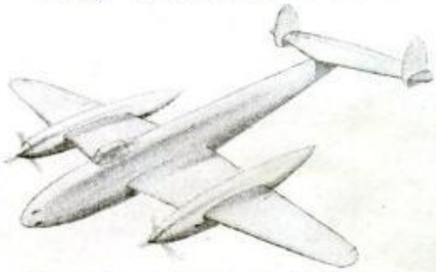
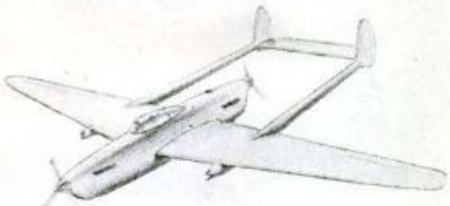
Design Ideas that led to the P-38

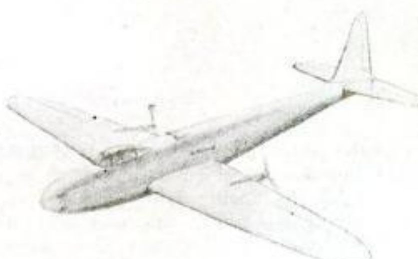


Conventional fuselage with twin tail unit.



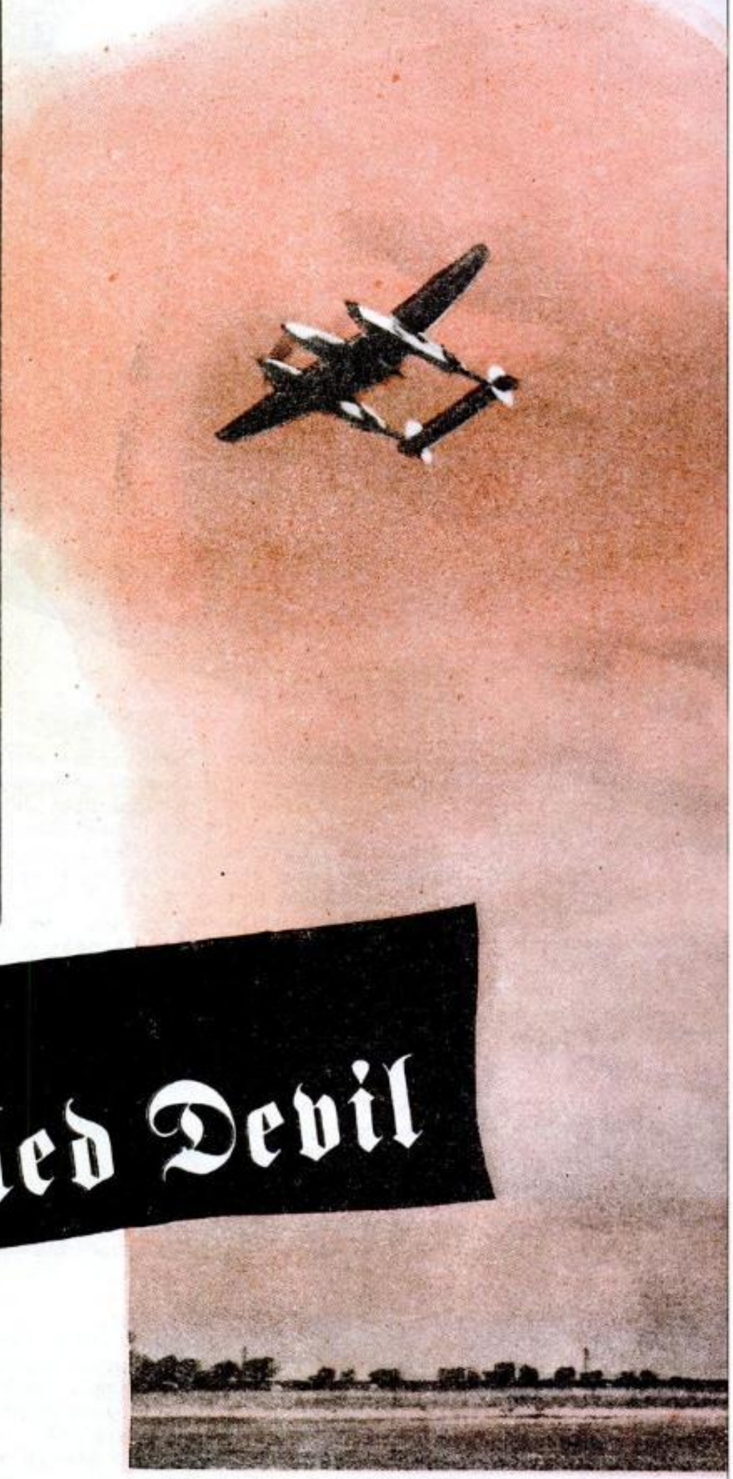
Twin booms, and tractor and pusher engines.

