

of copper 10 pounds, phosphorus 1 ounce, and was harder than the rolled bar. The third consisted of copper 10 pounds and phosphorus $\frac{1}{2}$ ounce. This was found to be about the same degree of hardness as

rolled copper, and was adopted as the alloy from which the burnt-out bars of the commutator were cast. The castings were dense and solid. Another alloy was made of copper 10 pounds and phosphorus $\frac{1}{4}$ ounce.

This was soft, and its fracture showed minute pin holes. It evidently contained a little less than the minimum amount of phosphorus necessary to produce solid copper castings.—The Foundry.

ROBERT FULTON AND THE SIDEWHEEL STEAMBOAT.

BY J. H. MORRISON.

Who *invented* the steamboat? has been a question of much discussion at periods for many years in this country as well as in Great Britain and in France; but where the first steam vessel was built, or who was the designer, having the vertical sidewheels on either side of the vessel, has not been so generally a theme of discussion. That the side paddle-wheels of Fulton's "Clermont" was one of the factors, if not the main one, of his success, is undoubtedly true. John Fitch in 1787 built and operated the first steam vessel in this country, on the Delaware River, but the motive power was applied to a set of paddles on either side of the boat.

The trials and discouragements attending the early experiments lay in the fact that they were unable to find an agent that would propel a vessel at a velocity of more than about three miles an hour; and up to about 1784, when James Watt built his first rotative steam engine in England for stationary purposes, the steam engine was not in a form to adapt it for steam navigation with any prospect of success.

The propelling of vessels by paddle-wheels had been

in October, 1796, by Edward Thomason. Patrick Miller, of Dalwinston, Scotland, obtained a patent in 1796 for a vessel to be "put in motion during calms and against light winds by means of wheels." "These wheels project beyond the sides of the vessel, and are wrought by means of capstans. . . . These wheels are built with eight arms, which consist entirely of plank." There is no record that any experiments were made under these proposals. Patrick Miller had made use of the vertical wheel in his experiments before this period, but it was with a single wheel placed between two hulls in a double-hull vessel.

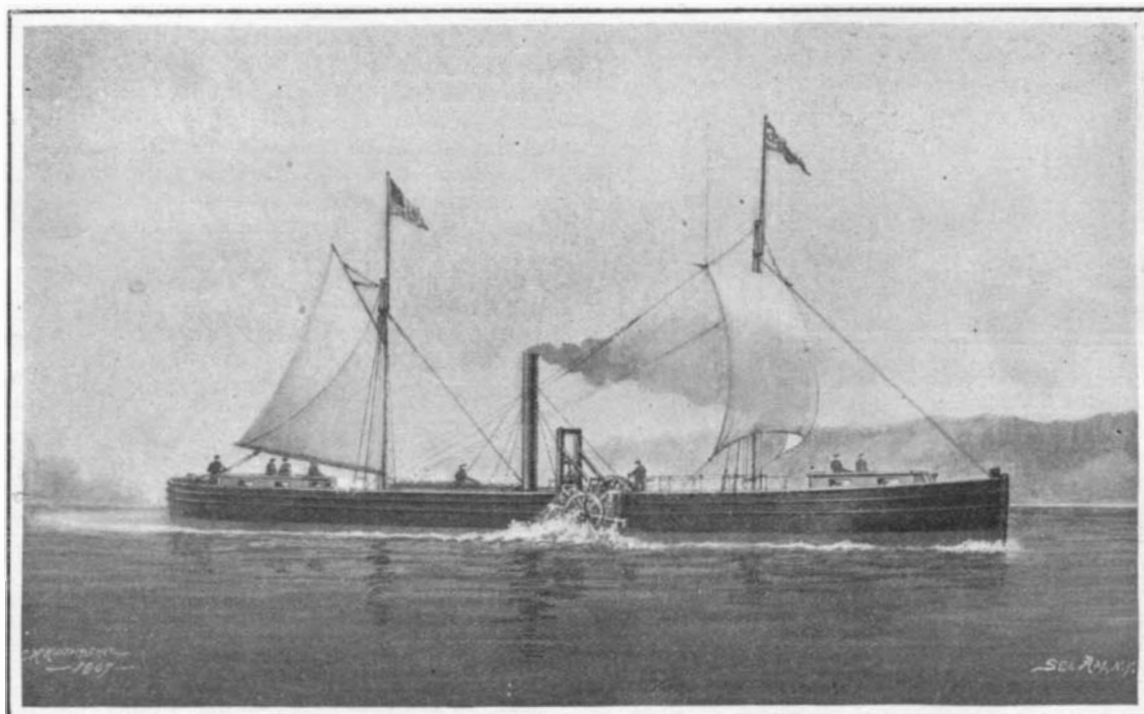
The earliest use in this country of the paddle-wheel at the sides of a vessel was in an experiment made by Nathan Read in 1789, where he attached the paddle-wheels to an axis extending across the gunwales of the boat, that were turned by a crank. By this means he propelled himself by manual power across the river opposite Danvers, Mass., thus demonstrating in a small way that the side paddle-wheels had some merit as a practical means of navigation. A few years later, one of the most practical of the very few American

