EXHIBIT A-9

DR. SEAN A. KINGSLEY

PART 9

ANNEX 14

ANNEX 14

TO

EXHIBIT A

14.1. Stammers, M.K., 'Iron Knees in Wooden Vessels – an Attempt at a Typology', *International Journal of Nautical Archaeology* 30.1 (2001), 115-21.

14.2. A supposed iron knee from Delgado annex 9.9.

14.3. A supposed iron knee from Delgado 9.24.

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Iron knees in wooden vessels—an attempt at a typology

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Knees were brackets in the structure of a wooden ship. They were introduced in the second half of the 18th century and were in common use for naval and merchant ships in the 19th century. They were fashioned in various designs. A typology of these is proposed based on archaeological and documentary evidence. Iron knees could used to assist the dating of unidentified shipwrecks.

Key words: iron knees, wooden ships, 18th- and 19th-century shipbuilding techniques, East India Company, Royal Navy, Falkland Islands wrecks.

A ship's knee is a timber or metal bracket fashioned into an angle (usually a right angle) to provide strengthening and support at the junction of major components (especially frames and deck beams) in a wooden vessel. Iron knees were a common substitute for 'grown' wooden knees from the late 18th century. This study is based on documentary sources such as contemporary works on naval architecture and fieldwork among the surviving hulks of 19th-century ships lying in Stanley harbour in the Falkland Islands. These are the British-built ships, *Vicar of Bray* of 1841 lying at Goose Green, and the *Jhelum* of 1849; the American clipper *Snow Squall* of 1851, the packet ship, *Charles Cooper* of 1856, the Canadian *Actaeon* of 1838 and the *Egeria* of 1859.

Iron knees appear to have been first introduced in substantial numbers by the French Navy in the mid-18th century. They were a substitute for the usual 'grown' wooden crooks which were becoming scarce. They were, for example, found on the wreck of the French warship *Invincible* built in 1744 and lost off Portsmouth in 1758 (Quinn *et al.*, 1998). Falconer in his *Marine Dictionary* specifically stated they were a French innovation (Falconer, 1780). Gabriel Snodgrass, surveyor to the East India Company between 1757 and 1794, appears to have been the first British proponent of the use of iron knees. Again, this probably arose from the difficulty in procuring supplies of suitable timber. Iron knees also offered superior strength and compactness. Snodgrass appeared to have strengthened some East Indiamen with iron knees retrospectively. However, on retiring he wrote a report in 1796 to the Company's directors firmly advocating the use of iron knees and stanchions from new (Fincham, 1851). By 1810 Company ships were being built with iron knees, stanchions, breast hooks and crutches (Steel, 1823).

Plans of the East Indiaman *Farquharson* of 1820 in the National Maritime Museum, Greenwich, show she was fitted with iron hanging knees and horizontal 'staple' knees, which were fixed between two deck beams. Their use must have spread to other builders in this decade because the Shipowners' Lloyd's Register first included them in 1814 and their underwriting rivals did the same in the 1818 edition of their Register. The Royal Navy adopted the practice of retrospectively fitting iron knees to vessels strained by long periods enforcing the Blockade during the Napoleonic War. The systematic installation of ironwork into new ships began under the auspices of Sir Robert Seppings, the Navy's chief surveyor from 1813 to 1832.

Peter Hedderwick's, *A Treatise on Marine Architecture* of 1830, provides a useful overview of contemporary mercantile as opposed to naval shipbuilding practice. His illustrations included staple (i.e. double knees). He also referred rather enigmatically to 'many ways' of fastening deck beams to frames without elaboration (Hedderwick, 1830). In 1839 Jonathan Fell, manager of the Workington Shipbuilding and Rope

