THE UNITED STATES

STRATEGIC BOMBING SURVEY

THE JAPANESE AIRCRAFT INDUSTRY

AIRCRAFT DIVISION

May 1947

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This report was written primarily for the use of the United States Strategic Bombing Survey in the preparation of further reports of a more comprehensive nature. Any conclusions or opinions expressed in this report must be considered as limited to the specific material covered and as subject to further interpretation in the light of further studies conducted by the Survey.

FOREWORD

The United States Strategic Bombing Survey was established by the Secretary of War on 3 November 1944, pursuant to a directive from the late President Roosevelt. Its mission was to conduct an impartial and expert study of the effects of our aerial attack on Germany, to be used in connection with air attacks on Japan and to establish a basis for evaluating the importance and potentialities of air power as an instrument of military strategy for planning the future development of the United States armed forces and for determining future economic policies with respect to the national defense. A summary report and some 200 supporting reports containing the findings of the Survey in Germany have been published.

On 15 August 1945, President Truman requested that the Survey conduct a similar study of the effects of all types of air attack in the war against Japan, submitting reports in duplicate to the Secretary of War and to the Secretary of the Navy. The officers of the Survey during its Japanese phase were:

Franklin D'Olier, *Chairman.*
Paul H. Nitze, Henry C. Alexander, *Vice-Chairmen.*
Harry L. Bowman,
J. Kenneth Galbraith,
Rensis Likert,
Frank A. McNamee, Jr.,
Fred Searls, Jr.,
Monroe E. Spaght,
Dr. Lewis R. Thompson,
Theodore P. Wright, *Directors.*
Walter Wilds, *Secretary.*

The Survey's complement provided for 300 civilians, 350 officers, and 500 enlisted men. The military segment of the organization was drawn from the Army to the extent of 60 percent, and from the Navy to the extent of 40 percent. Both the Army and the Navy gave the Survey all possible assistance in furnishing men, supplies, transport, and information. The Survey operated from headquarters established in Tokyo early in September 1945, with subheadquarters in Nagoya, Osaka, Hiroshima, and Nagasaki, and with mobile teams operating in other parts of Japan, the islands of the Pacific, and the Asiatic mainland.

It was possible to reconstruct much of wartime Japanese military planning and execution, engagement by engagement, and campaign by campaign, and to secure reasonably accurate statistics on Japan's economy and war-production, plant by plant, and industry by industry. In addition, studies were conducted on Japan's over-all strategic plans and the background of her entry into the war, the internal discussions and negotiations leading to her acceptance of unconditional surrender, the course of health and morale among the civilian population, the effectiveness of the Japanese civilian defense organization, and the effects of the atomic bombs. Separate reports will be issued covering each phase of the study.

The Survey interrogated more than 700 Japanese military, government, and industrial officials. It also recovered and translated many documents which not only have been useful to the Survey, but also will furnish data valuable for other studies. Arrangements have been made to turn over the Survey's files to the Central Intelligence Group, through which they will be available for further examination and distribution.

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Part I

SUMMARY

There is little need to establish here the importance of Japan's aircraft industry to her war effort. Both in day-to-day tactical applications and in plans for a final all-out "Kamikaze" defense of the homeland, the high command counted heavily on the air force of the Army and Navy. Obviously, it was of vital importance to them to keep new aircraft flowing from factories to operational units and to our interest to disrupt that flow. It was not chance, therefore, that earmarked Japan's aircraft industry as the number one target for our bombers.

It is now apparent that the Jap fell far short of his own expectations for aircraft and engine production even before the weight of out bombardment fell on the home islands. By the time we came within striking range, internal economic conditions were deteriorating rapidly. Essential supplies were dwindling, skilled manpower was short and morale was declining. How soon the tide might have turned had we not bombed the aircraft plants directly is, of course, a matter for conjecture. When we struck, the industry was already decidedly sick. Our attacks not only made certain that any recovery would be completely impossible, but also forced production of aircraft engines, propellers and finished combat aircraft well below what would otherwise have been obtained.

The prewar history of the Japanese aircraft industry is not impressive. In the years since 1918 an industry of sorts had been built up mainly around designs obtained under license from German, British and United States manufacturers. A scattering of small shops provided a miscellany of military and commercial types during the 1920's and formed the nucleus of the prewar expansion. A few big names (Mitsubishi, Nakajima, Kawasaki) thread back through the whole pattern. A number of smaller fry were brought into the industry during the course of the war.

Slowly and irregularly Japanese aircraft production rose from a modest 445 planes in 1930 to 1,181 in 1936. During the next 5 years, a period of fighting in China and of preparation for Greater East-Asia co-prosperity, there was a rapid rise in aircraft deliveries. In 1941, 5,088 planes (more than four times the 1936 output) were made available to the military forces. But the real expansion, the "all-out" national effort, came during the war years, 1942 to 1944. Nearly six times as many airplanes rolled off the lines in 1944 as in 1941. The effort was even greater than the figures indicate, because the aircraft increased in weight and improved in performance, and because the ratio of combat types to trainers and transports went up. Of the 28,180 produced in the peak year, 1944, three-fourths were combat types.

Measured against the volume of aircraft production in the United States for the same years the Japanese totals are not great, but taking into account the relative resources of the two countries in materials, manpower and technological development, the effort was creditable. Table I–I shows the total output for aircraft, engines and propellers in the war years. For comparative purposes, the total aircraft production figures for the United States and for Germany have been set up in Table I–II.

TABLE I–I.—*Japanese aircraft, engine and propeller production by years 1941–45*

	1941	1942	1943	1944	1945 [1]	Total
Combat type aircraft	3,180	6,335	13,406	21,058	8,263	52,242
Trainer aircraft	1,489	2,171	2,871	6,147	2,523	15,201
All other aircraft	419	355	416	975	280	2,445
Total aircraft	5,088	8,861	16,693	28,180	11,066	69,888
Engines	12,151	16,989	28,541	46,526	12,360	116,577
Propellers	12,621	22,362	31,703	54,452	19,922	141,060

[1] Seven and one-half months.

TABLE I–II.—*Comparative production United States, Germany, Japan, total aircraft* *

	1941	1942	1943	1944	Total, 4 years
Japan	5,088	8,861	16,693	28,180	58,822
Germany	11,766	15,556	25,527	39,807	92,656
United States	19,433	49,445	92,196	100,752	261,826

*All figures include gliders.

During the course of the war a considerable variety of types, models and variations on models

appeared. No less than 90 basic types (53 Navy and 37 Army) and 164 variations on basic types (112 Navy and 52 Army) were carried on our identification lists. Not all were in production at any one time. Such diversification may have seemed necessary to the tacticians, but it did not make procurement any easier.

During the course of the war, emphasis shifted from bombers to fighters as operations became more and more of a defensive character. The same trend was observed in Germany during the latter phases of the European war. There, however, it was of greater significance because the change-over to single engine fighters tended to reduce the load on industry in terms of airframe weight. In Japan, the increasing emphasis on fighter aircraft production did not ease the manufacturers' problem since the fighters had increased in airframe weight and engine horsepower and since many of the bomber types discontinued were of the single engine variety.

Four companies (Nakajima, Mitsubishi, Kawasaki, and Tachikawa) turned out more than two-thirds of all aircraft built between 1941 and 1945, and three companies (Nakajima, Mitsubishi, and Kawasaki) produced three-fourths of all combat types for the same period.

Prior to dispersal, the Japanese aircraft industry was concentrated in and around the principal cities of Tokyo, Nagoya, and Osaka. The bulk of the engine assembly operations were carried out in the Nakajima Musashi plant near Tokyo and in the Mitsubishi engine plants in Nagoya. These large plants, with a relatively few other engine plants and four propeller plants, comprised the most highly concentrated and vulnerable target systems within the aircraft industry. The primary responsibility for destroying and disrupting the aircraft industry was assigned to and carried out by the Twentieth Air Force, which flew 86 percent of the sorties and delivered 98 percent of the bomb tonnage to these targets. Carrier-based planes assisted in several instances, flying 14 percent of the sorties and delivering two percent of the bomb tonnage. In general the planned attacks were distributed reasonably well and in accordance with the relative importance of the targets.

From the standpoint of physical damage, our attacks were extremely effective. The degree of destruction of physical plants was high. Individual plant reports of the Aircraft Division contain ample photographic evidence on that score. With few exceptions the plants hit were made useless for continued production. Some departments escaped direct hits or fire damage and certain well protected heavy equipment (hydraulic presses, heat-treating furnaces and forging hammers) was kept in operation by prodigious effort. Operations, however, were generally disrupted and scattered and operating efficiency knocked down well below the average level.

By late spring of 1945, some of our attacks fell on practically empty plants. The tools and personnel they had originally housed had "taken to the hills." Following the initial strikes by B–29s in November and December 1944, a panic dispersal of the industry took place. Tools, men and materials were scattered far and wide. By the time of the surrender there was scarcely a village or town of any size that did not house some sort of aircraft manufacturing activity such as dispersed plants, subcontractors and supplies of parts and materials. Many such shops and subfactories were housed in schools, textile mills, warehouses, and even shrines. They suffered severely from our area raids. Early in 1945 a large number were being moved underground.

Dispersal was planned early in 1944 but the constant pressure for production caused the government to withhold permission to disperse to semiunderground and underground plants until production could be maintained or expanded in the process. Although many companies had anticipated a government order to disperse and had actually started to dismantle their plants in the late fall, it was not until February 1945 that an act, "the Urgent Dispersal of Plants Act," making such action mandatory, was passed. This ordered the general underground, semiunderground and surface dispersal of industry, with aircraft having first priority in construction, transportation, building material and finance. It was April or May, however, before the movement became general, and by then it had become too late.

The precipitous terrain of Japan is well suited for underground plants. New tunnels were dug in hills of sedimentary and volcanic rock which were comparatively easy to excavate, and which required little or no shoring for overhead support. Abandoned mines, stone quarries, railroad and streetcar tunnels, railroad viaducts and department store basements also were used.

Six months of prodigious effort brought some 100

underground aircraft plants to various stages of completion. The 100 plants had a total planned area of 12,540,000 square feet, of which approximately 7,230,000 square feet had been excavated. For underground aircraft plants alone, some 7.5 million man-days were expended in excavations between March and August 1945. Koreans and Chinese POW's made up a large part of the labor force. By the summer of 1945, it was estimated that 35,000–40,000 workmen were employed underground, that 11,000 machine tools were in place, and that 32 plants were in some degree of operation. Most of the machines, however, were only in the process of alignment and testing and not yet ready for use.

Despite the haphazard planning, shortages, and other difficulties encountered, the Japanese had achieved between 50 and 60 percent accomplishment of the underground program. Most aircraft men interviewed felt that the total plan would have been in operation by December 1945. Events proved them to be over-optimistic, but each succeeding month after August 1945 would have brought increasing gains in output. As it was, however, actual production amounted to very little. Not more than 30 engines, 10 aircraft and a few thousand parts were produced.

During the dismantling of plants and the moving and reestablishment of production lines, the loss in production was greater than that due to direct air attacks. Fear of air attacks drove many plants to scatter and store their tools and supplies until adequate dispersal sites were built.

It is believed that the difficulties encountered by the aircraft industry (engines and airframes) would have increased rather than diminished during the first half of 1945. The increasing scarcity of critical raw materials would have caused the output of engines to decline to approximately 3,000 by July 1945 and perhaps level off at this figure. For the same reason the output of airframes would probably have declined to approximately 1,750 by July before leveling off. These estimates assume that no dispersal would have been undertaken, or air attacks made. Under air attack and dispersion, however, aircraft engine production fell to 1,257 by July 1945 and aircraft production decreased to 1,131.

The estimated loss in the production of engines from December 1944 to July 1945 due to direct and indirect effects of air attacks amounted to 11,000 engines, or 43 percent of the number which might have been produced if dispersal and direct attacks had not taken place. The loss in airframe output is estimated at 2,800 planes or 18 percent of the number which might have been produced during that 7-month period (table I–III.).

TABLE I–III.—*Estimated loss in aircraft and engine production due to direct and indirect (dispersal) effects of air attacks*

	Engine production			Aircraft production		
	Actual	Estimate without attacks or dispersal	Estimated loss	Actual	Estimate without attacks or dispersal	Estimated loss
1944						
October	3,789	3,789	.....	2,371	2,371	.....
November	3,819	3,819	.....	2,220	2,225	.....
December	2,991	3,500	500	2,110	2,150	50
1945						
January	1,987	3,400	1,425	1,836	2,075	250
February	1,695	3,300	1,600	1,391	2,000	600
March	1,787	3,250	1,475	1,713	1,950	225
April	1,734	3,200	1,450	1,567	1,900	350
May	1,677	3,150	1,475	1,592	1,850	250
June	1,669	3,100	1,425	1,340	1,800	450
July	1,257	3,000	1,750	1,131	1,750	625
Total	22,405	33,508	11,100	17,271	20,071	2,800

The relationship between the government and the aircraft industry was never happy. Throughout the war aircraft manufacturers enjoyed top priority ratings for the allocation of materials, machine tools, and labor. Their requirements were covered as far as conditions in the national economy would permit. They were handicapped, however, by the completely uncoordinated demands of the Army and the Navy. Frequently, inter-service competition attained comic opera levels. In some respects Army and Navy procurement agencies carried on a continuous civil war which made the manufacturers' position difficult, and which undoubtedly cost the empire many aircraft. The transfer of control to the Air Ordnance Bureau of the Munitions Ministry in November 1943, was designed to eliminate such troubles, but its efforts were only partly successful. The military forces never fully relinquished their notions of autonomy, and their representatives acted accordingly up to the end.

The aircraft industry received relatively little direct financial aid from the government during the course of the war. In most cases, funds required for initial plant expansion came in the form of loans negotiated by the manufacturers

with certain designated banks. The government, in turn, guaranteed the bank loans.

For assistance other than financial, the Japanese aircraft industry owed more to the United States than it did to its own government. It is sad, but true, that United States fighter and bomber pilots fought against aircraft whose origins could be traced back to United States drafting boards. Many Jap engines and propellers came from American designs which had been sold under license in prewar years. Many top Jap aeronautical engineers could claim degrees from Massachusetts Institute of Technology, Stanford, and California Tech. Their best production men had served apprenticeships with Curtis, Douglas, Boeing, or Lockheed. Here and there, war-time German influence was evident, especially in the jet- and rocket-powered types that never became operational, but it can be fairly stated that the Jap fought the war with aircraft on which the strongest influences in design were American.

In manufacturing efficiency, however, the Jap fell far below standards set by United States and German manufacturers. During the war the United States Aircraft Resources Control Office developed a formula which yielded comparative efficiency indices from which the relative performance of our manufacturers could be gaged. These indices took into account all the known variables and resulted in a figure of pounds of airframe produced per employee working day. Table I–IV gives the comparative score for the dates indicated.

TABLE I–IV.—*Manufacturing efficiency indices*

	United States	German	Percent to United States	Japanese	Percent to United States
July					
1941	1.42	1.15	81.0	0.63	44.4
1942	1.88	1.30	69.1	.63	33.5
1943	1.88	1.50	79.8	.71	37.8
1944	2.76	1.25	45.3	.71	25.7
1945	2.36			.42	17.8

The Japs thus made a miserable showing. They averaged about one-third the efficiency of United States manufacturers. One answer is to be found in the low grade labor on which all Japanese industry was based. For certain of the heavy industries this factor was not particularly important, but when it came to building up the highly specialized labor force required for the manufacture of aircraft, the necessary skills were not available, and not enough people could be trained in time. When drafts for the Army and the Navy threatened a man-power shortage, large numbers of women, high school children, and soldiers were put to work on aircraft, and productive efficiency and quality suffered further decline.

The number of people employed in aircraft activities is difficult to determine with accuracy because of the extent to which subcontracting to other industries was used. In February 1944 it was estimated that approximately a million people were employed in aircraft manufacture in one way or another. At peak employment (which occurred in the fall of 1944), the probabilities are that the figure rose to about 1½ million.

The enthusiasm of the aircraft worker for his job appears to have been high up to the summer of 1944. Until then the propagandists had been able to keep the idea of ultimate victory uppermost in the minds of the people. Workers put in an average of 10 hours a day, 28 days a month in the factories, with little complaint. When the fall of Saipan was announced, however, the morale of workers in the aircraft industry slumped. That this carefully guarded "Key to the Empire" had been lost was at once incredible and alarming to the average Japanese. A feeling of "what's the use" began to pervade the aircraft industry. It became increasingly difficult to keep people on the job. As food shortages became acute, workers stayed away from work to forage for supplies. After our air raids began, absenteeism in the aircraft industries rose rapidly. Direct attacks caused workers to scatter into the countryside. As our strikes increased in frequency and severity, the first sound of any "alert" caused complete shutdowns. Attacks on urban areas wrecked many workers' homes, disrupted family life generally and kept people away from their jobs. All such factors combined to cause losses of productive man-hours of from 20 to 35 percent in the aircraft industry by the spring of 1945.

Both quality and quantity of aircraft suffered from shortages that developed in the supply of parts and basic materials. A big push for production, promoted by the Munitions Ministry, that took place in the spring of 1944 cleaned many essential items off the shelves and depleted stock piles of aircraft raw materials. The planning for the replacement of many items proved entirely inadequate.

When asked to explain the reason for this situation, General Endo, Saburo, chief of the Air Ordnance Bureau of the Munitions Ministry said, "Both the Army and the Navy had decisive battles to win. The Navy considered the decisive battle to be coming in June 1944 north of New Guinea; the Army thought their decisive battle would be in August 1944 in the Philippines. Until this was accomplished, dispersion was secondary. The Japanese disregarded all plans for the year and shoved everything towards production. After the peak was achieved (and battles not won), the employees required rest, the machinery was worn out and had to be repaired, parts and supplies were exhausted, and readjustments had to be made. The drop in production was due to these factors, as well as dispersion, earthquake, bombing, and the low morale of the people."

By mid- 1944 the blockade and loss of shipping had created a critical situation. The effect was felt first on aircraft engine production. Shortages of cobalt, nickel, chromium, molybdenum, and tungsten—alloying materials necessary to make the special high strength steels required in modern high performance aircraft engines—posed serious problems for the manufacturers. Attempts to use substitute materials not only slowed down production, but raised the rate of rejections at inspection and increased the number of failures on test stands and in flight. As shown in Figure II–14, engine output reached a peak of 5,000 engines in June 1944, after which it fell off to 3,800 engines in November—when the air attacks began.

By October the supply of engines was scarcely adequate for installations in airframes and spares were disappearing rapidly. Engineless airplanes began to pile up at factories, units in the field went without spares and production lines were slowed down.

By the summer of 1944 stocks of aluminum sheet were dwindling, but inability to produce on the desired scale, because of later dispersion and bombing damage, prevented complete drainage of available stocks. If the planned programs for aircraft had been met, however, all available supplies of aluminum would have been used up long before the end of the war. As it was, the use of secondary metal was increasing rapidly at war's end. Anticipating a progressively deteriorating situation, Japanese engineers were working on all-wood and all-steel designs for production late in 1945 and early 1946.

Altogether, the Japanese aircraft industry was in far worse shape by the fall of 1944 than we realized. It was not generally known that the production peak achieved in the fall of 1944 was gained only at the expense of exhausting stock piles. We did not fully appreciate how far the entire national economy had thus been undermined by blockade and by the demands of a prolonged war against all basic commodities.

The bombing of the aircraft industry was, however, fully justified. If we had not attacked their aircraft plants directly, they might in time have succeeded in halting the downward trend. They might have effected a leveling off of airplane production at some point below that attained in the summer of 1944, but still sufficiently great to constitute a real threat to our military plans. By attacking them heavily as soon as we were in range, we headed off any trend toward recovery and reduced production substantially below what otherwise might have been attained. The initial attacks not only destroyed an appreciable part of their planned productive capacity but, more important, they frightened the Japanese into a hasty and ill-planned dispersal.

Our estimates as to the output of combat aircraft were fair up to the spring of 1944. After that we gave them about 20 percent more credit than they were entitled to, in the light of postwar findings. We gaged quite well the rate of production loss that followed our November and December strikes, but because we knew as little as we did about their dispersal program, we overestimated their ability to recuperate in the spring of 1945 by about 13 percent. All intelligence estimates pointed to a partial recovery and a rise in production during that period. What we did not know was they were so busily engaged in dismantling plants and in moving tools and equipment into caves and tunnels, that loss of production from dispersion and subsequent bombing attacks caused production to continue on a generally downward course to the day of the surrender. We erred in our estimates of Jap aircraft production, but we erred on the safe side. In the situation we faced in the spring of 1945 in the Pacific, it was far better to overshoot than to fall short of our requirements by underestimating enemy strength.

Part II

THE JAPANESE AIRCRAFT INDUSTRY

A. BACKGROUND

Although certain progressive individuals may have been interested in aviation earlier, World War I brought about the real beginning of aircraft manufacturing activity in Japan. The "Big Three" of the aircraft industry were launched in 1917. Mitsubishi and Kawasaki aircraft started as departments of the heavy industries of the same name. Nakajima, independent of direct connection with other industry, was originally financed by the powerful Mitsui family.

The Japanese turned to France for the first aircraft and engine designs to put the three producers in business. Mitsubishi purchased the Nieuport airplane and Hispano-Suiza engine; Nakajima settled on Lorrain designs and Kawasaki bought manufacturing rights to the Salmson airplane and engine.

During the war period (1917–18) the Japanese were content to study French designs and made no actual aviation contribution to the war. The early twenties saw production of the French models in experimental quantities. The Army, whose growing requirements had initially interested the financial barons in aviation, bought all types.

At the end of 1921, 10 engineers, including the chief of the Sopwith Airplane Manufacturing Co. of England, builders of the famous Sopwith fighters, visited Japan by invitation of the Japanese Navy. American experiments with the USS *Langley*, our first carrier, undoubtedly were responsible for the Japanese naval interest. Shortly thereafter Mitsubishi started work on carrier fighter-, torpedo-, and scout-plane models, the beginning of naval aviation in Japan. In 1921 a wind tunnel of the Gottengen type was completed for Mitsubishi at Nagoya.

High points in Nakajima progress during these years were their success in the Tokyo to Osaka air-mail contest in 1919, and their development of a sea-scout plane. Kawasaki was hard at work on Army bombers designed around German BMW engines, built in Japan under license. During these years Japanese technical missions visited France, England, Germany, and America.

Foreign Influence

While waves of Japanese technicians were studying America's factories, America's top engineering schools were training the men who, on their return to Japan, were to design the Zero fighter, Betty bomber, and other planes on which the Japanese bid for Pacific domination was to be based.

By 1930, the Japanese Army and Navy had decided the industry should stand on its own feet, and established a policy of self-sufficiency, whereby only aircraft and engines of Japanese designs would be considered. No more foreign engineers were to be hired. This was intended mainly as a sop to Japanese nationalistic pride, however, and did not prevent their technical missions from continuing to buy the best foreign models as starting points for Japanese designs. In 1935 Nakajima purchased licenses on the early Corsair from Chance Vought Corp., and it acquired designs of the Whirlwind and Cyclone engines from Wright Aeronautical Corp. in 1937. Mitsubishi purchased a French radial engine, which became the basis for their famous Kinsei series and secured plans for a Curtiss fighter in 1937. Sumitomo Metals bought rights on the American Hamilton Standard and German VDM propellers. Kawasaki secured rights on the German Diamler-Benz engine, from which came the only Japanese liquid-cooled engine in the war. Tachikawa Aircraft, a newcomer in the industry, obtained designs of the Lockheed 14. Licenses were also obtained on some of America's best instruments. No important aircraft company in America escaped the attention of these frenzied buyers. Front men on the American sector of these negotiations were Mitsui & Co. and Okura & Co. of New York, expert representatives of Japan's two largest Zaibatsu.

From 1937 onward the Japanese aircraft industry, in general, and Mitsubishi, in particular, was shrouded in purposeful secrecy. At a time when we were granting visas to Japanese technicans, the lid was clamped on tighter and tighter as the Japanese Government moved toward closer control of the aircraft industry. In 1938 a new law required that all aircraft companies capitalized at 3 million yen or more (Mitsubishi-50 million yen) be licensed by the government and controlled as to equipment, techniques, and production plans. The law encouraged and protected such companies

by exempting them from income and business taxes, export duties and, in some cases, by monetary grants. Only licensed companies were permitted to engage in final assembly of aircraft.

Prewar Expansion

This was a period of expansion for the Japanese industry designed to support the China venture. This was the era in which Nakajima began to climb toward a par with Mitsubishi, through construction of the huge Ota airframe assembly plant and the large engine plant at Musashino, near Tokyo. Newspapers were heralding the Mitsubishi Nagoya airframe plant as the second largest in the world. (For a period during the war it was actually holder of first place.) Kawasaki Aircraft was separated from the parent corporation's Kobe facilities and set up in immense modern plants at Akashi and Kagamigahara near Nagoya.

In 1941 the industry was given a last prewar expansion "shot" by the Government. Nakajima doubled itself and Mitsubishi fared equally well.

Lulled into a false sense of security by easy victories, the Japanese industry coasted on a production plateau during the first 2 years of the war. In late 1943 the defeats at Midway and the Solomons awoke the Japanese to some realization of the real requirements for their home defense. In a frenzy they began expanding the aircraft industry by taking over and converting other facilities, chiefly spinning mills. In late 1944 the government ordered the industry to disperse but at the same time ordered production doubled.

Cooperative effort at this stage among the aircraft manufacturers was vital but nothing constructive ever was accomplished. In the summer of 1944, when the production situation became increasingly critical, several of the top industry leaders discussed the formation of an association for the interchange of technical and production information and for the control of allocations of tools and materials, following the precedent established by United States manufacturers, but nothing came of it. People were too busy with their own troubles to worry about competitors' problems. The advantages of mutual interchange of ideas and of joint action for the common good apparently had little appeal to the Japanese mind.

The Army and Navy and the Aircraft Industry

Prior to the war, the relations between government agencies and the aircraft industry were similiar to those in the United States. The services awarded contracts for aircraft in accordance with their particular needs. The responsibility for the procurement of raw materials and labor rested with the contractor.

Until 1941 factories expanded or contracted in accordance with the volume of business on their books. In March of that year, however, the Army and Navy gave several selected companies definite orders to expand. The government did not furnish the capital to cover the expense but did guarantee loans made through industrial banks.

Although the services seldom gave direct financial aid they did, however, offer numerous forms of indirect aid. When a contract was made with the Navy, for example, a 20-percent down payment was made. Forty percent more was paid when the aircraft was completed, and the remaining 40 percent when delivered. The chief of naval air admitted that models that were unsatisfactory were sometimes ordered so that the aircraft manufacturers might benefit by the contract even though the Navy did not and could not use the aircraft.

The Army and Navy owned or controlled a pool of machine tools which were leased or loaned to the different aircraft companies in accordance with their needs. But Army machine tools could not be used for naval production, and vice versa.

The research and development work was carried on by both the Army and Navy in their own depots as well as by the individual companies. One of the principal duties of the military and naval attaché's in foreign countries was to keep Japanese manufacturers informed of new aeronautical developments and to arrange for the purchase of licenses to produce foreign aircraft. They also arranged for the import of special machine tools.

The Army and Navy set up inspection procedures and developed standards for acceptance for all classes of aeronautic material. Technical representatives and inspectors were stationed in the factories to see that quality standards were maintained. These officers also acted as advisors to the plant managers. If the two of them had a difference it was settled by a board from the Army or the Navy. As a result of this system, the Army and Navy representation had a large amount of power and virtually controlled the management of the plants. These representatives were responsible for the maintaining of quality standards. These

standards were usually laid down at the time the contract was let.

With the outbreak of war the services continued on the same general procurement program but on an expanded scale. The two air headquarters were reorganized in order to cope with enlarged programs. Figures II–1 and II–2 are the organization charts of the Army and Navy air activities. Each in itself appears straightforward and workable. What they lacked was effective liaison. Each operated independently—and most of the time at cross purposes.

The Army and Navy headquarters were responsible to the appropriate ministry of War or Navy. The War and Navy ministers were especially powerful because they had direct access to the Emperor while the other ministers had to go through the Prime Minister. Proper coordination appears to have been lacking, even at this high level.

In the latter part of 1941, certain materials became critical. Even at this early date problems resulting from control and allocation became increasingly difficult. As a result, the Army and Navy each organized its own control of raw materials within its own sphere of influence. Each had a group of producers from which it obtained raw materials which in turn were allotted to the manufacturers that were handling their particular contracts.

Both Naval air headquarters and Army air headquarters set up two general categories for material allocation, (1) materials for production and (2) materials for expansion. Certain factories were selected for production and so notified, and each plant was asked to specify its needs for raw materials during the year for both purposes, based on the schedule of aircraft desired for the coming fiscal year. Headquarters then allotted the material available to the manufacturers on the basis of their requirements. Allotment tickets were issued every 3 months to cover the quarterly requirements. These tickets were submitted to the government control agency that handled the particular material involved.

Orders for parts and components (for spares and for productions were issued from air headquarters direct to the manufacturer. They were ordered to be shipped to the depots or to the airframe or engine assembly plants. The materials required for making such parts were allotted under the general plan, but were sometimes given special priority calculated to meet requirements of the final user.

As might have been expected, difficulties appeared. Production failed to meet planned figures, requiring frequent modification of the programs. The original plans collapsed and general confusion, red tape, skulduggery and competition abounded. The lack of cooperation between the two services seriously hindered their ability to produce aircraft. At times, the two services actually came to the point of physical combat over certain parts and materials. Armed patrols of one actually seized and carried off supplies designated for the other. This became steadily worse as the war progressed.

Prior to the forming of the Munitions Ministry neither the Army nor the Navy made any attempt to control or allocate labor. Manufacturers had to get along as best they could in recruiting and training people for their plants. With notable lack of foresight, the armed services complicated the labor problem tremendously by making continual drafts against the civilian labor forces without regard to skills or to industry requirements.

The Army and the Navy had control of a large portion of the country's machine tools. Prior to the war they arranged for the import of foreign tools and after the outbreak they took over the Japanese production of machine tools. They were either loaned or leased to the aircraft producers. This system was advantageous because in this way tools could be put in the places where they would be put to the best use. Again, because of inter-service competition, the system backfired. Army machine tools could not be used for Navy production or vice versa, even if they were urgently needed.

The Japanese Army and Navy produced aircraft in their air depots. These depots, four Navy and one Army, were producing the same aircraft as certain manufacturers. In a sense, they were in competition with their own contractors. At Tachikawa, Army air depot, and Yokosuka, Navy air depot, research and development was done on new types of combat aircraft. Individual companies also carried out research and development on their own. This work was coordinated with that done by the Army and Navy depots. All depots came under the direct control of the Army and Navy air headquarters and were operated as subordinate units.

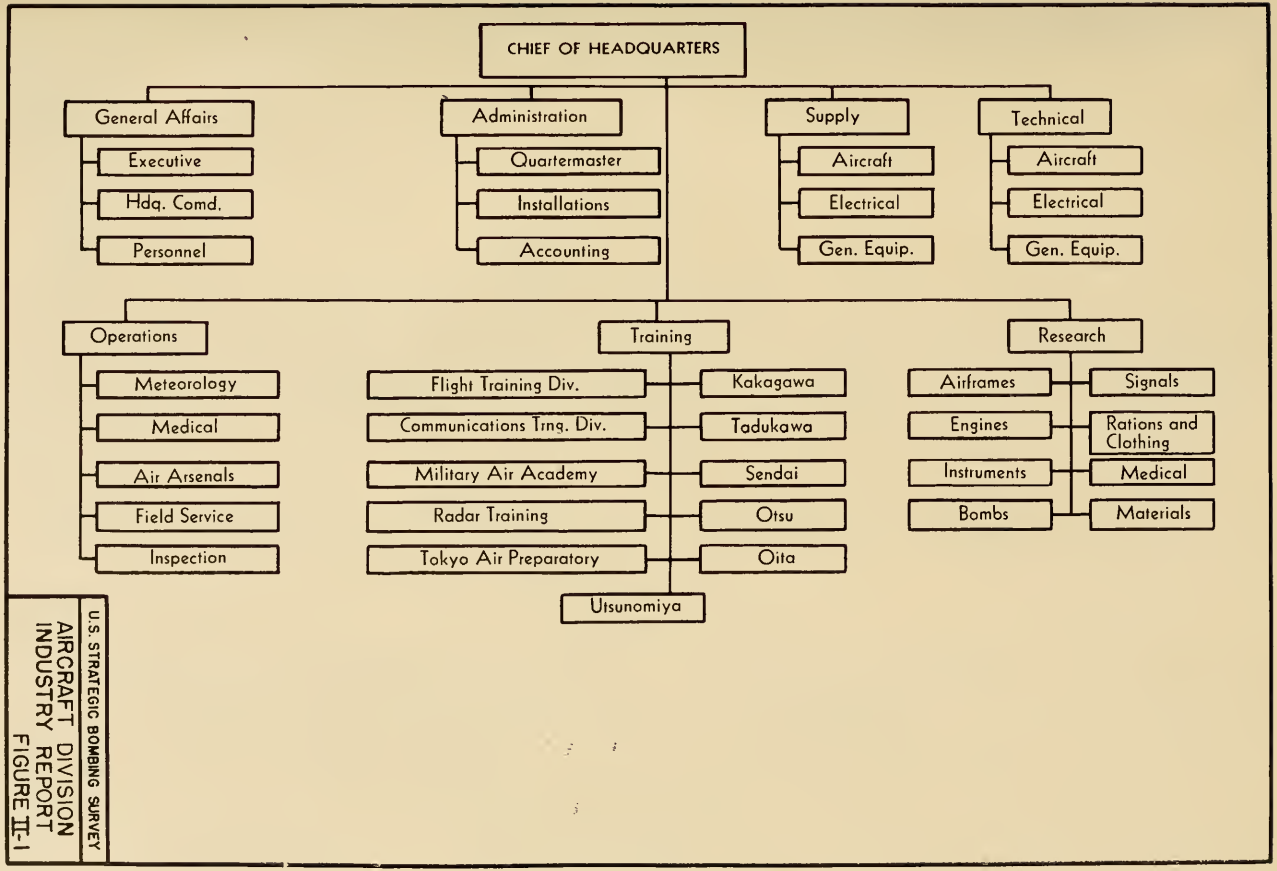


Figure II-1.—Organization of air headquarters—War Ministry

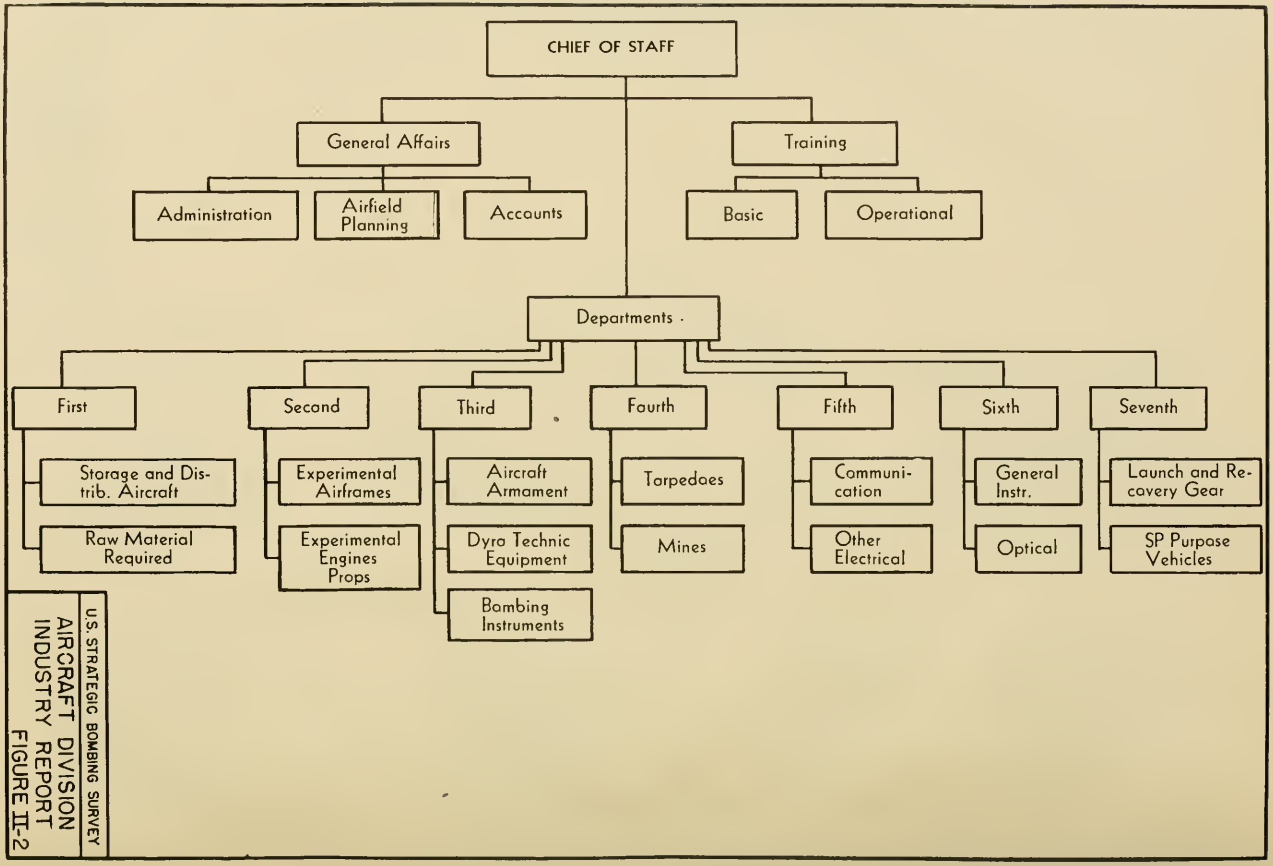


Figure II-2.—Organization of Naval Air Headquarters

The Role of the Air Ordnance Bureau

The Munitions Ministry was established in November of 1943 in an effort to unify and to simplify the control of all administration and production of military goods and military raw materials. Before that time plans for industrial mobilization and expansion were formulated by the planning bureau attached to the Diet, but execution was left in the hands of the various governmental departments including the Army and the Navy. As might be expected, divergent views and uncoordinated requirements led to a chaotic situation.

The Munitions Ministry was designed to administer all matters having to do with production, including the control of labor and wages (formerly under the Welfare Ministry), control of accounting (originally under the Finance Ministry) and the allocation of electric power (from the Communications Ministry).

The administration of production of goods necessary for making military equipment (machinery and basic raw materials) was brought under the Munitions Ministry. Liaison officers from the Army and Navy were assigned to various industrial fields which produced materials for aircraft.

In order to strengthen the control and administration of factories, various officials attached to the Commerce and Industry Ministry, the Welfare Ministry, and the supervisors from the Army and Navy were combined and administered by district offices directly attached to the Ministry.

One of the principal reasons for the formation of the Munitions Ministry was to expedite the production of aircraft.

The Air ordnance Bureau (Fig. II–3 for organization) was intended to bring together the control of production, planning, equipment, and raw materials under a single head, and to end the regime of the Army and Navy. Decisions regarding requirements, both for types and numbers of aircraft remained under the aegis of the Army and Navy, but the Munitions Bureau was to administer production to meet those requirements.

In spite of an elaborate program to control industry by an impartial body the Army and Navy continued to exert undue influence.

In actual practice the services set up their own organizations to control all munitions production. They continued to place their own supervisors in the munitions factories and did what they could to keep the more important factories under their control. As a result, the Munitions Ministry was hamstrung. Especially with respect to armament, parts and raw materials for aircraft production, the Army and Navy set up their own plans and did not even give any of the details to the Munitions Ministry. The Ministry was allowed to administer certain basic materials, but it became little more than a government office which handled civilian goods for the machine tool industry, chemical manufacture, etc. Although the basic plan for materials mobilization was made by the Munitions Ministry and approved by the Cabinet, an understanding had to be reached first with the Army and Navy because their independent requests for basic goods were so great. The Army and Navy, however, would not reduce their requests below a certain figure, nor would the Munitions Ministry yield ground on civilian requirements. As a result an impasse quickly developed which practically nullified the materials mobilization plan.

Apart from the failure to control materials, the Munitions Ministry was never able to harmonize the administration of labor, capital and accounting. It was never able to coordinate even the simplest problems related to the production of munitions. Here again the Army and the Navy created difficulties. Many Army and Navy officers held important positions in the Ministry. Although as individuals these men were generally capable and worked diligently, the turnover in assignments was very high and caused frequent changes or reversals of policy within the Ministry. The Army and Navy would not change their policies in this respect, in spite of the fact that it disturbed the work and blocked the activity of the Ministry.

Attempts to Control Aircraft Production

In order to coordinate aircraft industrial capacity and needs, the Munitions Ministry set up a system of determining production requirements. The Joint General Staff decided on the number of planes required for the tactical situation and sent a proposed program to the Navy and War Ministers. The Navy and War Ministers would approve and forward the plan to the Munitions Ministry and Army and Navy air headquarters for procurement. The Munitions Ministry then discussed the program with the aircraft-manufacturing companies with reference to expansion, materials, employees, machine tools, and equipment. The manufacturers would then review their capacity and send

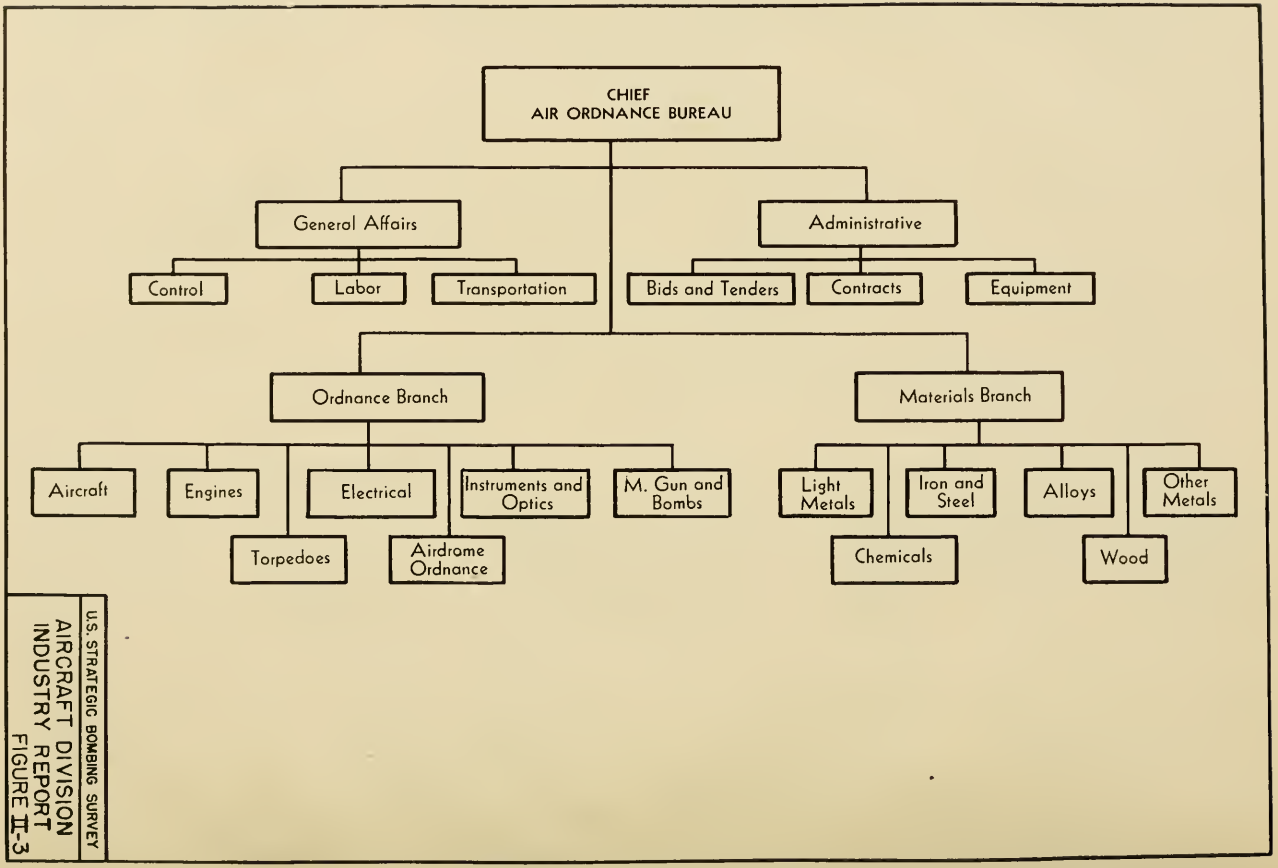


Figure II-3.—Organization of air ordnance bureau—munitions ministry

an ability report to the Munitions Ministry. The Ministry and the Army and Navy air headquarters would get together and decide on a monthly program for each company, which would be forwarded to the companies via the Munitions Ministry (Fig. II–4).

At the time the Munitions Ministry was formed an order was issued stopping any new expansion of aircraft parts. It was felt that there was plenty of plant space and that the big need was to increase efficiency in the existing plants.

An attempt was also made to control the production of parts and spares. There were two basic categories—general parts and special technical parts. General parts were those produced by the airplane manufacturer or his subcontractors, such as fuel tanks, wings, and machined parts. Special technical parts were broken down into three classes: (1) controlled parts, (2) government-coordinated parts, and (3) government-supplied parts. Controlled parts (bolts, nuts, rubber goods, springs, and packing) were made under government supervision, but were distributed as required by the manufacturer. For government-coordinated parts (coolers, pumps, and carburetors) production orders were issued to certain parts companies for delivery to airplane or engine companies for inclusion in final assemblies. Government-supplied goods (wheels, spark plugs, guns, and radios) were ordered directly by the government, and delivered to the government for distribution. All spare parts were delivered to the air arsenal designated by the Government.

B. WHO WAS WHO IN THE AIRCRAFT INDUSTRY

The historical background of the several companies that made up the Japanese aircraft industry during the war is of interest in connection with their relative importance as producers and as targets for our bombers. Below is a series of thumbnail sketches of the principal aircraft and engine manufacturers of Japan. These have been briefed from the more extensive corporation reports, Appendix II, produced by the Aircraft Division as a part of this study. Some of the products of these companies are discussed in the section on aircraft types.

The historical sketches are arranged in alphabetical order of the anglicized version of the company name.

Aichi Aircraft Co. (Aichi Kokuki K. K.)

The Aichi Aircraft Co. in the city of Nagoya produced both aircraft and engines for the Japanese Navy. During the war Aichi produced 6½ percent of all combat aircraft and ranked fourth in the industry. During peak engine production in 1944, the company produced 3 percent of the industry total.

Its chief products were the carrier-based dive and torpedo bombers Val (Type 97), Kate (Type 99), and Judy (Suisei), in chronological order. New models getting into production at the end of the war were Grace, an inverted gull wing torpedo plane, and Paul, a fast float plane. Aichi was also starting to produce George Kawanishi's fast, single-engine fighter, at the end of the war. Principal products of the engine section was the Atsuta, in-line, liquid-cooled engine of the 20 (1,185 horsepower) and 30 (1,380 horsepower) series, designed from the German Daimler-Benz.

The company, an outgrowth of the Aichi Clock & Electric Co., entered the industry in 1920. Its first plant was the Funakata works, followed by the Atsuta and the Eitoku works, all located in Nagoya. Atsuta concentrated on producing the Atsuta engines, with Funakata and Eitoku devoted to airframes, the large airframe production being at the newer Eitoku plant. The company also had a small plant at Ogaki, north of Nagoya.

In addition to the Daimler-Benz licensing arrangements, German advisers on production were in company plants. Throughout the war the company enjoyed much assistance from the government and in January 1945 a "War Industrial Enterprise" was appointed bringing more direct control by the government (Report No. V).

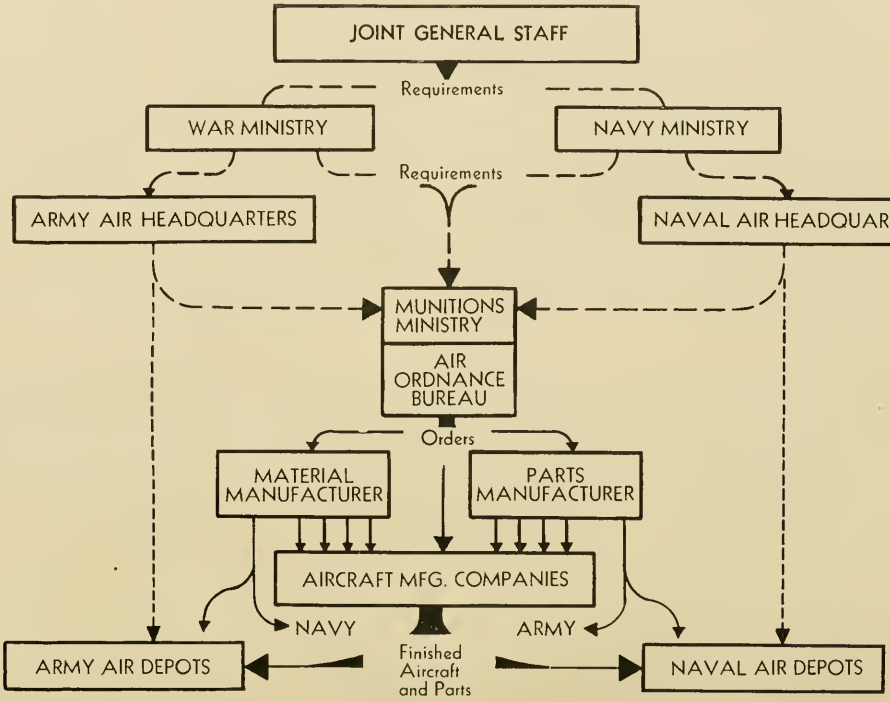
Fuji Airplane Co. (Fuji Hikoki K. K.)

Fuji Airplane Co. (Fuji Hikoki K. K.) with plants in Tokyo, Osaka, and Taira, was one of the smaller aircraft producers in the Japanese industry. The only complete aircraft produced was the Type 93 intermediate trainer, Willow. Production of this trainer amounted to 1.2 percent of the total Japanese aircraft production from 1941 through 1945, making this corporation thirteenth in the list of civilian aircraft producers. In addition to its production of trainers, the company engaged in fabrication of subassemblies for Nakajima Aircraft Co. It also made main wing and tail assemblies for the rocket-propelled suicide bomb Oka, Model 11, Baka. (Report No. XI).

Hitachi Aircraft Co. (Hitachi Kokuki K. K.)

The Hitachi Aircraft Co. produced both airframes and engines: 13,571 engines (11.6 percent of the industry total) and 1,783 aircraft (2.6 percent of the total) during the period from January 1941 to the end of the war. Most of these planes and engines were small training types.

In May 1939 the company began operating three plants near Tokyo (in Omori, Tachikawa, and Haneda) purchased from the Hitachi Manufacturing Co., parent corporation. In August 1939, a casting plant was opened at Kawasaki, and in 1942 a new large plant opened at Chiba. Tachikawa produced for the Army and Chiba, Haneda, and Omori for the Navy throughout.



U.S. STRATEGIC BOMBING SURVEY
AIRCRAFT DIVISION INDUSTRY REPORT
FIGURE II-4

FIGURE II–4. Pattern for procurement

The chief products were the Willow trainers with a small proportion of Zeke trainers. Their engines were the Ha 13 Ko, Ha 26 and Ha 23 (Tempu series) (Report No. VII).

Ishikawajima Aircraft Industries Co., Ltd. (Ishikawajima Koku Kogyo K. K.)

Ishikawajima was a small aircraft engine producer, with its main facilities near Yokohama at Tomioka. During 1944 the company averaged a little less than 100 Ha-35s per month.

The company was founded in 1937 as a branch of the Ishikawajima Shipbuilding Co. (Report No. XIII).

The Japan Aircraft Co. (Nippon Hikoki Kabushiki Kaisha)

The Nippon Airplane Co. (Nippon Hikoki Kabushiki Kaisha) was founded in October 1934 and consisted of two plants, located at Tomioka in Yokohama and at Yamagata City, Yamagata Prefecture.

The Tomioka plant was established in October 1936, with a floor area of 70,000 square feet, but had expanded to more than 700,000 square feet in 1945. The Yamagata plant was established in May 1941, with a floor area of 173,903 square feet, but at the end of the war it had expanded to 290,000 square feet.

The company was principally concerned in the manufacture of primary and intermediate trainers for the Navy. The two principal types were the K5Y1, a Type 93 intermediate land-based trainer, Willow; and the K5Y2, a Type 93 intermediate seaplane trainer, Willow. In 1943 and 1944 the company produced approximately 20 percent of the total trainers manufactured in Japan; in 1945 its position had declined to 12 percent. The only combat plane produced was the E16A1 Zuiun, a reconnaissance plane, Paul, of which there were only 59 completed up to the end of the war, or 2 percent of the total Japanese reconnaissance planes manufactured.

Dispersal began after the bombing attack of 10 June 1945 although plans for the Yamagata plant had its beginning as early as June 1944. The total planned dispersal area for the two plants was 380,498 square feet, of which the underground consisted of 141,654 square feet. Approximately 70 to 80 percent of the above-ground dispersal had been completed. The underground development ranged from 40 to 80 percent complete, due primarily to the reduction in planned area (Report No. XIV).

Japan International Air Industries, Ltd. (Nippon Kokusai Koku Kogyo K. K.)

Japan International Air Industries, one of the country's smaller producers, centered its activities at Okubo, on the outskirts of Kyoto. This plant, comprising 736,550 square feet of productive floor area, concentrated on the production of Cypress Model 1, primary trainers, 630 of which were manufactured in 1943 and 1944. The company made a handful of transports in 1944 and 1945. These were Mitsubishi's design, a conventional twin-engine, all-metal airplane, and Ki-105, a twin-boom, twin-engine, all-wood transport (Report No. VIII).

Japan Musical Instrument Manufacturing Co. (Nippon Gakki Seizo Kabushiki Kaisha)

The Japan Musical Instrument Manufacturing Co., located in Hamamatsu, was the second greatest producer of propellers, accounting for 28 percent of the propellers that were made in Japan during the years 1941–45, inclusive. The best monthly production attained by this company was 1,789 propellers produced during July 1944 and 2,505 auxiliary fuel tanks during July 1943. Peak employment was reached in April 1945 when 9,008 persons were on the pay rolls of the two principal plants. When the war ended, the company immediately reconverted to the manufacture of music instruments and furniture (Report No. IX).

Kyushu Airplane Co. (Kyushu Hikoki K. K.)

The Kyushu Airplane Co., known until 1943 as the Watanabe Ironworks, was located on the island of Kyushu, with its three small plants centered around the city of Fukuoka. Easily the largest of these was the Zasshonokuma works where the company started the manufacture of trainers in 1931. During the war the company produced the reconnaissance float plane Jake (E13A1) and Lorna (Q1W1), a twin-engine patrol bomber for the Navy. During June and July 1945 the company tooled up for production of the radial-engine pusher fighter Shinden and the twin-jet suicide aircraft Kikka. In addition to their small production of aircraft, the company manufactured landing wheels (Report No. XVII).

Kawanishi Aircraft Co. (Kawanishi Kokuki Kabushiki Koisha)

The Kawanishi Aircraft Co. was the sixth largest combat producer in the Japanese aircraft industry. The company manufactured only airframes and was exclusively a Navy contractor. It accounted for 5 percent of the combat airframes produced in 1944.

The Kawanishi Aircraft Co. was founded in 1928 and assumed all assets and activities of the Kawanishi Engineering Works at Kobe which started producing seaplanes in 1921.

The company had four primary plants, all of modern construction, three aircraft assembly plants, and one aircraft-component parts plant. Of the three aircraft assembly plants, the Naruo plant near Osaka was the largest, the Konan plant between Osaka and Kobe was the next largest, and the Himeji plant 40 miles northwest of Kobe was the third largest plant. Takarazuka plant, the aircraft-parts plant, was 6 miles north of the Naruo plant.

Kawanishi operated 5,847,424 square feet of productive floor space before air attacks. At the peak of employment in January 1945 there were 66,000 employees. The peak of employees engaged directly in production was 47,000, which existed from May through September 1944.

George (N1K1J and its modification N1K2J), a single-engine, land-based fighter airplane, was the most important plane produced by Kawanishi. Next in importance was the Nakajima-designed Francis, P1Y1, a twin-engine, land-based fighter. During the end of 1944 and in 1945 all of Kawanishi's production capacity was devoted to production of the above two types of aircraft. Mavis (H6K1–2–3–4–) and Emily (H8K1–2–3–), large, four-engine flying boats, were next in importance, and in the earlier stages of the war and before the war started various flying boats, observation planes, and trainers were produced by Kawanishi (Report No. III).

Kawasaki Aircraft Industries Co., Ltd. (Kawasaki Kokuki Kogyo Kabushiki Kaishi)

Kawasaki occupied third place in Japan's aircraft industry. The company manufactured both aircraft and engines, and was exclusively an Army contractor. It accounted for 17 percent of the combat airframes and 12 percent of the combat engines in 1944, the industry's biggest year.

By far the greatest proportion of the company's facilities was concentrated in two large plants, one manufacturing aircraft and engines at Akashi near Kobe and the other aircraft only, at Kagamigahara (Gifu) near Nagoya. Smaller plants producing complete airframes were at Iehinomiya, also near Nagoya, and at Miyakonojo on Kyushu. Additional engine plants were at Futami and Takatsuki, both in the Osaka-Kobe area.

The company operated 3,217,814 square feet of productive airframe floor area and 2,155,680 square feet of engine floor area before the air raids. The raids reduced these figures to 100,000 square feet and 1,202,300 square feet, respectively. At peak employment there were 97,000 workers in all branches of the company.

Kawasaki's best known airplane was the Tony fighter (Ki–61), a small, single-engine design with liquid-cooled engine. It greatly resembled the German Me 109. In 1944, two-thirds of the company's airframe production was in Tony. In order of importance the next two Kawasaki models were Nick (Ki–45), a twin-engine, two-place fighter, and Lily (Ki–48), a twin-engine light bomber. An improved version of Nick was Randy (Ki–102). The company's prewar and early war production was mostly on transports, such as a Japanese version of the Lockheed 18, and trainers.

The company's main engine effort was on a liquid-cooled German design, the Daimler-Benz, designated Ha–60, Model 22, and in a later version Ha–60, Model 33. These were in the 1,050–1,350-horsepower range. Despite major concentration on its own design, the company's largest unit production toward the end of the war was in the Nakajima radials, Ha–35, Model 35, rated at 1,150 horsepower take-off, and Ha–45, Model 21, rated at 1,970 horsepower take-off.

As previously indicated, the German influence was the predominant one in Kawasaki design; however, the company's activities started in 1919 with the purchase of the French Salmson aircraft design. At this time the parent organization, Kawasaki Heavy Industries Co., Ltd., organized the aircraft subsidiary. Throughout the next 20 years, fostered by a series of government orders, the company expanded steadily. After the start of hostilities this expansion was accelerated, but the corporation still managed to finance and control all of its facilities (Report No. IV).

Mitsubishi Heavy Industries Ltd. (Mitsubishi Jokogyo Kabushiki Kaisha)

Mitsubishi, as the industry's largest engine producer, manufactured 38 percent of all combat engines during the war and, as the second largest airframe producer, accounted for 23 percent of all combat airframes. Its activities were centered in 6 airframe and 11 engine works, each of which was composed of diverse plant units often widely scattered, mainly in south and central Honshu. In addition to these large assembly plants, Mitsubishi owned and controlled several hundred plants making parts throughout the empire.

Center of Mitsubishi's activities was Nagoya, where its largest airframe facilities and largest engine facilities were located. The Nagoya airframe plant totaled 4,250,000 square feet of productive floor area, making it one of the largest aircraft plants in the world, and the Nagoya engine works housed 3,800,000 square feet of productive area. These concentrations represented two-thirds of the corporation's airframe and more than half of its engine manufacturing area.

Other airframe assembly plants were at Nagano, Takaoka, Suzuka, Kagamigahara, Inami, Obu, Tsu, Okayama, Yawata, Yokkaichi, Naruo, Mizushima, and Kumamoto; other engine plants were at Kyoto, Shizuoka Nagano, Hiroshima, Ogaki, Fukui, Koromo, and Niigata.

Mitsubishi's best-known airplanes were Zeke (A6M1, 2, 3, 4, and 6) and Jack (J2M2 and 3), Navy fighters; Betty (G4M1 and 2) famous Navy bomber; as well as their Army bombers Sally (Ki–21) and Peggy (Ki–67) and Army reconnaissance planes Dinah (Ki–44) and Sonia (Ki–51). New planes under development were the Navy's Sam (A7M1) and the Army's Ki–83, a twin-engine bomber without allied code name. Their most successful engines were the Kasei and Kinsei radials for the Navy, designated Ha–32 and Ha–33 in the Army versions, which centered in the 1,500-horsepower (take-off) range. In 1944 the corporation went into quantity production on Ha–42, 18 cylinder radial, which developed 2,040 horsepower at take-off and promised 2,450 horsepower at 15,000 feet.

Aviation activities of the corporation started in 1918 on French licenses and developed steadily through the twenties and thirties. Despite large expansion during the war, the company managed to retain financial and management control of their facilities (Report No. I).

Nakajima Aircraft Co. (Nakajima Hikoki K K)

The Nakajima Aircraft Co. was Japan's leading producer of aircraft and, second, by a small margin, to Mitsubishi in engines. Their production was for the Army and Navy, in almost equal proportions. Nakajima accounted for 37½ percent of the combat airframes and 30 percent of all aircraft engines in 1944.

Activities of the Nakajima Co. were centered in the Tokyo plain area with three of their airframe assembly plants there and one near Nagoya. The Tokyo (Kanto plain) area plants were Ota and Utsunomiya, which were exclusively on Army production, and Koizumi, a Navy plant. The Handa plant near Nagoya was the second navy plant. The Musashi engine plant producing for both the Army and Navy and the Omiya plant producing for the Navy alone, were also in the Tokyo area. The Hamamatsu engine plant, halfway between Tokyo and Nagoya, was devoted entirely to Army production. In total floor area the airframe facilities amounted to 9,660,000 square feet and the engine plants to 3,550,000 square feet.

About 80 percent of the total airframe production at Nakajima was fighters: Frank (Ki–84) and the Mitsubishi-designed Zeke (A6M2–5), Oscar (Ki–43), Tojo (Ki–44), Nate (Ki–27), Rufe (A6M2–N), and Irving

(J1N1–5). Bombers were Jill (B6N2), Frances (P1Y1), Nell (L3Y1), Helen (Ki–49), and Sally (Ki–21). The company also manufactured Myrt (C6N1), a naval reconnaissance plane.

The principal engine produced was the Homare, designated Ha–45 by the Army, an 18-cylinder radial of 1,850 horsepower take-off rating.

Nakajima reached a peak employment of 146,000 workers in the airframe division and 78,000 workers in the engine division.

Nakajima started manufacturing airframes in 1917 and formed an engine division in 1924. Although independent of any major financial interests, the Mitsui Trading Co. acted as sole sales agent. In March 1941 the Japanese Government underwrote loans to Nakajima allowing them to expand, and at the end of the war they owned more than 80 organizations feeding into their main engine and aircraft plants. On 1 April 1945 the Nakajima Aircraft Co. was nominally transferred to state management and called the First Munitions Arsenal (Report No. II).

Nissan Automobile Co. (Nissan Jidosha K K)

The Nissan Automobile Co. in Yokohama and Yoshiwara produced very small aircraft engines, beginning in August 1943, and ranked sixth in unit engine production for 1944 and 1945.

The company had manufactued the Ha–11, four-cylinder in-line 100-horsepower engine, in Yokohama until 1 January 1945, when the aircraft division moved to a new factory at Yoshiwara, halfway between Nagoya and Tokyo.

Ninety-five percent of Government-planned production was completed in 1944, and 96 percent in 1945 (Report No. XVIII).

Showa Airplane Co. (Showa Hikoki K K)

The Showa Airplane Co., in the town of Showa near Tokyo, started producing naval aircraft in 1939. Peak production in 1943 represented 3 percent of total Japanese naval aircraft production.

The chief products were the transport Tabby 22 (L2D3) and the dive bomber Val 22 (D3A2).

The company had one large plant at Showa, near Tokyo, built in 1937 and three feeder plants one at Matsumoto, built in 1943, one at Ome, built in 1944, and one at Shinonoi, built in 1945.

Showa Airplane Co. became part of the Mitsui interest in 1945 (Report No. XII).

Sumitomo Metal Industries, Propeller Division (Sumitomo Kinzoku Kogyo K K, Puropera Seizosho)

The propeller division of Sumitomo Metal Industries was the leading Japanese propeller manufacturer, producing 67 percent of all propellers used in Japanese aircraft: practically all propellers for the Navy and 40 percent of those used by the Army.

They produced chiefly the Hamilton standard counterweight type and the Vereinigte Deutsche Metallwerke type. Peak production in July 1944 was 3,140 propellers.

Propeller production began at the Sumitomo copper works at Sakurajima, near Osaka, in 1933. The VDM and Hamilton patents were purchased in 1935. A new plant at Kanzaki, north of Amagasaki, went into operation in 1941. Propeller Division headquarters moved there, and a research and design section for prototype propellers was set up. In 1943 a cotton mill in Tsu was converted to propeller production.

The propeller division was one of six divisions of Sumitomo Metal Industries and was dependent financially upon the parent corporation, which was itself dependent upon the Sumitomo Trust, for financial support (Report No. VI).

Tachikawa Aircraft Co. Ltd. (Tachikawa Hikoki K K)

The Tachikawa Aircraft Co., Ltd., which in 1944 produced approximately 9 percent of Japanese aircraft, owned and operated three plants, located at Tachikawa, Okayama, and Kofu. These totaled approximately 3,600,000 square feet of floor area under roof, most of which was at Tachikawa, 20 miles west of Tokyo, the third largest airframe plant in Japan.

A major share of the company's production was concentrated on Hickory (Ki–54), a twin-engine trainer, and in the Nakajima-designed Oscar fighter (Ki–43), both of which were produced at the Tachikawa plant. At the war's end the company was launching an extensive production program on Patsy (Ki–74), a twin-engine, high-altitude reconnaissance airplane.

At peak employment the company had 31,000 workers. The Okayama and the Kofu works were small assembly plants supplied by the main plant, Tachikawa.

The company was privately financed (Report No. X)

Army and Navy Air Depots

The Japanese Army and Navy air depots were similar to those of other countries in that they handled repair, modification, and distribution of aircraft. One Japanese Army air arsenal and four naval air depots were themselves producers of aircraft.

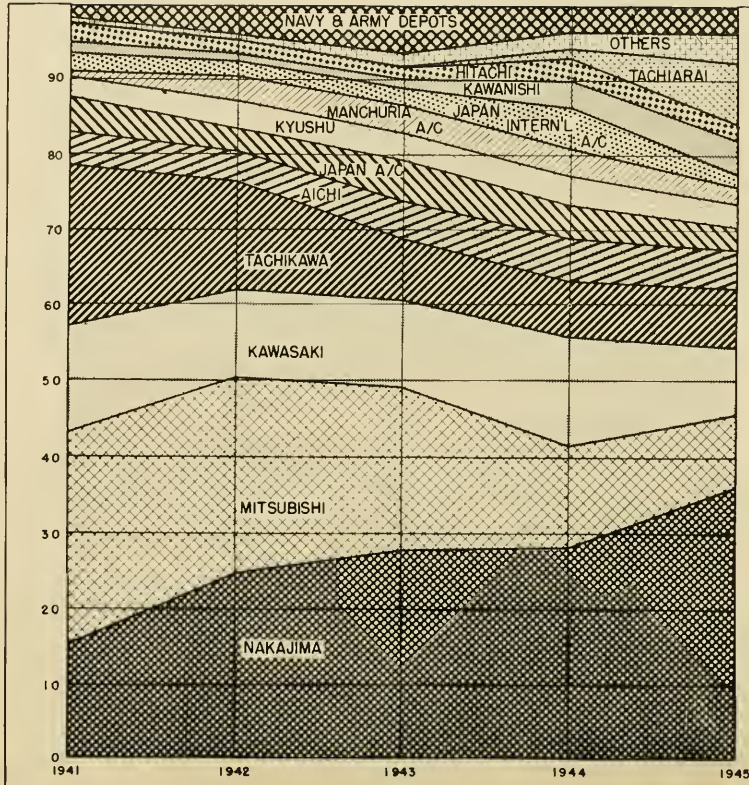
The Army Air Arsenal at Tachikawa produced both airframes and engines, as did the Eleventh Naval Air Depot at Hiro and the Twenty-first Naval Air Depot at Omura. The First Naval Air Depot at Kasumigaura produced trainer aircraft and the rocket-propelled suicide bomb, Baka; the Koza Naval Depot near Atsugi produced aircraft only.

The military depots accounted for 4.4 percent of the total Japanese combat aircraft production and 5 percent of the total engine production from 1941 through 1945. The military services themselves were the sixth largest producer of combat aircraft and the fifth largest producer of engines in the Japanese aircraft industry (Report No. XIX).

The Standing of the Clubs

The relative importance of the fifteen corporations and five Navy and Army arsenals which made up the bulk of the Japanese aircraft industry at the close of the war is shown in Table II–I and in Figures II–5 and II–6. The first gives the percentage of total aircraft production accounted for by each corporation and the second gives the percentage distribution of combat aircraft production for each manufacturer.

