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## **Technology and innovation at Bosch**

### **An outline of Bosch product history**

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January 7, 2019  
Kuhlitz/C/CCH

Robert Bosch never saw himself primarily as an inventor. History backs up his self-image – he was more an entrepreneur than an inventor. For ever since his company was founded in 1886, it has been known for taking good ideas and turning them into marketable and innovative products.

From the very beginning, the company has been characterized by the remarkable talent of both Robert Bosch and his successors for recognizing interesting inventions and ideas that have the potential to make successful products.

This “nose” and the ability to turn ideas or basic designs into large-scale series products are also central to the company’s rise from a small workshop to a major technology group.

#### **Technology from the workshop – the birth of a company**

On November 15, 1886, Robert Bosch opened a small craft business in Stuttgart which he called “Workshop for Precision Mechanics and Electrical Engineering.”

Bosch and his two associates constructed and installed electrical equipment of all kinds, including telephone systems and remote electrical water-level indicators. Initially, Bosch did not develop any of its own products, instead opting to focus on existing products that were usually manufactured and installed in line with customer requirements.

Even the low-voltage magneto ignition device that Bosch produced at the request of a customer in 1887 for a stationary internal-combustion engine was initially just one of many products. Bosch scrutinized such objects in great detail, made up his own drawings of them, and improved them wherever possible. In the years that followed, up to 1897, the magneto ignition device accounted up to 50 percent of sales at the small company. The device alone did not bring massive growth for the company, but its use in an automobile did.

#### **From innovation to large-scale series production: magneto ignition**

In autumn 1897, the installation of a magneto ignition device in a three-wheeled vehicle was the start of the company’s development as a successful



automotive supplier. Robert Bosch's factory manager succeeded in improving the design so that the magneto ignition device could also be used in high-speed automotive engines. It was the only automotive ignition device that could be relied on in everyday driving conditions – and Bosch was the sole supplier.

January 7, 2019  
Page 2 of 8

But Bosch could not have known just how important magneto ignition would become for his company, as the true potential of the automobile was yet to be revealed. Nonetheless, the company scored its initial success when the device was unveiled at the “First Motor Vehicle Exhibition” in Berlin in 1898 and the first customer, Gottlieb Daimler, was secured. Bosch achieved its commercial breakthrough in 1902 when it designed an improved version of the device: the high-voltage magneto ignition system with spark plug. The system design had been optimized to allow it to be installed in almost every popular type of vehicle with relatively little effort.

### **Everyday technology for the car**

Magneto ignition rapidly established itself as the standard automotive ignition system. This achievement was also reflected in the company's development. Bosch opened its first factory in 1901, employing 45 associates. One year later, the factory produced its 50,000th magneto and, by 1912, one million units had rolled off the production lines.

By around 1900, Robert Bosch was marketing a range of twelve different product variants for motor vehicles – all of them magnetos. This dependency on a single product was risky. In order to counter this business risk, Bosch expanded its product portfolio in 1913 to include the “Bosch automotive lighting system”, a complete electrical lighting system for motor vehicles comprising generator, headlights, regulator, and battery. It formed the basis for an on-board electrical power supply that allowed a number of further components to be added – such as starters, electric horns, windshield wipers, direction indicators, and car heating systems. Bosch concentrated on components such as these, since they were needed to make the car suitable for everyday driving.

One important example of such an addition to the company's product portfolio was the electric starter. This device represented an enormous improvement for drivers, as it spared them the strenuous procedure of cranking up the car, meaning there was also no need to worry about the crank handle kicking back and causing injuries.

### **Motorization fuels demand**

The starter was typical of many products which Bosch launched between the end of the First World War and the first automobile industry crisis in 1926. The company's aim was to eliminate the shortcomings in operation and safety that were coming to light as motorization really took hold. Robert Bosch primarily looked for new product ideas that lent themselves to further development, or



that were conceived in-house and then developed until ready for series production. The hand-operated rubber wiper developed by Prince Heinrich of Prussia became the electric windshield wiper, the electric horn replaced the manual bulb horn, and car heating systems consigned hand warmers and long johns to the history books.

