United States Patent [19]

Dull

[11] **3,854,412**

[45] **Dec. 17, 1974**

[54] **SWITCH FOR USE IN A MAGNETIC SUSPENSION RAILROAD**

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[73] Assignee: **Siemens Aktiengesellschaft,** Munich, Germany

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[21] Appl. No.: **388,755**

[30] **Foreign Application Priority Data**

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Aug. 25, 1972 Germany 2241789

[52] **U.S. Cl.** ..... **104/148 MS,** 308/10
[51] **Int. Cl.** **B60m 7/00,** B61b 13/08
[58] **Field of Search** ..... 104/148 MS, 148 SS, 130; 308/10

[56] **References Cited**

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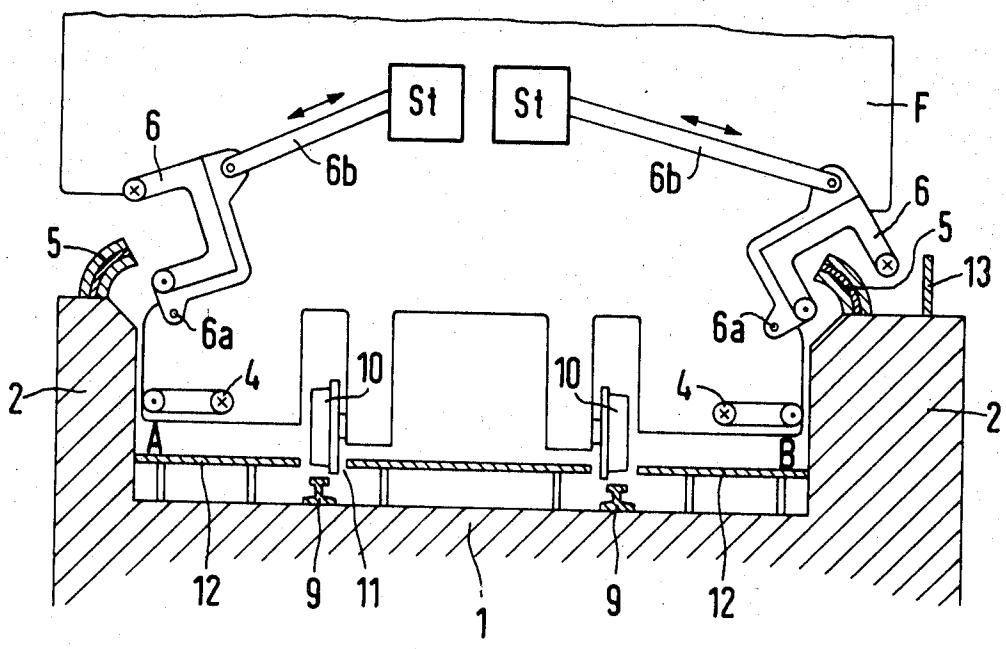
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Primary Examiner—Robert S. Ward, Jr.
Attorney, Agent, or Firm—Kenyon & Kenyon Reilly Carr & Chapin

[57] **ABSTRACT**

An improved switch for use in a magnetic suspension railroad of the type wherein primary conductor loops in a vehicle react with secondary conductor loops or conducting plates installed in the roadbed to provide support and/or guidance of the vehicle, in which, at the area of the switch, the secondary conductor loops or plates are provided only on the two outer sides of the switch and the primary current carrying loops in the vehicle are mounted so that they can be moved out of the action range of the secondary conductor loops or plates in order to select the direction of travel when the switch is encountered. In an alternate embodiment the secondary plates are adapted for movement out of the action range of the primary loops.

