Look Out, Hitler—

LIBERATOR BOMBERS ROLLING OFF ASSEMBLY LINES SHOW HOW MASS PRODUCTION WILL SWAMP THE AXIS

By HICKMAN POWELL

Photos by Ford Motor Company

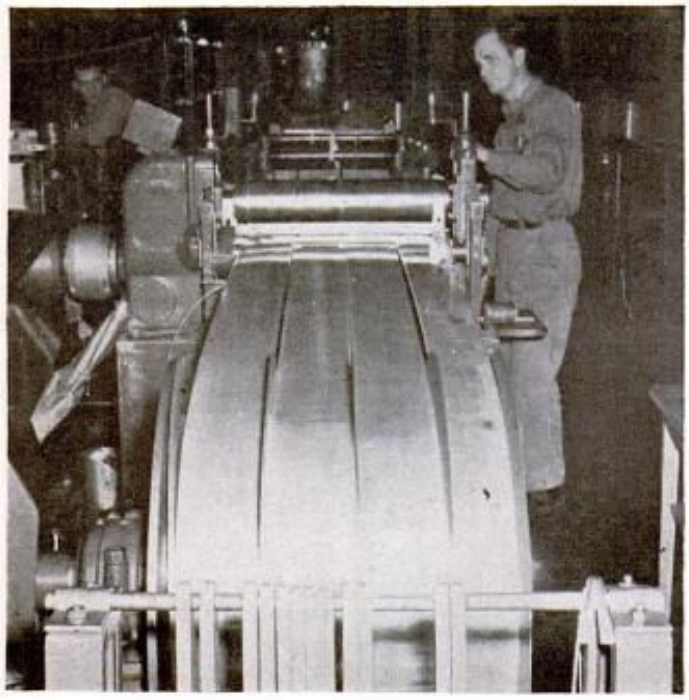
I HAVE just spent two days trying to absorb a quick glimpse of a fantastic future. My feet hurt from walking so far; my eyes ache from straining to see so many complex things; I feel somewhere between a state of brain fag and bewilderment, from trying simply to appreciate the immensity of an act of industrial imagination and faith so vast that it is beyond the possibility of quick human comprehension. I have been visiting the Willow Run bomber plant, created in the open country of Michigan by the Ford Motor Company and the Army Air Forces.

Willow Run is America's big all-out attempt to apply the technique of automobile mass production to the rapid manufacture of a four-engine bomber—the Liberator, the Consolidated B-24. Less than two years ago this vast site was a woodlot among the fields; most of its thousands of workers were untrained grocery clerks, farm hands, stenographers, and home girls. Today, after passing through all the preliminary acres of fabrication, you come to four long assembly-line conveyors, which eventually merge into two closely packed moving rows of bombing planes on the verge of completion. These are not just airplanes, mind you. The long-distance bomber is the most complex precision machine ever devised by man.

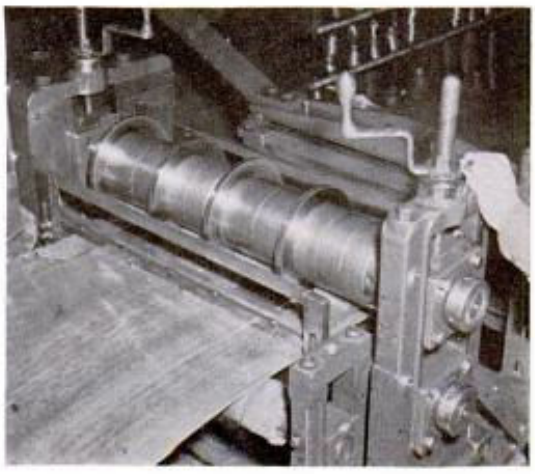
How often these assembly lines move—how frequently planes roll out to join their predecessors on the plant's great flying field—no one is permitted to say. In any case, a figure that is true today would be false a month from now. But it is possible to say that Willow Run is running. The river is rising. Mr. Hitler, here comes the flood!

Those thousand-plane bombing raids over Germany were mere dress rehearsals. All the books and articles and talk about air power and bombing the Axis to its knees—they were mere advance scriptwriting for this mechanical drama which now begins to move. Mystery and secrecy and rumors have surrounded it. There were whispers from those who said it couldn't be done, and from those who said it should have been done faster. True, there have been monumental difficulties and delays. After all, Rome was not built in a day. But now that

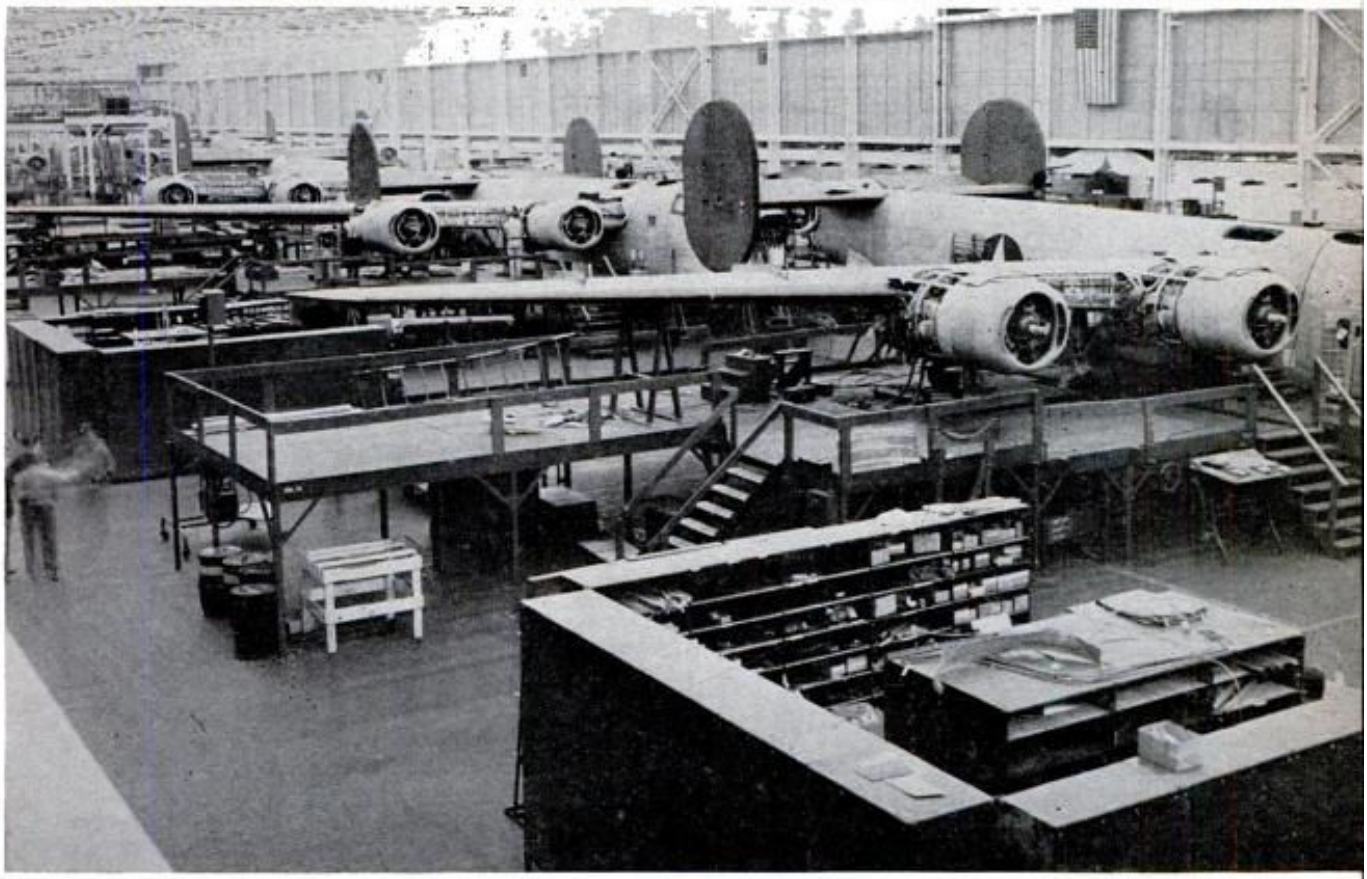
SHEET METAL IS CUT INTO STRIPS, SHAPED BY MACHINE



1 Production starts with small rivulets of materials entering at one end of the mammoth plant. At the left, aluminum alclad strips coming from a Yoder slitting machine are wound up on rolls for easy handling. In the machine, the knives shown below are spaced to cut the metal into strips for stringers with a minimum of waste



HERE COMES THE FLOOD!