was jointly interested in this enterprise with the Rev. Burgess Allison, who was at this time giving some attention to improvements in steam vessels. The latter had at one time a large academy for the instruction of boys in the sciences, and it was well equipped with apparatus for instructive experiments that were made by his own hands. Morey says of this experiment he "there devised the plan of propelling by means of two wheels, one on each side. The shaft ran across the boat with a crank in the middle worked from the beam of the engine with a shackle bar. . . . I found that my wheels answered the purpose very well, and better than any other mode that I had tried; and the boat was openly exhibited at Philadelphia." There does not seem to have been any record left of the dimensions of the vessel, nor where the engine and boiler were constructed. Dr. Allison says: "With a steam engine on board and wheels at the side, similar to those of Fulton's boats: and that she was exhibited in the presence of numbers of citizens with complete success. It was only for want of funds that we did not then bring it into public use." This was but a few years after the last of John Fitch's experiments with the steamboat on the Delaware River. Oliver Evans made use of a paddle-wheel in propelling his dredging machine at Philadelphia, in 1801, but the wheel was placed in the stern of the vessel.

Daniel Keller, of Huntington County, Pa., applied for a patent that was granted in May, 1795, "for an improved mode of propelling vessels by horses or oxen," the specifications and cut showing there were a pair of paddle-wheels near either end of the proposed vessel, that were to be driven by a bevel-gear motion from a platform located in the center of the length of the vessel. The cut giving an end view of a paddle-wheel, accompanying the patent, shows it to have eight arms. As this was the first patent issued in this country where the paddle-wheel is mentioned, and the fifth for an improvement in the propelling of boats, a part of the specifications relating to the propelling agent will be of interest at this time: "And fixed on the shafts crossing the boat at a right angle, in the ends of the shaft projecting from or over the boat, are arms supporting the oars, paddles, or floats, the whole of which to be of an optional length, thickness, and breadth. . . . In revolving, each oar, paddle, or float dips in the water in a rotary succession by means of the power applied to the arms of the main horizontal wheel, and from that to the specified wheels and shafts, constitutes the means of propelling boats." How much this patent had to do with the development of the paddle-wheel as an agent in the propelling of steam vessels in this country, after it became a matter of public record, is impossible to say at this late day.

It is thus seen from these proposals for side wheels, and the trials made with this type of propulsion, that they were some years prior to Robert Fulton's experiments with steam navigation in France. The Allison and Morey experiment on the Delaware River was evidently the first steam vessel to have two side paddle-wheels that there is any record of at this day, either in this country or in Europe. This was about six years after the close of John Fitch's experiments on the Delaware River, and about a year prior to Nicholas J. Roosevelt's suggesting the use of side wheels in his experiments where John Stevens and Robert R. Livingston were interested. Almost all the experiments made at this early period were with some agent to take hold on the water other than the paddle or bucket-wheel at the sides of the vessel, as the latter was considered out of the question, too absurd to be considered as a propelling agent, let alone to be adopted for experimental purposes.

It was but about two years after N. J. Roosevelt had suggested the use of side wheels in their experiments, that Robert R. Livingston was appointed by President Jefferson as minister to France, where he arrived in January, 1801. His relation to Robert Fulton, in his own language, is thus noted: "Robert R. Livingston, when minister in France, met Mr. Fulton, and they formed that friendship and connection with each other, to which a similarity of pursuits generally gives birth. He communicated to Mr. Fulton the importance of steamboats to their common country; informed him of what had been attempted in America, and of his resolution to resume the pursuit on his return, and advised him to turn his attention to the subject. It was agreed between them to embark in



FULTON'S STEAMER "CLERMONT."

