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SKELETAL MATERIALS

Their structure, technology
and utilisation c. A.D. 400-1200

by

Arthur MacGregor

Thesis submitted for the degree of Master of
Philosophy to the University of Durham, 1980

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14 MAY 1984

CONTENTS

<u>ABSTRACT</u>	i
<u>ACKNOWLEDGEMENTS</u>	iii
<u>INTRODUCTION</u>	v
<u>RAW MATERIALS</u>	1
INTRODUCTION	1
BONE	3
Formation	4
Structure	5
Morphology	9
ANTLER	12
Formation	12
Structure	14
Morphology	15
TEETH	17
Formation	17
Structure	19
Morphology	20
KERATINOUS HARD TISSUES	24
Formation	25
Morphology	25
Horn	25
Baleen	26
AVAILABILITY	27
Introduction	27
Bone	27
Antler	31
Elephant ivory	41
Walrus ivory	45
Beaver	46
NOTES	48
<u>SKELETAL TISSUES AS MATERIALS</u>	50
MECHANICAL PROPERTIES	53
Definitions	55
Comparative values	58
APPLICATIONS	59
NOTES	63
<u>WORKSHOP PRACTICE</u>	64
TOOLS AND WORKING METHODS	68
Cutting and splitting	68
Smoothing and polishing	71
Turning	72
Drilling	74
Scribing	76

Rouletting	77
Gauging	77
Clamping	78
Riveting	79
Softening and moulding	79
Colouring	89
NOTES	91
<u>THE ARTIFACTS</u>	92
SPINNING AND WEAVING EQUIPMENT	92
Combing	93
Spinning	95
Weaving	99
Tablet weaving	106
'Smoothing boards'	110
Miscellaneous implements	111
POINTS	118
CLEAVERS	123
HAMMERS	124
STAMPS	125
SCOOPS	126
PLANES	127
HANDLES	129
WRITING MATERIALS	133
SEAL MATRICES	140
MOULDS	143
SWORD HILTS	146
COMPOSITE BOWS	150
CROSSBOWS	155
HORN HELMETS	162
AMULETS AND PENDANTS	165
IVORY 'BAG RINGS'	173
BUCKLES AND STRAP-ENDS	177
PINS	180
Materials	182
Production	183
Classification	184
COMBS	199
Composite combs	204
Horn combs	239
One-piece combs	241
COMB CASES	243
STRINGED INSTRUMENTS	246
WHISTLES AND FLUTES	251
BLAST HORNS AND DRINKING HORNS	256
GAMING DICE AND PLAYING PIECES	258
DICE	258
PLAYING PIECES	264
GAMES AND GAMING BOARDS	275
BONE SKATES	284
SLEDGE RUNNERS	299
CASKET MOUNTS	304

CASKETS	310
TRIAL PIECES	313
NOTES	316
 <u>TABLES</u>	
TABLE 1	322
TABLE 2	322
 <u>BIBLIOGRAPHY</u>	 323
 <u>FIGURES and PLATES</u>	 After page 370

FIGURES

- 1 Cartilage bone
- 2 Membrane bone
- 3 Cross-section of long bone shaft
- 4 Structure of mammalian bone
- 5 Haversian systems : structure
- 6 Haversian systems : formation within bone
- 7 Haversian systems : formation at periphery of bone
- 8 Growth of laminar bone
- 9 Growth of laminar bone
- 10 The mammalian skeleton
- 11 Antlers : growth and shedding
- 12 Antlers : morphology
- 13 Growth in bone and dentine
- 14 Tooth structure
- 15 Tooth morphology
- 16 Tusks
- 17 Horn
- 18 Baleen
- 19 Stress concentrations
- 20 Blunting effects of interfaces
- 21 Stress-strain curves
- 22 Stress in woven bone
- 23 Bending strength and deformation
- 24 Forces acting in bending tests
- 25 Stress and strain in dry and wet bone
- 26 Stress and strain in bone and antler
- 27 Saws
- 28 Axes
- 29 Knives and draw-knives
- 30 Drills and awls
- 31 Clamps
- 32 Softening
- 33 Horn breaking
- 34 Wool combs
- 35 Spinning equipment
- 36 Warp-weighted looms
- 37 Sword beaters
- 38 Pin beaters
- 39 Weaving combs
- 40 Tablet weaving
- 41 'Smoothing boards'
- 42 Miscellaneous textile equipment
- 43 Points
- 44 Cleavers
- 45 Hammers
- 46 Stamps
- 47 Planes
- 48 Handles
- 49 Writing materials
- 50 Seal matrices

51	Moulds
52	Sword hilts
53	Composite bows : structure
54	Composite bows : energy diagrams
55	Composite bows : force-draw curves
56	Crossbow nuts
57	Helmets
58	Amulets
59	Antler rings and buckles
60	Ivory bag rings
61	Buckles and strap ends
62-5	Pins
66	Combs : terminology
67	Combs : construction and repairs
68-78	Combs : single-sided
79	Chronology of single-sided combs
80-2	Combs : double-sided
83	Comb cases
84	Stringed instruments
85	Whistles and flutes
86	Dice
87	Playing pieces
88	Skates
89	Sledge runners
90-1	Casket mounts
92	Franks casket : construction
93	Trial pieces

PLATES

1	Cancellous tissue
2	Compact tissue
3-5	Nutrient foramina
6	Vessels in bone
7	Vessels in antler
8	Sawn antler burrs
9	Utilised pedicles
10	Double saw cuts
11	Antler splitting
12	Knife-cut tines
13	Draw-knife facets
14	Draw-knife shavings
15	Chatter marks
16	Drilled perforations
17	Antler whorls
18	Jawbone whorls
19	Long-toothed 'weaving combs'
20	Teeth of long-toothed 'weaving combs'
21	Weaving tablets
22	Writing tablets
23	Seal matrices

24	Sword hilts
25	Composite bow splints
26	Triangular-backed combs
27	Hog-backed combs
28-29	Double-sided combs with decorative end-plates
30	Horn comb with bone stiffeners
31	Double-sided single-piece bone comb
32	Double-sided morse ivory comb
33	Double-sided cetacean bone comb
34	Plano-convex playing pieces
35	Horse tooth playing pieces
36	Antler playing pieces
37	Cetacean bone playing pieces
38	Morse ivory discoid playing pieces
39-45	Chess pieces of bone and morse ivory
46	Bone skating (after Olaus Magnus)
47	Casket mounts
48-51	Franks casket
52	Trial pieces

ABSTRACT

In the absence of previously published integrated studies, an attempt is made here to lay the foundations for a systematic approach to the examination of artifacts made from skeletal materials. Four principal groups of raw material are discussed in terms of formation, structure, morphology and availability : skeletal bone from species found within the geographical limits of the study; antlers from extant species of deer and from reindeer, which are no longer found within the region; ivory from mammalian teeth, including the tusks of walrus, elephant and mammoth; keratinous hard tissues (which are not of skeletal derivation but which may usefully be considered in association with the other materials reviewed here). The mechanical properties of these materials are compared and contrasted, their fitness for particular roles being demonstrated scientifically : the reasons for the widespread preference of antler as a raw material are identified in this way and certain constructional features of composite objects explained. Working methods used in manufacture are discussed on the basis of close examination of the objects themselves, together with other evidence from archaeological sources and, to some extent, from records of practices noted more recently among related crafts. Chemical softening as a method of moulding and working skeletal materials is discussed and illustrated with the results of practical experiments carried out by the writer. A typological review of the artifacts follows, principally those found in the British Isles during the period c. A.D. 400-1200; both geographical

and chronological limits are freely crossed, however, in order to incorporate further evidence which may illuminate the material under review. The objects concerned are placed within a wider technological and historical background, while reference is made wherever possible to the considerations dealt with in earlier chapters. Catalogues of find spots are given for the objects on which the discussion is based.

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INTRODUCTION

To an increasing degree, archaeologists have come to expect more from finds reports than mere considerations of stylistic and typological factors. Reviews of artifacts in certain materials are now commonly accompanied by scientific analyses : the study of coins, for example, has been revolutionised by the application of metallographic techniques, while thin sectioning and neutron activation have added new dimensions to pottery research. Indeed, enthusiasm for such methods has occasionally led some workers to overlook the contributions which can still be made by more traditional methods. Objects of skeletal materials, however, have taken little part in this revolution. Just as they have been viewed in the past as among the least tractable or informative categories of artifact, these items fail to respond to many of the scientific methods now in common use. The result has been a continuing and widespread neglect.

In this survey, an attempt is made to remedy this situation. The principal materials - bone, antler, ivory and horn - are reviewed in terms of their structure, morphology and availability; their mechanical properties are compared and quantified in objective scientific terms; the working methods applicable to them are considered, drawing on the evidence of manufacturing techniques visible on the objects themselves and that of tools recovered from archaeological deposits. There follows a review of objects made from skeletal materials during the period c. AD 400-1200 : in this section, every effort is made to take account of the considerations outlined above, which prove often to have acted as determining factors in the evolution of typologies. Other evidence

is included from archaeological sources and, where appropriate, from more recent practices as recorded by students of European folk life and ethnography. In each case, a catalogue of the items on which conclusions are based is included, although it must be stressed that these catalogues are not comprehensive but selective, the selection being based on the amount and type of material needed to illustrate the points being made. No assessment has been attempted from an art-historical point of view : artistically carved objects have indeed been excluded from this study, attention being concentrated rather on the humbler ephemera of everyday life which have previously escaped comprehensive consideration. For the purposes of this exercise, dating evidence as published has generally been accepted, so that interest could be focused on more relevant topics. Nevertheless, the conclusions given are based on a thorough review of the material, some of which has not previously been illustrated or discussed.

By treating together the disparate objects which are considered here and the evidence of varying kinds which can be brought to bear on them, it is hoped that this study may help to form the basis for a more comprehensive and integrated approach to the examination of artifacts made from skeletal materials.

RAW MATERIALS

INTRODUCTION

The element of objectivity given to this study by a consideration of each of the raw materials is necessary for more than the demonstration of academic credibility. Many of the properties which distinguish from each other the materials in question came to be appreciated by those who utilised them as the result of a lifetime of close personal observation and of generations of inherited knowledge, in the same manner in which any craftsman learned his trade in the days before a grounding in theoretical technology was added to the curriculum of the trainee technician. By the time he had finished his apprenticeship, such a craftsman would have acquired a 'feel' for his materials ^{based} on the experience he had gained for himself and had absorbed from his superiors. He might well find difficulty in expressing precisely why one piece of raw material was particularly suitable for one purpose or another, but his judgment would be no less valid and accurate for that. In our attempts to reconstruct the factors which led to the evolution of particular craft practices in antiquity we are, in the case of skeletal materials, denied access to any body of accumulated knowledge since nearly all use of these materials ceased long ago and written records relating to them are few. Instead we shall substitute scientifically-obtained data by which objective classifications can be made and from which we can attempt to infer the qualities which led to their consistent adoption for specific purposes.

A further important consideration is the manner in which the gross characteristics of particular materials, especially bones, directly conditioned



the evolution of typologies which, in the past, have all too often been studied with no reference whatever to these factors. In many cases it can be shown that the morphology of the raw materials had a primary influence in these matters and, in some cases, even led to the conditioning of forms subsequently executed in other materials in which these primary controls were absent (pp. 99, 101).

The overall picture which emerges places skeletal materials in a new light : whereas there has in the past been a tendency to regard bone, antler and horn as inferior substitutes for metal or even for ivory, the respective mechanical properties which each of these possesses are in many ways truly remarkable and often render each of them supremely suitable for particular tasks.

An initial problem encountered in this study is one of suitable terminology. Osseous skeletons, while consisting of many diverse components, are structurally distinct from teeth; neither of these in turn has anything in common with the keratinous material of which horns are composed. In an attempt to produce an appropriate portmanteau word which would encompass all animal substances used in the production of tools and implements, the term 'osteodontokeratinous materials' has been adopted by some archaeologists,* while Halstead (1974) has settled for the more mundane 'vertebrate hard tissues'. While both of these alternatives possess a higher degree of biological precision than that adopted here, the term 'skeletal materials' is preferred as it conveys to the non-specialist a more comprehensible (if strictly less accurate) impression of the scope of this enquiry.

* R.A. Dart, 'The osteodontokeratinous culture of Australopithecus Promethews', Memoirs Transvaal Museum 10 (1957) 1-105

Since a good deal of emphasis is to be laid here on the conditioning exerted on the evolution of artifacts by the raw materials from which each of them was formed, it will be necessary to begin with an account of each category of material in turn; in this way, the nature of each can be assessed, mutual comparisons can be made, a working terminology established and the characteristics by which each can be identified made known.

BONE

The archaeologist with an interest in bones is already well served by a number of publications, of which those of Brothwell (1972), Chaplin (1971), Cornwall (1974), Ryder (1968) and Schmid (1972) deserve particular mention. In each of these works, however, particular emphasis is placed on the morphology of bones and on their distribution and function within the living skeleton. Although these morphological factors are of some considerable importance in the present context, they represent only one of the aspects which will be considered. As the various materials reviewed here are considered outside the environment for which they were originally evolved, their fitness for their original function is not of direct importance, although often the qualities which recommend them for utilisation in a particular way are the result of this same evolutionary process. No assessment of skeletal materials from this point of view has hitherto been made.

Formation

According to the manner in which it develops at the foetal stage, a distinction is drawn between membrane (or dermal) bone, which originates in fibrous membrane, and cartilage bone, whose origins lie in pre-existing foetal cartilage. Both types develop through a process of ossification, in which soft tissue is progressively replaced by bone through the action of specialised osteoblast (bone-producing) cells, although details of the process differ for the two varieties. Ossification continues after birth at the growing points until the definitive size is reached. Cartilage bones (Fig. 1) are formed by gradual replacement with bone tissue of embryonic cartilage models and are extended by progressive ossification of the proliferating epiphyseal cartilage which separates the diaphysis or shaft from the articular ends or epiphyses (endochondral ossification), the process being completed with maturity (Ham 1965, 408-31). In the case of membrane bones (Fig. 2) growth takes place around the peripheries (intramembraneous ossification), the junctions or sutures between certain bones again becoming fused in maturity (op. cit. 394-6; Weimann and Sicher 1955, Fig. 57).

An important bone-forming membrane, the periosteum, covers the external surface (Fig. 3) while the interior cavities of certain cartilage bones are lined with a corresponding membrane, the endosteum, which also covers the trabeculae of cancellous bone and the walls of Haversian systems (p. 7). In addition to its normal osteogenic functions during growth, the periosteum may be stimulated to produce new bone in order to repair damage or in response to demands from the muscles or tendons for more secure anchorages (McLean and Urist 1961, 7; Ham 1965, Fig. 1814).⁽¹⁾

The entire bone structure undergoes continual change throughout life, some old bone being resorbed in tubular channels by bone-destroying osteoclast cells and new bone being deposited in its place in characteristic Haversian systems (see below, p. 7). In old age the process slows down somewhat, so that an increasing proportion of the bone is made up of old tissue, resulting in an increase in brittleness. Even in youth the quality of the bone may fluctuate considerably since the skeleton is in a state of constant metabolic exchange with the rest of the body, acting as a mineral reservoir and releasing its reserves in response to demands from other bodily systems. During pregnancy and lactation in particular, calcium and other minerals may be resorbed from the skeleton. In the case of deer, which have rapidly to produce large quantities of new bone in the form of fresh antlers each year, certain mineral requirements are again met by the rest of the skeleton (see below).

Structure

Bone tissue consists of an organic and an inorganic fraction in intimate combination. The organic matrix accounts for a considerable part of the weight (variously estimated at between 25% and 60% of the total) and volume (between 40% and 60% of the total) of adult bone (Sissons 1953, 24; Wainwright et al. 1976, 169; see also Frost 1967, Fig.25). It consists of c. 95% of the fibrous protein collagen (which is also a major constituent of tendon, skin and horn), along with other forms of proteins and polysaccharide complexes. Typical collagen has a structure of rope-like fibrils arranged in close proximity to each other and frequently interlinking (Currey 1970a, pl 2).

In the natural process of ossification, crystals of the mineral hydroxyapatite ($\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2$), a form of calcium phosphate, impregnate and surround the collagen fibres.⁽²⁾ There is some dispute (summarised in Wainwright *et al.* 1976, 169-70) concerning the shape of these apatite crystals : the commonly held opinion is that they have the form of needles, but some authorities have claimed that these 'needles' are, in fact, plates viewed end on. Whatever their form, these crystals (Currey 1970a, pl 2) are distinguishable only with very high resolution equipment (their thickness being in the order of 4 nm), so that they are quite invisible under the conventional optical microscope.

The apatite crystals are aligned with and bonded to the collagen fibrils. A certain amount of amorphous (non-crystalline) apatite is also present in the inorganic fraction.

With these basic ingredients arranged in various ways, bone is produced in a number of forms. Following Currey (in Wainwright *et al.* 1976, 169-73), the different bone structures encountered in the mammalian skeleton may be classified as follows (Fig. 4).

A primary distinction may be made between woven and lamellar bone. Woven bone (Fig. 4b) is characterised by an absence of marked orientation in its structure, both in terms of the collagen fibres which proliferate in all directions and of the apatite crystals which frequently do not adopt the orientation of the fibrils. Compared with lamellar bone, it displays a higher proportion of amorphous mineral and a higher mineral/organic ratio.

In contrast, the collagen fibrils in lamellar bone (Fig. 4c) are arranged in distinct layers or lamellae. Within each of these the fibrils are

generally aligned in the plane of the lamella and are grouped into distinct 'domains'. The fibrils within each domain display a preference for a particular orientation, although adjoining domains may vary from each other in their preferred alignment. Some variation in the dimensions of lamellae is distinguishable, but typically they are about $5\mu\text{m}$ thick while the width of the average domain is c. $30\text{--}100\mu\text{m}$. Most (but not all) authorities believe adjoining lamellae to be separated from each other by a perforated sheet of 'interlamellar bone', pierced here and there by occasional fibrils passing from one lamella to another.

Running through bone tissue of either of the above types can be seen small cavities or lacunae, which interconnect with each other and with neighbouring blood vessels by means of small channels named canaliculi. Within the lacunae lie osteocytes (bone cells), ⁽³⁾ sub-spherical in the case of woven bone and oblate spheroid in lamellar bone, whose processes ramify through the above-mentioned channels.

At the next higher order of structure, Currey distinguishes four principal types of bone (Fig. 4d-g). Woven bone may be found proliferating in any direction for several millimetres in extent, pierced randomly by blood vessels (Fig. 4d). Primary lamellar bone found at this level of magnitude has the lamellae oriented parallel with the local surface of the whole bone and is permeated by blood vessels with the same general orientation (Fig. 4e). Either of these types can be modified after their initial formation into a third type characterised by so-called Haversian systems (Fig. 4f). These are formed by resorption of bone around blood vessels by osteoclast cells, the resulting channels subsequently becoming filled up with newly deposited lamellar bone oriented with the channel

walls (Fig. 5). The collagen fibrils within each lamella run spirally to the axis of the channel, the direction of the fibrils changing between successive lamellae (McLean and Urist 1961, 27). Weinmann and Sicher (1955, 31-3) estimate 5-20 lamellae per system, while Ham (1965, 423) gives the usual number as 'less than half a dozen'. Haversian systems may form around vessels within the thickness of the bone (Fig. 6) or at the peripheries (Fig. 7). The outer limit of the Haversian system is delineated by a 'cement line' of calcified mucopolysaccharide through which pass only very few canaliculi, those in the outermost lamellae generally looping back on themselves. The blood vessels lying at the heart of the Haversian system are therefore isolated from adjacent cells, except where they interconnect through the so-called canals of Volkmann, which also connect with the periosteal and endosteal blood supply (Fig. 3; Fig. 5). Fourthly, at this level of structure laminar bone may be encountered (Fig. 4g). The laminae in question result from a particular method of bone formation incorporating both woven and lamellar bone (Fig. 8; Fig. 9). Each increment is formed by the growth of a scaffolding of woven bone around the network of blood vessels distributed on the surface of the bone. Woven bone quickly engulfs the vessels, which are left lying in a series of cavities. While further laminae are being formed on the new outer surface by continuation of this process, lamellar bone gradually forms on the insides of the cavities, filling them in and adding strength and rigidity to the whole bone. The resultant bone, therefore, has alternating layers of woven and lamellar bone.

Moving to the final level of structure in Currey's system, two categories are distinguishable : compact bone and cancellous bone. Compact (or cortical) bone (Fig. 4h) may be formed of any of the middle order types described above.

In practice several types of middle order bone may occur together (Fig. 3). As the term implies, there are no gaps in the structure of compact bone, other than those occupied by blood vessels. By contrast, cancellous (or trabecular, or spongy) bone has an open structure of trabeculae formed of lamellar or Haversian bone (Fig. 4i). It is at this level that bone will generally be treated here and, although compact and cancellous bone are immediately distinguishable from each other with the naked eye, their similarities at a microscopic level should be borne in mind : their essential similarity is underlined by the fact that cancellous bone can be converted into cortical bone by the deposition of lamellar tissue (Ham 1965, Fig. 18, 11-12) while under other circumstances cortical bone may be resorbed to a cancellous form.

Morphology : the mammalian skeleton

A major division into two parts can be made of the mammalian skeleton (Fig. 10) : axial bones either lie along the medial line of the torso (in which case they are symmetrically shaped, as in the case of the skull, sternum and vertebrae) or else they are ranged symmetrically on either side of the median, as with the ribs; appendicular bones, which form the second major group, include the limbs and their respective girdles. A third group, the visceral bones, which develop in various soft organs, will not concern us here.

The axial skeleton includes both flattened bones, such as the ribs, which help in the support and protection of the organs, and also irregular bones, principally the vertebrae, which form a strong but flexible channel for the spinal cord and are also provided with complex wings for the attachment of

muscles. In the appendicular skeleton, most important from the point of view of utilisation are the long bones, basically elongated hollow cylinders with expanded articular ends, which act as supporting columns for the limbs and provide a system of levers on which the muscles and tendons may act. There are also a number of short or compact bones concentrated in the area of the wrists and ankles, the dimensions of which are more closely comparable in all axes. In their definitive forms, bones of either group comprise a certain amount of internal cancellous tissue (Pl. 1) and an external envelope of compact tissue (Pl. 2) the relative abundance of each varying widely according to the form and function of the particular bone.

As well as providing support and protection, as mentioned above, living bones are bound up with various other physiological systems which directly condition their detailed form. Various foramina exist for the passage of nutritive blood vessels (Pl. 3) and, for example, to allow inter-connection with the blood-forming red marrow found within the flat bones of the skull, sternum and ribs and in the cancellous extremities of long bones. Yellow marrow, mostly fat, occupies the interiors of the long bone diaphyses of mammals (medullary cavity), but in birds this marrow is absent and the hollow cavities or sinuses so formed are linked with external air, forming so-called pneumatic bones.

Clearly there is a great deal of variation between the bones of different species : for details of these variations, reference should be made to the standard works quoted on p. 3 . A knowledge of the distinguishing features between them is invaluable in the study of bone artefacts and, even when the gross shape of the bone cannot be used as a guide, the trained eye can detect clues which may permit identification of the type of bone used

or even the species concerned. A few examples may usefully be quoted.

The sandwich-like structure of cancellous bone between two thin layers of compact tissue which is a characteristic of some discoid playing pieces distinguishes them from others of identical manufacture but which are solid (Fig. 87) : the former category can be shown to derive from the mandibles of horse and cattle, which exhibit this same structure, while the nutrient foramen which pierces the cancellous tissue on some examples (Pl. 5) locates the precise spot on the jawbone from which they were cut (Pl. 16); the solid counters are of antler.

A glance at the expanded-headed pin shown in Pl. 4 might suggest that it was one of the series of pig fibula pins which naturally display this form (Fig. 65); a closer look, however, reveals that it is pierced by a nutrient foramen, which demonstrates that it has been cut from the shaft of a long-bone from a cattle- or horse-sized animal, so that the raw material can have had no conditioning effect in this instance.

As a final example, the flat decorative strips identified below as casket mounts (p. 304) have few features to distinguish them from each other or to relate them to any particular source on the obverse (decorated) surface, but when the reverse is examined some display a cancellous structure which relates them to ribs of cattle-sized animals (Pl. 6) while others are more comparable with antler (Pl. 7); a third group, which is made up of large plates of thin and flat material (Pl. 47) occasionally display a stripe of cancellous bone which confirms that they have been cut from scapulae, the spongy stripe marking the location of the spina scapulae (Fig. 10).

Other examples of similar clues will be quoted as they are encountered in the section on artefacts.

ANTLER

Paired antlers, like horns, are restricted to the Artiodactyla or even-toed ungulates. The similarity ends there, however, for unlike horn (a modified, non-deciduous skin tissue) antlers are outgrowths of bone.⁽⁴⁾ They are carried by most members of the deer family (Cervidae) and, with the exception of reindeer and caribou, are limited to the stags only. Their principal function is to impress and they are important as objects of display rather than of combat. Chapman (1975, 156-7) records examples of stags without antlers (hummels) which nonetheless lead normal lives in the herd.

Formation

Antlers grow each year on small permanent protruberances of the frontal bones, named pedicles, which usually develop in the animal's first year. In the past there has been considerable disagreement surrounding the nature of the ossification process in antlers (summarised in Chapman 1975, 125-31), but it now appears that a form of endochondral ossification takes place at the growing tips while a certain amount of tissue is added intramembraneously to the surfaces of the antler. The rate of growth may be as much as 20mm per day (Chapman 1975, 129), promoted by immense numbers of osteoblasts which quickly become engulfed in tissue to form bone cells. Blood is supplied internally to the growing antler by way of the frontal bones and the pedicles, which are highly vascular at the beginning of the cycle, while the soft, hairy skin known as velvet which covers the antler

during the growing period carries an external blood supply within its numerous vessels. The formation of tissue around this network of arteries leaves the surface of the antler characteristically channelled or 'guttered'. As the base of the antler gradually ossifies, the internal blood supply diminishes to such an extent that ligation of the velvet at this stage results in the death of the antler (Chapman 1975, 127-8). As the antler reaches its definitive size and becomes fully ossified, the blood supply to the velvet too begins to dry up so that the velvet eventually shrivels and falls away, beginning at the tips of the tines. It has been suggested (Macewen 1920, 15; Matthews 1952, 283) that the occlusion of the blood vessels in the velvet is brought about by the development at the base of the antler of a bony coronet around the burr (Fig. 11), whose processes engulf and eventually strangle the larger vessels and which, by continuing to press against the velvet, restricts the passage of further blood, causing the skin to wither. Others have claimed more recently that the process is controlled by hormonal activity (Chapman 1975, 136). The period taken for full development of the antlers varies according to species and prevailing conditions : sample growing times of approximately three months for roe deer and four months for fallow deer in captivity have been recorded, while wild red deer in Russia are said to take from about four and a half to six months to complete the growing cycle including the shedding of the velvet (quoted in Chapman 1975, 137). Further information on the development cycles for various species in different habitats is given by the same author (1975, 138-9).

The cycle is completed by the shedding of the antlers. Numerous osteoclast cells ranged along the distal end of the pedicle gradually erode the tissue along the junction with the antler burr until a resorption sinus is

formed (Fig. 11). This cavity expands eliptically until finally the antler detaches itself at the pedicle junction which, after only minimal bleeding, is covered first of all by a scab and later by new skin tissue.

