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A NATIONAL COMPARISON, 1920-1940

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Diesel Engineering in Germany and France: A National Comparison, 1920-1940

Mikael Hård[1] and Andreas Knie[2]

The Diesel Engine--A German Machine?

At a meeting with the German Engineering Society (VDI) in 1925 Imanuel Lauster expressed his "deep satisfaction" with the latest, successful developments in diesel engineering. As a board member of the Bavarian-based Maschinenfabrik Augsburg-Nürnberg (M.A.N.), he was pleased to note that it was *German* engineers and companies that deserved the credit for this success. Lauster claimed that "the diesel engine in its present form is still a German engine" and hoped that "it will remain so."[3]

Lauster did not utter these words in connection with any kind of celebration or anniversary. His reasons for asserting the German-ness of the diesel engine at this time were, so-to-speak, politically founded. The growing international diffusion of the engine threatened ultimately to shift the initiative away from German firms and over to foreign companies. Lauster's hope was, as it were, a desperate attempt to build a German coalition that could withstand foreign competition. As we will show below, similar attempts would a couple of years later actually lead to the collective design of a German "unitary diesel" (*Einheitsdiesel*).

Lauster had his own axe to grind. Rudolf Diesel had grown up in France--but had been forced to leave that country in connection with the Franco-Prussian war; he had had the Frenchman Sadi Carnot's idea of the optimally efficient heat-engine process as his visionary goal; and he had lived a decade in Paris as a grown-up. The following comment that Diesel is said to have made later on thus makes Lauster's worries more understandable: "If I had not been chased out of

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[3] Imanuel Lauster, "Entstehung und Entwicklung des Dieselmotors," *in* Verein deutscher Ingenieure, eds, *Dieselmaschinen*, Vol. I, Berlin, VDI-Verlag, pp. 31-33.

France, then the engine that carries my name might have been French."[4] As things turned out, it was in Germany that Diesel would begin to work out his first design plans and to build a network of industrialists that could help him materialize his ideas. Central in this network had been the Maschinenfabrik Augsburg, one of the parent firms of M.A.N.[5] Remaining conveniently silent about the subsequent foreign influence also on M.A.N. designs, Lauster regarded it as a question of honor that as much as possible of the design characteristics that had originated in this early period be acknowledged--at least by German companies.

With their claims that the diesel engine was a German machine Lauster and Diesel reflected views that slowly began to emerge also among historians and sociologists at the time.[6] Conrad Matschoß, the founding figure of history of technology as an academic discipline in Germany, could in 1908 discern what he meant to be national differences between the ways that steam engines had been designed in Germany and Great Britain, respectively.[7] Thorstein Veblen, the free-thinking American sociologist and economist, delivered during the First World War an analysis where he compared the industrialization paths of the same two European countries.[8] It would, however, take more than half a century before such ideas began to reemerge in a serious fashion in the writings of historians and sociologists interesting in technological change. As in many other discourses, Lewis Mumford played a considerable role here.[9] His discussion about how authoritarian technologies have developed in some parts of the world and democratic in other parts anticipated what during the last odd decade became an exploding interest in the political, social, and cultural basis of technology.[10] In

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[4] According to *Le praxis*, No. 36, Jan. 1976, p. 31, Rudolf Diesel--looking back at how he and his family had been forced to leave Paris (where he was born) after the French-German war in 1870--is supposed to have said this to his friends; orig.: "Si l'on ne m'avait pas chassé de France, peut-être que le moteur qui porte mon nom aurait été français [...]."

[5] Lynwood Bryant, "The Development of the Diesel Engine," *Technology and Culture*, Vol. 7, 1976, pp. 432-46; C. Lyle Cummins, *Diesel's Engine: Vol. 1: From Conception to 1980*, Wilsonville, Carnot Press, 1993; Eugen Diesel, *Diesel - Der Mench, Das Werk, das Schicksal*, Hamburg, Hanseatische Verlagsanstalt, 1937; Andreas Knie, *Diesel - Karriere einer Technik. Genese und Formierungsprozesse im Motorenbau*, Berlin, Ed. Sigma, 1991; Donald E. Thomas, *Diesel: Technology and Society in Industrial Germany*, Tuscaloosa, Alabama, The University of Alabama Press, 1987.

[6] Mikael Hård, *Appropriating the Machine: German Discourses on Technology and Society, 1905-1935*, STS working paper 1/95, University of Trondheim, 1995.

[7] Conrad Matschoß, *Die Entstehung der Dampfmaschine*, Berlin, Springer, 1908, p. 107.

[8] Thorstein Veblen, *Imperial Germany and the Industrial Revolution*, New York, McMillan, 1915.

[9] Lewis Mumford, "Authoritarian and Democratic Technics," *Technology and Culture*, Vol. 5, 1964, pp. 1-8.

[10] See anthologies from Donald MacKenzie and Judy Wajcman, eds, *The Social Shaping of Technology: How the Refrigerator Got Its Hum*, Milton, Keynes, Open University Press, 1985, over Meinolf

this wave of interest national differences in how technologies are developed and used have been quite extensively analyzed. The sociologist Werner Rammert has, for instance, drawn our attention to the various shapes and user patterns that characterize the telephone system in various countries, and the historian Hans-Liudger Dienel has compared refrigeration technology in Germany and the United States.[11]

Several scholars use the concept of "style" as an tool for national and regional comparisons. Perhaps most well known is the historian Thomas Hughes, who applies the concept of "technological style" in his analysis of the different characteristics of the electricity networks in Berlin, London, and Chicago.[12] Dienel has picked up this thread in suggesting that the style of German refrigeration was strongly influenced by the engineering sciences, whereas the American style was much more governed by the structural demands posed by mass production. John Staudenmaier has referred to the American inclination for standardized parts and products to illustrate how "style" can be used to describe those patterns of technological action that can be found in a cultural sphere,[13] and the French historian Alain Dewerpe has talked about "national styles of production" in relation to ship-building technology in France, Germany, Great Britain, and Norway.[14]

Despite these attempts, it has to be said that "national style" has mostly been applied in a metaphorical manner. It can hardly be claimed that its conceptual fruitfulness has been univocally proven--something which no doubt has to do with the fact that such an investigation has to be quite elaborate to be convincing. In the case of automotive technology, for example, it would be quite dissatisfying if "style" were applied only to point out the physical differences between a Peugeot or a Citroën on the one hand and a B.M.W. or a Mercedes on

Dierkes and Ute Hoffmann, eds, *New Technology at the Outset: Social Forces in the Shaping of Technological Innovations*, Frankfurt a.M. and Boulder, Col., Campus Verlag and Westview Press, 1992, to Leo Marx and Merritt Roe Smith, eds, *Does Technology Drive History? The Dilemma of Technological Determinism*, Cambridge, MA: The MIT Press, 1994.

[11] Werner Rammert, *Technik aus soziologischer Perspektive. Forschungsstand, Theorieansätze, Fallbeispiele*, Opladen, Westdeutscher Verlag, 1993; Hans-Liudger Dienel, *Hochschule und Industrie. Wechselwirkungen zwischen technischer Thermodynamik und industrieller Kältetechnik in Deutschland und den Vereinigten Staaten 1870-1930*, Munich, Ph.D. dissertation, Ludwig Maximilian University of Munich, 1992.

[12] Thomas P. Hughes, *Networks of Power: Electrification in Western Society, 1880-1930*, Baltimore, MD, The Johns Hopkins University Press, 1983.

[13] John M. Staudenmaier, *Technology's Story-Tellers: Reweaving the Human Fabric*, Cambridge, MA, The MIT Press, 1985, p. 200.

