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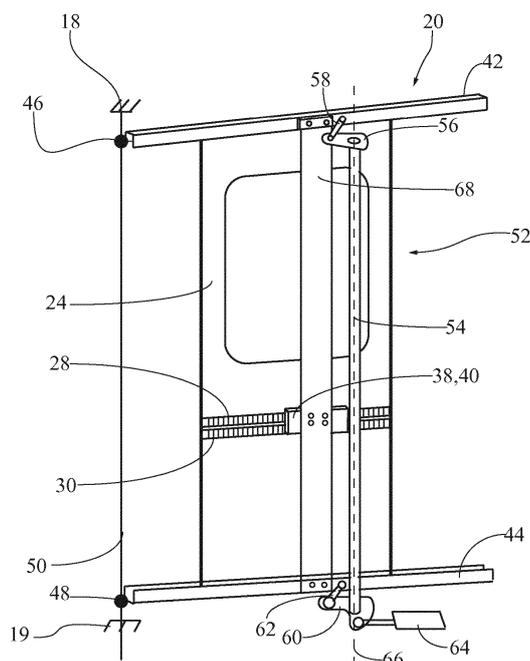
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(54) **Articulated sliding door assembly for a public transportation vehicle, in particular for a railway vehicle**

(57) An articulated sliding door assembly comprises a door leaf (24) and a guide rail assembly (20) for guiding the door leaf (24) in translation parallel to a horizontal sliding direction (100) relative to the guide rail assembly (20) between a first end position and a second end position and a linkage for guiding the guide rail assembly (20) with respect to a doorway (10) between a recessed position and a protruding position. The doorway (10) is

closed by the door leaf when the guide rail assembly (20) is in the recessed position and the door leaf is in the first end position, and open when the guide rail assembly (20,42) is in the protruding position and the door leaf is in the second end position. The linkage allows only a pivoting movement of the guide rail assembly (20) about a vertical pivot axis (50) fixed relative to the doorway (10).

Fig.1



## Description

### TECHNICAL FIELD OF THE INVENTION

[0001] This invention relates to an articulated sliding door assembly for a public transportation vehicle such as a railway vehicle.

### BACKGROUND ART

[0002] Articulated sliding doors for rail vehicles are known in a variety of embodiments, which have in common the fact that they can be moved out of the closed position by a transverse or swinging movement into a position which is ready for opening, and subsequently moved parallel to the outer wall of the vehicle into a position which clears the door opening, as illustrated e.g. in EP 0 312 450. Such movement involves complex and bulky guiding and driving systems.

[0003] There is therefore a need for an alternative guiding system that is both simpler and more compact.

### SUMMARY OF THE INVENTION

[0004] According to one aspect of the invention, there is provided an articulated sliding door assembly for closing a doorway, comprising:

- a door leaf;
- a guide rail assembly for guiding the door leaf in translation parallel to a horizontal sliding direction relative to the guide rail assembly between a first end position and a second end position;
- a linkage for guiding the guide rail assembly with respect to a doorway between a recessed position and a protruding position whereby the doorway is closed by the door leaf when the guide rail assembly is in the recessed position and the door leaf is in the first end position, and open when the guide rail assembly is in the protruding position and the door leaf is in the second end position, wherein the linkage allows only a pivoting movement of the guide rail assembly about a vertical pivot axis fixed relative to the doorway.

[0005] The guide rail assembly is particularly simple and robust, and does not require a complex and bulky linkage.

[0006] According to a preferred embodiment, the articulated sliding door assembly further comprises driving means for moving the door leaf between the first end position and the second end position, which may advantageously comprise a stationary part that is fixed relative to the guide rail assembly.

[0007] The driving means can include a rotation motor having its stator fixed relative to the guide rail assembly

and its rotor coupled to the door leaf via a transmission mechanism such as e.g. an endless belt transmission, a worm gear or a rack and pinion system.

