**With pierced steel planking, you could have a runway where you needed one. Even the holes in it were functional.**

# Marston Mat

BY RICHARD K. SMITH

IT WAS ten feet long, fifteen inches wide, covering 12.5 square feet with a surface resembling Swiss cheese stamped out of steel, and it weighed 66.2 pounds. Locked together, 60,000 of them created a durable all-weather surface 5,000 feet long and 150 feet wide that routinely accepted punishment from airplanes weighing up to 60,000 pounds thumping down at speeds of ninety miles an hour. This is the material that provided the quickly built platforms from which American combat aviation was projected around the world during World War II.

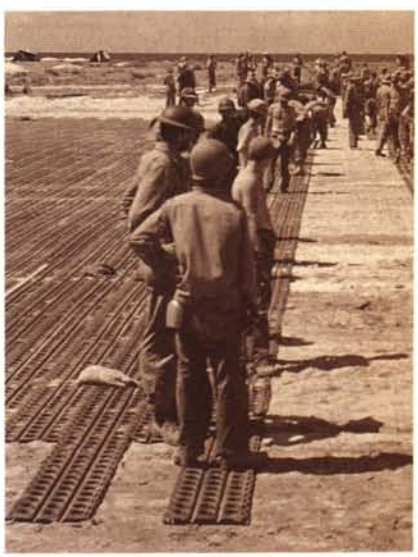
During 1941–45, the material was generally known as "Marston mat." This led many to believe that it was invented by someone named Marston. Or maybe it was a British invention, manufactured near Marston Moor, England. The truth is more prosaic. The name comes from a whistle-stop on the Seaboard Coast Line Railway, thirty-five miles west of Fort Bragg, N. C.

Here on a low hill a mile east of US Route 1 and two miles northeast of Marston, N. C., the material was first put to practical use. That was during the Army's Carolina Maneuvers of November 1941, just before Pearl Harbor. The novel steel mat gave an eminently satisfactory performance—one fraught with epochal consequences.

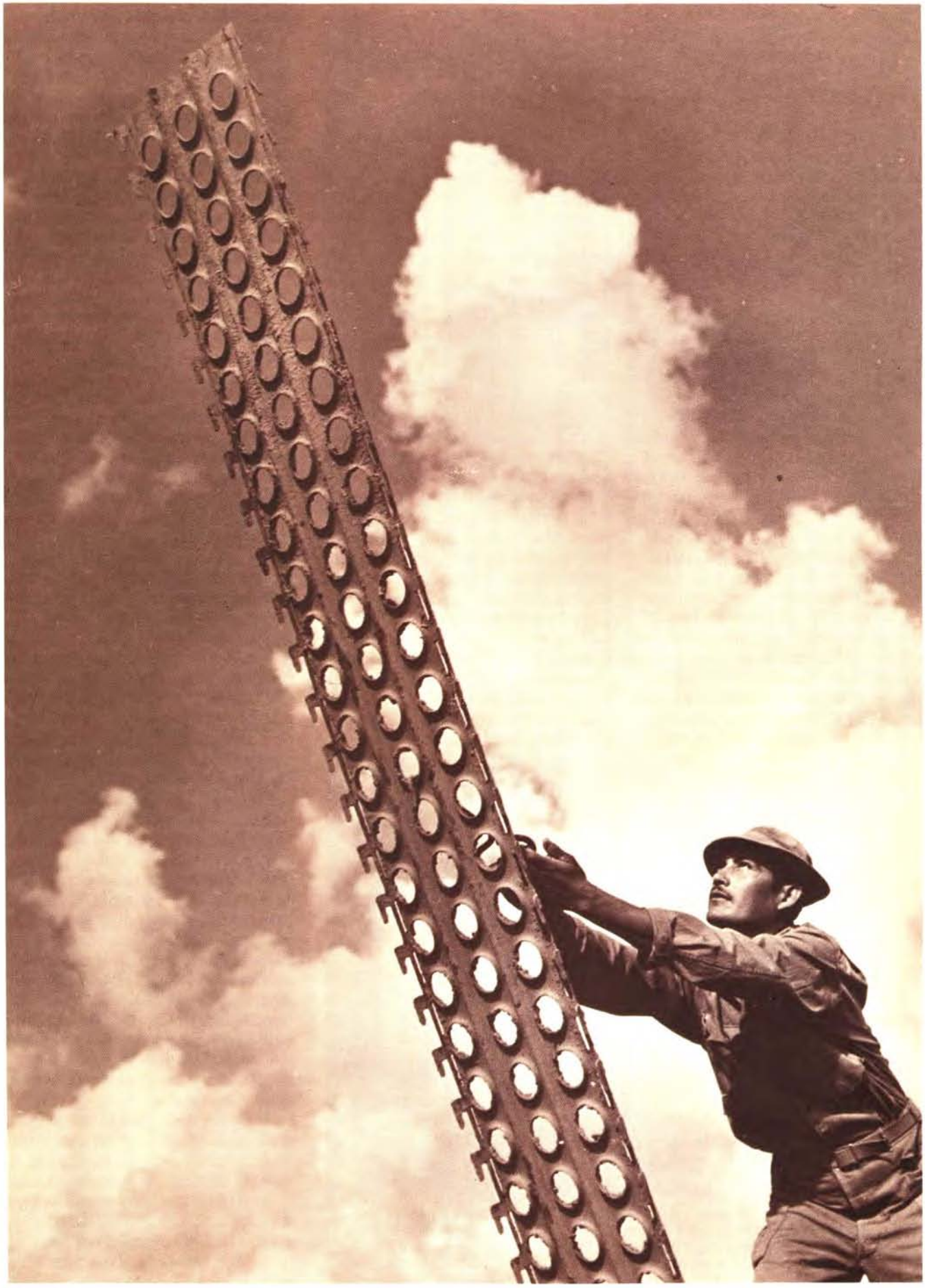
Gen. H. H. "Hap" Arnold, Chief of the Army Air Forces, visited the "Marston strip" and hailed it as "the year's greatest achievement in aviation."

