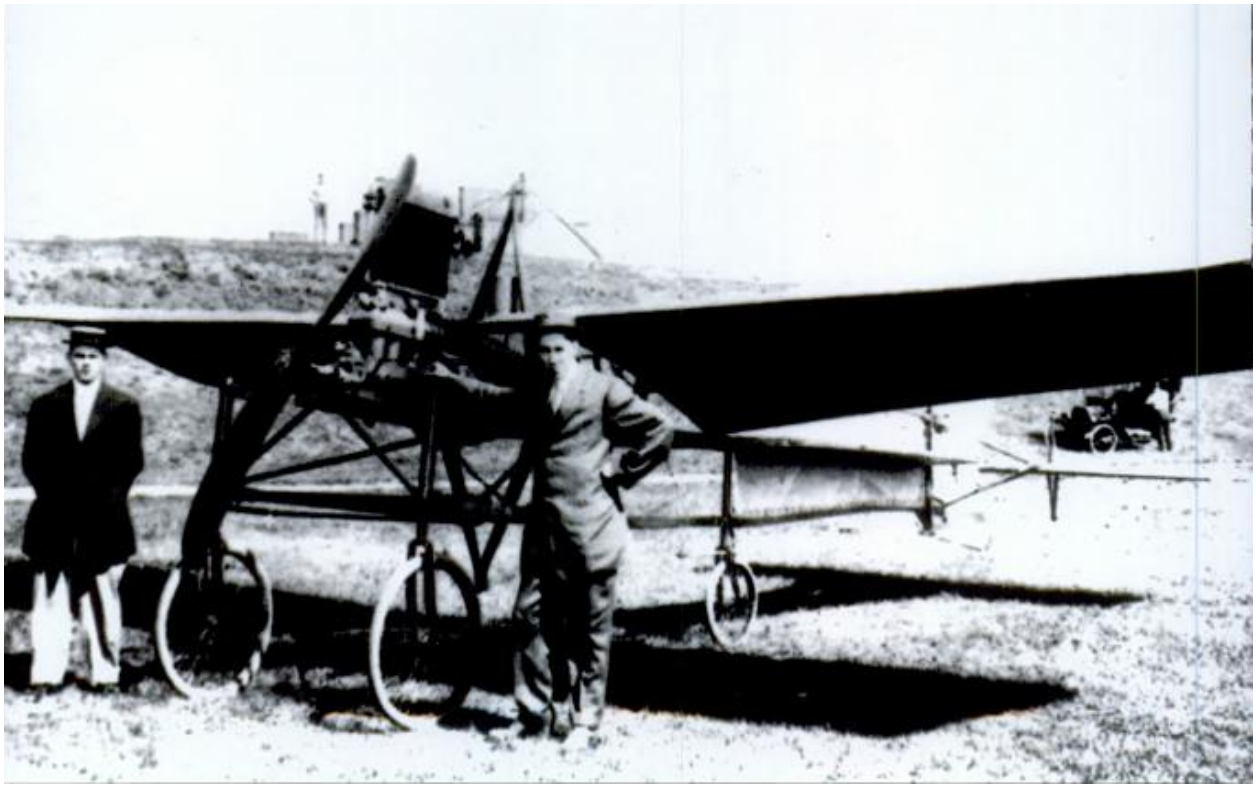
From Cars to Planes and Back Again, Part Three
by Andre Swygert

The first two articles in this series about automobile manufacturers who have also produced aircraft separately looked at two divisions of General Motors that made military planes during World War II (WWII). This third installment begins an exploration of Ford Motor Company's involvement in also building airplanes during WWII by focusing on the story of its facility in Willow Run, MI. This plant assembled the B-24 Liberator, a bomber that was produced in greater numbers than its more famous colleague the Boeing B-17. The mating of Henry Ford's mass production technology to build such a complex aircraft, in which Ford was the only builder of five companies making B-24s that did not have military aircraft manufacturing experience, is one of the legends of American industrial history. Ford's achievements at Willow Run and the lessons learned from that experience have contributed to its place as probably the most well-publicized and studied example of all of the auto companies that have produced aircraft. Its influence can still be felt through the development of manufacturing processes such as Just-In-Time (JIT) and Lean Manufacturing which are used in every industry today and which contain many elements that were derived from Ford's efforts.

