In the Service of America

FORD MOTOR COMPANY • DEARBORN, MICHIGAN

3


PRODUCTION STARTS HERE
FORESTS
SHIPPING
STEEL MILLS
PRODUCTION PLANNING
ENGINEERS
MINES
VILLAGE INDUSTRIES
ROUGE PLANT
FORD
FINAL ASSEMBLY

Foreword

During the summer of 1940 a youth, shouldering a heavy basket, paused to survey row upon row of crisp green vegetables maturing under the sunshine at Camp Willow Run. He was a future farmer, learning the ways of the soil under guidance of farm experts provided by Henry Ford. The soil had been kind, and 1940 saw a bumper crop.

That was a year of plenty. America sent her children to school. Highways hummed with transport from farm to market. Family cars sped through the towns, and on to vacation centers, while farmers planted, tilled and harvested. This was America the beautiful.

This, too, was America the bountiful, and Henry Ford and the Ford Motor Company were enjoying their thirty-seventh year in the service of America. Together, man and company, they trained youth in mechanics and the use of tools, opening new opportunities and encouraging the spirit of enterprise and individual endeavor.

More than thirty millions of the automobiles, trucks and tractors seen along the highways up to that time were products of the Ford Motor Company. Each succeeding model was the answer to an economic, social or transportation problem. Henry Ford and the Ford Company had but one purpose—to excel in the service of America.

Thunderheads of European turmoil rolled over the horizons in that year. The world's moral fiber was strained to breaking point. The strands snapped one by one and on December 8, 1941, we were at war.

These were times that tried men's souls. The cry for arms went 'round the globe. Schools became training centers; industrial plants became war plants; peaceful production ceased and as demands increased, available manpower decreased, until even the home-makers left their firesides to stand beside their husbands at drillpress and lathe. This was not the Ford way of doing business, yet a determination swept through the organization—to continue to excel in service to America.

We achieved. Massive tanks rolled off the line. Jeeps and army trucks took over space where once automobiles were born. Aircraft engines

emerged from an air conditioned building, and on the cabbage patch where the youth stood arose the world's largest bomber plant.

Although devoted to peace and humanitarian pursuits the Ford Motor Company had now diverted its abilities and resources to building machines whose purpose was destruction. That is the penalty of war.

Yet out of all this grew an opportunity to justify once more the nation's trust in the Ford name. Since weapons must be built, we at Ford determined to build the *fastest* bombers, the *safest* tanks, the most *dependable* engines, so that our youth who fought might have more than an even chance, and to build in such quantity that never again could it be said: "too little and too late."

To assure this to our boys we produced *finished* products. Bombers were flown away completed. Tanks, trucks, Jeeps rolled out in fighting form. We did not approve of "bits and pieces" production, for our policy was to approach perfection as nearly as was humanly possible.

This volume presents the simple story of our arms production, our efforts toward lasting peace. It is compiled with the hope that during these years of peace we shall continue to achieve equally as well *In the Service of America.*

WILLOW RUN

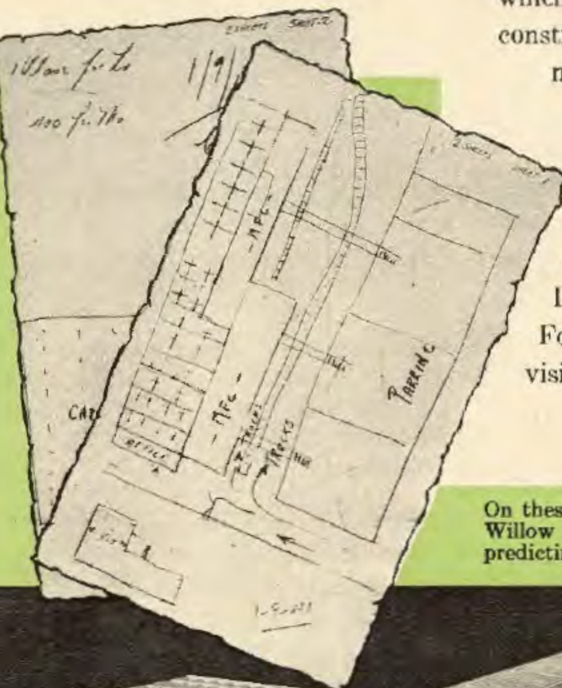
WILLOW RUN represents the first application of precision mass production and engineering to the building of airplanes. As the pioneer of modern continuous-line manufacture in great volume, with all its attendant benefits of low costs and interchangeability of parts, the Ford Motor Company was able swiftly to translate this principle into a steady flow of airplanes at the rate of a completed bomber an hour.

A brief analysis of the total task which the engineering, designing, constructing, equipping and manning of Willow Run involved, is perhaps the simplest way to arrive at an understanding of the achievement which Willow Run represents.

In January, 1941, Edsel B. Ford and a group of Ford officials visited the Consolidated Aircraft Corporation plant in San Diego, California. Their purpose was to study the technique then being followed by Consolidated in the production of the B-24 "Liberator" bomber and to consider how best to apply the methods and short-cuts learned in 40 years of automobile production. Upon analysis, the job was recognized as involving:

1. The devising of a new technique.
2. The design and construction of a vast number of new fixtures and machine tools.
3. The building of an extremely large new airplane plant, with an adequate airfield adjoining.
4. The setting up of a new organization, and the training of its personnel in a totally new field.

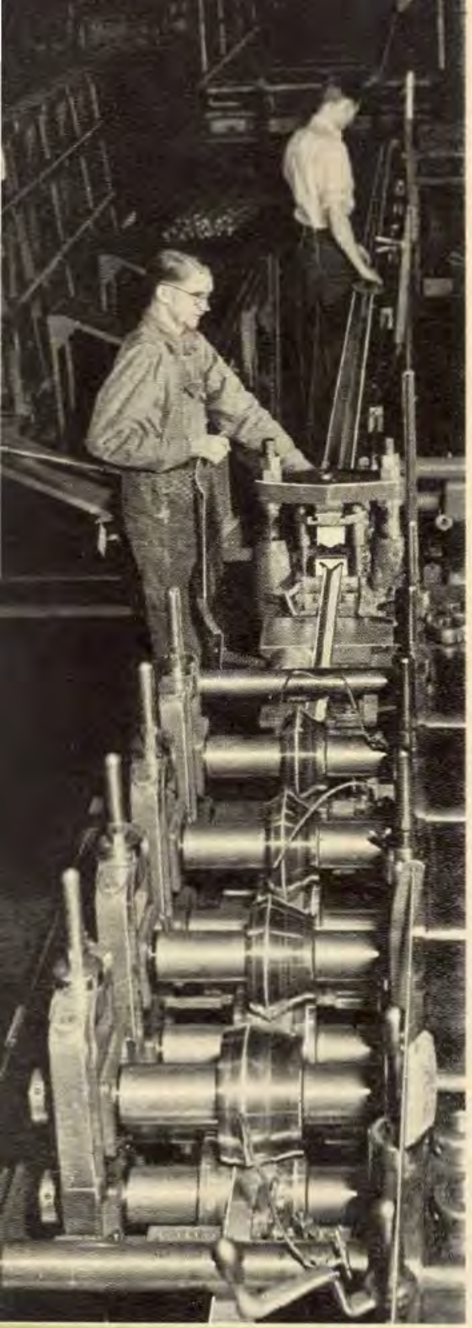
First step in determining the size and general layout of the new plant that would be required was a "breakdown" of the B-24 itself into its logical major component assemblies. It was discovered that the ship could be reduced to some seventy items which could be assembled separately. Further breakdown of these seventy assemblies into smaller operations made possible a concentration of workers for



On these sheets was the original concept of Willow Run. Note the date, and notation predicting a bomber an hour or 400 a month.

Speed in building the bomber plant did not mean haphazard construction. A scale model showed the location of every steel beam, window and craneway before construction started.

When completed Willow Run was the largest single manufacturing operation that had ever been housed under one roof.



A Liberator began here. This former shapes aluminum strip into channel beams and ribs. Later, these are stretched to size, making them stronger.

each of the many successive steps.