Five manufacturers, Nakajima, Mitsubishi, Kawasaki, Tachikawa and Aichi, accounted for

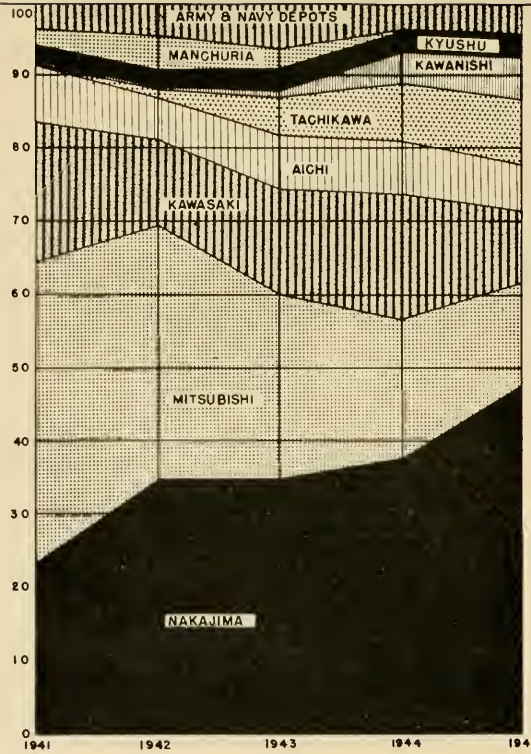


TOTAL AIRCRAFT PROD.
DISTRIBUTION BY MANUFACTURER
(SEE APPENDIX I-3)

CORPORATIONS ARE RANKED FROM BOTTOM TO TOP OF CHART IN ORDER OF IMPORTANCE IN PRODUCTION OF ALL TYPES AIRCRAFT FROM 1941 TO 1945.

CORPORATION	% PROD. 1941 — 1945
NAKAJIMA	28.0
MITSUBISHI	17.9
KAWASAKI	11.8
TACHIKAWA	9.5
AICHI	5.2
JAPAN A/C	4.1
KYUSHU	3.7
MANCHURIA A/C	3.1
JAPAN INTERN'L A/C	3.1
KAWANISHI	2.9
HITACHI	2.6
TACHIARIA	1.7
FUJI	1.2
SHOWA	0.9
TOKYO A/C	0.4
NAVY & ARMY DEPOTS	3.8

U.S. STRATEGIC BOMBING SURVEY
AIRCRAFT DIVISION
INDUSTRY REPORT
FIGURE II-5



COMBAT AIRCRAFT PROD.
DISTRIBUTION BY MANUFACTURER
(SEE APPENDIX I-4)

CORPORATIONS ARE RANKED FROM BOTTOM TO TOP OF CHART IN ORDER OF IMPORTANCE IN COMBAT AIRCRAFT PRODUCTION FROM 1941 TO 1945 (4½ YEARS)

CORPORATION	% PROD. 41-45
NAKAJIMA	37.1
MITSUBISHI	23.0
KAWASAKI	14.9
AICHI	6.9
TACHIKAWA	6.0
KAWANISHI	3.1
KYUSHU	2.9
MANCHURIA	1.5
ARMY & NAVY DEPOTS	4.4

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FIGURE II-6

nearly three-fourths of all aircraft output during the period 1941 to 1945 (Table II–I). The remaining production was distributed among 10 corporations and 5 arsenals, none of which made as much as 5 percent of the total output. The smaller manufacturers, however, did increase in importance during the war. In 1945 they were responsible for 40 percent of all output compared with only 15 percent in 1941.

Eliminating the production of trainers, transports, gliders and similar planes and ranking the manufacturers according to their production of combat types, the concentration among a few manufacturers is much more apparent (Table II–I). During most of the war period the two large corporations, Nakajima and Mitsubishi, made approximately 60 percent of all combat aircraft. If Kawasaki, Tachikawa and Aichi are added, the "big five" made 88 percent of all combat aircraft.

TABLE II–I.—*Relative importance of producers of Japanese aircraft*

[Production from 1941–1945]

Name of manufacturer	All aircraft	Percent	Combat aircraft	Percent
Nakajima Aircraft Co	19,561	28.0	19,396	37.1
Mitsubishi Heavy Industries	12,513	17.9	12,039	23.0
Kawasaki Aircraft Industries	8,243	11.8	7,770	14.9
Tachikawa Aircraft Co	6,645	9.5	3,130	6.0
Aichi Aircraft Co	3,627	5.2	3,611	6.9
Japan Aircraft Co	2,882	4.1	59	.1
Kyushu Aircraft Co	2,620	3.7	1,507	2.9
Manchuria Aircraft Co	2,196	3.1	798	1.5
Japan International Aircraft Industries	2,134	3.1	14	(1)
Kawanishi Aircraft Co	1,994	2.9	1,629	3.1
Hitachi Aircraft Co	1,783	2.6	----	----
Tachiarai Aircraft Co	1,220	1.7	----	----
Fuji Aircraft Co	871	1.2	----	----
Showa Aircraft Co	616	.9	1	(1)
Tokyo Aircraft Co	258	.4	----	----
Mitsui Mining Co	17	(1)	----	----
Matsushita Air Industries	4	(1)	----	----
Total	67,184	----	49,954	----
Navy air depots	1,700	2.4	1,284	2.5
Army air arsenal	1,004	1.4	1,004	1.9
Total	2,704	----	2,288	----
Grand total	69,888	100.0	52,242	100.0

[1] Less than one-tenth of one percent.

The rise in importance of Nakajima and the corresponding decline of Mitsubishi is worthy of note. From 23.1 percent in 1941 Nakajima increased its output to 47.4 percent of all combat planes produced in 1945. Mitsubishi declined from 41.4 percent in 1941 to 23 percent in 1945. Although Tachikawa and Kawanishi were small producers of combat aircraft, they grew considerably during the war years. Together they produced less than 1 percent of the 1941 total and by 1945 accounted for 15.4 percent of the combat type output.

At no time during the war did the Army air arsenal or the four Navy air depots produce many aircraft. Less than 5 percent of the Japanese aircraft were made by the Army and Navy in their own facilities.

The production of aircraft engines was also concentrated in Nakajima and Mitsubishi factories (Table II–II). Two-thirds of all engines made in Japan during the war were made by these two manufacturers. Except in 1945, Mitsubishi led in relative importance in the engine industry, producing almost 36 percent of the total. Hitachi and Kawasaki together produced about a fifth of the engines during 1941 to 1945. (For change in relative standing during the war years, Fig. II–7.)

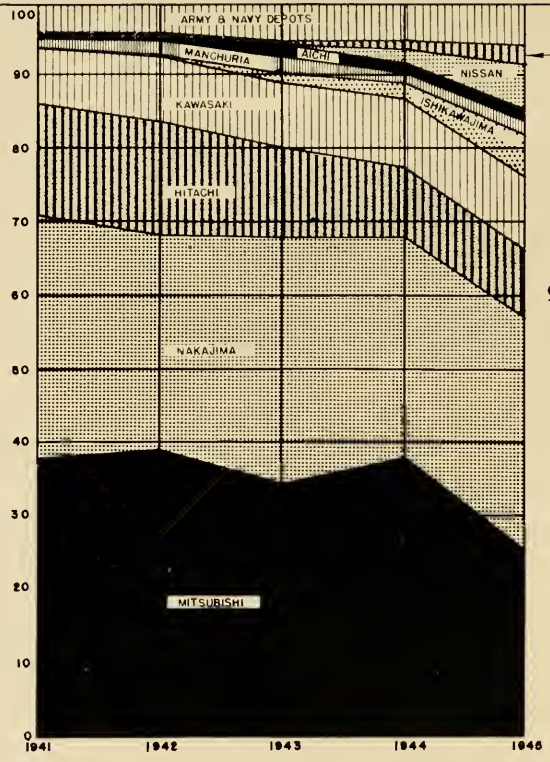
The most important inference to be drawn from the analysis of production by the manufacturers is the growing importance of Nakajima and its final dominance of the airframe and engine industry.

TABLE II–II.—*Relative importance of producers of Japanese engines—production from 1941–1945*

Name of manufacturer	Number of engines	Percent
Mitsubishi Heavy Industries	41,534	35.6
Nakajima Aircraft Co	36,440	31.3
Hitachi Aircraft Co	13,571	11.6
Kawasaki Aircraft Industries	10,274	8.8
Ishikawajima Air Industries	2,286	2.0
Manchuria Aircraft Co	2,168	1.9
Aichi Aircraft Co	1,783	1.5
Nissan Auto Co	1,633	1.4
Japan International Aircraft Industries	837	.7
Toyoda Auto Co	160	.1
Total	110,686	94.9
Navy air depots	4,452	3.8
Army air arsenal	1,439	1.2
Total	5,891	5.0
Grand total	116,577	99.9

C. CHARACTERISTICS OF THE WARTIME AIRCRAFT INDUSTRY

By the spring of 1944 Japan had at her disposal a very considerable plant capacity for the manufacture of aircraft. Although the exact amount of



ENGINE PRODUCTION
DISTRIBUTION BY MANUFACTURER
1941 – 1945
(SEE APPENDIX X – 5)

CORPORATIONS ARE RANKED FROM BOTTOM TO TOP OF CHART IN ORDER OF IMPORTANCE IN ENGINE PRODUCTION FROM 1941 TO 1945

CORPORATION	% PROD. 1941–1945
MITSUBISHI	35.6
NAKAJIMA	31.3
HITACHI	11.6
KAWASAKI	8.8
ISHIKAWAJIMA	2.0
MANCHURIA	1.9
AICHI	1.5
NISSAN	1.4
JAPAN INTERN'L	.7
TOZODA	.1
ARMY & NAVY DEPOTS	5.0

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FIGURE II-7

productive plant area is not known, a reasonable estimate yields:

	Square feet
For airframes	49, 000, 000
For engines	22, 500, 000
For propellers	4, 250, 000

This can be only an approximation because of the lack of exact records (many of which were destroyed) and because of a Japanese tendency to throw into their estimates areas which were really nonproductive (offices, cafeterias, dormitories, and even plant yard space).

Until they had it brought forcibly to their attention late in 1944, Jap factory planners never considered the possibility of bombardment. Unlike Germany's plant engineers, they made no provision for the protection of plants or working personnel. As late as 1943 their aircraft factories were built as huge sprawling units, easily identified from the air, with buildings erected closely together, and without provision for underground shelter for workers or for essential records.

Individual buildings within plant compounds seldom exceeded 400,000 square feet, but in the aggregate, some of the Jap factories were among the largest in the world, running to some 4–4.5 million square feet.

Except where plants had grown "like Topsy," with expansion piled on expansion, the general lay-outs were reasonably good. This was especially true of the big producers, like Mitsubishi and Nakajima, who had a considerable background of industrial experience at their disposal and whose plants were generally manufacturing standard model airframes or engines in reasonably large quantities. Of course, after dispersal began confusion reigned, and well-planned flow patterns broke down. By the spring of 1945 the whole Japanese aircraft industry had reverted to an amorphous collection of job shops.

Even at best, the Japanese seem to have made relatively inefficient use of their available manufacturing space. Given comparable labor efficiency and material availability (neither of which they had) it is certain that both American and German producers would have counted on a much higher output per square foot of plant space than was ever achieved by the Japanese.

Building Construction

Predispersal plants were generally of steel-frame construction with asbestos or tile roofing and corrugated asbestos-composition siding. Large areas of glass were used. Saw-tooth roof design and proper orientation of buildings netted good lighting inside.

Steel framing was lighter than that dictated by American practice, but was good enough for the purpose. It was evident that the limited quantities of structural steel had to be spread as thinly as possible. When hit by high explosive the roofing and siding materials generally disintegrated, leaving the framing standing with only local damage in the immediate area of the hit. Where incendiaries were involved, however, and fires started, the light framing soon sagged and twisted out of shape under the heat. (Numerous examples are to be found in the plant reports of the Aircraft Division.)

Some plants had put up extensive wooden buildings when structural steel ran short. Such shops were, of course, easily destroyed by incendiary bombs. In some cases, however, the Japanese anticipated the bombings, evacuated the machinery to dispersal sites and razed the building themselves to remove the fire hazard.

Instances were noted of a reversal of this procedure. In cases where roofing and walls of a plant had been destroyed by bombing, temporary wooden structures were built inside the damaged shell to protect machinery or production lines that remained. Such construction was difficult to detect by aerial photography, and there is little doubt that some production continued under temporary, camouflaged cover in plants that were thought to have been generally destroyed. It is doubtful, however, that this production was sufficient to warrant re-attack. The Ota Plant of Nakajima is an example (Aircraft Division Report No. II–1).

By far the most interesting aspects of Japanese aircraft plant construction practice occurred after dispersal. They will be discussed at length in later sections.

Production Methods

The over-all planning and production methods employed in the original airframe and engine plants appear to have been reasonably good. Many production engineers and plant managers had served their time with Curtiss, Pratt and Whitney, Douglas and Lockheed before the war and much of the tooling and plant layout showed that such experience had not been wasted. Generally speaking, United States influence seemed much more apparent than German or Italian.

In engine plants particularly a high percentage of foreign built machine tools was in evidence. For precision operations, Swiss, German and United States tools were preferred. For the less precise requirements of the airframe plants, Japanese-built tools were good enough. One manufacturer estimated that the industry-wide average (airframe and engine plants combined) showed about 50 percent foreign built tools at the beginning of the war, with a drop to around 30 percent at the end.

The usual assortment of routers, shears and blanking presses were to be found in metal cutting departments of aircraft factories. Large hydraulic presses (3,000 to 5,000 tons capacity), many of them of United States manufacture, were used to form sheet metal parts. Sheet rubber and zinc dies mounted on roller tables were found with most of these presses. It is of interest to note that the big presses, together with the usual preheating and heat treatment furnaces, were almost the only pieces of equipment remaining in plants that had been dispersed. Their great size made moving impractical. The most carefully designed and most heavily built blast walls found in Japanese plants were around heavy press equipment. There is no doubt that they realized that the loss of their presses would have created a major bottleneck.

In spite of the fact that the experience level of the average aircraft worker was very low, little was done to provide specialized jigs and tools to compensate in part for lack of skill as was common in Germany and in the United States. There appears to have been a large amount of bench work, with individual workers chipping and filing on bits of metal and assembling small subassemblies by main strength and awkwardness. Generally speaking, the final assembly jigs and fixtures for wings and fuselage were lighter and less rigid than those in common use elsewhere. Light weight structural steel set into concrete was used in many places. There was evidence that some heavier tubular self-supporting jigs had been used. Some were portable to the extent of being mounted on wheels. Such varying practice must have resulted in a lack of standardization and interchangeability that probably handicapped subsequent maintenance operations on the aircraft.

Inadequate tooling also must have hampered final assembly operations, for in spite of the huge manufacturing areas and extensive tooling available at the big plants, a considerable percentage of airframe and engine subassembly manufacture was let out to subcontractors, and a high percentage of the parts came from a larger network of sub-subcontractors (Sec. V). Shops scattered throughout the industrial areas supplied the thousands of bits and pieces that made up the finished aircraft. Good master tooling, with tight control of subcontractors' tools is absolutely essential, if the pieces are to fit together properly at final assembly.

When area bombings began, hundreds of such suppliers were wiped out and their tools destroyed. Even before the attacks started many firms were in continual difficulty because of inadequate planning and control. One of the largest manufacturers admitted, for example, that even long before the bombing began it was sometimes necessary to send men out, by road and rail, with knapsacks on their backs to round up certain special parts to keep production lines going.

Labor Situation

For preliminary purposes over-all figures supplied by the Munitions Ministry as shown in Table II–III give an approximation of employment in the industry.

How far these figures take into account the sub- and sub-subcontractors is not certain. (See following section "subcontractors.") It is reasonably safe to assume, however, that many direct and indirect contributors to the aircraft industry have not been included. Making allowance for these, it seems probable that at least 1.5 million workers were involved in the manufacture of aircraft at the end of the war (Table II–IV for detailed estimate). How many more were engaged as common laborers, digging tunnels in hills and transporting materials on their backs is entirely unknown.

A breakdown of the average monthly employment for the major manufacturers for the years 1941 to 1945, inclusive, is shown in Table II–V. More detailed figures of the monthly variations of labor force in the several plants of the various manufacturers will be found in the plant and corporation reports (Index List, App. II).

TABLE II–III.—*Over-all employment—aircraft industry*

	December 1941	December 1942	December 1943	April 1944	December 1944	April 1945	August 1945
Airframes, assembly and other accessories	200,000	400,000	600,000	614,300	800,000	831,000	831,000
Engines and propellers	114,300	233,000	291,000	314,800	410,000	427,000	427,000
Total	314,300	633,000	891,000	929,100	1,210,000	1,258,000	1,258,000

TABLE II–IV.—*Estimated total employees—aircraft industries*

	1 Feb. 1944	1 Feb. 1945
Airframe	405,000	574,000
Airframe subcontractors	112,000	122,000
Engine	200,000	267,000
Engine subcontractors	34,000	53,000
Propellers	23,000	35,000
Propeller subcontractors	3,000	5,000
Component manufacturers	170,000	
Component manufacturers subcontractors	58,000	308,000
Total	1,005,000	1,364,000
Home industry	90,000	136,000
Total	1,095,000	1,500,000

TABLE II–V.—*Average monthly employment, 1941–45*

	1941	1942	1943	1944	1945
Nakajima Aircraft Co	51,004	93,422	120,222	190,555	214,169
Mitsubishi Heavy Industries	59,707	80,804	109,420	172,706	205,431
Kawasaki Aircraft Industries	17,048	26,924	48,161	80,533	76,408
Kawanishi Aircraft Co	13,377	23,234	37,173	56,290	51,144
Aichi Aircraft Co	7,337	12,647	22,868	33,254	32,265
Hitachi Aircraft Co	8,038	11,552	16,700	29,956	31,014
Tachikawa Aircraft Co	10,033	128,167	17,767	26,942	19,125
Kyushu Aircraft Co	9,540	13,515	16,174	20,563	24,040
Japan International Air Industries	2,039	3,913	8,661	19,364	23,839
Sumitomo Metal Industries	7,008	9,583	12,333	18,100	20,138
Showa Aircraft Co	3,646	4,646	6,499	9,992	12,034
Japan Aircraft Co	2,777	3,670	5,724	9,705	10,684
Japan Musical Instruments	3,678 (4 mo)	4,563	5,944	7,560	8,508
Ishikawajima Air Industries	2,122	2,820	3,518	5,637	5,777
Fuji Aircraft Co	1,731	2,488	3,597 (2 mo)	5,124	5,531
Matsushita Air Industries			49 (5 mo)	2,651	3,501
Nissan Auto Co			580	1,249	3,231
Navy air depots	20,388	31,752	40,820	57,786	67,539
Army air arsenal	3,264	5,205	6,940	8,970	10,830
Total	222,737	458,905	483,150	756,937	825,208

Figures II–8, II–9, and II–10 have been drawn to show the relationship between employment and output for the airframe, engine, and propeller industries, respectively. In each case there is a marked lag between the falling off of production and the tapering off of the labor force. During that period desperate efforts were being made to halt the production decline, but in spite of an increasing number on the rolls, their quality was so poor, and so many other problems were bedeviling industry, that the fatal slump could not be stopped.

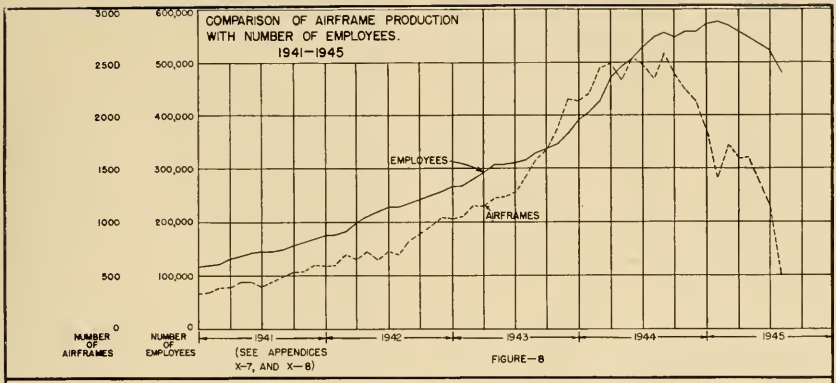
Quality of Labor

Women were not as widely employed in the aircraft industry in Japan as in America or in England. It is doubtful if the top figure exceeded 20 percent of the total. High school boys, physically substandard college students, and nonessential workers from other industries were drafted in large numbers to work in the aircraft plants to replace older men who had been drawn off for the military services. The demands of the military became so excessive in the spring of 1944 that the aircraft manufacturers protested to the government that the requirements of the Army and Navy for aircraft could not be met in view of the excessive drain on manpower.

Both quality and quantity suffered severely in the hands of the unskilled workers. Even at the beginning of the war, skilled labor was scarce enough. There was some evidence of manufacturer sponsored apprentice-training programs in Japan comparable to those that had served to tide Germany over the strains of rapid industrial expansion, but they proved far from adequate. Most airframe and engine plants dumped new adult workers, completely unskilled, into the plant without training. Boy and girl students served part time as apprentices in the plant while going to school. In other words, it was all on-the-job training in Japan.

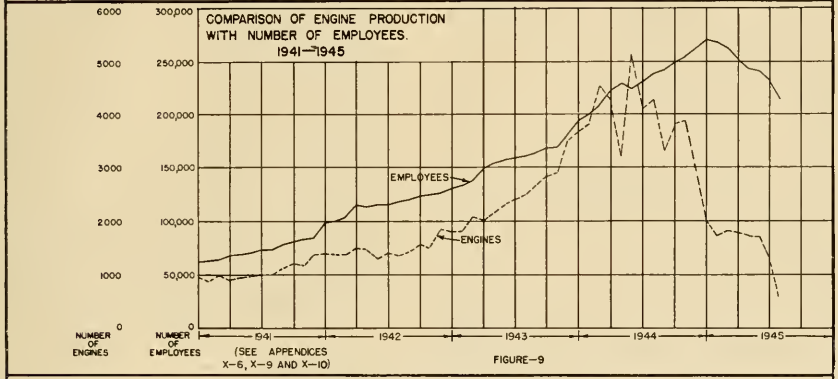
Plant expansion and dispersal, coupled with a rising demand for men by the armed services soon diluted engineering and production experience almost to the vanishing point. In some plants, managers complained that they had to get on at times with one skilled man where at least 20 would ordinarily be considered a bare minimum.

The situation finally became so critical that some key personnel, both engineers and production men, were released from the services to their former civilian jobs and a certain number of



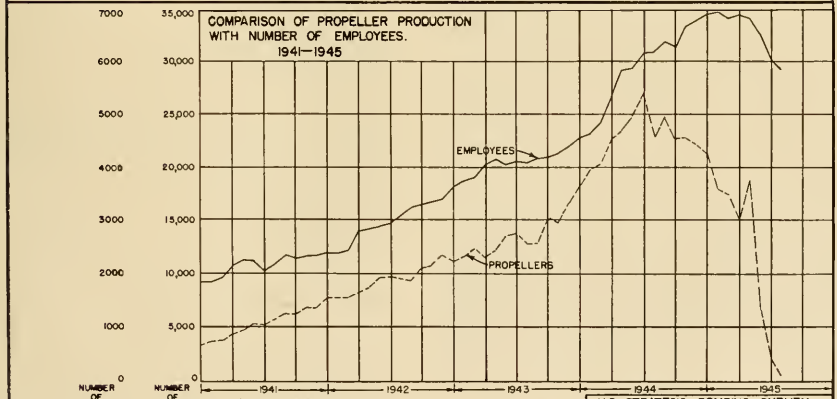
(SEE APPENDICES X-7, AND X-8)

FIGURE—8



(SEE APPENDICES X-6, X-9 AND X-10)

FIGURE—9



(SEE APPENDICES X-6, X-11 AND X-12)

FIGURE—10

U.S. STRATEGIC BOMBING SURVEY

AIRCRAFT DIVISION
INDUSTRY REPORT
FIGURE II— 8, 9, & 10.

skilled workers were detailed to private industry out of Army and Navy arsenals. In addition, large numbers of soldiers, regardless of skills, were detailed for temporary duty (usually for 6 months) with aircraft manufacturers. They were generally employed as common laborers. Their presence in the factories created considerable unrest and dissension among civilian workers because they were better clothed and drew far better rations than were available for the most highly skilled regular employees. The labor problem was never solved and contributed materially to the general decline in aircraft output which began in the fall of 1944 and continued without recovery to the end of the war.

Accurate statistics are lacking, but a study of plant and corporation reports, correlated with certain over-all considerations, would indicate a rough classification of workers in the aircraft industry by mid-summer of 1944 as follows:

15–40 percent regular, hired employees.
20–30 percent conscripted labor.
30–40 percent students (high-school equivalent or less).
10–15 percent soldiers.

The problem of production of high-precision parts and of the intricate mechanisms of the modern airplane with such a labor force is at once apparent.

Working Hours

During the years when the war was popular in Japan (up to the summer of 1944) workers in the aircraft industry worked increasingly long hours without complaints. The Emperor needed airplanes for victory. They did the best they could to give them to him, 12 hours a day, 7 days a week. After Saipan fell, enthusiasm began to wane. Materials were scarce; men were being drafted away from industry; food became scarce; and long before the bombings began a feeling of "what's the use" became current. Many companies attempted to double up on shifts—to work 20–24 hours a day, but additional workers were hard to get to fill the ranks, and supervision was spread so thinly by that night work could not be controlled or planned properly. Some plants managed to get some departments on a 24-hour a day program, but efficiency fell so low that the over-all effect of the additional effort was scarcely worthwhile.

Absenteeism

Absenteeism among aircraft industry workers was not great prior to the fall of 1944 and the beginning of air attacks. After the bombing began the greatest single cause was the "area" type raid which destroyed workers' homes and disrupted transportation facilities. Many examples can be found in the plant reports of the division. A few cited below illustrate typical cases.

1. An attack in July 1945 on the Handa plant of Nakajima resulted in the destruction of a large number of workers' homes. Many stayed away to care for their families and what possessions remained to them. This resulted in an 80 percent production loss the first week after the attack, and a 65 percent loss during the 2d and 3d weeks.

2. Absenteeism was negligible in the Mitsubishi Nagoya Engine Plant and the Aichi Nagoya Engine Plant prior to the area raids on that city in March 1945. In each case absenteeism increased greatly for about 1 week and then gradually decreased, again approaching normal about 3 weeks following the attack. The effect of increased absenteeism in the Mitsubishi Nagoya plant is shown in the average number of hours worked per month per employee. In November 1944 it was 206 hours per month. In March 1945, the month in which area attacks started, it dropped to 160, in May it was 137, in July 102.

3. An interesting comparison of absenteeism in an engine plant located in an area not attacked and one in an area heavily attacked is shown by the figures for the Fukushima plant of Nakajima, and the Musashi plant of Nakajima. Absenteeism was as follows for the undamaged Fukushima plant.

	Percent
March, 1945	6
April	7
May	8
June	9
July	11
August	12

On the other hand, in the Musashi plant and its dispersals in one of the most heavily attacked areas of the war absenteeism ran:

	Percent
January, 1945	21
February	26
March	27
April	30
May	27
June	30
July	35
August	41

Another factor became important as the air attacks increased. With declining morale among aircraft workers people simply stayed away from their jobs, especially as the danger increased.

For example, after an attack in May causing heavy damage to the Himeji plant of Kawanishi there was a major desertion to the farms by plant workers.

As a result of poorly planned dispersals, workers frequently encountered great difficulty in getting transportation from their homes to the dispersed plant sites. Many of them gave up trying to get to work. When, for example, Japan International Aircraft Co. attempted to disperse to forest areas in the vicinity of Kyoto, absenteeism increased to the extent that the whole dispersal program became ineffective.

Loss Due to Air Alerts

In many cases, especially as the frequency of attacks increased, the threat of an attack caused plants to shut down. During an alert it became the practice to evacuate plant sites except for fire-fighting and first-aid personnel. Thus a considerable number of man-hours were lost. In the Mitsubishi Nagoya engine plant 26 percent of the monthly total of man-hours were lost for this reason in March 1945, 27 percent in April and 24 percent in May. Although the Daimon airframe plant of Mitsubishi near Toyama was never attacked directly there were seven mass retirements due to air alerts between 24 May and 14 August 1945. On each occasion 2.5 hours of work were lost. This, plus an estimated 1 hour loss per day per worker due to loss of sleep, etc., resulted in an 8 percent loss in working time in July 1945.

Efficiency of Workers

One need know very little of the characteristics of the average Japanese worker to hazard a guess that the Jap is less efficient than his American or German counterpart. Although their industrial progress in the past 50 years has been remarkable, relatively few Japanese had more than a single generation of mechanical aptitude behind them. Certainly as a nation they lacked the huge poll of mechanical skills and experience from which to draw that was available to the expanding aircraft industries of the United States, or of the Third Reich. By the time the demand for skilled labor reached a peak, little was left to fill up the ranks of workers in plane and engine factories but a class of labor only one jump from the rice paddy.

To obtain some quantitative measure of worker efficiency a formula was applied that had been developed by the Aircraft Resources Control Office of the United States War Production Board to rate the relative efficiency of American aircraft builders. The same formula had also been used to clock the comparative performance of United States and German manufacturers (Report of the Aircraft Division, USSBS, on the German Aircraft Industry).

The method used to obtain the efficiency indices is outlined in the paragraphs which follow. Table II–VI gives the step-by-step computation of the indices for four stages of the war. The results are plotted in Figure II–11.

In Figure II–11 the suspicions regarding the efficiency of Japanese workers are confirmed. In terms of output per day per worker, their best was far below the average American performance. Their best showing was in mid-1943 when they reached about 40 percent of our then current level.

Calculation of Efficiency Index

The steps taken to determine an index of relative efficiency between Japanese aircraft production and American aircraft production are briefly as follows:

(1) The pounds of weight produced is converted to a common basis (that of fighter production). It has been determined that the unit cost of an airplane or the production hours per airplane varies inversely as the weight to the one-third power. The pounds of weight produced for a 3-month period is used to avoid fluctuations caused by shortages, weather, design changes, etc., which may have caused a drop in production 1 month only to be offset by an abnormally large production the following month.

(2) In order to reduce the results to a common unit the pounds weight produced in a given 3-month period is divided by the number of working days in that period:

$$\frac{\text{pounds produced}}{\text{number of working days}} = \text{pounds per working day}$$

(3) In determining pounds per employee per working day the number of employees used is that of the first month of the index period. This is done to give consideration to "Labor flow time" or the fact that parts produced in May will not be reflected in output until July although a large portion of July final assembly work will show up in July acceptances. The third step in the index as:

$$\frac{\text{pounds per working day}}{\text{number of employees}} = \frac{\text{pounds per employee}}{\text{working day}}$$

TABLE II–VI.—*Index of utilization of manpower in American and Japanese aircraft industries*

	July 1941		July 1942		July 1943		July 1944		July 1945	
	American	Japanese	American	Japanese	American	Japanese	American	Japanese	American	Japanese
Pounds weight including spares [1] (000#)	19,500.0	5,360.9	75,222.0	7,918.2	186,940.0	13,916.3	289,676.0	25,943.7	213,900.4	13,387.1
Fighter, (000#)	2,903.0	431.6	14,477.0	1,514.8	33,271.0	4,433.1	65,542.0	12,240.8	51,961.5	6,595.9
Bomber, (000#)	10,365.0	3,045.4	43,734.0	4,577.6	122,098.0	7,210.1	181,825.0	11,296.8	126,409.9	5,418.9
Transport, (000#)	893.0	868.8	5,087.0	280.0	16,258.0	770.7	35,501.0	632.2	31,850.7	
Trainer and N. E. C., (000#)	5,339.0	1,015.1	11,924.0	1,545.8	15,313.0	1,502.4	6,808.0	1,773.9	3,597.3	1,372.3
Pounds modified to fighter production (000#)	17,076.0	3,742.9	67,454.0	6,153.5	155,269.0	11,634.2	229,416.0	22,525.0	162,316.9	11,794.2
Fighter, (000#)	2,903.0	431.6	14,477.0	1,514.8	33,271.0	4,433.1	65,542.0	12,240.8	51,961.5	6,595.9
Bomber, (000#)	7,404.0	1,870.5	32,325.0	2,969.9	86,486.0	5,304.8	125,879.0	8,276.9	82,473.9	3,897.3
Transport, (000#)	609.0	510.3	3,760.0	179.0	13,819.0	528.7	27,783.0	435.2	22,408.7	
Trainer and N. E. C., (000#)	6,160.0	930.5	16,892.0	1,489.8	21,693.0	1,367.6	10,212.0	1,572.1	5,472.8	1,301.0
Pounds per working day	213,450	46,208	843,175	75,969	1,940,862	143,632	2,867,700	278,086	2,003,912	145,607
Employees including subcontractors [2] (000)	203	137	510	213	1,084	307	1,063	499	830	541
Pound per employee per working day	1.05	.34	1.65	.36	1.79	.47	2.70	.56	2.41	.27
Units per day [3]	3.92	1.43	6.62	1.79	8.69	2.79	9.24	4.76	11.02	2.60
Qf [4]	1.35	1.85	1.14	1.74	1.05	1.51	1.03	1.27	.98	1.54
IE	1.42	.63	1.88	.63	1.88	.71	2.78	.71	2.36	.42

[1] Three months production (May, June, July).
[2] Employees as of the first month of the index period.
[3] Average units produced per day per company based on representative sample of Japanese and American aircraft companies.
[4] Quantity factor derived from basic eighty-percent curve.

(4) The final step is to modify the results achieved so far to take into account the variation in the scale of production undertaken. It has been determined that each time the quantity to be produced is doubled the unit labor involved drops to 80 percent of the amount required in the original quantity ("Factors affecting the cost of airplanes," by T. P. Wright—Journal of the Aeronautical Sciences, February 1936.) Hence, the basic 80 percent curve was developed as a means of measuring variation in output with consideration given to the quantity produced. In deriving this index a representative sample of Japanese companies and American companies was chosen for each period shown, their unit acceptances modified to equivalent units of fighter planes and reduced to number of planes per company per day. The quantity factor (Q_f) is then read from the 80 percent curve. Hence the index of efficiency:

$$(\text{LB/emp/Day} \times Q_f = 1_E)$$

Subcontractors

All segments of the aircraft industry relied heavily on subcontractors. Subcontracts for approximately 29 percent of all aircraft production, as of the first quarter of 1944 were let by the by the prime contractors. Wings, empennages, nacelles, forgings and castings, small parts and subassemblies came from nonaeronautical sources. Machining, wire winding, and subassembly required by component manufacturers were naturals for the subcontractor. The general division of labor in the industry is shown in Table II–VII.

In Japan the subcontractor was called a cooperative contractor by those in the aircraft industry. This term grew out of the close affiliation between the prime and the sub which was much closer than in the United States. Not only were materials procured by the prime contractor but help was also given the subcontractor in the form of technical, financial, equipment and transportation aids. Subcontractors were usually spoken of in terms of the prime contractor, as a "Nakajima subcontractor."

The airframe manufacturers let about 35 percent of their work out to subcontractors. The usage of subcontractors varied from 31 percent by Aichi to 32 percent by Mitsuibishi and to 43 percent by Nakajima. Notwithstanding the tremendous increase in general employment and employment of students and soldiers by the airframe manufacturers during the war, the percent of subcontracting also increased and was at its highest level in 1945.

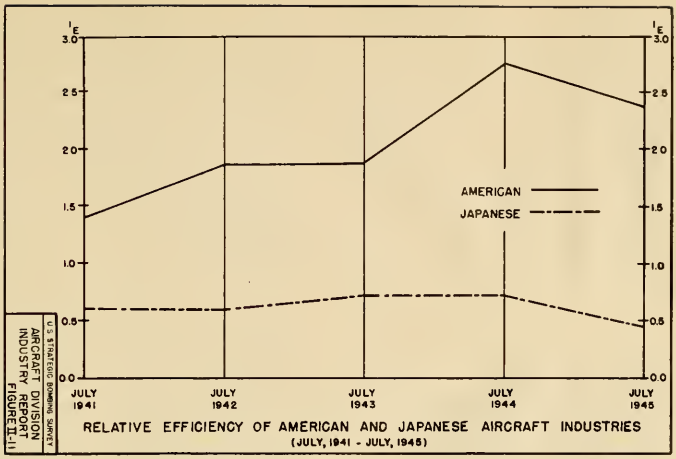


Figure II-11.—Relative Efficiency of American and Japanese Aircraft Industry—July, 1941–July, 1945.

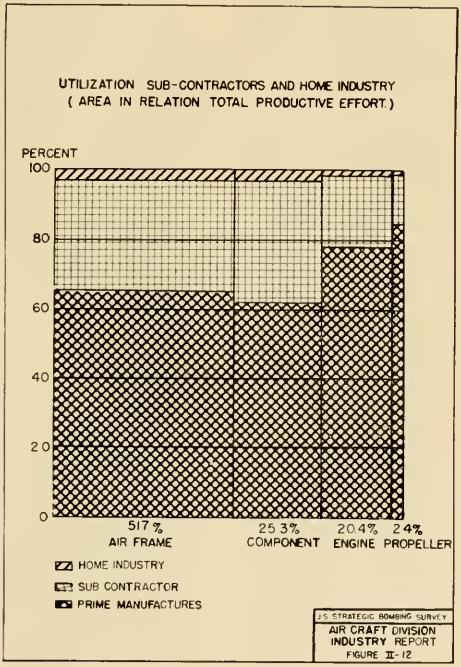


TABLE II–VII.— *Distribution of labor effort in aircraft industry*

[(As of 1 February 1944)]

	percent
Airframe manufacturers	37. 0
Subcontractors	10. 2
Engine manufacturers	18. 3
Subcontractors	3. 1
Propeller manufacturers	2. 1
Subcontractors	. 3
Component manufacturers	15. 5
Subcontractors	5. 3
Home industry	8. 2
Total	100. 0

[illegible] manufacturers subcontracted 36 percent of their output, engine manufacturers 24 percent, and propeller manufacturers only 16 percent. All manufacturers used home industry to a limited extent. Most home-industry effort in the aircraft field was as a result of sub-subcontracting. The chain extended from the principal manufacturer to the subcontractor, to the sub-subcontractor, who might well be a small shop keeper or machinist manufacturing various bits and pieces in his own home. The importance of subcontractors and home industry in relation to the total productive effort is shown in Figure II–12. It will be noted that although a larger percentage of component manufacture was subcontracted, the subcontractor effort was only half that for airframes.

Subcontractors were concentrated in the Tokyo, Nagoya, and Osaka industrial areas fairly close to the prime manufacturers which they served. Appendix VII shows the general locations prior to dispersal. They grew in size and numbers as the aircraft industry expanded. They varied from shops employing 10 people up to those hiring 2,000. Some of them worked only part time for a particular contractor; others worked 100 percent for one company.

For the purpose of this survey, subcontractors studies were limited to subcontractors giving 20 percent or more of their effort to a particular aircraft prime contractor. The Nakajima Co. listed 165 such subcontractors for its Koizumi plant, with 12,280 machines and 53,500 employees. The Ota plant listed 140 subcontractors, with 10,400 machines and 31,900 employees. The Musashi engine plant had 187 subcontractors, with 10,715 machines and 19,800 employees. Mitsubishi used subcontractors to a lesser extent, with its engine plants listing only 93 subcontractors, with 14,100 employees. The Mitsubishi No. 7 airframe factory had 25 subcontractors, with 15,800 employees, and its No. 9 airframe factory had 63 subcontractors, with 11,300 employees.

The dispersal of subcontractor factories was badly planned and poorly organized. One of the best was associated with the Nakajima Koizumi engine plant. There the prime contractor assisted in the planning. New locations were selected fairly close to the parent plants and there was reasonable maintenance of the flow of production. Figure II–13 shows the old and dispersed locations of the Koizumi subcontractors.

There was little general dispersal of subcontractor factories until early in 1945. After the first Tokyo raids there were wild and excited dispersal efforts. Machines were ordered out of the factories by every means of transportation and in many cases the only destination was back into the hills. The result was the crippling of subcontractor production. In some cases the prime lost all contact with his sub and had to attempt to develop new sources of supply. The dispersal and jamming of the transportation system cut the flow of raw materials to the subcontractor. Home-industry output normally fed into the aircraft industry through the subcontractor was disrupted.

Subcontracting as a whole and home industry in particular suffered heavy raid damage. Plants and shops concentrated in the congested sections of large cities. They were generally of flimsy wooden construction and easily destroyed. Miyazaki, general manager of Mitsubishi Denki, stated 60 percent of the communications equipment and 40 percent of their other electrical business was subcontracted, much of it into the home-industry shops. The first urban area raid on Tokyo in March had a very serious effect on production as many of the small shops were destroyed. Attempts were made to draw back parts manufacture in their own plants but this cut down the volume and dislocated assembly space and facilities. Some component manufacturers, especially in the communications field, came to almost a complete halt with the destruction of the small shops. By the end of June damage to Hitachi's subcontractors was reported at 50 percent with loss of home industries much higher. Kokusai Denki, which subcontracted 50 percent of its magneto production, experienced a delay in the receipt of 100,000 small machine parts during the March and April Tokyo raids with approximately one half permanently lost.

Production from subcontractors and home industry as a whole held up better than production of airframes and engines during the period from September 1944 to March 1945, but frantic dispersal beginning in March 1945 and damage from air raids sharply cut into all subcontract production in the second quarter of 1945. It is doubtful, however, if this cut in production had much effect on the rate of airframe production until almost the end of the war because the normal pipe line was from 1 to 3 months long.

Aircraft Production—Quantitative

In the course of the investigation, production and planning figures were obtained from many sources: the Munitions Ministry, the Army and Navy (independently), from the head offices of the various manufacturing companies, and from the records of many individual plants. These data have been rationalized and correlated. They appear to be in sufficiently good agreement to draw a set of curves to indicate the general trend of aircraft and engine production during the course of the war.

Figure II–14 tells graphically the story of the rise, decline, and fall of the Japanese aircraft industry. Monthly production figures for airframes (combat and total) and engines are plotted against time. Figure II–15 shows total accomplishment for airplane engines and propellers on an annual basis plotted from Table I–1 (summary).

The first significant increase in aircraft output occurred well off the left-hand margin of Figure II–14. About 1937, the demand for military aircraft was stepped up to meet the needs.

Planning Versus Production

In planning their programs, the Japanese made some attempt to be realistic and to cut their cloth to fit conditions of the moment. They were less adept at it than the Germans had been under similar circumstances, but they did make attempts to readjust their over-all requirements as their productive capacity melted, or was blasted away. How realistic some of their programs were is open to question. They may have been set partly for their inspirational value rather than on a strictly rational basis. There may have been political implications. It is not impossible that sensing ultimate defeat, the Government may have deliberately set production goals too high so that they might ultimately shift the blame for failure onto the manufacturers who failed to produce.

Figures II–16 and II–17 show the relationship between programs and accomplishment for both airframes and engines. Up to the beginning of 1944 deliveries of aircraft and engines corresponded closely to planned production. From that point on, however, divergence became wider and wider. They failed to meet the expectations even after plans had been drastically revised.

In the period between January 1944 and August 1945 procurement plans (on the adjusted basis) called for a total of 66,000 aircraft. Actual deliveries came to approximately 40,000, a loss of more than 30 percent. The engine picture was far worse. Out of an expected availability of 105,000 units, only 56,000 were actually delivered, a shortage of almost 50 percent.

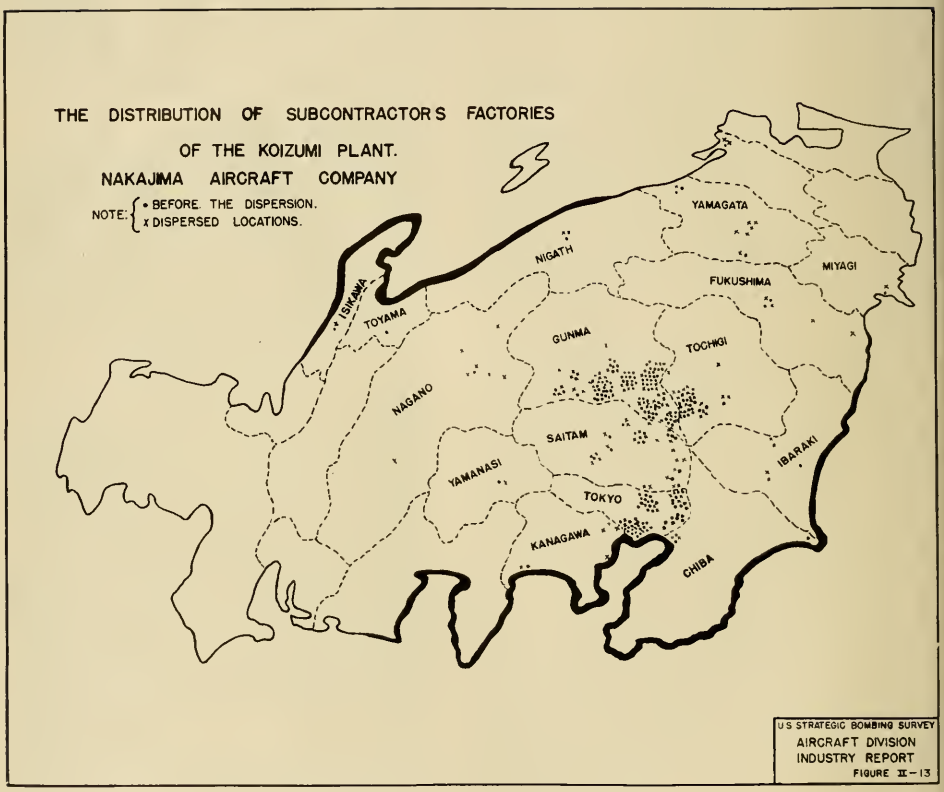
Whether or not the military services could have used the planned number of aircraft if they had been delivered is doubtful. Shortages of fuel and pilots would probably have kept many of them on the ground. Such speculation, however, is outside the scope of the present inquiry. These curves do, however, give some indication of the extent of failure of the Japanese aircraft industry to accomplish the task assigned to it.

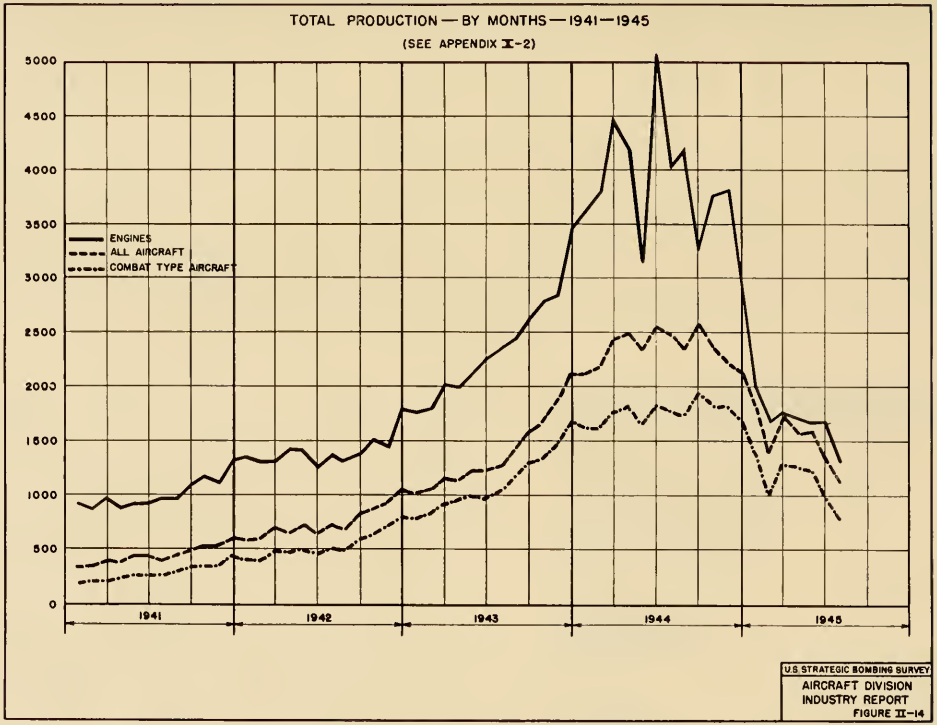
D. PLANT DISPERSAL

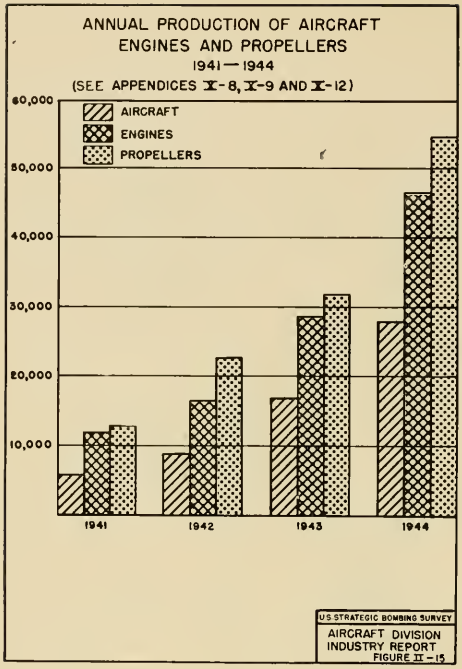
General

With the fall of Saipan, Japanese industrialists began to lose confidence in their supposed invulnerability from aerial attack. About that time the government suggested that plant dispersal might be a good thing but simultaneously put on pressure for greatly increased production of all military supplies, especially aircraft. On the horns of this dilemma, practically every aircraft manufacturer elected to try and meet the demands of the services, trusting in the gods to keep the bombers from knocking at his particular door. It was only when the bombs were actually raining down on Nagoya and Osaka and in the outskirts of Tokyo that the big industries began scurrying about like frightened rabbits looking for likely spots where they could dig themselves underground, or conceal their activities in woods and small villages.

The first bombs hit Mitsubishi and Nakajima in November and December 1944. A Government decree ordering immediate dispersal to underground and scattered sites came in mid-January 1945. To avoid too much confusion, certain areas were designed by Tokyo as dispersal zones for particular companies. Within those areas, however, each company was expected to select


THE DISTRIBUTION OF SUBCONTRACTOR'S FACTORIES
OF THE KOIZUMI PLANT.
NAKAJIMA AIRCRAFT COMPANY
NOTE: • BEFORE THE DISPERSION.
x DISPERSED LOCATIONS.
YAMAGATA
NIGATH
FUKUSHIMA
MIYAGI
ISHKAWA
TOYAMA
GUNMA
TOCHIGI
NAGANO
SAITAM
IBARAKI
YAMANASI
TOKYO
KANAGAWA
CHIBA
U.S STRATEGIC BOMBING SURVEY
AIRCRAFT DIVISION
INDUSTRY REPORT
FIGURE II-13


TOTAL PRODUCTION — BY MONTHS — 1941 — 1945
(SEE APPENDIX X-2)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
ENGINES
ALL AIRCRAFT
COMBAT TYPE AIRCRAFT
1941
1942
1943
1944
1945
U.S. STRATEGIC BOMBING SURVEY
AIRCRAFT DIVISION
INDUSTRY REPORT
FIGURE II-14



the most suitable site and to get underground as fast as it could. Labor for digging was sometimes provided by the Army and Navy. Sometimes private construction companies were called in to do the job.

Most companies did not wait for the order. Thoroughly alarmed, they began to dismantle their plants with little regard for production, and to move machine tools, jigs, dies, and materials into whatever schoolhouses, textile mills, shrines, and caves happened to be within reach. As fast as railroad cars, charcoal-burning trucks, oxcarts and coolie backs became available, they were loaded and dispatched to the hills.

The general level of efficiency of underground shops inevitably would have been very low. The in-line arrangement of benches and tools, coupled with restricted passageways, made material handling difficult and good work planning impossible. Bad lighting, dampness, and poor ventilation would not have improved the efficiency of individual workers. Precision tools and finished machine parts deteriorated rapidly from rust and corrosion. Worst of all, little thought seems to have been given to the transportation of materials and personnel to and from the tunnels. Many of them are remote from rail connections, and the roads leading in to them are frequently single tracks, negotiable with difficulty in a jeep in good weather, and probably impassable at some seasons of the year. In some localities air transport was contemplated, but air strips in the mountainous country generally selected for tunnels were few and far between.

Not all of the dispersals were completely underground. In many places semiunderground shops and hangars were built with roofs sodded over and planted with vegetation for concealment. In some places, also, the forest-type dispersal was adopted, with small sheds built in among overhanging trees as was done by Messerschmitt in southern Germany. Several extensive installations of this sort have been examined. (Aircraft Division Report No. VII–1.)

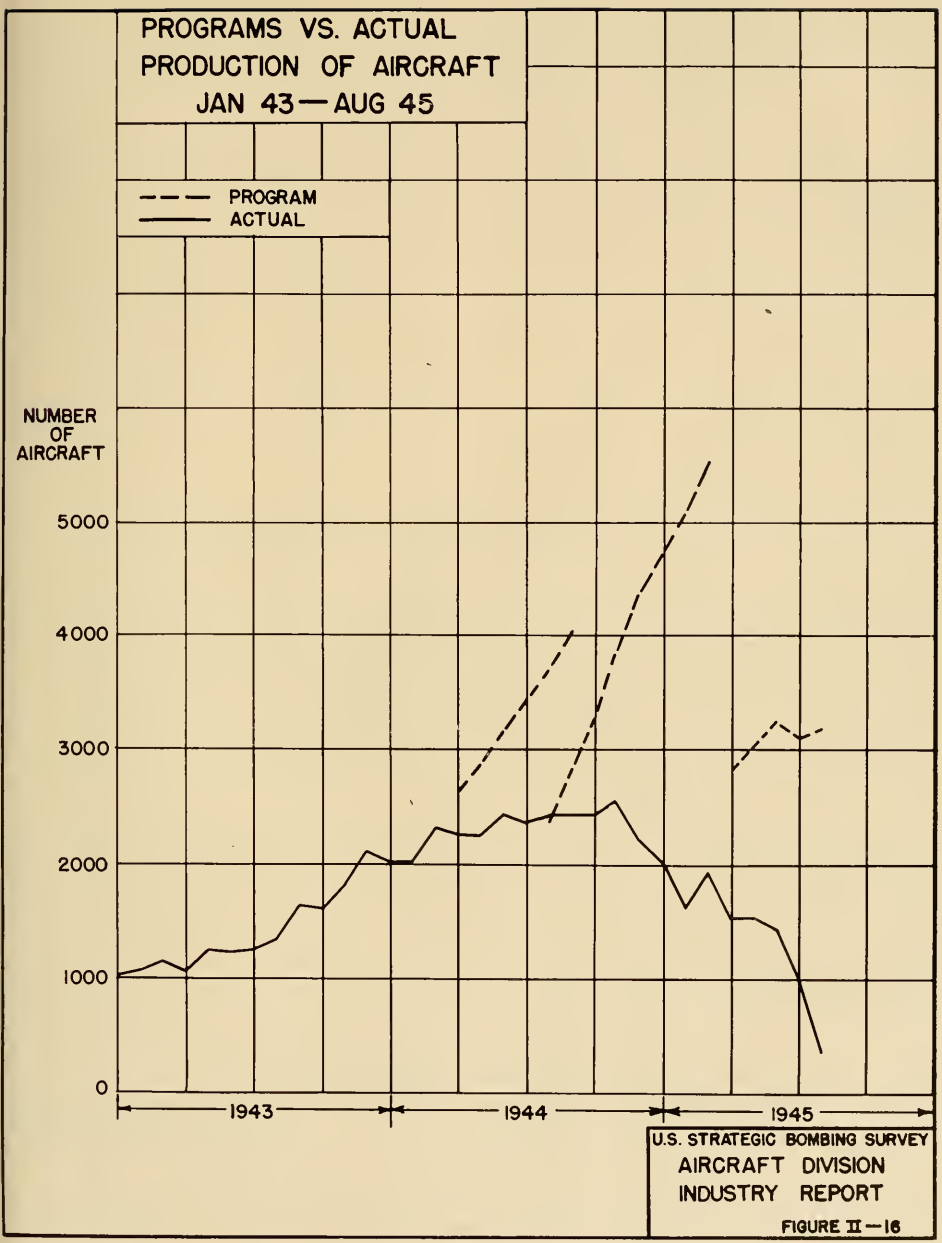
With the exception of tremendous underground units, such as the Nakajima plant at Shiroyama, the general practice in engine production was to place all or most of the precious machine tools in underground machine shops. Most of the machining of parts and some subassemblies were to take place underground but heat treatment, final assembly and the balance of subassembly were usually planned for semiunderground hangar-type buildings.

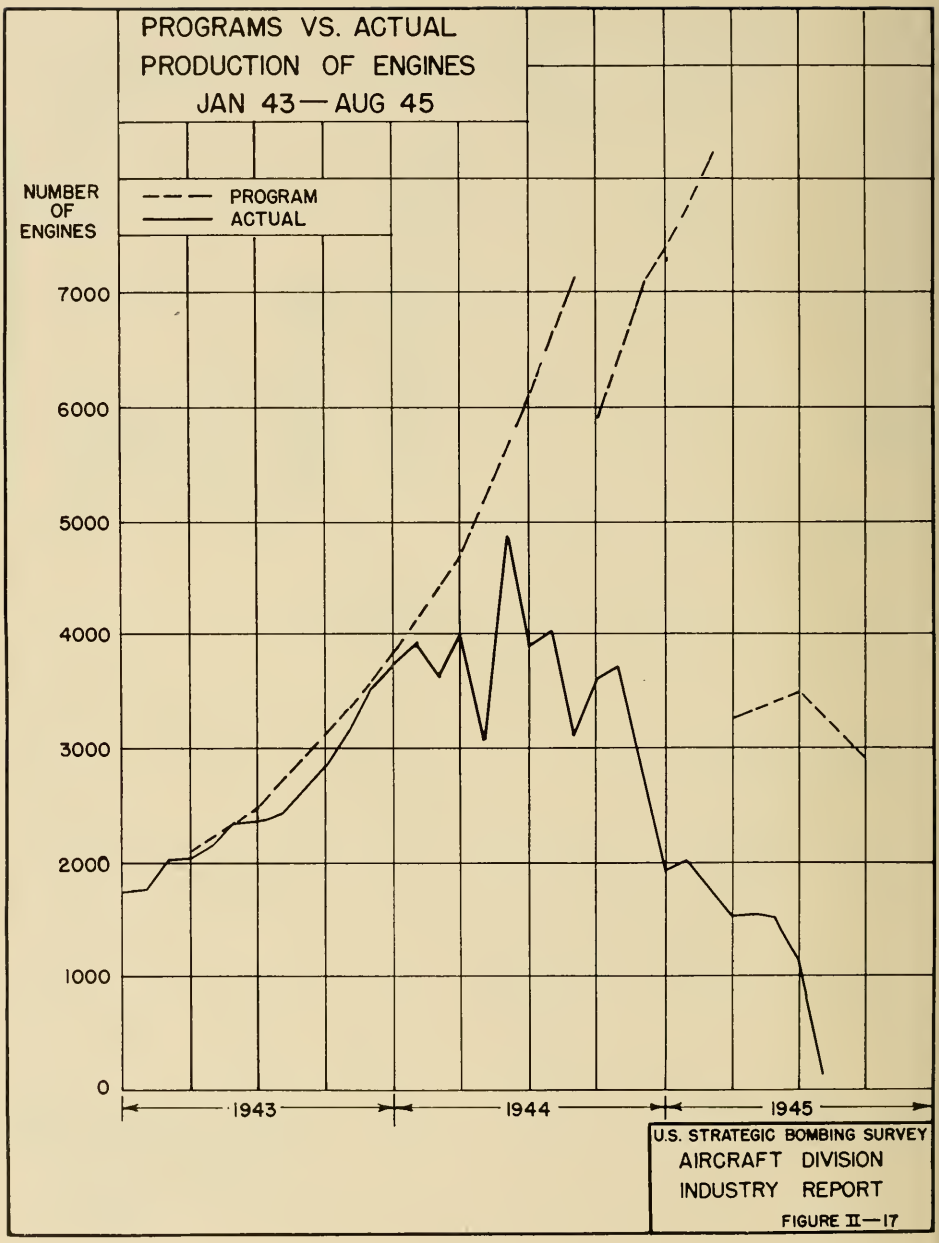
In the case of airframes, it was necessary to consider the air field from which the aircraft would fly. This meant, in many cases, that final assembly was undertaken in old hangars, newly constructed dispersed hangars, or in semiunderground hangar-type buildings at an air field. As with engines, machining and some subassembly took place underground with other subassembly in semiunderground plants.

The underground and semiunderground units were usually in close proximity to each other but the total area over which they were dispersed frequently amounted to several square miles or more.

Most semiunderground plants consisted of 20 to 60 hangar-type buildings that were 20 to 40 feet wide and 40 to 80 feet long. These buildings were built into the slopes of hills and were spaced at varying intervals around the bases of these hills.

With the front edge of the floor of the building at the edge of the hill, excavation was carried out into the slope until the area of the floor had been


PROGRAMS VS. ACTUAL
PRODUCTION OF AIRCRAFT
JAN 43 — AUG 45
PROGRAM
ACTUAL
NUMBER OF AIRCRAFT
5000
4000
3000
2000
1000
0
1943
1944
1945
U.S. STRATEGIC BOMBING SURVEY
AIRCRAFT DIVISION
INDUSTRY REPORT
FIGURE II — 16


PROGRAMS VS. ACTUAL
PRODUCTION OF ENGINES
JAN 43 — AUG 45
NUMBER OF ENGINES
PROGRAM
ACTUAL
7000
6000
5000
4000
3000
2000
1000
0
1943
1944
1945
U.S. STRATEGIC BOMBING SURVEY
AIRCRAFT DIVISION
INDUSTRY REPORT
FIGURE II—17

uncovered. Then the building was erected in this open depression after which the spoil was cast back over the roof and the half-exposed sides of the building. Vegetation was planted on this soil and merged with that of the original hillside. Thus the building was concealed in a small bump on the hill and was protected from all bombing except direct hits on the top or near misses at the entrances. Soil fully protected the other three sides.

Dormitory buildings which were constructed to house the workmen received the least protection. They were usually in a valley with no great efforts made to camouflage them, although it was planned to do so when circumstances permitted at a later date.

NOTE.—The Ogami plant of Mitsubishi No. 11 airframe works and the Matsumoto plant of Mitsubishi No. 1 airframe works illustrate the general coordination of underground, semiunderground, and surface plants into a whole productive unit. They also show the types of semiunderground buildings. (Aircraft Division Reports I–1 and I–11.)

The Japanese aircraft manufacturers denied that German experience in dispersal of the aircraft industry had set the pattern for Japan. They stated that aerial bombardment left only one course open to them—to move the factories where they would be hard to find and difficult to bomb. Although there was some knowledge of general German plans for dispersal and underground construction, any similarity of Japanese plans to the German plans was said to be due to chance rather than conscious application, that the course of events forced both countries into the only apparent possible solution.

What might have emerged if dispersal programs had been completed is difficult to determine. The Government plans had anticipated a resumption of production at about 50 percent of the mid-1944 peak by midsummer 1945. More realistic estimates by such people as Nakajima, and others who were well aware of the difficulties involved, counted only on a 40 percent basis by December 1945, assuming the over-all economic situation could have been maintained at the 1944 level. Even the latter figure now appears to have been unduly optimistic. (For detailed information, Aircraft Division Underground Report XX.)

Dispersal Planning

During November and December 1944 a number of big plants were hit hard by our bombers. ("Air Attacks on the Aircraft Industry".) The frightened Japanese undertook immediately a serious study of underground sites and possibilities. Although the Government was still demanding uninterrupted production as late as December 1944, several of the aircraft companies started active construction of underground plants at this time, anticipating the receipt of directives from the Government.

Generally speaking, the situation early in 1945 was as follows: (*a*) The Government was conducting surveys to find suitable locations for dispersed plants; (*b*) each aircraft company, on its own initiative, was making efforts to find obsolete tunnels, abandoned mines, and other sites available for underground works; (*c*) a few surviving spinning mills were ordered converted to aircraft production; and (*d*) schoolhouses were partially closed and utilized as factories.

It was not until February 1945, however, that determined measures were taken. With the passage of the Urgent Dispersal of Plants Act, dispersion was to be carried out by Government directive for the first time. The first step was to put local direction of dispersal under the production boards of the prefectural administrative councils.

In March 1945 a central counterplanning headquarters of production and defense was established in the Munitions Ministry. This office undertook to control top policy for dispersal, to facilitate the dispersal already under way, to prevent congestion of dispersed facilities by the assignment of dispersal areas, and to grant financial transportation, food, and construction facilities and priorities.

The first dispersal plan covered all industry but gave top priorities to aircraft and allied manufacturers. Of 172 projected underground plants, 97 were to produce aircraft, engines, and propellers, and 23 were to manufacture aircraft equipment. (Report on Japanese Construction Industry, Capital Equipment and Construction Division.) The ministry planned that this first dispersal program would be completed in May 1945.

A second dispersal plan to be undertaken upon completion of the first affected the aircraft industry but slightly.

Although construction of many underground plants got under way in late 1944 and early 1945 upon the initiative of the prefectural councils and the aircraft industry, it appears that a coordinated program was not forthcoming from the Munitions Ministry until early April 1945. Both the Mitsubishi and Nakajima Aircraft Companies and other smaller concerns indicate 4 April 1945 as

the date upon which the central government orders regarding dispersal were received.

The first plan of the Munitions Ministry was to disperse 993 plants. Of these, 674 were a part of the aircraft industry (565 to manufacture aircraft engines, 109 to manufacture aircraft equipment). Of the 674 dispersed aircraft sites, 120 were to be underground (97 to manufacture aircraft and engines, 23 to manufacture aircraft equipment).

In addition to the program ordered by the Munitions Ministry, the prefectural councils had undertaken the direction of certain dispersal within their local areas.

The combined totals of plants to be dispersed under the two headquarters were 1,977 plants to manufacture airframes and engines, and 356 plants to manufacture aircraft equipment out of a total of 5,822 dispersed plants for the whole of the Japanese economy.

The dispersal within the airframe and engine industries only (excluding aircraft equipment plants) was as follows:

	Munitions ministry orders	Prefectural council orders
Surface plants	397	1,366
Semiunderground	71	34
Underground	97	12
Total	565	1,412

Tables II–VIII and II–IX show the breakdown of plants to be dispersed and the percentage of completion of plants as obtained from Munitions Ministry sources.

TABLE II–VIII.—*Underground construction planned and actual*

Company	Number of underground plants	Planned area	Completed area [1]	Percent completion
		Square feet	*Square feet*	
Mitsubishi	33	3,726,400	2,212,700	59
Nakajima	16	3,719,200	2,094,500	56
Naval air depots	10	1,334,700	815,200	61
Kawasaki	4	950,400	433,000	46
Ishikawajima	7	643,000	439,300	68
Aichi	3	418,000	260,000	62
Sumitomo	3	389,000	371,000	95
Hitachi	3	387,500	119,000	31
Kawanishi	6	349,500	157,800	45
Tachikawa air arsenal	2	349,000	191,000	55
Nippon	6	142,600	91,900	65
Mitaka	1	72,000	7,200	10
Fuji	2	59,600	36,900	62
Kyushu [2]	4			
Total	100	12,540,300	7,229,500	58

[1] Completed area refers to excavation only, not to productive area.
[2] No specific data available.

Construction of Underground Plants

Although the construction of some underground plants began in November and December 1944, the large-scale construction did not start until January, February, March, and April, 1945.

Part of the construction work on aircraft plants was done by the Army and the Navy construction forces. The balance was done by private con-

TABLE II–IX.—*Number and percentage of completion of dispersed plants*

I. PLANTS ORDERED BY THE MUNITIONS MINISTRY

Type of plant	Total plants	Surface					Semiunderground					Underground				
		Total	Percentage				Total	Percentage				Total	Percentage			
			More than 80	50 to 80	30 to 50	Less than 30		More than 80	50 to 80	30 to 50	Less than 30		More than 80	50 to 80	30 to 50	Less than 30
Aircraft	565	397	269	76	16	36	71	38	13	11	9	97	47	15	12	23
Aircraft equipment	109	78	48	6	6	18	8	3	2	2	1	23	10	4	5	4
All other	901	716	355	109	134	138	53	22	11	11	9	132	46	29	27	36
Total for all industries	1,575	1,191	672	191	156	192	132	63	26	24	19	252	97	48	44	63

II. PLANTS ORDERED BY THE PREFECTURAL COUNCILS

Aircraft	1,412	1,366	432	208	273	453	34	18	6	3	7	12	5	3	1	3
Aircraft equipment	247	239	41	56	34	108	2		1		1	6	1	1		4
All other	2,588	2,488	497	484	306	1,111	57	15	11	11	20	43	9	7	6	21
Total for all industries	4,247	4,093	970	748	613	1,672	93	33	18	14	28	61	15	11	7	28

SOURCE—Capital Equipment and Construction Division, USSBS.

tractors who were hired by the manufacturers or by the government.

The drain of the underground aircraft plant program on the construction industry may be seen from the following quotation from the preliminary report of the Capital Equipment and Construction Division of the United States Strategic Bombing Survey:

> The underground program was the single biggest drain upon the construction labor force; although only 17 percent of all dispersal plants in the first plan were to be underground, 32 percent of all the man-days required by the program were put into underground work. The major underground construction effort was directed at the aircraft and the aircraft-parts industry, 68 percent of the man-days involved in underground construction going into work on aircraft and aircraft-parts plants. (Table II–X.)

TABLE II–X.—*Employment in man-days in dispersal works ordered by the munitions ministry*

[12 March–15 August 1945. All figures in man-days]

Type of plant	Total	Surface	Semiunderground	Underground
Aircraft	16,044,000	6,335,000	2,186,000	7,523,000
Aircraft equipment	2,811,000	1,634,000	464,000	713,000
Total—All industries (including aviation)	38,102,000	21,762,000	4,276,000	12,064,000

From the very beginning of construction, the Japanese were hampered by many factors which prevented the realization of their program. Transportation was a principal bottleneck and was listed by the Mitsubishi and Kawanishi companies as the chief deterrent. Most of the underground sites were located in hilly and mountainous areas and these sites generally were not served by railroads. The usual access to these sites were narrow, poorly maintained country roads, often wide enough for only one vehicle, sometimes barely passable by jeep. In only a few cases did an existing railroad pass within one-half mile of an underground plant. The outstanding plant of this type was the Nakajima plant at Yusenji near Komatsu on the northwest coast of Japan which was excellently served by both rail and highway. At the other end of the scale is the Mitsubishi plant at Nukatani south of Kanazawa. This plant was built 750 feet high into the hills several miles from the nearest highway. A new mountain road and several bridges had to be built before the plant became accessible. Furthermore the winter snows would close the mountain roads in this region for 4 months each year.