Ford-built B-24H serial no. 42-95051 on a post-assembly test flight from Willow Run, MI
Four other companies built B-24s as there was a great need for it in much of WWII. Unfortunately, this plane was shot down over Frankfurt, Germany on May 8, 1944; her entire 10-man crew was killed (source: ww2today.com)



Ford employee Charles Van Auken's plane built from French Blériot IX plans
This early design was the Ford family's first exposure to aviation (source: Michigan Aircraft Manufacturers)

Ford's Pre-war Aviation Interests: A perusal of just about any information concerning Henry Ford reveals that he was interested in all forms of motorized transport, including trains and ships. But it was his son Edsel who helped him to complete the triad of land, sea, and air involvement, as Edsel apparently became fascinated with flight through the exploits of the Wright Brothers, Glenn Curtiss, and other early aviation pioneers. Thus in 1909 then 15-year old Edsel persuaded Henry to loan three Ford employees to help him and his friend (and Ford employee) Charles Van Auken to build a small single-place airplane with a 28hp Model T engine. This tricycle gear design made a few short test flights before its crankshaft failed on its last flight and it ended up in a tree. Although the pilot (Auken) was unhurt the incident caused Henry to forbid his son to proceed with further flights. However, Edsel was undaunted in his enthusiasm and continually requested his father to keep an eye on future aviation developments. Henry not only monitored this growing industry but later with Edsel became very actively engaged in its development and promotion, as illustrated in the events and activities summarized in the following timeline:

1917-1918	Ford plant in Highland Park, MI, where Model T's were built, produced Packard-designed Liberty aircraft engines for the US military at a rate of 75 per day, in all making 3,950 complete engines.
1919-1920	Henry Ford confers with the Zeppelin Company concerning his interest in building dirigibles, eventually sending an employee to the company's facilities in Germany to study their production. Nothing further occurs, but Henry predicts that similar craft would be crossing the Atlantic by 1925; this actually starts in May 1930 via the German Graf Zeppelin.

1922	Henry, Edsel, and 125 other investors put in $1,000 each to fund the new Stout Metal Airplane Company, builders of the first metal-skinned airplane and designed for commercial use by founder William B. Stout.
January 25, 1925	At William Stout's request in late 1924, Ford begins building an airport in Dearborn, MI which is completed and dedicated on this date. Ford Airport has a passenger terminal, a shop for maintaining aircraft, a radio communications station, a weather station, and a blimp mooring mast.
April 14, 1925	Ford Air Transport Service begins scheduled cargo flights when a Stout airplane carries 1,000 lbs. of freight between Ford factories in Detroit and Chicago, later serving other Ford facilities in Cleveland and Buffalo.
August 1925	Henry buys out all other investors to take sole ownership of Stout Metal Airplane Company, renaming it as a division of the Ford Motor Company.
October 4, 1925, and annually through 1931	The first annual Commercial Airplane Reliability Tour (later shortened to National Air Tour) is held. Starting and ending at Ford Airport, the event was sponsored by Ford to increase the public's awareness of the safety of aircraft and air travel and to promote Detroit (and Ford) as the airplane capital of the country.
February 15, 1926	Ford Motor Company is the first private operator to fly the U.S. Air Mail.
June 11, 1926	The first of 198 Ford Tri-Motor aircraft is constructed as the first airliner that can carry multiple numbers of passengers on a transcontinental basis in relative comfort. Because of the success of the design Ford becomes the largest commercial airplane builder in the world. 
July 23, 1926	Ford unveils the Flivver, an airplane designed be "the Model T of the sky". It is small at just over 15 feet long, wingspan of just under 23 feet, powered by a 3-cylinder 35hp engine made by the Ford company Anzani, and weighed 350 pounds when empty. Only four were built after one was lost in 1928 along with its test pilot, after which the design was shelved. 
February 16, 1927	First successful radio guided flight, using a system developed by Ford.
August 12, 1927	On a visit to Dearborn, MI as part of a nationwide post-translantic flight tour Charles Lindbergh takes Henry and Edsel on their first airplane rides, and later becomes Ford Motor Company's chief pilot. He also accepts an invitation to fly the Flivver and reportedly declared afterwards that it was one of the worst airplanes that he ever flew.
1928-1929	First concrete paved runway in the world is installed at Ford Airport.

