United States Patent

Corey

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[54] MONORAIL SWITCHING DEVICE

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[52] **U.S. Cl.** **104/105,** 105/155

[51] **Int. Cl.** **E01b 25/26**

[58] **Field of Search** 104/88, 89, 94, 95, 96, 104, 104/105, 130; 105/154, 155

[56] **References Cited**

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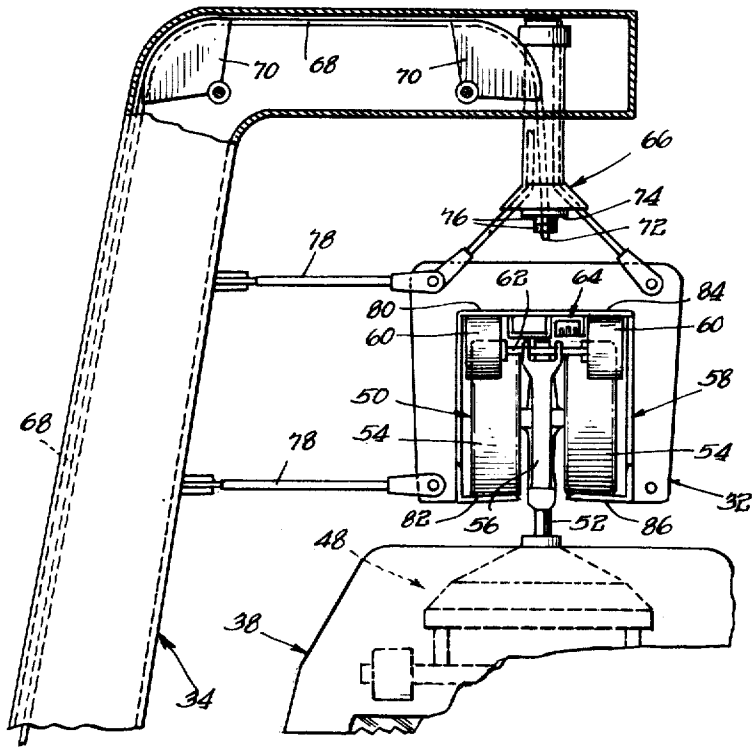
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[57] **ABSTRACT**

A vehicle switching arrangement comprises an overhead monorail guideway that includes a mainline section and a diverging section merging with the mainline section to define a switching station. In addition, a bogie unit is arranged for rollable transport along the guideway and includes port and starboard main wheels rollably engaging the guideway. The bogie unit also includes a guide arrangement for selectively acting against the guideway to load either the port or the starboard main wheels in excess of the normal vehicle load thereof for establishing a vehicle heading through the switching station. Furthermore, stationary fail-safe cams are provided on the guideway to cooperate with cam followers carried by the bogie unit for ensuring safe transit through the switching station in the event of malfunction.

17 Claims, 25 Drawing Figures



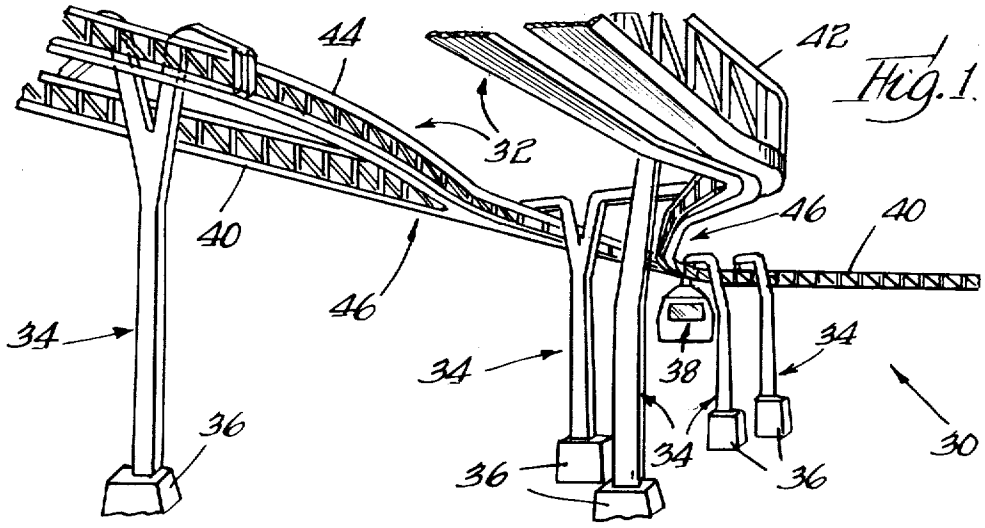
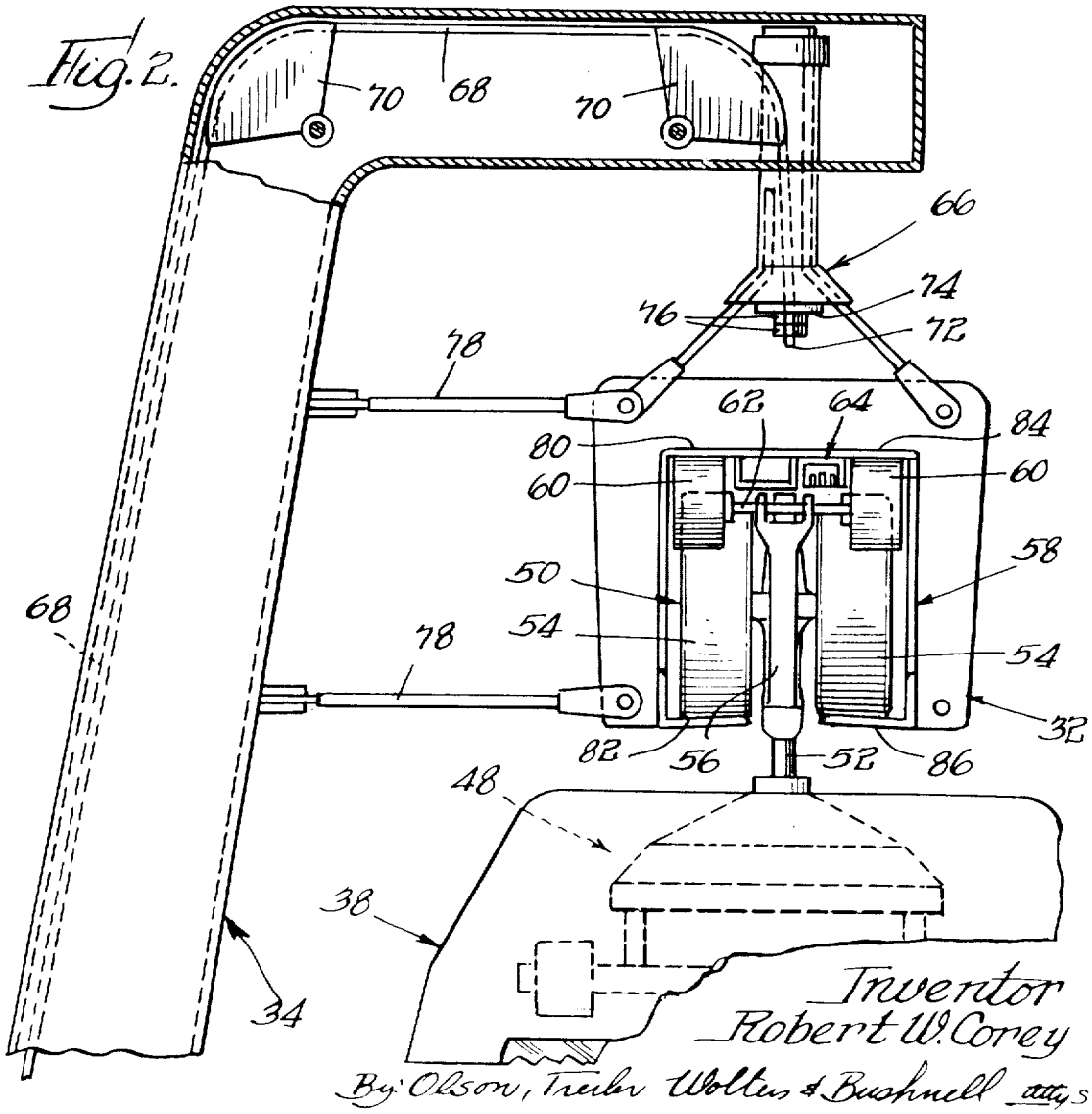


Fig. 1.

Fig. 2.