[0008] According to a preferred embodiment, the driving means includes a linear motor, with one or more flat stators (i.e. stationary electromagnetic circuits generating a controlled magnetic field) fixed relative to the guide rail assembly and one or more rows of permanent magnets fixed relative to the door leaf, each of the rows extending horizontally substantially from one vertical edge of the door to the other and consisting of adjacent poles of alternate polarities. The resulting assembly is particularly compact. This arrangement is particularly robust since it does not involve any transmission mechanism between the driving means and the door leaf.

[0009] The permanent magnets can be individual permanent magnets. The row or rows of permanent magnets can be located at an upper and/or a lower horizontal edge of the door leaf, e.g. close to a guide rail of the guide rail assembly. According to a preferred embodiment, however, the one or more rows of permanent magnets are each located at an intermediate position below an upper horizontal edge of the door leaf and above a lower horizontal edge of the door leaf, preferably at a distance of the guide rails of the guide rail assembly, such that the guide rail assembly can be kept simple and compact.

[0010] As will be readily understood, the stators are located at the same height as the associated rows of permanent magnets, such that they do not necessitate additional space at the level of the upper guide rail assembly. Access to the stators is particularly easy for maintenance purposes. The overall concept is particularly reliable since the upper rail assembly is independent and separated from the driving means. Preferably, the one or more stators face and overlap an end of the rows of permanent magnets close to a first vertical edge of the door leaf, so as to generate an electromagnetic force in the first position. During the subsequent motion towards the second position, the rows of permanent magnets progressively move past the associated stators with a constant air gap. When the door reaches the second position, the stators face and overlap a second end of the rows of permanent magnets, close to a second vertical edge of the door leaf.

[0011] According to one embodiment, the one or more rows of permanent magnets include at least two rows of permanent magnets and each of the two rows of permanent magnets consists of adjacent poles of alternate polarities, distributed such that when the stator associated with one of the two rows faces one of the poles, the stator associated with the other of the two rows faces a space between two adjacent poles.

[0012] The linkage may further comprise a coordination linkage for coordinating a translation motion of the door leaf with respect to the guide rail assembly and a motion of the guide rail with respect to the doorway. Alternatively or additionally, an independent driving means may be provided to move the guide rail assembly be-

tween the recessed and protruding position. A return means may also be provided to return or bias the guide rail assembly towards the recessed position. The return means can be a spring or an electromagnetic device.

**[0013]** The guide rail assembly preferably comprises an upper guide rail assembly for guiding an upper edge of the door leaf. The upper guide rail assembly may consist, as is well known in the art, of a rail provided with one or more raceways on which rollers attached to the door leaf can roll. In particular, the door leaf can be at least partially or preferably fully suspended from one or more carriages rolling on one or more raceways of the upper guide rail assembly.

**[0014]** According to a preferred embodiment, the articulated sliding door assembly further comprises a lower guide rail assembly for guiding the lower edge of the door leaf. The one or more rows of permanent magnets are preferably each located above the lower guide rail assembly, such that the lower guide rail assembly can be kept simple and compact. The door leaf is preferably at least partially and preferably fully supported on rollers rolling on one or more raceways of the lower guide rail assembly.

**[0015]** In one particular embodiment, the door leaf is completely supported on the lower guide rail assembly and the upper guide rail assembly provides only lateral guidance. Still in another embodiment, the door leaf is completely suspended from the upper guide rail assembly with a lower guide rail assembly providing lateral guidance only or without lower guide rail assembly.

**[0016]** The distance between the upper guide rail assembly or lower guide rail assembly and the row or rows of permanent magnets has to be adapted to take into account rolling friction between the door leaf and the lower and/or upper guide rail assembly. In the case of a fully supported door leaf, for instance, at least one of the one or more rows of permanent magnets is preferably located closer to the lower guide rail assembly than to the upper guide rail assembly. Conversely, in the case of a fully suspended door leaf, at least one of the one or more rows of permanent magnets is preferably located closer to the upper guide rail assembly than to the lower guide rail assembly.

**[0017]** According to one embodiment, the guide rail assembly further comprises at least one vertical beam for rigidly connecting the lower and upper guide rail assemblies. The stationary part of the drive means, e.g. the flat stators in the case of a linear motor can advantageously be fixed to the vertical beam.

