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Evolution of Turnout Technology and Construction Based on the "Album of Turnouts for S-type Rails With Spring Blades" from 1947

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Summary
Railway turnouts are the elements of the railway superstructure that have evolved the most in terms of design over the years. This has been influenced by the increasing speed of railway vehicles, automation and safety. Tests of that devices have been ongoing and will continue to varying degrees. They have led primarily to the standardisation of the design. The article refers to selected details of 1:9 and 1:10 turnouts based on the "Album of turnouts for S-type rails with spring blades"published in 1947, owned by the authors. The details of the various structural elements presented in the album are drawn at a scale of 1:1.

Keywords: railway turnout, technical documentation, railway turnout operation

1. Introduction

Turnouts are one of the most important elements of a railway line, hence a lot of space has been devoted to that subject in the professional literature, e.g. in [2–4, 8–13]. Initially, they were infrastructure elements that only allowed for branching of station tracks or connecting tracks of different railway lines. Over time, turnouts have been introduced for use in inter-track connections, mainly within railway stations. Their importance increased when the capacity of station track systems became an issue.

2. Turnouts as a key element of the railway superstructure

In the process of designing or upgrading a railway line to high speeds [13] or to have the possibility of long freight trains running on it [9], the installation of turnouts of various types must be taken into account. In the scope of introducing a new, heavy railway surface, the following works were carried out with the participation of track industry specialists:

- dimensioning of steel superstructure elements, concrete sleepers and turnouts,
- dimensional tolerances of these components (dimensional chains), strength properties,
- production technology,
- acceptance methods and conditions,
- rail and turnout welding technology,
- equipment for cutting and drilling rails in operating conditions,
- welding of steel components, etc.

In the case of turnouts, the starting point has always been the experience and development of previous works, e.g. [1]. This was followed by solutions in the form of turnout designs (with increasingly larger radii of turning track curves, with crossings with movable bow and with multiple locking mechanisms). Issues concerning the curvature of turnouts and its application [10] or its location on transition curves [11] are also analysed. The current railway regulations [12] introduce significant application restrictions for curved turnouts. They are permitted only in economically justified cases, i.e. when the use of basic turnouts would cause, e.g., the introduction of a local speed limit, excessive elongation or displacement of the turnout head or traffic control post, additional earthworks or the need to acquire new land (resulting from the need to shift or change the course of the track system) and collision with existing infrastructure elements (e.g. engineering structures).

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It is worth mentioning the evolution of the purposes of using turnouts throughout the years of railway operation. Initially, they were infrastructure elements that only allowed for branching of station tracks or connecting tracks of different railway lines. Over time, turnouts have been introduced for use in inter-track connections, mainly within railway stations. The significance of turnouts increased as traffic volume increased. To increase the capacity of track systems, the appropriate arrangement of turnouts and entire connections has become important. Therefore, based on research and calculations, appropriate principles and criteria for the location of turnouts at traffic signal boxes were developed. The following are included in the general principles:

- turnouts with the 1:9 angle may not be used in main railway tracks and main station tracks for a speed of 160 km/h and more;
- 190-1:9 – type turnouts may be used on main line tracks and main station tracks for a speed of 80 km/h and less, if located near engineering structures, intersections of lines with roads on the same level or in other justified cases;
- 300-1:9 – type turnouts may be used on railway tracks and main sections of railway lines for a speed of 80 km/h and less;
- 300-1:9 – type turnouts may be used on railway tracks and main sections of railway lines for a speed of of 120 km/h, if located near engineering structures, intersections of lines with roads on the same level or in other justified cases;
- in track connections, standard turnouts or possibly curved turnouts should be used;
- in main tracks and main sections of railway lines for speeds above 100 km/h, cross turnouts and track crossings on wooden switch sleepers may not be used;
- in main tracks and main sections of railway lines for speeds above 120 km/h, cross turnouts and track crossings on concrete switch sleepers may be used, if located near engineering structures, intersections of lines with roads on the same level or in other justified cases.

