A COMPARISON OF GERMAN AND AMERICAN TANK DEVELOPMENT AND PRODUCTION DURING WORLD WAR II

by

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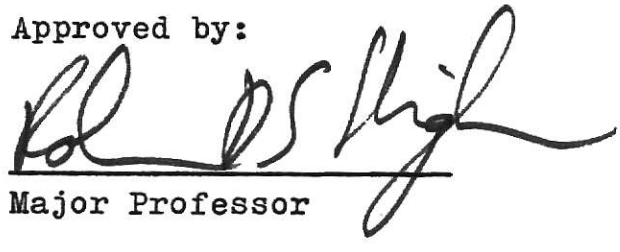

Major Professor

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INTRODUCTION

This report, a comparison of German and American tank development and production during World War II, looks at a number of points of interest related to the history of German and American armored fighting vehicles. Few sources on World War II deal specifically with a comparison of German and American tank development and production, a topic of interest to the historian since it helps explain some of the reasons for Germany's defeat in that war. Assisting the historian fill the gap in coverage of this topic is the purpose of this paper.

This report contends that the Germans expected a short war with few losses of tanks due to their use of the blitzkrieg strategy. They therefore subordinated their technological planning with regard to tank development and production to the theory of lightning warfare. Since few losses of tanks were expected, full-scale industrial development and production of tanks was slowed. It can be argued that it was only when the high losses in men and materials in the Russian campaign proved the short-war theory to be incorrect that the short-war idea was rejected and full mobilization, along with a great deal of confusion in the tank industry, began.

The Americans did not expect a short war and consequently based their tank development and production on the assumption that a long war would be required to defeat the Axis powers. Because of this belief, the Americans knew that massive numbers of tanks would be needed to fight the war

and planned their tank production accordingly.

Thus, the essential difference between German and American tank development and production during World War II lay in the differing views, short versus long, of what type of war would be fought. Those differing views, as we shall see, proved to be a hindrance to the development and production planning done by the Germans while being helpful to American planning.

Neither the details of the design and development of individual mechanical parts of German and American tanks will be discussed in this report, nor will a detailed description of each tank be made. Only general features such as size of armament, weight of the vehicle, and size of the crew will be mentioned.

Part I

GERMAN AND AMERICAN EXPERIENCES DURING AND AFTER WORLD WAR I

The history of German and American tank development and production begins during World War I, for it was then that both countries came into contact with tanks for the first time. During World War I the Germans first learned of tanks when, on November 20, 1917, British forces launched against the German lines history's first tank assault at Cambrai, France. The shock of that and succeeding tank attacks by the Allies forced the Germans to realize that they needed tanks of their own to counter the Allies' armored forces. It was only very late in the war when the first German-made tanks began to appear at the front.

The Americans, who had not expected to go to war, had, like the Germans, done virtually no work on tanks until late in the war. Tanks made in America during World War I were not used by American troops since borrowed Allied tanks were already in use and they fulfilled the necessary requirements for our men.

Interesting as the World War I period is regarding tank production by Germany and America, it is the period from the end of the First World War through World War II that is of key interest (to this paper). Germany and America gained their initial experience with tank development and production in World War I but it was only after the war that key developments took place that laid the basis for their experiences with tank production in World War II. In all, four main

postwar events can be mentioned. First was the development by the military of both countries of their view as to how tanks would be used in any new war. This development, in particular, was to have major repercussions on the German tank program during World War II. Secondly, there was the evolution of the necessary administrative techniques for tank-design selection in both countries. Third, there was the development by industrial firms in both countries of tank production techniques and, finally, there was the conversion of industry to tank production.

POSTWAR DEVELOPMENT OF MILITARY THEORIES

In the German Army in the 1920's, great progress was made in developing the basic philosophy of war that would guide German soldiers during World War II. While thinking on new military theories stagnated in the United States after the First World War, those in charge of the German Army were busily engaged in modifying old military ideas and developing new ones. The key man who studied the nature of what eventually came to be called blitz warfare was General Hans von Seeckt, Chief of the Army Command of the German Reichswehr. Seeckt was devoted to the ressurrection of the German army as a major military force after its defeat in World War I. He was also anxious to avoid, in the event of a future war, two other problems Germany faced in World War I. First was the tremendous slaughter of manpower that occurred in that war. The other was the tre-

mendous drain on the German economy caused by four long years of hard fighting. These problems, he felt, could be solved if wars could be fought in such a way as to destroy the enemy forces very quickly. The results of Seeckt's thinking came out in 1921 when he wrote a paper entitled "Basic Ideas for the Reconstruction of Our Armed Forces." In that paper Seeckt stated: "The whole future of our warfare appears to me to be in the employment of mobile armies, relatively small but of high quality. . . ."[1]

It did not take long for other German theorists to decide upon the exact method by which short wars could be fought most easily. Military leaders such as major (later Colonel-General) Heinz Guderian began by borrowing ideas on the mass use of tanks from other leading thinkers. Among these other thinkers were two Englishmen, Captain Sir Basil Liddell Hart and Major General J. F. C. Fuller. Remaining true to the Clausewitzian doctrine that called for a decisive battle for the destruction of enemy forces, Guderian combined the two ideas and advocated the use of massed formations of tanks as the spearhead for rapid, deep penetrations into an enemy's lines. These spearheads would surround pockets of enemy troops, disrupt communications, and throw supply lines into chaos, causing the enemy forces (and soon thereafter the enemy's government) to surrender very quickly. By the start of World War II, despite opposition from infantry generals who wanted tanks to be used for infantry support, Guderian's views had become the

most well accepted doctrine in the German army.[2]

Following their rise to power, Hitler and the other Nazi leaders also accepted the blitz warfare idea as a means of fighting short wars.[3] Several reasons account for this acceptance. First, the Nazi leaders also did not want to see a repeat of the bloodbath that characterized World War I. They also felt that quick wars would not require full mobilization of Germany's manpower or resources, both of which were in short supply. Because full mobilization would not be necessary, the Nazi leaders could be reasonably sure that there would be no decline in the standard of living of the German people and hence no decline in the popularity of the Nazi government. Finally, the top Nazi rulers, like the German generals, realized that Germany did not have the necessary resources or manpower to fight another war of attrition and that they could win a future war only if it was short in duration.

The Nazi view of the short war idea called for a guns-and-butter policy. Acceptance of that idea in turn meant that the economic planning for war would be dictated by whatever it was felt was necessary to fulfill the military needs as dictated by the short war view. In the 1930's, therefore, the Nazi war economy evolved into an economy centered around changes in emphasis from one section of arms production to another to suit the needs of each lightning campaign to be conducted.[4] This economy, which

was kept until 1942, was to have a harmful effect on German tank development and production. Such was the result of the Nazi belief that they could have war abroad and prosperity at home at the same time.

Because military thinking in the U. S. had not been advancing as had thinking in Germany in the 1920's and 1930's, the U. S. Army did not develop much interest in the idea of blitz warfare. Consequently, when we entered World War II, we were unfettered by any prior concepts on military strategy. Looking at the bleak situation prevailing in 1941, U. S. military men saw only victory after victory for the Axis powers. By the time of Pearl Harbor, France had been beaten, Britain was just hanging on, and German troops stood at Moscow's gates. Americans were under no illusion that the war would be a short, easy one as were the Germans. They knew it would be a hard war that entailed high losses of tanks. Unlike the case of Germany, American industrial production of tanks was based on the idea that high production would be needed to offset high losses. Sustained mass production from well-mobilized industries, rather than the German system of slow production from only partly mobilized industries, came to characterize American tank production as it did all U. S. war production.

