CHAPTER I

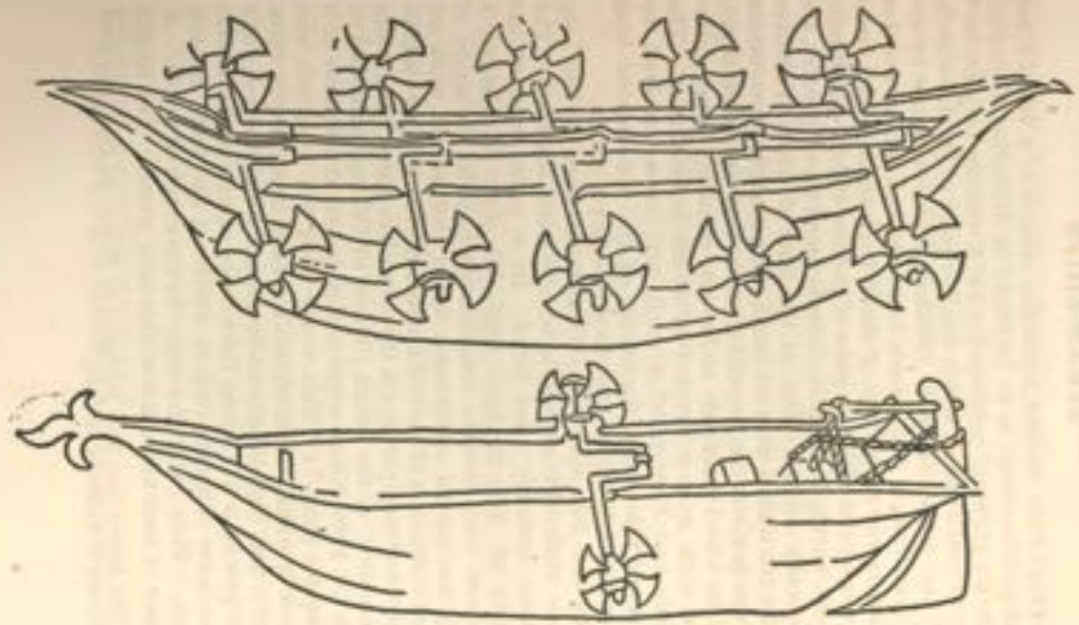
PRIMITIVE EXPERIMENTS IN PROPULSION—SOME EARLY EXPERIMENTS WITH STEAM

OPINIONS are divided as to whether the paddle-wheel is a development from the action of a man paddling a canoe, or the result of applying to a vessel an ordinary wheel, with blades to make it bite the water; or it may be stated thus: Did the paddle-blades grow out of the wheel, or the wheel out of a number of paddle-blades? There is no satisfactory evidence one way or the other; suffice it that the idea of revolving paddles was developed.

How the power which caused the revolution of the paddles was applied at first is as unknown as the identity of the man who first thought of making navigation easier by mechanical means. It was probably human power, as the first inventor can hardly have discovered how to utilise animals for the purpose, and from what we know of primitive expedients we may conjecture what the first contrivance used to urge a boat onwards without sails or oars was like. The craft would be a small one. Perhaps the proprietor was too poor to hire rowers. Perhaps, a subtle financier, he realised that if he could bring his goods to a certain place before rival shippers he would secure the market. Hence, stimulated by poverty or cupidity or both, he reflected, experimented, and finally

invented the revolving paddle. But his apparatus was probably nothing more than a smooth, straight branch or tree log, which projected over either side of the boat and carried at each end paddles fixed radially. He probably used two or four paddles, as it would be easier to attach them to the axle in pairs. The radii of the paddles consisted of two poles tied at right angles about the middle and there fastened to the axle ends, roughhewn boards or strips of bark being attached at the extremities of the poles to form the paddle-blades. The axle was doubtless kept in place either by pins in the gunwales placed before and after it, or by bringing two of the ribs on either side above the gunwale line and disposing the axle between them. In many modern rowboats one or other of these plans is adopted for the accommodation of the oars or sculls. This much being accomplished, it only remained to apply the power. The inventor now passed a rope twice round the middle of the axle, and tied the ends together. By hauling on it he got all the power he was likely to require; to go astern he had merely to pull the rope the other way. If more power was required more men tugged at the rope.