The chief means of transporting supplies to underground locations were trucks. In many instances, however, oxcarts were used. At Nukatani, previously mentioned, the machine tools were moved laboriously up the hill by sheer manpower pulling them on wooden rollers.

The transportation shortage was felt in the movement of machine tools and equipment from factory to dispersal location, in the transport of workers from area to area and to and from work, in the delivery of construction materials, and in the delivery of final products in those cases where production had begun.

The other shortages preventing greater realization of plans included the following:

heavy earth-moving equipment;
dynamite;
cement;
lumber (actually this was partially a transportation bottleneck which created local shortages of lumber); and
trained geologists and mining engineers.

The shortage of trained geologists arose when many factories started going underground simultaneously. Because qualified geologists were scarce, some plants were dug in improper sites which led to unexpected amounts of shoring, landslides, excessive water and moisture in the tunnels, and other difficulties.

The difficulties besetting the aircraft companies is well summarized by the Japan Airplane Co.'s statement:

> Our dispersal program was first planned in December 1944. At the beginning of this plan, almost all of the dispersal plants were designed as underground factories, so we made the utmost efforts to obtain suitable topography.
>
> At first we expected to accomplish these plans by May 1945. But the development of construction was very slow, owing to frequent air attack, difficulties in obtaining material, labor, food, and their transportation.
>
> The degree of construction of the underground factories was about 40 percent to 80 percent at the end of the war. Our attempt at the construction of underground plants had failed.

From the reports of the aircraft companies it is possible to account for 100 underground aircraft plants. These had a planned floor area of 12,540,300 square feet, of which 7,229,500 square feet, or 58 percent, of plan were completed. (Table II–VIII.)

The number and percentage of plants in various stages of completion is shown below in Table II–XI.

TABLE II–XI.—*Degree of completion of excavation for underground plants*

In percent	Number of plants	Percent
More than 80	40	42
51 to 80	14	15
30 to 50	18	19
Less than 30	23	24
Total	95	100
Unknown	5	
Total	100	

Cost of construction data are available for only two plants, the Taira and Ofuna plants of the Fuji Aircraft Co., both of which were to manufacture airframe parts.

The cost to 15 August of the Taira plant was 2,300,000 yen for the construction of 18,000 square feet of a planned 36,000 square feet. At Ofuna, 18,900 square feet of a planned 23,600 square feet were completed at a cost of 1,513,000 yen.

Both of these plants were newly excavated tunnels.

Types of Underground Sites

The precipitous Japanese terrain and the types of rock formations in the hills and mountains were admirably suited for the construction of underground plants.

Six different general types of sites were seen and are listed below in Table II–XII.

TABLE II–XII.—*Types of underground sites*

	Number	Planned area	Completed area
		Square feet	*Square feet*
Newly excavated tunnels	73	8, 815, 500	4, 570, 100
Stone quarries	7	1, 641, 600	1, 080, 900
Railroad and streetcar tunnels	5	854, 500	838, 500
Sand quarries	3	369, 000	336, 000
Department-store basements	3	356, 400	356, 400
Railroad viaducts	1	10, 700	10, 700
Unknown	8	492, 600	36, 900
Total	100	12, 540, 300	7, 229, 500

The usual type of newly excavated tunnel was located in the projecting slope or spur of a hill that allowed tunnels 600 to 1,200 feet long to be bored from one side of the hill to the other. The steep slope of the hills provided overhead cover of only several feet at the entrances but reached several hundred feet over the real network of tunnels.

Tufa, or tuff, was the most prevalent type of rock formation in which the tunnels were carved. Tufa is a light gray colored rock which is formed of compacted volcanic dust and ash and is usually stratified.

Among the most advanced plants of this type were the Kukuri plant of Mitsubishi No. 4 works, the Yoshimatsu plant of the Nakajima Omiya Works, the Seto plant of the Aichi Aircraft Company and the Yokosuka plant of the First Naval Air Depot. The Mizunami plant of the Kawasaki Aircraft Company had not reached a very high state of completion but eventually would have become the second largest of all underground plants with an area of 642,000 square feet.

Plants of the type just discussed occupied the most important part of the underground scheme. They totaled about 70 percent of planned and about 63 percent of the completed underground area.

Abandoned stone quarries or mines were second in importance as far as area is concerned but were by far the most spectacular plants and included the most advanced of all underground plants in Japan.

These seven plants were concentrated in two areas. Five were located on the northwest coast of Honshu between Kanazawa and Sabae. The other two were near Utsunomiya, 60 miles north of Tokyo.

The caves at Oya and Shiroyama and Utsunomiya had served as a source of building stone which for years had gone into shrines, temples, public baths and other buildings. Instead of open quarries, the Japanese tunneled into the sides of the hills and carved huge underground rooms some of which measured 40 to 80 feet high and 100 to 200 feet long.

The largest of all underground plants in Japan was the system at Oya and Shiroyama. The Nakajima Company had an airframe plant at Shiroyama with a planned area of 649,700 square feet and an engine plant at Oya with a planned area of 389,000 square feet. The completed areas were 333,000 and 289,000 square feet respectively.

The stone quarries on the northwest coast were similar to the ones at Oya but not on such a grand scale. These quarries furnished a building stone called "Shakutani stone," famous for its use in many of the modern buildings in Tokyo, Osaka, Nagoya and Kyoto.

Abandoned railroad and streetcar tunnels were a third type of underground area to be encoun-

tered. These sites provided tunnels that were complete, well reinforced, and ready for the installation of machine tools and equipment as soon as the rails were removed. Generally speaking these tunnels were in pairs and were sufficiently wide to permit the positioning of two rows of tools per tunnel.

The tunnels were usually quite long; for example, the Mochimune plant of Mitsubishi No. 6 engine works was situated in four tunnels, two of which were 3,300 feet long, the other two 3,000 feet long.

The Obonai railroad tunnel plant of the Omiya works of the Nakajima Company was the farthest north of all underground plants and was believed to be almost invulnerable to direct air attack. It was located in a deep valley in the central spine of mountains on the border of Akita prefecture between Morioka and Akita. This valley was ordinarily covered by clouds which gave rise to the feeling of security at this spot.

The comparative ease of preparation of these plants is indicated by the fact that three (Otani, Kiyotaki, and Mochimune) of the five were in actual production and that 98 percent of the planned floor area was ready.

The sand quarries as underground sites were localized in the low hills southwest of Tsu City which is southwest of Nagoya. These plants were enlargements of tunnels that had been dug to obtain sand for abrasives. There were 15 separate areas in use by Mitsubishi, Sumitomo, and Aichi Companies all of which were to work in conjunction with the Tsu Naval Arsenal.

The sand quarries more nearly resembled the excavated tunnels in style and did not begin to approach the stone quarries in degree of usefulness. They were small in size, built on several levels and required much work before being ready for production.

They provided a flying start, nevertheless, and all these plants were in production by the middle of the summer, 1945. Ninety-one percent of a planned 369,000 square feet were completed.

Department store basements are not, strictly speaking, underground plants but because of their dispersed nature and of their substantial overhead cover, they are mentioned here. Three cases of this type, two in Osaka and one in Kyoto, were studied.

The aircraft companies had taken over the first, second and third basements of these large modern structures. The heaviest machine tools were erected on the bottom level with lighter tools on the first and second basements.

The presence of power, light, sanitary facilities and comparative ease of transportation made it relatively easy to get these plants into production during May and June 1945.

The only case of a railroad overpass being used to house a machine shop was the Katsura plant of Mitsubishi No. 8 engine works near Kyoto. The erection of mud walls on the trestles which supported the viaduct served to enclose an area of more than 10,000 square feet and to make possible an efficient small machine shop of 72 machine tools which was effectively hidden from the eyes of the aerial camera. This plant also is not a true example of a completely underground plant. It would have been vulnerable to direct air attack if discovered or probably would have been destroyed in any systematic bombing of rail facilities.

In at least two instances, the Mitsubishi Company was considering the use of water tunnels of electric power plants as dispersed underground plants. However, these plans never got beyond the negotiation stage and were not investigated.

Geographical Location of Plants

The terrain of Japan made it possible to dig underground plants in almost any part of the country. In practice, they were constructed from one end of Honshu to the other, in Shikoku and in Kyushu. So far as is known, none were built in Hokkaido.

The principal areas in which the aircraft industry went underground were:

The hills just west of Tokyo, Yokohama and Yokosuka.

Hills and stone quarries up to 100 miles northwest and north of Tokyo.

Hills and stone quarries along the northwest coast of Honshu from Sabae to Toyama.

The hills 10 to 20 miles northeast of Nagoya.

The hills surrounding and northwest of Osaka and Kyoto.

The sand mines at Tsu City south of Nagoya.

The hills surrounding Kumamoto and Fukuoka on Kyushu.

Scattered points along the southern coast of Honshu.

One hundred thirty-nine degrees east longitude provides a rough boundary for the Nakajima and Mitsubishi companies. Only two of the Nakajima underground plants were west of that line while

only one of the Mitsubishi plants was east of the same line.

The Ishikawajima and Nippon aircraft companies were concentrated in the hills just west of Yokohama. The Kawanishi Company built north and northwest of Kobe. Kawasaki's plants were northeast of Nagoya and between Osaka and Kyoto. The factories of the other aircraft companies were at scattered points throughout Japan.

The map (Figure II–18) shows all of the known locations of underground aircraft plants. Photographs 1–29 show entrances, machine shops and types of construction of a few underground plants.

Planned Production

From the available data, it is not possible to make a statement regarding the over-all production that had been planned for the underground plants.

Data for certain plants, however, is shown in the summary of underground aircraft plants (Table II–XIII).

One portion of the planned underground production was obtained in full for the engine branch of the Nakajima Co. Those plans were as follows:

TABLE II–XIV.—*Planned Nakajima underground engine plants*

Plant	Planned area	Planned output (engines per month)
	Square feet	
Oya	389,000	300
Fukushima	353,000	300
Asakawa	353,000	500
Yoshimatsu	353,000	300
Haranoya	353,000	300
Total	1,801,000	1,700

The total planned monthly output of 1,700 engines compares with the highest monthly output of 1914 engines produced by Nakajima in March 1944, and with the highest monthly output following that of 1,275 in August 1944.

It is not possible to predict accurately the course that the underground plants would have followed had the surrender not occurred in August. The Nakajima Co. in its reports stated that December 1945 should be considered as the month when all machine tools would have been underground and in full operation. From the observations of the plants and from an analysis of the 6 months' work prior to 15 August it seems probable that all plants would have started production, but that 100 percent operation would not have been achieved by the end of 1945.

Production in Underground Aircraft Plants

By 15 August 1945, 32 underground plants were in production and another 6 were ready to go into production in a matter of days. These plants were distributed among the aircraft companies as follows:

TABLE II–XV.—*Underground plants in production, by company*

Company	Plants in production	Plants ready for production
Mitsubishi	8	4
Nakajima	6	1
Naval air depots	7	0
Ishikawajima	4	0
Sumitomo	3	0
Aichi	2	0
Hitachi	2	0
Kawasaki	0	1
Total	32	6

Thus, of the 100 known plants, 32 percent were in production and 6 percent were about ready to produce.

By type of product, the plants in operation and those ready to operate were as follows:

TABLE II–XVI: *Underground plants in production, by product*

Product	Number in production	Number ready to produce
Engines	16	5
Airframes	9	1
Propellers	3	0
Experimental equipment	1	0
Unknown	3	0
Total	32	6

In terms of output, the results are not in themselves impressive. In the aggregate, about 29 engines, 4 complete wing assemblies, 4 complete fuselage assemblies, and some thousands of airframe and engine parts were produced underground.

The twin plants of the Nakajima Aircraft Co. at Oya and Shiroyama near Utsunomiya were the most advanced in production.

The Oya engine plant recorded production as follows:

	June	July	August	Total
New engines	1	4	6	11
Repaired engines	18	25	12	55

Photo No. 1.—Entrances to Shiroyama plant.

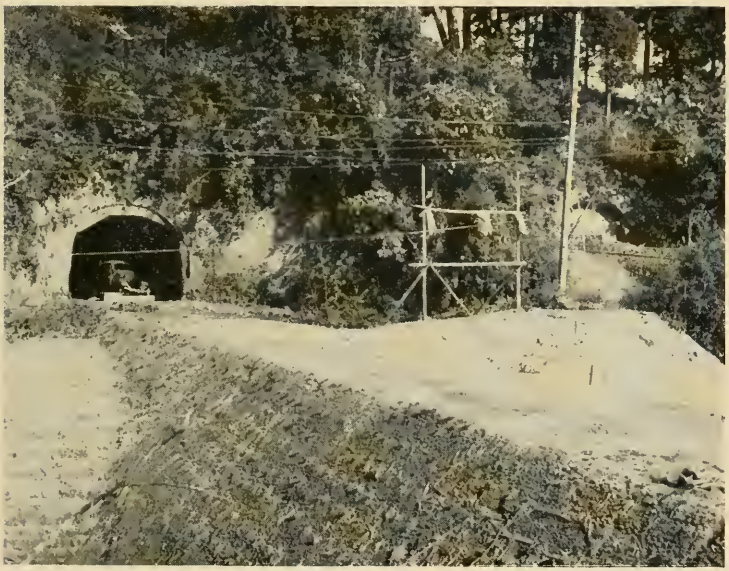


Photo No. 2.—Entrances to Oami plant. Note new roads camouflaged entrance.

Photo No. 3.—Shiroyama plant. Fuselage assembly.

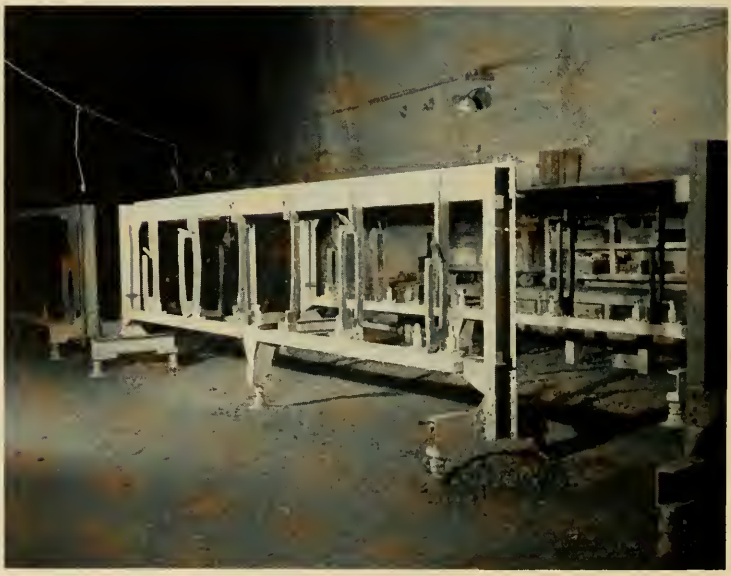


Photo No. 4.—Shiroyama plant. Wing assembly.

Photo No. 5.—Oya plant, machine shop. Work still on machine in right foreground.

Photo No. 6.—Shiroyama plant, machine shop.

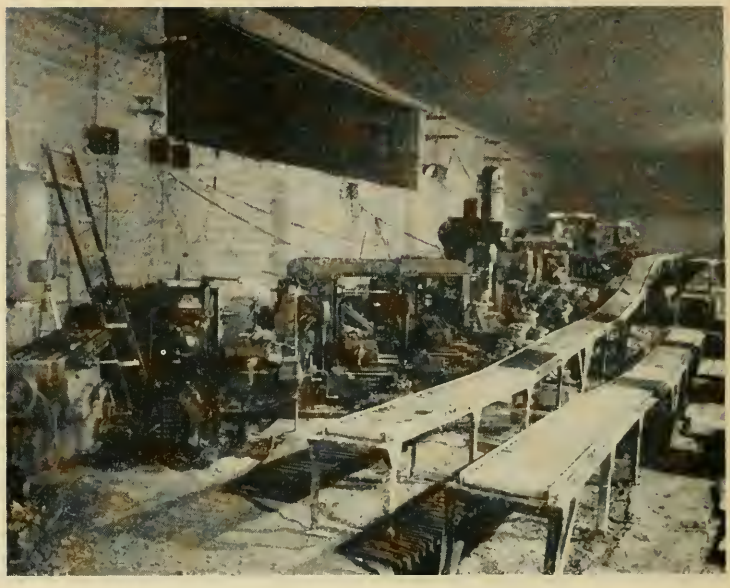


Photo No. 7.—Oya plant, machine shop.

Photo No. 8.—Oya plant, machine shop.

Photo No. 9.—Shiroyama plant, storage area.

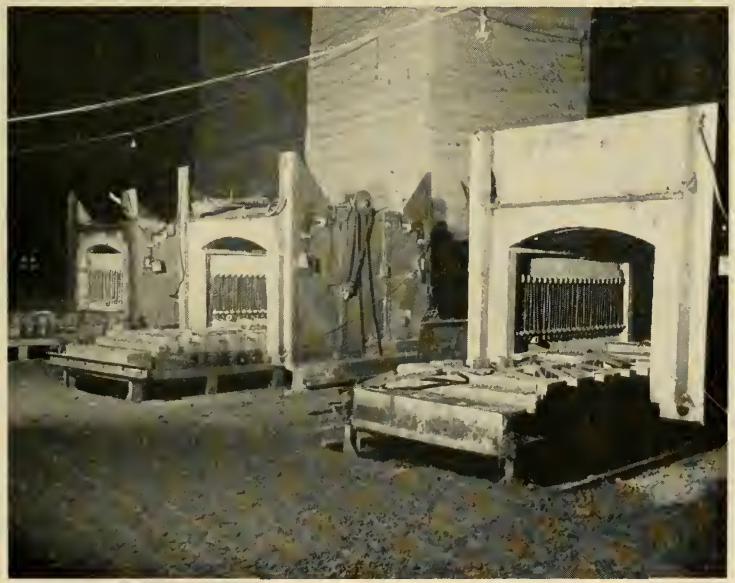


Photo No. 10.—Oya plant, electric furnaces.

Photo No. 11.—Yoshimatsu plant, heat treatment pits under construction in foreground.

Photo No. 12.—Oami plant. Note lumber roof.

Photo No. 13.—Asakawa plant. Cross tunnel used for storage of engine parts.

Photo No. 14.—Yokosuka plant, assembly tunnel.

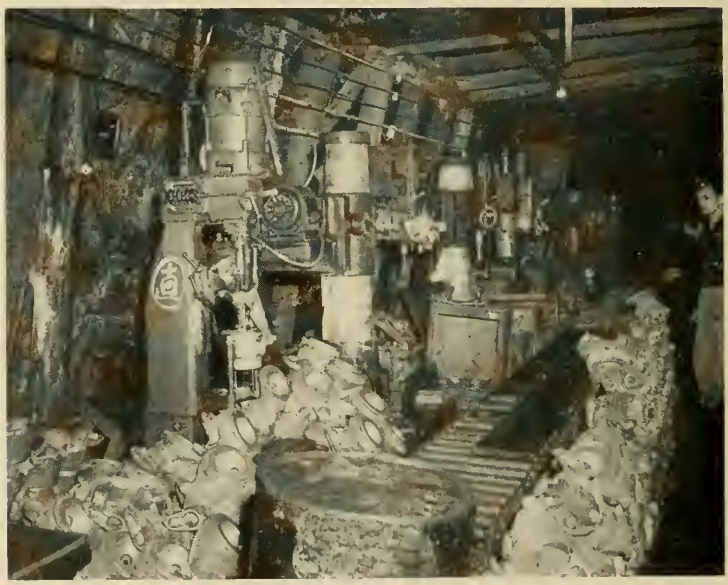


Photo No. 15.—Asakawa plant. Cylinder heads awaiting machining. Note roller conveyor.

Photo No. 16.—Site of Seto plant east Nagoya. Note spur of hill and tunnel entrance.

Photo No. 17.—Entrances to Yoshimatsu plant.

Photo No. 18.—Oya plant. Machine tools awaiting installation.

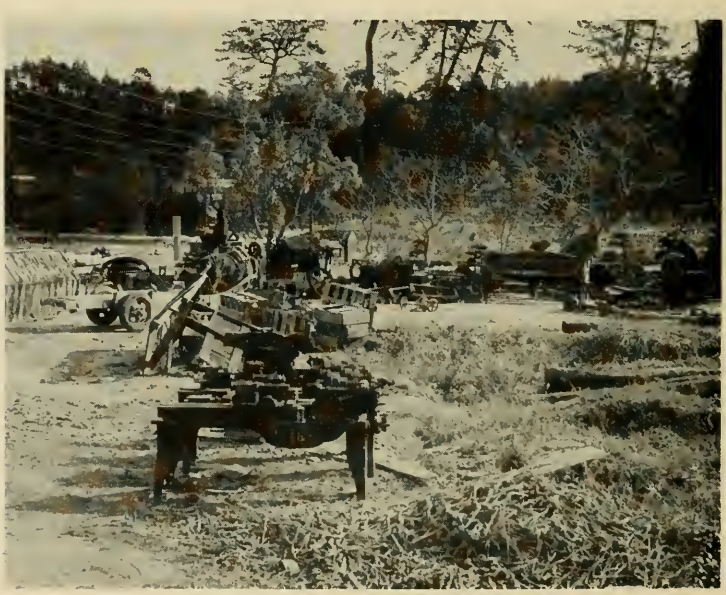


Photo No. 19.—Oami plant. Machine tools awaiting installation.

Photo No. 20.—Small tunnel used for installation of machine tools, Kukuri plant.

Photo No. 21.—Tunnels used for installation of machine tools, Asakawa plant. Note narrow gage track.

Photo No. 22.—Kukuri plant. Two long rows of machine tools.

Photo No. 23.—Kukuri plant. Machine tools being installed.

Photo No. 24.—Seto plant. Note extensive shoring.

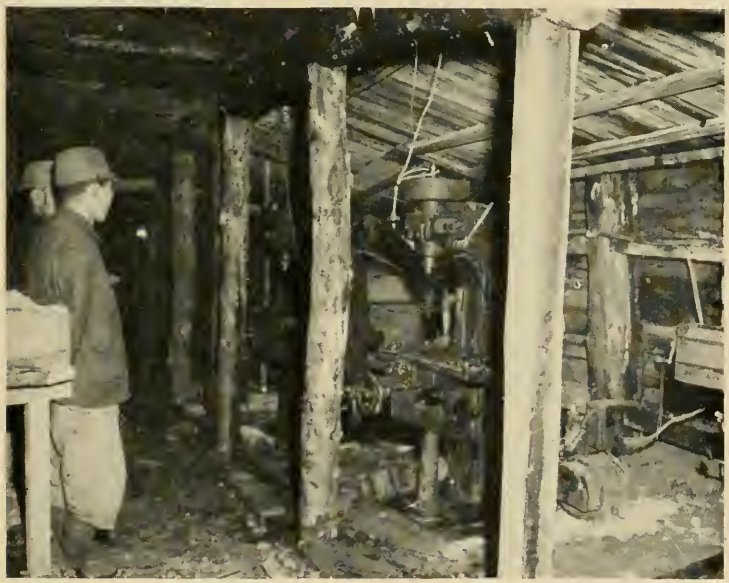


Photo No. 25.—Seto plant. The tight working quarters shown here were not uncommon.

Photo No. 26.—Yoshimatsu plant. Tunnels during construction. Soil is tufa (compacted volcanic dust).

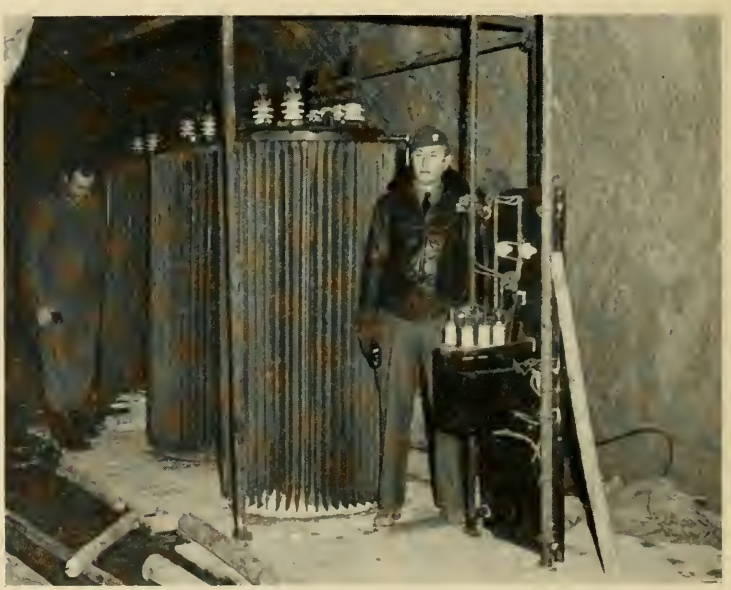


Photo No. 27.—Yoshimatsu plant. Three 250 KVA transformers.

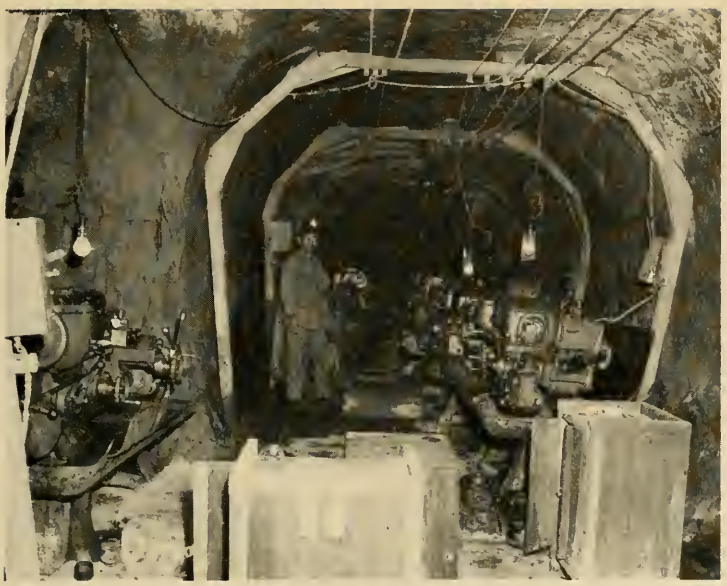


Photo No. 28.—Tunnels in sand mines near Tsu City, Handa plant.

Photo No. 29.—Handa plant. Note production tunnels opening into communications tunnel.

Production started at Oya in May with the manufacture of engine parts.

Shiroyama also started production in May and had made many airframe parts (for Ki–84, Frank) by the end of the war but the production of complete wing assemblies and complete fuselage assemblies amounted to only four each.

A list of the underground plants that were in production and known data pertaining to production follows:

TABLE II–XVII.—*Underground plants in production, by plant*

Plant and company	Date began production	Products and amount remarks
Ilisai, Mitsubishi		
Kame, Mitsubishi		
Tsuru, Mitsubishi		
Mochimune, Mitsubishi	11 June 1945	Gears, cylinders, other engine parts.
Katsura, Mitsubishi		All master rods for Kasei 25 engines.
Otani, Mitsubishi	May 1945	36 different kinds of gears.
Daimaru, Mitsubishi		Engine parts.
Kiyotaki, Mitsubishi	May 1945	Exhaust valves, planned output was 20,000 valves per month.
Yusenji, Nakajima	June 1945	Small airframe parts.
Shiroyama, Nakajima	May 1945	Airframe parts, four complete wing and fuselage assemblies completed.
Oya, Nakajima	May 1945	Made 11 new engines.
Fukushima, Nakajima		Engine parts.
Asakawa, Nakajima	June 1945	Produced 10 engines.
Yoshimatsu, Nakajima	June 1945	Produced 200–400 master rods, cylinder heads, crankshafts, counterbalances, etc.
Saiki, Ishikawajima	July 1945	Engine parts.
Somu, Ishikawajima	July 1945	Engine parts.
Yokosuka, Ishikawajima	July 1945	Engine parts.
Chuetsu, Isbikawajima	July 1945	Engine parts.
Seto, Aichi	July 1945	Wing spars.
Tsu, Aichi	July 1945	Produced eight engines.
Yokosuka, 13X naval air depot.	May 1945	Experimental equipment, jet engines, etc. Exact amounts unknown.
Isahaya, 213X naval air depot.		Experimental equipment, jet engines, etc. Exact amounts unknown.
Hiro 1, 10th naval air depot	October 1944	Airframe and final assembly.
Hiro 2, 11th naval air depot		Engines.
Yoshiura, 11th naval air depot.		
Kirigushi, 11th naval air depot.		
Iwakuni, 11th naval air depot		Fuselages.
Handa, Sumitomo	May 1945	Propeller parts.
Sogo, Sumitomo	July 1945	Propeller parts.
Matsuzakaya, Sumitomo	June 1945	Propeller parts.
Yokoto, Hitachi	August 1945	Engine parts.
Oami, Hitachi		Airframe parts.

Although the Mitsubishi Company had a greater number of underground plants in operation than the Nakajima Company, the floor area in use, the number of machine tools in operation, and the actual production by Nakajima was considerably greater than that of Mitsubishi.

Machine Tool Status

Of the highly valued machine tools which the Japanese wanted to protect, a known 9,698 were underground in various stages from testing and alignment to full production. In addition, a further 1,400 tools were estimated to have been in place. This estimate is based upon complete floor area or number of employees for those plants which failed to report the number of machine tools. Thus a total of approximately 11,000 machine tools were installed in underground factories.

Many machine tools were observed stored in schoolyards, temples, warehouses and other buildings in the vicinity of underground plants. These tools were awaiting the completion of further underground areas. It is probable that several thousand machine tools were stored in such places.

A majority of the machine tools seen underground were American made. In several cases, 100 percent of the tools were American while plants with 80 percent were common.

Employee Status

In the plants which reported the number of workers employed underground, the total number of employees was 23,400. In addition to this known figure it is estimated that approximately 15,000 more people were employed at plants which failed to report the number of employees. Thus it seems certain that between 35,000 and 40,000 workmen had been put to work in underground plants by August 1945.

Plant Layout

The most prevalent type of underground plant layout was the grid pattern followed in excavating new area.

Usually a series of parallel tunnels were dug from one side of a hill to the other. These tunnels formed the main productive area. A series of cross tunnels served as communications tunnels, roads, storage space and power plant as well as productive area in some cases.

Machine tools were lined along the walls of the main tunnels in one or two rows depending upon the size, design and use of the tunnels. The flow of material was straight-line flow from one end to the other, from the middle to both ends, or from each end to the middle.

In a few cases, narrow gauge tracks were installed for the transportation of materials. In a few other, roller type conveyors were erected along the rows of machines. However, at the war's end

by far the largest number of plants used hand carts as means of conveyance.

The layout of the plants built in stone quarries was different because of the different character of the space available. Rooms of irregular size and shape and built on several levels marked this type of site. For example, Oya, the largest of all plants, was built on three levels. It had some production areas in tunnels and others in large open rooms. Some rooms were small while others measured up to 500 feet by 300 feet. Ceilings varied from 12 to 80 feet high.

It is not surprising, therefore, that the plants built in stone quarries seemed to be better laid out and more efficient than those in tunnels.

Plant Operation Difficulties

The general level of efficiency of underground shops was very low. Except in unusual cases, the inline arrangement of work branches and machine tools coupled with restricted passageways made material handling difficult and good work planning almost impossible.

Many difficulties beset the management in attempting to achieve production. Among them were the following:

1. The damp atmosphere underground caused serious corrosion of precision machine tools, other tools and finished machined parts.

2. The damp atmosphere and moist or wet floors caused much illness among the workmen. Although the companies expected to install heating and ventilating systems, none were provided by the end of the war.

3. The critical transportation shortage was felt in the transport of machine tools, of materials and of workmen to and from the plant.

4. Worker morale was not generally high upon first going underground but improved in such places as Oya and Shiroyama where great security was felt. At other places, the dim eerie light, the damp atmosphere and the threat of the collapse of tunnels caused low morale.

Vulnerability to Bombing Attack

There are no records of any direct attacks with ordinary high explosive bombs on underground plants. Thus, it is not possible to do any more in this report than to state the protection afforded these plants by concealment and overburden.

From the standpoint of concealment from the eyes of the aerial photo interpreter or of the bombardier, there were all degrees of efficiency. In some cases, the spoil from excavation, the construction of new roads and other factors revealed the location of the plant. However, the final appearance of these plants upon completion would have made the job of the bombardier especially difficult. It was the plan, in many cases, to have as few as three entrances to the excavated areas and these entrances would have been a considerable distance away from the main plant. All of the pilot tunnels which were used as a means of ingress for the machine tools would have been closed and replanted with vegetation.

Thus at the time the war ended there was probably sufficient evidence to reveal the location of underground works. Nevertheless the task of the bombardier or the glide or dive bomber in seeking out these remote targets in steep and wooded terrain probably would not have been an easy one. As the plants were fully completed the task would have grown more difficult.

From the standpoint of protection from bombs, the subterranean works had earth cover ranging from a few feet to several hundred feet.

Typical amounts of earth cover at various spots over the tunnels are as follows:

Oya—180 feet and more.
Kukuri—60 to 180 feet over the main tunnels.
Handa—26 to 80 feet.
Mishma—15 to 20 feet.
Sabae—50 to 140 feet.
Asakawa—16 to 130 feet.
Yabutsuka—140 feet maximum.
Nukatani—155 feet maximum.
Seto—132 feet maximum.

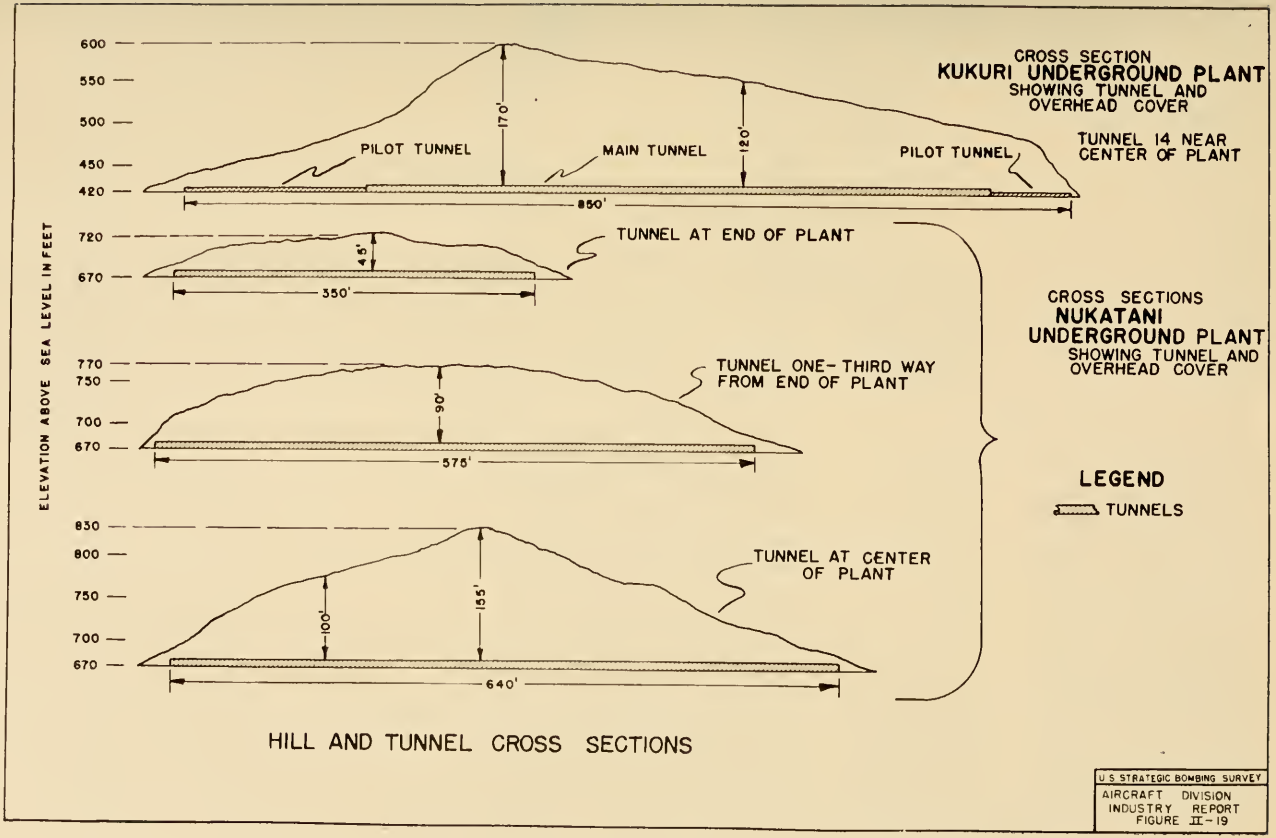
Examples of hill and tunnel cross sections are shown in Figure II–19.

Because of its reliance on transportation to keep it alive, the dispersed underground system would likely have collapsed under the impact of a strategic bombing campaign on transportation. This collapse occurred to the dispersed aircraft factories in Germany, and it is probable that the pattern would have been the same in Japan.

Many plant managers and officials in Japan agreed that the already inadequate transport system, if subjected to systematic attack, would have brought the underground and dispersed works to a virtual halt.

The indirect effect of area attacks was recorded by the Oya plant of the Nakajima Co. For 1 week after the attack on the city of Utsunomiya, city workers' attendance at Oya fell off about 20 percent.


GEOGRAPHICAL LOCATION
OF UNDERGROUND PLANTS
MILES
25 0 25 50 75 100 125
PLANTS WHOSE LOCATIONS ARE UNKNOWN
ICHIHARA
KANOZARA
MITAKA
MORURIKU
IWARUMI
KANEYAMA
UCHINOUMI
NIPPON AIRCRAFT GROUP
AOTOYAMA
HOSHIKAWA
NAGAOKA
MUBITA-CHO
HAKAMURA
MIYATACHO
SHIRAWAJIMA GROUP
SAIKI
AOTO
NEGISHI
SOMU
YOKOSUKA
CHUETSU
U.S. STRATEGIC BOMBING SURVEY
AIRCRAFT DIVISION
INDUSTRY REPORT
FIGURE II-18



HILL AND TUNNEL CROSS SECTIONS

U.S. STRATEGIC BOMBING SURVEY
AIRCRAFT INDUSTRY DIVISION REPORT
FIGURE II-19

No underground aircraft plants were in the vicinity of the explosions of the atomic bombs at Hiroshima or Nagasaki. However, the probable vulnerability of underground plants is illustrated by the experiences recorded in air-raid tunnels at Nagasaki and reported upon by the Civilian Defense Division of USSBS.

The following quotation is taken from the Civilian Defense Report No. 5, Nagasaki Field Report, Shelters, Atomic Bomb Experience (pp. 118–127):

> Investigation revealed that tunnel shelters of all types stood up well against the blast and the concussion effects of the atomic bomb. With the exception of baffle walls being blown into the entrances, none of the tunnels suffered damage, and this situation was true even of the tunnels which had no timber reinforcements.
>
> What the result would be if the bomb exploded on the ground is unknown.

In the same report the Japanese officials recorded a type of entrance which they felt would protect all personnel in underground tunnels. The plan of that entrance is shown in Figure II–20.

From the available data it is not at all clear that underground plants would be neutralized by direct air attack. The example of German collapse and the tight pinch of transport facilities in Japan leads to the belief that transportation attacks probably would have made the underground and dispersed plants worthless. The only data on direct attack with air burst of an atomic bomb shows the tunnel structure unscathed.

Only further studies beyond the scope of this report will disclose the exact vulnerability of underground plants to strategic bombing.

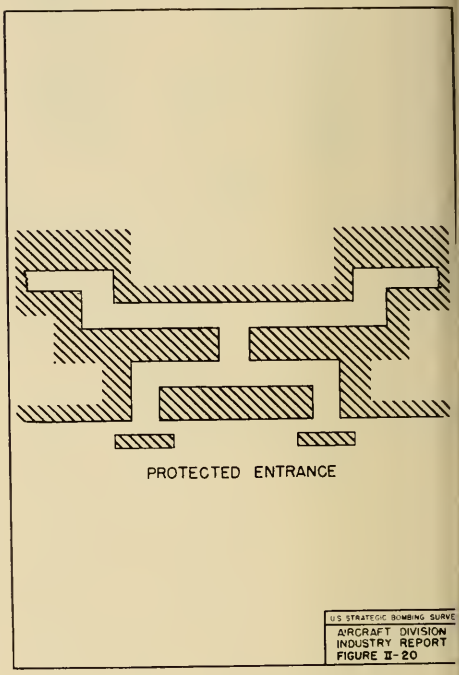


Figure II–20—Protected entrance.

TABLE II–XIII.—*Summary of underground plants*

Plant	Parent works	Prefecture	Area		Machine tools		Employees		Type of tunnel	Planned product	In production	Remarks
			Plan	Actual	Plan	Actual	Plan	Actual				
Mitsubishi Aircraft Company Air-frame plants												
1 Matsumoto	No. 1	Nagano	252,000	101,000	463	15	3,000		New excavation	Experimental aircraft.	No	Planned production of 20 experimental aircraft per month.
2 Kanozaka	No. 3		25,400	Nil		Nil		Nil	do	Airframe parts	No	
3 Hisai	No. 3	Mie	158,000	143,000	540	300	1,500	[1] 800	Sand quarry	Machined aircraft parts.	Yes	
4 Kawabe	No. 5	Gifu	198,000	160,000			4,200		New excavation	do	No	Parts for Ki–67 to be made.
5 Nikoda	No. 5	Nagano	224,200	89,000		Nil		Nil	do	do	No	Planned production of 40 Ki–83 per month.
6 Kame	No. 7	Okayama	85,000	84,000		[1] 100		[1] 200	do	do	Yes	
7 Tsuru	No. 7	do	42,500	14,400					do	do	Yes	
8 Kiba	No. 9	Kumamoto	106,000	19,100		22	1,066	600	do	do	No	
9 Yonetamura	No. 9	do	106,000	36,000		Nil	1,170	Nil	do	do	No	Parts for Ki–67 plane.
10 Shimazaki	No. 9	do	35,400	Nil		Nil	180	Nil	do	do	No	Do.
11 Sakizaka	No. 9	do	17,000	2,800		Nil	400	Nil	do	do	No	Do.
12 Kamabu	No. 9	do	14,200	1,900		Nil	250	Nil	do	do	No	Do.
13 Mizushima	No. 9	do	17,000	10,500		Nil	360	Nil	do	do	No	Do.
14 Sakashita	No. 9	do	53,000	Nil		Nil	940	Nil	do	do	No	Do.
15 Manbiyama	No. 9	do	70,800	6,400		Nil	264	Nil	do	do	No	Do.
16 Otsu	No. 9	do	35,400	Nil		Nil	430	Nil	do	do	No	Do.
17 Kamikumamoto	No. 9	do	17,700	11,900		Nil	500	Nil	do	do	No	Do.
18 Ogami	No. 11	Toyama	79,000	30,000		Nil		Nil	do	do	No	
Engine plants												
1 Kukuri	No. 4	Gifu	360,000	270,000	800	164	7,360	200	do	Engine parts	No	These 3 plants together were to produce complete engines.
2 Hiramaki	No. 4	do	252,000	38,000	700	Nil	6,000	Nil	do	do	No	
3 Gakuden	No. 4	Aichi	180,000	117,000	300		3,000		do	do	No	
4 Mochimune	No. 6	Shizuoka	162,000	146,000	577	496	[1] 1,500		Railroad tunnels	do	Yes	In production from 11 June 1945. Produced 25 sets of engine gears, cylinders, etc.
5 Fujikawa	No. 6	do	275,000			Nil		Nil	Powerhouse tunnel.	do	No	In negotiation stage only.
6 Katsura	No. 8	Kyoto	10,700	10,700	72	72	260	260	Railroad viaduct	do	Yes	Made all master rods for Kasei 25 engine.
7 Otani	No. 8	Shiga	123,700	123,700	[1] 550	290		800	Railroad tunnels	Gears parts	Yes	Production began in May 1945. Made 36 kinds of gears.
8 Daimaru	No. 8	Kyoto	28,400	28,400	170	170	900	900	Basement	Engine parts	Yes	
9 Nukatani	No. 12	Ishikawa	162,000	146,000	652	146	3,000	352	Stone mine	Injectionpumps, exhaust turbines.	No	Ready for production.
10 Kiyotaki	No. 14	Kyoto	48,800	48,000	223	120	1,000	500	Railroad tunnel	Exhaust valves	Yes	Production began in May 1945 Planned 20,000 valves per month.
11 Shakutani	No. 18	Fukui	144,500	144,500			308	647	Stone mine	Engines	No	Ready for production.
12 Sabae Toyomura	No. 18	do	34,200	34,200	800	137		300	do	Engine parts	No	Do.
13 Sabae Shinyokoe	No. 18	do	48,200	48,200		47		100	do	do	No	Do.
14 Ichiarakawa	No. 18	do	320,000	320,000	1,200	Nil		Nil	Powerhouse tunnel.	do	No	Under negotiation only.
15 Midorigaoka	No. 20	Hiroshima	38,900	27,200	[1] 200	[1] 50	[1] 800	[1] 160	New excavation	do	No	

See footnotes at end of table.

TABLE II-XIII.—*Summary of underground plants*—Continued

Plant	Parent works	Prefecture	Area		Machine tools		Employees		Type of tunnel	Planned product	In production	Remarks
			Plan	Actual	Plan	Actual	Plan	Actual				
Nokajima Aircraft Co. airframe plants												
1 Gokan	Koizumi	Gumma	214,000	160,000	950	250	4,500	400	New excavation	Airframe parts	No	Production ready to start.
2 Tano	do	do	263,000	184,000		Nil		Nil	do	do	No	Planned 45 a/c per month. Abandoned due to poor nature of rock.
3 Yabutsuka	Ota	do	214,000	107,000		Nil		Nil	do	do	No	
4 Tsutsumigaoka	do	do	71,000	7,000		Nil		Nil	do	do	No	
5 Shirakawa	do	Fukushima	42,500	4,500		Nil		Nil	do	do	No	
6 Ynsenji	Handa	Ishikawa	214,000	86,000		100		1300	Stone mine	do	Yes	Began prodnction in June 1945.
7 Shiroyama	Utsonomiya	Tochigi	469,700	333,000	420	420	10,000	5,200	do	do	Yes	Parts for Ki-84. Production began in May.
8 Mitaka	Kurosowajiri	Iwate								do		To be nsed for experimental airframe parts. Nothing known about plant.
9 Obonai	Omiya	Akita	1200,000	1200,000		2		Nil	Railroad tunnel		No	
10 Yada	Mishima	Shiznoka	140,000	110,000	160	20		Nil	New excavation	Gun mountings	No	
11 Ooka	do	do	110,000	15,000	40	(2)		Nil	do	do	No	
Engine plants												
1 Oya	do	Tochigi	389,000	289,000	1,451	592		3,673	Stone mine	300 engines per month.	Yes	Planned 300 engines per month. Actually produced 11 engines, beginning in May. Held up by lack of explosives.
2 Fukushima	do	Fukushima	353,000	100,000	1,450	245		1,500	New excavation	do	Yes	
3 Asakawa	do	Tokyo	353,000	257,000	1,200	329		4,000	do	500 engines per month.	Yes	Production began in June. 10 engines completed.
4 Yoshimatsu	Omiya	Saitama	353,000	320,000	1,600	450	4,025	500	do	300 engines per month.	Yes	Produced 200-400 master rods, cylinder heads, crankshafts, counterbalances. 200 tools in operation. Started prodnction in June.
5 Haraooya	Hamamatsu	Shizuoka	353,000	32,000	1,450	(2)		465	do	do	No	To make crankcases, large gears.
Kawasaki Aircraft Co.												
1 Mizunami	Gifu	Gifu	642,000	283,000		100			do	Ki-67 a/c	No	Planned 60 a/c per month.
2 Wachi	do	do	73,000	30,000		Nil		Nil	do	Ki-100 a/c parts	No	Planned 3 trial a/c per month.
3 Iwakuoi	do	do	35,400	20,000		Nil		Nil	do	A/C parts	No	
4 Takatsuki		Osaka	200,000	100,000	550	40			do	Engines	No	Ready for production.
Ishikawajima Aircraft Co.												
1 Saiki		Kanagawa	130,000	130,000	60	52		277	do	Engine parts	Yes	Completed July 1945.
2 Aoto	do	do	144,000	49,000	249	86			do	do	No	
3 Negishi	do	do	139,000	65,300	280	135			do	do	No	
4 Soma	do	do	170,000	170,000	123	123			do	do	Yes	Completed July at cost of 458,000 yen.

5 Yokosuka		do	[1] 40,000	[1] 40,000	78	78	100	100	do	do	Yes	Completed July at cost of 106,000 yen.
6 Chuetsu		do	[1](130,000	[1]120,000	228	225		454)	do	do	Yes	Completed January 1945.
7 Chetsu		do	[1](100,000	[1] 65,000	200	137	500	)	do	do	No	
Aichi Aircraft Co.												
1 Seto		Aichi	110,000	110,000	800	[1] 300		[1] 1,000	do	Airframe	Yes	Production began in July 1945. Spars for Judy.
2 Tsu		Mie	150,000	150,000	478	478		[1] 1,200	Sand Quarry	Engines	Yes	Production began in July 1945. Made a total of 8 engines.
3 Hokuriku			158,000	Nil	500	Nil		Nil	New excavation		No	
Naval air depots												
1 Yokosuka	1st NA depot	Kanagawa	375,000	375,000		[1] 800			do	Experimental	Yes	Began production about May 1945. Producing jet engines, other experimental equipment.
2 Isahaya	21st NA depot	Nagasaki	6,600	6,600					do		Yes	
3 Kaneyama	do		20,300	16,200					do		No	
4 Hiro (1)	11th NA depot		258,100	142,000				906		Aircraft		
5 Hiro (2)	do		206,200	94,300				700		Engines		
6 Yoshiura	do		112,200	84,500				265				
7 Kirigushi	do		39,200	23,000				119				
8 Kaitaichi	do		40,900	7,500				42				
9 Uchiumi	do		18,200	16,100								
10 Iwakuni	do		258,000	50,000				130		Fuselages		
Sumitomo Propeller Co.												
1 Handa, Tsu		Mie	61,000	43,000	640	271	4,500	725	Sand quarry	Propeller parts	Yes	Began producing in May 1945.
2 Sogo		Osaka	239,000	239,000	143	143	1,060	1,019	Basement	do	Yes	Began producing in July 1945.
3 Matsuzaka ya		do	89,000	89,000	247	247	1,600	1,116	do	do	Yes	Began producing in June 1945.
Kawanishi Aircraft Co.												
1 Shomeji	Fukuchiyama	Kyoto	69,500	69,000	154	154	500		New excavation	Airframe parts	No	Power not installed.
2 Isa	do	do	11,800	11,800					do	do	No	Do.
3 Shikoku	Shikoku	Tokushima	6,400	Nil		Nil		Nil	do	do	No	
4 Koyoen		Hyogo	7,800	7,000	123	123	500	500	do		No	Do.
5 Hojo	Himoji	do	75,000	[1] 64,000	309	261	1,200	1,000	do		No	
6 Kurakuen	Konan	do	179,000	40,000	209				do		No	Planned 30 a/c per month.
Army air arsenal												
1 Hayashi	Tachikawa	Ishikawa	177,000	53,000	800				do		No	
2 Shichisei	do	Tokyo	172,000	138,000	800				do			
Hitachi Aircraft Co.												
1 Yokoto		do	19,000	19,000	91	91	310	310	do	Engine parts	Yes	Completed August.
2 Oami	Chiba	Chiba	120,000	50,000	277	[1] 80	518		do	Airframe	Yes	
3 Yashima		Saitama	248,500	50,000	1,280	Nil	8,700	Nil	do	Engines	No	Planned for June 1946.
Mituka Aircraft Co.												
1 (Kobiki Hachioji)		Tokyo	72,000	7,200					do		No	

See footnotes at end of table.

TABLE II–XIII.—*Summary of underground plants*—Continued

Plant	Parent works	Prefecture	Area		Machine tools		Employees		Type of tunnel	Planned product	In production	Remarks
			Plan	Actual	Plan	Actual	Plan	Actual				
Fuji Aircraft Co.												
1 Taira		Fukushima	36,000	18,000	47	47			New excavation	Airframe parts		Cost of 2,300,000 yen.
2 Ofuna		Kanagawa	23,600	18,900	150	50			do	do		Cost of 1,513,000 yen.
Nippon Aircraft Co.												
1 Aoto-yama		do	58,000	26,000	80	Nil			do	Machine shop	No	
2 Hoshikawa		do	50,000	42,000	210	Nil			do	do	No	Project abandoned. All areas used as warehouses. Abandonment caused by slowness of construction, difficulty in getting materials, labor, food, and transportation.
3 Nagaoka		Shizuoka	6,000	6,000	20	Nil			do	Sheet metal	No	
4 Mugita-cho		Kanagawa	17,000	14,000	15	Nil			do	Airframe assembly	No	
5 Nakamura		do	7,300	2,900	32	Nil			do	Jig shop	No	
6 Miyata-cho		do	3,700	1,000	4	Nil			do	Forge shop	No	
Kyushu												
1 Ohashi	Itazuke	Fukuoka										Precise data unknown.
2 Kashii-miya	Kashu	do										
3 Wajiro	do	do										
4 Otogane	Zasshonokuma	do										

[1] Estimate from observation, remarks in corporation reports, etc.

[2] Plants which were visited by members of aircraft division, USSBS, or whose managers and staff were interviewed in the course of other investigations in that area.

Part III

JAPANESE AIRCRAFT—THE PRODUCT

A. SERVICE TYPES—GENERAL

Although before the war there had been a relatively small production of aircraft for private and for civilian transport use, from 1939 onward the entire output of the Japanese aircraft industry was absorbed by the military services.

During the course of the war a considerable variety of types and models and variations on models appeared. As shown in Table III–I, no less than 90 basic types (53 Navy and 37 Army) were carried on the identification lists. Clearly, the Japanese suffered from a severe case of "modelitis" with its attendant complications. All items were never in production at any one time, but as of the beginning of 1945, the Navy had in production three types of fighter, four dive bombers, two torpedo bombers, one medium bomber, five reconnaissance, one piloted bomb, one transport, one flying boat, and five types of trainers. The corresponding set-up for the Army was (by types) four fighters, three bombers, two recces, one transport, one suicide-piloted plane, and four trainers. Such diversification may have seemed necessary to the tactical planners, but it did not tend to make the procurement problems any easier.

Shift in Type Distribution

The change in type distribution during the course of the war is of interest from a production standpoint. Figure III–1 has been drawn to show the changing ratios by principal types, Army and Navy combined. There was a marked swing toward preponderance of smaller, lighter fighter types toward the end, as the war assumed a more defensive character. This change was doubtless of real military significance, rather than one designed for propaganda reasons. (Production of lighter airframes made possible a larger unit output while the actual weight production remained static or decreased.)

The relative importance in production of the major types of aircraft has been discussed. In Figure III–2, the actual production by quarters is shown. The most significant curve is that which shows the steep rise in fighter production from approximately 750 in the third quarter 1942 to 3,750 in the third quarter of 1944. Trainer production reached its peak of 1,812 planes in the second quarter of 1944, more than three times the production in the second quarter a year earlier.

TABLE III–1.—*Japanese military aircraft—Number of types, models, and variations on basic models (MIS–USN)*

Navy			Army		
Type	Basic models	Variations	Type	Basic models	Variations
1-engine fighter	6	14	1-engine fighter	7	11
2-engine fighter	4	5	2-engine fighter	2	2
Seaplane fighter	2	2			
1-engine bomber	6	15	1-engine bomber	3	3
2-engine bomber	4	11	2-engine bomber	9	13
4-engine bomber	3	4			
1-engine recce	12	13	1-engine recce	4	4
2-engine recce	3	3	2-engine recce	3	5
2-engine flying boat	1	1			
4-engine flying boat	2	6			
2-engine transport	2	8	2-engine transport	5	7
4-engine transport	2	2			
Trainer	6	28	Trainer	4	7
Total	53	112	Total	37	52
Combined totals for Army and Navy				90	164

Bomber production more or less leveled off beginning in the last quarter of 1943, while reconnaissance aircraft reached its peak during the same quarter. The rise in the production curve for other types is due to glider production in 1944.

Single versus Twin Engines

The concentration of production on combat aircraft types using one engine began after mid-1942. Production of single-engine planes rose from 403 for the first quarter in 1941 to 1,073 in the third quarter of 1942; by the third quarter of 1943 production of single-engine planes had reached 2,617. During these same periods twin-engine planes increased from 154 during the first quarter of 1941 to 864 in the third quarter of 1943. Figure III–3 gives the curves of production of single-engine and twin-engine airplanes.

The peak of single-engine aircraft output came during the fourth quarter of 1944, but the peak for twin-engine types had been reached a quarter earlier. It was fortunate that the Japanese Army and Navy had ordered a larger proportion of single-engine planes during this period, as the troubles with engine production and the downward trend after March 1944 would have made the final combat airplane output even smaller had there

been more twin-engine planes for which to provide original installation engines and a larger number of spares.

Bomber production increased during the war, but emphasis on this type of plane decreased. Generally speaking more than a forth of all planes produced from 1941 to 1943 were bombers. This proportion dropped to less than a fifth of the total during 1944 and 1945.

Reconnaissance aircraft showed little change in relative importance until 1944 when they dropped to less than 10 percent of the total output.

The changes which occurred in relative importance of trainer aircraft in the production picture are of considerable interest. During the first quarter of 1941 trainer aircraft comprised more than a third (37.9 percent) of the output; this proportion declined to 15.6 percent in the second quarter of 1943 and rose steadily for a year. The planned expansion of pilot training in late 1943 and in 1944 caused the great increase in trainer output. Trainer aircraft continued to be second only to fighter types during the remainder of the war, even though pilot training was abandoned in the spring of 1945. The trainers produced after 1 April 1945 were scheduled, for the most part, to be used as kamikaze or special attack suicide airplanes.

The Japanese never placed as much importance on transport aircraft as the United States did. One of the principal reasons was the fact that obsolete twin-engine bombers and, later in the war, twin-engine trainers were used for transport purposes. The few boats (included in "others" on the chart) were used for transport as well as reconnaissance. In the "others" group on the chart are included some gliders made in 1944 and about 100 special suicide planes made in the few months before the close of the war.

Although the relative importance of the various types changed during the course of the war, little effect in terms of airframe weight was noticed. Unlike the German pattern in which the rapid increase in fighter output was related to a negligible change in airframe weight output, it was found that the two measures of production—airframe weight and numbers of aircraft—followed the same trend with the peak of each measure in September 1944. Two of the reasons for this interesting pattern are the presence of a larger proportion of single-engine bombers and the absence of four-engine bombers in the Japanese production story.

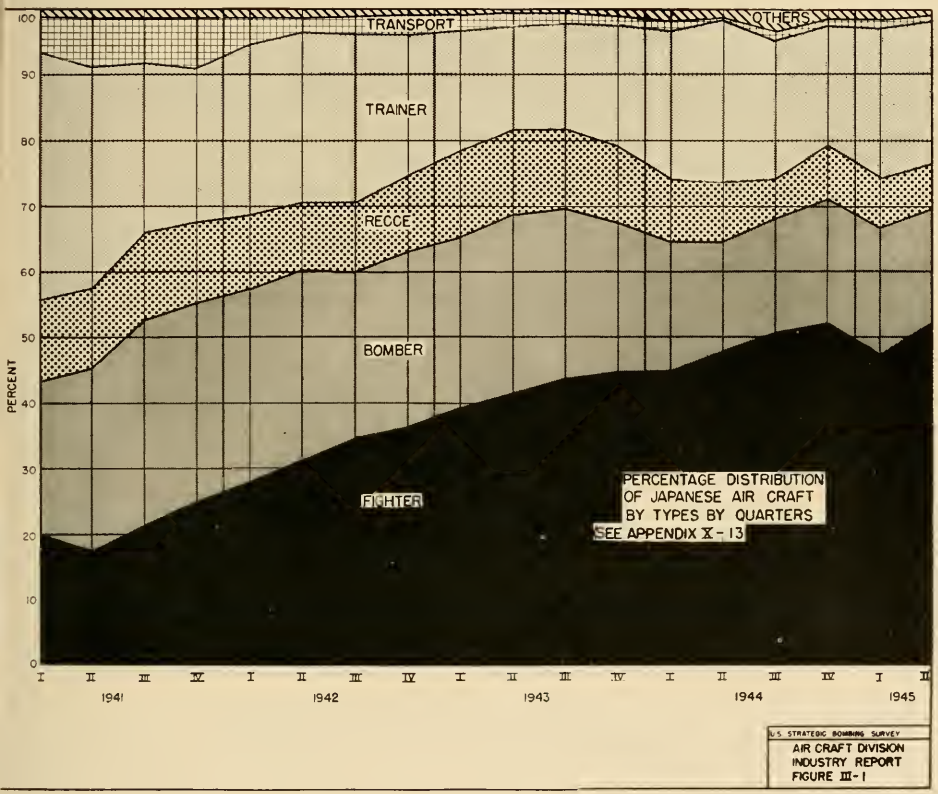
Number Versus Weight

Production measured in terms of airframe weight has frequently been used to indicate the impact of production schedules on the industry. It has been assumed that the greater the weight in pounds, the greater has been the load carried by industry. Thus when the number of airplanes remains constant but the weight of airframes produced increases, the conclusion drawn has been that the aircraft industry is increasing production. This was the case with the United States airplane industry when there was concentration on four-engine bombers and the output in numbers of planes actually declined. In Germany, however, the number of aircraft (single-engine fighters, for the most part) increased rapidly in 1944 while airframe weight produced changed very little.

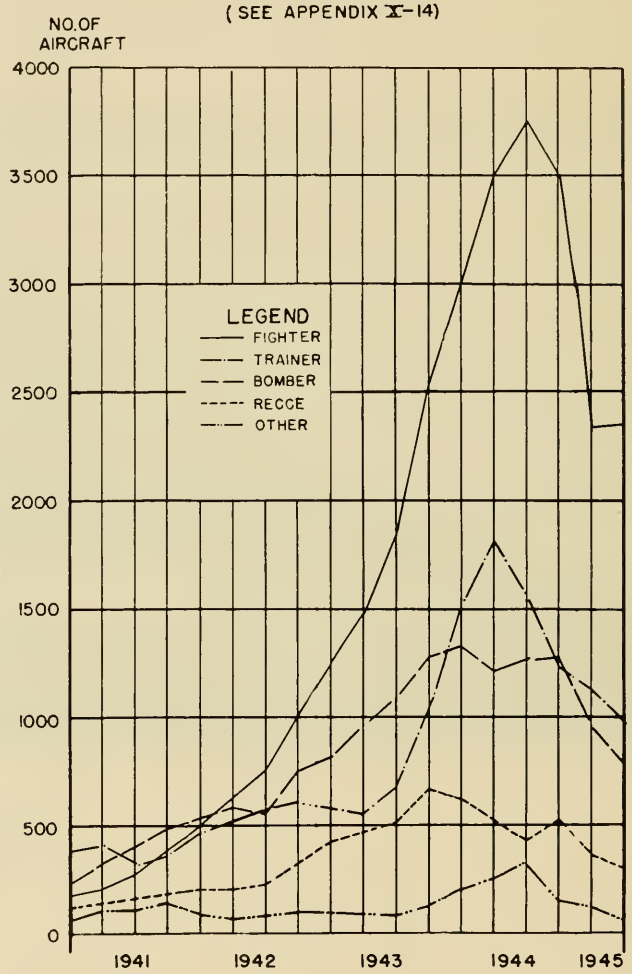
In Japan, neither the United States nor German pattern was followed. On Figure III–4 there are two curves; (1) index of airframe weight and (2) index of number of aircraft. It will be observed that production expressed in both numbers and weight rise and fall in the general pattern.

The relative increase in numbers of aircraft produced was slightly greater than airframe weight during the period October 1943 to July 1944 but the curves of both indices following the same pattern of change. The balance of types of aircraft did not change in sufficient degree to make airframe weight decrease while number of aircraft increased, as in the case of German production; and at no time did the Japs concentrate on heavy aircraft as did the United States.

Type distribution in Japan was much more stable than in Germany. Trainer production was maintained to the end in spite of evidence that pilot training was being cut to the bone because of shortages of aviation gasoline. It is probable, however, that these machines would have seen very little service as trainers. They were obviously intended for the final kamikaze effort against invasion. It is the opinion of some observers that the superior maneuverability and range of low-powered trainers carrying a reasonable load of explosives, as contrasted with the Baka-type piloted bomb, made them effective suicide attack weapons. Further, they were cheap to build and could be flown well enough by relatively unskilled pilots. They were considered expendable.

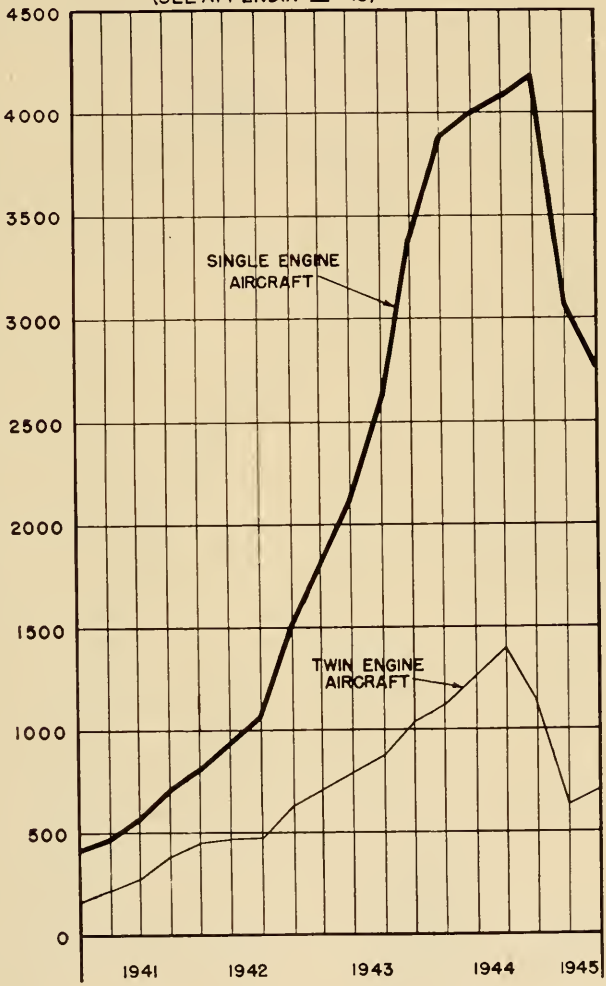

TRANSPORT
OTHERS
TRAINER
RECCE
BOMBER
FIGHTER
PERCENT
100
90
80
70
60
50
40
30
20
10
0
I II III IV I II III IV I II III IV I II III IV I II
1941
1942
1943
1944
1945
PERCENTAGE DISTRIBUTION
OF JAPANESE AIR CRAFT
BY TYPES BY QUARTERS
SEE APPENDIX X - 13
U.S. STRATEGIC BOMBING SURVEY
AIR CRAFT DIVISION
INDUSTRY REPORT
FIGURE III-1

QUARTERLY PRODUCTION OF JAPANESE AIRCRAFT
BY FUNCTIONAL TYPES
1941 TO 1945
(SEE APPENDIX X-14)

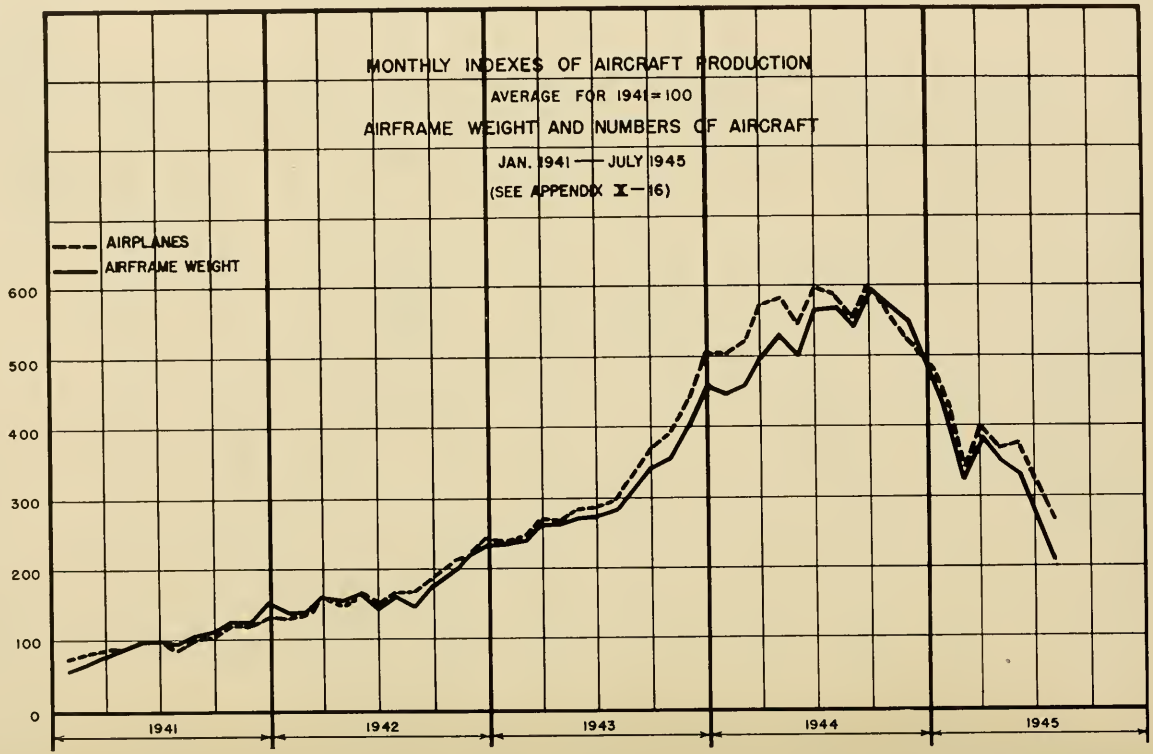


U S STRATEGIC BOMBING SURVEY
AIRCRAFT DIVISION
INDUSTRY REPORT
FIGURE III-2

QUARTERLY PRODUCTION OF JAPANESE COMBAT AIRCRAFT
BY NUMBER OF ENGINES INSTALLED
1941 — 1945
(SEE APPENDIX X—15)



U.S. STRATEGIC BOMBING SURVEY
AIRCRAFT DIVISION
INDUSTRY REPORT
FIGURE III—3



U.S. STRATEGIC BOMBING SURVEY
AIRCRAFT DIVISION
INDUSTRY REPORT
FIGURE III—4

B. CONVENTIONAL AIRCRAFT

In Mitsubishi's Zeke fighter and Betty bomber, both for the Navy, the Japanese started with the basic designs which they thought were capable of waging a winning war in the Pacific. When the fatal faults of inflammability and lack of fire power became evident in these planes, the Japanese developed the symptoms of "Modelitis" previously noted.