Engines in fuselage, geared to props in wing.



Fuselage engines side by side, pusher props.

A bright page in the history of American military aviation is turned, as production of the Lockheed Lightning tapers off.



The Fork-Tailed Devil

TO THE Germans the P-38 was "*der Gabelschwanz Teufel*"—fork-tailed devil. The Japs call it "Two Airplanes With One Pilot." The British dubbed it *Lightning*—and that name stuck. It earned its reputation from the outset of the war, racking up a long row of "firsts"—the first U. S. plane to shoot down an enemy plane after our entry into the war (a Focke-Wulf over Iceland); first over Tokyo after Doolittle's famous "Shangri-La" raid; first photo plane over Formosa; first fighter to land on Leyte and Luzon in the recent Philippine invasion, and the first land-based plane to land on Iwo-Jima to provide fighter cover.

More than 6,500 *Lightnings* have rolled off Lockheed and Consolidated Vultee production lines, although the *Lightning* was an "obsolescent" airplane from the first, avoiding becoming obsolete for years because of its design versatility.

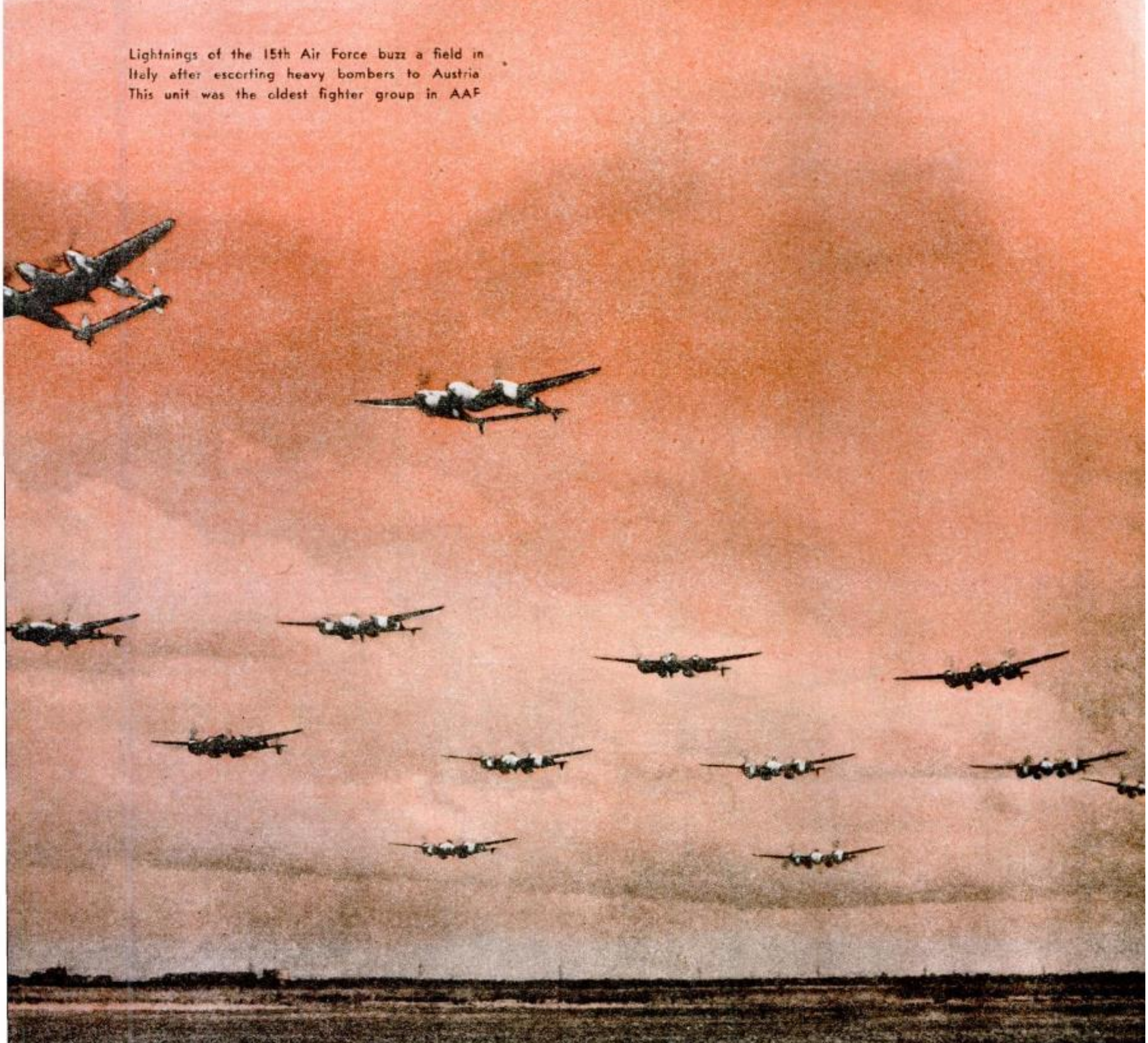
With the war against Germany ended, Lockheed is tapering off P-38 production to push production of newer models, including the jet-propelled *Shooting Star*. Thus the *Lightning* is about to take its rightful place in aviation history.