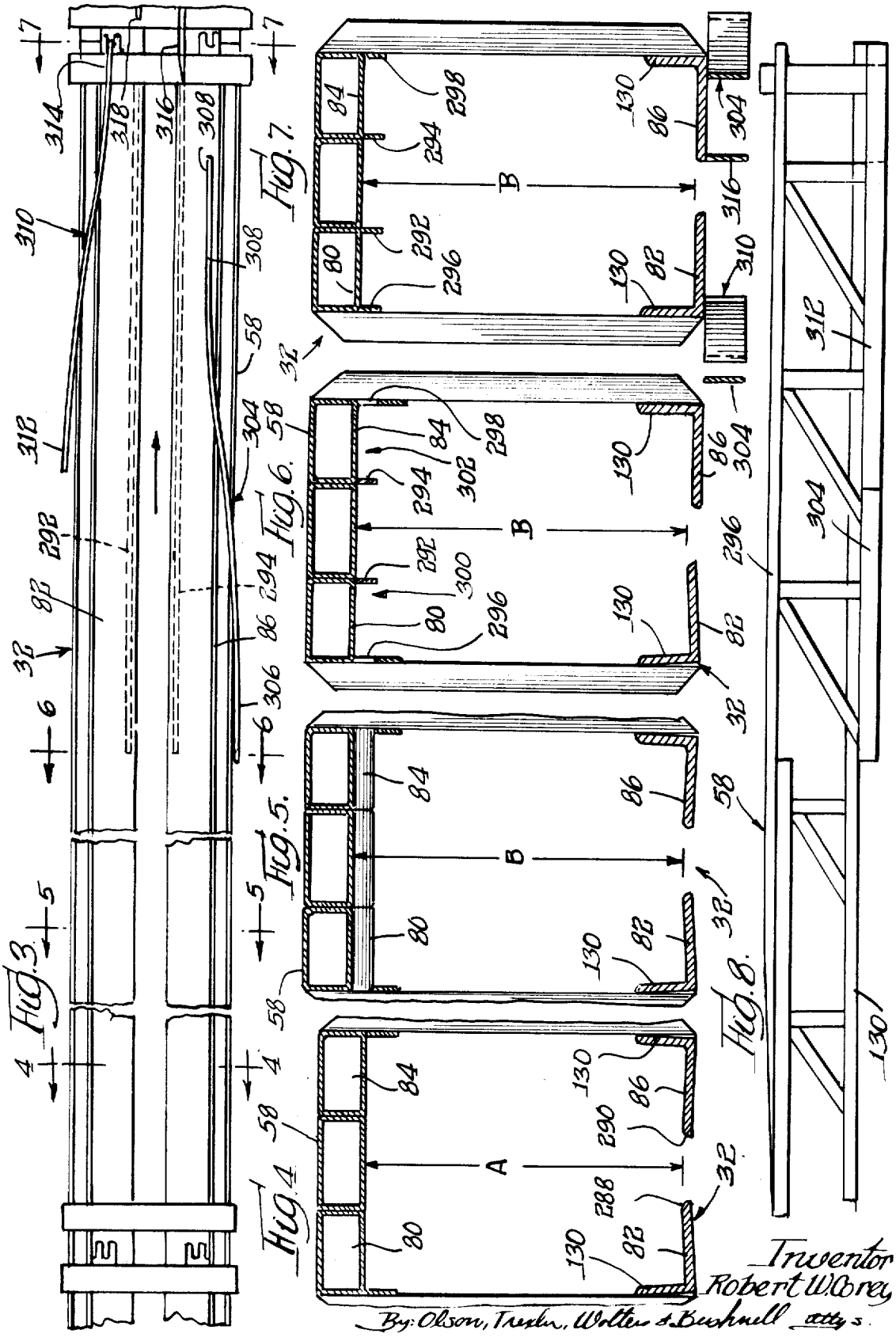
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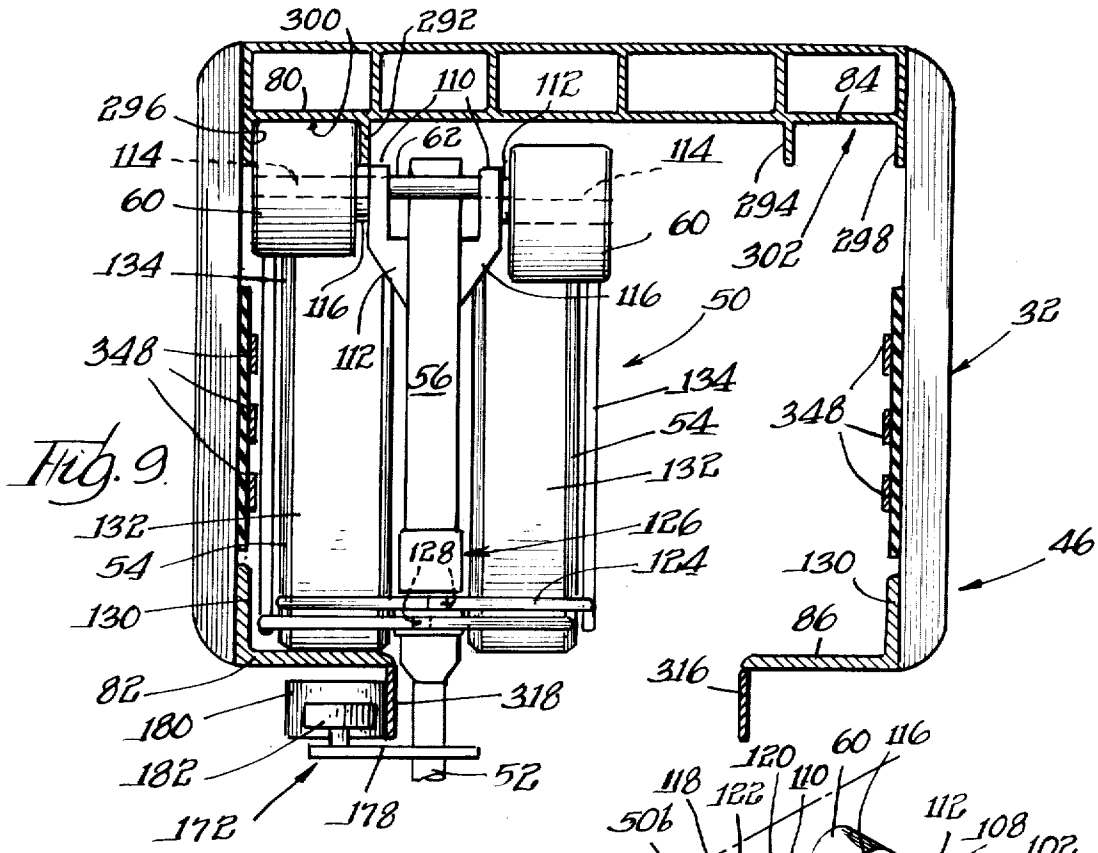


Fig. 9.

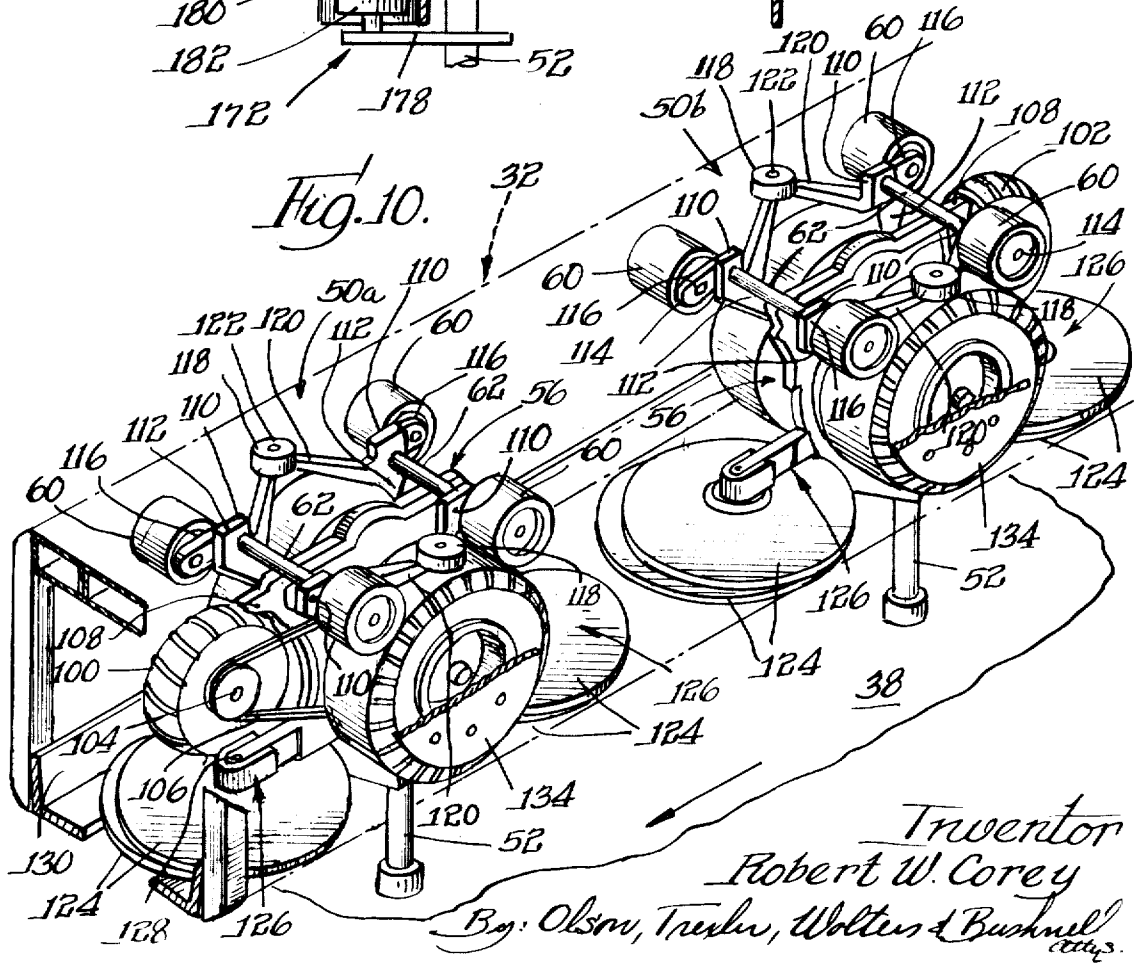


Fig. 10.

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Fig. 11.