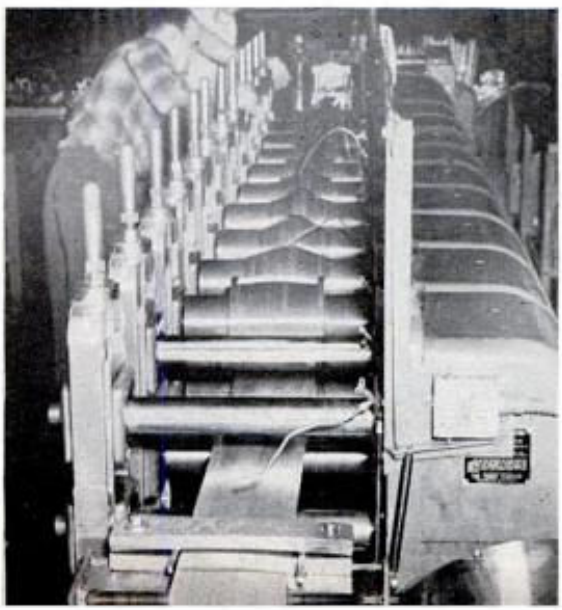
Consolidated B-24 Liberator bombers nearing the end of one of the two final assembly lines at the Ford Motor Company's gigantic Willow Run plant. Note that the ships farthest back in the line have not yet received their outer wing sections. Each time the line moves, the staging slides back sufficiently to clear the landing wheels and the planes are drawn forward by a cable under the floor, moving up one station

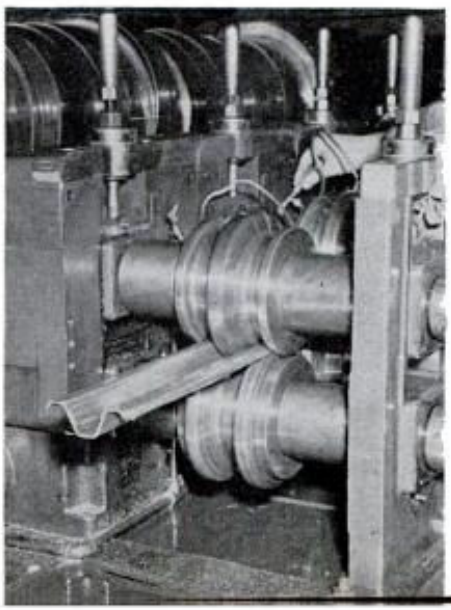
AND COMES OUT AS STRINGERS FOR THE BOMBER'S WINGS

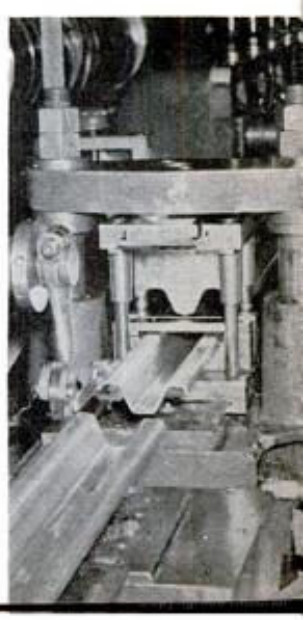
2 From rolls the strips are fed into the Yoder machine in which a series of progressively rounded rollers presses them into hat-shaped stringer sections. The little tubes bent over the strips carry oil which drips onto the metal to protect it from marring as it is rolled into shape. Alclad is duralumin with a pure aluminum coat to bar corrosion

3 Here the stringer section has assumed its final hatlike shape. A workman's hand can be seen adjusting the flow of oil. Protection against marring is important, as any scratch cutting through the pure aluminum coating on the duralumin will ruin the part by exposing it to corrosion

4 From the Yoder machine the stringer sections pass through a cutter in which a blade with the same hatlike shape cuts them to size without distorting their characteristic formation







the curtain lifts a little, it is possible to assure Mussolini that Rome *could* be destroyed in a few hours.

While Hitler's divisions drove through France, less than three years ago, President Roosevelt called for an increase of airplane production capacity to 50,000 planes a year. Practically everyone thought he was talking big, taking a random shot at the moon. Airplane building was then little beyond the handicraft stage, for the simple reason that big orders for big planes had been practically nonexistent. But then the aircraft industry proceeded to work miracles; and today the President's audacious production aim is a reality, almost a commonplace. The aircraft industry accomplished this by speeding up the natural development of its already tested methods of production.

To this miracle Willow Run contributed very little. This plant is something extra, added on top of all the rest. It is an attempt, starting from scratch, to encompass the natural industrial evolution of 20 years all in one big gulp. In place of the airplane craftsman's method of cut, bend, and fit—by which fighting planes are still produced—it seeks to sweep in the principle of interchangeable parts.

Willow Run has been making "parts" for a long time. This does not sound very impressive, until you discover that in Willow Run language a "part" may be something no more simple than a center wing section, 60 feet across—the structural element on which are assembled the four engines, the fuselage, the landing gear, and a complex infinity of hydraulic and electrical controls.

Counting 700,000 rivets, there are 1,250,000 separate parts in a B-24. You enter the plant at the manufacturing end, where the raw sheet duralumin comes in and is cut, stamped, and molded into these integral units. As you move on, into the great acreage devoted to subassemblies, the parts become more complex. For each part there is a jig or fixture (the terms seem to be used somewhat interchangeably, though most of the Willow Run installations are properly fixtures) into which the original parts are fitted and assembled into a precise pattern. No matter how big or complex, a "part" thus made will mate precisely with its adjoining parts, on the assembly line.

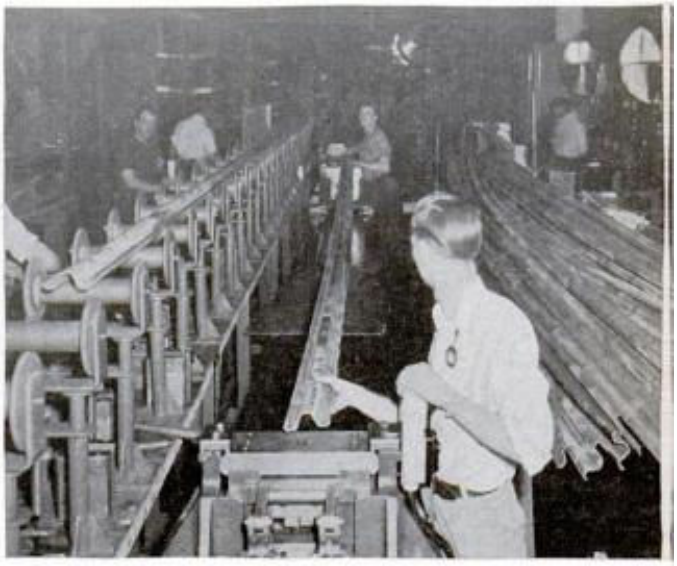
Far down the plant, the final assembly begins to take shape. The 60-foot center wing section, in crude form, is placed in a conveyor system, suspended by its ends. There is not just one of these conveyors; there are four of them side by side, each carrying a row of center wing sections on from station to station, gaining additional complexity at each stop. At one such station, for instance, the wing section encounters an Ingersoll milling machine which simultaneously carries out on it 26 different machining operations—doing in less than an hour a complex lot of metalworking which formerly took days. That is what happens at just one station.

