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PROBLEM OF BRAKING AS CONDITION FOR DEVELOPMENT OF RAILWAY TRANSPORT

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Key words: *Braking, Railway Vehicles, Dobrivoje Bozic, Bozic Brake.*

Abstract: *The aim of this paper is to give information about the problems and technical achievements in the field of braking of railway vehicles. A brief description of the difficulties related to the braking of railway vehicles from the occurrence of rail traffic till today is given. From this it can be seen how engineering challenge is braking for the further development of railway transport. The main problem of further development of passenger and freight railway transport is solved by increasing the degree of automation of braking on a completely new and original way. This problem was solved by the Serbian engineer Dobrivoje Bozic from Kraljevo. Since the adoption of his solutions in 1928 to date, this principle of braking has remained unchanged. The paper gives the description of his solution, and some details from his interesting life. Bozic was the first in the world who was designed and applied completely new solution of three-pressure distributor in the braking system of railway vehicles. Its main characteristic is related to the possibility of gradual release of brakes. This solution was increased a level of automation of braking and provided a faster, safer and better quality of development of railway vehicles and the entire rail transport.*

1. INTRODUCTION

Initially, the burden was moved with the muscle power, on the arms and back, and later on a stretcher or using a hitch. Heavy objects are moved by rolling across the wood rollers (logs) (Fig. 1). The roller is in fact a forerunner of wheel which invention leads to the revolutionary transformation of land transport.

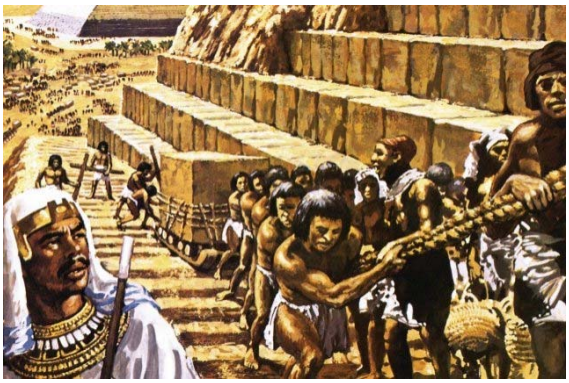


Figure 1. The transport of heavy burdens in past

The first railway line for public railway traffic was built in 1825 in England on relation Darlington – Stockton. George Stephenson (Fig 3a.) is, except of participation in construction of railway, designed and built a steam engine that was moving at an average speed of 15 km/h, which he called "Locomotion". Stephenson is personally drove this machine which was not equipped with a cabin and place for engine driver (Fig. 2). Due to the significant outcomes in development, 1825 was considered as the beginning of the organized railway traffic [1].

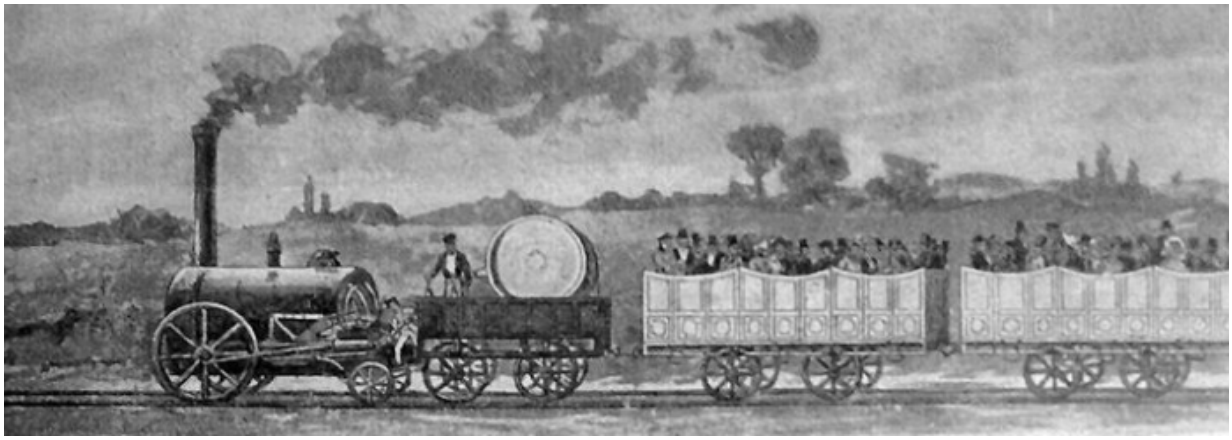
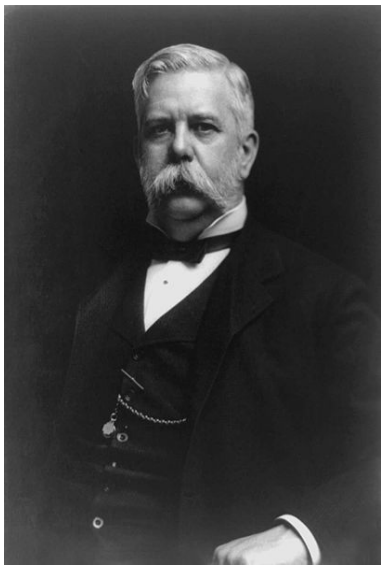


