Review
"The hun is not always ahead of us in secret weapons"

Some remarks on a new book on the history of the turbojet: Hermione Giffard, Making Jet Engines in World War II. Britain, Germany and the United States, Chicago, London 2016

by Lutz Budrass[1]

Überblick

Während es noch in den 1980er Jahren Stimmen gab, die die technische und industrielle Entwicklung in Großbritannien während des Zweiten Weltkriegs in den allgemeinen Niedergang der britischen Industrie einreihen wollten, hat sich in jüngerer Zeit die Auffassung durchgesetzt, dass die Kriegszeit in Wahrheit von einem bemerkenswerten Aufschwung geprägt war. Diese vor allem von David Edgerton, einem der führenden britischen Technikhistoriker, vorangetriebene Erkenntnis basiert zu einem nicht geringen Teil auf einem Vergleich mit der parallelen Entwicklung in Deutschland. Sie steht damit in einem Spannungsverhältnis zur Geschichtsschreibung über Technik und Industrie unter dem nationalsozialistischen Regime, in der in den letzten 20 Jahren eine ähnliche Kehrtwendung zu beobachten ist. Die jüngere Forschung hat herausgestellt, wie weit das NS-Regime Wissenschaft und Industrie bis in die letzten Kriegstage hinein mobilisierte und damit auch deren Verantwortung für die Verbrechen unterstrichen, die in der deutschen Kriegswirtschaft verübt wurden. Welches Dilemma durch dieses Spannungsverhältnis entstehen kann, zeigt die vergleichende Untersuchung einer Schülerin von David Edgerton, Hermione Giffard, über Entwicklung und Produktion der Strahltriebwerke in Deutschland und Großbritannien, die in der These gipfelt, die von den Nationalsozialisten als „Wunderwaffen“ apostrophierten deutschen Strahltriebwerke seien aus der Not geborene, technisch minderwertige Ersatz-„aero-engines“ gewesen. Bei allen Verdiensten, die sich Giffard mit der Analyse der Historiografie und der britischen Strahltriebwerksentwicklung erwirbt, ist dennoch festzuhalten, dass sie nahezu die gesamte jüngere deutsche Forschung über Wissenschaft und Industrie unter dem nationalsozialistischen Regime ignoriert.

1 I would like to thank Anette H. Storeide, Dietrich Eckardt, Manfred Grieger, Helmut Maier, Hartmut Pophanken, Helmuth Trischler and Ethan D. Veenhuis for their comments on earlier versions of this review.

1. Introduction

When, in 1986, Correlli Barnett published the second volume of his 'Pride and Fall' sequence, 'The Audit of War' on Britain during World War II, he caused an earthquake in British historiography.[2] Barnett tried to prove that a sentimental political elite was then already about to sacrifice economic growth and military power for building an all–embracing welfare state. Variating this argument Barnett also pointed out that the same elite had hampered technical and industrial development even during the war. To illustrate this, he analysed a number of British industries, but he devoted some 60 pages to shed doubt on the one which since the days of the Battle of Britain has an iconic status in British self-perception as a modern industrial nation: the aircraft industry. Barnett did not question the performance of the Spitfires, Hurricanes and Lancaster bombers which finally assured victory in 1945. But he insisted that all these successes had been achieved despite the neglect of military technology by the ruling elite and despite the improvised and wasteful manner by which aircraft were produced in Britain, in comparison with the US and, namely, Germany. By critizising the British practice Barnett implicitly praised the German aircraft industry, its efficieny in research, development and production, its industrial leadership consisting of academically qualified engineers and its advanced design techniques based on a superb engineering education. It was this praise for the German practice which certainly contributed to the uproar when 'The Audit of War' appeared at the height of the Thatcher government. To a degree Barnett traced both the industrial success of Western Germany and the industrial decline of post-war Britain back to structural features which had been apparent in World War II already.

Barnett's assault has since been tackled by numerous scholars, but most importantly by David Edgerton. Since 1991 Edgerton has produced a number of essays and books to refute Barnetts argument. Quite contrary to Barnett, Edgerton creates the impression that the British elites had not neglected, but heavily promoted the chances provided by modern technology to expand military power: During World War II Britain, supported by the resources of its dominions, turned into a warfare state which in terms of size, scientific foundation and mobilization even surpassed the US, not to speak of Germany. The aircraft industry looms large in Edgerton's writing. He started his critique of Barnett with an essay on 'England and the Aeroplane', and in his latest book which systematically unravels the nature of 'Britain's War Machine' aircraft still figure as the ultimate proof for Britain's technological and industrial superiority over the US and, above all, Germany.[3] The German

2 Corelli Barnett, The Audit of War. The Illusion & Reality of Britain as a Great Nation, London 1986.

3 David Edgerton, England and the Aeroplane. An Essay on a Militant and Technological Nation, London 1991; David Edgerton, Britain's War Machine. Weapons, Resources and Experts in the Second World War, London 2011.

aircraft and aircraft industry serve regularly as a comparative backdrop for Edgertons warfare-state hypothesis, although he has never addressed them by original research himself.

