The International Journal of Nautical Archaeology and Underwater Exploration (1984), 13.1: 33–44

Ancient anchors—technology and classification*

Gerhard Kapitän

Viale Tica 53, Siracusa, Italy

The technological understanding of ancient anchors is indispensable for the reliable identification, interpretation and evaluation of anchor finds, especially on wreck sites; for one has to take into account that anchors were not only lost with shipwrecks, but also on many other occasions. They are indeed far more often found as single objects, without a context that would date them. This is true especially in harbours, roadsteads and other places offering shelter, but also near shallows and almost everywhere along the coasts. Since in the course of time many anchors were lost, one may easily meet on wreck sites in such areas with intrusive examples.

The single anchor, it is true, cannot be securely dated by its technical characteristics alone, but the technology of the anchor as a whole offers the clue for a useful classification which corresponds well to the general development and chronology of this implement (Fig. 1). If one assesses cautiously the location of an anchor discovered on a wreck site or closeby and considers the datings already known for ancient anchors (Gianfrotta, 1977; Perrone Mercanti, 1979; cf. also Kapitän, 1982: a), a technological *in situ* examination will readily reveal whether it could have belonged to the ship in question or might be intrusive.

From anchor stone to stone anchor and stock anchor

Stones of no particular shape but sufficiently heavy and lashed to a rope (Fig. 2, anchor 1) were the first anchors for early craft, though not the only ones. Poles and branches to be stuck in the sea bed or loaded with stones were also used; they led to fixed mooring devices.

Stones of shapes particularly suited for attaching a rope stimulated the development of stone anchors and stock anchors: From a stone with a hole (Fig. 2, anchor 2), more or less regularly shaped stone anchors took their form. They had at first only a single hole for the rope

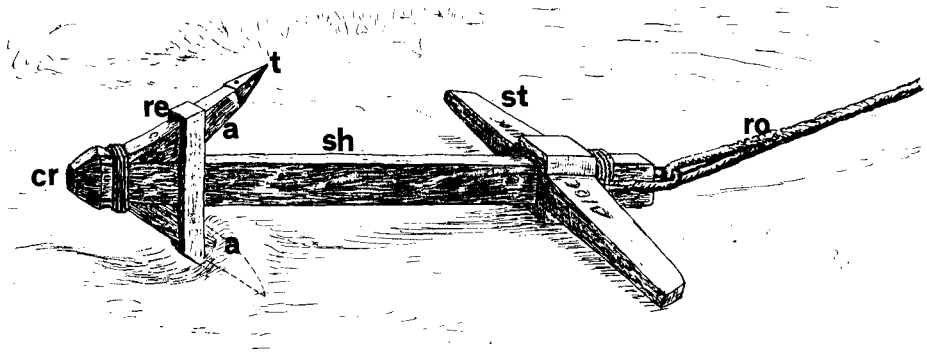

Figure 1. Two-armed wood anchor with fixed lead stock, anchored on sea bed: a—arm; cr—crown; re—repair or strengthening piece; ro—anchor rope; sh—shank or shaft; st—stock; t—arm tip.

* The views set out in this paper were the subject of a lecture given at the Bodrum 1982 Council of Europe Summer School on the Conservation of the Underwater Nautical and Maritime Cultural Heritage.