[14] Alain Dewerpe, "Le style et le drapeau. Les conventions du produit naval francais au début du XXème siècle," paper presented at the conference *Institutions et conventions du travail en France et en Allemagne 1890-1990*, arranged by IEPE-IRESCO-CNRS and WZB in Paris, May 1995; orig.: "style national de production."

the other. A hint at the complexity of such an analysis is given by Jean Baudrillard in his book *America*, where he depicts the culturally based differences between the United States and Europe that manifest themselves not only in how automobiles and highways are designed, but also in how they are used:

> In Europe, the street only lives in sudden surges, in historic moments of revolution and barricades. At other times people move along briskly, no one really hangs around (no one wanders about any more). It is the same with European cars. No one actually lives in them; there isn't enough space.[15]

By comparison, the American car is a place where you live:

> The way American cars have of leaping into action, of taking off so smoothly, by virtue of their automatic transmission and power steering. Pulling away effortlessly, noiselessly eating up the road, gliding along without the slightest bump (the surfaces of the highways and freeways are remarkable, matched only by the fluidity of the cars' performance) [...][16]

In our subsequent comparison between German and French diesel technology we do not have the ambition to present a story on Baudrillard's level. Our ambition is simply to test how far "style" can bring us in an investigation of the action and orientation patterns of German and French automotive firms. With our reference to Lauster we have already implied that at least some German actors went out of their way in trying to coordinate the actions of his colleagues by means of an idea of a national standard. To give this idea rhetorical power, it was sometimes couched under the name of the "true faith" (*reine Lehre*) of diesel engineering. No ambitions in this direction were discernible in France. Although French engineers and industrialists were always eager to point to French predecessors that could belittle foreign contributions, they did never cultivate a strong sense of communality and tradition. Whereas many Germans tried to cultivate their own designs in an orthodox manner, their French counterparts were remarkable open and flexible. The outcome: German technological leadership and French commercial success.

To anticipate our concluding remarks, we doubt that these national differences can be meaningfully analyzed by using "style." It must be admitted that the concept does have some advantages--in particular because it is usually taken to encompass both a mode of action and the visible outcome of that action.

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[15] Jean Baudrillard, *America*, London and New York, Verso, 1988 (orig. *Amérique*, Paris, Bernard Grasset, 1986), p. 18.

[16] *Ibid.*, p. 54; the references to Baudrillard have been inspired by Håkon With Andersen and Knut Holtan Sørensen, *Frankensteins dilemma. En bok om teknologi, miljø og verdier*, Oslo, Ad Notam Gyldendal, 1992, p. 268.

However, "style" has, for our purposes, two distinct drawbacks. It implies a degree of stability that we do not find in our French material, and it implies, at least in our understanding of the term, that conscious choices are taken by members of one group in opposition toward other groups. Sure enough, Lauster was quite conscious in his plea for a German diesel--as opposed to French or, God forbid, American diesels, but so were not most French actors whom we will meet below. "Style" implies what Pierre Bourdieu has called "distinction," something that in our story only a few highly self-conscious and vocal German engineers represented.[17] In contrast, most French firms might rather be said to have been, as it were, without style.

Since "style" thus does not allow us to make a symmetric analysis of the empirical material, we will instead try out some metaphors from the world of linguistics. We will suggest that terms like "meaning," "dialect," "language," and "grammar" might be better suited to describe the ways in which designs and engineering knowledge are worked out, formulated, and codified.

Market Patterns and Business Cycles

Diesel producers in both Germany and France faced new but different challenges in the wake of World War One. Whereas German firms were busy trying to regain old markets in the ship-building and electricity-producing industry, French machine producers worked hard to build more or less a completely new market from scratch. Statistics tell us that immediately before the war only 1% of the world's totally installed diesel power was to be found in France--to be compared with 45% in Germany.[18] (Statistically speaking, it thus seems appropriate to say that the diesel was a German machine at this time.) Simultaneously, the prospects of completely new markets began to open up in both countries. Due to the shortage and consequently high price of gasoline in the troublesome afterwar period, any engine that could be run on more accessible and relatively cheaper heavy oils or, perhaps better still, vegetable oils were welcomed--not least by road-vehicle owners.

It was, however, easier said than done to design an oil engine--such as the diesel--that was suited for automotive purposes. The classical diesel was a large, heavy, and slow engine that worked well at constant speed. Although it was well adjusted to stationary purposes and large ships, it could hardly be of any practical use for land transport before the heavy and bulky air pump be removed and the piston speed be increased. These were the problems that designers in several countries now began to address.

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[17] Pierre Bourdieu, *Distinction: A Social Critique of the Judgement of Taste*, London, Routledge & Kegal Paul, 1984 (orig.: *La distinction. Critique sociale du jugement*, Paris, Éditions de Minuit, 1979.

[18] Eugen Diesel and Georg Strössner, *Kampf um eine Maschine*, Berlin, Schmidt, 1950, p. 142.

When the automotive diesel began to be regarded as a serious option in the twenties, the potential market was particularly large in France. French industrial production had by 1924 reached the level of the pre-war period and continued to expand rapidly until 1931.[19] Not unconnected to this trend, the number of registered automobiles in France increased more than ten times in the 1920s, and the truck market developed in a booming manner.[20] Despite the commonplace conception of the "roaring twenties," German industrial production did not follow this pattern, and in 1930 it had fallen below its pre-war level. A direct comparison from the year 1929 shows that more than twice as many engine-driven road vehicles were manufactured in France than in Germany;[21] and statistics from two years later tell us that there were 94 citizens to each such vehicle in Germany, but only 27 in France.[22] The depression had also hit Germany harder and earlier than France. Between 1929 and 1932 the automobile market shrank dramatically in all Western-European and North-American countries, except Great Britain. In Germany vehicle production went down by over 60%, but in France by only 30%.

The picture reversed after 1933. Partly as a result of the automobile-friendly policy of the National Socialist government, German production soon returned to the 1929 figure, and by 1935 it was more than 50% above it. Simulataneously, French production figures continued to decline, and France lost is position as the world's second largest producer of road vehicles.[23] The number of automobile manufacturers decreased significantly, more so in France than in Germany. The historian Joseph Jones describes the French transport policy of 1933 thus:

> [it] consisted of increased taxes on road fuel and on heavy goods' vehicles explicitly aimed at compensating for the railway deficit by punishing the automobile [...][24]

Here, it was no talk of anything like *Volksmotorisierung*. With the creation of the state railway company, S.N.C.F., in 1937 the situation for French automobile

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[19] Dominique Renouard, *Les transports de marchandise par fer, route et eau depuis 1850*, Paris, Armand, 1960, p 73; Alfred Sauvy, *Histoire économique de la France entre les deux guerres*, Vol. III, Paris, Economica, 1984, p. 323.

[20] Louis Muron, *Marius Berliet (1866-1949)*, Lyon, LUGD, 1995, p. 117.

[21] The figures are 254,000 against 123,000; cf. Walter Ostwald, "Um die Zukunft der deutschen Kraftfahrt," *Automobiltechnische Zeitschrift*, Vol. 34, 1931, p. 225.

[22] Hans-Otto Neubauer, *Chronik des Automobils*, Gütersloh/Munich, Chronik-Verlag, 1994, p. 197.

[23] Jean-Pierre Bardou, Jean-Jacques Chanaron, Patrick Fridenson, and James M. Laux, *The Automobile Revolution: The Impact of an Industry*, Chapel Hill, The University of North Carolina Press, 1982 (translation of *La révolution automobile*), p. 140; Patrick Fridenson, *Histoire des usines Renault. I. Naissance de la grande entreprise 1898-1939*, Paris, Éditions du Seuil, 1972, p. 198.

