United States Patent [19]

Bertin

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[54] **IMPROVEMENTS IN RACK-AND-PINION SYSTEMS**

[75] Inventor: **Jean Henri Bertin,** Neuilly-sur-Seine, France

[73] Assignee: **Bertin & Cie,** Plaisir, France

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[30] **Foreign Application Priority Data**

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Sept. 21, 1972 France 72.33405

[52] **U.S. Cl.** .... **105/29 R,** 104/32, 74/422, 104/23 FS

[51] **Int. Cl.** **B61c 11/00**

[58] **Field of Search** .... 104/32; 105/29 R; 74/422

[56] **References Cited**

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Primary Examiner—Lloyd L. King
Assistant Examiner—D. W. Keen
Attorney, Agent, or Firm—A. W. Breiner

[57] **ABSTRACT**

The invention comprehends a rack-and-pinion system the rack having a rigid longitudinal base adapted to withstand the forces which the pinion applies to the rack, and a resilient element in band or strip or similar form which adheres to the rigid base over the whole length thereof and which receives the force from the pinion.

18 Claims, 11 Drawing Figures

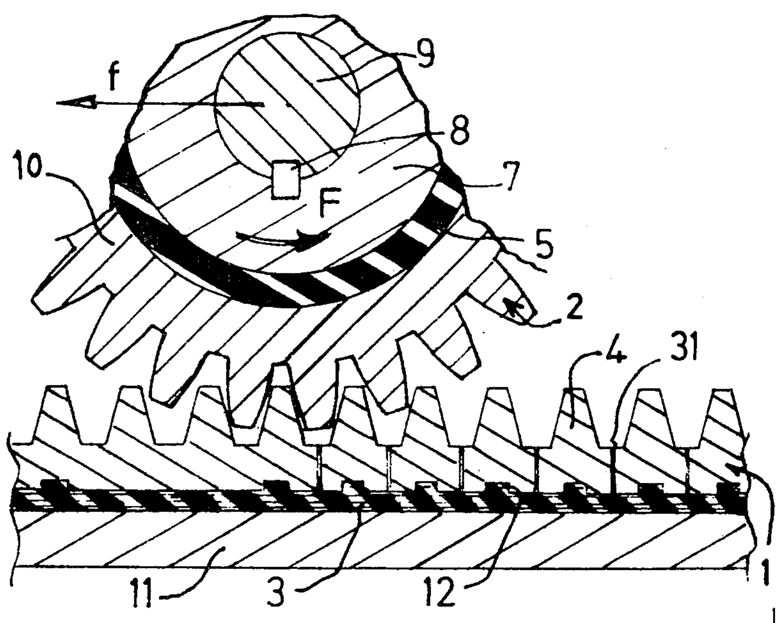


FIG. 1

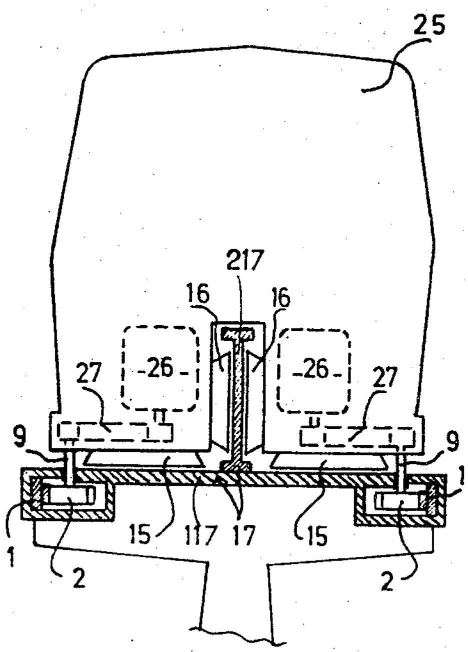


FIG. 2

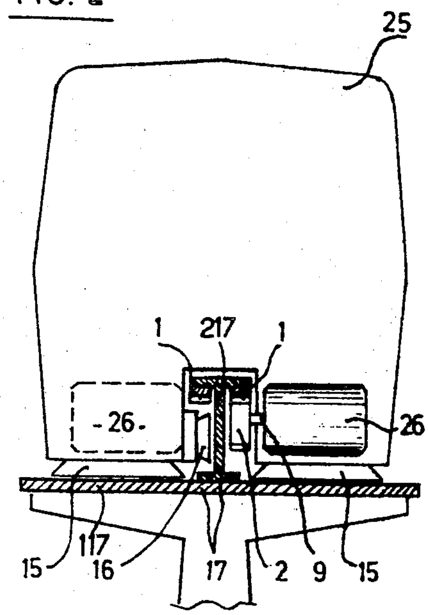


FIG. 4

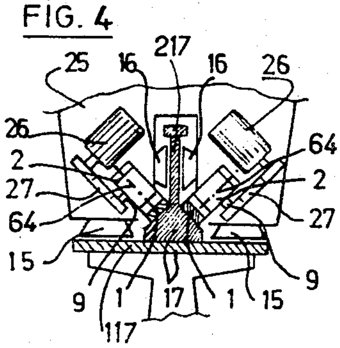


FIG. 3

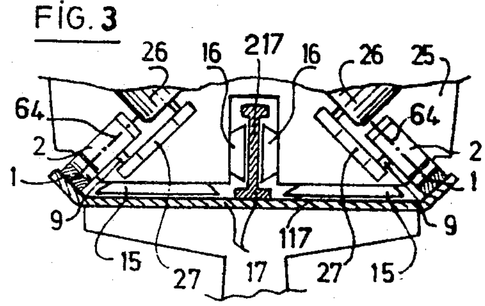


FIG. 5

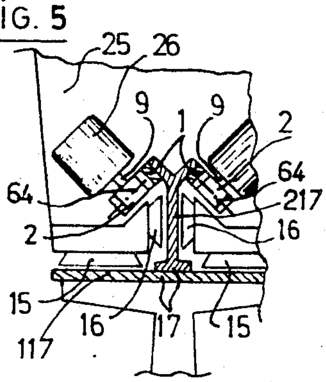


FIG. 6

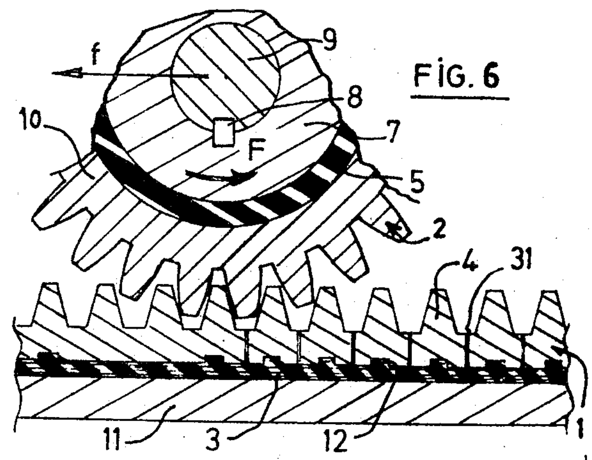


FIG. 7

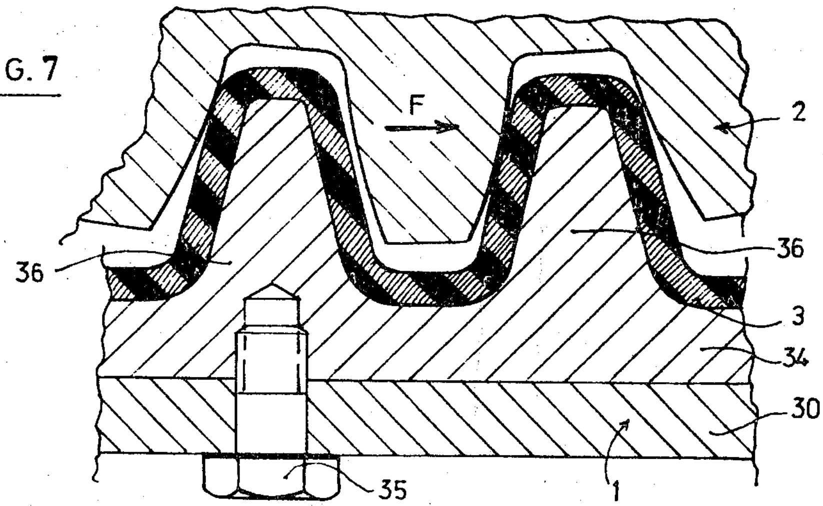


FIG. 8

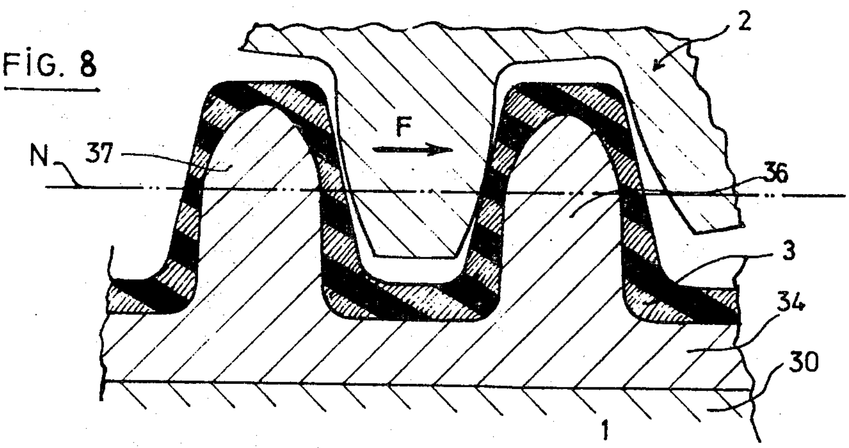


FIG. 9

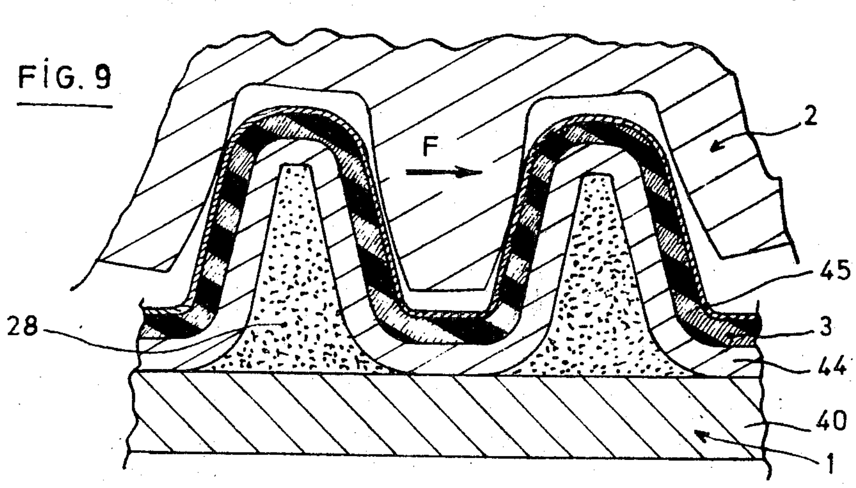
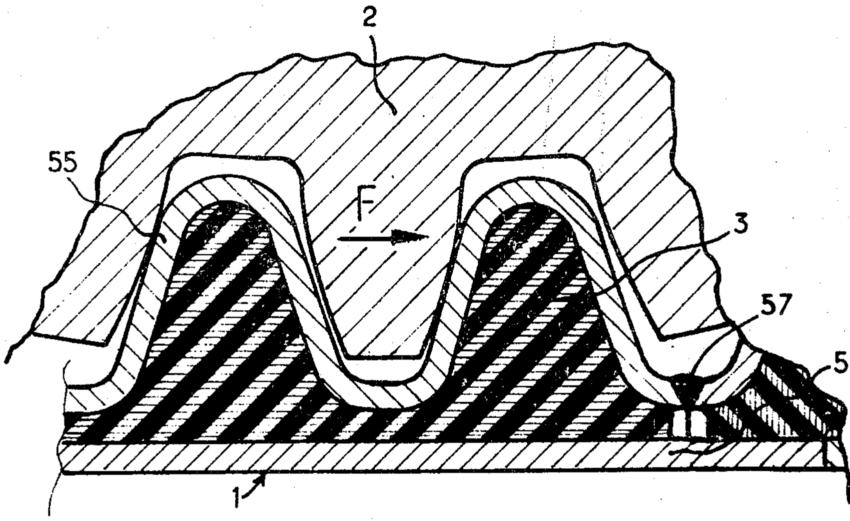