August 19, 1929	With backing from investors including Henry and Edsel Ford, the ZMC-2, the first all-metal airship, was built by the Aircraft Development Corp., a division of Detroit Aircraft Corp. Bouyed by helium, it successfully completed 752 flights and logged 2265 hours of flight time for the US Navy until it was scrapped in 1941.
November 29, 1929	Richard Byrd flies a Ford Tri-Motor Model 4AT-B over the South Pole.
July 1, 1931	The Dearborn Inn opens adjacent to Ford Airport, one of the first U.S. hotels specifically built for the air traveler.
October 23, 1934	With apparent permission from Henry Ford, American balloonists Jean and Jeannette Piccard took off from Ford Airport in a high-altitude balloon to perform atmospheric science studies and reached a record-breaking height of 57,000 feet during a flight of 800 miles, landing in Cadiz, OH.
1940	Henry Ford's continued interest to bring aviation to the average person is exemplified in his alleged prediction: "Mark my words: a combination airplane and motorcar is coming. You may smile, but it will come." It is unknown as to what situation or circumstance prompted the remark.

Ford Responds to a Call from the Government: In January of 1940 US national leaders realized that the country was being drawn into the growing war in Europe and that our military was woefully unprepared. As part of the effort to address this issue President Roosevelt's administration began soliciting commercial companies to make parts and components and supply them to traditional defense manufacturers in order to rapidly ramp up military production. Given the anticipated long distances in which they might have to operate, the Air Corps in particular foresaw the need for large numbers of airplanes with sufficient range and payload to enable them to reach distant targets.

A Curtiss P-40 (left) and one being examined by Henry Ford and senior executives in June 1940
The team's offer to build one plane/hour with a "frozen" design was rejected (source: http://corporate.ford.com)

As part of their due diligence in considering such a request Ford executives and senior managers, including Henry and Edsel, studied a Curtiss P-40 Warhawk fighter in June 1940 to ascertain its adaptability for mass production. They agreed that not only was it possible, but that they could eventually work up to produce one plane per hour as long as the design was left unchanged. This was a standard practice in the automobile industry but was an unacceptable provision to the Air Corps. Their experience was that aircraft must be continually modified for new missions or

features, particularly in the urgency of war, and thus no design could ever remain unchanged (which is still the case today). Eventually in January 1941 the company agreed to be a parts supplier to Consolidated Aircraft in San Diego, CA, who were then building their B-24 bomber at the rate of one a day as an answer to the previously stated Air Corps requirements. Shortly afterward a staff of Ford personnel, including Edsel Ford and Charles Sorensen, Vice-President of Production, went to observe Consolidated's operations. With thirty five years of experience in mass production Sorensen quickly saw inefficiencies in Consolidated's assembly methods. This was not unusual as airplane manufacturers of the day were still accustomed to building airplanes in small quantities, a reality that to them did not justify investing in the tooling and processes needed for mass production. After several expressions of his disappointment Sorensen was issued a challenge by the company's senior management to come up with something better.