Zeke and Betty, in improved versions, were still on the scene at the end of the war, but primary emphasis was shifting toward Mitsubishi's Peggy bomber and Nakajima's Frank fighter, both for the Army. The Navy's primary interest had shifted toward Nakajima's Frances bomber and Kawanishi's George fighter. The short range, heavily armed, and armored interceptor had become the favorite.

In type emphasis, the Japanese had shifted from a well-balanced offensive air force at the start of the war, equally divided between bombers and fighters to, in 1945, a production schedule calling for twice as many fighters as bombers (in Fig. III–1). This was a steady trend evident even in late 1942 and early 1943 when the Japanese were still on the offensive. This shift from bombers to fighters does not show the expected relative drop in total airframe weight, because most of the early bombers were twin-engine and of relatively light design while the late fighters were approaching American fighters in gross weight.

There is no intention in this report to go into the technical details of Japanese military aircraft. The air technical intelligence groups of our Army and Navy have sent special missions into Japan for the purpose of studying designs and design damages. They have examined many aircraft, engines and accessories in the field. Samples of every type of interest have been returned to the zones of the interior for complete flight and structural tests. Reports on such tests should be available to industry in due course.

In order to give a clear idea of the basic production problems of the several principal manufacturers, however, a series of three-view silhouettes of their combat aircraft are presented in the following pages (Fig. III–5).

Because certain special purpose and kamikaze types were a typically Japanese development, more attention has been given to their design features than to the more conventional types. With the exception of some bakas (Oka 11) released against United States invasion forces at Okinawa, few of these machines came into actual service.

C. ADVANCED TYPES

Jet and Rocket Fighters

Japan was 1 to 2 years behind Germany in the production of jet-propelled fighter aircraft. No original Japanese jet fighter designs reached the production stage before the close of the war. The entire emphasis was concentrated on one plane of German design. The J8M1 Shusui (Navy) and Ki–201 (Army) were patterned after the German ME–163.

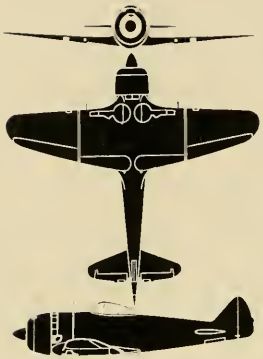
A sample ME–163 together with other aircraft equipment and plans and a complement of technicians were reported to have been sent to Japan by ship according to German sources. The plans were removed at Singapore and flown to Japan, but the ship was sunk en route, and models and technicians were lost. Japanese sources agree they received one set of prints but that no help in the design was ever given them by German engineers or technicians.

The First Naval Technical Air Arsenal at Yokosuka led in the development of the Shusui. It had been agreed that production planes were to be divided two-thirds to the Army and one-third to the Navy. Technical planning was concentrated at the Yokosuka Arsenal with Mitsubishi engineers assisting in the design.

The plane as produced shows variations from the original ME–163, as only sketchy technical data was reported received with the plans. It was the tailless type with ailerons used as elevators. Undercarriage was detachable at take-off and landing was made on a skid. It was powered by a Toku-Ro No. 2 chemical rocket using hydrogen peroxide-hydrazine hydrate. General specifications and performances as furnished by Japanese sources were as follows:

Span, 31.17 feet
Length, 19.19 feet.
Wing area, 190.52 square feet.
Weight empty, 3,185 pounds.
Normal load, 6,614 pounds.
Overload, 8,532 pounds.
Fuel capacity, 4,363 pounds.
Armament, two 30-mm. caliber cannon using magazines of 50 rounds ammunition in each gun.
Climbing, 2 minutes 30 seconds to 20,000 feet; 3 minutes 30 seconds to 33,000 feet.

NAKAJIMA

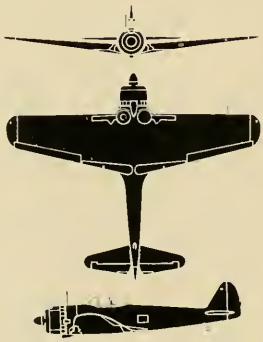


"TOJO"
ARMY FIGHTER

SPAN	31.0 FT.
LENGTH	29.2 FT.
APPROX. AIRFRAME WEIGHT	2700 LB.

"IRVING"
NAVY NIGHT FIGHTER

SPAN	55.7 FT.
LENGTH	39.9 FT.
APPROX. AIRFRAME WEIGHT	8100 LB.



"OSCAR"
ARMY FIGHTER

SPAN	35.6 FT.
LENGTH	29.2 FT.
APPROX. AIRFRAME WEIGHT	2850 LB.

NAKAJIMA

"HELEN"
NAVY BOMBER

SPAN	66.6 FT.
LENGTH	54.0 FT.
APPROX. AIRFRAME WEIGHT	10,700 LB.

"FRANCES"
NAVY BOMBER

SPAN	65.6 FT.
LENGTH	49.2 FT.
APPROX. AIRFRAME WEIGHT	14,500 LB.

"JILL"
NAVY TORPEDO BOMBER

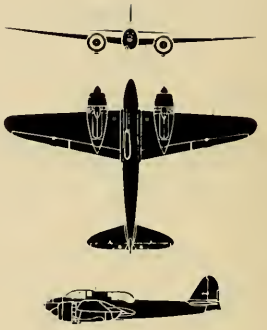
SPAN	49.0 FT.
LENGTH	36.1 FT.
APPROX. AIRFRAME WEIGHT	2875 LB.

KAWASAKI

"TONY"

ARMY FIGHTER

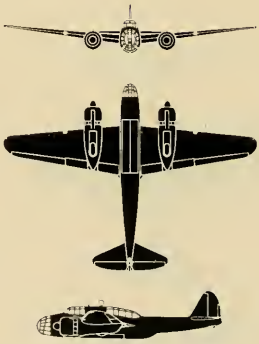
SPAN	39.3 FT.
LENGTH	28.9 FT.
APPROX. AIRFRAME WEIGHT	3700 LB



"NICK"

ARMY FIGHTER

SPAN	49.5 FT.
LENGTH	34.7 FT
APPROX. AIRFRAME WEIGHT	5700 LB.



"LILY"

ARMY BOMBER

SPAN	57.3 FT.
LENGTH	42.1 FT.
APPROX. AIRFRAME WEIGHT	7100 LB.

MITSUBISHI

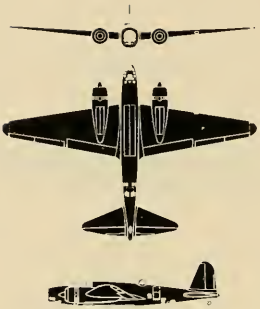
"ZEKE"
NAVY FIGHTER

SPAN	36.2 FT.
LENGTH	29.8 FT.
APPROX. AIRFRAME WEIGHT	2900 LB.

"JACK"
NAVY FIGHTER

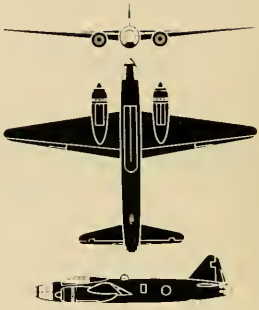
SPAN	35.4 FT.
LENGTH	31.8 FT.
APPROX. AIRFRAME WEIGHT	3200 LB.

MITSUBISHI



"SALLY"
ARMY BOMBER

SPAN	74.6 F T.
LENGTH	53.0 F T.
APPROX. AIRFRAME WEIGHT	16,400 LB.



"BETTY"
NAVY BOMBER

SPAN	82.0 F T.
LENGTH	64.5 F T.
APPROX. AIRFRAME WEIGHT	14,000 L B.

"DINAH"
ARMY RECONNAISANCE

SPAN	48.3 F T.
LENGTH	36.3 F T.
APPROX. AIRFRAME WEIGHT	5500 L B.

AICHI

"JUDY"

NAVY TORPEDO BOMBER

SPAN	37.8 FT.
LENGTH	33.6 FT.
APPROX. AIRFRAME WEIGHT	4000 LB.

KAWANISHI

"EMILY"

NAVY PATROL BOMBER

SPAN	124.7 FT.
LENGTH	92.3 FT.
APPROX. AIRFRAME WEIGHT	31,000 LB

Duration, 5 minutes 30 seconds after 33,000-foot climb at maximum speed of 500 miles per hour.

Original plans contemplated the production of 155 planes by March 1945, 1,200 by September 1945, and 3,600 by March 1946. Power-plant development was slower than planned, however, and it was necessary to revise the program downward twice, once in April, and again in July.

Schedule—number of aircraft—1945

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Total
Mitsubishi Jukogyo	5	30	120	15	26	40	20	70	100	426
Nippon Hikoki				12	30	60	10	40	95	247
Fuji Airplane Co.				5	10	20	5	10	20	70
Nisson Yuso Hikoki									1	1
Total	5	30	120	32	66	120	35	120	216	744

Actual production was greatly under scheduled production. The first complete plane with engine made by Mitsubishi and Yokosuka Air Arsenal was flown in July 1945. It crashed on the first flight because of trouble believed to have been caused by the uncovering of the standpipe in the fuel tank during a steep climb. The airframe for the second to the sixth planes were practically complete by the end of the war. At that time Nippon Hikoki and Fuji were also assembling their first planes. Fuel for the Shusui was made by Edogawa Kogyo-sho (N202) and Mitsubishi-Kasei (NH2) 2H20. These facilities were considered by the Japanese to have been inadequate. Had the war continued, it is believed this plane could not have progressed much beyond the experimental stage until well into 1946, notwithstanding the emphasis placed upon it to meet the incoming B–29 attacks.

Attention is invited to Appendix V which is from a report dated 6 December 1945, Tokyo, by Yasujiro Okano, managing director, Mitsubishi Jukogyo Kabushiki Kaisha (Mitsubishi Heavy Industries, Ltd.), covering in detail that company's part in Shusui development. It also contains a very interesting commentary on Army-Navy cooperation.

Kamikaze Aircraft Types

In all wars, there have been numerous instances where individuals and groups intentionally gave up their lives to accomplish an objective when there was no possibility of survival. The Germans tried it occasionally against the B–17 and B–24 bomber fleets. It remained for the Japanese, however, to develop aircraft, and to train pilots to be expended in what was termed by the Japanese as a "death defying, body crash" attack—"Kamikaze!" The glory of giving a life for the Emperor was played to its climax.

"Kamikaze—The Divine wind" is reported to have had its origin in the sixteenth century when during an attempted sea invasion of Japan by the Mongols their fleet was destroyed by a typhoon. This typhoon the Japanese considered to have been a "Divine wind," hence "Kamikaze."

"Kamikaze" had its modern origin with the Japanese Navy air arm which used the term to describe suicide air tactics first used in October 1944 during the Philippine campaign. Similar Army air attacks called "Tokkotai" were made during this period, but later both Navy and Army suicide air attacks came to be known as kamikaze.

Lieutenant General Kawabe, deputy chief, Imperial General Headquarters (USSBS Interview No. 377, Tokyo, 2 Nov. 1945) discussing kamikaze stated "the pilot did not start out on his mission with the intention of committing suicide. He looked upon himself as a human bomb which would destroy a certain part of the enemy fleet for his country. He considered it a glorious thing."

The strategy underlying kamikaze was outlined in the same interview. Kawabe said, "Our strategy was aimed solely at the destruction of your fleet and transport fleet when it landed here in Japan. It was not very difficult to manufacture makeshift planes, and it was not difficult to train pilots for such a duty; and since pilots were willing, we had no shortage of volunteers. It was more a question of manufacturing than shortage of pilots. We knew we could never win the war, but we never gave up the idea of continuing the fight, using whatever special attack planes we could manufacture."

Practically all specially built kamikaze airplanes had their training plane counterpart. Volunteer and selected pilots in both the Army and the Navy were given special training in kamikaze. There is every indication that in an invasion of Honshu and Kyushu, large scale kamikaze operations would have been inaugurated, using not only specially built aircraft, but also trainers, and all types of combat aircraft. The following discussion will cover only the specially built kamikaze aircraft. Specially designed and constructed kamikaze actually were to represent a small pro-

portion of what was to be the total kamikaze effort. All types of aircraft were to be used—particularly trainers, which, although slow, presented few vulnerable spots, and were difficult to destroy.

Oka 11

The Navy led in the development of special attack aircraft with "Oka" 11, commonly known by its allied code name "Baka." Oka 11 was the first of the baka type. It was strictly a suicide weapon from the drafting board up, and was an expression in itself of the state of mind of the Japanese nation in the closing months of the war. It was primarily designed as an anti-invasion or coastal defense weapon to be launched from a parent aircraft. Later designs were for catapult launching. The baka aircraft encountered at Okinawa were all Oka 11's. This baby aircraft was 19 feet 10 inches long and had a wing span of 16 feet 5 inches. The cockpit hood was the highest part being 3 feet 10 inches. About one-third of the length of the plane was taken up by the war head weighing 2,645 pounds. The cockpit in the central portion of the fuselage contained a small bucket seat with standard but limited primary-trainer-type controls and instruments. Voice communication was provided with the parent plane until launching. This first baka was powered by three solid-fuel rockets in the tail of the fuselage, but the effective range of the rockets was almost nil and it was necessary to release the plane practically within the gliding range of its target.

A Navy two-engined bomber, G4M3, Betty was modified to carry Oka 11 by nestling it below the bomb bay. This slow, cumbersome parent airplane proved to be extremely vulnerable in view of the necessity of approaching within a few miles of the target. The Okinawa campaign quickly proved its ineffectiveness and production of Oka 11 ceased in March 1945. In all, 755 Oka 11 were produced on the following schedule:

1944:		1945:	
September	10	January	160
October	50	February	197
November	95	March	150
December	93		

Of these, 155 were built at the First Naval Technical Arsenal at Yokosuka and 600 at the First Naval Air Depot at Kasumigaura. The Nihon Airplane Co., at Yokohoma City and the Fuji Airplane Co., at Kanagawa were subcontractors for wings and empenage.

Oka 22

Oka 22 was planned to be an improved version to overcome the difficulties encountered in the first Oka. The newer, faster, and more maneuverable Navy aircraft P1Y1 Francis was selected as a parent. Because of its more limited clearance it was necessary to reduce the size of the Oka 22 to a wing spread of 13 feet 11 inches but with a length of 22 feet 8 inches.

The war head was reduced from 2,645 to 1,320 pounds. In order to increase the range so that it could be released about 70 miles from the target, a Campini jet-type engine was installed. This engine was designated as Tsu 11 type in which the turbocompressor was driven by a four-cylinder in-line 100-horsepower engine built by Hitachi at Tachikawa, and shipped to Chiba where the jet unit was built and installed. Assemblies were then shipped to Yokosuka and Aichi for installation (Photos 23 and 24).

The production schedule for Oka 22 provided for 50 to be built at the First Naval Technical Air Arsenal at Yokosuka and 200 at the Aichi Aircraft Co., at Nagoya. Subcontractors of wings, tail and fuselage included the Murakami Airplane Co., of Nigata Prefecture, the Miguro Airplane Co., of Gifu Prefecture, and the Fuji Airplane Co., of Kanagawa Prefecture. Actual production was reported limited to 50 airplanes which were produced at Yokosuka. Aichi was supposed to start production in June, but never got under way because of raid damage to its plant. Additional production was assigned therefore to Yokosuka and elaborate plans were made to protect baka assembly. Four assembly jigs were installed and in operation in one of the large assembly buildings at Yokosuka at the end of the war. One assembly building was devoted to the building of the Oka 22 trainers which was accomplished by modifying the war head to provide a dual cockpit, the addition of flaps, and skids for landing. Wings of both the kamikaze and trainer types were of wood and the rest of the airframe dural.

By the end of the war all machines and bench work at Yokosuka had been removed to some 300,000 square feet of newly constructed tunnels adjoining the base. One of the larger tunnels was being set up as a final assembly line for Oka 22, and contained a large number of subassembly parts, also engines and completed wings. Final assembly of bakas could have been carried on at Yokosuka even under severe bombing conditions.

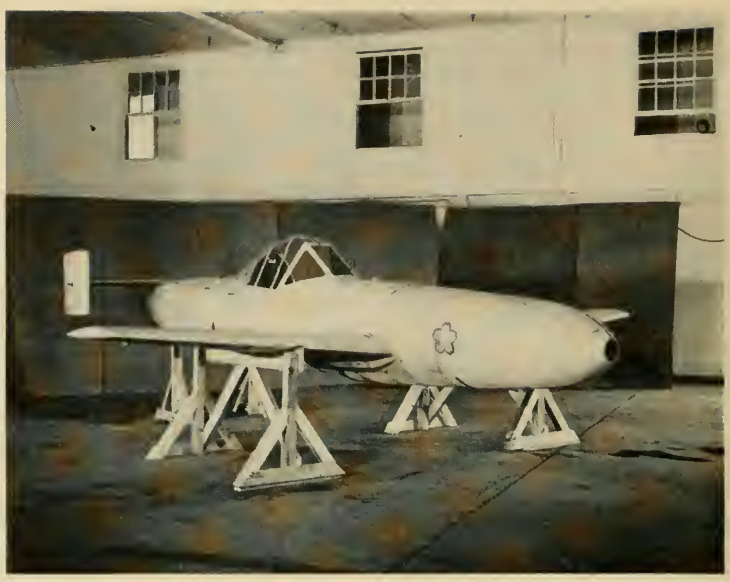


Photo No. 30.—Oka 11.

Photo No. 31.—Oka 11.

Photo No. 32.—Oka 22.

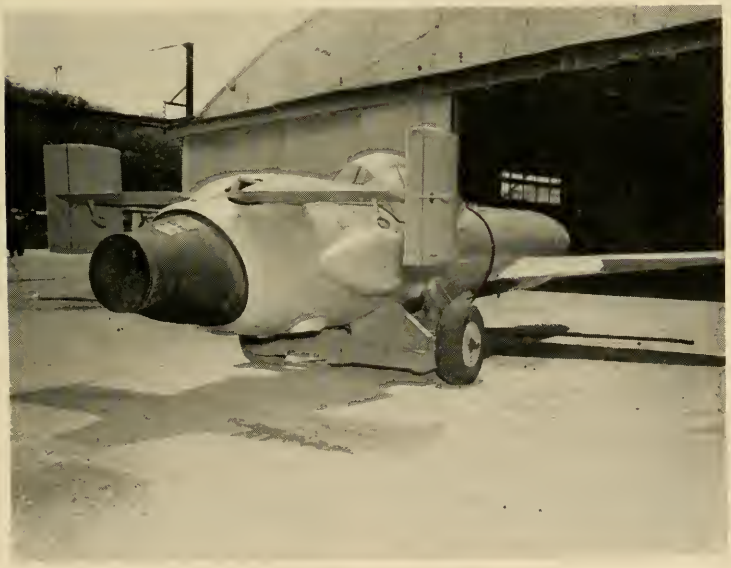


Photo No. 33.—Oka 22

Only one of the Oka 22 was reported to have been flight tested July 1945.

In the flight test, auxiliary rockets installed under the wings to give greater diving speed went off unexpectedly just after release causing a stall from which the pilot never recovered.

Auxiliary Powder Rockets

Three types of powder rockets, developed by the Navy, were used to provide extra acceleration on Oka 22, Oka 43, and Kikka all special purpose aircraft. These rockets were manufactured at the First Naval Air Depot at Kasumigura with powder from the No. 2 powder arsenal at Hiratsuka. Powder rocket specifications were as follows:

Type	Thrust (maximum)	Thrust	Time of action	Weight of charge
	Pounds	*Pounds*	*Seconds*	
Type 10	2,200	880	10	48 pounds, Oka 22 acceleration.
Type 20	4,400	1,760	10	70 pounds, Oka 43 acceleration.
Type 21	4,400	1,760	10	70 pounds, Kikka acceleration.

Jet Engines

An axial turbojet engine the "Ne" 20 was patterned after the German BMW003. Photographic prints only were received by submarine from Germany. A submarine carrying complete plans was lost. This engine had been under development at the First Naval Technical Air Arsenal at Yokosuka. The Oka series 30, 40 and 50 "Kikka" were designed to incorporate this new open type jet.

The "Ne" had a diameter of 24½ inches, a length of 105 inches, and a weight of 990 pounds. Fuel was 65 octane gasoline. Bench tests on this engine had been completed satisfactorily at Yokosuka. Test engines were then installed in "Kikka" which made a successful first flight but crashed on the second flight.

The first two "Ne" 20s were built at the First Naval Technical Air Arsenal but because of desire to place additional production projects at regular production facilities and not to load the experimental division further, it was decided to place the production of contracts for "Ne" 20s with the Naval Technical Department. It had been building naval surface ships, but because of war changed to producing jet aircraft engines to be used for kamikaze operations.

The Yokosuka Naval Yard was assigned to build 45 "Ne" 20s a month; Kure-Hiro, 20 per month; Maizuru, 20 per month; and Sasebo, 15 per month. These capacities were later to be increased by Hitachi and Mitsubishi facilities. By the end of the war, Yokosuka Air Arsenal had built 9 engines and Yokosuka Naval Base had built 12 engines. The latter were considered by the Japanese to be poor in quality largely because of lack of experience on the part of the naval shipyards in aircraft engine construction.

The Navy at the close of the war had under test three additional types of turbojet engines based on the German BMW003 and also a pulsation rocket based on V1, but no plans had been worked out for incorporating these designs.

Oka 43

The Oka series 30-40-50 which were to use the "Ne" 20s were alike except for differences in the methods of launching. Series 30 was intended to be launched from the Navy parent plane, G8N1 Rita, built by Nakajima. Neither Betty nor Francis were figured as being able to carry the greater weight planned for the Oka 30 series, which shortly was abandoned. The 50 series had been projected for launching from a tow plane. Runways, however, were too short to get the Oka air borne and this model did not progress beyond the idea stage.

Basically designed for the defense of Japan's own shores, the 40 series was intended to be launched from a land-based catapult. The following are details of Oka 43:

Span, 26 feet, 3 inches.
Length, 26 feet, 9 inches.
Weight, 5,500 pounds.
War head, 1,760 pounds.
Range, 125–175 miles.

Production of Oka 43 was scheduled as follows:

	1944						1945			
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
First naval technical air arsenal	2	4	....	....	....	....	....	....	....	6
Aichi Aircraft Co	....	5	10	20	30	50	50	64	64	293
Twelfth naval air depot	....	....	....	....	5	10	20	30	30	95

The first plane had not been completed as of the end of the war, but one of the large catapults had been built at Takeyama, west of Yokosuka and was in use to instruct Oka 43 pilots in catapult launching pending production of the weapon itself.

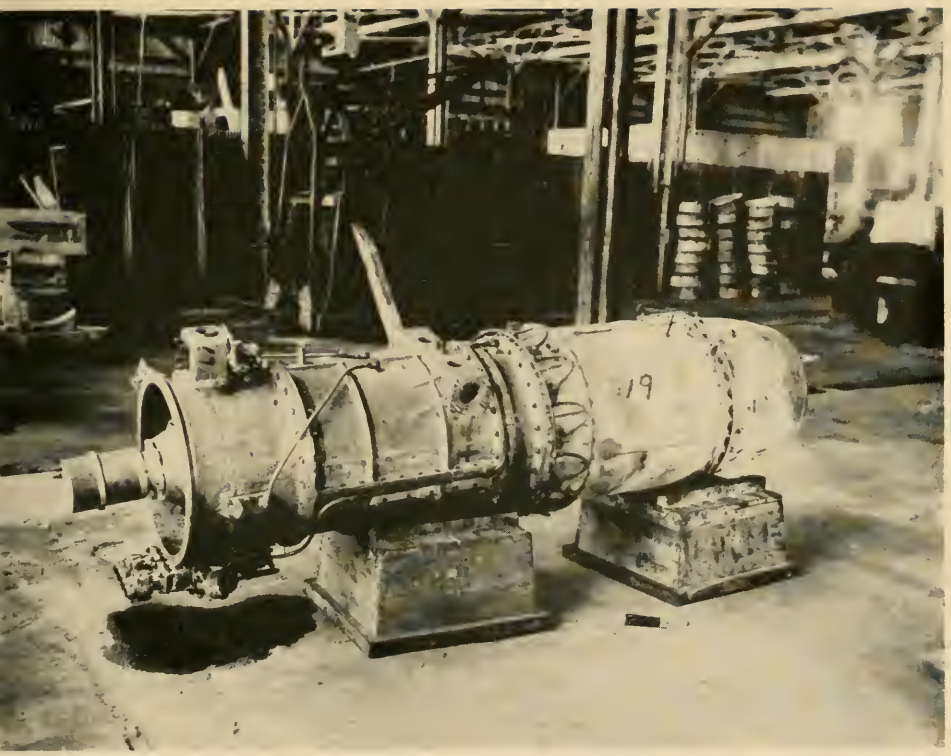


Photo No. 34.—"Ne" 20 type jet engine.

Kikka

The history of the Kikka followed closely the development of the "Ne" 20. This was to be strictly a Navy plane with no production to the Army. Its development was by the First Naval Technical Air Arsenal at Yokosuka, but in this case the Nakajima plant at Koizumi handled the design and construction of the plane.

The airplane based on the German 262 design carried two "Ne" 20 type turbine jet engines identical with the engine used in the kamikaze Oka 43. This plane was also intended to be used as a kamikaze. Construction man-hours were originally estimated at one-third the single-engine Navy fighter, but experience indicated man-hours at full production would be approximately 60 percent. Steel was used in the construction of the fuselage with wings of dural. Wings were designed to be folding for storage in caves. Starting rockets were installed under the wings. Landing gear was designed to be releasable. It carried a 1,100-pound bomb which could be released by the pilot.

This ability of the pilot to release the bomb shows a trend away from purely suicidal kamikaze philosophy and supposedly gave the pilot a fighting chance of survival. This change reflected an attempt to improve the low morale of nonvolunteer kamikaze pilots.

Principal dimensions and performance of Kikka:

Twin engine.
Low wing, single seat.
Height, 10 feet.
Span, 32.8 feet.
Length, 30.3 feet.
Wing area, 142 square feet.
Weight empty, 5,070 pounds.
Normal load, 7,716 pounds.
Overload, 8,818 pounds.
Amount fuel (normal), 1,543 pounds.
Amount fuel (maximum), 3,196 pounds.
Bomb, 1,100 pounds.
Maximum speed, 375 miles per hour at sea level.
Speed, 420 miles per hour at 20,000 feet.
Range at sea level —37 minutes; range at 20,000, feet, —49 minutes.

Scheduled production was as follows:

	1945								
	May	June	July	August	September	October	November	December	Total
Nakajima	1	2	22	45	60	50	40	20	240
Kyushu Hikoki	...	...	5	15	25	30	30	30	135
Sasebo Navy Yard	...	...	...	...	10	35	35	35	115
First naval air arsenal	...	...	...	...	...	20	30	30	80

Actual production by Nakajima was one structural test plane in May, one flight test plane in June which crashed on the second flight, and three air frames in July which were without engines and landing gears. Production was starting also at Kyushu Hikoki but no planes were completed.

"Ki–115" Army, Toka Navy

Both the Army and Navy Japanese Air Forces were greatly interested in the development of a cheap, easily built kamikaze, which would utilize small standard radial engines, and made use of the production capacities for thinly rolled steel plate to save aluminum. The Army led in the development of such a plane, and assigned its number as Ki–115. The Navy version was to be Toka.

The plane as developed incorporated an extremely simple design, and close inspection discloses that it had been pared to the bone of everything but the barest essentials for a single flight (Photo 35).

The Ha–115 engine was to be used by the Army and the Zuisei–12, Sakae 12, Kinsei 41, or Kotobuki 2 engines by the Navy. The propeller was a three-blade Hamilton type. An interesting feature of this plane was that the 1,100-pound bomb could be released by the pilot.

Principal dimensions and performance:

Single engine low wing monoplane.
Crew, 1.
Span, 31.8 feet.
Length, 27.8 feet.
Height, 10.2 feet.
Wing area, 141 square feet.
Weight, empty, 3,748 pounds.
Normal load, 5,291 pounds.
Overload, 5,512 pounds.
Range, 685 miles.
Fuel, 118.8 gallons.
Maximum speed, 322 miles per hour at 14,000 feet.

Modifications were contemplated to increase wing area to 155 square feet, to increase maneuverability, the addition of flaps and better shock absorbers for landing, and an improved canopy to better the pilots view.

Original design and experimental work was carried on by Nakajima, Mitaka Works with production at the Ota Works of Nakajima.

Planned production was as follows:

	1945										1946	
	March	April	May	June	July	August	September	October	November	December	January	February
Nakajima	3	40	110	210	220	270	280	(1)	(1)	(1)	(1)	(1)
Showa Hikoki K. K.						2	15	30	50	50	50	50
Yokosuka Navy Yard						5	30	100	150	180	18	180
Kure Navy Yard												

1 Open.

At the close of the war the Nakajima Mitaka plant had produced 22 experimental planes and the Ota plant was operating on a production basis. Monthly production at both plants was as follows:

	1945					
	March	April	May	June	July	August
Nakajima:						
Mitaka	2	2	1	5	8	4
Ota				26	55	1

Photograph 36 shows Ki–115 planes at the production line at the Ota plant. There was no production at the other facilities which were expected to start producing in August.

Pilotless Aircraft

Japanese production of pilotless aircraft was confined to radio-directionally guided missiles to be controlled by a parent plane. There was no production of gyro-controlled V1 or V2 German types, but an experimental V1 rocket motor was under construction. Mitsubishi Aircraft Co. was given an experimental Army contract in July 1944 to build a guided missile known as I–go–A. About the same time Kawasaki Aircraft Co. was ordered to develop a smaller version, known as I–go–B. The following are the principal dimensions and performance:

	I–go–A	I–go–B
Span	19.7 feet	13.1 feet.
Weight	3,250 pounds	1,650 pounds.
Speed	340 miles per hour	340 miles per hour.
Range	7 miles	7 miles.
Bomb size	1,760 pounds	660 pounds.

Both versions of I–go were powered by a hydrogen peroxide-hydrazene hydrate rocket motors similar to the Shusui. Designed for release against surface vessels, a preset altimeter maintained altitude of approximately 100 feet above the water with diving and lateral control by the parent airplane. Ki–67 Peggy was planned to be the mother which was to launch I–go in the general direction of the target at a distance of approximately 8 miles and then follow it for a distance, steering it as necessary. I–go–A never reached the production stage, but tests were reported to have been completed satisfactorily and it was ready for production at the close of the war.

Kawasaki had better success with I–go–B and built 30 units experimentally in 1944. In 1945 units were built on a production basis at the following rates:

	1945						
	January	February	March	April	May	June	July
Kawasaki	22	10	72	28	0	20	10

The Kawasaki production was carried on at its Kagamigahara (Gifu) plant. It received its propulsion units from Mitsubishi Nagoya works. A shortage of these units in May halted production which was resumed on a limited scale in June.

On completion of these units, they were shipped to the Tachikawa Army Air Depot. No units were found in the wrecked Kagamigahara plant, and those delivered to Tachikawa were reported destroyed in tests. Ministry officials stated the missile was not considered airworthy and was not sufficiently developed to have figured in the invasion defense.

D. DESIGN FEATURES

From a design standpoint, Japanese aircraft were reasonably good at the beginning of the war and improved steadily. In most categories, their flight performance was well up with our own because of their lighter weight and smaller dimension. Their lack of armor and fuel-tank protection made them vulnerable to our fire, but by the end of the war practically all models designed for tactical use were fitted with armor plate and self-sealing tanks

As a matter of fact, advanced design features (such as pressurized cabins and cockpits, laminar flow wings, counterrotating propellers, turbo- and direct-driven superchargers, jet-assisted take-off units and rocket-type engines) have been noted in the experimental aircraft discovered in many places. Few such machines ever reached the pro-

Photo No. 35.—Ki-115 Army—Toka Navy.

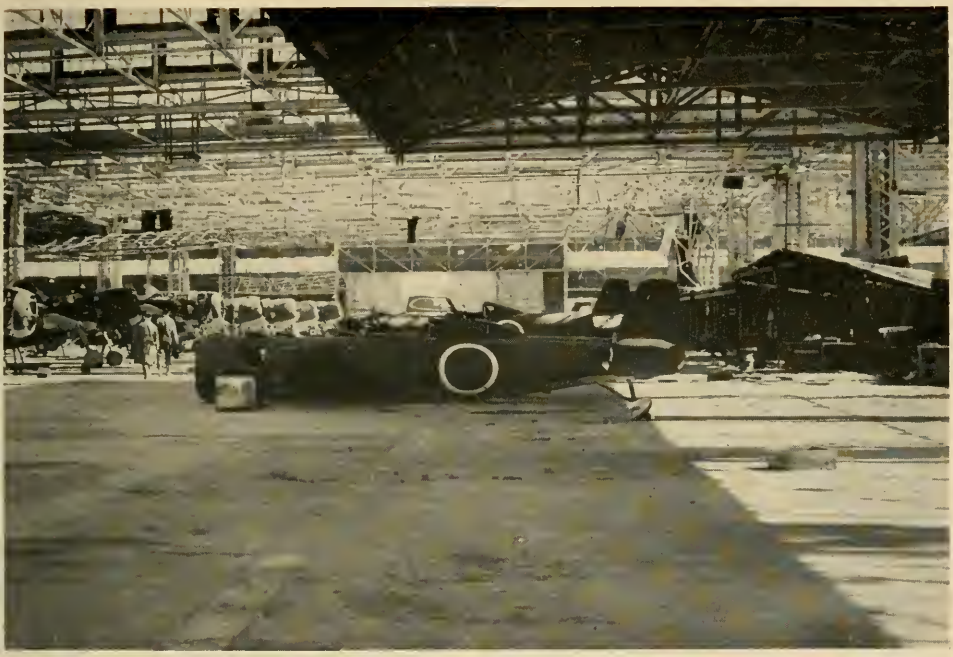


Photo No. 36.—Ki-115 plane production line Nakajima, Ota plant.

duction stage. Even if the industry had been left undisturbed by our bombers, it is doubtful if any radically new types would have become operational before spring of 1946. It would appear that aeronautical research in Japan was at least 1 to 1½ years behind that of other countries, and the application to production lagged at least another year. Their engineers were aware of technical advances elsewhere, but the country generally lacked the research capacity and talent necessary to keep up to date.

There is evidence that Germany tried to alleviate this deficiency by contributing several of the latest designs for jet- and rocket-propelled aircraft. Several German design and production men are still interned there, and have been interviewed. Experimental, Japanese-built samples of the ME–163 (single seat, tailless, rocket fighter) and the ME–262 (twin jet-propelled fighter) have been picked up. Experimental production of the JUMO 004 jet engine had been started. By the time such machines were ready for initial flight testing, however, the switch to the kamikaze type of defense had set in and the major applications of rocket and jet power went into the baka bombs.

Structural design was generally good and compared favorably with modern practice elsewhere as long as suitable materials were available. Toward the end, however, when duralumin sheet began to deteriorate in quality and strength (because of the high percentage of scrap and secondary aluminum that was used in its manufacture, and because of the shortages of copper and other alloying materials) certain design and construction compromises were made which deviated widely from good practice. In many instances, sheet-steel parts and steel fittings were substituted for dural parts, and steel and even brass rivets were used to make up the joints. Such combinations are an open invitation to rapid deterioration and eventual destruction of the structure by electrolytic corrosion. No effort was apparent to inhibit corrosion at such joints by the use of insulating materials or special coatings. Probably it was anticipated that the aircraft would have only a short operational life, and that the structure would hold together long enough to do the job for which it was intended.

By spring of 1945 the end of the aluminum supply was clearly in sight, and designers were turning their attention actively, if belatedly, to all-wood construction. Several examples of wood substitutions for wing tips, tail surfaces, tail assemblies, and fuselages as far forward as the cockpits have been found. Also several examples of almost 100-percent wood-for-metal replacement have turned up. No extensive production of either kind has come to the attention of the Aircraft Division.

Plastic materials were also short. Wood was used in many places inside cockpits for knobs, handles, and small control wheels where molded plastics normally would be found. More significantly, plain glass, much of it not even shatterproof, was used extensively in cockpit canopies, windows, and gun turrets in place of the transparent plastics common in United States and British military machines.

One of the most interesting cases of materials substitution observed so far is in the strictly suicide Type, Ki–115, which has been described in a preceding section. The whole design was an excellent example of the most economical usage of available materials. It was purely functional, without frills.

E.—QUALITY

In general, it may be said that the quality of aircraft produced was greatly reduced during the last 6 months of the war. The reasons for this reduction was the lack of equipment and supplies caused by bombing of factories and the blockading of the shipping lanes.

The documentary evidence of quality tests on airframes, engines, and raw materials was burned. All of the information was obtained through interrogation of Army and Navy officials.

The quality of the airframes is a rather difficult thing to evaluate in terms of requirements. It was stated by officials that because of the thin distribution of skilled labor the quality of airframes dropped off considerably. A large factor affecting airframe quality was the poor construction of jigs and fixtures. Poor jigs made interchangeability practically impossible. This, of course, resulted in a falling off of quality.

The test flight for aircraft at the beginning of the war and up until the last few months was 2 to 3 hours with five landings. At the end of the war an aircraft often received its test flight while enroute to the air depot where it was to be delivered. Again the reason for lowering standards was the shortage of fuel. Many of the training planes received no test flight at all.

One engine out of every 10 was withheld and broken down for a friction inspection and then

given a test run. At the outbreak of the war, all engines received this type of inspection, but, as the time factor entered in this, short cuts were made.

At the outbreak of the war the Army required approximately 7 hours running-in-time on engines, while the Navy required about 9 hours. These figures represent an average because some engines required more time and trainer engines and such required far less.

Table III–II shows the Army standards at the outbreak of the war compared with those just prior to the close of the war. Friction runs were a more drastically curtailed phase of the inspection.

TABLE III–II.—*Army engine test requirements*

Types of tests	Hours run				Remarks
	Before end of war		At outbreak of war		
Primary run.	*Hours*	*Minutes*	*Hours*	*Minutes*	
Friction run	1	00	2	30	
Take-off run		01		05	
Rated run		15		30	
Normal run		30	2	00	Normal run is eight-tenths of rated output.
Total	1	46	5	05	
Secondary run:					
Friction run		30	1	00	
Rated run		05		30	
Adjustment run		30		30	
Clearing run		05		15	
Total	1	10	2	15	
Grand total	2	56	7	20	

The Navy, whose specifications at the first of the war called for 7 hours primary run and 2 hours secondary run, reduced their requirements in the summer of 1944 to approximately 3 hours. Of this the primary run was 2 hours and the secondary 1 hour. In June 1945 the requirements were lowered to 2 hours and 11 minutes. This consisted of a friction run at 600, 800, 1,000, 1,400, 1,600, 1,800, 2,000, 2,200 revolutions per minute, for 10 minutes each at 2,400 revolutions per minute for 5 minutes, first rated horsepower for 10 minutes, second rated horsepower for 10 minutes, take-off power for 1 minute and 5 starts for a total of 35 minutes; grand total 2 hours 11 minutes.

The biggest reason for reduction of test requirements was the extreme shortage of aviation gasoline. In order to get around this difficulty, alcohol, low-grade gasoline with methanol, and water injection systems were used for test runs. These were not satisfactory and caused many difficulties. There was a great deal of trouble with the HA–35 and in July 1944 much trouble with HA–45 was experienced which slowed down production and caused changes in inspection standards.

The shortage of test cells was another reason for shortening of engine test times. This shortage was caused by the bombing of cells in operation and the shortage of materials to build new test cells for the expansion (Photo 37).

In the production of small parts, more tolerance was allowed on dimensions and general quality of castings. The officials were of the opinion that the degree of precision dropped was more than was necessary.

The shortage of raw material became more and more noticeable after June 1944. The materials that presented the greatest problem were those required for alloys. To give an example, the following table shows how materials used in the alloying of steel for crankshaft were reduced:

Alloy content reduction in stages	Nickel	Chromium	Molybdenum
	Percent	*Percent*	*Percent*
First	4.0	2.0	0.5
Second	2.0	2.0	.5
Third		4.0	.5
Fourth		4.0	

This was the case all over the aircraft industry for almost every type of material.

The procuring of metals became so difficult that the standard on flaws for magna fluxed materials had to be reduced in order to keep production going at all.

Photo No. 37.—Engine test cells, 21st Naval Air Depot, Omura.

Part IV

MATERIALS FOR AIRCRAFT CONSTRUCTION

Raw materials for the aircraft industry are confined largely to two principal types, alloys of aluminum and magnesium, and the various steels (steel alloy, high-carbon steels and ordinary steel). Aircraft production also requires a large variety of nonferrous materials, which, although limited in quantity in proportion to other uses, are extremely important.

The raw-material producers for aircraft were concentrated in four industrial areas. Names of the principal producers and areas where the plants were located is shown in Appendix VIII. This list is limited to steel, aluminum, and copper, and includes only sheet, bar tubing, extrusion, and forging plants. Refiners and producers of billets are covered in the basic materials report of the USSBS.

A. MATERIAL CONTROL

Prior to 1943 the Army and Navy exercised a limited amount of over-all control on aircraft raw-material requirements, concentrated largely in the aluminum and magnesium fields where the industries were new and were receiving Government encouragement. No real attempt was made before 1942 to determine the exact raw-material requirements for the aircraft program. In that year, both the Army and Navy (following American and British methods to some extent) attempted to forecast aluminum needs by computing requirements for individual planes. Calculations were based on the aluminum content of those planes and the amount of sheet, rod, pipe, wire, forging and casting material required for production, taking into account scrap and waste.

The forecasts for 1943 gave an average requirement for Japanese production of approximately 4½ metric tons per plane computed on weighted averages for estimated plane production. In practice this was found to be entirely too low because of the expansion of the aircraft program, the higher wartime wastage, and the need for stock-pile aluminum to eliminate bottlenecks as a result of the many types, shapes, and sizes required. New formulas were worked out and the aluminum estimate raised to approximately 5½ metric tons per plane for the 1944 requirement forecasts. The 5½-ton figure was found to be adequate for total requirements, particularly in view of instructions to the industry to reduce the average flow time of aluminum from ingot to finished plane, and also as the result of a greater concentration on fighters which required less aluminum than bombers.

Individual specialized items, however, were critical due to the inability of the Japanese to estimate their requirements properly. Navy Capt. Toshihiko Odawara of the General Affairs Section, Aeronautical Munitions Division, Munitions Ministry, in a round-table discussion on 17 November 1943 in Tokyo said:

> The problem of material unbalance must be solved by control techniques. It can't be solved if we continue to handle it as in the past. For instance, a great fuss is made over the shortage of aircraft duralumin, but an investigation at the factories shows enough for 8 or 9 months. However, there is only enough of specialized items for one-half month. The plan for manufacturing the material is at fault.

The analysis of the aluminum situation was equally applicable to steel and other materials. The failure of the government to provide adequate stock piles of nickel, cobalt, tungsten, molybdenum, and other alloying materials resulted in critical shortages of alloy steels. The glaring deficiencies in planning which would have crippled the aircraft industry completely had the war continued is evident in any analysis of individual materials going into aircraft production.

B. CRITICAL RAW MATERIALS

Aluminum

The importance of aluminum for aircraft production led to the early establishment of aluminum-producing facilities in Japan, Korea, Manchuria and Formosa. Production was started about 1933, using alumite imported from Korea and aluminous shale from North China. By 1936, production from these sources had reached 5,800 metric tons of ingots. These materials, however, proved to be less satisfactory as a source of aluminum than bauxite. Production from these sources never showed any material increase until 1944, when production was doubled by concentrating on shales as the shortage of bauxite began to be serious. Aluminum produced from shales and alumite was of considerably poorer quality than

that produced from bauxite. An attempt to develop production from clay obtained in Japan proper was unsatisfactory and never progressed beyond the pilot-plant stage.

Aluminum production from bauxite began in 1937, and production showed a rapid increase to 135,000 tons of ingot in the fiscal year beginning 1 April 1943. This was the peak. With main sources for bauxite in southern areas—Malaya, Bintan Island, and Palau—the supply was dependent entirely on shipping. The severing of connections with the southern bauxite resources by the air-sea blockade reduced primary aluminum production from an annual rate of 180,000 tons in May 1944 to 20,000 tons by June 1945. This production would have been curtailed further due to inability to obtain China shales as a result of the extension of the air-sea blockade.

Every effort was made to offset the decreasing supply of aluminum and to maintain the aircraft program. Prior to the war, aircraft production absorbed only 60 percent of primary aluminum. The balance went to civilian and other military usage. As the war progressed, the percentage allocated to aircraft increased to 100 percent by the end of 1944. All other uses of aluminum were eliminated.

The same was true in the use of secondary or scrap aluminum. Early in the war Japan followed American practice of incorporating not to exceed 20 percent manufacturing scrap with virgin metal for aircraft usage. The percentage of scrap used was increased in the fall of 1944, and from then on the deterioration in quality of available metal was extremely rapid. Aluminum was collected from all possible sources. Most of the usable scrap originated in the aircraft and aluminum industry. Damaged aircraft, utensils, coins, etc. supplied increasing amounts of casting material. By the end of the war, 80 percent of the aluminum supply came from scrap and only 20 percent from virgin pig.

It is doubtful, however, if much of the poorer grade metal ever reached the finished stage in fly-away planes except in limited amounts to fill unbalanced conditions. The pipe line from aluminum ingot to finished plane was 4 to 7 months long, and with the sharp decline in aircraft production from other causes, the bulk of the low-grade metal was probably in stock and in fabrication stages at the end of the war. The increase in operational difficulties and failures in planes undergoing delivery, although largely caused by poorer steel alloys, may be attributed to a limited extent to the use of secondary aluminum.

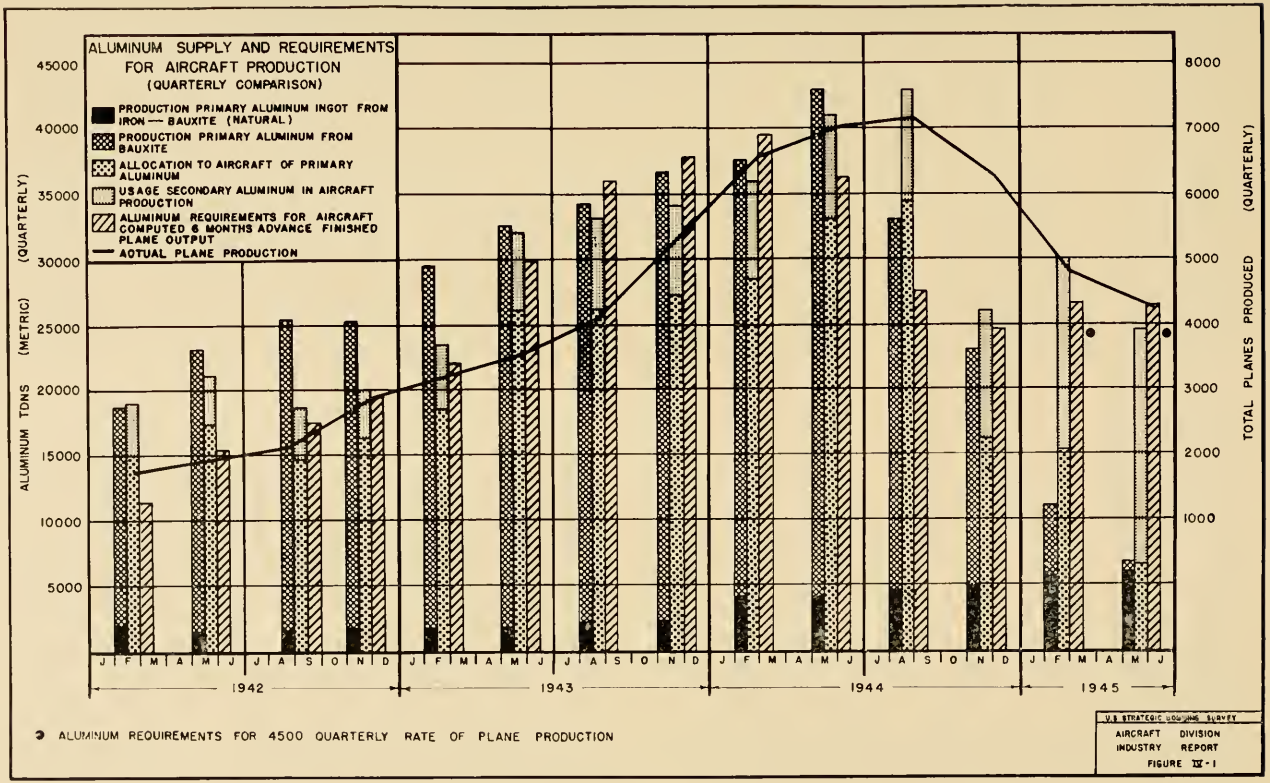
Figure IV–1 shows primary ingot production, both from bauxite and from nonbauxite sources, and its allocation to aircraft, together with the usage of secondary aluminum. For comparison purposes, production requirements of aluminum are plotted based on an estimated usage of 5.5 tons per plane multiplied by actual plane production with the product set back 6 months to allow for flow time. A curve of total plane production is shown for comparative purposes.

Allocations of primary and secondary aluminum to aircraft exceeded computed plane production requirements in 1942 and the first half of 1943. During this period production was increasing and increased stocks were needed for the larger amounts in process. The last half of 1943 and the first quarter of 1944 experienced a tightening in aluminum.

The downward trend of aircraft production in the second half of 1944 and the first half of 1945 decreased aluminum requirements. However, it will be noted on the chart that primary aluminum production declined much faster, and to meet aircraft production needs, sharply increased amounts of secondary aluminum were incorporated.

The rapid acceleration in aircraft production beginning with establishment of the Munitions Ministry in the fall of 1943 outran the allocated aluminum supply and would have required 100 percent allocation to aircraft of all primary aluminum production to meet the program. Only as a result of the slowing down of aircraft production in the late summer of 1944 and its rapid decline in the fall was a crisis in aluminum averted. Aluminum would not have been available for the continuation of the peak aircraft production rate of 2,505 planes reached in September 1944. Any increase to 5,000 planes a month as proposed by the Munitions Ministry would have been impossible. Plane production reached the level it did only by drawing on all available stocks, by better utilization of aluminum, and by shortening the production cycle. Shortages of individual and specialized items with continual need for substitution persisted and eventually forced the trend of aircraft production downward.

As of 1 January 1945 it is estimated that there were some 55 to 65 thousand tons of aluminum in stocks and in the pipe line. This would have been sufficient for a 2,500 plane production rate. The decline to a 1,500 per month rate in the first


ALUMINUM SUPPLY AND REQUIREMENTS FOR AIRCRAFT PRODUCTION
(QUARTERLY COMPARISON)
PRODUCTION PRIMARY ALUMINUM INGOT FROM IRON — BAUXITE (NATURAL)
PRODUCTION PRIMARY ALUMINUM FROM BAUXITE
ALLOCATION TO AIRCRAFT OF PRIMARY ALUMINUM
USAGE SECONDARY ALUMINUM IN AIRCRAFT PRODUCTION
ALUMINUM REQUIREMENTS FOR AIRCRAFT COMPUTED 6 MONTHS ADVANCE FINISHED PLANE OUTPUT
ACTUAL PLANE PRODUCTION
ALUMINUM TONS (METRIC) (QUARTERLY)
45000
40000
35000
30000
25000
20000
15000
10000
5000
TOTAL PLANES PRODUCED (QUARTERLY)
8000
7000
6000
5000
4000
3000
2000
1000
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J
1942
1943
1944
1945
ALUMINUM REQUIREMENTS FOR 4500 QUARTERLY RATE OF PLANE PRODUCTION
U.S. STRATEGIC BOMBING SURVEY
AIRCRAFT DIVISION
INDUSTRY REPORT
FIGURE IV-1

half of 1945 reduced requirements materially. Approximately 60,000 tons of properly balanced aluminum were required to build the 10,776 planes produced the balance of the war. Of the aluminum on hand 1 January, it is estimated only about half was of lower-than-average quality and very little, if any, would have been of the extremely poor quality produced later in 1945.

From 1 January 1945 to the end of the war some 20,000 tons of primary aluminum were produced. To this must be added 45,000 tons of secondary aluminum. The aluminum at the end of the war was estimated to have been roughly divided between stocks and in pipe line fabrication. Had production been maintained, aluminum would have become extremely critical in 1945 and forced a sharp reduction in output. The emphasis which the Japanese were placing in the latter months of the war on Kamikaze-type aircraft would have made possible the utilization of secondary aluminum and substitute materials. In Kamikaze aircraft secondary aluminum, wood, and ordinary steel were used extensively, and small amounts of the better-grade materials used judiciously could have supported a considerable program.

Magnesium

Magnesium is used in aircraft production, both as an alloy of aluminum, and for landing wheels, brackets, housings, mounts, covers, and similar parts. Japanese magnesium production paralleled that of aluminum except on a very much smaller scale. Output reached 4,947 tons in 1944, the largest year. Of the total production, 90 percent was consistently allocated to aircraft. Approximately one-third of the allocation was used to alloy with aluminum. Because of the small tonnage available, the use of magnesium for landing-wheel housings, etc., was always restricted. Only the most limited of stocks were on hand at the end of the war. Sufficient magnesium was always available and no decline in aircraft production was experienced as a result of the small supply.

Copper

Prior to the war, Japan imported more refined copper than it mined. Copper was critical throughout the war and was kept under strict allocation. The aircraft industry received 30.3 percent of the total, or 31,000 tons, in 1944. This amount barely covered the requirements for alloy, wire, and tubing, and critical shortages of such items were reported frequently. Copper would have become critical in 1945 had the maximum rate of plane production been maintained. As it was, there was always enough to fill current requirements, and no aircraft were held up because of copper shortage.

Aircraft Steels

A large amount of special alloy and high-carbon steels was used in aircraft production. Substantial amounts of ordinary steel went into jigs and fixtures and into plant construction.

Tables IV–I and IV–II outline in detail the distribution of special and ordinary steel for aircraft requirements, showing relationship between amounts planned and delivered. It will be noted the supply of ordinary steel was generally equal to aircraft requirements, but special steel was critical throughout 1944 and 1945. It was the failure of supply of high tensile strength alloy steels for engine production, landing gears, motor mounts, and terminal fittings which presented the most critical aircraft production material problems.

Although Japan was unable to effect any material increase in total finished steel output from 1937 to the end of the war (report of Basic Materials Division, USSBS), the emphasis put on alloy and high-carbon steels increased the output from some 328,000 tons in 1938 to 1,185,000 tons in 1944, as shown in Table IV–III.

Notwithstanding the sharp increase in special steel production outlined in Table IV–III the supply of every important ferro-alloy steel was insufficient to meet military requirements shortly after the outbreak of the war in 1941, and became worse as the war progressed.

In spite of every effort made to further increase alloy and high-carbon steel production, the shortage of alloy metals not only limited production but brought about a rapid decline in quality.

Prior to 1941, Japan produced approximately three-fourths of its manganese and chrome. The balance was imported chiefly from India and the Philippines. From 1943 on, manganese shortages resulted in the loss of steel production. It is estimated that only 90 percent of chrome requirements were met in 1943 and only 60 percent in 1944.

The shortages in nickel, cobalt, tungsten, vanadium, titanium, and molydenum were even more critical. Japan produced but a small percentage of these important metals. Nickel came from

New Caledonia and the Celebes, cobalt from Burma, vanadium from Peru and the United States, and molybdenum from the United States with scanty imports from Manchukuo.

The aircraft industry was given a special allocation category and top priority in the allocation for alloy steels in 1944.

The amount of ordinary and special steel delivered in the last half of 1943 and the first half of 1944 for 1944 plane production was at the rate of 9 tons per plane, with steel delivered during this period showing a substantial deterioration in quality. Subsequent receipts were of an even poorer grade.

TABLE IV–I.—*Raw material for aircraft production*

[Special steel [1] (1,000 metric tons)]

	1937	1938	1939	1940	1941	1942	1943					1944					1945	
							I	II	III	IV	Total	I	II	III	IV	Total	I	II
Air Forces (Army and Navy)																		
1. Aircraft frames and landing gear:																		
Planned												(25.6)	(32.0)	(32.8)	(23.6)	(114.0)	(19.5)	(12.6)
Delivered	0.3	8.2	6.8	16.6	17.7	23.7	5.8	7.5	9.6	11.1	34.0	18.0	22.5	22.7	22.1	85.3	15.2	.....
2. Aircraft engines and propellers:																		
Planned												(40.0)	(50.5)	(51.9)	(37.6)	(180.0)	(32.0)	(20.5)
Delivered	1.3	15.1	13.3	30.8	32.3	44.8	11.2	14.5	17.7	23.4	66.8	34.0	42.5	49.6	36.4	162.5	24.3	.....
3. Guns and bombs:																		
Planned												(38.4)	(47.5)	(49.0)	(35.1)	(170.0)	(30.5)	(19.5)
Delivered	.9	3.4	4.4	18.4	22.1	28.2	5.0	5.0	6.2	8.6	24.8	31.0	37.0	44.1	34.0	146.1	26.0	.....
4. Torpedoes:																		
Planned												(6.7)	(8.4)	(8.6)	(6.3)	(30.0)	(6.0)	(3.9)
Delivered	.2	.4	.6	3.2	3.5	4.3	.8	.8	.8	1.3	3.7	6.4	7.2	7.6	6.0	27.2	4.2	.....
5. Motorcars and bulldozers:																		
Planned												(3.1)	(3.9)	(4.0)	(3.0)	(14.0)	(2.2)	(1.5)
Delivered	.06	.2	.3	1.4	1.7	2.1	.5	.5	.5	.8	2.3	1.9	2.5	4.7	2.7	11.8	1.0	.....
6. Optical, measuring, and electrical equipment:																		
Planned												(5.3)	(6.7)	(6.9)	(5.1)	(24.0)	(4.0)	(1.4)
Delivered	.06	.2	.4	1.2	1.6	1.9	.6	.6	.6	.6	2.4	1.9	2.4	2.9	2.2	9.4	1.2	.....
7. Blocks for forging:																		
Planned												(5.3)	(6.7)	(6.9)	(5.1)	(24.0)	(4.0)	(2.6)
Delivered	.1	.3	.4	2.4	2.6	3.2	.6	.6	.6	1.0	2.8	4.8	6.4	6.5	4.6	22.3	2.8	.....
8. Machine tools and bearings:																		
Planned												(12.0)	(14.8)	(15.2)	(11.0)	(53.0)	(9.0)	(6.0)
Delivered	.2	.5	.8	4.3	4.8	5.9	1.0	1.0	1.1	1.8	4.9	7.0	8.0	12.8	9.9	37.7	6.7	.....
9. Repair parts:																		
Planned												(5.8)	(7.3)	(7.5)	(5.4)	(26.0)	(4.5)	(3.0)
Delivered	.2	.6	.8	3.1	3.9	4.6	1.1	1.2	1.2	1.6	5.1	6.5	8.0	8.8	5.9	29.2	4.8	.....
Total:																		
Planned												(142.2)	(177.8)	(182.8)	(132.2)	(635.0)	(117.7)	(71.0)
Delivered	3.3	28.9	27.8	81.4	90.2	118.7	26.6	31.7	38.3	50.2	146.8	111.5	136.5	159.7	123.8	531.5	86.2	[2] 48.0

[1] Special steel in 1944 and 1945 includes high-carbon steel in addition to alloy steels.

[2] Breakdown figures for second period not available.

TABLE IV–II

[Ordinary steel [1] (1,000 metric tons)]

	1937 [2]	1938	1939	1940	1941	1942	1943					1944					1945	
							I	II	III	IV	Total	I	II	III	IV	Total	I	II
Air Forces (Army and Navy)																		
1. Aircraft frames and fixtures:																		
Planned																		(5.8)
Delivered	23.1	26.8	27.5	30.1	38.6	33.9	9.4	10.5	10.3	10.8	41.0	13.8	13.0	9.0	7.6	43.4	6.0	
2. Aircraft engines and fixtures:																		
Planned																		(2.3)
Delivered	11.6	12.1	12.5	13.8	19.3	17.0	4.7	5.3	5.1	5.4	20.5	4.7	7.7	4.5	3.7	20.6	1.5	
3. Guns and bombs:																		
Planned																		(5.0)
Delivered	47.7	57.6	59.1	74.5	95.7	88.1	20.2	21.0	21.7	21.8	84.7	23.5	26.0	21.5	18.0	89.0	13.5	
4. Torpedoes and mines:																		
Planned																		(2.1)
Delivered	5.8	7.0	7.2	7.8	10.4	9.5	2.4	2.6	2.6	2.6	10.2		3.2	4.2	3.0	10.4	1.8	
5. Electric instruments:																		
Planned																		(1.9)
Delivered	5.4	5.5	5.7	6.9	9.1	8.2	2.6	3.0	2.7	3.0	11.3	1.9	2.8	1.7	2.1	8.5	1.4	
6. Optical instruments and gages and gas cylinders:																		
Planned																		(.8)
Delivered	2.7	2.7	2.8	3.4	4.4	4.0	1.3	1.5	1.4	1.5	5.7	1.2	1.0	1.2	.2	4.3	.8	
7. Base construction machinery:																		
Planned																		(7.2)
Delivered	38.5	40.6	41.8	50.3	67.2	61.1	17.7	19.6	19.2	20.4	76.9	20.5	25.5	16.5	12.3	74.8	7.5	
8. Construction, repairing materials, etc.:																		
Planned																		(9.6)
Delivered	57.8	55.1	57.0	63.5	96.8	85.0	24.5	27.4	26.7	28.1	106.7	45.1	24.7	16.0	22.8	108.6	11.0	
Total:																		
Planned												(79.9)	(128.9)	(57.6)	(65.9)	(350.3)	(65.0)	(34.7)
Delivered	192.6	207.4	213.6	250.3	341.5	306.8	82.8	90.9	89.7	93.6	357.0	110.7	103.9	74.6	70.4	359.6	43.5	

[1] Ordinary steel in 1937 to 1943, inclusive, includes high-carbon steels.

[2] Navy only.

TABLE IV–III.—*Production of special steel in Japan proper, 1937–1945 fiscal years*

[Thousands of metric tons]

Year	Total finished steel	Total special steel	Alloy steel	High-carbon steel	Special steel as a percentage of all steel
1938	5,568	328	208	51	5.9
1939	5,549	463	331	132	8.3
1940	5,384	447	320	127	8.3
1941	5,120	500	360	140	9.8
1942	5,166	651	432	219	12.6
1943	5,615	929	574	355	16.5
1944	4,320	1,185	626	559	27.4
1945 [1]	492	106	N A	N A	21.5

[1] First quarter.

C. EFFECT OF SHORTAGES ON AIRPLANE ENGINES

In the first half of 1944 there was a leveling off and subsequent partial collapse of production of aircraft engines. This was reflected in acute shortages of finished engines and a loss of production of airplanes, beginning in October and November 1944, before the Allied bombing had commenced. This appears to be tied up very closely with critical shortages of alloying elements for special steels. The Japanese were unable to make suitable substitutions or to develop adequate heat-treating processes to permit the use of steels of lowered alloy content.

Cobalt supplies were short in 1943. Stock supplies of Si–Cr steel used in valve making became low in July 1944 and vanished in December 1944. Supplies of Si-Cr-Mo steels were exhausted in November 1944 and Cr-Mo steel in December 1944. Because of the strong cushioning effect of the high priorities assigned to special steels for the engine and propeller industries, these shortages struck very suddenly and were reflected at the steel plants in changed specifications for alloy steels and at the engine plants in acute "inspection trouble" and production difficulties because of the substitutions.

A useful picture of the situation between 1943 and 1945 is obtained by studying the numbers of substitutions in steels put into effect on engines as reported by Mitsubishi (Aircraft Division Corpora-

tion Report No. I) and on changes approved by the Munitions Ministry for engines and propellers. Critical shortages of cobalt, nickel, and chromium in May 1943 led to alterations in 11 specifications. In most cases the changes involved use of molybdenum and tungsten as substitutes. In late 1943 molybdenum and tungsten supplies began to give out, and by May 1944 the decline was so acute that no fewer than 20 changes in alloy steels resulted. The relationship between these changes in steels and drop of production is shown in Figure IV–2, which gives the cumulative number of forced changes in special steel compositions against engine production.

The decline in quality is indicated in the changes in crankshaft alloy-steel materials, beginning in 1943:

Alloy content reduction in stages	Nickel	Chromium	Molybdenum
	Percent	*Percent*	*Percent*
First	4	2	0.5
Second	2	2	.5
Third		4	.5
Fourth		4	

As chromium became scarce, serious efforts were made to use larger quantities of carbon steels. Late in 1944, carbon-steel engine parts (crankshaft, propeller shaft, connecting rods, and cylinder barrels) were tested for a 450 horsepower engine, and by July 1945 production of carbon-steel parts had been completed for a 1,800 horsepower engine. However, tests were not completed by the end of the war. Tests were reported to have been proceeding successfully on nonnickel heat-resisting steel for exhaust turbine and rocket turbines, but these never reached the production stage.

Lower engine performance, loss in planes through failure of landing gears, and a host of minor difficulties resulted from the deterioration of steel.

At the Kawasaki Aircraft Co., Akashi plant, in overhauling 857 engines received from the Army air depots from April 1944 to April 1945, 457 were found to have failed because of defective material, largely bearings and crankshafts; the balance resulted from battle damage and poor maintenance.

An index of failure of landing gears is the increase from 40 percent ordered for spares in 1942 and 1943 to 57 percent ordered for spares early in 1944 and 70 percent ordered late in 1944 and 1945. An outstanding case of faulty material and poor maintenance was shown in a Japanese diary covering the delivery of 80 Ki–84 (Franks) from Japan to Lingayen Bay, 4 November 1944, where only 14 planes reached their destination. Trouble with engines, fuel systems, hydraulics, and failure of landing gears were the principal causes of trouble.

Substitution brought about not only a decline in the quality of Japanese aircraft but the manufacturing difficulties encountered played a very important part in starting the decline in aircraft production in June 1944. It is doubtful if production could ever have been regained using substitutions.

Nonmetallic Items

Wood, rubber, plastics, fabrics, and other nonmetallic items, on a limited scale, are necessary for plane production. Shortages in these items and the necessity of substitution resulted in a further lowering of quality, and, in many cases, an actual reduction in output.

The use of wood increased as the war progressed, particularly as a substitute for aluminum. Practically all planes were being investigated by the summer of 1944 to use at least some wood as a substitute. These substitutions had progressed to the production stage in a number of cases, particularly for trainer, kamikaze-type planes, propellers and propeller blades and for wings and tails of transports and bombers. In one case, the L2D3 (Tabby), wood was used for fuselage in addition to the wings and tail. Full advantage of wood construction was never realized in Japan because of a shortage of waterproof glues and limited plywood techniques. Use of plain sawed nonlaminated wooden spars was common.

Notwithstanding the capture of the great crude-rubber-producing areas, rubber was always short as a result of failure to put emphasis on the movement of crude to Japan until late in the war, when shipping was unavailable.

Part V

PARTS AND COMPONENT MANUFACTURE

A. PROPELLER INDUSTRY

Japanese propeller design was 5 or more years behind that of the United States. Their production types consisted only of modifications and adaptations of foreign designs. The largest production was of the old counterbalanced, two-position type produced originally under license from Hamilton Standard by the Sumitomo and Japan Musical Instrument Companies. The operating limitation of this propeller especially for planes and engines developed late in the war led to greater emphasis on the more efficient V.D.M. German type full feathering propeller, in spite of the fact that the V.D.M. required 70 percent more man-hours to produce and also that greater manufacturing and operational difficulties were encountered because of shortages of proper steel alloys. Production of the French Ratier type remained relatively insignificant. It was used only on Army Frank fighters.

Wooden blades as a substitute for aluminum had been developed and were just going into mass production in July 1945. Steel blades, developed as an aluminum substitute and not for higher activity factors, were ready for a limited production

Experimental work was concentrated largely at the Sumitomo Kanzaki plant. Only two test cells powered with 1,500-horsepower engines were available. A small wind tunnel was completed the last year of the war. There was little vibration and stress analysis equipment.

The lack of adequate propeller research in Japan must have been a retarding factor in the design of airplanes. It is difficult to believe that effective operation of Japanese aircraft at appreciably higher altitudes could have been possible without drastic improvement in propeller design, with particular attention to better vibration and stress analysis.

