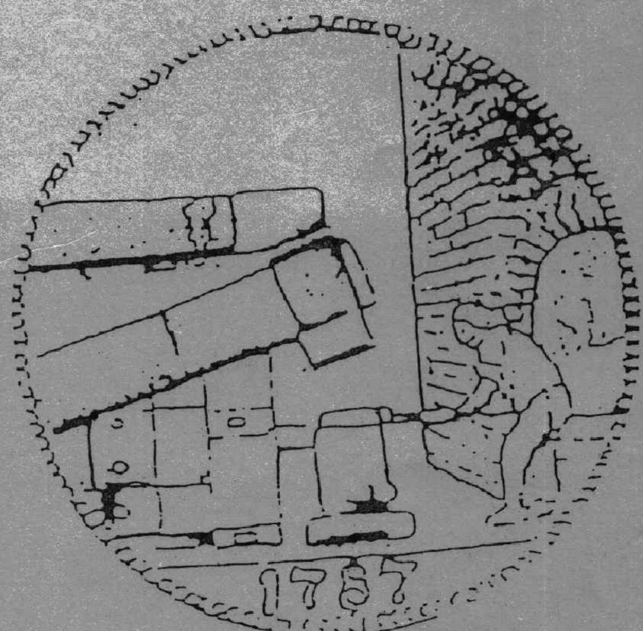
THE JOURNAL OF THE WILKINSON SOCIETY

IRON BOAT BICENTENARY NUMBER



No. 15 1987

E D I T O R I A L

This issue of the Journal is devoted entirely to one article, "John Wilkinson and the Early Iron Barges". Richard Barker's researches have resulted in the most authoritative account to date of this subject, and we feel it deserves a whole journal to itself.

The next issue of the Journal will include an update on Society notes and news, a tribute to the late Chris Whall and two feature articles.

N. J. Clarke
(July 1987)

Richard Barker

JOHN WILKINSON AND THE EARLY IRON BARGES

The Background

At the end of the eighteenth century the upper Severn was truly a river of contrasts and novelties, and its banks crowded with the burgeoning industrial revolution.

Primordial coracles mingled with wooden river trows capable of carrying a hundred tons of coal or iron; and the hellish sights of Coalbrookdale, and many other furnaces, forges and mines, were juxtaposed to some idyllic scenery.

Into this scene, within a quarter of a century, would be placed the first major iron bridge, the first large commercial iron barge, the first major iron aqueduct [1], some of the first high pressure steam engines, the first experimental railway engine; and Trevithick would even convert a steam engine lying on board a barge waiting for transport downriver to propel the barge itself [2].

Not all entrepreneurs were so peaceable as the Quakers. John Wilkinson made his fortune in part from the manufacture of guns, initially during the Seven Years' War, and by 1787 he controlled an industrial empire. He came to be hailed as the "King of the Ironmasters", or in his own phrase "Father of the Iron Trade".

The Severn was the crucial artery of this revolution: the Dale may have had its fuels and ores and originally water power, but its heavy transport links were rudimentary: that to the expanding canal system, the markets, and the ports was the river - 27 miles of intractable water to Stourport alone.

The river trades were a pole apart from the activities of the ironmasters. The bargemen and bow-hauliers traditionally fought for their rights (and appropriated much that was not theirs); they violently opposed improvements as simple as horse-towing paths, let alone canalisation of the river itself (seriously proposed and defeated in 1784-6). Watermen have always been a race apart, and whether as a representative of the class of ironmaster or as a notoriously difficult individual, John Wilkinson appears to have met resistance, or simple inability (subject as they were to the vagaries of the rainfall over Wales), to provide the expansion of regular transport facilities that was required to sustain his industrial expansion. Wilkinson had, too, a factory at Bradley, on the Birmingham Canal: perhaps he wanted a direct link between Willey and Bradley.

Randall, and Dickinson following him, ascribed the problems that led to the *Trial* to the barge builders; and lack of suitable timber has also been suggested as a cause. I regard these as doubtful. Narrow boats did not require prime shipbuilding timber for the most part (neither did the river barges), nor large quantities of timber. The canals were by then so long established (and largely remote from the old river systems), that a monopoly of narrow boat building by recalcitrant Severn barge builders (for which I know of no evidence) seems highly improbable.

The real shortage that is noted in several accounts was that of manpower to actually manage the boats, both on the rapidly expanding canal systems, and on the Severn itself, during the relatively short periods when laden barges could be moved, and particularly upstream under tow [3]. Nothing Wilkinson could do with iron barges could alter these problems.

If there was a supply problem behind the construction of the *Trial*, it was simply that there were so many new canals being opened in the late 1780's, that there was insufficient skilled labour available to meet the demand for new canal boats. Besides, the full evidence from Stockdale appears to be that Wilkinson was experimenting at Bradley for a full year or more before actually building the *Trial* at Willey. It was not a sudden argument with Severn barge builders that precipitated her construction.

We might also note that the start of these experiments coincided with the failure of the 1786 Navigation Bill for the Severn. It was not, apparently, triggered by any sudden advance in metal-working (despite Cort's recent Patents for rolling and puddling wrought iron). Indeed, there is substantial evidence that the basic material of these iron boats was actually cast iron: certainly it cannot at present be proven that they were built from wrought iron, as is generally read into one selected part of the evidence.

Against this background, John Wilkinson constructed the *Trial* in 1787, commonly celebrated as the first iron boat (though this is not actually correct). It was followed by another three vessels in 1788, committing Wilkinson to a substantial programme of work: it is known that the cost of each boat was at least three times that of a comparable wooden boat.

It is immediately apparent that the published material for Wilkinson's (and other early) iron boats is quite inadequate to form a precise picture of any of them. Whether from the misunderstandings of reporters (confusing cast and wrought iron, for example) from the approximations used in accounts (about 8 tons, upwards of 32 tons, etc), no absolutely clear description of the *Trial* emerges that is not immediately contradicted by another source.

The Birmingham journalist stated that the boat was of equal draught to wooden narrow boats, but the probably more reliable Svedenstierna is adamant that the iron boats he saw at Bradley in 1803 were markedly lighter than wooden boats. It is not even possible to be certain of the number of boats built by Wilkinson in 1787-8, let alone subsequently. The newspaper reporting is somewhat random: none of them mention two of the four launches, nor more than one of the other two. Even the place of actual construction, and that of launching, are not known precisely. Most accounts can be interpreted in different ways, from the simple ambiguity of language.

I have considered it best to provide in appendices verbatim texts of the most important early references, so that readers may judge for themselves, and to collect as a starting point the relatively few undisputed facts about the *Trial*. It should be self-evident that many of the accounts are contradictory and fanciful.

The balance of the essay will be an attempt to collect direct and comparative material for early iron boats in general, as near contemporary as possible, and to interpret the conflicting evidence. One aspect of particular interest is the question of whether the principal material was cast or wrought iron; and if wrought, whether rolled or hammered, if cast, flat or flanged. The answers to such questions are crucial to an understanding both of Wilkinson's boats, and of why others were apparently so slow to follow.

The fact is that it is not at present possible to answer the most fundamental questions about the *Trial*, and unless further contemporary evidence comes to light she will remain an enigma.

The *Trial* - facts (more or less).

Launched into the Severn on Monday 9th July, 1787, within easy distance of the Apley rookery, an occasion marked by the firing of 32-pounder guns.
Principal builder: John Jones, "O'Lincoln", smith.
First master: Edward Palmer, who lived near the Wood Bridge.
Nominal size: 70 feet long, 6 feet 8½ inches broad. Draught empty 8 or 9 inches.
Weight: about 8 tons.
Capacity: upwards of 32 tons (in deep water).
Material: English iron, noted as 5/16 inch thickness, riveted (or at least where visible when laden). Gunwale lined with elm; beams of elm; posts of wood.
Bows triangular, (*if* one of those seen at Bradley in 1803).
Registered with two sister-vessels in 1795, as 20 ton boats, used solely on the Birmingham Canal (*unless* further boats were registered at Stourport).

The mysterious first iron boat from Helton Tarn.

The tale of Wilkinson's supposed first iron boat is a classic of the growth of legends. It is now quite impossible to establish fact from any secondary source, and one is left to conclude that there is a desperate need for a comprehensive biography of John Wilkinson.

The background to this alleged boat is the attempt by Isaac and/or John Wilkinson to smelt the rich Furness haematite ore with peat dug from Lindale Moss. Even the basic events are not consistently described and dated in the secondary sources, but there is a desire to credit John with an iron boat in his youth, in the 1740's.

Stockdale is the earliest published source (see appendix), and states that about 1748 Isaac and John Wilkinson started operations at Wilson House. Among their first works was the cutting of a canal at Wilson House into the peat deposits, for which an iron boat was built. The date of this is either 1748 or 1750, depending on when the relevant passage was actually written. Stockdale gives the date of John's move to Mr. Hoo, at Bradley, as about 1755/6 (p213). He also states (p203) that John Wilkinson bought Castlehead about 1765, and there is no subsequent mention of attempts to smelt with peat, or of other activities at Castlehead.

Chaloner gives a different chronology. John went to Bersham with his father in 1753, and lit the first coke blast furnace in the Black Country in 1757-8. The Wilson House *Estate* was, on the evidence of a 1776 letter from Wilkinson to Watt, to be purchased at the same time as Castlehead, that is about 1777-8, with the intention of making iron with the abounding local peat; a scheme which in economic terms was a failure [4]. This in itself must raise questions about the actual activities at Wilson House in 1748-1753: was peat really involved at that time ? No peat: no boat, even if Isaac had built it.

Fell states that John Wilkinson experimented with peat smelting at Backbarrow in 1770; and Smith that the first coke blast furnace at Bradley was started in about 1766 [5].

Palmer [6] adds the information that the boat was built "it was said" by Isaac at the suggestion of John.

Dickinson [7] gives some dates. John was away at school until about 1745 (when aged 17), and was then almost immediately apprenticed in Liverpool for five years; therefore to about 1750. About 1751 or 1752 John left home to work in the Midlands, prior to Isaac's move to Bersham about 1753. Dickinson notes the ambiguities in early accounts (even without Chaloner's evidence), but clearly accepts that there was indeed an early iron boat in Helton Tarn in 1800. He suggests that possibly the boat was produced at the time of the Castlehead works - 1779 or later, and possibly even at Willey in the 1787-8 period.

As for the boat itself, it is reported to have been abandoned in (or, only near) Helton Tarn, which is actually the silt-filled remains of peat-workings on the banks of the River Winster, about 2½ miles north of Wilson House; and possibly nothing to do with the original work at Wilson House, which was said to have peat on three sides of it, not at a distance. What is more, Stockdale also says abandoned in the canal cut for it: there is no canal at Helton Tarn. The present river channel between the two sites tends to confirm that it was a relatively small boat. That presupposes both that there really was a boat, and that it was in Helton Tarn at all in 1800, neither of which can be regarded as certain, while the earliest documentary record is of folk-memories in 1872.

Dickinson, writing in 1914, notes current, then unsuccessful, attempts to locate the remains. More recently, the Windermere Nautical Trust have co-ordinated attempts to locate any remains with modern search equipment, again totally without success. Curiously, it emerged, in the course of inquiries in 1979, that a similar local story exists of an old iron boat at the Lower Mill of Halton Forge, near Lancaster. This was seen in childhood by a man born about 1892, but again escaped the eye when the pond was drained more recently.