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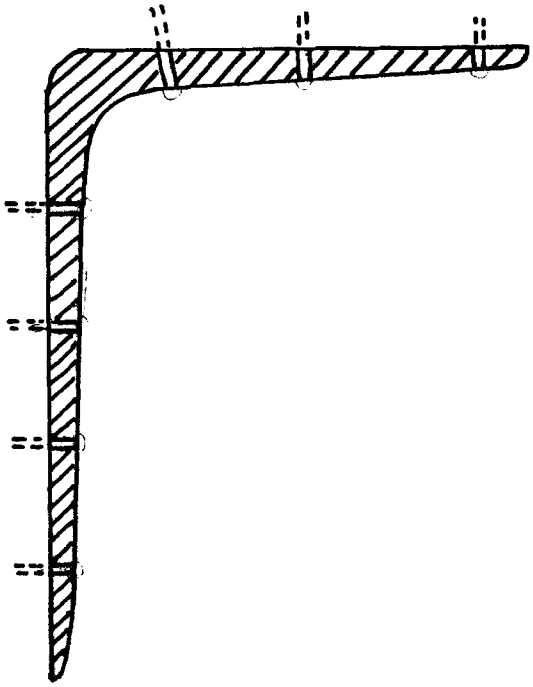

Figure 1. Right-angle knee (hanging or lodging).

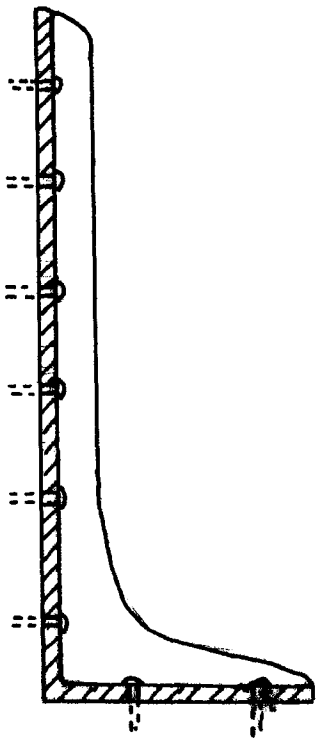

Figure 2. Standard knee, cast-iron version from box boat No. 337, preserved at the Boat Museum, Ellesmere Port, Cheshire.

Making Co., patented another lodging knee whose two main components were in cast iron. These would have been considerably cheaper to manufacture than the equivalent wrought-iron forging. Unlike some patents, it was put to use. According to the *Cumberland Pacquet* of 28 January 1840, it had gained the approval of Lloyd's Register and was being installed in ships being built at Workington and Maryport.

As the size of wooden merchant ships increased and timber supplies became more difficult to obtain, there was a gradual increase in the use of iron components in British-built vessels. For example, simple, short, right-angled hanging (vertical) knees were developed to strengthen the lower hull by extending them to long diagonal riders. The bows were reinforced with iron breast-hooks (horizontal) and the sterns with iron crutches (horizontal). This can be seen in vessels such as the ship (later barque) *Vicar of Bray*, built at Whitehaven in 1841. This represents an interim stage before the arrival of the composite hull with all its structural members in iron, with wooden planking. While there were several pioneering experiments with this type of construction before 1850, John Jackson's launch of the small composite schooner *Excelsior* at Liverpool in that year, marked the start of a widespread adoption of composite building in British shipyards (MacGregor, 1988). The *Carrick* (*City of Adelaide*), 1864 and the *Cutty Sark*, 1869, are two surviving examples. However, it was expensive and most wooden vessels continued to have the main framing components fashioned in wood and strengthened with iron. This goes right into the 20th century; the last Mersey flat (barge), the *Ruth Bate* launched in 1953, had forged lodging knees which could have come from a vessel a century earlier.

Nineteenth century North American wooden shipbuilders had access to vast supplies of timber and iron components were kept to a minimum. Crothers categorically states that American clippers with one exception were not built with iron knees (Crothers, 1997). This is borne out by the American packet of 1856, the *Charles Cooper*, which has only small iron brackets fastening the deck-beams to the hold stanchions and the remains of the bow of American clipper *Snow Squall* contained two pairs of iron knees which were used as part of wood and iron composite hold knee riders.

