Rubric 2: SCIENTIFIC AND PRACTICAL DEVELOPMENTS
Field "Transport"

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THE USE OF THE BILATERAL LEVITATION OF TRANSPORT PODS RELATIVELY TO THE ARCH TRESTLE

Background: The arch trestle allows using two working surfaces: internal (under the arch) and external (over the arch) which may be used for moving of the transport pods. Transport pods include magnetic field sources, and the trestle is equipped with a stator winding. The stator winding is subdivided into the accelerating winding and suspension and levitation winding. As an option, the winding providing levitation can be replaced with permanent magnets.

Aim: to show capacities of the arch trestle for transportation of passengers and goods.

Methods: patent search, modeling.

Results: simultaneous transportation of goods and passengers is possible both in the same and opposite directions.

Conclusion: the efficiency of the transport system increases due to bilateral movement of modules.

Keywords: arch trestle, magnetic levitation, transport pod, stator winding, magnetic field source, cargo cabin, passenger cabin.

Рубрика 2. НАУЧНЫЕ И ПРАКТИЧЕСКИЕ РАЗРАБОТКИ
Направление «Транспорт»

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ИСПОЛЬЗОВАНИЕ ДВУХСТРОННЕЙ ЛЕВИТАЦИИ ТРАНСПОРТНЫХ МОДУЛЕЙ ОТНОСИТЕЛЬНО АРОЧНОЙ ЭСТАКАДЫ

Обоснование: Арочная эстакада позволяет использовать две рабочие поверхности: внутреннюю (под аркой) и внешнюю (над аркой), которые могут быть задействованы для перемещения транспортных модулей. Транспортные модули включают в себя источники магнитного поля, а эстакада оборудуется статорной обмоткой. Статорная обмотка подразделяется на ускоряющую (propulsion) обмотку и обмотку, обеспечивающую поднятие или подвешивание (levitation) транспортных

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модулей. Как вариант, обмотка, обеспечивающая левитацию, может быть заменена постоянными магнитами.

Цель: показать возможности арочной эстакады для перевозки пассажиров и грузов.

Методы: патентный поиск, моделирование.

Результаты: возможна одновременная перевозка грузов и пассажиров как в попутном, так и противоположном направлениях.

Заключение: повышается эффективность транспортной системы за счет двухстороннего перемещения модулей.

Ключевые слова: арочная эстакада, магнитная левитация, транспортный модуль, статорная обмотка, источники магнитного поля, грузовая кабина, пассажирская кабина.

Introduction

The elevated transport systems find extended use in passenger and cargo transport. Among them there is:

maglev [1],

vacuum [2],

monorail [3],

string and other types of transport, as well as combination of constructive elements.

In many cases, when affordability of passenger and cargo transport comes in the first place followed by its massive application, i.e. in Russia’s northern regions, it is small-size elevated transport systems that can be more efficient and reliable [4]. In particular, the SkyWay test facility near Minsk, Yunitsky string transport line tests are underway, that use new infrastructure element, that is arch-type supports for rigid track structure [5]. The hanging and suspended passenger and cargo pods will be used as rolling stock. The string transport engineers consider the steel wheel-rail interaction to be one of the most significant aspects of the system’s functioning.

Unlike string technologies, the maglev technologies enable contactless movement of transport pods (vehicles) relatively to the elevated track, which excludes friction whatsoever. The air resistance is the only phenomenon left to be overcome at the speeds of more than 300 km/h.

Description of arch trestle and transport pods

The T-formed (German) and U-formed (Japan) designs of maglev systems have acquired the most widespread usage.

This paper covers possible options of development of small-size maglev systems using arch-type supports or ⋂-formed arch-type trestle [6]. The spans are commonly a rigid structure, equipped with magnetic field sources, that provide acceleration and levitation/suspension of transport pods [7].

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The arch trestle allows using two working surfaces for transport pods: the internal (under the arch) and the external (above the arch). Depending on this design, the transport pods can be either top-mounted (upper arrangement) and suspended (lower arrangement).

The main elements of the transport pod are cabin (passenger or cargo) and mover (one or several). The mover is a unit with permanent magnetic field source (PMFS) to interact with the magnetic field sources in the trestle, that provide propulsion. The mover and the cabin can be connected either directly or through mechanical joining, or by other methods.

The propulsion of the transport pod can be created by virtue of the linear electromagnetic motor, for which the trestle is equipped with the stator winding. To ensure the best magnetic force, the windings of the electromagnets can be set inclined relatively to the transport pod motion direction [8].