At last, after the wing section has ac-

STRINGERS ARE HEAT-TREATED, STRETCHED, STRAIGHTENED

5 Long stringer sections are loaded onto a large rack which is rolled into a heat-treating furnace. After this treatment the rack moves into a quencher where cold water twists and curls the hot stringers as seen below

6 Stretching the stringer 3½% in this machine removes the kinks and also strengthens the metal by changing its molecular structure. The rollers at the left carry it to another station



quired its landing wheels, the four conveyor lines are drawn together into two final assembly lines pulled by underground cables. This makes room for the planes to take on their outer wing sections and attain their full spread of 110 feet.

Elements of mass production have been introduced in all military-airplane plants. At Willow Run, planned originally for mass production, the Ford organization has introduced speed-up changes which fall into four main categories. They can best be made clear by taking them up one at a time.

1. The use of great, heavy presses with hard steel dies, such as are used for stamping out automobile bodies, for drawing, bending, cutting, and forming various duralumin parts.

The big Ford presses stamp out parts like so many biscuits, but it required great ingenuity to make this possible. Special steels had been developed for automobile stamping, and the special properties of airplane metal were quite different. Its cold flow is such that it tends to wrinkle and fold; dies had to be devised to allow for this. There were those who thought it impossible, but it has been done.

Outstanding in the press work are the complicated frameworks for such parts as the pilot's and bombardier's transparent enclosures. A single stamping in one case now forms a piece formerly made with 33 parts. This was accomplished by using a softer, thicker grade of metal, which would draw better. The extra weight was counterbalanced by elimination of rivets and overlapping joints.

2. Better tooling than the airplane industry ever before could afford. In small aviation contracting the tooling cost was always the most dangerous item. At Willow Run no expense was spared to get the best tool for each operation; and the jigs and fixtures are more accessible and more heavily constructed than ever before. For assembling stringers, for instance, it had been customary to use loftboards—great tables bearing full-scale drawings, which made workmen dependent on ink or pencil marks for their dimensions. At Willow Run every such operation has its own steel bench or framework, with dimensions unalterably and precisely fixed in tool steel.

3. The plane is broken down into smaller parts for subassembly than ever before. The jigs and fixtures are so constructed that detailed installations can be made long before the final assembly line has been reached.

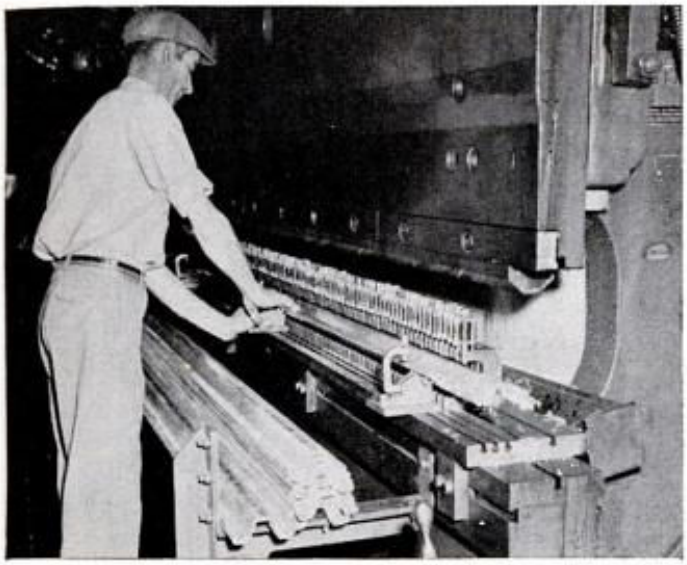
When an airplane fuselage is built as a unit, for instance, its interior is a very crowded place in which to work. In the forward section of a fuselage, a half dozen workers would find themselves crowded and interfering with each other. But when that section is constructed as four separate panels—top, bottom, right, and left, then two dozen men can work on the interiors of these panels simultaneously with plenty of room.

4. The final big *(Continued on page 202)*

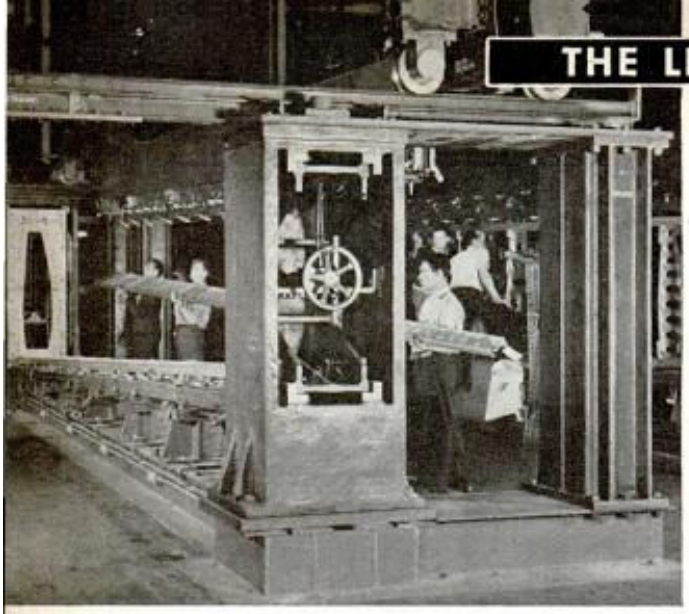
PUNCHED WITH DRILL CENTERS, MADE READY TO INSTALL

7 Stamped for identification of its particular use, the stringer is placed under a huge punch press which pierces it with a precise pattern of small holes to guide in drilling holes for rivets

8 At the stringer assembly bench, a woman worker drills holes in the end of the stringer section preparatory to attaching it to a forging. The assembly bench replaces loftboards (CONTINUED)



THE LIBERATOR'S WINGS TAKE SHAPE



9 In this massive fixture, specially developed for the Willow Run plant, an outer wing section will take shape. With the top rolled back, workmen are placing the forward spar in position

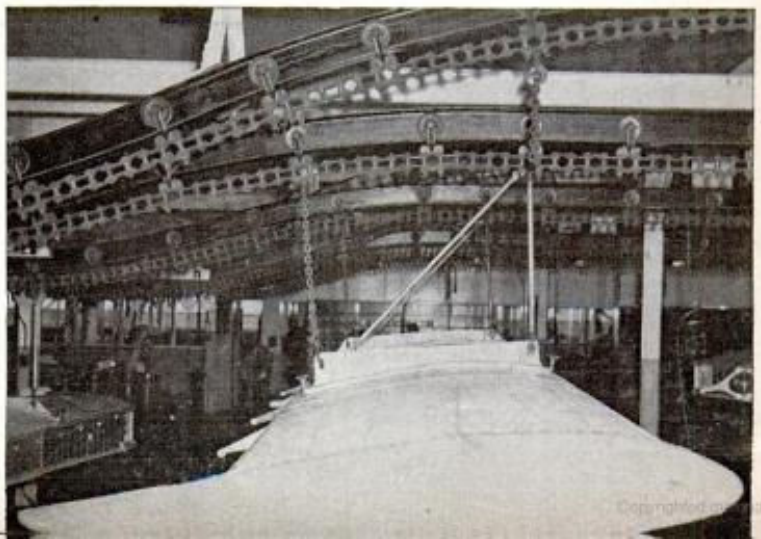
10 Here the spars and bulkheads are in place in the fixture. The wing section is assembled in a vertical position, with spars laid horizontally at top and bottom and bulkheads set between them

13 This close-up shows two workmen riveting the skin through holes drilled to line up with the stringers, which are on the other side of the skin. This is the lower wing surface