0305–7445/84/010033+12 $03.00/0

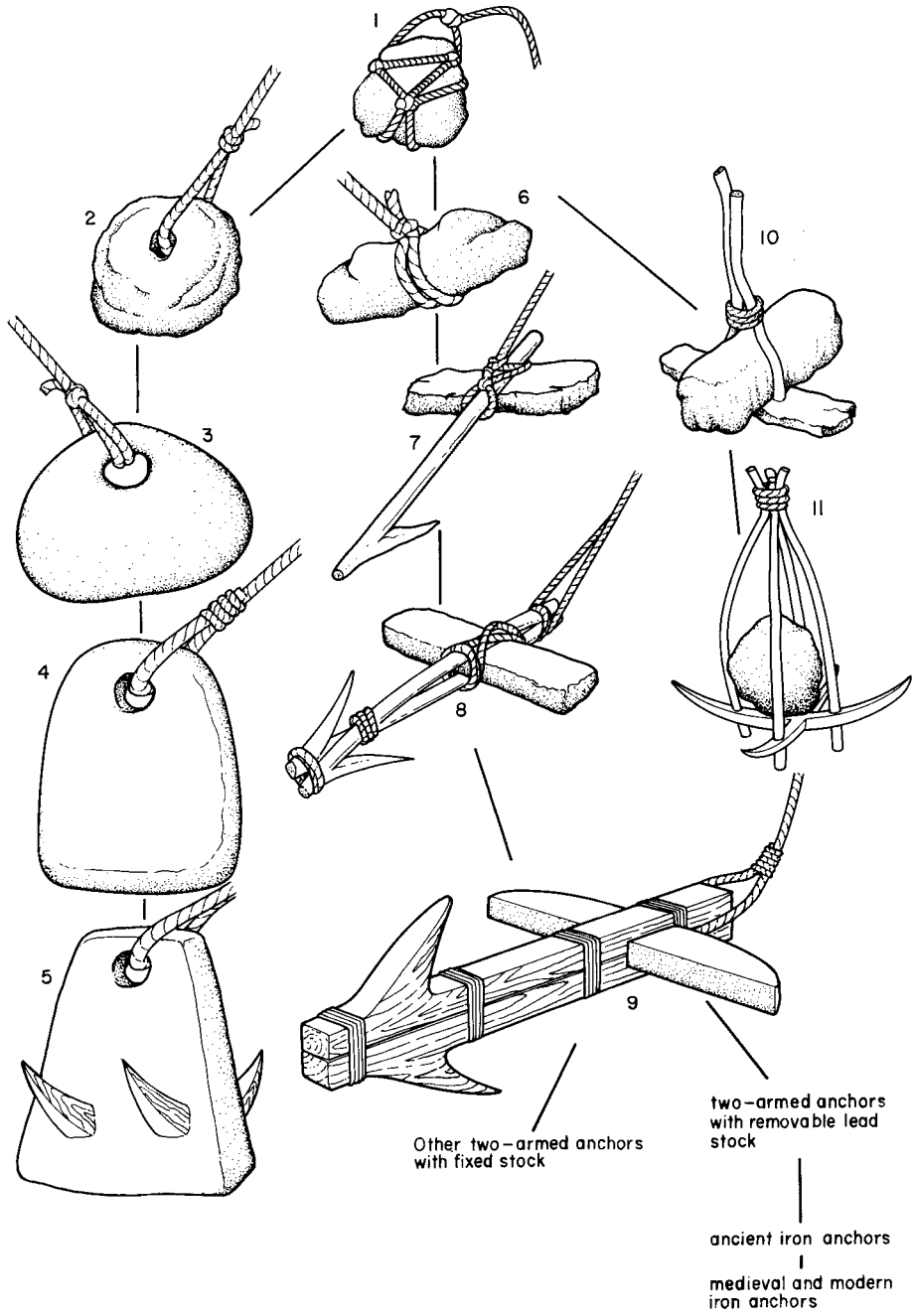

Figure 2. Diagram illustrating the development of ancient anchors. Sketches 1–7, 10 and 11 represent archaeological and ethnological artifacts; the anchor form 8 is hypothetic and 9 is a reconstruction.

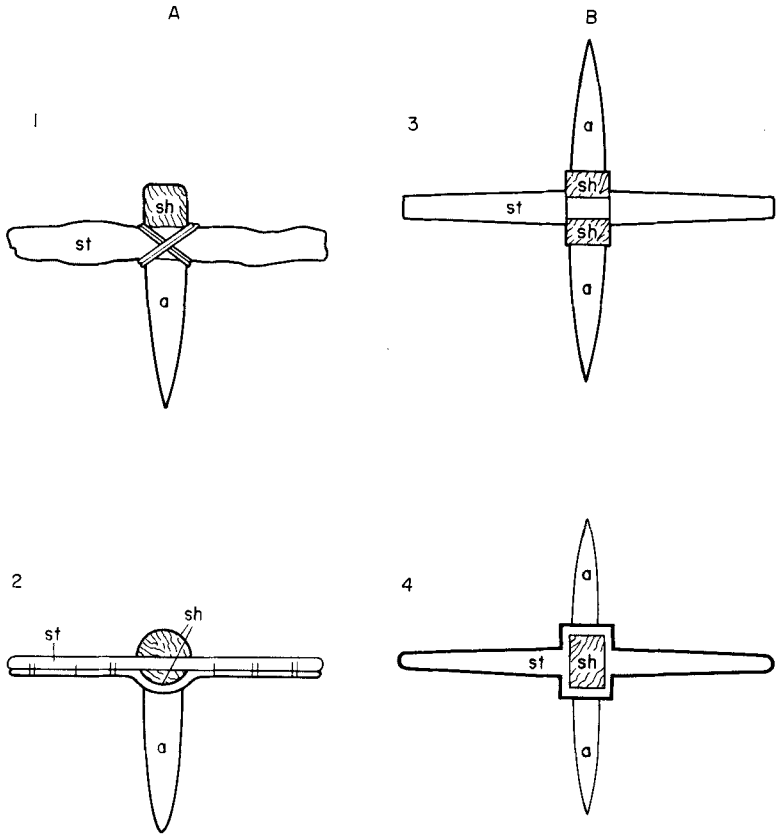

Figure 3. Sketches explaining the distribution of weight in four examples of wooden stock anchors, shown from above with the shank cut in section:
A—one-armed anchors; B—two-armed anchors.

made in a marginal position (Fig. 2, anchor 3). Consequently these stone anchors came to have a more longish shape, becoming prevailingly oval or trapezoidal (Fig. 2, anchor 4). Finally they were additionally provided with one or two more holes for lodging wooden plugs pointed at both ends (Fig. 2, anchor 5). By this, the simple weight anchor became a gripping stone anchor. This anchor, however, did not develop further. The occasional attempt to transform the stone into a sort of anchor shank (cf. Frost, 1979: 158) had to fail since stone is not a suitable material for forming a shank which works as a lever when the anchor is lifted and its gripping arm breaks out of the seabed.

Another development followed from longish stones to which the rope could safely be lashed at a central narrowing or cut (Fig. 2, anchor 6). Such anchor stones, besides their function as weight anchors, worked also as bulgy logs gripping between stones, rocks and other obstructions on the sea bottom. On a soft, flat bottom this anchor device would grip only after a hook had been lashed to it. The attachment of a bifurcating bough, the shorter leg of which formed the gripping arm, contributed to a surprising improvement; it transformed the anchor stone into a one-armed anchor with stone stock (Fig. 2, anchor 7). It is quite likely that later on the two-armed wood anchor developed simply from the addition of a second hooking bough of the same size and shape, bound in a corresponding way to the stone stock, but on its other side (Fig. 2, anchor 8). Probably soon after this invention, which guaranteed that the anchor gripped in all

circumstances, the two-armed wood anchor with stone stock was introduced in a fully developed form (Fig. 2, anchor 9), since it had to be well-balanced in all its parts in order to be sure that the anchor gripped equally with both its arms (cf. Fig. 3B).

Along with this, other constructions made of stones, sticks and boards produced special types of gripping anchors as e.g. two-armed 'killicks' (Fig. 2, anchor 10) and four-armed grapnels (Fig. 2, anchor 11). From the two-armed wood anchor with stone stock (Fig. 2, anchor 9) all the other kinds of ancient stock anchors, either of wood or iron, derived, and from the latter, the iron stock anchors of medieval and modern times.