POSTWAR DEVELOPMENT OF ADMINISTRATIVE TECHNIQUES FOR SELECTING TANK DESIGNS

Simultaneous with the further development of the short

war idea in Germany in the 1930's was the development by the German Army of the system for selecting tank designs. The Army Weapons Office of the Replacement Army was assigned the task of preparing technical specifications for tanks once the basic requirements for a new tank had been decided upon. These specifications were then farmed out to various firms, usually two or more, which built prototypes of these tanks. In this manner, the German Army, though not controlling the details of the tank's design, was able to place the problem in the hands of experts who would be able to settle detailed design problems in the best possible manner. The prototypes were then returned to the Army Weapons Office for further tests and demonstrations to the Army for acceptance or rejection for use in battle tests.[5] This system worked until 1942 when the Army Weapons Office became discredited for having failed to meet the needs of the army as German forces suffered heavy losses in the Russian campaign. After that time non-military authorities such as Albert Speer, Hitler's Minister of Armaments and War Production, as well as Hitler himself, gradually usurped control over research and development of tanks from the Army Weapons Office.[6] Eventually, as we shall see later, interference from non-technical persons was to be just as damaging to the German tank development and production effort as the short war idea.

The American system for selecting designs of tanks also developed in the 1930's. Our method differed from the

German system in that it did not originally allow for the flexibility inherent in the German system. As can be seen in Table 1 below, the Office of the Chief of Ordnance, not factory experts, prepared designs of tanks once the Chief of Infantry had prepared general characteristics. Completion and testing of the prototype by the firms involved in tank production (others than Rock Island Arsenal seen below were involved in tank design work later) plus subsequent tests followed in a manner similar to the German system. The U. S. program helped stifle engineering creativity present in the German method, inasmuch as the design for a tank was already laid out in considerable detail before it reached the hands of the factory experts, who might have been able to improve upon the design.

Table 1. Primary steps in the designing of U. S. tanks.

1. Military characteristics prepared by Chief of Infantry
2. Preliminary design by Office, Chief of Ordnance
3. Approval by the Secretary of War
4. Completion of pilot design by Ordnance Department, Office, Chief of Ordnance, and Rock Island Arsenal
5. Manufacture of pilot tank by Rock Island Arsenal
6. Shop test by Rock Island Arsenal (about 500 miles)
7. Independent test for Chief of Ordnance by Aberdeen Proving Ground
8. Test by Infantry Board at Fort Benning for Chief of Ordnance
9. Standardization by Secretary of War on recommendation of Chief of Infantry and Ordnance

Source: John K. Christmas, "The Manufacture of High Speed Tanks." Mechanical Engineering, LXI, i (January 1, 1939), 15.

The U. S. tank development method also suffered from use of committees which defined what the characteristics of the tank would be. Speed, armament, crew size, and armor protection were among the things these technical service committees decided upon.[7] Unfortunately, the committees often tended to water down the best ideas of the individuals on the committee and passed on ideas representing compromise agreements among the committee members. The committee method risked losing some of the quality in a tank when final plans for a vehicle were drawn up.

It was not until after the U. S. entered World War II that the post-World-War-I method was improved upon. In September, 1942, in an effort to establish closer relations between the auto industry involved in tank design and production and government agencies, the Tank Automotive Center was established. This agency handled all aspects of tank development, testing, production, procurement, distribution, and maintenance, thus making it a virtual duplicate of the Ordnance Department.[8] By renovating their tank development and production procedures in this manner, the U. S. Army created a satisfactory procedure that it kept throughout World War II.

DEVELOPMENT OF INDUSTRIAL PRODUCTION METHODS, 1918-1941

Inasmuch as the armies of both Germany and the U. S. had set up their administrative machinery for tank design selection as well as their views on how tanks would be used

in war in the future, the only steps remaining for both countries to be prepared for war were two in number; as industry would have to develop tank production techniques and convert to tank production. German and U. S. tank production techniques were similar and will be discussed together. The steps followed by Germany and the U. S. in producing tanks is summarized in Table 2 below.

Table 2. Basic steps in tank production.

Primary steps

1. Feasibility studies
2. Project studies
3. Detail design
4. Construction of prototype
5. Tests of prototype
6. Design modifications
7. Modification of production equipment

Secondary steps (the following steps do not necessarily come in their order of appearance here)

1. Facilities planned
2. Processes planned
3. Tooling designed (and/or):
4. Machines purchased
5. Tooling made
6. Equipment installed
7. Materials purchased

Source: R. M. Ogorkiewicz. Design and Development of Fighting Vehicles. (London, 1968), p. 154.

Drawing up designs, construction of half a dozen or so prototypes, testing of the prototypes and preparing the machinery needed for production were all major steps. In Germany's case, as we shall see later, prototype testing was one step that was ignored in an effort to rush a tank into

production.

INDUSTRIAL PRODUCTION OF TANKS

In the 1930's German and American planning for the development, production and use of tanks in a future war had progressed far enough that only conversion of industry to production and the actual production itself remained to be put into practice. Prior to discussing the conversion of the two industries and their wartime production, it is necessary to first examine the basic resources important to industrial production of tanks. These resources were the natural minerals that were processed into tank parts and the manpower that built the tanks themselves.

Of major concern to the German industrialists was the lack of mineral resources for tank production. The second Four Year Plan instituted in 1936 under Reichmarshal Goering attempted to cope with the problem posed by the desire to rearm a country which had an economy that lacked needed resources for full mobilization. Hitler's orders to Goering demanded two goals be realized: that the German Army and the German economy be ready for war in four years.[9] Nonetheless, the Germans could not create resources that did not exist within their own boundaries, and by the time the war started the tank industry faced a number of problems common to the arms industry as a whole.

With the exception of coal, in which Germany was self-sufficient, all other raw materials for tank components had to come, in part at least, from outside sources. Of chrome,

nickel, and tungsten for shells and machine tools Germany had none.[10] Much of the iron for steel needed for tank hulls, turrets and other parts was imported from Sweden. By the start of World War II, Germany was importing ten million tons of iron ore a year from that country.[11] Rubber for bogie wheels and tracks had to come from synthetics once imports from Indochina were cut off at the start of the war. In other categories of metals used in tank production, such as copper, lead, and vanadium, imports were also needed.[12]

The amazing thing about Germany's situation with regard to raw materials needed for tank production was that there were never any shortages of necessary materials. Production in the early war years, as can be seen in the Appendix at the end of the report, was low and did not reduce the size of stockpiles of materials greatly. Even when full mobilization began after the start of the Russian campaign substitutions of one material for another and use of synthetics meant that no shortages of materials for tank production existed.[13]

The U. S. had little to worry about so far as mineral resources such as iron, steel, copper, vanadium and other major metals were concerned. We were a major world producer of the above items and were able to import other needed metals from Mexico and Canada. The U. S. did have to rely on foreign supplies for rubber but, like the Germans, resorted to synthetics to make up for any shortages. Overall, U. S. production of raw materials needed for construction of tanks

was vastly greater than that of Germany even prior to our entry into the war. For example, in 1940 Germany produced only 21,067,000 tons of steel compared to 66,983,000 tons for the U. S.[14]

The second basic resource needed by both the German and American tank industries for the production of tanks was a sufficient amount of labor. Compared to the U. S., the Germans experienced definite initial difficulties in obtaining both the quality and quantity of labor they needed for manufacturing tanks. The pre-war labor supply was limited due to the interregnum from 1918 to 1933 which caused both skilled labor and the machinery it needed to be in short supply.[15] Labor difficulties were straightened out by the time the war began and no new problems with the labor supply arose after the start of the war. Light tank losses in Poland and France plus the short-war idea that full mobilization was not necessary helped keep the labor force in the German tank industry rather small, about three to four thousand men directly employed in tank factories and another six to ten thousand in component plants.[16]

Expansion in the size of the tank industry labor force began only after the start of the Russian campaign when a total mobilization of the economy was decided upon. The expansion was gradual and was in part possible because the tank industry received only 3.8% of the total military budget, leaving it with a great deal of room for growth.[17] By 1943 the labor force had reached 110,000 men (a figure

equal to only 10% of the U. S. labor force in our tank industry) and remained there through 1944 despite the fact that production doubled in the meantime.[18] One factor assisting this expansion was the use of foreigners and prisoners of war, some of whom replaced German workers drafted and sent to the front. German firms were willing to use these people even though they felt them to be only 70% as effective as German workers.[19]

The use of foreign workers and prisoners of war was of special interest to the German tank industry. The Germans had used prisoners in factories during World War I.[20] This prior experience with prisoners plus continuing shortages of labor were the major factors behind the Nazi decision to use foreign labor in their arms industries during World War II.

