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Göran Ahlström

DEPARTMENT OF ECONOMIC HISTORY, LUND UNIVERSITY

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Department of Economic History, Lund University
Postal address: P.O. Box 7083, S-220 07 Lund, Sweden
Telephone: +46 46 2227475
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# “The Edison of Sweden”

## C.E. Johansson and the 'Standards of Standard'[*]

*Göran Ahlström*

In Europe during the 19th century, manufacturing based on interchangeable parts was referred to as “the American System of Manufacture”. Industrial production had always required precision of measurement in the individual manufacturing shop, so that, for example, various types of gauges with upper and lower limits of tolerance had gradually been devised. These gauges also had to be checked against some standard dimension. However, with the growth of interchangeability of products, the measurements themselves had to be standardised, since otherwise parts used in one shop would not fit perfectly with parts made in another. The inventor of such standards was a Swedish machinist, Carl Edward Johansson,[1] founder in 1910 of the firm of *C J Johansson & Co* (*C E Johansson Ltd* from 1911). The standards came in the form of gauge blocks, “jo blocs” as they were called after their inventor, which made possible accuracies of a few millionths of an inch and were available in sets – the first set of measures sold consisted of 102 gauge blocks arranged in 3 series – in which any dimensions could be set up to the order of accuracy.[2] In the early 20th century the gauge blocks and another Johansson device called the “gauge with progressive tolerance” (1907) were patented[3] and used in countries all over the world. In a letter of 1926 Johansson wrote, not without some pride: “My sets of gauge blocks have become for the engineering industry what types are for the printing industry. ”[4] By this time he had become internationally famous and had been collaborating closely with Henry Ford, for example, since 1923.

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[*] Paper presented at the XXI International Congress of History of Science in Mexico City, 8–11 July, 2001.

[1] See Althin, T., *C.E. Johansson 1864-1943. Måttens Mästare*. Stockholm 1947, p 14.

[2] Woodbury, R.S., "Machines and Tools", in Kranzberg, M. and Purcell, C.W.Jr (eds), *Technology in Western Civilization*, Vol. 1. Oxford University Press, London/Toronto/New York 1967, p 625.

[3] See footnote 26.

[4] Quoted in Althin (1947), p 93.

C E Johansson (1864-1943) was trained as a cabinet-maker. After some years of studies and practical work in the United States he was employed in 1885 as a filer and engine fitter by the Eskilstuna engineering firm of *E V Beronius Mekaniska Verkstad*. Two years later he began his career at *Carl Gustafs Stads Gevärsfaktori*, the Eskilstuna gunmaking firm, and in 1890 he became the firm's armoury inspector.[5] As an armourer he controlled the operation of the specialised machines, tools and precision gauges connected with the production of rifles. It should be emphasised that in the 1880s the making of rifles "/was/ probably ... the most exacting in its demand for precision of any engineering industry manufacturing in long production runs"[6] and it should be remembered too that from the moment in the 1860s when production of the Remington was launched, the Eskilstuna rifle factory became the most modern firm in Sweden.

It was in connection with the introduction of a new type of rifle, the Mauser, into the Swedish army, and a possible future collaborative arrangement (manufacture under licence) between the Eskilstuna firm and the German *Mauser-Werke*, that Johansson conceived the idea of the gauge blocs. An order was placed with the German firm in 1894, and a Swedish inspection committee visited the factory at Oberndorf. The most active member of the committee was C E Johansson[7]– and it was after this that his revolutionary idea was born.

It seems clear that the international exhibitions of the 19th century filled an important function in the dissemination of technological knowledge and skill[8], and that the history of precision gauges represents a very good example of this circumstance. It is therefore appropriate to draw attention to certain facts concerning the development and use of micrometers and vernier callipers, and also to Johansson's attitude to exhibitions.

As the precision of machine work improved during the 19th century, it became desirable for the engineer to make accurate measurements at the workbench. Although the micrometer existed by the middle of the century – Watt had constructed a portable screw gauge for his own use and in 1848 the Frenchman J R Palmer had produced a micrometer very similar to those of the present day – such devices were seldom used in most machine shops at that time.[9] The introduction of the vernier calliper

[5] Eskilstuna 100 km west of Stockholm.
[6] See Althin, ibid, p 36. The only other comparable lines of production at that time were sewing machines and, of course, watchmaking.
[7] Althin, ibid, p 44.
[8] See Ahlström, G., *Technological Development and Industrial Exhibitions 1850 - 1914. Sweden In An International Perspective*. Lund University Press, 1996
[9] Woodbury, ibid, p 624 f.