Canadian shipbuilders took a different course. They were using iron knees at Quebec as early as 1811 (Marcil, 1995). Not all Canadians used iron

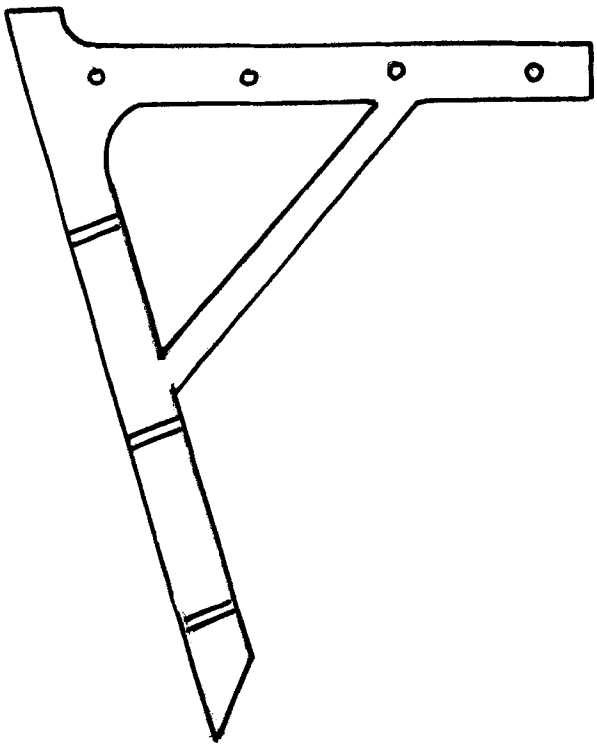

Figure 3. Braced knee, Snodgrass' design.

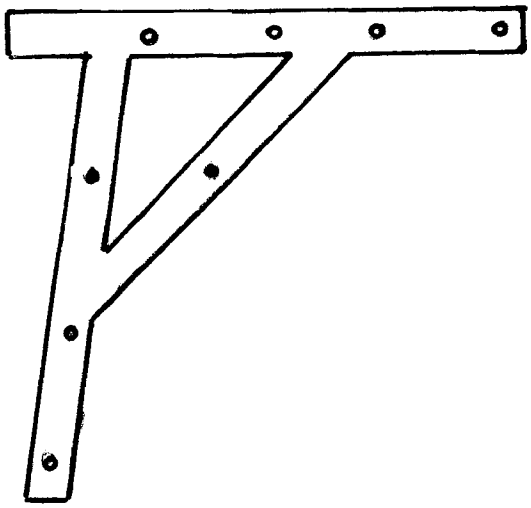

Figure 4. Braced knee, Seppings' version with 'tail'.

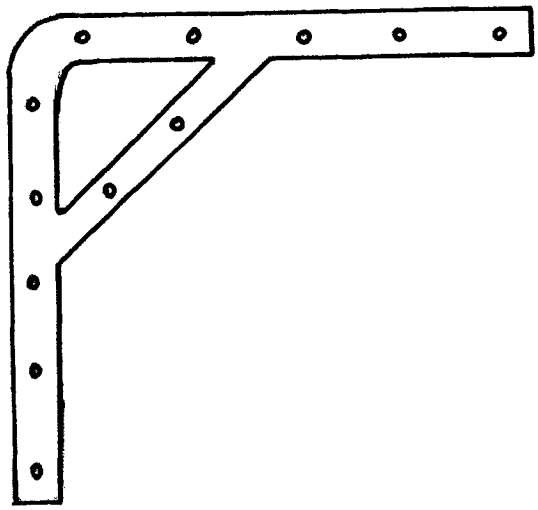

Figure 5. Braced knee, Seppings' second variant with curved end.

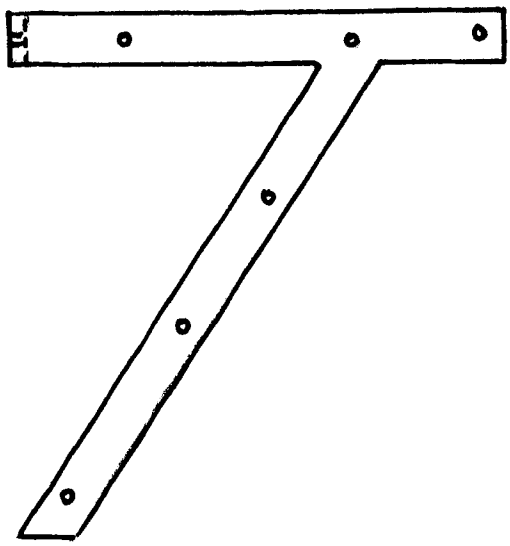

Figure 6. T-shaped knee, Seppings' third variant.