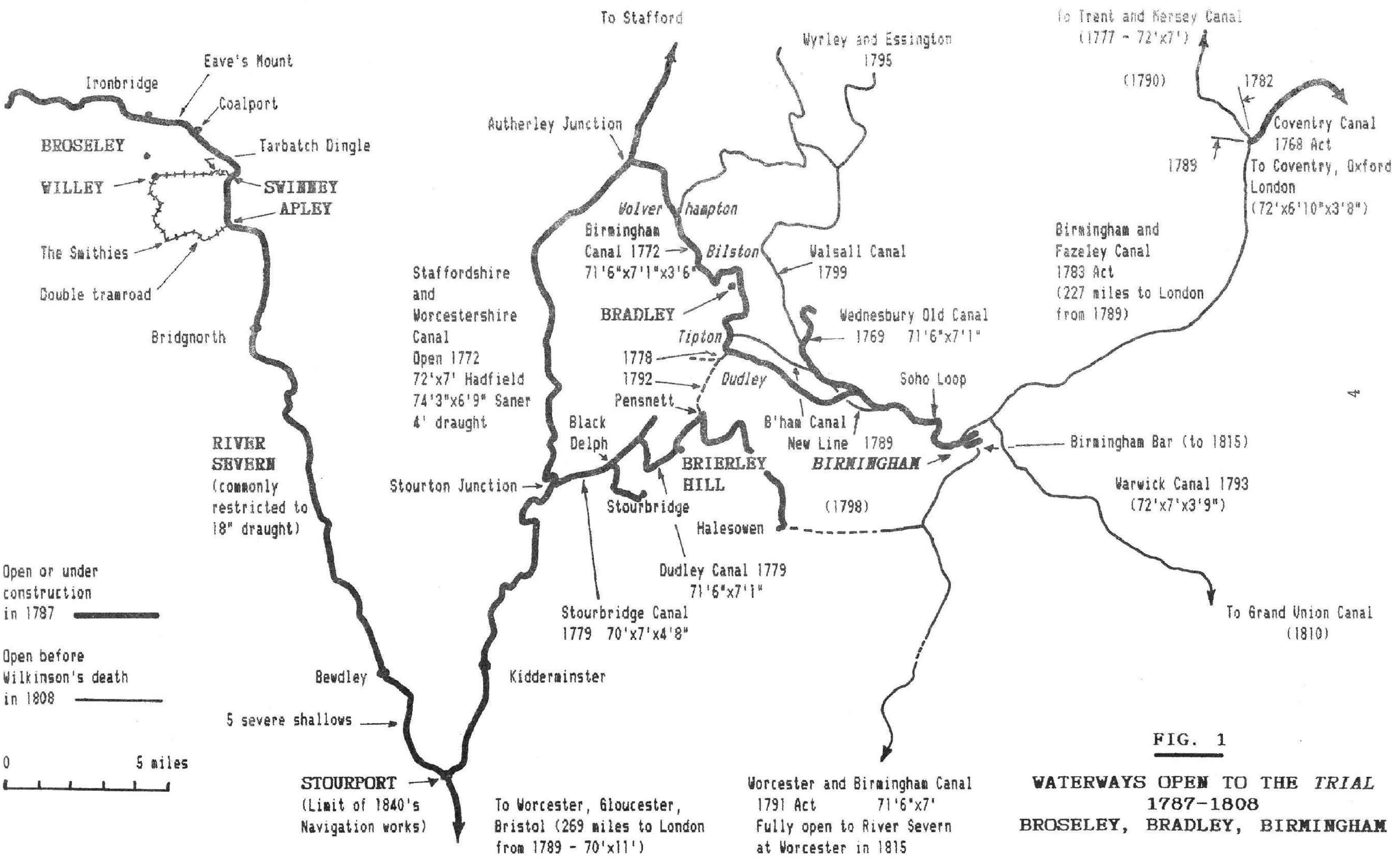


FIG. 1

WATERWAYS OPEN TO THE *TRIAL* 1787-1808
BROSELEY, BRADLEY, BIRMINGHAM

Since there was definitely an iron boat built elsewhere in 1777, we cannot even claim that any boat built by John Wilkinson for Wilson House would have been unquestionably the first iron boat ever made. We have also to suppose that Wilkinson knew of the York boat: openly reported in a widely circulated magazine, it must have been commented upon within his circle of acquaintances. In that era, technical information seems to have travelled far and fast. The issue awaits a fortunate outcome of archival research, if it is ever to be resolved. I am not personally convinced, and suspect a conflation of half-remembered stories, resulting in far too early a date for this boat. If Wilkinson had already built this boat, why did he name the *Trial* as he did ?

Since the boat was a small one, could it even be the result of the early experiments at Bradley, that Stockdale reports as preceding the *Trial* ?

The Bradley Experiments

Stockdale's account, written in 1872, but apparently based on extant letters written by Wilkinson himself, states that Wilkinson had begun to experiment with boatbuilding at his Bradley Works in 1786, (or even earlier, since it is not clear from this account whether he had started before a visit to France in 1785, rather than 1786 (p214)). It also appears that Bradley had begun to make boilers at this date [8]. The coincidence suggests that any such boat would have been made in the same way as a boiler, from hammered plates. Bradley was equipped with the new Boulton and Watt steam-powered helve hammer for just this sort of work in 1783, the makers having been driven to supply it by Wilkinson. Clearly from the accounts surviving there was a period in which they were experimenting to find the right combinations of speed and lift for the hammer.

The *Trial* was designed to be used primarily on the Birmingham Canal, based at Bradley: of that there is little doubt. Why, then, did the actual construction of the *Trial* and the other three vessels move to Willey ? If Stockdale's account is correct, this must be almost the greatest conundrum of the whole affair. We are almost obliged to suppose that the experiments at Bradley were only a partial success, but that Wilkinson was confident that some facility at Willey would enable a change to be made in the method of construction, that could be expected to succeed. Could this have been expertise at Willey in the casting of thin iron plates that were sufficiently malleable to be riveted ? The nine year delay between the York boat and these experiments may also be related to the practicalities of working iron in a form suitable for the heavy usage of a large commercial vessel.

The *Trial*: The waterways available to the barges - the key to dimensions.

The dimensions of the *Trial* reflect the absurdity of the English canal systems. Although the basic network in the Midlands was laid down within one decade (the 1770's), the critical structural features such as the locks were determined without consideration for the eventual common wealth: possibly for the same commercial reasons that bedevil the world of computing today.

A boat built to take maximum advantage of the Birmingham Canal Navigations could not reach the Severn via the Staffordshire and Worcestershire Canal: it was marginally too wide. A boat built for the Staffordshire and Worcestershire could not traverse the Birmingham system: it was too long. The largest boat that could navigate both these systems, and also the Stourbridge Canal, which in 1789 would complete a short cut between them for the Severn traffic, was 70 feet by 6 feet 9 inches [9], with a maximum draught of 3 feet 6 inches. Headroom was less of a problem, with 5 feet 9 inches available to an empty boat.

Pursuing the idea, however, we may note that by 1787 the Birmingham and Fazeley Canal was under construction, leading to the Coventry Canal and its route south towards London (completed in 1789), and north to the Trent and

Mersey Canal (completed in 1790 by the Birmingham and Fazeley). Critically, the Coventry Canal was built for boats not exceeding 6 feet 10 inches breadth.

Equally, the Thames and Severn Canal route to London was completed in 1789, for boats up to 70 feet by 11 feet (which might reflect in the dimensions of the river barge, though no vessel is recorded as having completed the journey direct from Coalbrookdale to London before 1800).

With this in mind, the dimensions of the *Trial* are perfectly rational, and Wilkinson's intention clearly stated in the result. The odd half inch in the beam might be represented by rivet heads; beam can besides be measured in several different ways. In no way does it invalidate the proposed origin of the beam selected for the *Trial*, that it should have been capable of use throughout the main Midland canal systems then existing or planned. The respective dates and dimensions of the largest boats accepted by the various major lines of waterway are indicated in Fig.1.

At the time, only the Ketley Canal among the Shropshire canals was actually under construction - but for tub boats: the Shropshire canals can be neglected entirely in this context.

The other factor is the Severn itself - an inescapable part of the route from Broseley to the Black Country and Birmingham - whose critical feature was the series of shallow rapids, including those between Stourport and Bewdley, which would halt the navigation works of the 1840's. Surveys in this section survive from a moderately dry season in 1784, and reveal a minimum depth sufficient to pass vessels drawing 18 inches or more [10] - rather more than today for a variety of reasons.

That is not, despite frequent suggestions to the contrary, so shallow as to stop all river traffic, but it does prevent economical river movements of bulk materials between the individual deeps [11]. A typical Severn river trow would, as far as can be established, draw at least 9 inches when empty, and carry perhaps 20 tons at 18 inches draft. However, the passage time and the incidental costs would be much the same as for a fully laden vessel carrying 70 tons or more. Clearly there was an incentive to wait for the next fresh in the river, or (at least for intermediate cases) to lighten the vessel by transferring cargo into lighters at the worst shallows. (The same principle is used in the age of the supertanker: the longest part of a voyage, in deep water, is made by the larger, more economical tanker, which then completes its journey at part-cargo into continental waters.) The periods during which fully laden large barges could not move on the upper Severn were commonly two months at a stretch, and might affect half of each year in all. (Precision is impossible: the Severn was a steadily deteriorating waterway long before 1800; no two years were the same; and the effect varied with the route being described.) Wilkinson's transport problems were not confined to the plan dimensions of the narrow canal system.

Draught - a forgotten key to iron construction of river vessels

One of the few solid facts we have for the *Trial* was that she drew about eight inches when empty; for the river barge that it had a remarkably light draught, and indeed exceeded Wilkinson's own expectations. We have here strong evidence for one of the motives behind later iron construction of river vessels world-wide; further confirmed by Svedenstierna's observations of 1803.

In view of Wilkinson's supposed earlier construction of a smaller boat, of his own words, and of comparable evidence that in the simplest environment enterprising builders did make prior estimates of draught [12], we may suppose that Wilkinson had anticipated the slight draught of his barges. The benefits that would arise would be obvious to anyone concerned with transporting heavy cargoes on shallow waterways.

There are several early references to the implications of light draught of iron river vessels. Those of Thompson and of Vernon are given in the appendices. In these it is the draught relative to that of comparable wooden boats that is stressed (together with greater ruggedness and durability). The case of the *Aaron Manby* illustrates that the effect was even more marked in larger vessels.

We can even quantify the effect, thanks to a series of gaugings of canal narrow boats that survive for the Trent for the years 1801-8 [13]. Sixty boats were gauged very thoroughly, presumably as a basis for assessing tariffs on the weight of cargo. The records as far as they go are well suited to our purpose. An analysis of 59 of these boats that were very closely of a size with the *Trial*, and some of which had been in service for up to 23 years when gauged, reveals that the average wooden boat had the following characteristics:

Average length: 69 feet 10 inches	(68'4" to 74'6")
Average breadth amidships: 6 feet 8.4 inches	(6'2" to 7'1")
Average unladen draught: 9.8 inches	(8-1/16" to 12-3/4")
Maximum gauged capacity: 26.73 ton	(24 to 30 tons)
Maximum draught: 38.9 inches	(36.34" to 42.62")
Plan prismatic coefficient at light draught: 0.80	(0.745 to 0.872)
Plan prismatic coefficient at laden draught: 0.847	(0.79 to 0.922)

Within these averages there were considerable variations. Some clearly had vertical sides throughout, other must have flared considerably, with up to 18% changes in plan area from light to laden.

Despite the variations, and the variety of different routes and builders among so many boats with nothing but the Trent in common, it is conspicuous that the majority fall within quite a small range of dimensions. Of the 59:

Length	Breadth
50 are between 69'0" and 70'0"	29 are between 6'8" and 6'9"
Only 5 exceed 71'0"	Only 4 exceed 6'10"
Only 2 exceed 72'0"	Only 2 exceed 7'0"

More remarkably, one of the boats is noted as having no internal floor, *being built of iron*. She was built in Measham in 1804, and given the name *No.3*. The gauging reveals a near-vertical side throughout (there is a slight change at one point which could correspond to an out-strake in the plating, but no more than that). More curiously, unless there is a misprint, the waterplane area is only four square feet less than the product of length and breadth (70 feet, 5 feet 9 inches), implying that she was virtually square-ended as well as straight-sided: not a good form for the route of over 100 miles on which she was apparently used. One wonders whether the breadth should have read 6 feet 9 inches: the locks on any route in the area would allow 70 feet by 6 feet 10 inches [14], and she would then have conformed closely to the average patterns. The only reason for making it 5 feet 9 inches would then have been related to the width of plates available for the bottom. Of special interest is her very light draught of 7-7/16 inches, a full half inch less than any wooden boat listed, and 2.35 inches less than the average, despite the penalty of apparently much narrower breadth [15].

There is no reason to suppose that the *Trial* was fundamentally different in shape, nor that the Trent boats were radically different from the boats of the Black Country, so we may compare the *Trial* directly.

Taking the dimensions and capacities stated in the contemporary accounts, we can derive comparable information for the *Trial*. Prismatic (also block) coefficient at light draught was 0.915 (8 tons, 8 inches draught, vertical sides). The maximum draught would have been about 40 inches, and height of side perhaps 42 to 45 inches. Most significantly, the saving in draught of 1-3/4 inches would yield an increase in capacity of about 2 tons in any given depth of water, compared with the average wooden boat (provided that the cargo was dense, such as iron or coal, but not coke, for example [16]. On the Severn, in the dry season, that represented a 25% increase in cargo capacity. It does not matter whether the narrow boats were used repeatedly on the river, or not: the principle is the same for the larger barge, and the gain in payload is effectively permanent, since the Severn is limited by shallows for most of the year, even if the percentage gain is reduced in the wet seasons. Provided that the canals maintained their advertised depths, then the operational benefit disappears for narrow boats up to 42 inches maximum draught. That they did not is evident from the letter from Enoch Smith (given with the Boat register in the appendix).

It seems to me that in dry seasons there could be an incentive to take the narrow boats up the Severn, rather than tranship entirely from part-laden river barges at Stourport, or stop the traffic altogether, which could be examined as a matter of economics [17]. The remains of narrow boats at Coalport demonstrate that it was quite feasible to do so, though not necessarily that it was a common occurrence. Wilkinson's boats at least would not have had to negotiate the notorious Eave's Mount, scene of so many wrecks [18].

Whatever the particular usage of these first barges, they opened the way in principle to considerable advances in river navigation across Europe, and much farther afield. In practice their development had to wait for rolled plates of uniform thickness and much greater size than available in 1787. The Loire would become a passenger carrier over much of its length only after the introduction of iron hulls of almost paper thinness, for example [19].

Cast or Wrought Iron ?