in 1851 – probably presented at The Great Exhibition in London that year – by the American Joseph R Brown, brought into being the first practical precision measuring instrument for ordinary machine-shop use. The instrument made possible a precision of one thousandth of an inch. At the Paris Exhibition in 1867 the Palmer gauges were seen by Brown and Lucian Sharpe, the founders of the American firm *Brown and Sharpe Co*[10]. They recognised their importance and developed the technology. By 1877 they were offering a micrometer with one inch between the jaws, and by the 1880s this was in use by engineers all over the United States. By the early 1890s the Brown & Sharpe micrometer was also in use at the Eskilstuna rifle firm, which had about forty of them by 1899.[11] Johansson praised the Brown & Sharpe micrometers.[12]

As we have remarked, however, Johansson was looking for change and simplification in precision measuring. On his visit to the German *Mauser-Werke* he realised, to his great surprise, that although the German firm had the best machines and tools of the time, there was no particular system: the firm had produced and collected gauges in thousands and arranged them by size in individual pigeon-holes.[13] This was how, in 1894, he came to conceive the idea of his gauge blocks, which he presented to the Eskilstuna rifle firm in 1896. Swedish firms were the first buyers of the gauge blocs in 1899,[14] and by 1906 twentyeight Swedish and three foreign firms were using them. A booklet of 1913 stated that fiftyfive Swedish firms had acquired the blocks as well as about four hundred foreign testing institutes, colleges, engineering firms and manufacturers of rifles, ball bearings and vehicles, and shipyards. In that year the "C E Johansson System" was sold to thirteen European countries as well as to the United States, Japan and Brazil. For example, the US War Department bought the firm's products, and in 1915 it was decided that the Johansson system should be the norm or standard for all civil and military firms in the United States producing war material. Althin, in his study of C E Johansson, said: "With some exaggeration it has ... been said that C E Johansson's gauge blocks won the First World War. What is certain is that they contributed in the highest degree to the raising of the Allies' war potential. "[15] The American subsidiary company *C E Johansson Incorporated* was established in 1918 to produce and sell the gauge blocks. It was originally located in New York City but moved to Poughkeepsie in 1919.

[10] Ibid.
[11] See Althin (1947), pp 43, 47
[12] Ibid, p 73.
[13] Ibid, p 45.
[14] Ibid, p 71.
[15] Ibid, p 131.

Johansson visited the United States on many occasions during his lifetime, but when he arrived there in 1919, 35 years after his first visit as an unknown Swedish emigrant, he had become a very famous personage and was hailed in the American press with such sobriquets as "The Edison of Sweden" or "The most accurate man in the world. "[16]

One of the prerequisites of very high precision in measurement at that time was the quality of Swedish steel, and it has been observed that the development of the Johansson gauge blocs represented a fruitful collaboration between Swedish metallurgy, steel processing, machining and manual dexterity.[17] One example of an international verdict on the quality of the blocks is professor Samuel W Stratton's statement in 1907, when the American National Bureau of Standards, together with a large number of scientists, made an investigation of the planeness of the blocks: "this is an accuracy, that we have up to now considered impossible in metal. "[18] It had been possible before to attain such accuracy and planeness – 4-8 millionths of a millimeter between the gauge's contact surfaces – with glass, but never with metal. A similar experiment was carried out in Paris with a similarly favourable outcome.

Thus it was that C E Johansson became a very distinguished figure in industrial and scientific circles. His system of measurement had been successfully presented to the *Société d'Encouragement pour l'Industrie Nationale* in Paris in 1903, and he was awarded the *Médaille de Vermeil*.[19] The first gauge blocks were sold abroad in the following year. Dr J A Brinell, chief engineer of the Swedish Ironmasters' Association, presented the Johansson system to the Royal Academy of Sciences in 1908, and Johansson was awarded a prestigious Swedish prize.[20] It should be observed that the Johansson system was also presented to the French *Académie des Sciences* in 1909 by professor J Carpentier. In this way the system received further international publicity, since the report was printed in various journals and translated into foreign languages.

Johansson's excellent relations with the Swedish engineering and export industries were also of great importance in the marketing of the gauge blocks. The fact that well-known Swedish firms such as *AB Separator* (today *Tetra-Laval AB*) and *Köping Engineering Works* – renowned for its high-speed steel and the firm which manufactured the gearboxes for the newly-established firm of *Volvo* in 1926 – bought the blocks early on in the 20th century has been remarked on as an important factor in successful sales; the latter firm particularly gave the blocks

[16] Ibid, p 135.
[17] Ibid, p 73.
[18] Ibid, p 55.
[19] Ibid, p 82.
[20] The Arnberg prize.

