

The Review Of Patented Technology Of Bridge Basin Bearings

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Abstract—In recent years, with the rapid development of bridge engineering, bridge bearings have gradually become a research hot spots, and basin bearings have also begun to receive attention as an important branch of bridge bearings. This article introduces the development context of basin bearings from the perspectives of the principle, classification, and technical branches of bridge basin bearings. From the perspective of basin support technology patents, this paper analyzes the number of patent applications, distribution of patent applications, key applicants, key patents, main inventors and core patents in this field. Strive to restore the development status of bridge basin bearing technology at home and abroad and look for the hot spot of future development in this field.

Keywords—*Bridge; Basin Bearing; Development; Patent*

I. INTRODUCTION

According to the force requirements of the bridge, it is often necessary to set up supports between the bridge span structure and the piers. Its function is to transmit the supporting reaction force of the superstructure, including the vertical force and horizontal force caused by constant load and live load; at the same time, it can ensure that the structure can be freely deformed under the action of live load, temperature change, concrete shrinkage and creep, etc., so that the actual stress condition of the superstructure conform to the static structure of the structure. Basin type support is a kind of rubber support which combines steel parts and rubber parts on the

basis of plate rubber support. Generally, the basin bearing is in unconfined compression state, so its compressive strength is not high enough. At the same time, the displacement depends on the rubber shear deformation and the bearing height, and the greater the displacement, the thicker the bearing is required. Therefore, the bearing capacity and displacement of plate rubber bearing are limited accordingly. Large-span continuous beam bridges generally use basin bearings [1-2].

A. Basic principle of basin support

The basin bearing is a new type of bridge bearing developed abroad in the late 1950s. It uses the rubber plate set in the steel basin to bear pressure and rotate, and uses the plane sliding between the PTFE plate and the stainless steel plate to meet the displacement requirements of the bridge. At present, basin bearings have been widely used in road and railway long-span bridges in our country, and have become the main bearing type for highway and railway bridges. In the structure, the basin support mainly includes a rubber plate, a polymer material slide plate and a stainless steel plate, a steel lining plate, a tight ring, a rubber sealing ring, a lower support plate, and an upper support plate, as shown in Figure 1 [3]. At present, the design reaction force of the bearing is generally 1~50MN, and the bearing uses the continuous beam bearing of the railway passenger dedicated line with the maximum tonnage of 80MN [4].

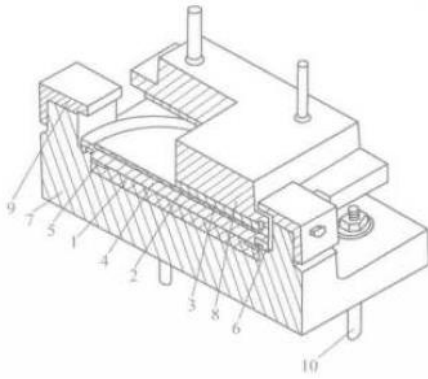


Fig. 1. Schematic diagram of basin support structure.

1 –pressure-bearing rubber; 2 –polymer material skateboard; 3–stainless steel plate; 4–steel liner; 5–tightening ring; 6–rubber sealing ring; 7–lower support plate; 8–upper support plate; 9 –Upper and lower support connecting plate; 10–support enclosure

B. Classification of basin bearings

Basin supports can also be divided into three types according to their working characteristics: fixed bearings, multi-directional movable bearings and unidirectional (longitudinal or horizontal) movable bearings [5]:

a)The fixed bearing is composed of an upper bearing plate, a lower bearing plate, a pressure-bearing rubber plate, a rubber sealing ring, a tightening ring, and an anchor bolt. It is mainly used to bear the vertical reaction force and corner of the support, and bear the longitudinal and lateral horizontal force of the bridge.

b)The multi-directional movable bearing is composed of upper bearing plate, lower bearing plate, pressure-bearing rubber plate, rubber sealing ring, tight band ring, steel liner plate, polymer material slide plate, stainless steel plate and anchor bolt. It is used to bear the vertical reaction force and corner of the support, and can adapt to the needs of the bridge's longitudinal and lateral displacement.

c)The unidirectional movable bearing structure is to set a guiding limit structure on the basis of the multi-directional movable support to limit the support to only unilateral displacement. According to its structural characteristics, it can be divided into two types:

double-sided guide groove or central guide groove to limit the horizontal (or longitudinal) displacement of the bearing.

II. PATENT ANALYSIS OF BASIN SUPPORT

The statistics of this time are as of December 2020. The following will analyze the annual distribution of patent applications, the global and domestic geographic distribution of patent applications, the distribution of major applicants, and the status of core patent applications.