The direction indicator – which became known as electric turn signals from around 1950 – carried out the function previously performed by the driver's outstretched arm.

## **Diesel and gasoline**

### **Diesel injection**

A diesel or gasoline engine generates power by burning an air-fuel mixture. This mixture has to be delivered in the right amount and at the right time to the engine's combustion chamber. In the 1920s, this was done by means of a carburetor in gasoline engines, and by means of an injection pump in diesel engines. And while the mixture is ignited by means of a spark in the gasoline engine, in the diesel engine pressure and a high temperature alone are sufficient. When the first diesel-engine trials were carried out in trucks from 1920, this was cause for concern at Bosch. After all, the diesel engine did not need an ignition system, but ignition systems were the main source of Bosch sales. If diesel technology were to prove successful, then the company knew it had to be ready for it at all costs. Accordingly, it began to develop diesel injection pumps in 1922.

It took five years to get this challenging technology ready for series production. Injection technology demanded precision metering at high pressures. Manufacturing of the product began at the end of 1927 and, soon after, Bosch began supplying its first customer, the truck manufacturer MAN. Bosch launched the first diesel injection pump for passenger cars in 1936 – it was the first time the world had seen the diesel engine as a series-manufactured product in a passenger car. Step by step, Bosch modified and improved this technology, launching the common-rail high-pressure injection system in 1997. Within a few years, it became the standard technology for diesel injection.

### **Gasoline injection**

Bosch derived gasoline injection from diesel injection. The diesel pumps had to be adapted for gasoline. Unlike diesel, the new fuel did not lubricate the moving metal parts. Initially, gasoline injection was only developed for use in aircraft and entered series production in 1937. Improved performance and operational dependability were major advantages, as injection was a much more reliable means of delivering fuel in aircraft operation than the carburetor technology established in road vehicles.

The road vehicle market itself did not come into play until the beginning of the 1950s, when the benefits of improved performance brought fuel injection to



the attention of the racing scene. Moreover, the system's advantages in terms of consumption and exhaust emissions met with new market requirements for the first time. The electronically controlled Jetronic, introduced in 1967, was a milestone, setting the standard for today's engine management systems in gasoline engines.

### **Alternative drive systems**

However, Bosch is not just a leading supplier of diesel and gasoline injection systems. For over four decades, the company has been researching electric drives for road vehicles. Since 2010, it has been supplying solutions for hybrid systems, which combine an internal-combustion engine with an electric motor. Apart from core components such as power electronics and the electric motor, Bosch also supplies the management system, including the electronic control unit. On the basis of a wealth of sensor data, this unit governs whether the vehicle is powered by the electric motor, the internal-combustion engine, or both. Bosch is also ready for the all-electric automobile. Since the autumn of 2010, a joint venture with Samsung has been manufacturing lithium-ion batteries for electric vehicles. And for bicycles, Bosch has been supplying electric drives in combination with an electronic control since early 2011.

### **Automotive electronics**

It is no longer possible to imagine cars without electronics. Whether air conditioning, braking assistance, or airbags, a vast range of functions are now controlled electronically. When automotive electronics was still in its infancy, Bosch was looking for a way to make automotive equipment durable and low-maintenance. Semiconductors proved to be products with good potential. They were to replace breaker-triggered circuits that were prone to wear and tear, and offered the benefit of smaller dimensions, a complete absence of mechanical movement, and therefore an almost unlimited service life.

Bosch first used semiconductors in 1958 in generators and also began manufacturing the components in-house. The benefits of electronics also came to the fore in other areas such as ignition, transmission control, and gasoline injection systems. In 1968, the company decided to set up a plant specifically for semiconductor manufacturing in Reutlingen, near Stuttgart, where production started in 1970. The reason behind this move was that the electronic components available on the market until then had not been suitable for the extreme conditions in the automobile (temperature fluctuations, vibrations, humidity). As in the case of industrial technology, Bosch decided to be its own supplier because of a lack of suitable products on the market.

