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INFLUENCE OF BOZIC BRAKE ON DEVELOPMENT OF RAIL TRAFFIC

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Abstract *– The paper gives a brief view of development of rail traffic in the world before the invention of Serbian engineer Dobrivoje S. Bozic. At that time, undeveloped braking system of railway vehicles was a significant obstacle for further development of rail traffic. The problems that existed in braking of railway vehicles before the introduction of Bozic's innovations are analyzed. Bozic's solution and its influence on the development of pneumatic braking systems of passenger? and freight railway vehicles is described. In this invention, Bozic is the first in the world who designed, made, implemented and patented the distributor with three pressures in the brake system of railway vehicles. This innovation has significantly contributed to faster development of railway vehicles, as well as the entire rail traffic.*

Keywords – Dobrivoje Bozic, Bozic brake, braking, railway Vehicles.

1. INTRODUCTION

Invention of the steam engine in 1782 of Scottish inventor James Watt significantly contributed to the rapid development of industry, and especially traffic and transport. The development of rail transport is closely linked to the success of the first steam vehicle on the tracks, designed by the Richard Trevithick in 1804 (Fig. 1). This vehicle is hauled a certain number of laden wagons, wherein the moving speed was about 10 km/h.

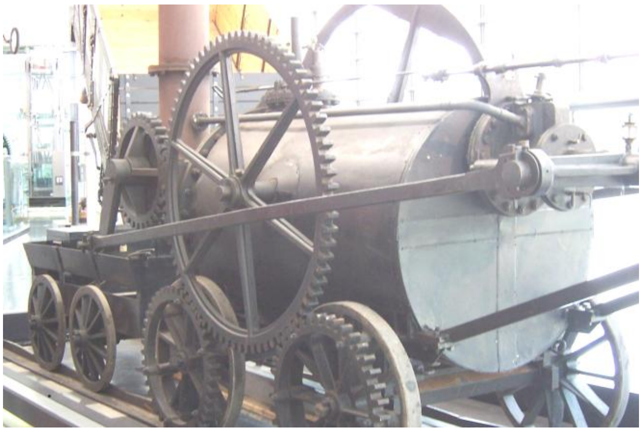

Fig.1. The first steam vehicle on the tracks, designed by the Richard Trevithick in 1804

During the 19th century, in almost all of Europe, railways changed the existing network of stagecoaches (Fig. 2).

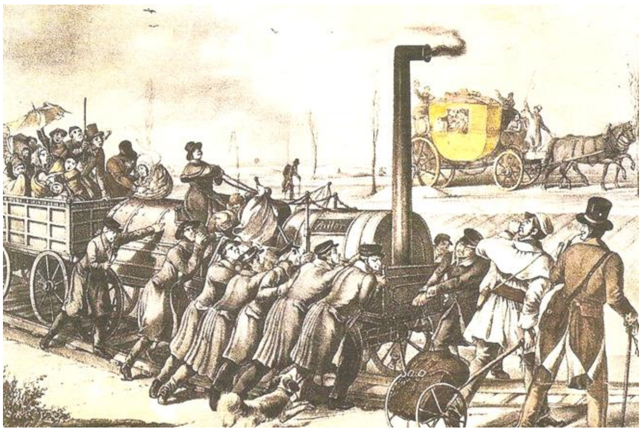

Fig.2. The stagecoaches and railway during the 19th century

The first railway line for public rail traffic was built in 1825 in England on relation Darlington – Stockton (Fig. 3). English engineer George Stephenson designed and made a first stem locomotive that was hauled 22 passenger and 12 freight wagons, apart from participating in building this railway. This locomotive was called "Locomotion" and its maximal speed was 16 km/h (Fig. 4a). Stephenson was personally driving this locomotive which was not equipped with a cabin and a place for driver (Fig. 3). Due to the significant outcomes in development, 1825 was considered as the beginning of the organized railway traffic, while the

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name "locomotive" entered into the official use.