A drawing prepared on the basis of old models and contemporaneous cuts and descriptions.

known to the Romans, for Appolo Vitruvius, the architect, in the fifteenth century, makes mention of two wheel boats, one having a pair, and the other five wheels on a side. These boats were to be operated by men, horses, or oxen. In the second volume of Harris's "Lexicon Technicum," printed in London in 1710, there is a description of an engine for rowing ships, having "paddles or wheels of six or eight on each side of the ship," to be operated by hand labor through the capstan, that was geared to the water-wheel shaft. The Chinese in the eighteenth century, according to the Jesuit missionaries at Peking at the time, had a war vessel fitted with two paddle-wheels on a side that was operated by men.

In this country the first mention of paddle-wheels is made by Benjamin Franklin in 1785 in his paper on "Maritime Observations," where he says: "Several mechanical projectors have at different times proposed to give motion to boats, and even to ships, by means of circular rowing, or paddles placed on the circumference of wheels to be turned constantly, on each side of the vessel. But this method, though frequently tried, has never been found so effectual as to encourage a continuance of the practice. I do not know that the reason has hitherto been given. Perhaps it may be this: that a great part of the force employed contributes little to the motion." He thought there was too much power lost in the movement of the immersed buckets through the water, to make the wheel of any practical use, which he described with a cut of a paddle-wheel. This was one year before Robert Fulton left the United States for Great Britain.

The earliest proposal for a steam vessel having vertical wheels at the sides, and to be operated by a steam engine, is in the description of a fire ship that was laid before the Lords of the Admiralty in England

engineers at that period, Nicholas J. Roosevelt, who had a foundry and machine shop at Belleville, near the present Newark, N. J., and who was interested with Robert R. Livingston and John Stevens at the time in their experiments with steam vessels, and was at a later date interested with Livingston and Fulton in their first steamboat enterprise on the western rivers, proposed to Chancellor R. R. Livingston in September, 1798, for one of their experiments, "that we throw two wheels of wood over the sides, fastened to the axis of the flys (flywheels) with eight arms or paddles; that part which enters the water of sheet iron, to shift according to the power they require either deeper in the water or otherwise." But no! Livingston, who had a system of propulsion that he considered to be superior to any other system, replied that "vertical wheels, they are out of the question." So they were never tried during the joint experiments of Livingston, Stevens, and Roosevelt.

There were two other Americans who were engaged at an early period in experiments on steam navigation, whose claims for the adoption of the side wheels seem to merit attention. These experiments were the work of Samuel Morey, of Orford, N. H., who at a later date was a civil engineer and a contributor to the pages of our technical journals of that period. He commenced his experiments with steam vessels about 1790 on the Connecticut River, and three years later exhibited to Robert R. Livingston and others at New York a small steamboat fitted with a stern wheel that he had constructed. Being encouraged by the small improvements made from his many trials, and hopeful to obtain a better agent of propulsion, he continued his labors toward that end for a few years, and in June, 1797, went to Bordentown, N. J., on the Delaware River, where he constructed a steamboat. He

the enterprise, and immediately to make such experiments as would enable them to determine how far, in spite of former failures, the object was attainable. The principal direction of these experiments was left to Mr. Fulton, who united in a very considerable degree practical to a theoretical knowledge of mechanics."

The union of the interests of Robert Fulton and Robert R. Livingston in the development of steam navigation at this time was the initial step that ultimately led to the construction of the first commercially successful steam vessel in the world. Livingston had been engaged in experiments with Stevens and Roosevelt for two or three years prior to his appointment as minister to France, although he had been interested in the subject for some time before taking any active part in the experiments. He was well informed, as were his associates at the time, of what was being done by others in this country toward improved methods of propelling a vessel by steam. Livingston says, after meeting Fulton, "informed him of what had been attempted in America." That the proposals made by Roosevelt to him "to throw two wheels of wood over the sides of the vessel," and the building of the steamboat by Morey and Allison with side wheels, that were both before Livingston went to France, were laid before Fulton for his consideration, with much other information on the same subject that had transpired in this country, is not for a moment to be doubted, as it was to their mutual interest.