[24] Joseph Jones, *The Politics of Transport in Twentieth-Century France*, Kingston and Montreal, McGill-Queen's University Press, 1984, p. 45.

manufacturers and their customers got even worse. One of the means that the government now announced was to increase "the tax on diesel-oil, which had previously been far less heavily taxed than petrol."[25]

The effects of these policies were clear. French manufacturers of trucks, buses, and diesel-engines experienced very difficult times: "By 1938, only one in four of French trucks was under five years old, compared to 60 per cent in Germany [...]."[26] In the same year 30,000 trucks were produced in France, as compared to as many as 88,000 in Germany--one fourth of the latter being delivered to the military.[27] However, it was still the case that the total number of automobiles was higher in France than in Germany: 1.8 as compared to 1.3 million.

Germany: Grammatical Codification

Against this background, the concerns that *Ingenieur* Lauster expressed in 1925 become more understandable. The situation in the mid-twenties clearly indicated that the diesel engine might be on its way of finding the most expanding markets outside the German *Reich*. Germany was still the technologically leading nation in diesel engineering, but it could well be expected that the initiative move to other countries through a kind of "demand pull" process. Adolf Nägel, perhaps the leading combustion-engineering professor in the whole of Germany, had already in 1923 given his fellows in the VDI a somewhat worried report about the non-German contributions to the field.[28] Although Nägel was happy to conclude that foreign design solutions had not been able to make an inroad into Germany, he could not hide his concerns that the works of people like Akroyd-Stuart of Great Britain, Brons of the Netherlands, and Hesselman of Sweden could develop into serious challenges in the near future. Nägel's immediate worries did not, however, concern market shares, but engineering quality. These non-German engineers had launched solutions that departed so much "from the much tried and well manifest main principles" of the original diesel engine that they threatened its "well founded reputation."[29]

[25] *Ibid.*, p. 89.

[26] *Ibid.*, p. 102.

[27] Otto-Peter A. Bühler, "Nutzfahrzeugsgeschichte international," *in* Olaf von Fersen, ed., *Ein Jahrhundert Automobilgeschichte. Nutzfahrzeuge,* Dusseldorf, VDI-Verlag, 1987, pp. 10-119, at p. 24; Wolfgang H. Gebhardt, *Taschenbuch Deutscher Lkw-Bau*, Vol. I, Stuttgart, Frankh, 1989, pp. 7-20.

[28] Adolf Nägel, "Die Dieselmaschine der Gegenwart," *in* Verein deutscher Ingenieure, eds, *Dieselmaschinen*, Vol. I, Berlin: VDI-Verlag, 1923.

[29] *Ibid.*, p.28

Here, Nägel voiced a conviction that appears to have been quite typical to the German engineering profession: sound and accepted engineering solutions are more worth and more important than market success or customer adaptation. As we will illustrate below, central German engineers--often as an official task given to them by their own peers--took it upon themselves to define what was to be considered legitimate knowledge and correct design solutions. Or, in other words, they formulated an *engineering grammar*. Nägel, for instance, put much effort into getting accepted the definition that all heat engines where ignition starts as a result of high pressures be called "Diesel engines," thereby "honoring a German engineer who has helped German engineering secure a well deserved advantage."[30]

M.A.N.: Defenders of "Pure Faith"

Two of the most precious ideas of this "German engineer" had been that the fuel be injected directly into the cylinder and that the combustion space have a simple shape.[31] Banning all kinds of added combustion chambers and complicatedly formed piston heads, Rudolf Diesel had, in other words, become the first proponent of the *direct-injection* system in what would later become a heated technological controversy against various *combustion chamber* systems.

This controversy did not really get off until after Diesel's dead, when it became possible to do away with the above-mentioned air pump. One could now choose between having the fuel pass directly from the fuel tank into the cylinder or mixing it with air in a specially designed space before entering into the cylinder. Perhaps not surprisingly, the company that felt most reverence toward Rudolf Diesel, M.A.N., chose the former. For about a decade representatives of the Maschinenfabrik Augsburg-Nürnberg turned out to be the most astute defenders of this "true gospel."[32]

When M.A.N. in 1923, as one of the pioneering firms in the world, announced its first diesel-driven truck, this vehicle was, consequently, equipped with a direct-injection engine without an air pump. The definite advantage of this machine was its low fuel consumption; the definite disadvantage its rough performance. Buyers were, as Rudolf Diesel himself certainly would have been, pleased with fuel costs below half of those of a gasoline engine, but drivers were less than happy with being placed in a vehicle that reminded them more of a tractor than a gasoline truck and had an engine that could be very tricky to get started under hard climatic conditions. The result: after having sold a total of only 210 diesel trucks, M.A.N. was forced to withdraw the direct-injection machine

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[30] *Ibid.*, p. 5.

[31] Rudolf Diesel, *Die Entstehung des Dieselmotors,* Berlin, Springer, 1913, pp. 9f.

[32] Theo Delfried Domina, "Antriebstechnik," *in* O.v. Fersen, *op. cit.*, 1987, p. 130

from the market in 1931. Customer demands turned out to be stronger than engineering reverence.

Always seemingly immune to what today is called market signals, the engineering community--represented by the central members of the VDI--had already in the mid-twenties declared that direct injection belonged, as it were, to the acceptable *grammar* of diesel engineering. Such acceptance was, especially in the German setting, not unimportant for industrial practitioners. Wilhelm Riehm of M.A.N. went out of his way at the VDI expert annual meeting in 1925 to get his company's new design solution accepted by his peers as legitimate knowledge, on *a par* with the precombustion, the hot-head, and the particular Brons system.[33] His plea was heard. Direct injection soon received serious treatment by, among others, Fritz Modersohn--representative of the Gasmotorenfabrik Deutz that went for the precombustion system--and Julius Magg--author of an influential diesel textbook.[34]

Modersohn's contribution to the precombustion/direct-injection controversy is interesting in that it includes an attempt to bypass the "unnecessary" competition that so many German commentators were displeased with in the interwar period.[35] If manufacturers could agree on a compromise, then he was willing to accept both systems as legitimate solutions for the construction of high-speed automobile diesel engines. His suggestion was that they choose precombustion injection for small and direct injection for large engines.

In practice, another compromise developed. After M.A.N. had been forced to accept the commercial failure of its direct-injection engine, the firm went ahead designing a diesel that included characteristics of both the direct-injection and the precombustion engine. Before the fuel entered into the cylinder it had to pass through a wide injection channel, where combustion got started. This compromise did indeed catch on so well also among other automobile companies that it developed into a "unitary diesel." Under the supervision of the Nazi government five firms in fact introduced this engine into their production program.[36]

The preoccupation of German engineers with defining acceptable, legitimate solutions and of German firms with orienting their design activities toward common solutions is noteworthy. It is also, as we will see later, in sharp contrast to the attitudes and practice of their French colleagues. Julius Magg was

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[33] Wilhelm Riehm, "Dieselmotoren mit Strahlzerstäubung," *in* Verein deutscher Ingenieure, eds, *Dieselmaschinen*, Vol. II, Berlin, VDI-Verlag, 1926, p. 63.

[34] Fritz Modersohn, "Druckeinspritzung oder Vorkammerverfahren?" *in* Verein deutscher Ingenieure, eds, *Dieselmaschinen*, Vol. III, Berlin, VDI-Verlag, 1927, p. 72; Julius Magg, *Dieselmaschinen. Grundlagen, Bauarten, Probleme*, Berlin, Springer, 1928, p. 262.