It was intended that non-German workers would be used mainly in areas where little skill and training were needed.[21] This view fitted the tank industry well, since assembly line techniques involving repetition of the same job were used. As a result, 50% of the labor in the German tank industry in 1944 was non-German, and of this total, some 55,000 or so workers, only 10% to 20% had any prior experience at the job on which they worked.[22]

Unlike their American counterparts, German workers did not experience a great increase in their work week once Germany was at war. Even late in the war, some firms maintained only one shift a day and made no real effort to go on

a crash production basis.[23] Another detrimental practice followed was the continuation of a four-year apprenticeship program for mechanics.[24] Training of workers was left up to each plant, no schools having been set up by the government.[25] The plants continued their traditional four-year training program during the war years, thus slowing production by constricting the availability of skilled labor. Any change in the program was resisted, however, and it was not until the last year of the war that the four-year requirement was cut to three years.[26] By then it was too late to gain many benefits from the change.

On the whole, it can be said that the German tank production program was not seriously jeopardized by labor problems. Much of this was because the tank firms were not producing as many tanks as they could have even with the available supply of labor. The gradualness of the expansion program also did not place any sudden and tremendous strain on the capacity of the plants to produce in the initial years of the war and, when a sudden, major increase was needed later in the war, the slack was taken up by prisoners and foreigners.

It might also be mentioned that strikes or walkouts by labor in the tank industry were never a problem. German labor had traditionally recognized that a symbiotic relationship with management existed and that what was good for management was good for labor. This, plus the depression which made jobs very scarce and a highly centralized trade

union structure that exacted good discipline from local unions, helped tame German labor.[27] Most important of all, however, was the strict regimentation of workers into the Labor Front following the Nazi takeover in 1933. Strikes, of course, were forbidden after that time.

U. S. labor contrasted sharply with its German counterpart. After Pearl Harbor the labor force in the U. S. tank industry expanded from one-half million to one million men not counting those employed in firms producing component parts. Shortages of labor therefore did not cause any major slowdowns in tank production. This does not mean that all was well on the American labor scene during World War II, for the effects of labor problems were still present.

Strikes did occur during the war but they were generally harmless. An example can be seen by one strike which occurred in June, 1943. At that time 49,300 rubber workers at Akron, Ohio, and 51,400 auto workers at Detroit and Hamtrack went out on strike. Bogie wheel production stopped as a result but there was no loss in production, since the strike, like most of those that did occur, was of short duration, usually a week or less in length.[28]

If strikes were not a major problem there were other troubles that bothered the U. S. tank industry. Deliberate slowdowns in work occurred in some companies when workers became dissatisfied with working conditions. In other companies, featherbedding was a major problem. The American Car and Foundry plant, for example, was faced with a union demand during the war that the same number of workers per

unit of output be kept employed even though the use of machinery had cut the number of workers required.[29]

Unfortunately, it is impossible to gauge how much subtle practices such as slowdowns and featherbedding hindered tank production. No doubt some effect was felt, although it is likely that it was only minimal.

As in other war industries, tank production firms sought to increase output by increasing the length of the work week put in by their workers. The increase in the length of the work week in the tank industry, as can be seen in Table 3 below, came almost immediately after Pearl Harbor. This increase, which came as a result of greatly expanded government orders for tanks and the willingness of Americans to work more hours as a way of getting better pay while helping the war effort, alleviated any shortages in production due to strikes or slowdowns.

Table 3. Length of work week in American tank factories in February, 1942.

Hours	Number of Firms Involved
less than 40	2
46-47.9	2
48-49.9	2
50-51.0	1
52-53.9	3
54-55.9	1

Source: "This Industrial Week." Anon rev., The Iron Age, CIL, ixx (May 7, 1942), 103. (No figures are given in the article as to how many workers were affected by the above changes in hours.)

In the last few pages it was seen that both Germany and America had the necessary resources for tank production and needed only to convert to tank production and begin production itself for both countries to be ready for war. In the case of Germany, the presence of Allied inspectors on German soil following World War I forced the German industrialists to work only on tank designs in Germany while doing the actual construction of tanks in holding companies under German control in other countries. In Sweden, Krupp achieved substantial control (six million of nineteen million shares) of the famed Borfors armament company and, in 1925, began developing and producing heavy guns, antiaircraft guns and tanks.[30] Tank work also proceeded at Kazan in Russia, where the two post-World War I outcasts of Europe, Germany and Russia, cooperated in studying ideas on tanks that came from German firms.

It was only after the rise of Hitler to power in 1933 that work on conversion of industry to tank production and tank production itself proceeded in the open. Initial difficulties in converting German industries to arms production led the German military and industrial leaders to decide in 1934 to start from scratch on the rearmament effort rather than just continue where the economy left off in 1918.[31] Priority was given not to raising and equipping of new formations but to barracks construction and building of training grounds, airfields, and dockyards. Tank production was given only a low priority. The tank industry

did not start production until 1934 and did not receive government encouragement to install new machinery until 1935 when new investments were allowed to be written off over a period as long as three years.[32] New Firms gradually acquired the needed manpower, proper machines and other necessities for tank production. From two plants producing tanks in 1934, the German tank industry, as Table 4 below shows, expanded to a total of six factories well scattered out around Germany by the time World War II started.

Table 4. German industrial firms involved in tank production by World War II.

Name	Location	Date Production Started	Tank Produced
Krupp-Gruson	Magdeburg	1934	Mark I
" "	"	1939	Mark IV
M. A. N.	Nurnberg	1935	Mark I
"	"	1936	Mark II
"	"	1939	Mark III
Miag	Brunswick	1939	Mark III
Henschel	Kassell	1936-7	Mark I
"	"	1938-9	Mark III
Alkett	Berlin-Borsigwalde	1938	Mark III
Daimler-Benz	Berlin-Marienfelde	1934	Mark I
" "	"	1938-9	Mark III

Source: The United States Strategic Bombing Survey Reports: European War; Tank Industry Report. (Washington, D. C., 1945), p. 3. (Report of the Strategic Bombing Survey team.)

All of the above German tank firms (except Alkett which was under control of Rhine-Metal Borsig, a subsidiary of the government-controlled Herman Goering Works) were privately

owned stock companies with stock available for purchase by the public. All (except Alkett) also produced other items such as trucks, locomotives, and heavy equipment in addition to tanks.

In addition to the above firms that produced the Mark I through IV tanks (which will be described later), other firms in the German motor vehicle industry became heavily involved in tank production, though only after the war began. Vomag Maschinenfabrik at Plauen, formerly a truck factory, switched to tank production in 1942. Lanz at Mannheim, formerly a tractor plant, and Daimler-Benz at Marienfelde, which previously produced half-tracks, switched over in 1943.[33] Still other firms, such as the Skoda tractor plant at Prague, the Miag tractor plant at Brunswick, and the M. A. N. truck plant at Nurnburg, switched to tank production in 1944-5.[34]

After 1938 Czech firms producing the 35(t) and 38(t) tanks were added to the list of firms supplying the Wehrmacht with armored vehicles. Czech equipment was used more extensively by the German Army than equipment from any of the countries later occupied by Germany. By the start of the French campaign one-fourth of the tanks in the German Army were of Czech origin.[35] In addition to this, the Czech 38(t) tank chassis also served as the basis for an assault gun later in the war.