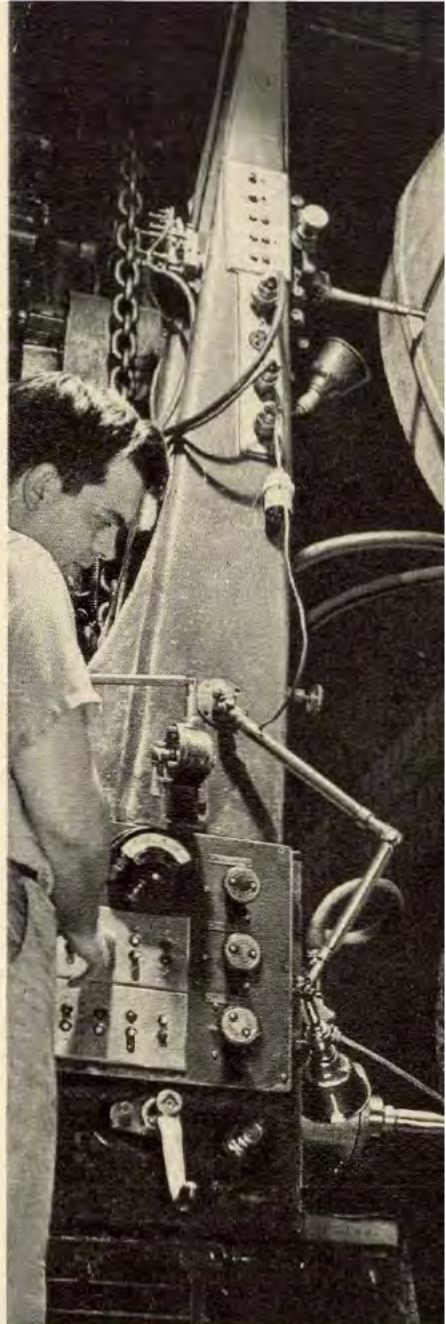
When the facility requirements for all of these varied operations were translated into terms of floor space, it called for the largest building of its kind ever constructed. It was 1,278 feet wide and 3,121 feet long. Simultaneously, an adjoining airfield of 1,379 acres, with more than 280 acres of concrete in its apron and runways, had to be built. The construction job was completed on December 4, 1941, only 94 working days after the start. A total of 33,000 tons of structural steel, fifty miles of steam piping, five million bricks and sixteen million creosoted wood flooring blocks were needed. The airport runways would make a two-lane, 20-foot concrete highway 115 miles long.

Tool-up of the plant began before construction was completed—indeed, some parts production was under way at Willow Run before the plant was fully roofed. More than 2,600 machines and 8,000 fixtures had to be made and installed. This alone called for more than 7,500,000 man-hours.

Since mass production of heavy bombers had never before been attempted, the principal tools and fixtures required at Willow Run had to be designed. Many of these resembled nothing ever built before. Characteristics were their great size and enormous weight, and consequent rigidity. Although the Willow Run tooling cost Ford several times that of a comparable plant using old-line aircraft production methods, Willow Run produced *in a few days* bombers worth the total cost of tooling.

The relatively small additional investment paid for itself many times in terms of greater numbers of heavy bombers when heavy bombers were needed most.

One example of the modifications in basic mass production procedure is in press work. When a press is put to work on an automobile part and the dies have been finally set and checked, the press may be run for

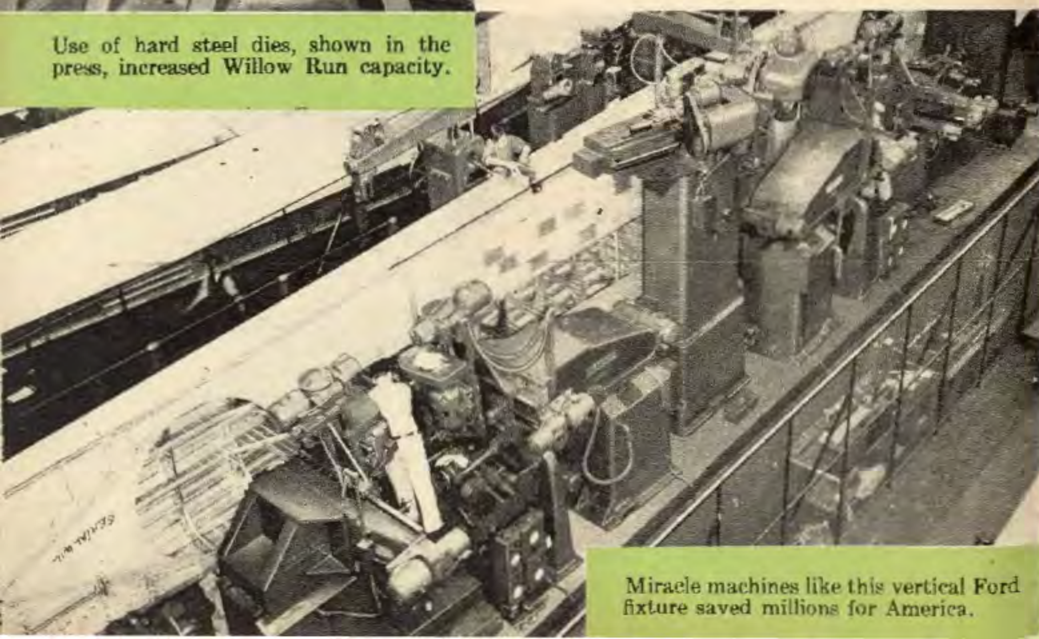


This massive chunk of steel is being engraved into a die according to the upper pattern. It was used to stamp out framework of the pilot's enclosure.

These presses formerly made automobile bodies, helped meet bomber quotas.

Use of hard steel dies, shown in the press, increased Willow Run capacity.

weeks without change, because hundreds of thousands of those parts may be required. A similar press, forming an aluminum part at Willow Run, might easily produce in a few days a sufficient quantity of that particular part to feed the bomber production line for months. As a result, the process of die-setting went on continually. More than eight thousand die changes were made every forty days at Willow Run. Thousands of pairs of these hand-graven steel dies were kept convenient to the presses ready for intermittent periods of service, to assure a constantly replenished



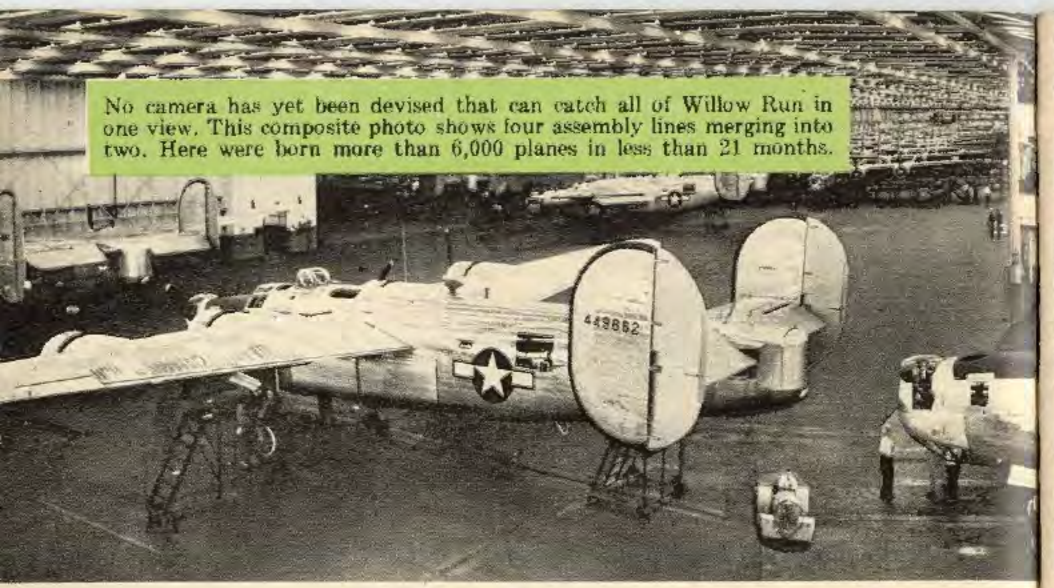
Miracle machines like this vertical Ford fixture saved millions for America.

An automobile is dwarfed by the center wing section. This view gives an impression of Ford automotive assembly methods adapted to mass production of aircraft.

stock of parts. Steel dies were a costly innovation in aircraft, which heretofore had used only soft rubber dies, but their economy and precision were eventually proved.

An example of what Ford production engineering and tool designing achieved at Willow Run is illustrated in the method of assembling the center wing section of the Liberator. This section is 55 feet long. It supports the fuselage and the four engines as well as the racks

Fuselage sections gleam under fluorescent lights ready to move to final assembly. Extra sections are on balcony.



No camera has yet been devised that can catch all of Willow Run in one view. This composite photo shows four assembly lines merging into two. Here were born more than 6,000 planes in less than 21 months.

which carry four tons of bombs. Also it houses the twelve main fuel cells and six auxiliary tanks in addition to retractable landing gear mechanism. Truly it is the "heart and lungs" of the great bomber.

By standard practice, 5,500 man-hours were required to completely assemble the wing section. After Ford inventive genius had been ap-

Out from her hangar and into the night, this Liberator is ready for active duty backed by all the skills of Ford engineering and workmanship.

plied to the problem, this time was reduced to 460 man-hours.

This was accomplished by enormous vertical fixtures performing many automatic operations, which bored, reamed, faced, threaded and checked for tolerance in one operation, at the same time holding the entire section in perfect alignment for hand riveting. Under standard

Her landing gear almost retracted, a Liberator, after taking off soars away into the blue, destined for her maiden voyage and test flight.

practices 250 man-hours were required to assemble and dismantle a wing fixture alone. Ford did the job in two minutes. Also under standard practices thirteen days elapsed before a wing section was ready to move. Ford was able to complete the cycle in fifteen hours.

All of this helped Ford achieve the goal of a bomber an hour when bombers were needed most, and also this one tooling improvement saved our government more than ten million dollars.

