



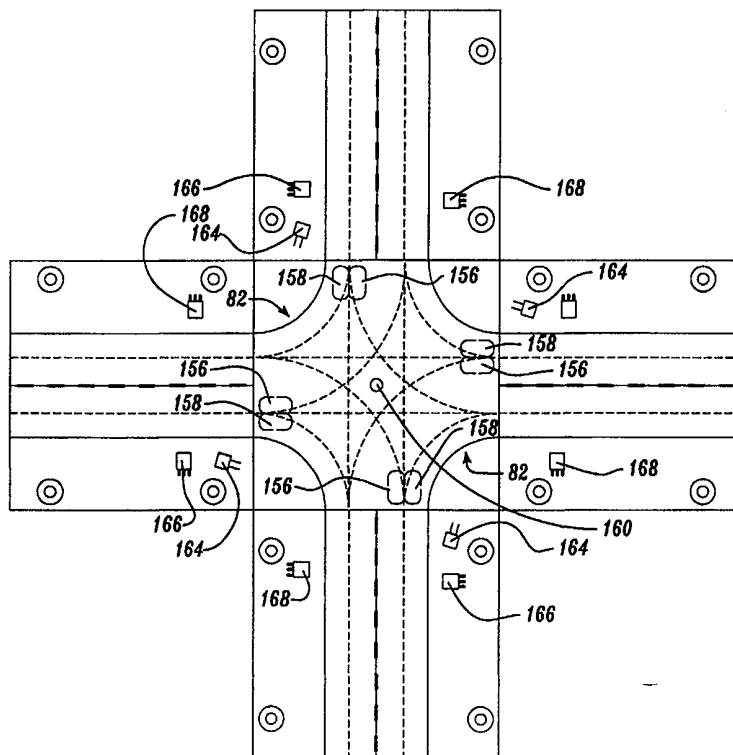
## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification</b> <sup>6</sup> : <b>A63H 33/26</b>	<b>A1</b>	<b>(11) International Publication Number:</b> <b>WO 99/17858</b>  <b>(43) International Publication Date:</b> 15 April 1999 (15.04.99)
<p><b>(21) International Application Number:</b> PCT/US98/18201</p> <p><b>(22) International Filing Date:</b> 1 September 1998 (01.09.98)</p> <p><b>(30) Priority Data:</b> 08/943,545                      3 October 1997 (03.10.97)                      US</p> <p><b>(71) Applicant:</b> PARVIA CORPORATION [US/US]; 800 5th Avenue #101-160, Seattle, WA 98104 (US).</p> <p><b>(72) Inventors:</b> CYRUS, Peter; 1075 Summit Avenue East, Seattle, WA 98102 (US). MAKSYMUK, Peter, M., IV; Apartment 15C, 80 First Avenue, New York, NY 10009 (US). FERNEKES, Leo, M.; Apartment 11, 632 East 11th Street, New York, NY 10009 (US). RUBLOWSKY, Stefan; 103 N. 8th Street, Brooklyn, NY 11211 (US). KOGAN, Eduard; Apartment 2G, 84-29 153rd Avenue, Howard Beach, NY 11414 (US). KOLB, Scott, J.; Apartment 1C, 235 2nd Avenue, New York, NY 10003 (US). MOORE, Eric, S.; Apartment #3, 18 Spring Street, New York, NY 10012 (US). YAVID, Dmitriy; 2nd floor, 1735 61st Street, Brooklyn, NY 11204 (US). COSENTINO, Christopher, S.; 1 Peru Street, Staten Island, NY 10314 (US).</p>		<p><b>(74) Agent:</b> WYLIE, Roger, D.; Christensen O'Connor Johnson &amp; Kindness PLLC, Suite 2800, 1420 Fifth Avenue, Seattle, WA 98101 (US).</p> <p><b>(81) Designated States:</b> CA, JP, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).</p> <p><b>Published</b> <i>With international search report.</i></p>

**(54) Title:** TOY VEHICULAR ELECTROMAGNETIC GUIDANCE APPARATUS

**(57) Abstract**

The present invention is a guidance apparatus for movable toy vehicles (12) that includes a track, or roadway (10), on which the toy vehicles move. The track has an intersection (82). The intersection has a magnetic guidance mechanism for steering the toy vehicles in alternate directions through the intersection. An intersection magnetic sensing mechanism, i.e., electromagnets (150) at the intersection and magnets in the vehicles, stops the vehicles prior to entering the intersection. Additionally, the vehicles stopped at the intersection can be actuated by a timing mechanism after passage of a predetermined time period. Furthermore, the vehicles stopped at the intersection can be actuated only after a mechanism for sensing vehicle presence in the intersection senses no vehicles in the intersection.



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## TOY VEHICULAR ELECTROMAGNETIC GUIDANCE APPARATUS

### Field of the Invention

The invention relates to the guidance of toy vehicles and, more particularly, electromagnetic guidance thereof on a predefined track.

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### Background of the Invention

U.S. Patent No. 1,084,370 discloses an educational apparatus having a transparent sheet of glass laid over a map or other illustration sheet that is employed as a surface on which small moveable figures are guided by the movement of a magnet situated below the illustration sheet. Each figure, with its appropriate index word, figure or image is intended to arrive at an appropriate destination on the top of the sheet and to be left there temporarily.

10

U.S. Patent No. 2,036,076 discloses a toy or game in which a miniature setting includes inanimate objects placeable in a multitude of orientations on a game board and also includes animate objects having magnets on their bottom portions. A magnet under the game board is employed to invisibly cause the movement of any of the selected animate objects relative to the inanimate objects.

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U.S. Patent No. 2,637,140 teaches a toy vehicular system in which magnetic vehicles travel over a toy landscape as they follow the movement of ferromagnetic pellets through an endless nonmagnetic tube containing a viscous liquid such as carbon tetrachloride. The magnetic attraction between the vehicles and ferromagnetic pellets carried by the circulating liquid is sufficient to pull the vehicles along the path defined by the tube or channel beneath the playing surface.

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U.S. Patent No. 3,045,393 teaches a device with magnetically moved pieces. Game pieces are magnetically moved on a board by reciprocation under the board of

a control slide carrying magnetic areas or elements longitudinally spaced apart in the general direction of the motion path. The surface pieces advance step-by-step in one direction as a result of the back and forth reciprocation of the underlying control slide.

5 U.S. Patent No. 4,990,117 discloses a magnetic force-guided traveling toy wherein a toy vehicle travels on the surface of a board, following a path of magnetically attracted material. The toy vehicle has a single drive wheel located centrally on the bottom of the vehicle's body. The center of the gravity of the vehicle resides substantially over the single drive wheel so that the vehicle is balanced. A  
10 magnet located on the front of the vehicle is attracted to the magnetic path on the travel board. The magnetic attraction directly steers the vehicle around the central drive wheel along the path.

#### Summary of the Invention

The present invention is a guidance apparatus for movable toy vehicles that  
15 includes a track, or roadway, on which the toy vehicles move. The track has one, and preferably more than one, intersection. The intersection has a magnetic guidance mechanism for steering the toy vehicles in alternate directions through the intersection. An intersection magnetic sensing mechanism, electromagnets at the  
20 intersection and magnets in the vehicles, stops the vehicles prior to entering the intersection. Additionally, the vehicles stopped at the intersection can be actuated by a timing mechanism after passage of a predetermined time period. Furthermore, the vehicles stopped at the intersection can be actuated only after a mechanism for sensing vehicle presence in the intersection senses no vehicles in the intersection. Preferably, the guidance mechanism for steering toy vehicles through an intersection  
25 includes an electromagnet under each roadway of the intersection. Each electromagnet has a pair of poles that straddle the path of the toy vehicle. The toy vehicle has a magnet on its undersurface. Each of the electromagnets under the roadways is actuatable for current to flow in each of two directions through the electromagnet for each of the two poles of the electromagnet to be either a positive or  
30 a negative pole. The two poles of each electromagnet can thus either attract or repel the pole of the magnet on the underside of the vehicle, depending on the direction of current flow through the electromagnet. Since the two poles of the electromagnet straddle the path of the toy vehicle, when energized, one pole will attract and the other pole will repel the vehicle magnet to guide the vehicle in a first direction (i.e.,  
35 right). Reversing the current through the electromagnet reverses the polarity of the

two poles, thus guiding the vehicle in the opposite direction. No current flow through the electromagnet results in no magnetic interaction with the vehicle, and the vehicle proceeds straight.

5 Preferably, a surface roadway is located over the track or roadway described above. Additionally, a surface toy vehicle is movable on the surface roadway in reaction to movement under this surface toy vehicle of the toy vehicle (i.e., powered subsurface vehicle) on the track or roadway under the surface roadway. Each powered subsurface vehicle has a motor therein and a collision avoidance mechanism. The collision avoidance mechanism includes a magnet on the rear of  
10 each of the subsurface vehicles and a magnetic field sensor on the front of each of the subsurface vehicles. The magnetic field sensor is adapted to de-energize the power source of the associated subsurface vehicle when the magnetic field sensor senses the magnetic field of the magnet of another subsurface vehicle located ahead of the subsurface vehicle. In this manner, following subsurface vehicles stop prior to  
15 impact with leading subsurface vehicles. A similar type of Hall effect system, with a magnet on the vehicles and a sensor adjacent the intersection can determine when a vehicle is approaching the intersection. A vehicle approaching an intersection can be stopped by one of the electromagnets adjacent each roadway that function to electromagnetically block intersection access on command.

20 Preferably, guidance of the toy vehicles through the intersection can be accomplished with a remote control that provides vehicle guidance instructions to the electromagnetic guidance mechanism of the intersection. Alternatively, the electromagnetic guidance mechanism of the intersection can be preprogrammed to guide the toy vehicles through the intersection on, for example, a random basis.

25 Brief Description of the Drawings

The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated as the same becomes better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

30 FIGURE 1 is an isometric view of a toy building set including the upper roadway and lower roadway of the present invention;

FIGURE 2 is a diagrammatic section view of the upper roadway, lower roadway, surface vehicle and powered subsurface vehicle of the present invention;

35 FIGURE 3 is a partially exposed isometric view of the powered subsurface vehicle of the present invention;

FIGURE 4 is a diagrammatic section view of attractive forces between two magnets showing no offset;

FIGURE 5 is a diagrammatic section view of attractive forces between two magnets showing horizontal offset;

5        FIGURE 6 is a diagrammatic plan view of the magnetic interaction between the surface vehicle and the subsurface vehicle of the present invention during straight movement;

FIGURE 7 is a diagrammatic plan view of the magnetic interaction between the surface vehicle and the subsurface vehicle of the present invention during a turn;

10       FIGURE 8 is an electrical schematic of the control circuit of the subsurface vehicle of the present invention;

FIGURE 9 is a plan view of a leading subsurface vehicle and a following subsurface vehicle showing collision avoidance thereof;

15       FIGURE 10 is a transverse section view of the upper roadway, lower roadway, two surface vehicles and two powered subsurface vehicles of the present invention;

FIGURE 11 is a diagrammatic side section view of the upper roadway, lower roadway, surface vehicle and powered subsurface vehicle of the present invention;

20       FIGURE 12 is a plan view of the lower roadway of the present invention with electromagnetic direction controllers;

FIGURE 13A is a detail view of the electromagnetic direction controllers of FIGURE 12;

FIGURE 13B is a partially exposed isometric view of the electromagnetic direction controllers of FIGURE 12;

25       FIGURE 14 is a detail plan view of FIGURE 12 showing the electromagnetic direction controllers of the present invention;

FIGURE 15 is a diagrammatic section view of the interaction between the guidance control elements located adjacent an intersection and on the subsurface vehicle of the present invention; and

30       FIGURE 16 is an electrical schematic of the guidance control electronics of the intersection of FIGURE 12 of the present invention.