Structure

Antler tissue consists primarily of woven bone, a type of structure particularly suited to the rapid growth requirement of antlers. In cross section (Pl. 8) it is seen that the compact outer tissue encloses a spongy core which permeates the length of the beam and each of the tines, the tips of the latter being capped with compact tissue. (There is no blood-forming tissue within this cancellous core.) The proportion of cancellous to cortical tissue varies during the growing cycle, according to the level of blood being supplied internally at that particular stage. In the region of the burr, in particular, extra tissue is progressively deposited until flow stops. Sections through the pedicle and burr of mature antlers just before shedding show dense bone tissue completely sealing off the antler at the burr, with the blood trapped in the antler now congealing and disintegrating (Macewen 1920, Figs.9-10). Some Haversian systems develop, either as a result of direct deposition of bone mineral or through replacement of the outermost spongy tissue by compact bone, after the definitive size has been reached. This activity ceases soon after the period of growth and calcification has expired and from then on the antler is effectively dead. The unbroken canals which characterise the cancellous tissue of antler are immediately distinguishable from the more discrete formations found in skeletal bone (Pls. 6, 7).

The density and the ratio of mineral to organic matter in antler is comparable with skeletal bone. To some extent, the enormous mineral requirement for the annual production of antlers is met at the expense of the skeleton, a certain amount of mineral resorption from the skeleton taking place during the growing period, the degree of resorption probably becoming greater in the event of the available diet being mineral-deficient (Chapman 1975, 141-3).

Morphology

According to Morris (1965, 363-4) there are 41 living species of deer, but the antlers of only those likely to be recovered from archaeological contexts in northern Europe need be considered here. Hence, five species are examined, the antlers of which have a common micro-structure conforming to the description given above but which vary considerably in morphology (Fig. 12).

As deer develop in maturity their antlers tend to increase in complexity as well as size. The variations between species are discussed in general terms below, but in each case detailed development is conditioned by a number of factors, among which diet and health are important in addition to age. Hence, in a year of poor weather, scarce fodder or ill health, first antlers may fail to develop in young deer, while in older animals elaboration of the antlers may be curtailed. Furthermore, once maturity has been reached no further elaboration of the antlers takes place in succeeding years and, indeed, regression sets in as the beast continues to age.

The simplest antlers are those of roe deer (Capreolus capreolus L.), which have a relatively straight slender beam and a normal maximum of six

tines per head when fully grown (Fig. 12D). Whitehead (1964, 488-9) quotes lengths of just over 30cm and a circumference around the coronet of 12.5cm amongst the best recently-shot heads from the British Isles. The surface of the antler is normally markedly gnarled and guttered.

Fallow deer (Dama dama L.) have antlers which are larger and smoother than those of the roe and are distinguished by their palmate upper parts (Fig. 12C). Lengths of up to 44cm and beam circumference of 12.5cm have been recorded among modern populations (Whitehead 1964, 490).

Red deer (Cervus elaphus L.) have somewhat more complex antlers, with a normal maximum of twelve or fourteen points per pair in the wild (Fig. 12A), although up to forty-seven points were recorded in 1892 from a park-bred British stag (Whitehead 1964, 487). The greatest length recorded (op. cit., 486) for modern antlers is 121.5cm and the greatest circumference of the beam 16.5cm. The surface can be quite heavily guttered or it may be fairly smooth; in any case, the tines normally have a smooth surface, sometimes enhanced by the effect of wear suffered while the stag has been rooting for food.

Antlers are carried by both sexes of reindeer (Rangifer tarandus L.), those of the bulls being heavier. The upper points are often palmate and bulls often display a forward-facing 'shovel' close to the base of the antler. Half way up the beam a back tine projects. Whitehead (1964, 467) records good average dimensions for the antlers of wild Scandinavian reindeer of 127cm length and 12cm circumference of the beam, with twenty-eight points per head.

TEETH

Mammalian teeth are formed in the soft tissues of the jaw. An enamel crown is laid down initially, followed by the body of the tooth in the form of dentine. As the crown erupts through the gum, roots are developed which anchor it firmly in place. In most mammals the majority of the teeth present in adult dentition are preceded in youth by a set of deciduous (milk) teeth.

Formation

The cells involved in the formation of enamel, the ameloblasts, are distinct from the osteoblasts responsible for bone manufacture. An enamel matrix in the form of an amorphous gel (Wainwright et al. 1976, 224) is secreted by the ameloblasts, taking on a honeycomb appearance with the development of mineral crystals. Distinct groups of secretory vessels develop into elongated processes (the Tomes processes) which become incorporated into the honeycomb structure, where they deposit filaments of apatite. These filaments develop into crystallites of relatively large dimensions compared with those of bone and dentine, reaching sizes of 160 x 40 x 25 nm (Halstead 1974, 87). As the apatite crystals increase in size and become more closely packed, the organic matrix is gradually squeezed out to the external border, so that in mature enamel it declines to negligible proportions (about 1%) (Weidmann 1967, 15).

Seen in cross-section under the electron microscope, the cellular honeycomb structure is dominated by a series of horseshoe-shaped features

whose interfaces are accentuated by the differing orientations of the crystals laid down by the Tomes processes and by an interposed sheath of organic matrix (Currey 1970a, Pl. 11). In certain groups of species the secretions of individual Tomes processes affect adjacent 'cells' in the honeycomb structure, resulting in the partial breakdown of the basic prismatic appearance (Halstead 1974, 88-90).

The enamel prisms of mammalian enamel are arranged in zones, running radially from the dentine junction to the periphery of the tooth. Within each zone the prisms follow a somewhat wavy path, the direction being constant for alternate zones. Under reflected light these zones appear alternately dark and light, producing characteristic 'Hunter-Schrager bands'. Incremental rings, the so-called 'striae of Retzius', are also distinguishable in some mammalian enamel.

Dentine is also formed by specialised cells, the odontoblasts. In the initial stages of formation, however, another group of cells arranged in a subodontoblast tissue layer secrete an organic matrix of predentine, consisting largely of collagenous fibres, and the same cells are responsible for the initial calcification of this matrix. Subsequently the odontoblasts take over this process and, as the secretion of further matrix continues, the odontoblasts withdraw, leaving characteristic 'dentinal tubules' along which extend the principle cell processes (Fig. 13); unlike bone, therefore, the cells are not trapped within the matrix as it forms. As development continues, the odontoblasts become more closely packed and take on a columnar appearance (Halstead 1974, 73-5). Mineral salts are deposited in the form of spheres (calcospherites), interspersed with non-mineralised tissue. Depending on the degree of

calcification which takes place, one of three types of dentine may ensue : if no further activity follows, so that the calcospherites are interspersed with numerous non-mineralised areas, it is known as interglobular dentine; full calcification, when the calcospherites fuse together and exclude all non-mineralised tissue, produces fully mineralised dentine; at an intermediate stage, when small non-mineralised areas survive, marbled dentine is produced.

A third form of mineralised tissue, termed cement, is also to be found in teeth. Structurally it compares more closely with bone than with dentine or enamel.

Structure

Three major elements are distinguishable in the structure of teeth (Fig. 14) : the crown protrudes from the gum and forms the cutting or grinding surface; the root is buried in the tissues of the gum; the neck connects these two extremities. In section the tooth displays a central cavity filled with dental pulp, extending from the crown to the tips of the roots where it connects through canals with the central nervous and nutrient systems. Generally these canals narrow with maturity, but in the specialised teeth which grow throughout the lives of certain species (such as the tusks of elephant and walrus) the pulp cavity remains widely open (Cornwall 1974, 74). The bulk of the crown is made up of dentine, capped over its exposed area by an envelope of enamel. Generally speaking, the enamel has a maximum thickness over the cusps on the grinding surfaces and tapers away towards the roots. On the outer surfaces of the roots is a thin, hard coating of cement, which may also invade the folds of the enamel of the crown.

Following initial deposition of the enamel cap, growth takes place as a result of the action of odontoblasts lining the pulp cavity. Usually, growth will cease when a definitive size has been reached in maturity, but in the case of specialised teeth in certain species, such as the incisors of rodents, growth is constant throughout life; elephant and walrus tusks also continue to be incremented, though in later years production is limited to maintaining equilibrium as material is worn away from the tips.

Morphology

Teeth have evolved differently in different species according to feeding habits. A fully diversified set of mammalian dentition includes four distinct classes of teeth : the incisors, used for cutting or tearing food; canines for seizing prey or for rooting in the ground; molars for crushing or grinding food; premolars, which are intermediate in location between the incisors and the molars and may be adapted to assist in the functions of either, according to species. The full complement of teeth on each side of the jaw, upper and lower, is three incisors, one canine, four premolars and three molars, all adding up to forty-four teeth and normally expressed by the following formula :

$$I \frac{3}{3} \quad C \frac{1}{1} \quad P \frac{4}{4} \quad M \frac{3}{3} \times 2 = 44$$

Only a few mammals with relatively unspecialised dentition, such as the pig, have all these teeth fully represented. Most have less, but a few (notably some of the toothed whales) have more. An analysis of mammal and other dentition, species by species, is given by Cornwall (1974, 74).

Special mention will be made here only of some of the teeth of larger mammals which feature in the production of artefacts.

Foremost among these are the walrus and the elephant, each of which is equipped with a pair of teeth of such enormous size that they are distinguished with the name of tusks. In both instances the tusks are composed almost entirely of dentine, with little more than a cap of enamel. In the walrus the teeth in question are the upper canines, while in the elephant the tusks are highly developed upper incisors. Both animals have the capacity to go on depositing new dentine in their tusks throughout life, although in later years production seems to be limited to maintaining an equilibrium as material is worn away from the tips. Although they are limited to males in the Asiatic elephant (Elephas maximus) both male and female African elephants (Loxodonta africana) carry tusks. As well as these massive incisors, which can grow up to 3.0m or more in length and weigh up to 85kg (190lb), elephants do have other teeth, which are all molars : the formula for elephant dentition is thus :

$$\begin{array}{cccc} \underline{1. & 0. & 0. & 3} \\ 0. & 0. & 0. & 3 \end{array}$$

The molars seem never to have been prized by craftsmen, however, for although they are of prodigious size they are not at all homogeneous in construction and are heavily sheathed in enamel (Penniman 1952, Pl. V).

The large adult tusks of the elephant are preceeded in the normal way by two deciduous incisors, which reach only about 5cm in length before they are shed. A pulp cavity extends part way along the length of the

adult tusk : since the tusk continues to grow throughout the life of the elephant, the cavity remains wide open in the manner described above (p. 19). In transverse section the ivory is seen to be permeated by characteristic dentinal tubules which radiate from the pulp cavity and incline obliquely towards the tip (Penniman 1952, Pls. I-II). The regular gyrations performed by these tubules produce, in the words of Professor Owen (1856, 67), 'striae proceeding in the arc of a circle from the centre to the circumference in opposite directions, and forming by their decussations curvilinear lozenges'. Opaque strata interspersed between and inter-connected with the tubules form concentric contours which, in longitudinal sections, appear as pale lines running parallel to the pulp cavity. The unique modification of dentine structure seen in elephant ivory is thought (R. Owen 1856, 69) to have been developed to produce a tougher and more elastic material, in response to the unusual degree of stress imposed on it by the enormous weight of the tusk and by the manner in which they are used by the elephant. Viewed in section, ivory has a tendency to split along these lines running parallel to the pulp cavity, producing a characteristic 'cone-within-cone' effect (Gaborit-Chopin 1978, 11-2, Pl. 4; Penniman 1952, Pl. IV), although this effect may only appear with antiquity or excessive drying. Elephant tusks have no enamel coating except at the tips. A certain amount of cement covers the base of the tusk (C. I. A. Ritchie 1969, 40).

One extinct member of the elephant family may be mentioned here : this is the mammoth (E. primigenius), whose remains survive in sufficient quantity in certain regions (p. 43) to have become an article of commerce. Penniman (1952, 21) notes that freshly preserved mammoth ivory can be

distinguished from that of our contemporary elephants by its finer striae which intersect at more acute angles. Sanford (1973, 34) has, however, stressed the practical difficulties of distinguishing mammoth from other elephant ivory, particularly when it survives under less than ideal conditions.

Walrus tusks, which can grow up to 1.0m in length, are found both on males and females, those of the male tending to be more massive and curved (Gaborit-Chopin 1978, 12; King 1964, 39). The dentine is laid down in two distinct layers : the outer coating is homogeneous in structure, although coarser in structure than elephant ivory and with a yellow tinge, while the innermost layer, which builds up in the former pulp cavity, is of marbled dentine and is translucent and crystalline in appearance. Walrus ivory lacks the intersecting arc structure typical of elephant ivory : in walrus the dentinal tubules are straight and parallel, interrupted by globular areas of secondary dentine (Sanford 1973, Pls. 2c, 2s). Towards the roots of the tusk there are said to be cavities in the marbled dentine (Madden 1832, 244). The tusks are specially developed for grubbing up hard-shelled molluscs on which the walrus mainly subsists, crushing them easily between its well-developed cheek teeth (Cobb 1933, 654-68; King 1972, 39-40), and for manoeuvring on the ice.

Amongst other marine mammals, certain of the toothed whales (the Odontoceti, as opposed to the Mysteceti or whalebone whales) have teeth which are remarkable for their number as much as their size, up to fifty being found in each side of the jaw in some species (L. Matthews 1952, 320-22); other species, however, have only a single pair (loc. cit.). Whale teeth are relatively undifferentiated, being adapted for seizing

prey under water but not for masticating it. Most of them have a simple conical shape, with the microscopic dentinal tubules running very straight (Sanford 1973, 30).

Finally, the teeth of the narwhal, one of the Arctic whales, may be brought to notice. In the male of the species are found two tusks of which the right hand one is almost vestigial, hardly protruding beyond the maxillary bone, while that on the left side is deeply embedded in the skull and extends forward in line with the body axis, reaching a length of up to 3.0m (Sheppard 1940, 223-24). The pulp cavity extends for virtually the whole length of the tusk, while on the exterior surface a spiral groove winds all the way to the tip. At a microscopic level the structure of narwhal ivory is relatively coarse, with random clustering of the dentinal tubules (Sanford 1973, 30, Pl 2y).

Narwhal tusks were highly prized during the medieval period, when they were believed to be unicorn horns and to possess prophylactic powers (Humphreys 1953, 16-19).

KERATINOUS HARD TISSUES

By definition, keratinous tissues are not derived from the bony skeleton; they occur rather on the body surface and function as exoskeletal elements. Amongst the hard keratins (which also occur in the form of nails, hooves, hair and feathers), horn and baleen in particular have formed the bases of manufacturing industries which are briefly considered below and, since the uses to which they were put sometimes overlap with those relating to skeletal materials, it may be convenient to include here an account of their respective structures.

Formation

In each case the keratin, which has a rigid fibrillar structure, is synthesised in the epidermis. Cells gradually migrate from the innermost (Malpighian) layer into a cornifying layer in which three strata are distinguishable (J. Z. Young 1957, 33) : the stratum granulosum, characterised by granules of keratohyalin (the origin of which is obscure, but which seems to be involved in the formation of soft keratin); the stratum lucidum (a clear translucent layer in which the cells become closely packed and cease to be distinguishable as separate entities); finally, the stratum corneum, which itself consists of many layers, is made up entirely of fully keratinised dead cells.

In contrast to the forms of extracellular deposition described above for skeletal tissues, keratin is laid down within the actual cell, which eventually becomes so overloaded that it dies. Whereas in soft keratinous tissues (such as skin) dead cells are continually being sloughed off, in hard keratins they are retained permanently, being continually added to from the underlying regenerative zone and, to some extent, becoming calcified (Halstead 1974, 94).

Morphology

Horn

The horns carried by certain mammals - cattle, sheep, goats and antelopes - consist of a non-deciduous cuticle composed of keratin and laid down in the form of a sheath surrounding bony horn-cores (the os cornu) projecting from the frontal bones of the skull. The surface of the horn, characterised by a structure of fine parallel lines, is immediately distinguishable from bone, antler and ivory. A great range of sizes and shapes is exhibited according to species and a wide variety of colour

according to breed (Hartley 1939, 205). Different degrees of ridging on the surface are also displayed, which may increase with age, but in all instances the horn displays a uniform non-nucleated structure throughout.

The keratinous structure of horn has, therefore, nothing in common with the material of deer antler which, as has been emphasised, is a form of bone. Hence the terms horn and antler should never be used interchangeably.

Baleen

Baleen, generally referred to as 'whalebone', is derived from the keratinous brush-like plates which take the place of teeth in the Mysteceti (p. 23) and function as huge sieves, filtering from seawater the shrimp-like krill which form the basis of the whales' diet. The baleen is suspended in numerous sheets from either side of the upper jaw. Each plate is constructed in the form of a sandwich a few millimetres in thickness (Fig. 18), with a medial stratum of tubules arranged in a matrix of cementing tissue and flanked on either side by horny covering plates. Each element in the sandwich consists of a different kind of keratin, of which only the tissues of the tubules become partly mineralised, apatite crystals being laid down in concentric formation to add strength to the structure. In use the covering plate and the cementing matrix are progressively worn away by the action of the tongue towards the distal end of the lingual surface; the fringes of tubes exposed in this way form the basis of the filtration system (Halstead 1974, 100-2).

AVAILABILITY

Introduction

The factors controlling availability in antiquity varied in kind for each category of raw material. Bones from butchered animals would presumably have been freely available to all and sundry throughout the period; horn, on the other hand, at least by the medieval period, was largely monopolised by the powerful horners' guilds and hence would seldom have found its way at this time into unprofessional hands; the reservation of the deer as a 'beast of the forest' (p. 31) in the early medieval period would again have ensured that few antlered carcasses would have come within the reach of the general public but, as will be shown, the antler-working industry depended primarily for its sources on shed antlers and hence was subject to other sorts of control; and finally, with the possible exception of fossil material (p. 43), ivory arrived in Britain only through very long-distance trade routes whose fortunes fluctuated widely over the centuries under consideration. No statement can, therefore, be made concerning general availability, so that each material must be considered in turn.

Bone

Easy availability must have been a major factor in encouraging the utilisation of bone; certainly there can seldom have been any shortage of raw material to satisfy the needs of professional and casual user alike. For the most part, the species involved were identical with those generally

exploited for food or motive power and no evidence has been found of particular animals having been sought out exclusively for their skeletons. Every midden was a potential source of raw material for the manufacturer, although we may assume that where organised workshops were concerned, specified bones would have been reserved by the butchers for sale to the trade, thereby eliminating the need for scavenging. The fact that the mechanical properties of bone may be adversely affected by prolonged heating would rule out the use of cooked bones for some purposes at least. The masses of unutilised bones recovered from every settlement excavation would suggest, however, that supply far exceeded demand. On the other hand, it has already been stressed (p. 10) that bone is by no means a uniform material and that utilisation was never a random process : even if there were a well-developed bone-working industry in operation in the vicinity, we can be sure that the majority of bones would have been scorned as unsuitable by the craftsmen. The consistent utilisation of specific bones is a theme to which increasing evidence will be brought to bear here. As more large groups of excavated animal bones are published in a comprehensive manner, it will be interesting to see whether certain species are consistently under-represented by particular bones, as this may form evidence for this process at work. For the moment, the evidence from rubbish pits such as those found at Southampton (Holdsworth 1976, 45) and York (MacGregor 1978, 48) demonstrates the deliberate selection of long-bones and ribs respectively. Other evidence provided by the artefacts themselves is presented below.

One domestic animal whose bones were commonly utilised but which would not normally have been slaughtered was the horse. There still seems to be some doubt as to whether horse flesh was widely eaten in post-Roman

Europe, but the fact that its consumption was prohibited by Pope Gregory III c. 732 (Dümmler 1892, 279) and again by the English synod of 786 (Liebermann 1912, 615) seems to imply that the practice was current in some regions at least. The Confessional of Archbishop Egbert of York (732-66) mentions that horse flesh may be eaten although many people refused to do so (Thorpe 1840, 130). A number of complete carcasses found buried in medieval levels at York, suggest that horses were not eaten at this time, although conceivably these individuals could have been diseased and hence unfit for consumption. It may be significant that the great majority of utilised horse bones seem to be metapodials : in skinning smaller animals such as rabbits these lower limb bones are normally left in the skin when it is first removed and only later are they separated; conceivably, then, the apparent abundance of horse metapodials may be the result of a common trade in horse skins.

Although there were undoubtedly variations in the density of different species of animals in different areas, only one group may be singled out as having a significantly limited distribution in the British Isles, namely the large cetaceans. Although isolated individuals do stray southwards, they are certainly more at home in the more northerly latitudes. This is reflected in the widespread utilisation of cetacean bone in the north and west of Scotland, where it was used to produce a range of implements which generally occur in other materials elsewhere (see, for example, p. 131), or which are unparalleled in other regions. The latter circumstance may partly result from the development of specialised toolkits in the more northerly environment (as for example, the so-called blubber mattocks (Clark 1947, 97; Scott 1948, 84) discussed elsewhere) but may also be due to the fact that their counterparts elsewhere may have been made in wood which has failed to survive under well-drained soil conditions.

Even in house building bone sometimes replaced timber for structural members, for in the northern isles the comparative abundance of bone helps to offset a corresponding shortage of wood. I have argued elsewhere (MacGregor 1974, 105-6) that this abundance may not be entirely due to natural circumstances and that occasional strandings are unlikely to have furnished sufficient bone to permit the development of the widespread uniformity which can be recognised among these specialised implements. The implication seems to be that these maritime communities undertook deliberate whaling expeditions whose primary goal would have been meat and blubber, the valuable skeleton being merely a by-product. Evidence for whaling during this period has also been claimed for Scandinavia (Sjøvold 1971, 1203-4).

That the practice of whaling was not entirely limited to the northern latitudes is demonstrated by a passage in Aelfric's Colloquy. The lines concerned (116-20) run as follows (Garmonsway 1947, 30) :

Forþam leofre ys me gefon fisc þæne ic mæa ofslean,
 þonne fisc, þe na þæt an me ac eac spylce mine gefaran
 mid anum slege he mæg besancean oþþe gecpylman.
 7 þeah mænige gefoþ hþælas, 7 ætherstaþ frecnysse,
 7 micelne sceat þanon begytaþ.

Even though the fisherman does not take part in whaling himself, he clearly knows a great many who do. Unfortunately, we are given no indication of where the whaling was carried out, but the fact that it was a lucrative pastime presumably indicates that it was not an everyday occurrence.

Although a number of artefacts of cetacean bone are found in southern Britain before the Scandinavian incursions and subsequent settlement, their occurrence increases significantly during the Viking period, presumably as a result of their being diffused southwards by a culture in which cetacean bone was an important raw material in the homeland.

Antler

From the Roman period onwards, as will be seen, it was antler rather than bone which provided the bulk of the raw material for utilisation. Until the advent of increasingly strict forest laws in the medieval period, it seems likely that the general availability of antler varied little. Thirty-one deer parks were already in existence by the time Domesday Book was compiled, however, so that deer were certainly not free for all before the Conquest. The ultimate decline of the antler industry may nonetheless be attributed, at least in part, to the increased protection extended to deer during the medieval period or to their reservation for the king's purposes (cf. p. 160).

Roe deer have formed a permanent element in the fauna of the British Isles since the last glaciation, although their distribution in the wild has become progressively more limited during the present millennium. According to Turner (1899, X), the roe suffered the greatest single blow to its continuing survival by being demoted in the 14th century from its status as a beast of the chase : in his Select Pleas of the Forest, Turner (loc. cit.) records that in the thirteenth year of the reign of Edward III, the court of the King's Bench ruled that the roe was to be considered thenceforth as a 'beast of the warren' and not of

the forest. In losing the protection which had hitherto limited its enemies to the upper echelons of society, the roe would have become the subject of widespread extermination from game forests throughout England. Other evidence can be found, however, to suggest that this ruling was not generally applied or was limited to the peculiar case of the Manor of Seamer which occasioned this decision (Cox 1905, 30). As far north as southern Scotland the roe deer population suffered further from the spread of farming and the consequent contraction of the forest cover. Today it survives only in the extreme north and west of England and in north and central Wales and Scotland. Whitehead (1964, 260) gathers together a certain amount of literary evidence to counter the widely held belief that the roe was unknown in Ireland, but the early history of the species there remains obscure.

Red deer are also indigenous to the British Isles and formerly enjoyed a much more widespread distribution than currently, wild stock being limited now to Devon and Somerset, the Lake District, central and northern Scotland and isolated parts of Ireland (Whitehead 1964, 451-2). The red deer was the supreme animal of the hunt and, as such, enjoyed protection from all but the King and the favoured nobility throughout the vast acreage of royal forests, which were a major feature of the English countryside from the Conquest until the early Tudor period. The royal privilege was not to be lightly violated, for illegal taking of the King's deer was punishable by death, mutilation or blinding until the time of Edward I, when corporal punishment was replaced by heavy fines (Whitehead 1964, 76). Nevertheless, considerable stocks of deer were lost to poachers : in 1251 it was charged that the Earl of Derby and four companions had taken

no less than two thousand deer over a period of six years from the royal park of Peak Forest, while on a single day in 1334 a party of forty-two men slew forty-three (sixty-three, in some accounts) red deer in Pickering Forest (Whitehead 1964, 110, 121). More important depredations were made as a result of the gradual spread of agriculture into areas which had previously been given over to forest and the turmoil of the Civil War dealt a final blow to many of the surviving herds.

Unlike roe and red deer, fallow deer were artificially introduced to the British Isles. The date of introduction seems as yet uncertain : Whitehead (1964, 268-9) quotes a number of opinions which have been expressed on the subject, none of them with any demonstrable basis of fact, which credit variously with their importation the Romans, the Gauls and even the Phoenicians! Jennison (1937, 89) concludes that by the 3rd century AD the species was well established for, towards the end of the reign of Severus, Gordian (later the Emperor Gordian I) was said in the Scriptores Historiae Augustae to have imported to Rome a large number of stags of fallow deer (cervi palmati) including some from Britain. In this conclusion, however, he appears to be mistaken : a recent edition of the Scriptores (Magie 1960, 384-5) translates the passage cervi palmati ducenti mixtis Britannis as 'two hundred stags with antlers shaped like the palm of a hand, together with stags of Britain ...'. Being denied this single reference, we are thrown back on archaeological evidence for an introductory date. Here the earliest indication of their presence seems to be a pendant made from the palmate end of an antler, found at Lloyds Bank, Pavement, in York (p.168). . . . The Lloyds Bank site spans a period from about the

9th to the 11th century (MacGregor, forthcoming) so that an early Norman rather than an Anglo Scandinavian date for it cannot be ruled out. The 11th century would, therefore, be the last possible date for the introduction of the fallow deer. Such was its subsequent success as a park animal in the medieval period that by the 17th century, when stocks were held in over seven hundred parks in England, it was claimed that there were more fallow deer in a single English county than in the whole of the rest of Europe (Whitehead, 1964, 270). During the Civil War these stocks were again greatly depleted and many of the surviving feral herds may have been established in the wild at this time.