It should be borne in mind that, in addition to their traditional tasks, the location and parameters of turnouts determine the capacity of the railway line. In the case of stations with significant passenger train traffic as well as heavy freight traffic, there is an extensive system of turnouts [4]. Within the station, there may be scheduled line and shunting traffic. It is necessary to design the station track layout and route traffic through the station in such a way as to ensure the required capacity and smooth traffic flow. This is determined by the most heavily loaded turnout or set of turnouts in the station head. This is the so-called critical element or bottleneck (Fig. 1). A similar situation occurs when upgrading a station or an entire railway line.

3. Sources for knowledge about former turnouts

The evolutionary development of turnout technology can be observed thanks to the archival catalogues and documents that are still available. One of these is undoubtedly the "Album of turnouts for S-type rails with spring blades" [1]. The document, in the form of a large-format album (675 mm × 510 mm plus selected fold-out pages), consists of technical drawings of standard and cross turnouts with the angles of 1:9 and 1:10. Even though the document is from the year 1947, it reflects the technology from the years 1934–1937, as evidenced by the stamp with a specific date and signature on each drawing. The album is at the authors' disposal.

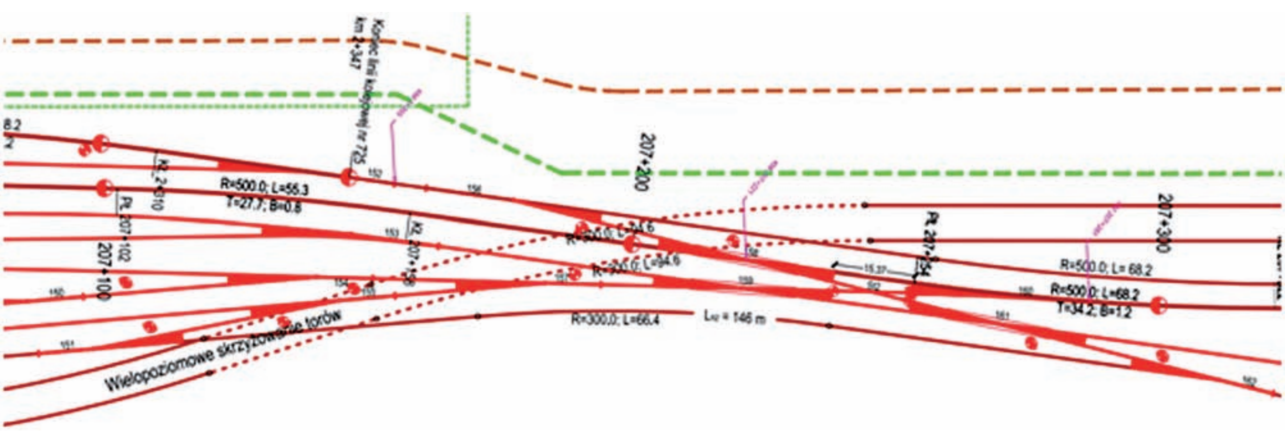

Fig. 1. Example of a main turnout with critical elements – 151 and 159 turnouts [4]

Since some of the elements were made or adjusted using economic methods, it was necessary to provide very detailed solutions for each structural element. Hence, the scales of the presented drawings are very large, ranging from 1:50 for the entire turnout to 1:1 for individual structural elements of the turnout.

The album is proof of the efforts to standardise the railway network by maintaining identical solutions. At this point, it is worth recalling that the Polish railway network included equipment and technical solutions originating from the three partitioning countries. The use of a hook-and-loop coupling was regarded as a target solution.

Turnouts with the angle of 1:9 and a radius of 205 m appear in the above-mentioned document (Fig. 2) and with the angle of 1:10 and a radius of 265 m. While the 1:9 – 205 turnout was and sometimes is still used today, in the case of the 1:10 turnout, it is difficult to find such a solution in track systems as it was used to a very limited extent. It can be concluded that both types of turnouts were soon replaced by a commonly used turnout with the angle of 1:9 and a radius of R = 300 m.