11 Claims, 9 Drawing Figures



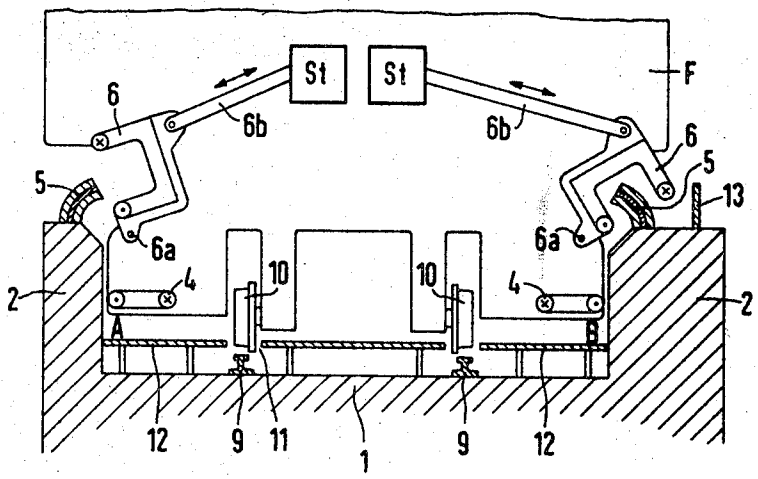

St
St
F
6
6b
6b
6
5
5
13
6a
6a
4
10
10
4
2
2
A
B
12
9
11
1
9
12

Fig.1

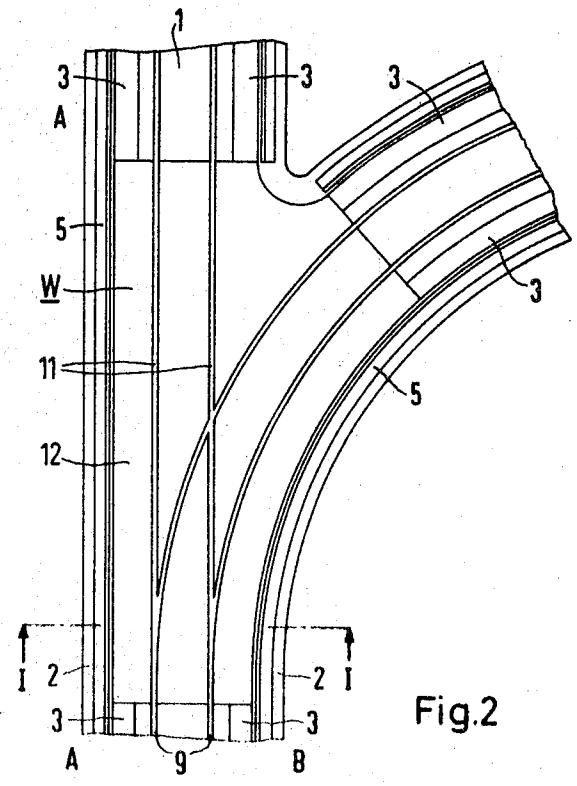

1
3
A
3
3
5
W
3
11
5
12
I
2
2
I
3
3
A
9
B

Fig.2

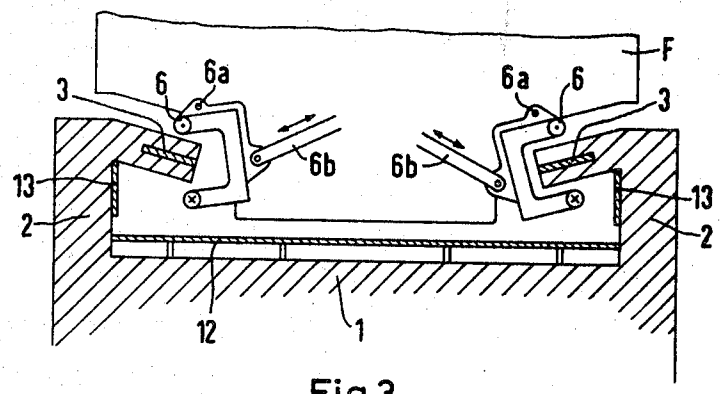


