Theodor v. Kármán, "War, technology, science," *Pester Lloyd* (18 October 1914): 2-3.

If according to a famous saying the victorious battles of the German Army forty and fifty years ago were won by the German schoolteacher, then one could claim with nearly the same justification that the German engineer stands behind the present successes. And here much has happened that has surprised more than just the layman; often the genuine expert has also had to concede his astonishment. There are indeed some "specialists" who, for example, dismissed the Zeppelin airship and more or less all of German air technology with supercilious laughter not so long ago, and now explain with just as much superiority that there is nothing more natural than the fact that German diligence and German persistence had to bring about victory, and that the French had only exaggerated their successes in the domain of aviation. Anyone who is now moderately well-oriented knows very well that in reality genuine work has been achieved on both sides, and however pleasant it also is that German technology has proven itself in such overpowering fashion in various domains, the superiority of Germany cannot, however, then be explained—as one can read ever more often even in serious newspapers these days—by a devastating indictment of English and French industry and engineering. It is a much more interesting problem that will occupy scientists and industrialists for a long time, which disciplinary circumstances led to German technology being able to surpass England and France in domains where they had been, so to say, its teachers.

The achievements of the German air fleet and especially the German airplane—and surely not least in France itself—are a great surprise for the wider public. This victorious advancement of German air technology, which incidentally was already demonstrating itself in the final months before the war by breaking several international records, this enormous work capacity now proven in war, has deeper grounds—apart from the great national character qualities of the pilots, whose influence also cannot be denied, of course, and the brilliant organization of the flying corps—grounds which can only be understood properly at the hand of the development of aviation. Everyone knows that the emergence of the airplane is not due to any fundamentally new discovery; the essential premise that a Renard or a Lilienthal lacked, and that first made it possible to translate the dream of human flight into reality, was the design of sufficiently light motors. "No more than one kilogram per unit horsepower," that was the rule of thumb of the French designer who surprised the world with bold flight results six to eight years ago in Paris. They did indeed manage to design the kinds of motors that for example at 50 horsepower had no more than 50 to 60 kilograms weight in operation. Anyone who still had the chance in 1907 or 1908 to visit the modest work spaces of the French airplane design bureau in the western suburbs of Paris could still see the designers pondering over the drawing board where a few grams of weight could be saved in the constituent parts. An excess of cleverness and skill was expended along these lines during implementation—or wasted, one might well say today. For the chief strength of the German aviation industry consists precisely in having abandoned the principle of weight-trimming as the lone leitmotiv, and put in its stead the principle of the highest possible operational safety and strength. The most successful German airplanes are equipped with engines that weigh up to 2.5 kilos per horsepower instead of one, but this offers just the guarantee for its operational safety and for its functionality in difficult circumstances.

The brilliant trick by which the French designers attained the most substantial decrease in weight consisted in the invention of the “rotary engine,” which in its most refined model resulted in the “Gnome engine.” The rotary engine has radially arranged (canted) operating cylinders that run around the shaft and are thus cooled energetically through their own motion, so that the very substantially greater weight that goes to water cooling in the normal idling gas engine can be saved. Besides this the complete mass balancing has been extolled as an advantage of the Gnome engine, and the independence of the engine from the configuration of the airplane. In fact the acrobatic pieces of [French designer] and followers are only possible in airplanes that are equipped with rotary engines, but for this one has to take into account the high sensitivity of his design. German aviation technology, which from the beginning seemed to incorporate military prowess, turned down the rotary engine after a few tests. It has thus foregone the construction of very light aircraft with great mobility, however, as represented for example by the Bleriot machine. It is true that more complex models were created for this, but they were thought through and redesigned in all details of the safety designs, and have now brilliantly proven themselves in the war.

French aviation technology has essentially two chief models: the race with 150-160 HP engine for more than 150 kilometer [per hour] speed, which has barely any military significance, and the normal light aircraft with 70-80 HP for 90-100 kilometer [per hour] speed, whose main models are represented by the Bleriot monoplane and the Farman biplane. As against the 400-700 kilogram operational weight of the Bleriot aircraft the normal military monoplane of the German air corps, the “Dove” with 100-120 HP engine power, has around 950 kilogram total weight. According to the specifications obtained such an aircraft must lift into the air, in addition to the weight of two people (airplane pilot and observer), 200 kilograms of useable weight, 150 kilos of gas, and 18 kilos of oil. If we assume this is 520 kilos total, then 430 kilos remain for the design as against the 250-320 kilo design weight of the Bleriot monoplane. Since the speed of both models is the same and thus each square meter of wing surface of both of them carries roughly the same weight, the German machines must possess much larger wings. Naturally the lighter design has advantages, too: the heavier “Doves” land somewhat too stiffly and are hard to “head off” during landing, but on the other hand the increased capacity is first of all beneficial for arming with war materiel, and secondly it permits not only the construction of completely solid engines without normal water cooling, but also the powerful design of the landing gear and many parts requiring particular strength. One can provide for each part the form and weight according to calculation.