Ford VP Charles Sorenson

Consolidated B-24 in company's outdoor final assembly area

Sorensen's visit to Consolidated's factory after Ford agreed to be a supplier firmly convinced company officials that they could build the whole plane faster and cheaper (source: The Henry Ford Online Collections)

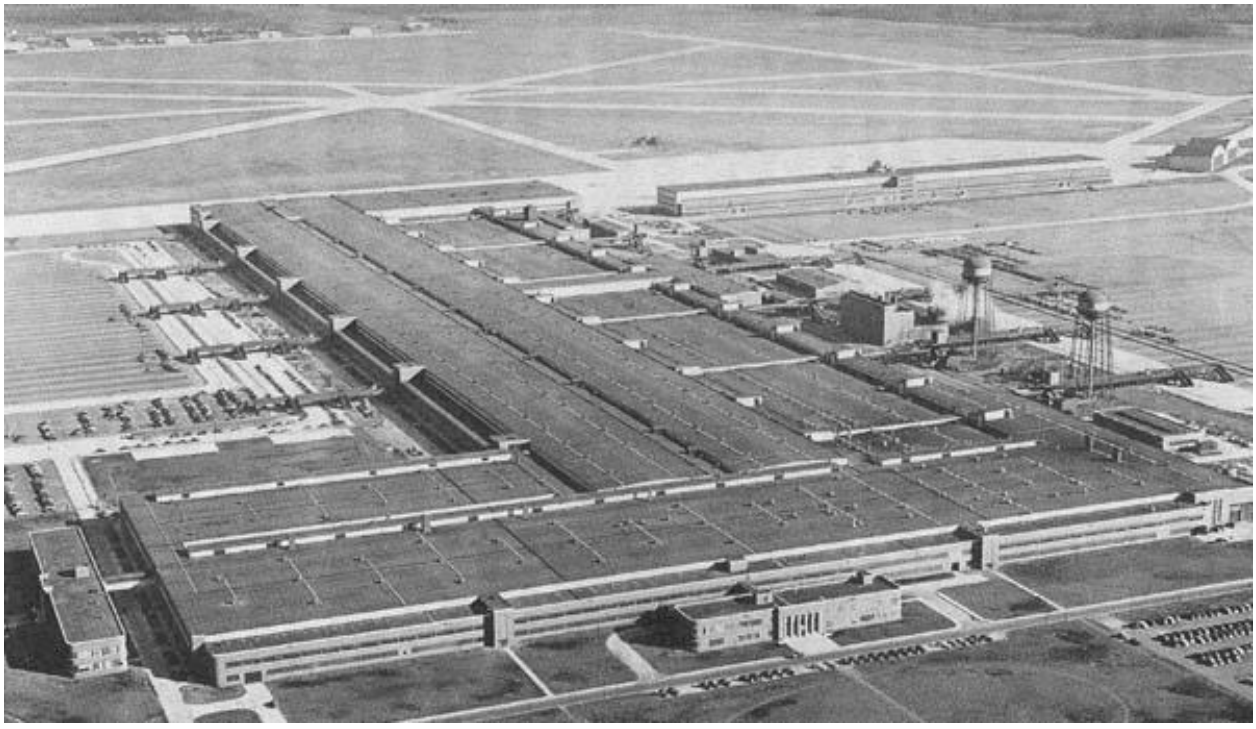
Working late into the night in his hotel room that night Sorensen successfully sketched out an assembly line that could not just build components but could more efficiently and quickly produce a complete aircraft. At breakfast the next morning he showed his work to Edsel and gained ready agreement, as Edsel and other auto manufacturer leaders chafed at the thought of just supplying parts and components for the war effort. They were convinced (especially Ford) that with their hard-won expertise in mass production that they could make anything in larger quantities and with better quality than anyone. The keys to their plan involved extensive use of production tooling. Basically, they intended to use specially-built machines and tools composed of two categories: one group would be developed to simplify and speed the pace of production and a second group would be designed to ensure accuracy and interchangeability of components. In this way Ford would essentially automate the entire production process in ways that the traditional aircraft manufacturers had never considered. As a result Sorensen's recommendations may have been the final confirmation of the company's plan to build complete aircraft, especially since they had previously received a contract to produce one B-24 aircraft for familiarization purposes. Ford personnel took this a step further by examining the plane in such a way as to plan mass production of it at a rate of one per hour, the goal of Sorenson's design.