#### Detailed Description of the Preferred Embodiment

The present invention is a toy vehicular electromagnetic guidance apparatus as shown and described in FIGURES 1-16. As best shown in FIGURE 1, the toy  
35       vehicular guidance apparatus of the present invention can be used in a toy building

set 2 having a lattice 4 and modular bases 6. More specifically, lattice 4 provides the substructure of toy building set 2 and supports modular bases 6 which are spaced above lattice 4 by a predetermined distance. Lower roadway 8 is also supported by lattice 4, but on a lower portion of lattice 4 at a predetermined distance below modular bases 6. Upper roadway 10 is comprised of some of modular bases 6 that have been specialized in design to provide a smooth traffic bearing surface for movement of surface vehicles 12 thereon. Most preferably, the road pattern of upper roadway 10 and lower roadway 8 are identical so that subsurface vehicles 14, as shown in FIGURES 2 and 3, can travel on lower roadway 8 to guide surface vehicles 12 on upper roadway 10 in a manner further described below. Preferably, the distance between lower roadway 8 secured to lattice 4 and upper roadway 10, also secured to lattice 4, is large enough to allow ingress and travel of subsurface vehicle 14 between lower roadway 8 and upper roadway 10.

Next referring to FIGURE 2, the magnetic interconnection between surface vehicle 12 and subsurface vehicle 14 is shown whereby subsurface vehicle 14 travels between lower roadway 8 and upper roadway 10 such that surface vehicle 12 can be transported on upper roadway 10 by subsurface vehicle 14. As shown in FIGURE 2, power supply 16 interconnects a lower conductive layer 18 and upper conductive layer 20. Lower conductive layer 18 is located on the upper side of lower roadway 8. Upper conductive layer 20 is located on the under side of upper roadway 10. Power supply 16 thus energizes lower conductive layer 18 and upper conductive layer 20. Subsurface vehicle 14 accesses the electrical power in lower conductive layer 18 and upper conductive layer 20 in a manner described below to travel on lower roadway 8. Power supply 16 can be either direct current or alternating current, of preferably a shock safe voltage level, for example, about 12 volts. Lower conductive layer 18 and upper conductive layer 20 consist of thin metal sheets, foil layers or a conductive coating that may be, for example, polymeric. The conductive sheet, coating, or composite most preferably includes copper as the conductive metal.

Still referring to FIGURE 2, subsurface vehicle 14 has a chassis 21 with an upper brush 22 located on the top of chassis 21 adjacent the under side of upper roadway 10 on which upper conductive layer 20 is located. Chassis 21 also has a lower brush 24 located on the under side thereof adjacent the upper surface of lower roadway 8 on which lower conductive layer 18 is located. Upper brush 22 and lower brush 24, which can be metal, graphite or conductive plastic, provide electrical interconnection between chassis 21 of subsurface vehicle 14 and upper conductive

layer 20 and lower conductive layer 18, respectively for transfer of electrical power from power supply 16 to subsurface vehicle 14. Upper brush 22 and lower brush 24 are preferably elastic or spring loaded in order to accommodate changes in the distance between upper conductive layer 20 and lower conductive layer 18 to ensure a reliable electrical connection to subsurface vehicle 14. Upper brush 22 and lower brush 24 each have a head 25 that is contoured, or in another way shaped, for low friction sliding along upper conductive layer 20 and lower conductive layer 18, respectively, when subsurface vehicle 14 is in motion. Lower conductive layer 18 and upper conductive layer 20 can be located on substantially the entire upper surface of lower roadway 8 and under side of upper roadway 10, respectively, in order to ensure electrical interconnection of subsurface vehicle 14 to power supply 16 despite lateral movement across lower conductive layer 18 and upper conductive layer 20 by subsurface vehicle 14 due to, for example, turning of subsurface vehicle 14 or uncontrolled lateral movement thereof. Alternatively, lower conductive layer 18 and upper conductive layer 20 can be located in troughs or grooves in the upper surface of lower roadway 8 and the under side of upper roadway 10, respectively, into which head 25 of lower brush 24 and head 25 of upper brush 22, respectively, can reside in order to control the tracking of subsurface vehicle 14 in an electrically conductive environment by minimizing lateral movement of subsurface vehicle 14 relative to lower roadway 8 and upper roadway 10. Upper brush 22 and lower brush 24 are both electrically connected to control circuit 26 that is located on the front of chassis 21 of subsurface vehicle 14. Generally, control circuit 26 controls the electrical functioning of subsurface vehicle 14, and more specifically controls, and is electrically interconnected with, electromotor 28. Control circuit 26 thus controls the direction of movement, acceleration, deceleration, stopping, and turning of subsurface vehicle 14 based on external control signals, or control signals generated by subsurface vehicle 14 itself. Control circuit 26 is described in further detail below in conjunction with FIGURE 8. Electromotor 28, electrically interconnected with control circuit 26, can be a direct current motor with brushes, a direct current brushless motor, or a stepper motor. Electromotor 28 is mechanically interconnected with transmission 30 that transfers rotation of electromotor 28 to drive wheel 32 employing the desired reduction ratio. More than one electromotor 28 can be employed for independent drive of a plurality of drive wheels 32. Additionally, transmission 30 can be a differential transmission to drive two or more drive wheels 32 at different speeds. In this manner, more sophisticated control of the

acceleration, deceleration, and turning, for example, of subsurface vehicle 14 can be employed. Chassis support 34 is located on the under side of chassis 21 of subsurface vehicle 14. Chassis support 34 is spaced from drive wheel 32, also located on the under side of subsurface vehicle 14, and can be, for example, rollers or  
5 low friction drag plates that are preferably flexible to allow compensation for distance variation between lower roadway 8 and upper roadway 10. Magnets 36 are preferably disposed on the top of subsurface vehicle 14 adjacent the under side of upper roadway 10. Magnets 36 are preferably permanent magnets, but can also be electromagnets supplied with power from power supply 16 via control circuit 26.

10 Still referring to FIGURE 2, surface vehicle 12, while preferably being a car, truck, or other vehicle, can be any type of device for which mobility is desired in the environment of a toy building set. Surface vehicle 12 includes wheels 38 which are rotatable to allow movement of surface vehicle 12 on upper roadway 10. Instead of wheels 38, a low friction drag plate can be employed. Magnets 40 are located on the  
15 under side of vehicle 12 adjacent upper roadway 10. Magnets 40 are sized and spaced on vehicle 12 to be aligned with magnets 36 on the top of chassis 21 of subsurface vehicle 14 for magnetic interconnection of surface vehicle 12 and subsurface vehicle 14. Magnets 36 are 0.1 x 0.125 inch round permanent rare earth  
20 magnets with residual flux around 9,000 Gauss. Preferably, the same type of magnets are employed for magnets 40 of surface vehicle 12. Reliable magnetic coupling has been observed at a distance of up to 0.2 inches between magnets 40 of surface vehicle 12 and magnets 36 of subsurface vehicle 14.

Next referring to FIGURE 3, a preferred embodiment of subsurface vehicle 14 is shown. Subsurface vehicle 14 of FIGURE 3 is designed to move  
25 between an ABS lower roadway 8 with a lower conductive layer 18 and an ABS upper roadway 10 with an upper conductive layer 20. Subsurface vehicle 14 of FIGURE 3 has one drive wheel 32 and two chassis supports 34 having low friction pads 35. Two upper brushes 22 and two lower brushes 24 are preferably present and are made from copper. Upper brushes 22 and lower brushes 24 are loaded by torsion  
30 springs. The above configuration assures a substantially uniform force on drive wheel 32 regardless of the clearance between lower roadway 8 and upper roadway 10, and also facilitates passage of subsurface vehicle 14 along inclines or declines of lower roadway 8 and upper roadway 10. Two rear magnets 62 are located on chassis 21 for collision avoidance with another subsurface vehicle 14 as described  
35 further below. Electromotor 28 is preferably a direct current brush motor, for

example, Namiki model No. 10CL-1202, rated for 0.22 W maximum output at approximately 17,000 RPM at 4.5 volts of direct current power supply. Transmission 30 consists of a Namiki 100A gear train blocked with motor 28 along with a crown gear and associated pinions. The total reduction ratio of transmission 30 is 1:40, and the efficiency is about 25 percent. Subsurface vehicle 14 operates at speeds of up to 9 inches per second at an incline of up to 15°. Lower magnet 64, on the underside of chassis 21, guides subsurface vehicle 14, and associated surface vehicle 12, on lower roadway 8, and causes subsurface vehicle 14, and associated vehicle 12, to turn based on magnetic interaction with electromagnetic direction controllers adjacent lower roadway 8 described in further detail below. Lower magnet 64 is preferably conic shaped with a protruding tip and is most preferably a 0.5 x 0.2 inch permanent rare earth magnet with a residual flux of about 9,000 Gauss. The protruding tip 65 of lower magnet 64 is preferably steel for more precise guidance on lower roadway 8. A pair of Hall effect sensors 67 straddle control circuit 26 on the front of chassis 21 for control of surface vehicle 14 in a manner further described below.

Next referring to FIGURES 4-7, the principles of the magnetic forces interconnecting surface vehicle 12 and subsurface vehicle 14 by magnets 36 and magnets 40 are described. As shown in FIGURE 4, when two magnets are placed one above the other, with opposite poles toward each other, a magnetic force  $F_z$  between them exhibits based on the following equation:

$$F_z \approx 6 \frac{M_1 \cdot M_2}{r^4}$$

where  $r$  is the distance between parallel planes in which magnets are situated and

$M_1$ ,  $M_2$  are magnetic moments of both magnets. For permanent magnets,  $M$  is proportional to the volume of magnetic substance cross its residual flux density. For electromagnets,  $M$  is proportional to the number of turns cross the current.

As shown in FIGURE 5, when two magnets, one above the other, are shifted slightly to be horizontally offset by a distance  $b$ , the horizontal force  $F_x$  occurs:

$$F_x \approx 6b \frac{M_1 \cdot M_2}{r^5}$$

Next referring to FIGURES 6 and 7, the principles described above and shown in FIGURES 4 and 5 are discussed in relation to movement of nonpowered surface vehicle 12 by powered subsurface vehicle 14 due to the magnetic

interconnection between magnets 40 of surface vehicle 12 and magnets 36 of subsurface vehicle 14. First referring to FIGURE 6, during straight line movement, the horizontal offset  $b$  between surface vehicle 12 and subsurface vehicle 14 increases as subsurface vehicle 14 moves until forces  $F_1$  and  $F_2$  become large enough to overcome friction, inertia and, possibly, gravitational incline. At this point, surface vehicle 12 moves to follow subsurface vehicle 14. During a turn, as shown in FIGURE 7, forces  $F_1$  and  $F_2$  have different directional vectors. Thus, forces  $F_1$  and  $F_2$  not only create thrust, but torque as well, that causes surface vehicle 12 to follow subsurface vehicle 14.