The "Marston strip," 150 feet by 3,000 feet, was operational for only a few weeks. When the maneuvers ended, the runway was dismantled, loaded into eighteen railroad gondola cars, and hauled away to Langley Field, Va.—taking with it the name of Marston. Thus, the "Marston strip," as it was called, entered Army vernacular, and the material became known as "Marston mat."

Years later, when memories of World War II had faded and acronyms took charge of military vocabularies, the village of Marston lost its claim to fame as bureaucrats reduced the material's name to "PSP"—pierced steel planking. A quarter of a century after 1945, the generation that laid hundreds of



*By itself it's not much (right), but stick a few together and you have a well-drained, dust- and mud-controlling, instant runway capable of supporting heavy bombers. This versatile material became the footprint of Allied airpower in World War II.*



thousands of tons of Marston mat throughout South Vietnam had no idea who or what Marston might have been or that a Marston existed. The material was simply "PSP."

### Anglo-French Inspiration

In the spring of 1939, the Army Air Corps took note of operations in Britain and France where air forces were experimenting with steel grids for unimproved airfields. Unlike the situation in the United States, on the eve of World War II there were few concrete runways among European airports, but their turf airfields were among the best in the world. They were carefully sited, well tiled for drainage, often having collecting points and pumping stations installed, and were carefully planted with various species of grass whose root systems absorbed moisture. However, this was a technology not susceptible to rapid improvement.

With war imminent, the Anglo-French air forces required hundreds of airfields for dispersal, and the casual pastoral expedients of World War I could not serve airplane weights of 1939. A Sopwith Camel fighter of 1918 weighed 1,950 pounds, a Hawker Hurricane of 1939, 6,600. Furthermore, unlike the flying machines of 1918, the airplanes of 1939 had brakes. Nothing tears up an airfield's turf like the frequent use of brakes by heavy airplanes.

British runway mat was similar to heavy-duty chicken wire. Shipped in huge rolls weighing tons, it was difficult to handle. Once in place, it was difficult to repair, and it seemed inadequate for medium bombers. The more versatile French type was a heavy steel chevron gridwork similar to that used in bridge decks or industrial catwalks. But each section weighed more than a hundred pounds, installation was complex, and much of the runway had to be taken apart to repair just one section.