The distribution of weight in wooden one-armed and two-armed stock anchors

Physical principles

Generally: The stock is attached at right angle to the axis of the arm(s) and shank (Fig. 3).

The distribution of weight in the four sectors which are formed by the crossing axis of the stock and arm (or arms) is as follows:

Fig. 3A—One-armed anchors: The weight of the stock is concentrated in the sectors in which the single arm is placed. Accordingly van Nouhuys writes that the stock was 'always lashed' at the same side of the shank 'where the single prong stood out' (van Nouhuys, 1951: 29).

Fig. 3B—Two-armed anchors: The weight is equally distributed in all four sectors in order to make sure that the anchor frequently falls equally on both its arms. This is achieved if all parts of the anchor are made of equal lengths, i.e. symmetrically, and the stock is mounted well-balanced and precisely in the centre of the shank. (Hence also the importance of the production of two-armed anchors in antiquity for the development of precision work in mechanics!)

Examples

1. One-armed wood anchor with stone stock: Neither the shank nor the stock need to be regularly shaped and this is also true for the central groove or cutting of the stock.
2. One-armed wood anchor with wooden stock and thick leaden sheet which obviously had been attached beside the stock by means of nails. The lead piece was found at Acitrezza, Sicily (Collection Naxos No. 31). If provided with a second corresponding sheet attached to the other stock side, the anchor would have the characteristics of a two-armed example.
3. Two-armed wood anchor with stone stock: The anchor shank consisted probably of two wooden beams as is suggested by the anchor representations on coins from Apollonia Pontica showing also the characteristically shaped stone stock (Kapitän, 1982b). Compare also Fig. 2, anchor 9 and Fig. 6, 1.
4. Two-armed wood anchor with fixed lead stock: cf. Fig. 1 and Fig. 4, stocks 3.

Material and types of fixed stocks used with two-armed wood anchors

Four types of stock are considered: stone stocks, wooden stocks filled with lead, lead stocks and wooden stocks covered with lead.

Stone stocks (see Fig. 4, stock 1) are characterized by symmetrical shapes and, as a rule, by very regular surfaces which are also often smoothed. The latter is always true for the surfaces of the central cutting, which is worked at least on two sides if not on all four, in order to obtain a perfect seating with the corresponding cutting in both parts of the shaft (cf. Fig. 2, anchor 9, Fig. 3, anchor 2 and Fig. 6, anchor 1).

Wooden stocks filled with lead [See Fig. 4, stocks 2 (a), (b)] The leaden fillings of these stocks are generally trapezoidal in section in order to keep the metal fixed in its wooden case. If the metal were to move, the stock casing would break under the jolts from the heavy mass in it. All the other features which may be met in leaden fillings were for the same purpose: a cutting in the middle which is usually trapezoidal, triangular cuttings in the ends and/or in the sides of the central cutting, connections between pairs of fillings, protruding cast bolts or 'nails' which indicate the thickness of the boards used for the wooden case, 'covers' cast on top of the smallest side instead of the wooden covering board, the addition to the cast lead of stones and pre-cast leaden pieces, channelled surfaces, etc. There are two systems of manufacture:

(a) Lead fillings cast separately into each case forming half a stock. Usually these fillings form