The P-38 was born early in 1937, when the U. S. Army Air Corps sent manufacturers specifications for a single-seat military airplane—specifications which set up rigid performance requirements. Lockheed had never produced military aircraft. It then was a small company with fewer than 2,000 employees, and had produced only 107 aircraft during its entire history.

Numerous designs were proposed. First sketched was a twin-engined fighter with conventional fuselage and twin rudders [see sketches accompanying this article]. Next, a pusher-tractor type with twin engines mounted fore and aft of the pilot's gondola, with twin booms reaching the now-famous twin tail. Then came a conventional fuselage design with two engines housed behind the pilot, with only the pusher blades projecting from the trailing edges of the wing, one on each side of the fuselage. This was followed by a similar proposal, but with the propellers on the leading edge of the wing. From the fifth and final drawing was evolved the basic design of the P-38.

The two-engine design, with guns mounted in a central nacelle and firing straight ahead, promised the pilot better visibility, more effective concentration of firepower and avoidance of synchronizing firepower with the speed of the propellers. Twin booms did not comprise an attempt at streamlining but stemmed

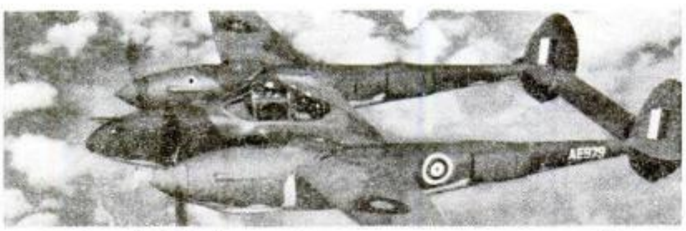
Lightnings of the 15th Air Force buzz a field in Italy after escorting heavy bombers to Austria. This unit was the oldest fighter group in AAF



Lightning Prototype and Offspring

Here is XP-38, from which evolved all subsequent Lightning versions.