Robert Fulton acquired all his mechanical knowledge and experience, prior to the construction of the "Clermont," while in Europe. He went to London in 1786 from the United States when twenty-one years of age, and spent two years in Devonshire, near the southwest coast of the British isle. His principal occupation would then appear for several years to have been portrait painting, and later mechanical drawing and sketching. He had resided during some of this early period in a part of the island where he acquired some knowledge of mechanics, and he no doubt put his skill for drawing to good use in the line of mechanical work. In 1796 he published a treatise on canal navigation, and during the latter part of the same year went to France, having spent about ten years in Great Britain. In December of the next year he made his first experiment with the torpedo, on the River Seine; and in July, 1801, made the first descent with his submarine boat in the harbor of Brest. He was now engaged for some years in experiments with the torpedo and the submarine boat, both in France and in England, and no doubt gained much mechanical knowledge from these trials that was of service to him in his experiments with the steamboat.

That Robert Fulton entertained the idea of the application of steam power for the propulsion of a vessel at an early date is found in a letter he wrote to Boulton & Watt on November 4, 1794, where he says:

"I shall esteem it a favor to be informed of the expense of a steam engine with a rotative movement of the purchase of three or four horses, which is designed to be placed in a boat. You will be so good as to mention what size boat it would occupy, and I wish to have it in as little space as possible: and what you conceive will be the expense when finished complete in the boat. Whether you have one ready of the dimensions specified, or how soon one might be finished, with the weight of coals which it will consume in twelve hours, and quantity of purchase you allow to each horse. As I am desirous to apply some engines of the above dimensions as soon as possible, your immediate answer will oblige. ROBT. FULTON.

"Bridgewater Arms, Manchester."

It was but a few months prior to the date of the above letter that the correspondence between Lord Stanhope and Robert Fulton occurred, where the former says on October 7, 1793, "in which you propose to communicate to me the principles of an invention, which you say you have discovered, respecting the moving of ships by the means of steam. It is a subject on which I have made important discoveries. I shall be glad to receive the communication which you intend, as I have made the principles of mechanics my particular study." Fulton also refers to his early consideration of navigation by steam vessels in the introduction in his treatise on canal navigation, where he says, "and having some communication with his Lordship on the practicability of navigating vessels by steam." It is to this correspondence with Lord Stanhope that so much claim has been made for Robert Fulton for his early adoption of the paddle-wheel, but there is no warrant for such a claim in any papers of Robert Fulton's that have thus far been brought to public notice. The production of the certified copy of Fulton's letter to Lord Stanhope of September 30, 1793, with the accompanying drawing, that was used in the New Jersey legal contest, and that was a cause of much strong feeling in the argument of the counsel on both sides at the time, would be of interest to show us what Robert Fulton did say on the subject. He wrote Lord Stanhope on April 11, 1811, saying in part, "You will recollect I wrote you in 1793 that I

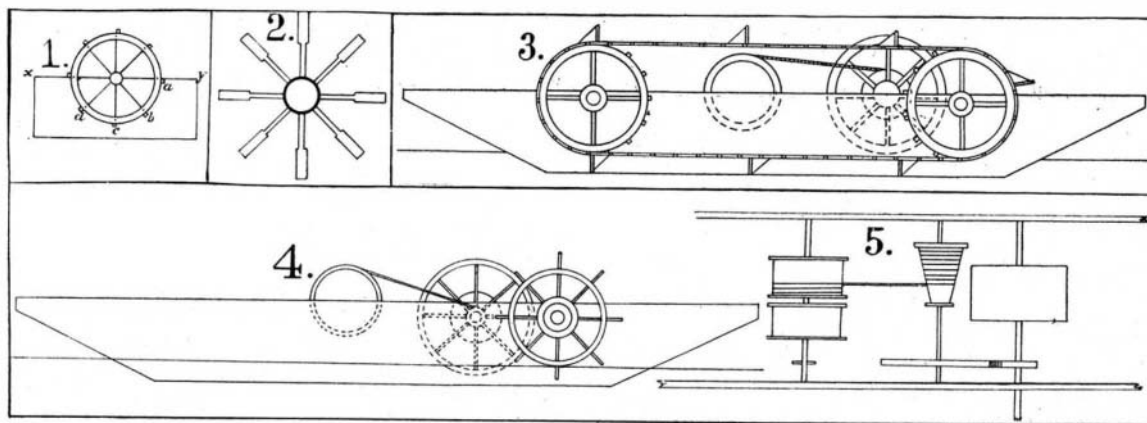
had a plan for upright oars or wheels to propel steam vessels"; and asking him to have a copy certified for his use. This was at the time he began his action against Aaron Ogden to prevent his running a steamboat in New York waters.

