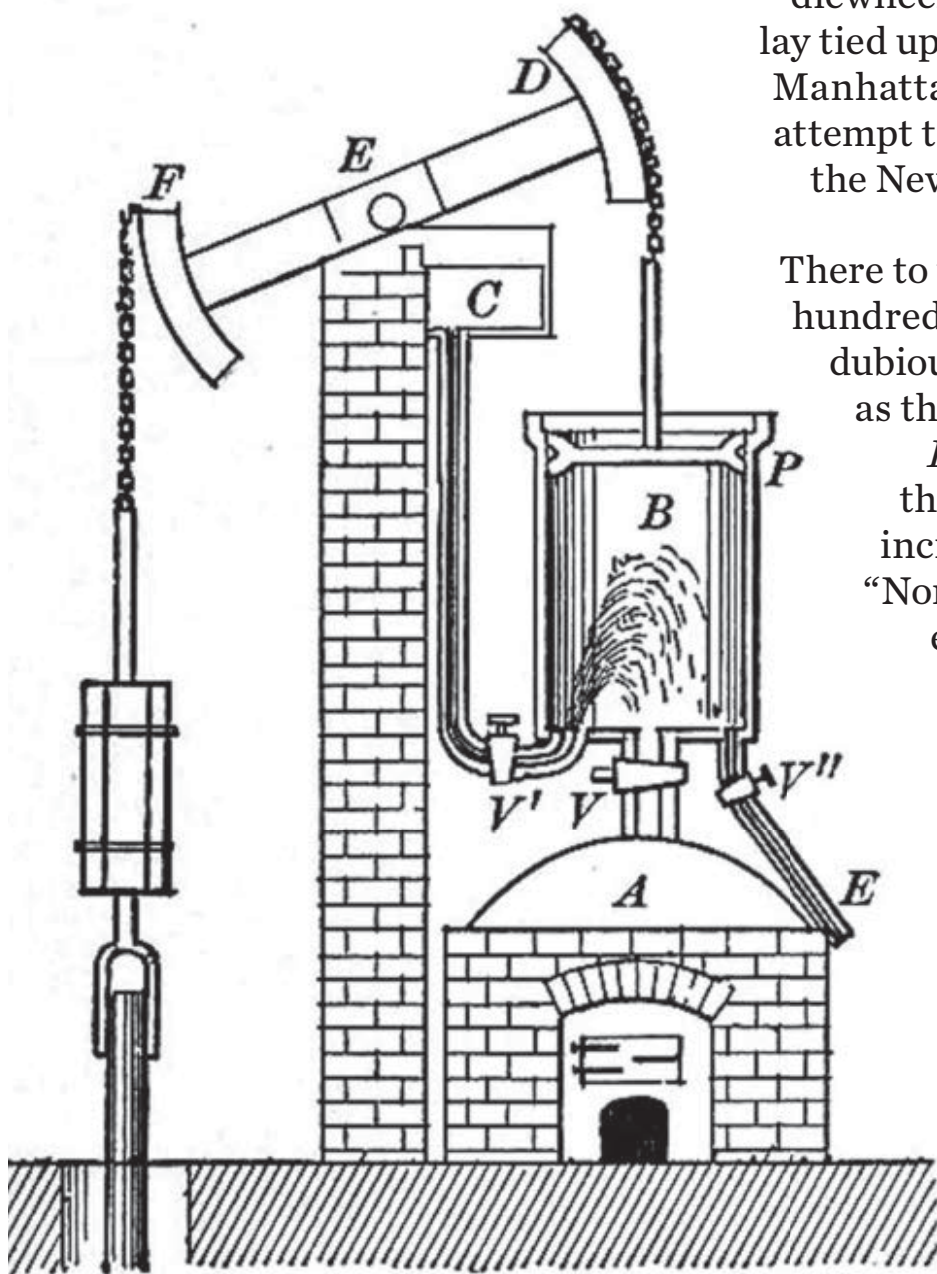


“Something Trouble the

Steamboat design during the first generation.

By John Laurence Busch

On Monday, August 17th, 1807, inventor Robert Fulton was finally ready to go. His newly built creation, a boat with paddlewheels powered by a steam engine, lay tied up to a wharf on the west side of Manhattan Island. Fulton was going to attempt to take this craft all the way to the New York State capital of Albany, some 100 miles to the north. There to witness this experiment were hundreds of spectators, many of them dubious of the whole enterprise. Yet as the so-called *North River Steam Boat* splashed its way out onto the Hudson River, “all were still incredulous,” Fulton later wrote. “None seemed willing to trust the evidence of their own senses.” With the successful voyage of his *Steam Boat* that day, and repeated trips along the Hudson during the remainder of 1807 and again in 1808, Robert Fulton achieved something truly epochal in the annals of history: he proved that it was possible for humans to alter artificially



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Matter with the Engine”

where they were, and when they were there, to practical effect. That had never been possible before, and accordingly makes steam-powered vessels the first high technology in history.