Hermione Giffard's book on 'Making Jet Engines in World War II' attempts to fill this gap by reassessing British and German contributions to the invention of the turbojet. Since the end of World War II the history of the turbojet has served as the prime evidence for the leading role of Britain and Germany in modern aviation alike as the new power unit was simultaneously invented and developed there, and not in the US which dominated aviation in the decades after the war. Giffard's book is based on a PhD thesis supervised by Edgerton which is listed already in the bibliography of 'Britain's War Machine'. A PhD thesis is an autonomous piece of work and the author alone is responsible for its contents. But Giffard uses a number of Edgertonian assumptions without making it plain that those were originally conceived to refute Barnett's argument. Edgerton's analytical preferences are clearly reflected in the composition and, even more, the conclusions of her book. Consequently, she acknowledges Edgerton as the one "who encouraged me to embark on this project and who patiently supported my subsequent efforts to radically rethink the history of the jet" (260).

2. The British model of success

The conventional story which Giffard tries to rethink, runs like this: The first practical ideas for applying a turbojet to an airplane had been devised in Britain, by Alan Arnold Griffith and Frank Whittle who on January 16, 1930, first applied for a patent for a turbojet engine, long before similar activities started in Germany. There, an official of the Air Ministry, Helmut Schelp, interested two of the major aero-engine producers, BMW and Junkers, by the mid-1930s to research turbojets, namely Herbert Wagner, then chief of aircraft development at Junkers. But it was a physicist of the University of Göttingen, Hans Joachim Pabst von Ohain, who finally succeeded. He had on his own approached aircraft industrialist Ernst Heinkel to support his concept for a turbojet, and that led to the first flight of a turbojet-powered Heinkel aircraft on August 28, 1939. Meanwhile, Frank Whittle had not been able to attract support on a sufficient scale. Almost two more years passed until his first engine was flown on an aircraft on May 15, 1941. As a consequence, the German aircraft industry overtook their British rivals in development and production. While some 745 turbojets were produced in Britain until the end of the war, German aero-engine firms built almost 6,500. In 1945, the Messerschmitt Me 262, powered by two Junkers Jumo 004 engines, was widely used by the remaining Luftwaffe units.

Giffard deals with this conventional story mainly by emphazising the steps of inventing, developing and producing the turbojet differently. She prioritizes production because "planning for engine production fundamentally shaped other creative processes" (7). The structure of her book follows the steps of her argument: At first, production in the respective war economies is discussed, then development in industry, finally "inventive institutions". By organizing her book in that manner, however, Giffard postpones the part of her book which is the most innovative one. Her discussion of the historiography of the turbojet which forms the last part of her book would have had deserved greater prominence. Here she convincingly points out that the "dual-inventor narrative" about Whittle and Ohain was deliberately phrased in the US to outweigh the official British narrative on Britain's inventive genius epitomized in Whittle's pioneering of the revolutionary device. US firms had started developing their own turbojets very late, jumpstarted by Whittle's design. But as Ohain as well as Schelp and Wagner (were) moved there after the war, military and industrial authorities in the US were indirect heirs of the German project and as such vividly interested in emphasizing its achievements.

Her interpretation of the "dual-inventor narrative", however, forms the bulk of what Giffard has to say on the turbojet project in the US. Although she presents her book as a comparative study of Britain, Germany and the United States, the history of the latter is confined to six pages where she describes American attempts to produce turbojets of British design and another twelve where she lays out the cooperation and information exchange about heat resistant alloys between British and US firms, namely General Electric. Essentially, her book is a comparative study of the approach to the turbojet in Germany and US-aided Britain.

With such a comparison of the British and German turbojet projects, Giffard is, of course, not without predecessors. It is mainly the analysis of Edward W. Constant she wants to depart from. Constant in his 1980 study placed 'the Origins of the Turbojet Revolution' into a differentiated theoretical framework by which he was able to compare revolutionary technological change in different countries without drawing on obscure national virtues in invention and development.[4] At its core lies the 'presumptive anomaly' by which Constant terms the fact that the failure of a future development of a technological system is foreseeable from a theoretical point of view although it still works properly under present conditions. The piston-engine driven aircraft provides a striking example for this theorem. Research in supersonic aerodynamics had suggested by 1930 already that the efficiency of the propeller as well as the conventional airfoil would decline dramatically at high speeds. The insight into this prospective failure was a necessary prerequisite for the turbojet revolution. Another one was that the new device would work completely different to a piston engine: That its efficiency would increase at high speeds due to the compression of the air so that even a turbojet with a small nominal thrust could greatly improve the performance of an aircraft. By

4 Edward W. Constant II, The Origins of the Turbojet Revolution, Baltimore, London 1980.

emphasizing these realizations Constant is able to explain why only a handful of men, Whittle, Ohain, Schelp and Wagner, created the turbojet, men who had the aerodynamical knowledge necessary but were alien to the established aero-engine industry.