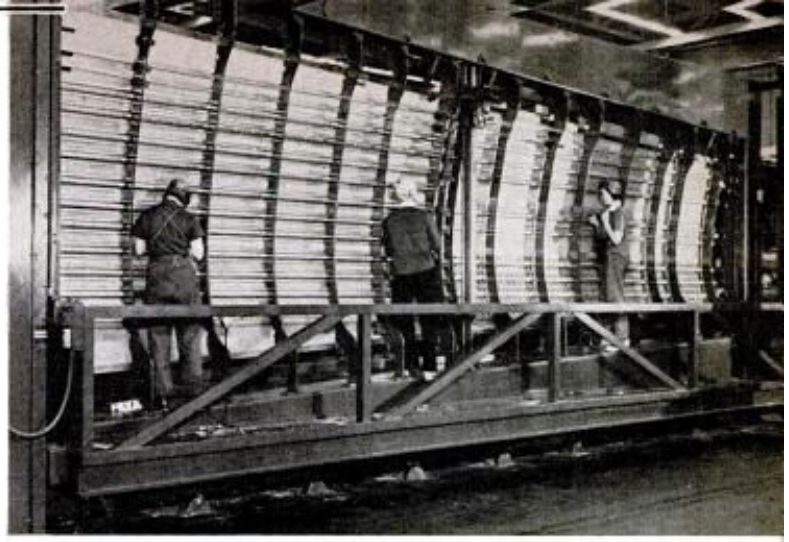
14 When the skin and stringers have been assembled, they are moved to the bulkhead fixture for attachment to the wing. The lower skin, which is put on last, has holes in it through which riveters can work. Women are widely employed at Willow Run, and eventually will compose 25 percent of the plant force

17 At one of the stations, a man and a woman lift the wing tip into position. The leading edge has not yet been attached (note spar visible at left of man's elbow)

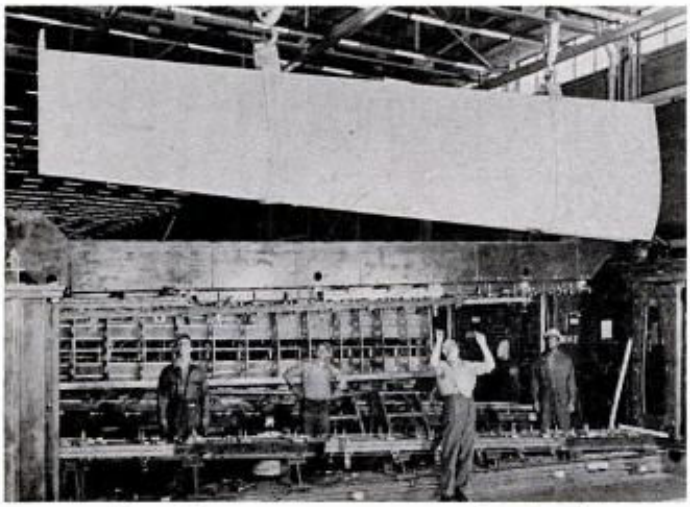
18 Now the wing section is picked up by an overhead conveyor and soars through the plant toward the final assembly line. It already has a finished look, although the leading edge and aileron still remain to be attached



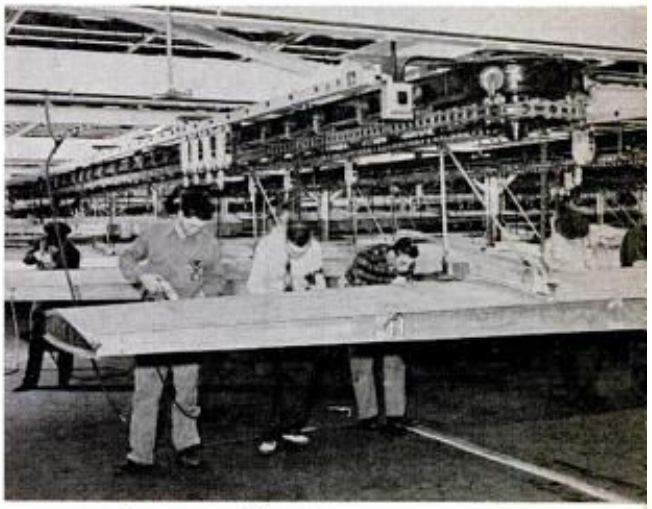
11 In another fixture, stringers are put in position for attaching to the wing skin. The stringers have been assembled so that they are lighter toward wing end (right)



12 Now the metal skin is riveted to the stringers. The curved uprights on which stringers are held simulate the contours of the surface. Riveters stand on an elevator platform which raises them for work on the higher levels



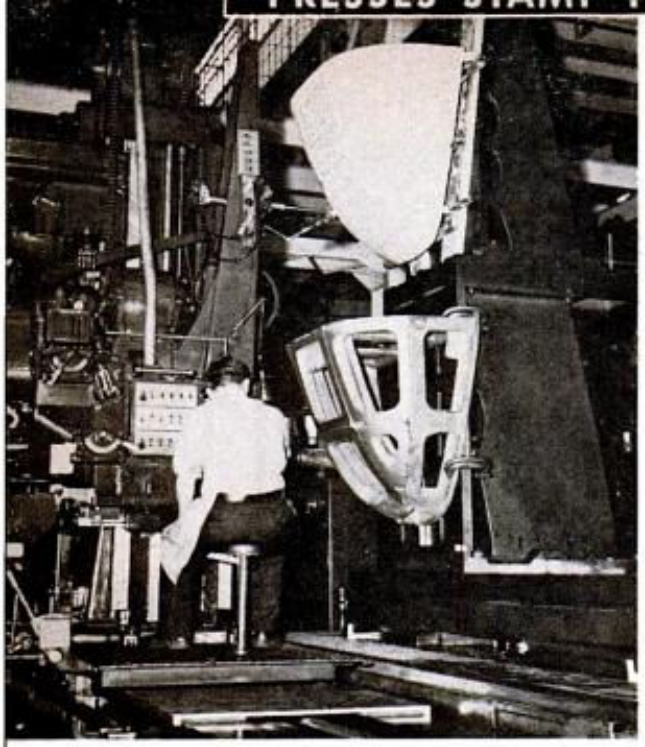
15 Now the wing section is completed. The upper bridge of the fixture is rolled aside and an overhead crane lifts the wing panel out and carries it to a conveyor system. As soon as it is out of the fixture, the upper bridge is replaced and work begun on a new section



16 In the meanwhile, the wing section has been placed on a horizontal conveyor system which carries it from station to station where it receives its furnishings, including the wing tip, aileron, and the leading edge

19 Here three workers, two of them women, are seen lifting an aileron into place. This step takes place after the outer wing section has been attached to the center section. Aileron is rigged for operation by pilot

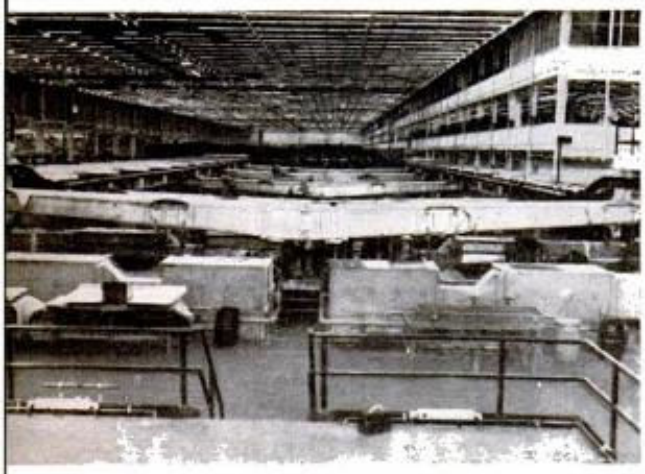
20 The leading edge of the wing goes on. A rubber de-icing mechanism is built into this edge as a protection against the formation of ice at high altitudes (CONTINUED)



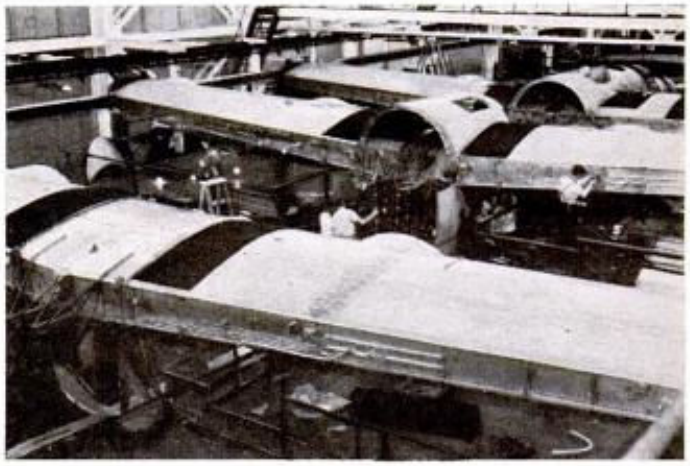
21 In the meanwhile, other parts are coming into the main stream. Here a profiling machine traces a pattern and cuts a die for drawing out part of the bombardier's enclosure