It is but one example of how the Ford method treats a sub-assembly containing 6,439 individual parts held together by 78,606 rivets and 1,000 bolts, and weighing approximately two and a quarter tons.

Not all work at Willow Run is large-scale. Here a woman adds a tiny part to a tiny tube which will fit into the bomber's complicated "nerve system." Such tubes carry wires, oil, fuel and hydraulic fluid.

Ford-built Aircraft Engines

A $27,000,000 air conditioned building was constructed in record time in spite of winter weather. The entire structure was housed in a weatherproof "cocoon" so that work could proceed. Ground breaking ceremonies were held September 17, 1940, and the building was completed and ready for use March 17, 1941.

REPRESENTING perhaps the most exacting of all large-unit, close-tolerance manufacture, the aircraft engine had always been produced by what was essentially a toolroom procedure. This method was slow, required additional man-hours in nearly exact ratio to any increase in output, and greatly interfered with interchangeability of parts.

Therefore the Ford Motor Company's assignment to build the 18-cylinder Pratt & Whitney 2,000-horsepower engine in quantities never before considered, called for a total change in production technique. The original Ford schedule calling for 1,800 engines a month, was increased to 3,400 a month.

Parts production, sub-assembly and final assembly were synchronized and routed in accord with principles developed in forty years of Ford automobile manufacture. Specially designed multiple-purpose machines turned out the individual parts. These passed from machine to machine until finished and inspected, then were conveyed to sub-assembly lines, where engine sections were assembled before passing on to the final assembly line.

The final assembly line ran at right angles to the sub-assembly lines, picking up parts, finished castings, sub-assemblies and accessories in the sequence in which they were added to the finished product. These small parts, in turn, were scheduled to arrive at the final assembly station at proper intervals, assuring a balanced rate of production that had been developed into a science during automobile manufacturing.

It was because of this knowledge and painstaking planning that a steady continuity of aircraft engine production was achieved. Beginning with raw materials, parts flowed in a planned direction. Each machining and inspection operation took the part nearer the finished engine, moving steadily toward test cell and shipping dock with a combat zone as its ultimate destination.

After an engine had undergone a test run it was torn down, precision inspected, rebuilt and sent to duty. But during the test run Ford conserved the nation's natural resources by coupling each engine to a generator, thereby providing the modern, air-conditioned Aircraft Building with the electric power used to operate the machinery.

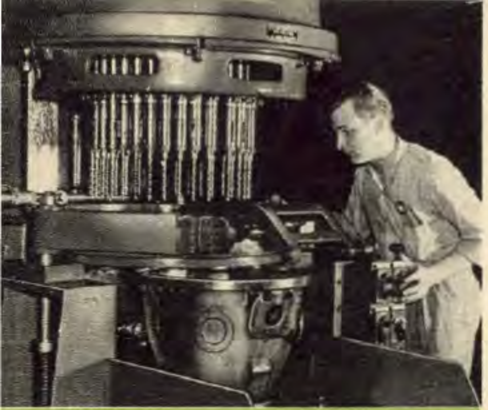
Many Ford advancements in processing and machining also contributed to outstanding results.

Individual cylinder barrels were formerly forged. Ford applied centrifugal casting, making a better barrel, reducing machining time and cost of equipment, releasing machines for other uses, and saving 35 pounds of steel on each barrel.

Barrels are threaded for attachment of cylinder heads—an operation formerly requiring six successive cuts for a full-depth thread. Ford methods finish-cut threads in one operation.

The cylinder muffs—finned exteriors which enclose the barrels—required eleven minutes' machining time for inside finish. Ford-designed

The Pratt and Whitney engine required precision in every detail. To power many of the most famous of America's fighter planes Ford turned out these 18-cylinder engines on an automotive mass production basis.



Multiple tools are used at Ford. This machine drills forty holes at one time.

These cylinder head assemblies for one engine are lined up awaiting inspection.

tools reduced this to four minutes, while machining time on the fins, supposedly an operation impossible to simplify, was reduced from 66 minutes to only 26 minutes.

Combining the boring and face-reaming operations speeded preparation of barrel flanges for assembly by more than 300 per cent.

Crankshaft machining was accelerated by the addition of auxiliary tool holders to milling machines, and the elimination of seven tool changes and two hours of counterboring by setting up a six-spindle machine to bore flyweight holes.

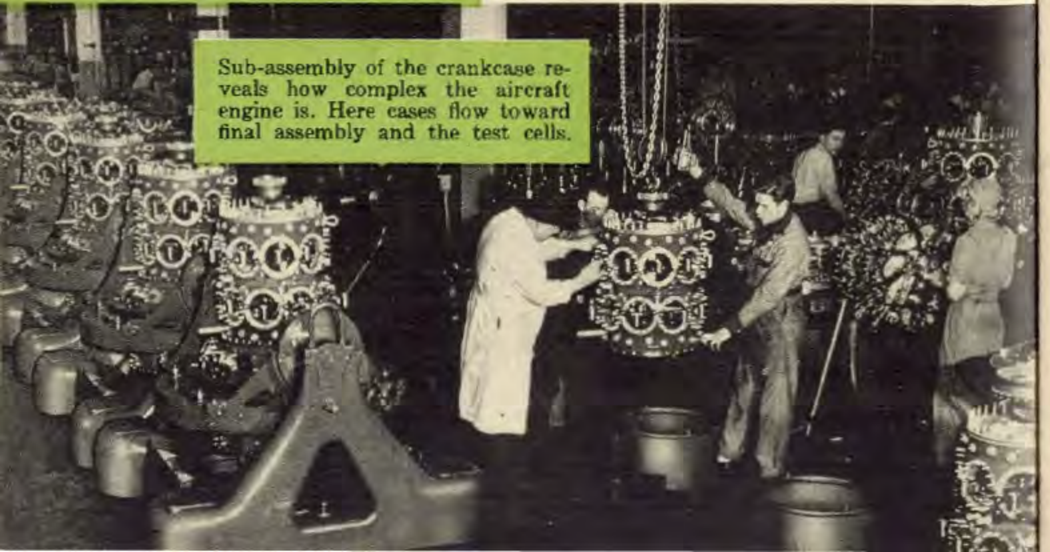
Similar multiple machining was applied to production of propeller shafts, connecting rods and rocker arms, as well as to painting, plating, inspection and test running. Resultant savings in man-hours and materials ran into tremendous figures.

Precision operations were not limited alone to the Aircraft Building at the Rouge plant. A vast amount of parts and sub-assembly work was done in branch plants and Village Industries which required entirely reorganizing and retooling of these facilities. Rough castings were shipped to these branch plants where they were worked into finished parts, then returned to the Rouge plant for final assembly. It was one of the first evidences of decentralization during the war.

Much of the improvement over former standard practices in aircraft engine manufacture was the result of constructive independent thinking on the part of Ford employes, rather than deliberate production-engineering research. These men, intensely eager to do their patriotic best in the service of America, applied to their problems a wealth of practical experience. In the true American tradition, they met necessity with invention.

Centrifugal casting of cylinder barrels results in better quality, less machining, and saves metal. It is a Ford innovation.

This electronically-controlled tool prevents breakage as it drills small holes.



Sub-assembly of the crankcase reveals how complex the aircraft engine is. Here cases flow toward final assembly and the test cells.

Like a gift for the boys in combat this engine is packaged for shipment.

DISTRIBUTOR HEAD

A new type distributor head that enabled fighter planes and bombers to fly at much higher altitudes was another Ford Motor Company achievement. The problem was to produce a head light in weight, arc-proof, moisture-proof and durable, using tools at hand.

After research had proved the stamina of a new design, a thermo-setting plastic material was selected. On presses which formerly turned out plastic automobile parts Ford produced these complicated heads for new engine production and for shipment all over the world to replace other heads.

By increasing the distance between electrodes, efficiency was increased 300 per cent, and failure of these metal inserts virtually was eliminated by use of single cold forgings.

Increasing arc resistance in the ignition systems of aircraft engines becomes of greater importance as planes increase their ceilings. As the density of the air decreases at higher altitudes, electrical impulses have a greater tendency to short-circuit or "arc" from one point to another. Each Ford head was tested under simulated conditions of maximum altitude to withstand 12,000-volt resistance.

The Ford distributor head is shown coupled to the complete ignition wiring system, undergoing tests. Inside construction of this improved head may be seen at left.

Final supercharger assembly line was "manned" by women. This delicate, balanced mechanism was assembled in a dust-proof, air-conditioned department where automobile bodies were once built.

SUPERCHARGER

Turbo-superchargers are delicately machined turbines which force air into aircraft engines to obtain greater horsepower at high altitudes. Using the General Electric Company's design Ford turned out thousands of these machines in a section of the Rouge plant where automobile bodies were built, constantly reducing cost to the government and conserving materials.

Ford successfully substituted low carbon sheet steel, of which there was plenty, for 37 pounds of scarce aluminum in construction of the compressor casing.

Another improvement was the butt welding of the forged wheel and shaft in the rotor assembly, reducing to one piece what formerly was a precision fit of the two pieces held together by three bolts. This was a vital safety factor, since the wheel and shaft, weighing 22 pounds, spin at more than 20,000 revolutions a minute. Small buckets welded to the rim of this turbine wheel convert the engine exhaust velocity into power to turn the rotor.