The next generations of semiconductors that Bosch developed in the 1970s – integrated circuits, hybrid, and microhybrid circuits – made it possible to



develop a whole series of new products. These products include exhaust gas regulation systems using the lambda sensor (1976) and the ABS antilock braking system (1978) – all of which are systems we take for granted today. These reliable, maintenance-free auxiliary components have evolved to become sophisticated control centers virtually indispensable for the driver.

January 7, 2019  
Page 5 of 8

### **“More strings to the bow...”**

Up until 1913, Bosch had really only manufactured one kind of product – the magneto ignition device, later the magneto ignition system. To minimize the risk that this dependency created, the company initiated a comprehensive expansion of its portfolio of electrical equipment for the automotive industry. However, this was still not a broad enough basis to ensure consistent growth. The crisis that hit the European automotive industry in 1926 highlighted how susceptible Bosch was to fluctuations in this industry. As a result, the company diversified into other business fields.

Bosch developed new products outside the automotive sector, such as household appliances (1933), TV cameras and broadcasting equipment (1929), and power tools (1928). It also extended its product portfolio by acquiring other companies. Examples include the takeover of the natural gas-fired appliances business of Hugo Junkers (1932), the purchase of the radio company Ideal (1933: later to become Blaupunkt), and the acquisition of the cinema projector manufacturer Bauer in 1934.

### **Drills, screwdrivers, grinders**

Another new business field was power tools. In 1928, the Bosch subsidiary Eisemann marketed a hair-cutting device called Forfex that had a small electric motor installed in its handle. This device was the precursor of the compact electric screwdrivers and drills we know today. Bosch engineers came up with the idea of using the same basic design to create hand-held power tools that were urgently needed for the manufacture of diesel injection pumps. The first tools were ready for use in 1930, and proved to be so good that Bosch launched the design onto the market in 1932 as the “hand-held motor”, the forerunner of all modern lightweight Bosch power tools.

At the same time, Bosch engineers were working on heavy-duty power tools for use on construction sites. The result of their work, the Bosch hammer drill, was launched at almost the same time as the smaller power tools and was marketed as a replacement for the construction tools used for manual chiseling and drilling work. At first, Bosch only offered these tools for professional use, but in the 1950s the company developed tools for use in the home.



Today, Bosch is a leading manufacturer of power tools for do-it-yourselfers and professional users, as well as of electrically powered garden tools.

January 7, 2019  
Page 6 of 8

### **In-car music and navigation**

Bosch had been supplying radio parts to the Berlin-based radio equipment manufacturer Ideal since 1930. This business relationship culminated in the gradual takeover of Ideal in 1932. In the same year, Bosch and Ideal presented a jointly developed product: “Auto Super 5,” the first series-production car radio in Europe, which was marketed under the brand name “Blaupunkt”. The Ideal subsidiary was renamed “Blaupunkt-Werke” in 1938. Apart from car radios, Blaupunkt’s main products at the time were radios for the household. With its numerous innovations including stereo sound, CD players, and the traffic news decoder, the share of the business accounted for by the car radio continued to grow over the decades. From 1990, Bosch – still under the Blaupunkt brand up to 2008 – began focusing exclusively on in-car radio and the new navigation sector, which was unveiled in 1989 with the “TravelPilot IDS”. Today, the Bosch Car Multimedia division manufactures in-car infotainment systems for cars, incorporating navigation systems and radios.

### **Electric helpers in the home**

At the Leipzig Spring Fair in 1933, Bosch presented an electrically powered refrigerator for domestic use. This, too, was the result of efforts to establish business fields outside the automotive industry. In technical terms, the refrigerator was nothing new, as electricity was already in widespread use to keep foodstuffs cool in the food and catering industries. However, the truly innovative aspect of the product was Bosch’s idea of producing a device that was affordable for private households and which would make electrical refrigeration part of everyday life in ordinary homes.

This refrigerator formed the basis for the Household Appliances business unit, which was expanded in 1951 to include numerous products such as food processors, washing machines, and dishwashers. In 1967, Bosch transferred its household appliance activities to a joint subsidiary with Siemens AG, thereby creating what is today known as BSH Bosch und Siemens Hausgeräte GmbH.