22 An innovation at Willow Run is the use of powerful presses, such as are employed in the automobile industry, for aircraft manufacture. Four 1,000-ton hydraulics like this draw out parts for enclosures and fairings

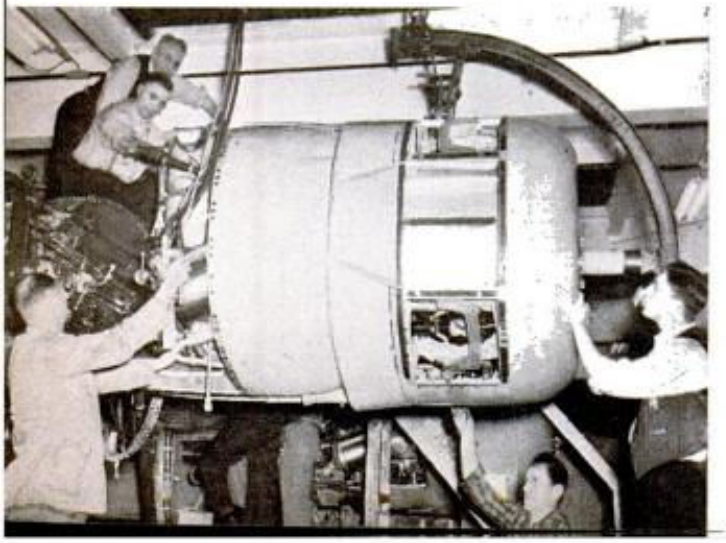
CENTER WING SECTIONS GRADUALLY BLOSSOM INTO PLANES



25 Center wing sections, 60 feet wide, start down the final assembly. There are four parallel lines like this, on which other parts from the subassemblies are gradually added

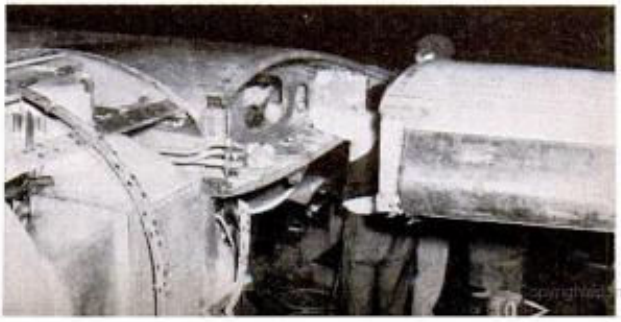


26 Now the Liberator really starts to take form. At the first mating station, bulkheads, longeron bomb racks, and side panels are installed. At the second, the nose is attached to the center wing. The stream flows on

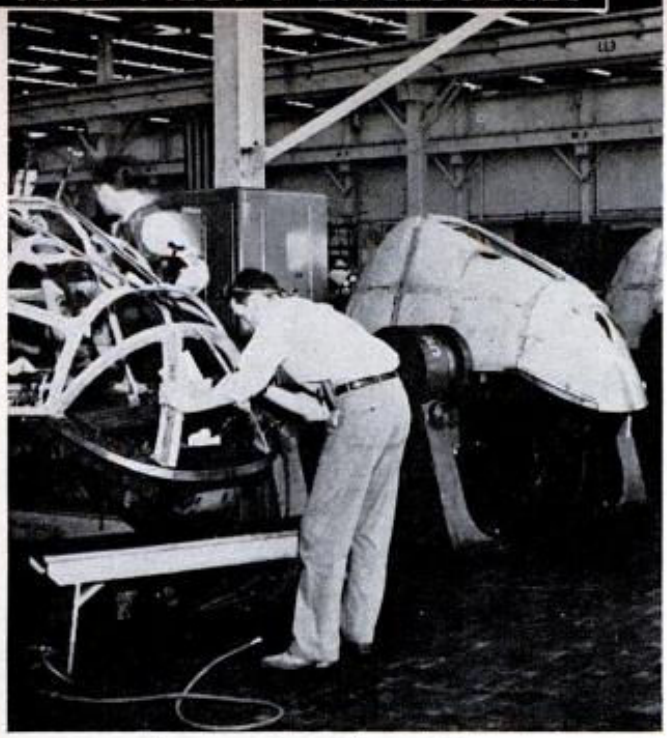


27 Down through a hole in the ceiling comes one of the four huge 1,250-horsepower Pratt & Whitney engines ready for installation

28 Next the outer wing sections move in and are attached. Made on separate fixtures, they mate perfectly. Note man inside center wing



AND PILOT'S ENCLOSURES



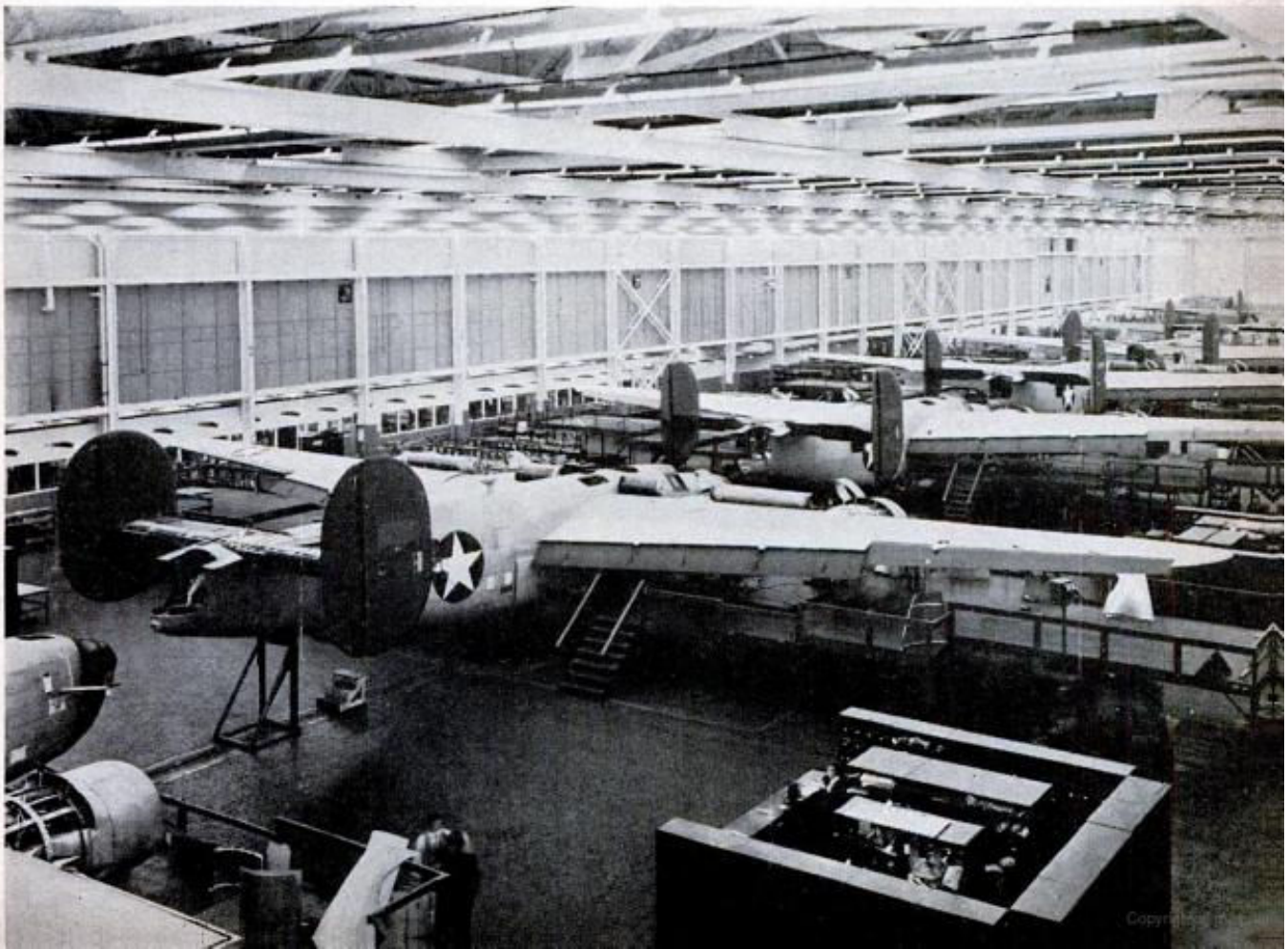
FUSELAGE SECTIONS ARE JOINED AND PASS ON TO ASSEMBLY LINE