"Droop-snoot" bomber had Norden bombsight, bombardier, was used in ETO.

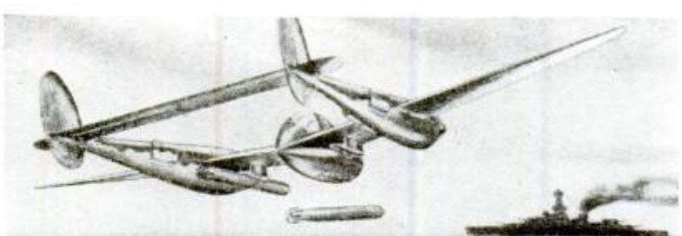


British model lacked superchargers or opposite-turning propellers.

Proposed Versions of the Lightning

Here is how proposed twin-float Lightning would look.

One P-38 ski plane with full-retracting skis was built.



P-38 torpedo-bomber carried torpedoes under wing, was actually tested.

from the business of solving the major problem in *Lightning* design—what to do with its turbosuperchargers. Placed within the fuselage, their bulk would have made streamlining impossible, so the engine nacelles were extended back of the wing to house the two superchargers. Once this was done it seemed logical to extend them still further and join them with the horizontal stabilizer.

Design specialists finally agreed that "this was it". Performance calculations, photographs of a mockup and drawings of the structure were submitted to the Army. A contract was signed in June, 1937. Where contemporary fighter planes lifted from 20 to 25 pounds with each foot of wing area, the prototype (designated XP-38) boosted wing loading to 35 pounds without sacrificing speed or maneuverability. Wing surface loss was offset by reduced drag and added power, and Lockheed-Fowler flaps were grafted to the design to aid in take-off and to permit slow landing speeds. Two 980-h.p. Allison V-1710-C9 liquid-cooled engines provided the power. It is significant that the length and span of the P-38 has always remained constant.

In wind tunnel tests the aerodynamically new wing wanted to flop on its back. Another wing developed a flap flutter at a wind tunnel speed of 150 m.p.h. This was cured by putting holes in the wing at a point where the flaps were attached.

Tests were run on the new and radical tricycle landing gear. A three-wheeled tow truck was constructed and pulled at high speeds, carrying the approximate gross weight of the airplane. These tests eliminated nose-wheel shimmy.

The hand-built prototype first rolled from its hangar on New Year's Eve, 1938, and trucked to March Field, near Riverside, Calif., where Lieut. (now Col.) Benjamin F. Kelsey ran ground tests for several days. On its maiden flight, on January 27, 1939, the flap link broke and developed a flutter. Kelsey retracted the flaps and landed at less than 100 m.p.h.

On February 11, Kelsey took off from March Field for New York City, made one refueling stop en route and 7 hr. 43 min. later (actual flight time, 7 hr. 2 min.) crash-landed in a ravine bordering a golf course just short of Mitchel field, L. I. Fatigued by the long test hop, Kelsey reduced throttle too much when his approach overshot the field. Reapplying power, he choked the engines and had to put the plane down in the ravine. Though he was unhurt, the plane was a total washout.

However, as a result of Kelsey's enthusiastic reports, the Army authorized building 13 YP-38's. Major changes were included, such as upping military horsepower 170-h.p. per engine, designing the airplane for mass production, elimination of 1,300 pounds gross weight; revolving propellers outboard at the top instead of inboard, redesigning the armament compartment for a 37-mm. cannon to replace a Swedish-made 23-mm., and two of the four .50-cal. machine guns with .30's.