Fulton’s triumph sparked a variety of responses from those who saw his Nature-defying machine. For some, skepticism remained. For others, such as John Stevens of Hoboken, N.J., the reaction was one of admiration mixed with a sizable helping of jealousy. Stevens had been experimenting with steamboats for several decades, only to see his dreams of being first dashed by a younger man. And for still others, such as a coastal sailing sloop captain named Moses Rogers, the experience of seeing a vessel propelled by an artificial power resulted in a fever—*steamboat fever*.

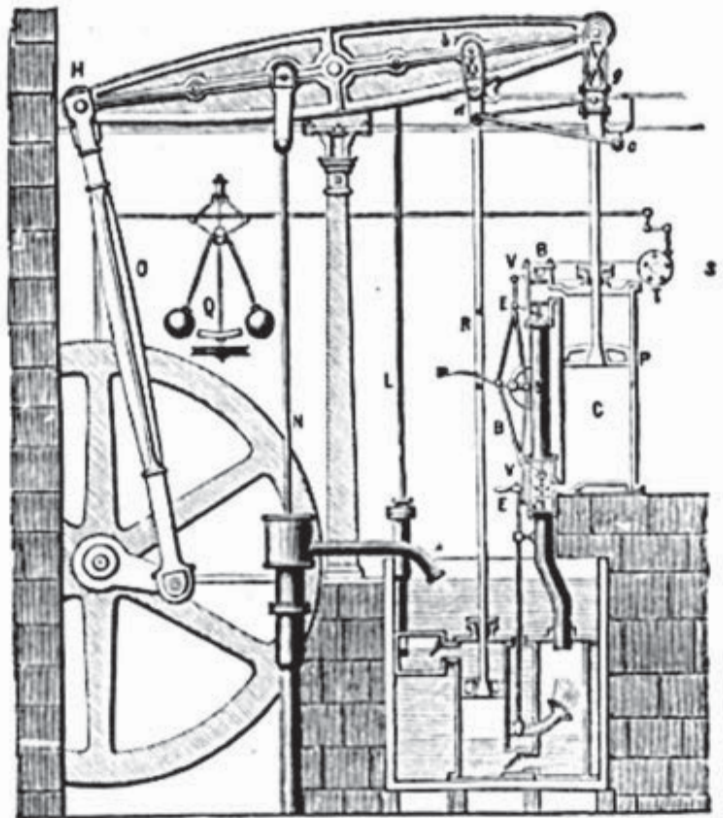
As Fulton built additional steamboats, John Stevens responded by constructing his own (hiring Moses Rogers along the way, making him one of the first steamboat captains in history). Once their rivalry intensified, more entrepreneurs became convinced that this “new mode of transport” was for real, and jumped in. By the mid-teens, there were dozens of steamboats operating in the United States, mostly in the Northeast and along the Mississippi and Ohio Rivers.

All of the individuals participating in this new technology—from investors to shipbuilders, to steam engine manufacturers, to mechanics, to captains and crews—had a lot of learning to do. After all, there was no one to tell them how to build and operate these incredible inventions. Everyone had to learn by doing, accepting both the benefits and the burdens of trial and error.

The source of power for these floating contraptions was the improved steam engine, as invented by the brilliant Scotsman James Watt. There were a number of innovations in Watt’s engine that made it far more powerful and efficient than the previous generation of Newcomen-style engines.

Among them was the creation of a steam regulator. Newcomen’s engine only directed steam into one end of the cylinder (usually the bottom), making it what was referred to as “single-acting.” This was inefficient, because it led to an uneven motion of the piston inside, as well as the rest of the drivetrain. Watt’s regulator was able to alternately inject steam into both the top and bottom of the cylinder, making it “double-acting” (or reciprocating). This meant the motion of the piston inside the cylinder was not only more uniform, but faster, making the engine more powerful.

Also of great import was Watt’s creation of a separate condenser. Newcomen’s engine injected cold water directly into the steam-filled end of the cylinder, thereby condensing the



The Newcomen steam engine (opposite) was succeeded by James Watt’s more efficient design (above). Advances embodied in the Watt engine made the steamboat practical.

steam and creating a vacuum, which forced the piston to the bottom. This too was very inefficient, because it meant the cylinder was constantly being heated (by the newly injected steam) and cooled (by the cold water that followed). Watt’s condenser kept the cold water in a separate container. Whenever the automatic valve which connected it to the cylinder was opened, the steam in the cylinder was condensed and “vacuumed” into the condenser, thereby keeping the cylinder at a constant temperature.

These two improvements, in conjunction with tubular boilers, made the Watt condensing, double-acting, single-cylinder steam engine powerful enough to take on much more strenuous tasks, including the pushing of a wooden hull through the water.

