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Presenting the (economic) value of patents nominated for the European Inventor Award 2012

Inventor file Josef Theurer

1. The invention

1.1 Historic account

1.1.1 The state-of-the art before Josef Theurers inventions

The life time of Josef Theurer is plastered with a high number of break-through inventions, which he successfully commercialised, hereby revolutionising the railway track maintenance sector and industry. Long before Steven Jobs (and also after him), the innovative and entrepreneurial spirit of Josef Theurer created a multinational large, worldwide industry leader from a small start-up in 1952 in Linz, Austria.

Rail track maintenance requires a number of characteristic activities. The three most important activities tackle three problem areas:

- Rails have to be positioned and aligned to each other in a very precise manner, laterally as well as vertically. Allowed tolerance/error margins are in the mm order. From the time rail tracks have been built in the 19th century, it has become obvious that rails will not stay forever in the position they have been initially laid down, due to the traffic they have to carry. Tracks need to be examined regularly for positioning/alignment errors.
- Another problem comes with the ballast that carries the track (i.e., the 'stones' commonly seen underneath the rail tracks). These stones should be homogeneously distributed beneath the rails, with individual 'grain' sizes (the technical term for an individual stone is 'grain') measuring between 35 and 65 mm when the rail track is new. However, with time, the ballast is infiltrated with smaller particles. Some of the small grain is the result from the crushing of larger stones into smaller pieces due to the railway traffic; other small grain may originate from the nearby environment. The danger of the small grain is that it will weaken the ballast to the point where it cannot carry the rail tracks and, eventually, the trains anymore. Hence, ballast needs to be regularly cleaned, i.e. the small grain removed/filtered.
- The third problem area occurs when the rail tracks themselves have been completely worn out and need to be replaced. A full replacement requires the exchange of the tracks, the wooden and/or concrete sleepers[1] as well as the other components in the most efficient manner.

Surprisingly, most of these activities were carried out manually – meaning with manual labour - as late as the 1950s and early 1960s. Positioning errors were, for example, spotted visually. For correcting vertical positioning errors, workers had to lift the rails with the help of a winch. They then made sure that right amount of ballast was placed underneath the track to secure the correct elevation. They did so by tamping the ballast manually, with hand tools, at the required places. For lateral positioning errors, workers would hammer the rails from the side manually back into position. For cleaning the ballast of small corn, workers would employ special forks, perhaps reminding some of the way leaves are swept in gardens with the help of a rake.

[1] *"A railroad tie/railway tie (North America), or railway sleeper (Europe) is a rectangular support for the rails in railroad tracks. Generally laid perpendicular to the rails, ties transfer loads to the track ballast and subgrade, hold the rails upright, and keep them spaced to the correct gauge…railroad ties were traditionally made of wood, but pre-stressed concrete is now widely used especially in Europe and Asia."*, taken from Wikipedia

It was not until the 1920s and 1930s when the first machines were developed to support rail track maintenance activities. For example, a Swiss firm, Scheuchzer, developed a simple tamping machine as well as a simple cleaning machine for the ballast in the 1930s. However, the period of innovation activity was rather brief and there were little to no follow-up innovations/improvements. The firms designing these machines were satisfied with the achieved sales and saw no reason for further investment into R&D.

Mr. Wenty, director marketing and technical sales at Plasser & Theurer in Vienna/Austria, explains that this was the starting point for an inventor and company success story spanning seven decades:

> *"Josef Theurer was at that time, at the beginning of the 1950s, working as engineer at an Upper Austrian ship building company. Another Austrian company was working in track maintenance for Austrian Railways at that time. This firm had recently imported some of the aforementioned Matisa tamping and cleaning machines for ballast. Josef Theurer was tasked with maintenance work on these machines; he soon found the technology to be outdated and had ideas for improvements. He told Mr. Plasser about this, who owned part of the Austrian construction firm. However, neither the Austrian firm nor the Swiss manufacturer were interested. This has led Mr. Theuer and Mr. Plasser to leave the construction firm – Mr. Plasser was paid out his shares of the company – and to set up their own business, in 1952 which was the start of the company later to be known as Plasser & Theurer,."*

1.1.2 Milestone inventions

What followed was a series of inventive milestones in rail track maintenance:

- Milestone 1 - 1953: The first patent of 1953 was, according to Mr. Wenty, of particular importance. It demonstrated that improved technology would lead to improved quality of work AND, at the same time, to higher efficiency. The patent described the technique of *asynchronous hydraulic tamping*.