knees. Many of their ships were fitted with iron knees retrospectively, usually on arrival for sale in the United Kingdom. For example, Joseph Salter of Moncton, New Brunswick, received a letter from his broker in Liverpool, Messrs. Miller, Houghton & Co. about his latest ship: '... remembering that buyers of ships warranted to class 7 years, have a right to expect all the fastenings required are either in the ship or will be supplied at the expense of the seller, save the iron knees'. In a subsequent letter they reported they had '... entered her for the Graving Dock intending to knee (i.e., put in iron knees) and copper (copper sheathing on the hull below the underline) her and me think it very probable until she goes in and can be seen throughout she may not find a buyer'.[1]

This preliminary study has identified a number of categories of iron knees, some of which have sub-divisions. These are: the right-angled, braced, T-shaped, bifurcated, knee rider, staple and Fell's patent knees, plus the specialized knees at the bow and stern.

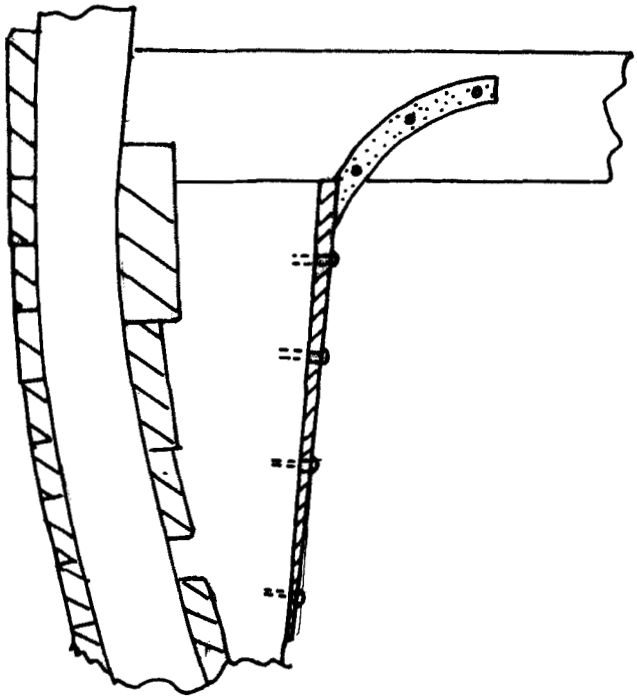

Figure 7. Bifurcated knee, again a Seppings' design and found on HMS *Unicorn*, 1824.

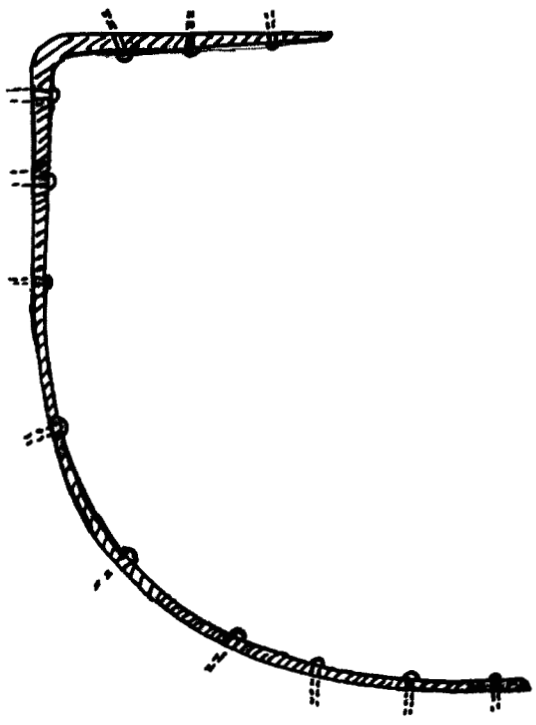

Figure 8. Knee rider, a hanging knee for hold beams and strengthening the lower part of the hull.