Giffard does not put up a theoretical framework of her own against Constant's. There are some loose thoughts on the necessity to view production, development and invention as related activities, however, but she rather adopts a two-stage approach. A detailed account of the history of the British turbojet project during the war forms the basis for her argument. From this she distills a British model of success by which she assesses the history of the German project in due course. That British model was hallmarked not by the initiative of the inventor of the turbojet, Frank Whittle, but rather the established aero-engine producers, namely Rolls-Royce. After an early decision to produce the turbojet which was hampered by a number of setbacks, Rolls-Royce, in close connection with the Ministry of Aircraft Production (MAP), but also De Havilland finally mastered the development of "highly reliable and powerful jet engines" that "dominated world jet production after 1945" (17). It is that continuity of established producers which Giffard insists on: "It was well-established insiders, not outsiders to the aero-engine industry, who were the most successful at turning the new engine into usable machine," (71) hence the focus on development and production. Giffard dismantles the mythology of Frank Whittle and his firm Power Jets who vested their energies in patent conflicts instead of getting the production job done. This even after MAP had decided to cover all expenses of the firm which was finally nationalized in 1944.

At a closer look, however, Giffard rather underpins than rebuts Constant's theory. Her story of the turbojet project in Britain, steeped in primary sources, is full of examples where the established firms and MAP did not fully understand the revolutionary quality of the turbojet and sidelined it. Rolls-Royce's first turbine designed by Alan Arnold Griffith was far too complicated because he was preoccupied with matching the "aero-engine standard" of performance, a fact already noted by Constant.[5] Nonetheless, Griffith had to rely on a piston engine designer to translate his ideas to the staff of Rolls-Royce to be able to continue his work (76). The order for an experimental airframe was placed with a somewhat redundant firm, "not otherwise engaged on crucial war work" (21), where it still had "low priority" in 1943. In general the development of the turbojet was supported by MAP only as long as it did not impact development and production of conventional engines. It has to be asked if Whittle's and Power Jets' obsession with patent rights stemmed from the fact that they were coerced to cooperate with an immensely powerful partner whose commercial interests were not clear, namely, whether Rolls-Royce really wanted

5 Constant, Origins, p. 215.

to further the interests of Power Jets or just wanted to secure an asset. In any case, it becomes clear from Giffard's narrative that the British project acquired momentum only after the German jets had first been encountered. In her general remarks Giffard fails to note that the development of those "highly reliable and powerful jet engines" in the British aero-engine industry was mainly a matter of the last year of World War II when MAP finally devoted close attention to the turbojet. This was meant to show that "the hun is not always ahead of us in secret weapons" (35) and the commercial perspective was then, naturally, geared to the post-war world market.

While Giffard glosses over the importance of the last year of the war in the British case, she emphasizes it in her German story. It is a well known fact that the radicalization of the Nazi regime deeply impacted the conditions of production of the turbojet and the respective airframes. What had started as an attempt to equip the Luftwaffe with superior aircraft driven by a revolutionary power unit ended up in 1945 with what some called the "Volksjäger": a wooden aircraft with a single turbojet, hastily developed and poorly tested. It was fabricated under the supervision of the SS in underground dispersal sites, the erection of which had already cost the lives of thousands of slave workers. As such, the Heinkel He 162 forms the epitome of the moral corruption of the German aircraft and aero-engine industry in the Nazi period. It was not developed and produced because of the hope for superior performance but because the airframe just used what was left in the German war economy: steel and wood. Further it saved those Germans who were working on it erstwhile from being drawn into the tornado of defeat.