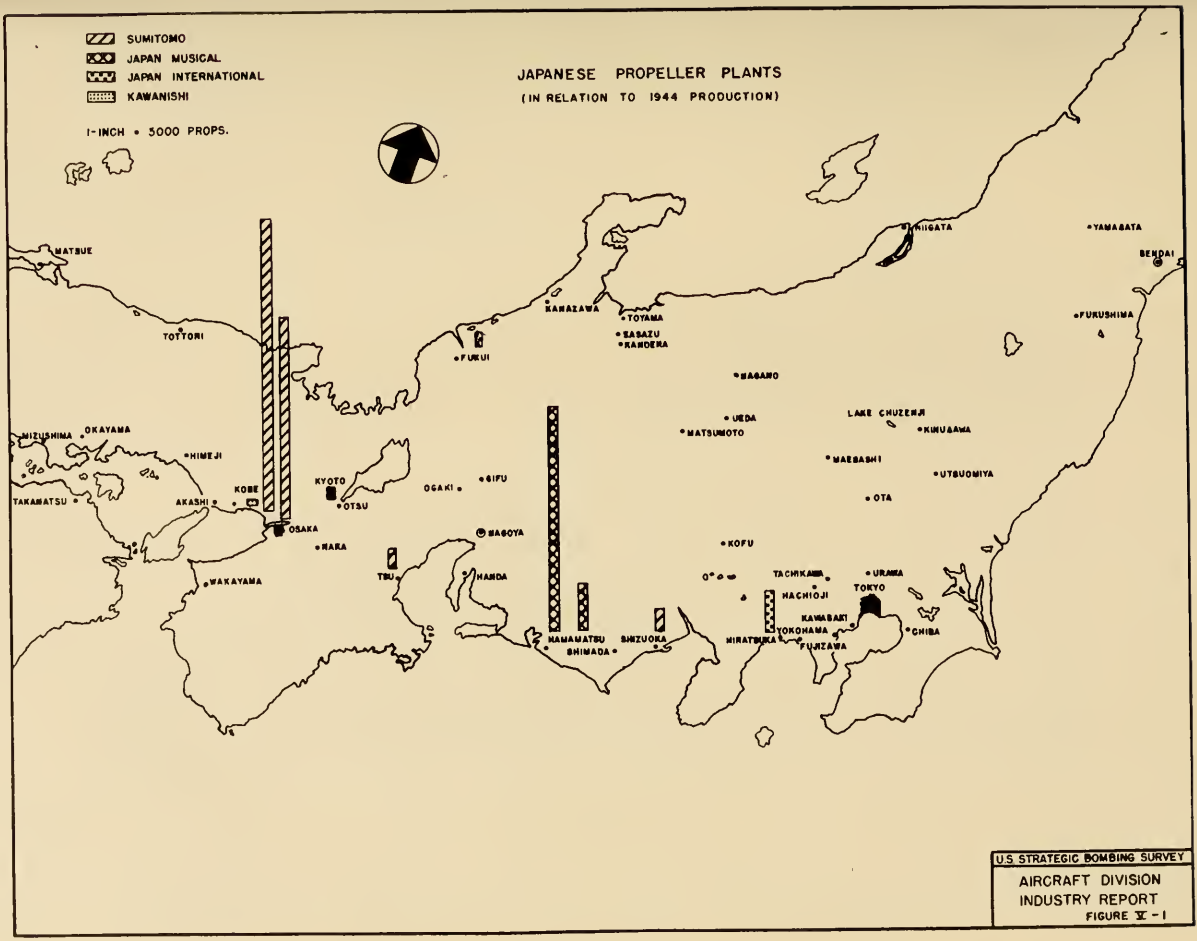
Concentration of Propeller Industry

Productionwise, the Japanese propeller industry was off to an early start to meet requirements for both plane production and spares. The Sumitomo Company's Sakurajima plant at Osaka had been established in 1937 and the Kanzaki plant, 8 miles west of Osaka (the largest propeller plant in Japan) was completed in early 1941. The production of the Kanzaki plant, combined with other new construction and expansion of the other plants, raised total output from 672 propellers a month in January 1941 to 5,257 in July 1944. By 1944 production came from three companies with eight plants. Three of these plants turned out 83 per cent of the total. Of these plants, two were located at Osaka and the other at Hamamatsu. The location of all plants, with bars indicating their relative 1944 production, is shown in Figure V–1. Note the concentration in the Hamamatsu and the Osaka areas.

The propeller division of Sumitomo Industries accounted for 65 percent of all Japanese production from January 1941 to the end of the war. Except for 400 combination wood-on-metal propellers which were made in 1945, it manufactured only metal propellers, divided between the Hamilton Standard (United States) and V.D.M. (Germany) types. Some 24 different sizes were produced. The large number of sizes acted as a limitation on the full utilization of productive capacity. This company supplied all of the Navy's and a considerable portion of the Army's requirements for metal propellers. Its plants were well laid out and equipped. Its employees worked 7 days per week in two 12-hour shifts with 1.8 off for meals and rest. The majority, 85 percent, worked on the day shift. Absenteeism averaged 12 percent in 1944 but, during the periods of alerts and bombings in 1945, increased to 50 percent.

The Japan Musical Instrument Company, converted 100 percent from its former business, was the second largest producer. It made Hamilton standard type propellers, wooden propellers, and a combination metal hub wooden blade propeller (based probably on the German Schwartz pattern). The proportion of its business in wooden and combination propellers increased during the war. In July 1944, it amounted to 34 percent of total Japanese production. This percentage would have increased had the war continued.

The third Japanese propeller producer, Japan International Company, accounted for 6 percent of total Japanese production at the peak. Its


SUMITOMO
JAPAN MUSICAL
JAPAN INTERNATIONAL
KAWANISHI
1-INCH = 5000 PROPS.
JAPANESE PROPELLER PLANTS
(IN RELATION TO 1944 PRODUCTION)
MATSUE
TOTTORI
FUKUI
KANAZAWA
TOYAMA
SABAZU
KAMOERA
NIIGATA
YAMAGATA
SENDAI
FUKUSHIMA
NAGANO
UEDA
MATSUMOTO
LAKE CHUZENJI
KINUGAWA
MAEBASHI
UTSUNOMIYA
OTA
MIZUSHIMA
OKAYAMA
HIMEJI
TAKAMATSU
AKASHI
KOBE
KYOTO
OTSU
OGAKI
GIFU
OSAKA
NARA
NAGOYA
WAKAYAMA
TSU
HAMADA
KOFU
TACHIKAWA
URAWA
HACHIOJI
TOKYO
KAWASAKI
YOKOHAMA
FUJISAWA
CHIBA
HAMAMATSU
SHIMADA
SHIZUOKA
HIRATSUKA
U.S. STRATEGIC BOMBING SURVEY
AIRCRAFT DIVISION
INDUSTRY REPORT
FIGURE V - 1

entire production was of a metal, electric control (French) Ratier type propeller. A fourth company, Kawanishi Aircraft Company, produced only a few wooden propellers for training planes. (For details regarding the propeller companies and their plants, see Aircraft Division Reports No. III, VI, VIII, and IX.)

The variations in propeller production are shown in Figure V–2 and complete production statistics are given in Appendix IX.

Production Difficulties

The decline and leveling off of propeller production in August 1944 is directly attributable to increased production difficulties arising from changes in design, a shortage of alloy steels for hub parts manufacture, poor planning, and a dropping off of labor efficiency. An indication of the difficulties from alloy steel shortages is shown in the changes in specifications for propeller manufacture in Table V–1. Each change resulted in a decline in quality and increased production and operational difficulties.

Continuation of plane production at the maximum rate reached in 1944 would have found a shortage in propeller supply. As shown in Figure V–3 the amount available for spares declined from 73 percent of new plane requirements in December 1942 to 65 percent at the peak in September 1944. From then to the close of the war the percentage for spares declined rapidly because of lowered output and high operational losses.

Dispersal of Propeller Industry

Dispersal of the Sumitomo propeller plants was ordered by the Government in December 1944. In March 1945, the company began dispersal of the Kanzaki plant to six locations, of which the principal one was a tunnel and forest site at Hirono. At the time of the first big attack by our bombers (15 June 1945) some 30 percent of machine tools and 20 percent of personnel had been dispersed. Of the tools remaining, 32 percent were destroyed and 26 percent damaged in the raid. Production, except for final assembly clean-up was stopped permanently. In the following month all but 27 of the 500 heavy productive tools were dispersed. The almost empty plant was completely wrecked in a heavy raid on 24 July. Shizuoka began dispersal in May and at the time of 19 June fire attack on the city had dispersed 60 percent of its machine tools. Those remaining were destroyed. The Tsu plant had not made any dispersal to the end of the war. It was only slightly damaged in a raid of 26 June.

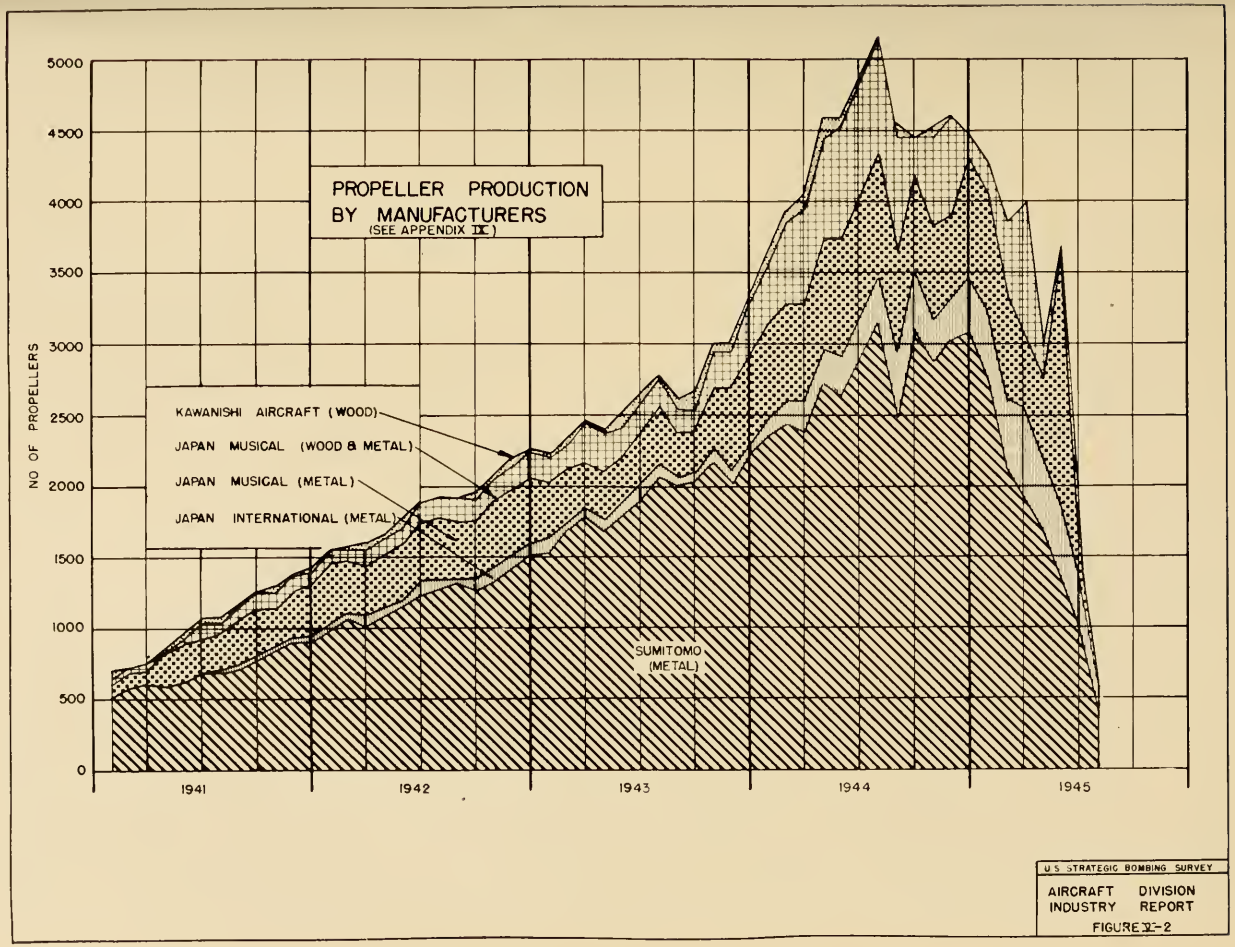
Japan Musical dispersal had been planned in January 1945, but no tools had been moved from the Tenryu plant at the time of the 19 May attack on Hamamatsu. The plant was 50 percent destroyed and production ceased. The main Hamamatsu plant was attacked as a target of opportunity by a single B–29 on 10 June. Thirty percent of the machine tools were damaged and production for the balance of the war was reduced to a few propellers assembled from parts already manufactured.

Japan International at Hiratsuka dispersed early in June. The plant was inoperative at the time it was struck during the urban fire attack of 16 July and the attack by Navy on 30 July. Hukui plant also had dispersed in June and was not producing when it was 90 percent destroyed in an area fire raid on 14 July.

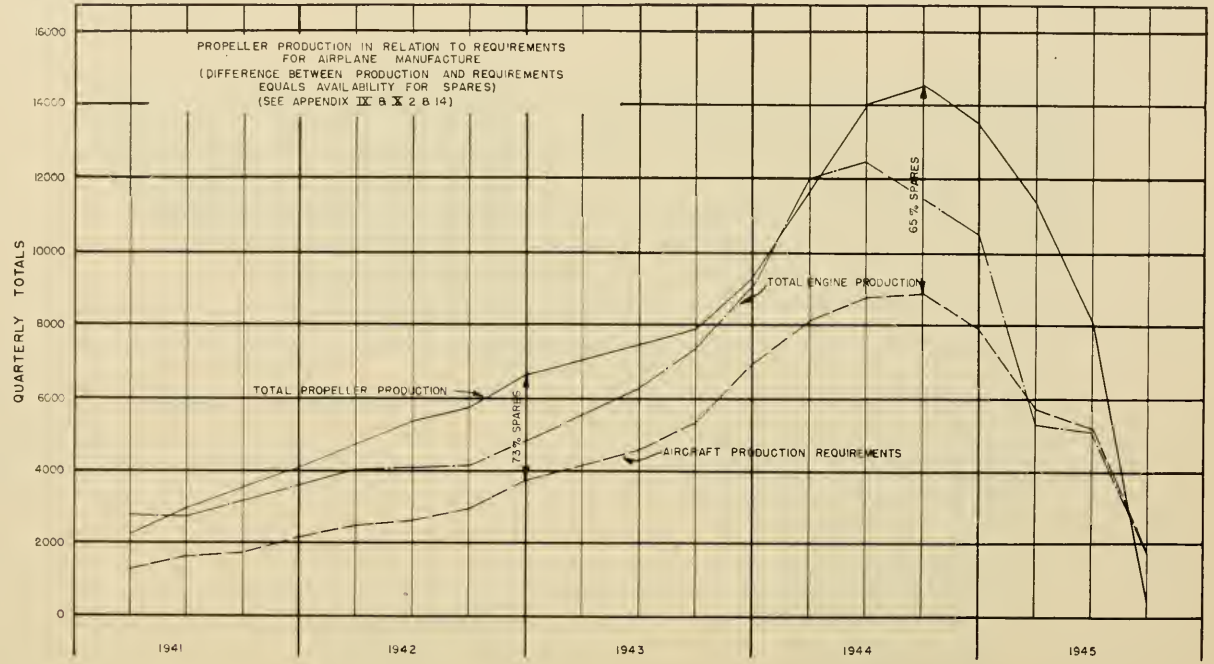
TABLE V–I.—*Modification list of material for propellers*

[Approved by Munitions Ministry]

Name of parts	Original material	Modified material	Date of modification	Reason for modification
Gears for V. D. M	1137	1103	August 1943	Shortage nickel.
Piston and cylinder head, etc	11004	1206	do	Shortage nickel and molybdenum.
Barrel, counterweight	1234B	1206	do	Do.
Spider	1234B	1209	do	Do.
Cam and blade root bushing	TO206	TO204	do	Shortage nickel.
Most of gearbox gears	1203	1225KO	October 1943	Shortage molybdenum.
Tightening nut	1203	1224KO	do	Do.
Draw bolt nut	1203	1224KO	do	Do.
Most of gear box gears	1225KO	1003	January 1944	Shortage molybdenum and chrome.
Gear box	1203	1232KO	February 1944	Shortage molybdenum.
Hub	1203	1232KO	March 1944	Do.
Most of gearbox gear shaft	1203KO	1232KO	do	Do.
Blade root worm and gear	1103	1137	April 1944	Shortage nickel.
Gear box fixing flange	1203	RO232	May 1944	Shortage molybdenum.
Spider	1111	1131	July 1944	Shortage nickel.
Front cone	TO204	1232KO	October 1944	Shortage molybdenum.
Eccentric box	1203	1232KO–1003	February 1944–January 1945	Do.
Most of gearbox gear shaft	1232KO	1003	1 January 1945	Shortage chrome.



U.S. STRATEGIC BOMBING SURVEY
AIRCRAFT DIVISION INDUSTRY REPORT
FIGURE IX-2



U.S. STRATEGIC BOMBING SURVEY
AIRCRAFT DIVISION
INDUSTRY REPORT
FIGURE V-3

The attacks on the propeller plants came relatively late in the war. Since more than 80 percent of propeller production was concentrated in the Kanzaki, Sakurajima, and Hamamatsu plants, their destruction prior to June 1945 would have prevented dispersal of machinery and seriously delayed any possible recovery. Plane production might have been maintained at reduced rates for some months, however, by reworking damaged propellers and by use of spare stocks. Appendix IX also shows volume of spares manufactured. No data are available on rate of spares consumption.

B. OTHER COMPONENTS

Component manufacturers, comprising 17 percent of the aircraft industry, produced the landing gears, wheels, tires, communication items, engine and propeller equipment, and the numerous accessories required in plane production. A list of component items with the principal manufacturers showing their relative standing in the industry is given in Appendix VII. It will be noted that before dispersal, 68 percent of the production of landing gears was concentrated in two companies with five plants; radio, 67 percent in three companies and three plants; magnetos, 60 percent in one company with four plants; and bearings, 83 percent in two companies with five plants. Other items showed similar concentrations.

Relation to Subcontractors

A component manufacturer was a distinct entity from a subcontractor. Airframe, engine, and propeller manufacturers received their orders directly from the government and the same was true of the component manufacturers. Subcontractors, on the other hand, received their orders and worked for the principal manufacturers. In some cases a single manufacturer might serve in both categories, but usually the subcontractor was limited to supplying experimental and replacement items. The principal items were ordered by the government from the component manufacturers with the provision that direct shipment be made to the plane builders for the quantities required for plane production, with other quantities to be shipped to Army and Navy depots for use as spares. Plane manufacturers did not draw accessories from depots for production except in occasional cases of acute shortage.

Prior to dispersal, the plants of component parts manufacturers were concentrated in the Tokyo, Nagoya, and Kobe areas. One major exception was the Nippon Hikoki type K. K. plant at Fukuoka, which is reported to have produced 55 percent of the aircraft tires.

Dispersal Pattern

Component companies generally followed the dispersal pattern of the airframe and engine plants. The dispersal order of the Munitions Ministry early in 1945 applied to the component industry, and dispersal was started in the spring of 1945, in spite of the fact that Government assumed responsibility for all costs of transportation, development of the new sites, and production losses. Many of the smaller companies had not dispersed and were only in a delayed planning stage at the end of the war.

A few typical cases will serve to illustrate what happened.

The Tokyo Keiki Seisakusho plant, located in Kamata-ku in the northeast part of Kawasaki, producer of 65 percent of aircraft starters, and the Tokyo Koku Keiki K. K. plant, located in Kitsuki-ku, also in the northeast part of Kawasaki, producer of 50 percent of aircraft compasses, were under common ownership and management. In addition to these products these plants produced substantial amounts of aircraft instruments. Realizing the vulnerability of this production, company officials started dispersal in 1944 and by March 1945 an underground plant at Kizaiki and an underground plant in Nagano prefecture were in operation, with some 30,000 employees working on a 12-hour, two-shift basis. This production was not affected when the two original plants of this company were damaged in the Tokyo-Kawasaki raids of 14 April, 23, 24, and 25 May.

Landing-gear and wheel production was partially protected by the dispersal of the Kayabo plant from Tokyo to Sendai and Takinogawa by April 1945, but the Okamoto plants at Nagoya lost 40 percent of their capacity in a February 1945 high-explosive raid, and the plants were destroyed in the March 12 and May 17 incendiary raids. Okamoto dispersal to Godo, Ichinomiya, and Tarui had started in January but was not completed until July because of critical transportation conditions. Landing-gear and wheel production was seriously affected.

Production of aircraft radiators and oil coolers was never sufficient for aircraft needs from the beginning of the China War. This condition became critical in 1945. Sixty percent of Japanese

production was made by the Nitto Kokukiki K. K., with factories in Kawada-ku section of southeast Tokyo and Fukae in Honjo-mura near Kobe. The Kawada factory was destroyed in the early Tokyo area raids while production was severely cut at the Fukae factory in the Kobe raids. This company failed to disperse. The selection and early destruction by bombing of the Nitto factories, the Osaka Kinzoku Kogyo K. K. Osaka factory, and the Toyoda Jidosha Kogyo K. K. Nagoya factory would have eliminated more than 80 percent of aircraft cooler output.

The Japanese had learned of the bombing of the Schweinfurt ball-bearing plants and had expected their ball-bearing plants to be among the first targets. They were puzzled when attacks did not materialize. Bearings were short but never critical. Productive capacity had been expanded greatly, beginning in 1937, and limitation on production was mostly from the poor quality of ball-bearing steels and shortage of skilled labor. Dispersal of the industry was actively undertaken in the fall of 1944 mostly to the Fukui, Aichi, Yamanashi, and Nagano prefectures. It is doubtful if effective bombing could have been accomplished in view of the dispersal, notwithstanding the concentration of 83 percent of the bearing production in two companies.

Spares Situation

Component production went first to satisfy production needs, then to cover spares requirements. Spares were ordered in accordance with estimated usage, expressed as a percent of production requirements. For example, sufficient tires were ordered for aircraft production requirements and spares varied from 100 percent to 300 percent of production requirements. For items where normal wear and tear was less, lower spares percentages were ordered.

The general state of affairs with respect to aircraft component production can be gained by a comparison of spares orders with actual spares receipts. Table V–II shows the situation from 1939 to the end of the war for a number of important component items. Wherever requirements were not fulfilled, the probabilities are that operations and perhaps aircraft production were affected in some degree.

The trend of the supply for spares of the six most critical component items is shown in Figure V–4. It shows the percentage of orders placed that were actually delivered. In no case were average spares requirements fully covered. One reason for the critical engine shortage is apparent. Going back well into mid-1944, only half as many carburetors were delivered as were ordered. By mid-1945 the deliveries were approaching the vanishing point.

It will be noted that the percentage of spare landing gears increased in 1945. Actually, production declined sharply but the drop-off in aircraft production was such that larger diversions could be made for spares. Pressure on the component factories for delivery of spares became increasingly heavier with breakage from faulty materials and poor workmanship as well as from the losses of active military operations.

General

Component manufacturers were allotted materials by the Munitions Ministry in the same way as were the airframe and engine manufacturers. Some component manufacturers were operating in wooden steel-frame type plants built after the China incident, but many of the older plants and those converted from civilian items late in the war were made of brick and wood. Many such plants were located in congested areas and were destroyed in the area bombings.

Few of the component companies operated on a two-shift basis. One 10-hour shift 28 days a month was general practice even up to the end of the war. Line production methods with several operations per station were common, particularly in equipment and instrument manufacture.

About 15 percent of landing-gear production was subcontracted, and instruments and electrical equipment went as high as 50 percent. Most of the work was done in small, scattered shops. With such a high percentage of work let out, the component manufacturers found themselves in an increasingly difficult position from dispersal difficulties and from area raid losses. Production of component items as a whole, however, showed faster recuperation than airframe and engine production. This can be attributed largely to their smaller size and more versatile operation.

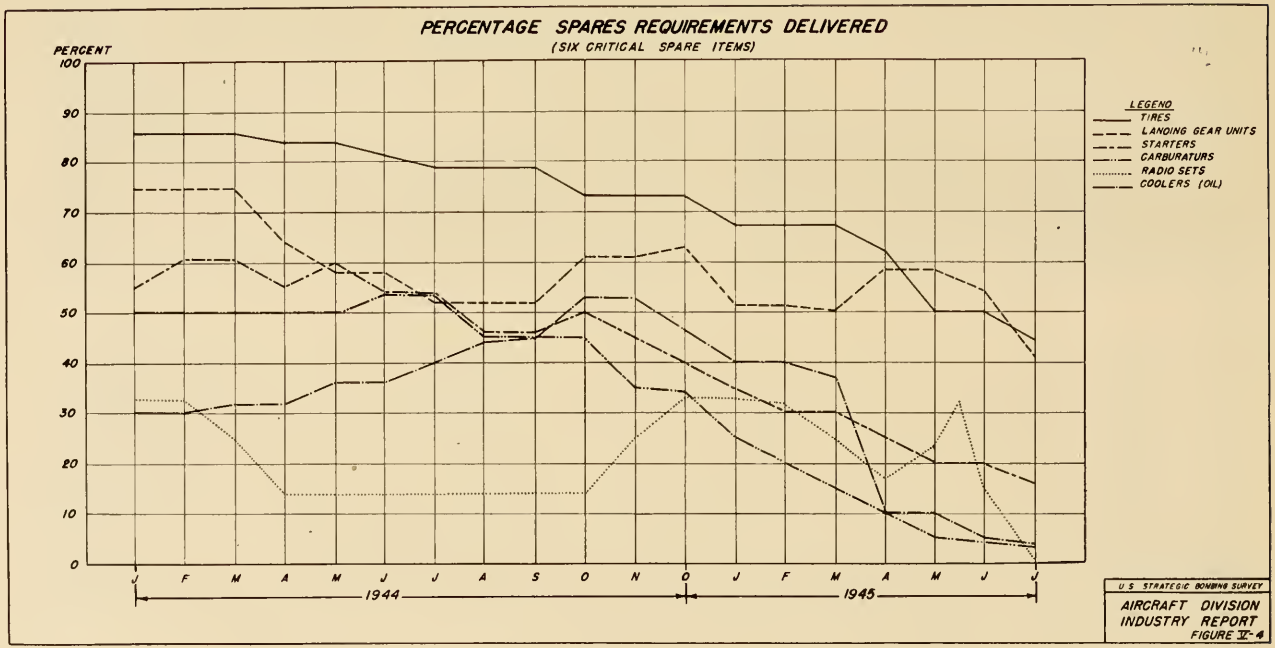

PERCENTAGE SPARES REQUIREMENTS DELIVERED
(SIX CRITICAL SPARE ITEMS)
PERCENT
100
90
80
70
60
50
40
30
20
10
0
J F M A M J J A S O N D J F M A M J J
1944
1945
LEGEND
TIRES
LANDING GEAR UNITS
STARTERS
CARBURATURS
RADIO SETS
COOLERS (OIL)
U.S. STRATEGIC BOMBING SURVEY
AIRCRAFT DIVISION
INDUSTRY REPORT
FIGURE IV-4

TABLE V–II.—*Spare components ordered and received*

FOR ARMY AIRCRAFT

[In percentages]

	1939	1940	1941	1942	1943	1941												1945						
						1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7
Radio						0	0	0	0	(30) 0	0	0	0	0	0	10	10	10	10	(30) 10	10	20	10	0
Generator						0	0	0	0	(15) 0	0	5	5	7	8	10	8	0	0	(15) 0	5	5	0	0
Magneto	(24) 23	(24) 22	(23) 19	(22) 20	(20) 18	15	14	15	14	(20) 14	14	13	11	10	11	11	11	8	8	(20) 8	7	7	5	6
Landing gear	(20) 18	(30) 28	(30) 16	(40) 13	(40) 35	(40) 35	35	35	(57) 38	38	38	41	41	41	43	43	44	(70) 52	52	52	58	58	54	54
Wheel	(30) 31	(35) 31	(35) 30	(40) 32	(50) 53	44	44	44	46	(50) 46	46	46	46	48	48	48	48	72	72	(55) 72	72	72	72	72
Tire	(105) 105	(105) 105	(200) 180	(225) 185	(300) 300	300	300	300	275	(300) 275	275	250	250	250	220	220	220	195	195	(300) 195	170	110	110	110
Starter	(25) 24	(25) 23	(25) 23	(22) 19	(20) 17	11	13	13	11	(20) 12	11	11	9	9	10	9	8	7	6	(20) 6	5	4	4	3
Fuel and oil pump	(20) 20	(20) 19	(20) 17	(20) 16	(20) 16	13	13	13	12	(17) 12	12	12	12	11	10	10	10	9	8	(17) 7	7	7	6	5
Radiator and oil cooler	(50) 8	(50) 10	(50) 15	(50) 22	(50) 20	20	20	20	20	(50) 23	23	25	26	26	28	28	28	25	25	(50) 24	5	5	2	3
Bearing						15	15	15	15	(15) 15	15	15	15	15	15	15	13	10	10	(15) 8	7	7	7	7
Fuel injection pump				(15) 10	(20) 10	4	4	4	4	(20) 3	4	7	9	12	15	12	14	16	17	(20) 15	10	10	8	3
Turbine (exhaust) blower						1	3	5	5	(50) 6	9	12	5	14	14	18	19	22	10	(50) 8	7	2	2	1
Carburetor	(15) 8	(15) 11	(17) 13	(19) 13	(17) 12	10	10	10	10	(20) 10	11	11	9	9	9	7	7	5	4	(20) 3	2	1	1	1
Electric motor						10	10	10	10	(30) 10	10	10	10	10	10	10	10	0	0	(30) 0	0	0	0	0
Altimeter [1]	(30)	(30)	(30)	(30)	(30)	0	0	0	0	(30) 0	0	0	0	0	0	0	0	0	0	(30) 0	0	0	0	0
Compass [1]	(30)	(30)	(30)	(30)	(30)	0	0	0	0	(30) 0	0	0	0	0	0	0	0	0	0	(30) 0	0	0	0	0
Bank indicator [1] (turn indicator)	(30)	(30)	(30)	(30)	(30)	0	0	0	0	(30) 0	0	0	0	0	0	0	0	0	0	(30) 0	0	0	0	0

FOR NAVY AIRCRAFT

Radio						20	20	20	10	(30) 10	10	10	10	10	10	10	10	10	(30) 10	0	0	0	0	0
Generator						5	5	5	5	(25) 5	5	5	5	5	12	18	8	5	(25) 5	5	5	5	5	0
Magneto	(24) 23	(24) 22	(23) 19	(22) 20	(20) 18	15	14	15	14	(20) 14	14	13	11	10	11	11	11	8	(20) 8	8	7	7	5	5
Landing gear	(10) 9	(20) 15	(20) 20	(20) 20	(20) 13	(25) 16	16	15	12	12	12	(30) 9	9	9	14	14	14	(56) 18	18	18	(62) 20	20	20	10
Wheel	(20) 20	(30) 27	(33) 32	(33) 32	(32) 17	18	18	18	24	(30) 24	24	25	25	25	23	23	23	25	(35) 25	25	19	19	19	18
Tire	(100) 80	(150) 95	(200) 150	(210) 190	(210) 150	(210) 150	150	150	(300) 225	225	225	225	225	225	220	220	220	200	(300) 200	200	190	190	190	175
Starter	(25) 24	(25) 23	(25) 23	(22) 19	(20) 17	11	13	13	11	(20) 12	11	11	9	9	10	9	8	7	(20) 6	6	5	4	4	3
Fuel and oil pump	(20) 20	(20) 19	(20) 17	(20) 16	(20) 16	13	13	13	12	(17) 12	12	12	12	11	10	10	10	9	(17) 8	7	7	7	6	5
Radiator and oil cooler	(30) 10	(30) 13	(30) 15	(30) 22	(30) 20	10	10	12	12	(50) 13	13	15	18	20	25	20	18	15	(50) 15	13	5	5	5	3
Bearing						15	15	15	15	(15) 15	15	15	15	15	15	15	13	10	(15) 10	8	7	7	7	7
Fuel injection pump				(15) 10	(20) 10	4	4	4	4	(20) 3	4	7	9	12	15	12	14	16	(20) 17	15	10	11	6	3
Turbine (exhaust) blower						1	3	5	5	(50) 6	9	12	5	14	14	18	19	22	(50) 16	8	7	2	2	1
Carburetor	(15) 8	(15) 11	(17) 13	(19) 13	(17) 12	10	10	10	10	(20) 10	11	11	9	9	9	7	7	5	(20) 4	3	2	1	1	1
Electric motor						10	10	10	10	(30) 10	10	10	10	10	10	10	10	0	(30) 0	0	0	0	0	0
Altimeter [1]	(30)	(30)	(30)	(30)	(30)	0	0	0	0	(30) 0	0	0	0	0	0	0	0	0	(30) 0	0	0	0	0	0
Compass [1]	(30)	(30)	(30)	(30)	(30)	0	0	0	0	(30) 0	0	0	0	0	0	0	0	0	(30) 0	0	0	0	0	0
Bank indicator [1] (turn indicator)	(30)	(30)	(30)	(30)	(30)	0	0	0	0	(30) 0	0	0	0	0	0	0	0	0	(30) 0	0	0	0	0	0

[1] Received only salvaged instruments.

Figures in parentheses = $\frac{\text{Spares required}}{\text{Production requirement}}$

Open figures = $\frac{\text{Spares received}}{\text{Number used in production}}$

Part VI

AIR ATTACKS ON THE AIRCRAFT INDUSTRY

This chapter presents a statistical analysis of the air attacks on the Japanese aircraft industry. It is based largely on data taken from the individual plant and corporation reports of the Aircraft Division which show (*a*) estimated tonnage of bombs delivered on targets and (*b*) effectiveness of attacks in terms of physical damage and reduced production. These data have been correlated with the attack data (both for direct and indirect attacks) compiled by the Tabulating Section of the United States Strategic Bombing Survey. They have also been cross-checked with the figures compiled by the military analysis section.

The studies made by the Aircraft Division did not include detailed analysis of physical damage and weapon effectiveness. For certain plants of particular interest in this respect, the physical damage division made several detailed studies of selected aircraft plant targets.

Damage to the Japanese aircraft industry was caused by two kinds of attack: direct and indirect. Direct attacks are defined as those in which a particular industrial plant was the specific target for the attack. Indirect attacks are those in which the industrial plant was damaged by bombs aimed at other targets. Thus damage to a plant from (*a*) an urban area attack, (*b*) spillover effects of attack on nearby or adjoining target, (*c*) jettisoning bomb loads or (*d*) error in identification or bombing technique is considered as an indirect attack. Data analyses in this chapter differentiate between these two classifications.

A. TARGET SELECTION FOR STRATEGIC BOMBING

In order to develop a plan to bomb out the Japanese war industry, organizations were early established to include the necessary intelligence and command chains. The Joint Chiefs of Staff made the basic decisions, advised by the joint target group and various other Army and Navy intelligence units. Decisions made by the Joint Chiefs of Staff were transmitted to Commanding General Air and Chief of Naval Operations and from these through the chain of command to operational forces.

In August 1944 a decision by the Joint Chiefs of Staff was reached which set forth a general target directive. Largely as a result of studies made in Australia by the Allied Air Force, this directive established the Japanese aircraft industry as the top target priority and specifically, the aircraft engine factories as the top target objective within that system. That basic priority was not changed thereafter.

The bombing of the Japanese home islands was carried out entirely by United States Armed Forces. Participating units were the Twentieth Air Force (both China- and Mariana-based). Navy carrier forces, and the Seventh, Fifth, and Thirteenth Air Forces. Total tonnage dropped against the Japanese home islands is shown in Table VI–I.

In contrast with operations against the German aircraft industry, the attack on the Japanese aircraft industry was on a smaller scale and of shorter duration. In Germany, some 90,671 tons (about 4 percent of the combined Allied bombing) were dropped on aircraft manufacturing activities in about 2½ years. In Japan, some 16,300 tons (about 9.7 percent of the total) were dropped in 13 months.

TABLE VI–I.—*Bomb tonnage dropped on Japan*

	Tons	Percent of total
Twentieth Air Force	147,576	91.4
Navy Air Force	6,788	4.2
Seventh Air Force	5,102	3.2
Fifth Air Force	1,905	1.2
Thirteenth Air Force	6	Nil
Total	161,377	100.0

TABLE VI–II.—*Direct attack on industrial targets (tons)*

Target category	Twentieth AF	Navy	Seventh AF	Fifth AF	Total	Percent of total
Aircraft industry	[1] 16,310	316	2	.....	16,628	47.8
Oil industry	10,253	44	68	8	10,373	29.8
Army and Navy arsenals	3,430	133	24	40	3,627	10.4
Railroad installations	753	154	584	254	1,745	5.0
Chemical industry	484	27	65	.....	576	1.7
Ferrous metals	226	11	.....	.....	237	.7
Nonferrous metals	202	26	.....	.....	228	.6
Miscellaneous and unidentified	948	321	69	53	1,391	4.0
Total	32,606	1,032	812	355	34,805	100.0

[1] Includes 349 tons dropped on Manchuria Aircraft Co., Mukden.

No break-down of tonnage distribution by target classification was available from the Tabulating Section of United States Strategic Bombing Survey. Industrial target attack data were extracted, however, from various publications of that section, and combined in Table VI–II. Of the 161,377 tons dropped on Japan, about 34,805 tons or 21.6 percent, were dropped on industrial targets. Except for the one variation noted (Manchuria Aircraft Co.), all the direct attacks listed in Table VI–II were against plants on the four home islands.

B. DIRECT ATTACKS

Ninety direct attacks were made against the Japanese aircraft industry: 73 were by the Twentieth Air Force, flying 3,353 aircraft; 16 by the Navy, flying 530 aircraft; and one by the Seventh Air Force, flying 1 aircraft. Distribution of direct attack tonnage is shown in Table VI–III.

TABLE VI–III.—*Direct attack tonnages classified by target*

Type of plant	Twentieth Air Force	Navy	Seventh Air Force	Total
Airframes	6,141	235		6,376
Engines	6,512	35		6,547
Airframes and engines	2,472	13	2	2,487
Propellers	921			921
Airframes and propellers	264			264
Airframes, engines, and propellers		33		33
Total	16,310	316	2	16,628

Geographically speaking, the total tonnage on Japan was delivered onto seven main areas. (Fig. I–3 of Summary). Of these seven areas, Tokyo, Nagoya, and Osaka received 82.2 percent of the total tonnage. This concentration was justified because of the productive importance of those areas, as shown in Table VI–IV below.

TABLE VI–IV.—*Attacks by area*

	Percent of total tonnage dropped on aircraft industry	Percent of total production		
		Engines	Airframes	Propellers
Tokyo area	30.5	45.1	46.8	4.2
Nagoya area	32.9	38.8	34.6	1.8
Osaka area	18.8	10.3	6.9	59.0
Total	82.2	94.2	88.3	65.0

The detailed record of each attack is given in Tables VI–V and VI–VI. Table VI–V lists the strikes chronologically. Table VI–VI is an alphabetical arrangement by company, and includes an estimate of certain effects of the bombings. The statistical material on which the estimates have been based are not complete. The damage effect rating has been derived from evidence presented in the individual plant reports.

The first direct attack on the aircraft industry was a small, ineffective, one-plane mission directed against the Twenty-first Naval Air Depot at Omura, by the China-based XX Bomber Command on 7 July 1944. Repeat missions, also light, were flown on 25 October and 21 November. On 24 November, in accordance with the JCS directive which established the aircraft engine industry as top target priority, the first mission against the aircraft industry was flown from Mariana bases. Between that date and 24 March, 28 missions were flown. These were general attacks against engine and airframe factories, as opportunity offered. Beginning on 24 March, however, in accordance with this priority system, large-scale attacks were pressed against the engine industry. In the 22-week period through 14 August, 5,494 tons were dropped on engine plant targets. Of this total, 2,174 tons were directed against Mitsubishi's Nagoya plants and 2,285 tons against Nakajima's Musashi plant. Beginning on 29 March and continuing until the end of the war, concurrent attacks on airframe targets were also carried out. In this 21-week period, 5,705 tons were dropped on airframe targets, and of this amount, 1,270 tons were directed against three Kawanishi plants, 1,186 tons against three Mitsubishi plants, 1,065 tons against four Nakajima plants, and 797 tons against Aichi's Eitoku plant (Table VI–V).

Monthly tonnages rose steadily, with one minor peak in December 1944, to a high of 4,199 in April 1945. Tonnage dropped appreciably in May, rose high in June and again declined rapidly in the last 2 months of the war. Table VI–VII shows direct attack tonnages chronologically by month. Note that only 7.2 percent of incendiaries were used against the aircraft industry.

Figure VI–1 breaks down the direct-attack tonnage analysis on a weekly basis. It is interesting to note that the mass of weight—10,916 tons—was delivered in 7 weeks, between 19 March and 29 July. No incendiaries were used after 3 April.

A broad analysis of tonnage dropped weekly on the two top target priorities (engine and airframe plants) is shown in Figure VI–2. From this and Figure VI–3, which gives cumulative totals, the trend of the attack program against the indus-

TABLE VI–V.—*Record of direct attacks—Chronological*

[TOTALS: 99 ATTACKS]

Date	Company	Plant	Location	Product	Airforce	Aircraft	Tonnage		
							HE	IB	Total
1944									
7 July	21st NAD		Omura	AE	20	1	2		2
25 October	21st NAD		Omura	AE	20	59	91	64	155
21 November	21st NAD		Omura	AE	20	61	132	71	203
24 November	Nakajima	Musashi	Tokyo	E	20	46	79	33	112
2 December	Nakajima	Musashi	Tokyo	E	20	59	99	43	142
7 December	Manchuria		Mukden	AE	20	80	184	79	263
12 December	Mitsubishi	Nos. 2 and 4	Nagoya	E	20	71	96	85	181
17 December	Mitsubishi	Nos. 3 and 5	Nagoya	A	20	63	149	6	155
19 December	21st NAD		Omura	AE	20	17	27	25	52
21 December	Mitsubishi	Nos. 2 and 4	Nagoya	E	20	48		130	130
21 December	Manchuria		Mukden	AE	20	19	41	45	86
26 December	Nakajima	Musashi	Tokyo	E	20	39	41	64	105
1945									
6 January	21st NAD		Omura	AE	20	28	45	45	90
8 January	Nakajima	Musashi	Tokyo	E	20	18	42		42
13 January	Mitsubishi	Nos. 3 and 5	Nagoya	A	20	40	95		95
18 January	Kawasaki	Akashi	Aksashi	AE	20	62	154		154
22 January	Mitsubishi	Nos. 2 and 4	Nagoya	E	20	28	49	34	83
1 February	Mitsubishi	Nos. 3 and 5	Nagoya	A	20	1	3		3
9 February	Nakajima	Ota	Ota	A	20	84	187	50	237
10 February	Nakajima	Ota	Ota	A	20	3	9		9
14 February	Mitsubishi	Nos. 2 and 4	Nagoya	E	20	33	72	34	106
16 February	Nakajima	Ota	Ota	A	N	64	39		39
17 February	Tachikawa		Tachikawa	A	N	74	59		59
17 February	Nakajima	Musashi	Tokyo	E	N	73	35		35
25 February	Nakajima	Koizumi	Koizumi	A	N	65	39		39
25 February	Nakajima	Ota	Ota	A	N	20	15		15
3 March	Aichi	Eitoku	Nagoya	A	20	7	10	4	14
3 March	Nakajima	Musashi	Tokyo	E	20	34	108	4	112
18 March	Mitsubishi	No. 9	Kumamoto	A	N	8	1		1
19 March	Mitsubishi	No. 7	Mizushima	A	20	1	4		4
19 March	Mitsubishi	No. 7	Mizushima	A	N	1	1		1
19 March	11th NAD		Hiro	AE	N	13	6		6
24 March	Mitsubishi	Nos. 2 and 4	Nagoya	E	20	224	1,196	314	1,510
26 March	21st NAD		Omura	AE	20	39	88		88
29 March	Mitsubishi	No. 7	Mizushima	A	20	1	2		2
30 March	Tachiarai		Tachiarai	A	20	105	417		417
30 March	Mitsubishi	Nos. 2 and 4	Nagoya	E	20	12	50		50
1 April	Nakajima	Musashi	Tokyo	E	20	115	1,019		1,019
3 April	Nakajima	Koizuuni	Koizumi	A	20	48	275		275
3 April	Mitsubishi	No. 6	Shizuoka	E	20	48	176	5	181
3 April	Tachikawa		Tachikawa	A	20	61	490	13	503
6 April	Nakajima	Musashi	Tokyo	E	20	101	490		490
6 April	Mitsubishi	Nos. 2 and 4	Nagoya	E	20	154	614		614
11 April	Mitsubishi	No. 6	Shizuoka	E	20	11	56		56
11 April	Nakajima	Musashi	Tokyo	E	20	94	490		490
13 April	Tachikawa		Tachikawa	A	20	1	3		3
18 April	Nakajima	Musashi	Tokyo	E	20	1	3		3
23 April	Hitachi	Tachikawa	Tachikawa	E	20	101	474		474
23 April	Tachikawa		Tachikawa	A	20	11	43		43
25 April	Mitsubishi	No. 7	Mizushima	A	20	1	3		3
29 April	Japan Musical Inst	Hamamatsu	Hamamatsu	P	20	9	45		45
1 May	Nakajima	Musashi	Tokyo	E	20	1	3		3
4 May	11th NAD		Hiro	AE	20	148	578		578
10 May	Kawanishi	Konan	Fukae	A	20	92	461		461
11 May	11th NAD		Hiro	AE	20	1	3		3
14 May	Mitsubishi	No. 9	Kumamoto	A	N	113	66		66
20 May	Kawasaki	Aksahi	Akashi	AE	20	1	2		2
8 June	Aichi	Atsuta	Nagoya	E	20	42	271		271
8 June	Kawasaki	Akashi	Akasbi	AE	20	24	144		144
8 June	Kawanishi	Naruo	Amagasaki	AP	20	44	264		264
9 June	Tachikawa Army Ars		Tachikawa	AE	20	30	169		169
9 June	Japan Airplane	Tomioka	Tomioka	A	20	32	173		173
9 June	Hitachi	Chiba	Chiba	AE	20	27	144		144
9 June	Nakajima	Ogikobu	Tokyo	E	20	7	38		38

TABLE VI–V.—*Record of direct attacks—Chronological*—Continued

Date	Company	Plant	Location	Product	Airforce	Aircraft	Tonnage		
							HE	IB	Total
21 June	Mitsubishi	No 5 Branch	Kagamigahara	A	20	18	98		98
21 June	Mitsubishi	No. 7	Mizushima	A	20	108	603		603
21 June	Kawanishi	Himeji	Himeji	A	20	52	351		351
21 June	Kawasaki	Oifu	Kagamigahara	A	20	18	116		116
21 June	Kawasaki	Akashi	Akashi	AE	20	26	155		155
25 June	Sumitomo	Sakurajima	Osaka	P	20	64	382		382
25 June	Kawasaki	Akashi	Akashi	AE	20	31	184		184
25 June	Aichi	Eitoku	Nagoya	A	20	50	346		346
25 June	Mitsubishi	No 5 Branch	Kagamigahara	A	20	60	412		412
25 June	Kawasaki	Gifu	Kagamigahara	A	20	21	121		121
23 July	Sumitomo	Sakurajima	Osaka	P	20	83	494		494
23 July	Kawanishi	Takarazuka	Takarazuka	A	20	78	458		458
23 July	Aichi	Eitoku	Nagoya	A	20	66	451		451
23 July	Nakajima	Handa	Handa	A	20	78	544		544
28 July	Kawasaki	Oifu	Kagamigahara	A	N	9	2		2
29 July	Nakajima	Musashi	Tokyo	E	20	1	5		5
30 July	Japan International	Hiratsuka	Hiratsuka	AEP	N	20	7		7
4 August	12th NAD		Oita	AE	7	1	2		2
7 August	Nakajima	Ota	Ota	A	20	51	244		244
8 August	Nakajima	Musashi	Tokyo	E	20	60	280		280
13 August	Japan International	Hiratsuka	Hiratsuka	AEP	N	48	26		26
13 August	1st NAD		Yokosuka	AE	N	7	7		7
13 August	Nakajima	Utsunomiya	Utsunomiya	A	N	8	2		2
13 August	Mitsubishi	No. 5 Dispersal	Nagano	A	N	7	2		2
13 August	Koza ND		Atsugi	A	N	11	9		9
14 August	Toyoda Auto		Nagoya	E	20	3	15		15

Key to abbreviations. A: Airframes; E: Engines; P: Propellers; 20: Twentieth Air Force; 7: Seventh Air Force; N: Navy.

try is discernible. Analyzed separately as to engine and airframe plants, engines were the first to be hit hard. This was in accordance with the Joint Chiefs of Staff Target Priority Directive. Concentrated and heavy attacks against the airframe industry, however, began about 2 weeks after the heavy engine attacks started, built up somewhat more slowly, and in late July, approximated engine tonnages.

Effectiveness of Direct Attacks

In order to analyze physical effectiveness of the bombing program, certain results of each air attack were tabulated. These are shown in Table VI–VIII. These data were obtained partially from on-the-ground inspections and partly from questionnaires returned by the various Jap companies. They are presented in greater detail in the individual plant and corporation reports. To arrive at damage rating for any attack, several factors were weighed. Total tonnage dropped on the plant area (and percent which struck buildings was determined from bomb plots and known attack data. Building areas destroyed and damaged were obtained from plant layout plans, supplemented by on-the-ground findings. Other factors weighed were: (1) damage and destruction of machine tools and equipment, (2) man-hours lost, (3) production and productive capacity losses, (4) casualties and (5) the progress of dispersal attained prior to the attack. The following rating scale was applied to both direct and indirect attack analyses:

Very heavy.—Complete or almost complete physical destruction of the plant, both physically and as a producing unit.

Heavy.—A large percentage of complete and partial destruction; large losses of machine tools and equipment; destruction and/or damage of key fabrication units; serious production and capacity losses.

Medium.—Appreciable destruction and/or damage, but not so severe as that in the Heavy rating.

Light.—Generally less than 5 percent of total area destroyed and damaged; small tool and equipment losses and little effect on production.

Negligible.—No serious damage and minor productive losses.

Table VI–VI rates each direct attack for which information was available. No information had been obtained for 6 of the 90 direct attacks made. From these data, a summary of damage-effect ratings, by company, was derived and is presented in Table VI–VIII.

From these data, the following summary of major damages inflicted on several of the producers has been derived:

Nakajima.—About one-third of the attacks directed against this company were highly destructive in the Handa airframe, Ota airframe, and Musashi engine

TABLE VI–VI.—*Alphabetical record of direct attacks and attack analysis*

Company	Plant	Location	Date of attack	Air Force	Tons dropped	Tons striking plant		Approximate (%) building area		Machines		Man-hours lost	Months production lost	Casualties	Damage effect rating
						Area	Buildings	Destroyed	Damaged	Damaged	Destroyed				
Aichi	Atsuta	Nagoya	8- 6-45	20	271	4	2	20	10				0.3		Heavy.
	Eitoku	Nagoya	3- 3-45	20	14	0	0								No hit.
			25- 6-45	20	346	8	5	10	(1)	0	0		.1	44	Medium.
			23- 7-45	20	451	25	14	20	10	2	10		1.0	30	Heavy.
	Chiba	Chiba	9- 6-45	20	144	19.5	0.5	(1)	(1)	1	0	66,200	.2		Light.
Hitachi	Tachikawa	Tachikawa	23- 4-45	20	474	136	29	40	20	138	361	780,000	3.0		Very heavy
Japan Airplane	Tomioka	Tomioka	9- 6-45	20	173	1.8	0.8	5	10	22	3	358,000	1.0	38	Medium.
Japan International	Hiratsuka	Hiratsuka	30- 7-45	N	7	7	3.5	5	10	0	0		0	15	Light.
			13- 8-45	N	26	(1)	[2]3	(1)	(1)				0		Negligible.
Japan musical instrument	Hamamatsu	Hamamatsu	29- 4-45	20	45	0	0								Not hit.
Kawanishi	Himeji	Himeji	21- 6-45	20	351	57.2	45.7	80	20				2.0	222	Very heavy
Do	Konan	Fukae	10- 5-45	20	461	36.5	24.0								Heavy.
Do	Naruo	Amagasaki	8- 6-45	20	264	164	107							265	Do.
Do	Takarazuka	Takarazuka	23- 7-45	20	458	202	88	75	10			21,700			Very heavy
Kawasaki	Akashi	Akashi	18- 1-45	20	154	57.8	33.0	50	30						Do.
			20- 5-45	20	2	0	0								Not hit.
			8- 6-45	20	144	0	0								Do.
			21- 6-45	20	155	82	52	25	25						Very heavy
			25- 6-45	20	184	28	18	10	15						Heavy.
Do	Gifu	Kaganigahara	21- 6-45	20	116	30	22	50	40	5	107		2.0		Very heavy
			25- 6-45	20	121	23.5	10.0								Heavy.
			28- 7-45	N	2	0	0								Not hit.
Manchuria		Mukden	7-12-44	20	263	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	
			21-12-44	20	86	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	
Mitsubishi	Nos. 2, 4, and 10	Nagoya	12-12-44	20	181	112	29	15	20	36	152		4.0	351	Heavy.
			21-12-44	20	130	83	[2]40	(3)	(1)	0	0		0	10	Light.
			22- 1-45	20	83	38.8	[2]16	0	(1)				.0	0	Do.
			14- 2-45	20	106	22.3	18.5	5	(1)	1	12		.1	45	Medium.
			24- 3-45	20	1,510	[2]117	[2]60	0	(1)				(1)	23	Light.
			30- 3-45	20	50	0	0								Not hit.
			6- 4-45	20	614	119	92	75	15	414	446		4.0	27	Very heavy
Do	Nos. 3 and 5	Nagoya	17-12-44	20	155	16	8	10	5	11	13	325,000	,3	464	Medium
			13- 1-45	20	95	0.8	0.8	(1)	0	0	0		0	66	Negligible.
			1- 2-45	20	3	0	0								Not hit.
Do	No. 5 Dispersal	Nagano	13- 8-45	N	2	1.0	0.8	0	(1)						Light.
Do	No. 5 Branch	Kagamigahara	21- 6-45	20	98	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	
			25- 6-45	20	412	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	
(Mitsubishi)	No. 6	Shizuoka	3- 4-45	20	181	0	0								Not hit.
			11- 4-45	20	56	31	14	10	5		60		1.6		Heavy.
Do	No. 7	Mizushima	19- 3-45	20	4	0	0								Not hit.
			19- 3-45	N	1	0	0								Do.
			29- 3-45	20	2	0	0								Do.
			25- 4-45	20	3	3	3	(1)	(1)	0	0	7,324	0	17	Negligible
			21- 6-45	20	603	[2]175	[2]100	50	10	165	70	15,104	2.0	5	Heavy.
Do	No. 9	Kumamoto	18- 3-45	N	1	1.0	0.5	0	5	0	4		.3	14	Light.
			14- 5-45	N	66	20	7	5	25	344	25		.8	6	Medium
Nakajima	Handa	Handa	23- 7-45	20	544	27.0	5.8	10	30	13			.5	9	Heavy.
Do	Koizumi	Koizumi	25- 2-45	N	39	31	12	10	40	29	5		.5	89	Do.
			3- 4-45	20	275	6	2	5	15	0	0		.1	0	Light.

See footnotes at end of table.

TABLE VI–VI.—*Alphabetical record of direct attacks and attack analysis*—Continued

Company	Plant	Location	Date of attack	Air Force	Tons dropped	Tons striking plant		Approximate (%) building area		Machines		Man-hours lost	Months production lost	Casualties	Damage effect rating
						Area	Buildings	Destroyed	Damaged	Damaged	Destroyed				
Nakajima	Ogikobu	Tokyo	9- 6-45	20	38	0	0								Not hit.
Do	Ota	Ota	9- 2-45	20	237	26.0	6.5	15	25				1.0		Heavy.
			10- 2-45	20	9	0	0								Not hit.
			16- 2-45	N	39	3.0	1.5	10	20				3.5	122	Heavy.
			25- 2-45	N	15	0.8	0.3	(1)	(1)				0		Negligible.
			7- 8-45	20	244	0	0								Not hit.
Do	Musashi	Tokyo	24-11-44	20	112	12.3	8.0	(1)	(1)	10	34	199,760	(1)	122	Negligible.
			2-12-44	20	142	6.0	2.8	5	(1)	2	3	180,000	.1	81	Light.
			26-12-44	20	105	6.8	2.8	5	(1)	8	25	239,140	.1	48	Do.
			8- 1-45	20	42	9.3	2.3	(1)	(1)	2	13	238,140	.1	14	Do.
			17- 2-45	N	35	15.0	7.5	25	(1)	42	130	441,548	.4	195	Heavy.
			3- 3-45	20	112	0	0								Not hit.
			1- 4-45	20	1,019	4.0	0.5	(1)	(1)	9	14	316,220	(2)	5	Negligible.
			6- 4-45	20	490	138	43	10	(1)	56	58	345,320	.1	2	Heavy.
			11- 4-45	20	490	43	17	10	(1)	52	55	373,285	.2	2	Do.
			18- 4-45	20	3	0	0								Not hit.
			1- 5-45	20	3	0	0								Do.
			29- 7-45	20	5	0	0								Do.
			8- 8-45	20	280	64	35	10	(1)	0	0		0		Light.
	Utsonomiya	Utsonomiya	13- 8-45	N	2	2	0.5	(1)	5				.3		Do.
Naval Air Depots: 1st NATD															
		Yokosuka	13- 8-45	N	7	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)		
11th NAD		Hiro	19- 3-45	N	6	2.5	1.2	(1)	10				.1	149	Light.
			4- 5-45	20	578	38	23	40	30		530		1.0	246	Heavy.
			11- 5-45	20	3	0	0								Not hit.
12th NAD		Oita	4-8 -45	7	2	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	
21st NAD		Omura	7- 7-44	20	2	0	0								Not hit.
			25-10-44	20	155	40	13	30	15				5.7	503	Very heavy.
			21-11-44	20	203	0	0								Not hit.
			19-12-44	20	52	8.3	1.0	(1)	0	0	0		0	2	Negligible
			6- 1-45	20	90	6.3	1.3	(1)	(1)	1	1		0	1	Do.
			26- 3-45	20	88	0	0								Not hit.
Koza ND		Atsugi	13- 8-45	N	9	[2] 6	[2] 2	5	(1)				0	8	Light.
Sumitomo	Sakurajima	Osaka	25- 6-45	20	382	0	0								Not hit.
			23- 7-45	20	494	[2] 250	[2] 125	90	5	10	5		0	21	Very heavy.
Tachiarai		Tachiarai	30- 3-45	20	417	[2] 200	[2] 100	90	10				4.5		Do.
Tachikawa Aircraft		Tachikawa	17- 2-45	N	59	12.0	5.8	(1)	5	0	0			69	Medium.
			3- 4-45	20	503	15.0	3.5	5	(1)	0	0			29	Do.
			13- 4-45	20	3	0	0								Not hit.
			23- 4-45	20	43	22.0	8.5	10	5	0	0			123	Heavy.
Tachikawa Army Arsenal		Tachikawa	9- 6-45	20	169	[2] 15	[2] 5	5	(1)						Light.
Toyoda auto		Nagoya	14- 8-45	20	15	0	0								Not hit.

[1] Less than 5 percent.
[2] Approximate value.
[3] No information.

works. The latter two locations were particularly heavily affected as major producing units.

Mitsubishi.—Between one-third and one-quarter of the attacks against Mitsubishi were highly effective. The Nagoya engine works was about one-half completely destroyed and the Shizuoka engine and Mizushima airframe works badly damaged.

Kawasaki.—More than one-half of the effort expended against this company resulted in extensive and heavy damage to their two main plants at Akashi and Kagamigahara, the former producing both engines and airframes and the latter only airframes.

Kawanishi.—All four attacks against this company were appreciably damaging. The Himeji plant was completely destroyed, the Takarazuka works badly crippled, and the Konan and Naruo works hard hit. All four of these were important airframe producing units. Naruo, in addition, fabricated training propellers.

Aichi.—Two of four attacks damaged two major production units; both the Atsuta engine works and the Eitoku airframe plant were hard hit.

Hitachi.—One attack almost completely eliminated the Tachikawa airframe and engine plant as a major production unit.

Sumitomo.—The Sakurajima plant, Japan's prineipal propeller producer, was almost completely destroyed in one attack.

Tachiarai.—This small airframe plant was completely destroyed in one attack. (Report of Team No. X on Kyushu.)

Twenty-first Naval Air Depot.—The main plant was so badly damaged its production was only negligible thereafter.

Table IX and Figure I–4 of the summary compare and contrast relative importance of the various companies against bomb tonnages aimed at them. Tonnages dropped on both Mitsubishi and Nakajima, the two major producers, were justified in the light of their relative importance. It is believed, however, that some of the tonnage delivered against Kawanishi, naval air depots, Aichi and Tachiarai, all relatively small producers, might have been directed more profitably against more important producers such as Kawasaki, Hitachi, Tachikawa, Japan Airplane, and Japan International.

Accuracy of Direct Attacks

An attempt has been made to measure the degree of bombing accuracy in Table VI–X. However, in considering this analysis it must be borne in mind that attacks were made by the Army from high altitudes and by the Navy at low levels. No attempt has been made to take into account differences of daylight visual and night radar-aided attacks. Further, tonnage of hits is not necessarily the criterion for measuring bombing effectiveness. One bomb, properly placed, might hit a vital spot and be all that would be necessary to do the job.

Since no similar study was made in Germany, the accuracy of bombing of aircraft industries in the two countries cannot be directly compared. Based on bombing accuracy studies made on other industrial categories in Germany, however, the figure of 8 percent of tonnage striking Japanese aircraft plant buildings represents an improvement in bombing accuracy. The 82 percent which missed plant areas did not mean a total loss. In some known and many suspected cases damage to adjacent targets was highly profitable. A large percentage of this tonnage was dropped on secondary missions.

TABLE VI–VII.—*Direct attacks against aircraft industry, tonnages, by months*

	HE	IB	Total
July 1944	2		2
August			
September			
October	91	64	155
November	211	104	315
December	637	477	1,114
January 1945	385	79	464
February	458	84	542
March	1,183	322	2,205
April	4,181	18	4,199
May	1,113		1,113
June	3,971		3,971
July	1,961		1,961
August	587		587
Total	15,780	1,148	15,928

TABLE VI–VIII.—*Damage effect ratings—direct attacks*

Company	Very heavy	Heavy	Medium	Light	Negligible	Complete	
						Miss	Total
Nakajima		7		6	3	7	23
Mitsubishi	1	3	3	4	3	6	20
Naval air depots	1	1		1	3	4	10
Kawasaki	3	2				3	8
Kawanishi	2	2					4
Aichi		2	1			1	4
Tachikawa		1	2			1	4
Hitachi	1			1			2
Sumitomo	1					1	2
Japan International				1	1		2
Tachiarai	1						1
Japan Airplane			1				1
Tachikawa Army							
Air arsenal				1			1
Japan Musical Instrument						1	1
Toyoda Auto						1	1
Total	10	18	7	14	10	25	84
By Army	10	15	5	8	8	23	69
By Navy	0	3	2	6	2	2	15

TABLE VI–IX.—*Relative importance versus direct-attack tonnages*

Company	H. E.		I. B.		Total		Percent 1944 production		
	Tons	Percent	Tons	Percent	Tons	Percent	Air frames	Engines	Props
							Percent	*Percent*	*Percent*
Mitsubishi	3,748	24.2	608	53.0	4,356	26.6	14.8	37.7	
Nakajima	4,086	26.4	194	16.9	4,280	24.5	28.0	30.1	
Kawaoishi	1,534	9.9			1,534	9.4	3.8		2.2
Naval air depots	990	6.4	205	17.9	1,195	7.3	2.3	4.0	
Aichi	1,078	7.0	4	.3	1,086	6.5	5.3	1.6	
Kawasaki	878	5.7			878	5.4	13.0	9.1	
Sumitomo	876	5.7			876	5.4			60.7
Hitachi	618	4.0			618	3.8	3.0	9.6	
Tachikawa A/C	595	3.8	13	1.1	608	3.7	7.8		
Tachiarai	417	2.7			417	2.6	1.1		
Manchuria	225	1.5	124	10.8	349	2.1	3.6	1.2	
Japan A/C	173	1.1			173	1.1	4.3		
Tachikawa Army	169	1.1			169	1.0	1.1	1.0	
Japan Musical Instrument	45	.3			45	.1			30.9
Japan International	33	.2			33	.2	5.1	1.2	6.2
Toyoda Auto	14	.1			14	.1		.1	
Kyushu							4.0		
Fuji							1.8		
Showa							1.0		
Tokyo							.1		
Mitsui Miniog							Nil		
Matsushita							Nil		
Ishikawajima								2.5	
Nisson Auto								2.0	
Totals	15,479	100.1	1,148	100.0	16,351	100.0	100.1	100.1	100.0

TABLE VI–X.—*Accuracy of direct attacks*

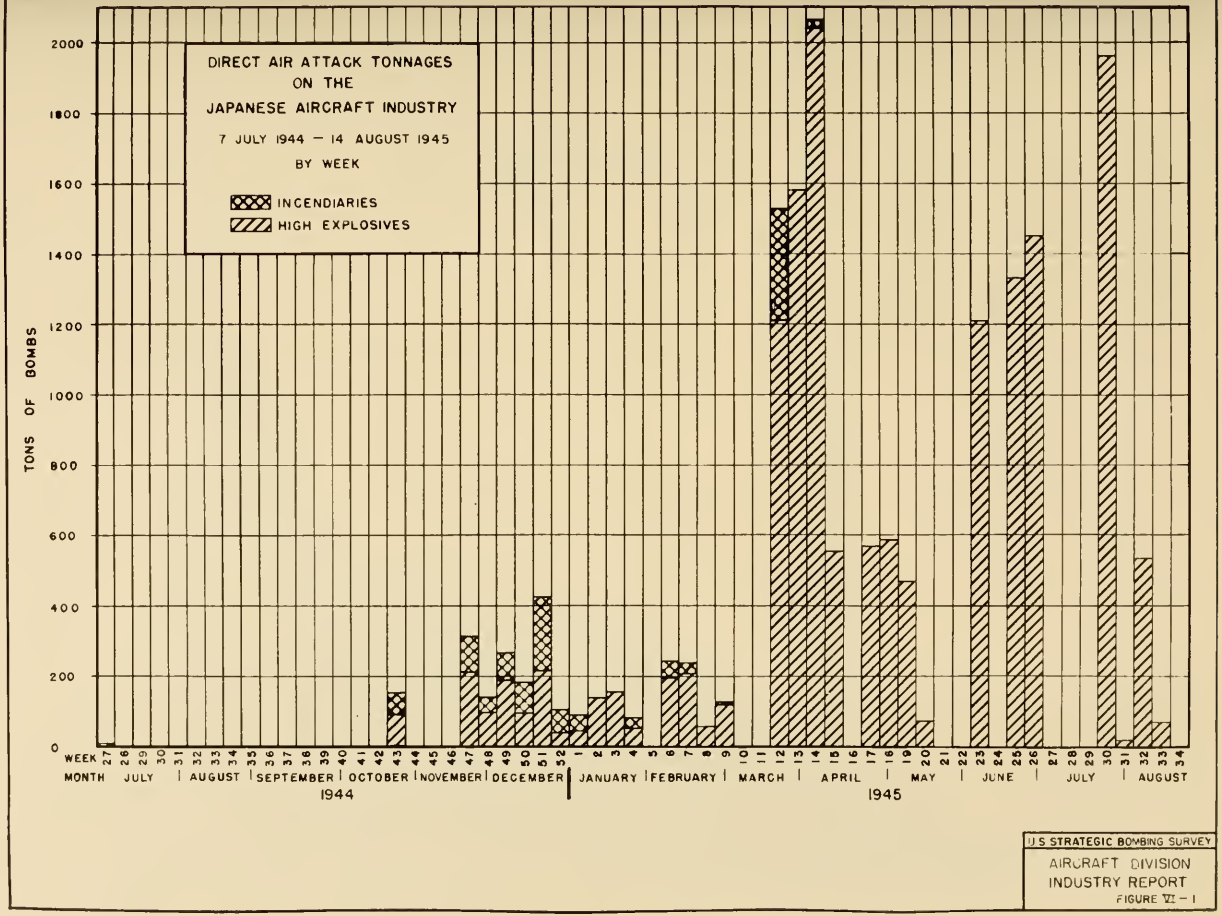
[Figure I–5]

	Army	Navy	Total
Total bomb tonnage	16,312	316	16,628
Unknown effects	861	7	868
Tonnage analyzed	15,451	309	15,760
Tonnage on plant area:			
(1) Struck buildings:			
Tons	1,238	46	1,284
Percent	8.0	14.9	8.1
(2) Struck open plant area:			
Tons	1,292	65	1,357
Percent	8.4	21.0	8.6
(3) Total tonnage on plant area:			
Tons	2,530	111	2,641
Percent	16.4	35.9	16.7
Tonnage missing plant area:			
Tons	12,921	198	13,119
Percent	83.6	64.1	83.2

Table VI–XI presents an analysis of missions which did not hit the target at which aimed. The tonnages were included in "Tonnage missing plant area," of Table VI–X. Of these 25 missions, 17, carrying only 154 tons, were made by fewer than 10 airplanes each. Of these 17, 11 were 1-plane missions, carrying a total of 31 tons.