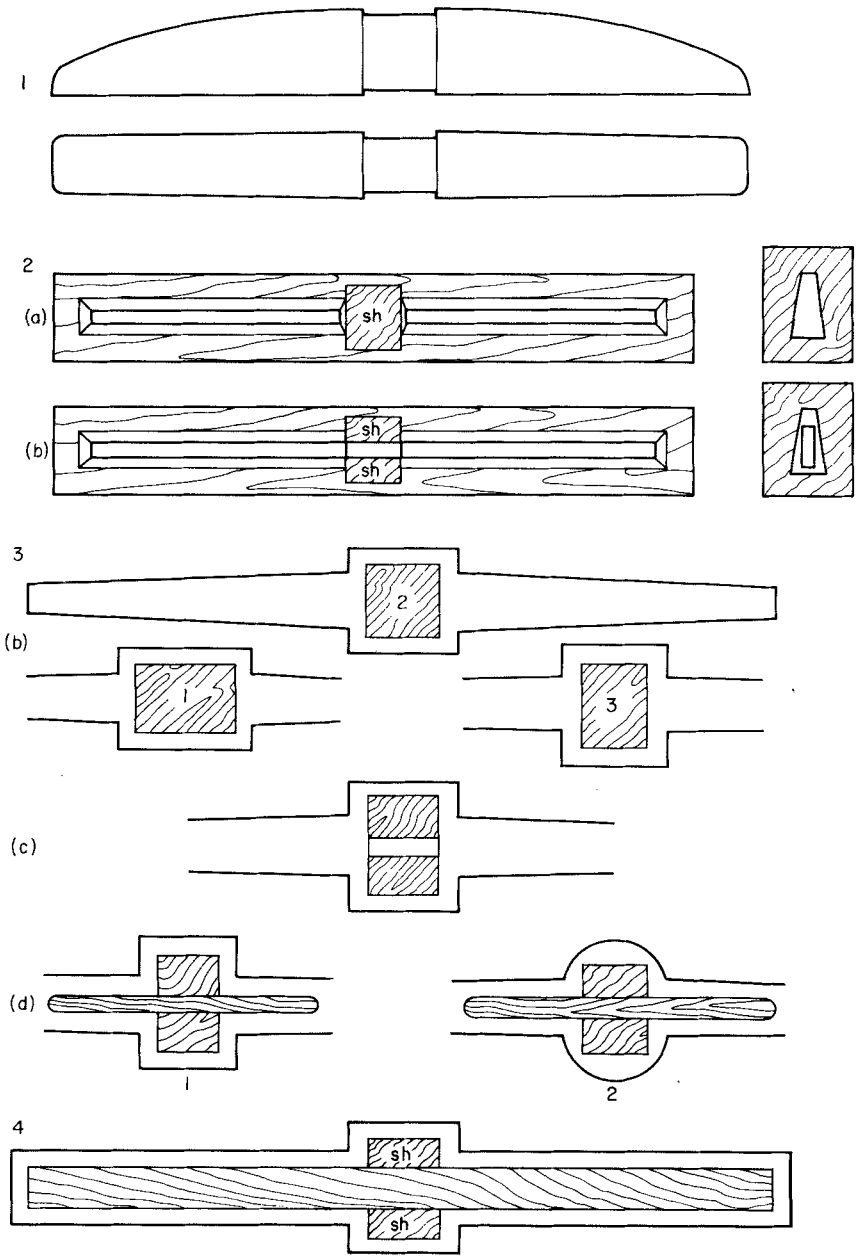

Figure 4. Types of fixed stocks used with two-armed anchors—wooden parts hatched.

a pair of almost equal size, shape and weight and present roughly the same special features.
(b) An opening through the anchor shank between both parts of the stock casing gave rise to a pair of connected fillings. Finds of this type have been made off the coast of Thracia Pontica at Sozopol (Dimitrov, 1979: 75). Some are also known from Sicily (Kapitän, 1980: 46ff.).
The wooden remains of these anchors and their stocks are still to be discovered.
Lead stocks (see Fig. 4, stocks 3):

(a) The first lead stocks were possibly imitations of stone stocks with a central cutting, i.e. of shapes such as Fig. 4, stock 1. A lead stock of this type was reported in an Italian diver journal (Papò, 1970: 487), but was not salvaged.
(b) Stocks with a central box (or 'eye') surrounding the shank, without a bar in the box. The inner dimensions of the box correspond to the section of the shank. Various finds from Sicily demonstrate that this section developed from an unsuitable rectangle laid out in the longitudinal axis of the stock (1) to a square (2), and then to a rectangle with its longitudinal axis crossing that of the stock (3). The latter corresponds to the most suitable section of the shank when it works as a lever during the lifting of the anchor.
(c) Stocks with a cast cross-bar in the central box. The bar proves that the stock was directly cast on the shank after a hole had been made in it. With this a stronger connection between the leaden stock and the wooden shank was achieved.
(d) Stocks with a wooden cross-bar in the box instead of a leaden one. In the hole made through the shank a wooden peg sufficiently protruding at both sides was inserted before casting. The wooden bar improved the connection of stock and shank.

The wooden bar usually decayed like the other wooden parts of the anchor, leaving in the lead the ducts which it had occupied. However occasionally it is still preserved, that is when it is partly covered by thin layers or strips of lead. These had filled up the small spaces which remained between the inserted bar or peg and the walls of the hole in the shank.

The exterior of the box of this type of stock being at first rectangular (1) was then rounded off assuming a more or less oval design (2) which was less of an obstruction than the angular box.

Wooden stocks covered with lead (see Fig. 4, stocks 4): Instead of a wooden bar, a big stock-shaped beam crosses the anchor shank. To make it sufficiently heavy, it was made up to the usual shape of a lead stock by casting lead around the wood. There are also examples of this type with externally rounded box, similar to that in Fig. 4, stock 3 (d) 2.

This type and the preceding Fig. 4, stocks 3 (d) may be commonly described as stock 'with a wooden core', a term first used by F. Benoît (Benoît, 1952: 267; 1955: 120). However, the stock of wood covered by lead was an important improvement compared with the other types of fixed lead stocks; it was more resistant against torsion. Hence this particular construction should be technologically distinguished from that with a small wooden bar, though sometimes it may be somewhat difficult to establish clearly the extent of the wooden 'core'.

To type 4 belong small stocks as well as big ones and e.g. also the biggest lead anchor stock so far discovered, at Qawra Point, off Malta. The length of this stock, which was salvaged in two pieces broken at the box, and then restored, is about 4·25 m, and the calculated weight of the lead alone is at least 1850 kg (Zammit, 1964: 7 and Fig. 6; cf. also Kapitän, 1978: 269 ff.).

Removable lead stocks of wood anchors

The prevailing curved upper side of removable (or detachable) lead stocks recalls the shape of most of the stone stocks as illustrated in Fig. 4, stock 1 (see Fig. 5). The invention of the removable stock could indeed have been stimulated by the method of lodging the stone stock in the shank (cf. Fig. 2, anchor 9, Fig. 3, anchor 3, and Fig. 6, anchor 1), that is when it once became detachable after for some reason the seating had become loose.

So far two methods of attaching the removable lead stock to the shank are known:
1. The stock is provided with a hole in its centre. The bolt (of wood?) to be inserted in it for attachment, also passing through the centre of the shank.

A remarkable number of stocks of this type have been found in the Black Sea off the Thracian coast (Dimitrov, 1977: 160ff.). From the Mediterranean I know of two finds only, a small stock at Syracuse and a 1 m long example at Athens which was listed in 1960 among the finds from the Antikythera shipwreck (diary note, courtesy Miss H. Frost).
2. The stock is provided with a hole and a step, both close to the centre. When the stock is inserted in the shank, it stops when the step touches the shank. Then the position is fixed with a bolt pinned in the hole at the other side of the shank. The distance between hole and