Since the natural distribution in Great Britain of red and roe deer in the period considered here is likely to have included a very large part of the country, no special significance can be given to the mere fact of the occurrence of their respective remains in archaeological contexts. The bones of deer form a fairly normal element among food refuse, although the numbers of individuals represented is seldom very high. In contrast, remains of antlers, particularly those of red deer, are very numerous in urban manufacturing centres, leading to the conclusion that the antlers themselves were brought into the city and that they were not simply utilised as waste material from butchered animals. This conclusion is further reinforced by the fact that antler bases displaying natural ruptures at the burr (indicating that they were shed in the wild - see p. 13), far outnumber those in which the burr and pedicle are intact and which would, therefore, have been removed from dead carcasses. This situation has been noted wherever large-scale antler working has been established, as at York (MacGregor 1978, 46) and Dublin (Ó Ríordáin 1971, 75) and at several sites on the Continent

including Århus (Andersen et al. 1971, 121) and Hedeby (Reichstein 1969, 61-70). Among remains from early medieval Lund too, red deer were represented overwhelmingly by antler fragments, apart from a jawbone fragment and some pieces of calvaria, the latter presumably introduced into the city attached to the antlers of slaughtered deer (Bergquist and Lepiksaar 1957, 20-1; Ekman 1973, 48).

Clearly, therefore, shed antlers were being collected from the forests and hillsides to supply this industry, which no doubt paid a going rate for its raw materials. It is suggested elsewhere (p. 203) that some at least of the antler workers may have been employed throughout the year in pursuit of their trade, yet the supply of material in the form of shed antlers must have been highly seasonal (p. 13). Red deer cast their antlers over a two month period in the late spring and fallow deer follow a similar pattern. (Roe deer, on the other hand, shed from October to early December, but the small size of their antlers meant that they were not utilised interchangeably with those of the other two species.) The fact that shed antlers are subject to deterioration if uncollected re-affirms the suggestion that this must have been an intensive seasonal operation : those which escape the attentions of the deer themselves, which frequently gnaw antlers and other bones (Sutcliffe 1974, 270-2; ibid. 1977, 73-6) eventually degrade under the action of weathering and particularly of frost. We must therefore envisage the antler worker stockpiling his raw material and, perhaps, his suppliers doing the same in anticipation of better prices during the winter months of scarcity. A system of exchange (presumably of finished articles for raw materials) between urban craftsmen and the population of the surrounding countryside has been suggested as a common means of acquisition of antlers in Poland (Cnotliwy 1956, 179).

Attempting to gauge the extent of the catchment areas on which manufacturing centres could draw for their materials is a fascinating exercise, but conclusive answers are elusive. Given the former country-wide distributions of our native species of deer, it seems impossible for the present to distinguish the products of any one region from another,⁽⁵⁾ and as yet no remains of exotic deer have been distinguished from archaeological excavations in Britain (see, however, the reference to the Abbots Bromley antlers on p. 38). At Hedeby, Ulbricht (1978, 20-2) has distinguished reindeer and elk antler in small quantities among the mass of red deer remains and Ekman (1973, 49) has found reindeer antler among the material from Lund and elsewhere in Sweden : in both instances these authors diagnose importation of this antler to their respective regions, where the animals in question are normally not to be found. The significance of an elk antler found at Dorestad is as yet unclear, since there is yet doubt as to whether elk were indigenous to the region during the floruit of the town (Prummel, pers. comm.). Even when dealing with locally-available species, some tentative conclusions may be drawn from the remains : Müller-Using (1953, 65), for example, in his study of antler material from Wolin, has suggested that the virtual absence of remains of paired antlers from slaughtered deer in the excavated material may be an indication that the deer had been killed at some distance from the settlement; for convenience of transport the antlers were then separated from the skulls on the spot and eventually bundled up with others similarly treated, with the inevitable result that antlers which were originally paired often became separated before they reached the workshops. Conversely, the presence of some pairs of antlers still attached to the frontals in the excavated material from Lund has been taken to indicate (Bergquist and

Lepiksaar 1957, 22) that some at least of the raw material used there came from locally-slaughtered deer. (In the case of naturally-shed antlers, it should be noted that although both antlers are normally cast within a short time of each other they would not necessarily be shed on the same spot and, considering the wide range of territory which might be covered in a day by a herd, several miles could easily separate a single pair cast within an hour.)

Some consideration must now be given to the reindeer. Although they were undoubtedly common in Britain down to the time of the last glaciation, reindeer have long been held to have been totally absent in the post-Pleistocene period. Against this view, three kinds of evidence must be taken into account - archaeological, literary and representational.

The first of these concerns physical remains of reindeer found on a number of northern habitation sites. The evidence of this material is summarised by J A Smith (1870, 186-222). Smith mentions remains from the brochs of Cinn Trola, Keiss, Kintradwell and Yarhouse and from the vicinity of some hut circles at Tain, as well as others recovered from geological rather than archaeological strata. In addition, Munro (1879, 244) describes two antler fragments from Lochlee Crannog, Ayrshire, which he considers to derive from reindeer. Since no firm indication of the survival of reindeer in Britain can be found in the post-glacial period,⁽⁶⁾ some explanation must be found for the presence of these pieces. One important fact which has not previously been commented upon but which is of crucial significance here is that all of these remains are of antlers. No skeletal fragments have been recovered.

Two possibilities suggest themselves : the first is that the antlers mentioned were imported from Scandinavia as raw materials for manufacture; the second is that the fragments in question represent fossil material recovered from waterlogged peat bogs and brought into the settlements for utilisation.

A certain amount of evidence for the trading of reindeer antlers beyond the sphere of their natural distribution (which is shown in a map reproduced in Ulbricht 1978, Abb 10) has been found on the Continent : numerous fragments have now been recovered from Lund (Bergquist and Lipiksaar 1957, 25-6; Ekman 1973, 49) and elsewhere in Sweden (Ekman, loc. cit.), while further examples have been found among the antler working debris from Hedeby (Ulbricht 1978, 20-1). While Lochlee Crannog might seem an unlikely (though by no means impossible) destination for imported antler, Viking-period interest in former brochs is well attested and it would be perfectly possible for imported material to find its way to those sites for local utilisation. The stratigraphic origins of all these pieces are too imprecise to allow any close dating. It may be noted that no evidence of Scandinavian settlements before the early years of the 9th century can be found in northern Scotland (Klindt-Jensen 1969, 194). For more concrete evidence of the importation of Viking period antlers, the result of a radiocarbon date recently obtained from the well-known Abbots Bromley 'horns' may be cited : the so-called horns are in fact reindeer antlers mounted on head-dresses and still worn by village dancers in an annual circuit of the parish (Alford 1933, 203-9); recently they have produced a radiocarbon date of AD 1065 $\pm$ 80 (T Buckland, forthcoming) which, unless already ancient antlers were imported at a later period (which seems even more unlikely), must mean that they were shipped to England around the 11th century.

Returning to the Scottish antlers, the second possible origin must now be considered, namely that they represent fossil material dug out of the peat and subsequently introduced to the above mentioned settlements.

Reindeer antlers of Pleistocene date are certainly found from time to time, embedded in peat bogs : examples from Orkney, Lanarkshire and Dumbartonshire are illustrated by J A Smith (1870, 209, 212, 217) and from Dumfriesshire by the same author (*ibid.*, 1879b, 361). The fragments mentioned above could also have been found in this way, perhaps during peat-cutting, and, since the dampness of the peat would have preserved a good deal of the original appearance and mechanical properties of the antler, they would quite naturally have been saved for utilisation. (At least one fragment from Keiss Broch, Caithness (J A Smith 1879a, 77), showed some signs of working.) This is the explanation which seems to have most to recommend it, but the question can finally be resolved only with the aid of scientific dating methods : perhaps when improvements in technique bring down the minimum sample size required for radiocarbon dates it will be possible to settle the matter once and for all.

In the meantime, before the reindeer can be dismissed from the list of species available in Britain for everyday utilisation, one literary reference must be taken into account. The following passage occurs in Orkneyinga Saga (CII) :

Þat var siðr jarla nær hvert sumar at fara yfir á
Katanes ok þar upp á merkr at veiða rauðdýri eða hreina.
(Guðmundsson 1965, 275)

A literal translation may be given as follows⁽⁷⁾ :

It was the earls' custom to go over to Caithness nearly every summer and up into the woods there to hunt red deer or reindeer.

In the absence of corroborative evidence for the currency of reindeer in Scotland at that time, the accuracy of the sagaman's statement must be open to doubt. Two considerations must be borne in mind. The first is that the saga was written by an Icelfander who, although he had visited Orkney (and, almost certainly, Norway), is not known to have set foot in Caithness; he is unlikely, therefore, to be speaking from first-hand experience of the country or indeed of the animal, for the reindeer was unknown in Iceland at that time. The second is that, bearing in mind his likely unfamiliarity with the animal, he may not have meant to imply that reindeer were hunted as an alternative to red deer but used the terms synonymously (see E Magnusson, quoted in Harting 1880, 73-4). Both these contentions find favour with present-day scholars of Icelandic literature.⁽⁸⁾

Finally, one representation on a Pictish slab must be considered. The stone (Fig. 12), from Grantown-on-Spey, Inverness-shire, has incised on it a representation of a deer which, it must be admitted, bears a certain likeness to a reindeer. Taking into account the stylised treatment of the beast and the absence of other unequivocal evidence for their existence, however, we may suggest that the resemblance must be accidental and that it was a red deer which the sculptor intended to portray.

Having taken into account the above considerations, it may be concluded tentatively that the reindeer was not among the species whose antlers were systematically utilised in Britain during the period in question, although further research will be necessary before it can finally be dismissed.

Elephant ivory

During the Roman period Britain lay at the north-west frontier of an empire whose south-eastern fringes bordered on the oriental world and which, for all its size, possessed a communications network which was impressive by any standards. Hence, goods and materials from the east and the far south were widely diffused over the entire Roman world, and among them was ivory.

A great deal of ivory reached the Roman empire through trading posts founded on the Red Sea coast. The original function of these stations, several of which had been planted in the 3rd century BC, was to acquire live elephants from Ethiopia and the eastern Sudan for military purposes. Following the rout of Ptolemy IV's African elephants by a similar force of Seleucid Indian beasts at the Battle of Raphia (217 BC), their military significance declined but the Red Sea ports were maintained, partly to carry on the now established trade in ivory (Jennison 1937, 29-40). Indian ivory was also imported on a considerable scale through Egypt, particularly after the annexation of the latter territory by Rome (ibid., 40).

In the immediately post-Roman world, the disruption of former commercial trade routes resulted in little ivory reaching northern Europe. The Islamic expansion of the 7th and 8th century also took its toll. When ivory begins to appear again in northern Europe it is almost exclusively in what may broadly be termed ecclesiastical contexts, in the form of croziers, reliquaries and 'liturgical' combs (p.241). Under the impetus

of the Carolingian renaissance the volume of ivory working resumed something of its former importance (Volbach 1952, 17), although for another three centuries or more the overwhelming consumer (and, perhaps, importer) of the raw material remained the church and the royal households. In the earlier part of this period, the evidence of re-cut ivories demonstrates some continuing scarcity of raw material (Longhurst 1927, 11), although by the middle of the 9th century the size and thickness of the carved plaques testifies to a more plentiful supply (Gaborit-Chopin 1978, 15). Even so, this plenitude was more marked in the Ottonian courts with their close relations with Italy than elsewhere in northern Europe where ivory remained scarce for a further four centuries or so.

The agencies by which ivory reached the European market in the post-Roman period were primarily Byzantine. Lombard (1953, 12) notes that until the 14th century no reference can be found among the Arab geographers' writings (which form the principal source of information on matters of this kind) to ivory originating in west Africa and reaching the Mediterranean across the Sahara. The Byzantine demand was met for the most part by the Islamic markets in Iraq and Egypt, through which passed ivory from India and from east Africa. Zanzibar, Madagascar, Ethiopia and Upper Egypt or the Sudan are mentioned as important sources of African ivory for the Egyptian markets,⁽⁹⁾ while a certain amount of Indian material arrived there via Ceylon (Labib 1965, 48, 84, 88, 335). By way of the important fairs of Pavia and elsewhere, this ivory eventually found its way into the workshops of northern Europe. Only in the later 13th and 14th century did the French and Flemish ports begin to play a significant role in its direct importation (Gaborit-Chopin 1978, 15).

In the renewed affluence of the medieval period ivory began to reach a much wider market, in the form of handles, pommels, gaming pieces, mirror-cases and a range of further wholly secular objects. The continuing development of international trade ensured the supply of raw materials on an appropriate scale, to the extent that in Paris by 1258, for example, no fewer than three different degrees were recognised among the ivory carvers of the city (Cust 1902, 144). The extent to which the ivory carvers worked closely with craftsmen in precious metals and enamels and were essentially involved in the same artistic movements during the medieval period is stressed by Gaborit-Chopin (1978, 16). Indeed the ivory sculpture of the period may have been executed by artists who also worked in other media, while a variety of specialists produced buttons, gaming pieces, buckles and the like (loc. cit.).

Special mention must be made here of one group of objects which fails to conform to this view of the course of the ivory trade. In a number of pagan Saxon graves dating from the 5th-7th century have been found a series of large ivory rings, interpreted as bag rings (p.173). The graves in question show no other sign of particular affluence and neither are other exotic imports much in evidence. Considering the absence of ivory from the more noble Frankish graves of the period, its comparatively common appearance in rural cemeteries in England and, to some extent, on the Continent, is all the more puzzling.

One possible explanation suggests itself : it may be that the ivory in question derives not from contemporary elephants but from the fossil tusks of long-extinct mammoth. This possibility has previously been considered by Green (Myres and Green 1973, 101), who rejected it on the grounds that

fossil material from England invariably fractures within a short time of being uncovered. While this may well be true of tusks coming from well-drained gravel deposits, it does not hold good for all mammoth sources in this country : Dawkins (1869, 208) mentions a tusk from Clifton Hall, between Edinburgh and Falkirk, which was found 'in such preservation that it was sold to an ivory turner for £2. Before it was rescued ... it had been sawn asunder for the manufacture of chessmen'. R Owen (1846, 246) describes another tusk from Dungeness as yielding ivory fit for manufacture and a further specimen from the Yorkshire coast as hard enough to be used by ivory turners. Indeed, the tendency of ivory to split in the 'cone-within-cone' fashion already mentioned (p. 22) might even have encouraged its utilisation in this way, since these rings are merely cross-sections cut on or near the pulp cavity, while positively discouraging the development of other types of artifact. The bronze binding strips found on certain rings (Fig. 60) may have been designed to prevent further delamination rather than to repair accidental fractures.

The fact that only the outermost periphery of the tusk is used for these rings makes the positive identification of species difficult. As already described (p. 22) the angle of intersection of the radiating striae is said by Penniman (1952, 21) to be distinctive for elephant and mammoth respectively but this distinction is clearly seen only in the central area of the solid tusk, which is inevitably missing from the rings, and is less marked at the periphery. Sanford (1973, 34), however, is more circumspect in consideration of the differences. The surviving surfaces on many rings are, in any case, too eroded for this detail to be distinguished. The problem could immediately be resolved with the aid of a few radiocarbon determinations, since mammoth ivory could hardly be younger than c 10,000

years. As yet, however, radiocarbon sample sizes are unacceptably large for application to this problem, the minimum weight being in excess of that of many of the ring fragments themselves. (10)

As well as native sources, origins in Germany, where similar rings are also known (Vogt 1960, 70-90; Koch 1967, Taf 28; Roeren 1960, 245, Abb 21, 3-4) and from Siberia might also be considered. An account of the Siberian sources is given by Digby (1926) : in one year he saw about 1000 pairs of mammoth tusks, some of them in perfect condition and entirely suitable for the production of billiard balls, piano keys, combs and the like (Digby 1926, 53, 170-1). It must be admitted, however, that the possibility of direct importation of this material to Anglo-Saxon England is even more remotely possible than an African or Asiatic origin.

Walrus ivory

The increasing popularity of walrus ivory during the 10th-12th centuries as a raw material for working into secular and devotional objects can be related to the expanding commercial and political relations which developed with Scandinavia during this period.

The natural distribution of the Atlantic walrus today extends little south of 65°N , although formerly it may have been somewhat more widespread (King 1964, 38). Historical references mention isolated sightings as far south as the Thames, where William Caxton recorded one in 1456; between 1815 and 1954 a total of 21 sightings were noted, all but two of them off

the Scottish coast (loc. cit.). While a certain amount of material may, therefore, have been collected locally, it is unlikely that the market could have been satisfied from this source.

A passage of some importance in the discussion of this topic appears in Alfred's account of Ohthere's voyages to the North Cape; its precise significance, however, seems still to be open to dispute. The passage (lines 34-42) runs as follows (Sweet 1967, 18) :

Swiþost he for ðider, toeacan þæs landes sceawunge, for
þaem horshwælum, for ðæm hie habbað swiþe æpele ban on
hiora toþum (þa teð hie brohton sume þæm cyning): ond hiora
hyd bið swiðe god to scipaprum. Se hwæl bið micle læssa þonne
oðre hwalas: ne bið he lengra ðonne syfan elna lang: ac on his
agnum lande is se betsta hwælhuntað: þa beoð eahta and
feowertiges elna lange, and þa mæstan fiftiges elna lange:
þara he sæde þæt he syxa sum ofsloge syxtig on twam
dagum.

The difficulty lies in the last line where Ohthere says that he was one of six (men) who killed sixty in two days. The long-accepted interpretation, which is still observed by present-day authors (eg Foote and Wilson 1970, 40) is that the six men killed sixty whales in this space of time. Almost a century ago, however, Skeat (1888, 44), noting the near impossibility of this task, came to the conclusion that the reference was to the walrus of the previous sentence and not to the whales. Resolution of this grammatical problem lies beyond the scope of this study, although Skeat's interpretation seems inherently preferable.

Beaver

The teeth of one further species deserve special mention. Reference is made below (p.166) to several finds of the incisor teeth of beaver (Castor

fiber), an animal long since extinct in the British Isles. Its former presence in England is, however, recalled in a number of place names of Anglo-Saxon or Old English origin, such as Beverley, Beavercotes and others (Ekwall 1960, 25, 38, 40; A H Smith 1956, 28). No written or archaeological evidence can be found to suggest that it survived into the medieval period in England, but its presence in Wales can be attested up to at least the 12th century (Harting 1880, 33-40; Corbet 1964, 11). In addition to a number of Welsh place names commemorating the beaver - Beaver Pool, Beaver Dam, Vale of the Beavers, etc - Harting (loc. cit.) records two direct references to the animal. In the Laws of Hywel Dda (940), the king was named the sole beneficiary of all beavers, martens and ermines killed for the manufacture of garment borders; since, however, their skins were valued at 120 pence (compared with 24 pence for marten and eight pence for wolf, fox and other furs), they were evidently already scarce in Wales by that time. Over two centuries later, Giraldus Cambrensis mentions in his Itinerary (II, 49) of 1188, that beaver was then to be found in Wales only on the River Teifi in Cardiganshire. Giraldus (loc. cit.) states that the animal also survived on one river in Scotland in his day. Two 16th-century references to beaver surviving in sufficient numbers on Loch Ness in the previous century to have formed the basis of an export trade are open to suspicion in view of the fact that the animal is absent from a list of native fur-bearing animals included in an Act of Parliament of 1424 (Harting 1880, 40-1).

While the continuing survival of the beaver cannot, therefore, be demonstrated beyond the end of the 12th century, those teeth which were prized as amulets in the Anglo-Saxon period (p.166) could certainly have come from native animals.

THE RAW MATERIALS : NOTES

- (1) Interesting illustrations of this process at work may be seen among the Patagonians, who develop spiral grooves on their humeri from continually hunting with the bolas (Halstead and Middleton 1972, 4), and the Balearic slingers of the Roman army, whose humeri developed similar features (Wells 1964, 134, Fig. 24).
- (2) Halstead and Middleton (1972, 10) mention that when collagen is introduced into a solution of calcium phosphate the mineral readily precipitates : they describe collagen as 'the ideal seed bed on which crystals of apatite can form.
- (3) Osteocytes often start their existence as bone-forming osteoblasts, later becoming surrounded by calcified substance and embedded in the bone matrix.
- (4) While the distinction is of convenience and some importance to us, no lengthy history can be claimed for it. The Oxford English Dictionary (1933) explains that the term antler was originally reserved for the brow tine of a stag's horn (Old French antoillier, earlier antoglier, cf Latin ant(e)ocularum and German Augensprosse - the tine in front of the eyes) and later was applied to all tines; as late as 1864, reference is made to 'the brow antler of a stag's horn'. Its current application to the entire horn is, therefore of no great antiquity.
- (5) Dr D. R. Brothwell has suggested to me that trace element analysis might be used to distinguish between antlers from different ecological zones, but so far I have not had the opportunity of testing this possibility.
- (6) The presence of a fragment of reindeer antler, said to have been found under a Roman altar at Chester (Harting 1880, 65), may be explained in the same way as the others discussed here.
- (7) Dr Ruth Ellison has kindly studied the passage at my request and has provided the translation given here.

- (8) I am grateful to Dr Ellison for this information.
- (9) Mas'oudi (quoted in Lombard 1953, 26, n97) records in the 10th century that tusks of 228kg and more were obtained from Zanzibar.
- (10) I have been fortunate in gaining the tentative agreement of a laboratory currently developing new methods of dating small samples of material to apply itself to this problem when the process has been perfected.

SKELTAL TISSUES AS MATERIALS

From the histological descriptions already given, it will be clear that there are two elements - one organic and one inorganic - in intimate combination in the make-up of all skeletal tissue.⁽¹⁾ Individually, these have quite different mechanical properties, the combination of which makes skeletal tissues impressive as structural materials. As with other materials of composite structure, some qualities are contributed by one element and some by the other, the combination being greater than the sum of the constituent parts. The principles behind this phenomenon have been exploited since bricks were first made with straw and pottery tempered with grass, although it is only in comparatively recent years that they have been fully comprehended; the development of synthesised composite materials such as fibreglass and filled rubber,⁽²⁾ which embody the same principles, is counted among the most important advances in materials science of the 20th century (Gordon 1976, 173-205).

In the case of mammalian skeletons, the organic collagen may be said to provide tensile strength while stiffness and compressive strength are contributed by the mineral crystals. It must immediately be admitted, however, that this is an oversimplified statement which fails to acknowledge the intimate and complementary behaviour of the two materials. For example, although the collagenous matrix is capable of more elastic behaviour than the apatite crystals with which it is permeated, the mineral crystals would become cracked and broken if the tensile load exceeded their ultimate stress. In practice, bone displays a modulus of elasticity (see below, p.56) which is intermediate between that of

its two components. Fibreglass and similar 'two-phase' materials exhibit the same characteristics, having a modulus of elasticity midway between that of the two components but a greater strength than is possessed by either one (Halstead 1974, 112).

A further illustration of the advantages gained by skeletal materials from this composite structure is provided by an examination of the behaviour of cracks. All solids exhibit tiny surface or internal irregularities in the form of notches or holes which, from a structural point of view, present hazards since they have the effect of concentrating stresses around them (Gordon 1978, 65-9). Fig. 19a illustrates the manner in which lines of force acting on a single crystal run in regular fashion from one end to the other, while in Fig. 19b the stress-concentrating effect of a notch can be seen. If whole bones were constructed of solid mineral, such stress concentrations would be much more dangerous, since cracks would tend to run through the entire structure without impediment. As has been shown, however (p. 6), bone mineral in the form of apatite needles is arranged in closely-packed but discreet units clothed in a collagenous matrix, with the result that the likelihood of cracks running from crystal to crystal is diminished each time an interface is encountered, by means of the so-called 'Cook-Gordon crack stopper' effect (Fig. 20). This effect results in the force generated by a crack opening up a second crack at right angles to it; further spreading of the crack is blocked in this way (cf. Gordon 1976, 112-24, pl 11). The effectiveness of this arrangement is maximised by two factors : firstly, if the long axes of the crystals are aligned with the direction of the principal loads encountered, as tends to occur in stress-bearing laminar bone and,

secondly, if a sheath of pliant material can be introduced between the crystals, a specification fulfilled by the collagenous matrix. At a higher level of structural organisation, similar defence mechanisms can be observed, comparable weak interfaces being encountered between laminae, between lamellae and around Haversian systems (pp. 6-8). The normal alignments of osteocyte lacunae and of blood channels tend also to be with the main axis of the bone, ensuring that the stress-concentrating effects are minimised and providing further potential crack-stoppers.⁽³⁾

The form of structure just described is only desirable when the direction of stress is fairly predictable, however, since the high degree of orientation which makes the bone stronger in one direction inevitably makes it correspondingly weaker in others. The advantage of this anisotropic (directionally oriented) arrangement is that greater unit strengths can be achieved in directions normally subject to maximum loads than would be possible with a similar volume of isotropic (non-aligned) material. Hence woven bone, with its relatively non-aligned structure, may have a lower maximum strength than laminar bone but will be more consistent in performance in all directions (cf. Fig. 22), rendering it especially suitable for growing bone in which maximum stresses can change direction with development.

The ratios of organic and mineral matter in skeletal bone are finely balanced to produce optimum mechanical performance. The effect of deviation from this balance may be seen in certain highly specialised bones : for example, in certain ear bones (tympanic bullae) which are not expected to bear any degree of stress, the abnormally high level of mineralisation brings about a marked decline in elasticity and impact strength, while in antlers some of the ability to resist the impact

loads to which they are subjected during combat is achieved by an adjustment downwards of the 'normal' mineral content (Currey 1979, 313-9).

Further instances have been noted of ways in which structural features of bone can be considered as analogous to those found by scientists and engineers to be highly efficient in synthesised materials. Halstead (1974, 112), for example, has noted that the alternating alignment of collagen fibrils in successive lamellae of Haversian systems (p. 8) may be likened to man-made ply structures, the advantages of which are well known. There is no doubt that the whole bone gains in strength from the effects of this microscopic feature. At a higher order of magnitude, Gordon (1978, 295-9) has pointed out that the sandwich structure of certain flattened bones (p. 11) in which the space between the dense outer surfaces is filled with spongy cancellous tissue is one which, over the past fifty years, has been widely adopted for the construction of strong lightweight panels; in these, the outer skins are formed of wood or plastic and the interiors of paper honeycomb or, more recently, foamed resins. The excellence of this type of structure in resisting bending or buckling loads is obviously as important in the design of skeletons as it is in, for example, aircraft construction, in which the man-made versions were first used.

MECHANICAL PROPERTIES

A brief examination of the mechanical properties of the materials under consideration provides not only a better understanding of their respective qualities but also a body of factual data through which objective comparisons of the performance of each can be made. Furthermore, once armed with

this information we are equipped to demonstrate a number of conditioning factors which clearly determined the consistent choice of some skeletal materials in preference to certain others. Without this objective foundation, resting on scientifically established quantitative data, any survey of materials of whatever kind has immediately placed upon it the most severe constraints.

Although the principles embraced by the 20th century study of materials science have been elucidated for the most part in comparatively recent times (see for example, Gordon 1976 and 1978), they have applied no less inexorably to every physical artifact ever produced by the hand of man : in other words, their existence has not been dependent on our comprehension of them. This is not to say that their effects may not have been observed, however, and due allowance made for them : a craftsman's 'intuitive' knowledge of the potential and limitations of his material is in reality the result of close observation of its performance under everyday and extraordinary circumstances. Intuition of this kind may be the result of a lifetime of attention, enhanced perhaps by the inherited experience of many previous generations.

