape and an upper concave edge serving as a support for said element.

8. A safety rail structure as claimed in claim **7**, wherein said cap and transverse wall are removable from said post but loosely connected to the post by a slack flexible tie whose function is solely to prevent the cap from being thrown across the road upon impact.

9. A safety rail structure as claimed in claim **1**, wherein each support comprises a concrete bolster freely resting on the ground through a plane base, said bolster having an upper concave face in which said element is supported.

10. A safety rail structure as claimed in claim **1**, wherein said filling material consists of particles completely filling the cavity of said tube.

11. A safety rail structure as claimed in claim **1**, wherein said composite element has a section having a modulus of inertia expressed in cubic centimeters which has substantially the same numerical value as the linear mass of said composite element which is at least 100 kg/meter.

12. A safety rail structure as claimed in claim **1**, wherein said filling material is concrete and said supports comprise means defining shallow upwardly facing recesses in which said composite element is freely engaged the depth of said recesses being less than one-half of the vertical extent to said tube so as to normally retain said composite element in substantially correct position laterally of said composite element but allow said composite element to leave said recesses upon impact of a motor vehicle on said composite element.

13. A safety rail structure as claimed in claim **5**, wherein said tube has end portions of tube anchored in the ground.

* * * * *