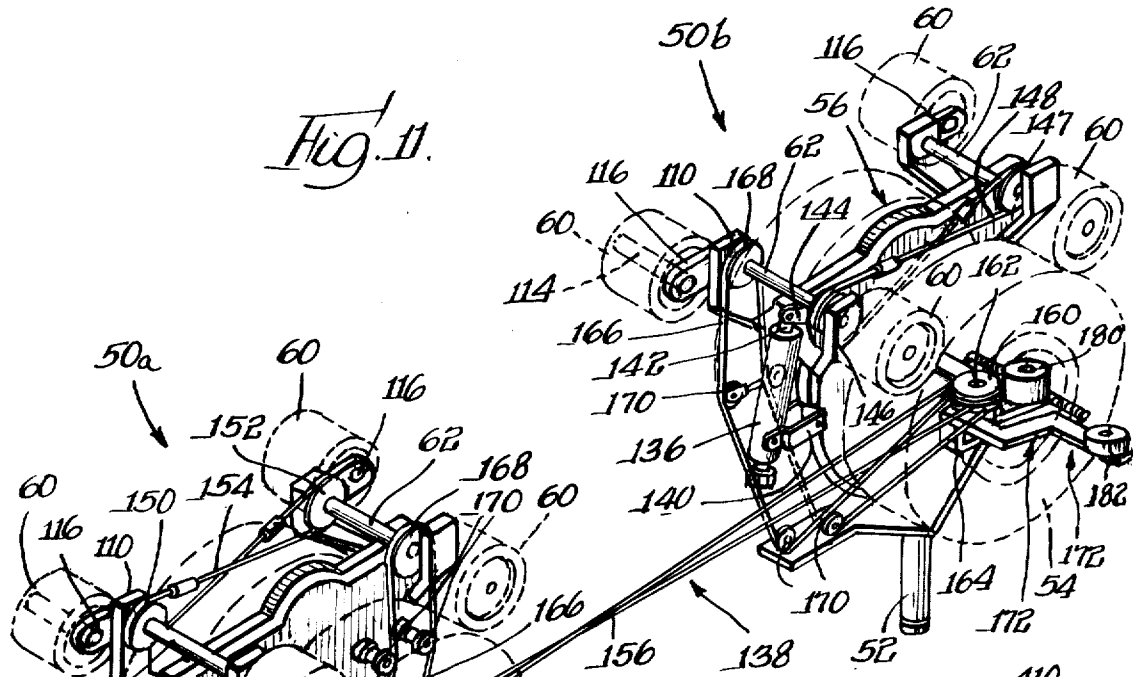
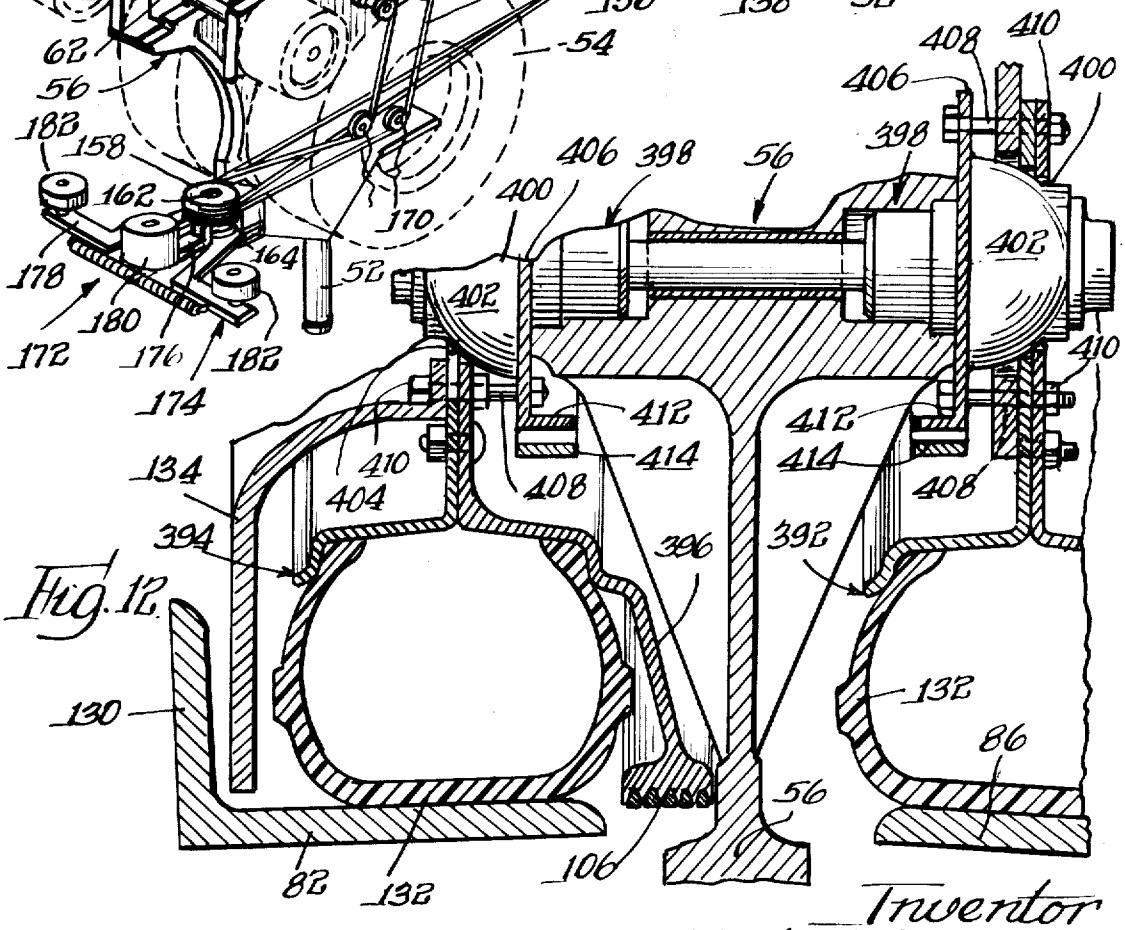
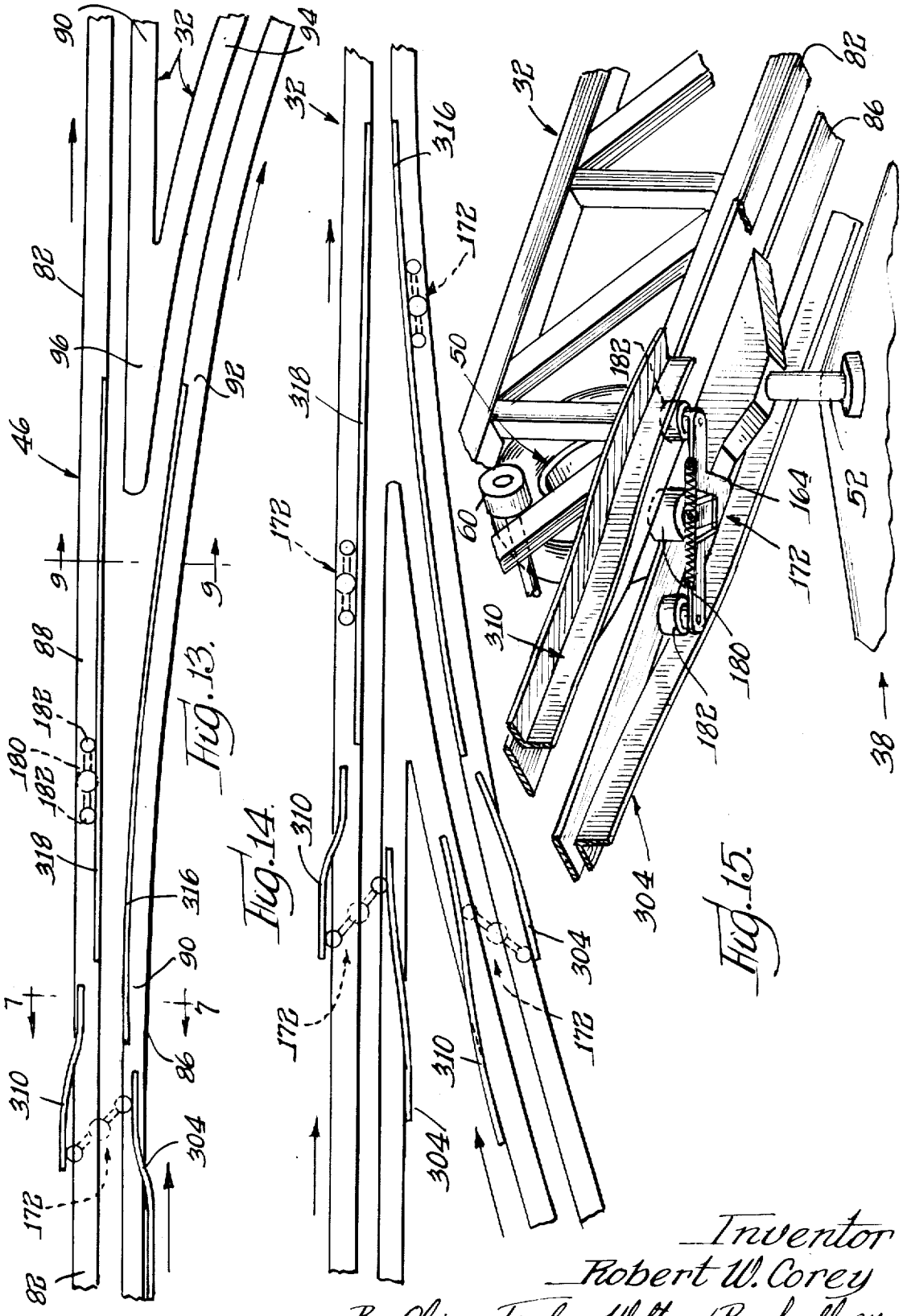


Fig. 12.



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Fig. 16.

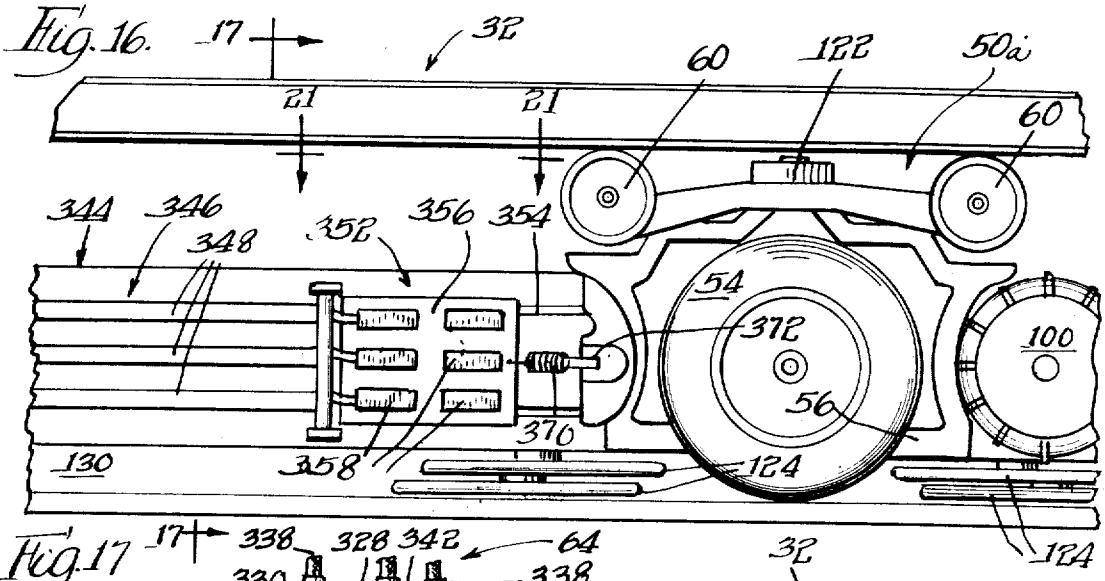
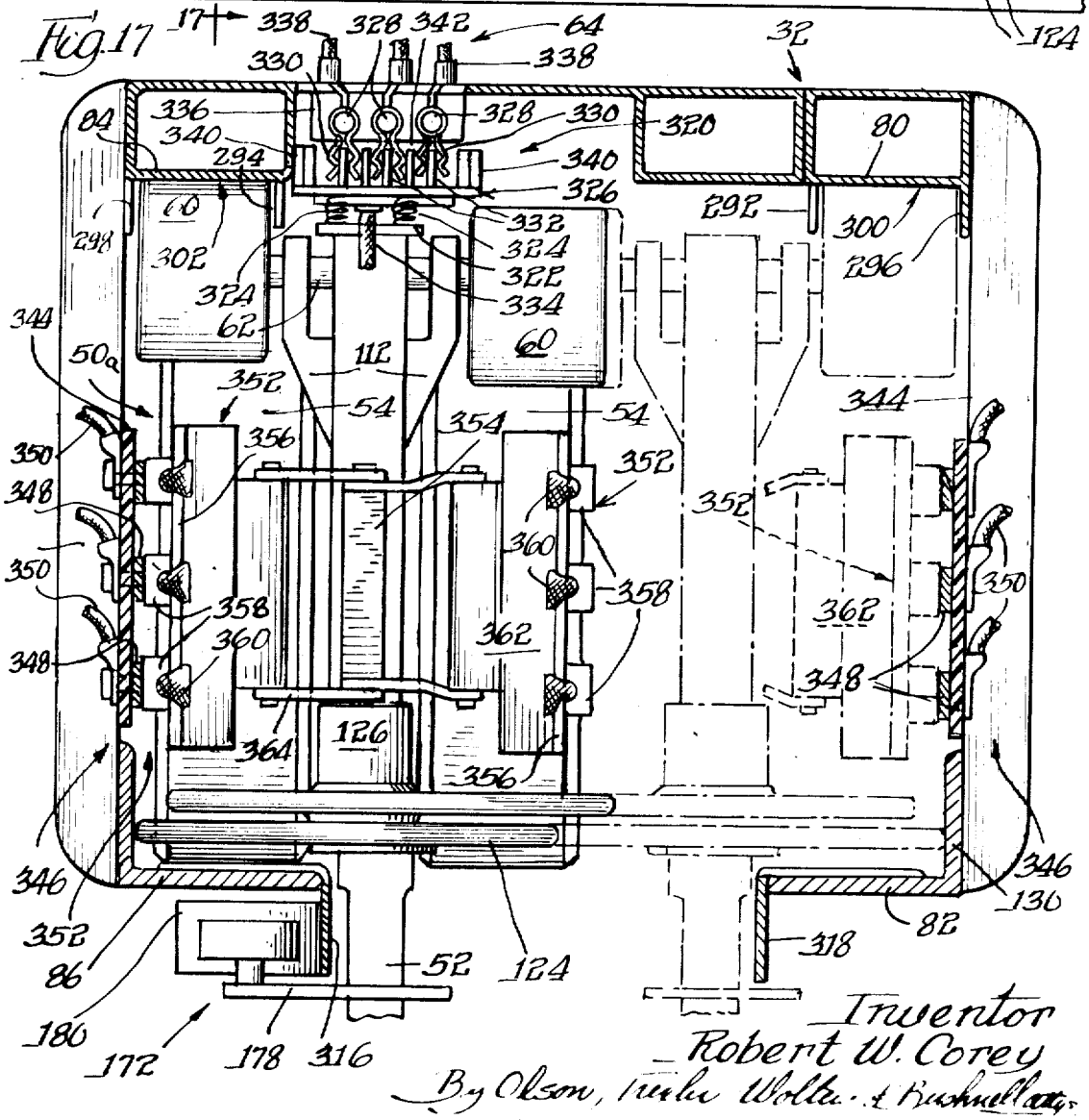