Ford engineers also made several contributions toward redesigning the original fabricated nozzle box, parts of which also were stamped out on body presses. Spot welding and seam welding technique of automobile manufacture were applied in building the nozzle box and the compressor casing. The reason again was to prevent engine failure which might cost a life.

The P-1 aircraft generator for the nation's leading fighters and bombers was built at the Ypsilanti village plant. Here is the final assembly operation.

GENERATOR

Production of thousands of P-1 aircraft generators, each capable of providing the electrical needs of several houses, was achieved by the Ford Motor Company village industry plant at Ypsilanti. The big 28-volt, 200-ampere generators went into eight different planes including the Ford-built Liberator bomber.

Ypsilanti plant also produced more than 150,000 generators and 240,000 starters for Jeeps and Amphibian Jeeps. Approximately 30,000 generators of 30 volts and 50 amperes were built for tanks, armored cars and universal carriers, and several thousand starters for the latter Ford-built vehicle.

The Ford bomb service truck is an example of the readiness with which the automobile industry found itself when war demands cut off peacetime production. Slight modification of a Ford truck produced these bomb derricks for the Army Air Forces on short notice.

The armor plated "mule," or as it is technically termed, the Ford Moto-Tug, is shown here towing the 6,000th Liberator bomber built by Ford from the hangar for its test flight.

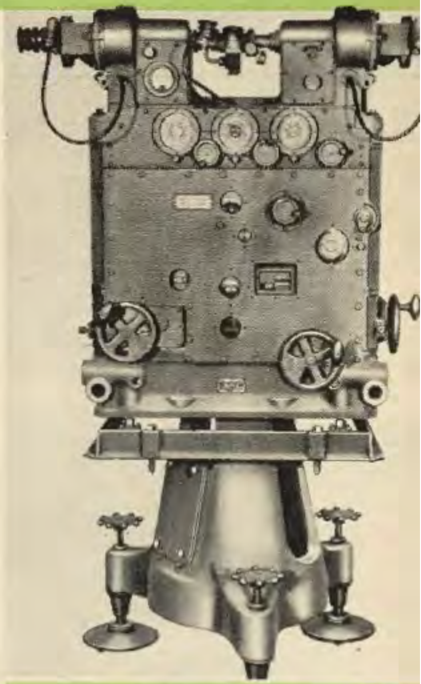
MOTO-TUG

The armor-plated "mule," or Moto-Tug, is a small, compact, highly maneuverable industrial tractor designed to push, pull and haul material aboard aircraft carriers, on beachheads and at Navy airfields.

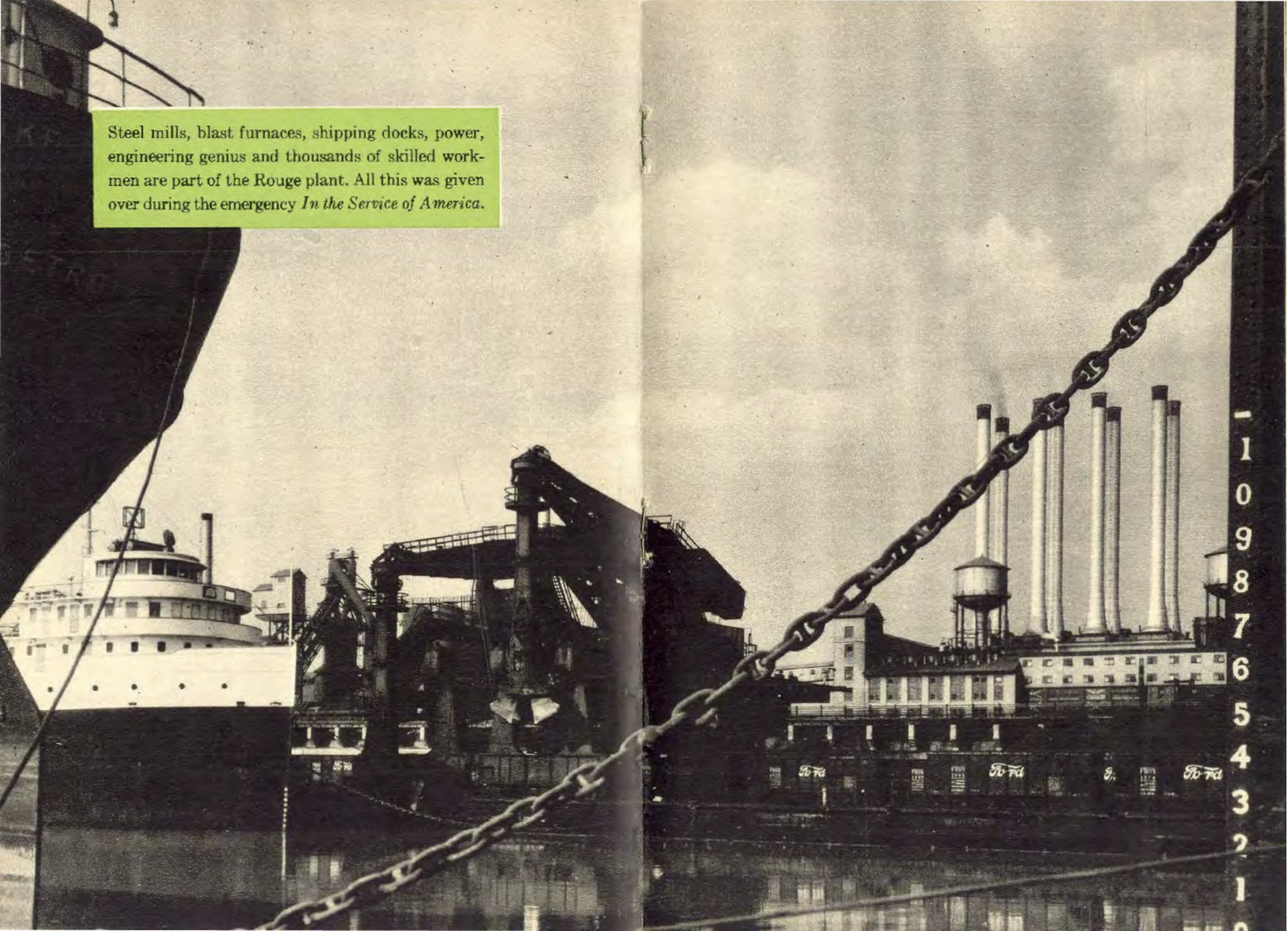
Tooling up for the Moto-Tug was completed and production started within 60 days.

To develop the Moto-Tug, engineers modified a Ford tractor, building it narrower and lower to make shorter turns and run under an airplane wing. Special weights were added to give more traction.

The unit weighs 3,600 pounds and has a draw-bar pull of approximately 2,500 pounds.



Such a complex high-precision mechanism as this anti-aircraft gun director was not easily produced in quantity. But Ford engineering solved the problem, meeting all quota requirements.



Steel mills, blast furnaces, shipping docks, power, engineering genius and thousands of skilled workmen are part of the Rouge plant. All this was given over during the emergency *In the Service of America.*

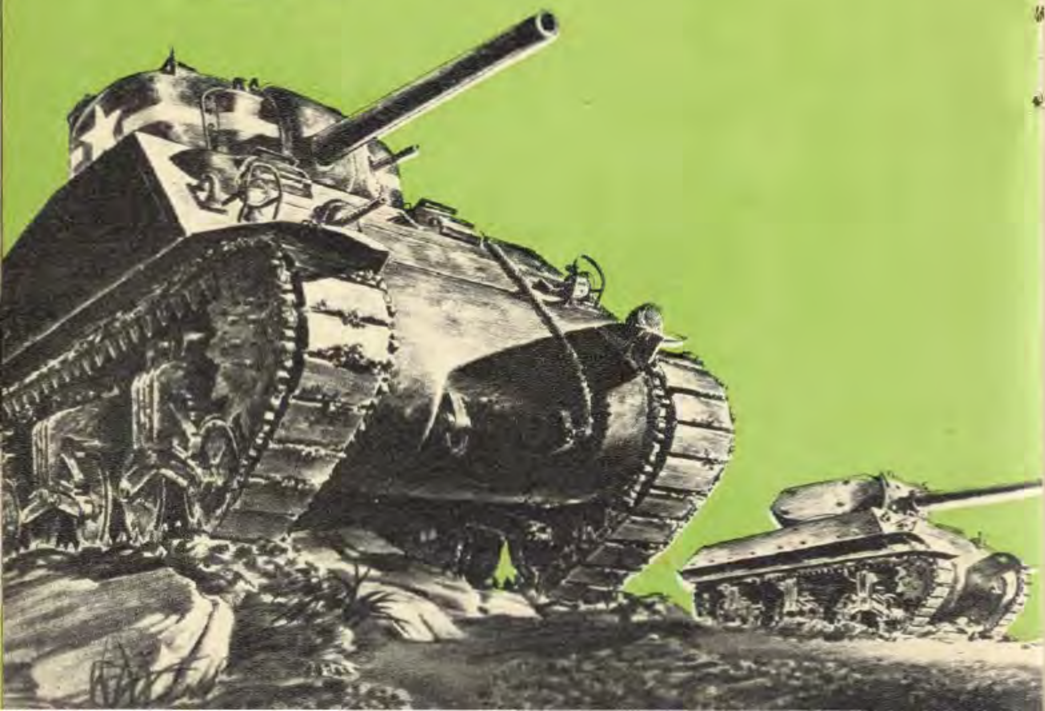
"M-10"

Universal Carrier

"M-4"

"M-8"

4 Famous Ford Armored Fighters



The M-8 Light Armored Car designed for speed, stamina, firepower and low silhouette.