That a newspaper should confuse cast and wrought iron, as did the *Gentleman's Magazine*, should occasion no surprise. When a work such as Rees' *Cyclopaedia*, written by experts, tells us twice that Wilkinson's vessels were of cast iron, or cast iron plates, we need to take notice. Svedenstierna (in translation from the German) only says sheet iron *or* iron plates. (We clearly need to study the Swedish original for this detail.) *Aris' Gazette* says English iron (possibly in contrast to Swedish bar iron ?) and laden with its own metal. (It also says 5/16 inches thick. Unless heavy rolled boiler plates were available much earlier than now supposed, this could only be a uniform thickness if of cast iron, or of very narrow plates. The writer may have seen 5/16 inch edges of hammered plates.) In this situation we cannot know for sure. The only other information is that the *Trial* was riveted, like a fire engine boiler (though it should be borne in mind that only part of the hull would have been visible in Birmingham). She was put together by a smith, but in a rather poetic account: any operation on assembly of a metal hull would have been carried out by a smith. There is no evidence, other than Rees', that points explicitly to either one material or the other as the primary constituent (it could have been a mixture). It is only a traditional assumption that the material was wrought iron.

It should not be supposed that cast iron was necessarily a fragile and unsuitable material (wrought iron also came in many grades: the Chinese have made massive bells from white cast iron for a millenium). Svedenstierna makes the point for us, describing a pig-iron forge hammer in the Dale:

> When the forgeman was instructed to show me the process of flattening with the aid of such a hammer, as these are very rare in England, he raised the guard too soon so that the hammer hit the anvil itself 7 or 8 times before the piece of iron was in place. I could only imagine that the hammer and anvil would be ruined but the smith assured me that this was a common occurrence and that the equipment was never damaged. I am mentioning this here in order to illustrate how these people have mastered the art of giving cast iron any required characteristic..... [20].

There is an interesting description from 1912 of the Madeley Wood Company's plant in Friends of IGMT *Newsletter* No.27, May 1977 [21]:

> The two haystack boilers are 16 x 14 feet and the egg-ended boiler is 6 feet in diameter by 28 feet long. This installation works at a steam pressure from 8 to 10 lbs. The boilers are constructed of 3/8 inch cast iron plates with single-riveted lap seams; the pitch of the rivets is 1-3/4 inches centre to centre....approximately 115 years old (ie about 1797)

An identically constructed haystack boiler was also seen at Blists Hill, dated about 1807. This is clearly from a technical, not journalistic, description, and on the face of it we have to accept that in the period of interest cast iron plates were indeed formed in double curvature and in thicknesses around 3/8 inches, and riveted. (Or have we another stray "cast-" in a text ?) Farey in 1827 gives a tantalising footnote to the effect that cast iron boilers of the common form had been frequently used for small fire-engines at an early period, following on from its use in brewing and dying pans. Another variant was to use cast iron flanged and bolted segments to form the dome of haystack boilers [22]. These latter must have been cast in mould boxes, so presumably unflanged curved plates could be too, for the boilers ostensibly described at Madeley Wood.

Evans, describing cylindrical boilers in 1805 [23] refers to the use of best iron rolled in large sheets and strongly riveted, but the ends may be made of soft cast iron - provided that they were not in contact with the fire.

Smeaton's cast iron boilers, such as that at Kronstadt in 1777, although low pressure devices, were colossal - 15-1/2 tons in five main sections, and 10 feet diameter. His portable fire-engine of 1765 was a curious mixture of cast and wrought iron components [24]. Curiously, he used cast iron for the fire-box, reversing the advice of Evans, and the practice of Trevithick.

Trevithick, indeed, used cast iron boilers habitually, for 50 lbs pressure and upwards, often cast at Bridgnorth:

> ...with an internal diameter of 8 feet and in 8 feet lengths, which were connected together by flanges and bolts up to any length required. Such boilers were unquestionably dangerous, although many wrought iron boilers of equal or greater diameter and probably of less strength are worked up to the same pressure now [25].

Cast iron, then, was used in ways that are now unfamiliar.

There are even two cast iron water tanks in the Science Museum, belonging to engines dated 1791 and 1797 (though possibly not the original tanks) [26]. One is of the order 5 x 5 x 6 feet, formed from plates not less than 3/4 inches thick, and with internal sub-division, but is (as now seen) bolted together. The other is more interesting, as it was apparently entirely riveted, with relatively small rivets at 5 to 6 inch centres. It was constructed on a flanged cast base about 73 x 51 inches, with an outwards flanged plate at each end, and flat cast plates about 78 x 45 inches and 3/4 inches thick on each side. The plates are severely corroded, but still show clear fractures, and integral cast features. One feature in both these tanks is the presence of a long tear in plates just inside the root of a flange. If that were symptomatic of the method of casting, then it would perhaps be a serious problem in the large thin plates that might have been used in a river barge.

It appears that it was common for cast iron products to be riveted in this period: the two halves of cast iron flywheels in Watt engines, for example. (I am indebted to Michael Wright for the information, and for authorising an unscheduled scramble over the 1791 riveted tank.)

Evidence also exists in two other directions. The deck plates of the Iron Bridge (1779) were cast iron, and of considerable size, (and flanged ?). The Longdon on Tern aqueduct, built in 1795-6, is an even more dramatic example of the use of iron in large panels (and also of the problems of warping of large plates as they cooled). In this case the plates are of the order 7 feet square, and 3/4 inch thick, all heavily flanged and bolted (possibly because a structure with such subtly shaped components would require a trial assembly before despatch to a remote site). It long withstood the buffetting of boats, perfectly successfully, as has its more illustrious successor at Pontcysyllte.

The most striking testimony however is on the Society's doorstep, at *The Lawns*, Wilkinson's own house. An inventory for the house in 1800 lists two cast iron soft water "furnaces" [27]. There are now three tanks there, and they should be the subject of a formal archaeological study: metallurgy, casting marks, patterns, fastenings, etc. In one case, the plates are three feet square, and no more than 3/8 inches thick, delicately flanged on three or four sides for bolting together. (It is difficult to see how some of the details could have been formed in a simple open mould.) In the other two, there are both flat and flanged plates, all rather heavier, and the sheets are too large to be rolled even in 1800. It is not clear on a superficial inspection. These two I believe to be the tanks already there in 1800. If they are indeed tanks built by Wilkinson they represent prime evidence for his techniques at least in the factory at which he built the *Trial*, though the dating remains uncertain.

Finally, albeit Willey produced bar iron in quantity, Wilkinson's real fame rests squarely on his mastery of cast iron [28], making it as soft as he wished.

Contemporary technology for the working of wrought iron

It is of some interest to describe the limitations of metal-working at the time of the *Trial*, and during the following 30 years when the techniques of iron boatbuilding were developed and brought to a matter of routine.

Prior to Cort's process of puddling iron (1784), at least, the only methods of preparing bar iron were at the forge, or in clay jars by Wright and Jesson's process, and the weight of the blooms was severely limited, rarely exceeding 56 pounds. This would then be worked under a forge hammer to produce somewhat irregular plates (see appendix: Piggott), varying in thickness from 1/4 inch at the edges to 5/8 inches at the centre. Indeed, up to the mid-eighteenth century the domes of haystack boilers were not built of wrought iron at all: the first known boiler slabs were only worked at the plating forge about 1750.

In 1790, the Horsehay Works are believed to have made the first rolled boiler plates, and were the only Shropshire works capable of doing so. These plates are supposed by Rhys Jenkins to have been made under the flattening rolls of a slitting mill, accounting for their width of only 8 inches [29]. (Their reported length of 4 feet and thickness of 1/2 inch correspond to a bloom of just under 56 pounds weight.) It has to be remembered that the overlap between plates was 1-1/2 inches, so these plates were very limited, unless there was some corresponding method of welding them into multiple widths, which has escaped notice. There is certainly much to be learned: one of the wrought iron guns recovered from the *Mary Rose*, and probably much earlier than 1545, has been found under Gamma-radiography to be formed from a single sheet of iron, rather than separate bars welded together, as previously encountered. That sheet was 7.75 feet by 1 foot [30], and I know of no account of such expertise.

By 1797, the widest plates generally available were still only 17 inches wide [31]. As late as 1813, it is known that Trevithick could obtain nothing larger than 12 x 36 inches in Cornwall. The development process was well over in this context by 1838, however, when the Coalbrookdale Company achieved a plate 10 feet 7 inches by 5 feet 1 inches and 7/16 inches thick, considerably exceeding any requirements of river vessels.

It should be said that these references derive from a limited number of sources, contemporary or otherwise. Corlett is reluctant to accept that rolled, and therefore uniformly thick, boiler plates were limited to 8 inches in width even in 1787, and identifies the date of the *Trial* with the availability of rolled iron plates almost immediately after Cort's patent of 1783 [32]. Certainly such an opinion largely removes the difficulty, and passing references to plate thicknesses as early as 1765 could be construed that way [33]: but there is no clear evidence. However, we have already noted that the ultimate in technology for boiler making at Bradley, in 1783, was the new steam hammer, and not rolling mills.

The methods of joining plates were equally crude. John Carr, in 1797, specifies riveting with 1/2 inch holes at 1-3/4 to 2 inch centre, with a 1-1/2 inch overlap for wrought iron boilers [34]. Caulking in low pressure boilers was done with white lead putty, or with rope-yarn, just as in wooden boats, and in all probability this was the method used in the *Trial*. These could be supplemented by beating up the edges of the seams with a chisel, and in time by rust. Yarn came to be replaced by cements, and by mixtures such as horse-dung and bran, as boiler pressures increased, and in nineteenth century shipbuilding cement was a common cure-all for watertightness, apparently. A particularly striking passage concerning the manual processes of making and joining boiler plates exists, and is worth giving at length in the appendix: Piggott, 1865.

We may note particularly the difficulty of aligning rivet holes. We should not underestimate the task of John Jones, if he really beat and riveted small plates in this way. He must have had several assistants, to hold the punches and chisels and plates, and to carry and hold up the rivets [35]. In mid-nineteenth century practice it was normal for a plater or riveter to have four assistants working with him [36].

Piggott refers to the rate of production of boiler-making: from 1831 to 1864, despite the advances, the output was only five tons per year per man employed in the task of assembly. That is less than one plate per man-day, trimmed, formed, punched, caulked and riveted in place. Rivets themselves were entirely hand made even in 1838: quite sufficient to explain the hammering reported by Randall, even if John Jones were assembling pre-formed plates.

But the *Trial* must have contained about 365 of Piggott's plates, if she was of hammered iron. Even assuming four assistants for John Jones, the rate could not have exceeded five plates per day on a novel prototype. If that rate is correct, assembly of the *Trial* took at least 73 days continuous work, the river barge rather more (over one hundred). The *Trial* required the spring and summer: reasonable. But how did they then launch the river barge in the six weeks between September 1st and October 15th 1788 ? Perhaps there were far more men engaged on the task, perhaps it was assembled concurrently with the boat launched about September 1st - or perhaps they were not made of hammered plates at all.

In this period there were no rolled angle irons. The sharp corner of the bilge of a narrow boat would therefore have to be beaten up by hand at the forge, and also joggled at each overlap, well enough to give a semblance of watertightness. There is no reference to frames in the *Trial* (they would be of little structural value in a shallow, narrow, boat), but we must ask how the adjacent plates were joined. If they were flat sheets, were they joggled, or connected through butt-straps ? Could cast-iron have been malleable enough (even red-hot) to joggle it at all, or to beat down the edges to close the joint? (There must be evidence, but I do not know of any study of such matters.)

It is in this area that one great advantage of cast iron would lie, as evidenced by the simple construction of the water tanks at *The Lawns*. Any plate could be flanged in the mould, as desired, eliminating the worst of the shaping of the plates. The triangular and rounded ends reported by Svedenstierna could be formed equally well in this way. The options are of course endless: perhaps the most likely combination would be a cast iron flanged bottom and wrought iron sides, complying with the description that she appeared in Birmingham to be like a fire-engine boiler.

Really, there were considerable advantages in the use of cast iron plates, at a time when, as far we know, rolled plates (and certainly angles) were simply not available. Again, the economics of construction might come to our assistance, if the correct data were assembled: we do know that these iron boats cost 3 to 4 times as much as a comparable wooden narrow boat. The cost of wrought iron boilers, on a pro-rata basis, and of cast iron products, might be compared with each other, and with the cost of wooden boats, and with luck provide decisive evidence about the material of construction.

The weight of the *Trial*.

While the level of confidence in the results cannot be high, we can make an assessment of the weight of the hull, under various assumptions about her construction. About 8 tons: between 7.5 and 8.5, and most likely 7.75 to 8.25 tons. We have to suppose that that includes the timber elements and other fixed items such as a mast and rigging. I estimate about 600 pounds for the timber as described, and propose 0.5 tons for all materials other than the hull plating. To satisfy myself, I then need to show that the shell weighed 7.25 to 7.75 tons.

The surface area is known to be 0.915 x 70 feet x 6.71 feet for the base, and the sides are of the order 146 feet x 3.5 feet: thence 940 square feet, within 5% or better.