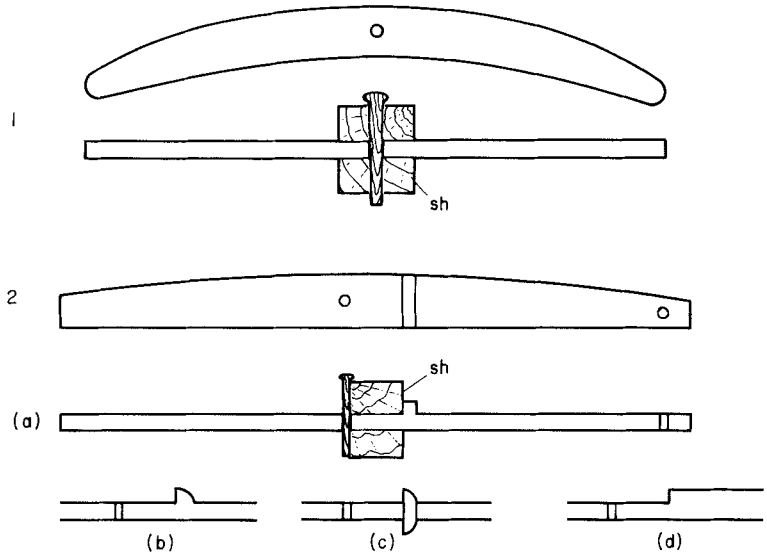

Figure 5. Types of removable lead stocks of wooden anchors.

step corresponds to the width of the shank. Usually this type of removable stock was provided with a second hole near the outer end of the half of the stock which has the step. This hole served to secure a line with which the stock was tied to the anchor, to make sure that the stock remained with it and the anchor could be made ready without loss of time. The step at the stock may be made in various profiles as shown in the Fig. 4, stocks 2 (a)–(d). The shape 2 (d) can be that of an unbalanced stock, possibly used with a one-armed anchor (cf. Kapitän, 1973: 389ff., Fig. 6b).

Compared with system 1, system 2 is technically more advanced as it enables the stock to be fastened in shorter time. Moreover it avoids the weakness of the shank which is created by the central bolt hole.

Anchors with removable stock need less space when stowed away than those with fixed stock. A disadvantage was that they had first to be made ready for use. Normally this took a few seconds, but a problem was to keep the stock always with the anchor. (Compare this with what is said with regard to Fig. 8 on the removable stocks with round sections of iron anchors in the final section). Moreover, inserting the stock means that its weight has necessarily to be limited, and consequently also the size of the anchor.

Junctions of the wooden parts of two-armed stock anchors

Wood anchor with stone stock

Archaeological evidence for the wood of these anchors is still wanting. Hence the reconstruction, shown in section in Fig. 6, anchor 1, is hypothetical. However, pictures of stone-stocked anchors on coins from Apollonia Pontica allow one to recognize the following features: the anchor shank consists of two beams and the arms are each made of one piece together with the adjacent shank beam. The beams with the hooking protuberances were probably cut from big bifurcating boughs.

It is for the present uncertain which way the two timbers which formed the shank and the arms were joined to each other. However, it is likely that, at least in the beginning, they were only bound together with cords, as shown in the figure. Subsequently, especially during the final period of employment of these anchors, the beams may have been joined additionally by means of bolts and then more efficiently by means of wedges and tenons.

The weakest point of these anchors was probably their stone stocks. Many stone stocks have been found broken at the central cutting (for more details see Kapitän, 1982b).

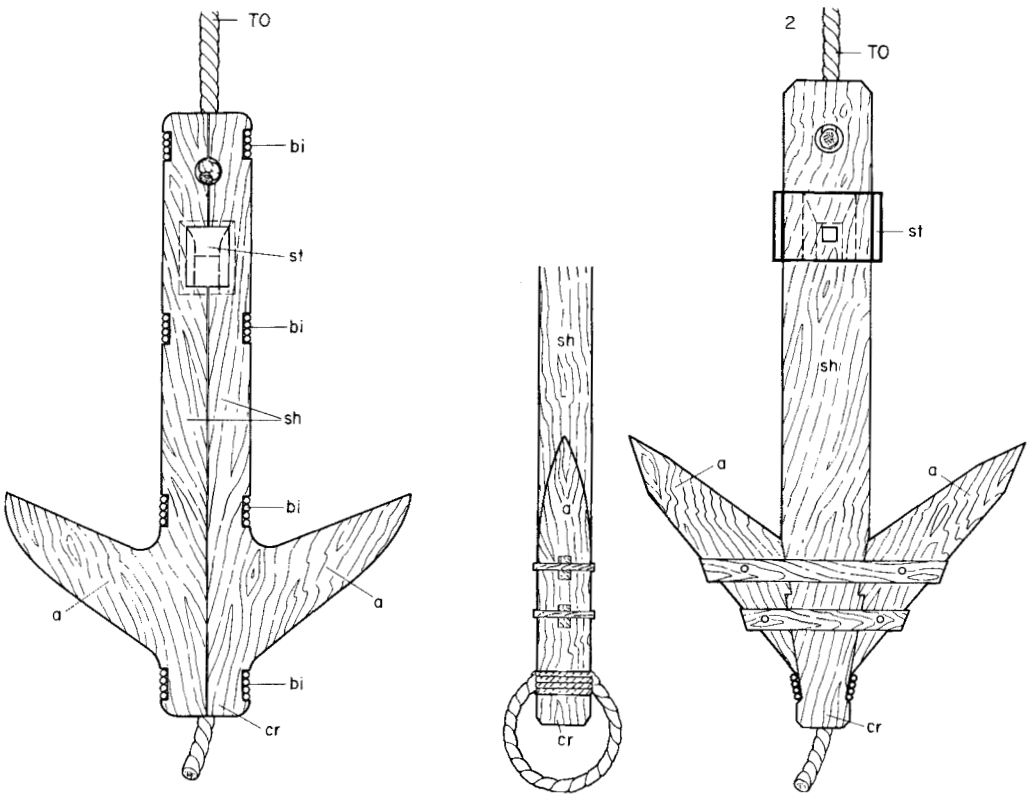

Figure 6. The junction of the wooden parts of two-armed stock anchors in longitudinal section: 1 with stone stock, 2 with fixed lead stock (bi—binding; other abbreviations as in Fig. 1).