23 Ingenious fixtures designed by company engineers provide steady, precise bases on which bombardiers' compartments and similar parts are assembled and prepared for installation in planes

24 Fuselages, each assembled from a dozen parts, take shape in another part of the plant. In the foreground are the aft fuselage sections receiving finishing touches; at rear, forward sections

AS ASSEMBLY LINES POUR LIBERATORS AGAINST THE AXIS

29 Like an inexorable flood, the line moves on. All the rivulets of materials and labor in the mammoth plant find their way to these final assembly lines, just as countless tributaries feed a mighty river. This line is a symbol of the rising torrent under which the Axis will soon be engulfed



SHE ISN'T MUCH TO LOOK AT— BUT THEY CALL HER

Ten .50 caliber machine guns protect the Liberator as she wings toward an enemy target. "A four-engined fighter" is what some call this bomber

OUR CONSOLIDATED B-24 BOMBER CARRIES A PROMISE OF DELIVERANCE TO THE WORLD

By ANDREW R. BOONE

WHEN Winston Churchill flew from England to French Morocco for his historic meeting with President Roosevelt at Casablanca, he used a Consolidated Liberator—the same plane, with the same American pilot, which had carried him to Moscow for his conference with Stalin. The fact is significant, for this long-range, high-altitude precision bomber has come to mean just what its name implies—a symbol of liberation for the oppressed peoples of Europe and of all other parts of the world where the Axis has set its heel.

Who gave the Army's B-24 her name may never be known. Two years ago, Major Reuben Fleet, then president of Consolidated Aircraft Corporation, wrote the Navy Department saying that here was a ship that would liberate the world from tyranny. Some time later, an unidentified Britisher dubbed her "Miss Liberator."

No one, not even her makers at the Consolidated plant in California, where she was born, is proud of her appearance. She looks fat and awkward indeed, and sits squat on an airfield, with husky .50 caliber machine guns sticking like pinfeathers from her nose, belly, back, sides, and tail. But don't let her seeming clumsiness fool you. She's one of the deadliest and most devastating weapons ever created by the hand of man; with that quality her builders—and, more important, the men who fly her—are tremendously satisfied, for she carries a heavier bomb load than any other ship of her class.

Sitting on a field, the Liberator bids for confidence. You can't see all the features that make her a much-feared aerial battleship. She rests on three wheels as the engines bark into action, when she rolls away with a throaty roar for a 120-m.p.h. take-off. Turbo-superchargers help carry her to great heights, and with two engines shot away she can maneuver normally. She's more heavily armed than the Flying Fortress, America's first gift to precision daylight bombing.

The Liberator is as truly tailor-made as the finest suit in your wardrobe. She rolls off the Consolidated assembly lines ready to fly. But she can't go to the pilots in Libya or the Aleutians or the Solomons until her engineer-tailors have fitted her for the precise job and conditions she will face.

If she's bound for cold country, shutters must be installed on the oil radiators, spe-

FACTS About the LIBERATOR

Heaviest, and one of the fastest, of American bombers.

Known to the Army as the B-24, to the Navy as PB4Y.

Present models armed with 10 .50 caliber machine guns.

Carries a crew of five to eight, more than four tons of bombs.

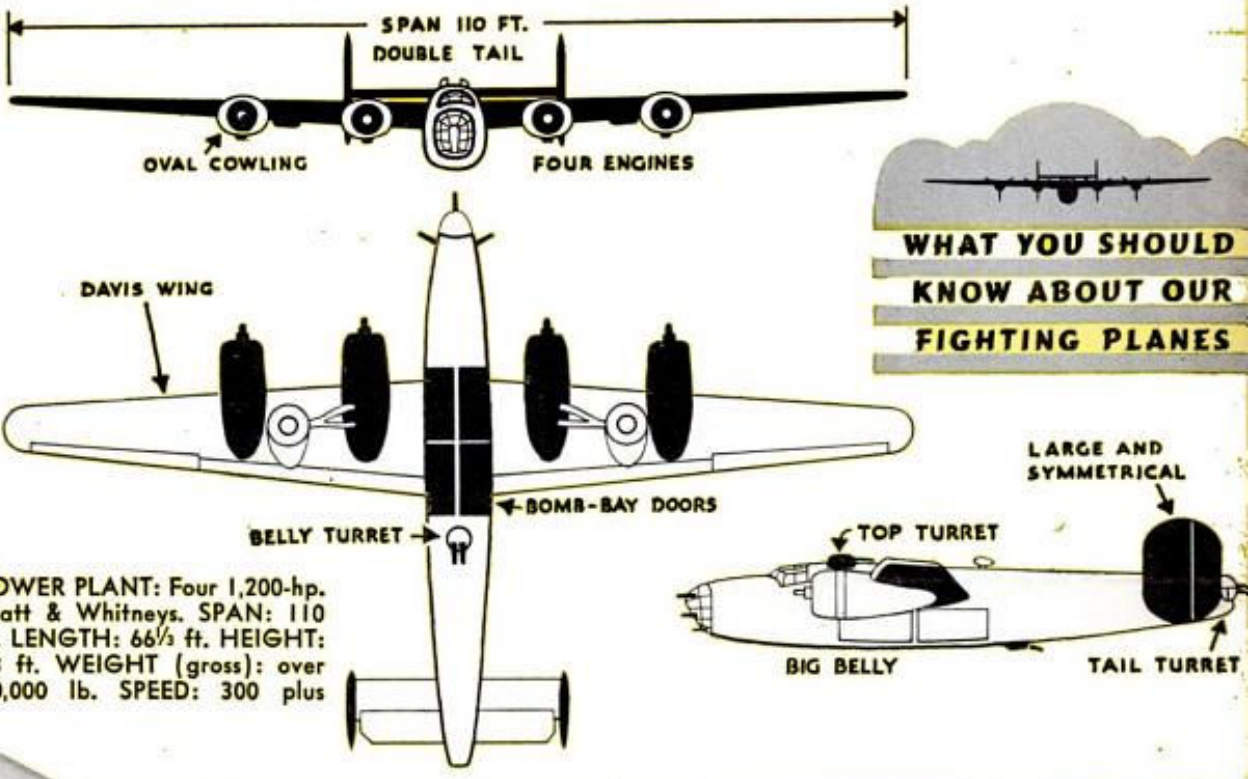
Service ceiling 19,000 feet, but is said to have bombed the Japs from 35,000 feet.