  Up until the invention, ballast was tamped synchronously under vibration: *"Under synchronous tamping, all particles compressed within the ballast travel the same distance"*, explains Mr. Wenty, *"with the new hydraulic asynchronous system, the vibrated particles were able to adapt and disperse individually. In areas, where more particles are needed more particles are accumulating and where less are needed (because the ballast there would be already dense enough), there would be less particles. The result was more homogeneous, better quality tamped ballast, achieved also in less time."* The invention had a huge impact – all manufacturers of tamping machines today still use this method to tamp the ballast.

- Milestone 2 – 1955: The second big innovation was the *cantilever design*. The tamping machine of 1953 was mounted on a train/wagon in the middle between the two axes. There was still the need to lift the rails with winches in front of the machine. The trade-off was that the rails could only be lifted to the extent that they would withstand the weight bearing of the vehicle with the tamping unit. By, simplified speaking, placing the tamping unit at the front of the wagon, this trade-off was minimised: Both the lifting of the rails and the tamping could occur at much closer distances to each other, only minimally affected by the mass of the vehicle with the tamping unit.

- Milestone 3 – 1960: Lifting and levelling of the rails in the tamping procedure was still done manually with winches. The patent on a *levelling lifting tamping machine* created an all in one machine which could at the same time lift rail tracks and tamp the ballast underneath the tracks. The technology consisted of two main components: On the one hand, a pair of lifting pincers and, on the other hand, a measurement system which could control for the right vertical positioning of the

rails. The measurement system used a measuring cord made of steel that was tautened in front of the machine. If the rails would have been lifted high enough, the cord would get in contact with a switch which, when activated, would cause the lifting to stop. *"This machine was a true break-through and of particular importance for the development of the firm"*, explains Mr. Wenty.

- Milestones 4 and 5 – 1962: The year 1962 saw two major innovations hitting the market. The machines available up to that point had been only usable on parallel tracks but not on railway switches[2]. The invention of *switch tamping units with tiltable tamping tools* overcame this problem. The second innovation concerned the development of machines that would hydraulically compensate for lateral displacements of rail tracks. The *lining machine with measuring cords* was able to hydraulically exert pressure from the side onto the rail tracks. The continuously exerted pressure improved also overall quality of the lateral re-positioning, if compared to the manual hammering employed before for that purpose.

The first five milestones could be considered base inventions, which eliminated hard manual labour. Later developments improved further the efficiency and effectiveness. A pattern becomes visible whereby a certain type of machine was developed for solving a particular problem, then the device was improved and, eventually, integrated into other machines to form 'all in one' machines:

- Milestone 6 - 1965: In 1965, a tamping machine was developed which could work on two sleepers at the same time. Working speed increased hereby by 80%, and overall quality was also improved as a larger piece of the rail track was processed in only one single step. The invention was also branded (and trademark protected) as Duomatic.
- Milestone 7 – 1967: In 1967, lining and levelling were integrated into the tamping machine with the invention of the *combined lining and levelling tamping machines*.
- Milestone 8 – 1968: The invention of the compact design machines marked a return to positioning the tamping units back into the middle of the maintenance trains between the two axes. This was possible because lifting, levelling and tamping were not separately handled working processes any more. Placing the units again in the middle of the wagons, and extending the distances between the axes from 2.5m to 8m enabled the creation of the so-called compact design. Compact design had a huge impact on the industry; it is still the standard of today. Today´s tamping machines have distances of up to 13m between the axes.
- Milestone 9 and later milestones – 1983 to 2005: As the tamping machines grew bigger, the weight bearing on the rail tracks and overall stress on the rail tracks from the machines increased, too. For example, vehicles as massive as 40t had to be accelerated and then again stopped for processing consecutive (sets of) sleepers. Josef Theurer came up with the idea to have two independent movements, i.e. separate vehicle movement from tamping unit movement: the wagon would travel continuously, while only the tamping unit mounted on a sub frame would move cyclically. The result was an increase in processing speed of 40% and, overall, a more steady operation. This technique was improved to handle three sleepers and, eventually, four sleepers, at once (in 2005).

Josef Theurer focussed his R&D on the continuous improvement of the tamping machines. However, he was also the inventor of a number of other technologies in rail track maintenance which had a strong impact on the industry:

[2] A railroad switch, turnout or [set of] points is a mechanical installation enabling railway trains to be guided from one track to another, such as at a railway junction or where a spur or siding branches off. (from http://en.wikipedia.org/wiki/Railroad_switch)

- In 1974, he developed a *dynamic track stabiliser*. This device solved a problem, which was introduced by tamping. While the tamping machine succeeded in creating homogeneous ballast, it also left some voids at the places where the tamping tools were inserted into the ballast and then retracted after maintenance was finished. A train passing for the first time over the track would force particles from underneath the sleepers into these voids, creating a sudden deterioration of the quality of track geometry upon first usage. The device developed created vibrations in the rails, causing the particles of the ballast to slowly enter the voids and to disperse again homogeneously. Today, this device is incorporated into the tamping machines.
- Further innovations concerned the development of devices to clean the ballast (in 1962, further improved for usage in railroad switches in 1975) and, truly revolutionary, in 1968 machines for continuous automated railroad reconstruction. This technology was able to lift old rails, to remove old sleepers, to replace them with new sleepers and to insert new rails in an automatic continuous process. One of the latest inventions of 2011 was the introduction of a measurement and alignment system for the welding of rails.

The economical impact of Josef Theurer´s inventions can be measured in terms of efficiency gains in rail track maintenance. For example, processing and maintenance costs for 1m of rail tracks in the 1980s were as low as 10% if compared to the times of manual labour (only some 20 to 30 years earlier).

2. The market

2.1.1 The company

In 1953, when the first invention hit the markets, Plasser and Theurer had 9 employees. Already in 1955 did the firm export its first tamping machine to Germany, and in 1957 to North America. The first firm subsidiary was established in Canada in 1958.

Today, there are production facilities in 10 countries, and the machines are exported to a total of 106 countries. Plasser and Theurer had (2011) some 3,500 employees worldwide, of which 1,650 were located in Austria. Outside of Austria, the largest number of employees is stationed in Germany (around 500) and the U.S. (around 350 employees). Worldwide, the firm produces some 200 to 250 railway maintenance machines per year, at an average unit price of around € 2 million. Export share is around 95%.

The company spends more than 5% of its sales on R&D, *"…but effectively it is more if general innovation activity is also included."* (Interview Wenty) Plasser and Theurer try to promote an innovation-friendly culture, and, according to Mr. Wenty, *"…innovation and improvement is an integral part of company policy."*

A key success factor was the creation of an effective distribution and sales organisation. The headquarters for sales and distribution are in Vienna, Austria. For every market, there is a team assigned in Vienna with combined technical and sales expertise. Local sales teams support the Vienna staff within the respective markets.