The objective definition of the properties of our materials will not serve as a substitute for the hard-won skills of the craftsman, but will make it possible for us to apprehend, perhaps more clearly than any lengthy practical apprenticeship, some of the controlling factors which lay behind the traditions and practices current among the tradesmen whose wares form the basis of the discussion below.

Definitions

The clarity of the discussion which follows may be enhanced by a few brief explanations of the terminology which will be used. These have been drawn from a number of sources : further reference may be made to Currey (1970b, 210-31) and Frost (1967, 3-39).

Stress

The stress acting upon a solid is an expression of the load or force applied to the material divided by the cross-sectional area. At any point in the material, therefore,

$$\text{Stress} = \frac{\text{load}}{\text{area}}$$

the equation being equally true for compressive and tensile stress. The SI (System International) unit for stress is the Meganewton per square metre (MN/m^2). (1 Newton = 0.102 kg force; 1 Meganewton = 1 million Newtons, almost exactly 100 tons force.)

Strain

Strain is an expression of the proportion by which a material is extended (or compressed) under stress, represented by the formula

$$\text{Strain} = \frac{\text{increase in length}}{\text{original length}}$$

The product is usually represented as a percentage.

Stress-strain diagram

The relationship between stress and strain for any given material can be expressed in the form of a graph (Fig. 21), which is constant for the

material. In the stress-strain curve given in Fig. 21a, OA is a straight line portion, in which an increase in stress produces a proportional increase in strain. This is the so-called region of elastic strain where, if the stress is removed, the strain will return to zero. If the stress is increased beyond point A where the curve begins to bend over, the material continues to behave elastically although the stress is no longer proportional to the strain. Beyond point B, however, known as the elastic limit, elastic behaviour ceases (ie the strain fails to return to zero when the stress is removed and the material remains deformed to some extent). In the example given in Fig. 21a, if the stress is increased to point B, the material remains deformed to the extent $0-0'$. This permanent change is known as plastic strain. Beyond the elastic limit the curve gets progressively flatter until at point C it finally breaks. The value CD is the ultimate stress of the material which may, for our purposes, be considered to represent its 'strength'.

The area contained within the stress-strain curve at the breaking stress is a measure of the work per unit volume which had to be expended in order to break the specimen; in other words, it is approximately proportional to the amount of energy which was absorbed before breaking. This expression we shall call 'toughness'. It is important to appreciate the distinction between strength and toughness : by reference to Fig. 21b, it will be seen that the material represented by the curve OGH, while having a lower ultimate stress (strength) than that represented by OEF, contains a greater area within the curve and hence is tougher.

Modulus of elasticity

Many solids produce a stress-strain diagram of the kind given in Fig. 21, in which part of the curve is occupied by a straight line, indicating that an

increase in stress within certain limits produces a proportional increase in strain. Under these circumstances, the ratio of stress to strain, as expressed by the slope of the straight line, is a constant, known as the elastic modulus or Young's modulus of elasticity.⁽⁴⁾ Hence :

$$\text{Elastic modulus} = \frac{\text{stress}}{\text{strain}}$$

Young's modulus, measured in GN/m² (1 Geiganewton = 1,000,000,000 Newtons) is effectively a measure of stiffness; the less the deformation for a given load the stiffer the material. (This is not the same thing as 'strength', however : cf values for stiffness (E) and ultimate tensile strength for collagen and keratin in Currey 1970a, Table 1.)

Bending strength (modulus of rupture)

Measurement of the bending strength provides a further useful index of the properties of materials and has the advantage of being fairly easily established : Fig. 23 gives a comparison of the relative ease with which the deformation involved in the bending test can be measured compared with extension in the establishment of strain. The degree of accuracy necessary in the production of test specimens is also markedly less for the bending test (Currey 1970b, 214). The value is gained by the formula

$$\text{Maximum stress} = \frac{\text{bending moment} \times \text{deflection}}{\text{moment of inertia of section}}$$

Because the forces operating on the specimen are more complex than those involved in a straightforward tensile or compressive test (Fig. 24), however, the product cannot be regarded as identical with the ultimate stress and is referred to as the modulus of rupture. Currey (1970b, 220-2) suggests a division of the value for the modulus of rupture by 1.5 to produce a more accurate figure for ultimate stress.

Comparative values

Although a considerable amount of work has been carried out in determining the mechanical properties of bone (see Currey 1970b for a review) the other skeletal materials considered here have attracted scant attention in scientific circles. Furthermore, the results which have been achieved with bone relate mostly to living skeletons in which the bone functions in a wet environment, whereas artifacts made from this material were used (and also, at least in some instances, manufactured) while dry : considering the differences in the values obtained for wet and dry tissue respectively (Fig. 25), the importance of obtaining figures under appropriately dry conditions will be self evident.

Table 1 lists such figures as I have been able to obtain for skeletal materials. The results were obtained by machining test specimens from the raw material to a size of approximately 30 x 3 x 2mm and loading them in three-point bending (Fig. 24) in an Instron table testing machine with a head speed of 2 mm per minute. The work was carried out in the laboratory of Professor J. D. Currey at the University of York. For these facilities and for much patient guidance and help I am greatly indebted to Professor Currey.

In brief, bone and antler are shown to have comparably high bending strengths in the longitudinal axis, testifying to their structural excellence. Both materials yield significantly lower values in the transverse axis : while this is as might be expected from the anisotropic structure of the tibia (p. 52), the marked difference exhibited by the antler, which has a less obviously oriented structure (p. 14) is surprising.⁽⁵⁾ The practical effects of this situation are assessed below (p. 59). While the values

obtained for ivory are rather lower, it should be noted that the ivory samples were tested wet while the others were dry : judging from the figures obtained for wet bone and antler, the wet strength is likely to be about two-thirds that of the dry tissue.⁽⁶⁾ The effect of soaking the tissue can be seen by comparing the stress strain curves shown in Fig. 25.

The same process accounts for the very low value for the modulus of elasticity shown for ivory in Table 1, compared with the much stiffer bone and antler. The value for horn is an accurate one, however, and this impressive property is one which is important in the context of the use of horn as an energy store in, for example, composite bows (p. 150).

Applications

An appreciation of the differing mechanical properties of the skeletal materials and of the significance of these differences is fundamental to a proper understanding of the development of the industries which depended on these materials for utilisation. One example may be chosen from the widely varying types of artifact reviewed below which demonstrates the manner in which such an appreciation can be of basic importance.

Composite combs are amongst the most complex of objects made from skeletal materials. A discussion of their various structural, morphological and stylistic features appears below (pp 199-240). The reasons why combs of this type should have evolved have never been satisfactorily explained (p. 206) and neither has the fact that the overwhelming majority of them are made from antler rather than bone. Considering the effort involved

in the manufacture of combs of this type and the more ready availability of bone compared to antler, explanations for these phenomena must be sought; the answers, however, can only be demonstrated by reference to the data established here.

Dealing first with the method of assembly, an examination of the surface structure of the antler used reveals that it is invariably aligned in the horizontal plane (ie, in the long axis) in the case of the side plates and vertically in the case of the tooth plates. Whereas many bones of larger animals and many of the more sizeable red deer antlers are capable of producing plates in which large numbers of teeth could be cut at right angles to the 'grain' of the tissue, the fact that the teeth in composite combs are cut with the 'grain' means that the tooth plates are necessarily restricted in length (as defined in Fig. 66) and hence it was only by riveting numbers of them side-by-side that combs of the types favoured from the late Roman period until about the 12th century could be produced.

The reason why the comb makers chose to cut the tooth plates in the vertical plane can be demonstrated by reference to Table 1, in which are shown the relative strengths in each axis for bone and antler : in each case the material is stronger by about three times in the long axis than across the grain - 343 as against 123 for antler and 299 as against 96 for bone. Immediately it becomes obvious that the apparently cumbersome and 'primitive' method of comb manufacturing was in fact cleverly devised to maximise the properties which are revealed to us only by means of scientific examination. To the craftsmen who made these objects, the disadvantages of teeth cut across the grain would have been self-evident.

By a further step the reason can be demonstrated why antler was preferred almost universally to bone, both in the manufacture of combs and indeed for a great many other purposes. The values for the bending strengths of bone given in Table 1 are lower in each axis than those for antler, but the differences are too slight to be of much significance - 343 for antler as against 299 for bone in the long axis and 123 compared with 96 across the grain. More significant are the properties revealed in Fig. 26. Here the similar values obtained for the modulus of rupture of the two materials are reflected in the almost equal heights achieved by the curves before the breaking point was reached. A more telling comparison can be made, however, by examining the area contained within the curves which gives a measure in each case of the work which had to be done on the specimen before it finally broke. It is quite clear from these graphs that a greater amount of work was needed to break the antler and, by reference to Table 2, we can see that the difference is in the region of three times in the longitudinal axis - 112 compared with 39; the transverse values again show a significant difference in favour of antler, this time in the region of two and a half times.

In practical terms, these figures mean that antler is a significantly tougher material than bone, with a markedly better capacity to absorb shocks and sudden impact loads such as the slender teeth of composite combs might suffer while being dragged through tangled hair or which might befall any number of the other implements commonly made from antler.

To my knowledge, these very significantly different properties of bone and antler have never before been compared in this way.⁽⁷⁾ The results are clearly of fundamental importance to the understanding of these

materials and, ultimately, to the explanation of the rise of the antler industry during the period under review.

SKELETAL TISSUES AS MATERIALS : NOTES

- (1) On the insignificant proportion of organic material in dental enamel, however, see p. 17.
- (2) Halstead (1974, 112-3) considers filled rubber to be closely analogous to bone.
- (3) On the importance of the angle of the nutrient foramen, for example, see Wainwright et al (1976, 182).
- (4) Young's modulus may be regarded as an expression of the stress which would double the length of the material if it did not break first; that is, the stress at 100% strain.
- (5) Currey (1979, 314) has noted some 'grain' in antler structure, visible under polarized light.
- (6) The initial series of tests for this project were all carried out using wet material, before it emerged that dry conditions would be more appropriate for archaeological considerations. By the time this realisation was made, my stocks of ivory had been exhausted and hence figures for dry tissue were not obtained. Wet bone was found to have a bending strength in the longitudinal axis of 199 and wet antler 178.
- (7) Professor Currey's recent paper in which comparisons are drawn between the mechanical properties of bone and antler was written after this particular project was begun and acknowledges the contribution of archaeology to its genesis (Currey 1979, 318).

WORKSHOP PRACTICE

To some degree, the title of this section begs the question of the extent to which skeletal materials were indeed fashioned into artifacts in workshops, with the implication that they were produced by an 'industry' which was in some way professionally organised. The question is one to which there is no simple answer, but nonetheless an attempt at assessment is clearly required.

Given the general availability of the raw materials concerned and the simple nature of the basic tool-kit needed for production of the more straightforward articles, it is inevitable that some level of manufacture was always carried on by individuals in response to immediate or everyday needs. Many of the simpler implements and toilet articles were no doubt produced in this way : few would have paid for a crude dress-pin cut from the fibula of a pig when pork was on everyone's menu. Less fallible criteria than those of quality of workmanship will, however, be required to establish with certainty the activities of professional craftsmen.

Perhaps the ideal evidence would take the form of an actual workshop with traces of the craft activity in situ. To date, archaeological activity in Britain has failed to match this ideal in terms of actual buildings, abandoned with the evidence intact within, but on a number of occasions there have been discoveries of rubbish pits or dumps which clearly served such workshops. The concentration of waste material in the form of off-cuts and broken or unfinished articles in such pits immediately distinguishes them from domestic refuse pits and from this waste a picture can be built up of the repertoire and working methods

of the associated workshops. In Dublin, for example, comb-making workshops have been postulated in certain areas of the High Street and Christ Church Place excavations on the evidence of concentrations of characteristic waste fragments and unfinished component parts (Ó Riordáin 1976, 140; Viking and Medieval Dublin, 15). Amongst the spoil from a rubbish pit, cut through by a mechanical excavator in York, were found many fragments of decorated ribs, seemingly from broken comb-cases : these too have been taken to indicate the presence of a specialist workshop (MacGregor 1978, 48).⁽¹⁾

On the Continent, unequivocal evidence for several comb-producing workshops is recorded from Wolin (Cnotliwy 1958, 228; ibid. 1970, 286-7), including the presence of many unsawn blanks for tooth-plates and rough-outs for side-plates. Another workshop is known from Kołobrzeg (Cnotliwy 1956, 177), associated with which were about 1700 waste and partly-worked pieces of antler. Further evidence of consistent workshop practice, possibly connected with comb making, is found in the form of sawn-off articular ends of cattle metapodials : examples cut in a standardised manner have been found in Münster, associated with 8th-century comb making (Winkelmann 1977, 112), in Dorestad (Clason 1978, Fig. 2) and in Saxon Southampton (Holdsworth 1976, 45). An early find of Iron Age date from Quenstedt (Grimm 1930, 169, Taf 18) demonstrates that specialist workers in skeletal materials had emerged well before the period with which we are concerned here and the high quality of workmanship and well-established methods of handling and cutting up the antlers (p. 204) and bones (see above) are additional factors in support of this claim. On the evidence of softening pits, see p. 83 .

Many other excavations, particularly in urban contexts, have produced unfinished comb fragments, but here we are insisting on concentrations of finds to justify our conclusions as to the presence of professional workshops. One salutary situation must be mentioned here, in which the opposite conclusion has been reached in the presence of enormous amounts of material. At Hedeby which, with over 280,000 antler fragments, has produced more evidence than any other site in Europe for the working of this material, the excavators have come to the conclusion that, since the raw materials were scattered widely over the site, there was certainly no 'comb-makers' quarter' and there were probably no workers who spent the entire year employed in the manufacture of these items (Ulbricht 1978, 117-9 : see also p.203). To deny that they were professionals in the sense in which we are attempting to establish the term here seems, however, to put too narrow a definition on the word. Cnotliwy (1956, 177), on the other hand, recognises that comb-making must have been in specialist hands because of the tool-kit involved, much of the more everyday bone working being carried out merely with a knife or axe. If a parallel activity which might have shared the attentions of the antler-workers had to be sought, then amber-working might be a possibility, the two activities having been found in association at Kołobrzeg (op. cit., 178) and sharing to some extent a common tool-kit.

Bone waste, as well as antler, is occasionally found in concentrations suggesting intensive specialist activity. Evidence of this in the form of so-called weaving combs (Pl. 19) and of fragments of the metapodials from which they were fashioned comes from the unpublished excavations in Schleswig, and the same town has produced large numbers of jaw-bones with neatly-drilled holes from which gaming pieces or spindle whorls have been cut (Pl. 16).

The activities of horners are occasionally recognised in urban excavations when the retting pits in which the horns were soaked are occasionally recognised (Ryder 1970, 418). Otherwise the archaeological evidence for horn-workshops is, as yet, rather scarce; current excavations in London are, however, producing information which may change this situation.

Ivory too is practically unknown in an unworked or unfinished state from archaeological excavations. Two waste fragments of elephant ivory, found in an Anglo-Scandinavian or Norman context in York were, however, judged to be refuse from the manufacturing stage (Radley 1972, 50, 64). It seems unlikely that any such commercial workshop would have worked exclusively in this costly material, although some ecclesiastical or monastic centres may have supported schools which did so. (The York fragments were found in a rampart following one side of the monastic enclosure of St Mary's Abbey, founded in 1089.)

Finally, a small amount of place-name evidence may be brought to notice here. Many towns have streets with names incorporating the element 'Horn' or 'Horner', as in Horn Lane, Hornpot Lane, etc., testifying to the former presence of horners' workshops. Many or all of these names date from the medieval period or later, when there is in any case ample documentary evidence for flourishing gilds of horners. In one instance it may be justifiable to see the survival of an earlier street name linked to an earlier industry : I have suggested elsewhere (MacGregor 1978, 46) that Hartergate in York, the name of which is identifiably Scandinavian in origin by its gate termination, may not as previously postulated (A. H. Smith 1937, 289) be derived from some person with the name Hjort (genitive Hjartr) but may instead refer to the presence there of the workshops of

'hartshorners' or antler-workers during the Viking period. Although certain philological reservations have been expressed to this suggestion (MacGregor 1978, 57, n7), it remains an interesting possibility.

TOOLS AND WORKING METHODS

Few tools have been found in circumstances which directly relate them to the working of skeletal materials. We may attempt, however, by reviewing the known range of implements available to the craftsmen of the period and by examining traces of working which may be observed on certain artifacts, particularly those which remain unfinished, to establish the range of the craftsman's tool-kit and the methods he employed in working his materials.

Cutting and splitting

Saws were certainly among the most important implements used in the working of skeletal materials. Much more control can be exercised in their use than in the percussive methods of cutting discussed below. Traces of their use can be seen, for example, on many discarded antler burrs where they have been separated from the beam (Pl 8). The saw marks show clearly how the material was rotated periodically so that the blade never became too deeply embedded. Saws for this type of work must have been comparatively robust : unfinished cuts of 2.6mm width have been observed on certain pieces of waste while, at the other end of the range, the saw cuts may be as narrow as 0.1mm (Ulbricht 1978, 36).

In addition to their use in cutting up material and in working the detailed structure of certain categories of artifact, saws were also used in applying

surface decoration. Close examination of the cuts in schemes of incised decoration shows that they are either V-shaped in section, indicating that they were cut with a knife, or else they are square in section in which case they have been saw cut. At Hedeby, careful measurement of saw-cut decoration has revealed that double saws were sometimes used for this purpose, two blades being mounted side-by-side to produce double cuts which were inevitably always parallel to each other and a fixed distance apart (Ulbricht 1978, 37). This type of decoration (double lines, arranged in crosses, bands, etc.) is widespread on combs of the Viking period and it seems certain that Dr Ulbricht's observations will now be repeated many times elsewhere (see, for example, Pl 10).

Only two saws have so far been found in Anglo-Saxon contexts, from Icklingham, Suffolk, and Thetford respectively (Wilson 1976, 257). The Icklingham blade (Fig. 27) is single-edged and was evidently held in a rigid backing of folded sheet metal. The teeth are quite fine, averaging some 4.6 teeth per cm over 13cm. The blade from Thetford (Fig. 27), which is incomplete, has teeth on both sides with frequencies of c. 3.7 and 6.1 teeth per cm respectively. No details of the set of the teeth or of the width of the cut which would result from their use have been published. Neither is the method of handling or hafting the Thetford saw discernable from the surviving fragment. In addition, fragments from an iron saw blade found at Lochlee Crannog, Ayrshire (Fig. 27) and published by Munro (1879, 192, Fig. 3), should be noted.

Berg (1955, 77-83) has published a fine Viking-age saw with a one-piece bow from Måstermyr, Gotland, while Hruby (1957, 216, Fig. 26) illustrates an alternative Slavic knife-like form which has a rectangular-section tang,

a broad back and a serrated edge (Fig. 27).

Traces characteristic of axe cutting are common on certain groups of artifacts. At Hedeby it has been noted that the antlers of slaughtered deer were detached with a number of axe blows to the frontal bones of the skull (Ulbricht 1978, 39). It was clear that the axes in question (which were presumably used by huntsmen or, perhaps, butchers) were much larger than the finer implements which were subsequently used by the antler-workers themselves. Horners too made use of axes, recognisable chopping marks having been noted on the bases of discarded horn-cores resulting from the detaching of the horn itself (Rackham, forthcoming). At the production stage, axes seem commonly to have been used in shaping such items as skates (Fig. 88) and socketed points (Fig. 43). Axes of varying sizes (Fig. 28) have been found on a number of sites (Wilson 1976, 255-7; Waterman 1959, 72). Wilson (loc. cit.) notes that some axes have butts showing signs of having been hammered, suggesting that they may have been carefully positioned before the cutting blow was delivered by striking the back of the axe. The process of splitting off thin slips of antler for the manufacture of comb tooth-plates must have required precise control of the kind which could have been achieved in this way. Broad chisels, which would have been equally appropriate for this task, are practically unknown in pre-Conquest levels : Wilson (1976, 257-8) notes only one certain example, from Southampton.

Wedges of iron which, along with those of wood, were important items in the carpenter's tool-kit, being used to split timbers along the grain, would have been less useful in working more homogeneous skeletal materials. A recent find from Hedeby has, however, given a unique insight into the use

of antler wedges in splitting up the thick beams of antlers for utilisation : one such beam section was found with a wedge cut from a tine driven into the cancellous core at one end of the beam (Pl.11), the longitudinal outlines of the desired strips already having been marked out by deep grooves gouged into the surface of the compact tissue (Ulbricht 1978, 39-40, Taf 26, 4-8).

Some shaping operations seem to have been carried out with the aid of knives. Traces of their use, in the form of small depressions where chips of material have been sliced off, can be detected on utilised antler tines (Pl. 12) and elsewhere. No doubt much of the incised free-hand decoration seen on bone objects - panels of interlace and the like - was executed with knives. The most likely alternatives, fine gravers or chisels, are unknown, although one example of a bone weaving comb of Iron Age date decorated in the 'rolled graver technique' is known from Meare lake village (Penney 1975, 65-6). Knives are amongst the best-attested implement types and include (Fig. 29) a variety of blade-sizes appropriate for a range of tasks from intricate carving to heavy chopping duties.

Although they survive only very rarely, draw-knives seem to have played an important part in the working of bone and antler. Flattened facets indicating their use can occasionally be seen on finished objects (Pl.13). Concentrations of shavings of antler from Hedeby (Pl.14) also provide a clear indication of their use there. Draw knives seem the most likely implements to have been used in shaving down tooth plates for the manufacture of composite combs.

Smoothing and polishing

Although a number of files have been recovered from excavations in Novgorod (Kolchin 1956, Fig. 47, 4; ibid., 1965, Fig. 5), early examples

are, as yet, unknown in Britain. Judging from the series of transverse parallel lines which may occasionally be detected on bone objects (Pl.15), some smoothing was done with the aid of a knife blade held crosswise and pulled along the surface, producing these characteristic 'chatter marks'. Otherwise, in the absence of suitable implements, various mineral and organic substances were most probably used for smoothing and polishing. It has already been suggested (MacGregor 1974, 92) that fragments of pumice collected from shorelines in the northern isles may have been used in bone-working. A fragment from an early tool-box from Orkney (Cursiter 1886, 49) may similarly have been used as an abrasive in woodworking. Other minerals which have been used in recent years for working skeletal materials include rottenstone (a decomposed siliceous limestone) and crushed chalk (And es 1925, 33-6). Organic alternatives recorded by the same author (loc. cit.) include powdered charcoal, ashes of bones or antlers, and shavegrass. Hard stems of shavegrass (Equisetum) were apparently chopped into finger-length pieces, thirty or forty of which were bound together, softened in water for half an hour, then used for scouring out blemishes in prepared horn (op. cit., 55). Another possible alternative was coarse fish skin, which was certainly used for smoothing ivory in the Roman period (Barnett 1911, 680); the practice could conceivably have been followed in northern Europe. The high degree of polish commonly imparted to such items as the side-plates of composite combs results in all traces of the coarser smoothing stages being obliterated.

Turning

The regular outlines of certain circular-section objects clearly demonstrate that they were lathe-turned. A well-attested series of Roman knife- or

sword-hilts with sinuous outlines (p. 129) seem to have been mass-produced in this way. From the Anglo-Saxon period, the common plano-convex gaming pieces which have been likened to slices cut from billiard balls on account of their symmetry are often said to be lathe-turned (p.265). It is indeed conceivable that they were made in this way, the roughed-out bone discs being moulded on the chuck of a lathe to which they had been attached in some way. A simpler method might also have been used : the twin (or multiple) blind holes which occur on the bases of some of these pieces might not, as is often suggested, have been for attachment to the lathe; instead, a simple forked implement could have been inserted in the back and used as a handle to spin the roughly-shaped bone disc in a suitably-shaped hollow in a stone. The result would be almost equally symmetrical to that obtainable on a lathe. The bone discs closing the ends of the cylindrical gaming pieces from Taplow may have been lathe turned or, perhaps, produced with a profiled centre-bit (p.267).

Pre-conquest lathe-turned bone objects are otherwise unknown in this country,⁽²⁾ but a carefully made Migration Period box from Pflaumheim in the Main-Tauber region (Koch 1967, 77, Taf 14, 10) can be recognised from its precisely-cut regular outlines as having been lathe turned. A comparable cylindrical box was found in a female grave of 7th-century date at Gammertingen, Hohenzollern (op. cit., 77).

From the 11th century onwards the practice seems to have become more common. Amongst the earliest lathe-turned products of this period are crossbow nuts, examples of which come from Goltho Manor in the late 11th century and from Wareham early in the following century (p.159). Later

in the medieval period, turned nuts of antler (and sometimes ivory) become fairly common. Bone styli (or parchment-prickers?) are frequently made in this way, their machine-made regular appearance distinguishing them from dress pins even when only a fragment survives (p. 135). These also make their appearance soon after the Conquest and to the same period may be attributed two bobbins of antler from Coppergate, York, ornamented with multiple circumferential grooves (Fig. 42). A mount, possibly the terminal from a wind instrument, which was found in an 11th-century context at Winchester (MacGregor, forthcoming), may also be noted in this context.

No lathes of this period are still in existence although some possible fragments have been found at Hedeby (Dr K. Schietzel, personal communication). These would almost certainly have been pole lathes such as were used in the manufacture of wooden bowls (MacGregor 1978, 51) as well as in the production of jet and amber rings and beads (op. cit., 41). An illustration of a lathe of this type appears in a 13th-century manuscript in the Bibliothèque National (ms Lat 11560, f. 84(1), reproduced in Salzman 1964, 172) and accounts of them are given by Salzman (loc. cit.), Hodges (1964, 117-8) and G. B. Hughes (1953, 92).

Drilling

Traces of the use of drills are very commonly found on artifacts of skeletal materials, particularly on articles of composite structure such as combs (p. 204) and caskets (p. 304). Although a considerable number of early drill-bits are known (Petersen 1951, 227-32; Wilson 1968, 146; Wilson, 1976, 258-9), most of them are shell-bits (or spoon-bits) which, although

effective on fibrous material like wood, would make little impression on bone, antler or ivory. Similarly, the punches which have been postulated as having been used for perforating bone and antler (Hruby 1957, 216) would have been quite ineffectual. For these dense and compactly-structured materials, implements incorporating well-defined pointed cutting ends would have been more appropriate, in the form either of angular-section awls for smaller perforations or of centre-bits, in which the cutting element describes an arc around the centre point, for larger holes. While awls are among the most commonly found implements on archaeological sites none have been found in circumstances specifically associated with bone working. Centre-bits, on the other hand, are unknown from early contexts, although tools employing the principles of the centre-bit were certainly employed for the production of ring-and-dot ornament from the period considered here (p. 76).

Implements of the centre-bit type with larger dimensions may also be postulated on the evidence of discoid playing pieces (Fig. 87) and spindle whorls (Fig. 35) cut from jaw bones. A large series of jaw bones (bovine mandibles) has been recovered in Schleswig (Pl. 16a), each drilled with one or more holes from which such pieces have been cut. Of necessity, the material which originally occupied the area within these perforations was not destroyed in the drilling process, so that some form of centre-bit must have been used. Interestingly, none of these gaming pieces has a deep central indentation as might be expected from using a standard centre-bit of present-day type. An antler burr with a large central perforation of 24mm diameter (Pl. 16b) from Hedeby was probably drilled in the same way.