**[0018]** According to another aspect of the invention, there is provided an articulated double sliding door assembly comprising two articulated sliding door assemblies as described above for closing a common doorway, the two articulated sliding door assemblies having a common vertical pivot axis fixed relative to the doorway.

**[0019]** Advantageously, the two articulated sliding door assemblies can be linked by an interlock for coordinating the motion of the guide rail assemblies of the

two articulated sliding door assemblies between their recessed and their protruding positions.

**[0020]** Various embodiments of the invention can be combined at will.

**[0021]** According to another aspect of the invention, there is provided a public transportation vehicle, in particular a railway vehicle provided with a single or double articulated sliding door assembly as described above, in particular a side door for accessing the vehicle.

## DESCRIPTION OF THE FIGURES

**[0022]** Other advantages and features of the invention will become more clearly apparent from the following description of specific embodiments of the invention given as non-restrictive example only and represented in the accompanying drawings, in which:

- Fig. 1 illustrates a articulated sliding door assembly according to one embodiment of the invention, in a closed position;
- Fig. 2 illustrates the articulated sliding door assembly of Fig. 1 in a closed position;
- Fig. 3 illustrates the articulated sliding door assembly of Fig. 1 in an open position;
- Fig. 4 illustrates a section through a lower guide rail assembly of the articulated sliding door assembly of Fig. 1;
- Fig. 5 illustrates a section through an upper guide rail assembly of the articulated sliding door assembly of Fig. 1;
- Fig. 6 illustrates a coordination linkage of a variant of the embodiment of Fig. 1.

**[0023]** Corresponding reference numerals refer to the same or corresponding parts in each of the figures.

## DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

**[0024]** Referring to Figs. 1 to 5, a doorway 10 in an external side wall 12 of a railway vehicle, has two vertical sides 14, 16 and a transom 18. The doorway 10 is equipped with an articulated guide rail assembly 20, which includes an upper guide rail 42 and a lower guide rail 44. The upper guide rail 42 is connected to the transom of the doorway via an upper axial pivot connection 46. Similarly, the lower guide rail 44 has one end connected to a doorsill 19 of the doorway 10 via a lower axial pivot connection 48. The lower and upper pivot connections 46, 48 define a common vertical pivot axis 50. A coordination linkage 52 between the upper and lower guide rails includes a vertical shaft 54 provided with an

upper bell crank **56** linked to the upper guide rail **42** via a connecting rod **58**, and with a lower bell crank **60** linked to the lower guide rail **44** by means of a lower connecting rod **62**. At least one of the lower and upper bell cranks **56, 60**, in this case the lower bell crank **60**, is driven by an actuator **64**, which can be an electromechanical actuator or a pneumatic cylinder. The vertical shaft **54** rotates about a vertical axis **66** fixed relative to the wall. A vertical flat support beam **68** is attached to the upper and lower guide rails **42, 44** and supports the stators **38, 40** of a linear drive assembly, such that the stators are fixed relative to the upper and lower rails **42, 44**. As illustrated in Fig. 4, the door leaf **24** is supported on a pair of lower carriages **70** provided with rollers **72**, which roll on a horizontal rolling track **74** of the lower guide rail **44**. The upper edge of the door leaf **24**, illustrated in Fig. 5, is provided with rollers **76**, which roll on vertical tracks **78, 80** of the upper guide rail to provide lateral guidance. The door leaf **24** is provided with two rows of permanent magnets **28, 30** at an air gap distance of the stators **38, 40**. As illustrated, the rows **28, 30** of permanent magnets and the stators **38, 40** are located at intermediate position between the upper and lower rails **42, 44**, closer to the lower rail **44**.

**[0025]** The assembly operates as follows. In the recessed position in Fig. 1, the guide rails **42, 44** are in the plane of the doorway **10** closed by the door leaf **24**, which is in a first position with respect to the guide rails. The upper and lower guide rails **42, 44** can be locked to the transom and doorsill and/or to the sides of the doorway by positive locking means (not shown). The door leaf **24** is preferably also directly secured to the wall by positive locking means.