When paddles were made larger to suit hulls of larger dimensions, it may fairly be assumed that a winch turned by several men was used, and that the power was transmitted to the axle of the paddle by means of an endless rope. But soon it occurred to the shipowners that animals might be used to produce the power instead of men. Horses or oxen were made to drive a turntable or capstan, to work in a cage after the fashion of white mice in their cylinders, or on a moving floor which imparted its motion to an axle connected by an endless rope with the axle of the paddle. Such boats, deriving their power from animals, were built by the Romans, were in use in the early centuries of the Christian era, and were not unknown in the nineteenth century in Britain and the United States.



PRIMITIVE PADDLE-BOATS.
From Valturius' "De Re Militari," 1472.

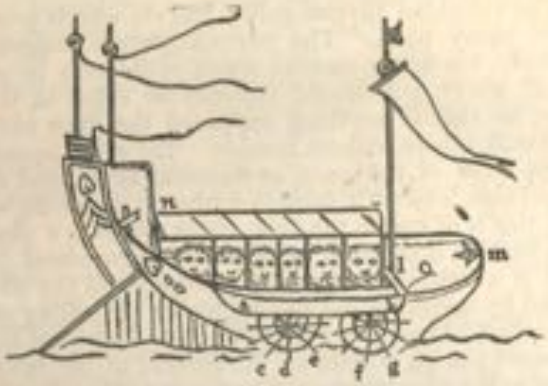
STEAM-SHIPS

One of the earliest authentic records of a vessel fitted with paddle-wheels is to be found in Robertus Valturius' "De Re Militari," published in 1472, wherein are pictures * of two boats, one of which has five pairs of paddle-wheels, and the other one pair. Modern engineers know by experience that if two wheels be placed one behind another —and in the early days of steam navigation several boats were equipped with two pairs of paddle-wheels—the hinder wheels, having to work in disturbed and moving water, are practically useless. But at the time of which Valturius writes the wheels were so small, the number of revolutions were so few, and the propelling power they exerted so slight, that no wheel was likely to have its efficiency much interfered with by any number of wheels in front of it. The wheels had four paddles each, and were revolved by cranks on their axles, the cranks of the ten-wheeled boat being connected by a rope to give uniform action.

In the Far East also, wheel-boats were in use long before steam-driven paddle-wheels were invented. The Chinese certainly used them. In a paper read at the Society of Arts in April 1858, Mr. John McGregor, a barrister, who devoted considerable time to the study of early mechanical appliances, stated that an old work on China contains a sketch of a vessel moved by four paddle-wheels, and used perhaps in the seventh century. In certain "Memoires" of the Jesuit Fathers at Peking, published at Paris in 1782, there appears this quaint description of a "barque à roues": "This vessel is 42 feet in length and 13 feet in width. The wheels are fixed in an empty space about a foot high situate underneath the strip between the stout planks *a b*. From the axle or centre of the wheels any number of spokes radiate which act like teeth for the wheels. They enter the water to the depth of a foot. A number of men make the wheels turn round. The length

* The designs have been attributed to Matteo de' Pasti, who lived at the court of Malatesta (d. 1464).

of the prow from *l* to *m* is 8 feet. The length of the body of the vessel from *n* to *o* is 27 feet, and the length of the poop 7 feet. Heads of tigers are represented on movable boards covered with leather, about 5 feet in height and 2 feet wide. These boards shelter from the



"Barque à Roues," Primitive Chinese Paddle-boat.

enemy the soldiers who are behind them. They are removed when the crew decide on boarding the enemy's vessel." The good Fathers in their "Memoires" add a recommendation to experts in Paris to study the principle with a view to its adoption in French vessels, and they point out that even if the extra speed attained were ever so slight it might be sufficient to bring a vessel out of a dangerous situation. It may well be doubted, however, whether the shipping experts in Paris at that date profited by this humanitarian suggestion. Be this as it may, the passage proves that the propulsion of vessels by revolving wheels was not a western idea only.