publicity on the international market, as Johansson is said to have observed with gratitude.[21] When Johansson himself delivered a detailed lecture to the Swedish Metal Trades Employers' Association (*Sveriges Verkstadsförening*) in 1908 the vote of thanks was moved by Sigfrid Edström, managing director of *ASEA* (today *ASEA Brown Boveri, ABB*) in these words: " ... for the sterling and assiduous labour he has devoted to furnishing us with the means needful for the control of precision. "[22] When the Royal Swedish Academy of Engineering Sciences (*Ingenjörsvetenskapsakademien*) was founded in 1919, C E Johansson became one of the Academy's inner circle.[23]

The numerous forms of national and international recognition such as those cited above, along with sundry diplomas and awards, say a good deal about the renown of C E Johansson's "Standards of Standard". As was pointed out above, the world exhibitions were of great importance in disseminating new technology – a fact of which C E Johansson was very well aware. For example, in the firm's letterhead both before and after the company's formation in 1911, not only is Johansson's Vermeil medal shown but also the firm's gold medal and diploma of honour from the world exhibition at Liège in 1905. But why then did Johansson not participate in the great world exhibition of 1900 in Paris, an exhibition which formed the culmination of an era of total exhibitions which had started in the middle of the 19th century with the central focus on industrial technology? The Great World's Fair in Paris in 1900 would have been a very important arena in which to display and present the "Johansson System". Yet Johansson did not take part, and a further decade was to elapse before his firm was established. We can only speculate as to the reasons for his non-participation, but it seems very likely that the main one may have been difficulties with the Swedish patent authorities over the grant of an idea-patent.[24]

C E Johansson had presented his application for a patent in March 1898. But the Patent Office did not consider the gauge blocks an innovation since the method of "placing two or more gauge blocks together for control purposes" had been in use for a long time. In November 1899 the application was rejected on the ground that the method "could not be regarded as an industrial product or a method of manufacturing such a product".[25] Of course Johansson would not accept the verdict and in May 1901 he submitted a new and somewhat modified

[21] Althin, ibid, p 84.
[22] Ibid, p 85.
[23] Ibid, p 154.
[24] Althin does not mention the Paris exhibition in his study of Johansson.
[25] Althin, ibid, p 91.

patent application. But again the patent authorities made objections. Supported by a study made by the Royal Technical University (Stockholm; *KTH*), however, the Government resubmitted the case to the Patent Office in June 1903. Not until January 1904 was ratification of the patent for the gauge blocks achieved.[26] During the period when the application was under consideration in Sweden, Johansson had applied for a patent in England too. Here the procedure was quicker: the application in June resulted in a patent in August 1902.[27] The English patent was the first of a long series of Johansson patents in the years that followed. In the light of these facts concerning the controversies with the Swedish patent authorities particularly, the absence of the gauge blocks from Paris 1900 is understandable. Had the blocks been patented by the time of the Paris exhibition it is very likely that they would also have been displayed there. As we have seen, C E Johansson was very well aware of the importance of publicity, and in this respect the exhibition was an important medium.

Fame does not always mean financial success, however, and Johansson's firms, both in Sweden and in the United States, were hit by the severe postwar depression of the early 1920s. But in the American case, as we hinted at the outset, this brought a close collaboration with Henry Ford and even greater fame.

The American subsidiary company was running at a loss, and to prevent his life's work from being shattered C E Johansson hoped he might manage to bring about a reconstruction of the firm through his own connections and personal exertions. Johansson contacted Ford by letter, offering his collaboration. Ford was interested in attaching Johansson personally to the *Ford Motor Company*, and by the summer of 1923 the negotiations had reached the point where a contract on collaboration was established. Ford also purchased C.E. Johansson Inc, and manufacturing was transferred from Poughkeepsie to Detroit.[28] The importance of the "jo-blocks" in effecting further improvements in the serial production of the Model A Ford – improvements which had been considered impossible to make – has been emphasised recently by Houndshell: "In fact, Ford's competititors believed it impossible to manufacture the Model A below the retail price (which initially was true). Perhaps more than any other aspect of the change /to the Model A/, Ford had anticipated refinement in precision manufacturing. Wishing to

[26] January 30, 1904; patent nr 17017 for C.E. Johansson, Eskilstuna. "Måttsats för precisionsmåttagning." Johansson's second idea-patent "Mått med progressiv tolerans" – patent nr 27255 – was granted July 31, 1909 with priority from, i.e. backdated to, November 25, 1907.
[27] Ibid.
[28] Ibid, p 136 f.