[35] Cf., e.g., M. Hård, *Appropriating..., op. cit.*

[36] W.H. Gebhardt, *Taschenbuch..., op. cit.*, pp. 16f.

one of the most active people in defining the "real" solutions. His textbook, *Dieselmaschinen,* was written on the initiative of the VDI to avoid "divided opinions about the general basis of diesel engineering." By codifying what should be considered correct and incorrect design solutions, Magg and his fellows hoped to be able to protect Diesel's original, "ideal process" in a time of technical and market uncertainty. In our interpretation, his and others' textbooks were meant to serve the same function in engineering practice as grammars are in language usage.

Daimler-Benz: "We Understand More of Automobile Engineering than the Customer Does"[37]

M.A.N. was by no means the only company to worthy the traditional diesel design ideals. When the Daimler-Motoren AG, the largest German truck producer, shortly after World War One decided to develop a diesel engine for their trucks, it stayed true to the classical layout. The first diesel truck that the firm brought onto the market in 1923 did even include the air pump that used to be the traditional standard in ship and stationary diesels.

The decision turned out to be commercially disastrous. Daimler did not manage to sell one single vehicle with this old-fashioned, albeit grammatically fully correct, engine. Having invested considerable work and prestige in this design, its engineers nevertheless struggled hard to retain it in the company's production line. They did not succeed. After Daimler in 1926 had fused with Benz & Co. their creditors went mercilessly through all activities in the new joint company.[38] Daimler's air-pump diesel did not pass the test. Instead, Benz's precombustion chamber engine became the company's joint product. This design was certainly better adjusted to the market, even though Daimler-Benz's notorious arrogance toward its customers--exemplified by the quotation above--and preference for engineering delicacy made it difficult for them to create a mass market. The company managed to sell its first diesel truck in 1930, but it would take more than half a decade before its automotive diesels began to be of any large importance; in 1937 it produced for the first time more than 10,000 diesel engines in one year.[39]

This relatively late--especially if compared with France--market success was not typical to Daimler-Benz. There were in 1933 only 1,000 diesel vehicles

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[37] Orig.: "Wir verstehen mehr vom Automobilbau als der Kunde." This was, for a long time, a catchword in the Daimler-Benz company; cf. Heinz C. Hoppe, *Ein Stern für die Welt,* Munich, Südwest, p. 258.

[38] Karl-Heinz Roth and Martin Schmidt, eds, *Die Daimler-Benz AG 1916-1948, Schlüßeldokumente zur Konzerngeschichte*, Nördlingen, Greno, 1987.

[39] W. Gebhardt, *Deutscher..., op. cit.,* p. 101.

in the whole of Germany, as compared to 5,000 in France.[40] The market began to open up only a couple of years later: in 1936 12% of all Germany-produced trucks and 33% of its buses were equipped with diesel engines.

Probably to *Herr* Lauster's delight, the designs of these machines were German through and through.[41] German companies went consciously out of their way not to pick up any foreign patents or other design solutions, and German engineers were busy building consensus about what should be considered appropriate designs. Daimler-Benz was certainly not alone among German firms in its occupation with design perfection and disinterest in customer demands and rational production.[42] Large markets shares were also indeed lost to, in the first place, American companies (like Ford).[43]

Krupp-Junkers: "Rather Original, but By No Means Ideal"[44]

The compact abhorrence of the engineering community toward unconventional design solutions and the seemingly irrational disavowal of the German machine industry toward market signals can be further illustrated by the case of Hugo Junkers' diesel. Already as a young engineer working with a gas-engine project in Dessau just after the turn of the century, Junkers had decided in favor of the opposed-piston, two-stroke system.[45] Such a solution was indeed a bold one. Although it would be theoretically possible to increase the degree of efficiency by having two pistons per cylinder instead of one, Junkers' engine challenged design traditions with roots back to 18th-century steam-engine technology. From Newcomen onward, it had been customary to construct combustion engines with one piston per cylinder.

When Junkers transferred his ideas from the gas-engine to the diesel-engine area, he thus met little positive response. In 1912 he presented his new diesel at a meeting with the Ship-building Engineering Society (*Schiffsbautechnische Gesellschaft*)--VDI's predecessor as the leading German institution for the discussion and formulation of legitimate engineering knowledge in the diesel

[40] James M. Laux, "Les moteurs Diesel pour les transports," *Culture technique*, Vol. 19, 1989, pp. 20-28, here: p. 24.

[41] Hans Christoph Graf von Seherr-Thoss, *Die deutsche Automobilindustrie*, Stuttgart, DVA, 1979, p. 271.

[42] Fritz Blaich, "Die 'Fehlrationalisierung' in der deutschen Automobilindustrie," *Tradition*, Vol. 18, 1973, p. 22.

[43] Louis Betz, *Das Volksauto. Rettung oder Untergang der deutschen Automobilindustrie*, Stuttgart, 1931, p. 11.

[44] Orig.: "Recht originell, aber keinesfalls ideal." From A.E. Thiemann, *Fahrzeug-Dieselmotoren*, Berlin, Richard Carl Schmidt & Co., 1929, p. 283.

[45] Günter Schmitt, *Hugo Junkers. Ein Leben für die Technik*, Planegg, Aviatic, 1991, p. 45.

field. The reception was very cool.[46] Junkers' calculations, showing the advantage of opposed pistons, could not shatter established conceptions of what constituted a well-designed machine. Since his ideas did not fit the legitimate grammar of combustion engineering in general and of diesel engineering in particular, they could easily be wiped away. Orthodoxy prevailed.

Being unable to pass the audition to the German engineering world--where he would remain an outsider, Junkers had to find acceptance in other camps. As we will discuss further in the following section, he experienced a short-lived acceptance in France. His largest German success came in the aeronautic industry. This young industry seems to have been less concerned with preserving age-old traditions than the ship-building and automotive industry.[47] In particular, it was open to any solution that promised to lower the engine weight per horsepower. When Junkers' diesel had reached below 0.5 kg./hp., it began to attract considerable attention.[48] In 1931 Deutsche Luft-Hansa put its first Junkers-equipped airplane in regular service across the Atlantic, initiating a short but commemorable hey-day period of the so-called *Jumo* (*Junkers-Motoren*) planes.

Junkers' inroad into the German automotive industry was marginal. None of the large companies picked up this strange "dialect." Instead, it was KRAWA, the relatively small vehicle division of the Krupp AG, that became Junkers' only German licensee in the automotive area.[49] Of course, Krupp was no marginal company, but its involvement in truck production was neither whole-heartedly planned nor consequently carried through. Although Krupp had taken part in the early work with diesel engines at the turn of the century, it never put any effort into developing its own automotive engine in the twenties. When M.A.N., Daimler-Benz, and other German truck manufacturers began to design their own automotive diesels, Krupp in 1928 took the easy way out and bought the rights to Junkers' patents. Production continued on and off for the ensuing three decades, but without any noteworthy innovative activity taking place.[50] KRAWA could offer Junkers trucks still in the mid-fifties, but their engines were basically the

[46] Hugo Junkers, "Studien und experimentelle Arbeiten zur Konstruktion meines Gegenkolbenmotors," *Jahrbuch der Schiffbautechnischen Gesellschaft,* Vol. 1, 1912, pp. 264ff.

[47] Cf. Edward Constant, II, *The Origin of the Turbojet Revolution,* Baltimore, MD: The Johns Hopkins University Press, 1980.

[48] Hermann Golle, "Zur Entwicklung des Junkers-Gegenkolbenmotors," *in* Urania, ed., *Kolloquium zum 125. Geburtstag von Hugo Junkers,* Dessau: Urania-Gesellschaft, 1984, pp. 71-80.