Panciroli, writing in the sixteenth century, describes an

extraordinary boat of which he had seen a picture. His book is not illustrated; but we find a representation of a *liburna*, or galley, which exactly corresponds to Panciroli's description,* in Morisotus' (Claude Barthélemy Morisot) "Orbis Maritimi . . . generalis Historia," published in 1643.

The vessel, an Illyrian galley, had six wheels propelled by as many oxen. The curious picture suggests an unwieldy, top-heavy concern which could only be of use in still water, and would probably be safest in shallow water, so that if anything happened the oxen and men could walk ashore without trouble. The cattle apparently occupy most of the space, an immense bird's head with a hooked nose juts out in front immediately above the water-line; this is of course the ram, above which is a platform upon which a dog stands as the vessel's figure-head.

It is unnecessary to go in detail into all the schemes devised by inventors and visionaries for propelling vessels by mechanical means. Several of them from time to time suggested placing wheels on the outside of the boat, and "turning the wheeles by some provision so that the wheeles make the boat goe," to quote William Bourne's proposition of 1578, but the "some provision" constituted a problem which he and many others found too much for them. David Ramsay in 1618 took out a patent "to make boats for carriages running upon water as swift in calms and more safe in storms than boats full sailed in great winds," and twelve years later another patent is recorded to his credit for making ships and barges go against the tide. The optimism of these and other

* "Vidi etiam effigiem Navium quarundam, quas Liburnas dicunt; quæ ab utroque latere extrinsecus tres habebant rotas, aquam attingentes: quarum quælibet octo constabat radiis, manus palmo e rota prominentibus: intrinsecus vero sex boves machinam quandam circumagendo rotas illas incitabant: et radii aquam retrorsum pellentes, Liburnam tanto impetu ad cursum propellebant, ut nulla triremis ei posset resistere."—Guido Panciroli: *Rerum memorabilium*, libri ii. Amberga, 1599.

mechanical pioneers was wonderful; indeed, had their inventive genius only equalled their imagination, some of the difficulties which until comparatively recently baffled

"Liburna" or Galley, worked by Oxen.
From Moriustus.

naval engineers and marine architects would have been long since overcome.

The webbed feet of water-birds suggested to many a form in which mechanical propulsion could be applied.

This was only natural, as early shipbuilders took as their models the birds which they saw floating before them. In 1759 a Swiss pastor named Genevois published at Geneva a proposal to use an oar fitted with a foot which should expand when used for propelling a boat and contract when being moved forward through the water for another stroke. Genevois visited London in 1760 to lay his proposal before the Government. His propellers were to be worked by springs which in turn were to be compressed by a kind of cannon with a piston. A pamphlet which he issued at the time of his application to the Government contains the interesting statement that he had been informed that a Scotchman had propounded a scheme thirty years earlier for propelling vessels forward by the recoil from the firing of cannon over the stern. The gunpowder of the period made up in smoke what it lacked in power; hence, although the vessels of his day were not large, the ingenious Scot "found, by the experiments made for that purpose, that thirty barrels of Gun-powder had scarce forwarded the ship the space of ten Miles"; and it is not surprising that this means of mechanical propulsion shared the fate of all of its predecessors.*

Many other extravagant schemes might be quoted. Edward Ford in 1646 was quite modest in his patent to "bring little ships, barges, and vessels in and out of any havens without or against any small wind or tide," to which he cautiously added the qualification "if the seas be not rough." With the exception, however, of a few sporting proposals of which the Scotch Gunpowder Plot is a type, no advance in solving the problem of producing the power for propulsion was made for centuries. The burden of physical exertion had been shifted from men to animals, but that was all; and yet in every age during the last two thousand years there seem to have been many

* "Some New Inquiries tending to the Improvement of Navigation," by J. A. Genevois, 1760.

people who were acquainted with the expansive power of steam, a fact which makes this slow development the more remarkable.