Fig. 17



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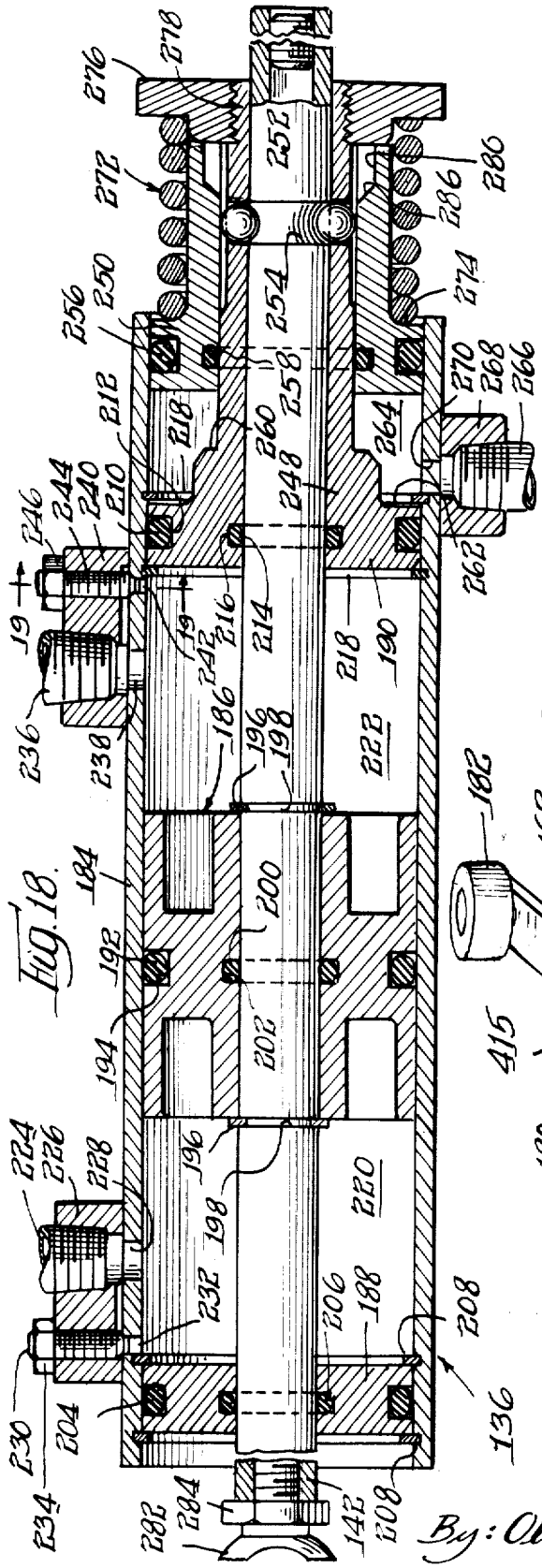


Fig. 18.

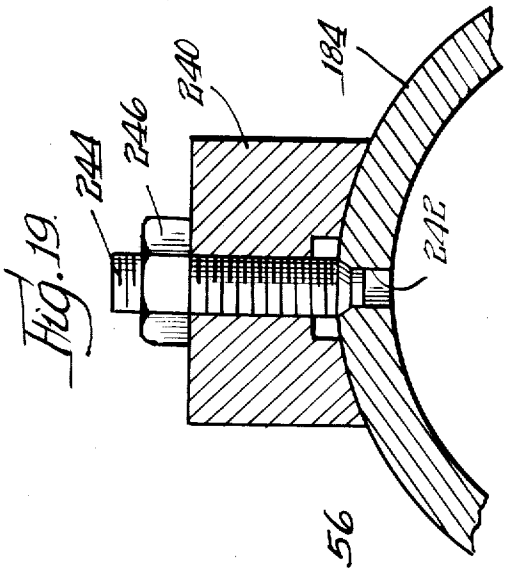


Fig. 19.

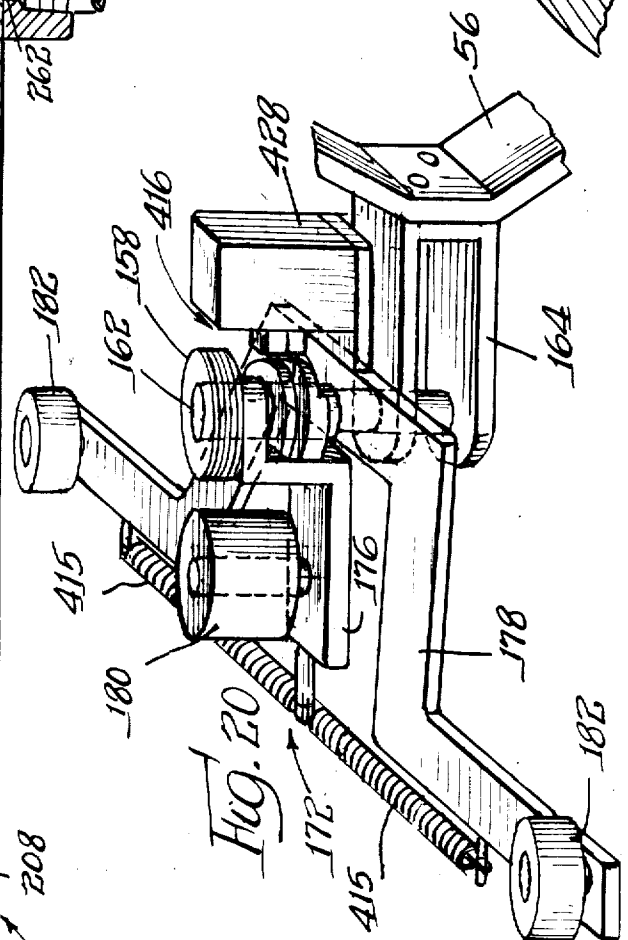


Fig. 20.

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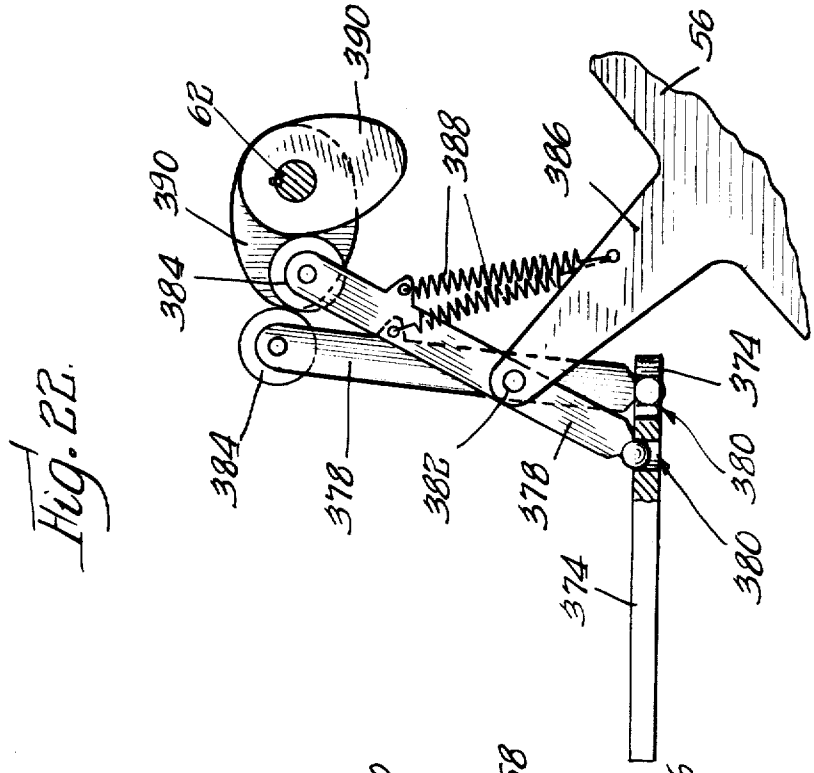


Fig. 22.

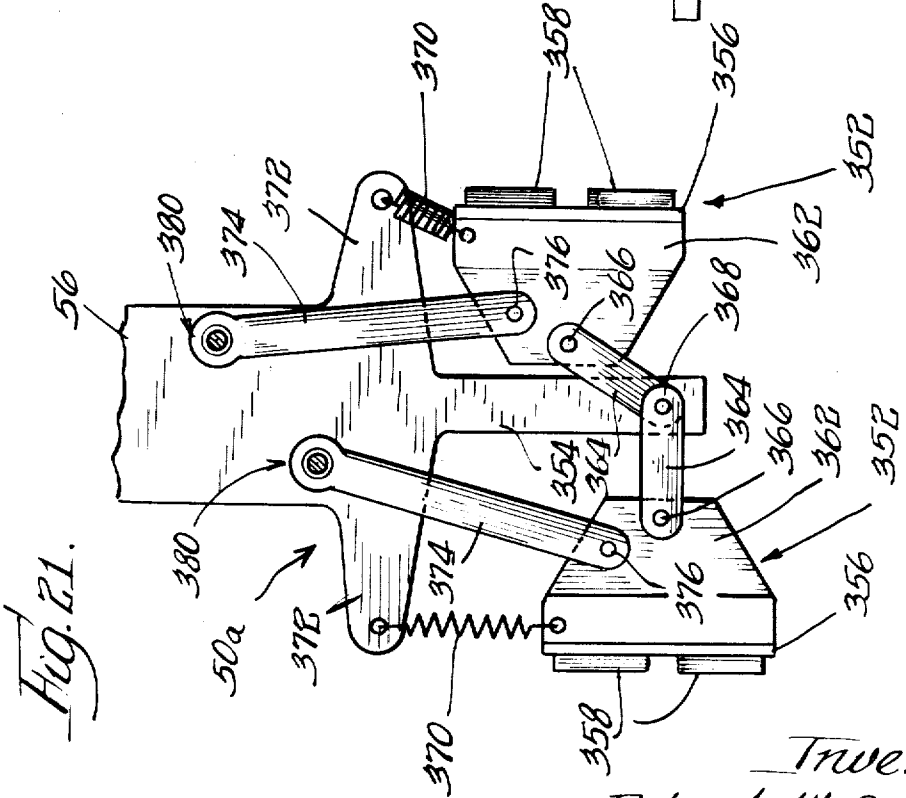


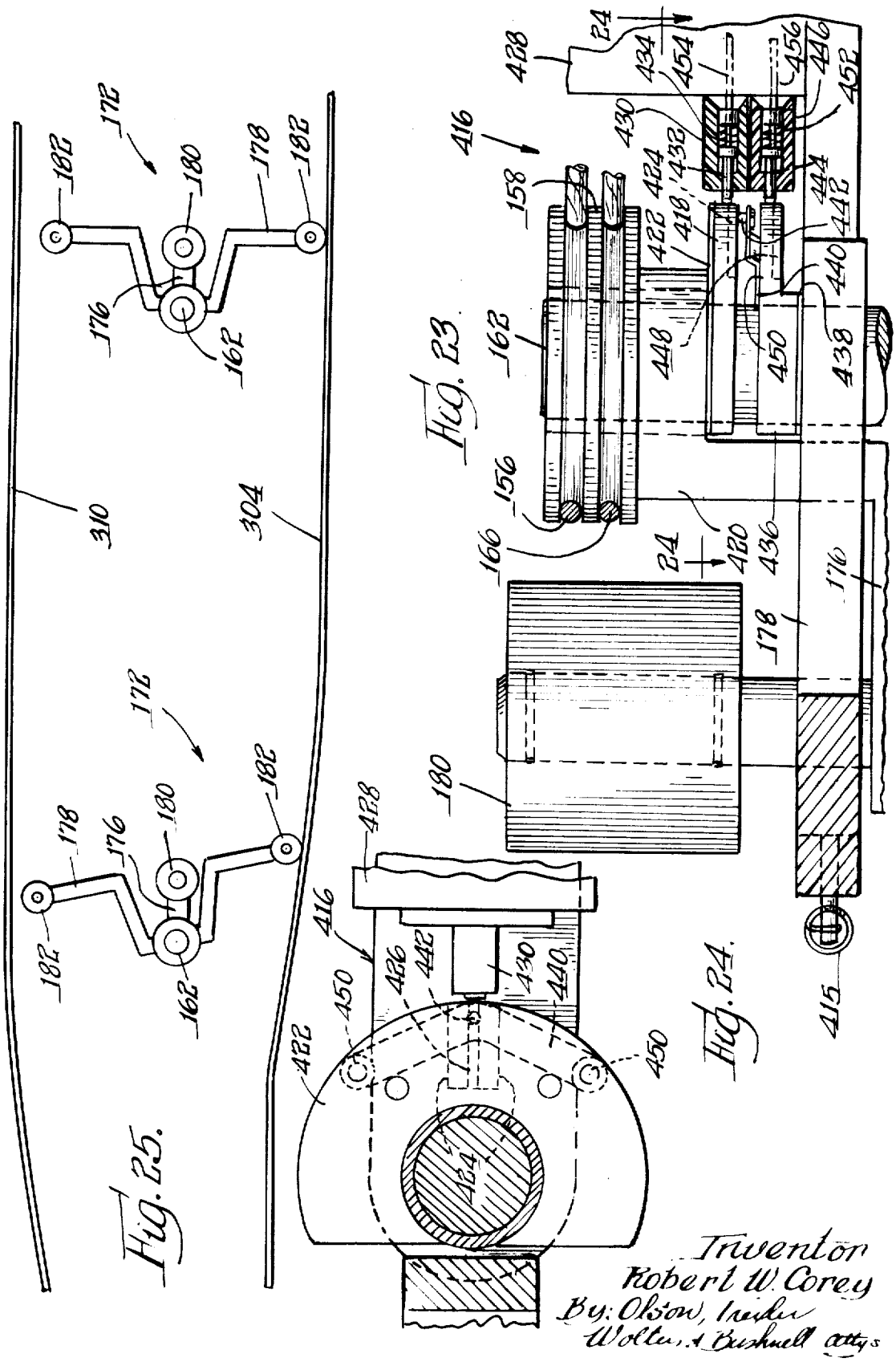
Fig. 21.