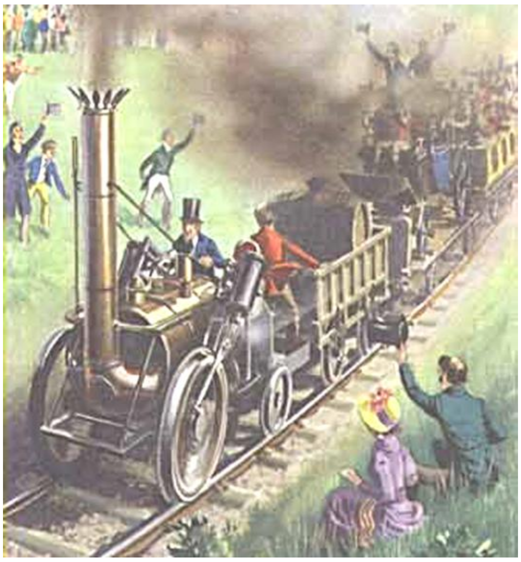
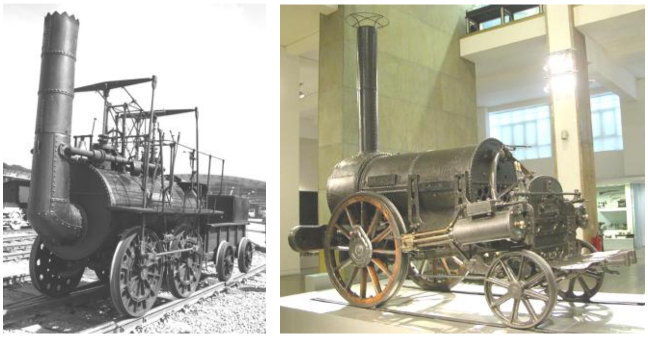


Fig.3. The beginning of the organized railway traffic in 1825

Numerous disadvantages and technological development caused that "Locomotion" very soon become outdated and unsafe. The first railway accident occurred in 1828, when a boiler of "Locomotion" exploded, and the train driver was killed.



a) "Locomotion" б) "Rocket"

Fig.4. The museum exhibits of Stephenson's locomotives

The substantial progress was achieved in 1827, when a Frenchman M. Segen invented the boiler with pipes. Two years later (1829), George Stevenson applied this invention on his famous locomotive "Rocket" (Fig. 4b), whose maximal speed was 47 km/h, which was incredible for that time.

After a certain time from development of steam locomotives, the development of electric locomotives and locomotives with internal combustion engines started. The first electric locomotives were made in Germany in 1879 and America 1880. With the advent of the diesel engine in 1897, which was designed by German inventor and engineer Rudolf Diesel, the development of diesel locomotives commenced. Although they had been designed before the diesel locomotives, electric locomotives had slower development until the end of the Second World War.

As in case of locomotives, there was race in the development of braking system of railway vehicles. After "Westinghouse" brake in America, in Germany is appeared the brake "Knorr", and in Switzerland brake "Oerlikon". While the Stephenson with his inventions enabled trains to move, Westinghouse, Knorr and others developed air brakes which had significant disadvantages until the appearance of the Serbian engineer Dobrivoje Bozic.

By signing the Congress of Berlin 1878, Serbia was pledged to build a railway line Belgrade – Nis – Vranje, that practically meant a merger of Ottoman and Austro-Hungarian empires. The railway line Belgrade – Nis was a part of a planned line Berlin – Baghdad. The completion of this line marks the beginning of the existence of Serbian Railways. The festive train passed the first Serbian railway on 4 October 1884, and after eleven days the official rail traffic on line Belgrade – Nis started.

For construction of the railway line Belgrade – Nis, Serbia contracted the so-called Bontoux concession. Immediately after the first contact with a major Western capital, one of the biggest financial scandals in Serbian history appeared. Inspired with the events of the downfall of Bontoux General Union for construction and exploitation of railways, even Emil Zola wrote the novel "Silver". In relation to this concession, prof. Slobodan Jovanovic wrote: "Spoilage of our political natures began immediately under the influence of foreign gold" [1].

2. BRAKING OF RAILWAY VEHICLES

The movement of train takes place under the influence of its total mass and different forces (traction forces, resistance forces, braking forces, etc.) (Fig. 5) [2].

Fig.5. The train movement under the influence of its total mas and forces of traction, resistance, braking, etc.

The braking system of railway vehicles has a role to slow and stop the train. The fact that even today the trains are moving faster uphill than downhill testifies about the size of technical problem of safe braking of mass of several thousand tons.