The sources of the trestle magnetic field that provide levitation of the transport pod can be either permanent magnets or electromagnets. In the latter case, the trestle is equipped with additional stator winding of the motion limiter [9].

"Stator–mover–cabin" and "stator–mover–propulsion–cabin" configurations

The below-presented arch trestle designs were developed by the authors of this paper, formalised with RF patent application № 2018144317 of December 14, 2018; the patent application received formal approval.

Fig. 1 shows one of the possible configurations of the arch trestle transport system with double-sided levitation of the transport pod, with the top-mounted cargo pod ("stator–mover–cabin" option) and the suspended transport pod ("stator–mover–propulsion–cabin" option), where:

1 – cargo transport pod cabin;
2 – cargo transport pod mover;
3 – cargo transport pod permanent magnet providing levitation;
4 – arch support;
5 – stator winding for levitation of cargo transport pod;
6 – stator winding of electromagnet;
7 – passenger transport pod;
8 – passenger transport pod cabin;
9 – passenger transport pod mover;
10 – connection rod;
11 – permanent magnetic field source for passenger transport pod;
12 – beam structure to accommodate mover and permanent magnetic field source for levitation of passenger transport pod;
13 – support surface.

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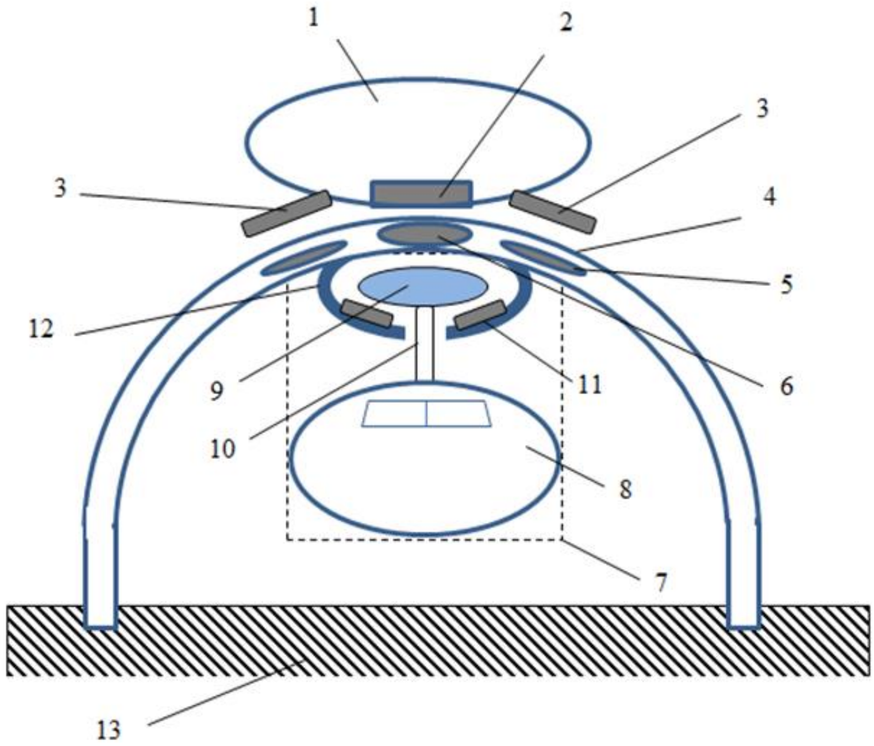

Fig. 1. Arch trestle transport system with double-sided levitation:
1 – cargo transport pod cabin; 2 – cargo transport pod mover; 3 – permanent magnetic field source of cargo transport pod providing levitation; 4 – arch trestle; 5 – stator winding for levitation of cargo transport pod; 6 – electromagnet stator winding; 7 – passenger transport pod; 8 – passenger transport pod cabin; 9 – passenger transport pod mover; 10 – connection rod; 11 – permanent magnetic field source for levitation of passenger transport pod; 12 – beam structure to accommodate mover and permanent magnetic field source for levitation passenger transport pod; 13 – support surface

In this configuration, the mover 2 of the cargo transport pod is fixed director to the cargo cabin 1, just like permanent magnetic field sources 3 that create levitation of the transport pod. The stator winding 5 for levitation is located on the left and right of the electromagnet stator winding 6, which has a dual purpose: it simultaneously gives acceleration to both the cargo (top-mounted) and passenger (suspended) transport pods.