Giffard discusses the history of the He 162 at some length, because this is from where she draws her central thesis. For her, the same central idea that governed the evolution of an airframe which, according to Heinkel, was conceived as late as September 1944 had already driven the development of its power unit which had started in 1939. In her argument the decision for mass producing the turbojet in Germany in 1943 was not meant to supply the Luftwaffe with superior aircraft, but as an adjustment of aero-engine production to design failures and to the shortages of fuel, raw materials and labour. Due to the "failure to develop new, faster, piston engined aircraft" (43) the German Air Ministry put engines into production which were ill-conceived and highly unreliable, even dangerous, but much better suited to production than conventional piston engines. So comparing the German turbojet development with the British model of success makes the former look like an utter disaster. In Giffard's story Hans Joachim Pabst von Ohain whose turbojet HeS 011 did not go into production, figures as a kind of German Whittle. Meanwhile, the decision to put them into production at an immature stage drove the projects of the established aero-engine producers Junkers and BMW into a dead end – if they ever had the technological potential to compete with Rolls-Royce and De Havilland anyway.

3. The German turbojet project: Claims and facts

That conclusion, however, is arrived at by doubtful means. The purpose of Giffard is to belittle the German turbojet project, and she does so by omitting, misinterpreting and confusing events, developments and sources. But her book suffers mainly from the fact that Giffard almost completely ignores modern German historiography. This is true for contributions to the history of the turbojet, such as Reinhard Müller's book on Junkers engines, but even more so for general scholarly work, be it on the nature of research and development in Nazi Germany or on the history of the German war economy. None of the major German scholarly studies of the last 25 years, with the exception of Ralf Schabel's book of 1994, are incorporated in her narrative. But even where she mentions Helmut Maier, Sören Flachowsky, Helmuth Trischler, Burghard Ciesla and others, as in a recent article for the Journal of Contemporary History[6], she dismisses their arguments in a complacent manner. Although I am lucky to receive some footnotes for a short article on Ohain, Giffard utterly neglects the research I have contributed to the history of the German aircraft industry and German air armament in the last 25 years, laid down in numerous articles and a book of some 900 pages. Of course, elderly men tend to be touchy about their past achievements, academics even more so, but this is not it. The main effort of German historians in recent years has been to show how the military machine of Nazi Germany so efficiently exploited science and industry. In the face of this Giffard's story is not just flawed but too simple and stereotype. There is too much of a notion of Prussian militarists piecing together the shabby version of a sophisticated machine, outweighing the lack of technological expertise by sheer brutality.

Only some remarks on her major claims will suffice to illustrate this. The first of many is her benchmarking of the respective projects. By claiming that the British Air Ministry decided as early as February 1940 to produce the turbojet while in Germany that decision was made as late as August 1943 (actually on May 25, 1943), she creates the impression that development in Britain followed a systematic, long-term approach while Erhard Milch, who as Generalluftzeugmeister was the head of what was the equivalent of the German ministry of aircraft production, acted hastily and under tremendous pressure, after "a low-level office" under Helmut Schelp had pursued turbojet development in a "leisurely" fashion only (42).

Quite to the contrary, Ralf Schabel has shown that turbojet development attracted considerable attention by the German Air Ministry since 1939, with Ernst Udet, Milch's predecessor, calling himself the patron of the project. In February 1939, still months before the first jet aircraft had become airborne, the German Air Ministry calculated to furnish the development of rocket

6 Hermione Giffard, Engines of Desperation. Jet Engines, Production and New Weapons in the Third Reich, in: Journal of Contemporary History 48, 2013, pp. 821–844, here p. 825.

engines and turbojets in 1940 and 1941 alone with some 25 million Marks which, given the 1939 exchange rate of 11:1, amounted to £2.27m.[7] That was considerably more than those £1.3m Whittle and Power Jets received from MAP between 1939 and the end of 1943 in total (173). And this was just meant to be initial funding. Under the standards of the German Air Ministry, industry had to fund research and development mostly from the profits of series production. So Heinkel covered the costs of the Ohain project to a great share at his own expense. And these costs were much higher than Giffard suggests. While she calculates that by 1940 some thirty people worked in the turbojet program at Heinkel (189), manpower statistics available at the Archives of the Deutsche Museum in Munich show that the Rostock Studien LLC which Heinkel founded in April 1941 to give Ohain's project a business framework employed 295 people from the start: Almost as many as Power Jets. Rostock Studien roughly kept that size until it was amalgamated with the Hirth Company which Heinkel bought to get Ohain's turbine into production. Hirth employed some 1,800 people, so it is fair to say that Heinkel alone financed an enterprise as large as the core of the British turbojet project until 1943, consisting of Power Jets and Rover's factory at Barnoldswick with some 1,600 employees. But Heinkel was not even the major part of the German turbojet project. It is difficult to determine exactly how much the huge Junkers combine (Junkers Flugzeug- und Motorenwerke) actually invested into turbojet development and production. But when Junkers sold a production license for its main production model, the Jumo 004B turbine, to Japan in late 1944, they demanded and received 20 million Marks (£1.8m) as a fee,[8] arguing that until then development costs alone had amounted to 15.2 million Marks (£1.4m). That was not a "leisurely" affair.