In the beginning of the development of railway vehicles, the braking force changed to manual one, after which the American entrepreneur and engineer George Westinghouse designed pneumatic brake. Despite this, until the First World War the trains braked manually in Europe.

At the conference of the winning countries of the

First World War in 1923, France submitted a proposal in which Westinghouse's brake was recommended. At the same conference, the representative of former Yugoslavia recommended the general reception of Bozic brake, as much better solution. Finally, this Bozic's patent was, after numerous tests, accepted in 1928.

Until the advent of Bozic's invention, braking of railway vehicles was performed directly (non-automatic), according to the scheme shown in Fig. 6.

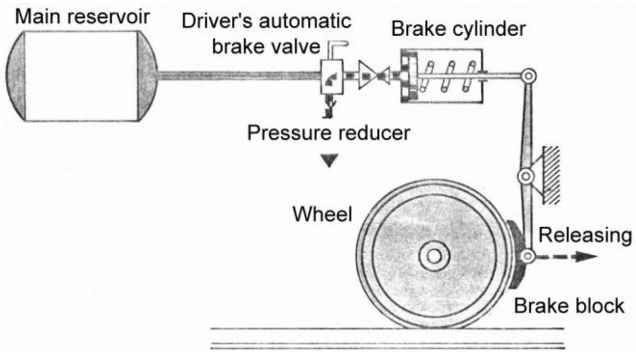


Fig.6. The direct (non-automatic – exhaustible) brake

In direct (non-automatic or exhaustible) brakes, air from the main reservoir via the air-operated equipment is arriving to the brake cylinder. These brakes have single-stage releasing, which means that once started, releasing can not be interrupted. In this case, the distributor of brake has the two distribution pressures: the main instalation – auxiliary reservoir. In these brakes, if the train is braked to any degree, as soon as the main installation is little supplemented, the brakes will fully stop with braking. At the same time, the auxiliary tank will not be completely supplemented because pressure in the main installation has not reached its maximum value. If the process of ''braking – releasing'' is repeated several times in succession, the braking force will be increasingly diminished as the pressure in the auxiliary reservoir is decreasing, i.e. the amount of compressed air is exhausted (Fig. 7).

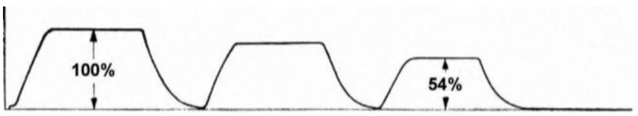


Fig.7. The exhaustible brakes – change of air pressure in brake cylinder

The big drawback of these brakes is that in the case of rupture of the train there will be no automatic braking. Beside that, at running on long downhills there is a risk that brake will not be able to provide sufficient braking force. The huge disadvantage of these brakes is that they do not have regulation of size of the braking force in relation to the mass and speed of the vehicle. Also, they do not have synchronization of braking from the first to the last vehicle, so individual vehicles were very often collided or train was ruptured.

3. CONTRIBUTION OF DOBRIVOJE BOZIC TO DEVELOPMENT OF BRAKING OF RAILWAY VEHICLES

From the previous chapters it is obvious that the biggest contributions to the development of railway gave English, French, German, and American engineers. However, the braking of railway vehicles was not resolved in an appropriate way. Further development of railway (increase of running speed and mass of railway vehicles) was not possible without solving this problem.

Dobrivoje Bozic (Fig. 8) was born on 23 December 1885 in Raska, Serbia. His invention was created in the period 1911–1914 when he worked in railway workshop in Nis. He designed and patented braking system of railway vehicles in which three pressures distributor was first applied (main installation – control cylinder – brake cylinder) [3].

Fig.8. Dobrivoje Bozic

With Bozic's distributor with three pressures (Fig. 9), the problem of gradual releasing of railway vehicles was resolved for the first time. Also, the risk of ineffectiveness of previous brakes with two pressures that, due to discharge (exhaustion) of the auxiliary tank on long downhills , do not achieve the necessary braking force, is eliminated with Bozic's solution (Fig. 10).