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MONORAIL SWITCHING DEVICE

BACKGROUND OF THE INVENTION

This invention relates generally to monorail transportation systems and more particularly to devices for switching a monorail vehicle from one heading to another.

According to conventional practice, mechanical switching arrangements for altering the direction of a transportation vehicle include a section of movable track which is pivoted or otherwise shifted in the route selection process. A considerable amount of power is commonly required to cause the movable track to execute these transitions and the process is time consuming. Slow switching of movable track sections can be permitted in transportation systems operating on a fixed schedule where the presence of a vehicle at a particular switch and at a particular time can be predicted; and having advance knowledge of vehicle destination, track personnel can have the switch readied for passage of the vehicle. Such complicated preparations are impossibly difficult in transportation systems operating in response to the demands on the system and without fixed schedules. The utilization of prior art switching arrangements of the movable track type has heretofore prevented demand systems from achieving their potential in speed and efficiency.

An important object of the present invention is therefore to provide a vehicle switching arrangement in which all the movable parts involved in route selection are carried onboard the vehicles.

A more general object of the invention is to provide a new and improved switching arrangement for track-borne vehicles.

Another object of the invention is to provide a vehicle switching arrangement which is fail-safe in operation.

Still another object of the invention is to provide a vehicle switching arrangement which achieves a coordinated response of switching elements carried respectively by a pair of coupled bogies.

A further object of the invention is to provide a vehicle switching arrangement which accomplishes a smooth transition of the vehicle through the switching station.

A yet further object of the invention is to provide a vehicle switching arrangement which is reliable in operation.

These and other objects and features of the invention will become more apparent from a consideration of the following descriptions.

BRIEF DESCRIPTION OF THE DRAWINGS

In order that the principles of the present invention may be readily understood, a single embodiment thereof is shown in the accompanying drawings wherein:

FIG. 1 is a low-angle perspective view of an overhead monorail guideway arrangement constructed in accordance with the present invention and including a mainline section and a number of switching stations;

FIG. 2 is an enlarged and elevational view of the monorail guideway arrangement of FIG. 1 showing the guideway arrangement suspended from a support column and illustrating the normal running condition of the vehicle bogies in the guideway;

FIG. 3 is a bottom view of a guideway section defining the entrance portion of a switching station;

FIG. 4 is an enlarged cross-sectional view taken along the line 4—4 of FIG. 3;

FIG. 5 is an enlarged cross-sectional view taken along the line 5—5 of FIG. 3;

FIG. 6 is an enlarged cross-sectional view taken along the line 6—6 of FIG. 3;

FIG. 7 is an enlarged cross-sectional view taken along the line 7—7 of FIGS. 3 and 13;

FIG. 8 is a side elevational view of the guideway section of FIG. 3;

FIG. 9 is an enlarged and elevational view showing the action of the upper and lower guide wheels and cooperating guideway structure in negotiation of a switching station;

FIG. 10 is an enlarged perspective view of the bogies employed in driving the monorail vehicle of the present invention, the means for uniting the bogies and the lower guide wheel assemblies being removed for clarity in illustrating various other arrangements;

FIG. 11 is a view similar to the showing of FIG. 10, illustrating the means for uniting the bogies but with certain of the related structures removed and others shown in broken lines for clarity of illustration;

FIG. 12 is an enlarged cross-sectional view of the main drive wheels used in the bogies;

FIG. 13 is a bottom view of a left-turn switching station constructed in accordance with the present invention;

FIG. 14 is a bottom view of a merging switching station construction in compliance with the present invention;

FIG. 15 is a low angle perspective view showing the fail-safe mechanism employed in the present invention;

FIG. 16 is a longitudinal cross-sectional view taken through the guideway of the invention and illustrating the power bus arrangement and cooperating takeoff used at a switching station;

FIG. 17 is an end elevational view of the guideway and bogie arrangements taken in partial cross-section to show the power bus arrangements and collectors and taken along the line 17—17 of FIG. 16, certain of the means for positioning the lateral power collectors being removed for clarity of illustration;

FIG. 18 is a longitudinal section view of the fluid-actuated jack used in manipulating the upper and lower guide wheels of the bogie units;

FIG. 19 is an enlarged cross-sectional view taken substantially along the line 19—19 of FIG. 18;

FIG. 20 is an enlarged perspective view of a lower guide wheel assembly and related electrical switching components;

FIG. 21 is an enlarged, fragmentary plan view of the lateral power collectors and related positioning means used in picking off electrical power from the guideway during transit of a bogie unit through a switching station, taken along the line 21—21 of FIG. 16;

FIG. 22 is a fragmentary, side elevational view of the cam and link members used with the positioning arrangement of FIG. 21;

FIG. 23 is an enlarged, side elevational view of the electrical switching arrangements used with the lower guide wheel assembly of FIG. 20;

FIG. 24 is a fragmentary plan view of the electrical switching arrangements of FIG. 23; and

FIG. 25 is a schematic view suggesting the relative motion in the lower guide wheel assembly which is sensed by the associated electrical switching arrangement.

DETAILED DESCRIPTION

Referring now in detail to the drawings, specifically to FIG. 1, a portion of an overhead monorail transportation system constructed in compliance with the present invention is indicated generally by the reference numeral 30. The transportation system 30 includes: a guideway or trackage 32 which defines the transportation routes; a suitable number of horizontally spaced support columns or towers 34 which are mounted on concrete pedestals or footings 36 and from which the guideway is suspended, and a suitable number of transportation vehicles 38 which are adapted to run on the guideway 32. In order to afford flexibility in the routing of the vehicles 38, the guideway 32 is arranged to include a mainline section 40, a secondary line section 42 and a parking section 44, the secondary line section 42 and the parking section 44 diverging from the mainline section at switching stations 46. As will be appreciated, the transportation system of the invention includes a multiplicity of secondary line sections and parking sections in accordance with the requirements of the facility being served by the system. It is to be appreciated that the instant transportation system will include various boarding and destination stations and that the term "diverging" when applied to sections of the guideway 32 shall encompass switching stations which accomplish merging as well as shunting.

Referring to FIG. 2, the transportation vehicle 38 includes a suitably sprung suspension 48 which is hung from a pair of bogies 50 (one of which is shown) by means of a spindle 52. Each bogie 50 includes a pair of laterally aligned main drive wheels 54 which are rotatably mounted on a central main frame 56, and the guideway 32 comprises a hollow box girder unit 58 which surrounds the bogies 50 and defines bearing surfaces for the drive wheels 54. Each of the bogies 50 also includes a pair of upper guide wheels 60 which are eccentrically rotatably mounted on a shaft 62 as will be described more fully hereinafter. As will also be described more fully hereinafter, the guideway 32 additionally includes an overhead power bus arrangement 64 from which the bogies derive electrical energy for powering the vehicle 38.

The guideway 32 is suspended from the support columns 34 by means including a hanger bracket 66; and when it is desired to suspend the guideway resiliently, as for example on sections of the guideway where the vehicles 38 might reach top speed, the hanger bracket 66 is connected to a cable 68 which is threaded over pivoted sector plates 70 within the interior of the columns 34 to be fastened elsewhere in the column by means of a mounting bracket (not shown). A threaded stud 72 is swaged or otherwise suitably secured to the outer end of the cable 68 so that the hanger bracket 66 may be fastened to the end of the cable by means of an abutment plate 74 and locknuts 76. In addition, lateral stabilizer arms 78 are mounted in horizontal position between the side of the support column and the guideway.

In accordance with an important feature of the invention, the switching stations or sections of the guideway 32 are completely static; and all movable switching parts are carried by the vehicle 38. More specifically, to accomplish route selection at one of the switching sections, a selected set of the upper guide wheels 60, that is, either the port or starboard set of upper guide wheels, is urged into forcible engagement with the corresponding ceiling portion of the guideway so that substantially the entire vehicle load is borne by the corresponding main drive wheels 54. Where a turn in the route coincides with a switching maneuver, the main drive wheels on the inside of the turn are preferably selected to bear the vehicle load. This action of the upper drive wheels is continued during vehicle transit through the switch in order to establish the selected heading.

Continuing with reference to FIG. 2 and recalling that the guideway shown therein is an ordinary or normal running section of the guideway rather than a switching section thereof, the box girder comprising the guideway 32 is shown to include a first upper track plate 80, a first lower track plate 82 aligned beneath the upper track plate 80, a second upper track plate 84 spaced laterally from the first upper track plate 80, and a second lower track plate 86 aligned beneath the upper track plate 84. Turning for the moment to FIG. 13, the lower track plate 82 is seen to comprise a continuous mainline section 88 while the lower track plate 86 comprises a first section 90 which parallels the mainline section 88 and a second section 92 which diverges from the mainline section 88 to define a switch at the switching section 46. The guideway 32 additionally includes a lower track plate section 94 which parallels the diverging section 92 and which merges with the downstream portion of the diverging section 90 at a common section 96. It will be appreciated that the upper track plates corresponding to the lower track plates illustrated in FIG. 13 trace patterns similar to those shown and described relative to the lower track plates. It will also be appreciated that the space or slot defined between the track plate section 88 and 90 and between the track plate section 92 and 94 accommodate passage of the spindles 52 which support the vehicle 38 from the bogies 50.

It has been described hereinabove that the upper guide wheels are selectively actuated to impose substantially the entire vehicle load on one set of the main drive wheels during transit through a switch. This condition of a bogie 50 is illustrated in FIG. 9; and considering the direction of vehicle movement to be out of the page, the track plates 80 and 82 become, respectively, the starboard upper and lower track plates. Correspondingly, the track plates 84 and 86 can be designated, respectively, the upper and lower port side track plates. Continuing in this framework of terminology, starboard upper guide wheel 60 is disposed in forcible engagement with the starboard upper track plate 80; and the starboard main drive wheel 54 forcibly engages the starboard lower track plate 82 through the reaction caused by its common connection to the central frame 56 of the bogie 50. Cooperatively, the port side upper guide wheel 60 is disposed out of engagement with the ceiling plate portions of the guideway.