Right-angled knees

This is by far the most common type. It can be a hanging, lodging or standard knee according to its position (Paasch, 1884). Hanging knees support the underside of a deck beam. The lower arm was usually longer and quite often cranked to fit round the two heavy longitudinal timbers below the deck beam—the shelf and the clamp. This was observed in the *Jhelum*, the *Vicar* and the *Actaeon*.

Lodging knees were fitted horizontally on either side of a deck beam. Both arms were usually of the same length. Even this apparently simple bracket called for skilled smithing work. A smith needed to work or 'upset' the wrought iron to thicken it at the right-angled bend and then taper it towards its two ends. He also had to punch holes through it for the fastenings. Punching was

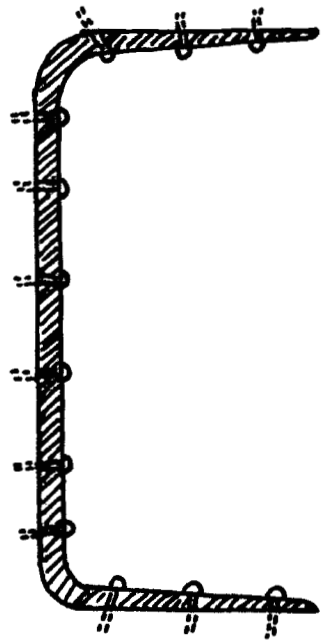

Figure 9. Staple knee, a double knee used in both hanging and lodging positions.

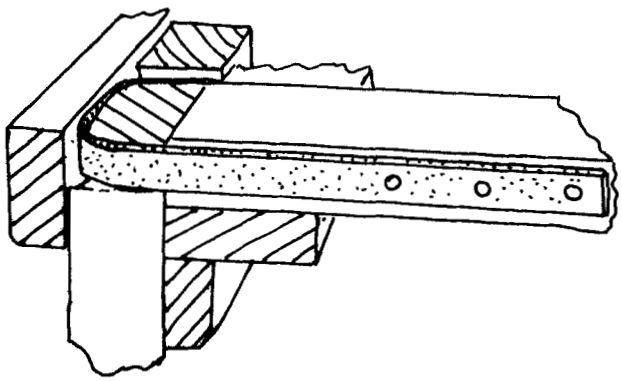

Figure 10. Staple knee found on wreck site SL10 on the Slufter survey.

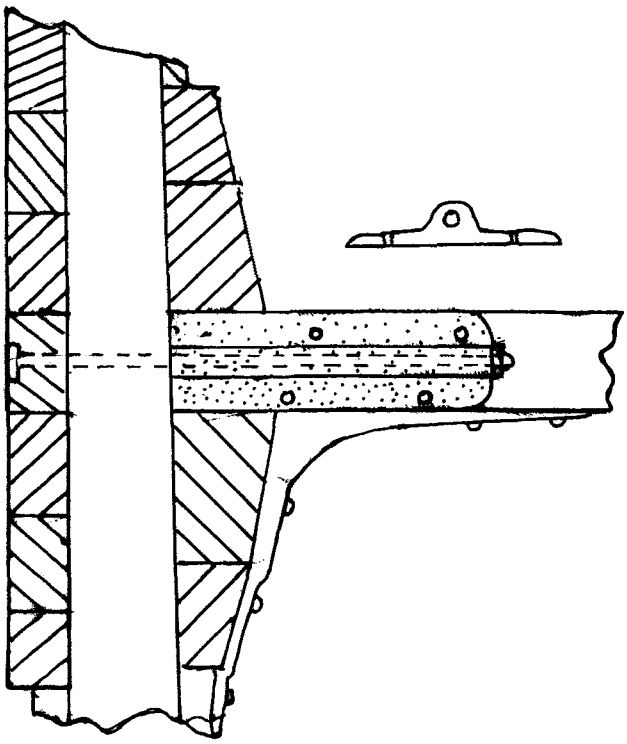

Figure 11. Fell's patent knee, first version patented in 1839.