And here another viewpoint comes into play which seems to me of decisive importance for the evaluation of the entire development. One can perhaps put it this way: the German airplane designer is by and large not an “inventor,” he is an engineer who had learned his engineering handwork properly and now carries over the experiences he has gathered in other domains to this new domain. I am very far from claiming that there are no well trained engineers to be found among the French aviators—one has only to name Breguet, who is really to be regarded as a first-class engineer. I also gladly admit that in France and England serious scientific circles have taken up the great national task of aviation with great excitement. Nonetheless, in no other country than Germany has it been the case to such a degree that the engineering world has devoted itself to the new task with full confidence and with the same natural gravity with which it also attained successes in other domains. Engine specialists, experts in mechanics, in statics and materials strength, materials testers and the most diverse manufacturers have gotten together and put their further experiences in service to the new industry. Well-tried global firms, at whose disposal stood a gigantic reserve of experiences in questions of organization and manufacture, took up the construction of airplanes. And one other thing: I do not want to overestimate the influence of science on the development of technology, but there was something thrilling when representatives of the army, navy, industry, and aviation praxis got together in the old scholarly town of Göttingen with a series of professors extending to the most abstract of mathematicians, in order to found a scientific society for aviation technology. And when the agreement was brought about, they kept on coming back, the gentlemen from industry and from military aviation, with their suggestions and with their doubts about this and that point of theory.

Perhaps it is a one-sided view of things, but I regard its scienticity as one of the chief traits of German technology. The first articles in which England suffered a shortage after the outbreak of war were the products of the chemical industry, which are the most closely tied of all the branches of industry with science and theory. But also in the branches of industry that are closely connected with warfare the hand of the scientist is clearly recognizable. There lies the great sting of the 42-cm siege mortars. The design details of the magnificent gun are still not known; certainly a long series of difficult problems had to be solved with it regarding transport capability, ballast, installation, and servicing of the gun, problems in which the practical sense of the soldier and the technician had to be reconciled in operation. But the first condition for such a design is the solution of the materiel question. And here the scholarly work, which for example the Krupp Works has achieved in their laboratories and materials testing installations, is not to be underestimated. Steel fabrication and metallurgy were previously predominately practical disciplines. But assiduous, systematic scientific work was what first led to achieving the highest possible efficiency with the materiel. And there are more scholars in Essen with and without professorial titles than one would suspect.

It is similar in shipbuilding. Right at the beginning of the hostilities one could read the English newspapers were incensed that the English cruisers lagged behind the German ones in speed. It was a difference of two knots: 25 versus 27. I have not verified details, but they are characteristic for the relation of the products of the two machine-tool industries in other domains as well. It is initially astounding: shipbuilding and ship machining have their home in England after all and had already attained considerable perfection, before one had to reckon with Germany as a competitor. But it is known for example that in steam engine construction—in a branch of industry that first counted England as home—the German manufacturers have more efficient coal consumption than the English. It is freely conceded that this is conditioned by economic grounds; with cheaper coal prices coal consumption plays a smaller role in England than in Germany. The chief ground lies elsewhere, however. The English machines are built by proficient technicians who truly have much experience at their disposal and have thoroughly learned the craft, but their whole training and their whole sensibility are not oriented toward extracting the most from the material and from the energy supply. For this you need an exact quantitative analysis of the problem, and scientific technology distinguishes itself from pure practice precisely in striving to measure quantitatively the productivity of the materials and the course of the natural processes, and thereby to attain the best performance with the best possible economy.

It seems to me—and I do not deny that I most surely have a one-sided view of things—it seems to me that alongside the brilliant institutions of the army and navy the scientific quarter of German technology and its representative, the German higher school, have been set a grand exam, and they have passed it.

Translation: KH