FAST MOVING Allied armies, beginning with the African campaign, required rolling fortresses capable of traveling up to 60 miles an hour. They had to be heavily armed for the offensive, and armored for defense. Also, they had to be adapted to widely varying terrain, dependable in action and easily serviced.

The Ford Motor Company combined engineering skill with the Army's creative mind. Out of this combination grew the exclusive Ford combat vehicles—the M-8 Light Armored Car, the M-20 Utility Command Car, and the Universal Carrier—along with the superior M-4 General Sherman tank and the M-10 Tank Destroyer. History was written with these vehicles. They, too, were adapted to automobile assembly line procedure for mass production.

Known as the "armored greyhound that hugs the ground," the M-8 was designed for speed, low silhouette, firepower, and to be able to outrun anything it could not outshoot. It was built in the company's Chicago and Twin City plants in volume always ahead of, or equalling, Army schedules. It is a seven-ton car which can travel 55 miles an hour over almost any terrain, and is capable of climbing a 60 per cent grade.

Its enormous traction is gained by being driven through its six wheels, equipped with pneumatic tires. However, when the going is less difficult, the front axle drive may be disengaged.

Designed for scouting and longrange cruising, the M-8 mounts a 37-mm. anti-tank gun as well as a .30 calibre machine gun. It has a revolving open-topped turret, and the crew is protected by armor plate and other protective devices. An all-welded hull enables the vehicle to travel through water 32 inches deep, and it has ample stowage space for provisions for its crew on several days of independent scouting.

Widely used as a command vehicle by officers directing operations, the M-20 Utility Command Car is similar in construction to the M-8. It differs from the M-8 in that it has no turret, but carries a .50 calibre machine gun on a circular frame. It also has two radios, one for constant contact with headquarters, and the other to direct combat units.

The engine is cradled between two sets of power-driven axles, making the rear end of the car a four-wheel drive. The front wheels may be engaged, making it a six-wheel drive. The rear sets of wheels work on a bogey-type suspension, giving the car extreme flexibility. It is equipped with puncture proof tires and a self-sealing gasoline tank.

Another outstanding Ford vehicle was manufactured for the British through lend lease arrangements. It is the Universal Carrier, designed for both land and water travel, and recognized by the British as fulfilling all of the utility requirements performed by the American Jeep.

This vehicle runs on self-laid track constructed of a special steel alloy developed by Ford to withstand strain and abrasion at high speed. It is powered by either Ford 85-horsepower V-8 engines or Mercury 100-horsepower engines, depending upon the requirements and place of manufacture. The original British design was re-engineered by Ford for manufacture in the Somerville, Mass., and Windsor, Ontario, plants. Productive efficiency displayed on this contract won the Army-Navy "E" Award for the Somerville plant.

Another Ford contribution was the improvement of the M-4 Tank by substitution of a single casting for the final drive housing, replacing the three-piece housing formerly used. This eliminated heavy bolted flanges, smoothed the contour, allowed sub-assembly as a component part and assured better alignment

The M-10 is a fighting man's tank. It is fast, carries heavy firepower and is easy to handle in action.

A train load of M-4 tanks leaves the production line destined for the fighting front. Ford swiftly attained volume output of this unit.

This is a telescopic view of the tank assembly lines at Highland Park. On the left are the M-10 Tank Destroyers and on the right M-4 General Shermans near completion.

of the final drive mechanism, at the same time saving material, time and weight. As a safety factor too, this change also provided better projectile deflection.

Ford engineering also greatly improved the gun-mount mechanism, providing easier action and more room for the tank's personnel. Other Ford innovations eliminated cracking of welded seams at the turret ring, provided better locking of the gun in position when the tank is in motion, and reduced the hazards of fire and gunfire damage.

Ford departures also speeded output and conserved millions of man-hours. In one instance, 144 holes were drilled at one time—an operation formerly requiring three separate set-ups; in another case, three operations were combined in the tapping of 122 holes at one time. Addition of extra milling cutters saved an hour on each housing.

Only at Ford's were all shaft boring and spot facing on the carrier portion of a tank done in one operation instead of twelve. Production of carriers was increased approximately 110 per cent by Ford tooling improvements applied to boring mills.

The machining of end-covers, as well as drilling and tapping, was done on machines specially devised by company engineers, resulting in important saving of time in laying out and setting up the work. The adoption of flame-hardening in the heat-treatment of turret rings and hatch rings by Ford produced better rings in less time.

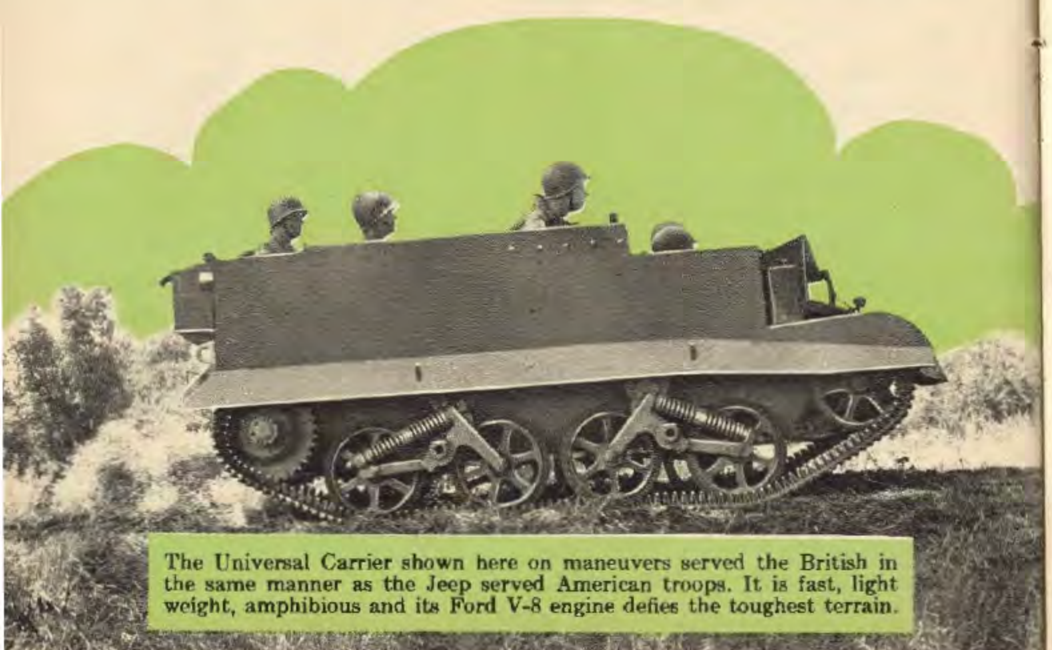
Another special portable machine devised by Ford, saved approximately three hours on each turret. Trunnion holes on turrets were bored and faced in one setting, through use of a double cutter head and a special fixture. A great deal of time was saved through a Ford-designed machine which swings around to present the work first to one operator, then to another, without handling.

All this has added up to more tanks, of a better quality, more quickly, at a cost to America of fewer dollars.

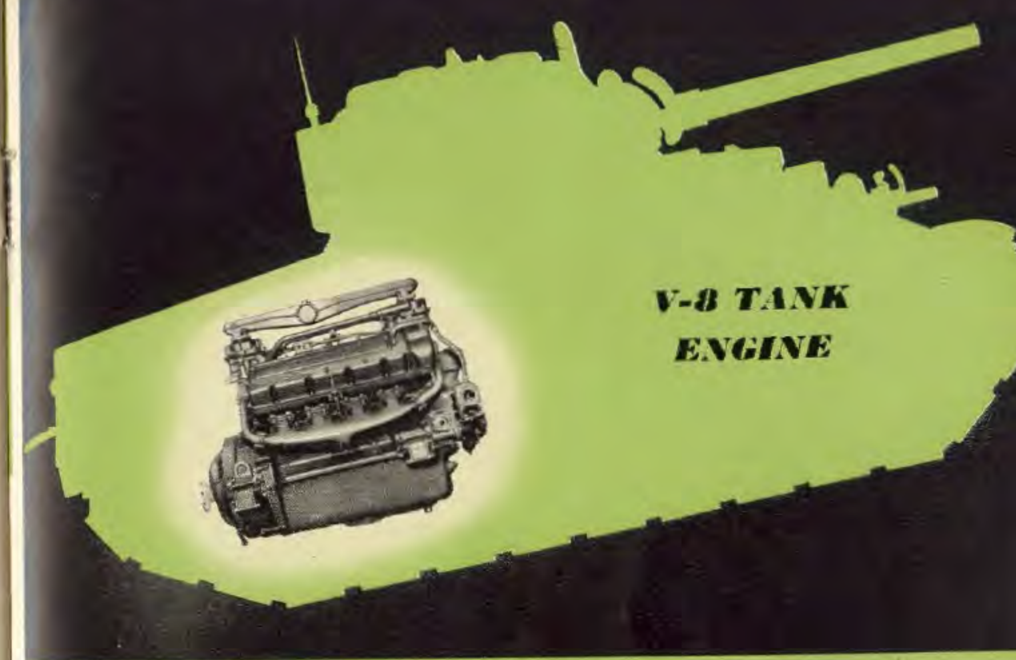
It is only logical that with the tremendous facilities at hand Ford should make the steel and process the armor plate that went into these various weapons. Here again developments continued and research progressed in the interest of safety, reliability and economy. Special alloys were introduced in critical parts, and a special Ford process was developed for manufacture of armor plate.