For comparison, we may estimate the weight of the Measham boat closely: 6.8 tons. Its surface area would have been close to 770 square feet, giving 20 pounds per square foot (or 840 and 18.3, if actually 6 feet 9 inches wide).

The first proposal we may dismiss is, then, that the *Trial* was of uniform 5/16 inch plate. With plates of Piggott's dimensions, the net area of each three square feet plate after overlapping is 2.58 square feet (they should have been more efficient than that, if from the same size blooms). That gives 6.1 tons of plate, to which must be added rivet heads, perhaps 0.25 tons. The actual weight is 15% greater than this result. (A similar calculation using 5/16 inch plates 8 inches wide and lapped 1-1/2 inches, leads to a weight of plate of about 6.6 tons, still some 8% too light.) If 5/16 inch is correct at all, it refers to the beaten edges of hammered plates, or to cast plates.

Piggott's plates, if the largest were 56 pounds, correspond to 18.7 pounds per square foot, or when overlapped to 21.7 – 9.1 tons plus rivet heads, and equally impossible. Using instead the thicknesses quoted by Piggott, the average plate was nearer 15 pounds per square foot, or 17.4 when lapped – 7.3 tons, which with rivet heads is nicely within the target range (but only by assuming 45 pound blooms, and the issue is unclear).

If the plates were cast iron, and if we assume flanged plates to match the height of the side, or half the width of the bottom, then we must allow for flanges on plates roughly 3.4 feet square, and half the plates unflanged on one side. If the flanges were (as seen, roughly) 0.5 x 2 inches, we reach an average plate weight of about 16 pounds per square foot – 6.7 tons. This falls slightly short of the target, especially since there would be fewer rivets with larger plates; but practically an open sand mould can be overfilled, and this is a more likely tendency than underfilling, to reduce failures. The plates may well have been smaller, too.

We are able to demonstrate, broadly, how the weight was made up, but not to draw conclusions about the materials used. One feature that does stand out, both in weight, and therefore in cost, is the penalty for using small plates, or hammered plates with excessive thickness in the centre.

Building and launching

Where was the *Trial* built and launched ? No near-contemporary source tells us precisely. The nearest we get to a launch site is Aris' Willey Wharf, whose precise whereabouts are still unknown. The *Trial* itself was launched somewhere near enough for guns and crowds to disturb Apley rookery.

Ray Pringle Scott has demonstrated convincingly (Journal No.13, 1985) that there was a major double line of tram-road from Willey to the Severn at Apley, and that this rather than the terminus of the Tarbatch Dingle ought to be considered the true identity of Willey Wharf. The difference in character of the river, alone, makes a strong case for Apley either as a wharf or as a launch site. There was also a forge established there; apparently Wilkinson's powder store; and it is very close to the foot of Caughley Dingle, where, according to Randall, many of the water pipes, stayed from export to France, lay for many years.

Wilkinson made a great spectacle of the event, no doubt hugely enjoying the common expectation that the boat would not even float. Curious, when anyone must have noticed that a pan or kettle will happily float. (Indeed precious metal funerary and votive models of boats are known from antiquity, from Ur to Eire.) The misconception would recur in Glasgow in 1819, during the construction of the *Vulcan*; but it was a much older phenomenon. William Bourne in his *Treasure for Travellers*, published in 1578, commences the Fourth Book as follows:

> ... as touching the nature or quality of water, for the sinking or swimming of things in it, and according unto the simple opinion of the common people, who think that things in the water do swim or sink, for that it is wood, iron, or stone: but the only cause of things that do swim, is this, that it is lighter then the proportion in quantity then the water is....

As for construction of the boats themselves, either casting, or flanging and curving of red-hot wrought plates, would have been done at Willey, with all the facilities there. Punching of rivet holes, and trimming, would have required much offering up of the work and trial assembly of components, but could have been carried out on cold wrought plates.

I am inclined to suppose that the final assembly at least was done on the river bank, as indeed one version of Randall suggests, and that this was the operation carried out in the "quiet rural spot" from which the infamous pipes and/or guns were exported to France. The river traffic would provide the derisive passers by, too, which might not have been the case within the Willey complex. The alternative is to suppose that the vessels were transported down the tram-roads. 32-pounder guns were heavy and long objects, but they were not wide and bulky too. Tarbatch Dingle would be a ludicrous route for a complete boat of 70 feet length. There are steep sections on the other route, too, and we would have to postulate very elaborate bogies to carry barges up to 70 feet long and 12 feet wide round bends on a tramroad. It seems an improbable option, but that is not proof that it was not done.

Some timber went into these boats. The lining to the gunwale would stiffen it, and also provide a wide enough platform to stand on when working the boat (more easily than by flanging a wrought plate), and to locate the ends of the beams across the hold. These latter would serve to strut the sides against the inward water pressure when the boat was deeply laden, and perhaps support any covers stretched over the cargo. The arrangement of the stem and sternpost described is not clear, but it may be that they were little more than fenders. Almost all the Trent boats carried either a firestand or a stove-grate, but there is no evidence in the surveys of any living accommodation as such: narrow boats at this time were evidently very rudimentary. The only equipment that they carried appears to have been a towing mast and line, mooring lines, poles, and sometimes deal planks, wheelbarrows, and covers, and in many cases a pump.

Failure of the river barge

The river barge was stated to have been less successful than the narrow boats, despite a promising start. By comparison with records of similar sized boats, the barge would have been a similar depth to the *Trial*, but roughly twice the width. I believe that this width may have been crucial in the river environment. There would almost certainly have been a longitudinal joint down the bottom, several if wrought plates were used. If the boat went aground on the shallows it would often be on a rock, causing very high concentrations of loading on the bottom, and working of the joints by imposing large shearing forces and bending moments on the expanse of the floor. Even heavy loads placed in the boat would have the same effect. This might progressively cause the fracture of plates at rivet holes, or flanges, or simply destroy the watertightness. A narrow boat would be far less prone to such problems, since the bottom is everywhere much closer to the support of the sides; it is much lighter, and would have fewer joints to be affected. On the canals, it would be relatively immune to such damage.

Whatever the cause of the problems, it did not deter Onions from repeating the experiment in 1810 (and Rees uses the plural of Wilkinson's river barge, too). By that time larger rolled plates were available, and iron narrow boats were becoming a commonplace. If it were indeed a structural weakness that caused disappointment in Wilkinson's river barge, then remedies would be available: stiffening frames across the bottom, in particular. One may note the profoundly different construction of wooden narrow boats and river barges, in this context. A narrow boat has thick planks across the bottom, without any longitudinal joints in the common recent form; a river barge had a massive internal keelson for stiffening, and a mass of heavy transverse ribs to hold the flat bottom stiff enough to keep the caulking intact, and to spread the load of the cargo. It was that internal framework that made a river barge so relatively deep-draughted, and which could be largely dispensed with in narrow boats. Did Wilkinson underestimate the need for stiffening in this barge ?

Alternative sources of evidence

In the 1870's, there were clearly a number of extant letters from John Wilkinson describing the various experiments in boatbuilding, in the possession of James Stockdale, grandson of Wilkinson's friend and agent. These must be a prime target of any search.

Another area which invites attention is the facilities at and output of Willey and Bradley in the 1780's, to determine the existence of any bias towards wrought or cast plate production (or indeed direct references to the boats). The tanks at *The Lawns* are a part of this evidence; but there are sufficient passing references to indicate that a great deal of information survives on these points, though neither collected nor readily accessible.

There are many local newspapers - all those for Shropshire, at least, which I have not yet been able to consult. It would be surprising if nothing emerged from them: Randall may well have used them.

There is one key piece of official evidence for the river barge that is missing: part of the 1795 Admiralty register of inland vessels over 13 tons (Act 35 Geo.3 ch 58, 112). One of the best of these registers is that for Staffordshire, with 531 boats listed, mostly narrow boats, and with a great deal of commercial information about owners, trades and crews, too. Those for Shropshire and Worcestershire are entirely missing, and only a small part exists for Gloucestershire, apparently a personal copy from one of the Justices responsible for compiling it. The Staffordshire list does not refer explicitly to the material of construction, which is slightly surprising, but it does list the three boats owned by Wilkinson in Staffordshire. Were there more boats at Stourport, or were Willey and Bradley still isolated ?

The Customs registers, either the Port Books for trade, or that for barges trading beyond Gloucester, are of no help: they do not survive for the necessary period. The Chepstow barge register, which includes many barges built and formerly used in Shropshire, contains not a single reference to iron river boats.

As an aside (or perhaps not), what are "Birmingham trows" ? William Chapman in his *Observations on the various systems of canal navigations*, 1797, says (of a proposal to link Newcastle-upon-Tyne to the Irish Channel):

> "These boats should be of the construction of the Birmingham trows (upright sided and flat-bottomed), and when light should only draw 6 inches water; then they will at 32 feet length and 6 feet width (if the declivity of the ground should limit the main canal to boats of 12 feet width), carry, according to the form of their ends from 8 to 10 tons each, when laden to 2 feet 6 inches..." (They were proposed to be used singly or in blocks of four, two by two.) Could these be iron boats, too ? I know of no other reference to such boats, though trows are known from elsewhere, for example the Chesil fleets.

What survives in France ? Apart from a large number of water pipes, supposedly laid in Paris, there may be accounts of Wilkinson's work [37]: he was in the middle of the Bradley experiments when he went to France in July 1786.

The early iron vessels - a preliminary chronology.

The chronology of early iron boats known to me is as follows:

? Wilkinson (Isaac or John), date unknown but before 1800, and possibly as early as 1744. The "Helton Tarn" boat, discussed separately.

1777 Small iron pleasure vessel built for the Foss at York. Only known from newspaper reports of its launch. Builder unknown. (see appendix.)
We know that two men conveyed it to the water: that limits the weight possible. If conveyed meant carried then supposing an upper limit of 300 pounds we can arrive at a plate thickness not exceeding about 1/16 inches, to make up the probable 100 square feet of surface, allowing for overlaps. This is very thin for hammered plates of any size, and perhaps too thin to caulk hammered (or any) plates successfully. If as seems more likely it was dragged from the river on rollers, the same lift had only to raise the bow clear of the water, and the maximum weight becomes nearer 1,000 pounds, which corresponds to scarcely half of the weight of boiler plates as decribed by Piggott. Stability provides no evidence: at any draught between 300 and 1,000 pounds plus loading, the centre of gravity would only have to be below 3 to 4 feet above the floor of the boat, which is not a problem. We are thus unable to deduce anything more about the form of the plating from the information given, than that it was very light, and probably from very narrow rolled plates such as had been made in slitting mills for a century and more: an eigth of an inch would be a reasonable estimate of the thickness.

1786 Experiments by Wilkinson at his Bradley works (which had also begun to make boilers at this time). It is probable that the experiments centred on the use of boiler plates. Could the Helton Tarn boat, known to be small, and of very uncertain origin, actually be the result of these experiments ?

1787 The *Trial*, a canal boat, was built and launched at Willey Wharf, as described. It was intended for use on the Birmingham Canal.

1787 A copper bottomed vessel was built by a Mr Stalcouth near Birmingham, as noted in the *Gentleman's Magazine*. Dickinson states that such a vessel was reported on the Thames in 1788, but failed because the metal was only 1/8 inch thick: too thin for the vessel to be put aground.

1788 Two or three vessels, one a river barge, built by Wilkinson. In 1803 Svedenstierna refers to seeing *several* lying at Wilkinson's factory at Bradley, on the Birmingham Canal. They were probably all Wilkinson's, even at this date, and while it might seem unlikely that all his iron boats would be seen on one occasion, the 1795 boat register lists only three boats owned by John Wilkinson, all stated to be used only on the Birmingham Canal. The river barge too appears to have survived to 1803, but is referred to in the singular (by Svedenstierna).
Launch dates were approximately 1st September, 15th October (the river barge, definitely at Willey Wharf), and possibly about 3rd November, unless this is a late report of the October launching.

1802 Grantham, writing in 1842, remarks that a few iron boats for navigating canals had been built so long back as 40 years, and some of these were thought still to exist (*Iron as a material for shipbuilding*, p6).

1804 Narrow boat built at Measham by Mr Jewsbury (see appendix). Named *No.3*.

1808 Grantham, in *Iron shipbuilding* (1858), states that iron narrow boats began to be more generally used about fifty years previously.

1809 Trevithick and Dickenson patent for iron ship construction. Hull and decks all of iron [38].

1810 *Victory*, a 50 ton lighter, built by John Onions & Son, Broseley, for the Severn. There is no indication in Randall whether this, like the following vessel, was prefabricated and assembled on the river bank, or transported complete from their works.

1810 A lighter prefabricated by John Onions and Son at Brierley, the first iron vessel to be seen on the Thames. Supplied to a Mr Bishop. (Randall - see appendix.)

1811 Several boats built by John Onions and Son at Brierley, to trade between Brierley and London (and therefore narrowboats) and between Broseley and Stourport (possibly river barges, since Stourport is the limit). (Randall)

1813 Raistrick & Trevithick drawing for a paddle steamer (Science Museum, [38])

1814 Aaron Manby had several iron barges at the Horseley Co. by this date, which are said to have required no repairs at least until 1821. (*Transactions of the Newcomen Society*, Vol XXIX, p78.)