The LIBERATOR

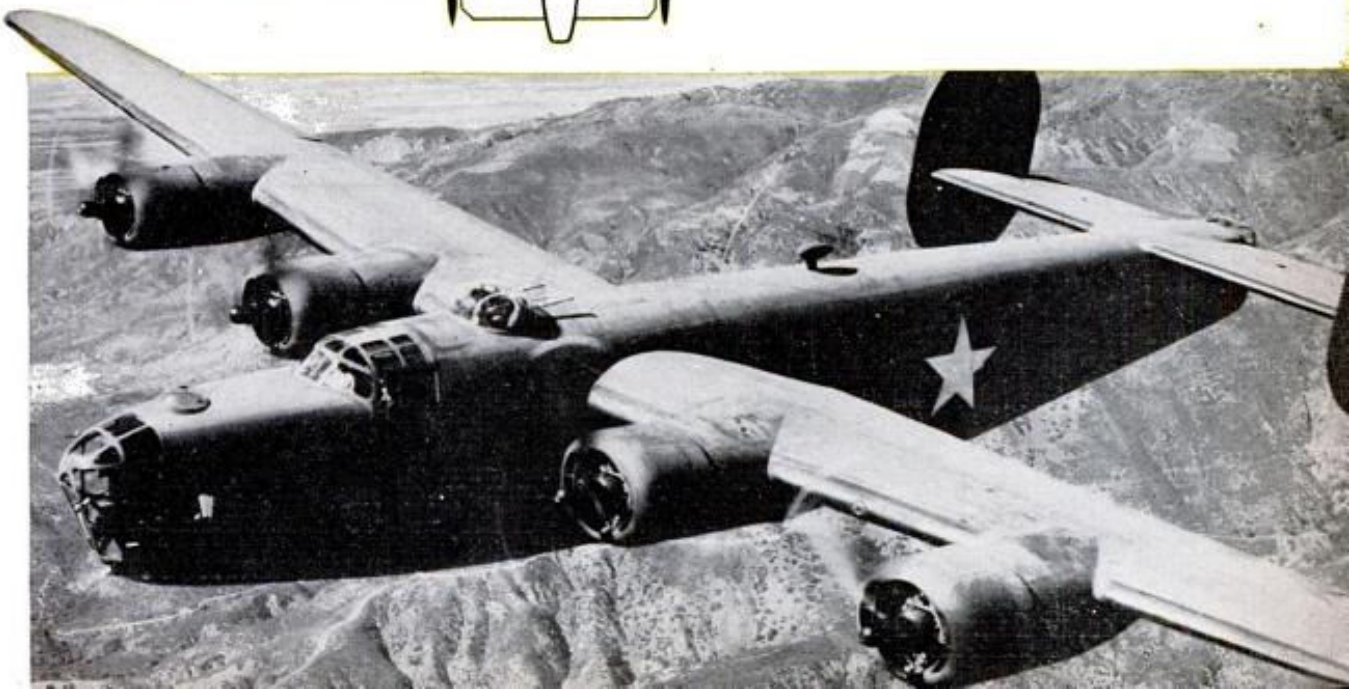
cial preservatives applied to the engines, lighter oils and hydraulic fuels poured into her tanks. For desert duty, special filters are installed to keep sand out of her induction and fuel systems. These modifications are made at several depots, and when they're completed, the Liberator is ready for the firing line.

During a brief battle career this four-engine monster already has proved her deadly efficiency. The British first used her to stalk submarines. They equipped her with depth bombs, and in a matter of weeks sank a large number of German subs in the Bay of Biscay alone. Almost before the camouflage dried on her rounded belly, every Englishman was convinced she was in truth a Liberator.

Improved Liberators began to reach American battle lines in mid-1942. Almost overnight, great stories of their hard-hitting



WHAT YOU SHOULD KNOW ABOUT OUR FIGHTING PLANES



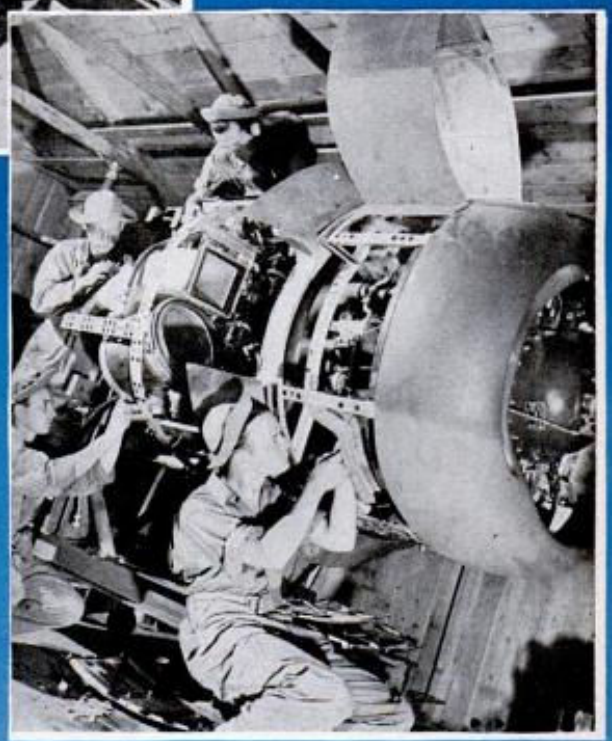
accuracy with bombs of all sizes began clicking across the cables and radio. Bombs from Liberators rained on Roumanian oil fields last June. That was a pasting heard around the world, for it announced that Uncle Sam was about ready to tackle Europe with daylight raids, sending over increasing numbers of precision bombardiers. Soon the Liberators' attacks increased in both the Far and the Near East.

You'll have to skip around the map a bit to follow their trail of destruction. Liberators helped punish the Japs at Attu, Agattu, and Kiska, stemming a northern advance that might have doomed Alaska and threatened the American mainland. Working with Lockheed P-38 Lightnings, the Liberators made sweep after sweep over Kiska, sinking Japanese transports, destroyers, and cruisers; wrecking important military installations; kindling large fires and spreading terror among the little brown enemy. Punching holes in enemy installations and ships from six miles up became commonplace.

Meanwhile, American airmen riding high in Liberators swooped across Libya and began slugging Axis shipping in Suda Bay, Crete. Other squadrons started dogging Rommel, unloading hot cargoes on Tobruk, strafing shipping with their bombs and machine guns, and making deadly passes at German and Italian tanks. One returned to its base carrying 200 bullet holes, but was

CAMP CONSAIR TRAINS MECHANICS TO SERVICE LIBERATORS

Retired to school service after being damaged in a fire, this Liberator with its fuselage and nose panels removed gives the student mechanics a good idea of the location of all the complicated parts of the ship they are to service. In classroom shops, like the one shown below, they overhaul and repair 1,200-horsepower engines, doing all the jobs they will encounter when they work on the big bombers on the war front



IT TAKES 15 highly trained mechanics to keep one Liberator in the air. To insure adequate ground crews for our armadas of B-24's, Consolidated Aircraft Corporation, originator and one of the builders of the plane, co-operate with the Army in operating a mechanics' training school at a California plant. Called Camp Consair, this school takes men from basic mechanics' schools and from the Army, and gives them several weeks of intensive training in the maintenance and overhaul of the big bombers. As a graduation present, each man is offered a ride over southern California in a Liberator he has helped to put in good working order. Acceptance is voluntary, but who would dare refuse to fly in a plane that he had helped to fix?

still flying and fighting when the enemy disappeared.

In a matter of days, Liberators bombed three Italian cruisers in the harbor at Pylos, Greece; joined the Russian air force at Sevastopol; smashed at Bengasi; laid more than 50,000 pounds of steel eggs in a second slap at Suda Bay; roared over France to attack Lille, Saint Nazaire, and La Palisse; smashed installations at Hong Kong; raided the Linshi coal mines in China. Now they are hitting at the Axis in Tunisia, delivering supplies and fighting men to distant Allied Pacific bases, striking the enemy wherever he can be found.