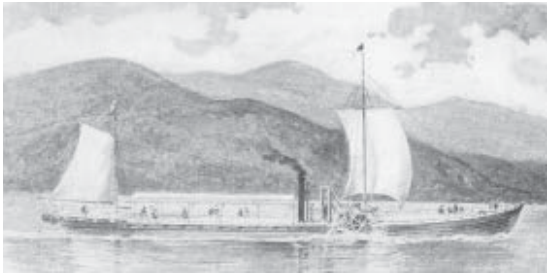
But beyond this generally accepted machinery, the first generation of steamboat practitioners had a series of choices to make, and challenges to confront, if they were to successfully create and maintain their vessels in any given market.

The most fundamental choice—engine placement—was really no choice at all. To ensure that the hull floated correctly, the engine had to be installed roughly amidship.

This placement in turn dictated the tools of propulsion, side-mounted wooden paddlewheels. Several entrepreneurs tried to build sternwheelers, but the drivetrain for such a design—with the engine necessarily placed amidship—is a complex one, and these early experiments were unsuccessful. The same was true of screw propellers, which John Stevens himself had attempted, again with poor results.

So with engine and paddlewheel placement set, the first real choice for steamboat builders became the precise orientation of the cylinder. For most steamboat entrepreneurs, this was an easy decision: it had to be installed vertically down in the hold. This set-up guaranteed that the tremendous vibration of the engine would not tear the cylinder from its moorings. However, this also meant that the engine's power loss was transferred right down into the keel of the hull, which often resulted in an uncomfortable throbbing of the whole vessel.

The solution to this throbbing problem, according to other builders, was to mount the cylinder at an angle, in front of the axle and just below the deck. Such a “horizontal” instal-



With his *Steam Boat*, Robert Fulton created the first high technology.



lation allowed the power loss to be diffused more broadly throughout the entire bow, significantly reducing vibration in the vessel.

Others were concerned that a horizontal cylinder might just shake itself loose from its cradle; or that its higher placement within the hull would dangerously raise the vessel's center of gravity; or that the lower side of the piston might be worn down over time, resulting in a loss of the all-important vacuum seal within the cylinder. With so many worries, it was little wonder that most steamboat builders opted for a vertical cylinder placement down in the hold.

The second major choice related to the type of drivetrain to install. Most parts of the wrought-iron drivetrain were a given: the piston rod usually connected to a crosshead beam, which moved a connecting pin, and this pin would serve to turn the paddlewheel axle. The choice came in deciding how to link the connecting pin to the axle. For this, there were two possibilities: a crank, or gears.

A crank was a small cast-iron piece shaped something like the figure 8. The crank was simple to manufacture and maintain. The disadvantage to using a crank was that it required the axle to be split in two, in order to allow the connecting pin to pass over the far midpoint of the axle. Also, the turning of the crank could result in a slightly uneven revolution of

the axle, as the connecting pin passed over that midpoint.

The solution to both of these problems was to use a series of gears to link the connecting pin to the paddlewheel axle. This allowed the axle to be one continuous piece, running straight through the hull. Furthermore, the gears had the added advantage of smoothing out the turning of the axle. Given how much these double-acting steam engines vibrated, this benefit was no small consideration. The primary disadvantage of all these gears was that they had to be made of cast iron, which meant this drivetrain was more susceptible to breakage than the crank arrangement.

The final choices related to the boilers. Tubular designs had been in use on steamboats since the creation in 1807, but with each new vessel came new versions, as builders tried to find the optimal boiler size, configuration, and installation.

Beyond the many new designs being tried, entrepreneurs had to decide what material to use in constructing the boilers. The most obvious choice was copper. Boilers made with it would be very corrosion resistant, and should last five to ten years, which was about the life of the whole steamboat at that early stage. Robert Fulton was a firm believer in the use of copper—every one of the steamboats he built featured red kettles.

But some early steamboat operators thought copper was too expensive to use, and they had a point. Copper cost about \$760 per English ton, which meant building boilers with the red metal could easily cost many, many thousands of dollars. So these builders thought iron was the more sensible choice. The finest imported iron from Sweden was only \$105 per ton, about one-seventh the cost of copper. Of course, boilers made with the black metal would corrode much more quickly, perhaps lasting only a few years, but the iron camp still thought

the cost advantage was worth it. Besides, the incredible innovations taking place in this new technology meant that when the iron boilers gave out, they could be replaced with a more advanced design.

There was one other boiler choice that had to be made, and that was determining the pressure at which they would operate. The standard was what came to be called “low pressure.” This meant that the boilers normally operated at a pressure of about 40 pounds per square inch. If a low-pressure boiler did burst, the damage could be substantial, but hopefully not disastrous.

