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(54) Rail grinding apparatus and method

(57) A rail grinding apparatus has a first power driven grinding section (20) and a second section (22) which rolls along the rail. Rotation of the wheel(s) of the second section (22) is caused by driving the apparatus along the rail, and the energy from this rotation at least partially drives the first section (20). The second section can also carry out a non-powered grinding operation as well as providing power for the first section.

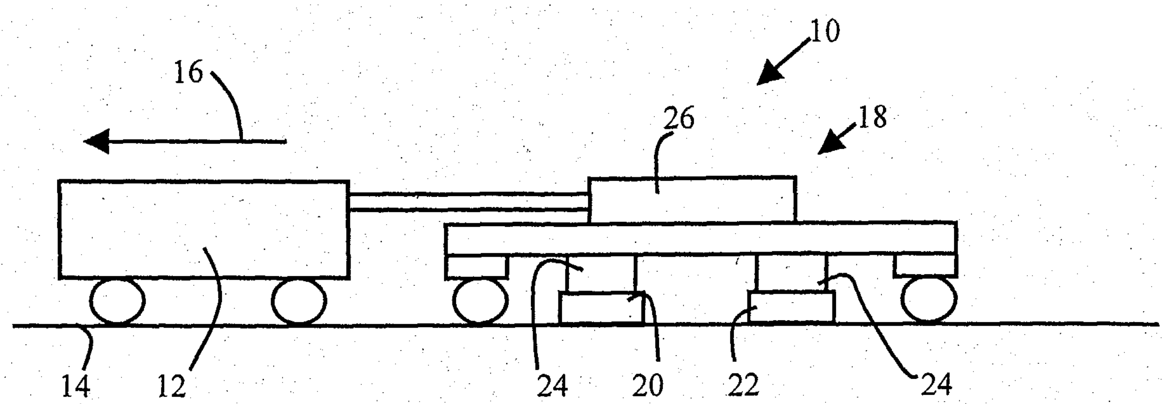

FIG. 1

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Description

[0001] This invention relates to rail grinding apparatus. The invention can be applied to train or tram rails or indeed other long metal sections which carry traffic flow.

[0002] It is well known that the surface on which rail wheels run must be relatively smooth and free of significant defects to avoid impact damage to the rail and to prevent defect growth, as well as for ride comfort.

[0003] Typically, a rail grinding apparatus uses carborundum or diamond grinding wheels on a powered or towed vehicle running on the rails. One known technique involves applying downward pressure to driven rotating grinding wheels in order to increase the friction between the grinding wheel and the rail. The depth of cut is then a function of the imposed pressure, the speed of passing of the vehicle along the rail and the fixed rotational speed of the grinding wheels.

[0004] US 5 580 299 discloses a grinding apparatus in which the grinding wheels are allowed to rotate freely as the apparatus is towed or driven along the rail. An angle of attack of the grinding wheels (the grinding wheels rotating about an axis which is not perpendicular to the rail length) causes them to drag against the rail with consequent light removal of metal from the surface. A downward pressure can be applied to the grinding wheels, although the weight alone may be sufficient. In this method, the depth of cut is a function of the speed of the vehicle for any given angle of the grinding wheels.

[0005] The prior art thus provides non-powered systems which can be used for light removal of metal, and powered systems for deeper metal removal.

[0006] According to the invention, there is provided a rail grinding apparatus for movement along a rail to be machined, comprising

a first section having at least one first grinding wheel which is driven to maintain a linear surface velocity relative to the rail, and

a second section having at least one second wheel, wherein rotation of the second wheel is entrained by movement of the apparatus along the rail, and the energy from which rotation at least partially drives the first section.

[0007] In this arrangement, the first section can be controlled such that there is slippage between the first grinding wheel and the rail. This slippage produces a grinding effect. The drive of the first section may be to retard the rotation of the first grinding wheel with respect to a purely rolling motion (up to and including contra-rotation), or it may be to advance the rotation of the first grinding wheel with respect to purely rolling motion. In this description and claims, "linear surface velocity relative to the rail" is intended to signify linear velocity of the surface of the wheel in question relative to the surface of the rail at the point where the wheel is in contact with the rail.