Fig.3

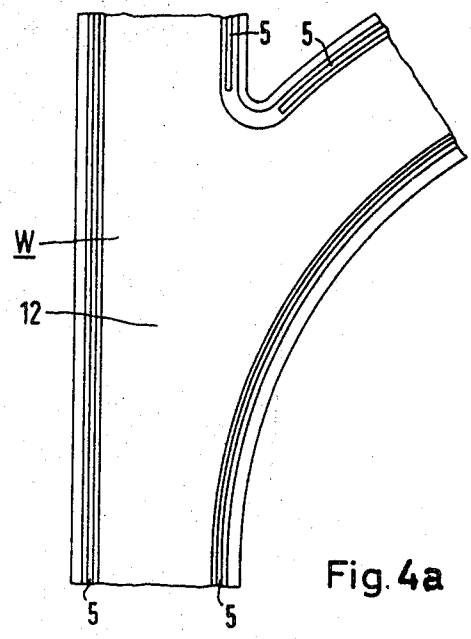


Fig. 4a

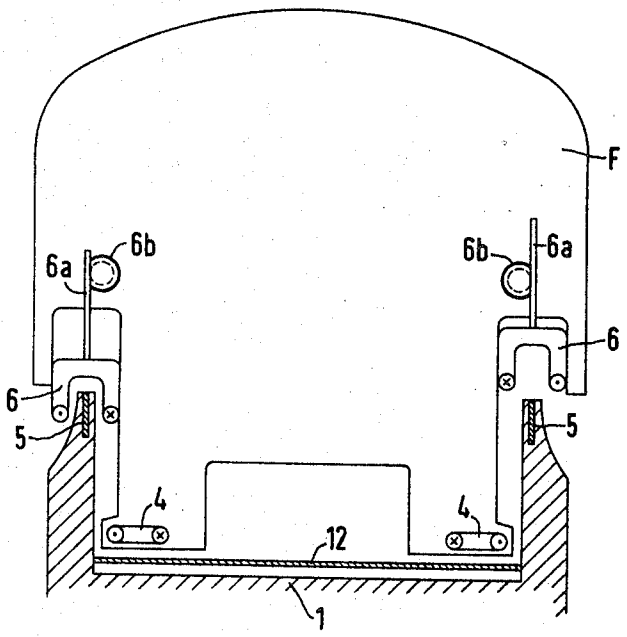


Fig. 4b

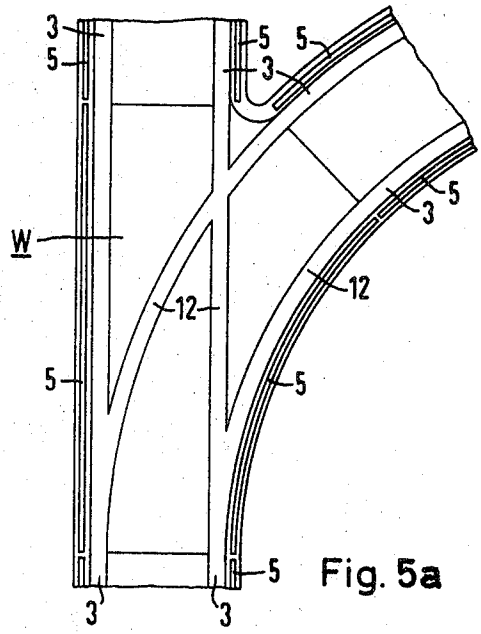


Fig. 5a

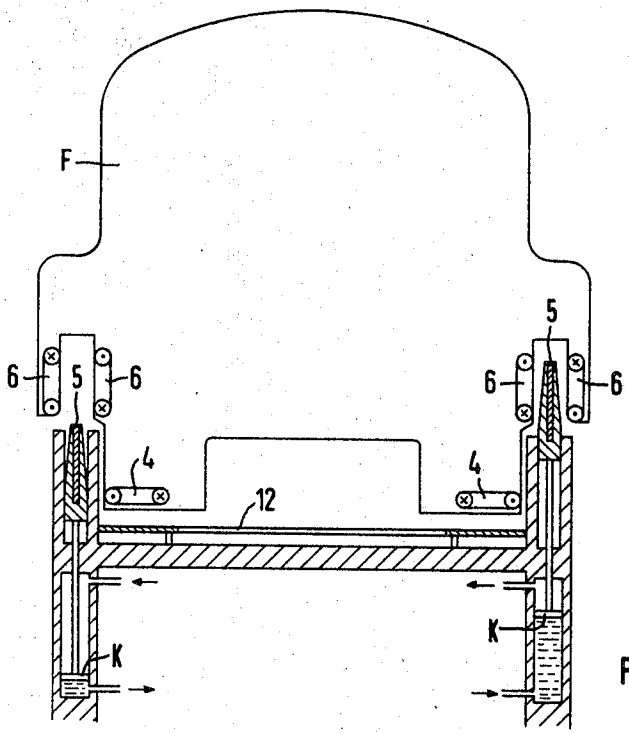


Fig. 5b

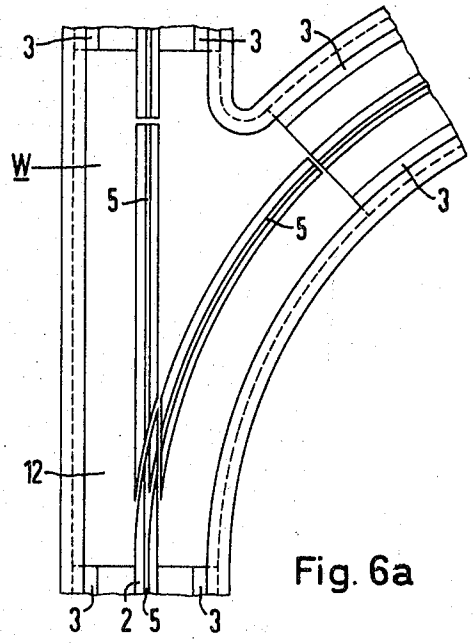


Fig. 6a