TABLE VI–XI.—*Direct-attack missions which missed targets*

	Army	Navy	Total
Missions analyzed	69	15	84
Tonnages carried	15,451	309	15,760
Aircraft	3,179	534	3,713
Failed to hit target:			
(1) Missions:			
Number	23	2	25
Percent	33.3	13.3	29.8
(2) Tonnages carried:			
Tons	1,555	3	1,558
Percent	10.1	.9	9.9
(3) Aircraft involved:			
Number	372	10	382
Percent	11.9	1.8	10.3



U.S STRATEGIC BOMBING SURVEY
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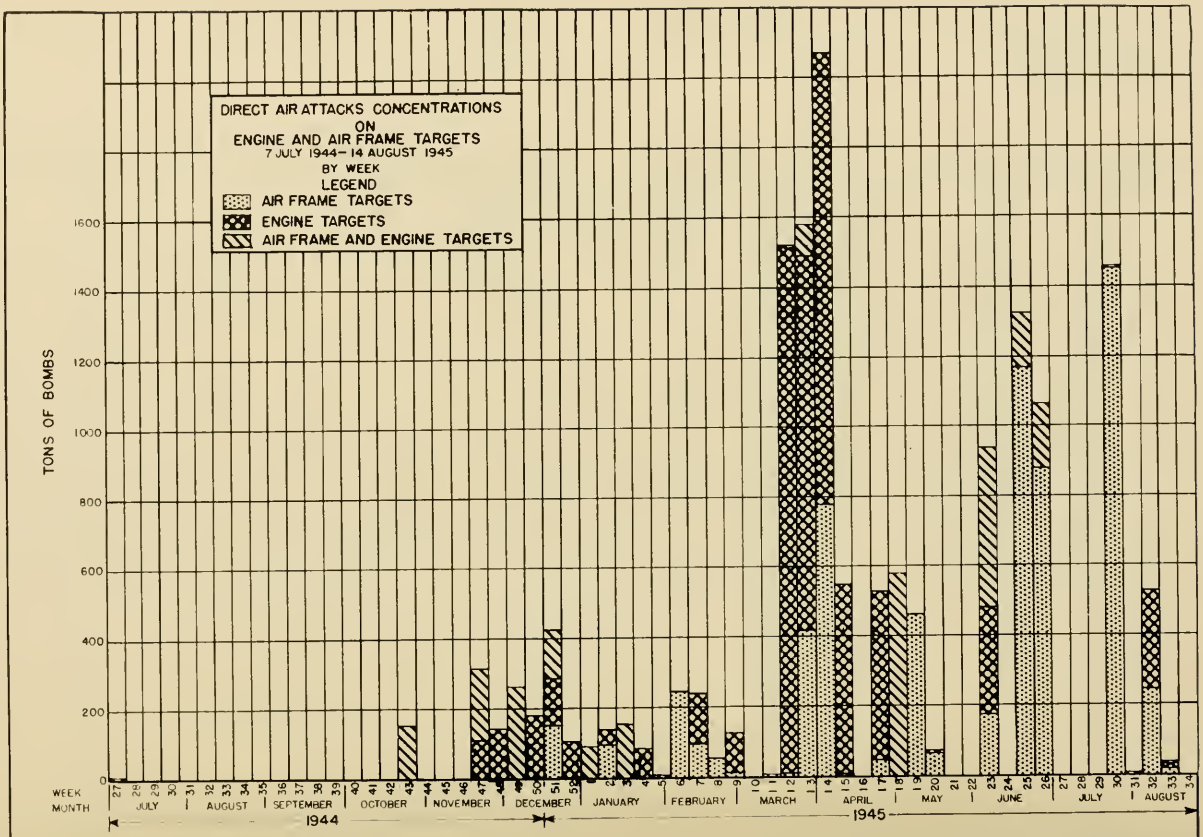
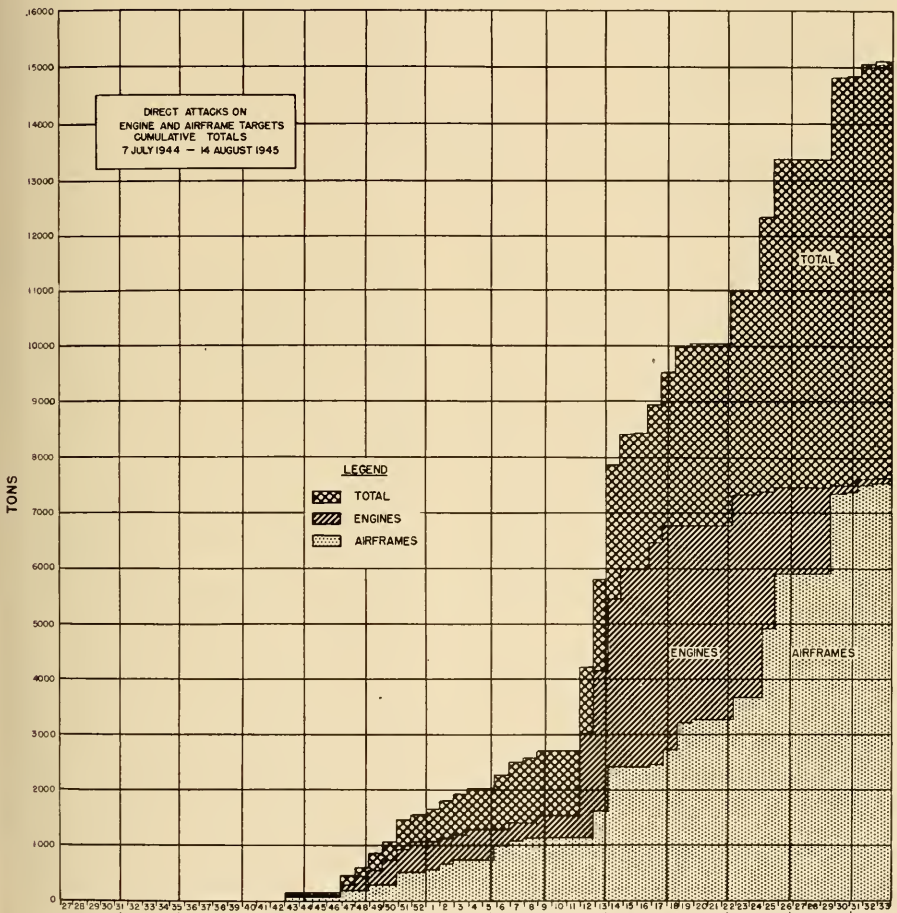
FIGURE VI — 1


DIRECT AIR ATTACKS CONCENTRATIONS
ON
ENGINE AND AIR FRAME TARGETS
7 JULY 1944 – 14 AUGUST 1945
BY WEEK
LEGEND
AIR FRAME TARGETS
ENGINE TARGETS
AIR FRAME AND ENGINE TARGETS
TONS OF BOMBS
0
200
400
600
800
1000
1200
1400
1600
WEEK
MONTH
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
1944
1945
US STRATEGIC BOMBING SURVEY
AIR CRAFT DIVISION
INDUSTRY REPORT
FIGURE VI - 2



U.S. STRATEGIC BOMBING SURVEY

AIRCRAFT DIVISION
INDUSTRY REPORT

FIGURE VI-3

C. INDIRECT ATTACKS

Air attacks against targets of other categories struck aircraft plants a recorded total of 160 times. These attacks were directed against targets as follows:

	Attacks
Urban areas	47
Airfields	30
Industrial plants	11
Untraceable origin	8
VII Fighter Command strikes	9
Unidentified and miscellaneous	5
First atomic bomb	1
Total	111

Several of these attacks struck a number of aircraft plants in one locality.

The 47 urban area attacks were the heaviest, involving loads up to 5,100 tons per attack. They were aimed primarily at important industrial centers. These struck aircraft plants 90 times and caused a great amount of damage.

Twenty-nine of the 30 airfield strikes were carried out by the Navy. Spillovers onto adjacent or nearby aircraft plants produced three heavy and three medium-damage cases out of the attacks.

Table VI–XII presents a chronological record of indirect attacks, together with damage effect ratings. The ratings are the same as those used for the direct-attack analysis. Air Force attack data were derived primarily from tabulating section records, supplemented by information from Japanese observations. Of the 160 plant hits, only eight could not be identified as to origin of attack.

Multiple effects from single attacks were common in the Twentieth Air Force's urban-area program. In 19 different missions from 2 to 10 aircraft plants were struck per mission. The most damaging were the 16 May Nagoya attack, in which 10 different aircraft plants were struck, and the 11 March 1945 Nagoya mission, in which 5 plants were hit.

Table VI–XIII is a tabulation of damage-effect ratings from the indirect attacks. The ratings were derived in the same way as for the direct attacks. In comparison with the direct attacks, both the incidence and effectiveness of "heavy" attacks appear to be greater than was actually the case since (1) fewer large production units were as heavily hit, and (2) more than twice as many strikes were made.

Japan International, Hitachi, and Aichi, important producers in the aircraft industry, were not adequately bombed in the direct-attack program (Tables VI–VIII and VI–IX), but were heavily damaged and partially neutralized by the indirect attacks. This was also true, to a lesser degree, for Japan Airplane Co.

D. EFFECTIVENESS OF BOMBS

Data extracted from direct-attack records of the Tabulating Section give the following figures for types of bombs dropped on aircraft industry targets:

	Tons	*Percent*
High explosive (HE)	15,200	93.0
Incendiaries	1,148	7.0
Total	16,348	100.0

A negligible quantity of fragmentation bombs was dropped by the Navy. These were included under the HE total. The greater portion of both HE and IB consisted of 500-pounders.

Bomb action and physical-damage effects were subjects of study by the Physical Damage Division for certain selected targets. Exact analyses may be found in the reports of that Division. Certain conclusions reached by the field teams of the Aircraft Division, however, are of sufficient interest to be included in this report.

It appears that (1) the 500-pound bomb, double-fuzed, was sufficiently heavy to cause appreciable structural damage to the average Japanese plant building, and (2) higher proportion of incendiaries might have been employed profitably. Japanese plant buildings were mostly of light steel construction covered with corrugated composition material. As the war progressed, new construction was almost entirely of wood. Observations indicate that a more widespread application of incendiaries would have multiplied damage and production losses. Certain targets, such as Nakajima's Musashi and Ota plants and Kawasaki's Akashi in which large, heavy concrete-and steel structures housed important units, were properly given doses of 1,000- and 2,000-pound bombs. (Plant Report Nos. II–3, II–1, and IV–2.)

E. PERSISTENCY OF ATTACKS

Nakajima and Mitsubishi, the two largest producers, were the most frequently bombed. Mitsubishi was the target for 22 and Nakajima 21 direct missions, or each about 25 percent of the total direct attacks. As a result of indirect attacks, Mitsubishi was struck 37 times (25 per

Air Force attack data										Effects on aircraft plant			
Date			Primary target	Location	Air Force	Number of A/C	Tons bombs			Aircraft company struck	Plant	Location	Damage effect rating
Day	Month	Year					IIE	IB	Total				
8	1	45	Urban area	Hamamatsu	20	6	16		16	Nakajima	Miyatake plant	Hamamatsu	Negligible.
3	2	45	do	Matsuzuka	20	15	40	3	43	do	Matsuzuka plant	Matsuzuka	Heavy.
4	2	45	do	Kobe	20	2	4		4	Kawasaki	Kobe Casting & Forging	Kobe	Negligible.
16	2	45	Seaplane base and airfield	Kasumigaura	Navy	12	9		9	Nakajima	Wakaguri plant	Wakaguri	Medium.
										1st NAD	Main plant	Kasumigaura	Light.
17	2	45	Airfield	Haneda	Navy	10	2		2	Hitachi	Haneda plant	Kawasaki	Negligible.
17	2	45	Nakajima, Musashi	Musashi	Navy	147	94		94	Nakajima	Mitaka plant	Mitaka	Do.
			Plant Tachikawa A/C	Tachikawa						Hitachi	Tachikawa plant	Tachikawa	Heavy.
11	3	45	Urban area	Nagoya	20	285		1,793	1,793	Mitsubishi	No. 10 works	Nagoya	Medium.
										do	Nos. 1, 3, and 5 works	do	Heavy.
										Aichi	Eitoku plant	do	Do.
										do	Funakata plant	do	Light.
										do	Sanno plant	do	Do.
										Showa	Main plant	Tachikawa	Negligible.
13	3	45	do	Osaka	20	274		1,733	1,733	Jap International	Kanzaki plant	Kanzaki	Heavy.
16	3	45	do	Kobe	20	306		2,331	2,331	Kawasaki	Kobe Casting & Forging	Kobe	Do.
18	3	45	Airfield	Omura	Navy	29	20		20	21st NAD	Main plant	Omura	Negligible.
18	3	45	Urban area	Nagoya	20	291	20	1,845	1,865	Mitsubishi	Nos. 1 and 3 works (Demachi).	Nagoya	Do.
										do	No. 5 works (Demachi)	do	Do.
										do	No. 10 works	do	Light.
										Aichi	Atsuta plant	do	Medium.
24	3	45	Mitsubishi Nos. 2 and 4 engine works.	do	20	224	1,196	314	1,510	do	Chikusa plant	do	Very heavy.
3	4	45	Tachikawa A/C	Tachikawa	20	61	490	13	503	Tachikawa Army Air Arsenal.		Tachikawa	Light.
										Showa	Main plant	do	Negligible.
3	4	45	Urban area	Kawasaki	20	47	375	19	394	Ishikawajima	Takashima Machi warehouse.	Yokahama	Heavy.
7	4	45	Not traceable							Mitsubishi	No. 3 branch works	Suzuka	Negligible.
12	4	45	do							do	No. 7 works	Mizushima	Do.
13	4	45	Tokyo arsenal area	Tokyo	20	327	2,037	82	2,119	Fuji	Kamata plant	Tokyo	Do.
15	4	45	South urban area	do	20	109	15	754	769	Mitaka	Main office and warehouses.	do	Light.
			Urban area	Kawasaki	20	194	1,072	33	1,105	Hitachi	Kawasaki foundry	Kawasaki	Very heavy.
										Fuji	Kamata plant	Tokyo	Negligible.
										Ishikawajima	Nakamura-Bashi plant	Yokahama	Light.
16	4	45	Not traceable							Mitsubishi	No. 14 works	Kyoto	Medium.
8	5	45	Vessels	Chiba	Navy	6	2		2	Hitachi	Chiba plant	Chiba	Negligible.
13	5	45	Airfield	Kumamoto	Navy	16	3		3	Mitsubishi	No. 9 works	Kumamoto	Medium.
13	5	45	North urban area	Nagoya	20	411		2,156	2,156	do	No. 10 works	Nagoya	Do.
										do	No. 22 works	Ozone	Do.
										do	No. 3 branch works	Joboku	Heavy.
										do	No. 4 works	Nagoya	Light.
14	5	45	Not traceable							Nakajima	Chiyru branch plant	Yatagawa	Heavy.

TABLE VI-XII.—*Indirect-attack record—chronological*—Continued

Date			Air Force attack data								Effects on aircraft plant			
						Number of A/C	Tons bombs			Aircraft company struck	Plant	Location	Damage effect rating
Day	Month	Year	Primary target	Location	Air Force		HE	IB	Total				
16	5	45	South urban area	Nagoya	20	457		3,609	3,609	Mitsubishi	Nos. 1 and 3 branches (Demachi).	Nagoya	Heavy.
										do	No. 3 branch (Nanko)	do	Do.
										do	No. 5 branch (Demachi)	do	Negligible.
										do	No. 5 works (Miznho)	do	Heavy.
										do	No. 11 works (Dotoku)	do	Medium.
										Nakajima	Atsuta plant	do	Very heavy.
										Aichi	do	do	Negligible.
										do	Sanno plant	do	Light.
										do	Funakata plant	do	Do.
										do	Eitoku plant	do	Do.
18	5	45	Urban area	Hamamatsu	20	334	1,834		1,834	Nakajima	Miyatake plant	Hamamatsu	Negligible.
										Japan Musical Instrument	Tenryu plant	do	Very heavy.
										do	Main plant		Negligible.
23	5	45	do	Tokyo	20	520		3,646	3,646	Fuji	Kamata plant	Tokyo	Medium.
										Hitachi	Omori plant	Kawasaki	Light.
25	5	45	do	do	20	464	4	3,250	3,254	Shoda	Main plant	Mitaka	Do.
										Mitaka	Main office and warehouses.	Tokyo	Do.
25	5	45	VII Fighter Command strike	Matsudo and Tokorozawa	20	73				Showa	Main plant	Tachikawa	Negligible.
28	5	45	Urban area	Yokohama	20	872	20	5,148	5,168	Hitachi	Omori plant	Kawasaki	Heavy.
										Japan Airplane	Tamioka plant	Tomioka	Negligible.
										Ishikawajima	do	do	Medium.
28	5	45	VII Fighter Command strike	Kasumigaura	20	63				Nakajima	Wakaguri plant	Wakaguri	Light.
										1st NAD	Main plant	Kasumigaura	Negligible.
31	5	45	Urban area	Osaka	20	458	81	2,708	2,783	Sumitomo	Kanzaki plant	Kanzaki	Do.
										do	Sakurajima plant	Osaka	Do.
4	6	45	do	Kobe	20	474	71	3,010	3,081	Kawanishi	Konan plant	Fukae	Do.
										Kawasaki	Kobe Casting & Forging	Kobe	Light.
6	6	45	do	Osaka	20	409	798	1,789	2,587	Japan International	Yodogawa plant	Osaka	Medium.
8	6	45	Aichi, A/C, Eiloku plant	Nagoya	20	41	242		242	Aichi	Funakata plant	Nagoya	Heavy.
										1st NAD	Main plant	Kasumigaura	Medium.
9	6	45	Seaplane base	Kasumigaura	20	23	123		123	Wakajima	Wakaguri plant	Wakaguri	Light.
10	6	45	Urban area	Hamamatsu	20	2	10		10	Japan Musical Instrument	Main plant	Hamamatsu	Very heavy.
11	6	45	VII Fighter Command strike	Tokorozawa	20	56				Showa	do	Tachikawa	Negligible.
14	6	45	Urban area	Amagasaki	20	251		1,773	1,773	Sumitomo	Kanzaki plant	Kanzaki	Heavy.
										Kawanishi	Takarazuka plant	Takarazuka	Light.
17	6	45	do	Yokkaichi	20	80	3	572	575	Mitsubishi	No. 3 branch works	Yokkaichi	Heavy.
19	6	45	do	Shizuoka	20	123		873	879	do	No. 6 works	Shizuoka	Negligible.
										do	No. 3 branch works	do	Do.
										Sumitomo	Shizuoka plant	do	Very heavy.
25	6	45	Osaka Army Arsenal	Osaka	20	99	758		758	Jap International	Yodogawa plant	Osaka	Light.
25	6	45	Urban area	Tsu	20	31	193		193	Sumitomo	Tsu plant	Tsu	Do.
										Mitsubishi	No. 3 branch works	do	Negligible.
25	6	45	Sumitomo Aluminum Co	Nagoya	20	29	150		150	do	No. 5 branch (Demachi)	Nagoya	Do.
										do	No. 5 branch (Mizuho)	do	Do.
28	6	45	Urban area	Okayama	20	138		1,964	1,964	Tachikawa	Okayama plant	Okayama	Light.
1	7	45	do	Kumamoto	20	155		1,121	1,121	Mitsubishi	No. 9 works	Kumamoto	Negligible.

2	7	45	do	Kure	20	157	13	1,082	1,095	11th NAD		Hiro	Light.
6	7	45	do	Akashi	20	123		975	975	Kawasaki	Akashi Oxygen plant	Akashi	Heavy.
6	7	45	do	Chiba	20	125	32	860	892	Hitachi	Chiba plant	Chiba	Light.
7	7	45	Not traceable							Aichi	Ibo plant	Nagoya	Negligible.
8	7	45	VII Fighter Command strike	Hyakurigahara, Yachimota, Takarazawa, Chofu.	20	114				Showa	Main plant	Tachikawa	Negligible.
9	7	45	do	Itami, Nishinomiya, Hamamatsu, Toyohashi.	20	122				Nakajima	Arai plant	Arai, Shizuoka	Do.
9	7	45	Urban area	Sakai	20	116		799	799	Kawasaki	Sakai plant	Sakai	Heavy.
10	7	45	Airfields	Kiryu and Koga	Navy	41	16		16	Nakajima	Ikusbima plant	Ikushima	Light.
10	7	45	Airfield	Kasumigaura	Navy	105	65		65	do	Wakaguri plant	Wakaguri	
										1st NAD	Main plant	Kasumigaura	Do.
10	7	45	do	Utsonomiya	Navy	68	32		32	Nakajima	Utsonomiya plaut	Utsonomiya	Do.
10	7	45	do	Tachikawa	Navy	16	4		4	Tachikawa	Main plant	Tachikawa	Negligible.
10	7	45	do	Atsugi	Navy	136	58		58	Koza Naval Depot		Atsugi	Do.
12	7	45	Urban area	Utsonomiya		20	115		803	803	Nakajima	Utsonomiya plant	Utsonomiya	Heavy.
15	7	45	VII Fighter Command strike	Meiji, Kagamigaharo, Kowa, Nagoya, Suzuka.		20	117				Mitsubishi	No. 22 works	Koromo	Medium.
											Nakajima	Okazaki plant	Okazaki	Light.
16	7	45	Urban area	Hiratsuka		20	133		1,163	1,163	Japan International	Hiratsuka plant	Hiratsuka	Heavy.
16	7	45	do	Kuwana		20	197	818	693	1,511	Mitsubishi	No. 3 branch works	Kuwana	Do.
18	7	45	Unidentified	Miyakonojo		5	16	8		8	Kawasaki	Miyakonojo plaut	Miyakonojo	Light.
18	7	45	Airfield	Kiryu	Navy	12	2			2	Nakajima	Ikushima plant	Ikushima	Do.
18	7	45	do	Atsugi	Navy	53	26			26	Koza Naval Depot		Atsugi	Negligible.
19	7	45	Nippon Oil Refinery	Amagasaki		20	83	685		685	Kawanishi	Naruo plant	Amagasaki	Medium.
19	7	45	Urban area	Okazaki		20	126		851	851	Mitsubishi	No. 5 branch works	Okazaki	Do.
19	7	45	do	Fukui		20	127		954	954	do	No. 18 works	Fukui	Very heavy
											Japan International	Fukui plant	do	Do.
											Aichi	Hokuriku plant	do	Light.
22	7	45	VII Fighter Command strike	Hami, Hansbin, Takamatsu, Tokosbima.		20	122				Mitsubishi	No. 7 works	Mizushima	Negligible.
23	7	45	Nakajima A/C, Handa Pl	Handa		20	78	544		544	Fuji	Chita plant	Hauda	Heavy.
											Nakajima	Yamagata plant	do	Do.
23	7	45	Urban area	Tsu		20	113	578		578	Aichi	Tsu plant	Tsu	Light.
24	7	45	Locomotive and docks	Okayama		Navy	21	3		3	Mitsubishi	No. 7 works	Mizushima	Negligible.
24	7	45	Town	Tanabe		Navy	4	1		1	Japan International	Okubo plant	Kyoto	Do.
24	7	45	Airfield	Itami		Navy	14	1		1	Kawasaki	Kobe Casting & Forging	Kobe	Do.
24	7	45	do	Nagoya		Navy	12	4		4	Aicbi	Iho plant	Nagoya	Do.
24	7	45	do	Himeji		Navy	18	2		2	Kawanishi	Uzurano plant	Himeji	Light.
25	7	45	do	Okazaki		Navy	6	2		2	Nakajima	Okazaki plant	Okazaki	Do.
25	7	45	do	Hamamatsu		Navy	11	3		3	do	Arai plant	Arai	Negligible.
27	7	45	Not traceable								do	Handa plant	Handa	Light.
27	7	45	do								Mitsubishi	No. 22 works	Koromo	Do.
28	7	45	Airfield	Suzuka		Navy	7	1		1	do	No. 3 branch works	Suzuka	Do.
28	7	45	Urban area	Ichinomiya		20	123		868	868	do	No. 5 branch works	Ichinomiya	Very heavy.
28	7	45	Airfield	Tsurasaki		Navy	26	4		4	Nakajima	Ikushina works	Ikushina	Light.
28	7	45	Urban area	Ogaki		20	93	5	659	664	Mitsubishi	No. 16 works	Ogaki	Heavy.
											Aichi	Ogaki plaut	do	Do.
29	7	45	Koriyama light industry	Koriyama		20	1	5		5	Nakajima	Koriyama plant	Koriyama	Light.
30	7	45	Airfield	Himeji		Navy	27	4		4	Kawanishi	Uzaraao plant	Himeji	Do.
30	7	45	do	Nagoya		Navy	37	12		12	Aicbi	Ibo plaut	Nagoya	Negligible.
30	7	45	do	Otsu		Navy	7	2		2	Japan International	Okubo plant	Kyoto	Do.
30	7	45	do	Sagami		Navy	61	17		17	do	Hiratsuka plant	Hiratsuka	Medium.
30	7	45	Not traceable								Mitsubishi	No. 22 works	Koromo	Light.
30	7	45	Airfield	Fuji		Navy	6	2		2	Nissan Auto	Yoshiwara plant	Yoshiwara	Medium.
1	8	45	VII Fighter Command strike	Hami, Akasbi, Okazaki, Nagoya, Toyohashi.		20	79				Mitsubisbi	No. 22 works	Koromo	Light.

TABLE VI–XII.—*Indirect-attack record—chronological*—Continued

Air Force attack data										Effects on aircraft plant			
Date			Primary target	Location	Air Force	Number of A/C	Tons bombs			Aircraft company struck	Plant	Location	Damage effect rating
Day	Month	Year					HE	IB	Total				
1	8	45	Urban area	Hachioji	20	169		1,594	1,594	Mitaka	Hachioji dispersal	Hachioji	Medium.
										Tachikawa	Main plant	Tachikawa	Light.
										Tachikawa Army Air	Arsenal	do	Medium.
										Showa	Main plant	do	Light.
5	8	45	do	Maebashi	20	92	33	691	724	Nakajima	Tsutsumigaoka plant	Tsutsumigaoka	Do.
5	8	45	do	Nishinomiya	20	255	81	1,923	2,004	Kawanishi	Konan plant	Fukae	Negligible
										do	Naruo plant	Amagasaki	Medium.
										Sumitomo	Nishinomiya plant	Nishinomiya	Heavy.
6	8	45	Unidentified	Miyakonojo	5	21		10	10	Kawasaki	Miyakonojo plant	Miyakonojo	Do.
6	8	45	Atomic bomb	Hiroshima	20	1				Mitsubishi	No. 20 works	Hiroshima	Light.
9	8	45	Airfield	Koriyama	Navy	194	109		109	Nakajima	Koriyama plant	Koriyama	Heavy.
10	8	45	do	do	Navy	29	22		22	do	do	do	Do.
10	8	45	Urban area	Kumamoto	5	44		28	28	Mitsubishi	No. 9 works	Kumamoto	Negligible.
10	8	45	VII Fighter Command strike	Tokyo area	20	82				Nakajima	Kameoka plant	Honjo	Dn.
										do	Honjo plant	do	Do.
12	8	45	Town	Miyazaki	7	105		84	84	Kawasaki	Miyazaki plant	Miyazaki	Heavy.
13	8	45	Airfield	Fujisawa	Navy	13	4		4	Japan Airplane	Tomioka plant	Tomioka	Negligible
			Naval arsenal	Hiratsuka	Navy	61	35		35				
			Urban area	Tokyo	Navy	38	21		21				
			Naval base	Yokosuka	Navy	8	8		8				
13	8	45	Airfield	Kasumigaura	Navy	32	15		15	1st NAD	Main plant	Kasumigaura	Light.
14	8	45	Urban area	Isesaki	20	87		614	614	Nakajima	Akagi plant	Isesaki	Negligible.
										do	Ikushina plant	Ikushina	Light.
										do	No. 1 plant	Isesaki	Do.
										do	No. 2 plant	do	Negligible.

TABLE VI–XIII.—*Damage ratings—indirect attacks*

	Very heavy strikes	Heavy strikes	Medium strikes	Light strikes	Negligible strikes	Total
Mitsubishi	2	8	8	7	14	39
Nakajima	1	7	1	13	9	31
Aichi	1	3	1	7	4	16
Kawasaki		5		2	2	9
Naval air depots			1	4	4	9
Japan International	1	2	2	1	2	8
Hitachi	1	2		2	2	7
Kawanishi			2	3	2	7
Sumitomo	1	2		1	2	6
Showa				1	5	6
Fuji		1	1		2	4
Ishikawajima		1	1	1		3
Mitaka			1	2		3
Japan Musical Instrument	2				1	3
Tachikawa				2	1	3
Army air arsenal			1	1		2
Japan Airplane					2	2
Nissan Auto			1			1
Akoda				1		1
Total	9	31	20	48	52	160
By Army	9	26	15	34	33	117
By Navy	0	4	4	11	16	35
Untraceable	0	1	1	3	3	8

TABLE VI–XIV.—*Persistency of attacks*

Company	Direct attacks	Indirect attacks	Total
Mitsubishi	22	37	59
Nakajima	23	31	54
Naval air depots	12	4	16
Kawasaki	8	9	17
Kawanishi	4	7	11
Aichi	4	16	20
Tachikawa	4	3	7
Hitachi	2	7	9
Sumitomo	2	6	8
Jap International	2	8	10
Manchuria	2		2
Tachiarai	1		1
Japan Airplane	1	2	3
Tachikawa Army Arsenal	1	2	3
Japan Musical Instrument	1	3	4
Toyoda Auto	1		1
Fuji		4	4
Ishikawajima		3	3
Mitaka		3	3
Nissan Auto		1	1
Shoda		1	1

cent) and Nakajima 31 times (21 percent) of the total of 147 hits sustained by the aircraft industry. Of the remaining 19 aircraft producers hit, 5 were struck 10 or more times—Aichi 20 times, Kawasaki 17, naval air depots 16, Kawanishi 11, and Japan International 10.

Table VI–XIV presents the persistency of both direct and indirect attacks. The attacks were not all of equal importance. In some cases they were too widely spaced. In others they were made after large-scale dispersals had been completed. In the case of 25 direct attacks, as previously noted, the targets were not hit at all.

F. PHYSICAL DAMAGE INFLICTED

The determination of the over-all, industry-wide physical damage to productive capacities existing at the times of attacks was made by analyzing bomb damage to productive areas and machine tools and, to a limited amount, production losses. This was supplemented in an appreciable number of cases by on-the-ground impressions and estimates. These data, presented in Table VI–XV, should be considered merely as a reasonable guide.

TABLE VI–XV.—*Damage inflicted*

[In percent]

Category	Total damage	Damage by direct attacks	Damage by indirect attacks	Percent of total damage caused by direct attacks
Engines	18	13	5	72
Airframes	27	16	11	59
Propellers	28	11	17	39

Had no dispersal been undertaken, the total weight of bombs falling on producing targets would have caused a markedly different picture. Based on this supposition, an analysis of these categories indicates that as much as 40 percent of engine, 30 percent of airframe, and 45 percent of propeller production facilities might have been destroyed and damaged by the attacks directed against them.

G. GENERAL CONCLUSIONS

The first relatively light bombings beginning in the fall of 1944 portended increasing attacks to come and served as a warning to the Japs to disperse. That warning went generally unheeded until after the first real attacks in November 1944. They began to scatter in panic and haste in late December and early January. We chased the Jap aircraft industry into villages, woods, and caves before our attacks had built up sufficient striking power to cause crippling damage. When the attacks finally did come in force, large scale dispersion had reached high proportions and in many cases our attacks struck empty or partially empty buildings. Figure I–5 of the summary indicates the trend.

This is verified by a study made of machine tool

dispersion from the main Nakajima Musashi plant and the three main Mitsubishi engine plants in Nagoya (Figures VI–4 and VI–5). Early attacks prior to March 1945 destroyed or damaged only a few machine tools of the total number at the plants. Dispersion of machinery had begun as early as September from Mitsubishi's plants and November from Musashi. By the time of the heavy attacks of March and April both Nakajima and Mitsubishi had dispersed about 60 percent of their machinery. The heavy attacks in those 2 months failed to destroy or damage any appreciable proportions of remaining machinery. One exception was the Twentieth Air Force 6 April attack against Mitsubishi's No. 2 and 4 engine works, in which 860 of the remaining 2,200 machine tools, or about 40 percent, were destroyed or damaged. This, incidentally, was the most severe case of machine tool loss recorded in the attacks on the Japanese aircraft industry.

Because of lack of critical materials, shortages of skilled labor and other factors, production of both engines and airframes had been on a downward trend since early in the winter of 1944–45. The industry was fairly sick before we touched it. How airframe and engine production trends were related to the cumulative bomb tonnage is shown in Figure VI–6. Prior to the heavyweight attacks beginning in March and April, engine production had dropped from a peak of 5,090 in July 1944 to 3,819 in November and 1,695 in February 1945, with no indications that an appreciable upswing might be in sight had the attacks not occurred. Similarly, airframe production had dropped from its September peak of 2,572 to 2,220 in November and a low of 1,391 in February, with a minor recovery in March. As the heavyweight attacks of the summer continued, engine production continued to drop slowly and airframe production fell off rapidly. Broadly speaking, operational limitations were such that the heavy, concentrated attacks could not be attained before March and April. As a result, it appears that the bombing program against the Japanese aircraft industry was a case of "too little" in the early stages prior to dispersal, with results in the latter stages not proportionate to tonnage dropped or destruction accomplished because the Japs had dispersed.

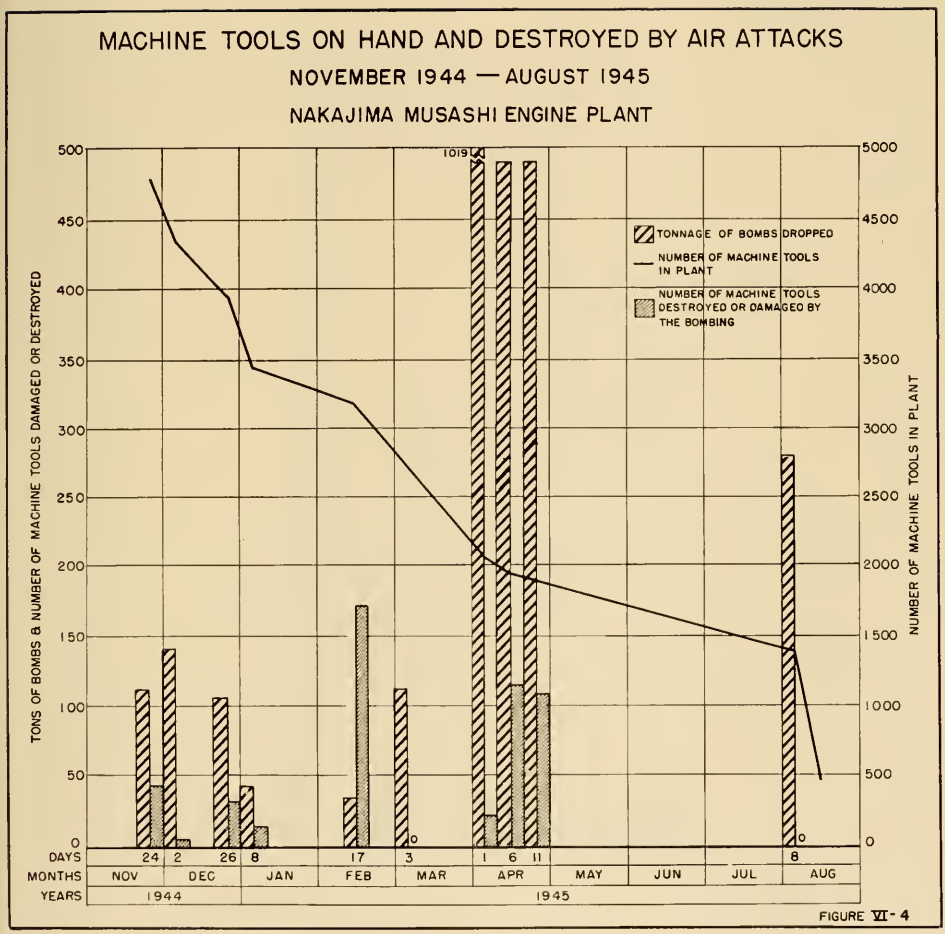

MACHINE TOOLS ON HAND AND DESTROYED BY AIR ATTACKS
NOVEMBER 1944 — AUGUST 1945
NAKAJIMA MUSASHI ENGINE PLANT
TONS OF BOMBS & NUMBER OF MACHINE TOOLS DAMAGED OR DESTROYED
NUMBER OF MACHINE TOOLS IN PLANT
TONNAGE OF BOMBS DROPPED
NUMBER OF MACHINE TOOLS IN PLANT
NUMBER OF MACHINE TOOLS DESTROYED OR DAMAGED BY THE BOMBING
1019
DAYS 24 2 26 8 17 3 1 6 11 8
MONTHS NOV DEC JAN FEB MAR APR MAY JUN JUL AUG
YEARS 1944 1945

FIGURE VI-4

MITSUBISHI MACHINE TOOL DISPERSAL AND DAMAGE BY AIR ATTACKS, NAGOYA (1944-1945)

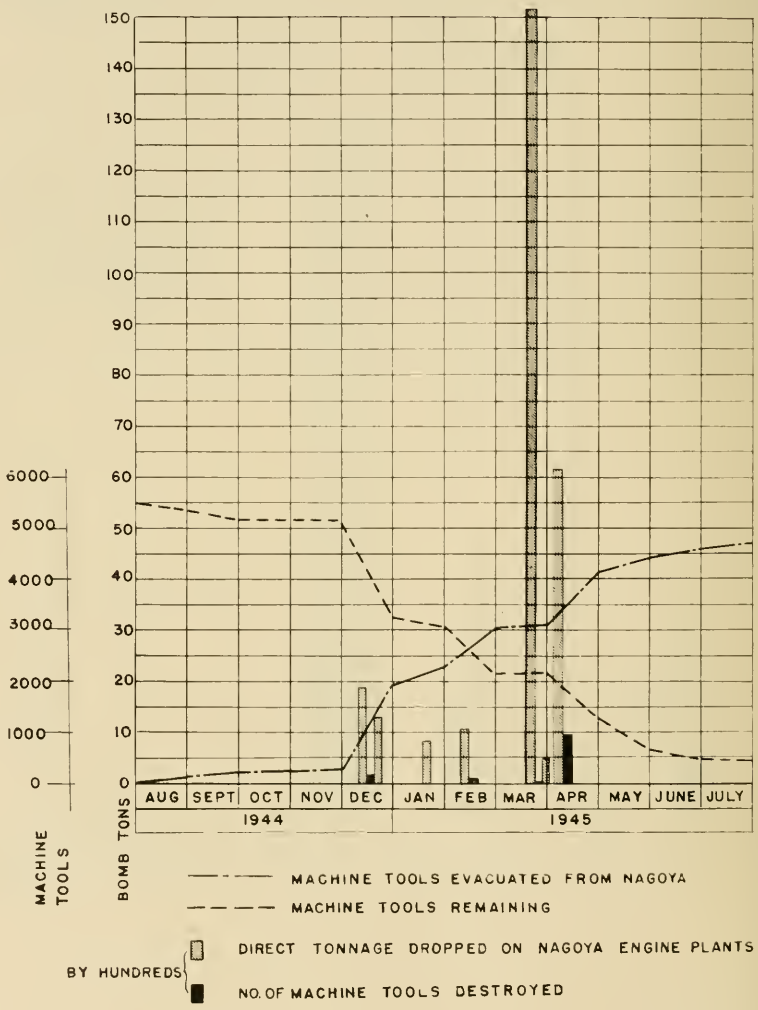
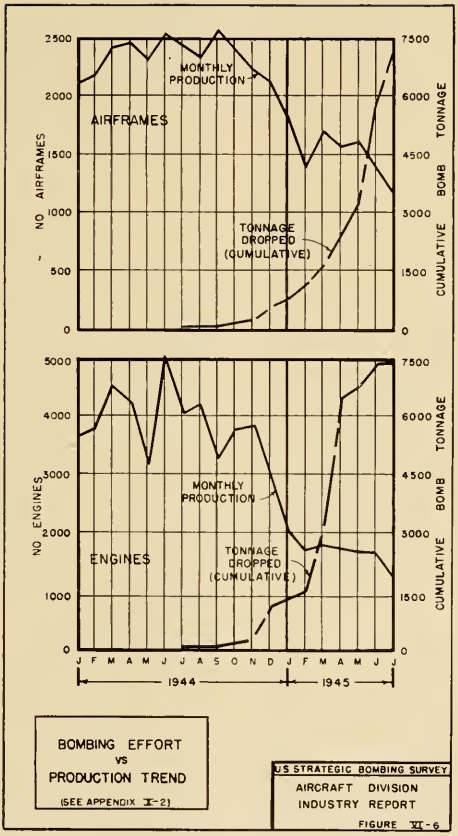


FIGURE VI-5


2500
2000
1500
1000
500
0
NO. AIRFRAMES
MONTHLY PRODUCTION
AIRFRAMES
TONNAGE DROPPED (CUMULATIVE)
7500
6000
4500
3000
1500
0
CUMULATIVE BOMB TONNAGE
5000
4000
3000
2000
1000
0
NO. ENGINES
MONTHLY PRODUCTION
ENGINES
TONNAGE DROPPED (CUMULATIVE)
7500
6000
4500
3000
1500
0
CUMULATIVE BOMB TONNAGE
J F M A M J J A S O N D J F M A M J J
1944
1945
BOMBING EFFORT
VS
PRODUCTION TREND
(SEE APPENDIX X-2)
U.S STRATEGIC BOMBING SURVEY
AIRCRAFT DIVISION
INDUSTRY REPORT
FIGURE VI-6

Part VII

INTELLIGENCE CHECK—FORECASTS VERSUS FINDINGS

Detailed knowledge of the Japanese aircraft industry was fairly extensive prior to the close of the war. Through the study of prewar industries, records, and documents captured during the war, examination of captured or crashed Japanese aircraft, and other means, a considerable body of intelligence was accumulated. In the spring of 1944, by agreement among the United States and British military and economic intelligence services, the work of estimating Japanese aircraft production rates was centered in Military Intelligence Service, G–2, War Department, Washington. Information from Army and Navy sources, from American, British, and other countries was sent to Military Intelligence Service for study and analysis. These studies resulted in the publication of estimates of production rates for individual plane types and the location of the plant making the aircraft.

Interest centered in production rates for combat type aircraft—fighter, bomber, and reconnaissance planes. Detailed estimates of production rates were published monthly beginning in October 1944, the figures extending back to 1940. The estimates compared with actual production in this chapter are taken from the report prepared in July 1945, with some reference to data published in January 1945.

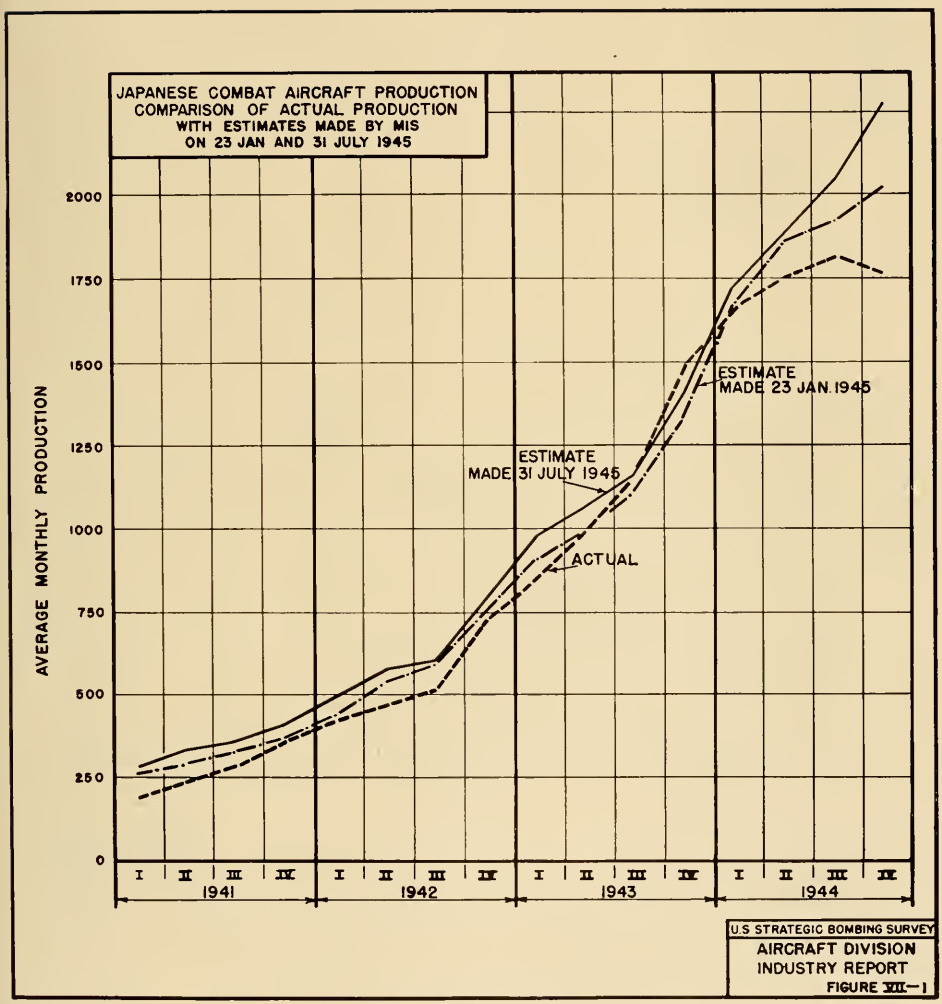
A comparison of actual production of combat type aircraft with estimates made by Military Intelligence Service shows certain discrepancies in the trend of production (Fig. VII–1). The figures are average monthly production for each quarter from 1941 through 1944. From the first quarter of 1941 through the second quarter of 1944, the estimates were close to the actual production. The last two quarters of 1944 saw the estimates drift away from the actual production. It is interesting to note that on an over-all basis the estimate made in January 1945 was a better one than that made 6 months later. The earlier estimate of aircraft produced during the 4 years 1941–44 was 5.2 percent higher than the actual production, while the later estimate was 9.6 percent higher.

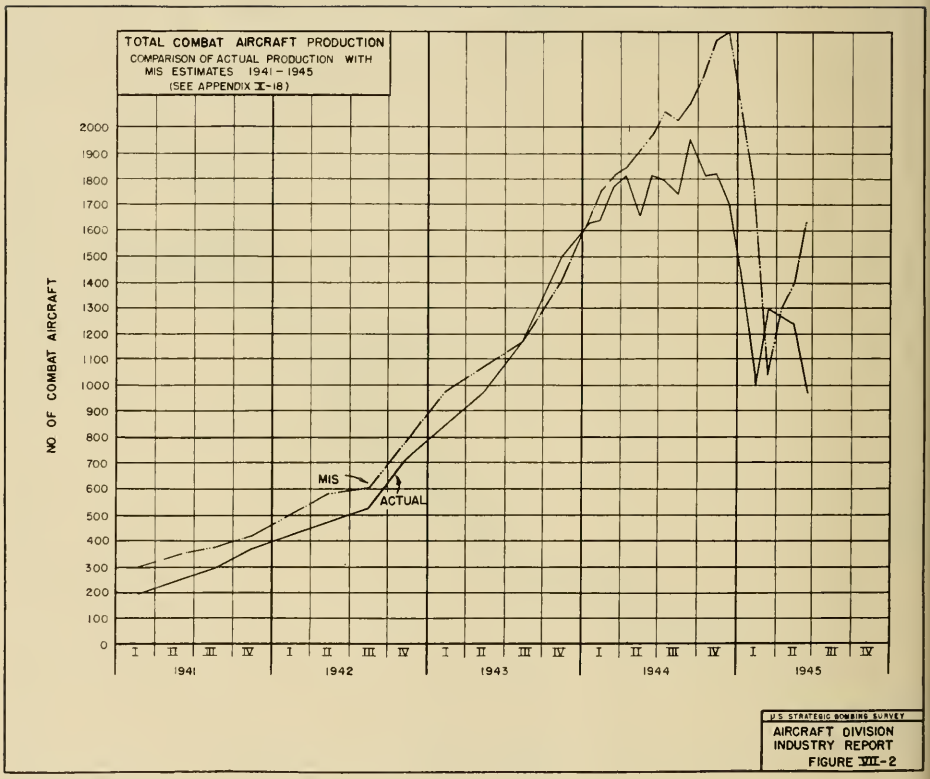
A comparison of monthly production of combat aircraft from January 1944 to June 1945 with Military Intelligence Service estimates shows the difference between the actual and estimated recuperative ability of the Japanese industry after the attacks (Figure VII–2). Lack of information on the troubles encountered by the Japanese aircraft industry in 1944 led to an overestimate of the numbers actually produced. The shape of the estimate curve is similar to the actual production curve, but the low point was reached 1 month later than the actual. The actual recovery in March is reflected in the estimate for April, but here the curves change direction. Assuming that dispersal had been progressing as planned, and that there had been a certain recovery of production from tools and facilities set up at new sites, Military Intelligence Service applied the recovery estimates prepared by the joint target group to their production estimates. As a result, the estimates of combat aircraft anticipated recovery and, therefore, an increased production when, in fact, production declined again after March 1945.

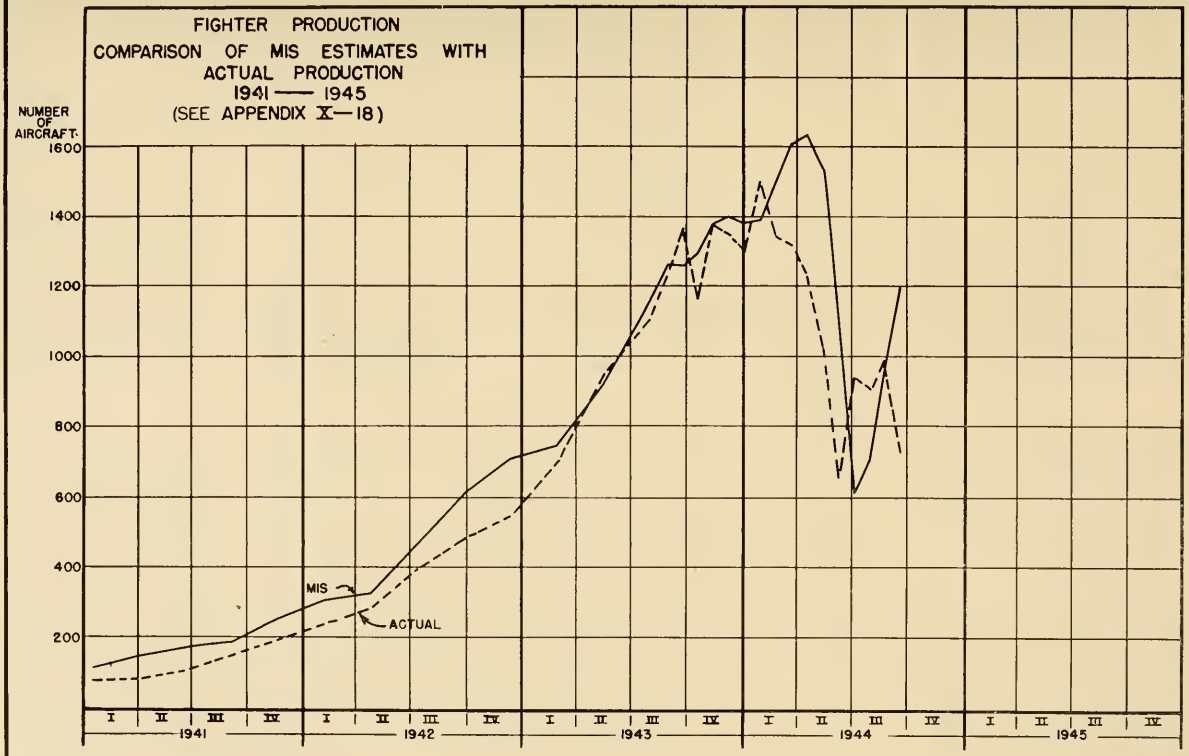
In April 1945 actual production reached 1,256 combat types, and Military Intelligence Service estimated 1,288 were produced. In May the estimate was 1,394 airplanes compared with an actual output of 1,230; by June the estimate was 1,628 or 68.5 percent higher than the actual output of 966 combat planes.

Monthly estimates of fighter production were the best made by Military Intelligence Service (Fig. VII–3). In 8 of the first 10 months of 1944, estimates of fighter production were within 8 percent of actual. The other 2 months had errors of less than 12 percent. It was not until November 1944 that the estimates had any very serious overstatement. The estimate in November was 22.3 percent high.

Bomber and recce production were less accurately estimated after the middle of 1944 (Figs. VII–4 and VII–5). The principal reason for the errors lies in the fact that the estimates continued to show production for aircraft which were either dropped from production entirely or reduced to very small numbers. The errors were made mostly in older Army planes, Helen, Lily and Mitsubishi Souia. Production of some of the more


JAPANESE COMBAT AIRCRAFT PRODUCTION
COMPARISON OF ACTUAL PRODUCTION
WITH ESTIMATES MADE BY MIS
ON 23 JAN AND 31 JULY 1945
AVERAGE MONTHLY PRODUCTION
2000
1750
1500
1250
1000
750
500
250
0
ESTIMATE
MADE 23 JAN. 1945
ESTIMATE
MADE 31 JULY 1945
ACTUAL
I II III IV
1941
1942
1943
1944
U.S STRATEGIC BOMBING SURVEY
AIRCRAFT DIVISION
INDUSTRY REPORT
FIGURE VII—1


TOTAL COMBAT AIRCRAFT PRODUCTION
COMPARISON OF ACTUAL PRODUCTION WITH MIS ESTIMATES 1941 – 1945
(SEE APPENDIX X-18)
NO OF COMBAT AIRCRAFT
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
MIS
ACTUAL
I II III IV I II III IV I II III IV I II III IV I II III IV
1941
1942
1943
1944
1945
U.S. STRATEGIC BOMBING SURVEY
AIRCRAFT DIVISION
INDUSTRY REPORT
FIGURE VII-2



U.S. STRATEGIC BOMBING SURVEY
AIRCRAFT DIVISION
INDUSTRY REPORT
FIGURE XII-3

important aircraft were estimated within a few percent of the actual output.

The following table gives a comparison of the Military Intelligence Service estimates and actual production of Army and Navy types, by 6-month periods beginning in 1944. The estimates of Army fighters were the closest of any of the forecasts; less than 1 percent error in the first half of 1944 and the first half of 1945, and 11 percent error in the second half of 1944. The very high percentages of error for Army bombers and reconnaissance planes in the last 12 months of the war has been explained above, i. e., carrying in production planes no longer being made.

Comparison of actual production with Military Intelligence Service (MIS) estimates for army and navy combat aircraft, by types, for 6-month period, 1944–1945

Type of aircraft	1944						1945		
	First half			Second half			First half		
	Actual	MIS	Percent difference	Actual	MIS	Percent difference	Actual	MIS	Percent difference
Navy:									
Fighters	2,652	2,817	6	2,726	2,993	10	2,100	2,905	38
Bombers	1,623	1,744	7	2,058	2,405	17	1,445	1,637	13
Recce	567	616	9	520	702	35	474	740	56
Total	4,842	5,177	7	5,304	6,100	15	4,019	5,282	31
Army:									
Fighters	3,909	3,887	0.6	4,524	5,036	11	2,598	2,594	0.0
Bombers	924	990	7	495	1,084	119	307	605	92
Recce	594	810	36	466	834	79	204	499	145
Total	5,427	5,687	5	5,485	6,954	27	3,109	3,698	19

Intelligence on types of aircraft in production at any time was generally accurate, especially with regard to the more important combat types. Accuracy decreased with the decreased combat activity of transport and trainer types, so that intelligence on noncombat types showed a greater amount of error in listing manufacturers producing the type and in the period of production of the type than did similar intelligence on combat aircraft.

Information on aircraft types under experimentation by the Japanese led information on production. Generally the start of production of such new types was estimated much too early. The device of assigning such types a nominal rate of production too soon resulted in a slight overstatement of total production.

The relative importance of the producers of Japanese combat aircraft was quite accurately assessed as shown in the following table:

Intelligence estimates of engine production, excluding low horsepower and experimental engines, were slightly higher than actual production in 1944 (Fig. VII–6). Intelligence erred in assuming the continued increase of engine production until the end of 1944, when in fact the peak was reached in mid-1944 and production decreased thereafter.

The status of intelligence regarding the dispersal of the aircraft industry was not adequate. It was known that a dispersal program was under way but specific data on the location of dispersed sites was meager.

TABLE VII–I.—*Percentage of production of combat aircraft by companies*

	Actual production 1944	MIS estimate November 1944
Nakajima	37.5	38
Mitsubishi	19.0	19
Kawasaki	17.4	14
Aichi	7.1	8
Tachikawa	8.0	6
Kawanishi	4.5	5
Kyushu	2.7	2
Japan International Showa	0	1
Army and Navy arsenals	3.4	4
Manchuria	.3	----
Japan Airplane	.1	----
Unassigned	0	3
Total	100	100

Excerpts from intelligence reports of 14 July 1945 read as follows:

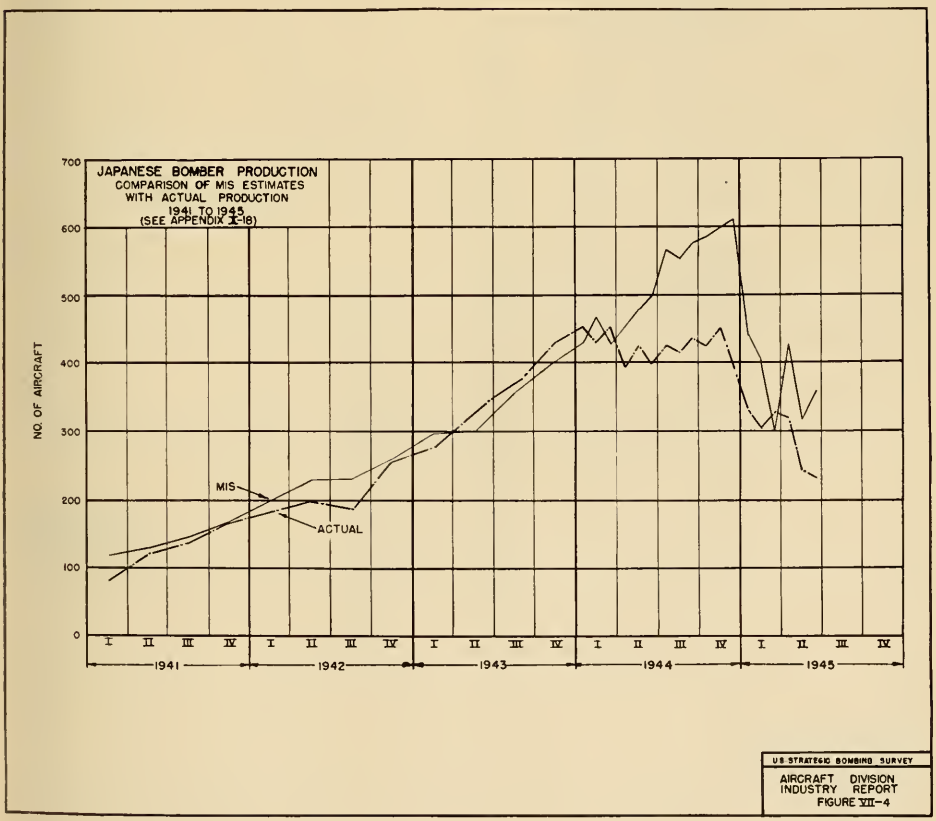
For at least 6 months Japanese official reports and statements have referred to underground dispersal.

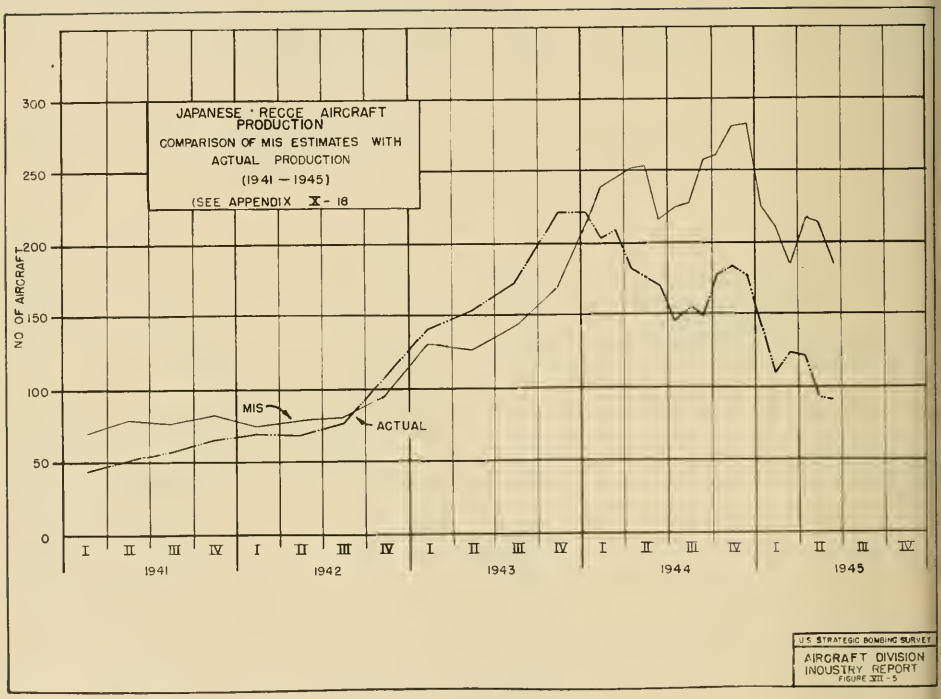
Documentary sources indicate that detailed plans for the dispersal of the Japanese airframe industry have been under consideration since December 1944.

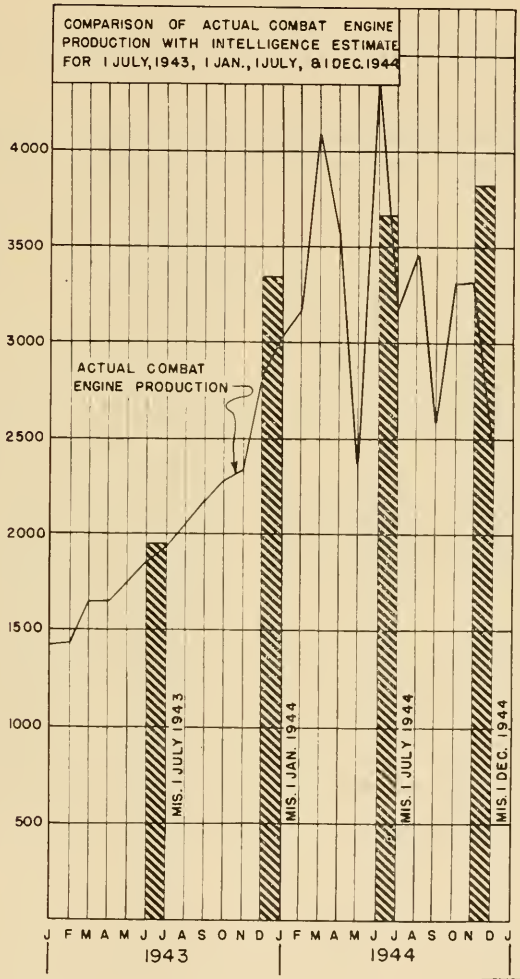
Dispersed complexes for fabrication and assembly of airframes may be planned for many of the smaller towns throughout Japan—such complexes may already be in existence.

In assessing specific locations, however, only three underground or semiunderground areas were known. Intelligence reported underground aircraft activity at the Musashi plant of Nakajima, at the naval air depot at Hiro, and at Fujisawa. Actually only a small amount of underground storage took place at Musashi, while Hiro was one of the advanced underground plants. The status of Fujisawa is not known, but it was not reported by any agency as an underground aircraft plant. Thus only 1 or 2 percent of the 100 underground plants were known. None of the semiunderground plants were reported.

Photographic coverage of Japan was too little to reveal the location of most of the semiunderground and underground plants. In attempting to spot dispersed plants on existing photo cover it has been found that the coverage does not extend far enough out from the photographed cities to cover one-third of the existing underground plants. In many of the photos in which the exact site of the factory is known it has been very difficult to find enough photographic evidence to prove the existence of the plants.




JAPANESE RECCE AIRCRAFT PRODUCTION
COMPARISON OF MIS ESTIMATES WITH ACTUAL PRODUCTION
(1941 — 1945)
(SEE APPENDIX X - 18
NO OF AIRCRAFT
300
250
200
150
100
50
0
MIS
ACTUAL
I II III IV I II III IV I II III IV I II III IV I II III IV
1941
1942
1943
1944
1945
U.S. STRATEGIC BOMBING SURVEY
AIRCRAFT DIVISION
INDUSTRY REPORT
FIGURE XII - 5



U S STRATEGIC BOMBING SURVEY

AIRCRAFT DIVISION
INDUSTRY REPORT
FIGURE VII-6

APPENDIX I

AIRCRAFT DIVISION—UNITED STATES STRATEGIC BOMBING SURVEY—PACIFIC

After completion of research work on the German aircraft industry a small staff of the original division returned to Washington early in September 1945 and started planning and reorganizing for the survey of the Japanese aircraft industry.

Lt. Col. Benjamin Weisberg was appointed field deputy by Commander (now Capt.) S. P. Johnston, USNR, and left Washington 21 August 1945 to make preliminary arrangements at Guam and in Tokyo prior to arrival of the personnel. A group of Japanese aircraft industry analysts was recruited from Military Intelligence Service in Washington. Their prior work for the joint target group made them invaluable to the Division. Other officers were assigned from organizations in the Pacific. Organization chart and roster of the Aircraft Division, United States Strategic Bombing Survey, Pacific, follow.

After completing necessary arrangements from Washington, Commander Johnston left Washington for Japan 10 October 1945.

The Division made its headquarters in Tokyo. Field teams were organized and sent out to visit aircraft plants. The general location of the industry as of the end of the war is shown on the accompanying map. This chart will also serve to indicate the scope of the activities of the field teams and several special missions carried out by certain officers.

Twenty-three individual plants were visited and separate reports made as appendices to the corporation report. (For an index of reports, Appendix II.)

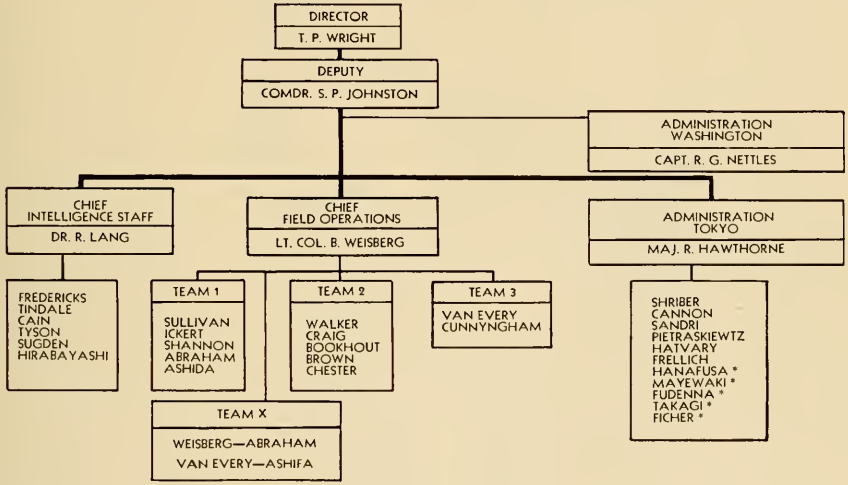
In addition to the industry studies mentioned above, officials of the Munitions Ministry and the Army and Navy were interviewed and records obtained for material to prepare the over-all report for the Division.

On 1 December 1945 the complete Division in the Pacific sailed for the United States. Work was carried on and completed in the Washington headquarters for the United States Strategic Bombing Survey.

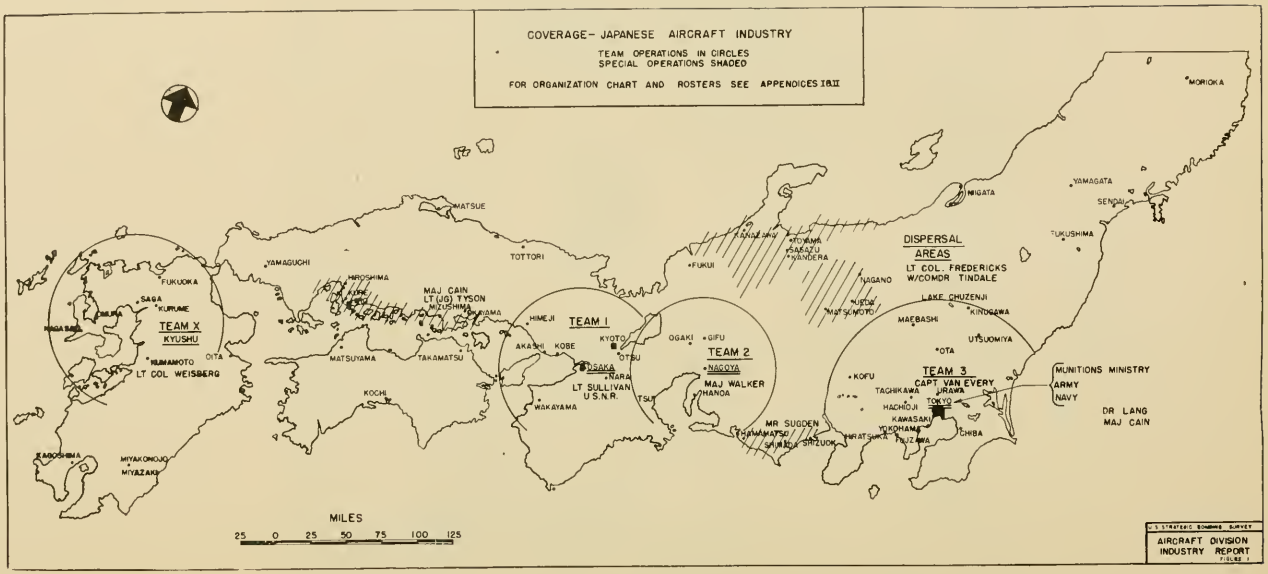
Following is a complete roster of all Aircraft Division personnel:

Capt. S. P. Johnston, USNR, 80442.
Lt. Col. Benjamin Weisberg, O–330553.
Lt. Col. Jacob W. Fredericks, O–430990.
Lt. Col. John R. Cain, O–447195.
Maj. Thomas L. Walker, O–335806.
Maj. Randolph Hawthorne, O–906612.
Maj. Harry E. Van Every, O–907660.
Capt. G. R. Nettles, WAC, L–115971.
Lt. John T. Sullivan, USNR, 167144.
Lt. Lawrence A. Brown, USNR, 292289.
First Lt. Francis Craig, O–1108586.
First Lt. Paul Ickert, O–1282607.
First Lt. William B. Cunnyngham, O–1059419.
First Lt. Richard J. Bookhout, O–1185794.
Lt. (j. g.) Theodore A. Chester, 282273.
Lt. (j. g.) Leonard S. Tyson, 293189.
Lt. (j. g.) John T. Shannon, 327484.
Second Lt. James H. Ashida, O–9932226.
Wing Commander Norman B. Tindale, RAAF, 284483.
Flight Officer Walter Abraham, RAAF, T–74141.
Master Sgt. Tarno H. Fudenna, 39005688.
Master Sgt. Ben Mayewaki, 39082424.
Technical Sgt. Harry O. Takagi, 19004289.
Sgt. Harold W. Shriber, 31298474.
Sgt. Harold Angle, 33875799.
Sgt. George Hanafusa, 37357765.
Sgt. Howard D. Sandri, 33509700.
Sgt. Matthew B. Pietraskiewcz, 33726169.
Sgt. George E. Hatvary, 36667329.
Sgt. Seymour Freilich, 12110682.
Cpl. Victor J. Heichert, 37787703.
Cpl. Clayton K. Cannon, 35781707.
Mr. Richard O. Lang, X–046023.
Mr. George M. Sugden, X–046012.
Mr. Martin Y. Hirabayashi, X–046017.