[0008] The axis of the first grinding wheel may be perpendicular to the rail length, or it may be at an angle to the perpendicular. The first section is driven, and the energy for this is at least partially provided by the second section. The second wheel rotates due to rolling as the apparatus is moved along the rail. This rolling is caused by friction between the surface of the second wheel and the surface of the rail.

[0009] The second wheel may be a grinding wheel, in which case the second section can perform a fine grinding operation, again as a result of slippage. The slippage in the second section is caused by resistance to rotation of the second grinding wheel. This resistance to rotation occurs because energy is transferred from the second section to the first section.

[0010] A control system is preferably provided for maintaining the slippage in the second section (i.e. the linear surface velocity) at a desired level or range of levels, to give rise to a desired amount of fine grinding in the second section.

[0011] Energy may be transferred from the second section to drive the first section by a mechanical coupling such as an arrangement of belts or chains.

[0012] The mechanical coupling preferably causes a deferential velocity between the surface of the first grinding wheel and the surface of the second wheel where they are in contact with the rail. This is achieved by gearing the mechanical coupling and selecting first grinding wheels and second wheels of appropriate diameter.

[0013] It may also be preferable to have the first grinding wheel and second wheel rotating in different directions.

[0014] Where a mechanical coupling is used to transfer energy from the second section to the first section, a system may be provided for varying the pressure between the surface of the first grinding wheel and the surface of the rail.

[0015] Energy may be transferred from the second section to drive the first section by an energy conversion system. This energy conversion system may comprise an electrical generator, for converting rotational energy of the wheel or wheels of the second section into electrical energy, and the first section is then power driven by an electric motor, at least part of the drive current being supplied by the generator. The generator/motor arrangement may be either alternating current or direct current.

[0016] Alternatively, the energy conversion system may comprise a hydraulic system, and the first section is then hydraulically driven.

[0017] The first section may be positioned forward, with respect to the direction of travel of the apparatus along the rail, of the second grinding section. Thus in this arrangement, the first section carries out relatively deep initial grinding and the second section carries out relatively shallow final grinding.

[0018] The apparatus is preferably driven by a locomotive which can also provide some additional energy for the drive of the first grinding wheel from a primary or auxiliary power source.

[0019] The invention also provides a method of machining the top surface of a rail, comprising driving a rail grinding apparatus along the rail, during which

a first driven section provides first controllable grinding, and

a second, non-driven, grinding section provides second grinding, wherein the second non-driven section is also used at least partially to drive the first section.

[0020] Providing second grinding preferably comprises allowing at least one second grinding wheel to be rotationally driven over the surface of the rail, and wherein the rotation of the second grinding wheel is controlled to maintain a desired linear surface velocity of the second grinding wheel relative to the rail. This control is achieved by controlling the degree of resistance to rotation, such that the second wheel drags.

[0021] According to a second aspect of the invention, there is provided a rail grinding apparatus for movement along a rail to be machined, comprising:

at least one first grinding wheel, and
at least one second grinding wheel, wherein the first and second wheels are coupled together such that there is a fixed relation between the rotational speeds of the first and second wheels, such as to provide different linear velocities of the surfaces of the wheels in contact with the rail.

[0022] This coupling provides energy transfer between the grinding wheels. The actual rotational speed of the two wheels can be variable (not independently or independently in a predetermined manner), for example depending not only on the speed with which the apparatus is driven along the rail, but also the pressure applied to one or more of the grinding wheels.

[0023] According to a second aspect of the invention, there is provided a rail grinding apparatus for movement along a rail to be machined, comprising at least one grinding wheel, and an electromagnetic arrangement for location in the vicinity of the rail to provide a variable downward force on the grinding wheel.

[0024] Examples of the invention will now be described with reference to the accompanying drawings, in which:

Figure 1 shows schematically a grinding apparatus of the invention;
Figure 2 shows the positioning of one grinding wheel for explanation purposes;
Figure 3 shows how different angles of attack of the grinding wheels may be employed;
Figure 4 shows how the grinding wheels of each section may be arranged in one embodiment of the invention with a mechanical coupling;
Figure 5 shows how the grinding wheels of each section may be arranged in another embodiment of the invention with a mechanical coupling; and
Figure 6 shows another embodiment of the invention which uses electromagnetic forces.