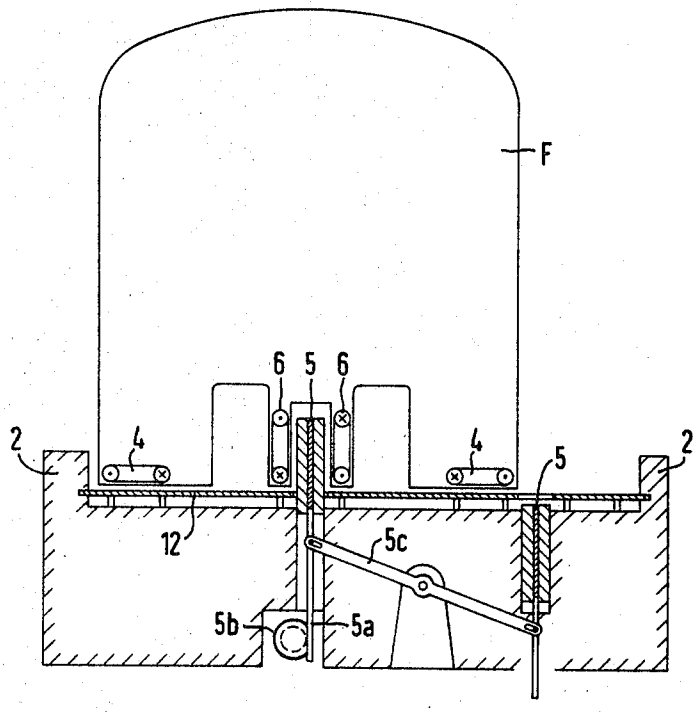


Fig. 6b

SWITCH FOR USE IN A MAGNETIC SUSPENSION RAILROAD

BACKGROUND OF THE INVENTION

This invention relates to magnetic suspension railroads in general and more particularly to an improved switching arrangement for such magnetic railroads.