YP-38 engineering began in April, 1939; fabrication began in August. In February, 1940, assembly work on the first

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The Fork-Tailed Devil

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plane (used for static testing) got under way. Production workers soon were calling the YP-38 "Yippee," a name derived from the plane's prefix designation, YP. The first YP-38 was flown by Marshall Headle, then Lockheed's chief test pilot, on the morning of September 18, 1940. Engineering on the production P-38 model began late in 1939, with deliveries beginning in July, 1941. The basic difference in the YP-38 and the later model was its use of .30-cal. machine guns rather than .50's.

The P-38D, evolved in 1940 and delivered in 1941, marked the installation of self-sealing fuel tanks and a change from a high- to a low-pressure oxygen system. In the next model the cannon was changed from 37-mm. to 20-mm., which has been standard in all subsequent models except for the unarmed camera planes. This model also saw the replacement of the hollow steel propellers with Curtiss electric constant speed propellers with dural blades.

About this time the Model 322 (or *Lightning I*) which was designed for the British, came along. It had low-powered engines, no superchargers and did not meet performance expectations. This model further suffered from British insistence that the propellers turn in the same direction. This added torque, which had been eliminated in the American model by turning the blades in opposite directions. The contract was ultimately cancelled and the handful of Model 322 planes was converted as nearly as possible to the model used by the AAF to train American pilots. So far as is known, not one of this model has been in combat.

The P-38 was slow to make itself felt in actual warfare. People began to wonder why the Army didn't use it in combat. The Army couldn't reveal that the *Lightning* was to make its debut in the invasion of Africa. There was a trickle of interest in the new plane when Capt. (now Col.) Karl Polifka was reported in Australian dispatches to have flown a P-38 photo plane over a Japanese fleet that was moving toward Australia.

News of P-38 activities blacked-out for about a year. Suddenly the reason for silence was made known—Africa was invaded. The first American planes to strike the enemy from air fields in Morocco and Algiers were P-38's that had been flown down from England. Not until a year after the feat had been accomplished did censorship allow the story of how fleets of P-38's, escorted by *Flying Fortresses* that served as navigational shepherds, had flown across the North Atlantic from America to England—the first fighter craft to make the crossing. Only one of these long-range *Lightnings* was lost at sea.

In the African campaign the P-38E also got its first taste of combat. These long-range fighters, equipped with droppable fuel tanks, struck at the enemy over great distances from fields well behind the lines. They served as tank busters at Kassarine Pass, escorted bombers in scores of raids against Axis-held Europe, bombed and strafed and photographed thousands of square miles of occupied territory and, in general, helped pave the way for invasion.

Development of P-38 camera planes began in 1941. First of its kind, the F-4 (an adaptation of the P-38E with new autosyn-type instruments) was equipped with four cameras. This model also was equipped with drop-tank brackets and was the first to be converted into the famous "piggy-back" plane for fighter pilot training—an advancement that substantially reduced the percentage of Army flight accidents in this phase of training from an index rate of 6.5 to 1.5 within two months.

In the fall of 1942 the F-5, a specially-equipped P-38F camera plane, was unveiled. It carried five cameras, had the Allison V-1710-F5 engine and was the 12th P-38 model to be released. The 13th, which was ready in May, 1943, upped engine horsepower to 1,000 normal, 1,325 war emergency for each engine.

Other modifications of the fighter craft followed rapidly, the most important being those incorporated in the P-38J. The J, first delivered in August, 1943, had more changes than had been made in total since the fifth model appeared. More horsepower was added by using Allison