[0025] Figure 1 shows a rail grinding (typically electrical or hydraulic power conversion) apparatus 10 of the invention, comprising a locomotive 12 which is driven along a pair of rails 14 in the direction shown by arrow 16. The grinding equipment is provided as a towed trailer 18 which provides the rail grinding. The apparatus 10 is designed to be driven at a specific speed, for example 20 or 30m/s.

[0026] The trailer 18 has a first section 20 and a second section 22. Each section 20,22 has a line of grinding wheels, and the sections are each suspended from the trailer 18 by a suitable suspension arrangement 24.

[0027] The grinding wheels of the first section 20 are driven to provide controllable grinding (which may include additional energy from locomotive or auxiliary power motive). In particular, the grinding wheels are rotationally driven to maintain a slippage of the grinding wheels over the rail. In other words, there is a linear velocity difference between the surface of the grinding wheel in contact with the rail and the rail itself. The drive to the grinding wheels thus prevents the grinding wheels from simply rolling. The drive may act to retard the rotation of the grinding wheels, up to and including contra rotation, relative to pure rolling. Alternatively, the drive may advance the rotation of the grinding wheels relative to pure rolling.

[0028] The rotational speed of the grinding wheels in the first section is controlled to maintain the desired slippage. The locomotive speed is used as an input parameter for this purpose from which the required rotational speed of the grinding wheels can be determined.

[0029] The second section 22 may also have a line of grinding wheels, but these are not powered. Forward motion induces the grinding wheels in the second section to rotate due to the friction. Energy from these grinding wheels at least partially drives the first section 20. Energy can be transferred from the second section to the first section by a direct mechanical coupling, or through an energy conversion system.

[0030] This mechanical coupling or energy conversion system provides some resistance to the rotation of the grinding wheels in the second section 22, and as a result, there will also be some slippage of grinding wheels in the second section with respect to the rail. Again, this slippage provides a grinding operation, this may be a relatively fine grinding operation, as the grinding is passive rather than driven.

[0031] Alternatively, the second section 22 may have a line of non-grinding wheels (the surface of which has enhanced frictional qualities). In this case, the resistance to rotation of the non-grinding wheels in the second section results in the transfer of energy to drive the first section which may not be sufficient to cause slippage.

[0032] The slippage in the second section 22 can be maintained at a desired level or range of levels, to give rise to a desired amount of grinding in the second section 22. If the locomotive is driven at a constant speed, then this fixed slippage will give rise to a fixed speed of the grinding wheels in the second section, which in turn will correspond to a fixed energy transfer to the first section. The number of grinding wheels in the second section, as well as the design of the mechanical coupling or energy conversion system will thus take into account the desired operating speed so that an appropriate grinding operation is achieved as well as the required amount of energy transfer to drive the first grinding section 20. In this way, the apparatus can be designed so that it does not need external power.

[0033] A control system 26 is provided for the feedback control of the two sections. As mentioned above, the control of the first section is to drive the grinding wheels in such a way as to provide the required retardation or advance, and this can be varied to provide different grinding depth. The control of the second section is to vary the resistance to rotation of the second grinding wheels, so that there is the correct slippage for grinding and energy transfer.

[0034] As the system is designed for operation at a particular speed, the amount of feedback control required in the second section is not great.

[0035] The system may be implemented using electrical motors and generators. Thus, the grinding wheels in the second section may be coupled to the rotor (armature or magnet ring) of an ac or dc generator. The resistance of the generator to rotation of the armature can be controlled by varying the magnetic field excitation current, thus control of the excitation current (which may also be self-induced) is used to control the slippage in the second section. The grinding wheels in the first section are then driven by an electric motor, at least part of the drive current being supplied by the generator, under the control of the control unit 26.

[0036] Figure 2 shows schematically the coupling of a grinding wheel 30 to a motor (for the first section 20) or generator (for the second section) 32. As shown, the grinding wheel may not be cylindrical, but may have a bowed grinding surface. It is also shown as rotating about a non-horizontal axis 34, so that grinding is directed to one side of the rail. Different grinding wheels may have different orientations within each section 20,22.