With Edsel apparently convincing Henry of the viability of Sorensen's manufacturing layout, it was no doubt recognized that a plant to build such a large plane would require a lot of space. To

this end Henry quietly started buying additional land on top of his existing holdings near Ypsilanti, MI, some 30 miles west of Detroit, as the location for the proposed new facility. Interestingly, this was an effort that was initiated before the government had approved funding for the plant and before its agreement to Ford's plan to build complete aircraft.

The New Facility Takes Shape: On March 28, 1941, workers started clearing trees from the hundreds of acres of newly purchased land in preparation for the construction of the plant that was soon to be known as Willow Run. Designed by architect Albert Kahn at a cost to the government of $47 million (like many new facilities of the time it was owned by the government but in this case was leased to Ford during the war) it had the look and feel of an assembly facility: the main building alone was 3,200 by 1,180 feet, which encompassed over 3.5 million square feet of space. Its main production areas consisted of two major bays that were 150 feet wide, 30 feet high, and 2000 feet long. This was more space than the combined pre-war manufacturing areas of Consolidated, Douglas Aircraft (later McDonnell Douglas and now part of Boeing), and Boeing Aircraft. These areas were equipped with overhead cranes that had capacities of up to 19 tons, far more than what would be needed for just making components.

On April 18, 1941, ground was broken for the plant and less than two months later it was dedicated on June 16th. With a new contract from the government to produce complete B-24 aircraft finalized in October, production began in November 1941. In the following month the last concrete was poured on December 4, three days before Pearl Harbor, to finish the adjoining airfield needed for flyaway delivery of completed planes.



The massive scale of Ford's Willow Run factory facilities and airfield show well in this 1943 photo
The main assembly building alone covered some 67 acres, illustrating that Ford had intended from the very beginning to build aircraft here and not just parts and components (source: The Henry Ford Online Collections)

The government's contract to build complete aircraft provided Ford with the unique opportunity of joining the B-24 Production Pool, consisting of five companies who were awarded contracts

to build B-24s. Ford was the only member who was not previously an airplane builder, as the other facilities were part of traditional industry veterans Consolidated (in San Diego and Ft. Worth, TX), North American Aviation (Dallas, TX), and Douglas Aircraft (Tulsa, OK).

The speed by which Ford had successfully proceeded to set up manufacturing infrastructure was an impressive achievement. Unfortunately, it was not matched by the plant's initial production. The huge challenge that Ford faced is illustrated in the fact that a typical 1940 car was comprised of 15,000 individual parts while a B-24 was comprised of 152,000 parts, 30,000 of them unique, and held together by over 313,000 rivets. As a result Ford undertook a major effort to obtain as many copies of design drawings and other material as possible in order to plan for mass producing the B-24. A staff of over 200 spent months at Consolidated's facilities accumulating the required documents, an effort that when completed filled two train freight cars with material.

However, the many differences in aircraft manufacturing versus auto assembly soon became painfully apparent. For example, the B-24's design was not immediately adaptable for mass production as many components were laboriously welded together instead of being constructed as complete modules. Ford overcame this challenge by breaking the B-24 into 24 major subassemblies, combining what had been many separate components. Further, Consolidated's drawings followed standard aviation industry practice in being labeled in fractions instead of decimals, thus lacking details conducive to standardized production. This would require re-doing many of the over 30,000 drawings that had been copied over the previous months. Also, Ford personnel had little to no experience with aluminum which had different properties than the steel that they historically used, as aluminum is much more flexible and thus gave them problems with precision drilling and bending. The high frequency of design changes meant that tool settings for full production runs to fulfill a contract were not possible, such that production was more often curtailed while new configurations or other changes were completed. Such occurrences sometimes required modification or even scrapping of expensive production machinery that were not adjustable to new configurations.