**[0026]** In order to open the door, the locking means are unlocked and the actuator drives the shaft in the clockwise direction in Fig. 2, so that the upper and lower guide rails **42, 44** rotate about the vertical pivot axis **50** together with the door leaf **24** and the stators **38, 40** to reach a semi open position in which the door leaf **24** has not yet moved relative to the upper and lower rails and **42, 44** is still in the first position. Once this motion has been completed, the stators **38, 40** are powered and move the door leaf **24** towards a second, open position.

**[0027]** In order to close the door, the operations are reversed, with the stators **38, 40** being first powered to drive the door leaf **24** back to the first position, after which the door leaf **24** and drive rails **42, 44** are moved back to the recessed position with the actuator **64**.

**[0028]** According to a variant illustrated in Fig. 6, the upper and lower bell cranks **56, 60** can be replaced with two separate levers **70**, each of which is articulated at one end with a connecting rod **72** pivotally connected to the corresponding upper or lower rail **42, 44**, the other end of each of the two levers **70** being provided with a roller **74** which directly cooperates with the door leaf **24** and is received in a cavity **76** of the door leaf **24** in the first position. This arrangement renders the actuator and vertical shaft unnecessary. To move the door from the

closed to the open position, the stators **38, 40** of the linear drive are powered to move the door leaf **24** towards the right in Fig. 10. In the very first centimetres of the sliding motion of the door leaf **24**, the rollers **74** are pushed out of engagement with the cavities **76** provided in the door leaf and start to roll on the face **78** of the door leaf **24**. Simultaneously, the levers **70** rotate about their common rotation axis **80** and push the connecting rods **72** and the upper and lower guide rails **42, 44**, which rotate about the fixed pivot axis **50**. In order to close the door, the operation is simply reversed. A spring **82** or another type of return means, e.g. an electromagnetic return means can be added to bias the rails towards the recessed position.

**[0029]** According to another variant, the articulated sliding door assembly can be provided with two symmetrical door leaves **24**, each provided with its own linear drive.

**[0030]** More generally, it may prove advantageous in all embodiment to have one row **28** of permanent magnets located in the upper half of the door leaf **24** and the other row **30** located in the lower half, or at least to have the two rows **28, 30** spaced apart from one another by a distance of more than  $1/10$  of the door leaf height. It becomes possible to control the two stators **38, 40** such as to balance the effects of resulting magnetic forces on the upper and/or lower guide rails.

**[0031]** The linear motor can be replaced with alternative driving means, e.g. a rotary motor having its output shaft directly or indirectly connected to a pinion of a rack and pinion system.

## Claims

1. An articulated sliding door assembly for closing a doorway, comprising:

- a door leaf (24);
  - a guide rail assembly (20) for guiding the door leaf (24) in translation parallel to a horizontal sliding direction (100) relative to the guide rail assembly (20) between a first end position and a second end position;
  - a linkage for guiding the guide rail assembly (20) with respect to the doorway (10) between a recessed position and a protruding position whereby the doorway (10) is closed by the door leaf when the guide rail assembly (20) is in the recessed position and the door leaf is in the first end position, and open when the guide rail assembly (20,42) is in the protruding position and the door leaf is in the second end position;
- characterised in that** the linkage allows only a pivoting movement of the guide rail assembly (20) about a vertical pivot axis (50) fixed relative to the doorway (10).