The determination of the German Air Ministry and the German aircraft industry to support turbojet development was more intense because the insight into the aerodynamic inefficiency of the conventional piston engine and the conventional airframe at high speeds had been far more widespread than in Britain. That made itself felt in the discussion whether a highly powered piston engine should be developed. In March 1938 Willy Messerschmitt reported to the German Air Ministry about theoretical investigations into the use of the Daimler-Benz DB 604, a piston engine with 24 cylinders which was meant to produce some 2,350 h.p. Messerschmitt stated that he neither needed an engine of that size nor would he use it if it were available. Applying such an engine to his single- and twin-engined fighter aircraft would be a waste of fuel and raw materials unless a solution for the rapidly rising drag at a conventional airfoil nearing supersonic speed could be found, not to speak of the equally

7 Ralf Schabel, Die Illusion der Wunderwaffen. Die Rolle der Düsenflugzeuge und Flugabwehrraketen in der Rüstungspolitik des Dritten Reiches, München 1994, p. 42.

8 Lutz Budrass, Flugzeugindustrie und Luftrüstung in Deutschland, 1918–1945, Düsseldorf 1998, p. 764.

declining efficiency of a propeller and the considerable weight of such an engine.[9] So Messerschmitt opted for a revolutionary departure from conventional technology in aero-engine and airframe construction alike. In his case it was the swept-wing technology, later applied to his Me 262, the construction of which started shortly after Messerschmitt released his report. Other than in Britain, this was not a second-rate firm which was to supply the airframe for the turbojet, but one of the leading German aircraft designers. He called for a simultaneous revolutionary approach in aero-engines and airframes which ever since characterized the German turbojet project.[10] That had no match in Britain. Here high-speed aerodynamics did not imprint itself on airframe development while the turbojet project was further curtailed by the attention given to those wasteful (and, as it turned out: trouble-stricken) piston engines like Rolls-Royce's Vulture and Napier's Sabre. In Germany engines of that class were considered too heavy and too ineffective at high speeds the longer the war lasted and the more that emphasis was put on sophisticated airframe designs. To be sure, German firms kept developing highly powered piston engines as well, namely the Junkers Jumo 222 and those coupled Daimler-Benz DB 606 and 610 engines Giffard describes in length (44–45), but only for long-range bombers. They were, contrary to Giffard's assumption, never intended for fast fighter aircraft.

But in Giffard's narrative it was not the failure to develop an advanced piston engine which mainly determined the decision to produce a shoddy turbojet, but the lack of raw materials, the lack of fuel and the lack of labour. I will deal with these claims one after another, not only to show that Giffard is wrong but also to explain why turbojet development and production in Nazi Germany turned out to be a success.

First the lack of raw materials: It is particularly the scarcity of "metal", "Just moving to turbojets saved metals" (58), combined with the alleged shabbiness of its design from where Giffard draws her conclusion that the German turbojet was an "Ersatz aero-engine". Her consistent use of the term "Ersatz" alone shows that she has failed to understand basic features of German engineering and scientific research in World War II. The term "Ersatz" in the sense Giffard uses it was coined during World War I and it marked a traumatic experience for the whole of the German engineering profession. German engineers and scientists had to admit that most of their substitutes for imported raw materials were despite all pledges of an inferior, sometimes

9 Budrass, Flugzeugindustrie, p. 624 and p. 698; Schabel, Wunderwaffen, p. 40.

10 Burghard Ciesla, German High Velocity Aerodynamics and their Significance for the US Air Force 1945–52, in: Matthias Judt (Ed.), Technology Transfer out of Germany after 1945, Amsterdam 1996, pp. 93–106; Helmuth Trischler, Luft- und Raumfahrtforschung in Deutschland 1900–1970. Politische Geschichte einer Wissenschaft, Frankfurt a.M., New York 1992, p. 217.

despicable quality.[11] This experience shattered the faith in the elitist engineers to such a degree that they unanimously drew the lesson that this should never be repeated. Helmut Maier and Sören Flachowsky have forcefully shown how deeply that lesson influenced engineering and science in Germany.[12] The quest for new substitute materials, now called 'Heimstoffe', 'local raw materials', started in the 1920s and quickly became an obsession after 1933. That was not just a matter of saving 'metal', but of new alloys, different construction principles and new ways of treating and joining material. One thing, however, was crucial from the outset: Goods made of 'Heimstoffe' had to be as good, if not better than those made of imported raw materials.[13] So, in the case of the turbojets, the design of the 'Heimstoff' Jumo 004B started shortly after the Jumo 004A had first run on the bench in October 1940, as Giffard indeed notes. But that was as challenging a task as the design of the turbojet itself and certainly not a matter of sacrificing performance and reliability for the sake of reducing scarce metals. The search for new alloys, efficient turbine cooling devices and an improved fuel regulation were directed in particular to the task of efficiently exploiting the turbojet's combustion heat at low cost and low waste.[14]