Austrian media asserts that Plasser and Theurer are *"…the most successful Austrian firm in terms of market position…".3* In line with the assessment of the firm as a significant market player, the Austrian Chamber of Commerce lists Plasser & Theurer

[3] Leitner, K. (2008): Keine Bahnstrecke ohne Plasser & Theurer, in Wirtschaftsblatt 04/05/2008, http://www.wirtschaftsblatt.at/home/schwerpunkt/dossiers/europameister/325683/index.do

as one of the leading Austrian firms ('Leitbetriebe').4 The Chamber states that by 2010, Plasser & Theurer will have produced more than 14,400 heavy duty machines. All high speed trains of the world were built, extended and serviced using Plasser and Theurer machines. Plasser and Theurer products account for almost 0.7% of Austria´s total exports, and for about 6% of the national machinery, steel and metal construction sector.5

The firm itself is a family-owned business: 30% of shares are being held by Josef Theurer, 30% by his daughter Elisabeth Max-Theurer, 20% each by Dorothea Theurer and Hans-Jörg Holleis.

2.1.2 The overall market

There is no specific information publicly available on the size or structure of the market for railway track laying machines and/or track maintenance. Plasser and Theurer estimates that the global market size for railroad maintenance machinery to be around € 2 billion to € 3 billion p.a. Globally, the firm asserts that it may have a market share of around 50%. According to Mr. Wenty, the market size stayed, expressed in real monetary terms, rather constant between 1970 and around 2000; annual growth rates were on par with inflation rates observed. Since around 2000, market growth has accelerated, reflecting the increasing popularity of rail transport.

The market is dominated by a small set of larger actors, of which most are only regionally active. In Europe, competing firms are Matisa (CH) and Geismar (FR). German firm Robel is owned by Plasser and Theurer. In the U.S., there are more competitors such as Harsco Track International and Progress Rail which is part of Caterpillar. Further competition exists in Russia and in China. The Russian and Chinese competition is in part a follow-up to joint ventures and licensing agreements with Plasser and Theurer, who have been active in these markets since 1974 (Russia) and 1980 (China). However, the Russian and Chinese firms have hardly an impact on international markets. Of the competitors, Plasser and Theurer stand out as the only significant globally acting player.

Customers are usually railway operators, extending from local municipal subway and tramway operators to bigger private/national railroad operators. Another important market segment are railways in the industrial sector, i.e. within industrial plants or in mines. Construction firms, working on behalf of railroad operators, are also sometimes customers, although two thirds of the business occurs directly with the actual railroad operators.

While there are no figures publicly available for the specific market segment of P&T, it is clear that that there is a correlation with the railway market overall. A report by SCI Verkehr suggests that the global rail market grew by 29% between 2006 and 2008, from US$ 97 billion to US$ 125 billion. 6 Forecasts see the market grow to €160 billion by 2016, fuelled also by rapid growth in Asia. However, the report also *"...points out that the Chinese suppliers increased their market penetration in their home market, and are becoming more successful in foreign markets such as Argentina, Tunisia, Saudi Arabia, the Emirates, and India. However, Western Europe is not yet the main market focus of the Chinese, but that will change incrementally."*

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4 http://leitbetriebe.org/index.asp?p=metall&m=79016&lang=d

5 http://www.railwaygazette.com/nc/news/single-view/view/plasser-theurers-technical-advances-to-keep-ahead.html

6 http://www.railjournal.com/this-month/world-railway-market-focus-moves-east.html

3. The role of patents and Intellectual Property Rights (IPR)

3.1 Motives and benefits of patenting and employed IPR strategy

Mr. Wenty explains the IPR and innovation strategy as follows:

> *"The, probably by far, most important success factor of Plasser and Theurer was the constant thrive and achievement of technology and innovation leadership. Patents have been playing an integral role in this quest. Because of our success, competitors may be quickly tempted to copy our products. And because we cannot exert any control on who has access to and is able to disassemble our products at our customer´s premises, it is vital that we can benefit from the protection the patents grant us."*

In terms of patenting strategy, the firm opts to apply for patent protection in countries where, on the one hand, patents are enforceable and, on the other hand, where the most important markets (customers, competitors) are located.