Figure 2. George Stephenson at the opening of regular rail traffic

2. DEVELOPMENT OF BRAKING OF RAILWAY VEHICLES

The limiting factor for further, even more rapid development of rail traffic was the unsolved problem of braking, which is in the 19th century performed manually. Even Stephenson was not satisfied with the manual braking and from the beginning of rail traffic, all his knowledge and time were dedicated to the creation of an automatic braking system. In this aim, he connected the braking rods with buffers. When buffers are compressed, the braking rods are pressed the brake shoes on the wheels. Although interesting and simply solution, this brake has not been possible to automate, so this idea was abandoned.

a) George Stephenson



b) George Westinghouse

Figure 3. The creditable inventors for development of rail traffic and brakes

In the late nineteenth century, George Westinghouse (Fig. 3b) begins with the tests of air brake in America. It was about brakes with direct action (Fig. 4). During the braking, air is

coming into the main installation, while in the released position the atmospheric pressure is in the same installation.

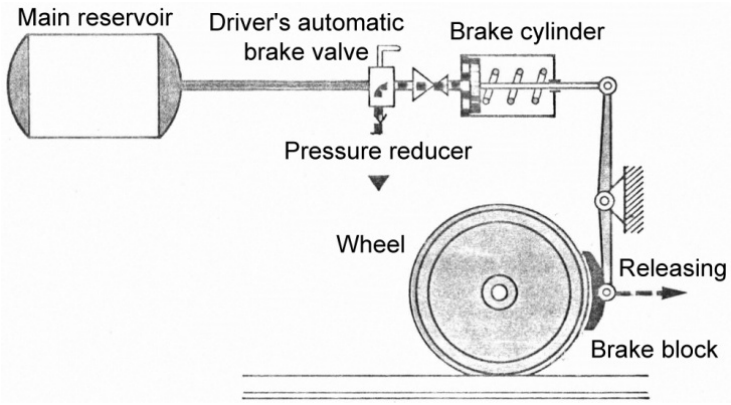


Figure 4. The direct (non-automatic – exhaustible) brake

These brakes have single-stage releasing which means that once started releasing cannot be interrupted. In this case, the distributor of brake has the two distribution pressures: the main installation – auxiliary reservoir. In these exhaustible brakes, if the train is braked to any degree, as soon as the main installation is little supplemented, the brakes will be fully released. 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. 5 and 6). So, there was a great danger that after the repeated braking, total force on the braking shoes will not be enough to stop a train [2].

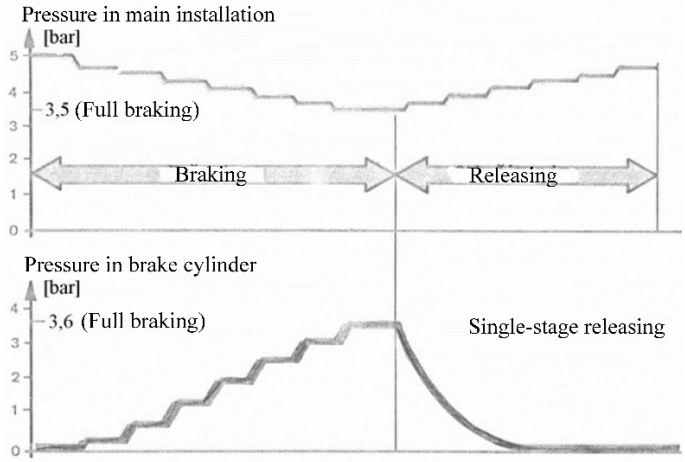


Figure 5. The change of pressure in main installation at braking and releasing of exhaustible brakes