That enterprise would probably have failed if the 'Heimstoff' debate within the reach of the German Air Ministry had not taken another turn at the height of the war. An investigation of the service time of German aircraft in 1942 confirmed that their average lifespan was considerably shorter than those 100 hours then still demanded for aero-engine time between overhauls. In 1942 a Bf 109 on the Eastern front on average was in service for just 65 hours before it was lost or damaged beyond repair, a Fw 190 on the Western front for just 25 hours. That realization gave rise to an overall review of the tight quality standards in German aircraft production which had until then remained on a level comparable to civilian aviation. The results of that movement which spread over the whole of the aircraft industry placed it on a completely new footing. Apart from the fact that lowering quality standards in production made the employment of a higher proportion of unskilled and semi-skilled slave workers possible, it also facilitated the use of raw materials which had been considered unfeasible before, namely all kinds of secondary aluminium from aircraft scrap. All aircraft and all aero-engines were subject to that redefinition

11 Helmut Maier, ‚New Age Metal' or ‚Ersatz'? Technological Uncertainties and Ideological Implications of Aluminium up to the 1930s, in: Journal of the International Committee for the History of Technology 3, 1997, pp. 181–201.

12 Helmut Maier, Forschung als Waffe. Rüstungsforschung in der Kaiser-Wilhelm-Gesellschaft und das Kaiser-Wilhelm-Institut für Metallforschung 1900–1945/48, Göttingen 2007; Sören Flachowsky, Von der Notgemeinschaft zum Reichsforschungsrat. Wissenschaftspolitik im Kontext von Autarkie, Aufrüstung und Krieg, Stuttgart 2008.

13 Maier, Forschung, p. 366.

14 Reinhard Müller, Junkers Flugtriebwerke. Benzinmotoren, Flugdiesel, Strahlturbinen, Oberhaching 2006, pp. 226–234.

of quality standards which did not affect performance but adapted the lifespan of German aircraft to the realities of war.[15] That, however, was most important for turbojet development. Despite numerous efforts German metallurgists did not find ‘Heimstoff’ alloys for the turbine blades and the turbine rotor which were as heat resistant as the British Nimonic alloy which contained some 50 per cent of nickel. For that purpose, Tinidur sheet, containing 30 per cent of nickel, and later Cromadur sheet, containing no nickel at all, lasted for just 25 hours. But that deficiency was controllable by applying tight overhaul intervals. The Jumo 004Bs of the Me 262 had to be replaced after 25 hours of service – and due to the efficient series production Luftwaffe units had more than enough spare Jumo 004B to follow that order.[16]

Meanwhile, all other difficulties that had cropped up during the design of the ‘Heimstoff’ Jumo 004B had been solved, not least due to the concerted effort of the Luftwaffe test stations, companies, universities and the huge aeronautic research institutes. When the final major design challenge surfaced in late 1943, resonance vibrations of the turbine rotor, it was solved by consulting Max Bentele of the Ohain-Heinkel project, a vivid proof that the effort for the turbojet even crossed company boundaries.[17] The Jumo 004B was, indeed, a “result of extraordinary design effort” as Constant notes,[18] namely through its hollow turbine rotor and its hollow turbine blades which greatly contributed to an improved heat dissipation and a weight reduction by 100 kg compared to the Jumo 004A. Giffard’s frequent claim that those hollow blades, made of folded Tinidur sheet (59), highlighted the “shoddy construction work” (61) has no basis. She presents neither a single reliable piece of evidence for this, nor for her general claim that “performance, quality and safety” of the Jumo 004B were intentionally sacrificed for production needs (65). Sometimes she even makes up references: Her claim that those hollow blades “increased the frequency of fatal, catastrophic engines failures” (58) is referenced with pages 208 to 211 of Constant’s book. Here, on page 211, is indeed a description of the design of the Jumo 004, but there is not a word on engine failures, least of all on catastrophic ones. On the contrary, sources suggest that the German turbojet was a remarkable technical achievement. When Milch assembled his department heads on May 25, 1943, to decide on the mass production of the Jumo 004B, his question on the state of development was answered by the head of aero-engine development, Eisenlohr, by

15 Budrass, Flugzeugindustrie, pp. 818–829; see also Lutz Budrass, Ideology and Business Strategy: Assessing Nazi Germany‘s Different Approaches to the Supply of Light Metals for the Luftwaffe, in: Hans Otto Frøland, Mats Ingulstad, Jonas Scherner (Ed.), Industrial Collaboration in Nazi-Occupied Europe. Norway in Context, London 2016, pp. 37–61.