Wood anchor with lead stock

Shanks of early examples may still have been composed of two beams (as stated in a preliminary report about a recent find at Haifa, courtesy A. Raban). The wooden remains of anchors of this kind so far discovered (Lake Nemi, Isola Lunga (Marsala), La Chrétienne C, and another near Haifa), all belong to shanks made of a single beam and two separately worked arms (see Fig. 6, anchor 2). The arms are fastened to the shank by means of wedges inserted into two corresponding mortices of rectangular section, and each wedge is kept in place by two round tenons passing through the arms. Moreover the adjacent sides of the arms and the shank each present an indentation which is cut in such a way that the force pulling on the anchor rope is transferred from the shank to the arms.

The junction by means of wedges and tenons allows a relatively easy replacement of an arm that has been damaged.

(Bibliography: Ucelli, 1950: 242ff.; Kapitän, 1971a: 13ff.; Kapitän, 1976: 33ff.; Joncheray, 1975a: 104ff.)

Repairs and strengthening pieces on wood anchors

Lead sleeves (Fig. 7, repairs 1) are repairs cast onto the shank where cracks had appeared in the wood and threatened its stability. Occasionally, the sleeve is provided with a crossing bar to give itself strength or it may present protrusions inside, where the metal penetrated the cracks during casting [repair 1 (a)]. Sleeves with lateral holes indicate that they were cast on the shank where a corresponding hole existed, either from the removable stock [repair 1 (b)] or for the anchor rope repair 1

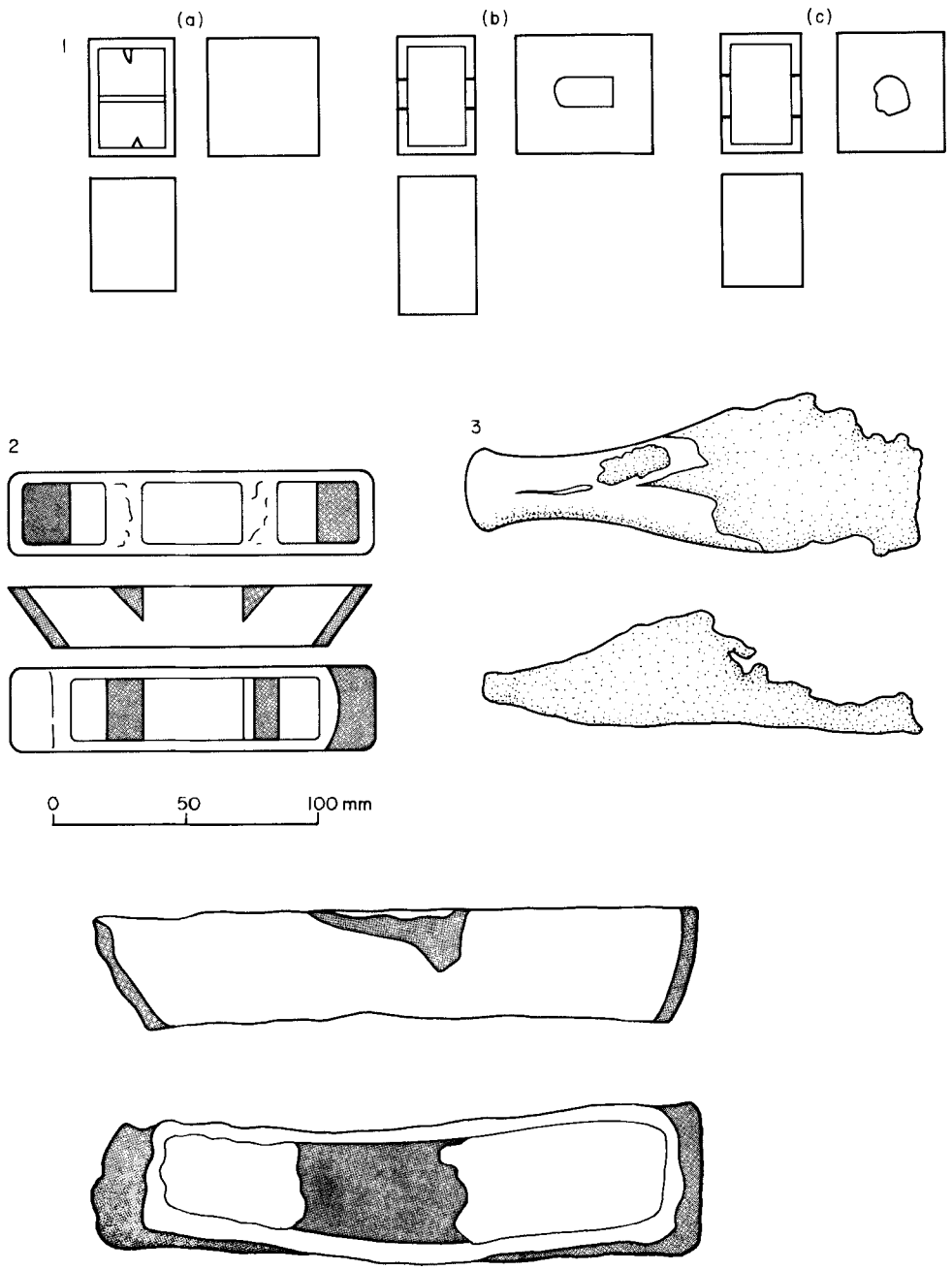

Figure 7. Repairs and reinforcing pieces on wood anchors: 1 lead sleeves; 2 lead connection piece with three holes, below, section and view of lower side of lead connection piece from a one-armed anchor (Brindisi, Museo Provinciale); 3 one of the bronze arm tips from the Porticello wreck, Calabria (Eiseman, 1979: 69).

(c)]. (A list of some sleeves is published in Kapitän, 1971a: 18ff.).