ORGANIZATION CHART—AIRCRAFT DIVISION



* Assigned to Field Teams.


COVERAGE- JAPANESE AIRCRAFT INDUSTRY
TEAM OPERATIONS IN CIRCLES
SPECIAL OPERATIONS SHADED
FOR ORGANIZATION CHART AND ROSTERS SEE APPENDICES I&II
TEAM X
KYUSHU
LT COL WEISBERG
TEAM I
MAJ CAIN
LT (JG) TYSON
LT SULLIVAN
U.S.N.R.
TEAM 2
MAJ WALKER
MANOA
MR SUGDEN
TEAM 3
CAPT VAN EVERY
DISPERSAL
AREAS
LT COL FREDERICKS
W/COMDR TINDALE
MUNITIONS MINISTRY
ARMY
NAVY
DR LANG
MAJ CAIN
MATSUE
TOTTORI
YAMAGUCHI
HIROSHIMA
FUKUOKA
SAGA
KUMAMOTO
OITA
MIYAZAKI
KAGOSHIMA
MATSUYAMA
TAKAMATSU
KOCHI
HIMEJI
AKASHI
KOBE
KYOTO
OSAKA
NARA
OTSU
WAKAYAMA
OGAKI
GIFU
NAGOYA
TSU
FUKUI
NIIGATA
YAMAGATA
SENDAI
MORIOKA
FUKUSHIMA
NAGANO
UEDA
MATSUMOTO
MAEBASHI
KOFU
TACHIKAWA
HACHIOJI
TOKYO
KAWASAKI
YOKOHAMA
UTSUOMIYA
KINUGAWA
LAKE CHUZENJI
OTA
HIRATSUKA
FUJISAWA
CHIBA
MILES
25 0 25 50 75 100 125
U.S. STRATEGIC BOMBING SURVEY
AIRCRAFT DIVISION
INDUSTRY REPORT

APPENDIX II

CORPORATION AND PLANT REPORTS

Aircraft Division

I. Mitsubishi:
- I–1 Matsumoto.
- I–2 Kyoto.
- I–3 Oe Nagoya.
- I–4 Nagoya.
- I–5 Oe Nagoya.
- I–6 Shizuoka.
- I–7 Mizushima.
- I–8 Kyoto.
- I–9 Kumamoto.
- I–10 Nagoya.
- I–11 Daimon.
- I–12 Nagoya.
- I–13 Kyoto (No. 14 works).
- I–14 Ogaki (No. 16 works).
- I–15 Fukui (No. 18 works).
- I–16 Hiroshima (No. 20 works).
- I–17 Koromo (No. 22 works).

II. Nakajima:
- II–1 Ota.
- II–2 Koizuma.
- II–3 Musashi.
- II–4 Handa.
- II–5 Omiya.
- II–6 Hamamatsu.
- II–7 Utsunomiya.

III. Kawanishi:
- III–1 Naruo.
- III–2 Konan.
- III–3 Himeji.
- III–4 Takosuguka.

IV. Kawasaki:
- IV–1 Gifu.
- IV–2 Akashi.

V. Aichi:
- V–1 Eitoku.
- V–2 Atsuta.

VI. Sumitomo:
- VI–1 Kanzaki.
- VI–2 Sakurajima.

VII. Hitachi:
- VII–1 Chiba.
- VII–2 Tachikawa.

VIII. Japan International.[1]

IX. Japan Musical.

X. Tachikawa.

XI. Fuji.

XII. Showa.

XIII. Ishikawajima.

XIV. Japan A/C.

XV. Kyushu.

XVI. Shoda.

XVII. Mitaka.

XVIII. Nissan Jidosha.

XIX. Army-navy depots:
- XIX–1. First Naval Air Depot.
- XIX–2. Eleventh Naval Air Depot.
- XIX–3. Twenty-first Naval Air Depot.
- XIX–4. Koza Naval Arsenal.
- XIX–5. Tachikawa Army Air Arsenal.

XX. Underground plants.

Reference reports:

[1] Includes Hiratsuka and Kyoto.

APPENDIX III

OUTLINE OF PLANT REPORT

I. *The plant and its function in the aircraft industry:*

A. Introduction:

1. Plant location, number of buildings and their utilization, total floor area; physical expansion and dates.

2. Affiliation with a corporation complex, including a statement of the history of the plant and company.

3. Relation to government, i. e., financial aid, direct supervision, outright Government ownership, etc.

4. List of products.

B. Plant organization and operation:

1. Names and function of key personnel (main department heads only).

2. Organization of plant by departments.

3. Schematic flow chart of production.

a. Amonnt of "production line" technique used versus "job shop" practices.

4. Employment and shifts worked.

a. Number of productive (direct) and nonproductive (indirect) employees as of specified periods.

b. Use of soldiers and student helpers.

c. Shifts worked and percentage of employees on each shift as of specified periods (1942, 1943, 1944, 1945).

C. Supply of materials and components:

1. Sources and kinds of raw materials and components.

a. Methods of acquiring allocations of raw material—making requirements, forms required, etc.

2. List of products fabricated from raw materials (aluminum sheets, etc.).

3. Components made into subassemblies at plant.

a. Components fabricated for other plants.

b. Subassemblies made for other plants.

4. Use of substitute materials.

a. Reasons for use of substitutes.

b. Development and success of substitutes.

c. Special research in use of plywood, tin plate, steel, etc.

D. Production statistics:

1. Production of airplanes and/or engines by major types (bombers, fighters, various engines by horsepower groups) by years from 1930 to 1939.

2. Production of airplanes and/or engines by specific types and models, by months, from 1939 to end of war.

3. Production ordered by Government by specific types and models, by months, from 1939 to end of war.

a. Production quotas set by Government, including planned production for 1945, and for 1946 if available.

4. Estimated production capacity of plant, by time periods, of capacity changes, from 1939 to end of war.

E. Rebuilding and repair of airplanes and/or engines:

1. Source of damaged or defective planes or engines.

a. Army air depots.

b. Navy air depots.

2. Types of break-downs which required aircraft to be returned to the factories.

a. Defective parts, wings, engines, etc.

b. Battle damage.

c. Damage in testing, ferrying, etc.

3. Monthly figures for rebuilt or repaired planes or engines.

4. Relations between figures for rebuilt planes and engines, and figures on new production of same.

a. If included as new production, give separate figures for both.

F. Diversion of plant capacity and effort to experimental aircraft:

1. Experimental aircraft and guided missiles.

a. Stage of development.

b. Planned production of new aircraft.

2. Relation of plant designing research department to army and naval airplane research development laboratories.

II. *Attack data:*

Intelligence data

Date and hour of attack

_____

Duration

_____

Attacking unit

_____

Altitude

_____

Number of aircraft over target

H. E.—Number, weight, and type

_____

H. E. fuzing

_____

I. B.—Number, weight, and type

_____

I. B.—Fuzing

_____

On the ground findings

H. E. number in plant area

_____

H. E. number of building hits

_____

H. E. number of UXB

_____

I. B.—Number in plant area

_____

I. B.—Number of building hits

_____

I. B.—Number of UXB

_____

III *Effects of Bombing:*

A. Direct air attacks on plant (each attack to be described separately):

1. Date, hour, and duration of attack.

2. Physical damage.

a. Bomb plots on building lay-out, showing damaged areas.

b. Estimated degree of damage to buildings, tools, and finished products.

c. Effectiveness of various types of bombs.

d. Amount of damage to raw materials, supplies, products in process, machine tools, finished components and subassemblies, finished products. Describe in detail.

3. Describe repairs of damage, if repairs were made.

4. Production loss due to air attacks on plant.

a. Quantities of finished products which would have been produced during period of recovery, if damage had not been sustained.

b. Rate of recuperation.

5. Number of casualties (fatalities and nonfatalities).

B. Countermeasures taken at the plant against attacks (for dispersion, see E below):

1. Departments placed underground, in sub-basements, etc.

2. Dismantling of least essential buildings.

3. Description of air attack precaution and defense systems, and their effectiveness.

4. Other measures.

C. Interruption to production due to alerts:

1. Quantities of finished products which would have

been produced if alerts had not been given. Express this loss in terms of percentage of a day's output.

D. Interruptions to production due to area attacks:

1. Power loss (power plants or power lines damaged).
2. Labor force (hours away from work because of destruction of workers' transportation facilities, and homes).
3. Other interruptions caused by air attacks.

E. Interruptions to production due to air attacks affecting receipts from subcontractors and other suppliers:

1. List of all suppliers, the interruption of whose products affected the plant production schedule. Give names and addresses of these suppliers.
   a. Plant requirements of supplier's products compared with amount delivered by months—6 months before interruption and each month during interruption.
2. Attempts to obtain new suppliers during interruption.
   a. Assistance by government.
   b. Success of attempts: quality and quantity of products from new suppliers.

F. Dispersal of plant operations:

1. Planned dispersal—how originated, time of planning, government aids in planning, etc.
2. Emergency dispersal after attacks—locations of dispersed subplants, attempt at underground construction, etc.
3. Future planning of dispersal, including underground.
4. Use of new plants originally planned for expansion of production as plants to which dispersal was sent.
5. Availability of labor, power and transportation facilities at planned and emergency dispersal locations.
6. Influence of German experience, if any, on dispersal plans.
7. Estimated loss or gain in production of airplanes and/or engines during period of dispersal as well as a result of lowered or increased efficiency after dispersal.

IV *Intelligence Check:*

1. Pre-attack information.
2. Pre-attack photo interpretation.
3. Post-attack photo interpretation.
4. Recuperation and recovery.

V *Vulnerability:*

1. General discussion of actual (proven by attacks) vulnerability of (*a*) buildings equipment and facilities (*b*) morale of labor force, (*c*) suppliers of components and parts, (*d*) all other points of proven vulnerability.
2. General discussion of potential (not attacked) vulnerable points similar to (1) above.

VI *Data Relevant to Other Division Studies:*

General discussion of such factors as transportation tie-ups and disruption, shortage of light metals, power failures, morale effects, shortage of building materials and any other similar relevant facts.

VII *General Impressions of Plant Inspection and Interrogations.*

APPENDIX IV

OUTLINE OF CORPORATION REPORT

I. *The Corporation and Its Importance in the Aircraft Industry:*

A. Introduction:

1. Relative importance of corporation's production to all production (airframe and engine). Principal products.
2. History and growth of the corporation—with dates.
   a. Include statement of foreign influence on design, factory lay-out, etc.
   b. Ownership, etc.
3. Location of principal plants, including those which may have been destroyed or abandoned since the threat of air attacks.
   a. Map showing plant locations, different symbols for airplanes, engines, propellers.
   b. List of principal products made at each plant (detailed listings to be put in appendix).
4. Relations with government immediately before the war and during the war—financial aid, direct supervision, etc.
5. War ministry or Navy ministry influences—special interests in corporation or plants.

B. Organization and operation:

1. Names and functions of key personnel of corporation and heads of plants, including chief of engineering (detailed listings to be put in appendix as exhibits).
2. Organization charts (show separate charts for airframes and engines).
   a. Interrelation of plants and subsidiaries.
   b. Flow chart of production—parts to major subassemblies to finished aircraft.
   c. Relations with other corporations.
3. Assembly-line techniques—modern production methods, etc.
4. Employment and shifts.
   a. Employment and/or man-hours July 1941, July 1942, July 1943, July 1944, August 1945.
   b. Use and efficiency of multiple shifts.
   c. Estimate of labor turn-over for selected months 1942–45.

$$\frac{\text{new employees hired during month}}{\text{total employees at beginning of month}}$$

   d. Effects of conscription of skilled workers for military service.

C. *Brief discussion of appended plant reports:*
1. Plants investigated and for which individual reports have been prepared.
2. Plants not investigated in detail, but for which some information has been assembled and summarized, and included in the appendix (B and C class plants).

D. *The dispersal program:*
1. General discussion of dispersed program covering:
   a. Policy of corporation relative to dispersal.
   b. Early planning, Government (Army, Navy, Munitions Ministry) relations.
   c. Problems of dispersal—types of dispersed plants (mills, caves, tunnels, etc.). Transportation, workers.
   d. Actual accomplishments compared to plants.
2. Diagrams or charts giving the locations to which the corporation plants dispersed.
3. Relation of dispersal to failure in aircraft production plans.

II. *The Air Attacks:*

A. *Air attack on plants:*
1. General effectiveness of attacks, including attacks on abandoned buildings.
2. Number and severity of attacks.
3. Tabulation of floor area by plants showing:
   a. Before attack.
   b. Superficially damaged.
   c. Severely damaged or destroyed.
4. Tabulation (or discussion if figures not available) of machine tools by plants showing:
   a. Number of tools before attack.
   b. Superficially damaged.
   c. Severely damaged or destroyed.
5. Employee casualties (general ARP policies).

B. *Air Attacks on urban areas:*
1. General affects of urban area attacks.
2. Plants located in or near to cities which were attacked.
3. Effects of area bombing—workers' absences, transportation, tie-ups, etc.
4. Interruption to production due to attacks on supplies of parts, components, fuel, etc.

III. *Production Statistics* [1]*:*

A. Over-all productive capacity of combat type airplanes and engines.
   a. Changes in capacity from 1933 to 1945.
   b. Comparison of Government orders with capacity of actual production with capacity.

B. Graph and figures of airplane or engine production from 1930 to 1945, by years, and by principal types (by horsepower groups for engines).

C. Graph and figures of airplane or engine production from 1939 to 1945, by months, for each plant (one graph with a curve for each plant).

D. Graph and figures of all plans for airplane and engine production compared with actual production, by months, 1939–45.

E. Production loss due to attacks.
   a. General statement—type of airplane (bomber, fighter, etc.), most affected.
   b. Decline in production following attack.

$$\frac{\text{Production per month immediately after attack}}{\text{Production per month proceeding attack}}$$

   c. Discussion of principal reasons for production loss.

IV. *Evaluation of Preattack Intelligence:*

A. Comparison of MIS official production estimates by months from 1941 to 1945 (show bombers, fighters, recce for Army-Navy—6 statistical series and 6 curves).

B. Types of airplanes engines etc. actually produced compared intelligence.

C. Discussion of any other important intelligence items.

V. *Vulnerability.*

VI. *General Conclusions.*

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[1] (Tabulated production statistics of specific types of airplanes, engines, and propellers to be put in appendix, as exhibits.)

APPENDIX V

REPLY TO QUESTIONS OF USSBS BY OKANA

(Based on an interview with Yasujiro Okana, director of Mitsubishi Heavy Industries, Ltd., in Tokyo, on 6 December 1945)

In mid-1944, the Navy Air Technical Department directed Mitsubishi to carry out experimental production of the Japanese version of the German Me–163 jet-propelled fighter. The design policy was to copy the Me–163 from German plans and to make no unnecessary changes other than armament. In the Navy prototype this was to consist of two experimental Type 17 30-mm cannons (with 50-round magazines), radio, and other accessories. The Navy was to conduct necessary aerodynamic research. Two airframes were to be completed by 15 December and one complete airplane by 31 December 1944.

After routine mock-up, spar, and structure conferences with both the Army and Navy, prototype construction was started. Some delays were caused by the earthquake in December and the 18 December bomb attack, so that the first airframe was not completed until January. It was flight-tested without engine (as a glider) at Hyakuri Airfield on 8 January 1945. This test showed no great defects and promised success. On the other hand, the fabrication of the jet propulsion unit showed very little progress because of delays resulting from air attacks. During this period nine additional test flights of the airframe were made and as a result of these the hydraulic system for undercarriage was modified and the aileron slit was reduced.

Because of the increased tempo and dangers of air attacks, Shusui prototypes were removed from Nagoya to the Yokosuka Air Base on 1 March and work was continued there. During this period the propulsion unit was giving much trouble and as a result the Army and the Navy each separately undertook research on these problems and each completed its first workable prototype engine in June.

The Army installed its jet engine on a Shusui airframe at Kashiwa Airfield but because of a leakage in the fuel system the flight was postponed. The Navy completed assembly of its first prototype airplane and made the first Japanese jet-propelled test flight at the small Yokosuka Airfield on 7 July 1945. Take-off and climb were both uneventful, but at an altitude of about 1,100 feet the engine failed. The pilot jettisoned his fuel, tried to turn back to land on the airstrip, but crashed into a nearby house. The plane was badly damaged and the pilot died shortly thereafter.

Investigation disclosed that the engine failure was due to fuel feed stoppage. This was explained as follows: Because of need for hurrying the test, Yokosuka Airfield was used. This was known to be too small for safety so a minimum of fuel was loaded. So small an amount was loaded that, with high acceleration and steep angle-of-climb soon after take-off, the fuel surface dropped below the outlet level and the flow of fuel failed. As a result of this finding the whole fuel system was redesigned. The drain port was relocated and enlarged and a jet pump was installed. Before the next prototype engine could be built, however, the Japanese surrender occurred.

Although the prime purpose of the Shusui had been intended for B–29 interception, its production had been been apportioned on a ratio of 2 to 1 between the Army and Navy. The Navy, however, had the mission of protecting the Home Islands against invasion. Initially, all experimental work on Shusui was under Navy direction and the Army showed little interest in it. Gradually, however, the Army became more and more interested until it took over the supervision of experimental work on the Army Shusui, known as Ki–83. Eventually it undertook the design of an improved-performance Shusui, called Ki–202, at the Tachikawa Army Air Arsenal. This caused some dissention by "middle-of-the-liners," who believed that production of the originally-planned Japanese version of the Me-263 was the primary consideration. The Mitsubishi plant itself did not seem to put much vigor into the entire undertaking, however, since workers doubted that the propulsion unit could be completed satisfactorily.

Deficiencies in Japanese ability to develop and design are many but fundamentally it can be said that Japanese technique depended very much on that of foreign fields. When European and American information was interdicted, the Japs were unable to carry on their own efforts and abilities. For these reasons very little original developments were originated or carried out in Japan and whenever it was possible to obtain data or aircraft from foreign countries, these were immediately copied.

Although the need for technical coordination between the Army and Navy was most apparent, the narrow-mindedness and low technical levels of the two services prevented an effective materialization. Because of this, the variety of production was tremendous—from aircraft and engines down to instruments and small accessories. As a result of this unprecedented demand the supply of technicians, short as it originally was in both quantity and quality, had to be broken up into small, weak project groups. Design and production suffered, accordingly, and failed to meet the requirements of the tide of war.

The Army, in spite of its generally low technological conceptions, began to exert such pressures that producers were ignored as to their technical logic and logistics and were directed to develop and produce fantastic orders which were impossible of fulfillment. Such orders could not, consequently, be produced and this status called for changes in orders, by the Army, which threw producers into further confusion. Even at the height of the war military leaders continued to ignore development and research projects. As a result, these fields showed very little progress.

When new foreign planes or data were obtained, the Army and Navy always insisted on studying them first. The manufacturers received the model or data for study after the Army or Navy finished with it, and gross delays thus occurred. Furthermore, when the Army or Navy did turn over the foreign plane or data to the manufacturer, only one manufacturer was chosen, the data given to it, and to all intents and purposes such new data remained a secret from all other companies. Many ridiculous cases occurred wherein both the Army and Navy turned over identical foreign aircraft to different companies for investigation, development, and production.

In the 2 years prior to the outbreak of war in 1941, an investigation and procurement mission had been set up to study foreign aircraft types. This organization was headed by Army and Navy personnel and included some civilian manufacturers' representatives. The mission visited Germany, investigated the German aircraft industry, studied design and production techniques, and brought back actual German products and made intensive studies of these. These products included He–100, He–109, He–119, Ju–88 airplanes, Daimler-Benz engines, and VDM and Junkers propellers. In addition to this organization, engineer agents of Mitsubishi, Mitsui, and Sumitomo visited foreign countries, and there, through inspection visits and Japanese military attachés, received various information.

After the outbreak of the war, such missions to foreign countries were interdicted and, except for capture of aircraft and documents, technical information was obtainable only through military attachés.

It is safe to say that no effective cooperation existed between the Army and the Navy, even in spite of central direction by high Government officials that this be carried out. Even within any one company performing work for both the Army and Navy, two separate entities existed, one for Army work and the other for Navy work. Probably the outstanding example of Army-Navy cooperation was the development of the Shusui. Ki–83 and Shusui were to have been a combined Army-Navy experimental job, but Ki–83 was directed by the Army and Shusui by the Navy. Moreover, the Army undertook the design of an improved Shusui called the Ki–202. The power plant for Shusui was made the Army's responsibility but the Navy, nevertheless, developed a separate engine of its own. This, allegedly, was close cooperation.

APPENDIX VI

MUNITIONS COMPANY ACT

The principal terms of the Munitions Company Act (October 28, 1943) are as follows:

1. Under this law, munitions companies shall be those companies that engage in enterprises necessary (to apply) arms, aircraft, warships, and other war materials, and shall mean those designated by the Government. The scope of the enterprises in the preceding clause will be prescribed by order.

2. Munitions companies, heeding the demands of the State for increased fighting strength, shall conform to the plans of the Government and shall assume responsibility in the carrying out of enterprises pertaining to sufficiency in munitions.

3. With regard to munitions companies, as fixed by the orders (of the Government), bans and restrictions imposed by laws shall be canceled, obligations shall be removed, and also special regulations may be enacted in connection with procures for permits, etc.

4. The Government, under the stipulations of these main points, in cases when it is deemed necessary to issue orders or to take measures, may, under the provisions of the orders, guarantee assistance as well as profits to munitions companies.

5. Munitions companies must select a person responsible for production from among the officials of the country. When selection of a responsible person for production cannot be made, the Government may appoint a person, in which case the person appointed shall become an official of the company. The person responsible for production will represent the munitions company, and is appointed to the office for the carrying out of obligations of increasing fighting power.

6. The munitions company, without the approval of the Government, may not dismiss the person responsible for production who was selected by the Government. The Government will designate to the munitions companies time, plans, quantities and other necessary matters, and may issue orders embracing the manufacture and repair of goods necessary for sufficient war materials.

7. The Government, according to the provisions of the orders, may issue orders to munitions companies or take measures for the establishment of now precautionary and . . . precautionary installations, or for the expansion and improvement of these installations, the acquisition, storage, and movement of basic materials, the improvement of technique, and supervisions of (trade) and labor, and other matters necessary to carry out the enterprise.

8. The Government may issue orders necessary for cooperation between the munitions company and those connected with carrying out the operation of cooperating factories and subsidiary factories, and other enterprises which the munitions company conducts.

9. The Government, according to the provisions of the orders, may issue to munitions companies orders necessary in connection with the taking over or taking custody of enterprises, the clarification (of articles of trust), or changes in the articles of incorporation, the delegation, transfer, or discontinuing or suspension of operations, to transfer of equipment, or (patent rights) belonging to an enterprise.

10. The Government may restrict or ban the munitions company from engaging in operations other than those designated by the Government.

11. The Government, according to the provisions of the orders, may issue orders necessary in connection with the amalgamation or dissolution of munitions companies.

12. The government, in accordance with the stipulations of the orders, may issue orders to munitions companies necessary to effect the adjustment and management of funds.

13. Persons responsible for production, or persons in charge of production in accordance with the provisions of the orders, have the right to recruit workers as provided by the national mobilization law.

14. The staff and employees of munitions companies will be under the orders of the person responsible for production or the person in charge of production.

15. The government may issue orders to munitions companies or take necessary measures regarding supervision.

16. With regard to the business matters of munitions companies, the government may gather reports, as well as inspect or examine them.

17. When the person responsible for production, or the person in charge of production, does not fulfill his responsibility, or when the staff and other employees of the munitions company do not obey the orders of the persons responsible for production, with the provision of the order, will find the means of imposing the necessary punishment.

18. Necessary penal regulations shall be enacted.

19. These main points may be applied to companies other than those engaged in the enterprise set forth in the first clause.

Aeronautical Ordnance Bureau

The Aeronautical Ordnance Bureau has charge of aircrafts and weapons, matériel, etc., pertaining to aircraft (including the regulations of allotment of materials for these articles and other relating duties).

The term "weapon, matériel, etc., pertaining to aircraft" does not include airframes, engines, propellers, etc., which are integral parts of the plane itself, but means the equipment used in developing fire power, in bombing, in signaling, photography, parachutes, etc. Furthermore, the general term "regulation of the allotment of materials and other relating duties" refers to requisitioning, contracting, estimating, calculating, and handling revenues and expenditures for aircrafts and aeronautical weapons, inspection and supervision of the management of civilian factories, supply and demand of capital, and estimating and setting costs, prices, etc.

As stated before, the Aeronautical Ordnance Bureau has an executive board, general affairs department, departments 1, 2, 3, and 4. The executive board has charge of matters pertaining to general affairs and inspections; the general affairs departments carries out the administrative functions for all departments; Department 1 has charge of those duties concerning aircrafts and engines; Department 2 has charge of matters pertaining to materials for aerial matériel; Department 3 has charge of materials for aerial weapons; and Department 4 controls the regulation of the allotment of aircraft weapons and matériel pertaining to aircraft, and other duties concerning this work.

Organization of the Munitions Ministry

(Date of Promulgation—1 November 1943—Imperial Rescript No. 824)

Clause I.

The Munitions Minister will supervise the following duties:

1. Fundamental matters concerning national mobilization.
2. General matters pertaining to the mining industry.
3. Matters concerning the production, distribution, consumption, and prices of mined and manufactured products, railroad wheels and safety installations, ships, ship materials, textile products and other daily necessities—omit other manufactured products—are classified as materials under the jurisdiction of the Munitions Ministry.
4. Matters concerning production control, subcontractor's orders, and adjustments of raw materials, materials of major war supplies and other special war materials.
5. Matters concerning the necessary regulations with respect to munitions in the utilization of private plants, its installations, and its management.
6. Matters concerning labor control, wages, adjustment of capital (omit problems of raising capital), and management and control of enterprises connected with the generation and distribution of electrical power and of those materials under the jurisdiction of the Munitions Bureau.
7. Matters concerning electricity and the generation of hydroelectric power.
8. Matters concerning alcohol and petroleum monopolizations.

The Munitions Minister may request data and explanations from the various prefectures concerned when necessary in carrying out the duties given in the preceding clause.

Clause II.

The Munitions Ministry will consist of a general bureau and eight other bureaus as follows:

General Mobilization Bureau.
Aeronautical Ordnance Bureau.
Machinery Bureau.
Iron and Steel Bureau.
Light Metals Bureau.
Nonmetallic Bureau.
Chemistry Bureau.
Fuel Bureau.
Electricity Bureau.

The Munitions Minister may form a unit or a unit and sections to control interbureau affairs.

Within the Aeronautical Ordnance Bureau will be the executive department, the general affairs bureau, and bureaus 1, 2, 3 and 4.

Clause IV.

The Aeronautical Ordnance Bureau will administrate matters concerning aircraft weapons and materials, etc. (will include adjustment of these materials and administrative matters pertaining to aircraft).

Clause VI.

Regulations of the various sections of the aeronautical ordnance bureau of the Munitions Ministry.

Clause I.

The Executive Department of the Aeronautical Ordnance Bureau (will be mentioned hereafter as "sókyoku") will administer the following duties:

1. The safeguarding of the aeronautical ordnance bureau and the executive's stamp.
2. Matters concerning law, common; law, security; and commendations.
3. Personnel matters.
4. Matters concerning general affairs, finance, allowance, and expenditure.
5. Matters concerning inquiry and statistics.
6. Matters concerning security of top secrets and counterespionage.
7. Matters pertaining to incoming and outgoing documents and to printed matters.

Clause II.

The General Affairs Bureau of the Aeronautical Ordnance Bureau is composed of the general affairs section, the administrative section, the technical section, the labor and transportation section, and the efficiency section.

Clause III.

The General Affairs Section will have the following duties:

1. Matters pertaining to the general affairs within the aeronautical ordnance bureau.
2. Matters concerning official orders, instructions, and policies.
3. Matters concerning the general regulations, organizations, etc.
4. Matters pertaining to the defense, security, and counterintelligence of the factories.
5. Matters pertaining to the fundamental factory installations.

Clause V.

The Technical Section will be charged with the following duties:

1. Matters pertaining to basic experimentation and research.
2. Matters pertaining to the supervision of the research and experimental organizations and to general development.
3. Matters pertaining to the unification of types and measurements.
4. Matters concerning commendations, patents, inventions, and designs.

Clause VI.

The Labor and Transportation Section will be charged with the following duties:

1. Matters concerning general labor mobilization.

2. Matters concerning supply and demand, adjustment, training of personnel (including technicians) essential to munitions mobilization.

3. Matters concerning the system of labor laws and regulations, and the supervision of labor (includes wages).

4. Matters pertaining to education, thought guidance, control, relief, and welfare of laborers.

Clause VII.

The efficiency section will be charged with the following duties:

1. Matters concerning the raising of efficiency in the factories.

2. Matters concerning investigations for the raising of efficiency.

Clause VIII.

The Aircraft Section and the engine section will be under Bureau 1 of the Aeronautical Ordnance Bureau.

Clause IX.

The Aircraft Section will be charged with the following duties:

1. Matters concerning the general affairs of bureau 1 of the aeronautical ordnance bureau.

2. Matters concerning the supervision, aid, and guidance of factories dealing with airframes and parts.

3. Matters concerning the experimentation, production, and supplying of airframes and parts.

4. Matters concerning production technics of airframes and parts.

5. Matters pertaining to those things not under the jurisdiction of other sections.

Clause X.

The Engine Section will carry out the following duties:

1. Matters concerning the experimentation, production, and supplying of engines, engine parts, and accessories.

2. Matters concerning the experimentation, production, and supplying of propellers, propeller parts, and accessories.

3. Matters concerning the experimentation, production, and supplying of spare engines and accessories.

4. Matters pertaining to the supervisions, aid, and control of the plants concerned with engines and engine parts, propeller and propeller parts, and spare engines and accessories.

5. Matters pertaining to the production technics of engines and engine parts, propellers and propeller parts, and spare engines and accessories.

Clause XI.

Bureau 2 of the aeronautical ordnance bureau will contain the strafing and bombing section, torpedo section, electrical instrument section, gages and optical instrument section, and the matériel section.

Clause XII.

The Strafing and Bombing Section will be charged with the following duties:

1. Matters concerning the general affairs of Bureau 2 of the Aeronautical Ordnance Bureau.

2. Matters concerning the experimentation, production, and the supplying of weapons, weapon parts, and accessories.

3. Matters concerning the experimentation, production, and the supplying of bombing equipment, parts, and accessories.

4. Matters concerning the experimentation, production, and supplying of pyrotechnics (powders, fuses, relating accessories, etc.)

5. Matters concerning the guidance, assistance, and supervision of factories connected with ammunition, bombing supplies, pyrotechnics, etc., and the parts and accessories of these things.

6. Matters pertaining to the production technics of ammunition, bombing supplies, pyrotechnics, parts and accessories.

Clause XIII.

The Torpedo Attack Section will be charged with the fowing duties:

1. Matters concerning the experimentation, production, and supplying of torpedoes, parts and accessories.

2. Matters pertaining to the guidance, assistance, and supervision of factories connected with torpedoes, parts and accessories.

3. Matters pertaining to the production techniques of torpedoes, parts and accessories.

Clause XIV.

The Electrical Instrument Section will be charged with the following duties:

1. Matters concerning the experimentation, production, and supplying of wireless materials, radio supplies; also their parts.

2. Matters concerning the experimentation, production, and supplying of electrical instruments and parts.

3. Matters pertaining to the guidance, assistance, and supervision of factories connected with wireless, radio, and electrical instruments and parts.

4. Matters pertaining to the production technics of wireless, radios, and electrical instruments and parts.

Clause XV.

The Gages and Optical Instruments Section will be charged with the following duties:

1. Matters concerning the experimentation, production, and supplying of gages and parts.

2. Matters concerning the experimentation, production, and supplying of optical instruments and parts.

3. Matters pertaining to the guidance, assistance, and supervision of factories connected with gages, optical instruments, and parts.

4. Matters pertaining to the production technics of gages, optical instruments, and parts.

Clause XVI.

The Matériel Section will be charged with the following duties:

1. Matters concerning the experimentation, production, and supplying of base ordnance, parts, and accessories.

2. Matters concerning the experimentation, production, and supplying of airfield construction materials, parts, and accessories.

3. Matters concerning the experimentation, production, and supplying of ordnance matériel not under bureau 1 or any other sections.

4. Matters concerning the experimentation, production, and supplying of base ordnance, airfield construction materials, and weapons matériel not under bureau 1 or any other section.

5. Matters pertaining to the production techniques of base ordnance and airfield construction materials and other weapons matériel not under the jurisdiction of the other sections.

Clause XVII.

Bureau 3 of the aeronautical ordnance bureau will contain the material section, iron and steel section, alloy section, chemical section, and the wooden material section.

1. Matters pertaining to the general affairs of bureau 3 of the aeronautical ordnance bureau.

2. Matters pertaining to supply, demand, and adjustment of materials.

3. Matters pertaining to collection of returned materials.

4. Matters concerning the acquisition and distribution of materials not under other sections.

5. Matters not included under or pertaining to other sections.

Clause XIX.

The Machinery Section will be charged with the following duties:

1. Matters pertaining to the supply, demand, and adjustments of machinery.

2. Matters pertaining to the supply, demand, and adjustments of tools.

3. Matters pertaining to the supply, demand, and adjustments of bearings (omit flat bearings—following is the same).

4. Matters pertaining to the investigation and research in the field of machinery, machine tools, and tools and bearings.

Clause XX.

The Iron and Steel Section will be in charge of the following duties:

1. Matters pertaining to the acquisition and distribution of steel, ordinary forged steel, cast steel, and pig iron.

2. Matters pertaining to the guidance, assistance, and supervision in the production, acquisition, and distribution of special steel (cast steel, forged steel, and rolled steel included) of the factories concerned with this work.

3. Matters pertaining to the acquisition and distribution of electrodes, heat-resisting bricks, and other raw materials related to steel production.

Clause XXI.

The Alloy Section will be in charge of the following duties:

1. Matters pertaining to the guidance, assistance, and supervision in the acquisition and distribution of light metal alloys in the factories concerned with this work.

2. Matters pertaining to the guidance, assistance, and supervision in the production, acquisition, and distribution of nonferrous alloys in factories concerned with this work.

3. Matters pertaining to the acquisition and distribution of raw materials for the two foregoing paragraphs.

Clause XXII.

The Chemical Section will be in charge of the following duties:

1. Matters pertaining to the guidance, assistance, and supervision in the production, acquisition, and distribution of optical glass matériel, bulletproof glass, and shatterproof glass of the factories concerned with this work.

2. Matters pertaining to the guidance, assistance, and supervision of synthetic rubber, and finished rubber products (omit those under other bureaus or sections) for the factories concerned with this work.

3. Matters concerning the guidance, assistance, and supervision in the production, acquisition, and distribution of electrical matériel of the factories concerned with this work.

4. Matters concerning the guidance, assistance, and supervision of the production, distribution, and acquisition of manufactured textile goods in the factories related to this work.

5. Matters pertaining to the guidance, assistance, and supervision of the production, acquisition, and distribution of paints, impregnating oil, and glue for factories concerned with this work.

6. Matters pertaining to the guidance, assistance, and supervision of production, acquisition, and distribution of raw materials for fuses etc. and photographic materials.

7. Matters pertaining to the guidance, assistance, and supervision of production, acquisition, and distribution of organic glass and manufacture of synthetic resins.

8. Matters pertaining to the acquisition and distribution of raw materials related to the foregoing paragraphs.

Clause XXIII.

The Wooden Material Section will be in charge of the following duties:

1. Matters pertaining to the acquisition and distribution of wooden materials.

2. Matters pertaining to the guidance, assistance, and supervision of the production, acquisition, and distribution of hardwood material, veneer, and plywood for aircraft use.

3. Matters pertaining to the production, acquisition, and distribution of glue for hardwood.

Clause XXIV

Bureau 4 of the aeronautical ordnance bureau will be composed of the accountant section, first contracting section, second contracting section, and installation section.

Clause XXV

The Accountant Section will be in charge of the following duties:

1. Matters pertaining to the general affairs of bureau 4 of the aeronautical ordnance bureau.

2. Matters pertaining to budgets and statement of accounts.

3. Matters pertaining to revenue, levy, and expenditures.

4. Matters pertaining to investigation and supervision of management, and compensation of losses by private factories.

5. Matters pertaining to demand and supply of capital of the private factories.

6. Matters pertaining to the investigation of costs in general.

7. Matters pertaining to the duties of an accounting official.

8. Matters concerning the system and regulations of accounting.

9. Matters not the concern of other sections.

Clause XXVI

The First Contract Section will be in charge of the following duties:

1. Matters pertaining to aircraft and aircraft weapon matériel (omit those covered by the second contract section) and the raw materials.

2. Matters pertaining to the cost of aircraft and aircraft weapon matériel (omit those covered by the second contract section).

Clause XXVII

The Second Contract Section will be in charge of the following duties:

1. Matters pertaining to the contracting of weapon matériels, machinery, machinery parts, tools, and bearings connected with the strafing and bombing section, torpedo section, electrical section, gages and optical section, and matériel section.

Clause XXVIII

The Installation Section will be in charge of the following duties:

1. Matters pertaining to contracting of land and construction according to special regulations for the promotion of manufacturing enterprise such as ordnance, etc.

2. Matters pertaining to national property.

3. Matters pertaining to acquisition and distribution of matériels for the construction of government-planned private enterprise.

4. Matters pertaining to construction regulations of privately owned factories.

APPENDIX VII

LIST OF COMPONENT AND ACCESSORIES SUPPLIERS

GENERATORS

Principal manufacturers	Location	Production by the company	
		Total production in Japan	Total business of the company
		Percent	*Percent*
1. Kobe Seikosho K. K.	Takegahana-machi, Yamada, Mie.	45	[1] 60
2. Hitachi Seisakusho	Tagāmachi, Ibaraki		
3. Chuo Kogyo K. K.	Omori, Tokyo	14	25
4. Mitsubishi Denki K. K.	Himeji	6	4
5. Fuji Denki Seizo K. K.	Kawasaki	4	30
6. Oano Seisakusho K. K.	Tokyo	3	35

[1] For the plant.

CARBURETORS

1. Nippon Kikaki	Kawasaki, Kanagawa-Ken.	30	95
2. Shimazu Seisakusho K. K.	Kyoto, Nakakyo Ken	22	40
3. Mitaka Seisakusho	Kamirenjaku, Mitaka-machi, Tokyo.	12	50
4. Asahina Tetsukosho	Tokyo	11	95
5. Tokyo Kiki Kogyo	Tokyo	11	80
6. Mikuni Shoko		2	5
7. Hitachi Seisakusho	Tokyo	2	20

BEARINGS

1. Toyo Bearing K. K.	Higashikata, Kuwana, Mie; Mukogun, Hyogo.	43	75
2. Nihon Seiko K. K.	Kugenuma Fujisawa, Kanagawa; Higashiosaki, Shinagawa Tokyo; Shimomaruko, Kamata, Tokyo.	40	67
3. Asahi Seiko K. K.	Sakai	5	70
4. Fuji Goshi Kozai K. K.	Toyama	4	60

INSTRUMENTS, ALTIMETERS

Principal manufacturers	Location	Production by the company	
		Total production in Japan	Total business of the company
		Percent	*Percent*
1. Tanaka Keiki Seisakusho K. K.	Omori, Omori-Ku, Tokyo	70	20
2. Yanagi Seisakusho K. K.	Tamagawa-Yogāmachi, Setagaya, Tokyo; Aichi-Ken, Nagoya-Shi, Minami-Ku.	20	30
3. Shinagawa Seisakusho	Tokyo-Shi, Shinagawa-Ku, Tokyo.	8	6
4. Tokyo Koku Keiki K. K.	Kanagawa-Ken, Kawasaki-Shi, Kitsuki.	1	1
5. Shimazu Seisakusho K. K.	Kyoto, Nakakyo-Ku, Sagaru Kawara-Machi.	1	1

INSTRUMENTS, ALTIMETERS (SENSITIVE)

1. Tanaka Keiki Seisakusho K. K.	Omori, Omori-Ku, Tokyo.	86	
2. Katsura Kenkyusho		14	

INSTRUMENTS, BANK AND TURN INDICATORS

1. Tokyo Koku Keiki K. K.	Kizuki, Kawasaki - Shi, Kanagawa-Ken.	65	10
2. Tokyo Keiki Seisakusho K. K.	Omori, Omoriku, Tokyo-Shi.	30	12
3. Shinagawa Seisakusho K. K.	Shinagawa - Ku, Tokyo-Shi.	1	1
4. Yokogawa Denki Seisakusho K. K.	Tokyo	1	1

INSTRUMENTS, COMPASSES

Principal manufacturers	Location	Production by the company	
		Total production in Japan	Total business of the company
		Percent	*Percent*
1. Tokyo Koku Keiki K. K.	Kitsuki, Kawasaki - Shi, Kanagawa-Ken.	50	30
2. Yokogawa Denki Seisakusho Co.	Kiebijoji, Musashino-machi, Tokyo.	21	15
3. Tokyo Keiki Seisakusho	Tokyo-Shi, Kamata-Ku	14	2
4. Shimazu Seisakusho K. K.	Kyoto-fu, Sagaru Kawara-Machi.	1	2
5. Shinagawa Seisakusho K. K	Tokyo-Shi, Shinagawa-Ku	1	2

LANDING GEARS AND STRUTS

1. Okamoto Kogyo K. K.	Kasadera-machi Minami-ku, Nagoya; Kanbe-machi, Gifu.	36	75
2. Kayaba Kokukeiki K. K.	Shibaura, Shiba-Ku, Tokyo; Tsuchida-mura, Kanigun, Gifu; Nagamachi, Sendai.	32	90
3. Mitsubishi Jukogyo K. K.	Nagoya	9	7
4. Nakajima Hikoki K. K.	Tokyo	7	4
5. Miyata Seisakusho K. K.	do	6	90
6. Dai Nihon Kikai K. K.	do	2	90
7. Osaka Kinzoku Kogyo K. K.	Osaka	2	5
8. Kakuwa Seisakusho K. K.	Tokyo	1	70
9. Nisshin Kogyo K. K.	Kawasaki	1	10

INSTRUMENTS, GYRO COMPASSES

1. Tokyo Koku Keiki K. K.	Kitsuki-ku, Kawasaki-Shi, Kanagawa-Ken.	86	5
2. Tokyo Keiki Seisakusho	Tokyo-Shi, Kamata-Ku	7	1
3. Kure Kaiguo Kosho	Kure	1	
4. Mitsubishi Denki K. K.	Nagoya	1	1

MAGNETOS

1. Kokusan Denki K. K.	Tokyo; Suoto; Odawara; Fukui.	60	90
2. Yokokawa Denki Co	Koganei, Tokyo	18	20
3. Mitsuhishi Denki	Nagoya, Osaka	15	8
4. Toa Koku Denki	Fukushima, Tokyo	2	50

PUMPS, FUEL AND OIL

1. Nakajima Hikoki	Tokyo	50	10
2. Mitsubishi Jukogyo K. K.	Nagoya	18	5
3. Shimazu Seisakusho	Kyoto	15	12
4. Mitsubishi Denki K. K.	Nagoya	5	2
5. Nippon Nainenki K. K.	Kanagawa	1	100
6. Mitaka Koku Kogyo	Tokyo	1	8
7. Tokushu Kosakusho K. K.		1	40
8. Aichi Koku Denki K. K.	Nagoya	1	2
9. Aichi Kokuki K. K.	do	1	2
10. Osaka Kinzoku Kogyo K. K.	Osaka	1	1

[1] For the plant.

PUMPS, INJECTION

Principal manufacturers	Location	Production by the company	
		Total production in Japan	Total business of the company
		Percent	*Percent*
1. Mitsubishi Jukogyo K. K.	Nishikawajimamachi, Aichi, Nagoya.	55	[1] 60
2. Hitachi Seisakusho K. K.	Kashiwa, Chiba prefecture	20	
3. Kawanishi	Takarazuka	12	[1] 15

RADIATORS AND OIL COOLERS

1. Nitto Kokukiki K. K.	Fukae Honjo-Mura, Hyogo-Prefecture.	60	100
2. Osaka Kinzoku Kogyo K. K.	Osaka	12	20
3. Toyoda Jidosha Kogyo K. K.	Nakagawa, Nagoya	10	50
4. Mitsubishi Jukogyo K. K.	Nagoya	4	2
5. Nissho Koku Kiki K. K.		2	100
6. Nippon Kentetsu Kogyo K. K.	Tokyo; Chiba	2	15
7. Sansho Seisakusho K. K.		2	20
8. Nishinomiya Nippon Cooler K. K.	Nishinomiya	2	
9. Aichi Kokuki K. K.	Nagoya	1	2
10. Kawanishi Kokuki K. K.	Kobe	1	2
11. Hayashiuchi Seisakusho		1	100
12. Osaka Aluminum Seisakusho K. K.	Osaka	1	15

RADIO (airborne transmitters and receivers)

1. Nippon Museo Denki K. K.	Kamireojaku, Mitakamachi, Tokyo.	35	60
2. Nippon Denki K. K.	Tokyo	20	30
3. Tokyo-Shibaura Denki Co.	Yanagi-machi, Kawasaki, Kanagawa.	12	25
4. Toyo Tsuchinki K. K.	Tokyo	9	40
5. Mitsubishi Denki K. K.	Nagoya	8	4
6. Adachi Denki K. K.	Tokyo	2	50

STARTERS

1. Tokyo Keiki Seisakusho	Tokyo-Shi, Kamata-ku	65	55
2. Mitsubishi Denki K. K.	Oka-machi, Wakayama	25	[1] 70
3. Kokusan Denki K. K.	Tokyo-Shi, Toshima-Ku	5	15
4. Shibaura Seisakusho K. K.	Tokyo	1	10

TIRES

1. Nippon Hikoki Tyre K. K.	Kyo-machi, Kurame, Fukuoka.	55	50
2. Fujikura Kogyo K. K.	Tokyo	20	
3. Meiji Gomu Seizosho K. K.	Misma	15	
4. Yokohama Gomu K. K.	Heiao-machi, Tsurumi, Yokohama; Misono-mura, Watarai Mie. Keo.	10	

TURBINE BLOWERS (exhaust)

Principal manufacturers	Location	Production by the company	
		Total production in Japan	Total business of the company
		Percent	*Percent*
1. Ishikawajima Shibaura K. K.	Takamiya, Matsumoto	35	[1] 75
2. Mitsubishi Jukogyo K. K.	Nishikawajima-machi, Aichi, Nagoya.	25	[1] 30
3. Hitachi Kokuki K. K.	Mito	20	10

[1] For the plant.

WHEELS

Principal manufacturers	Location	Production by the company	
		Total production in Japan	Total business of the company
		Percent	*Percent*
1. Okamoto Kogyo K. K.	Kasadera, Nagoya	50	20
2. Kyushu Hikoki	Itatsuke, Nakamura Tsukushigun, Fukuoka.	25	15
3. Miyata Seisakusho	Degawa-machi, matsumoto.	10	35
4. Kayaba Seisakusho K. K.	Tokyo	10	10

APPENDIX VIII

LIST OF PRINCIPAL SUPPLIERS OF METALS

STEEL

Name	Location	Production
Nippon Special Steel Co. (Nippon Tokushuko.)	Tokyo	(a), (e).
Daido Steel Co. (Daido Seiko.)	Nagoya	(a), (b), (e), (d).
Sumitomo Steel Co. (Sumitomo Seiko.)	Amagasaki	(a).
	Osaka	(a), (b), (e), (d).
Hitachi Works (Hitachi Seisakusho.)	Yasuki; Mito	(b), (e).
	Shimizu	(d).
Kobe Steel Co (Kobe Seikosho).	Kobe	(a), (b), (e).
Toyoda Automobile Manufacturing Co. (Toyoda Jidosha.)		
Nippon Steel Co. (Nippon Seitetsu.)	Yawata	(a), (b), (e), (d).
Nippon Forging Co. (Nippon Tanko.)	Kawasaki	(e).
Tokyo Forging Co. (Tokyo Tanko.)	Kawasaki; Osaka	(e).
Nippon Metallurgical Industry Co. (Nippon Yakin Kogyo.)	Kawasaki	(a), (e).
Nippon Stainless Steel Co. (Nippon Sutonresu.)	Naoetsu	(a), (e).
Kawasaki Industrial Co. (Kawasaki Seikosho.)	Kobe	(e).
Nippon Steel Tube Co. (Nippon Kokan.)	Kawasaki	(a) pipe.
Fujikoshi Steel Co (Fujikoshi Kozai K. K.)	Island, Ogura City, Kyushu.	(a).
Nippon Soda Indst. Co. (Nippon Soda K. K.)	Yonago City, Tottori P.	(a).
Misaku Casting Co (Misaku Imono.)	Tsuyama City, Okayama P.	(d).
Shoda Special Steel Co. (Shoda Tokuchu Ko.)	Yokohama	(e).
Nomura Steel Co. (Nomura Seikosho.)	Chiba; Ichikawa; Yasuki.	(a), (e).
Mitsubishi Steel Co. (Mitsubishi Seiko.)	Tokyo; Mihara	(a), (b).
Riken Industrial Co. (Riken Kogyo).	Tokyo	(b), (e).

STEEL—Continued

Name	Location	Production
Special Steel Co., Ltd. (Tokusbu Seiko.)	Tokyo; Kamata; Kawasaki.	(a), (b)
Tojo Aircraft Metal Co. (Tojo Koku Kinzoku K. K.)	Nishinomiya	(d).

ALUMINUM—(ALLOY MANUFACTURING COMPANIES)

Sumitomo Metal Co. (Sumitomo Kinzoku.)	Osaka	(i), (j), (k), (l)
	Nagoya	(i), (j), (k), (l)
	Toyohashi	(i), (l)
	Narumi	(j)
	Otsu	(j)
Furukawa Electrical Industries Co. (Furukawa Denko.)	Nikko	(i), (k), (l)
	Oyama	(i)
	Hiratsuka	(k)
	Osaka	(k), (l)
Kobe Steel Co. (Kobe Seikosho.)	Chofu	(i), (k), (l)
	Nakatsu	(i), (k), (l)
	Moji	
Special Light Alloy Co. (Tokushu Keigokin.)	Ogaki	(i), (k), (l)
	Nagoya	(i), (j), (k)
	Ichinomiya	(j)
Special Alloy Co. (Tokushu Gokin.)	Tokyo	(k), (l)
Nasu Aluminum Manufacturing Co. (Nasu Arumi.)	do	(k), (l)
Mitsubishi Metal Co. (Mitsubishi Kinzoku.)		(k), (l)
Mitsubishi Metal Industries Co. (Mitsubishi Kinzoku Kogyo).	Nagoya	(j)
Nakajima A/C Metal Industries Co. (Nakajima Koku Kinzoku.)	Tokyo	(j)
Nitto Metal Industries Co. (Nitto Kinzoku.)	do	(k), (l)
Takata Aluminum Manufacturing Co. (Takata Arumi.)	Sakai	(k), (l)
Mitsubishi Light Alloy Co. (Mitsubishi Keikinzoku.)	Osaka	(l)

ALUMINUM—(ALLOY MANUFACTURING COMPANIES)—Con.

Name	Location	Production
Suzuki Metal Industrial Co. (Suzuki Kinzoku Kogyo.)	Tateishi	(l)
Osaka Aluminum Manufacturing Co. (Osaka Aruminium.)	Osaka	(j)
Takada Aluminum Co. (Takada Arumi.)	do	(l)
Tanaka Die Casting Co. (Tanaka Dai Imono.)	Tokyo	(j)

Key to letter symbols in production column:
- Alloy producers (a)
- Carbon steel producers (b)
- Forging companies (c)
- Casting companies (d)
- Refineries.
- Forging companies (i)

Copper—(copper alloy)

Sumitomo Metal Co. (Sumitomo Kinzoku.)	Osaka	
Furukawa Electrical Industries Co. (Furukawa Denki K. K.)	Nikko	
	Osaka	m. k.
Kobe Steel Co. (Kobe Seiko K. K.)	Moji	k. a.
Special Alloy Co. (Tokushu Gokin.)	Tokyo	

Key to letter symbols in production column:
- Refineries—Continued
- Casting companies (j)
- Rolling mills, sheet (k)
- Extrusions—tube (l)
- Copper alloy (m)
- Bearing metals (n)

APPENDIX IX

PROPELLER REQUIREMENTS AND PRODUCTION BY TYPES, 1941–45

	1941												Total
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
Metal propellers													
Japan Musical Instrument	93	95	95	225	255	236	245	321	323	313	333	340	2,874
Japan International						9	6	35	43	38	50	59	240
Sumitomo	501	582	605	595	629	671	683	701	775	824	891	893	8,350
Total	594	677	700	820	884	916	934	1,057	1,141	1,175	1,274	1,292	11,464
Combination wood and metal													
Japan Musical Instrument													0
Kawanishi	48	5	5	10	5	60	12	20	31	5	9	10	220
Total	48	5	5	10	5	60	12	20	31	5	9	10	220
Wood propellers													
Japan Musical Instrument	30	40	45	60	65	110	105	105	111	89	97	80	937
Grand total	672	722	750	890	954	1,086	1,051	1,182	1,283	1,269	1,380	1,382	12,621
Aircraft production requirements	376	428	458	488	562	561	514	578	619	697	690	797	6,768
Spares	296	294	292	402	392	525	537	604	664	572	690	585	5,853

	1942												Total
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
Metal propellers													
Japan Musical Instrument	409	332	368	400	397	418	409	408	399	464	455	475	4,934
Japan International	64	67	103	35	35	99	75	37	103	69	88	85	860
Sumitomo	974	1,050	1,005	1,080	1,156	1,234	1,277	1,302	1,253	1,375	1,427	1,501	14,634
Total	1,447	1,449	1,476	1,515	1,588	1,751	1,761	1,747	1,755	1,908	1,970	2,061	20,428

PROPELLER REQUIREMENTS AND PRODUCTION BY TYPES, 1941–45—Continued

	1942—Continued												Total
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
Combination wood and metal													
Japan Musical Instrument					20	40	40	50	19	41	45	65	320
Kawanishi	25	13	10	40	65	30	30	0	0	45	35	96	389
Total	25	13	10	40	85	70	70	50	19	86	80	161	709
Wood propellers													
Japan Musical Instrument	88	91	75	95	95	95	105	105	116	120	120	120	1,225
Grand total	1,560	1,553	1,561	1,650	1,768	1,916	1,936	1,902	1,890	2,114	2,170	2,342	22,362
Aircraft productiun requirements	766	778	913	861	935	826	924	874	1,049	1,144	1,238	1,339	11,647
Spares	794	775	548	789	833	1,090	1,012	1,028	841	970	932	1,003	10,715

1943

Metal propellers													
Japan Musical Instrument	398	370	340	340	378	405	400	282	205	414	600	608	4,740
Japan International	93	63	61	76	102	86	96	48	66	100	92	62	945
Sumitomo	1,526	1,684	1,756	1,674	1,735	1,897	2,056	1,983	2,634	2,154	1,998	2,233	22,730
Total	2,017	2,117	2,157	2,090	2,215	2,388	2,552	2,313	2,305	2,668	2,690	2,903	28,415
Combination wood and metal													
Japan Musical Instrument	50	30	150	100	90	90	65	83	86	64	13	32	853
Kawanishi	45	30	40	20	10	95	0	45	40	95	62	80	562
Total	95	60	190	120	100	185	65	128	126	159	75	112	1,415
Wood propellers													
Japan Musical Instrument	116	128	145	108	104	136	143	130	155	200	232	328	1,925
Grand total	2,228	2,305	2,492	2,318	2,419	2,709	2,760	2,571	2,586	3,027	2,997	3,343	31,755
Aircraft production requirements	1,310	1,359	1,484	1,474	1,537	1,547	1,584	1,782	1,963	2,044	2,296	2,627	21,007
Spares	918	946	1,008	844	882	1,162	1,176	789	623	983	701	716	10,748

1944

Metal propellers													
Japan Musical Instrument	660	695	710	787	870	910	878	752	635	750	603	902	9,152
Japan International	139	175	201	240	280	293	318	370	482	220	286	354	3,358
Sumitomo	2,355	2,428	2,375	2,714	2,621	2,897	3,140	2,492	3,072	2,869	3,010	3,072	33,045
Total	3,154	3,298	3,286	3,741	3,771	4,100	4,336	3,614	4,189	3,839	3,899	4,328	45,555
Combination wood and metal													
Japan Musical Instrument	64	97	330	182	230	205	310	310	210	170	267	65	2,440
Kawanishi	85	120	105	90	160	25	10	0	24	0	43	20	682
Total	149	217	435	272	390	230	320	310	234	170	310	85	3,122
Wood propellers													
Japan Musical Instrument	340	465	362	500	550	550	601	526	450	423	422	56	5,245
Grand total	3,643	3,980	4,083	4,513	4,711	4,880	5,257	4,450	4,873	4,432	4,631	4,469	53,922
Aircraft production requirements	2,574	2,628	2,910	2,971	2,762	3,009	2,961	2,818	3,074	2,754	2,654	2,465	33,580
Spares	1,069	1,352	1,173	1,542	1,949	1,871	2,296	1,632	1,799	1,678	1,977	2,004	20,342

	1945								Total	1941–45 total
	January	February	March	April	May	June	July	August		
Metal propellers										
Japan Musical Instrument	880	775	622	480	170	7	17		2,951	24,651
Japan International	458	450	591	480	450	350	100		2,879	8,282
Sumitomo	2,719	2,118	1,826	1,695	2,926	901	195	50	12,430	91,189
Total	4,057	3,343	3,039	2,655	3,546	1,258	312	50	18,260	124,122
Combination wood and metal										
Sumitomo			45	75	100	120	60		400	400
Japan Musical Instrument	220	250	75	262	100	11	11		929	4,542
Kawanishi									0	1,853
Total	220	250	120	337	200	131	71		1,329	6,795
Wood propellers: Japan Musical Instrument	1		332						333	9,665
Grand total	4,278	3,593	3,491	2,992	3,746	1,389	383	50	19,922	140,582
Aircraft production requirements	2,105	1,630	1,969	1,836	1,871	1,529	1,200	573	12,713	85,715
Spares	2,173	1,963	1,522	1,156	1,875	−140	−817	−523	7,209	54,867

APPENDIX X

STATISTICS

Japanese aircraft production, by years, 1930–45

[Figures from 1930 to 1939 include estimates for certain manufacturers]

Year	Number of aircraft	Year	Number of aircraft	Number of combat aircraft
1930	445	1938	3,201	(1)
1931	368	1939	4,467	(1)
1932	691	1940	4,768	(1)
1933	766	1941	5,088	3,180
1934	688	1942	8,861	6,335
1935	952	1943	16,693	13,406
1936	1,181	1944	28,180	21,058
1937	1,511	1945	11,066	8,263

[1] Data not available.

Japanese aircraft production, all types,[1] by months, January 1941–August 1945

Month	Year				
	1941	1942	1943	1944	1945
January	306	564	1,010	2,122	1,836
February	339	580	1,049	2,199	1,391
March	357	687	1,147	2,435	1,713
April	367	646	1,141	2,473	1,567
May	420	706	1,207	2,318	1,592
June	426	639	1,217	2,541	1,340
July	380	705	1,259	2,473	1,131
August	435	678	1,418	2,346	[2] 496
September	462	804	1,573	2,573	
October	510	886	1,662	2,371	
November	514	943	1,862	2,220	
December	574	1,023	2,148	2,110	
Total	5,088	8,861	16,693	28,180	11,066

[1] Types included: Fighter, bomber, recce, trainer, transport, flying boat, glider and suicide, except the piloted bomb Baka, of which 755 were produced between September 1944 and March 1945 and 50 in June 1945.

[2] Less than ½ month.

Japanese combat aircraft production, by months, January 1941–August 1945

Month	Year				
	1941	1942	1943	1944	1945
January	168	396	793	1,622	1,383
February	193	393	819	1,628	999
March	196	466	904	1,757	1,294
April	210	465	950	1,806	1,256
May	244	483	987	1,647	1,230
June	245	458	978	1,809	966
July	245	491	1,032	1,786	762
August	292	485	1,154	1,748	[1] 373
September	306	569	1,295	1,941	
October	317	632	1,337	1,809	
November	338	704	1,463	1,820	
December	426	793	1,694	1,685	
Total	3,180	6,335	13,406	21,058	8,263

[1] Less than ½ month.

Japanese aircraft engine production by months, January 1941–August 1945

Mouth	Year				
	1941	1942	1943	1944	1945
January	938	1,359	1,775	3,633	1,987
February	872	1,320	1,797	3,789	1,695
March	973	1,317	2,037	4,530	1,787
April	886	1,439	1,998	4,216	1,734
May	905	1,423	2,121	3,163	1,677
June	925	1,269	2,261	5,090	1,669
July	966	1,381	2,350	4,038	1,257
August	976	1,325	2,441	4,203	[1] 554
September	1,099	1,388	2,643	3,266	
October	1,176	1,516	2,796	3,789	
November	1,112	1,455	2,863	3,819	
December	1,323	1,807	3,459	2,991	
Total	12,151	16,999	28,541	46,526	12,360

[1] Less than ½ month.

Relative importance of producers of Japanese aircraft—production of all types, 1941–45

[Fighter, bomber, recce, trainer, transport, flying boat, glider, and suicide types Fig. II-5]

Name of corporation	1941		1942		1943		1944		1945		Total	Percent
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent		
Nakajima Aircraft Co	785	15.4	2,215	25.0	4,646	27.8	7,896	28.0	4,019	36.3	19,561	28.0
Mitsubishi Heavy Industries	1,397	27.5	2,241	25.3	3,546	21.2	4,176	14.8	1,153	10.4	12,513	17.9
Kawasaki Aircraft Industries	733	14.4	1,034	11.7	1,984	11.9	3,665	13.0	827	7.5	8,243	11.8
Tachikawa Aircraft Co	1,048	20.6	1,224	13.8	1,289	7.7	2,189	7.8	895	8.1	6,645	9.6
Aichi Aircraft Co	255	5.0	377	4.3	997	6.0	1,496	5.3	502	4.5	3,627	5.2
Japan Aircraft Co	209	4.1	329	3.7	725	4.3	1,222	4.3	397	3.6	2,882	4.1
Kyushu Aircraft Co	166	3.3	278	3.1	697	4.2	1,124	4.0	355	3.2	2,620	3.7
Manchuria Aircraft Co	60	1.2	300	3.4	523	3.1	1,021	3.6	292	2.6	2,196	3.1
Japan International Air Co	95	1.9	163	1.8	340	2.0	1,429	5.1	107	1.0	2,134	3.1
Kawanishi Aircraft Co	71	1.4	97	1.1	235	1.4	1,060	3.8	531	4.8	1,994	2.9
Kawanishi Aircraft Co	139	2.7	205	2.3	405	2.4	833	3.0	201	1.8	1,783	2.6
Tachiarai Aircraft Co							300	1.1	920	8.3	1,220	1.7
Fuji Aircraft Co			23	.3	230	1.4	506	1.8	112	1.0	871	1.2
Showa Aircraft Co	22	.4	87	1.0	62	.4	286	1.0	159	1.4	616	.9
Tokyo Aircraft Co							33	.1	225	2.0	258	.4
Mitsui Mining Co							2	(1)	15	.1	17	(1)
Matsushita Air Industries									4	(1)	4	(1)
Total	4,980		8,573		15,679		27,238		10,714		67,184	
Navy air depots	43	0.8	111	1.3	648	3.9	639	2.3	259	2.3	1,700	2.4
Army air arsenal	65	1.3	177	2.0	366	2.2	303	1.1	93	.8	1,004	1.4
Total	108	2.1	288	3.3	1,014	6.1	942	3.4	352	3.1	2,704	3.8
Grand total	5,088	100.0	8,861	100.0	16,693	100.0	28,180	100.0	11,066	100.0	69,888	100.0

Relative importance of producers of Japonese combat aircraft—production of fighters, bombers and recce, 1941–45

[Fig. II-6]

Name of corporation	1941		1942		1943		1944		1945		Total	Percent
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent		
Nakajima Aircraft Co	736	23.1	2,203	34.8	4,646	34.7	7,896	37.5	3,915	47.4	19,396	37.1
Mitsubishi Heavy Industries	1,317	41.4	2,179	34.4	3,388	25.3	4,005	19.0	1,150	13.9	12,039	23.0
Kawasaki Aircraft Industries	605	19.0	753	11.9	1,920	14.3	3,665	17.4	827	10.0	7,770	14.9
Aichi Aircraft Co	255	8.0	366	5.8	992	7.4	1,496	7.1	502	6.1	3,611	6.9
Tachikawa Aircraft Co			70	1.1	614	4.6	1,689	8.0	757	9.2	3,130	6.0
Kawanishi Aircraft Co	10	.3	7	.1	145	1.1	951	4.5	516	6.2	1,629	3.1
Kyushu Aircraft Co	87	2.7	177	2.8	479	3.6	569	2.7	195	2.4	1,507	2.9
Manchuria Aircraft Co	60	1.9	300	4.7	370	2.8	61	.3	7	.1	798	1.5
Japan Aircraft Co							18	.1	41	.5	59	.1
Japan International Air Industries	2	.1	2	(1)	10	.1					14	(1)
									1	(1)	1	(1)
Total	3,072	96.6	6,057	95.6	12,564	93.7	20,350	96.6	7,911	95.7	49,954	95.6
Navy air depots	43	1.4	101	1.6	476	3.6	405	1.9	259	3.1	1,284	2.5
Army air arsenal	65	2.0	177	2.8	366	2.7	303	1.4	93	1.1	1,004	1.9
Total	108	3.4	278	4.4	842	6.3	708	3.3	352	4.2	2,288	4.4
Grand total	3,180	100.0	6,335	100.0	13,406	100.0	21,058	100.0	8,263	100.0	52,242	100.0

Relative importance of producers of Japanese aircraft engines from 1941–45

Name of corporation	1941 number	Percent	1942 number	Percent	1943 number	Percent	1944 number	Percent	1945 number	Percent	Total number	Percent
Mitsubishi Heavy Industries	4,589	37.8	6,645	39.1	9,708	34.0	17,524	37.7	3,068	24.8	41,534	35.6
Nakajima Aircraft Co	3,990	32.8	4,897	28.8	9,556	33.5	14,014	30.1	3,983	32.2	36,440	31.3
Hitachi Aircraft Co	1,837	15.1	2,645	15.6	3,530	12.4	4,469	9.6	1,090	8.8	13,571	11.6
Kawasaki Aircraft Industries	911	7.5	1,372	8.1	2,449	8.8	4,255	9.1	1,237	10.0	10,274	8.8
Ishikawajima Air Industries	1	*	29	.2	390	1.2	1,155	2.5	711	5.8	2,286	2.0
Manchuria Aircraft Co	220	1.8	448	2.6	735	2.6	551	1.2	214	1.7	2,168	1.9
Aichi Aircraft Co	134	1.1	198	1.2	444	1.6	733	1.6	274	2.2	1,783	1.5
Nissan Auto Co							911	2.0	722	5.8	1,633	1.4
Japan International Air Industries					51	.2	558	1.2	228	1.8	837	.7
Toyoda Auto Co							42	.1	118	1.0	160	.1
Total	11,682	96.1	16,234	95.6	26,913	94.3	44,212	95.1	11,645	94.1	110,686	94.9
Navy air depots	325	2.7	490	2.9	1,231	4.3	1,847	4.0	559	4.5	4,452	3.8
Army air arsenal	144	1.2	275	1.6	397	1.4	467	1.0	156	1.3	1,439	1.2
Total	469	3.9	765	4.5	1,628	5.7	2,314	5.0	715	5.8	5,891	5.0
Grand total	12,151	100.0	16,999	100.1	28,541	100.0	46,526	100.1	12,360	99.9	116,577	99.9

Total employment data

1941

	January	February	March	April	May	June	July	August	September	October	November	December	Total
Airplanes [1]	117,488	119,515	121,084	130,098	135,543	140,936	141,851	143,477	148,388	154,965	160,539	167,093	1,680,977
Engines [2]	60,656	61,610	63,278	66,798	67,307	68,082	70,051	71,077	75,463	78,674	80,223	82,392	845,611
Propellers	9,349	9,399	9,568	10,879	11,275	11,211	10,336	10,892	11,737	11,432	11,533	11,676	129,287
Total	187,493	190,524	193,930	207,775	214,125	220,229	222,238	225,446	235,588	245,071	252,295	261,161	2,655,875

1942

Airplanes [1]	172,203	175,391	181,625	198,349	210,902	219,220	227,645	228,753	235,064	240,481	249,149	255,360	2,594,142
Engines [2]	96,580	99,629	103,097	114,019	111,466	113,276	114,247	116,379	118,115	120,764	122,371	124,510	1,354,453
Propellers	11,831	11,840	12,113	13,892	14,150	14,429	14,663	15,314	16,083	16,410	16,663	16,992	174,380
Total	280,614	286,860	296,835	326,260	336,518	346,925	356,555	360,446	369,262	377,655	388,183	396,862	4,122,975

1943

Airframes	266,198	268,145	279,127	290,416	303,293	307,087	309,701	315,747	329,341	337,370	345,331	364,098	3,715,854
Engines	128,545	130,919	136,130	146,813	151,108	154,447	155,587	158,377	162,235	165,396	166,772	179,191	1,835,520
Propellers	18,093	18,551	18,936	20,144	20,541	20,142	20,436	20,383	20,706	20,869	21,277	21,810	241,878
Total	412,836	417,615	434,193	457,373	474,942	481,676	485,714	494,507	512,282	523,635	533,380	565,099	5,793,252

1944

Airframes	392,390	404,909	429,369	472,927	492,578	507,502	530,567	547,332	553,283	546,379	557,803	557,086	5,992,125
Engines	193,386	199,480	207,223	221,246	227,893	222,207	229,581	236,555	239,959	246,031	251,693	260,914	2,736,168
Propellers	22,697	23,166	24,229	26,736	29,121	29,354	30,621	30,829	31,698	31,343	33,189	33,797	346,780
Total	608,473	627,555	660,821	720,909	749,592	759,063	790,769	814,716	824,940	823,753	842,685	851,797	9,075,073

1945

Airplanes	571,820	574,184	570,486	558,944	544,777	535,410	523,182	485,820					4,364,623
Engines	268,628	266,976	260,993	249,907	240,499	238,659	231,303	219,602					1,976,467
Propellers	34,513	34,265	34,012	34,433	34,079	32,656	30,057	29,047					263,562
Total	874,961	875,925	865,491	843,284	819,355	806,725	784,542	734,369					6,604,652

[1] Employment data for the following airframe manufacturers not available:

1. Manchuria Aircraft Co.—produced 3.1% of all air frames. 1941–45.
2. Tachiarai Aircraft Co.—produced 1.7% of all air frames, 1941–45.
3. Tokyo Aircraft Co.—produced 0.4% of all air frames, 1941–45.
4. Mitsui Mining Co.—produced less than 0.1% of all air frames, 1941–45.