1815 Joshua Horton, of Tipton, constructed for Mr T Jevons of Liverpool a small iron boat used for sailing for pleasure (see appendix).

1817-20 T Jevons had made an arrangement with Horton's brother to open a yard in Liverpool for the construction of iron vessels, and planned an unsinkable iron lifeboat, eventually built by Joshua Horton. (see appendix.)

1818-9 *Vulcan*, the first iron vessel built in Scotland, by Thomas Wilson, to the design of Sir John Robinson. She was a passage boat for the Forth and Clyde Canal, built at Faskine, near Glasgow, launched in May 1819, to the astonishment of the local lightermen (who had expected her to sink).

F.M.Walker has described this vessel in *Song of the Clyde*, 1984, p 31, (with a drawing based on information from the Scottish Shipbuilders Association, 1864-5). She was the first iron vessel to be built in the form of a ship, fully decked, and with flowing lines, 61 feet x 11 feet x 4 feet 6 inches deep. She had a plate keel rising into the body of the vessel, and her plates were laid in vertical strakes 24 inches wide, butted flush onto angle iron frames. Each angle was made from flat bar bent on the blacksmith's anvil, since rolled angles were not then available. She was thus a revolutionary vessel, and set out principles of construction adhered to into the days of steel shipbuilding.

Note: it was reported in 1986 that British Shipbuilders Training Ltd, Govan, were to construct a replica of *Vulcan* as part of an MSC training scheme. It was commissioned by Monklands District Council, and was to be located at Coatbridge.

1821 ***Aaron Manby***. The first iron-hulled steamer. Prefabricated by Aaron Manby of the Horseley Company, Staffordshire, and assembled on the Thames. It crossed the Channel in 1822 for service on the Seine. (Grantham, 1842). A second boat, the *Commerce de Paris*, of 132 tons, was built in 1822-3, but was assembled in France, and two others wholly constructed there. (W.H.Chaloner and W.O.Henderson, *Aaron Manby, builder of the first iron steamship*, in *Transactions of the Newcomen Society*, Vol XXIX, 1954.) There is clear evidence that a significant reduction in draught, from about 30 to 18 inches, was a prime object of iron construction for these river vessels. One other interesting point emerges from the *Aaron Manby*, as recorded by Joshua Field, in his *Diary* of 1821: She was constructed of relatively thin plates on *common square angle iron* ribs, and included tee irons in the construction of the mast, at least (J.W.Hall, *The making and rolling of iron*, in *Transactions of the Newcomen Society*, Vol VIII, 1927, p 48). This makes an interesting comparison with the *Vulcan*, above. That angle irons had not been rolled prior to 1819 must have been a close run thing for them to be *common* in 1821. It is extraordinary how incomplete our knowledge of such developments remains.

1824-5 The Horseley Co. built a boat for the Shannon, the ***Marquis Wellesley***, constructed as a twin boat, with a central paddle wheel. Grantham's father superintended her construction. She was assembled at Liverpool. (Grantham 1842)

1829 Fawcett and Co. built a second boat for the Shannon, the first iron vessel built in Liverpool, under the superintendence of Mr Page.

1831-2 Sheet-iron gigs appeared as fly-boats between Paisley and Glasgow (Sylvia Clark, in *Transport History*, Vol.11, 1980.)

1831 ***Alburkah***, 70 feet x 13 feet x 6 feet 6 inches, a steamboat built on ribs by MacGregor Laird. This vessel was sailed to West Africa, and used on the Niger.

1833 Thompson built his first iron steamer on the Loire (see appendix).

* * * * *

By this period, iron ship-building was spreading rapidly, and was no longer a novelty. That it long remained a fairly imprecise science in the actual shipyards, reliant on brute strength and ingenuity, is attested by a writer in the journal *Naval Science*, in 1874, passages from which are given in the appendix. There can be little better testimony to the skill and enterprise of these pioneers, and in particular that of John Wilkinson and John Jones, almost a century earlier.

Postscript

Members of the Society may be surprised on reading this paper that I have made no direct mention of the work of Ralph Pee on the *Trial*, recently reprinted.

It is true that we all build upon the work of others in historical research, using references to sources found and reported long ago. The fact is, however, that I profoundly disagree with many of Ralph Pee's statements about the *Trial*: that was in itself a spur to pursue this research.

I am well aware that my pursuit of the possibility of a cast iron *Trial* may prove to be a false trail - it does however reveal the paucity of our knowledge of that era.

Time, and further research, may tell which of us was nearer the truth.

Notes

1. The Iron Bridge was preceded by at least two others, for example Kirklees (1769: *New Civil Engineer*, 20th October 1977, p 48), and Stourport (1774, by Pritchard: C.Hadfield, *Canals of the West Midlands*, 2nd Ed., 1969, p 51). There was a small cast iron aqueduct by Outram on the Derby Canal, completed in February 1795 (C.Hadfield, *op.cit.*, p162), which survived until recently. The Longdon iron aqueduct was only conceived after floods in early 1795 and completed in 1796 (Telford, article *Canals* (written in 1800), in J.Plymley, *General View of the Agriculture of Shropshire*, 1803, p300).
2. Conveniently collected in Trinder, *The Industrial Revolution in Shropshire*, 1973, pp165-7.
3. The difficulties on the canals are hinted at for the Staffordshire and Worcestershire (in 1770) in passages cited in C.Hadfield, *op.cit.*, pp66-7. "Publicola", *Reflections on the general utility of inland navigation*, 1798, Birmingham Reference Library Acc. 193510, indicates how a navigation that in summer only sporadically allowed laden barges to be floated over shallows, and then required more men to haul each barge against the current, imposed excessive demands on manpower.
4. Early moves: W.H.Chaloner, *John Wilkinson, Ironmaster*, in *History Today*, Vol.1, May 1951, p64. Castlehead: W.H.Chaloner, *The Agricultural Activities of John Wilkinson, Ironmaster*, in *Agricultural History Review*, V, 1957, p48.
5. A.Fell, *The Early Iron Industry of Furness and District*, 1908, p203: W.A.Smith, *John Wilkinson and the Industrial Revolution in South Staffordshire*, in *West Midlands Studies, No 5, 1972, p24*.
6. *A.N.Palmer, John Wilkinson and the Old Bersham Iron Works*, 1899, reprinted from the *Transactions of the Honourable Society of Cymmrodorion*, p8.
7. H.W.Dickinson, *John Wilkinson, Ironmaster*, 1914.
8. W.A.Smith, in *West Midlands Studies*, No.5, 1972. *op.cit.*, p26.
9. J.A.Saner, *On Waterways in Great Britain*, in Min. Proc. of the Institution of Civil Engineers, Vol CLXIII, 1906, actually gives 6 feet 9 inches as the maximum size of boat that could navigate the Staffordshire and Worcestershire Canal at that date, while Hadfield, *op.cit.* states 7 feet. The dimensions cited are taken from Saner and from Hadfield, *op cit.*
10. Jessop manuscripts dated 10th August and 30th October 1784, in the Library of the Institution of Civil Engineers. I have not yet been able to trace any survey for depths of water above Bewdley, though the sequence and names of all the shallows and the general declivity are known from another Jessop survey (IGMT).
11. This is explicit in Plymley, *op.cit.*, which states at p286: "1796.... there were not two months in which barges could be navigated, even down the river, with a freight which was equal to defray the expense of working them...". (It needed about three inches more water on the shallows to get a barge upstream than downstream, at the same draught of water.) There are

also numerous accounts of the necessity for, and evils of, lighterage in dry seasons.

12. See Thompson's text from the *Artizan*, in the appendix.
13. See the appendix, taken from the copy in the Derby Local Studies Library.
14. The limit was again the Coventry Canal. One might also note that the Cromford canal, to which this vessel traded for limestone, was exceptionally shallow - so was the boat.
15. If 5 feet 9 inches is correct, but the same mode of construction had been supported on a bottom of 6 feet 9 inches, then the draught would have been about 7 inches: so light as to reinforce suspicions about the breadth recorded.
16. *Annales des Ponts et Chaussées*, Vol V, 1843, 1st semestre, Fournel and d'Yevre, *Canaux souterrains de Worsley prés Manchester*, p201.
17. Ditto: this paper contains a range of component costs for loading, unloading, and operating both narrow boats and river barges, in the Worsley area.
18. Presumably a rock outcrop, now known to lie between Jackfield and the Iron Bridge, from a Jessop survey (IGMT).
19. Thompson quotes one eleventh inch thickness. Such plates were bent over moulds. In the wake of the *Princess Alice* disaster on the Thames (1878?), even 5/16 inches would be described as like brown paper, for passenger vessels. Anything less than 1/4 inch was very rare. Min. Proc ICE LIX, 1879-80, W Carson, *Passenger Steamers of the Thames, the Mersey and the Clyde*, pp82ff.
20. W.A.Smith, *Swedish View of the West Midlands in 1802-3*, in *West Midlands Studies*, Vol 3, 1969, p50.
21. From John S Leese, *Old English Power Plants*, in *Power*, 23 July 1912, Vol 36, No 4, pp 108-9.
22. John Farey, *A Treatise on the Steam Engine, Historical, Practical and Descriptive*, 1827 (reprinted 1971), p266.
23. Cited in H.W.Dickinson, *A short history of the Steam Engine*, p120.
24. John Farey, *op.cit.*, pp259ff.
25. John Vernon, *On the construction of iron ships*, in *Proceedings of the Institution of Mechanical Engineers*, 1863.
26. Francis Thompson atmospheric engine, inv. 1920-124. Originally at Ashover, moved to Oakerthorpe in 1841. Boulton and Watt engine, 1797, inv. 1885-121, known to have been altered to some extent in 1806.
27. Wilkinson Society Journal, No.7, 1979. R.Pee, *The Broseley Home of John Wilkinson*. I am indebted to Mr Michael Berthould for permission to examine these tanks.
28. There seems to be some question about the qualities of iron produced at Willey: was it worked beyond crown iron there in 1786 ? Or was Wilkinson's new plant at Bradley intended for that ? Could boiler plates be made from the initial grades of wrought iron ? There is a reference dated 1797 to the fact that Wilkinson could not himself make, nor get from others, boiler slabs for his works (at Willey ?), having offended all suppliers (Trinder, *op.cit*, p203).
29. Rhys Jenkins, *Boiler Making*, in *The Engineer*, July 19th, 1918, p52.
30. It appears that the only published details are still those from Alexander McKee's *How we found the Mary Rose*, 1982, p86 and Table 3, despite the fact that this gun was recovered in 1970. The thickness of the metal is not stated.
31. Rhys Jenkins, *op.cit.* He cites John Carr, *The Coal Viewer and Engine Builder's Practical Companion*, 1797. Uniform thicknesses of plate seem to be implied.
32. Which was of course for rounding bars, not rolling plates. E.C.Corlett, *Iron, Steel and Steam - Review Paper*, in *500 Years of Nautical Science*, National Maritime Museum, 1981, p 280, Figure 2. As drawn, Corlett's graph plots Williamson's (sic) barge and the rolling of plates as coincident at

1784. Svedenstierna's account includes this passage concerning the Bradley rolling mills in 1803: "The rolls had a diameter of 10 to 12 inches and were three to four feet long, and were turned and polished. After the sheet iron had received a certain thinness in the rolls, two and two, and finally four and more were laid together. Some of the sheets here were unusually large." Does that imply that by 1803 plates were welded together edge to edge; or is it only a reference to the practice of rolling thin (gauged) sheets by successive folding, followed by shearing (W.K.V.Gale, *The Rolling of Iron*, in *Transactions of the Newcomen Society*, Vol XXXVII, 1964, p42).? We may also note that Trinder (*op.cit.*, p164) is of the opinion that even twenty years after the *Trial*, the only Shropshire works capable of rolling boiler plates were Horsehay and Ketley.

33. For example in the account of Smeaton's portable engine, in Farey, *op.cit.*
34. Cited in Rhys Jenkins, *op.cit.*
35. In one Randall account, *The Wilkinsons*, John Jones was a foreman.
36. R. Harrison & J. Zeitlin (eds), *Divisions of Labour*, 1985.
    Chapter 5: K. McClelland and A. Reid, *Wood, Iron and Steel....*, p 165.
37. For example: *Annales des Arts et Manufactures*, Vol 7, pp11-12, contains a description of Wilkinson's process for making white lead, patented 18 June 1799.
38. H.P.Spratt, *Birth of the Steamboat*, 1958.

List of Appendices - Short Titles

YORK COURANT **Tuesday, May 27th, 1777.**

Last Tuesday, a new pleasure-boat, constructed of sheet-iron, was launched into the River Foss. She is twelve feet in length, six in breadth, has sailed with fifteen persons on board, and may be conveyed to and from the river by two men.