Lead connection pieces (Fig. 7, repairs 2) between shank and arms, usually characterized as 'pieces with three holes' or 'collars' were also repairs or served for strengthening, but were not necessarily 'counterweights'; for most of the wood anchors were not equipped with them. The connection piece was cast over the joint between shank and arms when the junction by means of wedges and tenons had become slack from the use of the anchor, and eventually also on new anchors as an additional strengthening to the carpenter's work. In an old river bed of the Rhine near Xanten (Germany) two connection pieces of particular shapes were found which may have been substitutes for the wedges and tenons (Kapitän, 1971b). A few other pieces with only two holes, formed from the shank and one arm, demonstrate that they had been cast on one-armed anchors, the use of which continued in the period of lead stock anchors (Kapitän, 1973: 386ff. and 394).

Metallic arm tips (Fig. 7, reinforcing piece 3) are casings made from bronze or iron sheet; they served to strengthen the points of the wooden arms. Whether these tips were commonly applied or only occasionally is an open question. Because of the rapid corrosion of such metallic sheets in sea water, especially if made of iron, the tips may not have been preserved as a rule, and this is perhaps the reason why as yet only a very few such finds have been made.

The arm tips should not be mixed up with flukes or palms which until now have not been attested archaeologically for ancient anchors. (Bibliography: Eiseman, 1979: 32ff, 68ff.).

The development of iron anchors

Table 1 gives a list of the main periods of use of the principle types of anchors together with sites of some dated examples. Ancient iron anchors were provided with a removable iron stock passing through the shank, an iron ring for the rope on top of the shank and, sometimes, also with a second ring fixed at the crown. The earliest type with straight arms in V-shaped position (Fig. 8A) derives from the two-armed wood anchor with removable lead stock and imitates its rectangular sections. Subsequently the arms took a rounded shape like a bow, still with scarcely distinguishable tips (Fig. 8B). In the next type the arms are

Table 1. *Development of iron anchors and sites of some dated examples*

Main period of use of principal types:	Sites of some dated examples:
A—Roman Republican	Isla Pedrosa (Foerster, 1969, 22f.) La Ciotat (Benoît, 1958: 25f.) Punta Scaletta, Giannutri (Perrone Mercanti, 1979: 26, pl. IV)
B—Early Roman Imperial	Lake Nemi (Ucelli, 1950: 235ff.) Pompei: anchor found in 1857 (Ucelli, 1950: 239f.), anchor found in 1959, of transitional type A/B (Elia, 1961: 210f.) Villapey (Benoît, 1960: 48f.)
C—Roman Imperial	Dramont D: two of three anchors are of transitional shape B/C (Joncheray, 1975b: 13–18) Dramont F: one anchor with round stock hole (Joncheray, 1975c: 116–120)
D–Late Roman and Byzantine	Dramont F: two anchors type D or transitional shape C/D, with round stock holes (Joncheray, 1975c: 116–120) Cervia (Bonino, 1971: 320ff. Fig. 4, left) Yassi Ada (Bass/van Doorninck, 1982: 121–140)
E–Late Byzantine and Arab	Serçe Liman (Bass/van Doorninck, 1978: 124; van Doorninck, 1982: 9f.)

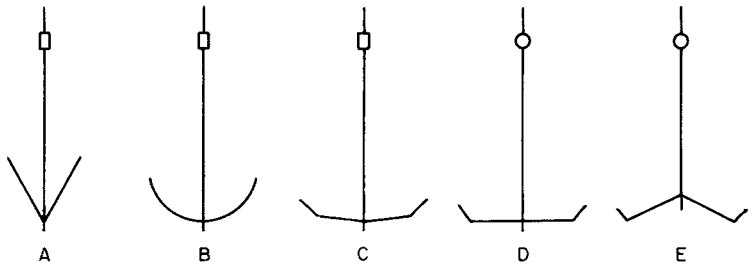

Figure 8. The main shapes of arms and openings for the stock of ancient iron anchors with removable stock.

more angled sideways, and the tips are slightly raised (Fig. 8C). The rectangular sections of the stock are usually still maintained. In the following T-shaped type straight arms are set at right angles to the shank and the tips point more upwards, sometimes having outward bent points (Fig. 8D). The removable stock now almost always has round section. These continue in the latest type (Fig. 8E) which is characterized by a Y-shape arrangement of slightly sloping straight arms with tips at a right angle pointing upwards. Besides these main types, other anchors of transitional shapes form links between neighbouring types; but there are also constructions which hardly fit into this scheme.

One of the reasons for the development in the positions of the arms, from the V-shaped arrangement to those at right angles and eventually at an obtuse angle, was probably the need for anchors which break out from the sea bed more easily when lifted. Another important improvement was the transition to round sections, at first of the shank and of the removable stock, and now and then also of the arms. The stock with round section could be inserted more quickly and, as it were, without looking, that is also in the dark.

On the other hand, the round stock became unintentionally a universal tool to be used as a lever etc., and for this reason it may often have been taken away from the anchor by the sailors, with the consequence that the anchor could not be made ready for use when needed. It was perhaps this experience which induced a complete abandonment of the removable stock, sometime in the twilight of antiquity. Significant in this regard, at the island Saint Marguerite (Cannes) an ancient iron anchor was found, the removable stock of which had been transformed into a fixed stock by casting lead onto it (Tchernia, 1969: 468f., fig. 5). Medieval iron anchors were once more equipped with a fixed stock, now of wood. The solution of the problem came only in the 19th century, thanks to the invention of the Admiralty anchor with movable iron stock which remains connected to the shank. It is bent at one end and provided with a spherical stop allowing the stock to be turned down but preventing its detachment. The ancient and the modern invention are technologically clearly different; hence they should be distinguished also terminologically, i.e. the ancient removable stock should not be called a movable stock.

Postscript

New evidence from finds in Turkey demands some additions:

Fig. 5, stock 1

The Bodrum Museum also has two lead stocks of this shape which were bought in 1978 from a sponge diver at Marmaris (courtesy O. Alpözen). F. Subay, Izmir, kindly informed me that other two removable stocks of this type, coming however from the Sea of Marmora, were acquired by the Museum of Bursa.