Now referring to FIGURE 8, control circuit 26 is described in further detail. Control circuit 26 is electrically connected to both upper brushes 22 and lower brushes 24. Control circuit 26 includes an FET 40 (for example, model No. ZVN4206A manufactured by Zetex) that is normally open because of 10k Ohm pull-up resistor 42. However, FET 40 deactivates electromotor 28 if a magnetic control or collision signal is detected by a Hall effect sensor 46 (element 67 of FIGURE 3) as further described below. Zener diode 48 (for example, model no. 1N5242 manufactured by Liteon Power Semiconductor) prevents overvoltage of the gate of FET 40. Diode 50 (for example, model no. 1N4448 manufactured by National Semiconductor), as well as an RC-chain consisting of 100 Ohm resistor 52 and 0.1mcF capacitor 54, protect control circuit 26 from inductive spikes from electromotor 28. Diode 56 (for example, model no. 1N4004 manufactured by Motorola) protects control circuit 26 from reverse polarity of power supply 16. As shown in FIGURE 9, Hall effect sensor 46 (element 67 of FIGURE 9) of control circuit 26 is employed to prevent a rear end collision between a leading and a following subsurface vehicle 14. Control circuit 26 is preferably located on the front of following subsurface vehicle 14 so that Hall effect sensor 67 will be in close proximity to the magnetic field of rear magnet 62 of leading subsurface vehicle 14. When the following subsurface vehicle 14 closes to a predetermined distance, the magnetic field of rear magnet 62 of leading subsurface vehicle 14 is sensed by Hall effect sensor 67. Hall effect sensor 67 causes FET 40 to deactivate electromotor 28, thus stopping the following subsurface vehicle 14. When the leading subsurface vehicle 14 moves away from the following subsurface vehicle 14, the increased distance therebetween removes the magnetic field of rear magnet 62 of leading subsurface vehicle 14 from proximity to Hall effect sensor 67 of following

subsurface vehicle 14. FET 40 thus activates electromotor 28 for movement of following subsurface vehicle 14.

Next referring to FIGURES 10 and 11, further structural detail of one embodiment of lower roadway 8 and upper roadway 10, between which subsurface vehicle 14 travels, is shown. Lower vertical supports 66 are aligned in two spaced apart sets to support horizontal plate 68, which is preferably comprised of aluminum or other metal alloy. Horizontal plate 68 is the foundation for lower roadway 8, which is preferably comprised of ABS. As stated above, lower conductive layer 18, comprised of nickel or other conductive material, is located on lower roadway 8. Lower brushes 24 are in electrical communication with lower conductive layer 18. Thus, longitudinal steel strip 69 passes through horizontal plate 68 and is nested in lower roadway 8 at a sufficient depth such that lower magnet 64, and specifically steel tip 65 thereof, is attracted to steel strip 69 for guidance of subsurface vehicle 14. Upper vertical supports 74 are preferably spaced apart in two sets. On the upper ends of upper vertical supports 74 is upper roadway 10, having upper conductive layer 20, preferably made of nickel or other conductive alloy, on its underside. Bolts 76 are employed to removably secure upper roadway 10 and upper conductive layer 20 to upper vertical supports 74. Upper vertical supports 74 preferably have a height precisely defined to allow electrical communication between lower brushes 24 of subsurface vehicle 14 and lower conductive layer 18, as well as between upper brushes 22 of subsurface vehicle 14 and upper conductive layer 20.

Referring to FIGURES 12, 13A, 13B and 14, intersection 82 and the electromagnetic direction control components thereof are shown in detail. As best shown in FIGURES 13A and 13B, an electromagnet 150 is located under each lower roadway 8 where the lower roadway 8 joins with intersection 82. Each electromagnet 150 is comprised of a U-shaped core 152 with a two section coil 154 thereon. U-shaped core 152 is preferably comprised of low carbon steel and coil 154 is preferably comprised of about 4,000 turns of #40 copper wire. Each electromagnet 150 is connected to an electric power source known in the art such that current in two alternating directions can selectively be passed through coil 154. In this manner, poles 156 and 158 of U-shaped core 152, which straddle steel strip 69, can be configured with either pole 156 being positive and pole 158 being negative, or pole 156 being negative and pole 158 being positive. Poles 156 and 158 can thus either attract or repel the pole of lower magnet 64 of subsurface vehicle 14 adjacent steel strip 69, depending upon the direction of current flow through

electromagnet 150 that has been selected. With current flowing through electromagnet 150 in a first direction, pole 156 will thus attract lower magnet 64 of subsurface vehicle 14 and pole 158 will repel lower magnet 64 to guide subsurface vehicle 14 in a first direction, i.e., right. Reversing the direction of the current through electromagnet 150 will cause pole 156 to repel lower magnet 64 and pole 158 to attract lower magnet 64 to guide subsurface vehicle 14 in a second direction, i.e., left. No current flow through electromagnet 150 results in no magnetic interaction of poles 156 and 158 with lower magnet 64, and subsurface vehicle 14 proceeds straight.

10 As shown in FIGURE 14, in addition to electromagnet 150 and associated poles 156 and 158, each intersection 82 includes a laser detector 160 that is actuatable by a remote control unit. When actuated, laser detector 160 causes infrared sensor 162 (shown in FIGURE 12) of this specific intersection 82 to receive infrared control commands from a remote control unit to selectively control the  
15 electromagnets 150 as well as stop coils 164 of the specific intersection 82. Stop coils 164 are electromagnets located on each lower roadway 8 adjacent intersection 82 that, when energized, actuate Hall effect sensors 67 to deactivate motor 28 of subsurface vehicle 14, thus stopping subsurface vehicle 14 prior to entering intersection 82 in order to control multiple vehicle traffic. Hall effect  
20 sensors 166, located on each lower roadway 8 adjacent intersection 82, detect when a subsurface vehicle 14 is approaching intersection 82. Hall effect sensors 168, also located on each lower roadway 8 adjacent intersection 82, detect when a subsurface vehicle 14 has left intersection 82. The data from laser detector 160, infrared sensor 162, Hall effect sensors 166 and Hall effect sensors 168 are fed to  
25 microprocessor U1 of FIGURE 16 to control intersection traffic, as described below.

Referring to FIGURE 15, the orientation of stop coil 164, Hall effect sensor 166 and Hall effect sensor 168 proximate to Hall effect sensor 67 and lower magnet 64 of subsurface vehicle 14 is shown. Hall effect sensor 166 adjacent  
30 intersection 82 senses lower magnet 64 of approaching subsurface vehicle 14. This data is processed by microprocessor U1 of FIGURE 16, below, to activate stop coil 164. Stop coil 164 triggers Hall effect sensor 67 of subsurface vehicle 14 to deactivate motor 28, thus stopping subsurface vehicle before it enters intersection 82. Hall effect sensor 168 detects lower magnet 64 of a subsurface vehicle 14 as it leaves intersection 82 and relays this data to microprocessor U1. The above interaction  
35 between stop coils 164, Hall effect sensor 166, Hall effect sensor 67, lower

magnet 64 and microprocessor U1 ensures that after one subsurface vehicle 14 has entered intersection 82, all other subsurface vehicles 14 are detained until that subsurface vehicle 14 has left intersection 82.

The above electromagnetic direction controllers of the present invention can be employed in a random mode whereby a Hall effect sensor 164 of a lower roadway 8 senses the approach of a subsurface vehicle 14, as described above. Microprocessor U1 then activates electromagnet 150 of the appropriate lower roadway 8 and randomly selects the current direction (or no current) so the subsurface vehicle 14 will randomly turn left, right or proceed straight through the intersection 82. When microprocessor first activates electromagnet 150, all stop coils 164 leading to intersection 82 are energized to block all traffic. After about 100 mseconds, the stop coil 164 of the lower roadway 8 on which the subsurface vehicle 14 to be controlled is located is deactivated by microprocessor U1 so that the subsurface vehicle 14 can enter intersection 82 to be guided by electromagnet 150. If more than one subsurface vehicle 14 is present at the intersection, microprocessor U1 commands them based on their order of arrival at intersection 82.

The above electromagnetic direction controllers of the present invention can be employed in a user control mode employing laser detector 160 and infrared sensor 162 of intersection 82, described above, to provide specific user command to allow a particular subsurface vehicle 14 to be guided in a specific direction through intersection 82. This user controlled mode operates substantially the same as the above random mode except that microprocessor U1 of FIGURE 16 does not randomly energize electromagnet 150 of the subject lower roadway 8. Instead, microprocessor U1 follows the infrared command signals it has received from infrared sensor 162 to energize electromagnet 150 in the manner directed by the user to accomplish the desired direction of movement of subsurface vehicle 14. As in the above random mode, all stop coils 164 are first energized, with one subsequently opened. Also, commands are followed by microprocessor U1 in the order received.

Next referring to FIGURE 16, the electrical circuitry of the electromagnetic guidance control of intersection 82 is described. All logic functions are performed by an eight-bit microcontroller U1 (for example, model No. PIC16C65, manufactured by Microchip). Microcontroller U1 is clocked by a 10MH quartz crystal X1, for example, model No. A143E manufactured by International Quartz Devices. Voltage monitor U7, for example, model No. 1381S manufactured by Panasonic, is responsible for the power-up reset and power supply fault protection.

When the logic supply voltage (plus 5V) drops below 4.2V, the voltage detector drives LOW the MCLR pin of microcontroller U1, thus shutting it down to prevent it from operation at reduced power supply voltage. When the logic supply voltage (plus 5V) is above 4.2V, the voltage detector drives HIGH the MCLR pin of microprocessor U1, thus resetting it and reinitializing the system. Two full bridge drivers U5, for example, model No. UDN2993, manufactured by Allegro, drive electromagnets L5, L6, L7 and L8 (element 150 of FIGURES 13A and 13B) of intersection 82. When pin ENA of driver U5 is HIGH, the state of pin PHA determines the direction of the current through the selected electromagnet L5-L8, and thus the turn direction of a subsurface vehicle 14. When pin ENA of the full bridge driver U5 is LOW, no current flows through the selected electromagnet L5-L8 and the subsurface vehicle 14 proceeds straight regardless of the state of pin PHA. Stop coils L1-L4 (element 164 of FIGURES 13A and 13B) are driven through Darlington array U4, for example, model No. ULN2003, manufactured by Motorola. Another channel of Darlington array U4 drives a buzzer or other sound device HN1, for example, model No. P9948 manufactured by Panasonic that provides user feedback for the hand-held remote control device. Hall effect sensors 166, described above, are designated H1-H4 and are, for example, model No. HAL506 manufactured by ITT Semiconductors. Hall effect sensors 166 sense when a subsurface vehicle enters intersection 82. Hall effect sensors 168 are designated H5-H8 in FIGURE 16, sense when a subsurface vehicle leaves intersection 82, and are preferably the same model as Hall effect sensors H1-H4. When activated by side magnet 64 of a subsurface vehicle 14, Hall effects sensors H1-H8 drive LOW inputs RB4-RB8 of microcontroller U1, thus denoting that a subsurface vehicle 14 has entered or left intersection 82. Since Hall effect sensors H1-H8 are open collector outputs, pull-up resistors R24-R27 are necessary to drive inputs of microprocessor U1 HIGH when no subsurface vehicle 14 is detected. Laser detector 160, described above, is denoted as LD1 and is connected directly to inputs of microprocessor U1 to provide input as to the desired electromagnetic configuration of intersection 82. The active level of laser detector LD1 is HIGH. Infrared sensor 162, denoted U6 in FIGURE 16, for example, model No. TFM5300 manufactured by Temic, selects the route of subsurface vehicle 14 via the interface of the remote control. The information pertaining to the desired direction of subsurface vehicle 14 from the remote control interface is transmitted serially to microprocessor U1 and is then decoded. The above circuit

requires three power supply voltages: +5V, +15V, and the voltage of the subsurface vehicle 14 that is adjustable between +3V and +6V.