The alternative was the high-pressure boiler invented and promoted by Oliver Evans of Philadelphia. (Richard Trevithick was developing them concurrently in the United Kingdom.) High-pressure boilers were designed to operate at 100 to 150 pounds per square inch, making the steam engines they ran much more powerful. However, virtually all early steamboat entrepreneurs, including Fulton, rejected “high steam” because they thought the risk of a catastrophic explosion was simply too great. Evans countered that his boilers were built to withstand the higher pressures, but he found it nearly impossible to convince the first generation of steamboat entrepreneurs that he was right.

A good part of the skepticism for high steam rested upon

the knowledge that the general public, while very intrigued by steamboats, was nevertheless a bit wary of these unnatural craft. Any steamboat accident of consequence—especially involving the boilers—was reported by the local newspapers, from which the news would spread all over the country. Even steamboat accidents in the British Isles would be reported in American newspapers (and vice versa), so keen was the interest in any calamities that befell this new mode of transport.

Accordingly, the first generation of steamboat mechanics and engineers stuck to what they believed they could manage:

Low-steam engines with pressure gauges properly installed and monitored; single cylinders and moving parts that were kept continuously lubricated with tallow; boilers that were kept as air-tight as possible by the periodic dribbling of molten lead around the outside of the rivets and plate seams; and on the insides of those boilers, a periodic scraping and cleaning of any salt build-up, which became a bigger and bigger problem as steamboats ventured into saltier waters along the East Coast.

Even with these precautions, there remained other risks to steamboats that were largely beyond the control of any crew—things that a lawyer would refer to as “acts of God.”

One such incident was experienced by Captain Samuel Howard, the father of steamboating in Georgia. Back in 1816, Howard was running his steamboat *Enterprize* during stormy weather on Charleston Bay when the vessel was rocked by a monstrous explosion. The resulting fire and smoke was so threatening that some of the passengers jumped into the water and swam for shore, while the rest crammed themselves as far forward as they could, wondering whether they too should leap for their lives.

Once Captain Howard and his crew had extinguished the flames, they were able to survey the damage. The left smokestack had been blown off, and the left boiler was blown wide open. Some of those scalded by the boiler explosion were beyond hope. Within a few days, the death toll stood at five, all of them passengers.

While many observers immediately concluded the boilers were at fault, Captain Howard believed he had ample evidence to conclude that a lightning strike had hit the left smokestack and traveled down into the left boiler. This jolt, he speculated, had popped some of the rivets on the left boiler, and may have simultaneously caused a surge in the “elasticity” of the steam inside. The result was a low-pressure boiler subjected to the sudden shock of high pressure, and an immediate explosion.

Acts of God perpetrated upon steamboats were not always so calamitous. That same year, Captain Moses Rogers was making a Baltimore-to-Elkton run with his steamboat *Eagle* when the engine suddenly seized up. Two hours of inspection turned up nothing, until someone checked the injection pipe which supplied water to the boilers. There, firmly lodged

within the pipe and obstructing the flow of water, was a catfish. The expired creature was removed, brought on board, and mounted in the main passenger cabin for all to see.

As if these many peculiarities and problems weren't enough, steamboat operators had to pay close attention to the competition, as well. This naturally led some entrepreneurs to skimp on maintenance, or run their charges far



Fulton's triumph spurred John Stevens (near left) and inspired Moses Rogers (far left). The *Paragon* (above) was the third steamboat on the Hudson.

harder than they should, which led to noisy, vibrating machines that unnerved some of the clientele.

Yet for every case of carelessness, there were also many examples of concern. These thumping, throbbing steamboats seemed virtually alive, and their crews treated them accordingly.

On occasion, this emotional connection between man and machine bordered on the surreal. In 1811, while Moses Rogers was captain of the steamboat *Phoenix*, he dreamt one night that “there was something trouble the matter with the engine.” This led Rogers to hurry down to the *Phoenix* the next morning, and check over the steam engine with a member of the crew. After a thorough examination, they tried to start the engine, only to discover it would not work.

As this wonderful new technology continued to expand into new territories, its true believers concluded that more powerful engines were needed. There was no greater proof of this necessity than the first crossing of the Atlantic Ocean by the steamship *Savannah*, in 1819, under the command of Captain Rogers. That epochal event proved to skeptics that steam-powered vessels were not just a provincial innovation, but a global one.

And it gave entrepreneurs the goal of expanding the new mode of transport out onto the sea. To do that, they would need larger hulls to carry more fuel, and more powerful engines. The result, starting in the early 1820s, was increased experimentation with two-cylinder engines and high-pressure boilers, both of which served to give steam-powered vessels the strength and stamina they needed to push a larger hull over greater distances. With their increasing adoption through the 1820s, multi-cylinder high-pressure steam engines marked the end of the first family of steam vessels, and the beginning of the next generation. ■