[49] B. Reinders, *Die Motoren- und Kraftwagenfabriken der Fa Fried. Krupp Essen 1920-1955/56,* Essen, Historisches Archiv der Fa. Fried. Krupp GmbH, without year (ca. 1957)

[50] J. Pietsch, "Bemerkenswertes über den 6,5-t Lastkraftwagen," *Technische Mitteilungen Krupp,* No. 1, February 1938, pp. 11-13.

same as they had been twenty-five years earlier.[51] It could be suggested that this disinterest in making or unability to guarantee continuous development was connected to the company's choice of a globally unusual design. If you posit yourself outside mainstream engineering, then you lose the possibility of drawing on others' experience. Strange and particular dialects have a tendency to disappear, and so Junkers' did.

France: Multilingual Competence

Regardless of whether the diesel was a "German" or "French" engine, it is clear that French commentators were concerned with what they considered the relative backwardness of French diesel engineering in the late twenties. Reviewing an automobile exhibition in 1928, G. Delanghe writes that four or five German firms have plans to make an inroad into the French market with their automotive diesels:

> [...] it is, unfortunately, not yet possible to meet them with an equivalent French engine. Even though various designers are presently working on this question, they do not yet seem to have passed the experimental stage [...].[52]

Although this asymmetry between German and French developments would remain for several years, the diesel enjoyed rapid acceptance in France. Already in 1931 the same author could happily conclude: "Almost all truck manufacturers offer their customers chassis mounted with diesel engines [...]."[53] In the next few years, the diesel truck area virtually exploded. Existing statistics is weak, but it seems as if, in 1939, a majority of (new) trucks being produced was equipped with diesel engines. The definite breakthrough of the truck diesel thus came in the mid-1930s.[54]

[51] H. Haase, "Aus der Entwicklung der Krupp-Fahrzeugmotoren von 1924 bis 1957," *Technische Mitteilungen Krupp,* No. 15, 1957, pp. 106-112.

[52] G. Delanghe, "Les salons européens de l'automobile en 1928," *Le génie civil,* Vol. 94, 1929, pp. 34-37, 62-64, here: p. 62; orig.: [...] il n'est malheureusement pas encore possible de leur opposer un moteur francais équivalent, car si divers constructeurs étudient actuellement chez nous la question, leurs travaux n'ont pas encore dépassé, à notre connaissance, le stade des essais [...]."

[53] G. Delanghe, "Le XXVe Salon de l'Automobile, Véhicules industriels," *Le génie civil,* Vol. 99, 1931, pp. 617-23, 647-54, here: p. 618; orig.: "Presque tous les constructeurs de poids lourds offrent à leur clientèle des châssis munis de moteurs Diesel [...]."

[54] In the literature on *Technikgenese*, one of the presuppositins is that certain ideas and social relations are for a long time being "frozen" into a technology in the early life; cf. M. Dierkes and U. Hoffmann, *op. cit.*

Peugeot-C.L.M.: "Economy, Safety, Simplicity!"[55]

Already in 1908 one of the famous automobile company Peugeot's associates, the mathematically well-educated engineer E.H. Tartrais, had begun to analyze and experiment with heavy-oil engines, but it was not until 1921 that his investigations began to show such promise that the company decided to spread the word about it. The campaign that followed was broad in scope. Technical descriptions and popular articles were solicited in various journals. In line with the tradition of those days, several well-staged journeys were made to attract public attention.[56] On the request of Peugeot's managing director, the journalist Henri Petit wrote favorably about a return trip that he made between Paris and Bordeaux shortly before the annual automobile exhibit in 1922.[57] Together with four companions, Petit made the 1,100 kilometer long trip in two days, allegedly without incidents: "[the engine] met all the expectations that the Peugeot company had created [...]."[58] The only nuisances that Petit recorded were that the oil engine ran more roughly that a gasoline engine, that it emitted "light smoke" (*légère fumée*), and that it was more difficult to get started. In *Omnia* (1922) Baudry de Saunier wrote with more unqualified enthusiasm:

> By giving its confidence and full assistance to the Tartrais engine, the house of Peugeot deserves the praise of our country. It has indeed oriented itself toward the engine of the future. Well done, engineers![59]

And, in *La science et la vie* (1924) it was stated with no less enthusiasm that the Tartrais engine would be particularly useful in the French colonies, since it might be possible to run on vegetable oils. Their dependence on imported gasoline and mineral oil would subsequently diminish.

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[55] *Économie, sécurité, simplicité* were norms that the C.L.M. company put forth in advertisements presenting their engines; cf. file "C.L.M. (F) Catalogues publicitaires" at Archive de la Fondation automobile Marius Berliet, Lyon (hereafter abbreviated AFAMB).

[56] Such trips were quite common in the early years of automobility. They served the double purpose of creating public interest and to sumit the engines and cars to an endurance and reliability test; cf. Mikael Hård and Andreas Knie, "The Ruler of the Game: The Defining Power of the Standard Automobile," *in* Knut H. Sørensen, ed., *The Car and Its Environments: The Past, Present and Future of the Motorcar in Europe*, COST A4, Vol. 2, Brussels and Luxembourg, The European Commission, 1994, pp. 137-58.

[57] A lengthy, *verbatim* part of his account is reprinted in Pierre Dumont, *Peugeot sous le signe du lion*, Paris, Éditions pratiques automobiles (E.P.A.), 1976, pp. 385-88.

[58] *Ibid.*, p. 386; orig.: "[le moteur] a parfaitement répondu aux espérances que la Société Peugeot concevait de lui [...]."

[59] Quoted in Pierre Dumont, *Peugeot d'hier et d'avant-hier*, Fontainebleau, Edifree, 1983, p. 379; orig.: "La maison Peugeot, en donnant sa confiance et tout son appui au moteur Tartrais, a bien mérité de notre pays, puisqu'elle oriente les recherches vers le véritable moteur de l'avenir. Inventeurs, à vos pièces!"

The Tartrais engine was heterodox *vis-à-vis* the common, established practice of diesel engineering on several scores.[60] It ran on heavy oil, but it was not defined by its contemporaries as a diesel engine. Tartrais departed from the orthodox diesel grammar in that he employed an electrically heated filament to support ignition. He had also designed two chambers that looked very similar to those of precombustion diesels, but their function was not the same. Furthermore, it was a two-stroke rather than a four-stroke--the latter being the most common solution both in the gasoline-engine and the high-speed-diesel areas of engineering.[61] This heterodoxy made it difficult to find outside assistance when trying to solve the problems that plagued the engine. Very little help could be found in France, and the German patents that Tartrais received in 1920 and 1921 were never picked up by firms in that country. Peugeot's engineers did not overcame the drawbacks that Petit had noted, and in 1926 the company decided to turn in more conventional directions.[62]

The ensuing accommodation of Peugeot's local dialect to the global diesel grammar was made in two ways. On the one hand, the firm left the semi-diesel area and turned the Tartrais engine into a pure diesel engine. The outcome was a two-stroke engine with precombustion chamber, where ignition took place only because of the high pressures in the cylinder.[63] This engine seems to have created more interest in engineering circles than among potential customers. On the other hand, Peugeot bought a license for a German patent. It illustrates not only the ease with which French firms switched designs, but also their dependence on foreign *Vorbilder* and patents.[64]

The German engine which in 1927 caught the attention of Peugeot was the Junkers design! When the French firm acquired the license rights in 1928, an era of French Junkers production started that would last as long as until 1963.[65] Peugeot decided that production should begin in its old plant in Five-Lille, and

[60] Ludwig Hausfelder, *Die kompressorlose Dieselmaschine. Ihre Entwicklung auf Grund der in- und ausländischen Patent-Literatur*, Berlin, M. Krayn, 1928, pp. 188-90.