Note: the above is copied verbatim into the *Gentleman's Magazine* for May 1777, giving the launch as Tuesday 20 (p 244). It is later repeated in a slightly different form (p 291). Curiously, the index item referring to these two entries is under *Cast Iron, Boat of.*

GENTLEMAN'S MAGAZINE **Vol.57, 1787, p 732.**

Birmingham, July 28.
A few days ago a boat built with English iron by J Wilkinson Esq. of Bradley Forge, came up our canal to this town, loaded with 22 tons and 1500 weight of its own metal, &c. It is nearly of equal dimensions with the other boats employed upon the canal, being 70 feet long, and 6 feet 8½ inches wide. The thickness of the plates with which it is made is about 5-16ths of an inch, and it is put together with rivets, like copper, or fire-engine boilers; but the stern-posts are wood, and the gunwale is lined with, and the beams are made of, elm planks. Her weight is about eight tons; she will carry in deep water upwards of 32 tons, and when light she draws about the same as a common wooden boat, viz. eight or nine inches of water.

Mr Stalcouth, at the instance of a copper company, is building a vessel whose bottom is to be entirely of copper without any planking, which, were it to be continually suspended in water, might answer every purpose of commerce; but whether it will be bear to be laid aground when loaded seems doubtful.

Note: This is the time-honoured source for the *Trial*, but there is a fuller account in *Aris's Birmingham Gazette* of Monday, July 30th, 1787. (Even this may not be the original source.) This account sandwiches the above text (with only trivial differences, such as "like coppers", but omitting Mr Stalcouth's copper boat) between two additional paragraphs:

We have pleasure to mention the following instance of the increasing manufacture, and opulence of those concerned in the iron trade in this kingdom.

The spirited proprietor of this vessel is, we understand, going to build another of a larger size.

ARIS'S BIRMINGHAM GAZETTE **Monday, 3rd November, 1788.**

Birmingham, November 3rd: The iron barge, built by John Wilkinson, Esq, was lately launched at Willey Wharf, to the admiration of some, the surprise of many, and the conviction of all: it was perfectly tight, moves very easy on the water, and draws about eight inches when quite freighted (*sic*). It was immediately laden with iron, for Stourport, where its arrival gained the attention of all that place.

UNIVERSAL Magazine. **Volume 83, November, 1788, page 276.**

November 8th: An iron barge built by John Wilkinson, Esq, was lately launched at Willey Wharf, Shrewsbury. She is perfectly tight, moves very easy on the water, and draws about eight inches, with every &. on board.

Note: Not only is the text slightly different from the quotation of this by Randall, but more significantly it is from a year later than implied by Randall.

REES' CYCLOPAEDIA **Article: CANAL, dated February 1806.**

p 333. *Construction of boats for canals and rivers.*
......Since the use of cast-iron has become so general, Mr John Wilkinson has constructed boats and barges of iron, some of which are used on the Severn river, and others upon the different canals in Staffordshire, Worcestershire, &c.

p 390. Mr John Wilkinson introduced some barges made of cast-iron plates for navigating this river.....

BOAT REGISTER. STAFFS C.R.O Ref Q/RUB 1. 1795-7

Certificates issued on 29th August 1795, under 35 Geo.3 ch 58:

Three boats, burthen 20 tons, owned by John Wilkinson, of Bilston.
Each was declared to be used from Autherley to Birmingham, 22 miles (ie on the Birmingham Canal, but excluding the links to Stourport, curiously). Their crews were a master and one man, employed for steering and driving the horse. They were to carry painted numbers related to the owner:

No.1, Master: Joseph Hill, of the Parish of Sedgley.
NO.2, Master: William Turner, ditto.
No.3, Master: John Whittle, ditto.

There is a loose letter in this Register, of some interest:

To Mr John Collins, Clerk of the Peace, Stafford. October 24th, 1795.
Sir,

I have 1 moore boat to register as I intend working. it is to work about 200 yards upon the Birm Canall, to carry coals from at Pitt of Mr J Wilkinson's to the Furnis. Boat is No.5 & it is able to carry 24 tons but being short of water I carry from 18 ton to 20 or 21. Thos Bate steers er of Tipton & a lad with him. I should be glad if you will register this boat No.5 & send me the sativikit. I will send the money by whom you will there is a carryer goes through Bilstone every Satturday wich I will send it by him if you are agreeable. Please to send in your letter how much it is. I shall take it as a favour if you will send it by return of post. NB please to direct for me at Copperfield near Bilstone, Yr most humble servant,

Enoch Smith, Coseley.

(*Note:* The only boats actually registered under this owner were Nos 10, 11, apparently used as a pair, with Master Joseph Coleborn, and two men, from Tipton to Oxford.)

JAMES STOCKDALE. ***ANNALES CAERMOELENSES.*** **ULVERSTON, 1872.**

p124. ...In my collection I have one of these silver coins: on the obverse is an excellent likeness of John Wilkinson, with the inscription "JOHN WILKINSON, IRONMASTER"; on the reverse, a ship (70 tons burthen) in full sail, being a representation of *the First Iron Ship ever built*, he being the builder and inventor, in 1787......

(*Note:* This coin was dated 1788. It is unfortunate that such a ridiculous description has been used here: it can but cast doubt on the reliability of the rest of the evidence, which ought to have been one of our best sources. Fell is rather dismissive of Stockdale as a source on other matters; and Stockdale himself refers to being unable to correct early errors, because the book was printed in sections as written.)

p210-1. Isaac Wilkinson and his son John must have acquired more or less means even in this petty trade of "flat smoothing iron making", for about 1742, or perhaps a little later, they built or purchased the iron furnace and forge at Wilson House, near Lindal, in the parish of Cartmel, intending to smelt there the rich haematite iron ore of Furness with turbary or peat moss, large tracts of which at that time were on every side, nearly, of the furnace, and up to which place the river Winster was then navigable for vessels of light burthen. The first operation after the purchase of the property was to cut a canal into the midst of this large tract of turbary, sufficiently wide for the passage of a small boat, intended to be used in conveying the peat moss to the iron furnace; which boat, tradition says, was actually constructed, not of wood, but of *Iron!* and there are people still living (amongst others Mr Nicholas Atkinson, of Cart Lane) who remember having seen it about seventy years ago. A novel idea had suddenly flashed across John Wilkinson's mind! a great but simple truth, till then hidden to all the world! that iron might be made to float in water! that a heavier body might be made, under certain circumstances, to float in a lighter! And may it not be reasonably assumed that the building of this small boat at Wilson House, in Cartmel parish, furnished John Wilkinson with the idea of building the much larger vessels he afterwards constructed of iron in 1787-8, at Willey, in Shropshire (described hereafter), and that *Cartmel* parish has the high honour of having had the first iron vessel constructed in it, and that too by the inventor, one of its own parishioners! Yes; that this Wilson House Iron Boat really was the parent of all the iron ships that have ever since been built - our noble iron-sided men-of-war, and that leviathan of ships, the "Great Eastern" herself, not excepted! *Labor omnia vincit!* or, as the old English rhyme has it - "By hammer and hand All things do stand".

(*Note:* we may notice 1787-8. But that Randall claims not to have seen Stockdale's book when he first wrote on the subject, one might suppose that this was the source of his own hyperbole.)

p216-8. Before taking his journey to France, John Wilkinson had made some attempts to build an iron boat for the canal at Bradley, and, as before said, had succeeded in building and using a small one on the canal he had made in the peat moss at Wilson House, in Cartmel parish. On his return from France in July 1786, he recommenced in earnest these iron boat building experiments, and in about a year afterwards addressed a letter to my grandfather, James Stockdale, of Carke, of which the following is a copy, and is proof positive that to him, a man so intimately connected with Cartmel parish, belongs the honour of inventing and building the first iron ship; iron now, in our day, being on the point of superseding wood altogether in ship building, so that hereafter the saying will be "the iron walls", not "the wooden walls of old England".

Broseley, 14th July, 1787.

James Stockdale, Esq., Carke.

Dear Sir, - Yesterday week my Iron Boat was launched. It answers all my expectations, and has convinced the unbelievers, who were 999 in 1,000. It will be a nine days' wonder, and then be like Columbus's egg.

I remain, dear Sir, yours very truly,
signed, JOHN WILKINSON.

This iron boat was launched at Willey Wharf, and floated very lightly on the water; she was of about seventy tons (some say only forty tons) burthen, and called "The Trial", her captain's name being Palmer. To commemorate this event, John Wilkinson had medals and tokens struck... date 1787....In another letter, also to my grandfather, dated Bradley Ironworks, October 20th, 1788, he says, "There have been launched two Iron Vessels in my service since September 1st: one is a canal boat for this (Bradley navigation), the other a barge of forty tons, for the river Severn. The last was floated on Monday, and is, I expect, at Stourport with a loading of bar iron. My clerk at Broseley advises me that she swims remarkably light, and exceeds my expectations...."

p596. In concluding this rather lengthy account of the Parish of Cartmel, I venture to claim for the district I am writing about, all the honour to which it may be entitled, and that cannot be inconsiderable, as the place where *the very first iron vessel ever built* was designed and constructed, and that too by one of its own parishioners, John Wilkinson, of Castlehead, called afterwards "The Great Iron Master", now about one hundred and twenty-two years ago - such having been my chief object in communicating this and other matter regarding Cartmel to Mr Smiles, the popular writer, in 1861); and to add further that this small vessel, which truly may be said to have been the parent of all the iron vessels ever built - "the *iron* walls of old England" not excepted - after being long disused on the canal John Wilkinson had cut for it into the Witherslack Peatmoss, laid for years nearly covered with mud at the bottom of the river Winster, near to or in Helton Tarn. There are some few persons still living who remember having seen it lying there.

"Tempus omnia revelat; tandem sit surculus arbor."

JOHN RANDALL, ***BROSELEY AND ITS SURROUNDINGS,*** **1879, pp 106-9.**

.......It was the difficulty of getting barges of the ordinary kind built fast enough to carry his castings (*pipes and/or guns for France*) that led Wilkinson to construct the

FIRST IRON VESSEL: *The Trial.*

Compared with the armed leviathans of the same metal now upon the ocean she was, it is true, a Severn minnow, a mere stickleback contrasted with a whale, but she was a notable innovation in that day, and created a wonderful sensation among the barge builders and barge owners, and indeed through the kingdom generally. The barge builders had a sort of monopoly, and thought Wilkinson could not do without them; and when he said "I will make an iron barge", they laughed at him. Wilkinson, however, set an ingenious smith, whose name was John Jones, but who went by the name of John O'Lincoln, to work; and during the spring and summer of 1787 John's hammer and tongs were plied in riveting and fastening plate after plate of Wilkinson's best iron, whilst many a joke was cracked by passers by, who denounced the innovation in terms embellished by rounds of oaths. Early and late John's hammer was heard - rat-at-tat-tat, rat-at-tat-tat, till the woods echoed back the busy sounds. It was a quiet rural spot; and its solitude had favoured, as we have said, the exportation of good gun iron to the French.

The autumn of 1787 arrived, and a great crowd came down to witness the launch. The woods wore their autumnal foliage, the sun sent down approving smiles, and the Apley rookery, disturbed by incursive visitors, furnished a hovering cloud of sable spectators. The plodding ploughman left his task, the artisan his shop, the pedlar his pack, and yeomen from vale and upland came pouring down to witness the launch. "Will she swim ?", "Will she work and prove manageable on the water ?", and "Who will he get to work her ?" were questions that served to occupy the time. Never did son of Vulcan look more proud than John O'Lincoln; if his descent direct from the patron god had been made out and patented he could not have felt more so. A discharge of 32-pounders told that all was ready; and before the white curling smoke had well died away, the *Trial* descended the way-pieces into the river with a splash. It carried 30 tons, and Edward Palmer, who lived near the Wood Bridge, as Coalport Bridge was then called, was her captain.

The following is Wilkinson's account of the event in a letter to Mr.Stockdale: (*Note:* exactly as in Stockdale, omitted here).

Wilkinson went on building other barges. In a letter, dated "Bradley Ironworks, 20th October, 1787", he says:

> There have been two iron vessels launched in my service since 1st September, one is a canal boat for this navigation - the other a barge of 40 tons for the river Severn. The last was floated on Monday, and is I expect now at Stourport with a lading of bar iron. My clerk at Broseley advises me that she swims remarkably light, and exceeds even my own expectations.

The *Universal Magazine* for that year, Volume 83, p 276, says:

> November the 8th, an iron vessel, built by John Wilkinson, Esq., was lately launched at Willey Wharf. She is perfectly tight, moves very easily on the water, and draws about eight inches with every accompaniment on board.

In 1810 John Onions and Son, of Broseley, built a lighter, of about 50 tons, called the *Victory*, which was designed for the Severn trade; and also one at their works in Brierley, which was sent to London, in parts, and which was, we believe, the first iron vessel on the Thames. In 1811 they built several which traded extensively between Brierley and London, and between Broseley and Stourport.

Note: The *Universal magazine* cited is actually 1788, not 1787; as is the Wilkinson letter from Bradley.