[0037] Instead of the electrical system described above, the apparatus may be implemented hydraulically. In this case, the grinding wheels of the second section drive a hydraulic pump arrangement. This energy is then stored or distributed by a pressurised vessel, which in turn is used to drive a hydraulic motor arrangement for the first section 20.

[0038] Although the system can be powered from the rolling of the wheels alone, the locomotive 12 can also provides some power for the drive of the first section 20, particularly where power surges are needed for localised heavy grinding.

[0039] The system may monitor the rail condition immediately ahead of the grinding sections, in order to determine the level of grinding required by the first section 20, so that the constant locomotive drive speed can be maintained despite different grinding requirements.

[0040] As shown in Figure 3, the grinding wheels in each section may be rotated about an axis perpendicular to the rail (wheels 30a), or at an angle to the perpendicular (wheels 30b). The orientation of the wheels 30b provides some drag to increase the grinding effect. The wheels may also be under their own weight, or an additional pressure may be applied.

[0041] By way of example, each grinding section 20,22 may have a line of 24 grinding wheels.

[0042] The system may alternatively be implemented using a mechanical coupling with an arrangement of belts or chains, or any other mechanical elements capable of transferring energy. Thus, the grinding wheels in the second section can be coupled to the grinding wheels in the first section and rotational energy is transferred. The coupling itself causes resistance to rotation of the grinding wheels in the second section, and this resistance to rotation can be controlled by varying the pressure between the surface of the grinding wheels in the first section and the rail surface. The resistance to rotation of the grinding wheels in the second section gives rise to slippage and thus the required grinding. The mechanical coupling may comprise elements that can change the gearing between the grinding wheels in the second and first sections. The gearing arrangement and the relative diameters of grinding wheels are important parameters in the design of apparatus with a mechanical coupling.

[0043] Figure 4 shows how the grinding wheels may be arranged in each section in one embodiment of the invention using mechanical coupling. The grinding wheel of the first section 20 is positioned between two grinding wheels of the second section 22. In this configuration the apparatus can be moved along the rail 14 in either direction and either grinding wheel of the second section 22 can provide second grinding after the grinding wheel of the first section 20 has provided controlled first grinding. The suspension arrangement 24 consists of a rigid chassis 38 and a system 40 for varying the pressure between the surface of the grinding wheel of the first section 20 and the surface of the rail 14. The system 40 for varying pressure could be a pressure cell.

[0044] The embodiment shown in Figure 4 transfers energy from the second section to the first section via a mechanical coupling 36. In this case, the grinding wheel of the first section 20 rotates in the same direction as the grinding wheels of the second section 22, but at a greater angular velocity because of gearing. Since the diameter of all grinding wheels in both sections is constant in this example, the linear velocity of the surface of the grinding wheel will also be greater for the grinding wheel in the first section. The suspension arrangement 24 can be used to control energy transfer by controlling the system 40 which varies the pressure between the grinding wheel in the first section 20 and the rail 14. For example, during initial acceleration of the apparatus along the rail 14, energy transfer can be minimised by reducing the pressure. When the apparatus is moving along the rail 14 at a constant velocity, energy transfer can be increased to drive the grinding wheel in the first section 20 and cause resistance to rotation, and thus slippage and grinding, of the grinding wheels of the second section 22.

[0045] The embodiment shown in Figure 4 comprises a single grinding wheel in the first section 20 and two grinding wheels in the second section 22. However, any number of grinding wheels could be used in either section and in any position relative to the direction of movement of the apparatus along the rail 14. The second section may also comprise wheels that do not experience slippage and do not cause grinding, but provide the energy to drive the first section.

[0046] Figure 5 shows how the grinding wheels of each section may be arranged in another embodiment of the invention using a different mechanical coupling. In this case, there is again one grinding wheel in the first section 20 and two grinding wheels in the second section 22. However, the grinding wheel of the first section is positioned forwards of the two grinding wheels of the second section 22 with respect to the direction of travel of the apparatus shown by arrow 42 along the rail 14. For the second section 22 to provide fine grinding after the deep grinding of the first section 20, the apparatus must be moved along the rail 14 in the direction shown by the arrow 42.