In a magnetic suspension railroad, current carrying primary conductor loops are installed in the vehicle and react with secondary loop or conductor plates installed at the roadbed to support and/or guide the vehicle. One type of magnetic suspension railroad is disclosed in the article Model Paper "The Magnetplane; Guided Electromagnetic Flight" by H. Kolm and Richard D. Thornton, Massachusetts Institute of Technology, Cambridge, Massachusetts, published May 1, 1972, pp. 7 and 8. As disclosed therein a section of track about a mile long for use with a magnetic suspension railroad is mounted on sliding bearing supports to make connection with a second or third track possible. Obviously such a design is prohibitively expensive.

In German Pat. No. 707,032 a magnetic suspension railroad in which the lifting forces needed for suspension are generated by electromagnets arranged on the roof of the vehicle which cooperate with stationary steel rails on the track is shown. In this railroad, lateral guidance forces are generated by electromagnets which are arranged on both sides of the vehicle and which react with steel rails placed alongside the path. To provide switching from one track to another steel rails for lateral guidance are provided on the two outer sides in the area of the switches. To select travel direction when encountering the switch, one of the rows of electormagnets is disconnected so that the vehicle will continue, guided by the oppositely directed forces of the support system and part of the guidance system. With a design such as this the need to move a section of track is avoided. However, the current in the conductor loops of the electromganets in the vehicle must be continuously controlled by spacing control devices using converters in order to maintain a given spacing between the electromagnets and the stationary steel rails. With this manner of operation, sufficiently large attraction forces can be generated in the direction of those lateral guidance magnets which are operative during switching but only small forces may be generated in the opposite direction. Thus, guidance of the vehicle is not reliably assured in all operating situations. Thus there is a need for an improved arrangement for switching a vehicle from one track to another in such a suspension railroad. Such a switching arrangement should avoid having to move sections of track and should provide stable lateral guidance at all times, without affecting the lifting function of the suspension arrangement.

SUMMARY OF THE INVENTION

The switching arrangement of the present invention fills these needs. In the arrangement of the present invention electric conductor plates are used as the secondary reaction members which react with the primary conductor loops in the vehicle. In some embodiments the primary conductor loops are arranged so that they can be moved out of the action range of the secondary conductor plates on either side to thereby select the direction of travel. This is accomplished in one embodiment by swinging the primary conductor loop out of the way and in another by retracting it. Removal of one of the magnets or primary conductor loops on the vehicle will cause the motion of the vehicle to continue in the one or the other direction of travel depending on which was removed. In this embodiment, in the area of the switches the secondary conductor plates are installed only on the outsides of the two paths to prevent interference as the train moves through the switch from one track to the other.

In another embodiment the same principal is employed with the difference being that rather than moving the primary conductor loops, the secondary conductor loops (throughout the specification the words secondary conductor loops and plates should be considered to mean one or both) are moved in the area of the switch. Thus, again interaction occurs only between one primary conductor loop and one of the secondary conductor loops installed on the outside of either the main track or the switched track. In a further embodiment, a single central secondary conductor for guidance is installed and means provided in the area of the switch to cause either the straight or curved section of secondary conductor to be moved into the action range of the primary conductor loops of the vehicle. The result is a simple design of the switch without any moving parts thereby increasing operational reliability and permitting closer spacing of trains since the direction of travel is set in the vehicle and can readily be monitored.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross-section through the roadbed of a magnetic suspension railroad and shows a vehicle having the movable primary conductor loops of the present invention installed.

FIG. **2** is a plan view of a switch constructed according to the present invention.

FIG. **3** is a cross-section through the roadbed illustrating a vehicle having a different type of conductor loop arrangement which is used for both suspension and guidance.

FIGS. **4***a* and **4***b* illustrate an arrangement in which the primary conductor loops may be retracted out of the range of the secondary plates.

FIGS. **5***a* and **5***b* illustrate another embodiment in which the secondary loops are selectively retractable.

FIGS. **6***a* and **6***b* illustrate an embodiment with a single retractable secondary loop in the center.