16 Müller, Junkers, pp. 235–236 and 244–245.

17 Müller, Junkers, p. 236.

18 Constant, Origins, p. 211.

stating that it was "technically more mature than any aero-engine".[19] But that was just the start of a discussion in an almost cheerful atmosphere where all of the technical officials were full of praise for the Jumo 004 which was as reliable and powerful as had been hoped.

Just one "difficult but not decisive" matter remained to be discussed: which type of fuel was to be used in the turbojet. That leads to Giffard's claim that the turbojet was produced because it saved aviation gasoline. Diesel fuel and gasoil were indeed the first choice because they were harder to ignite and, hence, safer than aviation gasoline. But diesel fuel, gasoil, gasoline and almost any other fuel had to be hydrogenated from coal and most of the hydrogenated gasoil and diesel fuel had to be kept back for the U-boats. So Milch decided in that very meeting on May 25, 1943, as suggested by Schelp, to switch two of the hydrogenation plants reserved to the Luftwaffe over to diesel fuel. Nowhere else is Giffard in a more head-on contradiction with historical reality than here. While she suggests that the decision for the turbojet was taken because it used the "more plentiful" diesel (60), the Luftwaffe in reality sacrificed its precious aviation gasoline to get the powerful new jet engine with a safer fuel into service.

The optimistic mood conveyed by the minutes of that meeting, however, stemmed in part from the fact that the long-standing problem of using available, more powerful piston engines with the existing fighters had been solved as well. By a simple lengthening of the fuselage of the Fw 190 it was possible to accommodate the new Jumo 213. So for only limited modifications to the production system of that airframe the Luftwaffe acquired a fighter which was a match for the aircraft of the Allies.[20]

Here the decisive issue of labour comes into play. The respective decisions for the Fw 190D and the turbojets highlight the importance of learning to the German war production regime. That was the main reason why I introduced the economies of learning to the debate on the nature of the German war economy.[21] A new design was introduced to mass production only if it either did not trouble the efficiency acquired through learning (as in the case of the Fw 190D), or showed remarkable superior performance (as in the case of the turbojets). That, again, underlines the sacrifice Milch had to make by opting for the mass production of the turbojet. Given the peculiarities of the Nazi Regime, it was also a dangerous move. Production of the turbojet made a retooling of a major part of the Junkers combine necessary, resulting in a considerable drop

19 „Es ist in der Serie weitaus reifer als jeder Motor", Amtschefbesprechung am 25.5.43, Bundesarchiv-Militärarchiv RL 3/20, fol. 438.

20 Budrass, Flugzeugindustrie, p. 849.

21 Budrass, Flugzeugindustrie, pp. 843–846; see also Lutz Budrass, Jonas Scherner, Jochen Streb, Fixed-price Contracts, Learning, and Outsourcing: Explaining the Continuous Growth of Output and Labour Productivity in the German Aircraft Industry during the Second World War, in: Economic History Review 63, 2010, pp. 107–136.

in production and a new cycle of learning and adapting to the new engine being produced. In the German war economy that could result in a serious setback in reputation as production records were the ultimate proof for the dedication to Hitler's cause. Albert Speer got a foot in the door of aircraft production by intentionally withholding resources for the production of the Me 262 and its engine, thereby reducing Hitler's esteem for Milch considerably.[22]

But when Speer finally took over responsibility for aircraft production he did not introduce a new production regime more apt to Nazi ideology. Giffard's claim that the turbojet lent itself better to the "brutal, authoritarian labor practices" (60) introduced by Speer ignores a central lesson of industrial production. It is not possible to produce a device as sophisticated as an aircraft, a piston aero-engine or a turbojet under death camp conditions. An absolute minimum of care, of supply and of safety even for slave workers was necessary, otherwise learning effects would disappear and production collapse. There existed a kind of morale of efficiency right to the very end of the war, even when a factory was turned into a concentration camp, as Manfred Grieger and I have shown some 25 years ago.[23] Speer was both more reckless and more successful in presenting his production records to Hitler, demonstrating his devotion to the "Führer", but his rhetoric should not be taken at face value. Conditions for the slave workers who built the huge underground dispersal sites were murderous, but their fate was different from those who later worked there in production.