Overall, the German tank industry contrasted with that of America in that a greater proportion of the tanks were produced in firms other than those producing autos. Much

of the reason for this lay in the fact that the U. S. had a larger industrial base centered on car production, as the statistics show. In 1939 Germany produced 250,788 autos.[36] The U. S. on the other hand, in 1940, produced 3,717,385 passenger cars.[37]

While the German firms previously listed handled most aspects of tank production, other firms were called on to produce tank engines. One was the Maybach plant at Friedrichschafen which formerly produced auto engines; the other was the Nordblau firm at Berlin.[38] It was not until Czechoslovakia came under German domination in 1938 that a third firm, B. M. M., was added to the list of those firms that produced tank engines. B. M. M., however, produced engines for Czech vehicles only.[39]

In the 1930', when German industries were buying new machines and hiring and training new workers for tank production, government control over the industry increaced. By the start of World War II, all of the companies had joined the Economic Board of the tank industry. This board handled all questions affecting the industry.[40]

Actual production of tanks, as was already mentioned, started in 1934. That production centered around efforts to build two tanks, the Mark III and the Mark IV. These tanks were designed with blitzkrieg tactics in mind. The Mark III was supposed to break through the enemy lines and plunge deep into the enemy's rear. For that purpose it was given a 37mm gun. The Mark IV was to assist the Mark III in eliminating with its short-barreled 75mm gun any centers

of resistance the Mark III could not handle. Both tanks were designed in such a way that heavier armor could be added without major changes in design of the vehicle. Also, sufficiently large turret ring diameters allowed for the later addition of larger guns.

Troubles soon appeared in the development plans for the Mark III and Mark IV, however, and the delays that resulted caused the German Army to decide to build temporary substitute vehicles, the Mark I and Mark II, which carried only light armor and firepower.

Added onto the growing numbers of tanks possessed by the German Army was the acquisition of the Czech 35(t) and 38(t) tanks in 1938 when Hitler's troops entered Czechoslovakia. To their embarrassment, the German armed forces found themselves in 1939 using half a dozen types of tanks of similar design, firepower, and armored strength but, because their industry (due to the short-war idea) had not been geared for mass production and unneeded models could not be replaced. Production of tanks had been so slow, in fact, that by 1938 only two of the ten armored divisions Germany was to use against France in 1940 were ready for war.[41]

The fact that German industry did not expand to its full potential so as to replace unneeded tank models illustrates one of the problems inherent in the short-war idea. Production of tanks became geared to the idea that tank losses in blitz warfare would be light and that the

resources saved by cutting tank production could be used elsewhere. Because of this the German Army simply had to wait until industry did expand production before old tanks could be replaced and the armored force increased in size.

The campaign in Russia in 1941 proved to be the undoing of the short war idea and had a major impact on German tank development and production throughout the rest of the war. Heavy tank losses and failure to defeat Russia before winter set in created a crisis within the German high command. As a result, a series of conferences were held in January, 1942 among top German leaders. At these confrences it was decided that the blitzkrieg economy would be ended and total mobilization of all of Germany's resources begun.[42]

The results of the change in the type of war economy Germany used were mixed. Tank production in 1942, as the Appendix at the end of the report shows, increased only slightly, while that of assault guns and self-propelled guns rose rapidly. In fact, 1942 was a period of great confusion within the German tank industry. The main problem underlying this confusion was the failure of the German tanks to match the Russian T-34 tank. The German tank industry simply did not have sufficient central direction that could guide the industry in such a manner as to create quickly and easily weapons capable of defeating the T-34. The T-34 problem created such confusion within the German tank industry that ". . . while the Wehrmacht ordered tanks and assault guns (and often found its orders varied or

revised by Hitler), industry could only blindly follow each contradictory instruction--always remembering that the SS was a separate agency whose requirements took priority over all others."[43]

Among the changes started in the German tank industry in 1942 were the following: old tanks such as the Mark I and Mark II and the Czech 35(t) were scheduled to be dropped and the production of the 38(t) was cut sharply, since none of them could stand up to the Russian T-34. The Mark III and Mark IV tanks were hastily given more armor and more powerful guns. Assault guns, which could be produced cheaply and easily, and which could knock out the T-34, became the object of a concentrated production effort.

Even with all these changes what was needed was a new standard tank which had the armor, speed, and firepower, and could be built in large enough numbers to beat the Russian tanks. No such tank was to be found immediately, for the German Army had not expected that any heavier vehicle than the Mark IV would be needed. Work on a heavier tank had begun years earlier but was given a low priority and was nowhere near ready for production when it was needed.

To make things worse for the German tank industry, instead of one new standard tank design, no less than three new designs were considered. Two of these, the Panther and Tiger I, will be examined in more detail later. The third, the Leopard, was never built. Three new designs were bad enough but confusion became greater when two competing

prototypes for both the Panther and Tiger I were considered by the German Army. Chaos was added to the confusion within the tank industry when the Army also demanded that work on the Mouse, a 140 ton supertank, conversion of Czech tank chassis for use as assault guns, and conversion of the Mark III (in a futile effort to enable it to carry a 75mm gun) were to be carried out simultaneously with the Panther and Tiger projects. The end result was that throughout 1942 and 1943 the Germans were wallowing around in confusion over priorities and goals.

It was not until 1944 that some order was re-established in the German tank industry. By the start of that year, it was decided that the Mark IV, Panther, and Tiger I would serve as the standard tanks while all other tank and assault gun projects would either be dropped or reduced sharply.[44] The clarity regarding priorities and goals provided by the new program did not last. At the end of the war the Germans were working on no less than five new tank projects, none of which reached completion before the end of the war.

Perhaps the most disturbing thing about the confusion within the German tank industry and the work on a whole variety of weapons, rather than just one or two standard ones, was the effect of all this on German tank production. Resources that could have gone into the production of the Panther or other tanks capable of matching or beating the best of the Allied tanks were wasted on production on other

vehicles such as the 140 ton Mouse. This cut the production of tanks such as the Panther at a time when Germany could least afford such cuts.

Unlike Germany, American industrial conversion to tank production did not begin in any meaningful way until just prior to our entry into World War II. In the 1920's and 1930's industrial mobilization plans were worked out by the Ordnance Department with the idea being that this would provide for quick mobilization of our industrial resources. Money, however, was the main problem that slowed preparation within American industry for tank production. Funds for the Ordnance Department for all arms projects in the mid-1930's averaged only a tiny $1,680,000 per year.[45] This shortage of money meant that the U. S. government was unable to provide industry with orders for tank parts without which industrial firms would not get the necessary experience for conversion to tank production.

To make things worse for the U. S. tank industry none of the U. S. tanks developed from 1919 to 1938 were standardized for production.[46] This left U. S. industry with very little time in which to get acquainted with mass-production techniques.

Thinking among military leaders in the U. S. also proved to be a problem. In the late 1930's a split in Army doctrine existed over what type of tank the U. S. Army would need for future warfare. Officers who emulated the German armored division generals advocated light, undergunned cavalry tanks capable of fast breakthrough attempts, while infantry

generals demanded slow, heavily armored infantry support vehicles.[47] Because of this split and the lack of money for research and development, little industrial planning was done on any medium tanks prior to our entrance into World War II. What work the Army did have industry do on tanks went into research on vehicles other than medium tanks. When the Army realized it needed a mobile, well-armed medium tank useful in blitz warfare, the only solution was to build an interrim vehicle that, despite its shortcomings, would serve until a better tank could be designed and built. The result was the development of the Grant as a fill-in until the arrival of the Sherman.

The U. S. tank industry was stimulated toward greater production in 1941. At that time rearmament in the U. S. had gotten under way. Also, the arrival of the British Tank Commission, which placed an order with Baldwin Locomotive Company and the American Locomotive Company for 685 medium tanks, was welcomed.[48] With this boost in production, American industries began the process of conversion to tank manufacturing.