Fig. 10



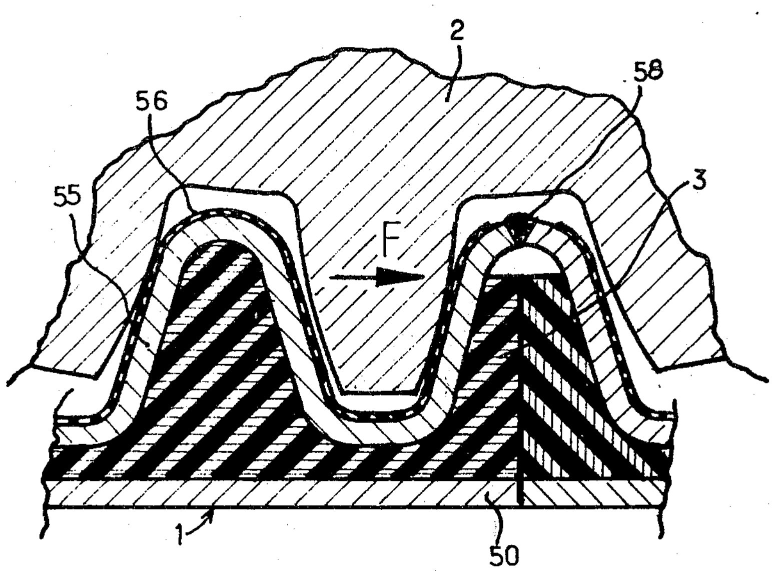


Fig. 11

IMPROVEMENTS IN RACK-AND-PINION SYSTEMS

This invention relates to rack-and-pinion systems of the kind comprising a rack and a toothed pinion, in mutual meshing engagement.

It is an object of the invention inter alia to reduce the unpleasant noise of conventional systems of this kind in which the racks and pinions are of steel. It is another object of the invention to facilitate the operation of such systems at starting.

The invention is of use more particularly, but not exclusively, in transport systems of the kind comprising a machine which is moved along a rack by means of a machine-mounted pinion meshing with the rack. Under this head, the invention is of use inter alia for transport systems in which a ground effect machine is borne and/or guided along a track with the inter-position of at least one pressure fluid cushion at a pressure above the ambient pressure or of at least one pressure fluid layer at a pressure below the ambient pressure.

According to the invention, in a rack-and-pinion system of the kind described, the rack comprises a rigid longitudinal base adapted to withstand the forces which the pinion applies to the rack, and a resilient element in band or strip or similar form adhering to the rigid base over the whole length thereof and which receives the force of the said pinion.

Advantageously, the resilient element can be made of a substance based on natural or synthetic rubber or a resilient silicone.

Clearly, the resilient element provides damping which helps to provide a considerable reduction in the noise made by the rack-and-pinion system, besides helping to increase the maximum starting torque by gradual storage thereof in the resilient element, in the form of deformation stresses.

The rigid base of the rack can comprise one or more superposed layers which can be secured to one another by any known means. One layer of the rigid base can be a corrugated metal sheet. The space between the same and a subfoundation plate also forming part of the rigid base can be filled with different filling materials to damp vibrations of the metal sheet and of the rack teeth. As examples of such filling materials there can be mentioned sand, concrete, fibres which may or may not be agglomerated, polyurethane and similar materials. The rigid base may be formed with protruding portions having the rough shape of the teeth.

The resilient element can be secured to the rigid base by any known means, for example by adhesion. If required, the resilient element can have projecting or recessed portions adapted to engage with corresponding recessed or projecting portions of an adjacent element forming part of the rack. The resilient element covers the rigid base over the whole of its operative length.

The resilient element can be shaped into corrugations adapted to engage the toothed pinion.