[61] True enough, two-strokes were were given a lot of attention in the early part of the century, but usually with limited practical success; cf. Rudi Volti, "Alternative Internal Combustion Engines, 1900-1915, *in* Mikael Hård, ed., *Automobile Engineering in a Dead End: Mainstream and Alternative Developments in the 20th Century*, Gothenburg, Gothenburg University, 1992, pp. 11-23.

[62] Christophe Dollet and Alain Dusart, *Les sorciers du lion. Un siècle dans le secret du Bureau d'Études Peugeot*, Paris, Calmann-Lévy, 1990, p. 55.

[63] L. Hausfelder, *Die kompressorlose...*, *op. cit.*, pp. 190-92; A.E., *Fahrzeug-Dieselmotoren*, Berlin, Richard Carl Schmidt & Co., 1929, pp. 219-21.

[64] Concerning the concept *Vorbild*, or *archetype*, see Mikael Hård, *Machines are Frozen Spirit: The Scientification of Refrigeration and Brewing in the 19th Century--A Weberian Interpretation*, Frankfurt a.M. and Boulder, Col., Campus Verlag and Westview Press, 1994, p. 50.

[65] Stephan Ittner, *Dieselmotoren für die Luftfahrt. Innovationen und Traditionen im Junkers-Flugmotorenbau bis 1933*, Berlin, Ph.D. dissertation, Technical University Berlin, 1995, p. 143.

set up a separate company with a capital of 35 million francs to this end: la Compagnie Lilloise des Moteurs (C.L.M.).[66]

C.L.M.'s work with adapting the Junkers design to the knowledge, skills, and physical facilities in Lille got quickly underway. The company's strategy was straightforward: build engines that can be easily fitted into existing boats, railcars, trucks, bulldozers, tractors, and even airplanes. The goal was to create, on the basis of Junker's patent, a multi-purpose diesel that could be used where high speeds were required. Although this strategy sounds simple enough, it was not an easy task at a time when the diesel was generally defined as a slow and heavy engine, unsuitable for motive applications, and in a surroundings which did not have any extensive experience with opposed-piston engines. The fact that Junkers already had been in this business for fifteen years did not relieve his French licensee from problems. Despite that C.L.M. had access to a well established automobile factory (with roots back to the nineteenth century), it took two years before the firm had adjusted so well to this foreign "dialect" that it could undertake production of all its central components on its own:

> From 1928 to 1930 the very intricate manufacturing of fuel pumps and injectors was brought to perfection--thanks to the quality of the workers and technicians.[67]

C.L.M. did, however, not wait until 1930 to market its engine. The first truck fitted with one of its diesels was shown at the Paris automobile exhibit already in the Spring of 1928, and soon C.L.M. diesels could be found not only in Peugeot, but also in Laffly and SOMUA trucks.[68] After one and a half year more than 1,000 engines had been sold.[69] Demand grew so rapidly that the 45,000-m^2 factory at Lille no longer could meet it, and an additional plant of almost the same size was erected in St. Etienne in 1930.[70] The numbers continued to rise, and by 1940 C.L.M. had produced a total of 25,000 diesel engines of 17 different models.[71] The multi-purpose strategy worked.

The Peugeot-C.L.M. case illustrates several points that we try to make in this paper. It shows how difficult it may be also for large and established firms to develop and manufacture unique products, and it indicates that the advantages of

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[66] In 1937 C.L.M. become a part of la Compagnie Generale des Moteurs, which Peugeot owned together with Crédit du Nord. In 1949 it left the Peugot sphere altogether and was drawn into Industrielle de l'Est et du Nord (INDÉNOR), only to return to its origins in 1965--as INDÉNOR was sold to Peugeot.

[67] File "Peugeot (F) - 120G/1201G (1921-1928)" at AFAMB; orig.: "De 1928 à 1930, grâce à la qualité des ouvriers et des techniciens, la fabrication très délicate des pompes à combustible et des injecteurs a pu être mis complètement au point."

[68] *Le génie civil*, Vol. 95, 1929, p. 607.

[69] *La vie automobile*, 25th June, 1928, p. 241; *Automobilia*, Nov. 1929, p. 27.

[70] *Les poids lourds*, 1st March, 1934.

[71] J. Laux, "Les moteurs Diesel...," *op. cit.*, p. 24.

adopting practices communal to a larger group of firms is quite difficult to refuse. By choosing the Tartrais engine, Peugeot' engineers isolated themselves from the national and international engineering community. Since they spoke a language that did not square with the diesel grammar, they got into a situation where they could not communicate with other engineering milieus in a satisfying manner. We want to interpret their choice to accommodate Tartrais' engine to the diesel grammar in 1926 as a way of getting out of this isolation. The decision to go for the Junkers engine can be interpreted in a similar way. Although this Bavarian dialect was considered quite heretic in the German context, it was easier to find acceptance for in the more open French context. Here, it had a long-standing tradition: "The Junkers engine [...] reproduces the mechanical outline that is well known from the Gobron-Brillié engines."[72]

Berliet: "Copy and improve!"[73]

Marius Berliet was a self-taught technician who belongs to the pioneers of French automobile engineering.[74] A restless tinkerer by nature, he quickly picked up new trends and was seldom afraid of taking on large challenges. It was thus no big surprise that the diesel engine began to catch Marius Berliet's attention toward the end of the twenties. His company had gone through a difficult period in the 1920s, but in 1930 it had managed to pay off its bank debts and was reasonably free to start up with new projects.[75] The knowledge about the high-speed diesel was, however, not very deep in France, so Berliet in 1929 went off to Germany to learn about the latest developments. The outcome of this trip was a license agreement in March 1930 between the Société des Automobiles Berliet and Robert Bosch AG about the production of diesel engines equipped with the so-called ACRO injection system.

After the agreement had been signed, feverish activity followed at Berliet's factory in Vénissieux, just outside Lyon. Here, he had everything that an automobile manufacturer could need: an engineering department, a foundry, shops, and assembly rooms. Under the supervision of André Cattin, the "perfectionist" head of the *bureau d'études*, drawings and models were made in

[72] *Automobilia*, No. 281, Feb. 1929, p. 19; orig.: "Le moteur Junkers [...] reproduit les dispositions mécaniques bien connues des moteur Gobron-Brillié.".

[73] This ("copier et améliorer") was part of a slogan that Marius Berliet, founder of the Société des Automobiles Berliet, used to characterize his business strategy; see Sanchez Annick, *Études et recherches chez Berliet-R.V.I.*, Lyon, Mémoire de Maîtrise d'Aménagement, Université Jean Moulin, 1988, p. 76.

[74] *Moteurs diesel*, Bologne-Billancourt, E.T.A.I., 1988, pp. 77ff.

[75] Paul Berliet, "La fabrication du moteur diesel chez Berliet", *manuscript*, Lyon, Fondation de l'Automobile Marius Berliet, Nov. 1994. Paul Berliet is Marius's son and started work in the company in 1935. He now directs the Fondation de l'Automobile Marius Berliet in Lyon.

the Spring and early Summer.[76] Since the Bosch license only concerned the injection system, several parts of the engine had to be designed from scratch--although the engineers could, of course, make extensive use of their experience from gasoline-engine design. In August the various engine parts were cast, and in September the first prototype was assembled.[77] So far, it seemed like an easy task to turn from gasoline to diesel, but a series of problems began to emerge as the engine was set to practical tests. Pistons broke, and test trucks had to be towed back to the factory. The engineers went through many sleepless nights.[78]

Most of the teething troubles were solved bit by bit in an iterative manner, and between 1931 and 1936 the company brought 7,400 ACRO diesels onto the market.[79] The design did, however, have its fundamental drawbacks. The piston was relatively heavy, which meant that it was practically impossible to exceed some 1,500 revolutions per minute (r.p.m.). Since consumers all over the world demanded ever higher engine speeds,[80] this limit became a serious competitive disadvantage.