The Air Corps required something more versatile, much lighter, and given to mobility. The specification is summed up by an old saying of the American aircraft industry: "Simplicate and add a bit of lightness."

In 1939, the gross takeoff weight of a typical single-engine fighter plane was 7,000 pounds; a medium bomber weighed 35,000 pounds. But the Air Corps required a surface also capable of supporting 55,000-pound heavy bombers, such as the Boeing B-17 Flying Fortress or the Consolidated B-24 Liberator. Furthermore, in 1939 the Air Corps was already getting ready for bombers like the B-29 Superfortress weighing more than 125,000 pounds.

***Marston mat's compact dimensions and relatively light weight made it easy to ship and to carry. Wired into bundles and subbundles, 375 square feet of runway surface stood only twenty-eight inches high. Two men could pick up a piece and run with it. Here, a Guadalcanal airfield is improved with Marston mat after the island's capture from the Japanese.***

### Adaptable to Global Logistics

Besides being able to support airplanes, the mat had to occupy minimum space for ocean shipment. This was of small consequence to Europeans, but everywhere Americans looked they were standing on the water's edge.

One piece of Marston mat fit neatly inside another; a bundle of thirty pieces stood less than twenty-eight inches high. Packed for shipping, the mat for a 150-foot by 5,000-foot runway weighed 1,986 tons and occupied 41,600 cubic feet. The lower hold of #3 hatch, the largest space in World War II's ubiquitous Liberty ship, had a bale capacity of 59,793 cubic feet.

Distinct from its cubic dimensions, the weight of this single runway constituted twenty-one percent of a Liberty ship's payload. The material was distributed among a ship's lower holds, like flooring. Bulkier and lighter cargoes were loaded on top of it. With combat loading, such low-density items as bulldozers, graders, trucks, rollers, and other vehicles were needed first; the high-density runway mat was the last material required.

For shipping and convenience in the field, five mats were wired into subbundles; six of these were banded into a full bundle. Each full bundle contained twenty-nine full-length mats and two half-lengths—a total of 375 square feet. With the mats laid in staggered brickwork fashion, the half-lengths were used to piece out the edges of a runway.

The material also had to be easy for its installers to handle. Installation had to be simple, even in darkness. The Air Force specified a material of no more than seven pounds per square foot; Marston mat was 5.3 pounds. Its unit weight was 66.2 pounds. One man could handle a section with ease; two men could pick up a piece and run with it. As a rule, the only tool necessary for its installation was a sledge to beat it into the earth.

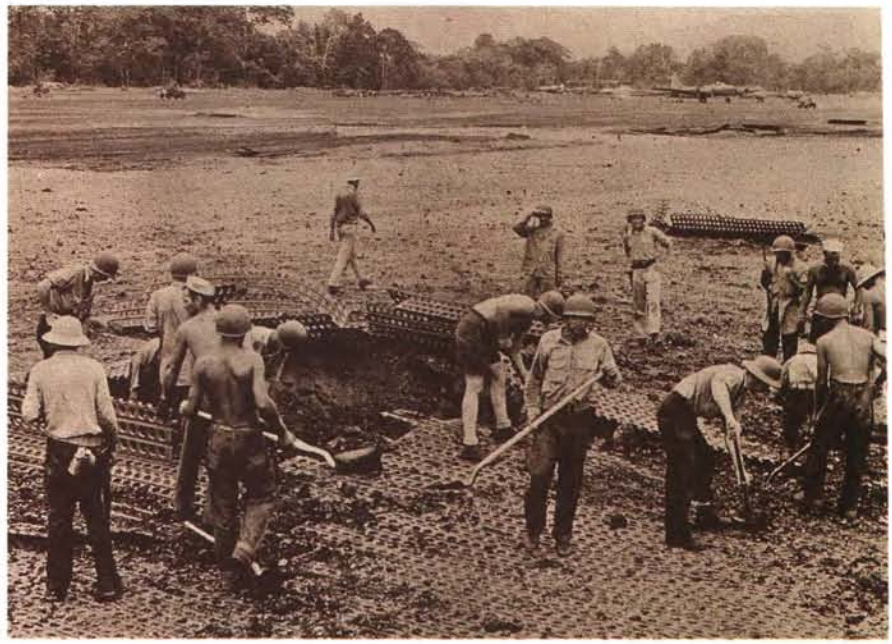
As inventions go, Marston mat ranks among the simplest. Although its function was to serve motion, it had no moving parts. A single mat consisted of a steel sheet with two ribs dividing its length into three flat channels. Each channel had twenty-nine holes punched along its length —eighty-seven holes per mat. The

holes were flared to increase the mat's rigidity.