[0047] In the embodiment shown in Figure 5, the grinding wheel of the first section 20 rotates in the opposite direction to the grinding wheels of the second section 22 due to the gearing arrangement 44. The gearing determines the relative rotational speeds of the wheels in the first and second sections. The pressure applied by the system 40 controls the equilibrium state. In particular, the greater the pressure applied to the grinding wheel 20, the more the second grinding wheels are retarded (because their resistance to rotate is increased). Thus, the system 40 can be used to provide the desired relative surface velocity and thus amount of fine grinding in the second section as well as the depth of grinding in the first section.

[0048] In the examples of Figures 4 and 5, the pressure applied to the first grinding wheel 20 is variable to change the grinding depth, and the pressure applied can be controlled with feedback to achieve the desired relative rotational slippage. One problem which can arise when applying a downward force to the grinding stone is that there is a progressive offloading of the wheels that support and guide the carriage in which the grinding wheels are mounted. This offloading is not desirable due to the risk of derailment.

[0049] Additional down force can be created without the disadvantages of reducing the stability of the carriage wheels by using electromagnetic forces, as shown in Figure 6, which shows a modification to the arrangement of Figure 4.

[0050] The powered grinding wheel 20 is suspended in a frame 50 which carries electromagnet coils 52 with a small air gap between the coils and the rail 14. By varying the coil currents, the downward force on the grinding wheel 20 can be controlled. This techniques can be used instead of, or in combination with, the pressuring varying device 40 shown in Figures 4 and 5.

[0051] The invention provides not only the combined coarse and fine grinding system shown in the drawings, but also relates to the powered retard or advance operation of the grinding wheels of the first section. This operation provides grinding by ensuring a desired slippage between the grinding wheel and the rail, for example by retarding the rotation of the grinding wheel with respect to the rotation of the wheel at which there is no slippage. Thus a grinding wheel is controllably driven to provide a desired linear surface velocity of the grinding wheel relative to the rail, and the desired linear surface velocity is selected in dependence on the desired depth of grinding.

[0052] A number of examples have been described, but it will be apparent to those skilled in the art that there are numerous other possible implementations of the invention.

Claims

1. A rail grinding apparatus for movement along a rail to be machined, comprising

   a first section having at least one first grinding wheel which is driven to maintain a linear surface velocity relative to the rail, and

   a second section having at least one second wheel, wherein rotation of the second wheel is entrained by movement of the apparatus along the rail, and the energy from which rotation at least partially drives the first section.

2. An apparatus as claimed in claim 1, wherein the second wheel is a second grinding wheel, and wherein resistance to rotation of the second grinding wheel gives rise to a linear surface velocity relative to the rail.

3. An apparatus as claimed in claim 2, further comprising a control system for maintaining the linear surface velocity of the second grinding wheel at desired levels or ranges of levels relative to the rail.

4. An apparatus as claimed in any preceding claim, wherein energy from the second wheel drives a mechanical system which drives the first grinding wheel.

5. An apparatus as claimed in claim 4, wherein the mechanical system drives the first grinding wheel so that the linear surface velocity of the first grinding wheel relative to the rail is different to the linear surface velocity of the second wheel relative to the rail.

6. An apparatus as claimed in claim 4, wherein the linear surface velocity of the first grinding wheel relative to the rail is in a different direction to the linear surface velocity of the second wheel relative to the rail.

7. An apparatus as claimed in any of claims 4 to 6, wherein the pressure between the surface of the first grinding wheel and the surface of the rail can be controlled at a desired level or range of levels.

8. An apparatus as claimed in any one of claims 1 to 3, wherein energy from the second wheel drives an energy conversion system which at least partially drives the first grinding wheel.

9. An apparatus as claimed in claim 8, wherein the energy conversion system comprises an electrical generator for converting kinetic energy of the second wheel into electrical energy.

10. An apparatus as claimed in claim 9, wherein the first grinding wheel is driven by an electric motor, at least part of the drive current being supplied by the electrical generator.

11. An apparatus as claimed in claims 9 or 10, wherein the electrical generator comprises a direct or alternating current device, and wherein the resistance of the electrical generator to rotation can be controlled by varying the magnetic field strength or frequency within the electrical generator.