The cited publication proves that along with the development of technology and scientific and technical research presentation techniques were also developed, which enabled the exchange of knowledge and information, as well as wider distribution to appropriate units and entities that had not had anything to do with rail transport. The rich content of the album is evidenced by the list of included drawings, as shown in Fig. 3, while the following figures (4, 5, 6) show:

- details of the design solutions of the standard turnout with the 1:9 angle [1],
- geometry details of a standard turnout with the 1:10 angle [1],
- design details of a cross turnout with the 1:10 angle [1].

4. Contemporary research on railway turnouts

Research on railway turnouts, or their elements, covers many areas. Noteworthy are studies concerning, for example, the experimental and numerical analysis of residual stresses in turnout blades [7], studies on dynamic interactions (including in terms of high speed), studies on the dynamic development

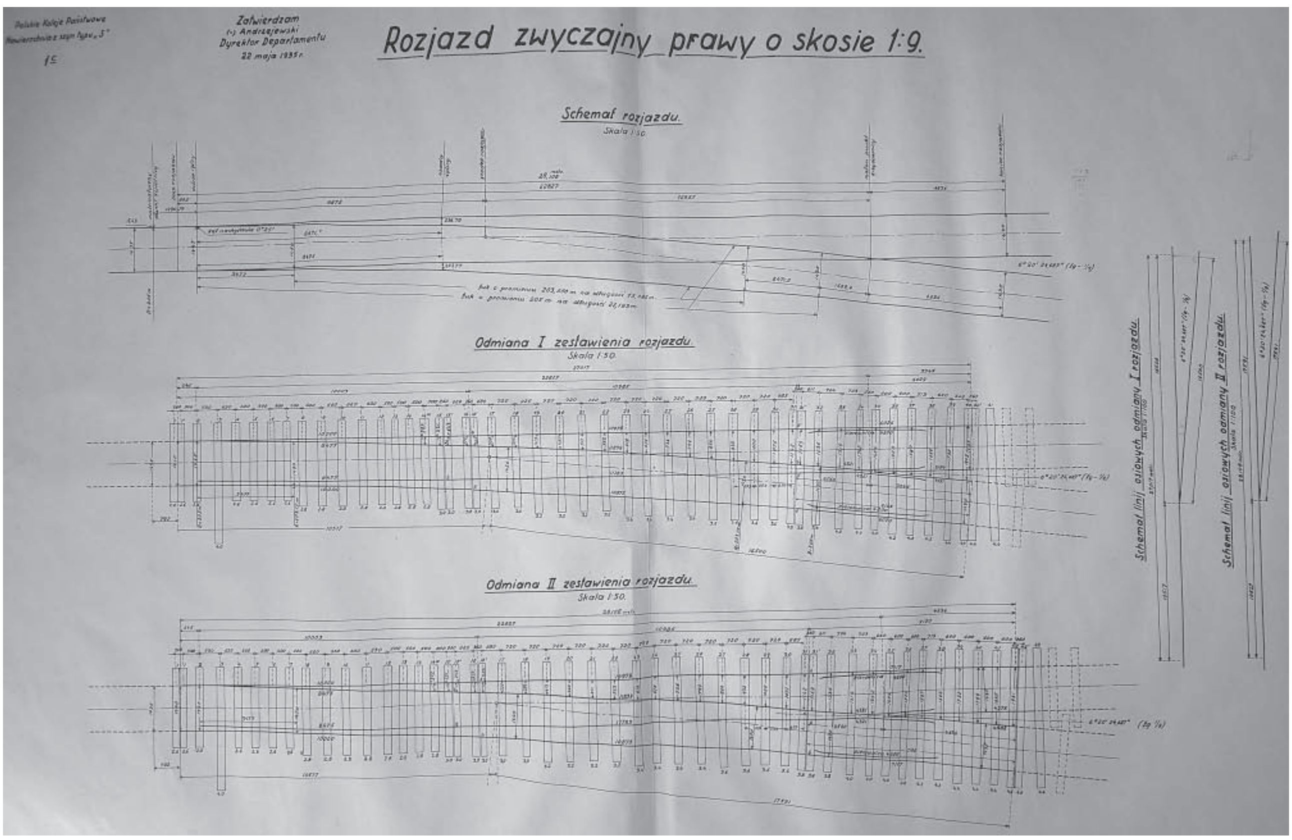

Fig. 2. Example of a drawing with detailed geometry of a standard 1:9 turnout [1]