To prevent premature wearing of the resilient element as a result of friction and deformation, the resilient element can have a protective lining of a substance, such as metal sheet, which is harder than the resilient element. It can also have provision for reducing the coefficient of friction between the rack and the pinion.

In order that the invention may be well understood there will now be described some embodiments thereof, given by way of example only, reference being had to the accompanying drawings, wherein:

FIGS. **1 – 5** are diagrammatic views, in cross-section and partial cross-section, of rack-and-pinion systems forming part of a transport system comprising a track and a machine movable therealong;

FIG. **6** is a view, in a vertical section parallel to the rack, of a pinion meshing with metal teeth borne by a resilient element which forms a damping seating for the teeth, the resilient element itself covering a rigid base;

FIG. **7** is a view, in a vertical section parallel to the rack, of a corrugated rigid base covered by a resilient element;

FIG. **8** is a view similar to FIG. **7** showing a resilient element whose thickness varies along a corrugation;

FIG. **9** is a view similar to FIGS. **7** and **8** showing the interposition of filling material in the gap between two parts of the rigid base;

FIG. **10** is a view similar to FIGS. **7** to **9** of a rack in which the resilient element has a protective covering; and

FIG. **11** is a view similar to FIGS. **7** to **10** of a rack coated with a layer of material which has a low coefficient of friction in its contact with the pinion.

FIGS. **1** to **6** show a transport system comprising a ground effect machine **25** borne and guided by a track **17** with the interposition of fluid cushions. The track **17** in shape resembles an inverted T having, for example, a substantially horizontal bearing portion **117** and a susbstantially vertical central guiding portion **217.** The fluid cushions are confined by chambers **15, 16,** for example of the plenum chamber kind, supplied with fluid at a pressure above the ambient pressure by means (not shown).

Alternatively, the machine **25** can be borne and/or guided by means of fluid layers whose pressure is below the ambient pressure.

The machine **25** is driven along the track **17** through the agency of two racks **1** each meshing with a pinion **2.** Each pinion **2** is rigidly secured to a shaft **9** driven by a motor **6** through a speed reducer **27.** Each rack **1** extends parallel to the length of the track **17.**

FIGS. **3 – 5** show arrangements in which each rack **1** is disposed at an inclination to the track **17** and meshes with an inclined pinion **2.** These arrangements are advantageous, particularly for limiting rolling movement of the machine **25.** To this end, the line on which the plane **64** containing the pinion **2** intersects the longitudinal centre-plane of the machine is, with advantage, near the roll axis thereof. In FIGS. **4** and **5,** each rack **1** is secured to the central guiding portion **217** of the track **17.**

The various constructions of rack and pinion which follow may be used in any of the arrangements of FIGS. **1** to **5.**

Referring now to FIG. **6,** there is shown a rack **1** meshing with a pinion **2.** The rack has a rigid longitudinal base **11** which can withstand the forces applied by the pinion **2** and which in the example shown in FIGS. **1** to **5** forms part of a track **17** co-operating with the machine **25.**

A resilient element **3** in band or strip or similar form has a substantially planar surface which is connected, for example by adhesion, to a corresponding planar surface of the base **11** over the whole length thereof. The element **3** can be either continuous or comprise a number of sections abutting one another in end-to-end relationship. The element **3** can be made, for example, of natural rubber or a synthetic rubber such as neoprene or perbunan or viton or of a resilient silicone. If required, some resilient synthetic or natural plastic substances are suitable for the element **3.**

That face of the resilient element **3** which is opposite the face adhering to the base **11** is substantially planar and bears metal teeth **4** co-operating with the pinion **2.** Via the teeth **4,** therefore, the resilient element **3** receives the force of the moving element **2** and thus acts as a seating providing resilient damping.

The element **3** is in engagement with at least one adjacent element, for example, the teeth **4** or the rigid base **11,** by way of projecting or recessed parts **12** which co-operate with correspondingly recessed or projecting parts of such adjacent element. The teeth **4** can be integral with one another as shown in the left-hand part of FIG. **6**; alternatively, and as shown in the right-hand part of FIG. **6,** the teeth **4** can be independent integers and separated from one another by small gaps **31** to improve overall resilience.