BRIEF DESCRIPTION OF THE PREFERRED EMBODIMENT

On FIGS. **1** and **2** the railroad roadbed is designated by the reference numeral **1.** Supported on the roadbed on each side thereof are line conductor plates **3.** These react with current carrying loops **4** in the vehicle to create a magnetic force which suspends the vehicle F above the roadbed. The conductor plates **3** are installed only in the areas of the roadbed outside of the switch as shown on FIG. **2.** Within the switch area plates **12** shown on both FIGS. **1** and **2** are installed in their place. The plates **12** which have a larger area are required since when going through the switch the primary loops may pass over various areas of the switch. By installing a plate **12** which essentially covers the whole switch area except for the wheel openings, adequate support is maintained no matter what the posi-

tion of the vehicle within the switch. On support members **2** associated with the roadbed are conductor plates **5** which react with current carrying loops **6** in the vehicle to generate magnetic lateral guidance forces. In conventional fashion the vehicle F will be provided with a stator part (not shown) of a linear motor which co-operates with a reaction rail on the line to generate propulsion forces. Also supported on the roadbed **1** are tracks **9** which are used for the takeoff and landing of the vehicle F using retractable wheels **10.** In operation the vehicle starts out with the wheels down resting on the tracks **9.** The linear motor is switched on and the vehicle F is accelerated from a standstill running on the wheels **10.** After a given minimum speed is reached lifting forces are generated in the support system comprising the conductor plates **3** and the conductor loops **4** and lateral guidance taken over by the conductor loops **6** reacting with the conductor plates **5.** Once so suspended, the wheels **10** of the vehicle F are retracted. In the area of the switch W, the secondary conductor loops or plates **5** are provided as on straight sections of the line but only on the two outer sides, designated A and B, of the roadbed. To select the direction of travel the primary loops **6** are adapted so that they can be swung out of the action range of the secondary conductor plates on either of the two outer sides A and B. For this purpose the conductor loops **6** are pivoted at a point **6***a* and are connected through an actuating rod **6***b* to a positioning device ST. The two positioning devices ST are interlocked so that only one of the loops **6** may be retracted at one time. As shown on FIG. **1** the left-hand conductor loop is swung out of the action range of its conductor plate **5** so that the vehicle will follow the curved branch track shown on FIG. **2.** If it were desired to continue straight the lefthanded conductor loop **6** would be left in engagement with the conductor plate **5** and the righthanded conductor loop **6** swung out of the range of its associated conductor plate **5.**

To facilitate the swinging out of the loops **6,** the secondary conductor plates **5** are of an arc shaped cross-section. This type of shaped section is provided at least in the area of the switch W. In order to allow presetting of the direction of travel before reaching the switch, a section of the line ahead of the switch W should also be equipped with the conductor plates **5** curved in the arc like fashion. If desired the whole line may be equipped with conductor plates bent in this nature thereby permitting a selection of travel at any time, even before the vehicle leaves the station. In the area of the switch, an additional ferromagnetic rail **13** is provided which will interact with the primary conductor loop **6** to exert an attraction force opposing the centrifugal force.

An alternate embodiment of the invention wherein swing-out primary loops are used is illustrated by FIG. **3.** In a manner similar to the embodiment of FIG. **1,** conductor plates **3** are supported on the roadbed so they interact with primary loops **6** in the vehicle F. In this embodiment, the two conductor plates **3** are arranged at an angle to each other and the primary conductor loops **6** arranged for rotation out of the range of the conductor plates in a manner similar to that described above in connection with FIG. **1.** In this embodiment, during normal operation the interaction of the loops **6** and the conductor plates **3** provides both support and guidance. During switch operation, the conductor loop **6** which is swung out so as to not react with the conductor plate **3** reacts with the conductor plate **12** therebelow to provide a suspending force on that side of the vehicle while the remaining primary conductor loop **6** reacts with its associated conductor plate **3** to provide both guidance and support as described above. Conductor plates **13** are also installed vertically on each side of the roadbed on supports **2** for use in lateral guidance. When the primary conductor loop **6** is swung out as shown by the left hand loop on FIG. **3** it is moved away from the plate **13** so that guidance is no longer effective and co-operates, as noted above, with the conductor plates **12** to maintain suspension.