Cadwallader D. Colden in his "Life of Robert Fulton," 1817, makes the fatal admission that Benjamin Franklin had considered the use of waterwheels in propelling vessels in these words: "It may be well to remark here that the idea of propelling vessels by waterwheels, which at present are believed to be essential to the success of steamboats, had occurred to Dr. Franklin, but he rejected them as impracticable, and with his essay read before the American Philosophical Society . . . Dr. Franklin gives a drawing of a water-wheel accompanied by what he supposes to be a demonstration that they cannot be used to any advantage." As Dr. Franklin's consideration of the paddle-wheel was made in 1785, it thus disposes of any claim that could be made by the introduction of Robert Fulton's letter of 1793 of a claim of priority.

It is not at all probable that Robert Fulton was engaged in any experiments with steam vessels until after he met Robert R. Livingston in France. This was the period of the "Steam Mania," in Europe as well as in the United States, and Robert Fulton may have come under its influence and been attacked by the same fever of discovery as others at the time, and merely "thought of it." He had been largely occupied with his improvements of canal navigation, and later with his experiments on the torpedo, and his plunging boat or submarine vessel, in France. It was while he was thus engaged with the latter that he made his first experiments with steam navigation. These experiments were begun in 1802 with a small working model, on which he used among other means of propulsion the chaplet, that was a series of floats on an endless chain, on either side of the vessel: a system of paddles, ducks' feet, and later tried the paddle-wheel on the sides of the model. This latter system of pro-

ments in France. His residence in Great Britain brought him in contact with the most advanced thought on the subject of the steam engine and canal navigation, for it was in the British isle at this time that the most progress was being made in the useful arts and sciences. Added to this condition of his being in the circle where most of the works on scientific subjects, both ancient and modern, were to be obtained, and it is seen what a great advantage in the study of the many intricate problems on the subject he possessed over those who were operating for the attainment of the same object in this country.

That Robert Fulton was not *the inventor* of the steamboat has been very generally recognized for many years, though those interested with him in his enterprises at the time had laid claim to such title for him. His success dates from the time of the adoption of the vertical paddle-wheels at the sides of the vessel in his experiments, though they had been used by others in this country long before his trials in France. During his last legal contest that ended in 1815 over the steamboat "monopoly," where Aaron Ogden, of New Jersey, tried to prevent a steamboat that was run under the Livingston and Fulton privilege from running in the waters of the State of New Jersey, Robert Fulton wrote a letter to Aaron Ogden that shows how Fulton viewed the improvements he had made in his steamboats, upon which he had but a few years before obtained patents. "And I have sent certificates of two experienced English engineers who are now engaged in Talman & Ward's manufactory in the Bowery, who state that the links claimed by Mr. Dod as his invention have been on all of Boulton & Watt's engines for fourteen years. When I put these links in my patent, I did not patent them exclusively for all kinds of machinery, nor did I patent the steam engine, nor Charnock's tables. I made use of all these parts to express my ideas of a whole combination, new in mechanics, producing a new and desired effect, giving them their powers and proportions indispensable to



MODELS USED BY ROBERT FULTON IN 1802, WHEN HE EXPERIMENTED WITH THE SYSTEM OF CHAPLETS, AND THE SIDE PADDLE-WHEELS. MADE FROM FULTON'S DRAWINGS.