The first person to observe the properties of steam, or at any rate the first to record his observations, was Hero of Alexandria in 120 B.C., but though he advanced from theory to practice, his æolipile does not seem to have answered any useful purpose. This machine consisted of a hollow glass ball supplied with steam at its axis. The steam escaped by means of a series of hollow tubes, placed at right angles and projecting from the globe at a circle on its circumference equidistant from the two poles, the tubes being closed at the ends and provided with orifices at the sides near the ends. Nothing came of his invention, so far as is known, and the æolipile remained an interesting toy and nothing else—a toy, however, which has the honour of being the first mechanical contrivance in which the expansive power of steam was used. After this, for many centuries, no attempt was made to use this great natural agency for the purpose of producing what Bacon called "fruits" for mankind. Unscrupulous priests worked "miracles" by this means for the edification of their flocks, and doubtless revived thereby many whose faith had become lukewarm. It never seems to have occurred to them that a far more direct means of moving mountains was already under their control.

At last in 1629 the use of steam as a means of producing power was suggested by Giovanni Branca of Loretto, who, apparently adopting a simplified form of Hero's device, planned so that a jet of steam blew against a series of vanes arranged on the rim of a wheel.

In the seventeenth century also, that eccentric genius the second Marquis of Worcester published his "Century of Inventions." In this he suggested a number of mechanical contrivances, some of which contained the fundamental ideas of later inventions, the most notable

being that of a steam-engine with a piston and lever; but he does not seem to have designed any vessel which would justify the claim sometimes made on his behalf that he was the inventor of the steamboat.*

About the same time, Sir S. Morland, another experimenter, estimated the expansive force of water at 2000 times, in which he was not far from the truth.

England, however, was not the only country to produce inventors. One Blasco de Garay, who flourished a hundred years before the Marquis of Worcester, is declared by his champions to have been the first to solve the problem of propelling a vessel by steam-power. But investigations as to the accuracy of the story tend to the belief that he did nothing of the kind, and that the beautifully circumstantial account of his experiment does greater credit to the imagination of the narrator than to his regard for accuracy.† De Garay's experiment was made at Barcelona in the year 1543 in the presence of representatives of the Emperor Charles V. Ravago, the Treasurer, reported to the Emperor that the vessel would go two leagues in three hours, but that the machine was complex and expensive, and that the cauldron in which the steam was generated might burst. This is exactly the report which a cautious financier, presumably not an expert in mechanics, might be expected to make. Other reports were more favourable to the project, the commissioners appointed for the purpose ascribing to the vessel a speed of a league an hour. What has been established beyond question, however, is that De Garay made the experiment with a boat fitted with paddle-wheels, but that the wheels were turned by men and not by steam.

Salomon de Caus, a native of Normandy, is sometimes

* Partington's edition of the "Century of Inventions."

† Mr. John McGregor reported to the Society of Arts that the claim that De Garay used a steam-engine is unfounded, human power being used.

claimed by French writers to have first thought of using steam as a motive power in 1615, but his invention does not seem to have fructified. Half a century later the unlucky Doctor Denis Papin, a native of Blois, entered the field of invention. He came to this country from France in 1675, was elected a Fellow of the Royal Society in 1681, and in 1690 described a steam cylinder fitted with a piston which descended by atmospheric pressure when the steam below it was condensed. He suggested that one of the uses to which his engine might be put was the revolution of paddle-wheels fitted to a ship, several cylinders being applied which worked alternately with the rackwork he designed. He may have been led to this by witnessing in 1681 the experiments on the Thames with a boat designed by Rupert, the Prince Palatine, with revolving fans, which easily left behind a boat manned by a number of oarsmen. It has been claimed for Papin that he was the inventor of the safety-valve, but this is disputed.* Prior, however, to his atmospheric engine he brought out in 1685 a machine for raising or pumping water, but the Royal Society treated it with contempt and referred to it as a "mere trick." Neither of his machines received the recognition which historians have since decided was their due, and he went back disheartened to France, whence he was driven by the Revocation of the Edict of Nantes to Marburg. He reappeared in England in 1707 and announced a project for moving ships by means of wheels and steam. Unfortunately for him, Thomas Savery, born in 1658, had already been at work on the problem, and had brought out his fire-engine, which among other things he thought might be used to propel ships. His machine lacked power, and was replaced by one made after the design of his partner Newcomen. Papin was also associated with Newcomen and Savery at one time. Savery says of his own machine that he would refer the question