September 10, 1942: Willow Run's first production B-24, serial no. 42-6976, is completed
Ford had previously completed a number of B-24s as non-flying kits that were shipped to other facilities to help them to set up for production on the aircraft as well (source: The Henry Ford Online Collections)

In addition, Ford was continually challenged by a shortage of labor throughout the plant's existence. At its peak Ford employed over 42,000 people, ranging as far as Tennessee and even Texas to recruit labor. Many of the selected individuals had to quickly undergo a very steep learning curve to become productive employees, and while most were successful in this endeavor with so many trainees on the shop floor production was further impacted. But this was just a part of the labor issue. Willow Run's remote location from population centers initially hindered daily commutes so a highway was built to the west side of Detroit that is now part of I-94. Also, many of the new workers came from other areas and needed places to live, but by early 1942 there were no rental rooms to be found within a fifteen-mile radius of Willow Run. As a result an entire town was built almost overnight called Willow Village, with dorms for single workers and small houses for families. Upon reaching peak employment by the end of 1943 Willow Village was providing temporary shelter for 15,000, a population greater than its home city of Ypsilanti.

This shot of the final assembly areas emphasizes the vastness of the Willow Run assembly line
By 1944 when this photo was taken, Willow Run was just hitting its stride in producing aircraft
(source: The Henry Ford Online Collections)

Gradually Ford overcame these and other challenges such that Willow Run's production numbers began to mount. Starting with a net output of fifty-six airplanes for all of 1942 Ford produced thirty-one airplanes in January 1943 and by June was up to 190 per month. By March 1944 B-24 production was reaching the levels that Charles Sorensen had expected in that it

produced 453 airplanes in 468 working hours. Unfortunately, Sorensen was not at Ford to witness this accomplishment, as he had just resigned from Ford after losing a power struggle following the death of Edsel Ford in May 1943. With the eventual development of efficient assembly line methods Ford delivered over 5400 aircraft from 1944-1945, leading to a remarkable drop in the delivered price of a B-24 from $238,000 in 1942 to $137,000 in 1944. In all, 6,782 B-24's were built at Willow Run before the last contract expired in June 1945, not including 1,894 knock-down kits shipped to other B-24 plants for assembly. The success of Ford's mass production techniques are further illustrated by the following percentages of complete aircraft that were delivered by the B-24 Production Pool:

Total B-24 production by all companies	18,417	
Consolidated-Vultee Aircraft, San Diego, CA	6,962	38%
Ford Motor Company, Willow Run, MI	**6,782**	**37%**
Consolidated-Vultee Aircraft, Fort Worth, TX	2,743	15%
North American Aviation, Dallas, TX	966	5%
Douglas Aircraft Co., Inc., Tulsa, OK	964	5%

June 28, 1945: Henry Ford II tows out B-24M 44-51928, the last one made by any manufacturer
In the last months of the war Ford was building 70% of all B-24s contracted for the Army Air Force (source: The Henry Ford Online Collections)

After the war Ford decided to not exercise its option to buy the Willow Run plant from the government and had completely vacated it by the end of the year. With a very big, expensive, and empty facility on its hands, the government was desperate for a tenant. The Kaiser-Frazer Company (K-F) was then just starting car production in competition with the Big Three and needed space to build its new vehicles. A deal was struck for K-F to take over Ford's lease for a 5-year period, and its first production Kaiser Special rolled out on May 29, 1946. K-F later worked out a purchase of the plant that was completed on December 3, 1948 for the bargain price of $15,100,000. More information about Willow Run's historic postwar career in automotive production will be included in a future article of this series.