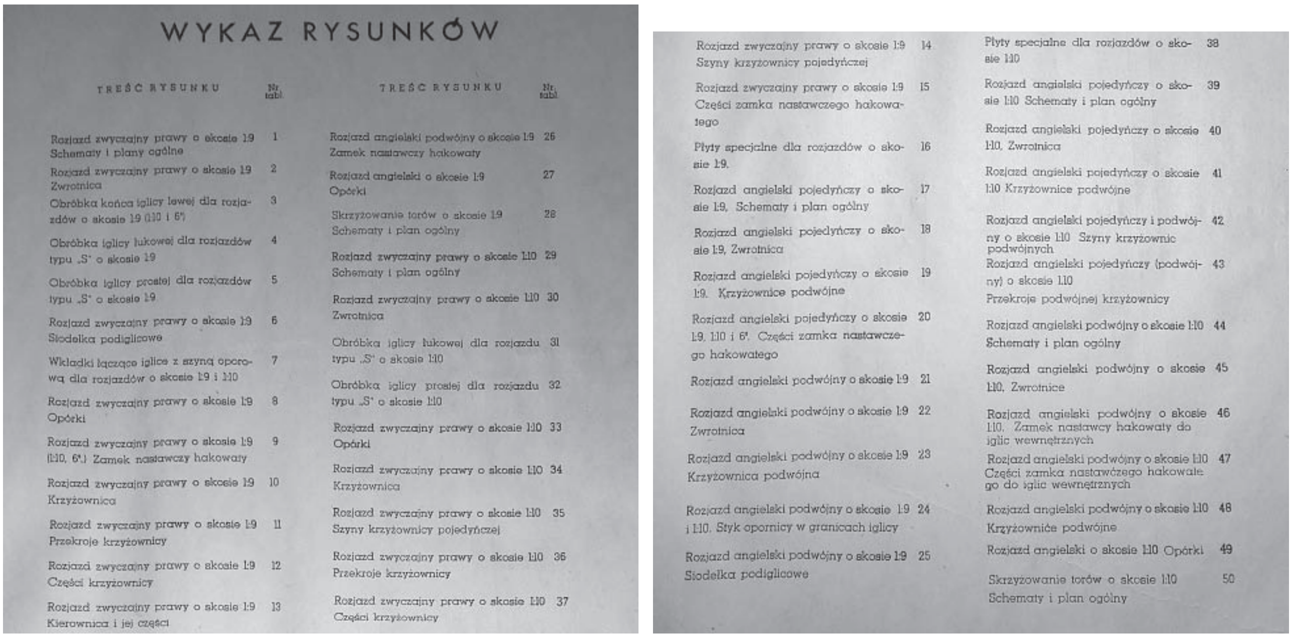

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Fig. 3. Page with the table of contents from the "Album of turnouts for S-type rails with spring blades" from 1947 [1]