Formerly the alloy steel armor plate was heated to above its critical temperature, quenched in water to a predetermined hardness, then given a secondary heating at a lower temperature to impart toughness. The resultant plate was warped out of shape, and its newly-acquired properties of hardness and toughness of course made straightening extremely difficult.

In the Ford plant, *the plate was quenched and flattened at the same time.* Pairs of specially constructed dies of unique design were used. They resembled huge waffle irons with hundreds of projecting pads, each pad having six perforations. Through these perforations jets of water were sprayed on both surfaces of the plate which had just emerged from the furnace, while proper pressure was applied. This prevented the plate from warping while it hardened, making it possible to cut plate to dimensions while still soft with assurance that dimensions would be held during quenching.



The Universal Carrier shown here on maneuvers served the British in the same manner as the Jeep served American troops. It is fast, light weight, amphibious and its Ford V-8 engine defies the toughest terrain.



V-8 TANK ENGINE

The Ford V-8 Tank Engine developing 500 horsepower was the only engine built exclusively for use in tanks. It was an entirely independent Ford project from its inception.

PRE-WAR developments by Ford Motor Company engineers made possible the hard-hitting Ford V-8 tank engine, the only engine produced in this country exclusively for use in tanks.

It is a liquid-cooled, V-type, 8-cylinder engine, weighing approximately 1,500 pounds and developing 500 horsepower at 2,600 revolutions per minute.

Basic specifications for its design were taken from a 12-cylinder aircraft engine designed by Ford as an independent project in 1940-1941. Mass tank engine production has been accomplished with a minimum of change in available machinery. Features which enabled it to top other engines in nearly all phases of performance during Army tests include light weight, obtained through liberal use of aluminum, and a high power output, resulting from an efficient valving system.

Each cylinder has four valves operated by dual camshafts for each cylinder bank, making a total of four camshafts in the engine.

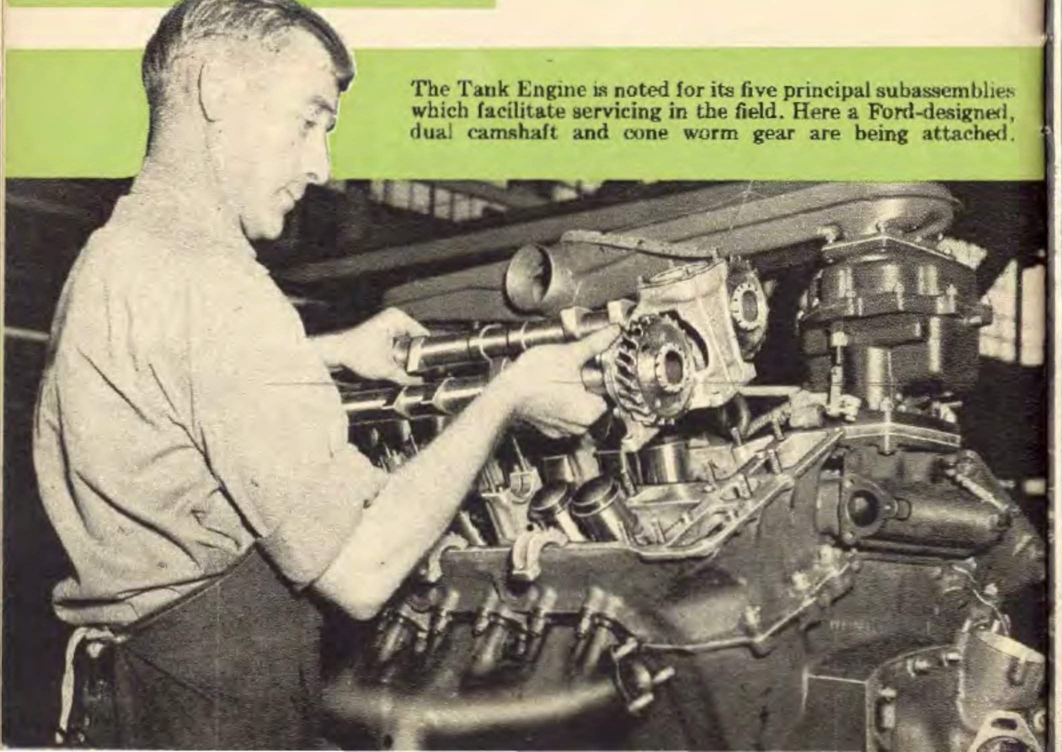
Most important feature of the engine, both in production and combat service, is the fact that it con-

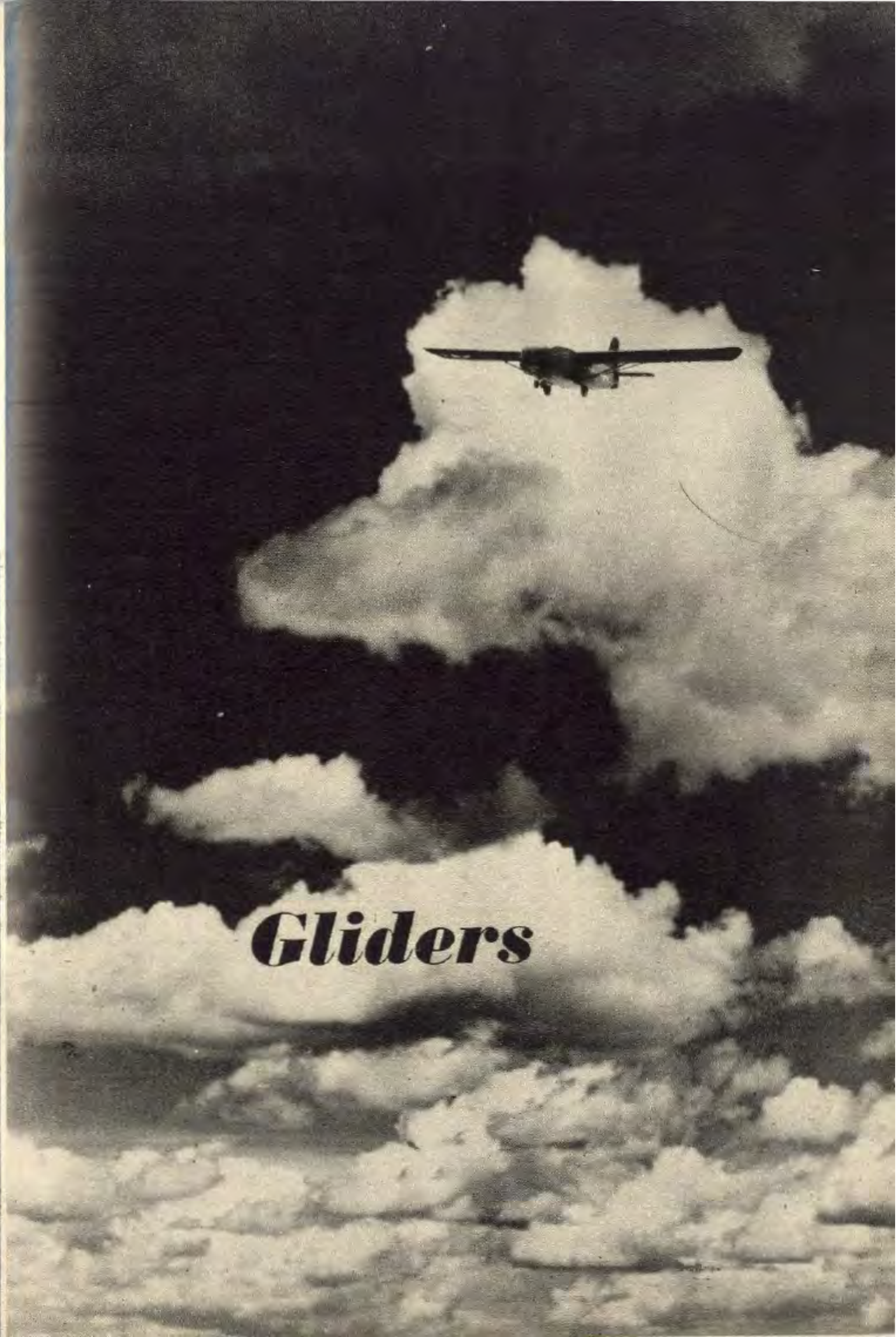
Here in light, clean and airy surroundings the Ford V-8 Tank Engine is assembled. This is typical of Ford working conditions.

tains five major sub-assemblies. The cylinder block, foundation of all sub-assemblies, is fitted with all main bearing cups and studs before another part is added. The cylinder head is assembled complete with valves, cams, drive gears and the exhaust manifold. Crankshaft and flywheel are combined in a unit. Carburetor and heater box are joined to each other. The accessory drive powers water pump, magneto, oil pump, fan and generator.