2. The articulated sliding door assembly of claim 1,

- characterised in that** it further comprises driving means for moving the door leaf between the first end position and the second end position.
3. The articulated sliding door assembly of claim 2, **characterised in that** the driving means comprise a stationary part that is fixed relative to the guide rail assembly. 5
  4. The articulated sliding door assembly of claim 3, **characterised in that** the driving means comprise a flat stator fixed relative to the guide rail assembly and one or more rows of permanent magnets fixed relative to the door leaf, each of the rows (28, 30) extending horizontally and consisting of adjacent poles of alternate polarities. 10
  5. The articulated sliding door assembly of claim 4, **characterised in that** the one or more rows (28, 30) of permanent magnets are each located at an intermediate position below an upper horizontal edge of the door leaf and above a lower horizontal edge of the door leaf. 15
  6. The articulated sliding door assembly of any one of the preceding claims, **characterised in that** the linkage further comprises a coordination linkage (70) for coordinating a translation motion of the door leaf with respect to the guide rail assembly and a motion of the guide rail with respect to the doorway. 20
  7. The articulated sliding door assembly of any one of the preceding claims, **characterised in that** it further comprises independent driving means (64) for moving the guide rail assembly between the recessed and the protruding position. 25
  8. The articulated sliding door assembly of any one of the preceding claims, **characterised in that** it further includes a return means (80) for biasing the guide rail assembly towards the recessed position. 30
  9. The articulated sliding door assembly of any one of the preceding claims, **characterised in that** the guide rail assembly (20) comprises an upper guide rail assembly (42) for guiding an upper edge of the door leaf. 35
  10. The articulated sliding door assembly of any one of the preceding claims, **characterised in that** the guide rail assembly further comprises a lower guide rail assembly (44) for guiding the lower edge of the door leaf. 40
  11. The articulated sliding door assembly of claims 9 and 10, **characterised in that** the guide rail assembly further comprises at least one vertical beam (68) for rigidly connecting the lower and upper guide rail assemblies. 45
  12. The articulated sliding door assembly of claims 2 and 11, **characterised in that** the drive means (38, 40) is fixed to vertical beam. 50
  13. An articulated double sliding door assembly comprising two articulated sliding door assemblies according to any one of the preceding claims, having a common vertical pivot axis (50) fixed relative to the doorway. 55
  14. The articulated double sliding door assembly of claim 13, **characterised in that** the two articulated sliding door assemblies are linked by an interlock for coordinating the motion of the guide rail assemblies of the two articulated sliding door assemblies between their recessed and their protruding positions.
  15. A railway vehicle provided with the articulated sliding door assembly of any one of the preceding claims.