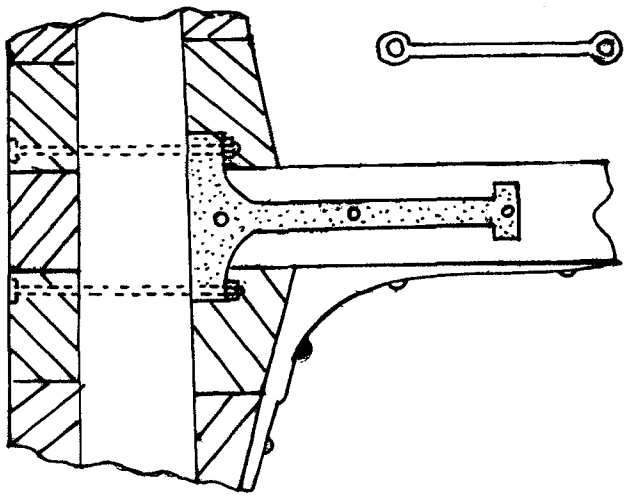

Figure 12. Fell's patent knee, second version for hold beams in the *Jhelum*, 1849.

a process that strained the metal considerably and great care was essential.

Standard knees were the reverse of hanging ones. They provided a connection between the top of the deck-beam and the frames. In some specialized small craft they could form part of the framing. Box boat No. 337 from the Manchester, Bolton and Bury Canal and dating from the early 20th century, is framed by a series of cast-iron standard knees. These were cast in one piece with a projecting central web for added strength.

Braced knees

These were advocated in Snodgrass' recommendations and a diagram of their design was subsequently included in Fincham (Fincham, 1851). The two arms are reinforced by a bracing piece. The design was subsequently modified by Sir Robert Seppings to two flat components which were bolted on either side of the deck-beam and to a large chock below the deck-beam. One version had a small 'tail' and a second was curved.

T-shaped knees

This again was a Seppings design of hanging knee, similar but of simplified design for supporting main or upper deck-beams of lighter scantling than the hold-beams.

Bifurcated knees

This had a chock below the deck-beam to land the lower arm. Unlike the two previous designs, it was a Y-shaped forging that clasped the deck-beam. Examples of this form can be seen on HMS *Unicorn*, frigate launched in 1824 and preserved at Dundee after long service as a naval drill ship.

Knee rider

This was a development of the first type and deployed to support hold-beams and to give additional strength to the lower hull. The lower arm was of considerable length running round the turn of the bilge and fastened through the ceiling planking to the frames behind. They were usually angled and not vertical and seemed to have been angled towards the bow forward of the vessel's mid-point and towards the stern aft of it. Particularly good examples were found on the *Vicar of Bray*, 1841 and the *Jhelum*, 1849 (Stammers & Kearon, 1993). It continued to be used extensively in British-built vessels into the 20th century and was recorded, for example, in the schooner *Emily Barratt* of 1913.[2]

Staple-knees

This is in fact a double knee but usually termed 'staple' by authorities such as Paasch. They could be fitted vertically as in the *Vicar of Bray* and were used to support the main deck-beam below and