While the preferred embodiment of the invention has been illustrated and described, it will be appreciated that various changes can be made therein without  
5 departing from the spirit and scope of the invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A guidance apparatus for movable toy vehicles comprising:  
a track on which the toy vehicles move, said track having an intersection, said intersection having magnetic means for guiding the toy vehicles in alternate directions through said intersection;  
means for stopping vehicles prior to entering said intersection; and  
means for actuating vehicles stopped at said intersection after said magnetic means for guiding the toy vehicles has been actuated.
2. The apparatus of Claim 1 further comprising:  
a motor in each of the moveable toy vehicles and means for collision avoidance on each of the toy vehicles, said means for collision avoidance including a magnet on each of the toy vehicles and a magnetic field sensor on each of the toy vehicles, said magnetic field sensor adapted to deenergize the motor of the associated toy vehicle when said magnetic field sensor senses the magnetic field of said magnet of another toy vehicle.
3. The apparatus of Claim 1 further comprising:  
a surface roadway over said track;  
a surface toy vehicle movable on said surface roadway in reaction to movement under said surface toy vehicle of the toy vehicle on said track under said surface roadway.
4. The apparatus of Claim 1 further comprising:  
means for remotely controlling said magnetic means for guiding the toy vehicles in alternate directions through said intersection.
5. The apparatus of Claim 1 wherein said magnetic means for guiding the toy vehicles in alternate directions through said intersection is preprogrammed to guide the toy vehicles based on predetermined variables.
6. The apparatus of Claim 1 further comprising:  
means for sensing a vehicle approaching said intersection.

7. The apparatus of Claim 6 wherein said means for sensing comprises a magnet on the vehicle and a magnetic field sensor adjacent said intersection.

8. A guidance apparatus for movable toy vehicles comprising:  
a track on which the toy vehicles move, said track having an intersection, said intersection having magnetic means for guiding the toy vehicles in alternate directions through said intersection;  
means for stopping vehicles prior to entering said intersection; and  
means for actuating vehicles stopped at said intersection after a predetermined time.

9. The apparatus of Claim 8 further comprising:  
a motor in each of the moveable toy vehicles and means for collision avoidance on each of the toy vehicles, said means for collision avoidance including a magnet on each of the toy vehicles and a magnetic field sensor on each of the toy vehicles, said magnetic field sensor adapted to deenergize the motor of the associated toy vehicle when said magnetic field sensor senses the magnetic field of said magnet of another toy vehicle.

10. The apparatus of Claim 8 further comprising:  
a surface roadway over said track;  
a surface toy vehicle movable on said surface roadway in reaction to movement under said surface toy vehicle of the toy vehicle on said track under said surface roadway.

11. The apparatus of Claim 8 further comprising:  
means for remotely controlling said magnetic means for guiding the toy vehicles in alternate directions through said intersection.

12. The apparatus of Claim 8 wherein said magnetic means for guiding the toy vehicles in alternate directions through said intersection is preprogrammed to guide the toy vehicles based on predetermined variables.

13. The apparatus of Claim 8 further comprising:  
means for sensing a vehicle approaching said intersection.

14. The apparatus of Claim 8 wherein said means for sensing comprises a magnet on the vehicle and a magnetic field sensor adjacent said intersection.

15. A guidance apparatus for movable toy vehicles comprising:  
a track on which the toy vehicles move, said track having an intersection, said intersection having magnetic means for guiding the toy vehicles in alternate directions through said intersection;

means for stopping vehicles prior to entering said intersection; and

means for sensing vehicle presence in said intersection; and

means for actuating vehicles stopped at said intersection after said means for sensing vehicle presence in said intersection senses no vehicles in said intersection.

16. The apparatus of Claim 15 further comprising:

a motor in each of the moveable toy vehicles and means for collision avoidance on each of the toy vehicles, said means for collision avoidance including a magnet on each of the toy vehicles and a magnetic field sensor on each of the toy vehicles, said magnetic field sensor adapted to deenergize the motor of the associated toy vehicle when said magnetic field sensor senses the magnetic field of said magnet of another toy vehicle.

17. The apparatus of Claim 15 further comprising:

a surface roadway over said track;

a surface toy vehicle movable on said surface roadway in reaction to movement under said surface toy vehicle of the toy vehicle on said track under said surface roadway.

18. The apparatus of Claim 15 further comprising:

means for remotely controlling said magnetic means for guiding the toy vehicles in alternate directions through said intersection.

19. The apparatus of Claim 15 wherein said means for guiding the toy vehicles in alternate directions through said intersection is preprogrammed to guide the toy vehicles based on predetermined variables.

20. The apparatus of Claim 15 further comprising:

means for sensing a vehicle approaching said intersection.

21. The apparatus of Claim 20 wherein said means for sensing comprises a magnet on the vehicle and a magnetic field sensor adjacent said intersection.

22. A guidance apparatus for movable toy vehicles each having a magnet therein, comprising:

a track on which the toy vehicles move, said track having an intersection and a vehicle path, said intersection having at least one magnet, said magnet having reversible poles straddling said vehicle path; and

means for reversing current through said poles to guide the toy vehicles due to magnetic interaction with the magnets of the toy vehicles.

23. The apparatus of Claim 22 further comprising:

a motor in each of the moveable toy vehicles and means for collision avoidance on each of the toy vehicles, said means for collision avoidance including a magnet on each of the toy vehicles and a magnetic field sensor on each of the toy vehicles, said magnetic field sensor adapted to deenergize the motor of the associated toy vehicle when said magnetic field sensor senses the magnetic field of said magnet of another toy vehicle.

24. The apparatus of Claim 22 further comprising:

a surface roadway over said track;

a surface toy vehicle movable on said surface roadway in reaction to movement under said surface toy vehicle of the toy vehicle on said track under said surface roadway.

25. The apparatus of Claim 22 further comprising:

means for remotely controlling said means for reversing current.

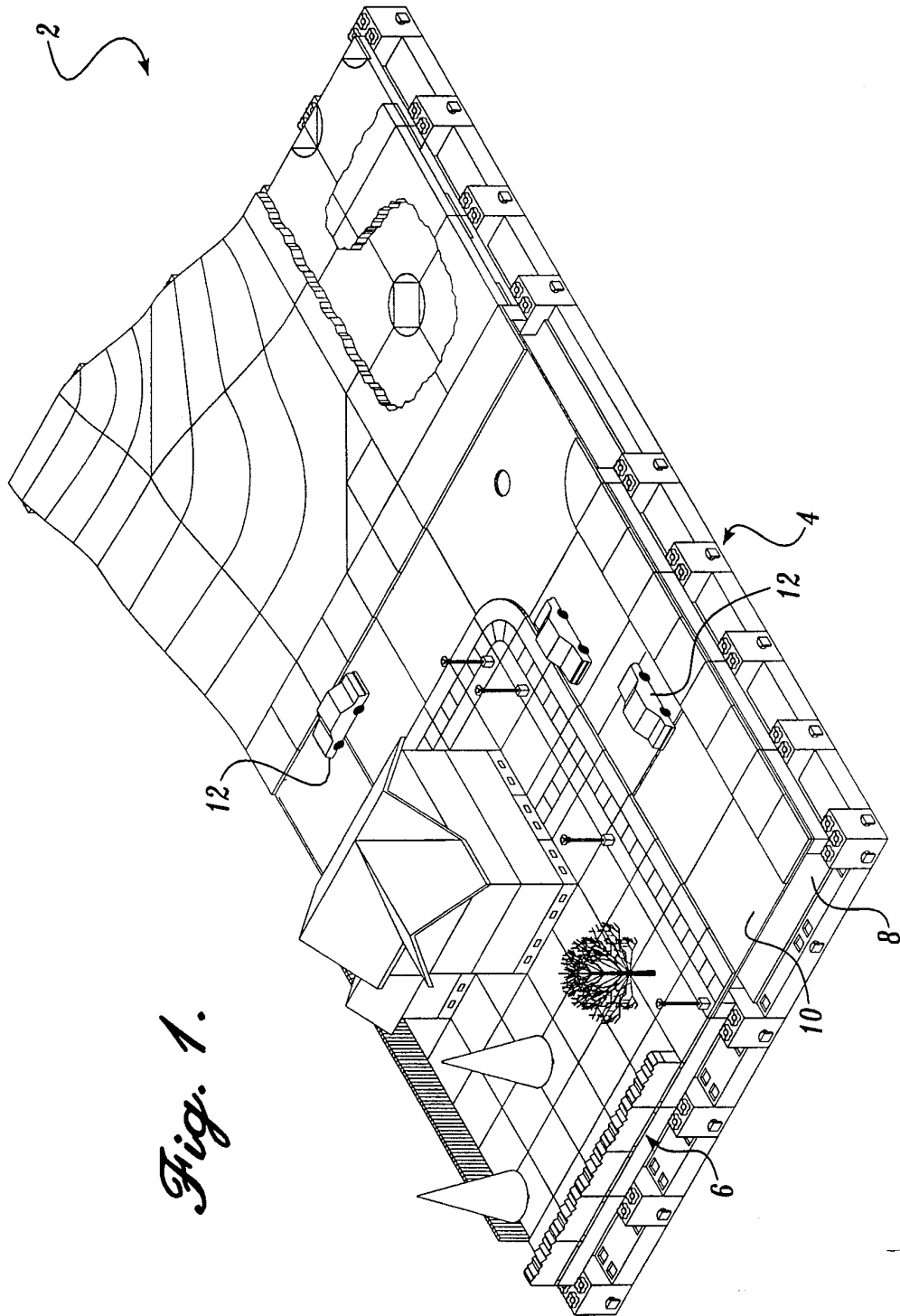
26. The apparatus of Claim 22 wherein said means for reversing current is preprogrammed based on predetermined variables.

27. The apparatus of Claim 22 further comprising:

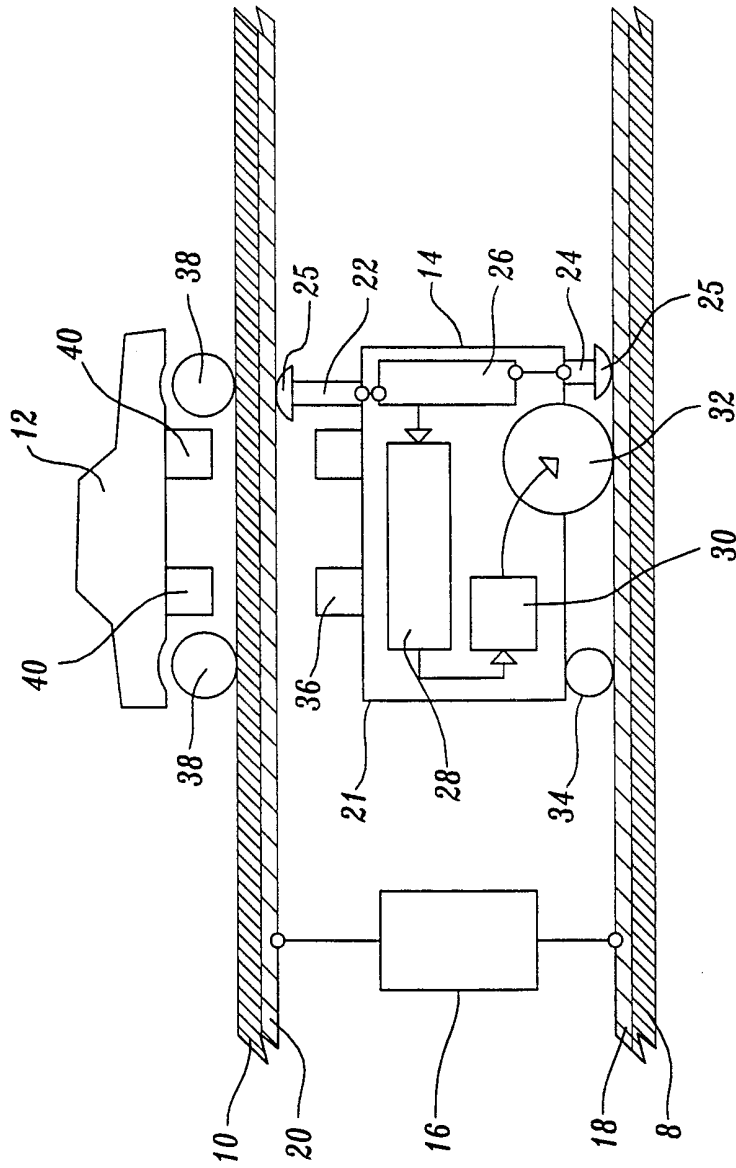
means for sensing a vehicle approaching said intersection.