In the conversion process three basic types of industrial plants were of major importance. Plants producing railroad locomotives were needed in the endeavor even though their work previously involved a high degree of accuracy but only a low volume of business.[49] The major industry responsible for tank manufacturing was the auto industry, since 60% of U. S. tank parts originated in this industry.[50] Moreover,

the auto industry also had both the experience with mass production and the desired manpower, 545,000 men, a figure nearly doubled after the start of the war.[51] In 1940, William S. Knudsen, a member of the National Defense Advisory Committee, proposed that in addition to the use of locomotive and auto firms, a new factory designed specifically for production of tanks should be built. This factory, the Detroit Tank Arsenal, was a government-owned, contractor-run plant designed to overcome the inadaptability of existing auto and locomotive plants to convert to mass production of tanks.[52]

Thus, by the time the U. S. entered World War II, three basic types of firms were producing tanks. These firms, like their German counterparts, were either government or privately owned companies that sold stock to the public.

The events of December 7, 1941 answered the question of whether or not American industry would need to convert to mass production of tanks. One typical example of the success of U. S. industries' conversion was the Fischer Tank Arsenal, formerly the Fischer Body Division of General Motors at Flint, Michigan. In January, 1942, the Fischer plant began to convert to tank production. Part of the plant was cleared for tank manufacturing immediately, and by mid-February the entire plant had switched over. To achieve rapidity of production, the Fischer Body engineers redesigned the hull of the M-4 Sherman so as to speed the welding process. Then a hull-assembly unit weighing thirty tons was employed to

hoist the entire hull, and rotated it sideways or lengthwise while welding was done. The hull itself was made by an eighty-ton auto press which previously shaped floor pans for cars.[53] Conversion was achieved so fast that the first tanks rolled off the assembly lines only forty-seven days after the changeover began.[54]

When U. S. tank production began in a major way seventeen firms became involved in the basic work of tank manufacturing. Of these seventeen, as Table 5 shows, five or six were the biggest contributors to the overall total of 88,410 U. S. tanks

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Table 5. Breakdown of facilities producing U. S. tanks. Experimental models not included.

Facility	Total Production Through Dec. 1945
Detroit Tank Arsenal	22,234
American Car and Foundry	15,224
Fischer Tank Arsenal	13,137
Cadillac Motor Company	10,142
Pressed Steel	8,648
Pullman-Standard	3,926
American Locomotive Works	2,985
Baldwin Locomotive Works	2,515
Massey Harris Company	2,473
Ford Motor Company	1,690
Lima Locomotive	1,655
Montreal Locomotive Works	1,144
Marmon-Herrington	1,070
Pacific Car and Foundry	926
Federal Machine	540
Rock Island Arsenal	94
International Harvester	7

Source: Harry C. Thomson and Lida Mayo. The U. S. Army in World War II: The Technical Services: The Ordnance Department: Procurement and Supply. (Washington, D. C., 1960), p. 242. Hereafter referred to as Thomson and Mayo Procurement and Supply.

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produced during the period from shortly before our entry into World War II to shortly afterwards. In the case of some of the industries in Table 5 above, such as International Harvester and Rock Island Arsenal, tank production was very low due to the fact that these companies switched to production of other military hardware just after they had begun to produce tanks.

It would be incorrect to say that only seventeen firms were involved in tank manufaturing, for there were literally hundreds of American firms that acted as subcontractors and suppliers of various tank parts. Cooperation between the numerous subcontractors was just as essential to the production process as was cooperation among the primary firms. An example of this was the case of Standard Steel Spring Company which turned out armor plate. Lacking equipment for planing and machining edges of armor, a legacy of the lack of preparation prior to December 7, 1941, Standard Steel Spring became the parent firm among similar firms. Standard received and cut the plates, another firm machined them, Standard got the plates back, assembled them, stenciled them, and shipped them off to the tank assembly plants.[55] This was an inefficient method of producing armor but, since the U. S. knew a long war lay ahead and lots of armor plate would be needed, such cases of inefficiency were tolerated so long as the needed amounts of armor plate were delivered. Problems of efficiency were tackled later.

By going to great lengths to boost tank production, as the case of Standard Steel Spring illustrates, the U. S.

was able, with remarkable ease, to outproduce the German tank industry, tied as it was to the short-war idea which, until 1942, called for low production. Table 6 below illustrates just how easily the U. S. outproduced Germany even after 1941 when the Germans made major efforts to increase tank production. When total German panzer production, including that of assault guns (as can be seen in the Appendix), is compared with U. S. tank production, the figures for the two countries are closer but the U. S. was still clearly in the lead with 88,410 armored fighting

Table 6. Total German and American tank production.

Date	German	American
1940	1,459	331
1941	3,256	4,052
1942	4,098	24,997
1943	6,083	29,497
1944	8,466	17,565
1945	988 (1st quarter only)	11,986
Total:	24,360	88,410

Source: Thomson and Mayo. Procurement and Supply, p. 263.

vehicles produced to Germany's 46,752 tanks and assault guns produced.

PART II

TANKS PRODUCED DURING WORLD WAR II

The war years saw a flurry of activity in Germany and the U. S. in the field of tank development and production. In both countries some of the highest quality tanks used in the war were produced only after each country had been fighting for some time. In Germany, the Panther, Tiger I, and Tiger II were manufactured; in America the Grant and Sherman.

GERMAN TANKS PRODUCED

Prior to the campaign in Russia in 1941, German armored equipment had shown itself capable of handling the armor possessed by any of its other opponents. The entire situation changed when Germany invaded Russia. The German tanks were completely outclassed by the T-34, lacking as they did sufficient armor, maneuverability, or firepower to stop the Russian tank. Even the best of the German tanks, the Mark IV, lacked a powerful enough gun to stop the T-34. Also, the T-34 could travel over muddy ground on its wide tracks, while the Mark IV became immobile in the same terrain.[56]

From 1941 on, the German development and production of tanks (and other vehicles as well) was largely geared to the demands of the eastern front. Tanks had to be given better maneuverability, larger guns, and more armor to function successfully on that front. Also, more tanks had to be manufactured to cope with the masses of tanks employed by

the Soviets. Consequently, when German and American development and production of tanks is compared this is one factor that must be taken into consideration.

In each case regarding the German tanks that will be discussed it should be noted that neither development nor production facilities had been planned for these tanks. Due to the short-war theory, it was not felt that either tanks of this sort or the facilities to produce them would be needed. Their rushed development, plus the slower rate of production than might have been possible with more far-sighted planning, stems from the failure of the German Army to prepare for a long war where massive production of medium and heavy tanks would be necessary.

The Army Ordnance Office and firms asked to submit designs for a new medium tank made up the planning commission for the Panther tank. The development process that followed the initial meetings in late 1941 was a difficult one due to a number of reasons that did not hamper Americans in their efforts to develop new tanks. A major factor was the interference of Adolf Hitler. Albert Speer, Hitler's Minister of Armaments and War Production, justifiably criticized Hitler for interfering with the Panther's design when he said: "Since the Tiger had been originally designed to weigh fifty tons but as a result of Hitler's demands had gone up to seventy-five tons, we decided to develop a new thirty ton tank whose very name, Panther, was to signify greater agility. Though light in weight, its motor was to

be the same as the Tiger's, which meant it could develop superior speed. But in the course of a year Hitler once again insisted on clapping so much armor on it, as well as larger guns, that it ultimately reached forty-eight tons, the original weight of the Tiger.[57]

The Germans were so desperate to find a solution to the T-34 that they made a cardinal mistake that the Americans never made. In order to get the Panther into production as quickly as possible, designs of the Panther were accepted in March, 1942, and, without bothering to test the prototypes, an unusual procedure for the German tank industry, production began in November of that year.[58] Because no tests were conducted on the prototypes it was only after production started that the results of Hitler's orders manifested themselves. One problem was that the increased weight added to the Panther caused excessive gear and shaft wear as well as extra strain on the suspension system. Another was that the powerful engine in the tank strained the transmission system. Others were the presence of a shell trap under the mantlet and lack of a bow machine-gun for self defense. Finally, it was also discovered that, rather than simply burning slowly when hit, the Panther had a dangerous tendency to explode.[59]

Of the original 325 Panthers recovered from battle in the early months of production, all had to be sent back to M. A. N. at Augsberf for rebuilding and repairs. As a result, changes were made in the original Model D Panther that led

to the Model A which alleviated many of the problems that had plagued the development of the tank.