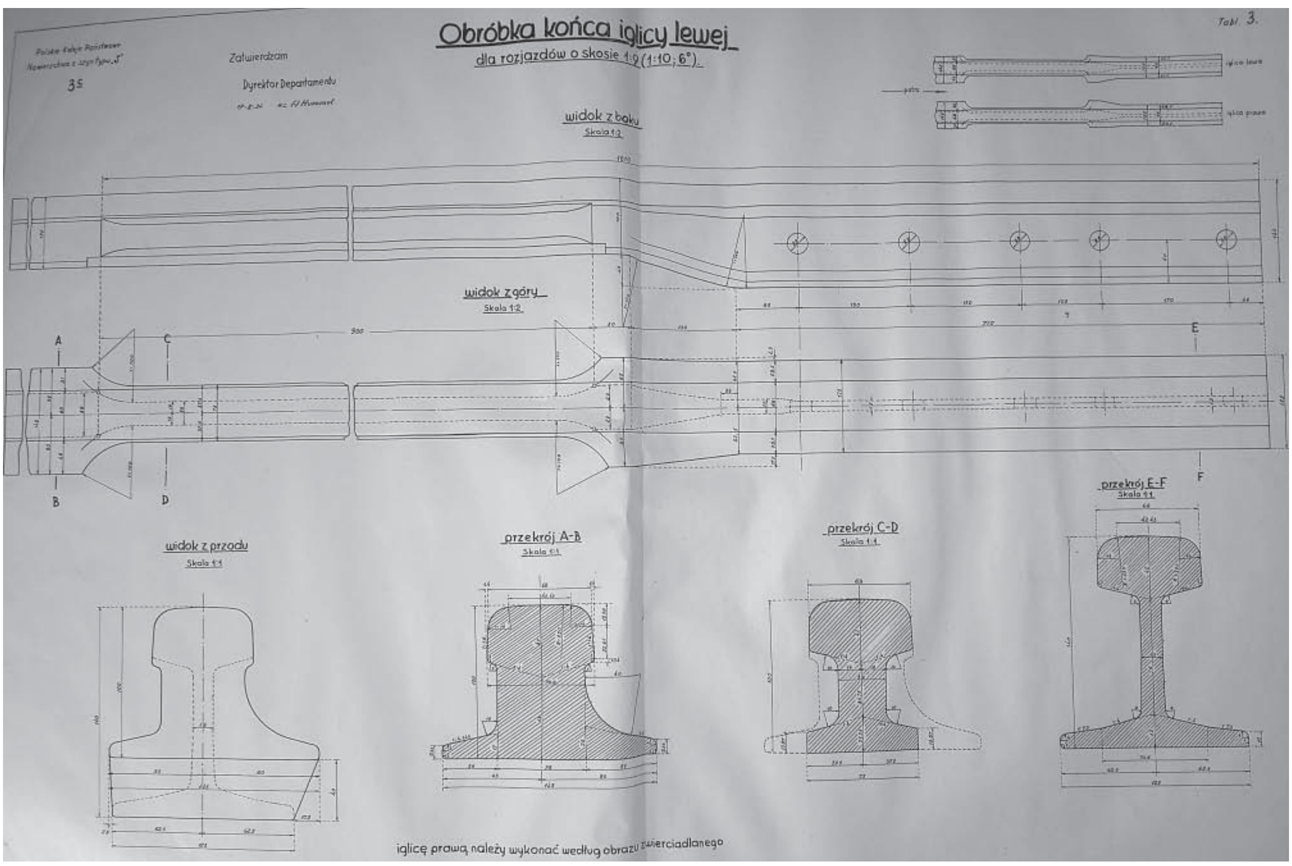

Fig. 4. Details of the design solutions of the standard turnout with the 1:9 angle from 1947 [1]