EVOLUTION OF THE LIGHTNING

Model	Engine Model (1)	H.P. Norm.	H.P. Mil.	Gross Weight (2)	Range in mi. (3)	Top Speed (4)	Armament Mach. Guns	Armament Cannon	MODIFICATION
XP-38	V-1710-C9	980	980	11,500	1,300	403	2—.30's 2—.50's	1—23-mm.	
YP-38	V-1710-F2	1,000	1,150	13,500	1,300	403	2—.50's	1—37-mm.	High-pressure oxygen equipment added. Turbosuperchargers moved to top of booms.
P-38	V-1710-F2	1,000	1,150	13,500	1,300	403	4—.50's	1—37-mm.	First regular production model. Same as YP-38.
P-38	V-1710-F2	1,000	1,150	13,500	1,300	403	4—.50's	1—37-mm.	Second production model. Armor plate, bullet-proof glass added.
P-38	V-1710-F2	1,000	1,150	13,500	1,300	403	4—.50's	1—37-mm.	Improved radio in 3rd model. New instruments, improved oxygen equipment.
P-38D	V-1710-F2	1,000	1,150	14,500	1,250	403	4—.50's	1—37-mm.	Self-sealing fuel tanks—new low-pressure oxygen equipment.
322	V-1710-F2	1,000	1,150	14,500	1,250	403	4—.50's	1—37-mm.	British model. No superchargers. Propeller rotation in same direction.
P-38E	V-1710-F2	1,000	1,150	14,425	1,250	403	4—.50's	1—20-mm.	New Autosyn type instruments.
P-38E (LR)	V-1710-F2	1,000	1,150	14,425	2,300	403	4—.50's	1—20-mm.	Long-range bombing model. Wing shackles hold one 150-gal. droppable fuel tank or one 1,000 pound bomb each.
F-4	V-1710-F2	1,000	1,150	14,425	2,300	403	None	None	Adaptation of P-38E. Four cameras.
P-38F	V-1710-F5	1,000	1,325	14,425	2,300	403	4—.50's	1—20-mm.	Resistance type instruments, desert equipment, battery-cart plug for field starts.
F-5	V-1710-F5	1,000	1,325	14,425	2,300	403	None	None	Adaptation of P-38F. Five cameras.
P-38G	V-1710-F10	1,100	1,325	14,425	3,050	403	4—.50's	1—20-mm.	Auto. engine temp. control; demand-type oxygen equip.; heavier wing shackles.
P-38H	V-1710-F15	1,100	1,425	14,425	2,700	403	4—.50's	1—20-mm.	New type turbosuperchargers.
P-38J	V-1710-F15	1,100	1,425	14,425	2,700	403	4—.50's	1—20-mm.	New core intercoolers, engine cowling; flat panel windshield of bulletproof glass.
P-38K	V-1710-F17	1,100	1,425	14,425	2,700	403	4—.50's	1—20-mm.	Propeller gear ratio changed to accommodate new 12 ft. 6 in. propellers.
P-38L	V-1710-F30	1,100	1,425	18,000	over 3,000	over 425	4—.50's	1—20-mm.	Improved superchargers. Propellers changed back to 11 ft. 6 in.

(1) All engines are Allisons.
(2) From model P-38E through P-38L, gross weight varied with duty of plane.
(3) Range is dependent upon gross load, altitude flown and whether equipped with belly- or wing-tanks.
(4) Top speed is given in m.p.h. Figures shown are those permitted by military security and are very conservative.

V-1710-F15 engines, and rate of climb increased 100 per cent at altitudes over 30,000 feet. Built-in, bulletproof tanks increased range 30 per cent, service ceiling was raised to "well above 40,000 feet," straightaway speed was boosted and single-engine speed increased to more than 300 m.p.h. It was during production of this model that the compressibility dive flap was introduced. Not only were the flaps incorporated into the assembly of the J model, but special kits were rushed overseas so that they could be added to earlier P-38's already in service. It was not until the L model was released that both dive flaps and aileron boosters were made standard equipment.

The P-38K had the Allison V-1710-F17 engine, which put out the same horsepower as its predecessor but had a different gear ratio to turn the new 12 ft. 6 in. propellers. This model had unusually high performance, but the engine manufacturers couldn't make the necessary changes quickly enough to insure quantity production. Hence production models jumped from J to L, with K written off as an experimental model.