These holes not only contributed to strength and reduced weight but also helped a section adhere to the earth. The holes also served drainage and helped dry out the terrain on which the mat rested. Vegetation could grow through the holes, reducing the problem of dust and making a small contribution to camouflage. The holes also made it possible for backfill to be poured into small soft spots in the earth.

Along each edge of a mat's length were thirty slots and thirty L-shaped hooks cut and bent from the mat's edges. Having hooks and holes in each mat made the mats interchangeable. The hooks of one mat were dropped through the slots of the adjacent mat, and then shoved forward two inches, locking the hook into the slot. Mats were further locked together by easily removed U-shaped steel spring clips that limited vertical motion.

For ease of removing a damaged mat, it was practice to install one course of mat with its hooks pointed in one direction, and the next course with its hooks pointed in the other. When a runway was complete, a single mat could be removed by two men with pry bars.



***Marston mat's simple design facilitated easy repair as well as easy installation. Locked together by a hook-and-slot design, beaten into the earth with sledge hammers, and secured by steel spring clips, sections of runway could be removed with a pry bar. Here, troops repair bomb-damaged portions of Henderson Field, Guadalcanal.***

### Design and Manufacture

The Marston mat owes its design to Gerald G. Greulich of the Carnegie Illinois Steel Co. and to many contributions by the Army Corps of Engineers. When first tested at Langley Field, Va., in the summer of 1940, the ribbed steel plank was solid sheet. Later, buttons were pressed into the flat channels to create a nonskid surface, but they didn't seem to make much difference. During the winter of 1940–41, it was decided that a solid surface was unnecessary, and holes were punched along the channels, giving the mat its distinctive appearance and reducing unit weight by 17.5 percent.

There were five steps in its manufacture: (1) the longitudinal ribs were pressed or cold-rolled into a blank sheet of 10-gauge low-carbon steel; (2) the slots and hooks were punched out; (3) the holes were punched and flared; (4) the hooks were bent ninety degrees to the mat; and (5) the mat was cleaned, degreased, and painted. By December 1941, two factories had already manufactured some four million square feet of the material. A year later, twenty-nine factories were producing Marston mat.

At the dawn of 1944, more than 180,000,000 square feet (some 477,000 tons) had been shipped overseas. This was enough for 240 runways 150 by 5,000 feet. By the end of the war, almost two million tons had been produced, representing enough steel to build 600 Liberty ships.

Sooner or later it is "General Mud" who commands too many battle situations. Mud does not occur in nature when rain only wets the earth; but given intensive use by heavy airplanes and a week of rain, the best turf airfield will degenerate into a crazy-quilt of badly rutted mud. Marston mat performed well on soft ground, overcoming most of the problems.

Similarly, Marston mat controlled dust. The airplane is an incorrigible dust maker, and on a busy airfield dust can be an operational nightmare. Dust ingested by engines shortens the time between overhauls—never mind the general wear and tear on an airplane and its interior parts.

In dusty North Africa, airplane engines had only half the life between overhauls compared with those operated from the well-prepared airfields of England. More frequent overhauls require more spare parts, more manpower, and more facilities to serve the work. In North Africa, the total increase in logistics requirements often became horrendous. Meanwhile, aircraft availability suffered.

Dust also creates operational and tactical hazards. After two or three airplanes take off from an arid, dirt runway, visibility is reduced to zero. Since airplanes take off into the wind, the dust they generate blows back among the planes waiting to take off. With each takeoff the dust becomes thicker. Precious minutes are lost before the next plane can get into the air.

In the worst conditions, it could take half an hour to get a squadron off the ground, an operation that normally took five minutes. Tank trucks sprayed water over the runway to hold down dust, but this created only a thin patina that evaporated quickly. The pressure of airplane tires broke the thin crust, and prop blasts blew away what remained.