28. The apparatus of Claim 29 further comprising:

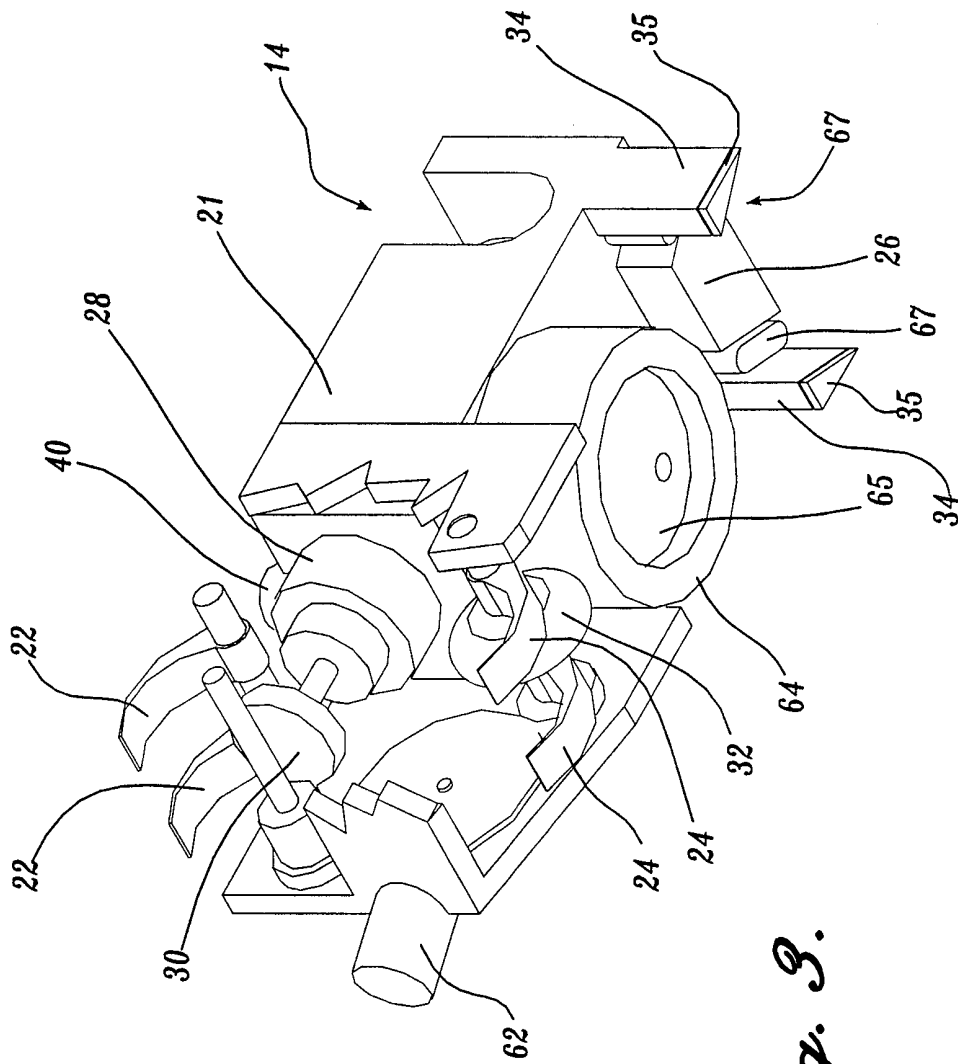
means for remotely controlling said means for reversing current.