Fig. 8, anchor E

The eight iron anchors of this type from the 11th century Serçe Liman wreck, the first replicas of which, made of artificial resin, we saw in Bodrum as well as some iron remains from inside the concretions (cf. van Doorninck, 1982: 9ff.), are provided with fairly large arm tips which appear clearly as a first stage to real flukes. The fact that none of the round-sectioned removable stocks of these anchors

were found, suggests that they were of wood. These and other technical details, as e.g. the forged joints in the shafts and arms will be examined by F. van Doorninck.

More recently, a new find of an anchor with wooden parts, of the type Fig. 6, anchor 2, was reported from Cavo, Island of Elba (Maggiani, 1982: 62ff., Fig. 30).

References

Bass, G.F. & van Doorninck, F.H., Jr., 1978, An 11th century shipwreck at Serçe Liman, Turkey. *IJNA* 7.2: 119–32.

Bass, G.F. & van Doorninck, F.H., Jr., 1982, *Yassi Ada, Volume I. A seventh century Byzantine shipwreck*. College Station, Texas.

Benoît, F., 1952, L'archéologie sous-marine en Provence. *Rivista di Studi Liguri* 18: 237–307.

Benoît, F., 1955, Jas d'ancre et pièces d'outillage des épaves de Provence. *Rivista di Studi Liguri* 21: 117–28.

Benoît, F., 1958, Nouvelles épaves de Provence. *Gallia* 16: 5–39

Benoît, F., 1960, Nouvelles épaves de Provence (II). *Gallia* 18: 41–56.

Bonino, M., 1971, Ricerche sulla nave romana di Cervia. *Atti del III Congresso Internazionale di Archeologia Sottomarina, Barcelona 1961*. Bordighera: 316–25.

Dimitrov, B., 1977, Anchors from the ancient ports of Sozopol. *IJNA* 6.2: 156–63.

Dimitrov, B., 1979, Underwater research along the south Bulgarian Black Sea coast in 1976 and 1977. *IJNA* 8.1: 70–9.

Eiseman, C.J., 1979, The Porticello shipwreck: A Mediterranean merchant vessel of 415–385 B.C. Dissertation, University of Pennsylvania. (University Microfilms International, Ann Arbor, Michigan, 1981)

Elia, O., 1961, Il portico dei triclini del pagus maritimus di Pompei. *Bolletino d'Arte* (Roma) 46: 200–11.

Foerster, F., 1969, Un ancla romana de hierro. *Cris Revista de la mar* (Barcelona) n. 122:22–3.

Frost, H., 1979, Egypt and stone anchors: some recent discoveries. *The Mariner's Mirror* 65: 137–61.

Gianfrotta, P.A., 1977, First elements for the dating of stone anchor stocks. *IJNA* 6.4: 285–92.

Joncheray, J.-P., 1975a, *L'épave 'C' de la Chrétienne*. (Premier supplement aux Cahiers d'archeólogie subaquatique).

Joncheray, J.-P., 1975b, Étude de l'épave Dramont D: les objets metalliques. *Cahiers d'archéologie subaquatique* 4: 5–18.

Joncheray, J.-P., 1975c, Une épave du Bas-Empire, Dramont 'F'. *Cahiers d'archéologie subaquatique* 4: 91–140.

Kapitän, G., 1971a, Rinvenuta nel mare dell'Isola Lunga un'ancora antica a ceppo smontabile. *Sicilia Archeologica* (Trapani) 4.16: 13–22.

Kapitän, G., 1971b, New evidence of ancient anchors. *Archaeology* 24.1: 52–3.

Kapitän, G., 1973, Greco-Roman anchors and the evidence for the one-armed wooden anchor in antiquity. In Blackman, D.J. (Ed.), *Marine Archaeology (Colston Papers 23)*: 283–95.

Kapitän, G., 1976, Anchor with wooden remains from Haifa, and the technique of junction of wooden anchors. *Sefunim* 5: 33–41.

Kapitän, G., 1978, Exploration at Cape Graziano, Filicudi, Aeolian Islands, 1977. Results with annotations on the typology of ancient anchors. *IJNA* 7.4: 269–77.

Kapitän, G., 1980, Meeresarchäologie in Bulgarien—Ankerfunde im Schwarzen Meer. *Das Logbuch* (Heidesheim) 16.2: 43–8.

Kapitän, G., 1982a, Review: M. Perrone Mercanti, Ancorae Antiquae. Roma 1979. *IJNA* 11.2: 179–82.

Kapitän, G., 1982b, On stone-stocked Greek anchors as found in Thracia Pontica. Suggested reconstruction of their wooden parts. *Thracia Pontica I Premier Symposium International, Sozopol 1979*. Sofia: 290–300.

Maggiani, A., 1982, Rio Marina. In Martinelli, M., Archeologia subacquea in Toscana. *Bolletino d'Arte*, 4 Supplemento: 37–86.

Papo, F., 1970, Archeosub. Un ceppo da recuperare. *Mondo Sommerso* (Milano) 12.4: 487.

Perrone Mercanti, M., 1979, *Ancorae Antiquae. Per una cronologia preliminare delle ancore del Mediterraneo*. Roma.

Tchernia, A., 1969, Direction des recherches archéologiques sous-marines. *Gallia* 27: 467–99.

Ucelli, G., 1950, *Le navi di Nemi*. Roma.

van Doorninck, F.H., Jr., 1982, An 11th century shipwreck at Serçe Liman, Turkey: 1978–81. *IJNA* 11.1: 7–11.

van Nouhuys, J.W., 1951, The anchor. *The Mariner's Mirror* 37.1: 17–47.

Zammit, C.G., 1964, Underwater Archaeology. *Report of the Working of the Museum Department for the Year 1963* (Malta): 7 and fig. 6.