The passenger cabin 8 and the mover 9 of the pod 7 are connected by the connection rod 10. The mover 9 is used both to provide levitation of transport pod and to propel it. Levitation is achieved when the permanent magnetic field source of the mover 9 interacts with the permanent magnets 11 located along the entire length of the trestle inside the beam structure 12. The mover 9 travels within the structure 12 under the forces of acceleration when certain coils of winding 6 are fed by the current, and thus the transport pod 7 travels with it. At the same time the cargo transport pod travels together with the mover 2. Depending on the polarity of permanent magnetic field sources in the movers 2 and 9, the top-mounted and suspended pods will travel either in same or opposite direction.

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The arch trestle maglev systems are capable of providing transportation of cargo and passenger in forest and swamp areas, as well as efficient response to snow banks and other weather conditions. Suspended cabins in these cases will be even more protected (Fig. 2).

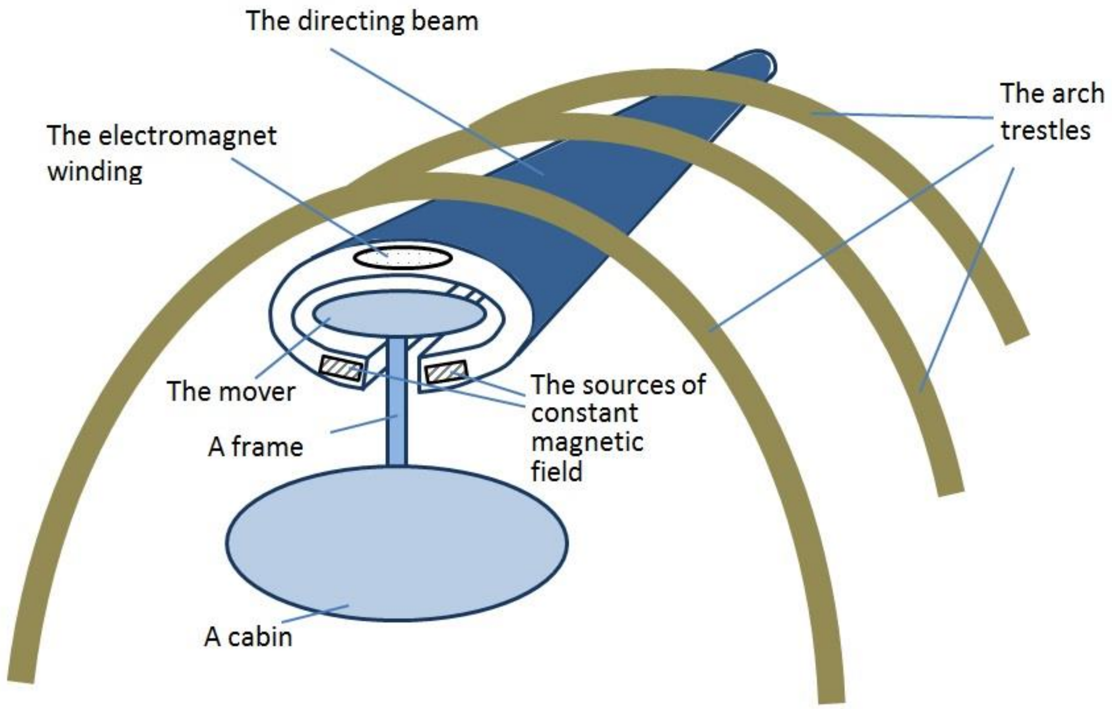

Fig. 2. Arch trestle maglev system with suspended pod

The supports and the guideway of the trestle can be made of plastic. The application of composite materials provides increase of durability and corrosion resistance of the structures [10, 11]. The weight of glass plastic makes only 20% of the similar reinforced concrete structure.

The sources of permanent magnetic field can be powerful rare earth elements magnets [12, 13].

As it was said above, the mover can accommodate the permanent magnetic field source too. It is desirable that the magnetic field of the mover should be induced, and the induction value should be set depending on the weight of the cabin and motion conditions. This function can be provided by disk-shaped cryostat, which has superconducting magnetic field source.

It is assumed that mover will be an intelligent device and, in addition to the magnetic field source, will contain a computer that determines the allowable loads, the route of travel, etc.

“Stator–mover–traveller–cabin” option

The next step in development of these transport systems can become contactless connection of the mover and the cabin, which is provided by magnetic potential pit [14], which is based on interaction of two ideally

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conducting rings. One of them will be the permanent magnetic field source of the mover (Fig. 3). We will call it traveller. In this case the guideway will be continuous beam, which will enable us to create favourable conditions for motion of the mover and stabilisation of its alignment. The traveller will repeat the motion of the mover.