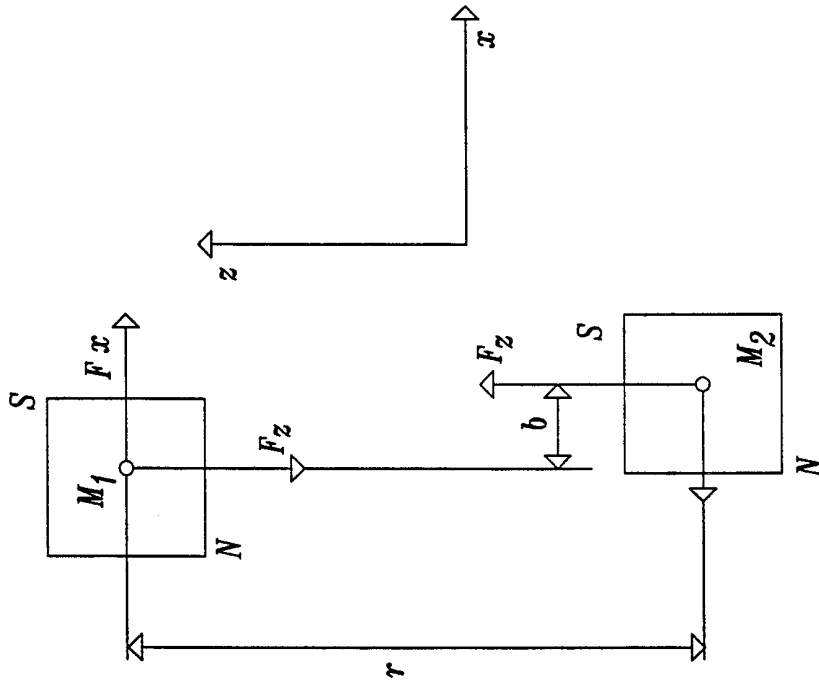
*Fig. 1.*



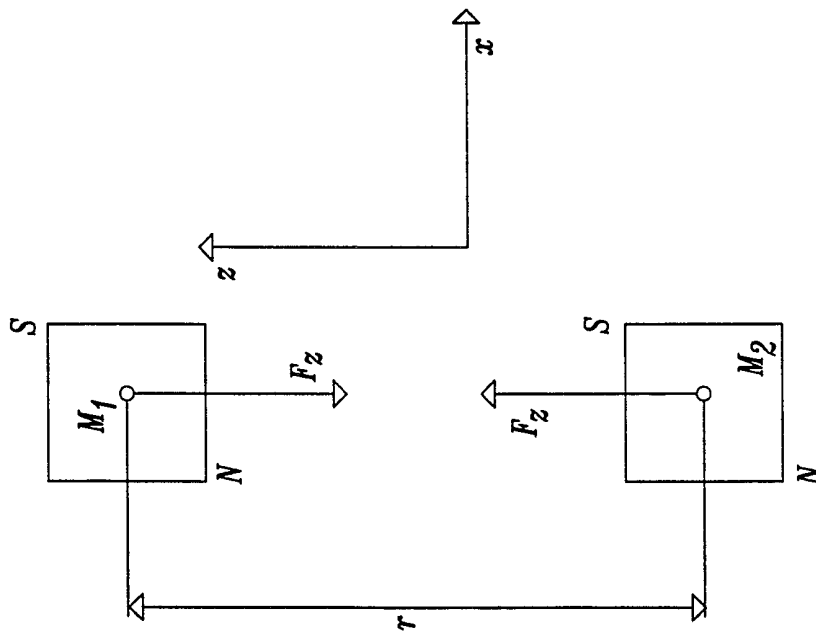
*Fig. 2.*



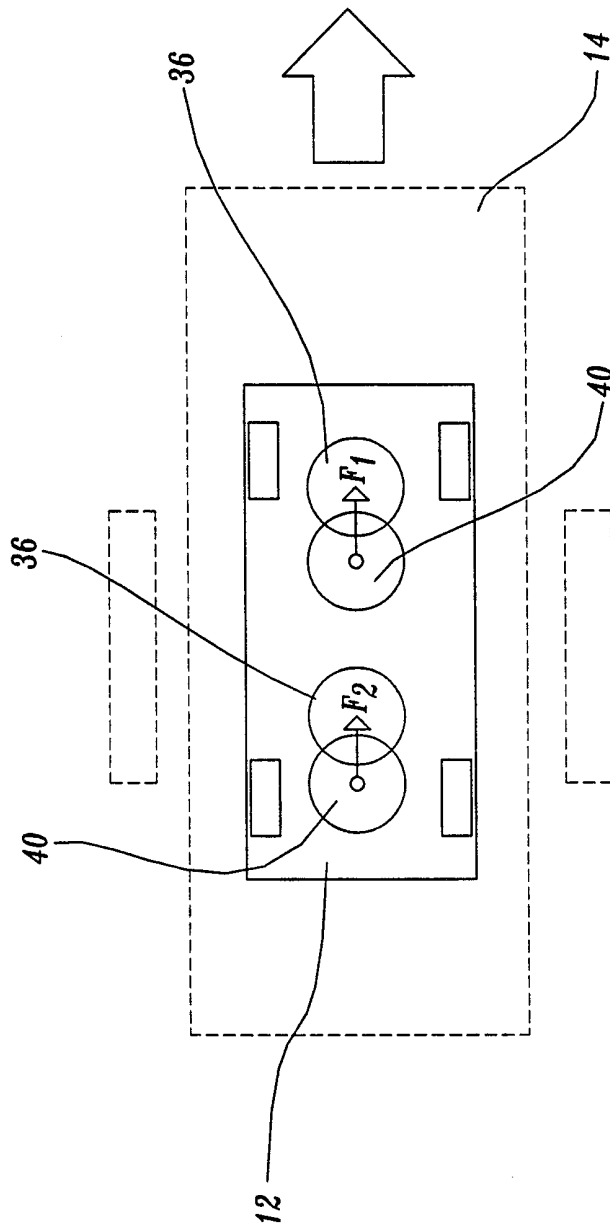
*Fig. 3.*



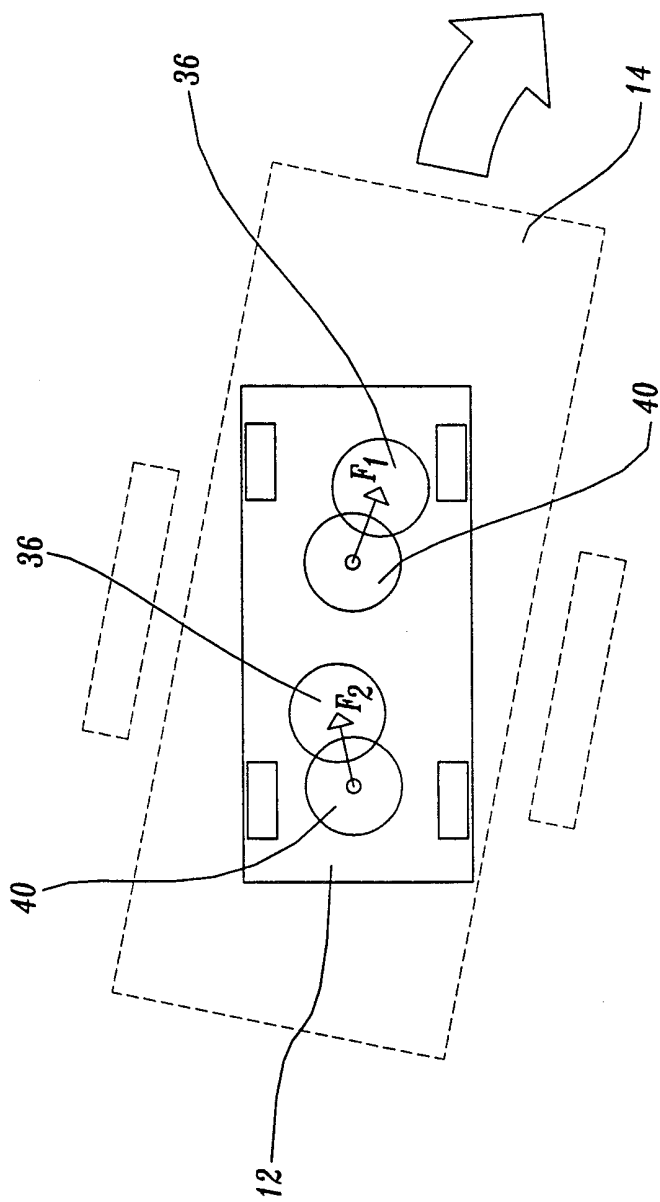
*Fig. 5.*



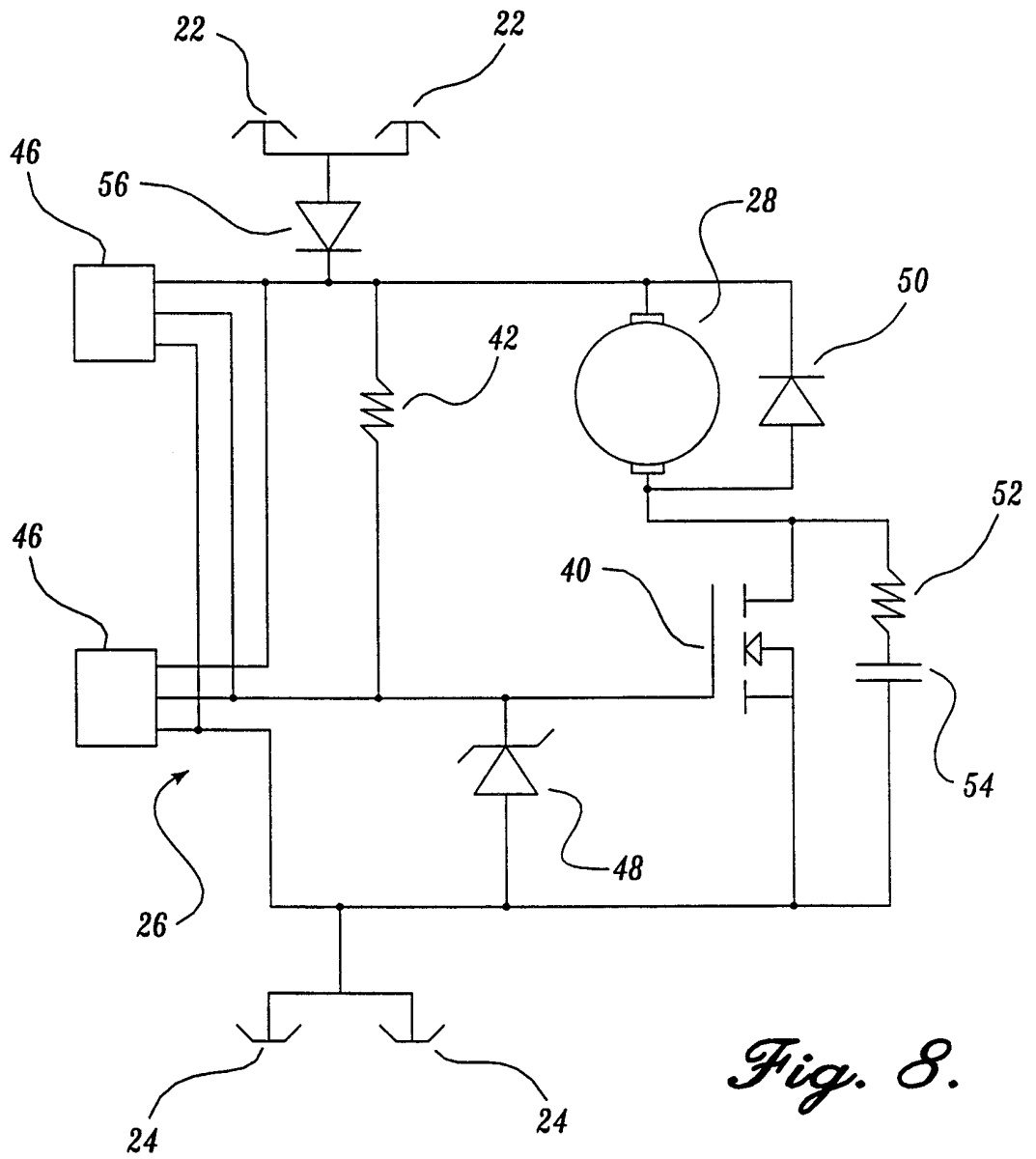
*Fig. 4.*



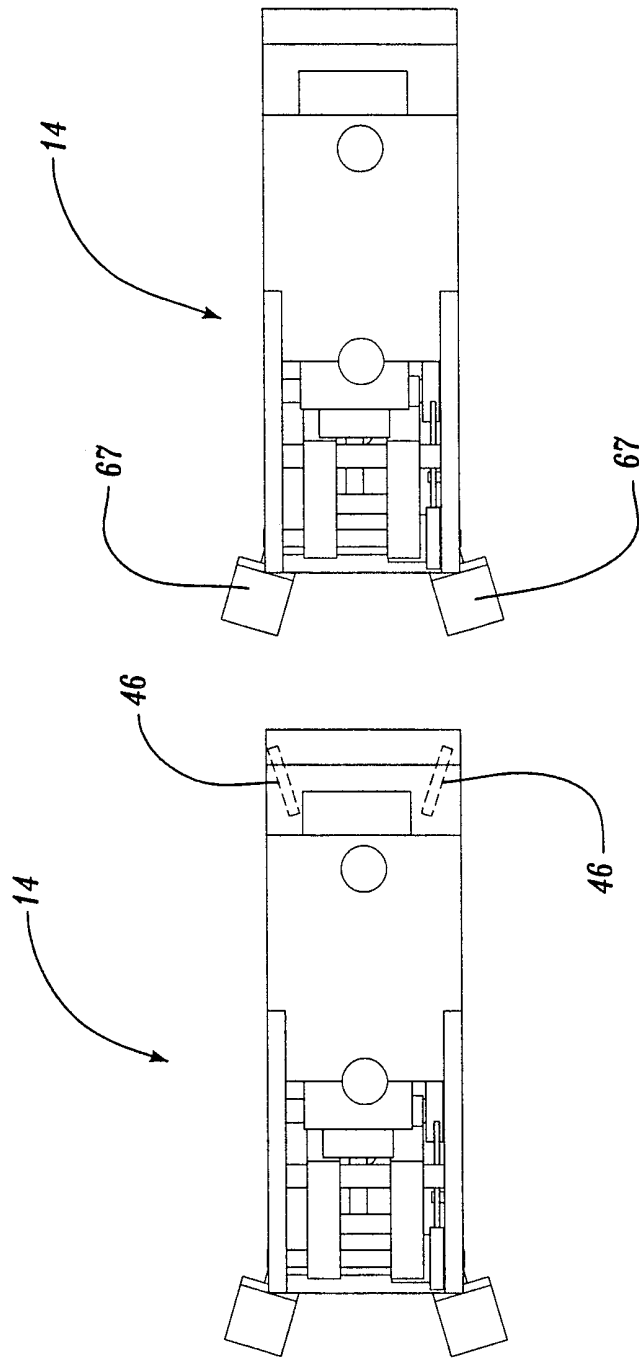
*Fig. 6.*



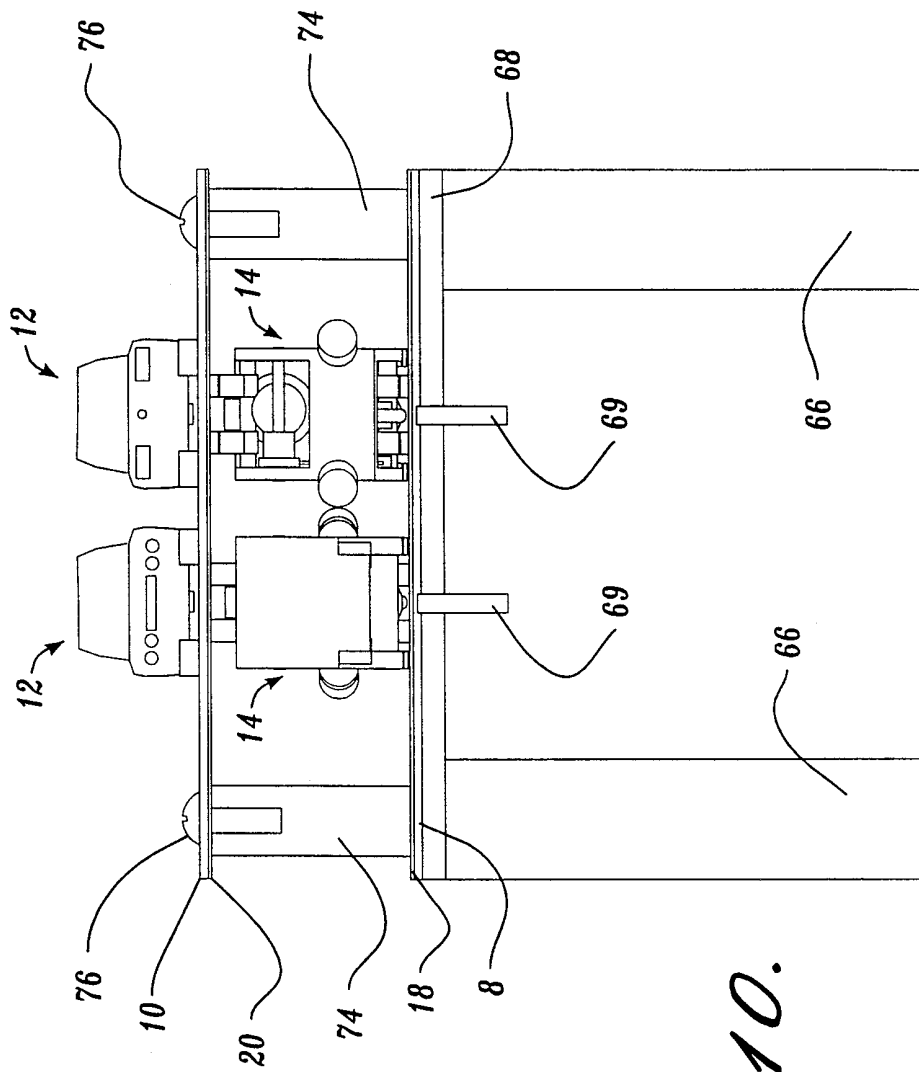
*Fig. 7.*



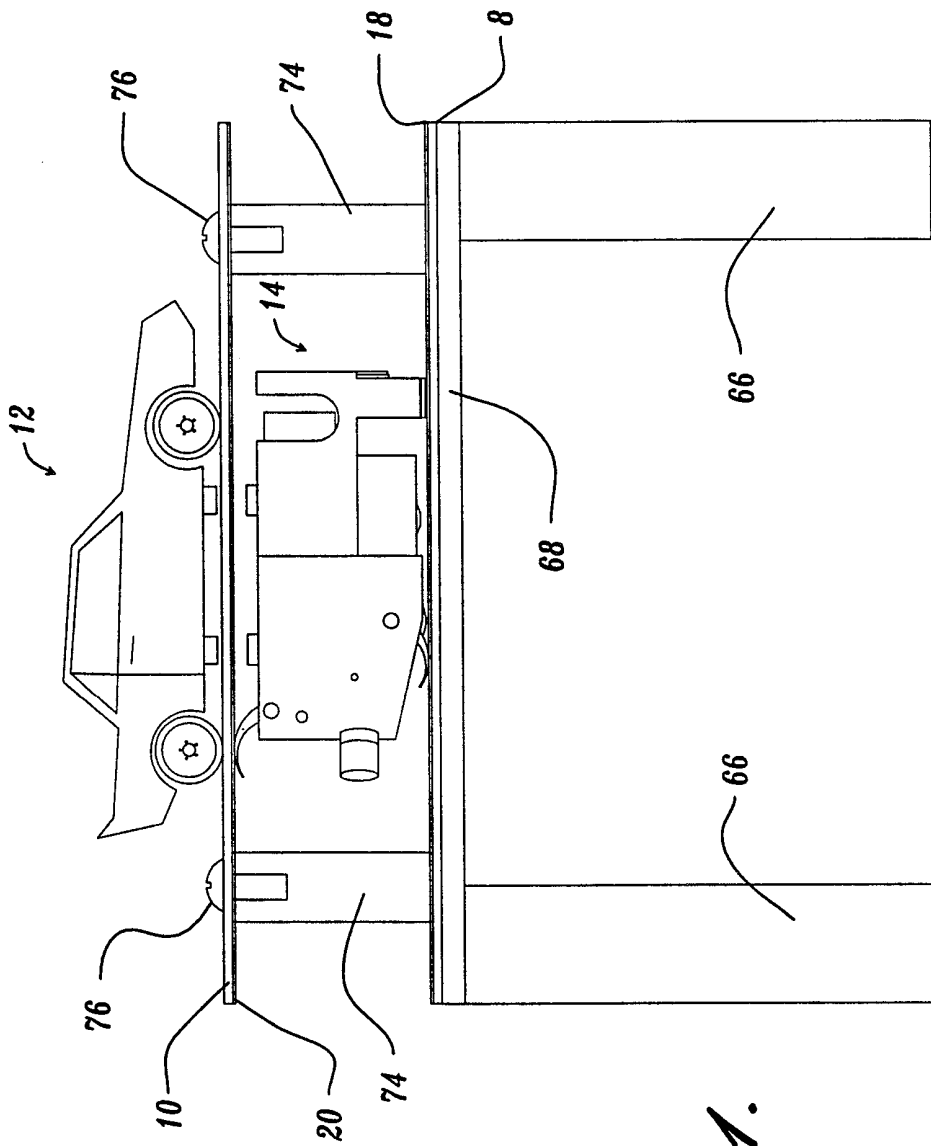
*Fig. 8.*



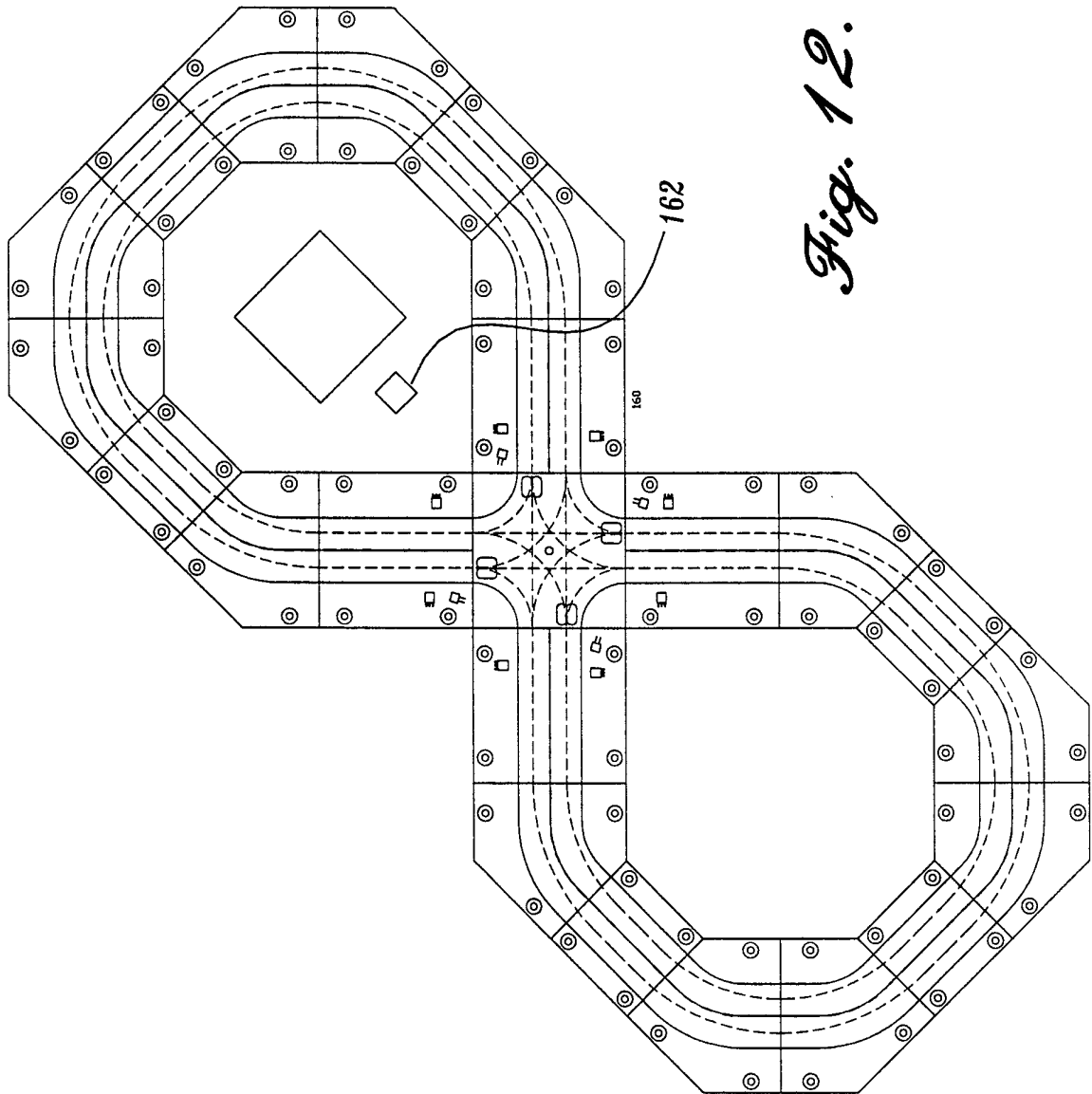
*Fig. 9.*



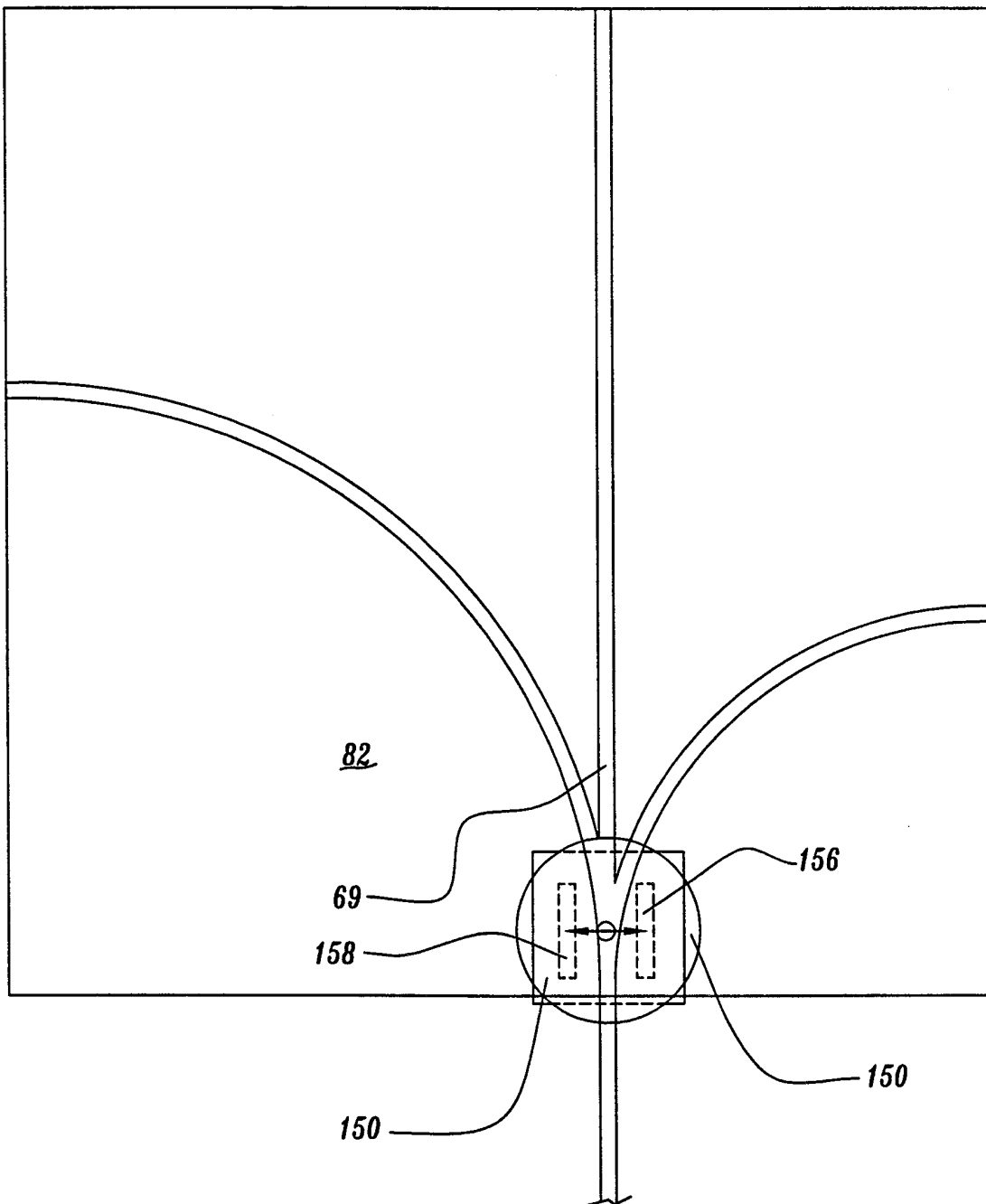
*Fig. 10.*



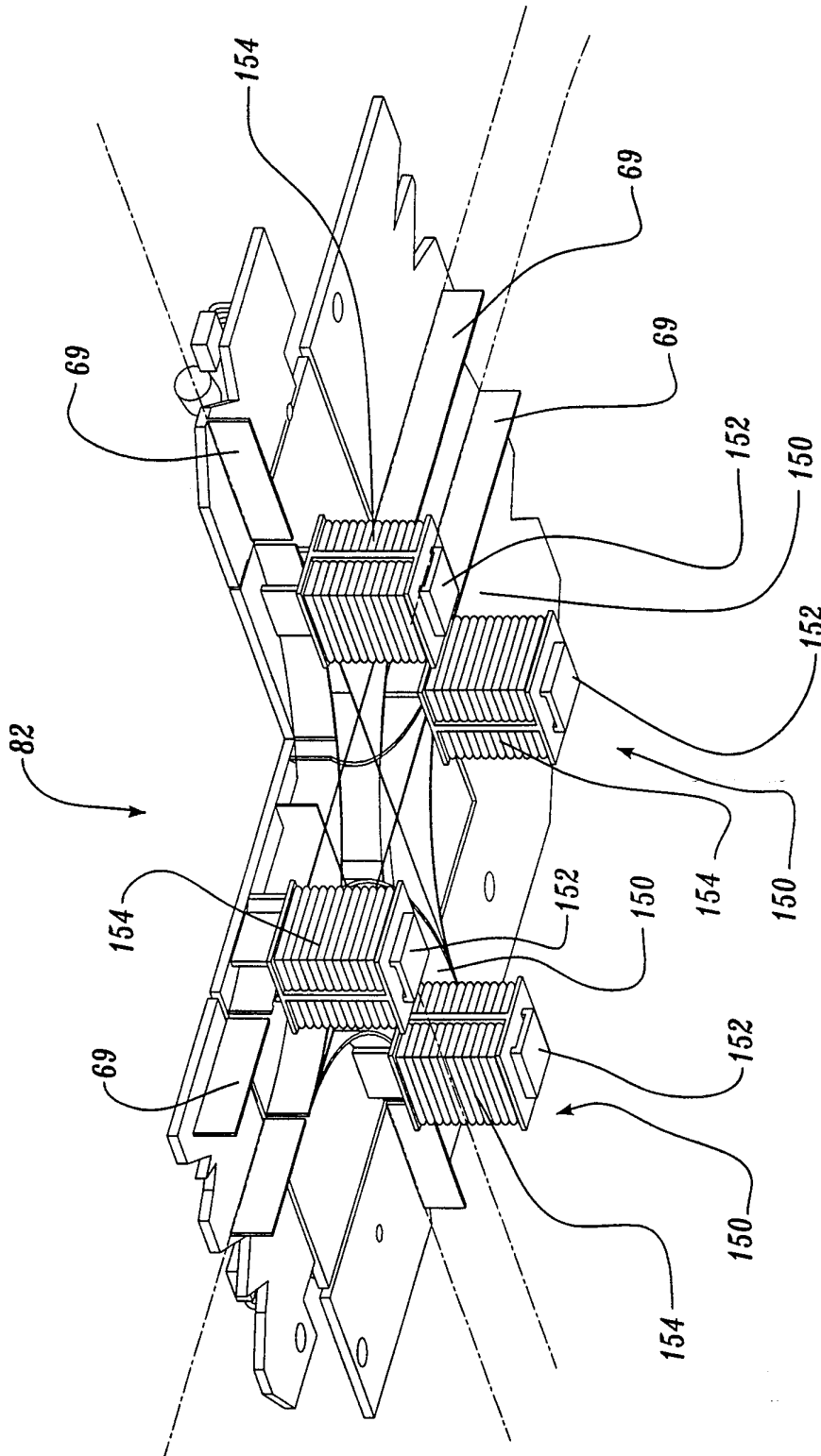
*Fig. 11.*



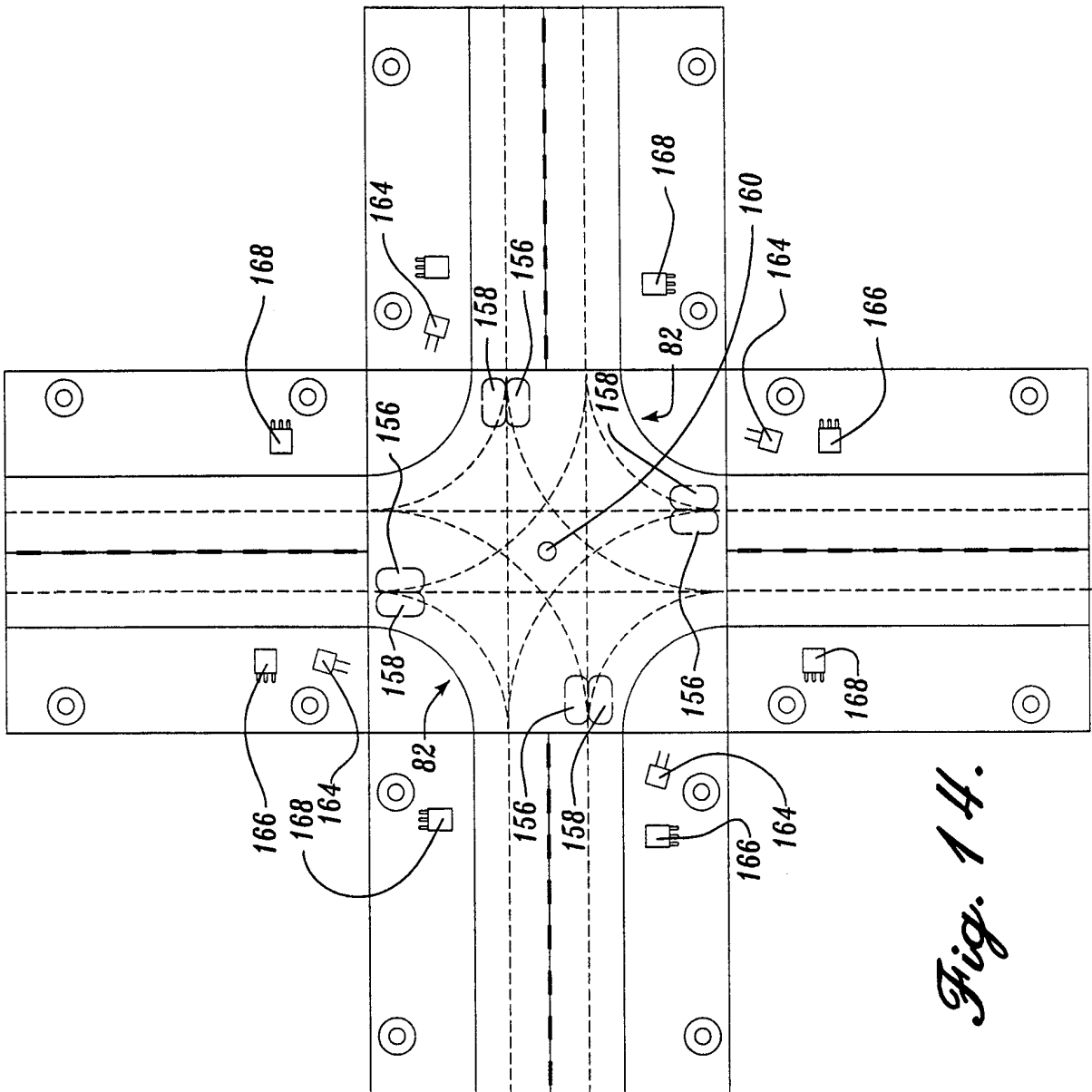
*Fig. 12.*



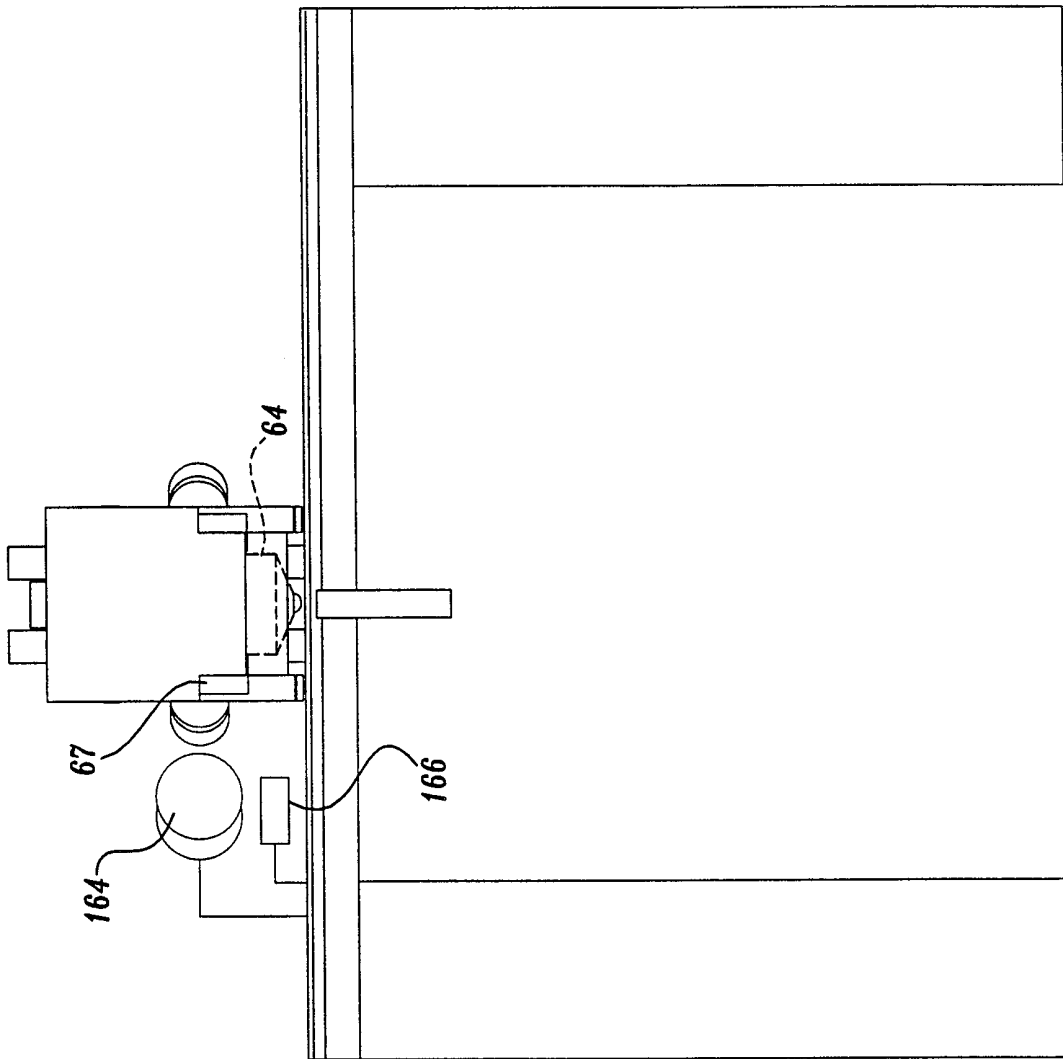
*Fig. 13A.*



*Fig. 13B.*



*Fig. 14.*



*Fig. 15.*



INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US98/18201