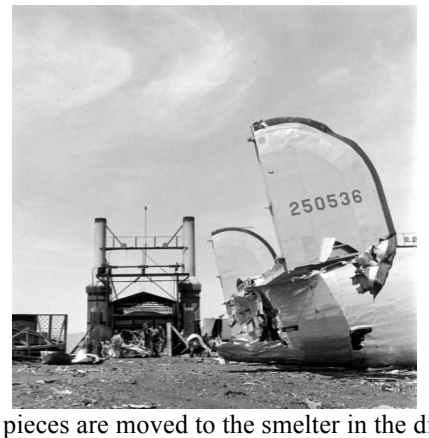
The fate of the B-24s that Ford and other companies had produced in such a prodigious quantity also took a very interesting turn. Many were quickly disposed of in a mass de-mobilization of the country's military forces in the immediate postwar years, a fate shared by vast numbers of other American aircraft produced for the war effort. Some aircraft were returned to the US to be scrapped and melted down into raw material for use in other products. Others were scrapped at their respective bases. Still others, especially in the Pacific, were rendered non-flyable and left to just decay wherever they were as it was deemed too expensive to bring them back.

Acres of B-24s parked and awaiting sale or the furnaces at Kingman, AZ after WWII
The photo above and the series that follows on the next page are from an April 1947 edition of LIFE Magazine, showing the progression of a B-24's typical journey from powerful warplane to recycled material.

Given the country's desire to return to peace and the massive effort to recycle defense products, it was not long before very few examples of many aircraft types were left. The B-24 was especially affected, as in the US today there are only two aircraft that are airworthy and six complete airframes that are on static display. Only one of these displays is a Ford-built plane, B-24J serial number 44-48781, at Barksdale Air Force Base near Shreveport, LA. It was used as a combat crew trainer during the war and was stationed at Chanute Field, IL and Langley Field,

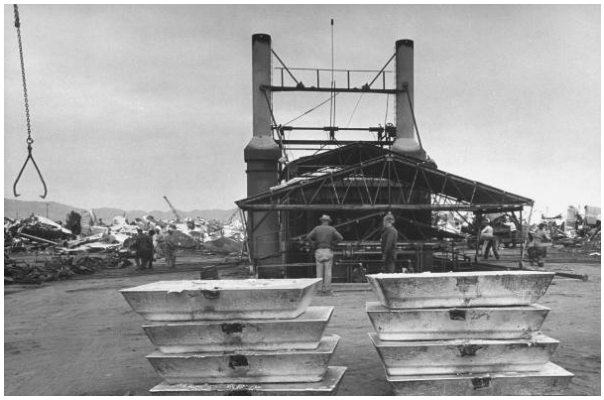
VA, thus it did not see combat. Nevertheless, it is a fitting memorial to the thousands of dedicated professionals who built and flew this valuable contributor to the Allies' victory.

1. Consolidated B-24M 44-41811 "Missouri Miss" getting chopped into pieces by guillotine



2. The pieces are moved to the smelter in the distance while Ford-built B-24J 42-50536 waits its turn

3. One of the three smelters, or furnaces, used at Kingman to melt small pieces of aircraft into ingots



4. Stacks of aluminum ingots ...the remains of the great American WWII bomber fleet

The postwar process used to dispose of WWII aircraft is illustrated in this series of LIFE Magazine photos
Many planes had distinguished combat records with some even coming directly from the production line

The following sources contain more information about Ford's aviation interests and B-24 production at Willow Run, some of which provided content for this article:

- Baugher, Joseph, "Consolidated B-24 Liberator", http://www.joebaugher.com/usaf_bombers/b24.html, retrieved April 2, 2014
- Bryan, Ford Richardson, Beyond the Model T: The Other Ventures of Henry Ford, Wayne State University Press, 1997
- Holley, Irving Brinton, Jr., Buying Aircraft for the Army Air Forces in World War II, Government Reprints Press, 2001, pp. 518-529
- Stoff, Joshua, Picture History of World War II Aircraft Production, Dover, 1993
- The Henry Ford Online Collections, http://collections.thehenryford.org/Collection, retrieved March 31, 2014
- Warren, Benjamin Kidder, Willow Run: Colossus of American Industry, KFT, 1995