Marius Berliet's search for another solution had begun already in 1933 during a trip to the annual truck and bus exhibit in London.[81] His attention had been especially drawn to A.E.C. buses that were being used with good results by London Transport. They were equipped Henry Ricardo's diesel engines, which had a much lighter piston than ACRO and could be run up to 2,000 r.p.m. Otherwise, the most well-known feature of Ricardo's engine was the so-called "turbulence chamber"--a space at the top of the cylinder designed to simplify the mixture of fuel with air, thus maximizing fuel efficiency. A license agreement could be signed in May 1935. Marius Berliet and his engineers now faced a challenge similar to the one four years earlier. The task was how to turn from the ACRO to the Ricardo system.

Despite the fact that this move took place within the diesel grammar and did not necessitate substantial changes of the overall truck design, it was not an easy and straightforward task. On the contrary. It would take one year before the first Berliet vehicle equipped with a Ricardo diesel was considered mature for the market--a year filled with frequent trips being made and a large number of letters,

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[76] L. Muron, *Marius Berliet...*, op. cit., p.123.

[77] S. Annick, *Études..., op. cit.*, p. 73.

[78] Jacques Borgé and Nicolas Viassnoff, *Berliet de Lyon*, Paris, Éditions pratiques automobiles (E.P.A.), 1981, p. 178.

[79] S. Annick, *Études..., op. cit.*, p. 73, wrongly states the number to have been 74,000.

[80] H.E. Degler, *Diesel and Other Internal-Combustion Engines*, Chicago, American Technical Society, 1943.

[81] The following account is to a large extent based on a contemporary description, written by an unknown collaborator of Ricardo: "Historique 'Ricardo,' 12.12.39," *manuscript*, Lyon, Fondation de l'Automobile Marius Berliet, 1939.

telegrams, and even engine parts being sent between Great Britain and France. All problems had, however, not even been solved in 1936, when the first trucks with Ricardo engines were brought onto the market: "In the beginning of the year 1937, we registered some complaints about broken cylinder heads and cracked injectors[...]."[82] Similar problems reemerged one year later. However, truck drivers seem to have been used to such nuisances in those days, and in the year 1938 Berliet managed to sell 1,720 engines of the Ricardo type.

Berliet discontinued the production of Ricardo engines already one year later, after a total of almost 8,000 had been produced. The diesel adventure went into a phase of hibernation that would last until after the second world war. Because the French army--contrary to the British and German military forces--had taken the decision to equip its trucks with gasoline rather than diesel engines, there was basically no market at all for diesels after the war had started. But in the second half of the forties Berliet returned to the diesel. Not surprisingly, the company picked up the Ricardo-Comet system again, but after another odd decade it decided to substitute, step-by-step, the British type with--once more--a German type. This time the choice fell on the "M" model, designed by M.A.N.

This flexibility and disinterest in protecting the company's technical "finger-print" is indeed striking. At Vénissieux no technical design seems to have been surrounded with an aura of prestige that precluded fundamental changes. Compared to several German and British firms, Berliet's attitude toward technical solutions was much more open, and the willingness to learn new languages and dialects was much more pronounced. The question that it remains to answer is, why that was the case.

We will return to this question on a more general, theoretically informed level in the concluding section. Let us here only provide a few hints that is directly concerned with Berliet's self-understanding and practice. Already in the heading to this section we saw that Marius Berliet's conscious business strategy was to "copy and improve" rather than "inventing at the expense of the customer."[83] One historian summarizes the company strategy such:

> Serious investigations should, in particular, be directed at the perfection of existing models, and newly designed models should only be taken into production after extensive and conclusive experiments had been made.[84]

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82 "Historique 'Ricardo'...," *op. cit.*, p. 10.

83 The complete slogan read: "N'inventez-pas aux dépens du client, commencez par copier et améliorer;" S. Annick, *Études..., op. cit.*, p. 76.

84 Gérard Declas, *Recherches sur les Usines Berliet (1914-1949)*, Paris, Mémoire de Maîtrise, Université de Paris 1, 1977, p. 37; orig.: "Études particulièrement sévères de perfectionnement aux modèles anciens, et création de modèles noveaux mis en fabrication seulement après essais prolongés et concluants."

As we have seen, the second half of this ideal was not always followed in practice. Customers were indeed drawn into the development process, as it were. It is, however, clear that imitation, as well as diversification, was an important vision that influenced the company's practice. The diversification strategy manifested itself in a large model array. In the thirties the company could offer its customers not only diesel *and* gasoline driven trucks; it could also give them a choice of half a dozen diesels and two dozen (!) gasoline vehicles of all sizes. Our interpretation is that the diversification strategy partly made Berliet chose to enter the diesel area, and that the copy-and-improve strategy led the company to pick different technological *Vorbilder* in a pragmatic manner. His strategy was similar to that of C.L.M., and certainly not less successful. The automobile historian James M. Laux thus writes: "At the outset of the second world war his [that is, Berliet's] engines dominated French truck production."[85]

Conclusion

We started out by asking ourselves if it makes sense to talk about "styles" in technology--especially national styles. Although we doubted the usefulness of this term, we subsequently showed that it *is* possible to observe differences in how German and French engineers conceived of and chose to design diesel engines in the 1930s. In this final section we will try to make plausible why these differences did exist, and put forth an alternative way of analyzing them. In fact, it seems as if the differences have increased over time--at least up until the fifties. In 1959, a French engineer could write:

> "Where in FRANCE, SWITZERLAND, and ITALY [...] the preference have generally been toward direct injection, [...] the Britons and the Germans orient themselves toward chamber injection."[86]

In the beginning of the paper we showed that certain German actors were deeply concerned with defining the diesel engine as a "German machine." Lauster and Nägel went out of their way to argue that the engine that Rudolf Diesel and M.A.N. had created was German through and through. Their concern was, as it were, to create a "national style" in diesel engineering. By introducing a national rhetoric, they gave the engine a *meaning* that went far beyond its practical usefulness. In opposition to the traditional engineering discourse and self-understanding, their analysis did not only focus on the instrumental

[85] J. Laux, "Les moteurs diesel...," *op. cit.*, p. 24; orig.: "Au début de la Seconde Guerre mondiale ses diesels dominaient la production francaise de camions."

[86] Raymond Brun, "Évolution de la technique du moteur diesel," *Ingenieurs de l'automobile*, No. 8/9, 1959, pp. 493-99, here: 496; orig.: "Alors qu'en FRANCE, en SUISSE et en ITALIE [...] la préférence allait, en géneral, à l'injection directe [...], les Anglais et les Allemands s'orientaient vers l'injection dans des chambres [...]."

performance of technical objects. Instead of pointing to factors like fuel-efficiency, they made the diesel engine *signify* German-ness.

As we have seen in the case of Delanghe, the Germans were not alone in regarding the diesel as a German machine. In France, however, this signification called forth quite a different action strategy. Instead of--like Lauster--utilizing the German character of the engine to defend an orthodox and conservative design, Delanghe took this meaning as an excuse for demanding that French engineers get their act together and design a diesel that could meet the market challenge posed by the Germans. Meanings are not ornaments, but calls for action.