* Hy. Frith's "Triumphs of Steam."

of its suitability for shipping to those more competent than himself to judge. Papin appealed to the Naval Department to consider his invention, but the Government of the day, after the manner of Governments when face to face with a new project, thought it useless, and made severe remarks on his presumption in continuing to invent for them. He exhibited his invention on the Thames, but no one took any interest in it. Thoroughly disheartened by the failures which attended all his efforts, Papin went to Germany, and is stated to have there built a steamer which was actually tried on the Fulda or the Weser, but the local watermen, fearing the rivalry of the new machine, smashed it, and that is the last which history has to record of Papin as a pioneer of steamboats. It is asserted that this boat was built for him by Newcomen and Savery in this country. As an experimenter he did valuable work, for he seems to have been the first to have grasped the importance of the vacuum under the piston.*

In 1730 another remarkable proposition was made for marine propulsion. Doctor John Allen thought it possible to move a boat by pumping in water at the bows and pumping it out again at the stern, this scheme being probably the earliest attempt to secure motion by what has since become known as the jet-propeller system. Like almost all other inventions of his period it was crude in its details and does not seem to have been put to any practical use.

The next inventor who turned his attention to the question was Jonathan Hulls, for whom it has been claimed, with some show of justification, that he was the actual inventor of the steamboat. That he did invent a steamboat is beyond question, but whether his vessel was ever built, and if so whether it attained any measure of success, are points upon which historical evidence is not conclusive. But if it was constructed, and there is strong

* Lindsay's "History of Merchant Shipping."

circumstantial evidence in support of this contention, then to the West of England, which has contributed so largely to the maritime glory of Britain, must be ascribed also the honour of being the birthplace of one of the two inventions which have done more than anything else to aid in the spread of civilisation and commerce. Hulls was born at Aston Magna in 1699. By occupation he was a clock repairer, a precarious trade at best. The difficulties he had to encounter through lack of means were very great, but he persevered, and a patron at last appeared in the person of a Mr. Freeman, of Batsford Park, near Chipping Campden, who supplied him with about £160 to develop and patent his invention. This enabled Hulls to proceed to London, and he petitioned Queen Caroline, as Guardian of the Realm in the absence of her Consort George II. at Hanover, for Letters Patent for the invention, which was accordingly granted to him December 21, 1736, provided he enrolled in Chancery within the following three months a specification describing his invention.* The patent read as follows:

"Whereas our Trusty and Well Beloved Jonathan Hulls hath by his petition humbly represented unto Our most dearly beloved Consort the Queen. . . . That he hath with much Labour and Study, and at Great Expense Invented and Formed a machine for carrying Ships and Vessels out of or into any Harbour, &c., which the Petitioner apprehends may be of great service to our Royal Navy and Merchant Ships, and to Boats and other Vessels, of which Machine the Petitioner hath made oath that he is the sole inventor, as by affidavit to his said petition annexed.

"Know ye therefore that we of our special grace, have given and granted to the said Jonathan Hulls our special

* Mr. J. H. Hulls' lecture at the Institute of Marine Engineers on "The Introduction of Steam Navigation," February 26, 1906.

license, full power, sole privilege and authority during the term of fourteen years, and he shall lawfully make use of the same for carrying ships and other vessels out to sea, or into any harbour or river.

"In witness whereof we have caused these our letters to be made patent.

"(Witness) CAROLINE,
"Queen of Great Britain.

"Given by right of Privy Seal at Westminster this 21st day of December 1736."*

Mr. P. C. Rushen, in referring to the experiment, writes:

"About this time it may be presumed that Jonathan set about constructing a vessel in accordance with his plans, and for this purpose he had the help of the Eagle Foundry at Birmingham, to which he forwarded rough model plans and sketches to aid in founding and forging the various parts. Until quite recent years these relics were existent, but on the sale and demolition of the foundry they seem to have been destroyed.