pulsion offering much better prospects of good results. a boat was built of 66 feet length by 8 feet beam early in 1803, but owing to an accident when the vessel was nearly completed it became necessary to rebuild the hull. The trials in the following August with this boat were entirely satisfactory to all those interested, although the velocity was not as great as Fulton had anticipated. This boat was fitted with paddle-wheels on the sides. He had such confidence that this means of propulsion, with a type of engine that was better adapted to the purpose, would prove successful, that on August 6, 1803, he ordered from Boulton & Watt, of Birmingham, England, "a cylinder of a 24 H.P. double effect, the piston making a four feet stroke; also the piston and piston rod; the valves, and movements for opening and shutting them. The air pump piston and rod: the condenser with its communications to the cylinder and air pump." The work does not appear to have progressed very rapidly with this engine, for in the following July he gave the builders further directions regarding some of the minor parts of the machine. This was the engine, or the main parts of the engine, that was furnished by Boulton & Watt and fitted in the "Clermont."

Fulton's success in his early "experiments" came from his knowledge of mechanics, and to this may be added his keeping in touch with the experiments in steam navigation; and as his interest in the improvement of canal navigation, and later in the development of his submarine boat and his torpedo, must have brought him into contact with those who were at the time interested in the navigation of vessels by steam power, it cannot be doubted but that he had seen some of the experimental steam vessels prior to his taking up the experiments in France in 1802. Add the diversified experience he had obtained in the mechanical line prior to his meeting Robert R. Livingston, to the data laid before him of the many experiments made in this country for the moving of a steam vessel with side wheels, and it will be seen that Robert Fulton was well equipped to make the experi-

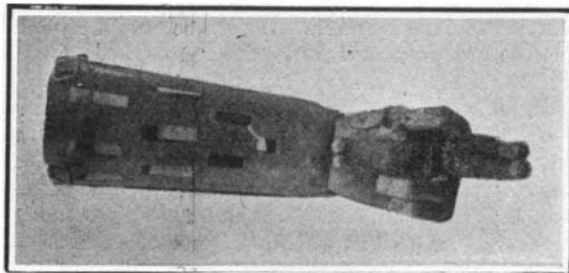
their present success in constructing steamboats; and these principles, those powers and parts which I combined for steamboats, and which never before had been brought together in any steamboat, I patented for that purpose and no other." In his patent of February 11, 1809, he refers to the waterwheel: "I prefer a propelling wheel or wheels to take the purchase on the water. . . . Hitherto I have placed a propelling wheel on each side of the boat, with a wheel guard or frame outside of each of them for protection. A propelling wheel or wheels may be placed behind the boat, or in the center, between the connecting boats." He sums with the declaration, after giving a description of his discoveries, inventions, and improvements on steamboats: "Having mentioned the essential component parts of a steamboat, and its mechanism, its successful construction and velocity will depend, *First*, on an accurate knowledge of her total resistance while running 1, 2, 3, 4, 5, or 6 miles an hour in still water. *Second*, on a knowledge of the diameter of the cylinder, strength of the steam, etc. *Third*, on a knowledge of the square feet or inches which each propeller should have, and the velocity it should run to drive a given boat 1, 2, 3, 4, 5, or 6 miles an hour in still water. It is a knowledge of these proportions and velocities which is the most important part of my discovery on the improvement of steamboats." In his patent of February 9, 1811, Fulton says: "Give the following description of my inventions and discoveries for constructing boats or vessels which are to be navigated by the power of steam engines, believing myself to be the original inventor or discoverer of the following combinations." He then mentions the use of Boulton & Watt's steam engine, or any other steam engine of equal power, "my claim not extending to the steam engine"; then the mode to determine the dimensions of the hull of the vessel, he mentions of the propelling agency: "Having been the first to demonstrate the superior advantages of a water wheel or wheels, I claim as my exclusive right the use of two wheels one on each side of the boat to take the

purchase on the water." Even with such a strong claim in his patent for the exclusive right to the use of two waterwheels, the infringements upon this one item were more than any other item in his patents on steamboats, and yet there is no record of a lawsuit brought for violation of his patent rights on that item. Fulton probably knew it would not hold water.

It will be noticed that Fulton claimed as his patent right the combination of the several parts in the construction of a steam vessel, and not of each individual part, as he was too well informed on the subject to make a claim for the separate parts of the combination. If he intended at any time after the "Clermont" was constructed to claim priority of invention of the steamboat in most of its parts, he was soon brought to realize during the suit against Aaron Ogden that improvements of the age were not known to a selected few.