A further embodiment of the invention is illustrated by FIGS. **5**a and b which are respectively a plan view of the switch and a cross-sectional view through a section of track. In a manner similar to that described above in connection with FIG. **1,** the interaction between the primary conductor loops **4** and either the secondary plates **3** or the plate **12** provide for suspension of the vehicle. The secondary guidance plates **5** are installed on the outsides of the switch W as shown on FIG. **5**a in a manner similar to the installation on FIG. **2.** These interact with the primary conductor loops **6** to provide for guidance of the vehicle. Each of the primary conductor loops **6** is supported for vertical motion with respect to the vehicle and will have a rack gear or the like arranged on a vertical member **6***a* which engages pinion gears driven by a motor **6***b* so that the primary coils **6** may be moved up and down. As shown, when in the up position the primary coils **6** are out of the action range and guidance is maintained by the remaining primary conductor loop in the manner described above. Operation of the up and down movement of the two primary conductor loops **6** will be controlled by interlocked controllers in a manner similar to the swinging out control of the embodiment of FIG. **1.**

The same results may be obtained by making the secondary conductors **5** in a manner such that they are retractable. Such an arrangement is shown by FIGS. **5***a* and **5***b*. As in the previous embodiments the secondary plates **5** in the area of the switch are provided on the outside only. (The one, more correctly, is on the inside of the curve). As shown by FIG. **5***a* the secondary plates **5** are constructed in sections, each of which sections is mounted for vertical motion up and down as illustrated by FIG. **5***b*. Also, as shown on FIG. **5***a*, the secondary conductor plates **3** used for support are carried through the switch. As indicated the plate **12** used in the previous embodiments may equally well be used herein.

FIG. **5***b* illustrates the manner in which the secondary conductor plates **5** are supported for vertical motion. Each of the sections of plate **5** are supported in suitable bearing means within a recess in which they can move up and down. The support in which the plates are mounted has attached to it a rod coupled to a piston K. Hydraulic pumps may be used in conventional fashion to supply fluid to or remove it from the cylinders containing the pistons K to thereby move the vertical plates **5** up and down in order to select direction of travel in the area of the switch. In the position shown the secondary conductor plate **5** for the curved switch section is in the up position and the plate **5** for the straight section of track in the down position. Thus the vehicle will be directed off the straight section of track onto the curved section.

FIGS. 6*a* and 6*b* illustrate a similar embodiment in which only a single secondary conductor plate **5** is used for guidance. The support arrangement with primary loops **4** and conductor plate **3** and/or **12** is as described above. For guidance purposes only a single secondary conductor plate **5** placed in the middle of the roadbed is used. In a manner similar to that described above, guidance is provided by the interaction of the primary loops **6** with the secondary plate **5.** In the area of the switch W, the secondary plate **5** is mounted for vertical motion. Separate plates **5** are provided for the straight section and th curved section. The section **5** for the straight portion is coupled through a rack gear or the like **5***a* to a pinion gear mounted on a motor **5***b* which may be used for driving the plate **5** up and down. Also attached to the coupling between the plate **5** and the motor **5***b* is a rocker arm **5***c* having its other end connected to a member coupled to the secondary conducting plate **5** associated with the curved section of track. Thus operation of the motor **5***b* in one direction will cause the secondary conductor plate associated with the straight section of track to be moved to the up position and that associated with the curved section to the down position. Reversal of the motor to retract the secondary plate **5** for the straight section of track will cause the secondary conductor plate **5** for the curved section to be raised. Thus, by the control of these two secondary conducting plates used for guidance, the vehicle can be caused to follow either the straight or curved path depending on which of the secondary plates is in the raised position.

In the embodiment of FIGS. 6*a* and 6*b* the conductor plate **5** may be arranged in the same plane as the reaction rail which is used with the linear motor, i.e., they would be contained within the same support and arranged one atop the other. Also the plate **5** may be used as both a secondary conductor plate for guidance and as the reaction rail of the linear motor.