The difficult development of the Panther tank is in sharp contrast to that of the Sherman which used well-known and previously tested equipment and whose development was carefully tested before production began. Even so, once the Panther's teething problems were overcome the Germans had in their possession a tank superior in almost every way to the Sherman due to its heavier armor and more powerful 75mm gun.

Even though the Panther may have been qualitatively superior to the Sherman, it was inferior in terms of numbers that were manufactured. Desperate to build up the size of its badly depleted tank force, the German Army decided that no less than 250 Panthers would have to be produced per month from the very start. A revision of the program in September, 1942, upped that figure to 600 units per month, a goal the German Army wanted to maintain through the spring of 1944. Even the first production goal was impossible to meet. The short-war idea did not provide for such a massive production program, and facilities for production could not be built overnight. In fact, the high point in production of the Panther, 400 units in one month, did not come until the middle of 1944.[60]

By 1943 high tank losses and a lack of facilities to manufacture more tanks had caused German tank strength to grow so weak that the Adolf Hitler Panzer Program was

inaugurated on January 22 when the Fuhrer order increased tank production "even if by these measures other important branches of the armament industry are adversely affected for a time."[61] The goal of the program, 1,200 units per month, was not reached until the end of 1944, partly because lack of adequate production facilities had prevented an increase in Panther production until mid-1943. Most of the increase in production, as can be seen in the Appendix, took place in factories producing the older Mark IV tank. This vehicle, having been given greater armor and a better gun, was able to keep German tanks on a par with the Allied vehicles until the Panther appeared in greater numbers. Consequently, during 1943, production of the Mark IV tripled as Panther production was getting under way.

When the two best tanks used by Germany and America, the Panther and the Sherman, are compared as to numbers produced the figures are overwhelmingly in favor of the Sherman. Total Panther production through the end of the war did not even meet Sherman production for a six month period. As the Appendix shows, fewer than 6,300 Panthers were produced overall whereas 13,000 to 14,000 Shermans came out of U. S. factories in 1943 (and 1944 figures were as high). Had the Panther used well-tested parts that did not require retesting and redesigning, production of that tank could have been higher. As it was the Panther's development was at least two years behind that of the Sherman due to needed extra testing and designing. Hence

the disparity between production of the two tanks was greater than it might have been had work on the Panther begun earlier.

The history of the development and production of the German Tiger tanks was similar to that of the Panther. Both of these tanks, the sixty-two-ton Tiger I and its heavier offspring, the seventy-five-ton Tiger II, or King Tiger, were designed to carry heavy armor, 88mm guns, and five-man crews. As such their increasingly heavy armor reflected a change in German strategy toward tanks that were defensive in nature.

Development time for the Tiger I was very short, only fifteen months.[62] Like the Panther, the utilization of more armor than was originally planned led to numerous mechanical difficulties which revealed themselves when Hitler ordered the first batch of Tigers into battle on the eastern front before adequate testing of the vehicle was conducted.

Efforts were made to simplify production and reduce the cost of the Tiger I by employing flat plates wherever possible. Both the belly and superstructure involved use of only one plate.[63] The Tiger I, due to its use of heavy armor, was still relatively costly to build, however, and could be manufactured only half as fast as a Panther tank.[64]

Even fewer Tiger I's were produced than the Panther. The first units came out in 1942 and by the time production ended in 1944, as the Appendix shows, only some 1,300 tanks had been built.

Of even less numerical importance to the German Army

was the Tiger II, which resulted from changes in the Tiger I requested by the Army High Command in the autumn of 1942. The German Army wanted to build a tank even more heavily armed and armored than anything in the Soviet arsenal. The Tiger II was designed with well-sloping armor, a good arrangement for the crew, easy accessibility of mechanical parts and excellent optical and gun systems. Unfortunately, the tank was also underpowered and had poor maneuverability and, once in production, showed the same penchant for mechanical breakdowns as the Panther and Tiger I. Many King Tigers, even after rail shipments as close to the front as possible, needed extensive repairs after failing to reach the front on their own power.[65]

The heavy weight of the King Tiger was also a disadvantage, since few bridges could hold its seventy-five-ton weight. To get around this problem, the Germans installed overall sealing and telescopic air intakes to enable the tank to ford rivers up to sixteen feet deep.

Production of the Tiger II began in the spring of 1944 at the Henschel and Son Company at Kassell. Each tank took two weeks to build and one week to test, since the vehicle was just coming into service. The war ended with less than five hundred King Tigers having been manufactured.

AMERICAN TANKS PRODUCED

Any examination of American tank development and production during World War II naturally has to take into

consideration three vehicles which are of primary interest, the M-2, the M-3 Grant and, most importantly, the M-4 Sherman. Light tanks, such as the M-5 Stuart, which was used extensively in the Pacific theater and in Africa but but was not used so extensively in the European theater, will be omitted.

U. S. tank production during World War II differed from German production in two essential respects. First, it was the view of the U. S. Army that large numbers of one standard medium tank was better than large numbers of several types of medium and heavy tanks. Secondly, the American tank program was characterized by an orderly and well-planned development from one tank to another with a minimum of waste and confusion ensuing from our efforts.

The M-2, a nineteen-ton, thirty-mile-per-hour vehicle, was designed in the late 1930's. Armed only with a 37mm gun, it was already obsolete by 1941 due to the use of a 75mm gun on the German Mark IV tank. The M-2 lacked a sufficiently large enough turret ring diameter to hold a 75mm gun; thus the Army had no choice but to cancel the plans for the M-2 and order the development of a tank with a 75mm gun. The most important feature about the M-2 is that it served as the chassis for the M-3 Grant and M-4 Sherman tanks that were to follow. This was fortunate for the U. S. because the M-2 was founded on basic components that emphasized simplicity and had been proved reliable in the 1930's.

As an interim design until the Sherman became available, U. S. industry hastily developed the M-3 Grant. Design of this vehicle was started in September, 1940, and was completed in May, 1941.[66] The end product was a four-man, thirty-two-ton vehicle armed with 75mm and 37mm guns and employing a maximum of two inches of armor.[67] The Grant lacked a turret that could hold a 75mm gun. Instead, the gun was placed in the right side of the tank chassis in a similar fashion to German assault guns. A very high silhouette resulted from the decision to place the 37mm gun in a turret. Another mistake in construction of the Grant occurred when the Army decided that the tank hull could be riveted instead of welded. American experts at first rejected as German propaganda that rivets would fly about in a tank like bullets if the tank was struck by an antitank shell.[68] British battle experience proved the German claims to be accurate and the Grant was the last U. S. tank to have a riveted hull.

Experience with the Grant soon showed that the Army needed, and industry would have to develop, a better tank gun and shell than those used on the Grant. In Africa, the lack of an explosive filler in shells used by the Grant, combined with a low shell velocity, left much to be desired. Tests showed that the 75mm shell used by the Grant could penetrate only 3.5 inches of armor at 1,000 yards compared to 4.5 to 5.9 inches of armor at the same distance for the 75mm gun used by the Germans, thus proving

that the Americans had not gained superiority in this vital area.[69] In fact, American tank crews often noted that their shells simply bounced off the hull of the German Mark III tanks at 1,100 yards and that it took successive hits to loosen the plates and make them fall off.[70] Lack of adequate firepower did not plague only the Grant for, as we shall see, the Sherman suffered from the same problem.