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :A63H 33/26  
US CL :446/130, 444, 455, 456  
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
U.S. : 446/130, 441, 444, 455, 456; 104/88.02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US 2,903,821 A (FAVRE) 15 SEPTEMBER 1959, FIGS 9, 10 AND COL 2 LINES 50-60.	22, 25, 26, 28 ----- 1-21, 23, 24, 27
Y	FR 2,674,141 A (TAFFIN) 25 SEPTEMBER 1992, ABSTRACT.	2, 3, 9, 10, 16, 17, 23, 27
Y	US 5,601,490 A (NAKAGAWA ET AL) 11 FEBRUARY 1997, FIG 3.	3, 10, 17, 24
Y	US 3,453,970 A (HANSEN) 08 JULY 1969, FIGS 6-8.	1-21
A	GB 673,321 A (OPIE) 04 JUNE 1952, FIGS 1-4.	

Further documents are listed in the continuation of Box C.  See patent family annex.

* Special categories of cited documents:	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
*A* document defining the general state of the art which is not considered to be of particular relevance	*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
*E* earlier document published on or after the international filing date	*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*G* document member of the same patent family
*O* document referring to an oral disclosure, use, exhibition or other means	
*P* document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search  
26 OCTOBER 1998

Date of mailing of the international search report  
05 NOV 1998

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INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US98/18201

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2,690,626 A (GAY ET AL) 05 OCTOBER 1954, FIGS 1, 2.	
A	US 2,106,424 A (EINFALT) 25 JANUARY 1938, FIGS 1, 2, 4.	