A. Annual analysis of patent applications

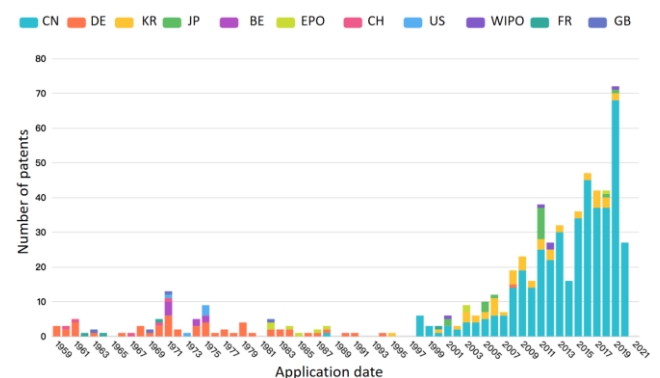


Fig. 2. Annual distribution of patent applications for basin bearing technology.

Figure 2 shows the annual distribution of patent applications for basin bearings. The light blue below the stacked histogram shows the annual distribution of patent applications for basin bearings in China. The other colors represent the annual distribution of patent applications in different countries. .

It can be seen from the figure that the number of patent applications for basin bearings is generally on the rise globally, starting in the 1960s, which coincides with the invention of basin bearings. Basin bearing was first developed in Germany in 1959 and officially used in Germany in 1962. The earliest invention of basin bearings came from Germany in 1959 (DE1199305B). Later in the period from 1959 to 1997, the number of applications for basin bearings was at a low level, and only fluctuated within a small range. With Germany's first proposal of basin bearings, some European countries began to apply for basin bearings. A certain amount of research and improvement has been carried out on the type support. However, the basin type

support is mainly used in large-span continuous beam bridges, due to the small number of long-span continuous girder bridges at that time, there were relatively few studies on basin bearings all over the world. It was not until around 2000 that the number of patent applications for basin bearings rose significantly around the world. Some Asian countries (such as China, South Korea, and Japan) gradually began to study basin bearings. At the same time, the number of applications for basin bearings in China began to appear in large numbers around 2000, and began to exceed the number of applications abroad. With the development of bridge construction in China, the continuous beams of large-span bridges and elevated roads are increasing, and the load of vehicles is increasing. The ability to adapt to the horizontal displacement of the superstructure puts forward higher requirements. The Ministry of Communications, Ministry of Railways and other relevant bridge construction design departments have also continuously improved the quality and tonnage of the basin bearings to meet the increasing needs of bridge construction, and gradually become the major technological contributors in the field.

B. Geographical analysis of patent applications

In order to compare the research and development capabilities and technical levels of various countries in the field of bridge basin bearings, this paper selects the indicator of original country for analysis. Among multiple applications of the same family, the statistics are only based on the original country. It can be seen from Figure 3 that China, Germany, South Korea, and Japan are the main originating countries for patent applications. The applications of the above four countries account for 90% of the total global applications. Since Germany is the first to advance basin bearings, In the early years of bearing research, there was a lot of technical reserves, and its global share was ranked second. However, in recent years,

the rapid development of bridge engineering in China, the corresponding research on basin bearings has gradually increased, of which China accounts for the world approximately 70% of the total number of applications.

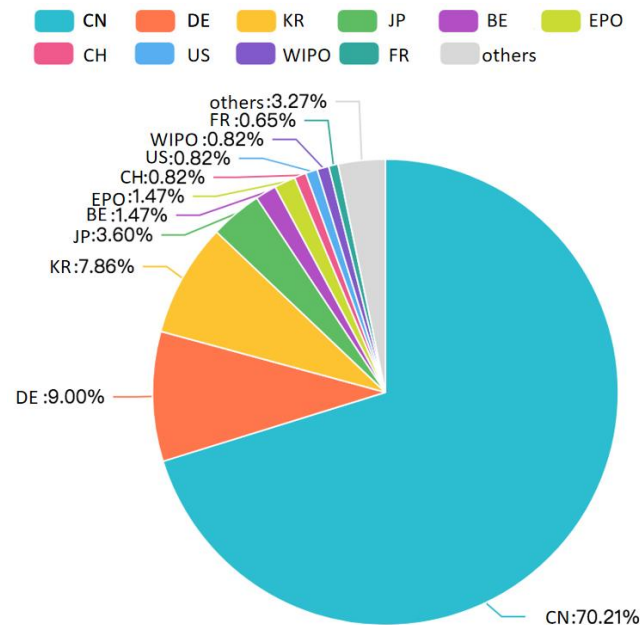


Fig. 3. Global patent distribution of bridge basin bearings.