JOHN RANDALL. *THE WILKINSONS.* **MADELEY**, no date

This account contains several differences from that above, the significant ones being summarised as:

but she was the first, and the precursor of others on the Clyde, the Mersey and the Thames..........the first iron keel was laid........... Wilkinson could not get barges of wood built fast enough. The bargebuilders had a monopoly of the trade, and were quite independent......He set to work at Willey Wharf, and John Jones...was foreman.....Wilkinson's iron was of the best quality......quiet, sylvan, rural spot.

following the quotation from the *Universal* magazine, he adds:

> The *Gentleman's Magazine* of the same year had, we believe, a similar notice. Others caught up the idea, and iron barges have been common to the Severn ever since...... In 1810.. a lighter..which was sent to Mr Bishop of London in parts......out of the metallic hills of Shropshire, therefore, came the first iron rails, the first iron barge and the first iron bridge.
>
> An anecdote is told of a local country blacksmith, who had dropped his hammer temporarily to listen for the first time, to the relation by a neighbour of the story he had heard of Wilkinson's intention to make a canal boat of iron; and who, with the utmost astonishment and incredulity, threw into his water bath the horse shoe he had been working on, and asked the relator if he thought iron would swim, when the shoe had sunk to the bottom in a moment.

SWEDISH VIEW OF THE WEST MIDLANDS IN 1802-3.
W.A.SMITH, in *WEST MIDLANDS STUDIES*, Vol 3, 1969, pp 66-7;
being a translation of the account by E.T.Svedenstierna
of his travels in 1803. At Bradley Ironworks:

Note: an independent translation of the complete work exists (also from the German translation rather than the Swedish original), and differs significantly in other matters of local interest. Phrases in square brackets come from this second translation - *SVEDENSTIERNA'S TOUR - GREAT BRITAIN 1802-3*, Trans. E.L.Dellow, Ed. M.W.Flinn, 1973.

On the canal near to the works there were several 20 ton barges made of sheet iron [iron plates] and of the same shape as the customary wooden barges, i.e. flat-bottomed with a rounded [blunt] stern and triangular bows. They lay altogether [in general] higher in the water and moved more easily than the wooden ones and were fairly water-tight and stood up to rough usage, however they cost 3 or 4 times as much as a wooden barge and since one of the latter can be used for 20 years with a few repairs it is not yet clear whether this experiment will be financially practicable.

Wilkinson is also said to have a larger vessel of sheet iron [iron plates] on the Severn, but for some reason it was less successful. I was unable to meet him personally, since he was in London when I visited his works, and I therefore had no opportunity to find out more about some of his experiments and plant. He is an old man now, although he still has a wealth of new ideas, even if these are said to have enriched science more than himself.

A.N.PALMER, *JOHN WILKINSON AND THE OLD BERSHAM IRON WORKS.* 1899
Reprinted from:
Transactions of the Honourable Society of Cymmrodorion, pp 7-8, 25.

In 1740, according to Mr Stockdale, Mr Isaac Wilkinson migrated to the village of Backbarrow in the parish of Coulton in Furness, where he had a good house, and began business in a small way by the manufacture of flat iron heaters. In this he was assisted by his eldest son John. They had, at first, no furnace of their own, but got their melted metal from a furnace worked at backbarrow by the Machells and others, bringing it in large ladles across the road, where they poured it into moulds. But "about 1748, or perhaps a little later, they built or purchased the iron furnace and forge at Wilson House, near Lindal, in the parish of Cartmel, intending to smelt there the rich haematite ore of Furness with turbary or peat moss, large tracts of which at that time were on every side nearly of the furnace." Into this turbary he dug a canal, and in order to bring the peat along this canal to the furnace, he made, acting, it is said, upon the suggestion of his son John, a small *iron* boat, "*the parent*, as Mr Stockdale says, "of all the iron ships that have ever since been built". The many experiments made by the two with the object of smelting iron ore with peat moss proved, however, unsuccessful, and they had to revert to the use of wood charcoal. Nevertheless, they here invented and patented "the common box smoothing iron, even to this day but little altered". (Stockdale.) Soon after, John Wilkinson left his father and got employment first at Wolverhampton, and then at Bilston, Staffordshire, where, after ten years he "succeeded in obtaining sufficient means to enable him to build the first *blast* furnace ever constructed in Bilston township, which he called *Bradley Furnace*, where he ultimately, after many failures, attained complete success in substituting mineral coal for wood charcoal in the smelting and puddling of iron ore.

As to the silver tokens....dated 1788, the design of which is identical in every respect with the copper tokens issued in the same year, containing, that is, on the reverse a ship in full sail. ...... It commemorates the large iron boat which Wilkinson launched in July 1787, at Willey Wharf, the first successor of the *small* iron boat which he had constructed years before at Lindal. Mr.Stockdale says that he has in his collection a silver token of the same design as that just described, but dated 1787...

A SET OF TABLES FOR ASCERTAINING THE WEIGHT OF CARGOES CARRIED BY NARROW BOATS, NAVIGATING ON THE RIVER TRENT, and other navigations communicating therewith, done under the direction of the Committee of Proprietors of the River Trent Navigation, printed by Samuel Tupman and E.B.Robinson, 1801-8. Nottingham.

Record **No.46.** **Mammatt & Co.,** Brinsley. **No.3.** S.**Kenney, Master.**

This boat was built by Mr. Jewsbury of Measham, for the late Mr. Joseph Wilkes of Measham, in the year 1804. The present owners are Mr. Wilkes' executors, and have chiefly employed her in the Lime Stone Trade on the Crumford Canal.

This boat had never been trimmed when these gauges were taken. She had no floor, being built of iron. Her length is 70 feet, and breadth, across the midships, 5 feet 9 inches. She drew 7-7/16 inches water when light, and 29.00 inches when laden with 20 tons.

When these gauges were taken, there were on board, a small jury-mast and line, only.

As 25 tons put this boat down 26.92 inches, one ton upon an average puts her down 1.07 inches.

(There follows a table of depths for each one ton increment in loading, from light to 25 tons. To 17 tons the immersion changes uniformly by 1.08 inches per ton; thereafter by 1.07 inches per ton)

Note: From internal evidence it would appear that this boat was gauged in 1806. The last six entries in the set, only, contain the additional information that plates were fixed at the quarter points of the hold, the length of which was recorded. It seems reasonable to suppose that four plates were affixed to each boat, two each side, calibrated in eigths of an inch or better to justify the use of two places of decimals, and averaged over the four results for an average draught, equivalent to the boat being on an even keel. The individual gaugings are so consistent that it is obvious that great care was taken over this work. It does not emerge from this booklet whether the gauge plates were permanent, or a single set re-used on each boat; but I would suppose the latter, as they would be unreadable after a period in service, and such accuracy would be of little use in normal service. (In many cases the weights of covers and miscellaneous equipment not on board is separately noted, and was up to a quarter of a ton.) The condition of the boats was also noted briefly. A few were noted as very foul, when the floors were taken up, but most were good. Not all had floors, which helps to explain the variations in draught, perhaps. We are however left to suppose that the boats were free of water. The jury-mast was universal, and associated with the towing line.

Measham was the terminus of the Ashby Canal, with two possible circuitous routes from the Cromford Canal, and a variety of lock sizes on each route.

JOHN GRANTHAM. *IRON AS A MATERIAL FOR SHIPBUILDING.* 1842, pp5ff.

Early History of Iron Vessels.

It is a common error to suppose that vessels have but recently been constructed of iron, and that the principle is only advocated by a few whose interest, as workers in iron, leads them to promote it. Many therefore, naturally enough, still view the subject with distrust, and regard it as one of the visionary schemes of this wonders-working age, which will soon be relinquished and forgotten. But I trust I shall be enabled to prove that the construction of iron vessels is not an invention of recent date; that the value of iron as a material for ship-building has long been known; and that it has for many years been making a sure. though slow, progress towards the improved state it has already attained.

Iron Canal Boats.

The first traces that I can discover of the construction of iron vessels, are of those built for the canals of this country. Of these, a few, I believe, were built as far back as forty years since, and it is stated by those who have had a good opportunity of knowing, that some of them may still be in existence. During the Meeting of the British Association in Glasgow, after a paper had been read on the subject of iron vessels, several gentlemen communicated facts, which had come within their own knowledge, with respect to their early introduction. A friend, in writing on this subject, states that a gentleman in Staffordshire was at that time cutting up some iron vessels which had been at work twenty-eight years. My partner, Mr Page, was engaged in building several canal boats of iron, upwards of thirty years since; and I have myself seen iron vessels in Staffordshire, of a still greater age, but the precise date of the construction of which I could not ascertain. These facts are interesting, not only as proving that the subject has long been under the attention of practical men, but as evidence of the strength and durability of iron vessels, points to which I shall hereafter more fully allude.

(*Note:* the text continues in some detail on the early adoption of iron steamers, and is the main source for such items in the chronology. By 1858, when he wrote the first edition of *Iron Shipbuilding*, Grantham was able to add the passage on the *Trial* from the *Gentleman's Magazine*. The wording of this and later editions is slightly different from the passage cited, but not as to materially alter the interpretation. There appears to be no published record of the Glasgow discussion.)

He incorporates a letter from his friend Thomas Jevons, of Liverpool, written in 1842:

...and having been the first individual, I believe, that ever launched an iron boat on salt water... In August 1815, I launched a small iron boat, which I fitted up as a pleasure boat, and frequently sailed in it on the river Mersey. It was built by Mr Joshua Horton, of Tipton, near Birmingham, but fitted up in Liverpool by the late Mr Roger Hunter, and the late F.J.Humble. When not in use, this boat was put up in the Duke's Dock, where it was open to the gaze of any passer by; and, not being what a sailor would term *ship-shape*, owing to its being built inland, it was rather a curiosity. Its buoyant powers, however, and the remarkable ease with which it maintained its way, when once put in motion, attracted the notice of many.....

(*Note:* the letter continues to describe the sabotage of this boat, which led to the construction of the first unsinkable, self-righting iron life-boat at Tipton between 1818 and 1820. This too was sabotaged at an early stage, but was recovered and sold to the West Indies.)

NOTES ON STEAM NAVIGATION ON SHALLOW RIVERS, being the result of eighteen years' experience on the Loire and Garonne, by a Practical Engineer.

Hugh Williamson identified the author of this extraordinary account for me, in the course of his studies of steamboats on the Loire. Thompson had been sent to France in 1827 by Fawcett as an engine erector. He stayed on in the Loire area for some fifteen years, pursuing a variety of interests.

> .....I had only been there two months when the boats were all stopped, owing to the shallowness of the water. The first year I did not think much about it, but the second, I began to think that something could be done to remedy this serious evil; but I was told by everybody that there was no help for it. I was not, however, of their opinion, and my first job was to make a high-pressure boiler, to replace one of Fawcett's, which I patented. This boiler was of cylindrical form with D-shaped flues, and weighed one ton less than the old one, which weighed 5 tons and worked at 4 lbs per square inch. By the increased pressure, 24 lbs per square inch, which this boiler would carry with safety, the power of the engine was nearly doubled, and the speed of the boat much increased. A very strong opposition had been started against our company by a rival company, which had got engines from Barnes and Miller of London, and their boats previously beat ours by an hour, and took all the traffic from us. With the new boiler we beat them by an hour and a half, and the opposition was soon over. This was in 1830. In 1831, I made a 24-horse engine for a boat that had had a 12-horse engine in, previously, but the new engine was lighter than the old one. I carried 30 lbs pressure in the boiler, and by making the condenser larger than usual, and keeping the air-pump the ordinary size, I found I could get as good a vacuum as in a low-pressure engine. In 1832, I began to think seriously about building light iron steamers, for the boats were all stopped about three months every summer, and at the very time when most money was to be made. But in this attempt I was worse off than Noah, for I had no one to give me the least instruction how to draught, or calculate, or build a boat, but I thought I would try, so I began by displacing a cubic foot of water and weighing it, and then I weighed a square foot of sheet iron, and a lineal foot of iron for the ribs. Then I made models and put them afloat, and worked on in this way the most part of 1832. In the beginning of 1833 I found that I could build a boat that would draw only eight inches of water, but I told the company nine inches, but they would not risk any money on it, so I spoke to some of my friends about it, and in three months we had the affair all settled. ..... I tried the engine on Christmas Day, and on New Year's Day (1834) we ran the boat about four leagues. She was drawing only six inches of water, but had nothing in her, except the engines, and boilers, and about a ton of coals. To give a better idea of the boat, I will describe her construction. Length, 100 feet; breadth, 10 feet 5 inches. The sheet iron she was built of was one eleventh of an inch thick, the ribs 3 lbs to the lineal foot, and two feet apart. The sides of the boat 3 feet 6 inches high, and where the engines were, 5 feet 6 inches. The iron for the paddle-boxes etc, was as light as I could get it. The cabins were made with strong canvas, with a light wood framing; the outside was well tarred, and the inside covered with fine cloth. Fore and aft the cabins there was a kind of platform, where the passengers could enjoy the air, under an awning. Where the cabins were, there was a small gangway, outside the boat, for the men to pass fore and aft without going through the cabins. The engine was a beam engine, of 24-horse power, with sheet-iron beams, made very thin and deep. In like manner every advantage was taken to use wrought iron, for strength and lightness. Diameter of cylinder 16

inches, and 2 feet stroke. Paddle-wheels 12 feet diameter, and 4 feet wide. Number of revolutions per minute, 43. Vacuum, 24 inches. Pressure of steam 38 lbs on the square inch. The engine, boiler, shafts, and wheels weighed 6 tons, and the boat and the engine complete, 14 tons.