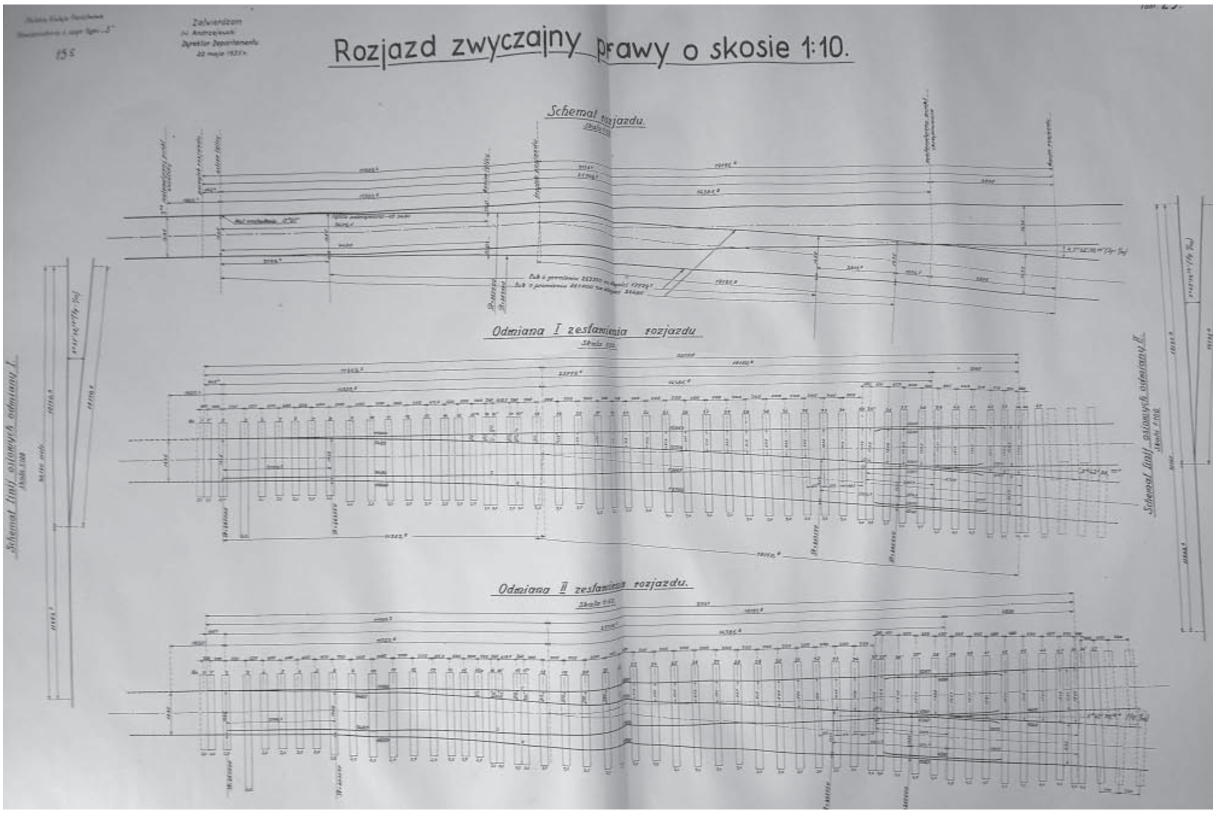

Fig. 5. Example of a drawing with detailed geometry of a standard turnout with the 1:10 angle from 1947 [1]