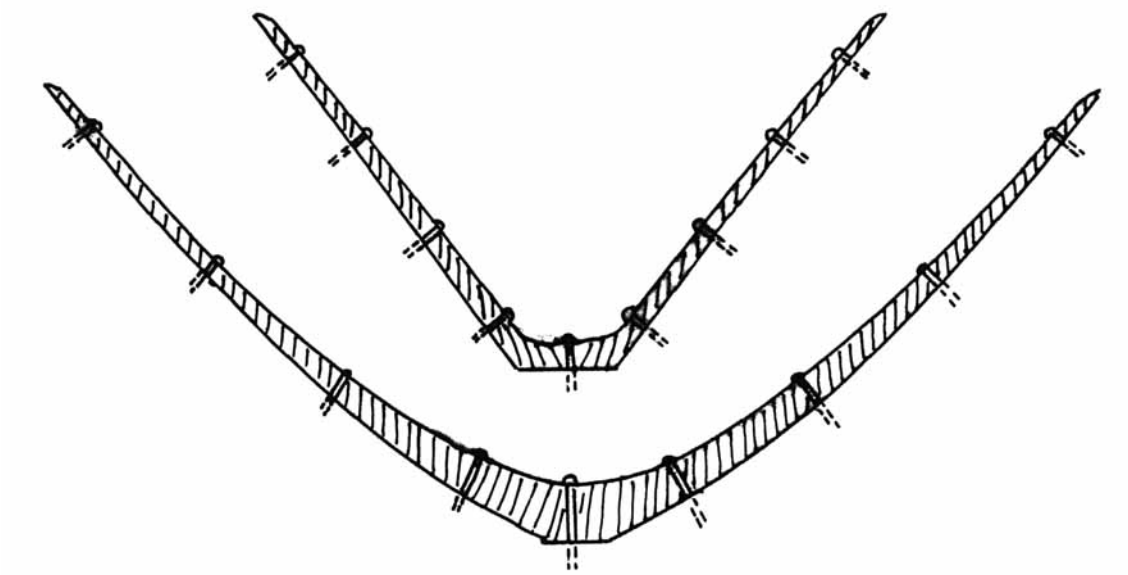

Figure 13. Specialized knees at bow and stern, breast-hook below, crutch above.

those of the poop deck above. The *Actaeon* had them fitted between the deck-beams of the poop (Stammers & Baker, 1994). Snodgrass also designed a staple knee of more complex design with the upper arm fitted with a brace, plus an extra downward diagonal arm to support a diagonal timber from the keelson to the 'tween deck beam (Fincham, 1851).

There was also a variation on the staple-knee that was used to bind a deck-beam to a single frame. It was found on wreck site SL4 of the Slufter surveys. The authors concluded that this was probably a product of one of the shipyards of north-eastern England (Adams *et al.*, 1990).

Fell's patent knees

The first version comprised two cast-iron plates which were bolted on either side of the deck-beam. Then there was a raised central section through which a long bolt could be passed to fasten the beam to the frames and the outer planking. This device dispersed with wooden or iron lodging knees. The patent drawing showed an iron hanging knee but Fell claimed one of his knees could be used instead (Bound, 1993). Lloyd's survey of the *Jhelum* in the archives of the National Maritime Museum specified Fell's patent knees. However, the knees actually in the *Jhelum*, while following the principle of the patent, were of different design. They were of two types. The first was of two wrought-iron T-pieces fastened on either side of a beam with the 'arms' of the T 'swelled' or thickened to form circular bosses through which the side fasten bolts could pass into the shelf and the waterway of the hold deck-beam, through two frames to the outer planking. The second was used for main deck beams and was L-shaped and acted in the same fashion as the T-shaped version.

Specialized knees at bow and stern

As ships were built to ever bigger tonnage, the need for additional strengthening became evident. The scarcity of good 'grown' timber also made the problem worse. In Liverpool, for example, the average size of vessel doubled between 1815 and 1843 (Stammers, 1989). Of course, these were very large wooden hulls over 1000 tons (mainly paddle steamers) that required massive strengthening because of the length of their hull and large weights of engines and boilers. The horizontal breast-hooks of the bow and the crutches of the stern had been internal strengthening timbers. They could be single pieces in smaller vessels or a compound structure of suitable 'crooked' timbers scarfed together. Iron forgings were not just substitutes but added materially to the strength of the bow and stern structures as well as saving space. Nevertheless such were the stresses and strains over a 20-year period that one breast hook on the *Jhelum* was found to have broken when surveyed in 1871 (Stammers & Kearon, 1992).

Conclusions

The various types of knee have all been identified from British sources. While it is clear that equivalent American vessels continued to use largely wooden knees, further work is needed to identify variations in other European countries. In general the presence or absence of iron knees can be a useful diagnostic towards dating undocumented wreck sites. In one case—Fell's patent—it would be possible to place a *terminus post quem* date on a site. The *Jhelum* was not unique. At least nine other north-west of England vessels have been identified and there were probably others from 1839 onwards (Stammers, 1998).

Notes

[1] Letters from Miller, Houghton & Co., Liverpool to Joseph Salter, shipbuilder of Moncton, New Brunswick, 13 May 1853 and 22 July 1853. Transcripts kindly supplied by Nancy R. Ross of Bedford, Nova Scotia.