Turning now to a consideration of FIG. **10**, the transportation vehicle **38** is seen to be suspended from a pair of bogies which, for purposes of distinction, shall be referred to as fore bogie **50***a* and aft bogie **50***b*. The bogies **50***a* and **50***b* are substantially identical except reversed in position, the bogie **50***a* being driven by a forwardly disposed electric drive motor **100** and the aft bogie being driven by a similar but rearwardly disposed electric drive motor **102**. It should be observed that the fore and aft bogies are mechanically coupled exclusively through their common attachment to the vehicle **38**. The motors **100** and **102** power the respective main drive wheels **54** by means of pulleys **104** mounted on the motor output shafts, endless flexible drive belts **106** and suitable pulleys secured to the drive wheels, as will be described more fully hereinafter with respect to FIG. **12**.

The main frame **56** forms the principal positional reference and mounting base for each bogie **50**. For example, motor mounting arms **108** extend longitudinally from the main frame **56** to receive and be coupled with the housings of motors **100** and **102** respectively. In addition, laterally spaced upper guide wheel shaft mounting ears **110** are connected with the main frame **56** by shoulder brackets **112**, the upper guide wheel shafts being journalled in the ears **110**. Considering FIG. **9** in conjunction with FIG. **10**, the upper guide wheels **60** are rotatably mounted on shafts **114** which are, in turn, fastened to oppositely extending eccentric plates **116**, the plates **116** being rigidly mounted on the guide wheel shaft **62**.

In accordance with the features of the present invention, means are provided on the bogies **50** for restraining the transportation vehicle **38** against such forces and moments as wind and the centrifugal force encountered during negotiation of a curve. Specifically and with reference to FIG. **10**, a pair of upper lateral restraint rollers **118** are mounted intermediate the fore and aft pairs of upper guide rollers **60** by means of mounting yokes which merge into the mounting shoulders **112**. Each roller **118** is freely rotatably mounted on an upright shaft **122** affixed to the corresponding yoke **120**. The upper lateral restraint rollers **118** are arranged to come into contact with the side of the guideway only when the bogie assembly leans away from the vertical direction. In addition, two sets of eccentrically mounted lower restraint wheels **124** are connected to the main frame **56** by means of longitudinally extending mounting arm assemblies **126**. The lower lateral restraint wheels **124** are rotatably mounted on eccentrically disposed stub shafts **128**, as is best shown in FIG. **9**; and these lower lateral restraint wheels may be preloaded against the lower sides of the guideway **32** by springs or other suitable means, not shown. In order to provide contact surfaces for the lower lateral restraint wheels **124**, the lower track plates **82** and **86** are provided with upturned flanges **130** disposed to confront the edges of the lower lateral restraint wheels. Continuing with reference to FIG. **9**, it is advantageous to provide the main drive wheels **54** with tubeless pneumatic tires **132**; and in order to protect against mishaps which might occur in the event of a flat tire or the unintentional overloading of the vehicle, metal safety wheels **134** are mounted on the hubs of wheels **54** to rotate therewith. The safety wheels **134** are of somewhat lesser diameter than the diameter of main drive wheels **54** when the latter are under normal load. Thus, the safety wheels do not ordinarily engage the track plates of guideway **32**.

In compliance with the features of the present invention, the activities of the upper guide wheels **60** are coordinated in order to insure that all of the guide wheels of the fore and aft bogies **50***a* and **50***b* move in unison. Referring to FIG. **11**, the means for coordinating the action of the upper guide wheels **60** include a single pneumatic actuating cylinder or jack **136** and a cable-and-pulley unit **138**. The cylinder **136** is affixed to the central frame **56** of aft bogie **50***b* by a bracket **140**, and the cylinder **136** includes an extensible and retractable piston rod **142** which is pivotally mounted to a radial arm **144**. The arm **144** is rigidly mounted on a pulley **146** which is, in turn, non-rotatably mounted on the forward upper guide wheel shaft of the bogie **50***b*. The cylinder **136** is thus capable of directing the forward pair of upper guide wheels into and out of forcible engagement with the ceiling of the guideway. In order to coordinate the movements of the rear pair of upper guide wheels with the forward pair, the cable-and-pulley unit **138** includes a pulley **147** which is non-rotatably affixed to the rear upper guide wheel shaft **62**, and an endless cable **148** is threaded over the pulleys **147** and **148** in the manner illustrated. In similar manner, the forward and rear upper guide wheel shafts **62** of fore bogie **50***a* are coupled for coordinated action by components of the cable-and-pulley unit **138**. Specifically, a pulley **150** is non-rotatably secured to the forward upper guide wheel shaft, a pulley **152** is non-rotatably mounted to the rear upper guide wheel shaft, and an endless cable **154** is threaded over the pulleys **150** and **152** in the manner illustrated in FIG. **11**.

In order to coordinate the upper guide wheels of bogies **50***a* and **50***b*, the cable-and-pulley unit **138** includes an endless cable **156** which is threaded, as shown, over the upper sheave portion of a double pulley **158** which is associated with bogie **50***a* and the upper sheave portion of a double pulley **160** which is associated with the aft bogie **50***b*. The cable **156** is situated generally interjacent the pairs of drive wheels **54** proximate the center line of the coupled bogies **50***a* and **50***b*, and the opposite end loop of the cable **156** may encompass the respective central frames **56** of the two bogies or reside on one side thereof. Each of the pulleys **158** and **160** is rigidly mounted on an abbreviated shaft **162** that is journalled in a bracket **164**, brackets **164** being welded, bolted or otherwise suitably affixed to the respective central frames **56**. Rotary motion is transmitted from the double pulleys **158** and **160** to the associated upper guide wheel shaft by other components of the cable-and-pulley unit **138**. Specifically, an endless cable **166** is threaded over the lower sheave portion of each double pulley and over a pair of drive pulleys **168** fastened, respectively, to the rear upper guide wheel shaft of bogie **50***a* and the forward upper guide wheel shaft of bogie **50***b*. Idler rollers **170** mounted on the frames **56** direct the cable **166** in a path around the other components of the bogie assembly.

While the fail-safe guidance mechanism will be described more fully hereinafter with respect to FIGS.

3–8, 13–15, 20 and 23–25, it will be valuable at this juncture to delineate the construction of that portion of the fail-safe guidance mechanism which is directly operated by the cable-and-pulley unit 138. Continuing therefore with reference to FIG. 11, a lower guide roller assembly 172 is fastened to each shaft 162 to rotate generally with the corresponding double pulley. Each of the assemblies 172 includes a T-shaped frame 174 comprising a lower guide wheel arm 176 and a yoke 178. The arm 176 is non-rotatably attached to the shaft 162 and carries a rotatable lower guide roller 180 in upright position, yoke 178 being rotatably affixed to the shaft 162. A pair of outboard cam rollers 182 are rotatably mounted on the yoke 178 in upright position.

It is contemplated that a system of mechanical linkages could be substituted for the cable-and-pulley unit 138.

Turning now to FIG. 18 for a description of the construction of the pneumatic actuating cylinder or jack 136, that unit comprises, in addition to the extensible and retractable piston rod 142, a cylindrical housing or shell 184, a piston 186 secured to the rod 142, and a pair of end plate members 188 and 190. The piston 186 is longitudinally slidably disposed within the housing 184 and an O-ring 192 is situated in an annular, radially outwardly opening groove 194 to provide a seal between the piston and the housing. The piston 186 is secured to the rod 142 by a pair of longitudinally spaced retainer rings 196, the rod 142 being fashioned with grooves 198 for reception of these rings. A small O-ring 200 is situated in a groove 202 located centrally of the piston 186 to form a seal between the piston and the rod 142.

The end plate member 188 is similarly provided with inner and outer seals, specifically a radially outwardly disposed O-ring 204 which seals against the inner wall of housing 184 and a radially inwardly disposed O-ring 206 which effectuates a seal against the rod 142. The end plate member 188 is securely fastened in permanent position by means of a pair of spaced retainer rings 208 which are fitted into appropriate grooves fashioned in the inner side wall of the housing 184.

The end plate member 190 is likewise secured and sealed in the housing. In particular, an outer O-ring 210 is situated in a groove 212 formed in the end plate member to confront the inner wall of housing 184 and provide a seal thereagainst; and an O-ring 214 is located in a groove 216 to confront the piston rod 142 and provide a seal against that element. A pair of longitudinally spaced retainer rings 218 are received in grooves formed in the inner side wall of housing 184 to hold the member 190 in place.

As will be appreciated, the piston 186 divides the space between the end plate members 188 and 190 into a pair of variable volume chambers 220 and 222; and a combination inlet-outlet line 224 which is fastened to the side wall of housing 184 by a mounting block 226 and communicates with the chamber 220 through a lateral aperture 228 fashioned in the side wall of housing 184. The mounting block 226 also receives threadedly a set screw 230 which normally closes a vent port 232 and which is secured in place by a locknut 234. The chamber 222 likewise communicates with an inlet and outlet line 236 through a port 238 fashioned in the sidewall of housing 184, the end of line 236 being fastened to the housing 184 by a mounting block 240. A vent port 242 is normally closed by a set screw 244 that is secured by a locknut 246.

In compliance with the features of the present invention, the pneumatic jack 136 is arranged to take a locked position when the bogies and guideway are in the normal running mode and to be unlocked in the event of a leak or failure of the pneumatic system or in the event of a failure in the electrical control circuitry. For this purpose, the end plate member 190 is provided with a tubular extension portion 248 which passes slidably through a piston 250. A suitable number of ball bearings 252 are located in a semitoroidal groove 254 formed in the periphery of piston rod 142 to establish a lock in the manner to be described shortly, and the extension portion 248 is apertured to pass the ball bearing 252 radially into an unlocked position. An O-ring 256 establishes a seal between the piston 250 and the housing 184, and an O-ring 258 provides a seal between the piston 250 and the extension portion 248. In order to provide a stop for the piston 250, the extension portion 248 is fashioned with an annular shoulder 260 confronting the piston 250. In addition, the extension portion 248 is provided with a relieved section 262 between the shoulder 260 and the adjacent retainer ring 218. An annular chamber 264 is thus defined between the portion 262, the adjacent regions of the extension portion 248 and the piston 250. An inlet-outlet conduit 266 communicates with this annular chamber through a mounting block 268 and a lateral aperture 270 provided in the sidewall of housing 184, aperture 270 being aligned with the space between shoulder 260 and the adjacent retainer ring 218 in order that abutment of the piston 250 with the shoulder 260 will not close off communication with the conduit 266.

The piston 250 is biased toward the shoulder 260 by a compression spring 272 which is confined between a shoulder 274 generated on the piston and a nut 276 which is turned onto the threaded end section 278 of extension portion 248. The piston 250 is provided with a counterbored cavity 280 for purposes which will appear immediately hereinafter.

At the opposite end of the pneumatic cylinder 136, an eyebolt 282 threadedly engages the exposed end portion of piston rod 142 to be secured in position by means of a locknut 284. The eyebolt 282 provides a convenient means for connecting the piston rod to the cable-and-pulley unit 138.