All model changes indicated by the suffix letter are dictated by the Army. Basic major changes have been made, however, with no change in model letter. All changes are, nevertheless, recorded by Lockheed in their own identification system. From this one learns that there were actually 50 to 60 versions of the *Lightning*. Master records show that more than 700 changes have been made. One change as an example, was the addition of aileron boosters and dive flaps on the model J after a large number of this model had been built, but it still remained the Army's model J.

The dive flap, which is *not* a diving brake, proved that the buffeting encountered by the *Lightning* in high speed dives was caused by airflow action on the underside of the wing when it entered the compressibility shock wave. Wind tunnel experiments were conducted, and finally W. W. Beman, Lockheed's chief aerodynamics engineer, proposed that a dam under the wing, well forward of the leading edge might control the flow of air in the compressibility field. A trial proved his theory correct and ended compressibility buffeting.

Model P-38L, the newest (and last) "On-To-Tokyo" P-38, is the only one factory-equipped with the hydraulic aileron booster control. The action of the boosters is automatic, enabling the pilot to roll the heavy twin-engined fighter more quickly than most lightweight fighter planes—negotiating a complete 360° wing-over in less than three seconds. A fast roll is one secret of combat efficiency in fighter craft and the P-38 can execute the maneuver on one engine. Even though the quoted terminal velocity for the P-38L is 575 m.p.h., and its level flight speeds more than 425 m.p.h., controls are never stiff. If boosters should be shot out by enemy action, control could still be maintained manually.

The P-38L, designed originally as an intercepter, has become more truly a fighter-bomber, carrying a bomb load of 4,000 pounds—greater than that of the early *Flying Fortress*. It has increased its already fast rate of climb to 3,200 f.p.m. at 3,000 r.p.m., using 54 inches of mercury. In spite of its 18,000-pound gross and 21,400-pound overload, the P-38 takes off in 1,030 feet. The P-38L returned to the 11 ft. 6 in. propeller, geared to Allison V-1710-F30 engines.

The *Lightning* was assigned to specific phases of aerial warfare because of its adaptability to certain operations. Its unique design, however, led to its consideration as a carrier-based fighter, a torpedo-bomber and a ski-equipped fighter for far-north operations. At least one P-38 with full-retracting skis was tested but never produced in quantity. Some specially-equipped models were tested as torpedo carriers, using dummy torpedoes. And while no known arrangements were made culminating in carrier tests of this plane, Lockheed engineers say such an adaptation would be feasible.

When converted to glider-towing, the P-38 theoretically became a 15-place transport plane. Tests proved that the P-38 could successfully tow a fully loaded CG-4A glider.

The *Lightning* is more effective for every duty assigned to it today than it was in prototype. This performance record has been established despite the addition of 3,898 pounds empty weight, 6,500 pounds gross weight, 6,190 pounds overload weight and an increase of 13 pounds in wing loading. The *Lightning*—the fork-tailed devil—did not grow obsolete with age—instead, it improved vastly. But progressive demands of aircraft science have pushed the P-38 to a place in history as newer and faster jet-propelled planes demand the attention of today and tomorrow. END

Kick that Ball

(*Continued from page 43*)

its right wing is still low. Now, you may not want to turn, in which case, level your wings. The airplane then will fly straight, the ball centered. But note that this one simple change—different rudder pressure—promptly put the airplane into a normal flight condition. Of course, in actual practical flying you center the ball and level the wings simultaneously. But the way in which you think about it makes a big difference in your flying.

Observe what happens in a turn, say to the left, at 45° of bank. The ball is off center to the right, or on the "high" side. What exactly is wrong? How would you correct it? The rate of turn depends on the angle of bank and the amount of back pressure on the control; the bank is always right for the turn, because it is what causes the turn. Steepening the bank will not return the ball to center. This can be proved if you change rudder pressures and simply steepen the bank without, at the same time, increasing the back pressure so as to hold altitude. You will finally have to give up because the angle of bank, "g"-load and

(*Continued on page 130*)