Scribing

Apart from saw- and knife-cut ornament, the most commonly encountered form of decoration on bone and antler objects is inscribed ring-and-dot motifs. Occasionally, the concentric ring elements display an irregularity which indicates that they were executed freehand (MacGregor 1974, Fig. 16, 204), but the vast majority are perfectly symmetrical and must have been produced with an implement of the centre-bit type. This type of decoration is occasionally referred to as 'compass-drawn',⁽³⁾ but a more simple tool with fixed-radius scribing points would seem to be more probable than a compass. Equally symmetrical double-ring-and-dot motifs (Fig. 69) show that some of these implements may have had two or more scribing points at differing radii although two single-toothed implements of differing dimensions could have been used successively to the same effect. The concentric rings sometimes incised on the surfaces of discoid playing pieces (Fig. 87) and spindle whorls (Fig. 35) carry similar implications.

Only one implement capable of producing ornament in this fashion has so far been found : Hruby (1957, 216, Fig. 26, 3) illustrates a tool (Fig. 30) shaped rather like a drill-bit, terminating in a central point flanked on either side by another point; the lateral points are of unequal length but seem to be equidistant from the centre, so that in use only a single circle would have been described around the centre point.

A second type of scribing implement may also be postulated. This produced incised lines at a fixed distance from the edge of the material, so that we may envisage a stop which followed the outline of the piece and one or more

teeth which executed the decorative grooves. The principle involved is therefore similar to a present-day carpenter's mortice gauge, except that there was unlikely to have been any facility for adjustment. Evidence of the use of these implements comes from casket mounts (Fig.90) and combs (Fig.76). In the latter case, the border lines which follow the profile on certain Viking age combs (Fig. 77) may be noted and also, more strikingly, the double border lines found on some end plates of complex outline from the same period (Fig.77). Grooves of this type are usually flat-bottomed in section, suggesting that a small chisel-like point was employed. No appropriate implements have yet been found.

Rouletting

A recent find from excavations at Coppergate in York has added a new technique to those recorded for bone decoration. The object (Fig. 91) is a wooden box lid decorated with bone strips cut from split ribs which, in turn, are ornamented with zig-zag and linear patterns of impressed dots, having the appearance of being rouletted. This technique, which is more appropriate for soft materials such as leather or (unfired) pottery, may have been used in conjunction with one of the softening methods discussed below (p. 79) : only with prior softening does it seem likely that sufficiently deep impressions could have been made with a rouletting wheel. No extant examples of the latter are known.

Gauging

For certain tasks, notably the production of tooth-plates for composite combs, the use of some sort of gauge or template seems to be implied. As

noted below (p.205), the teeth on combs of this type were invariably cut after the blanks had been riveted between the side plates. In order that the junctions between adjacent tooth-plates always coincided precisely with one of the saw cuts for the teeth, it seems necessary for the blank tooth-plates to have been cut to predetermined sizes corresponding to whole numbers of teeth. This could have been achieved either with a rule or gauge on which the appropriate spacings had been marked or else with a series of templates of suitable dimensions. One comb from Abingdon (Pl.29) displays scribed lines running from the ends of the saw-cut teeth; they are extremely irregular compared to the teeth themselves, however, and seem more likely to be of secondary origin than to be marking-out lines.

Clamping

One type of implement (Fig. 31) has tentatively been identified as having been used to secure small pieces of material while they were being worked. Characteristically, they consist of two elements of antler joined by a stout iron rivet. Each antler piece is D-shaped in section, the flat edges being contiguous; viewed from the side, the opposed faces of the antler grips diverge from each other towards one end. The method of use, as suggested by Jankuhn (1943, 149), is for the material being worked (such as tooth-plates for composite combs) to be inserted between the open jaws at one end which are then made to clamp around the object by means of a wedge hammered into the opposite (closed) end, the iron rivet marking the fulcrum point.

Clamps of this type are known from Hedeby (Jankuhn 1943, 149, Abb 74), Trelleborg (Nørlund 1948, Pl XXIX) Ytre Elgsnes, Trondenes (Simonsen 1953,

113-5, Figs. 3, 5) and also from Iceland (Eldjarn 1956, 349, Fig. 165), but have not yet been found in Britain.

Riveting

Composite items of skeletal materials were frequently assembled by riveting. The casket mounts discussed below (p. 304) were attached to their wooden boxes in this manner and all combs of composite construction (p. 204) were assembled by this technique. Two alternative methods of riveting can be found in each of these groups of objects, one using bone (or antler) and the other metal. The use of bone pins for either group had the advantage that incised decorative schemes could be continued over their heads; it should be noted, however, that the use of bone rivets on combs is both rare and largely limited to the Celtic world. Iron rivets were most commonly used for all purposes. A few Early and Middle Saxon period items, such as the Taplow gaming pieces (p. 267), make use of bronze rivets, but these remain uncommon until the beginning of the medieval period, when they are used more frequently and in greater numbers (p. 228).

Softening and moulding (Figs. 32-3)

The techniques mentioned hitherto in this section have been applicable equally to all the raw materials under discussion. On the question of softening and moulding, however, the differing physical properties of these materials demand individual consideration; only bone and antler may be considered together for these purposes.

Two objectives may be distinguished in this context : softening may be induced temporarily either with a view to altering the shape of the artifact (or the raw material) before restoring it to its original hardness or else to facilitate the process of fashioning or decorating it by making it easier to cut.

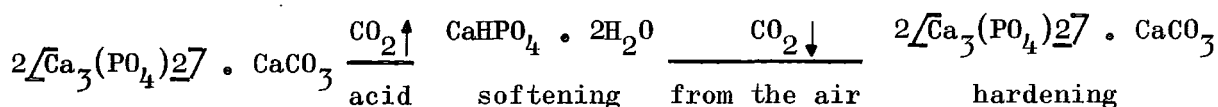
Bone and antler

Discussion of whether and by what means bone and antler may have been softened prior to working has generally been limited to a small circle of archaeologists in Poland.⁽⁴⁾ In particular, K Żurowski has conducted practical tests over the past thirty years and published his findings in a number of papers (Żurowski 1953; 1973; 1974). Żurowski's interest was first aroused by traces of working (particularly in the form of knife-cuts) on antler artifacts : he deduced that, since antler is a comparatively hard material, these cuts could have been made only after preparatory softening of the raw material. The fact that preliminary softening is a normal practice among antler and horn workers in contemporary Slavic folk cultures had come to the notice of other archaeologists and ethnologists (eg Moszynski 1967, 352); inadequate appreciation of the quite different properties of these two materials has, however, led to inconclusive results being obtained when these methods were applied indiscriminately during experimental attempts to induce softening (Żurowski 1974, 19-20).

In order to bring about temporary softening of bone and antler, the material may be immersed in an acid solution. Present-day exponents of Russian folk art use vinegar (acetic acid) in solution for this

purpose. Looking for naturally-occurring acids which would have been available to bone and antler workers in the past, Żurowski settled on sorrel (Rumex sp.), a plant rich in oxalic acid, the remains of which have occasionally been excavated from layers of early medieval date (Żurowski 1974, 20). Having prepared a soured broth of sorrel leaves, he immersed a red deer antler in the solution; every two days attempts were made to cut the antler with a knife and in this way he was able to demonstrate the progressive softening of the antler until, after six weeks, it could be cut like wood. On being removed from the solution and allowed to dry, the antler regained its original hardness within four days. Further experiments by the same author employed sauerkraut, sour milk and buttermilk, with which greatly accelerated reactions were obtained, the antler becoming soft within two to three days (Żurowski 1973, 486).

According to Żurowski (1974, 20), reversible reactions could be obtained with diluted chloric acid as well as a range of organic acids including acetic, lactic, propionic, citric and butyric acid, and with various preparations based on cabbage, gherkins and the like. The roots, as well as the leaves, of sorrel were said to be effective for this purpose. (Non-reversible reactions were said (loc. cit.) to be induced by solutions of tartaric, oxalic⁽⁵⁾ and sulphuric acids.) The chemical mechanism involved in the reversible reactions is given by Żurowski as follows :



Considering the complex and intimate nature of the union between the organic and inorganic elements in bone structure (p. 5) these claims

seemed inherently unlikely to be valid for, having once removed mineral from the bone it would be quite impossible to replace it. With the further co-operation of Professor J. D. Currey, therefore, the writer set out to evaluate the true effects of these various processes.

Using the methodology for establishing modulus of elasticity outlined on p. 56, a number of standard test specimens were manufactured from a single shed antler of red deer. Bulk quantities of lactic acid (sour milk, pH 4.32), acetic acid (malt vinegar, pH 2.83) and oxalic acid in the form of a solution of sorrel leaves (Rumex acetosa, pH 3.57) were sub-divided into test tubes in which the specimens were immersed for periods of six, twelve, twenty-four, forty-eight and ninety-six hours respectively before being loaded in three-point bending on an Instron table testing machine (cf. p. 58). To provide a check on the softening effect due simply to immersion in liquid (as opposed to chemical softening) a number of control specimens were immersed in water. The results, as given in Fig. 32, show a slight softening effect due to the action of water, a more marked effect from the lactic and oxalic acid and a very distinct degree of softening from the acetic acid.

Further sets of specimens were immersed in each of these solutions for a period of forty-eight hours, after which they were washed and dried before testing. In this way the degree to which the softening process could truly be said be reversible could be assessed. From the results obtained it is obvious that whereas the specimens treated in water effectively regained their original strength on being dried out, the mechanical properties of those specimens which had been chemically softened were permanently and seriously impaired. Clearly, none of the

methods of chemical softening discussed above could, therefore, be said truly to be reversible. Whereas the consequent impairment of the structure might be acceptable in the manufacture of, for example, bangles or in the folk-art carvings of the present day, it seems unlikely that it could have been tolerated in the manufacture of implements or items such as combs, particularly when (as argued on pp. 59-62) advantages of a lower order of magnitude were appreciated and seized on.⁽⁶⁾

Whether or not cold water softening was practised remains to be proven. Since it would have had no permanent effect on the material there seems no reason why it should not have been adopted, although the extent to which the degree of softening induced by this process would have been useful to the craftsman is unclear. An alternative method was experimented with by W. Szafranski (quoted in Żurowski 1973, 487, n 10), who established that it was possible to cut antler after boiling it in water for a period of seven to ten hours, although the material became hard again as soon as it cooled. Boiling in oil is also mentioned as a possibility by Cnotliwy (1956, 176). Cold or hot water softening would presumably function by action on the collagenous matrix rather than the mineral element in the bone.

Other evidence for deliberate softening comes in the form of pits full of bones and antlers found in a number of Polish excavations as at Błonie, Fordon and Poznań which are interpreted (Żurowski 1973, 485) as soaking pits associated with workshops. One of the pits found in Błonie is said (Cnotliwy 1956, 176) to have contained as many as 250 cut antler fragments. No such pits have yet been recognised elsewhere.

The alternative aim in inducing softening, namely to allow the bone or antler to be bent into a new shape before re-hardening, may be mentioned briefly, although there is no evidence that the practice was followed during the period under consideration here. Żurowski (1974, 21) was able to replicate a bone armband of Lengyel (Neolithic) type by splitting a bovine rib and immersing it in a bath of sour milk : after some days he was able to bend the plate of bone into a ring, which was then bound up and allowed to dry. When the bindings were removed, the plate was found to retain its new shape. Other evidence for this practice is more common but its significance seems not to have been noted by other writers : amongst ornaments of the Roman period are occasionally found narrow armbands or bangles of bone or antler, made by bending a thin strip into a ring and securing it in position with a riveted bronze band. A good example, made from a longitudinally-cut strip of antler, comes from York Minster (MacGregor, forthcoming). Some method of softening must certainly have been used to achieve this effect, which brings the technique to the very threshold of our period.

Ivory

Elephant ivory has a unique combination of working properties which are considered exemplary by artists and craftsmen all over the world (cf. C I A Ritchie 1969, 26-39), and it seems unlikely that it would normally have been subject to preliminary softening before carving in the normal way. Digby (1926, 185), however, notes that Siberian mammoth ivory was softened in very hot water prior to working by native craftsmen and Sandys-Wunsch (n.d., 15) recommends soaking mammoth ivory in vinegar for two or three days prior to carving. Evidence of softening elephant

ivory for special purposes has nonetheless been noted elsewhere in the past.

Panels or tablets of ivory measuring up to 75cm square were much favoured by 18th-century portrait painters such as Ross, Thorburn and Newton, who found that they made excellent vehicles for their art. These dimensions far exceed those which could be achieved by cutting cross-sections or longitudinal-sections from tusks and clearly result from an alternative method of production. Williamson (1938, 12) explains that these panels were cut from around the circumference of the tusk after the ivory had been softened by phosphoric acid : while still soft they were flattened out under pressure, washed and dried, after which they regained their former consistency. Volbach (1952, 16) mentions that a method of softening and flattening ivory had also been used by craftsmen in the classical world, but gives no details of the method employed.

The technique of softening ivory had an even greater antiquity, however, as is shown by a further instance which is from the Palaeolithic period. In this case, the objective was to soften the ivory with a view to eliminating the natural curvature and, since the tusk in question was from mammoth rather than elephant, the curve would have been considerable. In upper Palaeolithic levels at Vladimir, east of Moscow, a spear made of mammoth ivory was found in association with two skeletons : the spear was so straight that it could only have been made by softening the raw material from which it was made and straightening out the curvature (Żurowski 1973, 488). No evidence has yet been produced to suggest which chemical process might have been involved in this process.

From the period reviewed in this study no evidence for ivory softening has yet been noted, but the possibility of such a process having been used should be borne in mind during the examination of ivory artifacts.

Horn

As already stressed, the composition of horn is quite distinct from that of antler and hence the methods employed in working it can be very different. This is particularly true in the case of softening and moulding, which have for centuries been essential processes in the horner's repertoire.

Rendering horn soft and malleable is achieved simply by the application of heat, although delicate control is needed to avoid damaging the material. (No chemical change is therefore involved here, although Żurowski (1974, 19) mentions an alternative method of softening in which horn may be boiled in a solution of wood ash.) Following some four to twelve weeks of soaking in a tub or pit (p. 67), the horns were set to boil in a cauldron. After one to one-and-a-half hours' boiling, the horn was taken out and held over a fire with a pair of tongs or with a special toothed warming tool (Andés 1925, 44, Abb.1), to evaporate the excess water and further to soften the horn by gentle and even application of heat, when it was then ready for 'breaking' or opening. According to the account of a York horner working in the first quarter of the present century (recorded in Wenham 1964, 46-56), one of two methods of cutting would normally be used, depending on the desired shape of the resulting horn plate : after the solid tip had been removed, the cut could be made either in corkscrew fashion to produce an elongated rectangle when opened out with the aid of a pair of tongs, or else a straight cut could be made from the tip to the base, giving a

squarish plate (Fig. 33). Andés (1925, 43-9) stresses that the cut is normally made along the line of greatest weakness, namely the inside of the curve. The whole of the above process had to be carried out quickly and efficiently, without the horn being allowed to cool.

After some preliminary trimming and removal of blemishes with the aid of a scraping knife or a spokeshave, the plates of horn could then be returned to the cauldron for re-softening, after which they were further pressed between heated iron plates, the smooth surfaces of which had been smeared with grease.⁽⁷⁾ Final smoothing and trimming was then all that was necessary before the plates were ready for manufacture into items such as combs, boxes, etc.

Exceptionally thin and translucent plates, such as were used in the windows of lanterns (hence, probably, the Middle English form lanthorn), were produced by selecting suitably light horns, soaking them in water for about a month and then delaminating or splitting them into two or more leaves before subjecting them to pressure as above. Andés (1925, 46-7) mentions that translucency could be improved by smearing the horn plates with oil and warming them over a fire or else by boiling them in three parts water to one part of waste fat before pressing them for half an hour and finally laying them in a dish of cold water. A fine globular lantern incorporating plates of this sort is described by Way (1855, 374-6).

Sheets of horn could be welded together by pressing them between greased plates at temperatures higher than those employed in the processes described above (Wenham 1964, 53). The steel plates were heated over

a fire and placed in a press, where tallow was applied to them. When the temperature was judged to be right the horn plates were introduced and pressure applied. After a few minutes the horn plates would begin to 'run' and the pressure would be further increased. On cooling off, the horn plates would be stuck fast together, provided the appropriate delicate balance of temperature and pressure had been maintained.

Andés (1925, 53) gives a recipe for enhancing the elasticity (toughness) of horn, involving a solution of three parts nitric acid, fifteen parts white wine, two parts vinegar and two parts rain or river water. After treatment in this way, it is said (loc. cit.) that horn combs could withstand being trodden on without breaking.

The methods described here have been in common use for at least the past three centuries. Many of them probably have their origins in the early medieval period, when the horners' craft seems to have undergone a period of vigorous development, if not before. Archaeological proof of this, however, is so far lacking. In most of the known early artifacts in which horn was used other than in its complete form, too little generally survives of the organic material to demonstrate whether it had been worked in this way. The plates on the Benty Grange helmet (p.162), however, were judged (Bruce-Mitford and Luscombe 1974, 232) to have been softened and bent into shape. A fragment of thin horn with incised decoration, perhaps originally from a box or casket, found in a medieval context at York (Fig.90) may be an early piece of pressed or delaminated horn. The curious series of horn combs with riveted side-plates (p. 240) seem to consist of the entire thickness of the horn, which has simply been flattened and filed.

The full potential of horn as a versatile raw material was perhaps only fully recognised during the last century or so : several British Patents - eg 6402 (1899), 1021 (1908), 163, 219 (1920) - have been filed for processes involving the manufacture of such diverse items as umbrella handles, cigar holders and electrical switch covers from small scraps or powdered horn which, after treatment, was reconstituted and moulded in dies under heat and pressure.

Colouring

Some evidence can be mustered to show that colouring was occasionally used to enhance the appearance of objects made from skeletal materials. Occasionally colour contrast was provided by the employment of sheet-metal backing behind a pierced, openwork design (pp. 229, 307), while at other times colour was applied directly to the material. Green seems to have been a particularly favoured colour : green-stained pins have been recovered from Roman excavations at Rochester (Harrison 1972, 155) and York (MacGregor 1978a, 35, n 1) and again in York a Viking period buckle, highly polished and deeply coloured to look like bronze, was found in early excavations in the city (Waterman 1959, 91, Fig. 19); a green-stained die from Lincoln (Lincoln Archaeological Trust, F76, B70) came from recent excavations in Flaxengate. Traces of red staining have been noted on the Fife casket (Anderson 1886, 390; see also p. 310) and on a number of ivory book covers. Red colouring was also noted on a Migration period comb from Holzgerlingen, Württemberg (Veek 1931, 24) and the same author notes the use of white 'incrustation' to heighten the appearance of incised ornament on a comb from Oberflach (loc. cit.). From a 13th century context at Ludgershall Castle a die was recovered

on which the ring-and-dot values had been enhanced with black pigment, while playing-pieces from the same site showed traces of white and red pigments in the incised decoration (MacGregor, forthcoming).

According to the Plictho of Gioanventura Rosetti (written in Venice, 1548), bone could be dyed in a solution of red vinegar containing copper filings, Roman vitriol, roche alum and verdigris (Edelstein and Borghetty 1969, 129). An alternative method was to place the bones in a copper vessel containing a mixture of goat's milk and verdigris which was buried for several days in a mound of horse manure to keep it warm (op. cit., 158). Theophilus (III, 95), writing in the first half of the 12th century, recommends the use of madder for staining bone red (Hawthorn and Smith 1963, 188-9), while Andés (1925, 13-33) lists a wide range of vegetable and chemical dyes suitable for colouring skeletal materials, some of which at least would have been available to the medieval craftsman.

WORKSHOP PRACTICE : NOTES

- (1) The numerous bone and antler fragments found in Clifford Street, York, have also been taken to represent debris from a workshop (Ward Perkins 1949, 208).
- (2) A small ivory box with flanged lid, found during excavations at Jarrow in 1978, may be of pre-Conquest date (Professor Cramp, personal communication).
- (3) It is also said occasionally to be punched (see, for example, Dryden in Archaeol. J. 39 (1882) 422; Galloway 1976, 156), but this method seems never to have been used in bone and, indeed, would probably not be effective.
- (4) Hruby (1957, 216) mentions evidence of softening from Czechoslovakian finds, but does not elaborate on the matter.
- (5) Oxalic acid is in fact the principal softening agent contained in sorrel, which Zurowski describes elsewhere (p. 81) as the most likely reversible acid.
- (6) In evaluating the mass of antler material from Hedeby, Ulbricht (1978, 46-50) considered the question of whether any evidence could be found for softening and decided that it could not.
- (7) In the 1740s, a box press with a screw pressure control was developed for this purpose (G. B. Hughes 1953, 156), several iron plates and plaques of horn being interleaved in it.

THE ARTEFACTS

There follows a review of the principal types of objects manufactured from skeletal materials. In keeping with the aim of this review, the primary concern in each case is to highlight the features which particularly recommended these materials to the craftsmen concerned, although an attempt is made to locate these objects within a general functional context. Art-historical matters are not dealt with and items whose principal interest is to the art historian are omitted except where they have an additional functional role. (See Beckwith 1972 for a recent survey of the survey of ivory carvings of this period.) Dating derived from carved decoration is likewise not discussed but is generally accepted as published.

The material to be considered is divided according to function, each section being followed by a catalogue of sites producing the more significant examples on which the discussion is based : the catalogues do not, therefore, lay any claim to being exhaustive, but merely demonstrate the material basis for the conclusions which have been reached. Objects falling outside the geographical limits (ie the British Isles) and the chronological limits (ie c. 400-1200) of the survey are not generally catalogued, even though they may have been included in the previous discussion. The catalogues are arranged alphabetically, by county.⁽¹⁾

SPINNING AND WEAVING EQUIPMENT (Figs. 34-42)

Bone and antler have been utilised consistently in the production of implements for almost every stage of textile production. No doubt it

was the excellent physical properties of these materials which recommended them for these purposes, being easily shaped in the first instance and being tough and resilient in use. They also acquired an ever-increasing smoothness and polish, so having progressively less tendency to 'pick up' the fibres being worked. Wood, which was probably the most common alternative for most classes of implement, would have been much inferior in its wearing characteristics; in the case of whorls, where weight rather than resilience was the most important factor, ease of manufacture would have recommended the use of bone rather than the more usual alternatives, pottery and stone.

Combing (Fig. 34)

Before the process of spinning an even yarn could begin, the raw wool had to be freed from tangles and from foreign matter caught up in the fleece. Two processes may be distinguished : combing involves the use of a pair of handled combs, each set with two or more rows of iron teeth; carding is carried out with a pair of flat bat-like implements (cards), each set with many rows of short, fine teeth. Today the two processes are complementary.

The origins of carding are obscure : the classical references cited by Patterson (1956, 193-4) and Lemon (1972, 85) are not considered by Wild (1970, 195-6) to be wholly convincing. Primary archaeological evidence is in any case absent. The lack of physical remains may be due to the fact that, before the introduction of the more recent type of hand card set with multiple rows of fine wire teeth, an event which

Hoffmann(1964, 287) tentatively places in the 14th century, these implements had a different form and function : formerly they had been made with the heads of thistles (Carduus), from which they derived their name, or, more usually, teasels (Dipsacus fullonum), and were used solely for raising the nap on woven cloth. (Teasels continued to be used for this function long after the introduction of wire cards.)

Combing was certainly practised by the Roman period and a number of one-piece iron combs of this date survive from England and the Continent to demonstrate their currency in northern Europe (Wild 1970, 24-5, Table C). The type of wool-comb which survived in use until the mid 19th century, a short-handled T-shaped implement with several rows of long iron teeth, is first attested in manuscript illustrations dating to about 1300 (Lemon 1972, 85-90). Archaeological evidence for an earlier introduction of this type may now be cited from Jarlshof, Shetland (Hamilton 1956, 124) : in an early Viking period context, a T-shaped implement of antler with multiple perforations for the insertion of iron teeth (Fig. 34) was found; this can be identified with certainty as a heckle or wool-comb. Unfortunately, the implement is split through the first row of teeth, so that the original number of rows cannot now be estimated.

A number of finds of iron teeth from similar combs (but, presumably, with wooden handles) have been made elsewhere in England (p.104) and on the Continent, while early evidence for the use of warmers - whose function is explained by Lemon (1972, 87) - with wool-combs comes from Mucking, Essex (M U Jones 1975, 411-13).

Long-handled combs of the type discussed below (p. 103) are occasionally identified as wool-combs, but are treated here as weaving combs.

Spinning (Fig. 35)

Combing completed, the rovings of wool were normally (though not invariably) secured to a distaff. Often these were simple rods of wood or even bullrushes, although in the Roman period a number of more elaborate examples in jet and amber are known (Wild 1970, 31-2). They might be as short as 0.2m, but by the medieval period a length of 1m or over was considered normal. None has yet been found in bone.

Before the development of the spinning wheel (p. 99), spinning was practised with a spindle and whorl, a method with an ancestry stretching back to the Neolithic period (Henshall 1950, 142). The spindle was another rod-like implement, measuring some 120mm or more in length and usually having a slight swelling towards the lower end on which was fixed the whorl. A wisp of prepared wool was teased out from the distaff and twisted around the spindle, which was then spun and allowed to drop; the momentum of the spinning action was maintained by the whorl, functioning as a fly-wheel. In this way, the fibres were both extended and twisted into a yarn which, in the hands of a skilled operator, could be of extraordinary evenness. When the momentum was exhausted and the yarn spun sufficiently tightly, the newly formed thread was wound around the spindle, ending with a half-hitch at the top, and the process repeated.

Although they are not uncommon in the Roman period (Wild 1970, Table F),⁽²⁾ convincing examples of spindles from the succeeding centuries are rare.

Perhaps the majority were made then in wood, which has failed to survive except under conditions of exceptional preservation as at ^{Oseberg (Grieg 1928, 181, fig 108)} Lagore Crannog (Hencken 1950, 162-3) and Dublin (Viking and Medieval Dublin, 46-7). The numerous double-pointed bone implements sometimes (eg G B Brown 1915, 411) referred to as spindles are discussed below (p. 101) as pin-beaters. Waterman (1959, 82, Fig. 12, 5) mentions an 'object of uncertain use, possibly a bodkin' from Clifford Street, York, which may be a bone spindle (Fig. 38). An iron spindle has also been noted from Sutton Courtenay (Leeds 1947, 85).

Weight, rather than form, would seem to be the critical factor in choosing or manufacturing a whorl, and yet the wide range of weights encountered seems to show no particular clustering.⁽³⁾ Indeed, the 8g which is suggested (Ryder 1968a, 81) as an appropriate weight for spinning primitive Soay-type wool is practically never encountered, most whorls being markedly heavier. Some societies spin without any whorl whatever, while in others a simple expansion at the lower end of the spindle acts as a sufficient energy reservoir. Yet others spin with the whorl resting on the ground, so that its weight has a less direct bearing on the characteristics of the yarn. The weight of the whorl is, in any case, only one of the elements which condition the quality of the yarn, the diameter and length of the fibres being equally critical (Ryder 1968a, 82). It can be said, however, that whorls at either end of the range of weights would not have been interchangeable in their functions. Patterson (1956, 202) mentions that some of the stone whorls (as opposed to lighter whorls in wood, etc) could have been used for spinning flax. It is also possible that some of the heavier examples were used for doubling or plying yarns, or perhaps for making nets.