C. Core patent applications

When selecting core patents, it mainly refers to the number of citations. Generally speaking, the higher the citation frequency, the more critical the position of the patent in the technological development. Normally, the patent literature The earlier the publication time, the higher the number of citations. According to the frequency of citations of patent documents in the database and combined with manual reading and screening, the patent applications in this field are sorted, and 10 core patent applications are listed. See the table 1.

TABLE I. LIST OF CORE PATENTS

NO.	Title	Applicant	Application Number	Application date	Number of citations
1	STRUCTURAL BEARINGS	ELASTOMETAL LIMITED	US05410558	1973/10/29	40
2	Steel bearings with polychloroprene and fluorocarbon resin	Forniture Industriali Padova S p A	US05642112	1975/12/18	19
3	Novel seismic mitigation and absorption support and changing method thereof	Liuzhou Orient Engineering Rubber Products Co., Ltd.	CN201310111776.6	2013/4/1	16
4	Dynamometer rubber support	Liuzhou OVM Machinery Co., Ltd.	CN200920306925.3	2009/7/27	16
5	Bridges or similar structures for sliding bearing	KOBER AG	DE2461325	1974/12/24	16
6	Method for replacing bridge basin-type rubber support	Hangzhou Municipal Engineering Group Co., Ltd.	CN200810059189.6	2008/1/18	13
7	Pot bearing for structures	H STOECKLIN AG	DE3616250	1986/5/14	13
8	Sliding bearing	MUELLER HEINZ KONRAD PROF DR I	DE3202188	1982/1/25	13
9	Pot shaped, adjustable, bearing for bridges and similar structures - has an interior pressure pad adjoining the cover	GUTEHOFFNUNGSHUETTE STERKRADE	DE2527128	1975/6/18	13
10	Fixed point elastomeric bridge bearing and bridge assembly	Felt Products Mfg Co	US05574008	1975/5/2	12

As shown in Table 1, the 10 most cited patent applications were concentrated in the United States, China, Germany, and Japan. The most cited foreign patents were mainly concentrated in the early stages of the development of basin bearings. As China has gradually increased its research on basin bearings after 2000, the technical content of patents has also gradually increased, mainly after 2010, there have been many patents with more citations, which shows the development of Chinese bridge infrastructure. It

has also indirectly improved the scientific research level of Chinese corresponding supporting structure.

III. THE EVOLUTION OF PATENTED TECHNOLOGY

Through searching and reading related patent documents, the evolution route of patent technology in the field of bridge basin bearings is obtained, as shown in Figure 4.