Replacing the Grant was the Sherman, easily the most important American tank developed and manufactured during World War II. Close cooperation with British tank designers was an invaluable asset in the creation of the Sherman. The British had had prior knowledge of the type of tank needed in the deserts of North Africa to combat German vehicles, and systematic exchange of information between Americans and the British began as early as March, 1941.[71] In September, 1941, a mission headed by General Wesson, U. S. Chief of Ordnance, went to London to confer with the British War Office and Ministry of Supply on design and production problems. The British advised the Americans to build heavier tanks than the Grant were using. They also suggested the use of wider tracks for better maneuverability and a bigger gun.[72] These and other ideas were eventually incorporated into the design of the Sherman.

Even though the Sherman was a development of the Grant chassis, industrial planners still had to draw up between four and five thousand drawings for the tank's 31,150 parts, a job that took between 65,000 and 75,000 design man-hours.[73]

The Sherman's designers, like those of the Grant, found that their job in creating the Sherman was complicated by the requirement that the tank weigh less than forty tons. The reasons behind this Army request were numerous. First, both American and European flatcars could not handle heavier weights than forty tons. Further reinforcing the need for a weight limitation was the inability of either port facilities or bridges in Europe to handle heavier weights.[74]

One of the lesser problems faced by the Sherman's designers was the choice of what engine to use. In all there were four available: the Ford V-8, the Chrysler Multibank, the GM diesel, and the Continental 9-cylinder.[75] All of these engines had already been in production and were known to be mechanically reliable. Another advantage ensuing from adoption of well-tested engines was the fact that the machinery for their production was already available; thus tank production was not slowed up due to a lack of engines.

Aside from the mechanical reliability and a 33.5-ton weight, the Sherman did not show remarkably fine qualities. The 50mm of armor on the hull front was inadequate to stand up to the German tank guns, especially the famous 88mm gun.

The Sherman, like the Grant, also lacked adequate firepower. The American Army had developed the doctrine that tanks like the Sherman would be needed mostly for attacking targets only after a breach had been made in the

enemy line, and that tank versus tank battles on a large scale would be unlikely. Consequently, the Army did not initially request a tank gun powerful enough to be an effective antitank weapon. Efforts by the Army and industrial firms to correct the faults of the Sherman centered primarily around plans to give the tank a bigger gun. Simultaneously, plans were started on the T-20, a heavier tank designed to succeed the Sherman. This tank entered the scene at the very end of the war as the M-26 Pershing. Plans originally called for installation of a 90mm gun on the Sherman. Unlike the Germans, however, American tank designers apparently were not used to designing a tank so as to make major modifications on it later. Such was the case with the Sherman. The committee in charge of the project finally agreed upon the addition of a long-barreled 76mm gun which would give the Allies parity with the firepower of the Panther tank. The bigger gun was placed on the Sherman just prior to the D-Day invasion when better firepower of U. S. tanks was deemed to be of critical importance in helping insure the success of the invasion.

One other experiment conducted to improve the Sherman's firepower centered on an effort to design a stabilized power-control system that would fit the Sherman's gun system. The controls were supposed to enable the tank to fire accurately while on the move, thus enhancing the ability of the Sherman to hit targets while moving through gaps in the enemy line, the role for which the Sherman was

built.[76] The project was a failure.

One other problem with the Sherman stemmed from the initial design and was never solved. Like the Grant, the Sherman was given a high silhouette which made it an easier target to hit in open country. Only in a few areas where high shrubbery or some other obstacle served to hide the tank, such as the bocage country of Normandy, did this design fault lessen in importance.

Perhaps the most phenomenal aspect regarding the history of the Sherman tank was the fantastic numbers in which the tank was produced. The Sherman appeared as a prototype in September, 1941, and mass production began in July, 1942.[77] In the following five months no less than 14,000 Shermans were produced.[78] In 1943, production fell somewhat, not because of industrial difficulties, but because deliveries of Shermans exceeded the need for them. Production in 1943 was still high enough that American deliveries of Shermans surpassed total British tank production, thus enabling the British to adopt the Sherman as their own standard tank.[79] In 1944, 13,000 more Shermans were manufactured as overall U. S. tank production fell (see Table 6) from over 29,000 to over 17,000 tanks. This drop came despite the fact that American military power was not used to its greatest extent until after June, 1944. By then, however, enough Shermans had been built and a further increase in the stockpile of the vehicle was not necessary. In 1945, when the need for Shermans declined,

production dropped even further to only 6,793 vehicles.[80]

In all, so far as the Sherman tank was concerned, eleven firms were involved in the manufacture of this vehicle. Out of the grand total of 88,410 tanks of all types produced by the U. S. those firms manufactured 49,234 Shermans, clearly making it America's standard tank of World War II.[81]

The Sherman epitomized the philosophy the U. S. Army developed with regard to tanks. Military leaders in the U. S. demanded a standard medium tank that was mechanically reliable, fast, maneuverable, and had a reasonable amount of armor and firepower. Above all, they wanted to have the tank available in massive numbers so as to be able to overwhelm the qualitatively superior German tanks with sheer numbers when all else failed. The Sherman provided all of these things.

The numbers of Shermans produced also epitomized the type of view Americans had as to what type of war they would have to fight. Mass production of tremendous numbers of tanks which would enable the U. S. to fight a long hard war was the view U. S. leaders had in mind when Sherman production began.

It can be argued that one big disadvantage of the phenomenally high output of Sherman tanks was felt. Because so many Shermans were being built, the Army saw no need to produce, on an urgent basis, any other tank capable of handling the heavy German tanks. Plans for the heavier T-20 tank, for example, were dropped in early 1943. It

was only when it was realized that a heavier tank than the Sherman was needed that the T-20 plans came off the shelf in late 1943. The M-26 Pershing which resulted from these plans came too late in the war to play a significant role.

ADVERSE ASPECTS OF TANK PRODUCTION

The six tanks just discussed had a major impact on the war effort of both Germany and America. Yet, one should also note that it was only natural that by consuming needed resources and manpower, tank production was bound to have harmful effects on the war economies of both countries.

Germany was definitely harmed with respect to the adverse aspects of tank production. The Nazis were operating on leaner resources than the U. S. and increased tank production was bound to hurt war production in some other field. The harmful aspects of tank production were noticeable even when Germany operated on the blitzkrieg economy from 1939 to 1942. In order to keep production of civilian goods at a high level, production of arms in one area had to be cut to enable a buildup elsewhere so the needs for any individual campaign could be met. After the fall of France, for example, tank production increases had to be made up for by cuts in munitions production.[82]

With the introduction of full mobilization after 1942 tank production still cut into other arms programs. Albert Speer notes that one time in 1943 Hitler gave both the tank and submarine programs the highest priority in goals for production with the result that the two competed for

resources.[83]

In the U. S. fewer problems were encountered, since we had greater resources to work with. Engines did prove to be one of the bigger bottlenecks early in the war. Production of engines for tanks meant shortages in other branches of the services. This remained a problem as late as 1943. Another problem early in the war was the shortage of machine tools. Many were needed for tank production and were not available for other armament projects. This problem had existed as early as the first half of 1941 when even tank production was slowed due to the shortages of machine tools.[84] Fortunately, by the mid-war years, most areas of competition between tank production and other arms production were cleared up.

EFFECTS OF BOMBING ON GERMAN TANK PRODUCTION

One final factor of importance regarding German and American tank production during World War II was the effect of bombing. While not a problem affecting American tank production, bombing contributed to the disparity between total German and American production.