[2] The *Emily Barratt* was the last schooner built in Great Britain. After a long trading career she was converted to a yacht and eventually ended up as an out-of-the-water hulk at the Dock Museum, Barrow-in-Furness. Her deteriorating condition obliged the Museum to break up her sad remains in 1999. She was, however, recorded and full construction and lines plans are held by the Museum.

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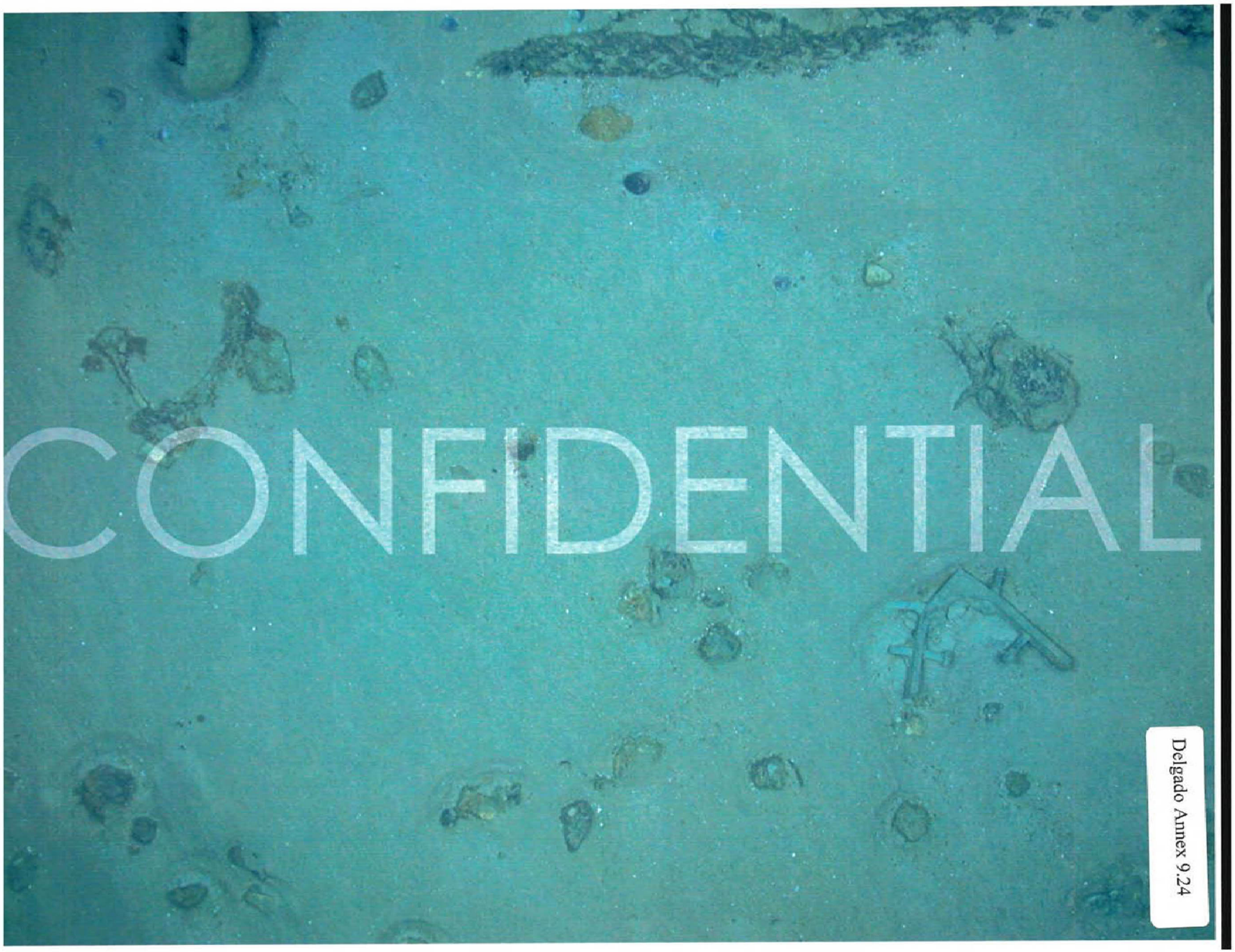
Annex 14.2



Annex 14.3