Leaving the cognitive level of analysis, we observe that, in the interwar years, diesel engineering was a much more fragmented practice in France than in Germany. French engineers were not concerned with developing the same degree of national uniformity as were their German colleagues, and French firms remained strikingly dependent on foreign--not least German--*Vorbilder*. In contrast to France, where pluralism ruled, there developed in Germany two forms of unity. One of those has been illustrated by the efforts to retain orthodoxy, and one by the rapid and wide-spread shift from air-injection to precombustion chamber technology. Our suggestion is that these phenomena can be treated in linguistic terms.

When Rudolf Diesel presented his ideas to the engineering community in 1893, they fell in fertile soil. His analysis and suggestions squared well with the well-established research and development program of *technical thermodynamics*.[87] This program had been developed by academically trained engineers like Gustav Zeuner and Carl von Linde (who had been Diesel's teacher), and served like a *grammar* for the proper analysis and design of heat-engines and refrigerating machines. Like "[...] grammarians, who hold the monopoly of the consecration and canonization of legitimate writers and writing [...],"[88] Zeuner, Linde, and their followers defined what should be considered legitimate knowledge in this field. The primary vehicles for the codification and diffusion of this knowledge were textbooks and educational programs in technical thermodynamics and related fields--just like grammars and schools serve the purpose of teaching children and grown-ups how one should write.

The quote in the paragraph above is taken from a paper by Pierre Bourdieu, where he analyzes "The Production and Reproduction of Legitimate Language." Bourdieu's chief object in this paper is to show how so-called "grammarians" use their social position to "fix and codify legitimate usage." Like central engineering educators, these men of letters have a considerable power in all modern countries.

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[87] Cf. M. Hård, *Machines..., op. cit...*, Ch. 7.

[88] Pierre Bourdieu, *Language and Symbolic Power*, Cambridge, Mass., Harvard University Press, 1991 (orig. *Ce queparle veut dire. L'économie des échanges linguistiques*, Paris, Arthème Fayard, 1982), p. 58.

Although they are powerful, grammarians at Oxford, Duden, and Larousse do not attempt to create disembodied, *formal* grammars. What they make are *descriptive* grammars that to a certain degree reflect changing language practices. Correct language usage is neither invented in an empty space, nor forever frozen and fixed. Rather, grammatical rules "[...] are derived *ex post facto* from expressed discourse and set up as imperative norms for discourse yet to be expressed."[89] The same can be said of codified engineering norms. It is well known that Sadi Carnot's classical work can be seen as a theoretical codification, *ex post*, of more than one century's steam-engine practice--which did not prevent his text from becoming the foundation for the modern science of thermodynamics and later become the basis on which Zeuner built his program.[90]

Zeuner's program became manifest in his "Basics of the Mechanical Theory of Heat," which ran through a number of editions from 1859 onwards.[91] It was spread through lectures and journal articles, and further discussed in engineering circles. The German Engineering Society (VDI) was the most important forum for such "normalization and codification" of engineering practice in Germany--and perhaps in the world.[92] Engineers from different corners of the *Reich* met at VDI's annual conferences to exchange information and discuss common problems. To these meetings each participant brought with them ideas and solutions that had been developed in his home environment, and formulated in his local, technological "dialect." But, despite this multitude of dialects, it was possible for the engineers to communicate. In other words, they did share a common "language." With this we do not mean the German language, but the language of diesel engineering. This language was, of course, in each instance informed by the grammatical rules that were codified in textbooks and documents of similar, half-official status, but it was not, therefore, static. In the face of changing dialects, first the language and then the grammar could be modified.

Take the challenge posed by the fast-moving diesel as an example. In the early 1920s the emergence of direct injection and precombustion technologies--answers to the increasing interest in automotive applications--threatened some of the design prescriptions that had been laid down already twenty-five years earlier. Lauster took it upon himself to defend both the established ("Oxford") grammar and the pure ("Queen's") design ideals of orthodox diesel engineering, but emerging local practices at numerous firms worked against him. Since these new dialects soon became strong enough to modify the whole language of diesel

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[89] *Ibid.*, p. 61.

[90] Sadi Carnot, *Réflexions sur la puissance motrice du feu*, Paris, J. Vrin, 1978 (orig. 1824).

[91] Gustav Zeuner, *Grundzüge der mechanischen Wärmetheorie mit Anwendungen auf die der Wärmelehre angehörigen Theile der Maschinenlehre*, 2nd ed., Leipzig, Felix, 1866.

[92] P. Bourdieu, *Language...*, *op. cit.*, p. 59.

engineering, the last defenders of purity had to give in. The grammar had to change.

The situation was different in France. There seems to have been no forum of the same impact and centrality in the French engineering community as in the German. Although, as is generally well known, a relative small number of former *grandes-écoles* students in state service dominated French engineering theoretically, it is unclear what influence they really had on the French design scene.[93] Writes the historian Terry Shinn:

> [...] a barrier arose between state engineering and the application of scientific knowledge to industry. As a consequence, the need for technical expertise in a growing industrial economy was not met. The second occupational group of engineers gradually emerged to meet this need, but it lacked the sense of identity and unity as well as the legal mandate enjoyed by the state corps.[94]

There is, for instance, no trace in the sources of Marius Berliet visiting or paying attention to the discourse at the French Society of Civil Engineers (la Société des ingénieurs civils de France). Of course, French engineers also wrote textbooks which defined legitimate spaces of thought and action and arranged meetings where common problems were debated. However, these fora do not seem to have had the same far-reaching power and unifying effect as its German counterparts. French books and journals in automobile engineering also had a more practical and descriptive character than the corresponding German ones. Both René Bardin's survey of diesels and semi-diesels and *Le génie civil* can be read as a catalog of dialects rather than prescriptive grammars.[95]

This liberal and open character of French engineering practice explains to a large extent the pluralism that we have found among French diesel manufacturers. Since all French diesel firms except Renault and Panhard-Levassor had license agreements with different foreign companies,[96] there never seems to have developed a strong need to cultivate a common French design language. Unlike *Herr* Lauster and his M.A.N. colleagues, *Monsieur* Berliet and his collaborators did not have any vested interest in a particular, "pure" design.

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93 The literature on the French *grandes écoles* is huge--see, e.g., Bruno Belhoste, Amy Dahan Dalmedico, and Antoine Picon (eds.), *La formation polytechnicienne 1794-1994*, Paris, Dunod, 1994--but it does not address the questions that interest us here.

94 Terry Shinn, "From 'Corps' to 'Profession: The Emergence and Definition of Industrial Engineering in Modern France", *in* Robert Fox and Georg Weisz (eds.), *The Organization of Science and Technology in France 1808-1914*, Cambridge, Cambridge University Pres, 1980, pp. 183-210, here: p. 185.

95 René Bardin, *Les moteur à combustion Diesel et semi-Diesel*, 3rd ed., Paris, Desforges, Girardot et Cie., 1933.

96 "Carnet des voyageurs...," *op. cit.*, pp. 47, 54f., at AFAMB.

Each local group was busy enough trying to understand the German or British dialect which it had decided to "copy and improve." In this situation of flux there was, furthermore, never any reason to formulate a uniform basis beyond that of a standard grammar. A French "uniform diesel" (*Einheitsdiesel*) was never on the agenda.

The advantages with the French approach are the same as those that have often been observed in the case of American engineering.[97] The open and flexible attitude made French firms relatively responsive to customer demands. By contrast, German firms were much more bound up by a feeling of reverence toward Rudolf Diesel and his legacy. The commercial results were obvious; from the mid-thirties onward the automotive diesel has enjoyed larger market shares in France than in Germany. Today more than half of the automobiles being produced in France are diesels, as compared to only every sixth German car.[98] Is it perhaps possible to say that the diesel is on its way to becoming a French engine?

[97] H.L Dienel, *op. cit.*

[98] *Frankfurter Rundschau*, 25 Feb. 1995, p. M10.