Bombing of German tank firms did not begin until 1943 and did not reach a peak until the latter part of 1944 and early 1945. When bombing did begin, American airmen found that the German tank industry as a whole was not concentrated in one area and was harder to destroy because of this factor. Only component plants, such as those at Hanover producing treads, those in the Rhur producing turrets and

guns, plants at Friedrichschafen producing engines and gears, and the ball bearing firm at Schweinfurt were concentrated to any appreciable extent. Destruction of any of these firms could have had major repercussions, but the most outstanding feature of the Allied bombing campaign against the various component plants was the failure to do any real damage to these firms. For example, when the ball bearing firm at Schweinfurt was bombed in October, 1943, the destruction of plant equipment was heavy. Tank production did not decrease, though, because heavy Allied losses in aircraft during the raid persuaded them to refrain from any further attacks for four months. In the interval, dispersal of the industry took place and Swedish imports of ball bearings and substitution of other items for ball bearings made up for any losses.[85] Possession of a year's supply of ball bearings was also of major assistance to maintaining industrial production.

Due to the failure of the Allies to bomb the tank factories early in the war the Germans were given the opportunity to expand their labor force, quantity of machinery, and, consequently, production of tanks in the mid-war period. The time to have bombed the industry was before, not after, the expansion began.

Allied airmen, nonetheless, can claim with some justification success in cutting German tank production in the latter part of the war. This success was based not on direct bombing of tank factories but mostly on indirect

effects of bombings of the cities in which the tank factories were located. A major effect of this type of bombing was the destruction of rail lines upon which spare parts and components were delivered to assembly factories, some of which were attempting to expand their production. Another indirect factor was due to the need of workers in tank plants to spend extra time in going to and from the plant and home amid bombed-out cities or the need for workers to be elsewhere in the city to assist in clearing away rubble. It is estimated that these indirect effects caused the loss of one-fourth of the total tank production possible in Germany in 1944.[86]

The results of direct damage to tank factories as a product of Allied bombing were disappointing. Only one German tank firm, Henschel, was bombed directly hard enough and often enough so that substantial losses in production resulted. Those losses, as can be seen in Table 7 below, accounted for an overall cut of 77% of planned tank production in the latter part of 1944 and early 1945. Even in this case, however it should be noted that the general disintegration of the German economy at that time was also a factor to be considered as contributing to the losses incurred.

Another disappointment to the Allied airmen was the discovery that bombing did not kill many workers in tank factories. In five of eleven plants hit, these being bombed the hardest, only 1%, some 464 of 45,332 workers, were killed by air attacks.[87] Losses in production as a result

of workers having been killed in air raids were therefore negligible. Even if large losses of life had resulted from the raids, it is likely that the resulting effects on production of tanks would still have been minimal, inasmuch as a sufficient supply of prisoners of war were on hand to make up for any shortages of labor.

Table 7. Losses in production of Tiger II tanks at Henschel.

	Planned Production	Actual Production	Loss
1944			
Sept.	120	60	60
Oct.	120	26	94
Nov.	140	22	118
Dec.	140	26	114
1945			
Jan.	140	40	100
Feb.	140	42	98
March	140	18	122
	940	234	706

Source: The United States Strategic Bombing Survey Reports: European War; Henschel and Sohn-Kassel, Germany. (Washington, D. C., 1945), p. 16.

Overall, the conclusions of the U. S. Strategic Bombing Survey team which examined the German tank factories after the war is one of the most authoritative sources on the subject of U. S. bombing of the German tank plants. In their own estimation, losses in production of German tanks due to bombing ". . .were due as much to indirect causes as to the bombing of tank plants. This raises the question

of whether tank plants were so immune to bombing that they did not warrant the expenditure of the necessary weight of attacks that would have been necessary to knock out the industry."[87]

CONCLUSION

If one looks at German and American tank development and production during World War II, the influence of the short-war versus the long-war ideas within Germany and the U. S., respectively, can be readily seen. The harmful effect of the short-war idea on the German tank program was tremendous. Industrial potential was not used until too late, badly needed medium and heavy tanks were rushed into production full of mechanical problems, and overall planning and production became confused and hindered when the switch was made from partial to full mobilization during 1942. All of these problems were avoided by the U. S. which knew a long war was at hand.

Sheer numbers play an important part in the comparison of German and American tank production. The discrepancy between 88,410 American and 22,360 German tanks produced during the war gives a good indication as to which side had the edge in economic resources, manpower, and industrial strength.

A final comparison to note is that the U. S. Army believed that what it needed most was one reliable medium tank that would serve in an all-around capacity, whereas

the Germans wanted a number of tanks that were more specialized in nature. U. S. production was made easier by the decision to produce only one standard tank. German production, already confused enough by the abandonment of the short-war theory and the rushed production of several new tanks, not to mention continued production of older vehicles, became even more confused. Production priorities were clear in the U. S., unclear in Germany.

When taken together, the above factors show that American tank development and production during World War II was superior in almost every way to that of Nazi Germany.

APPENDIX

GERMAN PANZER PRODUCTION 1940-1945

German Panzer Production 1940-1945

Model	1940	1941	1942	1943	1944	1945 Jan	Feb	March
Mark I & II	9	233	306	77	7			
Mark III	895	1,845	2,555	349				
Mark IV	280	480	964	3,073	3,371	175	168	74
Tank Destroyer IV					1,764	235	169	54
Assault Gun III/ IV	184	550	828	3,319	5,884	508	231	322
Panther				1,850	3,964	232	135	102
Jagd-Panther					215	72	42	52
Tiger I			78	647	623			
Tiger II					377	40	42	30
Jagd-Tiger				2	51	10	13	3
Self-Propelled Guns			1,248	2,557	1,248	60	22	5
Jagd-38					1,598	434	401	301
38(t)	275	698	195	87	124			
Total	1,643	3,806	6,147	11,961	19,226	1,776	1,223	943

Source: The United States Strategic Bombing Survey Reports: European War; Tank Industry Report. (London, 1945), "Exhibit A". (Report of the Strategic Bombing Survey Team.)

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A COMPARISON OF GERMAN AND AMERICAN TANK DEVELOPMENT AND PRODUCTION DURING WORLD WAR II

by

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A comparison of German and American tank development and production during World War II must include a number of factors. Among these are the basic doctrine of each nation as to what types of tanks they wanted, the productive capacity of each nation and, what factors, if any, adversely affected each nation's tank production plans.

In each of the above cases the German and American tank programs were different. German military thinkers during the 1920's and 1930's had come to the conclusion that for Germany to win any future war they would have to fight that war in such a manner as to defeat their enemies quickly. This way the attrition of manpower and resources that characterized World War I could be avoided. Led by men such as Heinz Guderian, German military men in the 1930's came to view the use of tank divisions as the best means to achieve the quick victory they desired. Because of this short war idea, German leaders did not feel that full mobilization of the nation's resources would be necessary should war come again.

Due to the acceptance of the short war doctrine, Germany had relatively little tank production capacity at the start of World War II and only gradually expanded production during the first half of the war. Then, following the crisis on the eastern front late in 1941, they embarked on a crash program which greatly increased production but still failed to come near American capabilities in this field. Conversion to total mobilization in 1942 came too late to

enable Germany to win the war.

The American experience contrasted sharply with that of Germany. America had a tremendous capacity to produce tanks and, because we believed that a long, hard war faced us, we used that capacity to the fullest extent immediately following our entry into the war.

The tank production experiences of Germany and the U. S. also contrasted in other ways. Compounding Germany's troubles was the decision to produce a number of different types of tanks. This caused confusion within the tank industry and supply and spare parts problems. Other notable difficulties included bombing, interference from Hitler on tank designs, competing prototypes for a number of new tank projects and the failure to remove all of the mechanical problems from the new tanks, the Panther, Tiger I, and Tiger II, prior to their use in battle. The U. S., which did not need to worry about bombing, solved its production problems by concentrating on the manufacturing of one basic tank, the Sherman, a vehicle built with mechanical parts of proven reliability.

All in all, considering the above factors, it can be said that the German tank development and production effort during World War II was inferior to that of the Americans.