"The new vessel was tried on the Avon, but tradition says it was a failure, by reason of the inventor not providing the proper means to communicate the power to the paddle. That the experiment was a failure seems evident from the fact that nothing more was heard of the boat, but for the given reason is very improbable, because the very ingenious means the inventor describes, although perhaps not quite practical on a large scale, are not palpably unworkable for a small experimental boat. Even if these means were a failure, it would be ridiculous to suppose that a clever mechanic such as Hulls shows himself to be in his pamphlet would be at a loss for some expedient.

"The more probable reason of Hulls' failure was the

* From copy of patent in possession of Mr. J. H. Hulls.

JONATHAN HULLS' PADDLE STEAMER, 1737. p. 51

want of financial support, that previously accorded him being perhaps withdrawn on the first hitch in the experiments, or for some other reason, this so disheartening him that he relinquished the idea. While Hulls had been at work on his project, he had worn a brown paper cap, as usual with mechanics at that time, and this fact was taken advantage of in a scathing doggerel, which was circulated upon his failure, and which ran:

"Jonathan Hull
With his paper skull;
Tried to make a Machine
To go against wind and tide,
But he, like an ass,
Couldn't bring it to pass
So at last was ashamed to be seen." *

The engine which Hulls used was an adaptation of Newcomen's. He published a lengthy description of his boat, in which he states that, in his opinion, it would not be practicable to place his machine on anything but a tow-boat, as it would take up too much room to allow of other goods being carried on the same vessel, and it could "not be used in a storm, or when the waves are very raging." Hulls died in London destitute, and the world inherited his ideas. Steam tow-boats are now found all over the world, and the despised stern-wheeler of his day was the forerunner of the great stern-wheelers of the Mississippi.

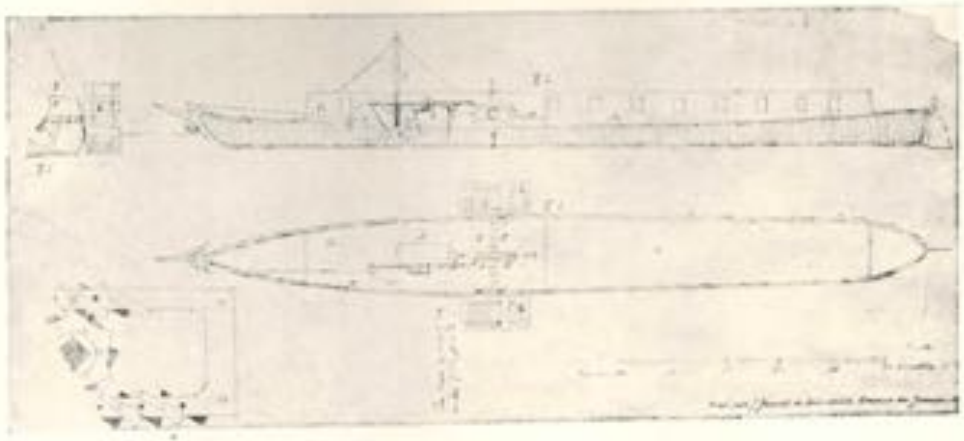
Another person who took up the subject seriously was a Frenchman, Jouffroy d'Abbans, better known perhaps as Claude François Dorothée, Marquis de Jouffroy. His invention was known as the Pyroscaphe. It was claimed for him by the Marquis de Bausset-Roquefort that "he was the first who carried out in practice a scheme for

* P. C. Rushen's "History and Antiquities of Chipping Campden in the County of Gloucester," 1899.

navigation by steam, his successful experiments on the Saône at Lyons in 1783 being attested by official documents, and by the evidence of thousands of spectators. The glory of the invention of the means of using steam-power in navigation belongs therefore to France, as is clearly shown by the archives of the town of Lyons."