Thus an improved arrangement for switching a magnetically suspended vehicle from one track to another has been shown. Although specific embodiments have been illustrated and described it will be obvious to those skilled in the art that various modifications may be made without departing from the spirit of the invention which is intended to be limited solely by the appended claims.

What is claimed:

1. In a magnetic suspension railroad in which a vehicle is magnetically suspended and guided by the reaction of primary current carrying conductor loops in the vehicle with secondary conductor means installed on the roadbed, an improved switching arrangement for switching the vehicle between a straight track and a curved track comprising:

a. first secondary conductor means following a direction parallel to the direction of the straight portion of track;

b. second secondary conductor means following the path of the curved section of the track;

c. means comprising primary conductor loops installed in the vehicle arranged to react with said first and second secondary conductor means; and

d. means to selcetively provide for relative movement of said primary conductor loops with respect to said first and second secondary conductor means so that in the switch area only one secondary conductor plate is in the action range of said primary conductor loops.

2. The invention according to claim **1** wherein primary conductor loops for guidance are installed on each side of said vehicle, said first secondary conductor means comprises a conductor plate arranged along the outside of the straight section of track, said second secondary conductor plate comprises a conductor plate arranged along the inside of said curved section of track and said means to provide relative motion comprises means to selectively move the primary conductor loops on one or the other sides of said vehicle out of the range of its associated secondary conductor plate.

3. The invention according to claim **2** wherein said means to move comprise means to swing said primary conductor loops away from their associated secondary plates.

4. The invention according to claim **3** wherein at least in the area of the switch the secondary conductor plates are arc shaped.

5. The invention according to claim **4** wherein a single primary conductor loop is provided on each side for both guidance and suspension and wherein there are installed in addition to said secondary conductor means a guidance conductor plate and a support conductor plate and wherein in the operating position said primary conductor loop additionally co-operates with said guidance conductor plate and when in the retracted position co-operates with said support conductor plate.

6. The invention according to claim **2** wherein said primary conductor loops are mounted for vertical up and down motion and said means to move said primary conductor loops comprises means for retracting said loops out of the range of their associated secondary conductor plate.

7. The invention according to claim **1** wherein said means for obtaining relative motion comprise means to move said secondary conductor means in a vertical direction in and out of the range of their associated primary conductor loops.

8. The invention according to claim **7** wherein said first secondary conductor plate is arranged on the outside of said straight section of track and said second secondary conductor means on the inside of said curved section of track, each of said first and second secondary conductor plates being mounted for vertical motion and said means to provide motion comprises means to selectively raise and lower said first and second secondary conductor plates.

9. The invention according to claim **8** wherein said first secondary conductor means comprises a conductor plate arranged in the center of said straight section of track and said second secondary conductor means comprises a conductor plate in the center of said curved section of track, each of said first and second secondary conductor plates being mounted for vertical motion and wherein said means for moving comprise means for selectively extending and retracting said first and second secondary conductor means.

10. The invention according to claim **9** wherein the first and second secondary conductor plates are located in the same plane as the reaction rail of the linear motor associated with said vehicle.

11. The invention according to claim **10** wherein a single plate is used to provide the function of both secondary conductor plate and the reaction rail of the linear motor.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,854,412
DATED : December 17, 1974
INVENTOR(S) : Hans-Jürgen Düll

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

Change inventor's name from "Hans-Jurgen Dull" to --Hans-Jürgen Düll--

In column 1, line 40, change "electromganets" to --electro-magnets --.

In column 5, line 12, change "th" to --the--

In column 5, line 65, change "selcetively" to --selectively--

Signed and sealed this 29th day of April 1975.

(SEAL)
Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents
and Trademarks

UNITED STATES PATENT OFFICE

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PATENT NO. : 3,854,412
DATED : December 17, 1974
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(SEAL)
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Attesting Officer

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and Trademarks