This view of the case, that he was not the inventor of the sidewheel steamboat, can be further strengthened from a legal point, made at the time. In Robert Fulton's suit brought in 1812 for the possession of a steamboat, that was the example of the most flagrant piracy of his patented improvements of steamboats that could be thought of, Judge Joseph C. Yates, of New York Supreme Court, said in his opinion, after reciting the many statutes of the State giving Livingston and Fulton their privilege of propelling vessels by steam, says: "After the most minute examination of those statutes I cannot find that Mr. Livingston, originally, nor Mr. Fulton, subsequently, pretended to be the inventors of this steamboat. On the contrary, by a recital in the law of 1798 Livingston represents himself to be the possessor of a mode of applying the

grant as *inventors* of the steamboat, and therefore the privilege is totally unconnected with the patent power." Robert Fulton's counsel, the Hon. Thomas A. Emmet, in his argument in the New Jersey case in 1815, insisted that "Mr. Fulton, if he had not discovered in the first instance the original principles of the steam engine, had yet *combined* by the native force of genius simple powers of mechanism so as to



IRON LEFT HAND FOUND IN THE RHINE AT ALTRUPPIN.

produce the important and beneficial effects which are observed in the present improved and useful state of steamboats."

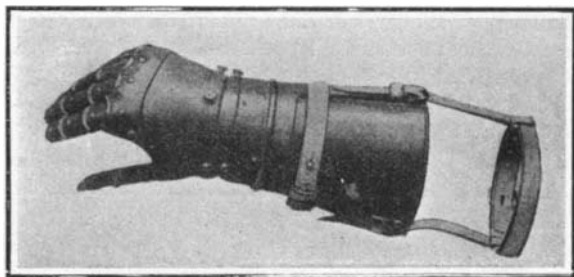
Robert Fulton left a water-colored drawing of 1806, "showing the impropriety of making small paddles to a large boat, and seeking the impulse by giving great velocity to the paddles"; where he figures out by pulley and weights attached to a boat, and a paddle, "each presenting a flat front of four feet to the water," his calculations of the size of paddle wheel for the dimensions of the boat.

There was no part of the "Clermont" when completed for her trial trip that was original with Robert Fulton, though he obtained two patents at later dates in this country for improvements on the hull and engine of a steamboat, when patents could be obtained on application for them. His theoretical knowledge of mechanics, and its adaptation to practical purposes, was the one secret of his success in steam navigation. His thorough knowledge of the failures made by the many seeking for the coveted prize showed him to a great extent what features of a design to select that offered the greatest prospective value, and with good mechanical judgment brought together those parts of the motive power and propelling agency that made the "Clermont" a commercially successful steamboat. That the vessel at first was not entirely a success as a structure, is seen from the fact that after three months service she was subjected to many changes in hull, propelling agents, and motive power, through knowledge gained during the short period of her operation. That is no more than could be expected in such a radical departure in mechanics. Robert Fulton in less than three months after the vessel was in

operation had in mind the building of another steamboat. He had noted that the "Clermont" was structurally weak, and required to make her fit for future service to have extra floor and top timbers, and knees with extra deck beams, and heavier deck plank, and to be sheathed over the outside planking; and if it was not better to build another vessel, such as experience would dictate, and use the material in the "Clermont" so far as possible in its construction. There has never been found, so far as all records show to this time, any plan of the vessel or model of the "Clermont." As the builder was one of the highest reputation as a shipbuilder at the time, he may have been given the dimensions of the vessel and estimated weights to be carried, and worked out such a plan of a vessel as he thought most adapted for the work to be done. But what became of the plans? Or was this during the "chalk" period?

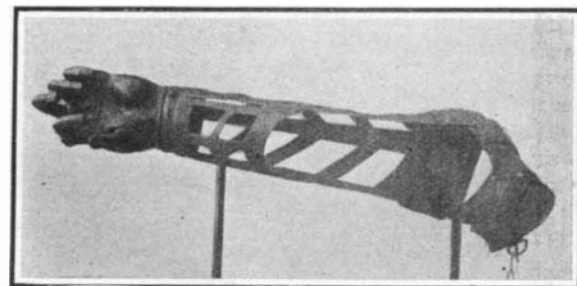
While all credit must be given Robert Fulton for the first commercially successful steamboat in the world, still there is indisputable evidence, from the highest authorities on the subject, that the parts of that vessel that made it a success were the thoughts of other minds prior to his labors with steam navigation; for without the side paddle-wheels and the steam engine it undoubtedly would not have been a steamboat.