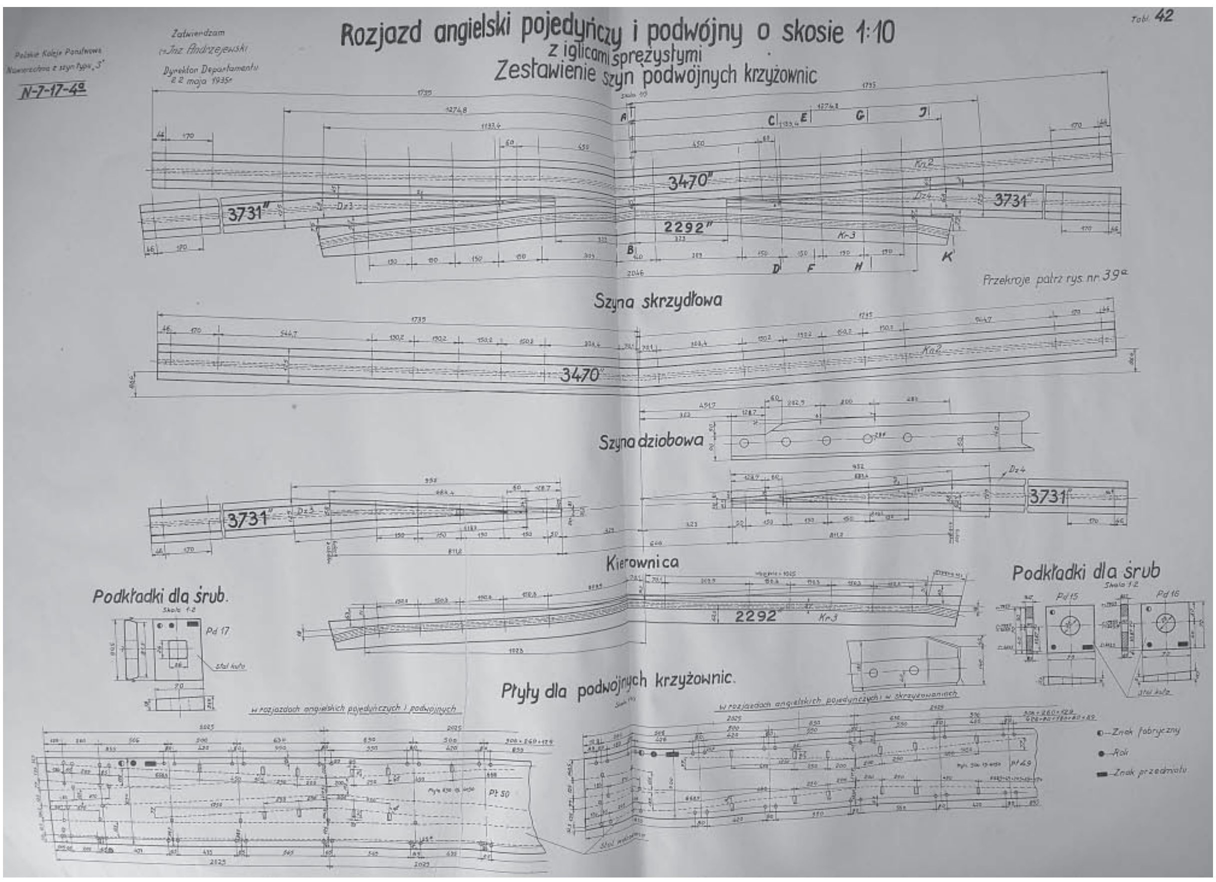

Fig. 6. Example of drawing with design details of a cross turnout with the 1:10 angle from 1947 [1]

of damage to turnout elements and material tests of turnout elements [6]. There is also research on new turnout design solutions, including the minimisation of friction surfaces (Fig. 7).

Fig. 7. Rail surface after application of Belzona friction component [photo: S. Grulkowski]

Turnout design solutions have also changed over the years. Fixed crossings of forged-welded structure, welded-welded, insert-type, manganese monoblock crossings, movable crossings (with the so-called "movable bow"), etc., were used. In each case, the materials mattered. Different types of steel were used, e.g. high-manganese (manganese) or hardened (reinforced) steel with a minimum hardness of 320 HB. Each type of steel had its advantages and disadvantages. For example, the aforementioned material is difficult to combine with rail steel (special joining or reconditioning technologies are necessary). A certain novelty was the use of bainitic cast steel, which is relatively easy to weld and good for hardfacing.

Manual switching of turnouts was replaced by electromechanical devices connected to railway traffic control equipment. Modern turnouts are heated, and there is no need for manual defrosting.

The maintenance of turnouts [5] includes their diagnostics, and this is subject to the rules for visual inspection of turnouts, the timing of visual inspections, the recording of the results of visual inspections of turnouts, the rules and timing of technical tests and their recording. In addition to turnout diagnostics, maintenance and repairs should be carried out according to the relevant rules.

As a result of day-to-day operation, turnout components wear out. The sign of wear of a selected turnout element does not constitute a reason to exclude it from further use. This is determined by the permissible values of wear of turnout elements, or more precisely, the criteria for replacing turnouts and their parts.

5. Summary and conclusions

The development of techniques and technologies requires research, testing and experiments [6, 7]. While we are able to reconstruct these processes from the period after World War II, when recording processes and techniques were widely available (photography, sound recordings, image recordings, text and number recordings), earlier achievements are quite difficult to identify due to the passage of time and war losses. Therefore, one of the ways to reconstruct the development process is to analyse publications, rules or technical documentation. Such documents also make it possible to reconstruct the process of technical progress in the railway industry. Reference to such materials, e.g. the briefly described Album, shows the high technical culture and professionalism of the railway workers in that period. Obviously, the presented materials were the starting point in later years for further development of the technical structures of various types of railway turnouts.

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