The Marquis de Jouffroy was born at Roche-sur-Rognon in 1751. A duel fought while he was page to the Dauphin caused his exile to Provence, where he studied the methods by which the ancient rowing galleys were propelled. He returned to Paris in 1775 and conceived the idea of inventing some form of steamboat while looking at the Chaillot fire-pump which Périer* had erected a short time previously. He communicated his project to Périer, who made some fruitless experiments and declared the idea impossible. Jouffroy, however, persevered, and in 1776 had constructed a machine which he adapted for use on a boat. "His first pyroscaphe was 13 m. long, and 1 m. 95 c. wide. The 'swimming' apparatus consisted of rods 2 m. 66 c. in length suspended on either side well forward and carrying at their extremity frames fitted with hinged flaps with a dip of 50 c. The frames were capable of describing an arc of 2 m. 66 c. (8 feet) radius and of 1 m. (3 feet) in length, and were drawn forward at the end of the stroke by a counterweight. A single-acting engine by Watt, installed in the middle of the boat, set in action these hinged flaps. The construction of this apparatus in a locality where it was impossible to obtain a cast and bored cylinder was a work of genius, courage, and patience. Despite its imperfections it was superior to anything attempted up to that time in navigation. The boat worked on the Doubs at Baume-les-Dames between Montbéliard and Besançon during the months of June and July." This system, since called the

* The name is spelt "Perrier" by some writers.



THE MARQUIS DE JOUFFROY'S STEAMBOAT. 1783. p. 16

"Palmipède," imitated the movements of aquatic birds, and was the only one that could be applied to the steam-engine as then known. It was, however, useless for moving large masses or for working against the current. "Jouffroy saw the defects caused by the fact that the rapidity of the boat's motion prevented the hinged flaps from reopening after the forward stroke, especially when the pyroscaphe was moving upsteam or against the tide. Hence the engine only acted at intervals instead of keeping up a sustained movement. But Jouffroy substituted paddle-wheels for the hinged flaps (*volets à charnière*) and devised a new machine in which the action of the steam was made continuous by means of two bronze cylinders, the top placed lengthwise with the run of the ship, making with the horizon an angle of about 50 degrees. The bottoms of the cylinders were encased in a metal box containing a sliding tile which opened and shut, alternately giving a passage to the steam and the intake of water in each cylinder.

"By July 1, 1783, Jouffroy had constructed a second boat which was launched at Lyons. Its dimensions were considerable, the length attaining 46 m. and the breadth 4 m. 50 c. The wheels were 4 m. diameter, the paddles 1 m. 95 c., dipping 65 c. The draught of water of the vessel was 95 c. The total weight was 327 milliers, of which 27 were for the vessel and 300 for the freight. This enormous vessel voyaged against the tide of the Saône from Lyons to L'île Barbe in the presence of the Commission de Savants and thousands of spectators, as officially recorded in the archives of the Municipality of Lyons." Arago says this vessel continued to navigate the Saône for sixteen months.*

Jouffroy now thought of starting a company to run

* Paper read by the Marquis de Baunet-Roquefort before the Lyons Literary Society in 1854, and preserved at the Mazarin Library (Academy of Sciences), Paris.

boats on the new system, and applied to the Government for the necessary permission. The question was submitted to the Academy of Sciences, who appointed a Commission to inquire into the matter, but among the members of the Commission was the unsuccessful Perier, whose opposition resulted in the Academy concluding that the experiments at Lyons were not decisive. The Marquis had not the means to continue building steamboats and, profoundly discouraged, he abandoned the rôle of inventor. He had already been subjected to much ridicule, and it was generally agreed that he must be mad to think of "making fire and water agree"; he was even nicknamed "Pump Jouffroy." He witnessed the experiments of Fulton in France, but did not think of claiming the merit of his discovery until 1816, when he issued a publication entitled "Steamboats." The same year he took out a patent, formed a company, and on August 20 launched a steamboat at Bercy, but the venture did not come up to the expectations of the shareholders, and this was his last effort. Jouffroy died of cholera at the Hôpital des Invalides in 1832. Arago, the historian, says that his claims to be the first inventor of the steamboat have been established, and, according to Larousse's "Dictionnaire universel du XIX^{e} siècle," Fulton himself openly acknowledged them in the United States law courts.