The engine was manufactured in the company's Lincoln plant.

The Tank Engine is noted for its five principal subassemblies which facilitate servicing in the field. Here a Ford-designed, dual camshaft and cone worm gear are being attached.





Gliders

THE MANUFACTURE of cargo and troop-carrying gliders was a Ford responsibility beginning in May, 1942, when Ford was commissioned to build an original 1,000 CG-4A Waco-designed gliders, having a carrying capacity of 15 men. Less than five months after issuance to Ford of the government's letter of intent, the first Ford-built glider was test-flown at Ford Airport.

A new glider, having a carrying capacity of 30 men, with clearance to transport two Jeeps, was developed and successfully test-flown at Ford Airport. Known as the CG-13 and later the CG-13A, this larger glider was designed to withstand a much higher towing speed and equipped with regular flight instruments, radio and tricycle landing gear. A conventional retractable wheel gear with hydraulic brakes was augmented by a pair of fixed skids for use where landing area is limited. Further changes provided seating for 42 men.

The Ford glider program was centered at the company's Iron Mountain, Michigan, plant away from the congested defense areas. A part of the machinery in that plant was adaptable to the production of glider parts, and labor skilled in woodworking was available.

Characteristic of the Ford approach to a new problem involving quantity production the entire glider was "re-lofted" from the original blueprints. This procedure insured the necessary accuracy for assembly line production with full interchangeability of parts.

Here again Ford engineering was

The CG-13A Waco Glider is in reality an airplane without engines. It contains nearly all the basic instruments and accessories customarily carried by a cargo plane, including an automatic pilot, radio and hydraulic system.

Airborne troops dash to gliders during maneuvers. Lined up are CG-4A Waco-designed gliders, which preceded larger CG-13A.

applied toward the betterment of the product itself, as well as the discovery of better and faster manufacturing procedures. Improvements in the control cable assemblies virtually eliminated hand splicing. Forgings were substituted for complicated riveted and welded fittings, resulting in greater strength, simpler construction and more accuracy. Plastic window frames and handhole service covers eliminated a needless use of aluminum, saved some twenty parts and reduced installation time appreciably.

A Ford-designed and patented gluing fixture reduced the time required for glue drying so drasti-

The nose of a Ford-built CG-4A Glider is lifted to permit the unloading of an artillery piece in pre-invasion troop maneuvers.

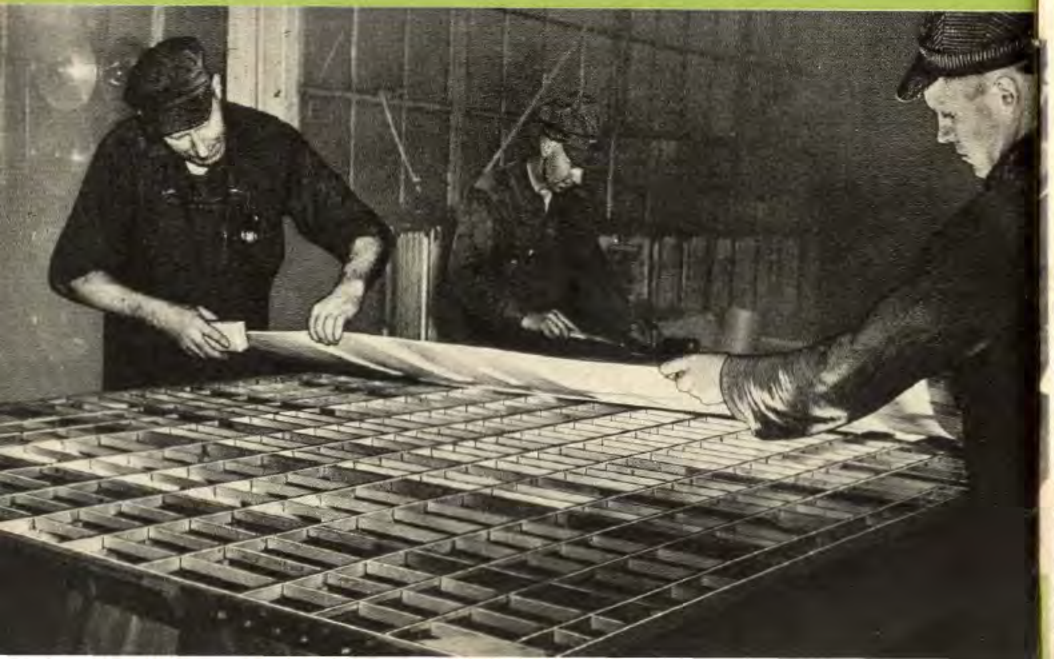
Complex wing structure of the CG-4A is shown by this scene on the production line at Iron Mountain. Interior bracings were glued by a special patented Ford process.

cally that the principle was used in all major glider assemblies.

So pronounced was the uniformity of the Ford-built gliders, as a result of proper engineering, tooling and manufacturing that Ford gliders were sent to all other glider manufacturers as standards for interchangeability of parts and assemblies.

Ford-built gliders, according to Army personnel, have stood up under 500 hours of training flight without repairs. One pilot wrote: "The Ford-built glider is one of the best, cleanest, easiest to fly, quickest to trim and smoothest in free flight."

These men formerly built station wagon bodies at Iron Mountain. Here they have the task of building the glider's floor structure. Honeycomb design adds greater strength with less weight.



Ford-made Jeeps Sweethearts of the AEF!

Such scenes as this must now be familiar from Cairo to Casa Blanca, and from the Solomons to the Rhine. It shows the American Jeep in action, the limousine of generals and runabout of GI's. Ford built them by thousands.

THE QUARTER-TON, four-wheel-drive reconnaissance car or Jeep, planned by the Army to take the place of a motorcycle and side-car, has proved to be the most versatile of military vehicles.

Ford and two other companies in October, 1940, were asked to build 500 units each. Slightly more than a month later the first Ford-built pilot models were delivered for test. Within seven months Ford engineering and tooling were completed and 1,500 units had been built. In the interest of uniformity, Ford agreed to duplicate the engine of another company to begin production. Tooling for this cost nearly $4,000,000. In 90 days production started.

Many improvements in the engineering of the Jeep and in methods of manufacturing the Jeep engine were introduced by Ford. Some of these innovations, even though approved and desired by the Army, were not adopted, mainly because tooling would have delayed production at a time when greatest numbers of units were needed.

Among Ford-originated improvements were: a lower silhouette; a better frame; protected dual-duty headlamps; increased foot room for the driver; direct-control center gearshift; handier, more effective parking brake control; rigid gun base mounting; cowl-hinged engine hood; tubular-designed windshield which reduced glass breakage; folding rear seat; new top-bow mounting; a stronger, less expensive brush guard; beaded-top body panels; better weight distribution and spare wheel mounting; new fuel tank design and location to simplify construction, reduce height and facilitate servicing.

Ford was asked in December, 1941, to suggest designs for an amphibious vehicle and later was commissioned to build it. The first Ford-designed Amphibian Jeep was completed in 60 days. Tooling for the hull construction, including die-making, was completed in less than ninety days—the fastest tool-up on record at Ford.

When Ford accepted a contract to design and produce the Amphibian, it was the first time such a vehicle had been considered for quantity production. Its introduction created widespread interest because of its varied possibilities for peacetime applications.

The Amphibian is essentially a Jeep in a hull, with wheels and springs protruding. It is driven and steered in conventional manner on land, and by a marine propeller and rudder when water-borne.

For the changeover only simple lever shifting is necessary.

For production of the Amphibian a multitude of difficulties had to be overcome.

A method had to be devised to seal all hull openings and still not hinder movement of exposed mechanism. A light-weight, sturdy hull was needed—one that could be welded for strength and water-tightness. An engine cooling system was needed, efficient even when the vehicle was in water, and hatches necessarily closed.