### **Warm home, hot water**

Hugo Junkers patented his “Kalorimeter” in 1895, a device that was the technological basis for machines that use natural gas to heat water. When his company – which, as well as producing natural gas-fired devices, was also well known as a manufacturer of aircraft and aircraft engines – encountered



financial difficulties in 1932, Junkers sold his natural gas-fired appliance manufacturing facilities to Bosch.

January 7, 2019  
Page 7 of 8

At the time, the product portfolio comprised a range of large devices for heating water in private homes and industry. Bosch expanded this range to include natural gas-fired boilers for room heating as well as devices that combined both functions.

Today, the Thermotechnology division at Bosch incorporates a range of brands including Junkers and Buderus. These brands offer natural gas-fired, oil-fired, and electrically powered heating systems and water heaters, as well as facilities that use renewable energy such as solar collectors and heat pumps.

### **Industrial technology and renewable energies**

The Industrial Technology business sector can trace its origins back to the construction of production machinery, which Bosch has been involved with since 1902. The grinders and lathes needed to produce magneto ignition systems were not available in the quality required. Ever the entrepreneur, Robert Bosch decided to manufacture them in-house.

These activities led to the establishment of a business unit that was initially named *Sondermaschinenbau*, which specialized in building manufacturing equipment. It was renamed the Industrial Equipment business unit in 1968, and was then finally merged with other product lines to form the Automation Technology division in 1996. A major milestone in this area was the world's first swivel-arm robot, which Bosch began developing in 1976 and launched in 1984.

In 2001, Mannesmann Rexroth AG and the Automation Technology division of Robert Bosch GmbH merged. Bosch Rexroth AG, the subsidiary that arose from this merger, supplies drive and control technology for manufacturing machinery as well as for such unusual applications as stage machinery in theaters and coastal flood barriers.

In the area of renewable energy, Bosch Rexroth is a leading manufacturer of gearboxes and drive solutions for adjusting rotor blades and turning the nacelles of wind turbines to face the wind. As a development partner for marine power, Bosch Rexroth works closely with plant manufacturers, whose first prototypes are generating power from wave energy and currents.

In acquiring the photovoltaics manufacturer *ersol solar energy AG*, which today is its Solar Energy division, Bosch added a decisive technology to its portfolio and enhanced its competence in the renewable energy field. The Solar Energy division, which also includes *aleo solar AG*, supplies products ranging from photovoltaics components to turnkey solar power stations.

### **Security and communication**

The company *Hanseatische Notruf AG*, founded in 1920, is the origin of what is today the Bosch Security Systems division. However, Notruf AG was not a



Bosch subsidiary, but rather one of many precursor companies – the current Security Systems division was not established until 2002.

It goes back to a range of Bosch activities related to the field of security systems, where the company has developed technological know-how over a period of decades. These include the skills of numerous security systems manufacturers with which the company has cooperated in the past or whom Bosch has incorporated into its own Security Systems division. Knowledge and experience has also flowed in from Bosch divisions where the company is no longer active, such as television technology and telecommunications. Today, this young Bosch division is mainly known for its intrusion systems, video surveillance systems, public address technology, access control systems, social-alarm systems, and biometric recognition methods.

### **Software solutions and networking**

For some time now, the ways in which the classic products connect with each other has been as important as the products themselves. In light of the increasing importance of the internet of things and services with some billions of connected devices within the next years, Bosch started developing connected solutions around ten years ago, covering now all core businesses of the company

The importance of the internet of things and services (IoTS) strongly grows in the field of mobility, and energy and building management. In 2014, Bosch Connected Devices and Solutions GmbH was founded, in the following years Robert Bosch Smart Home GmbH, and in 2018, the new mobility division Connected Solutions. And Bosch is also part of worldwide projects to make the connected „Smart City“ reality. So, Bosch is not only a leading company for developing and selling products in a literal sense, but also for software and services. The key to future success is combining expertise in these areas to integrated solutions.