As will be appreciated, the piston rod 142 is locked against movement relative to the cylinder housing 184 when the piston 250 is disposed in the position illustrated in FIG. 18. Specifically, pneumatic pressure in the chamber 264 situates the piston 250 in the illustrated location, compressing the spring 272 and retaining the ball bearings 252 in the groove 254 and between the end section 278 and the remainder of extension portion 248. Thus, the ball bearings 252 lock the piston rod 142 to the stationary extension portion 248. When it is desired to actuate the cable-and-pulley unit 138, the pneumatic pressure in chamber 264 is exhausted through conduit 266, allowing the piston 250 to move against the shoulder 260 in response to the force stored in spring 272. As the piston 250 moves toward the shoulder 260, the cavity 280 is moved into

radial alignment with the ball bearings **252** to allow these ball bearings to escape into the cavity and out of the groove **254** thereby releasing the piston rod **142** to the action of piston **186**. The piston rod **142** may be returned to its locked position by again pressurizing the chamber **164**, the ball bearings **252** being directed into the groove **254** by a conical guide surface **286** disposed at the inner end of cavity **280**.

Referring now to FIGS. **3–8**, for a description of the stationary switching arrangements associated with the monorail guideway, the box girder unit **58**, at a normal running region, has the upper track plates **80** and **84** spaced above the lower track plates **82** and **86** by a distance A, as shown in FIG. **4**. This spacing accommodates the neutral position of the upper guide wheels **60** shown in FIG. **2** wherein all of the guide wheels reside in contact with the corresponding upper track plates. In addition, the lower track plates **82** and **86** are provided with inner edges **288** and **290** respectively which are elevated slightly above the corresponding outer edges at the flanges **130**. This cambering of the lower track plates promotes even tracking of the main drive wheels during transit of the bogies through the guideway.

The guideway section illustrated in FIGS. **3–8** is that section of the switching station in which the bogies are readied to negotiate a divergence or convergence of the vehicle routes; and the first guideway transformation in the guideway configuration comprises a gradual increase of the spacing between the upper and lower track plates to the dimension B shown in FIG. **5**. This increase in the spacing between the upper and lower track plates allows rotation of the upper guide wheel shaft **62** so as to lower either the port or starboard upper guide wheels while raising the opposite upper guide wheels in the manner illustrated generally in FIG. **9**. It is also advantageous to reduce gradually the camber of the lower track plates **82** and **86** as the spacing between the lower and upper track plates is gradually increased.

The next transformation of the guideway includes the initiation of a pair of pendent inboard flanges or guide wall members **292** and **294** from the ceiling of the guideway as is shown in FIG. **6**. These flanges cooperate with corresponding outboard flanges or guide wall members **296** and **298** and with the upper track plates **80** and **84** to define a pair of downwardly opening slots or channels **300** and **302** respectively. These slots or channels capture and retain the elevated set of upper guide wheels as is shown in FIG. **9**. With the appearance of the flanges **292** and **294**, the camber of lower track plates **82** and **86** continues to recede, and these occurrences are accompanied by the initiation of the first pendent cam blade **304** which is secured to the lower track plate **86** as is shown in FIGS. **3** and **6**. With reference to FIG. **3**, the cam blade **304** curves from a generally outboard position **306** to a more inboard position **308**. Furthermore, the cam blade **304** cooperates with a second cam blade **310** in defining the stationary members of the fail-safe guidance arrangement. Like the cam blade **304**, the cam blade **310** curves from a generally outboard position **312** to a more generally inboard position **314**. The cam blades **304** and **310** are advantageously arranged as constant acceleration cams. The cam blades **304** and **310** coact with the roller assemblies **172** in a manner to be described more fully hereinafter with reference to FIGS. **13–15**, **20** and **23–25**.

The arrangement shown in FIG. **7** illustrates the final transition before the guideway **32** develops a switching gap or enlargement of the space between the lower track plates **82** and **86**. At this juncture, a port side lower steering blade **316** has appeared, and the camber of the lower track plates **82** and **86** has been completely eliminated. A short distance downstream from this point, a starboard lower steering blade **318** appears, steering blades **316** and **318** being secured respectively to the inner edges of lower track plates **86** and **82** and having respective laterally outwardly facing steering surfaces. As will be seen in FIG. **13**, the steering blades **316** and **318** continue through the switching section until such point as the switching maneuver has been accomplished.

In accordance with the present invention, means are provided for insuring a continuous supply of electric power to the bogie assemblies during transit through a switching section. Specifically and with reference to FIGS. **16** and **17**, electricity is normally supplied to the bogie assemblies from the overhead electric power bus arrangement **64** which is mounted in the ceiling of the guideway **32** at ordinary running sections of the guideway. A power pickup **320** is mounted on the main frame **56** of fore bogie **50***a* by means of a mounting plate **322** and a suitable number of coil springs **324**, springs **324** urging a collector carriage **326** upwardly toward the power bus arrangement **64**. The bus arrangement **64** includes three power conductors **328** which terminate in pendent, conductive channels **330**. Cooperatively, the collector carriage **326** includes three upstanding collector bars **332** which ride in the channels **330** in sliding contact with the walls of the channels in order to lead power through a cable **334** to the motor **100** and other electrically operated components of the bogie. The conductors **328** are housed in an insulating block **336** and receive power from respective lines **338**. In addition, the collector carriage **326** includes insulative side guides **340** and inboard insulative bars **342**.

In order to avoid unduly complicated electrical arrangements at the cross-over region of a switching station and in order to insure continuity of electrical supply, the guideway **32** is provided with oppositely disposed, electrically insulative sidewall panels **344** at the switching section; and a laterally disposed power bus arrangement **346** is mounted to each of the panels **344** to supply power to the bogie during transit through the cross-over region. Each power bus arrangement **346** includes three vertically spaced, horizontally disposed rectangular conductors **348**, and each conductor **348** is supplied with current through a cable **350**. A pair of power collectors **352** are laterally swingably mounted to an extension portion **354** of the main frame **56** for taking power off of a lateral bus arrangement **346**, and it will be appreciated that two such collectors are provided in order that suitable electric circuits may be completed regardless of whether the bogie is in the left-hand turn or right-hand turn condition. Each of the collectors **352** comprises an insulative panel **356** to which there are affixed three pairs of conductive brushes **358**. Each brush **358** makes sliding

electrical contact with the conductors **348**, and suitable electrical connections are accomplished by means of cables **360**.

It has proved advantageous to mount the collectors **352** so that they may be moved laterally to the proper position during transit through a switching section. It has also proved desirable to provide for positioning of the collectors **352** in coordinated fashion with the upper guide wheels **60** and the lower guide wheels **180**. With reference now to FIGS. **21** and **22** and with particular reference first to FIG. **21**, each of the insulative panels **356** is mounted to a triangular cage **362** which is itself swingably mounted to the extension **354** by two horizontal links **364** and a pair of pivot pins **366** and **368**, pivot pin **368** being a common connection for the links **364** at the frame extension **354**. The cages **362** are biased in the generally forward direction by means of tension springs **370** which are connected between the cages and respective flanges **372** extending laterally from the main frame **56**. Powered control of the motion of the cages **362** and therefore the brushes **358** is accomplished by means of horizontally reciprocal links **374** which are swingably mounted to the cages by pins **376** and which are joined to generally vertically disposed links, indicated in FIG. **22** by the reference numeral **378**, by means of ball-and-socket units **380**.

Continuing with reference to FIG. **22**, the links **378** are both journalled on a horizontal shaft **382** and carry cam rollers **384** at their upper ends. The shaft **382** is supported between a pair of upwardly inclined arms **386** which are affixed to the main frame **56**, and a tension spring **388** biases each cam roller **384** into engagement with a corresponding cam **390**, the cams **390** being rigidly secured to the upper guide wheel shaft **62** for actuation by means of the cylinder **136** and the cable-and-pulley unit **138**.

It is contemplated that the overhead power bus arrangement may be eliminated entirely and the lateral power bus arrangements be relied on exclusively for power collection. In the latter instance, the described means for repositioning the brush cages **362** ensures a synchronized break-before-make action of power collection from one side of the guideway to the other during negotiation of a switch.

As described hereinabove with reference to FIG. **2**, all of the upper guide wheels **60** are pre-loaded against the guideway ceiling when operating in their neutral or normal running conditions. This pre-loading permits the upper guide wheels to provide rotational and pitch restraint for the vehicle; and in addition, the lateral friction between these wheels and the guideway ceiling provides a yaw restraint. As described with reference to FIG. **2**, all four of the upper guide wheels **60** are positioned in rollable contact with the guideway ceiling in this normal running condition, pre-loading of these upper guide wheels being accomplished by proper selection of the distance between the lower track plates and the upper track plates, that is, the dimension A illustrated in FIG. **4**. The dimension A is selected so that, upon full inflation of the pneumatic tires **132** and despite a loading of the vehicle **38** to its full capacity, the upper guide wheels are situated in forcible contact with the upper track plates **80** and **84**. This creates a moderate lateral distension of the tires **132** as is shown in FIG. **12**.

Continuing with reference to FIG. **12**, the tires **132** are mounted on wheel rims **392** and **394**, the rim **394** being provided with a flange which is formed into a driven pulley **396**. The rim of pulley **396** is appropriately grooved to receive the drive belts **106**.

In order to mount the wheel rims **392** and **394** to the main frame **56**, bearing assemblies **398** are rigidly affixed to the main frame; and hub units **400** are secured on the rotatable outer member of the respective bearing assemblies. Each hub unit **400** includes a hemispherical body **402** which abuts the edge of a central aperture **404** in the wheel rim, each hub unit additionally including a radially outwardly extending flange **406** which is drilled to pass mounting bolts **408**. Bolts **408** extend slidably through appropriately sized apertures in the wall of the wheel rim to receive mounting nuts **410** on their threaded ends. The bolts **408** and the nuts **410** may also be employed in mounting the safety wheels **134** as is suggested in the left-hand portion of the figure. In addition, the flanges **406** advantageously terminate in collars or drums **412** which cooperate with shoes **414** of conventional automotive type brakes.

In compliance with the features of the present invention, the lower guide roller assemblies **172** are constructed so as to unlock the pneumatic cylinder **136** in an equipment failure situation, this being done so that the cam rollers **182** may cooperate with the fail-safe cam arms **304** and **310** in effectuating proper route selection. More specifically, motion in the connection between the lower guide wheel arm **176** and the cam roller yoke **178** is sensed electrically, and the resultant signal is used to trip the lock of cylinder **136**.

With reference to FIG. **20**, a slip ring switch **416** is configurated to trip on relative motion between the arm **176** and the yoke **178**, the yoke **178** being centered on the arm **176** by opposed tension springs **415**. Turning for the moment to FIGS. **23** and **24**, the switch **416** includes a top switch plate **418** which is fabricated from an electrically conductive material, such as stainless steel, and which is attached to a bracket portion of the lower guide wheel arm **176**. An insulator **422** is advantageously disposed between the plate **418** and the bracket portion **420** to prevent electrical contact. In addition, a pair of electrically insulative inserts **424** are situated in spaced recesses formed in the top plate **418** to define a conductive track **426** therebetween as is best seen in FIG. **24**. A bracket portion **428** of the yoke **178** secures a switch housing **430** in horizontal alignment with the top plate **418**; and a switch pin **432** is slidably mounted in the housing **430** to be urged into mechanical and electrical contact with the conductive edge of top switch plate **418** by a compression spring **434**.

Cooperatively disposed with respect to the top switch plate **418** and arranged for movement with the cam roller yoke **178** is a bottom switch plate **436** which is mounted to the yoke **178** by suitable means such as screws, not shown, a bottom switch insulator **438** being disposed between the bottom switch plate **436** and the yoke in order to provide electrical insulation. The bottom switch plate **436** carries a generally boomerang-shaped spring **440** which is fabricated from an electrically conductive spring material such as beryllium copper and which carries a contact element **442** in biased engagement with the underside of top switch

plate **418**. So situated, the contact **442** is able to complete a circuit from the conductive channel **426** to a switch pin **444** contained in a switch housing **446** through a conductive insert **448** and a pair of rivets **450** which mount the boomerang-shaped spring **440** to the bottom switch plate **436**. As with the case of switch pin **432**, the switch pin **434** is biased toward the corresponding switch plate by means of a compression spring **452**. Cables **454** and **456** complete an electrical control circuit which serves to exhaust the chamber **264** of pneumatic jack **136** through a normally closed, solenoid-operated valve upon breaking of the associated circuit through contact **442** being displaced from conductive channel **426** and onto either of the insulative inserts **424**.