Fig.2

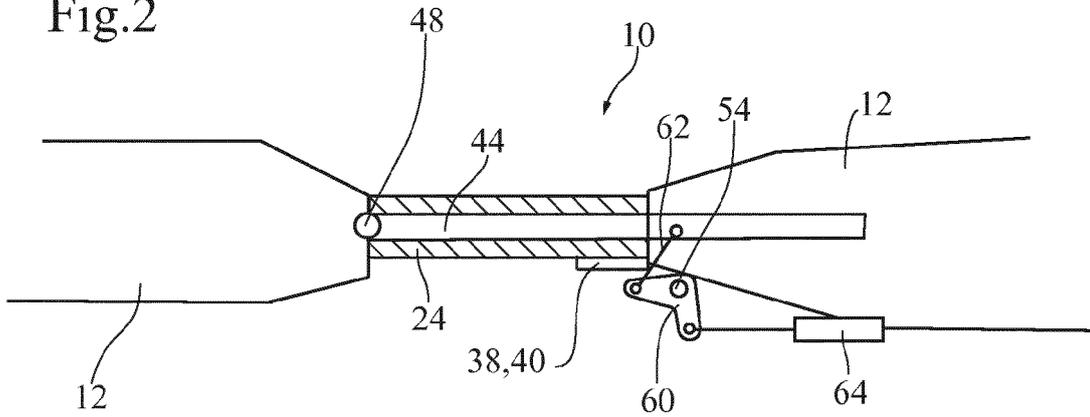


Fig.3

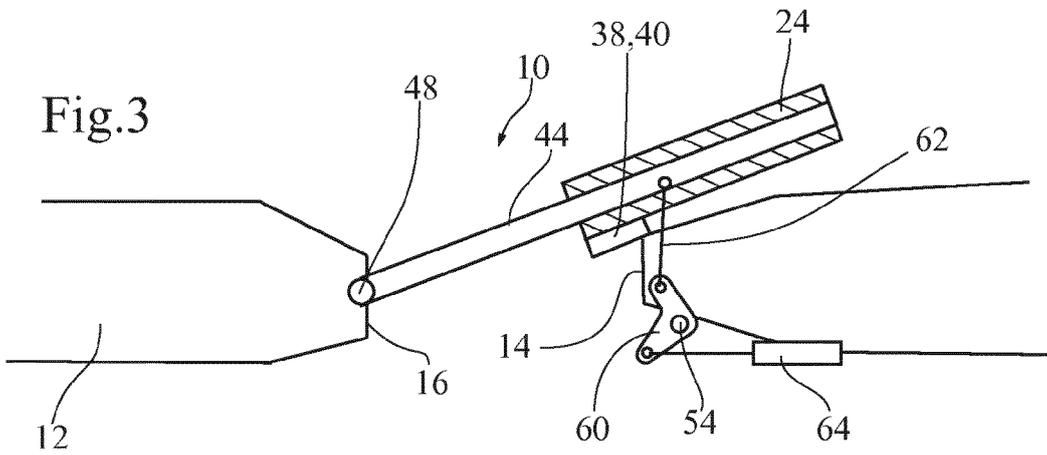


Fig.4

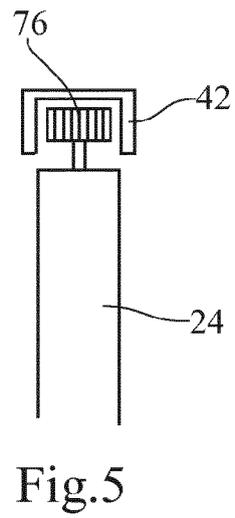
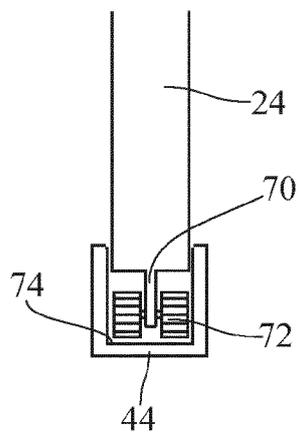
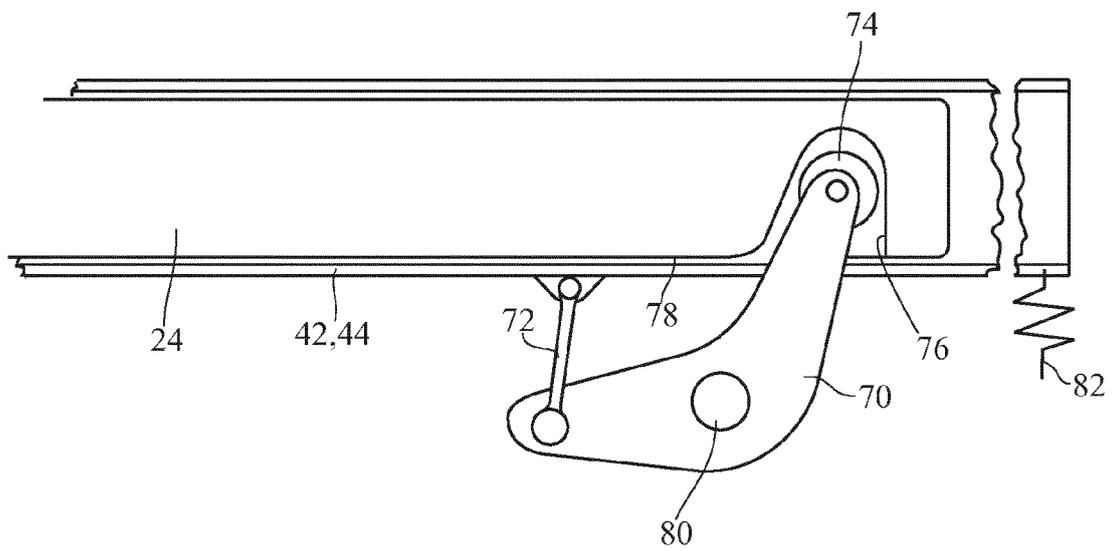


Fig.5

Fig.6





EUROPEAN SEARCH REPORT

Application Number  
EP 13 19 3211

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The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
The Hague		18 March 2014	Chlosta, Peter
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X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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**ANNEX TO THE EUROPEAN SEARCH REPORT  
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

**REFERENCES CITED IN THE DESCRIPTION**

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