12. An apparatus as claimed in claim 8, wherein the energy conversion system comprises a hydraulic system which at least partially drives the first grinding wheel.

13. An apparatus as claimed in any preceding claim, wherein the first section is positioned forward of the second section relative to the direction of travel of the apparatus along the rail.

14. An apparatus as claimed in any preceding claim, further comprising a locomotive for moving the apparatus along the rail.

15. An apparatus as claimed in claim 14, wherein the locomotive at least partially drives the first section.

16. An apparatus as claimed in any preceding claim, wherein the first and second sections each comprise a plurality of respective wheels.

17. An apparatus as claimed in any preceding claim, further comprising an electromagnet arrangement for location in the vicinity of the rail and for applying a downward force to a grinding wheel.

18. A rail grinding apparatus for movement along a rail to be machined, comprising:

at least one first grinding wheel, and
at least one second grinding wheel, wherein the first and second wheels are coupled together such that there is a fixed relation between the rotational speeds of the first and second wheels, such as to provide different linear velocities of the surfaces of the wheels in contact with the rail.

19. A rail grinding apparatus for movement along a rail to be machined, comprising at least one grinding wheel, and an electromagnetic arrangement for location in the vicinity of the rail to provide a variable downward force on the grinding wheel.

20. A method of machining the top surface of a rail, comprising moving a rail grinding apparatus along the rail, during which,
a first driven section provides first controllable grinding, and
a second, non-driven, section provides second grinding, wherein the second non-driven section is also used at least partially to drive the first section.

21. A method as claimed in claim 20, wherein providing second grinding comprises rolling at least one second grinding wheel over the surface of the rail, and wherein the rotation of the second grinding wheel is controlled to maintain a desired linear surface velocity of the second grinding wheel relative to the rail.

22. A method as claimed in claim 21, wherein the control of rotation of the second grinding wheel is achieved by controlling the resistance to rotation of the second grinding wheel.