Having thus described one construction of the invention, it is important now to state how the illustrated embodiment operates in both its normal running mode and the failure situation.

The normal running configuration of the bogies **50** and the guideway **32** is illustrated generally in FIGS. **2** and **4**; and these configurations appear at portions of the guideway not actually comprising a switching station, an approach to a switching station, or a departure from a switching station. In this normal running mode, the vehicle **38** is supported from both the port and starboard main drive wheels of each bogie assembly; and the upper guide wheels **60** are urged uniformly into forcible engagement with the upper track plates, the upper guide wheels being carried in the level or neutral condition by the pneumatic cylinder **136** which is locked in this configuration. As described hereinabove, forcing of the upper guide wheels into contact with the upper track plates preloads the pneumatic tires **132** and promotes stability in vehicular transit. The camber of the lower track plates **82** and **86** cooperates in promoting this stability.

In this normal operating mode, the energy for the propulsion motors **100** and **102**, as well as that for other electrical components, is collected from the overhead power bus arrangement **64**. Furthermore, the lower guide wheels **180** are situated in the neutral condition aligned longitudinally of the coupled bogies **50***a* and **50***b* as is shown in FIG. **11**. Lateral restraint in this transportation mode is accomplished by the paired lower wheels **124** and the paired upper wheels **118**. At the entrance or approach to a switching station, an information signal is received in the control circuitry for the vehicle propulsion arrangement; and this signal is timed to coincide generally with the beginning of the first order alteration of the guideway configuration (illustrated in FIG. **5**). This information signal is used to unlock the pneumatic cylinder through control of the pressure in chamber **264** and contains the sense information indicating which of the routes immediately ahead has been selected for travel. The information signal is also used to actuate the pneumatic cylinder **136** for raising the selected upper guide wheels **60** and rotating the lower guide roller assemblies **172** through the cable-and-pulley unit **138**. This rotation of the assemblies **172** situates the lower guide rollers **180** so that they will operate outboard of the selected route steering blade **316** or **318** (as is suggested in FIG. **13** in broken outline). Such relative motion between the lower guide roller arm **176** and the cam roller yoke **178** as is experienced during this rotation has no effect on the various guidance activities since the pneumatic cylinder **136** has previously been unlocked by the information signal.

Second and third order alterations of the guideway configuration are shown respectively in FIGS. **6** and **7** where the guide rollers selected for guidance activity will have been captured by one of the pendent plates **292** and **294**; and the lower guide wheels **180** will have been situated outboard of the corresponding steering blade **316** or **318**. In addition, the camber of the lower track plates **82** and **86** will have disappeared. As will be appreciated, in this normal, switch approach, the cam rollers **182** will have been rotated in powered fashion and will have not engaged either of the fail-safe cam blades **304** and **310**.

As the vehicle approaches the switching station and begins the actual negotiation of that region of the switching station where the track plates experience a lateral spacing wider than normal, application of power to the main drive wheels **54** will be continued; but all of the combined vehicle and passenger load will be borne by either the port or starboard wheels in accordance with the selected switching configuration. During this transitional configuration, electrical supply is supplied from one of the laterally disposed power bus arrangements **346**. Furthermore, the reaction loads on turning will be taken up by the cooperation of lower guide wheel **180** and the selected lower steering blade and by the corresponding upper guide wheels and the associated pendent blade **292** or **294**. This transitional configuration is illustrated generally in FIG. **9**.

Upon passing through the switching station, the guidance elements will be returned to the neutral configuration in reverse sequence. The vertical spacing between the upper and lower track plates will decrease; the blades **292**, **294**, **316** and **318** will disappear; the camber of the lower track plates **82** and **86** will reappear; and the pneumatic cylinder **136** will be actuated to re-situate the upper guide wheels **60** in neutral condition and will itself be locked in its neutral condition.

In the failure mode of operation, a substantially similar approach will be made to the switching section inasmuch as all of the switching gear on the guideway is static and does not change in response to the failure condition. However, the turn signalling circuitry or the pneumatic control system will have experienced a failure, and the lower guide roller assembly **172** and the upper guide wheel **60** will not have been rotated into the selected configuration prior to the fore bogie arriving at the initiation of the first fail-safe cam blade.

It is advantageous to arrange the fail-safe cam blades **304** and **310** to direct the vehicle into the mainline direction upon experiencing a system failure; and this type of predetermined vehicle direction is shown in both the left-turn switching station of FIG. **13** and the merging switching station of FIG. **14**.

Continuing with reference to FIG. **13**, by way of example, initial engagement of the cam blade **304** by the adjacent cam roller **182** will tend to rotate the yoke **178**; and because prior failure of either the electrical system not involving switch **416** or the pneumatic system will have prevented unlocking of the cylinder **136**, the lower guide wheel **180** will tend to remain in longitudinal alignment with the corresponding bogie

due to friction in the corresponding cable-and-pulley unit **138**. A resultant relative motion between the lower guide wheel arm **176** and the yoke **178** occur as is suggested in the left-hand portion of FIG. **25**. The switch contact **442** will thus be relocated onto one of the insulative inserts **424** to break the holding circuit to the pneumatic cylinder **136**, unlocking the cylinder and permitting further response of the lower guide roller assembly to the cam blades **304** and **310**. As will be appreciated, the resultant rotation of the guide roller assembly **172** will relocate the upper and lower guide wheels through the interconnection established by the cable-and-pulley unit **138**. This preselected rotation of the lower guide roller assembly **172** is shown in FIG. **14** as well as in FIG. **13**.

From the foregoing, it will be apparent that a preferred embodiment of the invention has been described with specificity. Equivalents, variations, and modifications of the principles of the invention will be apparent from the specific disclosures herein; and it is intended that the true spirit and scope of the invention be limited only as defined in the appended claims.

The invention is claimed as follows:

1. A vehicle switching arrangement comprising: overhead monorail guideway means including a first mainline upper track plate, a first lower track plate aligned beneath said upper track plate, a second upper track plate spaced laterally from said first upper track plate and having a first section paralleling said first mainline upper track plate and a second section divergent from said mainline section and cooperating to define a switch, and a second lower track plate aligned beneath said second upper track plate; and bogie means arranged for rollable transport along said guideway means, including port and starboard main wheel means rollably engaging said lower track plates, port and starboard upper guide wheel means carried by said bogie and rollably engageable with said upper track plates, and power-actuated means for forcing a selected one of said port and starboard upper guide wheel means into engagement with one of said first and second upper track plates whereby substantially the entire vehicle load is carried by the selected main wheel means during transit through said switch for establishing vehicle heading.

2. A vehicle switching arrangement according to claim **1** wherein said bogie means includes fore and aft port main wheel means, fore and aft starboard main wheel means, fore and aft port upper guide wheel means, and fore and aft starboard upper guide wheel means and wherein said power-actuated means includes cable-and-pulley means interconnecting said upper guide wheel means and an actuator coupled to said cable-and-pulley means for directing coordinated movement of said upper guide wheel means.

3. A vehicle switching arrangement according to claim **2** wherein said guideway means further includes substantially vertically disposed steering blade means having laterally outwardly facing steering surfaces and wherein said bogie means further includes lower guide wheel means swingably situatable into guiding engagement with a said steering surface to cooperate in directing transit of said bogie means through said switch, said cable-and-pulley means being connected to said lower guide wheel means for actuation thereof by said actuator.

4. A vehicle switching arrangement according to claim **3** wherein said guideway means further includes substantially vertically disposed cam blade means located upstream from said switch and wherein said lower guide wheel means includes a lower guide wheel for coaction with said steering blade means and a pair of cam followers mounted respectively outboard of said lower guide wheel for engagement with said cam blade means for directing safe transit of said bogie means through said switch in the event said actuator fails to operate properly.

5. A vehicle switching arrangement according to claim **4** wherein said cam followers are cam rollers.

6. A vehicle switching arrangement according to claim **4** wherein said cam blades are constant acceleration cams.

7. A vehicle switching arrangement according to claim **1** wherein said guideway means further includes substantially vertically disposed steering blade means having laterally outwardly facing steering surfaces and wherein said bogie means further includes lower guide wheel means swingably situatable into guiding engagement with a said steering surface to cooperate in directing transit of said bogie means through said switch.

8. A vehicle switching arrangement according to claim **1** wherein said bogie means further includes coupling means interconnecting said upper guide wheel means for coordinated operation, said upper guide wheel means having a neutral position in which said upper guide wheel means reside in a common overhead planar position, said upper and lower track plates being disposed a first distance apart in normal running sections thereof and in a second, greater distance in the switch section thereof whereby to permit situation of the selected one of said port and starboard guide wheel means in engagement with a selected upper track plate and the other of said port and starboard guide wheel means away from the other of said upper track plates.

9. A vehicle switching arrangement according to claim **8** wherein said bogie means further includes guide wall means pendent from each of said upper track plates in said switch section for restraining said selected one of said guide wheel means against lateral movement.

10. A vehicle switching arrangement according to claim **1** wherein said bogie means further includes guide wall means pendent from each of said upper track plates in said switch section from restraining said selected one of said guide wheel means against lateral movement.

11. A vehicle switching arrangement according to claim **1** wherein said bogie means further includes upper and lower lateral restraint means.

12. A vehicle switching arrangement according to claim **11** wherein said guideway means further includes sidewall means and wherein said lateral restraint means comprise wheels rollably engageable with said sidewall means.

13. A vehicle switching arrangement according to claim **1** wherein said bogie means includes electric motor means drivingly connected to said main wheel means; wherein said guideway means includes electrical power bus means mounted interjacent the respective upper and lower track plates; and wherein said bogie means further includes lateral electrical power collector means engaging said power bus means.

14. A vehicle switching arrangement according to claim 13 wherein said bogie means includes power-operated means connected to said lateral electrical power collector means for moving said lateral electrical power collector means into and out of engagement with said second power bus means.

15. A vehicle switching arrangement according to claim 14 wherein the power-actuated means for said upper guide wheel means includes cable-and-pulley means interconnecting said upper guide wheel means and an actuator coupled to said cable-and-pulley means; and wherein said power-operated means includes link means connected to said lateral electrical power collector means and to said cable-and-pulley means.

16. A vehicle switching arrangement according to claim 1 wherein said bogie means includes electric motor means drivingly connected to said main wheel means; wherein said guideway means includes first electrical power bus means mounted adjacent said upper track plates in said mainline section and second electrical power bus means mounted interjacent the respective upper and lower track plates adjacent said switch; and wherein said bogie means further includes upper electrical power collector means engaging said first power bus means during normal transit and lateral electrical power collector means engaging said second power bus means during transit through said switch.

17. A vehicle switching arrangement according to claim 1 wherein said power-actuated means includes an actuator having a cylindrical housing, piston rod means extensibly and retractably disposed in said housing, abutment means fixed relative to said housing, locking piston means slidably mounted on said piston rod means, locking means acting between said abutment means, said piston rod means and said locking piston means to lock said piston rod means relative to said housing in one position, and means biasing said locking piston means away from said one position whereby to allow unlocking of said piston rod means upon failure of the fluid supply to said actuator.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,702,590 Dated November 14, 1972

Inventor(s) Robert W. Corey

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 63 and Column 2, line 13, change "and elevational view" to --end elevational view--;

Column 2, line 47, change "section" to --sectional--.

Signed and sealed this 22nd day of May 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

FORM PO-1050 (10-69)

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