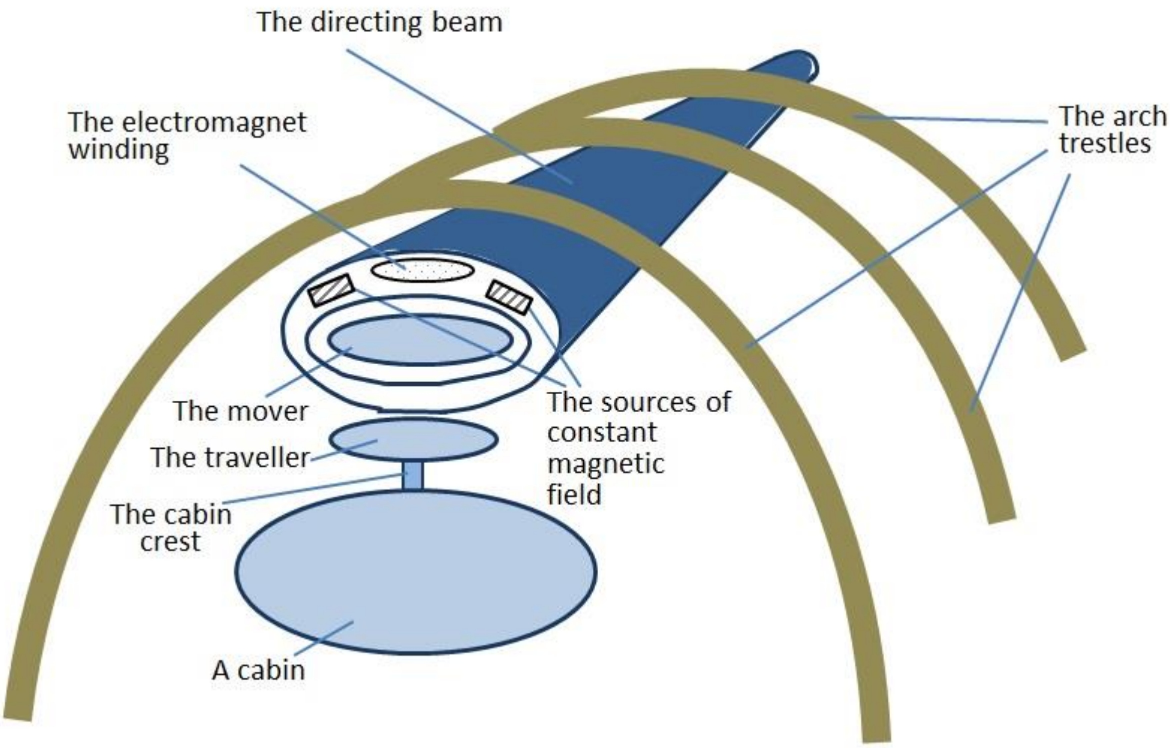

Fig. 3. Arch trestle maglev system with suspended pod and contactless between the mover and the traveller

Depending on the cabin weight and sizes, several types of travelers can be installed on it, each having its “personal” mover.

The mover located in highly rarified medium can travel at high-speed. However, the cabin travelling at high-speed will be subject to counter-airflow resulting in heating. Therefore, the speed of the cabin and the mover should not exceed the critical value of 300 km/h.

At the system’s construction stage [15], the structure of the trestle and transport pod can include safety elements to prevent possible damage, e.g. in the event of loss of the superconductivity of the permanent magnetic field source of the mover. With improvement of technology, these elements will become atavisms.

In the conditions of northern Russia, it is recommended that the enclosed arch trestle should be used [7]. In the areas without great wind loads and snow banks, it is also possible to use design options for the arch trestle proposed by the authors (see Fig. 2, 3). At the same time, the transport pods are equipped with the ridges, the height of which provides safe distance to the magnetic field sources, located in the beam structure [6].

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Conclusions

The transport systems with double-sided levitation of transport pods relatively to the arch trestle can be used for transportation of passengers and cargo with speeds up to 300 km/h, and at the same time:

– it is desirable that small-sized pods should be used;
– either passive stator winding or permanent magnets provide levitation of transport pods;
– the active stator winding interacts with the movers of transport pods;
– the ideal conditions are created for movers' motion;
– the travelers, in cased used, repeat the movers' motion;
– during construction of arch trestle maglev systems the design solutions of the innovative transport systems are used.

The authors make it expressly clear that:

1. No conflict of interests has taken or may take place;
2. The present article does not contain any researches with people as the objects involved.

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