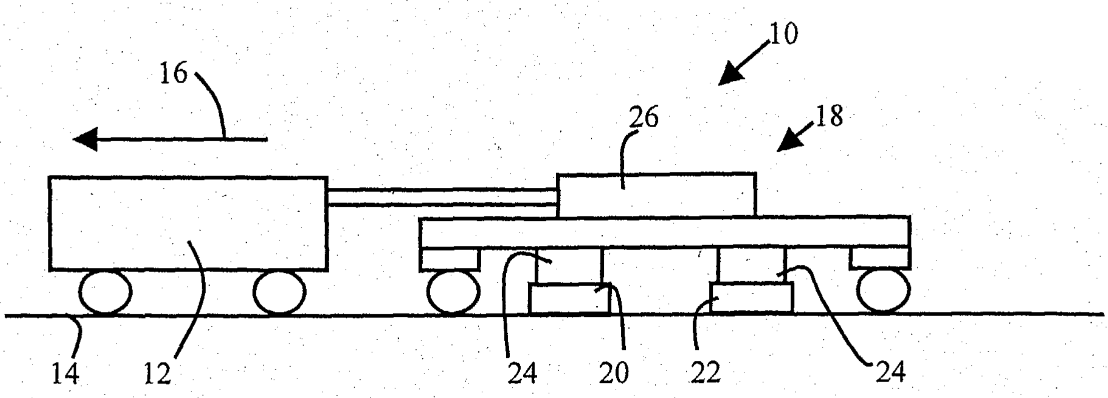

FIG. 1

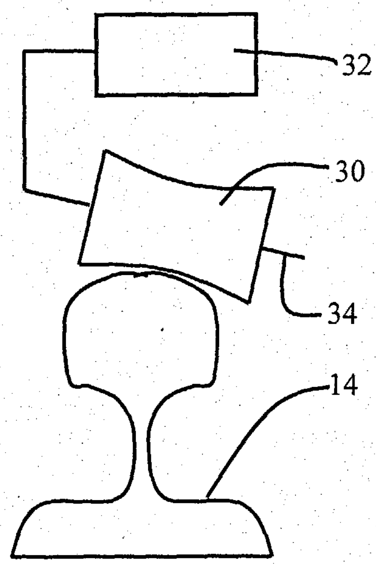

FIG. 2

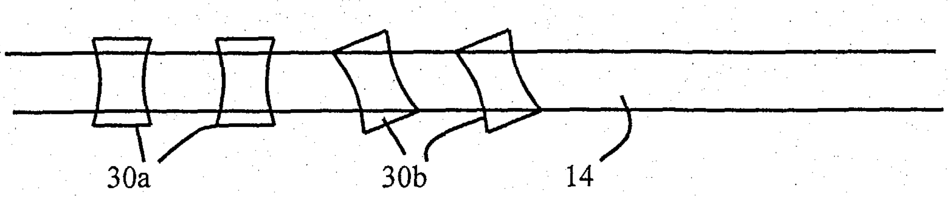

FIG. 3