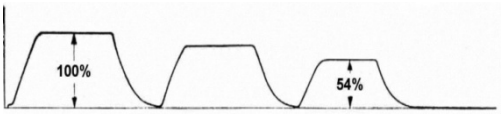


Figure 6. The exhaustible brakes – change of air pressure in brake cylinder

While Watt, Stephenson and other inventors with their inventions enabled trains to move, Westinghouse, Knorr, and many others, developed brakes of railway vehicles which had enormous disadvantages until the appearance of solution of Serbian inventor Dobrivoje Bozic [4]. The main disadvantages are reflected in the following: in the case of rupture of the train, there was not automatic braking of wagons; at running on long downhills there is a risk that brake will be exhausted; there was not regulation of size of the braking force in relation to the degree of loading of the train; there was not regulation of size of the braking force in relation to the running speed; brake transmission speed was a small (maximally 70 m/s). These deficiencies hampered the use of the railway on a larger scale, while there have been

frequent accidents and delays. Due to the blocking of the wheels, forming of wheel flats was particularly expressed as well as damages of the track.

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. 7) 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].

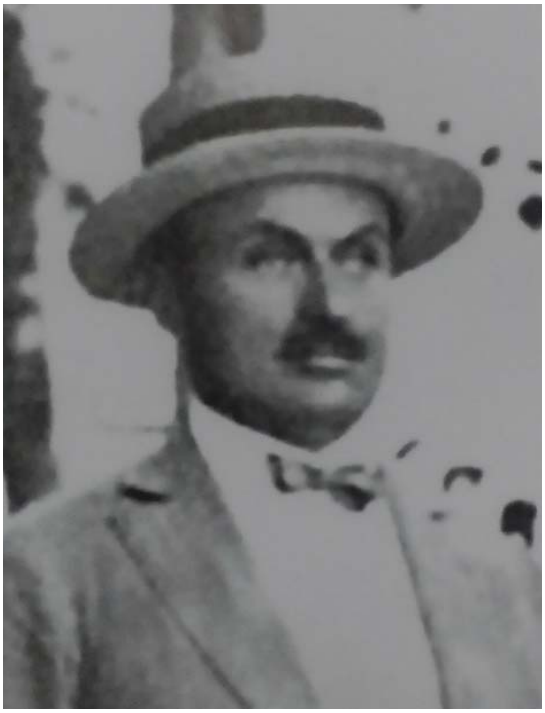


Figure 7. Dobrivoje Bozic

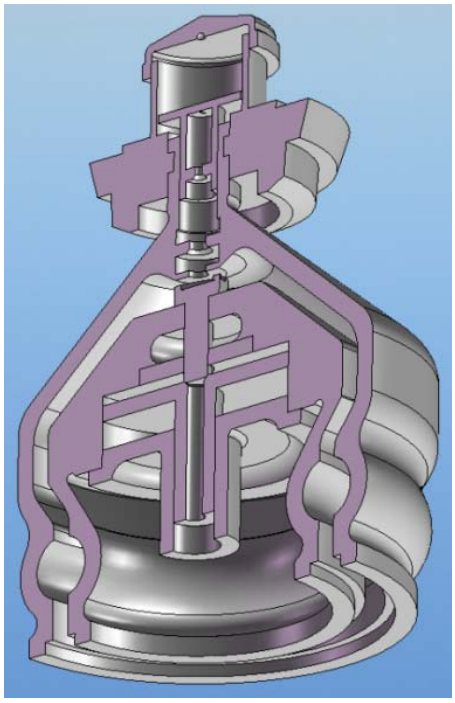


Figure 8. The cross section of Bozic's distributor

With Bozic's distributor with three pressures (Fig. 8), 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 of the auxiliary tank on long downhills, do not achieve the necessary braking force, is eliminated with Bozic's solution (Fig. 9).

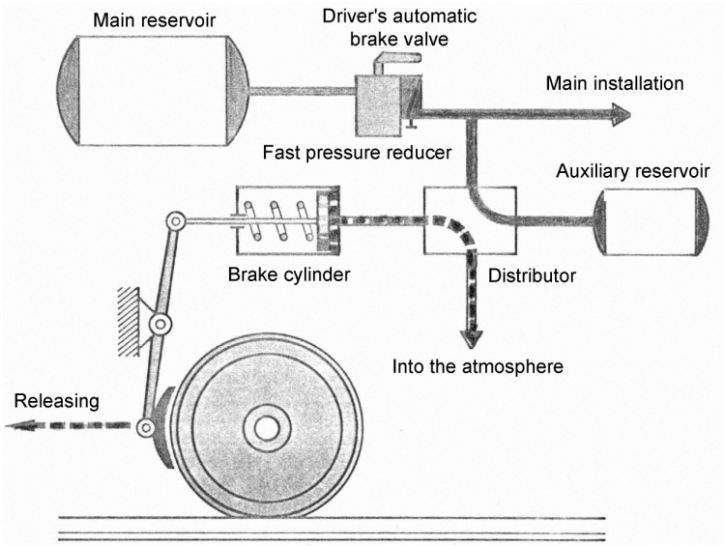


Figure 9. The working principle of indirect (automatic – exhaustible) or Bozic brake

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. 10).