For the purposes of this enquiry, taking the raw material rather than function as the starting point, two classes of whorl may be recognised : those which are turned out of solid material and those which adopt the form of the bone from which they were fashioned. The first of these groups is dominated by whorls made of antler (Fig. 35), this being the most generally available source of solid, dense tissue. From the comparatively small area of cancellous tissue exhibited by most of these, we may assume that they were cut from near the region of the burr (p. 14).

An alternative source which, on the basis of those so far found, seems not to have been exploited until around the time of the Norman Conquest, is the mandibles of cattle or horses. These bones have conveniently large flat areas of regular thickness from which discs of appropriate size could easily be cut. These two sources of raw material are immediately distinguishable from each other in finished whorls, the antler (Pl.17) being solid throughout and the jawbone whorls (Pl.18) having a band of cancellous tissue sandwiched between the two dense outer layers (p. 11). A number of playing pieces of similar date and appearance are noted below (p.270), and indeed it is only the central perforation which distinguishes these from the whorls described above. The polish often built up by wear on the inside of the perforation does suggest that it was functional, however, presumably being used for the insertion of the spindle, and was not simply an extension of the decorative scheme. The flat, regular surfaces of these discoid whorls invited decoration, which was frequently in the form of concentric bands of ring-and-dot ornament (Fig. 35). In addition to these simple discoid shapes, antler whorls were sometimes lathe-turned into a number of more decorative forms (Fig. 35), as permitted by the nature of the raw material. Occasionally, whorls inscribed with names (? of the

owners) are found (Boeles 1951, 466-7, Fig. 84; and (possibly) Jackson in A Ritchie 1977, 221-2).

The second category is made up principally of femur-head whorls. As outlined above (p. 4), the epiphyses of certain mammalian limb bones become fused to their shafts only in maturity and it seems possible that the widespread practice of utilising these may have developed through the ready availability of unfused femur heads from immature animals. Unfused epiphyses, however, are small and asymmetrically shaped (Fig. 35), and it is probably a mistake to assume (cf. MacGregor 1974, 88) that these were used for the majority of whorls, most of which were certainly cut from the fused bones of mature beasts. Cattle femur heads predominate, but occasionally others, including some derived from human bones (Scott 1948, 77, 98; A Ritchie 1977, 197), are found.

Femur head whorls first appear in Britain in the Iron Age, being represented for example among the large collections from the Glastonbury and Meare lake villages (Bulleid and Gray 1917, Table XIV; 1948, Table XIV). They continued in use sporadically from that time until the Anglo-Scandinavian and Norman periods, when they enjoyed a burst of renewed popularity : of 23 such whorls found at Lincoln,⁽⁴⁾ for example, four were dated to the 9th-10th century, six to the 10th-11th century, nine to the 11th-12th century; the remainder, from contexts dating to the 13th-14th century, the 15th and 18th century, are likely to be residual.

The only other instances of the original form of the raw material being retained is in whorls made from an antler burrs (Fig. 35), found at Lackford (Lethbridge 1951, 18) and Spong Hill (Hills 1977, 30, Fig. 136). Similar objects from Sweden, however, have been identified as fishing

gear (fiskpuls) (Kjellmark 1939, 359-62).

A number of alternative identities have been attributed in the past to these whorls, including dress-fasteners (A Young 1956, 321), pendants (Scott 1948, 78-9) and, in the case ^{of} one elaborately decorated example from Dorchester, Oxfordshire, a toggle or sword-knot (Kirk and Leeds 1953, 67, 72, Fig. 27, 12). None of these identifications, however, seem very persuasive.

A few whorls with the characteristic domical shape of femur heads were produced in stone (Fig. 35); there can be little doubt that it was the natural form of the bone whorls which was being reproduced skeuomorphically in these instances.

Other materials used in the manufacture of whorls include jet, shale, lead, glass and baked clay. The material was obviously not of great importance : Sir Arthur Mitchell, the eminent 19th century Scottish antiquary, found an elderly Scottish lady happily using a potato as a whorl, having used nothing else all her life (Mitchell 1880, 8-9).

Although they continued to be used in a minor way until the 19th century, the spindle and whorl were largely superseded by the much more efficient spinning wheel, introduced in the form of the 'great wheel' in the 13th century and in its more developed version with a treadle and flyer in the first half of the 16th century (Catling 1972, 101-2; White 1962, 119, 173).

Weaving (Figs. 36-9, Pls 17-20)

Throughout the period under review, the majority of textiles were woven on the vertical warp-weighted loom (see Hoffmann 1964, for an account of

these looms). As implied by the name, on looms of this type the warps were hung vertically and kept under tension by a series of weights (Fig. 36).⁽⁵⁾ Through the shed formed in the warp by a series of heddle sticks, the weft threads were passed and beaten into place with specialised implements. The beaters in question were of three basic types : the long sword-beater, the shorter dagger-beater or pin-beater, and the weaving comb.

The sword-beater, sometimes referred to as the weaving-baton or spatha, was generally some 0.25-0.50m in length and, being inserted horizontally in the warp shed, could quickly beat up a weft row either in large sections or all at a time, depending on the width of the textile. The origins of these implements seem to lie as early as the Bronze Age (Hoffmann 1964, 281). In our period many of those used in Britain may have been made of wood, which has not survived. (For a recently-excavated wooden weaving sword of the medieval period, see J C Murray et al. 1978, 18.) Others made of iron have been interpreted (Chadwick 1958, 35) as prestige items and are not very common finds. The resemblance of some of these latter implements to real swords, except that (in the Anglo-Saxon period, at least)⁽⁶⁾ they may have a tang-like extension at the tip, may not be entirely fortuitous since some examples were apparently manufactured from redundant swords (Chadwick 1958, 34). While weaving-swords of cetacean bone are not uncommon finds in Scandinavia (Petersen 1951, 285-319; Sjøvold 1971, 1200-2) and some are known further south on the continental mainland (Hoffmann 1964, 282), only one example has so far been found in Britain : this fragmentary beater (Fig. 37) inscribed with two Old English legends reading, respectively '+ EADBVRH MEC AH -' and '+ EADBVRH(M)EC AH:-', both meaning 'Eadbvrh owns me', was found in the destruction level of a house dated c. 1150 at Wallingford (Okasha 1971, 119, pl 118).

Many cetacean bone beaters from Norway have curved blades, a feature which Hoffmann (1964, 282) attributes to the natural shape of the bones from which they were fashioned. This curvature was of no particular benefit during use, so that the occurrence of wooden weaving-swords displaying the same shape (loc. cit.) is a further instance of the morphology of the skeletal raw material conditioning the development of tools in other media.

The shorter dagger- or pin-beaters were probably used in addition to (rather than instead of) sword beaters, although they survive much more numerous. Perhaps this is a result of their having normally been made of bone (which has a comparatively high survival value) rather than wood, although wooden examples have been noted from Hedeby (Schietzel 1970, Fig. 8, 4) and Amsterdam (van Regteren Altena 1970, Fig. 11). In addition, they would of course have been more easily manufactured from more readily available material than the much larger sword-beaters and they would also have been more easily lost. Hoffmann (1964, 135) describes the complementary functions of the two types of beater.

In contrast to the sword-beater, which operated parallel to the weft, the pin-beater was inserted between individual warp threads and was used at right angles to the plane of the weft. The transverse grooves which mark some pin-beaters (Fig. 38) were no doubt formed by friction against the warp. Three groups of pin-beaters may be distinguished at present :

- (1) Most numerous are the so-called 'cigar-shaped' beaters, circular or ovate in section and tapering to a point at either end from an intermediate swelling. Very often the maximum girth is not in the centre, with the result that one point is more slender than the other. The choice of



point for use on any particular occasion would have depended on the job in hand or the fineness of the cloth being woven.

- (2) A common alternative form is provided with a point at one end only, the other end being roughly trimmed and frequently displaying a curved section with a certain amount of cancellous tissue on the inside, demonstrating that they were cut from limb bones. Perhaps these were more general-purpose tools than those described above, or were associated with a particular section of the weaving industry producing one kind of cloth.
- (3) A number of beaters have been noted with a point at one end and a flat chisel-like butt at the other, perhaps indicating some special usage : it seems possible that the chisel end could have been used across the top of the warp in beating up a small section of the weft.

A number of rather poorly-associated cigar-shaped beaters from Roman sites in Britain are listed by Wild (1970, Table K), but the same author cites other more securely-stratified examples from the continent as confirmation of a Roman currency (loc. cit.). Numerous examples of Anglo-Saxon date are listed below (pp. 115-6) along with others of Anglo-Scandinavian origin. Hoffmann (1964, 279) mentions that pin-beaters are known by the name of hraell in Old Norse literature and that they survived in use along with the warp-weighted loom in Iceland until the last century. (7)

Occasional claims are made for other forms of beaters : Moore (1966, 409), for example, has claimed this identification for a pig's tooth found in the Anglo-Saxon settlement at Wykeham.

Beyond the sphere of Anglo-Saxon settlement and influence, pin-beaters of the double-pointed variety seem to be unknown. One may note the occurrence of other types of beater manufactured from the long bones of sheep and more closely related to Iron Age implements (cf G. Crowfoot 1945, 157-8), which occur in some broch deposits of Roman Iron Age or Dark Age date (MacGregor 1974, 78, Fig. 10). The dearth of properly excavated stratified sites in the Celtic realms renders firm conclusions about this situation difficult to reach, but it seems possible that the place of the beater was taken (in Scotland, at least) by the long-handled bone weaving-combs (Fig. 39) which also make their earliest appearance in Britain in Iron Age contexts (Henshall 1950, 146). They also occur on a number of Roman sites (Wild 1970, Table L), where they may indicate the presence of native weavers producing textiles for the Roman market. In post-Roman Britain they are more difficult to pin-point : one example from the Broch of Aikerness was found with a knife whose bone handle was inscribed with an ogham inscription judged to be of 5th-century or later date (Henshall 1950, 146), while at the Broch of Burrian, where occupation of some sort continued until the 8th century, some at least of the numerous weaving combs were of post-broch (although not necessarily post-Roman) date (MacGregor 1974, 84). Combs from a number of other sites are listed by Bulleid and Gray (1948, 71) and Henshall (1950, 160). One example was recovered from the Anglo-Saxon cemetery at Kempston, but has been judged in the past to be residual (Bulleid and Gray 1917, 275). Two others, thought to be English imports, have been found in Frisia and, although these latter combs are not closely dated, the Anglo-Saxon period might be

considered the most likely time for their transfer to the Continent (Roes 1963, 26, pl. XXXIII, 1-2).

The inventory of spinning and weaving tools included in the Gerefa (late 11th century), mentions both weaving comb (pihten - glossed pecten) and wool comb (wulcamb) (Liebermann 1903, 455), but the forms referred to are, of course, unknown. A number of iron-toothed implements are, however, known from Anglo-Saxon contexts, as at Wicken Bonhunt (M. U. Jones 1975, n4), Harrold (Eagles and Evison 1970, 42) and Shakenoak (D. Brown, in Brodribb et al. 1973, 134), although there is some doubt whether they are wool combs or linen heckles (D. Brown, loc. cit.).

As might be expected, antlers and columnar limb bones provided the bulk of the raw material for these implements. The curvature inherent in the latter has led some writers to doubt the suitability of these implements for weaving (cf. Cunningham 1923, 94; Roth 1950, 129-39) on the grounds that it would result in the displacement of the warp, but Crowfoot (1945, 158) has maintained that this would not necessarily have been a disadvantage and may even have served a useful function in thrusting the warp threads apart and counteracting the tendency of the web to 'waist' in the middle. Antler was frequently used instead of limb bones and in the Northern Isles cetacean bone was favoured for the manufacture of these implements : at the Broch of Burrian, for example, where eighteen such combs were found, one was made of antler and seventeen of cetacean bone (MacGregor 1974, 84). The 'fish-tail' terminal displayed by some weaving combs has been compared (Thomas 1961, 24) to the fish symbol in Pictish art, perhaps reinforcing the case for post-Roman survival.

Amongst the Burrian combs a significant disparity was noted between those combs with long handles and short teeth and those with comparatively short handles and longer teeth. It was suggested (MacGregor 1974, 84) that this variation might indicate some difference in function, the longer-toothed implements perhaps having been used for combing the wool preparatory to spinning, as has been postulated in the past (Coughtrey 1872, 153). Practical experiments conducted with the more standard form of comb have shown it to function entirely satisfactorily as a weaving comb (Reynolds 1972, 9-12). There are, however, still a few dissenting opinions : in recent years Alcock (1972, 153) has reiterated the opinion of some earlier writers that they might have been used to disentangle sinews.

There is a distinct type of long comb which is well known on the Continent (eg Herrmann 1962, Abb 24, c; Wachter 1972, Abb 21, b), but which seems never to occur in Britain.⁽⁸⁾ These combs (Pl. 19) have clearly been cut from long bones, apparently the metapodials of cattle and horses, as can be seen from the characteristic foramina and spongy tissue which often survives at the 'handle' end. The teeth are cut long and straight and show secondary shaping only at the tips (Pl. 20). There is never any sign of wear further up the teeth suggesting that, despite their length, it was only the extremities of the teeth which came into contact with the material being combed. This fact makes their identification as weaving combs (Nickel 1964, 132) seem unlikely, when compared to the heavy wear sustained to the very base of the shorter teeth on more certain weaving combs of the type already discussed (Fig. 39). It has been suggested to me (Professor B. Almgren, personal communication), that these implements might have been used in tapestry weaving, but I know of no firm evidence in support of this theory.

The majority of weaving tools of the types discussed here disappeared with the decline of the vertical warp-weighted loom in favour of the horizontal loom.⁽⁹⁾

Notice must be drawn to the remains of a specialist horizontal loom, used purely for band and tape weaving. The only evidence for this type of loom in Britain is in the form of a heddle frame made from centrally perforated bone strips fastened together by a riveted bronze sheath (Bosanquet 1948, 89-97; Wild 1971, 230-1). The frame was found on The Lawe at South Shields and, although it lacks any stratigraphic context, is generally accepted as Roman in origin. Although no evidence has been found for the currency of this type of loom in Britain during the period under review, the fact that very similar heddles are known from post-medieval contexts in, for example, Scandinavia (Hald 1946, Fig. 31; Hatt 1942, Bild 4; Hoffmann 1964, 106) and Poland (Dobrowolska 1968, pl. 25; Pinińska 1974, Fig. 8a) raises the possibility of their surviving in this country during the intervening period. Most tapes and braids found during these centuries have, however, been judged to be tablet woven.

Tablet Weaving (Fig. 40, Pl. 21)

An adjunct (or, in some cases, an alternative) to the warp-weighted loom was the method of weaving which employed tablets, small plaques which were often made of bone, although examples in wood, metal, horn and leather are also known (Schlabow, n.d., 446). Frequently they were square with a perforation at each corner, but a number of circular tablets with two holes have also been identified (Henshall 1950, 148-51,

App. C); during the Roman period in particular, triangular shapes with three holes were also popular (Wild 1970, Table 0), while hexagonal tablets have also been used at times (Schlabow n.d., Abb 138; Schuette 1956, 6). Sometimes a central hole is also present : this may be used for an extra warp if especially strong braids are to be produced (Schuette 1956, 4) or, with the insertion of a rod, as an aid to keeping the pack of tablets in order while tying the warps (Tablet Weaving, 5). The perforations are frequently marked by smooth radiating grooves worn by friction against the threads (Pl. 21). Individual warp threads were passed through each of the holes and the tablets ranged alongside each other in a pack (Fig. 40); the weft thread was passed through the shed so formed in the warp, the shed being changed by rotating the tablets before feeding through the next weft thread. Variations in the sequence of rotation produced different patterns : the simplest, quarter turns in unison, gave the effect of a series of parallel cords united by a hidden weft, but by differentially rotating individual or groups of tablets the technique could be used to produce patterned weaves of considerable complexity. Periodic reversal of the direction of rotation contributed to the decorative effect and prevented the warps from becoming tightly twisted. Unlike the effects produced on most other textiles, the patterns visible on tablet-woven cloth are almost always made up of warp threads, the weft normally being visible only at the edges (Tablet Weaving, 2).

Three methods of keeping the warp under tension may be cited : the simplest (Tablet Weaving, 4) is for one end to be secured to a hook and the other to the weaver's belt; alternatively, it may be tied to two pegs at either end of a horizontal frame (Schuette 1956, 4-8) or suspended from a vertical frame and weighted at the bottom (Schlabow n.d., 447, Abb 140).

Although entire garments such as stoles could be produced by this method (Henshall 1964, 155), it was more commonly used in the manufacture of braids and tapes and in the production of starting and closing borders on textiles woven on the warp-weighted loom. Among the former group may be noted three 12th-century seal tags woven respectively with 30, 32 and 52 four-hole tablets (Henshall 1964, 155), and the earlier series of braids and bands from the vestments found in St Cuthbert's coffin and thought to have formed part of a gift presented to Cuthbert's shrine by Athelstan in 934 (G. Crowfoot 1939, 57-80). Varying numbers of tablets from 7 to 51 were used in the production of these complex and beautiful braids. Other examples of tablet weaving have been found in Anglo-Saxon contexts at Cambridge, Mildenhall and Icklingham (G. Crowfoot 1950, 26-32; 1952, 190-1) and at Little Eriswell (E. Crowfoot 1966, 29-32), made at Lagore (Hencken 1950, 214-7) and Dublin (Viking and Medieval Dublin, 10). The method of tablet weaving integral borders on conventionally-produced textiles is described by Hoffmann (1964, 164-83), Hald (1950, 454) and Schuette (1956, 19); even these could be quite complex, as illustrated by a 3rd- or 4th-century textile from Gjeite, Denmark, woven with 137 tablets (G. Crowfoot 1939, 73), and a contemporary cloak from Thorsbjerg made with as many as 176 tablets (Schuette 1956, 20).

Although the examples quoted above clearly demonstrate that tablet weaving was practised during the Anglo-Saxon and early medieval periods, surviving tablets are not so easy to find. Six bone tablets of the 11th century and one of the 12th or 13th century have, however, recently been found in Dublin (Viking and Medieval Dublin, 47) : they average about 35mm square and have a perforation at each corner, one having an additional small hole in the centre (see p. 107); two have rudimentary decoration in

the form of incised lines and one is ornamented on each face with a saltire composed of incised ring-and-dot devices. Raftery (1960, Fig. 59) illustrates a further example with four well-worn holes linked by incised lines, found at Rathtinaun Crannog, County Sligo. Another Irish find, a triangular plate cut from the naturally flat expanse of an ox scapula and perforated with three unevenly-spaced holes, was discovered at Lagore crannog (Hencken 1950, 196, Fig. 106, 1479) : it may have been used as a weaving tablet, though the excavators made no such claim for it. A possible tablet of Anglo-Saxon date was recovered from Kingston Down cemetery; C. R. Smith (1856, 91-3) describes a 'square flat piece of ivory with a hole at each corner', but unfortunately this object no longer survives so that it cannot be examined for telltale wear marks. Interestingly, however, the same grave also contained two pin-beaters (loc. cit.), perhaps adding some weight to the identification of this piece as a weaving implement. Henshall (1950, App. C) records two circular tablets from early excavations at Jarlshof and one from the Broch of Burrian : any of these could belong to the period considered here, but none need necessarily do so. Another object from Jarlshof, originally published as a 'weaving card' (Hamilton 1956, Fig. 39, 6), has more recently been identified as a model shield (Thomas 1963, 48). A number of square and triangular tablets have been found in Frisia (Roes 1963, pl. LIX, 1-3). In Scandinavia where there is a long tradition of weaving by this method, the most spectacular find has been that made in the Oseberg ship burial (Grieg 1928, 335), where 52 wooden tablets threaded with an unfinished braid were discovered along with a loom for tablet weaving, all dated c. 850 AD.

The earliest evidence for the technique comes from Egypt and dates to the 10th century BC (Schuette 1956, 18). In northern Europe claims for a Bronze Age introduction have been made in the past but Schladow (n.d., 448) discounts all evidence prior to the late Iron Age. With the passage of time, the role of tablet weaving progressively changed. From about the 9th century AD its use in connection with woollen cloths declined, while the demand for tablet-woven braids in luxury materials such as silk and gold thread increased enormously. Patronage came from ecclesiastical circles, where vestments bordered with costly braids became more and more sought after, as well as from wealthy secular clients, the latter being most impressively represented amongst the graves at Birka (Geijer 1938, 58-67). Other examples from the tombs of medieval church dignitaries and secular nobility are cited by Schuette (1956, 23-5). The same author (loc. cit.) detects a decline in the craft from the 14th century and, by the 15th century, tablet-woven braids were largely supplanted by those decorated with embroidery. Thereafter the technique survived in the realms of folk art until it was 'rediscovered' by ethnologists towards the end of the last century (Schuette 1956, 2).

'Smoothing Boards' (Fig. 41)

The series of cetacean bone 'smoothing boards' which is well attested in Scandinavia is represented in Britain by only three examples (Fig. 41). The most complete of these, from Ely, appears to be unfinished (Björn and Shetelig 1940, 67, Fig. 39) : it incorporates the common motif of confronted animal heads (cf. British Museum Anglo-Saxon Guide, Fig. 216; Arbman 1943, Taf.152; Petersen 1951, Figs. 180-2; Rygh 1885, Fig. 449), although these are represented here only in rudimentary form by light

incisions; it is also provided with a handle, which is less usual. An incomplete example of unknown provenance is in the National Museum, Dublin : it is of similar form but has had more developed representations of the zoomorphic heads (Boe 1940, 98, Fig. 67). The third 'board', found in a grave on Arran, Argyll, which also contained a styca of Archbishop Wigmund of York (837-54), is even more fragmentary and displays decoration only of double-ring-and-dot devices (Grieg 1940, 26-7, Fig. 10).

The function generally ascribed to these flat plaques is that of smoothing linen (Sj vold 1971, 1202-3); in Scandinavia they are most frequently found in female graves, the richness of which has been taken to indicate that these plaques, like the weaving swords mentioned above (p. 100), were items of some prestige (loc. cit.).

A number of smaller undecorated cetacean bone plaques found at the Broch of Burrian (MacGregor 1974, 86, Fig. 14, 187-9) may have performed the same function; when first discussed by Anderson (1872, 560), however, they were confidently identified as 'the "rubbing bone" so well known to the Irish hand loom weaver, used for smoothing down the weft as it is woven'.

Miscellaneous implements connected with textiles (Fig. 42)

A small number of ancillary objects connected in various ways with textiles may also be discussed here.

Bone needles, which were developed to a high degree of uniformity of style and standard of production in the Roman period, are much scarcer in the succeeding centuries. Many of those which have been claimed as

needles are crudely made from pigs' fibulae, the articular end being perforated but untrimmed. Most of these are held here to be pins rather than needles (p. 192), in view of the usual lack of wear exhibited in the perforations and the comparatively large size of the head. Conversely, however, it might be conceded that some of those with narrowly-trimmed heads (Fig. 42) may be needles, though they are still rather large. Other more certain needles are known ^{from} Beckford (Birmingham Museum, unpublished), Bidford on Avon (J. Humphreys et al. 1932, Fig. 1), Lincoln (Lincoln Archaeological Trust, unpublished), Whitby (Peers and Radford 1943, 71, Fig. 21, 117) and Lagore Crannog (Hencken 1950, 203-14). Compared with the closely woven textiles of the 10th or 11th century, such as have been found at York (Addyman 1974, 224, pl. XLIV), all these examples are extremely coarse.

Sewing on materials of this type would probably have been carried out with finer implements of bronze or iron, for which a number of bone cases survive. Cases of this type, manufactured from the shafts of hollow long bones, are commonly found in pagan Saxon cemeteries on the continental mainland (see, for example, Böhme 1974, 219, Taf 1, 16; Jacob-Friesen 1974, 632, Abb 773). A number of Viking-period needle cases found in Scotland have been cut from the pneumatic leg-bones of large (goose-sized) birds (p. 10); sometimes they have a transverse perforation in the centre (Grieg 1940, 43, Fig. 24; Hamilton 1956, 123, Fig. 57, 3) and one (Hamilton 1956, 123, Fig. 57, 5) has been plugged with iron at one end.

Under the heading of 'bobbins' may be considered a lathe-turned antler rod with decorative terminals, found in a Saxo-Norman context at Coppergate, York, and also, perhaps, two other lathe-turned rods with circum-

ferential grooves and longitudinal perforations (Fig. 42). An object from Norwich of similar size, made of walrus ivory and with terminals in the shape of a female head at one end and a dragonesque head at the other (Fig. 42), is dated stylistically to the first half of the 12th century (B. Green 1973, 287-9). Another possible bobbin with zoomorphic terminals is in the British Museum (unpublished, OA543). These may have been used for winding linen thread. Other objects, consisting simply of carpal or metapodial bones of pigs or sheep with a single transverse perforation in the centre of the diaphysis (Fig. 42) are occasionally described as bobbins but there is no evidence which definitely connects them with the textile industry. Other suggestions made in the past are that they may have been dress fasteners (Curle et al. 1954), or toys (Hruby 1957, Fig. 29).

Blomquist and Mårtensson (1963, 174, Fig. 179) have published a double-pointed implement cut from the shaft of a long bone which they identify as a threadtwister. No information on the method of use is given. Although not identical to the find mentioned above (which is from Lund), a somewhat similar object has been recovered from a 12th-century context at Waltham Abbey (Huggins 1976, 119, Fig. 42, 3) (cf also p. 122).