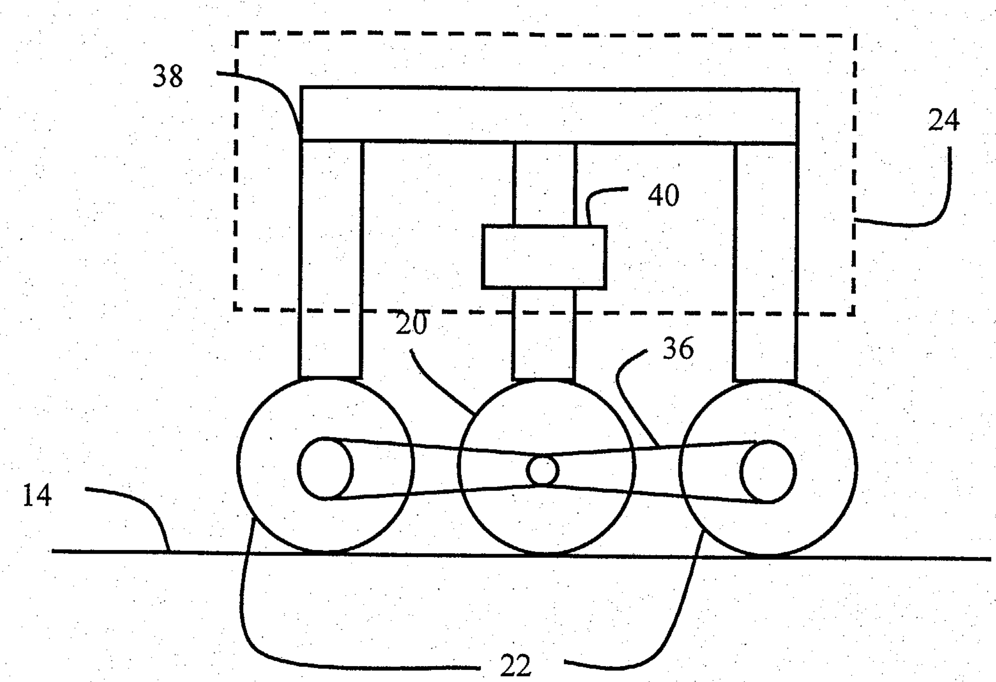

FIG. 4

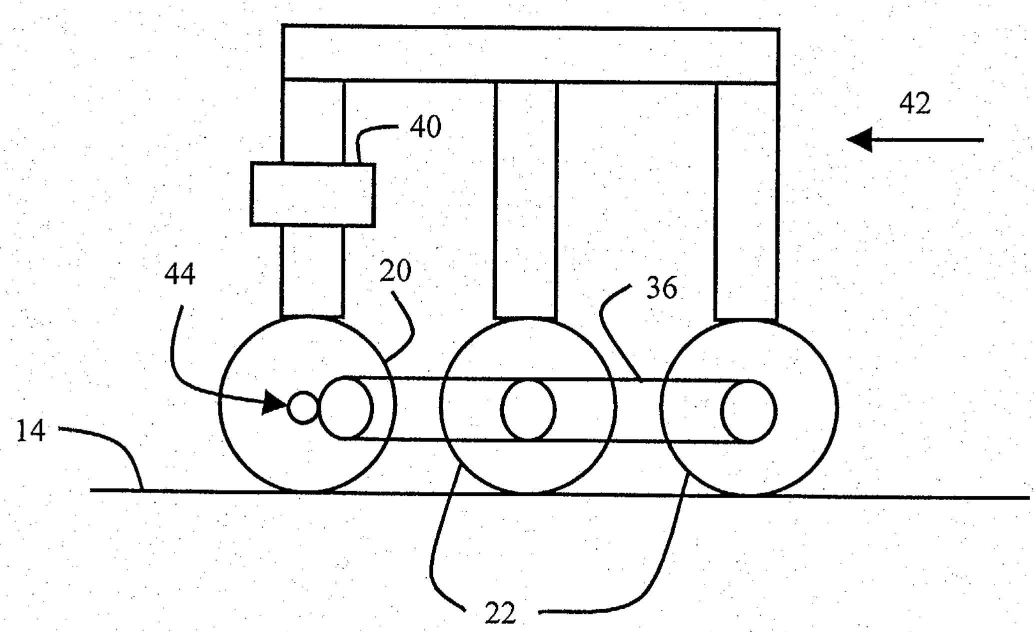

FIG. 5

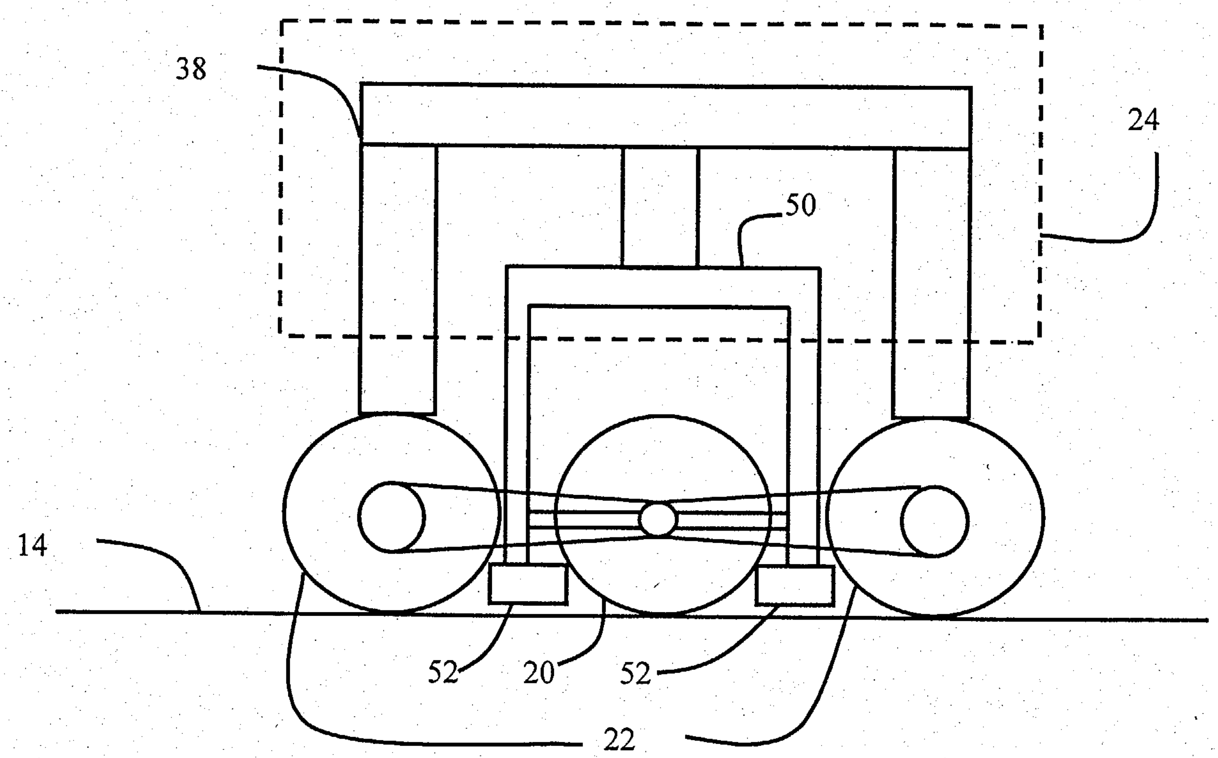

FIG. 6