Each hole in a piece of Marston mat provided a small reservoir for runway watering, retaining its moisture for fifteen minutes or more. It was soon discovered that if

***This Marine Corps photo from World War II shows an AAF B-17 Flying Fortress resting securely on a Marston mat runway on Guadalcanal. Basically unchanged some twenty-five years later, the material became known as "PSP," for "pierced steel planking," and hundreds of thousands of tons of it were laid throughout South Vietnam to support far heavier aircraft.***

you covered the runway area with local flora—leaves, small branches, palm fronds, or, if it could be found, hay—and laid the mat on top, you greatly reduced the dust problem. Even after these materials dried out, they maintained barriers between the mat and the dust, retaining hygroscopic qualities that made runway watering more effective.

After experience was gained, it was not unusual to have an area cleared and graded, the mat down, and airplanes operating within seventy-two hours. Creating an elevated subgrade was desirable and often necessary before laying the mat, although it added a few days to the job. The mat ordinarily was laid lengthwise, across the runway. Laying started from the middle and worked toward the sides and both ends. By 1943, a technique had been developed for laying mat from both ends and from the middle simultaneously, and everything usually came out right. A misalignment was corrected by having bulldozers drag the runway section into place. Any hundred yards of locked Marston mat always had some stretch in it.

### Universal Footprint

Marston mat created a universal footprint of Allied airpower in World War II. Everywhere the mat was laid, Allied airpower was projected forward—with speed. The Germans and Japanese had nothing remotely similar to it. Neither did the Russians until they received Marston mat via American Lend-Lease.

By the end of the war, Marston mat was being manufactured in an aluminum alloy. Otherwise identical to steel mat, its unit weight was 32.5 pounds. It was intended for special airborne operations, but the war ended before it saw combat.

Inevitably, Marston mat became damaged by use, but it was not discarded. Field engineers developed machinery for its rehabilitation. The diesel-powered unit weighed fourteen tons and reprocessed 250 mats per hour. The mats were straightened, cleaned, given a chemical bath, repainted, and made good as new.

This small industrial plant could be broken down for air transport among units in the field. Six C-47s were needed to move it. This airlift may seem excessive, but a C-47's cargo space was only 22.5 feet long within a tube ninety-two inches wide enclosing a usable 1,200 cubic feet. A C-47's maximum payload was 4,900 pounds. In 1944, a unit operating out of Australia airlifted its remanufacturing plant throughout the South Pacific, rehabilitating some fifty million square feet of runway mat.

When the 150-foot-by-3,000-foot pioneer strip was laid at Marston in November 1941, it took eleven days, including the time to clear and grade an area 350 feet by 3,800 feet and move some 50,000 cubic yards of earth. This was regarded as breathtaking speed, but during the war years, it was exceeded many times and in circumstances beyond any imagination in 1941.

Almost a half century after World War II, a tourist wandering the back roads of rural Algeria, Italy, Sicily, southern France, the Philippines, or a host of South Pacific islands may still find evidence of Marston mat. It is not laid flat, but sometimes stands vertically with one end buried a few feet in the earth, the other pointing skyward—coincidental monuments symbolizing an original function.

After 1945, thousands of farmers or rural householders collected the abandoned runway mat, pressing its hooks and slots together to create fences and walls that are still standing today. They are the hilt of a terrible sword that has been transformed into the proverbial plowshare: silent memorials to an air war of long ago.

Perversely, one place where a sample of Marston mat will not be found is among the World War II exhibits of any aviation museum. Here will be found the stuff of "aces" and airplanes and almost no end of sentimental ephemera. But there is nary a word about, much less a sample of, this dramatically simple invention that with minimum effort and maximum speed carried American combat aviation to the ends of the earth.

During 1941–45, Marston mat created the footprint of global airpower. Although not possessed of glamor or the mystique of "breakthroughs," Marston mat nevertheless ranks as one of the most subtle, versatile, and ultimately devastating "secret weapons" of World War II. ■

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*Richard K. Smith is the author of* The Airships *Akron* and *Macon*: Flying Aircraft Carriers of the US Navy *and the prizewinning* First Across! The US Navy's Transatlantic Flight of 1919, *both published by the US Naval Institute. This is his first article for* Air Force *Magazine.*