Catalogue

Wool combs

- 1.1 Jarlshof, Shetland (Fig. 34)
Hamilton 1956, 124

Weaving combs

- 2.1 Aikerness Broch, Orkney
Henshall 1950, 146
- 2.2 Broch of Burrian, Orkney (Fig. 39A-D)
MacGregor 1974, 84

Spindles

- 3.1 York, Yorkshire
Waterman 1959, 82, Fig. 12, 5

Spindle whorls

- 4.1 Dressogagh, Armagh
Medieval Archaeol. 9 (1965) 178
- 4.2 Abingdon, Berkshire
Leeds and Harden 1936, 43
- 4.3 Long Wittenham, Berkshire
British Museum, unpublished
- 4.4 Freswick, Caithness
Curle et al. 1954, 52
- 4.5 Girton College, Cambridgeshire
Hollingworth and O'Reilly 1925, 8
- 4.6 Chesterford, Essex
Fox 1923, 265
- 4.7 Kingston Down, Kent (Fig. 35A)
Smith 1856, 66-7
- 4.8 Sibertswold, Kent (Fig. 35B)
Liverpool Museum M6565, unpublished
- 4.9 Dinas Powys, Glamorgan
Alcock 1963, 153-4, Fig. 34, 13-14
- 4.10 Sutton Courtney, Leicestershire
Leeds 1923, 182, Pl. XXVIII, Fig. 1, A-C
Leeds 1927, 72, Pl. VII, Fig. 2, XVIII
Leeds 1947, 85, 89, Pl. XXII, a
- 4.11 Goltho Manor, Lincolnshire
MacGregor, forthcoming
- 4.12 Lincoln, Lincolnshire
Lincoln Archaeol. Trust; Lincoln Museum, unpublished
- 4.13 Skellingthorpe, Lincolnshire
Lincoln Museum, Carlbon Coll., 88, 50
- 4.14 Sleaford, Lincolnshire
Thomas 1887, 392
- 4.15 Lagore, Meath
Hencken 1950, 194, Fig. 106
- 4.14a London (Fig. 35F)

- 4.16 Caistor-by-Norwich, Norfolk
Myres and Green 1973, 173, Fig. 59, P24B
- 4.17 Don Cuier, Barra, Outer Hebrides
Young 1956, Fig. 13, 11-14
- 4.18 Dorchester, Oxfordshire
Kirk and Leeds 1953, 67, 72, Fig. 27, 12
- 4.19 Oxford, Oxfordshire
Jope 1958, 73, Fig. 25b
- 4.20 Shakenoak, Oxfordshire
Brodribb et al. 1972, 122, Fig. 60, 77
- 4.21 Spelsbury, Oxfordshire
Leeds 1940, 29, Pl. VIb
- 4.22 Yarnton, Oxfordshire
Leeds 1923, Pl. 29, Fig. 1
- 4.23 Yelford, Oxfordshire
Leeds 1923, Pl. 29, Fig. 1
- 4.24 Jarlshof, Shetland
Hamilton 1956, 181
- 4.25 Lackford, Suffolk (Fig. 35E)
Lethbridge 1951, 18, Fig. 4
- 4.26 Harnam, Wiltshire
Akerman 1855, 73, Pl. XXXVI, 4
- 4.27 Beckford, Worcestershire (Fig. 35D)
Birmingham Museum, unpublished
- 4.28 York, Yorkshire (Fig. 35H)
MacGregor 1978, 56, Fig. 36, 2

Sword beaters

- 5.1 Wallingford, Berkshire (Fig. 37)
Okasha 1971, 119, Pl. 118

Pin beaters

- 6.1 Seacourt, Berkshire
Biddle 1962, 184, Fig. 32, 1, 3, 4, 8
- 6.2 Southampton, Hampshire (Fig. 38A-E)
Addyman 1969, 72-4, Fig. 29
- 6.3 Kingston Down, Kent
Smith 1856, 91-3

- 6.4 Harston, Leicestershire
Dunning 1952, 50, Fig. 2, 2
- 6.5 Sutton Courtenay, Leicestershire (Fig. 38E)
Leeds 1923, 182f, Pl. XXVIII, Fig. 2, E-J; 1927, 77f, Pl. VII,
Figs. 2; 1947, 88, Pl. XXIIa, i
- 6.6 Goltho Manor, Lincolnshire (Fig 38D)
MacGregor, forthcoming
- 6.7 Lincolnshire
Lincoln Archaeol. Trust; Lincoln Museum, unpublished
- 6.8 Maxey, Northamptonshire
Addyman 1964, Fig. 16, 19-22
- 6.9 Dun Cuier, Barra, Outer Hebrides
A. Young 1956, 32, Fig. 14, 40
- 6.10 Á Cheardach Mhor, South Uist, Outer Hebrides
Young and Richardson 1960, Fig. 13, 38
- 6.11 Eynsham, Oxfordshire
Leeds 1923, 183, Pl. XXIX, Fig. 1
- 6.12 Oxford, Oxfordshire
Jope 1958, 73, Fig. 25
- 6.13 Shakenoak, Oxfordshire
Brodribb et al. 1973, 122, Fig. 62
- 6.14 Wolvercote, Oxfordshire
Leeds 1923, 183, Pl. XXIX, Fig. 1
- 6.15 Yarnton, Oxfordshire
Leeds 1923, 183, Pl. XXIX, Fig. 1
- 6.16 York, Yorkshire (Fig. 38C, F)
Waterman 1959, Pl. XVI, 10-14; MacGregor 1978, Fig. 36, 6

Weaving tablets

- 7.1 Dublin, Co. Dublin
Viking and Medieval Dublin, 47
- 7.2 Kingston Down, Kent
Smith 1856, 91-3
- 7.3 Rathtinaun Crannog, Co. Sligo
Raftery 1960, Fig. 59

Smoothing boards

- 8.1 Arran, Argyll (Fig. 41c)
Grieg 1940, 26-7, Fig. 10.
- 8.2 Ely, Cambridgeshire (Fig. 41A)
Björn and Shetelig 1940, 67, Fig. 39
- 8.3 Ireland (Fig. 41B)
Boe 1940, 98, Fig. 67.

Miscellaneous equipment

Needles

- 9.1 Lincoln, Lincolnshire
Unpublished, Lincoln Archaeological Trust
- 9.2 Lagore, Co. Meath
Hencken 1950, 203-14
- 9.3 Broch of Burrian, Orkney
MacGregor 1974, 71, Fig. 6, 43-6
- 9.4 Drimore, South Uist, Outer Hebrides
Young and Richardson 1960, Fig. 7, 5; Fig. 13, 32
- 9.5 Shakenoak, Oxfordshire
Brodribb et al. 1972, 129, Fig. 64, 110
- 9.6 Bidford-on-Avon, Warwickshire
J. Humphreys et al. 1923, Fig. 1
- 9.7 Beckford, Worcestershire
Birmingham City Museum, unpublished
- 9.8 Whitby, Yorkshire (Fig. 42A)
Peers and Radford 1943, Fig. 21, 117

Needle cases

- 9.9 Jarlshof, Shetland (Fig. 42B-c)
Hamilton 1956, 123, Fig. 57, 3 and 5
Grieg 1940, 43, Fig. 24

Bobbins

- 9.10 Freswick, Caithness
Curle et al. 1954, Fig. 21

- 9.11 Jarrow, Co. Durham (Fig. 42D)
Professor Cramp, personal communication
- 9.12 Winchester, Hampshire
D. Brown, forthcoming
- 9.13 Lincoln, Lincolnshire
Lincoln Archaeological Trust, unpublished
- 9.14 Norwich, Norfolk (Fig. 42H)
B. Green 1973, 287-9
- 9.15 York, Yorkshire (Fig. 42 E-G)
MacGregor, forthcoming

POINTS (Fig. 43)

A considerable number of bone and antler points of various types have now been recovered from excavations but, although they may be resolved into groups on the basis of material and appearance, their respective functions often remain obscure.

One such group has already been referred to under the heading of weaving equipment (p.101), where they were classified as pin- or dagger-beaters. The high degree of smoothness and polish often exhibited by these beaters agrees well with this identification: certainly it is not a feature displayed by the other categories of pointed implement. Transverse grooving occurring on some of these points, as from Goltho Manor, has been interpreted (MacGregor, forthcoming) as wear sustained from friction against the warps.

A possible identification as weaving implements was offered by Crowfoot (1945, 157-8) for a series of implements found mainly in Iron Age contexts: these are constructed of the metapodials of sheep, cut obliquely across the diaphysis to form a point and with the articular end perforated or removed to form a socket at the other end. Thirty similar points from

the Iron Age Hjortspring hoard in Denmark (Rosenberg 1937, 41, 44) were found with a large number of spearheads of iron and the bone points were also identified as spearheads : several of them had fragments of wooden shafts surviving in the sockets, either riveted in position or glued in place with resin. Although the use of sheep metapodials seems not to have outlasted the Iron Age, a number of similarly manufactured points made from the metapodials of cattle have been noted from Anglo-Scandinavian levels at Lloyds Bank in York (MacGregor 1978, Fig. 31, 9-10) : these lack the smooth finish associated with the sheep bone tools already mentioned (see, for example, Roes 1963, Pl. XXXVII), and are generally less carefully prepared. All are made from the proximal ends of the bones, where the flat articular surface is easier to work than the solid projecting condyles at the distal end; the epiphyseal tissue is hollowed out to form an irregular socket connecting with the natural medullary cavity of the bone. The tip of the point is formed by chopping obliquely across the diaphysis; the tips are often polished from use and, wherever it can be discerned, the direction of wear is parallel to the axis of the bone : it may be implied, therefore, that they were used with a thrusting or stabbing action, with no evidence of any rotary movement. Numerous unstratified examples are held in the collections of the British Museum and the Museum of London and others have been found in Ipswich (Layard 1908, 74). Layard (loc. cit.) was of the opinion that points of this type had been used as tips for skating poles (see p. 296), and the same identification is given in the Guildhall Museum Catalogue (1908, 154). No supporting evidence has been found for this theory, however, iron tips being normally used for this function (p. 296). Although the stabbing action suggested by the microscopic wear patterns on the tips is not at variance with such a function, some of the points seem too blunt to have gained any purchase

on the ice while others are so slender that they would almost certainly have broken under any stress of this kind. The question of their having been used as spearheads in the manner suggested for the Iron Age points discussed above can also be dismissed as the degree of technological sophistication achieved by urban societies of this period would certainly have made such primitive weapons totally unacceptable. The occurrence of six implements of this type in a leatherworking shop at York (MacGregor 1978, Fig. 31, 9-10) suggests rather that they had a craft function : similar objects, but with more rounded tips, have been identified by Roes (1963, 47) as tallow horns but, while this sort of function might better explain their presence in a workshop (where they could have been used to wax the thread used in sewing), we yet lack the evidence to make any firm conclusion.

Antler tines sharpened to a point with one or more oblique cuts are frequent finds on contemporary sites (MacGregor 1978, 48) though their simplicity of form and lack of direct associations permits no precise identification of function. A possible exception is the group of such points marked by transverse grooves (Fig. 43), apparently the result of repeated chopping with a blade : it may be conjectured that these cuts are of a secondary nature, received while the tine was being used as a wedge, perhaps in a simple clamping device or vice which held the material being cut. As for the others, they may have fulfilled a variety of functions as simple pegs : one suggestion (Radley 1971, 51) is that they could have been used to peg out hides in a tannery.

Mention may also be made here of a series of double-pronged points which seem only recently to have been recognised as bona fide tools

(MacGregor 1978, Fig. 31, 6-8), although it seems certain that they are more numerous than the paucity of published examples might suggest. The reason for this is that these points are simply the cut- or snapped-off ends of bovine nasal bones, which terminate in a natural double prong (Fig. 43). Even their fairly regular length (60-100mm) would not be enough to distinguish them as tools, since this might be a by-product of some butchering technique, but it has been noted among a series of such points from York (MacGregor, forthcoming) that points of this type exhibit an appreciable amount of smoothing when compared with unutilised skeletal fragments from the same archaeological contexts and that, in particular, the double points seem disproportionately smooth. The earliest known examples of this type of implement were found in a midden of a late Iron Age fort at Close ny Chollagh, Isle of Man, but were only tentatively identified by the excavator as having been utilised (Gelling 1958, 98, Fig. 5, 10-11); two more were noted from a Gallo-Roman settlement at Huy, Belgium (Willems 1973, Pl. XLIII, 1-2) and a contemporary example came from a Roman sewer in York (MacGregor 1976, 13); two were found during early excavations at Lochlee Crannog, Ayrshire (Munro 1879, 215), and more recently, six more have come from Viking period levels in York (MacGregor 1978, Fig. 31, 6-8). Many other examples must lie in museum collections where the fact that they have been utilised has gone unrecognised.

The tentative identification given to the Roman implement from York as a netting tool (MacGregor 1976, 13) seems less satisfactory now that a larger number has been studied : in particular, it is now clear that the smoothing which has come from handling or utilisation is generally limited to the outer periphery and especially to the points of the implement, the bottom of the terminal U-notch exhibiting little or no wear as might have

been expected had they been used for netting or for some related use such as bobbins. The same reservation might be advanced to an identification as thread-twisters on the basis of comparison with (manufactured) double-pronged implements of the type tentatively identified by Blomqvist and Mårtensson (1963, 174, Fig. 179), which, along with the example from Waltham Abbey (Huggins 1976, 119), forms the only comparable parallel (p. 113). Some correspondence may, however, be drawn with a series of double pronged bones of a different origin which have been noted on the Continent and which have been identified as the fulcral bones of sturgeon. Numerous examples have been found in the Frisian terps and in Dorestad (Holwerda 1930, Abb 71; Roes 1963, 38), in the medieval fishmarket in Hamburg (loc. cit.), and in Eketorp on Öland (Sellsted 1966, 215-6). Again there is some uncertainty about the extent to which all of these may have been used. Roes^(1963, 38) suggestion that they might have been used as forks for eating shellfish, although it cannot be proven, can be reconciled with the slight nature of any wear sustained by these bones and could equally be applied to the nasal bones discussed above. The identification of others from Gniezno as arrowheads (Kostrzewski 1949, 333) seems less plausible.

Catalogue

10.1	Lochlee Crannog, Ayrshire (Fig. 43C) Munro 1979, 215	10.1a Waltham Abbey, Essex (Fig. 43a) Huggins 1976, 119
10.2	London Guildhall Museum <u>Catalogue</u> (1908), 154	
10.3	Northampton, Northamptonshire (Fig. 43B) Williams 1979, 315, Fig. 139, 72	
10.4	Ipswich, Suffolk Layard 1908, 74	
10.5	York, Yorkshire (Fig. 43A, D, E) MacGregor 1978, Fig. 31; Radley 1971, 51	

CLEAVERS (Fig. 44)

These implements have long been known in Norway, but with two finds from Drimore, South Uist (MacLaren 1974, 15, 18, Pl. 2) and Dublin (Ó Ríordáin 1976, Pl. 15) respectively, they are only just beginning to be recognised in Britain. In the Norse homeland some fourteen of these implements are known, principally from the north of the country : two or three of them are said to be made of reindeer antler, while the remainder (like those from the British Isles) are of cetacean bone (Sjøvold 1971, 1203). A currency from the Merovingian to the Viking age is postulated for the Norwegian examples, the Drimore and Dublin implements being clearly the products of the latter period. The Drimore cleaver (Fig. 44), with a length of 153mm, is extremely roughly made, its tapering handle merging into a widely flaring blade with little distinction between the two. The Dublin implement, on the other hand, has a well shaped handle whose outline is carried over the clearly-marked shoulders of a squared spade-like blade, which is decorated with incised ring and dot motifs (Fig. 44). Both plain, workmanlike tools and other more decorative examples are known in Norway (Sjøvold 1971, 1203), where both flaring and spade-shaped blades are also recorded (Petersen 1951, Fig. 186-7); some of the Norwegian examples are decorated with more ambitious incised ornament than is found on our Scottish and Irish examples (Petersen 1951, Fig. 188-9). Their purpose has not yet been established : whereas Sjøvold refers to them as 'cleavers', the fact that Petersen groups them among weaving implements is an indication of the confusion which still surrounds them.

Catalogue

- 11.1 Dublin, Co. Dublin
Ó Ríordáin 1976, Pl. 15
- 11.2 Drimore, South Uist, Outer Hebrides
MacLaren 1974, 15, 18, Pl. 2

HAMMERS (Fig. 45)

Five hammers made from shed antler burrs have now been noted : only one of these, from Jarrow, is from a stratified context (a 13th-14th century pit), however, so that their currency before the 13th century remains conjectural. They are included here on the grounds that they could belong to this period which, as has been shown, was one in which antler was particularly heavily exploited.

Two of these implements have been found during excavations at Broad Street, Aberdeen (MacGregor, forthcoming), where they were unstratified; a third came from a multi-period site at Staines, Middlesex, appearing in an 18th century destruction layer (Crouch 1976, 124-5, Fig. 27, 37) and a fourth from Jarrow (Professor Cramp, personal communication). An unprovenanced example, possibly from York, is in the Yorkshire Museum (55.33.38). All of these pieces have in common a transverse perforation running through the base of the severed brow tine, into which a narrow handle would have fitted, and all have sustained damage on the face of the burr. It has been suggested that they may have been craft tools, used perhaps in sheet metal working (MacGregor, forthcoming). The toughness which is a feature of antler (p. 61) would have suited it admirably for this function.

Catalogue

- 12.1 Aberdeen, Aberdeenshire
 MacGregor, forthcoming
- 12.2 Jarrow, Co. Durham
 Professor Cramp, personal communication
- 12.3 Staines, Middlesex
 Crouch 1976, 124-5, Fig. 27, 37
- 12.4 York, Yorkshire
 Yorkshire Museum, unpublished

STAMPS (Fig. 46)

Stamps of skeletal materials, notably antler tines, have been recognised on the continent, but have as yet been found in Britain on only one occasion, when excavations at Jarrow produced a single example with a key pattern cut on the end (Fig. 46), dated before the middle of the 9th century (Professor Cramp, personal communication). A second possible stamp, in the form of a wedge-shaped block, possibly of antler with the narrow end carved into six small rectangles (Stevenson 1952, 189, Fig. 2, 5) was found in a wooden tool box of c. 8th to 10th century date in Orkney. Typical examples are published from early medieval Lund (Wahlström 1972, 151-2) and from the Frisian terps (Roes 1963, 40, Pl. XXXIX). Whereas the Lund stamps were thought to have been used in the ornamentation of leatherwork, Roes suggested that those from Frisia were potter's stamps. All of these continental examples have decorative motifs cut into the solid ends of the antler. Such claims as have been made for potter's stamps in this country rest on much more slender evidence : the shaft of a hollow long-bone from a 6th century urn at Lackford, ornamented with incised circles along its length (but undecorated on the end) has

been claimed (Lethbridge 1951, 19) as a potter's stamp, but seems to correspond more closely to the needle-cases which are well-known from contemporary contexts on the continent (cf. those from Altenwalde, Kr. Hadeln (Waller 1957, 12-15) and Wehden, Niedersachsen (ibid., 1961, 33), for example). Five bird bones in the Norwich Castle Museum, found at Thetford, are identified in the display as potters' stamps. Lethbridge (1951, 20, Fig. 27) notes that one urn from Lackford has been stamped around its girth with the molar tooth of a horse, the characteristic form of the grinding surface being reproduced on the wet clay.

Catalogue

- 13.1 Jarrow, Co. Durham
Professor Cramp, personal communication

SC00PS (Fig. 46)

From a Viking period context in York has come an excellent example of utilisation on the basis of the form of the raw material : it is an implement consisting of a scapula, from which the spine has been trimmed and through the end of which a hole has been driven, presumably for suspension, the whole having been used as a scoop (MacGregor 1978, Fig. 31, 12). The wide, flat blade of the bone provides an excellent basis for this purpose. Examples of similarly utilised scapulae of Roman date come from York (Interim 3, No. 3, 24) and from London (Department of Urban Archaeology, unpublished) : the latter example bears the inscription CIIRIIS IIQITU (?), implying that it has been used for scraping wax and underlining the fact that a wide range of functions may be concealed within this group of objects.

Catalogue

- 14.1 York, Yorkshire
 MacGregor 1978, Fig. 31, 12

PLANES (Fig. 47)

Excavations in 1863 at Sarre, Kent, produced what remains for Anglo-Saxon England a unique find : a small smoothing plane with a stock constructed of antler. The Sarre plane (Fig. 47) has a sole consisting of a bronze plate 128 by 33mm, with vertical stops at either end and with a transverse slot of 22 by 10mm to house the blade. The stock measures 130 by 30 by 30mm overall and is accurately matched to the sole to which it is attached by three rivets. The stock, although variously referred to as wood and horn (W. L. Goodman 1959, 198) is in fact made of antler (Dunning 1959, 196; Wilson 1976, 257). It is slotted at an angle towards the front to receive the cutting iron, which was probably held in place by a wedge driven under a metal crossbar, although the latter elements are now missing (for a reconstruction, see W. L. Goodman 1959, Pl. I). Towards the rear, the stock is narrowed and transversely perforated by an oval hole to form a finger grip, large enough for two fingers and the thumb.

The small size of the plane - Dunning (1959, 197) suggests that wood up to 6mm wide could be planed with it - marks it as a craftsman's implement rather than a general-purpose tool. The suggestion (Dunning, loc. cit.) that it could have been used in the manufacture of small wooden caskets is quite plausible, while Goodman (1959, 198) mentions the manufacturing of musical instruments as another possibility.

A number of Roman planes, although of larger size than that from Sarre, provide models on which to base this sole Anglo-Saxon example : a plane from Silchester (reconstructed in W. L. Goodman 1959, Fig. 2) shares a number of common features with it and references to numerous other planes of the Roman period are given by Wilson (1963, 149). Beyond the Roman frontier, a wooden plane dated to the 3rd century has been recovered from Vimose in Jutland (Engelhardt 1869, 29, Fig. 31, Pls. 18, 37), boat-shaped and with the ends turned up in the form of birds' heads. More closely contemporary examples have been found in the Frisian terps, all of them with antler stocks : they are distinguished by having carved scroll-like handles which rest against a small upright pillar at the rear and a slanting bed for the cutting iron at a slope of c. 45 degrees (Roes 1963, 40-2, Pl. XL). Some of these Frisian planes have entire bronze soles while in others an attempt has been made to save on metal by laying it down in thin strips; one of them incorporates on the fore-part of the stock a panel of incised interlace ornament, on the basis of which Roes (loc. cit.) dates it and all the Frisian planes to c. 700.

Recent excavations at Christ Church Place, Dublin, have produced part of a small wooden smoothing plane from a late 11th century context (Ó Ríordáin 1976, 137, Pl. 9). From the published photograph it seems to correspond closely with the Vimose plane mentioned above, being tapered towards its surviving end and terminating in an upturned bird's head.

W. L. Goodman states that antler continued to be utilised for the manufacture of plane stocks throughout the middle ages. This fact, together with the new find from Dublin described here, gives grounds for optimism that further finds of antler planes may yet be expected from archaeological contexts.

Catalogue

- 15.1 Sarre, Kent (Fig. 47)
Dunning 1959, 156-7; W. L. Goodman 1959, 198-201

HANDLES (Fig. 48)

Under this heading are grouped the handles of tools and implements (including those of knives) but not those of weapons, which are considered below (p. 146).

Several types can be identified, of which the following are the most numerous : hollow, longitudinal handles made from the shafts of limb bones and solid longitudinal handles, usually made from antler tines. Other types are also mentioned below (pp. 131-2). During the Roman period, many handles of the first type were produced from limb bones, particularly the metatarsals of horse, which are both robust and regular in section.⁽¹⁰⁾ These features made it possible to lathe-turn these handles; often they were given a sinuous profile which served as a finger-grip. Examples of such handles have been found intact on large knives and on swords (Braat 1967, Pl. II, 3). This type fell from popularity after the Roman period, however, and no examples of Anglo-Saxon date are known. Some of the smaller knives of this period were fitted with handles in a similar manner although, in keeping with their smaller size, the leg bones of lesser animals, notably sheep, formed the usual source of raw material. A handle of this type was found in the Anglo-Saxon village of Sutton Courtenay (Leeds 1947, 84) and two further examples from York, probably of Anglo-Scandinavian or early medieval date, are illustrated by Waterman (1959, Fig. 7, 10-11); both are mounted on iron knives and have been

ornamented with incised ring-and-dot ornament. A more elaborately decorated handle, with the end plugged with a bone insert, was found at Bush Lane in the City of London, where it was thought to have come from the upper layers of a pit of the 11th or 12th century (Johnson 1974, 278).

In order to secure the implement tang in a handle of this first type, it would probably have been necessary to fill up the hollow shaft with packing material, while some sort of terminal was necessary to engage the end of the tang. Solid handles (see below) are occasionally found with the implement tang secured with lead (Lethbridge 1952, 185). In the second type, the solid structure of the raw material would have given a much firmer grounding for the tang, comparing more closely with wood which, no doubt, provided the most common alternative. Most handles of this solid type are made from antler : the size of most indicate the use of tines rather than the beam, while the degree of straightness exhibited suggests that brow tines were most commonly utilised for this purpose (Fig.12). An example of this type, still retaining the iron tang of what was thought to be a knife, was found at Weeting (R. R. Clarke 1952, 71-3) : the lower end is decorated with incised triangles and ranged along the handle is an Ogham inscription which, together with stratigraphic evidence, suggests an early post-Roman date for this piece. Other Ogham-inscribed knife handles have been found at Bac Mhic Connain (Beveridge 1932, 56, Fig. 11) and at Aikerness Broch (Macalister 1940, 218). Macalister (loc. cit.) interprets the inscriptions as indicators of ownership. An alternative function for the type is demonstrated by a handle found on a two-pronged iron fork

in a Saxon grave at Harnham (Akerman 1855, 72-3, Pl. XXXVI, 1). Other antler handles without identifiable implements are known from the Saxon period at Sutton Courtenay (Leeds 1947, 84), and from the early medieval period at Southampton (Platt and Coleman-Smith 1975, 271, Fig. 247, 1919) and Lincoln (Fig. 48), one of the latter (from a 12th (?) century context at Flaxengate) being lathe-turned. Stevenson (1952, Fig. 2) illustrates a group of bone and antler handles of 8th to 10th century date, found in a wooden tool box in Orkney.

In the north, cetacean bone provided an alternative raw material to antler : a well-made handle of solid type came from excavations at Dun Cuier (Young 1956, 321, Fig. 14, 41).

Later in the medieval period ivory became increasingly commonly used for knife handles as the raw material became more generally available. At the same time the range of forms encountered becomes increasingly elaborate, anthropomorphic forms becoming increasingly popular. On more mundane implements horn handles became common, the solid tips of cattle horns forming the most usual source. Strip tangs, in which plates of bone or horn were riveted to either side of flat tang, re-appear in the late medieval period; they had previously been common in the Roman period (Guildhall Museum Catalogue, Pl. XVII), but little evidence for this type has been found in the intervening centuries. One exceptional find of this type must, however, be noted : this is an iron knife with a truncated blade, interestingly (if tentatively) identified as perhaps a bone-worker's knife, found in Castle Street, Canterbury (Graham-Campbell 1978, 130-3). The knife has a flat tang, to either side of which is riveted a bone plate : that on one side is decorated with carved interlace ornament

and on the other with a ring-chain pattern in Borre style, the two suggesting a date in the 10th century. It seems as yet to be unparalleled elsewhere.

Transverse handles are less common than might perhaps be expected. The increasingly well-known spoon bits of the Viking and early medieval periods are thought to have had handles of this type : Wilson (1976, 258) records one example found in a 13th century context at Mileham, Norfolk, with its transverse handle intact.

One further type of handle may be noted which, to judge from the external wear around its base, was inserted in some sort of socket during use : a function as a quern-handle has been suggested for a handle of this type (Young and Richardson 1960, 147).

Catalogue

- 16.1 Southampton, Hampshire (Fig. 48C)
Platt and Coleman-Smith 1975, 271, Fig. 247, 1919
- 16.2 Canterbury, Kent (Fig. 48E)
Graham-Campbell 1978, 130-3
- 16.3 Sutton Courtenay, Leicestershire
Leeds 1947, 84
- 16.4 Lincoln, Lincolnshire
Lincoln Archaeological Trust, unpublished
- 16.5 London (Fig. 48F)
Johnson 1974, 278
- 16.6 Weeting, Norfolk (Fig. 48B)
R. R. Clarke 1952, 71-3
- 16.7 Broch of Aikerness, Orkney
Macalister 1940, 218
- 16.8 Birsay, Orkney
Stevenson 1952, 189, Fig. 2
- 16.9 Á Cheardach Mhor, South Uist, Outer Hebrides (Fig. 48A)
Young and Richardson 1960, 147

- 16.10 Bac Mhic Connain, North Uist, Outer Hebrides
Beveridge 1932, 56, Fig. 11
- 16.11 Dun Cuier, Barra, Outer Hebrides
Young 1956, 321, Fig. 14, 41
- 16.12 Kilpheder, South Uist, Outer Hebrides
Lethbridge 1952, 185-7
- 16.13 Harnham, Wiltshire
Akerman 1955, 72-3
- 16.14 York, Yorkshire
Waterman 1959, Fig. 7, 10-11

WRITING MATERIALS (Fig. 49, Pl. 22)

The stylus and waxed tablet had a long history in the Greek and Roman worlds before becoming the everyday means of recording the ephemera of Celtic and Anglo-Saxon monasteries. In the classical world they had been used for a variety of purposes from school exercises and accounting to literary composition; two or more tablets were sometimes bound together by rings or thongs to form a codex which, as well as for jotting down notes, could be used as legal documents whose privacy was ensured by threads or tapes sealed by witnesses (Thompson 1912, 15).