There has been little information handed down to us regarding the builder of the "Clermont," but such as we have shows that Charles Browne was a builder of vessels on Manhattan Island at the foot of Houston Street, East River, and having as high a professional reputation, and the most progressive, in his line of



MODERN SHEET-IRON HAND USED IN THE PERFORMANCE OF GOETHE'S DRAMA "GOETZ VON BERLICHINGEN."

steam engine to propel a boat on new and advantageous principles." Judge Smith Thompson also said: "The appellants do not in the case before us claim as *inventors*, but only as *possessors*, of a mode of applying the steam engine to propel boats on new and advantageous principles." Chief Justice James Kent at the same time said: "But the respondents show no patent, and the appellants have not obtained their



A 15TH CENTURY IRON HAND IN THE BERLIN EDUCATIONAL COLLECTION.

business, of the constructors in the city, of which there were at the time comparatively few to what there were ten years later. In all probability he was the best qualified to work out the problem of a suitable type of vessel for the purpose. He had been established in business in 1807 about five years, and during that time had constructed six or eight sailing vessels for New York merchants.

IRON HANDS. SOME CURIOUS OLD CONTRIVANCES.

BY F. M. FELDHAUS.

GOETZ VON BERLICHINGEN was a gallant German knight of the sixteenth century, who espoused the cause of the oppressed peasants because of his personal quarrels with their oppressors, and thereby won undying fame as a champion of liberty. Goethe made him the hero of a drama, which is based upon his autobiography. He was known as Goetz of the Iron Hand because he had lost his right hand in battle and wore an iron hand so skillfully contrived that he could guide his horse with it. Two iron right hands made for Goetz are still in existence and in the possession

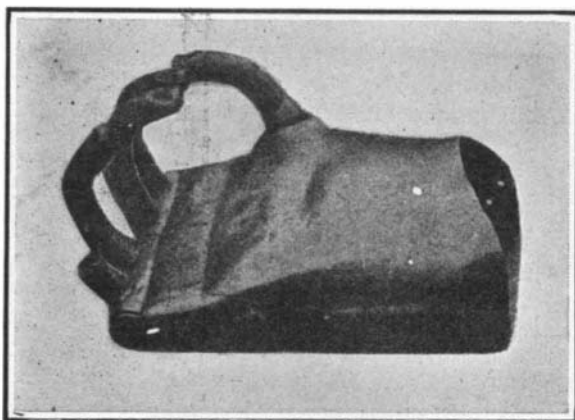
of two branches of his family. One of them, the Rossach hand, is comparatively simple and crude. It can be opened and closed by moving a button at

the back, but the four fingers move as a unit. The little finger is now broken, but the mechanism is intact.

The Jagsthausen hand is more elaborate. Indeed, it is one of the most remarkable pieces of mechanism of its period. Each joint of the fingers can be moved independently of the others, and held in any desired position by a spring catch. When the large button at the wrist is pressed, all the fingers spring back to the extended position shown in the illustration. The thumb has a single joint which is governed by the



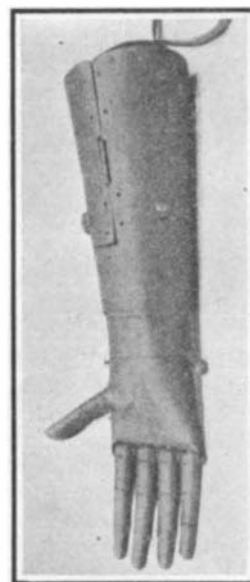
GOETZ VON BERLICHINGEN OF THE IRON HAND. (BORN 1481, DIED 1562.)



THE EARLIER OR "ROSSACH" IRON HAND WORN BY GOETZ VON BERLICHINGEN.



16TH CENTURY IRON HAND IN THE COLLECTION OF COUNT WILCZEK.



THE LATER OR JAGSTHAUSEN IRON HAND WORN BY GOETZ VON BERLICHINGEN.