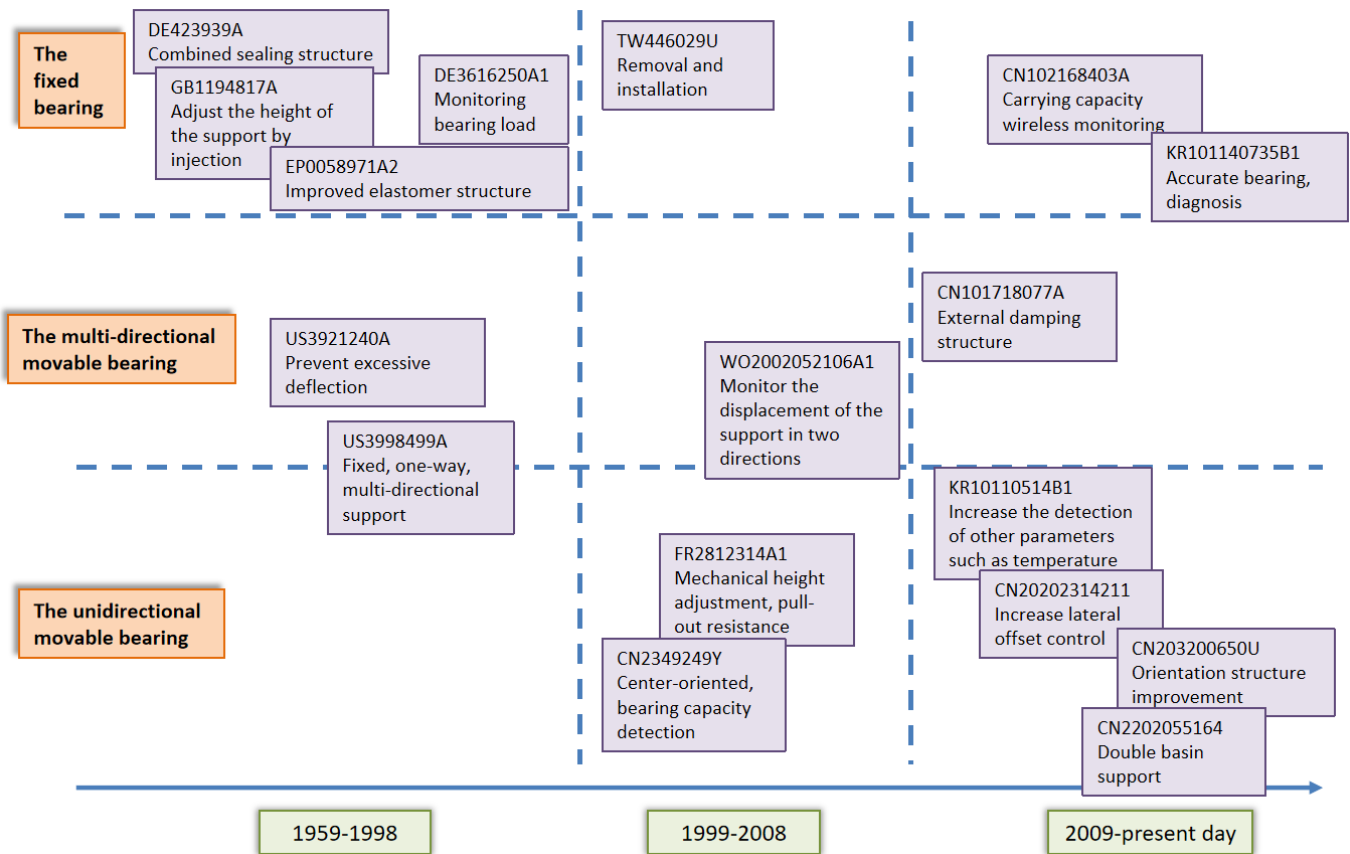


Fig. 4. Patent technology evolution of bridge basin bearing.

As can be seen from the above figure, the development of bridge basin bearings has roughly gone through the following three main development stages:

The first stage (1959-1998) is the initial stage. The basin bearings was mainly in the form of fixed support in the early stage. The focus of the invention was on the improvement of the sealing assembly of the bottom basin. The combined sealing ring setting form(e.g. DE423939A) and the sealing ring of different structural forms were proposed successively(e.g. CH389003A). At the same time, the European applicant has also noticed the need to monitor the bearing capacity of the bearing and the need for height adjustment of the bearing; at this stage, in order to adapt to the shear deformation of basin bearing under vibration load or wind load, it is also proposed to introduce a sliding board structure into the bearing, that is, the prototype of multi-directional movable bearings and unidirectional movable bearings (e.g. US3998499A). At this stage, several common forms of basin bearings were

proposed, which also marked the official beginning of the application of basin bearings in the field of bridges.

The second stage (1999-2008) is a stable development stage. At this stage, Asian countries gradually began to study basin bearings. In the aspect of basin support control, the monitoring of support displacement parameters has evolved (e.g. WO2002052106A), and the use of mechanical structures to realize the height adjustment of the bearing (e.g. FR2812314A1) has been proposed. At this stage, China began to research and develop basin bearings, research is mainly focused on the improvement of the basic structure of the basin bearings, including fixed bearings, guide structures, and seismic structures of multi-directional movable bearings or unidirectional movable bearings(e.g. CN2388218Y, CN2345579Y, CN2334796Y). At this stage, the domestic patent basically made simple structural improvements on the several basic support forms proposed in the previous stage.

The third stage (2009-present day) is the comprehensive development stage. At this stage, basin bearings have been fully developed based on the development of modern inspection technology and the new requirements in bridge engineering. In terms of control, new forms and methods for monitoring bridge bearings have been proposed, such as wireless monitoring technology, the application of new sensors such as fiber gratings, and the introduction of more comprehensive parameter monitoring (e.g. KR10110514B1, CN102168403A, KR101140735B1, CN202202252U). In terms of structure, in order to improve the seismic performance of the bearing, various forms of shock absorption structures such as dampers and springs have been added to the basin bearing (e.g. CN111305054A), or a new guide structure of the bearing has been proposed (e.g. CN203200650U). At the same time, in order to adapt to different working conditions, domestic applicants have begun to propose functional composite basin bearings. For example, it has both height adjustment and monitoring functions. At this stage, the number and quality of domestic applications have gradually taken the leading position in basin bearing applications, and more and more new bearing forms incorporating modern technology have been proposed to meet the rapid development of the bridge construction industry.

IV. CONCLUSION

In summary, although the bridge basin bearing technology in China started late, the current large-scale bridge construction in China has led to a rapid development of the bridge basin bearing technology. After 2009, the number of patent applications has increased significantly. By untangling the hot spots and development direction of bridge basin bearing technology, we can see that the technical development of bridge basin bearing is in a breakthrough period. At this stage, we must recognize the development direction and our own shortcomings, actively invest in research and development, and achieve technological leapfrogging.

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