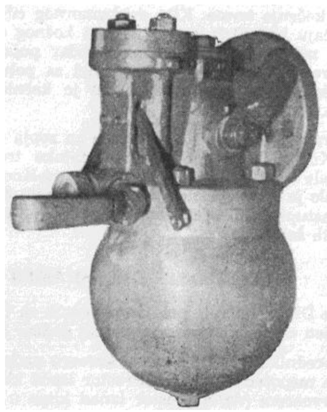


Fig.9. Bozic's distributor

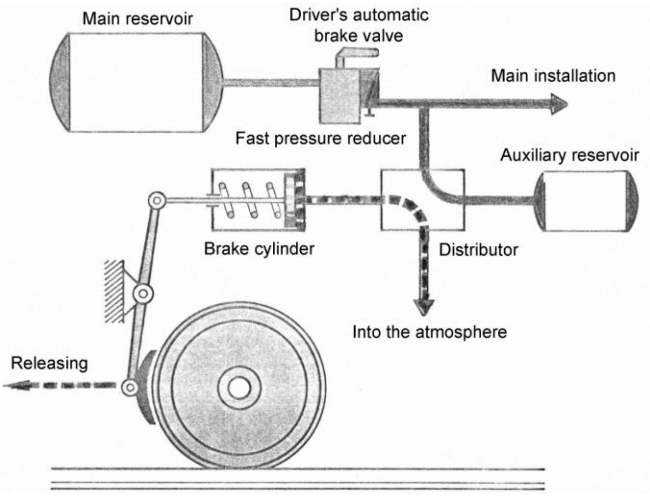


Fig.10. The working principle of indirect (automatic – exhaustible) or Bozic brake

In Bozic's brakes reducing the braking force can be performed gradually. These brakes are also called the inexhaustible, because the auxiliary tanks are being refilled for entire time of braking and releasing, so that pressure in the brake cylinder remains constant (Fig. 11).

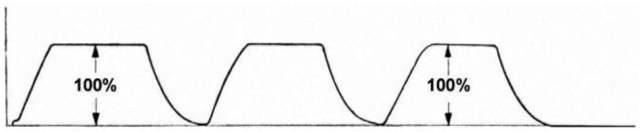


Fig.11. The inexhaustible brakes – change of air pressure in brake cylinder

Bozic's distributor was designed so that for each load of vehicle, the pressure in the brake cylinder was adjusted automatically. This is accomplished with a special beam scale device in distributor of pressure. In this way, empty or poorly loaded railway vehicles are braked with smaller force and more laden vehicles with greater force. It is important to note that in that time other countries were developing the brakes with two braking cylinders. In the case of empty wagon, only the one brake cylinder is in function.

Because of its interest, large companies tried to criticize Bozic's patent through their representatives, but all subsequent constructions of braking system were based on his simpler, safer and cheaper solution. The three Bozic's pressures are used even today.

In addition to the previously implemented and internationally accepted patents, Bozic designed and proposed a device based on the principle of centrifugal regulator which, at low speeds of the train, bring down the pressure in the brake cylinder on the appropriate measure. This would prevent blocking of the wheels at braking, and therefore the formation of so-called flat spots on the wheels of railway vehicles. This proposal would enabled problem solution of change of the braking force depending on the running speed of railway vehicles.

Although in this manner the braking distance of railway vehicles is significantly reduced, Bozic's proposal had not been accepted at that time. The main reason for that is probably because at that time there was not enough knowledge about the theory of contact of two rounded bodies. The science and engineering practice explained and accepted this Bozic's stance until many years later, and today it is in the application at modern railway brakes.

4. CONCLUSION

With his inventions Dobrivoje Bozic enabled safer, better and cheaper braking of railway vehicles. This has led to a further and more rapid development of rail traffic throughout the whole world. Based on all previous considerations it can be concluded that Bozic's contribution to the development of brakes of railway vehicles is at the planetary scale, and in many cases it was far ahead of time in which he had created it. With full right it can be say that Dobrivoje Bozic was the forerunner of the development of ABS braking system (Anti-lock Braking System), which is today widely used in the road vehicles.

Finally, it can be concluded that the development of rail traffic is not a mertit of one man, but it is a result of several generations of engineers and technicians from several countries. In that sense, thanks to the mechanical engineer Dobrivoje Bozic, Serbia has a very significant place. He is one of the examples of world inventor and victims in the same time, although he changed the world for the better.

ACKNOWLEDGEMENTS

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