It has still to be noted, however, that the impression of the terrible conditions under which these underground installations were put into place caused few and outstanding examples of resistance among German engineers and business officials. Some declined underground production orders, even if that could mean serious trouble. The fact that Hans Joachim Pabst von Ohain was threatened with a court martial in late 1944 for allegedly sabotaging the production of the HeS 011 jet engine in the Hirth-Heinkel underground factory at Kochendorf should be mentioned when considering the reasons why this turbine was finally not produced (305).[24]

In contrast, the people at Junkers, like most Germans, did not hesitate. So after the last design problems had been solved the production of the Jumo 004B commenced in the Nordwerk and other sites, largely unhampered by aerial attacks, with a very large number of slave workers, smoothly and efficiently. The production success of Junkers, however, rested on a development

22 Budrass, Flugzeugindustrie, pp. 865–867.

23 Lutz Budrass, Manfred Grieger, Die Moral der Effizienz. Die Beschäftigung von KZ-Häftlingen am Beispiel des Volkswagenwerks und der Henschel Flugzeug-Werke, in: Jahrbuch für Wirtschaftsgeschichte 1993/2, pp. 89–136.

24 Lutz Budrass, Hans Joachim Pabst von Ohain. Neue Erkenntnisse zu seiner Rolle in der nationalsozialistischen Rüstung, in: Friedrich-Ebert-Stiftung, Landesbüro Mecklenburg-Vorpommern (Ed.), Technikgeschichte kontrovers: Zur Geschichte des Fliegens und des Flugzeugbaus in Mecklenburg-Vorpommern, Schwerin 2007, pp. 52–69.

in the last few months of the war which Giffard, again, fails to note. The more Luftwaffe procurement was confined, beginning in October 1943, to fighters, bomber producing firms were laid idle. In the second and third quarter of 1944 Junkers lost production contracts amounting to almost 1.6 billion Marks (£145m) and the same was true for Heinkel.[25] They both desperately looked for new opportunities, not least because they were threatened to lose their workers to Messerschmitt who attempted to turn the success of the Me 262 into a hegemonic position in the aircraft industry. Heinkel grasped the chance to hastily develop and produce that "Volksjäger" mentioned above, while Junkers placed the bulk of its workers and the remaining resources on the Jumo 004. That in part explains why the production of the Jumo 004B quickly attained astonishing levels. Junkers produced 234 Jumo 004B in the second, and 894 in the third quarter of 1944. But in the last business report available it was calculated that with even more workers moving to the Jumo 004B production lines it would be possible to produce up to 5,000 per month by September 1945.[26] That indeed would have outclassed any mass-production launch of an aero-engine to this date, be it in Germany, Britain or elsewhere (60).

The abundance of labour in the wake of defeat was one reason why production of the Jumo 004B turned out to be such a success. The other was that Junkers simply brought the qualities of the German turbojet project to the fore, the Jumo 004B being the result of a continuous and intensive development of an engine which had been designed to be as reliable and powerful but simultaneously as suited to mass production as possible. As such it reflected peculiar virtues of German industry and science. The scarcity experienced during World War I had created an impulse for the rationalization of industry as well as an inventive zeal to substitute raw materials and procedures. It is fair to ask if the abundance of resources in which Edgerton identifies a central feature of Britain's war machine contributed to the fact that this impulse was somehow lacking in Britain.

4. Conclusion

In sum, Hermione Giffard's book shows that the desire of David Edgerton and his scholars to refute Barnett's arguments has at some point spun out of control. It was certainly sound to emphasize certain achievements in British military technology which normally escape attention when a continued decline of British industry beginning in the 19th century is construed. This, however, has turned into an uncritical praise for the genius inherent in British science, technology and industry which is apparently even more emphasized by an intentional discarding of German achievements in the same fields. German historians are not easily moved to join in a similar tune of praise for German

25 Budrass, Flugzeugindustrie, pp. 865–881.

26 Vierteljahresbericht für den Verwaltungsrat der Junkers Flugzeug- und Motorenwerke AG, Juli-September 1944, no Date (Jan. 1945), Bundesarchiv R 8121/142.

science, technology and industry, not because Germany lost the war, but because those have been contaminated to their very core by the crimes of the Nazi regime. To always remind of the crimes whenever achievements are pointed out has become a specific art of German historians which has resulted in a number of methodological and theoretical innovations. By applying these innovations German historians have at least succeeded in doing away with those reminiscences of contemporaries like Albert Speer, Erhard Milch, Ernst Heinkel and others which have far too long dominated the discussion. We have also created a history of German science, technology and industry which is less shining and less glamorous, sometimes of a German thoroughness, but cautiously depicted and balanced. Simply ignoring it for the sake of inventing a simplified story of German failure which puts the British model of success even more into the limelight is likely to defy historical reality.

Address of the author: Dr. Lutz Budrass, Historisches Institut, Ruhr-Universität Bochum, 44780 Bochum, E-Mail: lutz.budrass@rub.de