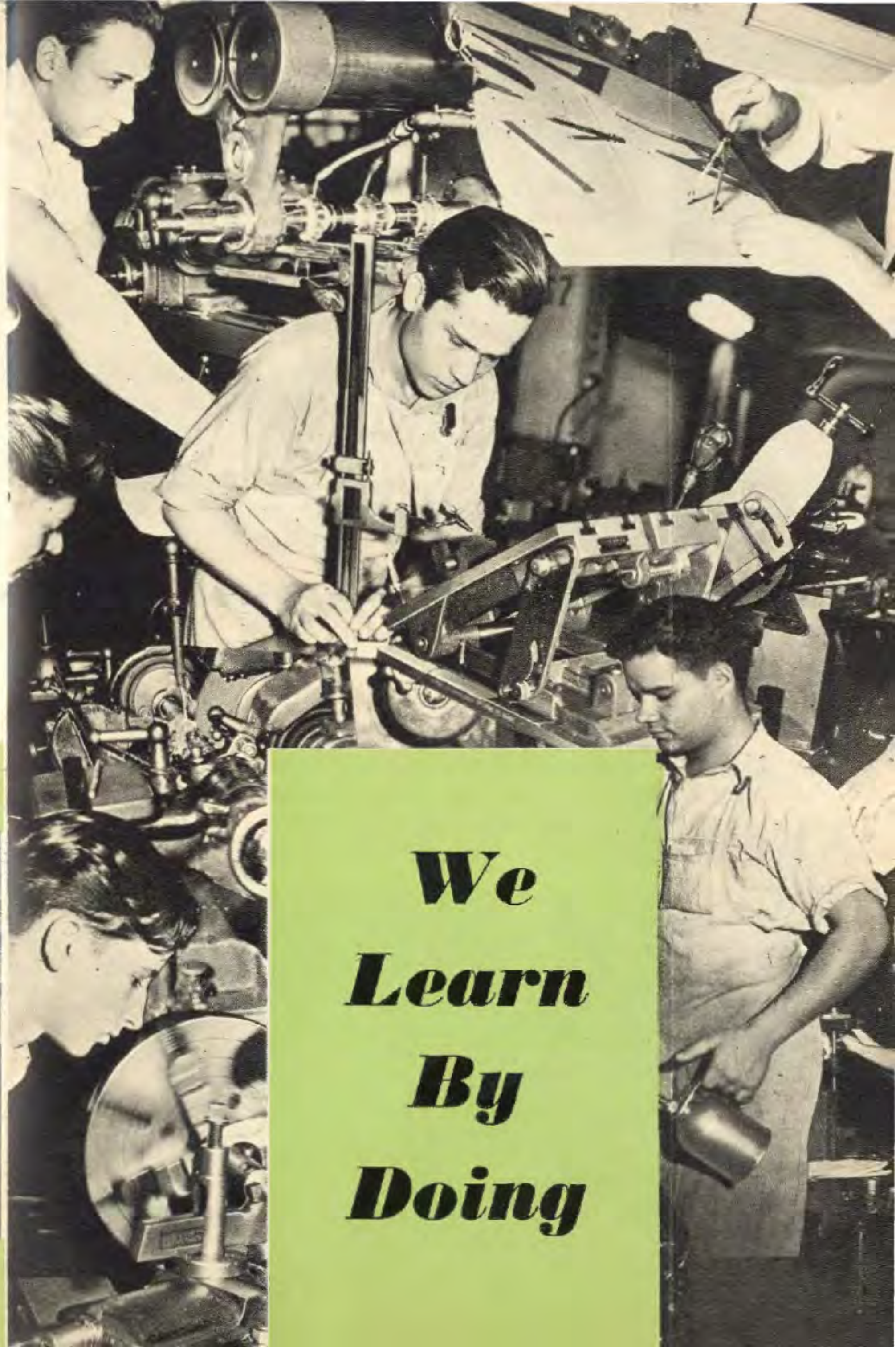
The Jeep went to sea when Ford created an all-welded hull and engineered the chassis into it. This amphibian served with distinction in Sicily and in the South Seas.

Defying the swift current of a river, this Ford Amphibian hauls four men and their fighting equipment.

A power bilge pump of capacity greater than that of peacetime civilian types had to be provided to keep the hull dry and the craft afloat even if perforated by bullets. A power capstan was required to pull the vehicle up steep and slippery banks and out of holes. A frame was needed to give strength and stiffness to the hull, while leaving mechanical units accessible for servicing. Means of mounting the propeller and rudder high enough to insure safe road clearance and yet provide for an adequate unobstructed flow of water for efficient propulsion and steering had to be worked out.

The hull, frame or any part of the Amphibian may be removed and replaced in much the same sort of service operation required in repairing a standard truck or car. Ford engineering carries through to facilitating field servicing, in war as in peace.

Once on dry land, the Amphibian becomes a road vehicle, hauling combat troops and evacuating the wounded.

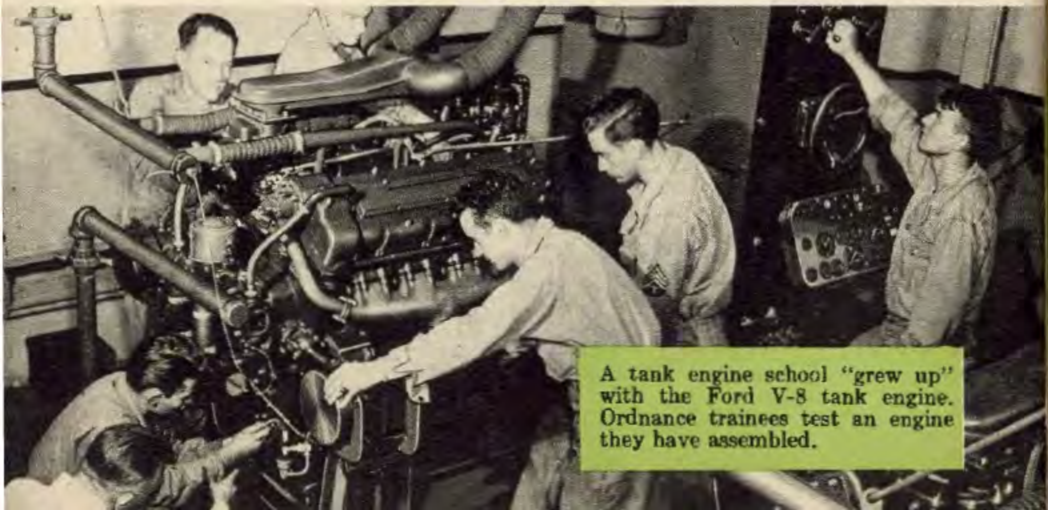


We Learn By Doing

These barracks housed Navy trainees working for Machinist's Mate ratings. More than 20,000 Navy men were trained in the Rouge Plant and Henry Ford Trade School.

VAST RESOURCES for training military personnel in maintenance and service of Ford-built products were immediately available when the need arose. Working through the long-established Ford educational system, training in the bomber, aircraft engine, tank engine and the Navy's machinist program were quickly set up. Barracks were made available near the various plants, and classrooms were established immediately adjacent to production lines so that first-hand information could be obtained from skilled engineers on the job.

All of this was carried on without interfering with the existing Trade School curriculum, or with the training of new workers who were



A tank engine school "grew up" with the Ford V-8 tank engine. Ordnance trainees test an engine they have assembled.

A trained ground crew was waiting to receive each bomber that rolled from the Willow Run plant. A trained crew chief selected for ability and leadership headed each crew.

entering the factory for the first time to assist in the production battle. Altogether, nearly 40,000 military personnel were trained in service and maintenance, while more than 50,000 civilians were trained as riveters, welders, inspectors, assemblers and machine operators.

Here lies the nation's richest source of skilled manpower for our future needs. Already trained in the fundamentals of industry and engineering these graduates will continue to apply their knowledge and will learn more through experience so that for years to come they will be providing us with intelligent, practical improvements. They have indeed been trained for duty in the service of America.

Army students studied the 2,000-horsepower Pratt & Whitney engine 36 hours a week in this overhaul laboratory.

SERVICE TO AMERICA, highest wages to labor, training of youth, and the best product at the lowest price are the foundation stones supporting the Ford way of doing business. We are dedicated to this proposition, and to it we will return.

Our great steel mills are looking forward to prosperity without inequality. Our mines, our ore fields and our forests are giving up their vast stores of natural resources to provision our industry. Farm lands, suffering from lack of manpower and mechanical equipment, are looking forward to abundant crops, more and more of which will be diverted to industrial uses as our chemists learn to adopt them.

Building automobiles, trucks and tractors is our business, but like every other American enterprise our total facilities were given over to building weapons of war in order to preserve peace. That it will be lasting and equitahle is our hope.

We do not feel that the preceding war years have been entirely lost, for we have gone ahead much faster in our thinking. The new discoveries of the war period have taught us new methods of production. These lessons can be applied to civilian goods. These goods in turn will make for better living. If we keep looking ahead, giving our best in work, wages and quality, we will enjoy our greatest era of real prosperity.


PRODUCTION STARTS HERE
FORESTS
SHIPPING
STEEL MILLS
PRODUCTION PLANNING
ENGINEERS


MINES
VILLAGE INDUSTRIES
ROUGE PLANT
FORD
FINAL ASSEMBLY

An industry made strong and productive by engineering is the material foundation of our social structure. We move to the future over a bridge sustained by those who labor in the three principal arts—agriculture, manufacturing and transportation. For more than forty years the Ford organization has mastered these arts in order to strengthen that foundation *In the Service of America.*