The list of countries to be covered for patent protection includes also China:

> *"China has shown remarkable progress when it comes to establishing an effective patent system, and firms should make sure that they patent also early in China. There may be problems if Chinese firms try to patent an invention already in use somewhere else, and if they succeed in obtaining intellectual property protection, it is quite cumbersome to prove that you have been the actual inventor. But, generally, enforcement of IP is now much better in China."* (Interview Mr. Wenty)

In terms of enforcement, Plasser and Theurer are ready to go to courts if they encounter infringed technologies, and they have won already some rather large litigations. However, in general it turns out to be sufficient to warn competitors and/or potential customers about on-going infringements, as especially the customers – mostly state-run railroad operators – do not want to be associated with patent infringement activities.

Other types of IPR play less of a role. Trademarks are, of course, used but only for the most important products and brands. Licensing is also of limited importance. Plasser & Theurer out-license their technologies only when necessary, e.g. in the course of joint venture activities required in countries where the firm cannot be active on its own without a local partner. Some know-how in the production processes of the machines is kept secret (which is known as 'trade secrets'), as it is hardly possible to learn about such techniques by disassembling the end-product.

IP (including patents) are centrally managed through a dedicated IP department.

Perhaps interesting to note – and reflecting the value of the inventions of Josef Theurer – is the fact that many patents have retained their state-of-the-art nature even after the patent lifetime has expired. These technologies are still widely in use today.

3.2 Patent statistics and patenting trends

According to Plasser and Theurer, the company has applied since its inception for around 10,000 patents, of which more than 2,000 are still in force. Josef Theurer has been the main contributor to the inventive activities. An analysis of available patent databases shows that Josef Theurer has applied for some 1,050 patent families throughout his life.[7] 247 of these have been applications, for

[7] As patents are a regional concept (no such thing as international patents exists), it is necessary to obtain patents in each country an applicant wants to have patent protection for. The set of national patents referring to the same invention is called ‚patent family'.

which the worldwide PCT or EPO standardised application procedures for multiple countries have been used. The European Patent Office has so far granted 204 patents.

The internationalisation process and the growing significance of IP protection in emerging markets can be traced in time. In the 1950s, the patents applied for were mostly for Austria, Germany, the U.S., Canada, Great Britain, France and Switzerland. In the 1960s, patent protection covered, in addition, usually Japan, Spain, Poland, Hungary, Sweden, the Soviet Union and Brazil. In the 1980s, China was added to this list. And in the 1990, South Korea was added.

A measure of patent value, similar to that in academic journals, is the number of times a patent is cited by other patents as prior art (the assumption being that the more a patent is cited, the higher its value). For the last 20 years, Josef Theurer´s patents have been cited on average 44.2 times a year (which can be considered a large value). Applicants citing the patents most were the competitors MATISA, CANRON, GBM and HARSCO CORP. Plasser and Theurer are by far the leading patent applicant in the relevant technology classes and fields.

4. Conclusions

The lifetime of Josef Theurer is plastered with a high number of break-through inventions, which he successfully commercialised, hereby revolutionising the railway track maintenance sector and industry. Long before Steven Jobs (and also after him), the innovative and entrepreneurial spirit of Josef Theurer created a multinational large, worldwide industry leader from a small start-up in 1952 in Linz, Austria.

The following are the main success factors:

- The constant strive for innovation and technology leadership
- The establishment of an innovation-friendly firm culture
- The usage of patents to protect the intellectual property
- The early and aggressive push for internationalisation
- The establishment of an effective sales and distribution network with combined technical and sales experts
- The personality of Josef Theurer: *"Josef Theurer is important for all of us within he firm. He has a unique eye for identifying the right technological trends and what the market would demand, and constantly produces original ideas for improvements and new products." (*Interview Mr. Wenty)

Already in 1976, the Technical University of Graz awarded Josef Theurer an honorary PhD title, in recognition of his creative achievements.. As of 2012, he is still the acting CEO of the firm.