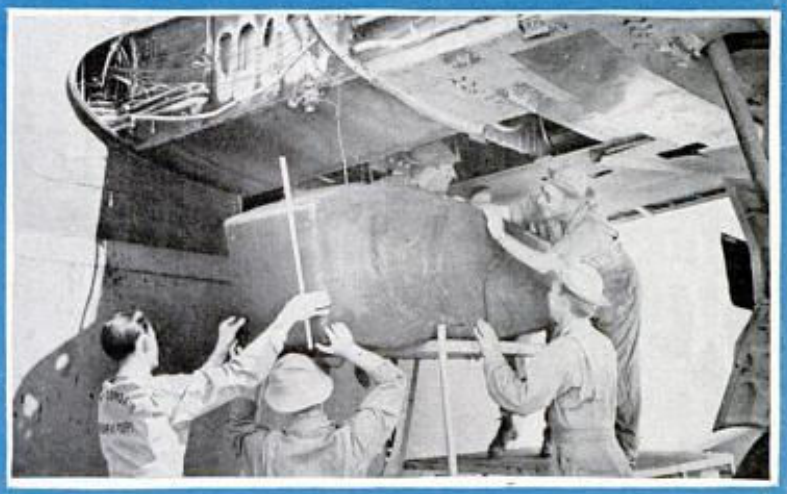
Hitler never will forget that Lille affair. It was on October 9, 1942, when 115 Liberators and Fortresses made a tight-formation attack. Five hundred fighters accompanied them part way, then swung aside to shoot up several airdromes, hoping to lure German fighters away from the main attack. The bombers smashed a plant engaged in building 150 main-line locomotives a year, downed 48 Focke-Wulf and Messerschmitt fighters, damaged and probably destroyed 59 others. American losses? Two Liberators, two Fortresses.

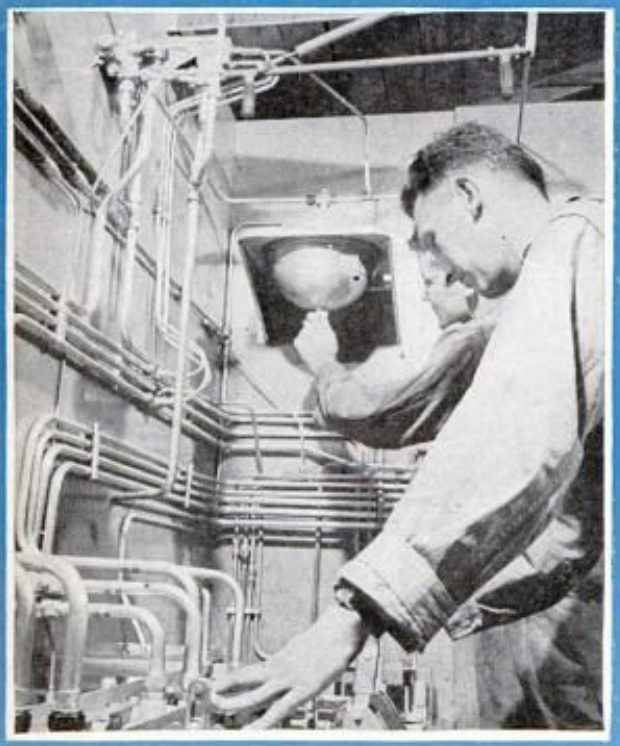
Though her guns are deadly, her wing is the real secret of the Liberator's success in waging long-range aerial warfare. We've got to go back a bit for that story.

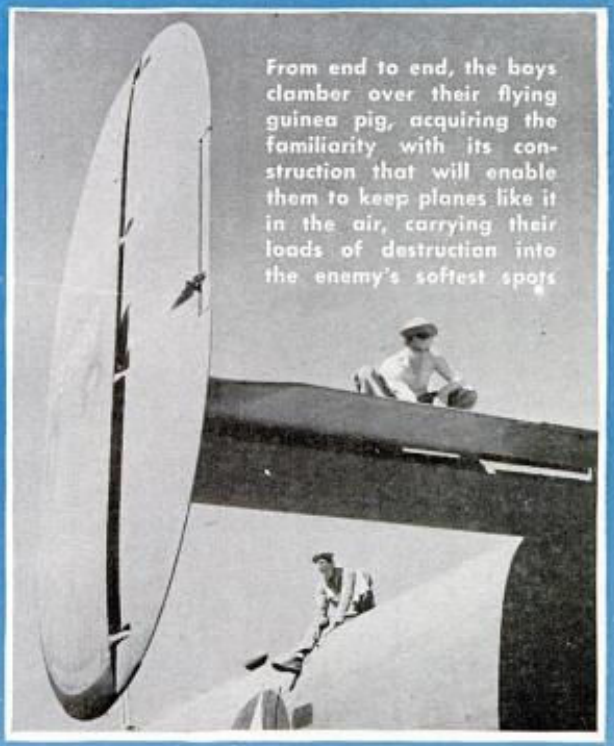
In the fall of '38, the Air Corps, scanning the coming clouds of war, wheedled from

IN THE FIELD

At the right, students take out one of the self-sealing fuel cells. Another feature that gets plenty of attention is the hydraulic system. In a mock-up system that exactly matches the installation in the B-24, they trace the maze of pipes and learn just what each part does when the ship is in flight. Below, one of the mechanics examines the ball-shaped pressure accumulator while another trips a control that sets an electric motor spinning with a pump







From end to end, the boys clamber over their flying guinea pig, acquiring the familiarity with its construction that will enable them to keep planes like it in the air, carrying their loads of destruction into the enemy's softest spots

FIRST LIBERATORS to reach England looked like the camouflaged submarine hunter at left. Note the absence of top and tail guns, which were added later. Below, a modern B-24 loads up for a raid at a U. S. Army Air Forces station in England. The men are preparing a 1,000-pound present for Hitler. In a raid on Lille, France, in company with Flying Fortresses (115 planes in all), the Liberators helped wreck a big plant building locomotives for the Nazis. Incidentally, they and the B-17's brought down or damaged 107 German fighter craft

Congress an appropriation to raise our force of military planes from 2,500 to 10,000. Of these only 100 were to be big bombers. Lieut. Gen. H. H. Arnold, Chief of the Air Forces, ordered 100 Fortresses, the only big fellows then available, and induced Boeing and Consolidated to make them, one by Consolidated for every two by Boeing. Then the Federal lawmakers whacked the appropriation in half, Boeing got the order, and Consolidated sat out in the cold.

But Arnold had a substitute plan ready. He called Edgar N. Gott, Consolidated vice-president, and asked, "Can you fellows turn out a long-range land bomber, and how soon?" "We can deliver a bomber in nine months," Gott answered promptly. All he had to rely upon for the promise was Consolidated's experience in building the Model 31 long-range twin-engine flying boat. Bombers those days could scarcely clip off 1,200 miles. Gott knew he'd have to turn out one capable of reaching Ireland or Hawaii, in order to meet the demands of the changing pace of air war.

Nine months and 10 acres of blueprints slipped by, and the B-24 arrived. Would she deliver, as the Army demanded, 307 miles an hour top speed, reach a 30,000-foot ceiling, cruise at 220 m.p.h. three miles up, and maintain a three-mile altitude with two engines out? Could she cruise 3,000 miles without refueling?

Her slick aluminum skin shone brightly in the California sunshine, her tail arched gracefully from her plump belly, her wings stuck out stiff and stark. She was slightly on the heavy side, but on that warm California morning she flew gracefully, and that instant was recorded a series of firsts which marked her an airplane to be reckoned with. For the Liberator was the first heavy plane to use tricycle landing gear, first to employ Hamilton hydromatic quick-feathering three-blade propellers, one of the first to use Model R-1830 1,200-hp. Pratt & Whitney radial engines. *(Continued on page 210)*

THE "EXPRESS LIBERATOR": A CARGO-PLANE VERSION

An adaptation of the B-24 for cargo and personnel carrying, the C-87 "Express Liberator" makes scheduled ocean runs transporting officers, ammunition, and repair parts to the fighting fronts. It carries a pay-load cargo of 10 tons with speed above 300 m.p.h. Lieut. Gen. H. H. Arnold, chief of the Air Forces, is seen at right inspecting the interior of a C-87

LIFE RAFTS CAN BE RELEASED FROM INSIDE OR OUTSIDE PLANE

In addition to its deadly destructive power, the Liberator has many features to provide for safety. One of these is the ingenious arrangement shown at the right, by which life rafts can be released from the outside when the plane is forced down on the water. Release handle (A) on back of plane operates the life-raft door-locking mechanism (B) and a cradle compression spring (C) tosses the raft out. The drawing below shows location of doors, hatches, fire extinguishers, and other factors in safety for personnel