Also shown by way of example is a resilient mounting of the pinion **2** by means of a resilient ring **5** co-operating coaxially with a hub **7** and with a tooth-bearing rim **10** which forms part of the pinion. The hub **7** is secured to the shaft **9** by a key or cotter or the like **8.** The ring **5** can be made of the same substance as the resilient element **3.** An arrow F indicates the direction of pinion rotation, and an arrow f indicates the direction in which the machine **25** moves.

In the embodiment shown in FIG. **7,** the rigid base of the rack **1** comprises two superposed layers **30, 34** which are connected together by bolts or screws **35.** The proximal face (with respect to the pinion **2**) of the rigid base **30 – 34** is shaped into corrugations **36** of the same ptitch as the teeth of the pinion **2.**

The resilient element **3** is of substantially constant thickness and is shaped on its distal face (with respect to the pinion) to match the corrugations **36,** which it covers externally. On its proximal face (with respect to the pinion **2**), the resilient element **3** is thus also shaped into corrugation which engage by direct contact the teeth of the pinion **2.** The pinion **2** can be made, preferably, of a material marketed under the name of Nylon 6 or Nylon 66 or a similar material. The arrow F indicates the direction of pinion rotation.

FIG. **8** shows a variant of the previous embodiment wherein the layer **30** of the rigid base forms part of the track. The shape of the corrugations **36** is somewhat different and the thickness of the resilient element **3** varies along a corrugation, increasing towards both the crest and root of the corrugation from the region N where the pitch circle of the pinion meets the rack.

FIG. **9** shows a variant of the two immediately preceding embodiments wherein the rigid longitudinal base of the rack comprises a subfoundation **40** bearing a corrugated metal sheet **44** which is secured to the subfoundation **40** by means (not shown). The metal sheet **44** is relatively rigid and is corrugated before being positioned and before receiving the resilient element **3.** The gap between the elements **40** and **44** is filled with a substance **28** such as sand or concrete or agglomerated or unagglomerated fibres or polyurethane or the like.

The corrugated metal sheet **44** is covered by the resilient element **3**; however, in the present case there is no

direct contact between the resilient element and the pinion teeth, to which end a protective lining **45** for the resilient element is secured thereto, for example by adhesion, thus preventing premature wear of the element **3** as a result of friction and of possible overstressing by the pinion teeth.

The lining **45** can be made of a thin but hard material based, for example, on hardened natural or synthetic rubber or on an appropriate hard plastics material. Alternatively, the lining **45** can be a corrugated metal sheeting. Advantageously, the material used for the covering **45** has a low coefficient of friction in the presence of the pinion teeth. The filling material **28** helps inter alia to damp vibrations of the sheet metal **44** and therefore of the rack teeth.

In the embodiments shown in FIG. **10** the rigid longitudinal base takes the form of a planar sheet metal member **50.** A corrugated lining **55** of substantially uniform thickness engages the teeth of the pinion **2.** The resilient element **3** takes up all the space between the two sheet metal members **50, 55,** to which it is secured, for example by adhesion, over the whole extent of the contacting surfaces. The resilient element **3** can be premoulded, then secured in position; alternatively, it can be moulded directly between the two members **50** and **55.** The element **3** can be made of natural or synthetic rubber.

If the torque applied to the pinion **2** is fairly high, the lining **55** may need to be fairly thick so as not to become permanently deformed by the pressure of the pinion teeth; in this case, however, the resilient material used for the element **3** can be relatively flexible. For instance, the lining **55** can be made of 4 mm thick mild steel for teeth having a pitch of 30 mm, with rubber having a Shore hardness of 60.

FIG. **11** shows the same rack adapted for improved operation without lubrication; to this end, the rack is coated with a substance **56** which has a low coefficient of friction in the presence of the teeth of the associated pinion **2.** If the pinion is made of steel, the metal lining **55** can be treated with, for example, molybdenum disulfide or given the "sulfinuz" process or covered by a polyethylene film.

If the pinion is made of light metal it is advisable for its surface to be hardened, for example, by chromium plating. In this case it has been found that a low-friction layer **56** can, with advantage, be a 0.2 mm thick film of the substance called "Kletene" which is adhesively secured to the lining **55** with the interposition of a 0.4 mm thick intermediate layer of rubber.