have the best toolroom gauges possible, Henry Ford purchased the famous gaugemaking operation of the Swede C E Johansson in 1923 and soon moved into the laboratory facility in Dearborn ... . "[29] As is well known, the Ford Motor Company too was hit by marketing and competitiveness problems, but amelioration of this situation was achieved as well, and the company's own newspaper, "Ford News", reported that of Ford's twelve departments, C E Johansson's was one of the most important to the expansion of the company. It also has to be said that Ford and Johansson became good friends, and that C E Johansson seems to have been the only person, along with Henry Ford's son Edsel, who was permitted to enter Henry Ford's office without knocking on the door.[30]

By virtue of his position with Ford and through the reconstruction of Johansson's Swedish company in 1926, he "personally superintended and maintained" – to quote Althin's words – "the correct standard measures both for America's industry and for industry in the other countries of the world".[31] For example in 1933, when the relation between the inch and the millimeter was at last established internationally (1 inch = 25.4 mm) at a defined measured temperature (+20° C), this was a result of the fact that American industry had been exclusively using Johansson's gauge blocks in inches ever since 1923; and that this being so he took this relation between inch and millimeter as given.[32]

In the summer of 1936, C E Johansson returned to Sweden and Eskilstuna for the last time, which brought his crossings of the Atlantic to no fewer than 22 and his periods of residence in America to a total of nearly 20 years of his life.[33] By this time Johansson had rceived further awards and decorations for his work, for example the John Ericsson gold medal awarded him by the Society of Swedish Engineers in the United States (*Svenska Ingeniörsföreningen i USA*) in 1932.[34] In 1940 he received the grand gold medal of The American Society of Mechanical Engineers, a distinction seldom granted to a non-American,[35] and in 1943 he was posthumously awarded the grand gold medal of the Royal Swedish Academy of Engineering Sciences (*Ingeniörsvetenskaps-*

[29] Hounshell, D.A., *From the American System to Mass Production 1800 - 1932. The Development of Manufacturing Technology in the United States.* The John Hopkins University Press, Baltimore and London, 1984, p 286.
[30] Althin, ibid, p 141.
[31] Ibid, p 143.
[32] Ibid, p 123.
[33] Ibid, pp 144, 152.
[34] Ibid, p 154.
[35] Ibid, p 155.

*akademien*), which his widow received from the hands of Sweden's then Crown Prince.[36]

This is not the place, of course, in which to attempt a rounded description of C E Johansson the man: it is his achievements in the fields of technology and engineering science that are our focus of interest, and as far as they go the facts presented speak for themselves. It is a commonplace fact, too, that biographies of well-known personalities have a tendency to embellish the subjects of their study. The biographical underpinning of the present article – Althin's study entitled *C.E. Johansson 1864-1943. Måttens Mästare* – is no exception in portraying a quite splendid personage! C E Johansson emerges as a conscientious, hardworking man "with both feet on the ground" – loyal, unassuming and humane. Moreover he seems to have had a sense of humour. Perhaps this was so. At all events I shall conclude by presenting a few extracts from Johansson's letters and personal notes, along with episodes from his life in which we catch glimpses of aspects of his personality such as reflectiveness, self-deprecating irony and humour.

– With the floating of his company in prospect in 1910, these words from a letter of 1909 show wariness – and language full of imagery: "what matters is to steer the craft so that it doesn't run aground. And it's certainly better to get ashore from a smaller boat than to suffer shipwreck on a vast ocean with a big vessel."[37]

– In 1926; when the temperature-conditioned room – a room with constant temperature – at Ford is ready and the reconstruction of the company has been completed: "I have always worked with a certain degree of exactitude, I have never been in a hurry, and so I have had an idea or two which no one else has had. "[38]

– While living in the United States in the 1920s, Johansson travelled every day by car from his home in Detroit to the Ford plant at Dearborn, a journey of about 20 km, to reach his place of work punctually. In December 1926 he had a puncture and arrived 7 minutes late: "Annoying, but the only time in three years. "[39]

– Johansson is reputed to have related the following episode often and readily: In 1919 he met Thomas Alva Edison at the latter's laboratory. They both suffered from deafness, and when Johansson took out his hearing aid, which he called his "peacepipe", Edison said: "So you are deaf, too. " Then they leaned towards each other while Johansson demonstrated his set of gauge blocks with an accuracy of a millionth of

[36] Ibid, p 161.
[37] See ibid, p 125.
[38] Ibid, p 143; spoken words.
[39] Ibid, p 147; note in diary.

an inch. “You must have something beyond millionths in your own measuring, ” remarked Edison, whereupon C E Johansson admitted that he had a method which made possible measurements of a ten-millionth of an inch – but that he was unwilling to disclose how it worked. “Won't tell, eh? – Well, he's right, ” replied Edison, who knew from his own experience that inventions were best not talked about[40] – at least not before a patent had been applied for .... Perhaps also an argument for C E Johansson’s sobriquet: “The Edison of Sweden”.

[40] iBID, P 156.

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