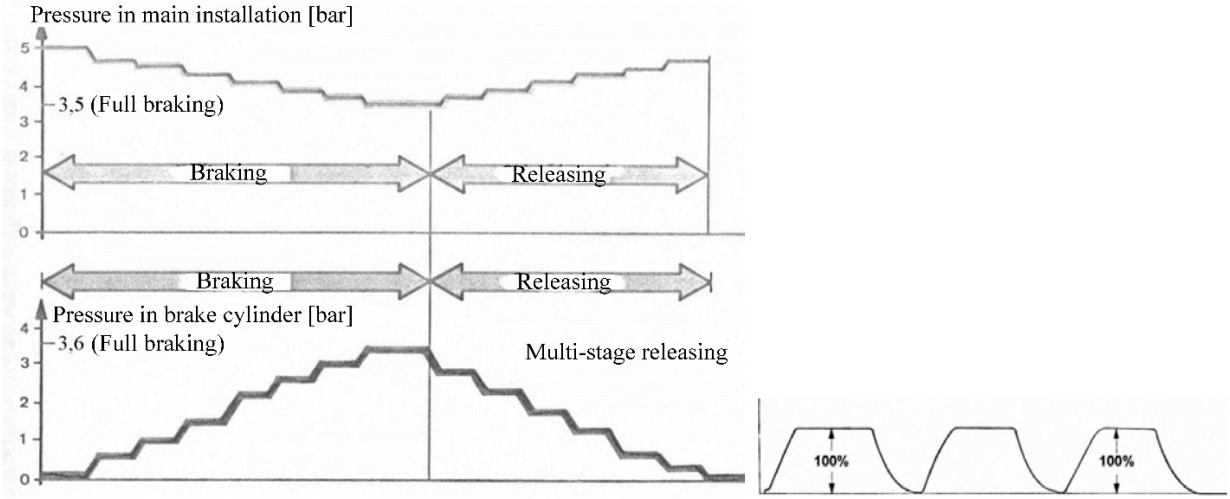


Figure 10. The inexhaustible brakes – change of air pressure in brake cylinder

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

After the Second World War Dobrivoje Bozic is unjustly accused for collaboration with the enemy. The whole his assets is confiscated (one example is shown in Fig. 11), and he was forced to emigrate in America where he remained until 1964 when he returned to Serbia with a huge desire to start production of railway brakes. There he died on 13 October 1967. 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. 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.

Figure 11. Today's appearance of Bozic's house in Kraljevo

ACKNOWLEDGEMENTS

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ПРОБЛЕМА СПИРАНЕ КАТО УСЛОВИЕ ЗА РАЗВИТИЕТО НА ЖЕЛЕЗОПЪТНИЯ ТРАНСПОРТ

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Ключови думи: *Спиране, Железопътни возила, Добривое Божич, Спирачка на Божич*

Резюме: *Целта на тази публикация е да даде информация за проблемите и техническите постижения в областта на спирането на железопътните превозни средства. Направено е кратко описание на трудностите, свързани с прилагането на спирачки в железопътните превозни средства от датата на възникване на железопътния транспорт до днес. От направеното изложение може да се види какви предизвикателства поставя спирането пред инженерите за по-нататъшното развитие на железопътния транспорт. Основният проблем на развитието на пътническия и товарния жп транспорт е решен чрез увеличаване на степента на автоматизация на спиране по един напълно нов и оригинален начин. Този проблем е решен от сръбския инженер Добривое Божич от Кралево. От приемането на неговите решения през 1928 г. към днешна дата, този принцип на спиране е останал непроменен. Статията дава описание на неговото решение, и някои детайли от интересният живот на сръбския инженер. Божич е първият в света, който е проектирал и приложил изцяло ново решение в спирачната система (въвеждането на три налягания) на железопътните превозни средства. Основната му характеристика е свързана с възможността за постепенно освобождаване на спирачките. Това решение увеличава нивото на автоматизация на спиране и осигурява по-бърза, по-безопасна и с по-добра фективност спирачна система, а от там и по-добро качество на производство на железопътни превозни средства и на железопътния транспорт като цяло.*