[2] Employment data for the following engine manufacturers not available:

1. Manchuria Aircraft Co.—produced 1.9% of all engines, 1941–45.
2. Toyoda Auto Co.—produced 0.1% of all engines, 1941–45.

Employment data by months, by manufacturers—Airframes only (Fig. II–8)*

[1941]

	January	February	March	April	May	June	July	August	September	October	November	December	Total
Nakajima Aircraft Co	33,388	33,794	34,142	38,794	40,002	40,442	38,847	38,935	41,527	42,430	45,608	47,998	475,907
Mitsubishi Heavy Industries, Ltd	25,620	25,953	26,380	28,564	28,872	29,084	29,296	29,661	31,300	32,705	33,149	33,648	354,232
Kawasaki Aircraft Industries	8,739	9,007	8,943	9,198	9,635	10,340	10,542	10,006	9,534	9,628	10,009	10,848	116,429
Tachikawa Aircraft Co	9,000	9,000	9,100	9,360	10,000	10,300	10,700	10,800	10,500	10,600	10,600	10,500	120,400
Aichi Aircraft Co	3,500	3,500	3,500	3,550	3,600	3,650	3,700	3,900	4,100	4,300	4,700	4,900	46,900
Japan Aircraft Co	2,342	2,483	2,510	2,784	2,925	2,900	2,839	2,910	2,954	2,889	2,905	2,885	33,326
Kyushu Aircraft Co	7,995	8,214	8,450	8,599	8,786	9,480	9,795	10,296	10,389	10,371	10,698	16,405	114,478
Japan International Air Industries, Ltd	134	134	134	594	594	3,036	3,099	3,183	3,127	3,246	3,085	3,056	23,422
Kawanishi Aircraft Co	9,900	10,000	10,400	10,500	12,700	13,125	14,225	14,800	15,400	15,800	16,200	17,380	160,530
Hitachi Aircraft Co	1,220	1,350	1,400	1,500	1,560	1,600	1,675	1,680	1,710	1,770	1,774	1,774	19,013
Fuji Aircraft Co	1,332	1,366	1,399	1,673	1,715	1,755	1,801	1,857	1,916	1,942	1,997	2,021	20,774
Showa Aircraft Co	3,358	3,469	3,466	3,602	3,654	3,649	3,657	3,694	3,681	3,753	3,833	3,932	43,748
Matsushita Air Industries													
Total	106,528	108,370	109,824	118,658	124,043	129,361	130,176	131,722	136,138	139,434	144,558	150,347	1,529,159
Navy air depots	9,375	9,550	9,650	9,680	9,710	9,735	9,755	9,805	9,900	12,781	13,221	13,636	126,798
Army air arsenal	1,585	1,595	1,610	1,760	1,790	1,840	1,920	1,950	2,350	2,750	2,760	3,110	25,020
Total	10,960	11,145	11,260	11,440	11,500	11,575	11,675	11,755	12,250	15,531	15,981	16,746	151,818
Grand total	117,488	119,515	121,084	130,098	135,543	140,936	141,851	143,477	148,388	154,965	160,539	167,093	1,680,977

[1942]

Nakajima Aircraft Co	50,572	51,799	54,438	59,011	61,532	65,645	68,346	69,030	70,724	71,617	71,674	72,627	767,015
Mitsubishi Heavy Industries, Ltd	33,790	33,155	34,499	37,945	39,265	40,076	41,950	41,468	43,016	43,854	47,126	48,208	484,352
Kawasaki Aircraft Industries	10,733	11,288	11,966	12,592	17,148	17,247	18,280	18,645	19,145	19,240	20,702	21,463	198,449
Tachikawa Aircraft Co	10,500	10,700	10,800	12,800	13,000	13,000	13,400	13,500	13,700	14,000	14,200	14,200	153,800
Aichi Aircraft Co	5,100	5,300	6,000	6,500	6,750	7,000	7,500	8,050	9,000	9,500	10,000	11,000	71,700
Japan Aircraft Co	3,122	3,064	3,114	3,476	3,603	3,672	3,784	3,902	3,981	4,159	3,744	4,421	44,042
Kyushu Aircraft Co	11,403	12,278	12,400	12,514	12,891	14,109	14,250	14,300	13,575	14,096	15,014	15,355	162,185
Japan International Air Industries, Ltd	3,010	2,937	2,882	3,343	3,632	3,716	3,640	3,578	3,685	3,978	4,067	3,857	42,325
Kawanishi Aircraft Co	17,690	18,090	18,100	20,300	22,850	23,950	24,900	24,000	25,175	26,400	28,100	29,250	278,805
Hitachi Aircraft Co	1,774	1,786	1,762	2,501	2,388	2,408	2,723	2,636	2,673	2,651	2,757	2,760	28,819
Fuji Aircraft Co	2,048	2,086	2,120	2,389	2,477	2,543	2,605	2,636	2,671	2,724	2,746	2,813	29,858
Showa Aircraft Co	3,975	4,006	4,054	4,431	4,530	4,681	4,785	4,899	5,021	5,043	5,116	5,205	55,746
Matsushita Air Industries													
Total	153,717	156,489	162,135	177,802	190,066	198,047	206,163	206,644	212,366	217,262	225,246	231,159	2,337,096
Navy air depots	15,356	15,762	16,340	17,197	17,456	17,763	18,052	18,529	19,018	19,379	19,943	20,141	214,936
Army air arsenal	3,130	3,140	3,150	3,350	3,380	3,410	3,430	3,580	3,680	3,840	3,960	4,060	42,110
Total	18,486	18,902	19,940	20,547	20,836	21,173	21,482	22,109	22,698	23,219	23,903	24,201	257,046
Grand total	172,203	175,391	181,625	198,349	210,902	219,220	227,645	228,753	235,064	240,481	249,149	255,360	2,594,142

No employment figures available for Manchuria Aircraft, Tachiarai Aircraft Co., Tokyo Aircraft Co., Mitsui Mining Co.

[1943]

Nakajima Aircraft Co	74,383	70,515	72,095	73,137	75,088	76,630	77,649	78,642	81,137	80,705	81,568	87,095	929,244
Mitsubishi Heavy Industries Ltd	50,577	50,292	56,048	54,274	55,519	56,280	56,573	56,948	64,823	67,071	68,054	70,964	707,423
Kawasaki Aircraft Industries	23,141	24,752	26,310	29,258	31,518	30,996	31,081	33,398	34,744	37,288	38,226	43,244	383,963
Tachikawa Aircraft Co	14,300	14,600	14,700	17,400	17,500	17,700	18,200	18,100	18,200	19,700	21,300	21,500	213,200
Aichi Aircraft Co	12,821	13,049	13,568	13,848	14,907	15,752	15,566	16,147	16,605	16,579	17,988	19,289	186,119
Japan Aircraft Co	4,570	4,764	4,953	5,613	5,715	5,750	5,785	5,861	6,113	6,289	6,449	6,826	68,088
Kyushu Aircraft Co	15,582	16,114	16,290	16,579	16,371	16,748	16,925	17,231	16,421	16,439	14,514	14,875	194,089
Japan International Air Industries Ltd	4,319	4,387	4,539	4,554	5,861	6,056	6,124	6,372	6,891	7,563	8,349	9,012	74,027
Kawanishi Aircraft Co	30,150	32,300	33,100	34,000	38,100	38,075	38,500	38,750	39,200	39,550	41,700	42,650	446,075
Hitachi Aircraft Co	2,935	2,889	2,961	4,470	4,372	4,827	4,508	5,137	5,482	5,965	6,001	6,596	56,143
Fuji Aircraft Co	2,876	2,935	2,960	3,312	3,385	3,779	3,788	3,811	3,856	4,039	4,156	4,268	43,165
Showa Aircraft Co	5,333	6,026	6,115	6,459	6,643	6,677	6,699	6,717	6,743	6,914	6,885	6,786	77,997
Matsushita Air Industries											15	83	98
Total	240,987	242,623	253,639	262,904	275,579	279,270	281,398	287,114	300,212	308,112	315,205	333,188	3,380,231

Employment data by months, by manufacturers—Airframes only (Fig. II–8)*—Continued

1943

	January	February	March	April	May	June	July	August	September	October	November	December	Total
Navy air depots	21,141	21,252	21,208	22,932	23,124	23,217	23,683	23,903	24,339	24,458	25,126	25,690	280,163
Army air arsenal	4,070	4,270	4,280	4,580	4,590	4,600	4,620	4,640	4,790	4,800	5,000	5,220	55,460
Total	25,211	25,522	25,488	27,512	27,714	27,817	28,303	28,633	29,129	29,258	30,126	30,910	335,623
Grand total	266,198	268,145	279,127	290,416	303,293	307,087	309,701	315,747	329,341	337,370	345,331	364,098	3,715,854

1944

Nakajima Aircraft Co	93,693	100,368	106,069	110,230	116,541	13,298	131,116	140,717	143,059	134,120	133,348	136,450	1,469,009
Mitsubishi Heavy Industries Ltd	76,743	77,604	83,490	94,581	92,651	94,376	99,168	102,538	103,067	109,774	117,651	116,148	1,167,791
Kawasaki Aircraft Industries	48,425	47,272	50,041	54,231	56,658	59,690	64,494	63,841	64,511	64,312	64,142	62,447	700,064
Tachikawa Aircraft Co	22,000	23,500	26,000	30,400	30,400	29,700	28,800	28,800	28,000	25,300	24,300	25,300	323,300
Aichi Aircraft Co	20,633	20,835	21,354	22,353	24,116	24,633	24,778	25,589	26,240	25,955	26,024	26,114	288,624
Japan Aircraft Co	7,196	7,441	7,812	8,858	9,837	9,932	10,103	10,645	11,092	11,149	11,311	11,083	116,459
Kyushu Aircraft Co	15,631	15,961	16,617	16,916	20,628	20,387	21,867	22,035	22,769	22,230	25,518	26,192	246,751
Japan International Air Industries Ltd	9,647	10,359	16,031	12,501	13,217	14,376	16,343	17,415	17,661	16,703	17,962	17,943	175,158
Kawanishi Aircraft Co	46,650	48,800	51,350	56,175	59,350	59,700	59,550	59,750	59,175	58,875	58,550	57,550	675,475
Hitachi Aircraft Co	6,683	6,806	7,270	9,913	10,145	10,195	10,074	10,214	9,966	9,460	9,429	9,616	109,871
Fuji Aircraft Co	4,275	4,319	4,362	4,862	5,110	5,092	5,401	5,442	5,424	5,699	5,753	5,748	61,487
Showa Aircraft Co	7,230	7,392	7,576	8,497	9,306	9,900	10,618	11,592	11,811	11,744	12,033	12,203	119,902
Matsushita Air Industries	799	1,390	1,748	2,745	2,907	2,990	3,221	3,183	3,301	3,153	3,194	3,181	31,812
Total	359,705	372,047	394,720	432,262	450,866	464,269	485,533	501,761	506,876	498,474	509,215	509,975	5,485,703
Navy air depots	27,365	27,542	28,829	34,845	35,892	37,413	39,214	39,751	40,587	42,085	42,768	41,291	437,582
Army air arsenal	5,320	5,320	5,820	5,820	5,820	5,820	5,820	5,820	5,820	5,820	5,820	5,820	68,840
Total	32,685	32,862	34,649	40,665	41,712	43,233	45,034	45,571	46,407	47,905	48,588	47,111	506,422
Grand total	392,390	404,909	429,369	472,927	492,578	507,502	530,567	547,332	553,283	546,379	557,803	557,086	5,992,125

1945

Nakajima Aircraft Co	142,632	146,343	146,248	144,117	141,041	142,212	139,164	138,237					1,139,994
Mitsubishi Heavy Industries Ltd	126,137	126,380	126,489	121,952	115,464	113,840	113,917	97,054					941,233
Kawasaki Aircraft Industries	60,622	59,207	58,555	59,023	58,359	57,955	55,339	55,120					464,180
Tachikawa Aircraft Co	23,000	22,500	22,000	20,700	18,600	17,500	15,000	13,700					153,000
Aichi Aircraft Co	25,784	26,005	25,757	24,608	23,871	23,455	21,788	22,763					194,031
Japan Aircraft Co	11,076	10,952	10,747	10,595	10,525	10,584	10,529	10,460					85,468
Kyushu Aircraft Co	26,547	26,973	26,570	26,352	24,085	20,626	30,577	20,590					192,320
Japan International Air Industries Ltd	18,054	18,280	17,916	17,724	17,820	17,263	16,973	15,745					139,775
Kawanishi Aircraft Co	59,025	58,150	55,950	54,550	53,125	48,650	47,000	32,700					409,150
Hitachi Aircraft Co	9,584	9,473	9,500	9,431	9,308	9,287	8,878	8,872					74,333
Fuji Aircraft Co	5,609	5,567	5,441	5,361	6,094	6,280	6,341	3,554					44,247
Showa Aircraft Co	12,392	12,333	12,371	11,701	12,008	12,436	11,628	11,403					96,272
Matsushita Air Industries	3,205	3,444	3,414	3,334	3,388	3,444	3,928	3,852					28,009
Total	523,667	525,607	520,958	509,448	493,688	483,532	471,062	434,050					3,962,012
Navy air depots	42,033	42,427	43,228	43,196	44,789	45,578	45,820	45,770					352,841
Army air arsenal	6,120	6,150	6,300	6,300	6,300	6,300	6,300	6,000					49,770
Total	48,153	48,577	49,528	49,496	51,089	51,878	52,120	51,770					402,611
Grand total	571,820	574,184	570,486	558,944	544,777	535,410	523,182	485,820					4,364,623

Monthly airframe production by manufacturers, 1941–45

[Fig. II-8]

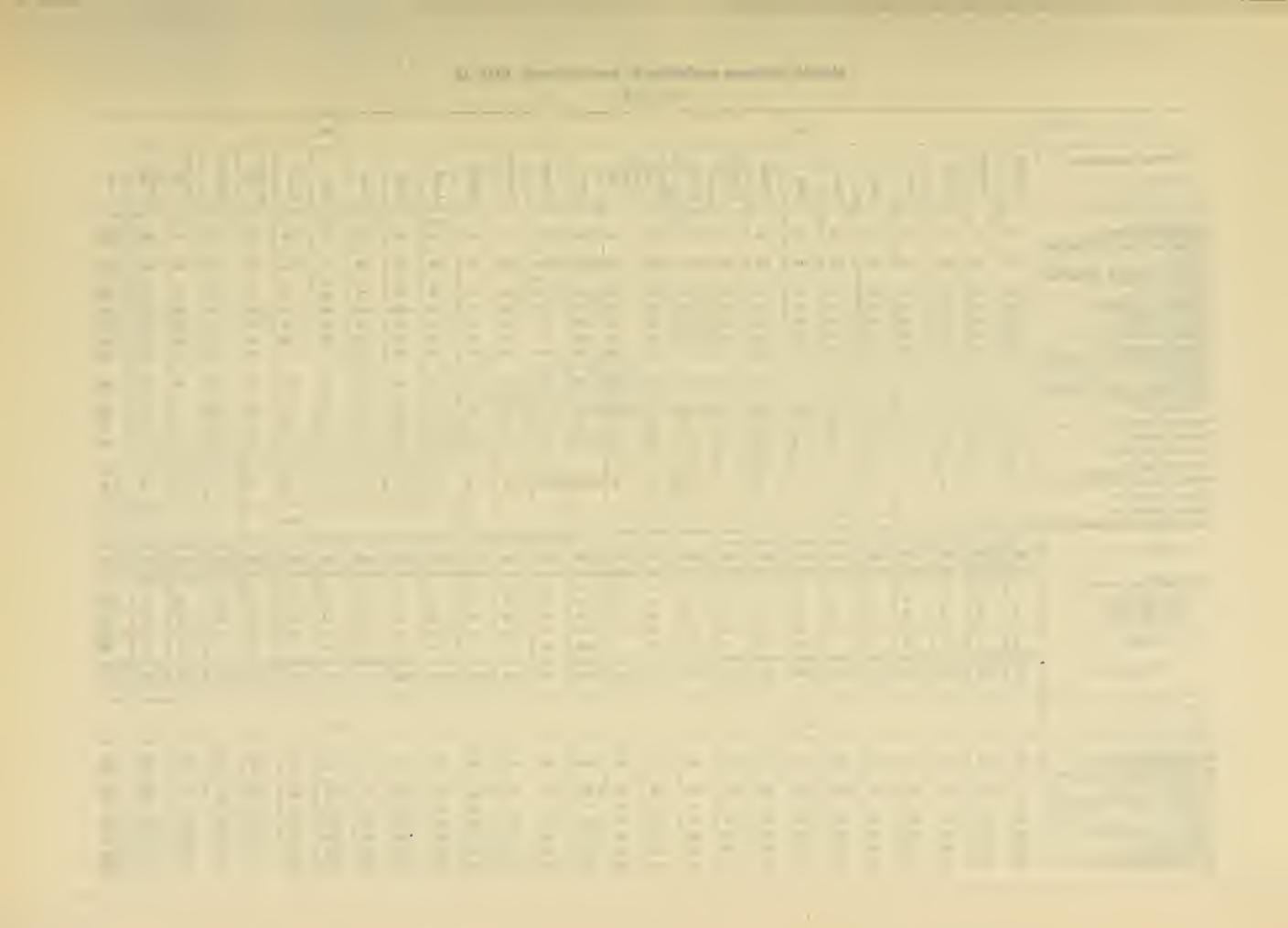
Private corporations	1941													1942											
	January	February	March	April	May	June	July	August	September	October	November	December	Total	January	February	March	April	May	June	July	August	September	October	November	December	Total
Nakajima Airplane Co.	42	57	32	44	58	60	55	64	78	71	90	134	785	115	115	168	154	169	161	177	173	212	227	258	286	2,215
Mitsubishi Heavy Industries Ltd.	73	73	104	96	115	117	109	128	130	137	137	178	1,397	167	167	175	167	177	169	172	165	200	208	225	249	2,241
Kawasaki Aircraft Industries Ltd.	35	45	55	57	60	61	57	56	67	70	79	91	733	85	89	93	93	88	72	69	77	81	97	98	92	1,034
Tachikawa Aircraft Co.	80	86	81	96	101	91	72	87	87	124	93	50	1,048	67	84	111	80	109	71	108	99	115	119	126	135	1,224
Aichi Aircraft Co.	15	15	15	20	20	20	25	25	25	25	25	25	255	25	25	25	35	31	32	29	26	23	31	39	56	377
Nippon Airplane Co.	18	18	17	23	25	21	11	10	15	20	15	16	209	29	32	30	25	27	31	27	16	25	35	26	26	329
Kyushu Airplane Co.	24	23	23	10	10	10	10	10	10	10	12	14	166	14	8	14	13	13	18	17	14	21	45	49	52	278
Manshu Airplane Manufacturing Co.				1	1	3	5	10	10	10	10	10	60	10	10	10	15	20	25	30	30	35	35	40	40	300
Nippon International Air Industries Ltd.						13	11	12	13	14	15	17	95	13	12	11	16	18	15	15	15	16	10	5	17	163
Kawanishi Aircraft Co.	7	8	6	4	6	5	6	5	5	6	7	6	71	7	9	8	9	10	2	7	8	8	10	9	10	97
Hitachi Aircraft Co.	4	5	11	6	13	15	8	16	13	11	19	18	139	17	15	23	22	20	21	25	22	26	8	6	----	205
Tachiarai Aircraft Co.																										
Fuji Airplane Co.																	1	1	1	----	2	1	4	4	9	23
Showa Airplane Industries Ltd.			1		1	1	1	2	3	4	3	6	22	5	3	6	3	9	5	10	3	5	14	15	9	87
Tokyo Aircraft Co.																										
Mitsui Mining Co.																										
Matsushita Air Industries Ltd.																										
Total	298	330	345	357	410	417	370	425	456	502	505	565	4,980	554	569	674	633	692	623	686	650	768	843	900	981	8,573
Army and Navy depots:																										
Naval air depots	2	2	4	4	4	5	5	6	2	3	3	3	43	3	3	3	6	5	5	5	12	17	19	18	16	111
Army air depots	6	7	8	4	6	4	5	4	4	5	6	6	65	7	8	10	8	9	11	14	16	19	24	25	26	177
Total	8	9	12	8	10	9	10	10	6	8	9	9	108	10	11	13	13	14	16	19	28	36	43	43	42	288
Grand total	306	339	357	365	420	426	380	435	462	510	514	574	5,088	564	580	687	646	706	639	705	678	804	886	943	1,023	8,861

Private corporations	1943													1944											
	January	February	March	April	May	June	July	August	September	October	November	December	Total	January	February	March	April	May	June	July	August	September	October	November	December	Total
Nakajima Airplane Co.	272	272	311	327	343	353	342	394	489	456	512	575	4,646	587	497	657	685	704	672	602	601	754	720	633	784	7,896
Mitsubishi Heavy Industries Ltd.	255	255	269	275	271	267	274	290	312	316	357	405	3,546	385	364	344	326	321	364	376	382	375	389	360	190	4,176
Kawasaki Aircraft Industries Ltd.	91	111	124	139	143	132	146	175	193	217	238	275	1,984	304	310	296	340	240	352	407	354	330	330	223	179	3,665
Tachikawa Airplane Co.	124	131	130	95	77	78	80	85	96	110	126	157	1,289	59	151	153	185	173	196	198	192	261	111	293	217	2,189
Aichi Aircraft Co.	48	48	55	62	74	86	91	102	86	99	115	131	997	142	148	140	129	134	123	107	87	113	117	121	135	1,496
Nippon Airplane Co.	18	31	34	34	50	59	66	78	81	85	88	101	725	105	114	142	144	133	140	126	111	70	74	34	29	1,222
Kyushu Airplane Co.	64	65	66	60	61	44	45	52	48	55	71	76	697	88	91	101	101	107	103	78	85	59	95	83	133	1,124
Manshu Airplane Manufacturing Co.	40	45	45	40	31	32	35	35	40	50	60	70	523	100	130	150	110	100	100	100	30	40	50	51	60	1,021
Nippon International Air Industries Ltd.	21	25	26	13	25	24	25	28	32	33	30	58	340	65	81	97	101	114	159	145	195	260	161	24	27	1,429
Kawanishi Aircraft Co.	10	12	9	6	5	5	15	21	28	34	39	51	235	41	64	88	107	27	82	101	101	116	117	115	101	1,060
Hitachi Aircraft Co.				13	35	46	46	54	45	51	55	60	405	62	65	69	75	84	95	77	74	63	69	75	25	833
Tachiarai Aircraft Co.																	1	3	6	10	20	30	50	80	100	300
Fuji Airplane Co.	7	9	9	7	14	15	18	15	17	34	40	45	230	45	45	60	68	62	35	58	32	35	16	33	17	506
Showa AirplaneIndustries Ltd.	10	4	7	6	5	6	----	5	5	3	5	6	62	8	17	18	6	7	24	27	32	31	43	37	36	286
Tokyo Aircraft Co.																				1	----	2	5	10	15	33
Mitsui Mining Co.																							1	----	1	2
Matsushita Air Industries Ltd.																										
Total	960	998	1,085	1,077	1,134	1,147	1,183	1,334	1,472	1,543	1,736	2,010	15,679	1,991	2,077	2,315	2,378	2,209	2,451	2,413	2,296	2,539	2,348	2,172	2,049	27,238
Army and Navy depots:																										
Naval air depots	23	25	29	39	47	44	49	57	75	85	87	88	648	86	82	80	65	75	75	46	38	23	8	28	33	639
Army air depots	27	26	33	25	26	26	27	27	26	34	39	50	386	45	40	40	30	34	15	14	12	10	15	20	28	303
Total	50	51	62	64	73	70	76	84	101	119	126	138	1,014	131	122	120	95	109	90	60	50	33	23	48	61	942
Grand total	1,010	1,049	1,147	1,141	1,207	1,217	1,259	1,418	1,573	1,662	1,862	2,148	16,693	2,122	2,199	2,435	2,473	2,318	2,541	2,473	2,346	2,572	2,371	2,220	2,110	28,180

Private corporations	1945								1941–1945 total
	January	February	March	April	May	June	July	August [1]	Total	
Nakajima Airplane Co.	740	349	899	591	565	486	510	179	4,019	19,561
Mitsubishi Heavy Industries Ltd.	141	178	169	155	152	155	73	130	1,153	12,513
Kawasaki Aircraft Industries, Ltd.	110	99	92	172	195	109	37	13	827	8,243
Tachikawa Airplane Co.	139	118	189	83	138	103	86	39	895	6,645
Aichi Aircraft Co.	94	92	85	90	50	55	31	5	502	3,627
Nippon Airplane Co.	79	96	78	46	37	33	17	11	397	2,882
Kyushu Airplane Co.	76	71	62	26	38	38	28	16	355	2,620
Manshu Airplane Manufacturing Co.	50	41	41	30	41	42	42	5	292	2,196
Nippon International Air Industries Ltd.	42	24	26	7	2	2	3	1	107	2,134
Kawanishi Aircraft Co.	75	91	102	111	96	33	17	6	531	1,994
Hitachi Aircraft Co.	23	8	34	21	31	23	15	46	201	1,783
Tachiarai Aircraft Co.	100	100	100	120	150	170	150	30	920	1,220

Private corporations	1945								1941–1945 total
	January	February	March	April	May	June	July	August [1]	Total	
Fuji Airplane Co.	26	22	29	18	14	1	2	----	112	871
Showa Airplane Industries Ltd.	42	22	34	21	17	8	10	5	159	616
Tokyo Aircraft Co.	20	20	20	30	40	40	50	5	225	258
Mitsui Mining Co.	----	1	1	2	3	3	3	2	15	17
Matsushita Air Industries Ltd.	----	----	----	----	----	----	1	2	4	4
Total	1,757	1,332	1,661	1,823	1,570	1,301	1,075	495	10,714	67,184
Army and navy depots:										
Naval air depots	39	31	62	44	22	33	37	1	259	1,700
Army air depots	40	28	----	----	----	6	10	----	93	1,004
Total	79	59	52	44	22	39	56	1	352	2,704
Grand total	1,836	1,391	1,713	1,567	1,592	1,340	1,131	496	11,066	69,888

[1] Less than one-half month.



Engine production by manufacturer, by months, 1941–45

[Figure 11–9]

1941

Private corporations	January	February	March	April	May	June	July	August	September	October	November	December	Total
Mitsubishi Heavy Industries	347	336	344	350	351	360	373	379	400	427	439	483	4,589
Nakajima Aircraft Co	281	288	290	328	328	299	312	317	367	397	312	471	3,990
Hitachi Aircraft Co	196	129	185	111	114	131	132	136	152	177	177	197	1,837
Kawasaki Aircraft Industries	50	55	60	48	60	70	80	80	103	95	105	105	911
Ishikawajima Air Industries												1	1
Manchuria Aircraft Co	10	10	12	12	15	21	21	21	22	22	25	29	220
Aichi Aircraft Co	29	30	47	7	1	1	2	4	5	3	4	1	134
Nissan Auto Co													
Japan International Air Industries													
Toyoda Auto Co													
Total	913	848	938	856	869	882	920	937	1,049	1,121	1,062	1,287	11,682
Army and Navy arsenals:													
Navy air depots	20	19	25	20	[illegible]	25	29	34	40	40	30	20	325
Army air arsenal	5	5	10	10	13	18	17	5	10	15	20	16	144
Total	25	24	35	30	36	43	46	39	50	55	50	36	469
Grand total	938	872	973	886	905	925	966	976	1,099	1,176	1,112	1,323	12,151

1942

Private corporations	January	February	March	April	May	June	July	August	September	October	November	December	Total
Mitsubishi Heavy Industries	520	535	547	492	566	437	612	580	575	586	577	618	6,645
Nakajima Aircraft Co	399	411	382	508	390	356	357	326	336	435	436	561	4,897
Hitachi Aircraft Co	252	191	186	230	231	229	172	205	221	232	185	311	2,645
Kawasaki Aircraft Industries	110	115	122	126	129	137	126	65	113	105	90	134	1,372
Ishikawajima Air Industries			1	2	1	3	3	5		2	2	10	29
Manchuria Aircraft Co	30	25	28	30	32	39	40	43	43	45	45	48	448
Aichi Aircraft Co	3	1	5	2	15	13	13	26	22	28	37	33	198
Nissan Auto Co													
Japan International Air Industries													
Toyoda Auto Co													
Total	1,314	1,278	1,271	1,390	1,364	1,214	1,323	1,250	1,310	1,433	1,372	1,715	16,234
Army and Navy arsenals:													
Navy air depots	25	27	31	31	39	40	41	47	46	53	53	57	490
Army air arsenal	20	15	15	18	20	15	17	28	32	30	30	35	275
Total	45	42	46	49	59	55	58	75	78	83	83	92	765
Grand total	1,359	1,320	1,317	1,439	1,423	1,269	1,381	1,325	1,388	1,516	1,455	1,807	16,999

1943

Private corporations	January	February	March	April	May	June	July	August	September	October	November	December	Total
Mitsubishi Heavy Industries	651	660	711	722	742	773	798	834	866	935	981	1,035	9,708
Nakajima Aircraft Co	570	562	694	654	708	730	740	772	876	923	1,031	1,296	9,556
Hitachi Aircraft Co	238	247	264	233	245	274	327	330	345	347	306	374	3,530
Kawasaki Aircraft Industries	115	137	141	156	182	206	226	242	228	290	210	366	2,499
Ishikawajima Air Industries	10	12	16	20	27	35	32	45	50	30	48	65	390
Manchuria Aircraft Co	45	40	42	60	60	73	46	8	60	80	100	121	735
Aichi Aircraft Co	40	30	52	29	28	34	38	54	47	39	36	17	444
Nissan Auto Co													
Japan International Air Industries				1	1	1	1	1	4	10	7	25	51
Toyoda Auto Co													
Total	1,669	1,688	1,920	1,875	1,993	2,126	2,208	2,286	2,476	2,654	2,719	3,299	26,913
Army and Navy arsenals:													
Navy air depots	65	68	90	105	106	112	118	125	128	101	100	113	1,231
Army air arsenals	41	41	27	18	22	23	24	30	39	41	44	47	397
Total	106	109	117	123	128	135	142	155	167	142	144	160	1,628
Grand total	1,775	1,797	2,037	1,998	2,121	2,261	2,350	2,441	2,643	2,796	2,863	3,459	28,541

Engine production by manufacturer, by months, 1941–45—Continued

1944

Private corporations	January	February	March	April	May	June	July	August	September	October	November	December	Total
Mitsubishi Heavy Industries	1,175	1,365	1,526	1,651	862	2,310	1,416	1,796	1,798	1,570	1,339	716	17,524
Nakajima Aircraft Co.	1,355	1,200	1,914	1,346	761	1,252	1,002	1,279	409	1,208	1,217	1,071	14,014
Hitachi Aircraft Co.	357	415	223	373	516	465	515	387	382	264	320	258	4,469
Kawasaki Aircraft Industries	347	378	393	362	360	415	396	240	229	275	450	410	4,255
Ishikawajima Air Industries	65	70	100	70	130	150	110	60	80	120	93	107	1,155
Manchuria Aircraft Co.	105	110	11	.....	.....	5	56	84	74	57	39	10	551
Aichi Aircraft Co.	26	45	77	52	107	91	101	83	14	26	76	35	733
Nissan Auto Co.	.....	.....	21	50	81	131	68	117	102	100	91	150	911
Japan International Air Industries	38	12	37	34	51	1	82	30	72	72	70	59	558
Toyoda Auto Co.	1	.....	.....	.....	.....	3	10	6	6	2	4	10	42
Total	3,469	3,595	4,302	3,938	2,862	4,823	3,756	4,082	3,116	3,694	3,699	2,826	44,212
Army and Navy arsenals:													
Navy air depots	121	155	185	212	233	197	210	99	100	95	120	120	1,847
Army air arsenals	43	39	43	65	68	70	72	22	.....	.....	.....	45	467
Total	164	194	228	277	301	267	282	121	100	95	120	165	2,314
Grand total	3,633	3,789	4,530	4,215	3,163	5,090	4,038	4,203	3,266	3,789	3,819	2,991	46,526

1945

Private corporations	January	February	March	April	May	June	July	August [1]	Total	1941–45 total
Mitsubishi Heavy Industries	438	626	517	340	227	344	335	241	3,068	41,543
Nakajima Aircraft Co.	763	472	581	519	548	606	340	154	3,983	36,440
Hitachi Aircraft Co.	312	167	178	141	140	102	50	.....	1,090	13,571
Kawasaki Aircraft Industrries	158	69	50	292	285	195	128	60	1,237	10,274
Ishikawajima Air Industries	95	101	150	100	107	91	67	.....	711	2,286
Manchuria Aircraft Co.	.....	12	21	35	30	30	86	.....	214	2,168
Aichi Aircraft Co.	32	34	41	48	50	21	21	27	274	1,783
Nissan Auto Co.	.....	15	55	151	202	151	127	21	722	1,633
Japan International Air Industries	71	77	80	.....	.....	.....	.....	.....	228	837
Toyoda Auto Co.	6	7	5	18	36	26	26	.....	118	160
Total	1,875	1,580	1,678	1,644	1,619	1,566	1,180	503	11,645	110,686
Army and Navy arsenals:										
Navy air depots	46	56	92	89	58	101	72	45	559	4,452
Army air arsenal	66	59	17	1	.....	2	5	6	156	1,439
Total	112	115	109	90	58	103	77	51	715	5,891
Grand total	1,987	1,695	1,787	1,734	1,677	1,669	1,257	554	12,360	116,577

[1] Less than ½ month.

Employment data by months, by manufacturers, aircraft engines only,[1] *1941–45*

[Fig. II–9]

	January	February	March	April	May	June	July	August	September	October	November	December	Total
1941													
Mitsubishi Heavy Industries	26,597	27,179	27,991	30,025	29,963	29,980	30,001	30,359	30,421	32,619	33,341	33,772	362,248
Nakajima Aircraft Co	9,108	9,041	9,491	9,746	9,784	9,890	11,443	11,829	13,400	13,781	14,111	14,514	136,138
Hitachi Aircraft Co	6,185	6,194	6,276	6,301	6,234	6,214	6,547	6,597	6,610	6,653	6,872	6,757	77,440
Kawasaki Aircraft Industries	5,336	5,565	5,735	6,731	7,185	7,724	7,642	7,724	8,203	8,455	8,535	9,308	88,143
Ishikawajima Air Industries									2,044	2,111	2,010	2,321	8,486
Aichi Aircraft Co	3,130	3,136	3,135	3,235	3,306	3,369	3,433	3,488	3,595	3,680	3,779	3,860	41,146
Nissan Auto Co													
Japan International Air Industries													
Total	50,356	51,115	52,628	56,038	56,472	57,177	59,066	59,997	64,273	67,299	68,648	70,532	713,601
Navy air depots	9,375	9,550	9,650	9,680	9,710	9,735	9,755	9,805	9,900	10,050	10,200	10,450	117,860
Army air arsenal	925	945	1,000	1,080	1,125	1,170	1,230	1,275	1,290	1,325	1,375	1,410	14,150
Total	10,300	10,495	10,650	10,760	10,835	10,905	10,985	11,080	11,190	11,375	11,575	11,860	132,010
Grand total	60,656	61,610	63,278	66,798	67,307	68,082	70,051	71,077	75,463	78,674	80,223	82,392	845,611
1942													
Mitsubishi Heavy Industries	34,968	35,932	36,700	40,271	40,865	41,373	41,610	41,889	42,443	42,649	42,883	43,711	485,294
Nakajima Aircraft Co	24,972	25,409	27,395	29,337	30,125	30,686	30,414	30,487	30,762	31,126	31,604	31,731	354,048
Hitachi Aircraft Co	7,551	7,851	7,971	8,717	8,746	9,042	9,241	10,029	10,136	10,108	10,167	10,262	109,821
Kawasaki Aircraft Industries	9,273	10,141	10,305	13,188	8,886	9,005	9,326	9,463	9,746	11,462	11,816	11,996	124,637
Ishikawajima Air Industries	2,366	2,417	2,464	2,903	2,848	2,826	2,820	3,080	3,007	3,031	3,033	3,039	33,834
Aichi Aircraft Co	3,940	4,094	4,172	4,388	4,636	4,844	5,046	5,271	5,536	5,778	6,048	6,316	60,069
Nissan Auto Co													
Japan International Air Industries												315	315
Total	83,070	85,844	89,007	98,804	96,106	97,776	98,457	100,219	101,630	104,154	105,581	107,370	1,168,018
Navy air depots	12,050	12,275	12,550	13,650	13,750	13,850	14,075	14,400	14,650	14,750	14,890	15,200	166,090
Army air arsenal	1,460	1,510	1,540	1,565	1,610	1,650	1,715	1,760	1,835	1,860	1,900	1,940	20,345
Total	13,510	13,785	14,090	15,215	15,360	15,500	15,790	16,160	16,485	16,610	16,790	17,140	186,435
Grand total	96,580	99,629	103,097	114,019	111,466	113,276	114,247	116,379	118,115	120,764	122,371	124,510	1,354,453
1943													
Mitsubishi Heavy Industries	44,426	45,178	46,207	50,764	51,176	51,134	51,291	51,519	52,196	53,692	52,252	55,781	605,616
Nakajima Aircraft Co	33,080	33,375	36,572	39,244	41,384	43,173	44,006	44,850	46,540	47,225	48,604	55,363	513,416
Hitachi Aircraft Co	10,876	10,865	10,967	11,545	11,978	11,948	12,046	12,170	12,528	12,775	13,147	13,403	144,248
Kawasaki Aircraft Industries	12,267	13,120	13,416	15,230	15,949	16,490	16,613	17,140	17,816	17,881	18,549	19,497	193,968
Ishikawajima Air Industries	3,075	3,090	3,114	3,081	3,323	3,476	3,562	3,549	3,650	3,908	3,965	4,427	42,220
Aichi Aircraft Co	6,512	6,662	6,853	7,076	7,223	7,878	7,425	7,531	7,661	7,726	7,817	7,937	88,301
Nissan Auto Co								500	500	600	600	700	2,900
Japan International Air Industries	324	354	401	448	490	543	569	813	809	849	853	903	7,356
Total	110,560	112,644	117,530	127,388	131,523	134,642	135,512	138,072	141,700	144,656	145,787	158,011	1,548,025
Navy air depots	16,000	16,250	16,500	17,250	17,350	17,525	17,700	17,850	18,050	18,225	18,400	18,575	209,675
Army air arsenal	1,985	2,025	2,100	2,175	2,235	2,280	2,375	2,455	2,485	2,515	2,585	2,605	27,826
Total	17,985	18,275	18,600	19,425	19,585	19,805	20,075	20,305	20,535	20,740	20,985	21,180	237,445
Grand total	128,545	130,919	136,130	146,813	151,108	154,447	155,587	158,377	162,235	165,396	166,772	179,191	1,835,520

[1] No employment figures available for Manchuria A/C Co. and Toyoda Auto Co.

Employment data by months, by manufacturers, aircraft engines only, 1941–45—Continued

	1944												
	January	February	March	April	May	June	July	August	September	October	November	December	Total
Mitsubishi Heavy Industries	61,136	62,267	66,522	72,973	73,806	74,063	76,869	78,461	80,206	83,196	84,479	90,702	904,680
Nakajima Aircraft Co	59,917	60,679	63,009	66,605	70,406	64,410	67,934	69,643	70,891	71,701	73,704	78,754	817,653
Hitachi Aircraft Co	15,719	16,839	18,145	19,431	20,557	20,805	20,295	23,162	23,760	23,684	23,526	23,681	249,604
Kawasaki Aircraft Industries	19,526	22,274	21,599	21,956	22,493	22,210	22,627	23,115	22,209	22,388	23,001	22,933	266,331
Ishikawajima Air Industries	4,832	4,819	4,754	5,464	5,888	5,427	5,965	5,950	5,897	6,213	6,242	6,188	67,639
Aichi Aircraft Co	8,010	8,027	8,276	9,415	9,009	8,633	8,614	8,588	8,536	8,488	8,374	8,311	102,281
Nissan Auto Co	800	850	900	950	1,000	1,050	1,100	1,203	1,296	1,769	1,985	2,082	14,985
Japan International Air Industries	1,011	1,025	1,053	1,257	1,269	1,518	1,590	1,556	1,805	1,807	2,246	2,218	18,355
Total	170,951	176,780	184,258	198,051	204,428	198,116	204,994	211,678	214,600	219,246	223,557	234,869	2,441,528
Navy air depots	19,700	19,880	20,060	20,250	20,405	20,936	21,377	21,582	21,939	23,195	24,386	22,135	255,845
Army air arsenal	2,735	2,820	2,905	2,945	3,060	3,155	3,210	3,295	3,420	3,590	3,750	3,910	38,795
Total	22,435	22,700	22,965	23,195	23,465	24,091	24,587	24,877	25,359	26,785	28,136	26,045	294,640
Grand total	193,386	199,480	207,223	221,246	227,893	222,207	229,581	236,555	239,959	246,031	251,693	260,914	2,736,168

	1945												
Mitsubishi Heavy Industries	97,481	95,989	93,648	88,866	82,944	83,932	83,254	76,099					702,213
Nakajima Aircraft Co	78,950	78,861	75,853	73,447	71,721	69,120	63,122	62,305					573,359
Hitachi Aircraft Co	23,700	23,308	23,650	21,796	21,301	21,205	20,356	18,465					173,781
Kawasaki Aircraft Industries	22,621	21,642	19,848	18,517	16,862	16,310	16,509	14,773					147,082
Ishikawajima Air Industries	5,944	5,984	5,917	5,607	5,456	5,763	5,608	5,935					46,214
Aichi Aircraft Co	8,185	8,153	8,105	8,085	8,002	7,956	7,918	7,687					64,091
Nissan Auto Co	2,410	3,032	3,261	3,311	3,373	3,435	3,527	3,500					25,849
Japan International Air Industries	2,365	2,331	2,292	1,916	1,834	1,969	1,931	1,900					16,538
Total	241,656	239,300	232,554	221,545	211,493	209,690	202,225	190,664					1,749,127
Navy air depots	22,847	23,256	23,829	23,492	23,751	23,419	23,438	23,438					187,470
Army air arsenal	4,125	4,420	4,610	4,870	5,255	5,550	5,640	5,400					39,870
Total	26,972	27,676	28,439	28,362	29,006	28,969	29,078	28,838					227,340
Grand total	268,628	266,976	260,993	249,907	240,499	238,659	231,303	219,502					1,976,467

Employment data by months by manufacturers—propellers only

[Fig. II-10]

1941

	January	February	March	April	May	June	July	August	September	October	November	December	Total
Sumitomo Metal Industries	6,000	6,000	6,100	7,100	7,500	7,300	6,500	7,100	7,900	7,500	7,500	7,600	84,100
Japan Musical Instrument Co	3,349	3,399	3,468	3,779	3,775	3,761	3,686	3,642	3,687	3,782	3,883	3,926	44,137
Japan International Air Industries, Ltd	.....	.....	.....	.....	.....	150	150	150	150	150	150	150	1,050
Total	9,349	9,399	9,568	10,879	11,275	11,211	10,336	10,892	11,737	11,432	11,533	11,676	129,287

1942

Sumitomo Metal Industries	7,600	7,600	7,800	9,100	9,300	9,500	9,600	10,200	10,900	11,100	11,100	11,200	115,000
Japan Musical Instrument Co	3,981	3,990	4,063	4,542	4,600	4,679	4,663	4,714	4,783	4,845	4,925	4,970	54,755
Japan International Air Industries, Ltd	250	250	250	250	250	250	400	400	400	465	638	822	4,625
Total	11,831	11,840	12,113	13,892	14,150	14,429	14,663	15,314	16,083	16,410	16,663	16,992	174,380

1943

Sumitomo Metal Industries	11,500	11,700	11,800	12,300	12,600	12,200	12,300	12,200	12,500	12,500	13,000	13,400	148,000
Japan Musical Instrument Co	5,380	5,489	5,639	6,153	6,187	6,119	6,089	6,096	6,047	6,147	5,961	6,023	71,330
Japan International Air Industries, Ltd	1,213	1,362	1,497	1,691	1,754	1,823	2,037	2,087	2,159	2,222	2,316	2,387	22,548
Total	18,093	18,551	18,936	20,144	20,541	20,142	20,426	20,383	20,706	20,869	21,277	21,810	241,878

1944

Sumitomo Metal Industries	13,800	14,200	14,900	16,300	18,000	18,800	19,500	19,500	20,200	19,600	21,200	21,200	217,200
Japan Musical Instrument Co	6,194	6,208	6,499	7,500	8,165	7,531	7,844	8,014	8,013	7,994	8,224	8,538	90,724
Japan International Air Industries, Ltd	2,703	2,758	2,830	2,936	2,956	3,023	3,277	3,315	3,485	3,747	3,765	4,059	38,856
Total	22,697	23,166	24,229	26,736	29,121	29,354	30,621	30,829	31,698	31,343	33,189	33,797	346,780

1945

Sumitomo Metal Industries	21,600	21,700	21,300	20,900	20,500	19,800	18,100	17,200	.....	.....	.....	.....	161,100
Japan Musical Instrument Co	8,801	8,914	8,568	9,008	8,865	8,206	7,903	7,797	.....	.....	.....	.....	68,062
Japan International Air Industries, Ltd	4,112	4,151	4,144	4,525	4,714	4,650	4,054	4,050	.....	.....	.....	.....	34,400
Total	34,513	34,765	34,012	34,433	34,079	32,656	30,057	29,047	.....	.....	.....	.....	263,562

Japanese propeller production by manufacturers, by months, 1941–45

[Fig. II-10]

1941

	January	February	March	April	May	June	July	August	September	October	November	December	Total
Sumitomo Metal Industries	501	582	605	595	629	671	683	701	775	824	891	893	8,350
Japan Musical Instrument Co	123	135	140	285	320	346	350	426	434	402	430	420	3,811
Japan International Air Industries	.....	.....	.....	.....	.....	9	6	35	43	38	50	59	240
Kawanishi Aircraft Co	48	5	5	10	5	60	12	20	31	5	9	10	220
Total	672	722	750	890	954	1,086	1,051	1,182	1,283	1,269	1,380	1,382	12,621

1942

Sumitomo Metal Industries	974	1,050	1,005	1,080	1,156	1,234	1,277	1,302	1,253	1,375	1,427	1,501	14,634
Japan Musical Instrument Co	497	423	443	495	512	553	554	563	534	625	620	660	6,479
Japan International Air Industries	64	67	103	35	35	99	75	37	103	69	88	85	860
Kawanishi Aircraft Co	25	13	10	40	65	30	30	.....	.....	45	35	96	389
Total	1,560	1,553	1,561	1,650	1,768	1,916	1,936	1,902	1,890	2,114	2,170	2,342	22,362

Japanese propeller production by manufacturers, by months, 1941–45—Continued

1943

	January	February	March	April	May	June	July	August	September	October	November	December	Total
Sumitomo Metal Industries	1,526	1,684	1,756	1,674	1,735	1,897	2,056	1,983	2,034	2,154	1,998	2,233	22,730
Japan Musical Instrument Co	564	528	635	548	572	631	608	495	446	678	845	968	7,518
Japan International Air Industries	93	63	61	76	102	86	96	48	66	100	92	62	945
Kawanishi Aircraft Co	40	30	20	10	10	90	.....	45	30	95	60	80	510
Total	2,223	2,305	2,472	2,308	2,419	2,704	2,760	2,571	2,576	3,027	2,995	3,343	31,703

1944

Sumitomo Metal Industries	2,355	2,428	2,375	2,714	2,621	2,807	3,140	2,492	3,072	2,869	3,010	3,073	33,046
Japan Musical Instrument Co	1,064	1,257	1,402	1,469	1,650	1,665	1,789	1,588	1,295	1,343	1,292	1,023	16,837
Japan International Air Industries	139	175	201	240	280	293	318	370	482	220	286	354	3,358
Kawanishi Aircraft Co	80	120	100	90	160	125	162	128	141	105	.....	.....	1,211
Total	3,638	3,980	4,078	4,513	4,711	4,980	5,409	4,578	4,990	4,537	4,588	4,450	54,452

1945

	January	February	March	April	May	June	July	August	Total	1941–45 total
Sumitomo Metal Industries	2,719	2,118	1,871	1,770	3,026	1,021	255	50	12,830	91,590
Japan Musical Instrument Co	1,101	1,025	1,029	742	270	18	28	.....	4,213	38,858
Japan International Air Industries	458	450	591	480	450	350	100	.....	2,879	8,282
Kawanishi Aircraft Co	.....	.....	.....	.....	.....	.....	.....	.....	.....	2,330
Total	4,278	3,593	3,491	2,992	3,746	1,389	383	50	19,922	141,060

Percentage distribution of Japanese aircraft production by functional types, by quarters, 1941–45 (figure III–1)

Year and quarter	Type of aircraft					
	Fighters	Bombers	Recce	Trainers	Transports	Other [1]
1941						
I	19.9	23.2	12.6	37.9	5.4	1.1
II	17.3	28.1	12.3	33.4	7.7	1.2
III	21.5	31.3	13.2	25.9	6.8	1.3
IV	24.8	30.6	12.2	23.4	7.6	1.3
1942						
I	27.7	29.5	11.3	26.1	3.9	1.4
II	31.3	29.2	10.1	26.0	2.2	1.3
III	34.9	25.2	10.5	25.8	2.4	1.1
IV	36.5	26.6	11.6	21.4	3.1	.9
1943						
I	39.4	25.8	13.3	18.2	2.5	.8
II	41.5	27.3	13.0	15.6	2.2	.5
III	43.9	25.8	12.2	16.1	1.4	.6
IV	44.8	22.8	11.7	18.4	1.3	1.0

Percentage distribution of Japanese aircraft production by functional types, by quarters, 1941–45 (figure III–1)—Continued

Year and quarter	Type of aircraft					
	Fighters	Bombers	Recce	Trainers	Transports	Other [1]
1944						
I	45.0	19.7	9.4	22.7	1.3	1.8
II	48.0	16.6	7.2	24.7	1.1	2.4
III	50.8	17.3	6.1	21.3	1.3	3.4
IV	52.2	19.1	8.0	18.4	1.0	1.3
1945						
I	47.5	19.4	7.5	23.0	1.1	1.5
II	52.3	17.6	6.8	21.7	.7	.9
III [2]	47.6	11.2	10.9	25.3	.7	4.3

[1] Other include flying boats, gliders, and suicide types.
[2] July and part of August only.

Japanese aircraft production by functional types by quarters, 1941–45 (fig. III–2)

Year and quarter	Type of aircraft					
	Fighter	Bomber	Recce	Trainer	Other[1]	Total
1941						
I	199	232	126	380	65	1,002
II	210	340	149	404	108	1,211
III	274	400	169	331	103	1,277
IV	397	489	195	374	143	1,598
Total	1,080	1,461	639	1,489	419	5,088
1942						
I	507	541	207	478	98	1,831
II	623	582	201	517	68	1,991
III	764	552	229	565	77	2,187
IV	1,041	758	330	611	112	2,852
Total	2,935	2,433	967	2,171	355	8,861
1943						
I	1,264	827	425	583	107	3,206
II	1,480	973	462	558	92	3,565
III	1,864	1,098	519	684	85	4,250
IV	2,539	1,291	664	1,046	132	5,672
Total	7,147	4,189	1,046	2,871	416	16,693
1944						
I	3,043	1,331	633	1,532	217	6,756
II	3,518	1,216	528	1,812	258	7,332
III	3,752	1,275	448	1,573	343	7,391
IV	3,498	1,278	538	1,230	157	6,701
Total	13,811	5,100	2,147	6,147	975	28,180
1945						
I	2,345	960	371	1,135	129	4,940
II	2,353	792	307	977	68	4,499
III[2]	776	182	177	411	81	1,627
Total	5,474	1,934	855	2,523	280	11,066

[1] Other include flying boats, transports, gliders, and suicide aircraft.
[2] July and part of August only.

Production of Japanese combat aircraft by number of engines installed, by quarters 1941–1945 (fig. III–3)

Year and quarter	Single-engine aircraft	Twin-engine aircraft	Year and quarter	Single-engine aircraft	Twin-engine aircraft
1941			*1943*		
I	403	154	IV	3,449	1,045
II	461	238	Total	10,013	3,393
III	570	273			
IV	698	383	*1944*		
Total	2,132	1,048	I	3,895	1,112
1942			II	4,013	1,249
I	804	451	III	4,076	1,399
II	935	471	IV	4,195	1,119
III	1,073	472	Total	16,179	4,879
IV	1,501	628	*1945*		
Total	4,313	2,022	I	3,043	633
1943			II	2,752	700
I	1,812	704	III[1]	939	196
II	2,135	780	Total	6,734	1,529
III	2,617	864			

[1] July and part of August only.

Index numbers of Japanese aircraft production airframe weight and numbers of aircraft (average for 1941=100) by months, January 1941 to July 1945 (fig. III–4)

	Airframe weight	Number of aircraft		Airframe weight	Number of aircraft
1941			*1943*—Con.		
January	56.6	72.2	May	270.5	284.7
February	65.0	80.0	June	273.5	287.0
March	75.8	84.2	July	281.6	296.9
April	87.3	86.1	August	314.6	334.4
May	99.9	99.1	September	345.7	371.0
June	100.5	100.5	October	354.2	392.0
July	93.3	89.6	November	402.6	439.2
August	104.9	102.6	December	465.7	506.6
September	111.8	109.0			
October	126.9	120.3	*1944*		
November	126.3	121.2			
December	151.7	135.4	January	447.0	500.5
			February	458.2	518.6
1942			March	499.9	574.3
			April	530.9	583.3
January	138.8	133.0	May	499.2	546.7
February	139.3	136.8	June	566.9	599.3
March	161.1	162.0	July	569.7	583.3
April	155.1	152.4	August	541.1	553.3
May	164.3	166.5	September	592.8	606.6
June	142.5	150.7	October	569.7	559.2
July	161.3	166.3	November	546.7	523.6
August	147.0	159.9	December	488.3	497.6
September	178.6	189.6			
October	196.4	209.0	*1945*		
November	218.9	222.4			
December	235.8	241.3	January	421.9	433.0
			February	324.4	328.1
1943			March	382.7	404.0
			April	353.2	369.6
January	234.2	238.2	May	342.5	375.5
February	239.7	247.4	June	274.3	316.0
March	263.1	270.5	July	210.1	266.7
April	261.4	269.1			

Comparison of Military Intelligence Service estimates as of 23 Jan. 1945 and 31 July 1945 with actual production of combat aircraft, average monthly production by quarters, 1941–44

[Fig. VII–1]

	Estimate made on 31 July 45	Estimate made on 23 Jan. 45	Actual production
1941			
I	285	260	186
II	329	299	233
III	367	335	281
IV	409	365	360
1942			
I	492	441	418
II	575	538	469
III	598	582	515
IV	771	743	710
1943			
I	972	901	839
II	1,061	983	972
III	1,162	1,106	1,160
IV	1,403	1,338	1,498
1944			
I	1,726	1,682	1,669
II	1,895	1,873	1,754
III	2,056	1,929	1,825
IV	2,295	2,042	1,771

Comparison of actual combat aircraft production with Military Intelligence Service estimates, by functional type; average monthly production by quarters from 1941 through 1943, and by months from January 1944 through June 1945

[Figs. VII-2, VII-3, VII-4 and VII-5]

	All combat aircraft		Fighters		Bombers		Recce	
	MIS estimates	Actual production	MIS estimates	Actual production	MIS estimates	Actual production	MIS estimates	Actual production
1941								
I	285	186	100	66	115	77	70	43
II	329	233	123	70	128	113	78	50
III	367	281	150	91	141	133	76	56
IV	409	360	162	132	165	163	82	65
1942								
I	492	418	224	169	193	180	75	69
II	575	469	273	208	224	194	78	67
III	598	515	289	255	228	184	81	76
IV	771	710	419	347	256	253	96	110
1943								
I	972	839	548	431	293	276	131	142
II	1,061	972	638	493	296	324	127	154
III	1,162	1,160	667	621	352	366	143	173
IV	1,403	1,498	833	846	400	430	170	221
1944								
January	1,618	1,622	970	950	428	451	220	221
February	1,748	1,628	1,045	996	463	429	240	203
March	1,812	1,757	1,140	1,097	426	451	246	209
April	1,838	1,806	1,137	1,234	450	390	251	182
May	1,897	1,647	1,168	1,044	476	427	253	176
June	1,951	1,809	1,244	1,240	491	399	216	170
July	2,055	1,786	1,261	1,215	569	426	225	145
August	2,023	1,748	1,241	1,179	554	414	228	155
September	2,084	1,941	1,251	1,358	574	435	259	148
October	2,194	1,809	1,349	1,206	584	426	261	177
November	2,330	1,820	1,451	1,186	598	450	281	184
December	2,368	1,685	1,476	1,106	610	402	282	177
1945								
January	2,044	1,383	1,376	915	443	330	225	138
February	1,596	999	982	586	403	304	211	109
March	1,030	1,294	546	844	299	326	185	124
April	1,288	1,256	641	816	429	319	218	121
May	1,394	1,230	867	894	313	242	214	94
June	1,628	966	1,087	643	355	231	186	92

NOTE.—Quarterly figures are monthly averages.

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The following is a bibliography of reports resulting from the Survey's studies of the European and Pacific wars. Those reports marked with an asterisk (*) may be purchased from the Superintendent of Documents at the Government Printing Office, Washington 25, D. C.

European War

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*1 The United States Strategic Bombing Survey: Summary Report (European War)
*2 The United States Strategic Bombing Survey: Overall Report (European War)
*3 The Effects of Strategic Bombing on the German War Economy

AIRCRAFT DIVISION

(By Division and Branch)

*4 Aircraft Division Industry Report
5 Inspection Visits to Various Targets (Special Report)

Airframes Branch

6 Junkers Aircraft and Aero Engine Works, Dessau, Germany
7 Erla Maschinenwerke G m b H, Heiterblick, German
8 A T G Maschinenbau, G m b H, Leipzig (Mockau), Germany
9 Gothaer Waggonfabrik, A G, Gotha, Germany
10 Focke Wulf Aircraft Plant, Bremen, Germany
11 Messerschmitt A G, Augsburg, Germany — Over-all Report; Part A; Part B; Appendices I, II, III
12 Dornier Works, Friedrichshafen & Munich, Germany
13 Gerhard Fieseler Werke G m b H, Kassel, Germany
14 Wiener Neustaedter Flugzeugwerke, Wiener Neustadt, Austria

Aero Engines Branch

15 Bussing NAG Flugmotorenwerke G m b H, Brunswick, Germany
16 Mittel-Deutsche Motorenwerke G m b H, Taucha, Germany
17 Bavarian Motor Works, Inc., Eisenach & Durrerhof, Germany
18 Bayerische Motorenwerke A G (BMW) Munich, Germany
19 Henschel Flugmotorenwerke, Kassel, Germany

Light Metal Branch

20 Light Metals Industry of Germany — Part I, Aluminum; Part II, Magnesium
21 Vereinigte Deutsche Metallwerke, Hildesheim, Germany
22 Metallgussgesellschaft G m b H, Leipzig, Germany
23 Aluminiumwerk G m b H, Plant No. 2, Bitterfeld, Germany
24 Gebrueder Giulini G m b H, Ludwigshafen, Germany
25 Luftschiffbau, Zeppelin G m b H, Friedrichshafen on Bodensee, Germany
26 Wieland Werke A G, Ulm, Germany
27 Rudolph Rautenbach Leichmetallgiessereien, Solingen, Germany
28 Lippewerke Vereinigte Aluminiumwerke A G, Lunen, Germany
29 Vereinigte Deutsche Metallwerke, Heddernheim, Germany
30 Duerener Metallwerke A G, Duren Wittenau-Berlin & Waren, Germany

AREA STUDIES DIVISION

*31 Area Studies Division Report
32 A Detailed Study of the Effects of Area Bombing on Hamburg
33 A Detailed Study of the Effects of Area Bombing on Wuppertal
34 A Detailed Study of the Effects of Area Bombing on Dusseldorf
35 A Detailed Study of the Effects of Area Bombing on Solingen
36 A Detailed Study of the Effects of Area Bombing on Remscheid
37 A Detailed Study of the Effects of Area Bombing on Darmstadt
38 A Detailed Study of the Effects of Area Bombing on Lubeck
39 A Brief Study of the Effects of Area Bombing on Berlin, Augsburg, Bochum, Leipzig, Hagen, Dortmund, Oberhausen, Schweinfurt, and Bremen

CIVILIAN DEFENSE DIVISION

*40 Civilian Defense Division—Final Report
41 Cologne Field Report
42 Bonn Field Report
43 Hanover Field Report
44 Hamburg Field Report—Vol I, Text; Vol II, Exhibits
45 Bad Oldesloe Field Report
46 Augsburg Field Report
47 Reception Areas in Bavaria, Germany

EQUIPMENT DIVISION

Electrical Branch

*48 German Electrical Equipment Industry Report
49 Brown Boveri et Cie, Mannheim Kafertal, Germany

Optical and Precision Instrument Branch

*50 Optical and Precision Instrument Industry Report

Abrasives Branch

*51 The German Abrasive Industry
52 Mayer and Schmidt, Offenbach on Main, Germany

Anti-Friction Branch

*53 The German Anti-Friction Bearings Industry

Machine Tools Branch

*54 Machine Tools & Machinery as Capital Equipment
*55 Machine Tool Industry in Germany
56 Herman Kolb Co., Cologne, Germany
57 Collet and Engelhard, Offenbach, Germany
58 Naxos Union, Frankfort on Main, Germany

MILITARY ANALYSIS DIVISION

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60 V-Weapons (Crossbow) Campaign
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MUNITIONS DIVISION

Heavy Industry Branch

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67 Coking Plant Report No. 1, Sections A, B, C, & D
68 Gutehoffnungshuette, Oberhausen, Germany
69 Friedrich-Alfred Huette, Rheinhausen, Germany
70 Neunkirchen Eisenwerke A G, Neunkirchen, Germany
71 Reichswerke Hermann Goering A G, Hallendorf, Germany
72 August Thyssen Huette A G, Hamborn, Germany
73 Friedrich Krupp A G, Borbeck Plant, Essen, Germany
74 Dortmund Hoerder Huettenverein, A G, Dortmund, Germany
75 Hoesch A G, Dortmund, Germany
76 Bochumer Verein fuer Gusstahlfabrikation A G, Bochum, Germany

Motor Vehicles and Tanks Branch

*77 German Motor Vehicles Industry Report
*78 Tank Industry Report
79 Daimler Benz A G, Unterturkheim, Germany
80 Renault Motor Vehicles Plant, Billancourt, Paris
81 Adam Opel, Russelsheim, Germany
82 Daimler Benz-Gaggenau Works, Gagenau, Germany
83 Maschinenfabrik Augsburg-Nurnberg, Nurnberg, Germany
84 Auto Union A G, Chemnitz and Zwickau, Germany
85 Henschel & Sohn, Kassel, Germany
86 Maybach Motor Works, Friedrichshafen, Germany
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88 Volkswagenwerke, Fallersleben, Germany
89 Bussing NAG, Brunswick, Germany
90 Muehlenbau Industrie A G (Miag) Brunswick, Germany
91 Friedrich Krupp Grusonwerke, Magdeburg, Germany

Submarine Branch

92 German Submarine Industry Report
93 Maschinenfabrik Augsburg-Nurnberg A G, Augsburg, Germany
94 Blohm and Voss Shipyards, Hamburg, Germany
95 Deutschewerke A. G, Kiel, Germany
96 Deutsche Schiff und Maschinenbau, Bremen, Germany
97 Friedrich Krupp Germaniawerft, Kiel, Germany
98 Howaldtswerke A G, Hamburg, Germany
99 Submarine Assembly Shelter, Farge, Germany
100 Bremer Vulkan, Vegesack, Germany

Ordnance Branch

*101 Ordnance Industry Report
102 Friedrich Krupp Grusonwerke A G, Magdeburg Germany
103 Bochumer Vercin fuer Gusstahlfabrikation A G, Bochum, Germany
104 Henschel & Sohn, Kassel, Germany
105 Rheinmetall-Borsig, Dusseldorf, Germany
106 Hermann Goering Werke, Braunschweig, Hallendorf, Germany
107 Hannoverische Maschinenbau, Hanover, Germany
108 Gusstahlfabrik Friedrich Krupp, Essen, Germany

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*109 Oil Division, Final Report
*110 Oil Division, Final Report, Appendix
*111 Powder, Explosives, Special Rockets and Jet Propellants, War Gases and Smoke Acid (Ministerial Report #1)
112 Underground and Dispersal Plants in Greater Germany
113 The German Oil Industry, Ministerial Report Team 78
114 Ministerial Report on Chemicals

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115 Ammoniawerke Merseburg G m b H, Leuna, Germany—2 Appendices
116 Braunkohle Benzin A G, Zeitz and Bohlen, Germany
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117 Ludwigshafen-Oppau Works of I G Farbenindustrie A G, Ludwigshafen, Germany
118 Ruhroel Hydrogenation Plant, Bottrop-Boy, Germany, Vol. I, Vol. II
119 Rhenania Ossag Mineraloelwerke A G, Harburg Refinery, Hamburg, Germany
120 Rhenania Ossag Mineraloelwerke A G, Grasbrook Refinery, Hamburg, Germany
121 Rhenania Ossag Mineraloelwerke A G, Wilhelmsburg Refinery, Hamburg, Germany
122 Gewerkschaft Victor, Castrop-Rauxel, Germany, Vol. I & Vol. II
123 Europaeische Tanklager und Transport A G, Hamburg, Germany
124 Ebano Asphalt Werke A G, Harburg Refinery, Hamburg, Germany
125 Meerbeck Rheinpreussen Synthetic Oil Plant—Vol. I & Vol. II

Rubber Branch

126 Deutsche Dunlop Gummi Co., Hanau on Main, Germany
127 Continental Gummiwerke, Hanover, Germany
128 Huels Synthetic Rubber Plant
129 Ministerial Report on German Rubber Industry

Propellants Branch

130 Elektrochemischewerke, Munich, Germany
131 Schoenebeck Explosive Plant, Lignose Sprengstoff Werke G m b H, Bad Salzemen, Germany
132 Plants of Dynamit A G, Vormal, Alfred Nobel & Co, Troisdorf, Clausthal, Drummel and Duneberg, Germany
133 Deutsche Sprengchemie G m b H, Kraiburg, Germany

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} Special papers which together comprise the above report
134a Industrial Sales Output and Productivity

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136 Railroad Repair Yards, Malines, Belgium
137 Railroad Repair Yards, Louvain, Belgium
138 Railroad Repair Yards, Hasselt, Belgium
139 Railroad Repair Yards, Namur, Belgium
140 Submarine Pens, Brest, France
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206 I to 10 in Vol I "Utilities Division Plant Reports"
207 II to 20 in Vol II "Utilities Division Plant Reports"
208 21 Rheinische-Westfalische Elektrizitaetswerke A G

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5 Field Report Covering Air Raid Protection and Allied Subjects, Nagasaki, Japan
*6 Field Report Covering Air Raid Protection and Allied Subjects, Kyoto, Japan
7 Field Report Coveriug Air Raid Protection and Allied Subjects. Kobe, Japan
8 Field Report Covering Air Raid Protection and Allied Subjects, Osaka, Japan
9 Field Report Covering Air Raid Protection and Allied Subjects, Hiroshima, Japan—No. 1
*10 Summary Report Covering Air Raid Protection and Allied Subjects in Japan
*11 Final Report Covering Air Raid Protection and Allied Subjects in Japan

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*12 The Effects of Bombing on Health and Medical Services in Japan
*13 The Effects of Atomic Bombs on Health and Medical Services in Hiroshima and Nagasaki

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*14 The Effects of Strategic Bombing on Japanese Morale

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*18 Kawanishi Aircraft Company
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(Kawanishi Kokuki Kabushiki Kaisha)
(Airframes)
*19 Kawasaki Aircraft Industries Company, Inc.
Corporation Report No. IV
(Kawasaki Kokuki Kogyo Kabushiki Kaisha)
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*20 Aichi Aircraft Company
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