We started with her for Orléans on the 24th March, 1834, when there was only 8 inches of water, and the novelty of this circumstance caused it to be remarked on by the newspapers. She ran for some time, between Tours and Orléans, and when the boats that ran from Nantes to Angers were stopped for want of water, she was put upon the latter station, and very soon repaid the owners her cost. I was then commissioned to build a boat, 125 feet long by 14 feet beam, but before she was laid down......I took the two engines and built two light boats for them, with decks fore and aft; otherwise, and in the strength of the iron, they resembled the first one. The deck planks were 5/8 of an inch thick; deck beams 2 inches x 1½ inches, and placed two feet apart, with two rows of light columns inside. The deck was covered with strong canvas, for it would not stand caulking. These boats were 125 feet long and 10 feet broad, and drew 10 inches of water.......a boat of 140 feet long and 13 feet broad. I changed the system of the boilers in this boat, making a cylindrical shell and a cylindrical flue through it; the shell 30 inches, and the flue 22 inches diameter, and thirty feet long. At the furnaces it was 3 feet 6 inches diameter. A steam chest on each, 5 feet high. These boilers worked at 60 lbs on the square inch, and the steam was expanded and condensed. This boat was partly built to oppose a boat, built and fitted with engines in France, which had non-condensing engines working at 75 lbs pressure. She beat all our boats, but drew too much water for the summer time; however, when our new boat started, she was full master of her, and finally ran her off the station. In 1837, I built another boat, 146 feet long and 11 feet 6 inches broad, with a 55 horse engine, working at 68 lbs pressure and condensing, and she ran 48 leagues in 11½ hours.

......I fear I have wearied your readers with this egotistical narrative, but I am no writer, and you have the facts as I have noted them down.

In 1838 I was chiefly occupied in constructing some land engines for flour and cotton mills, and did not build any boats. However, about this time, all my plans having become well known, a French builder tried his hand at light iron boats, but his first attempt was a failure;- she did not draw much water, but she would not go. He was supported, however, by some noblemen, and went to work again. This time he succeeded in getting a fair speed with 10 inches draft of water. Those of your readers who have ever been employed abroad, will easily understand that as soon as one of their own countrymen could imitate my work, I was *de trop*, or in plain English, that my room was more welcome than my company.

(Author's note: A detailed drawing of one of Thompson's boilers is contained in *Annales des Ponts et Chaussées*, 2nd Series, 1842, 2nd semestre, in an account of the formal inquiries into a number of boiler explosions in France.

Other issues in the 1830's and 1840's contain detailed accounts of river navigations, both the introduction of steamboats on rivers other than the Loire, and of the maintenance and improvement of the waterways themselves. Some of these will form the basis of a future paper.)

GEORGE PIGGOTT. *BOILER PLATE WORKING.* 1865
in *British Association, Birmingham and the Midlands Hardware District,*
Reports edited by Samuel Timmins, 1866.

....Less than half a century back nearly everything was done by manual labour, now nearly everything is done by the aid of machinery. Formerly the boiler maker punched the holes in the plates by repeated blows with a sledge hammer on the head of a punch, and it required about five or six blows with a hammer of 14 pounds weight to punch a hole 5/8 inch diameter through a plate 3/8 inch in thickness. Screw presses were then used, and afterwards lever presses, combining a pair of cutters for shearing, were introduced, but still worked by manual labour and very slow in operation. It is about 40 years since punching and shearing machines were generally driven by steam power......
....Before the introduction of rolled iron, the rivets for boiler making were made from square hammered bars; the iron was rounded to the size of the intended rivet in a tool on the anvil at a smith's fire, then cut off and headed in a tool, with a hand hammer, just as wrought iron nails are now made by hand. This mode of making rivets was continued long after the introduction of rolled round bars. One man could make about 300 rivets per day. The first machine for making boiler rivets was invented by Mr. Griffiths, of Smethwick, in the year 1838......
.....Setting plates and putting them together used to be pretty nearly one process in boiler making, for each plate was formed to an approximate shape and then temporarily fixed in its place on the boiler whilst red hot. It was then and there hammered into its required form, and when cooled was marked for punching from the holes of the adjoining plates to which it had been fitted. Many rude contrivances were resorted to to place and keep the work in shape, and it was no uncommon thing for a boiler, when it was put together ready for rivetting up, to be so full of stretching screws to pull in one place, and props to push out in another, that there was little space left for the holder-up man.
....The boiler maker of the present day reaps many advantages from the improvements made in the manufacture of iron; not in the quality, for that is deteriorated, but in the variety in form in which it is now made, and in the length of bars and increased size of plates produced. Going back to the period before rolled plates were known, boilers were then made of hammered plates; they were about 2 feet long and 15 inches to 18 inches wide, and about 5/8 inch thick in the middle, tapered all round to about 1/4 inch thick at the sides. As it was only the thinned edges of the plates that could be punched, the boiler maker was compelled to put them in his work of the size and form that he received them from the forge, and it was usual to order a few "half plates", that is, plates of about half the ordinary width, to be used as closers in completing each row or circle of plates in the boiler, and this practice of using half plates was retained after the introduction of rolled iron.
.....The general form of the boiler was what has been called the "balloon" shape. The upper part of this boiler being hemispherical was composed entirely of taper plates, but the boiler maker of that day was ignorant of the method of calculating, or by any way obtaining the proper taper for the plates, so he had to guess it, and it sometimes that it happened that the vertical joints got very far out of perpendicular in consequence of the plates being tapered too much, this he at once rectified by putting in a parallel plate, or if needful, one with the wide end uppermost. The writer of this has seen a balloon-shaped boiler in which were several "half-plates", and some plates reversed for the purpose of rectifying the excess of taper; the rivets were 5/8 inch diameter made from square iron.

HUGH WILLIAMSON, ***STEAMBOATS ON THE LOIRE, 1822-1852,***
(privately printed by his widow, Mrs Kathleen Williamson, 1986)

Note: This work reproduces the evidence of arbitrators of the Nantes Chamber of Commerce, concerning the reason for delays in the construction of two iron steamboats during the winter of 1837-8 at Mons. Guibert's yard. Their report is very revealing of contemporary methods and problems. It relates to the construction of boats typically 35 metres long, 4 metres wide, working at about 0.25 metres draught, and powered by side paddle-wheels:

> 18th January.
> We proceeded to the shipyard of Messrs Guibert Frères, Prairie de la Magdalene, opposite the Pompe à Feu. Monsieur Guibert showed us the hull of an iron boat in six sections. These sections had been raised clear of the wooden building frames and were ready for turning over, so that they could be moved to the water's edge for rivetting together. On the second building frame we saw all the ribs of another iron boat in place with about half the bottom plates rivetted to them. In the workshop we saw a sizeable quantity of pieces of sheet iron ready for the second boat. There were no workmen in the yard nor in the covered workshop,
> We agreed that five working days would have been sufficient to get the first boat on to the water, so that work on the interior could proceed. Since the 7th of this month, however, the cold has been so intense that the workmen have had to halt, as we know to be the case in all open yards, including those constructing wooden boats. Not only are the men unable to hold their tools, but both wood and iron have become unworkable. We were shown a slightly curved iron sheet that had developed a large crack, even though it had been rolled in the workshop. The wooden building frames have to be set up in the open because of the crane that has to lift the six hull sections.

On the 22nd January, Guibert reported that he had been able to get the workmen back on to the second boat, but he was immediately interrupted by floods, which prevented further work until the 3rd April.

JOHN VERNON. ***ON THE CONSTRUCTION OF IRON SHIPS.*** **1863.**
In *Proceedings of the Institution of Mechanical Engineers.*

...which is the more remarkable from the fact that less than twenty years ago it was considered by many persons of great experience to be a matter of doubt whether iron ships could be adopted at all for general service with any advantage. This doubt however was not shared in by many thoughtful mechanical men, who were strongly impressed with the advantages to be obtained from the introduction of iron; and the correctness of their views is now thoroughly established by the practical results that have been obtained on such an extensive scale.

The first consideration in the order of the subject will be the main points of superiority of iron ships over those built of wood. These consist in the superior strength, greater durability and less cost of iron ships, together with their larger carrying capacity, greater facility of construction, and the more certain supply of the material.

...There is perhaps no branch of iron shipbuilding in which more special advantages are obtained from the use of iron than in the construction of flat bottomed boats for river navigation. The extremely small draught of water thereby obtained may be said to be utterly impossible except by the use of iron as the material of construction.

(Anonymous) ***ON THE BUILDING OF IRON MERCHANT VESSELS.***
In *Naval Science*, Volume 3, 1874

....We would like to ask, in the first place, whether there exists any legitimate or sensible reason why a length of bar-keel, intended to be straight, rectangular, and "out of winding", should be crooked from end to end, with sudden inequalities on either side, with its section not rectangular in many places, and its ends winding to form the letter "X" ?

....The results are that the keels of many vessels are crooked and winding; the rivet holes in them are not square to their work; the scarphs are ill-fitted and unduly strained; the keel rivets are required to fill roughly-gouged and unfair holes, and are consequently leaky.

....We shall say nothing here about keels of other forms.... except to mention that the foremost and aftermost plates, in cases of flat keel plates, are often most severely burnt and unmercifully battered through the want of proper care and foresight in the first heating and bending to form.

....where stems with much curve have the rivet holes in the way of the curves drilled before the curves are effected, the said holes are drawn into an oval form, and the probability is that the rivets do not fill them. The consequences need not be stated. Very often, too, the scarph uniting the stem and keel is very poorly fitted, the butts not fitting as to length, and not conforming as to breadth. The under surface is chipped fair, but the fact remains that it is "slop-work", unpleasant as the phrase may sound.

....it would seem ....that even were the bevellings given not quite correct, they could not be far out in the breadth of the flange of an angle iron; that even if they were out here and there, iron was of a ductile nature, and a few good blows from a sufficiently heavy hammer would set matters right.

....the plating is brought on to this unfair and ill-bevelled collection of frames, and if it be of only moderate thickness it cannot possibly be got to fit them, notwithstanding the screwing and battering that it and they receive. A very unfair outer surface is nearly sure to follow; the plating itself has been battered and distressed and "drifted" out of its natural strength and tenacity; holes that perhaps once conformed conform no longer; the inevitable gouge and drift-punch are brought to bear upon them, and the riveting, as a natural consequence, is unsound.

....For the most part these evils are not observable when we congratulate ourselves upon a successful trial, for even in an iron vessel a large proportion of the vital work is covered up; cement and ceiling - so easily applied, so quickly wrought - may hide from a too inquisitorial eye much that may be open to serious objection; and how often may we note how quickly these stages of the work are carried out ?

....Without doubt again, the rivet holes about the bilges should not be put through until the frames are bent, for otherwise the holes must necessarily become elongated, and hence are not properly filled.

....one would imagine that *now*, at any rate, the butts of all plates helping to form the skin of the vessel would be planed. This, however, is not the case; many vessels are even now under construction wherein the butts of the plating know no contact with the planing machine. The old process of beating up a ridge across each butt before the plates are put in position, and of beating the ridges down again when the plates are in position, is still in vogue. It is a process valuable for the facility it offers of quickly rendering a slovenly-fitted butt apparently close, and hence it is dying hardly.

....Then, again, the amount of carelessness observable in the disposition of the rivet holes in the edges of the plating is still a reproach to us. With the system of templates usually adopted, we fail to see why this should be so; but perhaps much of the cause lies in the fact that the class of men who perform the work cannot be said to be skilled mechanics in the strict sense of the term. It is almost impossible to refer to the subject without experiencing the natural regret that our shipwrights in years past should have deemed such work beneath their dignity, and allowed it to pass to a class then so much inferior to them, for some of the best fitted work we have ever seen has been performed by shipwrights, and notably in some instances where it has been their first attempt.

....As another practical point requiring mention we would call attention to the carelessness often displayed in dealing with the plates requiring to be bent to fit the bilges. These plates are punched before being brought to the rollers for bending, and this fact alone should be sufficient to insure their being carefully dealt with, for there is no gainsaying the fact that in the present day ship plates generally are much wanting in malleability. The truth, however, is that they very frequently receive very improper treatment through the wish to bring them to the desired curvature too suddenly; hence we find many plates broken through at the butts, and not unfrequently along the middle.

....During the process of bending it is desirable to insure that the edges of the outside strakes should receive quite their full amount of curvature, in order that when placed in position the caulking edges may be brought in close contact with the plating beneath; but what can be said of supervision while it is possible to find that this end is sought to be obtained by hastily placing chips, or gravel, or handfuls of earth along the edges of the plates to be so bent ? Is it any wonder that plates are found cracked and unfair when recourse is had to almost any rough expedient to bring them to something like the required form ? This bending process is, too, the one especially calculated to test the amount of scale and blister upon plates, and it is certainly nearly time that iron manufacturers should be given to understand that with plates even for shipbuilding purposes some line or limit of roughness should be drawn.