A rack according to the invention can be embodied by consecutive sections of reduced elementary length, for example, by 40-tooth sections. Joints between consecutive sections can be either at the corrugation roots, as at a place **57** in FIG. **10,** or at the corrugation crests as at a place **58** in FIG. **11.** It will be appreciated that the rack teeth or corrugations do not contact the pinion teeth at the places **57, 58.**

The abutting ends of the lining sections **55** are secured to one another, preferably by welding, to which end the resilient element **3** and the antifriction layer **56** are interrupted for some distance on either side of the joins to enable the weld to be made.

I claim:

1. A rack-and-pinion system including a rack and a toothed pinion in mutual meshing engagement, said rack comprising:

a rigid longitudinal base having a proximal face with respect to the pinion; and

a resilient longitudinal element having:

a distal face with respect to the pinion, which distal face rests upon and is fixed to said proximal face of the said rigid longitudinal base, and

a proximal face with respect to the pinion, which proximal face is shaped into corrugations adapted to engage the teeth of the pinion.

2. System as claimed in claim **1,** wherein said proximal face of the rigid longitudinal base, and said distal face of the resilient longitudinal element which rests thereupon, are also both shaped into corrugations having the same pitch as and coextensive with the said corrugations of said proximal face of the resilient longitudinal element.

3. System as claimed in claim **2,** wherein said rigid longitudinal base comprises a strip of corrugated sheet-metal having a proximal face with respect to the pinion, whereupon the said resilient longitudinal element rests, and a distal face with respect to the pinion.

4. System as claimed in claim **3,** wherein said distal face of the strip of corrugated sheet-metal bounds a space, said system further comprising vibration-damping material filling said space.

5. System as claimed in claim **2,** wherein the thickness of the said resilient longitudinal element, measured between the two corrugated faces of said element, is variable along a corrugation.

6. System as claimed in claim **5,** wherein the thickness of the said resilient element is at a minimum in the region where the pitch circle of the pinion meets the rack, and increases from said region towards both the crest and the root of the said corrugation.

7. System as claimed in claim **1,** wherein said proximal face of the rigid longitudinal base, and said distal face of the resilient longitudinal element which rests thereupon, are both substantially planar.

8. System as claimed in claim **1,** further comprising a lining which coats the said corrugated proximal face of the resilient longitudinal element, via which lining said corrugated face engages the teeth of the pinion.

9. System as claimed in claim **8,** wherein said lining is made of hardened rubber-based material.

10. System as claimed in claim **8,** wherein said lining comprises a strip of corrugated sheet-metal.

11. System as claimed in claim **10,** wherein said strip of sheet-metal is of substantially uniform thickness.

12. System as claimed in claim **10,** wherein said rigid longitudinal base comprises a substantially planar strip of sheet-metal which together with said strip of corrugated sheet-metal defines a space, which space is filled with said resilient longitudinal element.

13. System as claimed in claim **1,** wherein the rack is coated with a substance which has a low coefficient of friction with respect to the teeth of the pinion.

14. System as claimed in claim **1,** wherein the rack has a number of sections placed end-to-end, and wherein two consecutive sections of said rack are interconnected in the root region of a corrugation.

15. System as claimed in claim **1,** wherein the rack has a number of sections placed end-to-end, and wherein two consecutive sections of said rack are interconnected in the crest region of a corrugation.

16. System as claimed in claim **1,** wherein said resilient longitudinal element is made of rubber-based material.

17. System as claimed in claim **1,** wherein said resilient longitudinal element is made of resilient silicone-based material.

18. A rack-and-pinion system for use as a means for driving a machine along a track, said system comprises a toothed pinion carried by the machine and a rack disposed along the track, said pinion and rack being in mutual meshing engagement, said rack comprising:

a rigid longitudinal base having a proximal face with respect to the pinion; and

a resilient longitudinal element having:

a distal face with respect to the pinion, which distal face rests upon and is fixed to said proximal face of the said rigid longitudinal base, and

a proximal face with respect to the pinion, which proximal face is shaped into corrugations adapted to engage the teeth of the pinion.

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