A number of references to the use by monks of styli and waxed tablets in Anglo-Saxon England still survive (Peers and Radford 1943, 64). Waxed tablets dating from the later medieval period are known from Italy and Germany (Thompson 1912, 17; Warncke 1912, 233), while one example in wood with characters in Irish and Latin still inscribed in the wax is in the National Museum of Ireland (Coffey 1909, 82-4, Figs. 88-9). The old find from Springmount, Co. Antrim of an entire 'book' of waxed wooden leaves (Armstrong and Macalister 1920, 160-6) has taken on a new interest by recently being dated to the 7th century (Hillgarth 1962, 184). From

the period under review here, however, only one example in bone is known from the British Isles : a tablet of cetacean bone, found at Blythburgh (Pl. 22), has a characteristic recessed area in which the wax was spread and two perforations by which it could have been found to a second tablet in the manner described above. An Anglo-Saxon date for this piece is indicated by a panel of low-relief interlace carved on its unrecessed face which, to judge from surviving bronze rivets, was originally overlaid with an equal-armed cross (British Museum Anglo-Saxon Guide, 112-3).

Only a few Anglo-Saxon styli are known, most of the incontrovertible examples being of bronze, as at Kempston* (British Museum Anglo-Saxon Guide, 75), Whitby (Peers and Radford 1943, 64-5) and, perhaps, Canterbury (Radford 1940, 506-8). Of those published examples in bone, one (Fig. 49) from Whitby (Peers and Radford 1943, 71) compares broadly in outline with those in metal from the same site (ibid., Fig. 15), although it lacks the usual circumferential bands on the shank. Waterman (1959, 83-5) mentions that some objects with spatulate heads normally identified as pins could have served as styli : one particularly likely example from York (Fig. 49) is carved in dragonesque form with a projecting spatulate tongue which could have served as an eraser, an essential element on any stylus (Waterman 1959, 82; see also Ward Perkins 1949, 207-8). In a forthcoming consideration of writing materials from Winchester, Mr. David Brown⁽¹¹⁾ expresses doubt that styli could ever have been made from bone since (he suggests) it would have been necessary to heat the spatulate end in order to melt the wax and to facilitate erasure. There seems to be no supporting evidence for this theory, however, and indeed the mention of a corneum grafium among the personal relics of St. Desiderius,

* Not all authorities accept even this as a genuine Anglo-Saxon stylus.

who was murdered in the mid 7th century (Mon. Germ. Hist. Script. Rer. Merov. VI, 62) indicates the contrary.

A more common type of implement which may be discussed along with writing materials seems to belong to the early medieval period. It is characterised by being lathe-turned, with an oblate or spherical head and a short, tapering or parallel-sided shank; the shank is usually ornamented with one or more bands of multiple incised lines and tipped with an inset metal point, usually of iron but sometimes of bronze or even silver. Two of these from Whitby (Peers and Radford 1943, 71), although published with the Saxon material from that site, are more likely (on the evidence of finds from elsewhere) to have come from medieval levels. Others of equally equivocal date may be noted from Jarrow, where one example, lacking a ball head and terminating instead in a flat top (Fig. 49), may be of pre-Conquest date (Professor Cramp, personal communication). A group of five such implements from a 13th-century well at York Minster (MacGregor, forthcoming) are of identical type (Fig. 49), while two further examples (both lacking their tips but almost certainly styli rather than pins, as published) from Southampton are of 13th- and early 14th-century date respectively (Platt and Coleman-Smith 1975, 271-4). A number of others have been noted from sites listed in the catalogue below (p. 139). Earlier finds from London, published by Wheeler as possibly of Roman date (Wheeler 1930, 58) are again probably of medieval origin. Somewhat similar implements found in Rome and taken to be of Roman date demand notice before all the British examples are dismissed, but the outline of their shanks, tapering towards a ball head (Mårtensson 1961, Bild 1) is unlike any of those discussed here.

While the medieval date of these objects may, therefore, be taken as fairly certain, their function has not hitherto been convincingly explained. Their identification by several of the above authors as still is difficult to support, since all these objects lack the essential spatulate eraser at the head. In his forthcoming report on Winchester writing materials, D. Brown makes the convincing suggestion that these implements are in fact parchment prickers. It was the custom of medieval scribes to lay out the pages of their manuscripts with great care (see Ivy 1958, 42-4). Vertical margins were drawn at the edges of each column and horizontal lines guided the hand of the scribe in his task. The spacing of these horizontal lines was controlled by a series of small pricked holes on either side of the page : variations in the positioning of these holes - whether within the text area, on the inner and outer margins, at the extreme edges of the page, whether they were executed before or after the page was folded - all these factors have been shown to be of significance in assigning manuscripts to particular scriptoria or to a particular period of time (see, for example, Lowe 1935, x; Ker 1960, 41-4). The character and alignment of the prickings can be equally illuminating to the expert eye (L. W. Jones 1946, 389-403). The advantage of pricking manuscripts in this way is that several pages can be laid out at any one time by superimposing two or more bifolia and pricking through several leaves at once. Coveney (1958, 18-9) states that the normal Late Saxon insular practice was for an entire quire of four double leaves to be folded and pricked at once. Subsequent ruling could also be carried out on more than one sheet at a time since, at least until the mid 12th century, ruling was executed with a dry point which made a furrow on the upper side of each sheet of parchment (often the hair side) and a corres-

ponding ridge on the reverse. The lead point or plummet progressively replaced the dry point from around the 12th century and was in turn superseded by ink in the 15th century (Diringer 1953, 210; L. W. Jones 1946, 389).

Since some of the implements described here seem to be of post 12th century date, it seems unlikely that they can correspond to the dry point used for ruling (Ligniculum), as this practice had lapsed by that time. It remains a distinct possibility, however, that they could be prickers, since pricking outlasted dry point ruling. Early sources mention two categories of pricker : the circinus, denoting compasses or dividers with sharp points, and the awl, subula or punctorium. L. W. Jones (1946, 389-403) discusses various forms of perforation which could have resulted from each of these implements (as well as a putative pricking wheel provided with multiple spikes); amongst these are circular holes similar to those which might be made by the items being considered here. In addition, D. Brown (forthcoming) comments on the useful 'shoulder' formed by the bottom of the shank, which would prevent the iron tip from penetrating too deeply and forming an undesirably large hole. The overall size of the implement is well suited to this use while the ball head, so inappropriate for a stylus, may have served as a burnisher to treat small blemishes in the parchment, since many of them show signs of wear or polishing on some part of the head.

Although this identification remains slightly speculative, an interesting association of an implement of this type with other writing materials may be noted : in a drain in the grounds of St Jacob's School at Lülbeck, a group of objects dating from the medieval period and relating to the

functioning of the school was found, including a number of writing tablets, jettons, inkwells and an implement of the general type under discussion (Warncke 1912, 16-33). Although this example was made of maplewood and had an anthropomorphic head rather than a simple ball terminal, the shank and the metal tip correspond exactly to the form described here. The implication that it played a part in the school curriculum seems fairly strong and further enhances the suggestion already made as to their use.

Two further categories of writing equipment may be noted here. A number of goose radii with obliquely cut and pointed ends have been tentatively identified as medieval pens : Hurst (1965, 172-4) describes one from a 13th or early 14th century pit at Barn Road, Norwich, and three more from Coventry. Other examples come from broadly contemporary contexts at St. Aldates, Oxford (Henig, in Durham 1977, 163), Boston (Moorhouse 1972, 43) and London (Tatton-Brown 1974, 198). An unpublished example is in the Museum of London collection (11,112) and another has been found more recently in the excavation of the College of the Vicars Choral at York (MacGregor, forthcoming). In a discussion of this type of object, Biek (in Hurst, 1965, 172-4) notes that they lack the split ends which give added flexibility and, perhaps, capillarity to quill pens, but concludes that they could have been used as lining pens if loaded with viscous ink and held with the open side upwards and almost horizontally. The similarity in form of a Roman bronze pen from London (Wheeler 1930, 58) is of interest here, although the 'nib' on this Roman implement is cleft. Residues of ink on those from Coventry were deemed to be of doubtful antiquity, but the pieces from York and Boston certainly have contemporary ink stains on them. An alternative function suggested by Biek (loc. cit.) was for scooping out or measuring quantities of softened oak galls for preparation with boiling water as ink, while other suggestions made elsewhere (in Moorhouse 1972, 43) include pipettes for charging quill pens and 'economisers' for broken quills, the end of the quill being inserted into the hollow bone.

Brief reference may be made to parts of two pen cases of Late Saxon workmanship, one from Sweden (Blomqvist and Mårtensson 1961, 213-6) and the other, dating to about 1100, from London (Goldschmidt 1926, 14, Pl. VII, 28).

Also of interest in this context is the interpretation placed on a bone plate (Fig. 49) inscribed with a runic legend on one side and acquired (though not necessarily found) in Derby : Bately and Evison (1961, 301-5) have suggested that it might have been used as a ruler or spatulate implement for turning pages of manuscripts or indicating the place, adding that the two holes at one end could have served for the attachment of a ribbon or strap, the whole forming a decorative book mark.

Catalogue

Styli

- 17.1 St Neots Priory, Cambridgeshire
Tebbutt 1966, 51-3, Fig. 4e
- 17.2 Jarrow, Co. Durham (Fig. 49F)
Professor Cramp, personal communication
- 17.3 Southampton, Hampshire
Platt and Coleman-Smith 1975, 271, 274, Figs. 247-8
- 17.4 Winchester, Hampshire
D. Brown, forthcoming
- 17.5 Eynsford Castle, Kent
Rigold 1971, 148-9
- 17.6 London
Wheeler 1930, 56-8
Tatton Brown 1974, 198
- 17.7 Kings Lynn, Norfolk
Carter and Clarke 1977, 314, Fig. 143, 39
- 17.8 Clare Castle, Suffolk
Knocker 1959, 145
- 17.9 Bordesley Abbey, Worcestershire
Rahtz and Hirst 1976, 221, Fig. 39

- 17.10 Hull, Yorkshire
P. Armstrong 1977, 70, Fig. 29, 137
- 17.11 Whitby, Yorkshire (Fig. 49 A, C, D)
Peers and Radford 1943, 70-1, Fig. 21, 107-9
- 17.12 York, Yorkshire (Fig. 49 B, E)
MacGregor, forthcoming; Waterman 1959, 82, Fig. 12, 6

Pens

- 17.13 Boston, Lincolnshire
Moorhouse 1972, 43
- 17.14 Norwich, Norfolk (Fig. 49 I)
L. Biek, in Hurst 1965, 172-4, Fig. 14, 14
- 17.15 Oxford, Oxfordshire
Henig, in Durham 1977, 163
- 17.16 Coventry, Worcestershire (Fig. 49 G, H)
L. Biek, in Hurst 1965, 172-4, Fig. 14, 15-7
- 17.17 York, Yorkshire
MacGregor, forthcoming

Writing tablets

- 17.18 Blythburgh, Suffolk (Pl. 22)
British Museum Anglo-Saxon Guide 112-3

Writing cases

- 17.19 Goldschmidt 1926, 14, Pl. VII, 28
SEAL MATRICES (Fig. 50, Pl. 23)

These are not numerous finds in any material during the period under review (see, for example, British Museum Anglo-Saxon Guide, 110-112), those in skeletal materials being very rare indeed. Of necessity, the lettering and design on these objects must be clearly cut to a reasonable depth and must be unobscured by any surface texture. Ivory provides the best medium for clear and accurate carving in this manner and all the matrices discussed below are of elephant or morse ivory, marking them further as the possessions of wealthy institutions or individuals.

Best known among these matrices is that found in 1879 in Wallingford (Pl. 23). It consists of a circular element, carved with the matrix proper, and a handle formed by a lobed extension at the top. The obverse has in the centre a bust of a man holding an upward-pointing sword in his left hand, surrounded by an inscription in Anglo-Saxon capitals reading + SIGILLUM GODWINI MINISTRI, 'The Seal of Godwin the Preist' (or Taane) (Okasha 1971, 118). An additional letter between the first and second words may be a decorative addition or an error (Okasha, loc. cit.), but it has also been interpreted as a B, perhaps for BEATI (British Museum, Anglo-Saxon Guide, 112). On the obverse of the handle are carved God the Father and God the Son with, under their feet, a figure probably representing Satan; it seems likely that they were originally surmounted by a dove representing the Holy Ghost and completing the Trinity, though this has been broken off. The reverse is also cut as a matrix : a female figure sitting on a cushion and holding a book is surrounded by the inscription + SIGILLUM GODGYTHE MONACHE D^oDATE, 'The Seal of Godgyth, a Nun Given to God'. The reverse of the handle is undecorated. A date in the 11th century has been favoured for both these inscriptions (eg, British Museum Anglo-Saxon Guide, 112; Goldschmidt 1926, 19-20) but, using numismatic evidence, Dolley (quoted in Okasha 1971, 119) has suggested that the reverse may date to the last quarter of the 10th century while the obverse may have been cut in the middle of the 11th century. It is difficult to distinguish any structural detail on the Wallingford matrix : possibly it is of walrus ivory. It represents both the earliest and the finest example of the ivory die-cutter's craft.

A date towards the end of the 12th century may be postulated for a matrix found in a post-medieval context at Aldwark, York (Fig. 50). A peripheral inscription on the obverse in Lombardic capitals reads + SIG SNARRI THEOLENARI, 'The Seal of Snarr, the Toll Gatherer', while in the central field a figure, perhaps Snarr himself, is represented in a wide-sleeved gown girdled at the waist, wearing fashionably pointed shoes and carrying a bag which presumably contains the fruits of his toll gathering. The reverse is uncarved and displays some marbling of the dentine (p. 23), indicating that the matrix is made of walrus ivory. At the top is a small projecting lug, perforated for suspension. Of similar date is a matrix of closely comparable form (Fig. 50), now lacking its suspension lug, found at Witney, Oxfordshire (Ashmolean Museum, unpublished). This example, also of morse ivory, bears an incised figure of Sagittarius, surrounded by the legend + SIGILLUM ROBERTI DE FONTANETO.

Three somewhat similar matrices are published by Goldschmidt (1926, Nos. 56-8) : the first is of French workmanship and is identified by its inscription as belonging to St. Stephen's Cathedral, Sens; the second bears within an architectural setting a bust identified as that of the 12th century Pope Lucius and an inscription around the edge relating it to Holy Trinity Cathedral, Roskilde; the third matrix displays a figure identified as William, Abbott of St. Martin's but, although it is of French origin, the abbey in question has not been located. The latter two examples, although twice the size of the York and Witney pieces, are close to them in form, having similar suspension lugs on top, and are also formed of walrus ivory : all three are dated to the 12th century. Unlike them, however, the York matrix clearly belonged to a secular

official, presumably one who had purchased the right to collect tolls on a highway, river or market place.

Two unfinished and unpublished matrices have been noted during the compiling of this study ; one is of walrus ivory, is unprovenanced and is in the British Museum (unnumbered) and the other, of uncertain skeletal material (possibly walrus ivory) was found in the Guildhall car-park, London, with pottery judged to be of later 13th-century date (Museum of London, ms. catalogue, 24303).

Catalogue

- 18.1 *Sittingbourne, Kent (Fig. 50B)*
British Museum, loan collection
- 18.1a London
Museum of London, unpublished
- 18.2 Wallingford, Oxfordshire (*Pl. 23*)
British Museum Anglo-Saxon Guide 112; Okasha 1971, 118
- 18.3 Witney, Oxfordshire (*Fig. 50C*)
Ashmolean Museum, unpublished, 1929, 463
- 18.4 York, Yorkshire (*Fig. 50A*)
MacGregor, forthcoming

MOULDS (Fig. 51)

Included in the published catalogue of small finds from medieval Southampton is an object described as an 'unfinished bone artefact, probably a gaming-piece', for which a 12th-century date is suggested (Platt and Coleman-Smith 1975, 271). It was recovered from an excavation by J. Wachter (site E) between Brewhouse Lane and St. John's Lane, in the south-west quarter of the medieval town. The object was found in a late disturbed context, associated with the demolition of a 13th-century wall, although accompanying 12th century rim sherds (131, 170) supported the earlier

date given to the piece in the catalogue (op. cit., 161-4). It is suggested here that the object is in fact a mould used in the production of discoid ornaments and that a 10th or early 11th century date would be more appropriate for it.

The Southampton mould (Fig. 51) is cut from the base of a shed antler, almost certainly from a red deer. It has been sawn obliquely, close to the burr, where the spongy tissue which permeates most of the antler core (p. 14) is least in evidence. Part of the corona surrounding the burr has been removed and the naturally rough surface of the antler beam has been shaved into a series of parallel-sided facets, probably with a draw-knife; the brow tine has been sawn off, leaving an expansion on this part of the face. A discoid depression has been sunk into the cross-sectional surface, its symmetrical outlines indicating that it was cut with a centre-bit or similar implement. Within its circumference are three concentric rows of drilled indentations with shallow, tapering cross-sections, a similar indentation marking the centre point. The decorated surface is partly eroded. There is also some damage to the periphery of the junction of the brow tine, but there are traces here of what appears to be an ingate (see below).

Several related objects are known from excavations at Hedeby (Capelle 1970, 9-23; Capelle and Vierck 1971, 93-5; Ulbricht 1978, 75-6), of which one in particular closely resembles that from Southampton : this example (Ulbricht 1978, Taf 36, 5) has been cut in a similar manner from a reindeer antler burr and subsequently incised with a decorative motif comparable with that already described. The general dating limits set by the period of occupation of the Hedeby settlement are from its founda-

tion in the late 8th or early 9th century until the end of the first quarter of the 11th century (Eckstein and Schietzel 1977, 157). In considering the function of the Hedeby pieces, several authors have concluded that they were used as moulds in the production of ornaments. In a discussion of one pre-war find, Jankuhn (1944, 227) suggested that models or patterns had been formed by pressing softened wax into the antler matrix, subsequently to be invested with clay and used to produce series of cire perdue castings. The idea that they were used to produce wax models was also favoured by Capelle (1970, 19) on the grounds that direct casting of molten metal in these moulds would have damaged the carefully-prepared antler. The low melting point of the wax, posing no danger of damage to the mould, meant that the moulds could be used to mass-produce large numbers of models.

More recently, however, Drescher (1978, 84-115) has carried out practical experiments using reproduction moulds, the results of which shed new light on the potential of these antler matrices. Drescher encountered no difficulty in making repeated castings of lead and tin ornaments in antler moulds of this type : in one instance, fifty castings were made from a single mould which suffered no damage beyond some discoloration from the heat. In these experiments the second valve of the mould was reconstructed in wood : in the case of a replica based on the Hedeby mould most closely resembling that from Southampton, the wooden element had to include an ingate, since none exists on the antler matrix. The Southampton mould appears to have an ingate incorporated in the brow tine expansion, however, so that none would have been necessary on the second element.

The ornaments produced from the Southampton mould would have taken the form of flat discs decorated on the obverse with concentric rings of raised dots. Some idea of their appearance can be gained from a plated copper alloy ornament found at Ødsted, Denmark, and dated to the first half of the 9th century (Brøndsted 1936, 121, Fig. 30) and from a lead alloy brooch with a slightly bossed centre found at Winetavern Street, Dublin (Ó'Riordáin 1976, Pl. 19).

In addition to the re-identification suggested for the Southampton piece, therefore, an origin some two or three centuries earlier than the 12th century date suggested in the published catalogue may also be postulated; several discoveries of pre-Conquest material have been made in recent years in the vicinity of Brewhouse Lane and St. John's Lane, providing a background for the presence of this piece. Finally, it introduces a new technique to the repertoire of casting methods established for the British Isles in the early medieval period.

Catalogue

- 19.1 Southampton, Hampshire (Fig. 51, Pl. 13)
Platt and Coleman-Smith 1975, 271, Fig. 247, 1915

SWORD HILTS (Fig. 52, Pl. 24)

A certain amount of historical evidence exists (Ellis Davidson 1962, 52) to suggest that sword hilts of the 9th and 10th century were made by groups of specialist craftsmen rather than by the armourers' workshops in which the blades were made. Additionally, these craftsmen may have been employed in the periodic repair of damaged hilts (Jankuhn 1951, 215). Surviving

hilts in skeletal materials are rare, however, and little generalisation is possible from archaeological sources.

Three distinct elements can be distinguished in the hilts discussed, each of which was threaded in turn over the narrow tang. (Strip tang swords with hilt plates riveted on either side were not favoured during the period considered.) First of all, a guard in the form of a projecting cross-bar was fitted, seated across the shoulders of the blade; the more-or-less cylindrical hand-grip was then slid over the tang; the third element, the solid pommel, completed the sequence, the end of the tang then being burred over to keep it in place and to lock fast the entire assembly.

The grips, pommels and guards of Roman swords were frequently made of bone, antler or, less frequently, of more expensive ivory. Typical grips of such swords are made from the naturally-cylindrical shafts of long-bones (perhaps most often the metapodials of cattle and horses) and were shaped by hand or on the lathe. Those made by hand are often square or hexagonal in section with a sinuous outline to accommodate the fingers (eg Malton Museum R.30.326) while the lathe-turned examples may be similarly sinuous or simply cylindrical (eg Braat 1967, Pl. II, 1-2).

Something of this sinuousness can be seen in the only surviving Anglo-Saxon sword grip, that forming part of a complete hilt found in Cumberland and made of horn ornamented with gold filigree panels and with a triangular setting of garnets (Pl. 24). The tapering outline of this example is, however, a non-Roman feature. Åberg (1926, 144) assigned the Cumberland handle to the 7th century on the basis of its decorative metalwork, a date which Behmer (1939, 36) found acceptable on more general grounds. The

hilt itself, however, is thought (Ellis Davidson 1962, 58) to be earlier. The absence of further grips of the Anglo-Saxon period indicates that organic materials, no doubt principally wood (cf. Wilson 1965, 48), had replaced those of skeletal origin as the normal source of sword grips during this period.

The guard of the Cumberland hilt is also of horn (Fig. 52), with a curved gold plate running round one end, presumably that normally worn to the front. A noteworthy feature of the Cumberland guard is that, in addition to having a perforation for the tang, it is provided on its underside with a slot to accommodate the heel of the blade, a characteristic common on iron guards of the later Saxon period (Wilson 1965, 49) and in the Scandinavian world (Petersen 1919, passim). This feature is also found on an antler guard from Clifford Street, York (Waterman 1959, 72, Fig. 5,3); the double convex outline with squared ends on this piece (Fig. 52) suggest a date (in common with the remainder of the Clifford Street material) in the Saxo-Norman (9th-12th century) range, probably in the earlier part of that period. An elongated example of this type of guard from Frisia is illustrated and discussed by Roes (1963, 75, Pl. LVIII) : in this instance the slot is on what was judged (on account of the polish which it exhibited) to be the upper side of the guard and it was suggested that it engaged with the lower end of the grip.

The fact that skeletal materials were used as guards (in which function they would have been exposed to savage cuts) is an indication that their toughness was recognised as being appropriate for this role. Ellis Davidson (1962, 62) does not attribute a high degree of functional importance to Anglo-Saxon guards, however, as they were often made of

perishable material (presumably wood). A number of more decorative Scandinavian sword guards demonstrate that this use of skeletal materials was not limited to everyday weapons : one example from Sigtuna is carved with Mammen style ornament (Uggla 1944, 207); Kossina (1929, 303, Abb 4) describes one example with ivory grip and guard now in Prague (St. Stephen's sword) thought to have been carved in Scandinavia in the 10th or 11th century; Goldschmidt (1923, Taf XLIX, 142) illustrates another (with matching pommel) of walrus ivory, judged to be Scandinavian and of 12th-13th century origin.

With the exception of the pommel on the Cumberland sword and another example from Lakenheath Fen (Fig. 52), the latter made of antler, pommels of skeletal materials are unknown in the British Isles. Behmer (1939, Taf 1, 10) illustrates a pommel and guard from a sword found in the Nydam Mose, Denmark, which, like the later examples mentioned above, echo each other's elliptical outline; they are distinguished from each other both in size and in the fact that the pommel has a small circular hole for the tang while the guard is, of necessity, provided with a much wider rectangular slot. This distinction may serve to differentiate one and the other in the absence of other characteristic features, such as a blade slot.

Catalogue

- 20.1 Cumberland (Fig. 52A, Pl. 24)
 British Museum Anglo-Saxon Guide, 92-3, Pl. VII
- 20.2 Lakenheath, Suffolk (Fig. 52B)
 British Museum, unpublished
- 20.3 York, Yorkshire (Fig. 52C)
 Waterman 1959, 72, Fig. 5, 3

COMPOSITE BOWS (Figs. 53-5, Pl. 25)

It was during the Roman period that composite bows were first introduced into the British Isles, arriving as part of the armoury of the Imperial forces. An Hadrianic tombstone from Housesteads portrays an archer equipped with a bow of this type (D. Smith 1968, 286-91, Pl. XVI). Physical remains of composite bows from a number of Roman sites are discussed below (p. 153).

In the Mediterranean world the composite bow had found widespread favour since at least the early first millenium BC, when it won fame for both Scythians and Persians; Rausing (1967, 148), however, estimates that it may have been developed some 3000 years earlier. Many variations in detail are found among the composite bows which came to be dispersed among totally disparate cultures over three continents, but a generalised description of the type which found its way to northern Europe may be attempted on the basis of Roman period fragments and of more complete extant bows from more recent periods (based on Balfour 1890). The core of the weapon (Fig. 53) is a wooden grip, from which flexible arms spring symmetrically on either side. At the extremities of the springy arms are cut rigid 'ears' which, in some instances, continue the line of the curve but, more generally, may diverge markedly from the line of the arms. The nocks, which engage the end of the bow-string and which are frequently made of bone or antler, were let into the ears as strips, while lateral bridges at the elbows served to control the movement of the string when it was released. Strong strips of cattle horn were fixed with a suitably resilient animal glue to the belly of the bow, that is, the surface of the bow facing the archer when in use; these strips were thickest and strongest towards the grip, gradually thinning out until they terminated at the elbows. The back of

the bow (the surface furthest from the user) was covered with sinew, disposed longitudinally along the bow, mixed with glue and moulded in one or more layers on to the wood. This combination of materials resulted in the bow adopting in its unstrung state a 'negative' curve, with the extremities of the bow pointing forwards; stringing the bow resulted in the direction of curvature being reversed, producing the classic 'Cupid's bow' shape.

This composite structure produced a number of mechanical advantages, making it inherently unlikely that the type was developed merely in default of suitable timber, as suggested by some authorities (summarised in Rausing 1967, 145). The one-piece long-bow of yew (*Taxus baccata*) which became for a time the English weapon par excellence, was particularly suited to the temperate climate of northern Europe : recent research has shown that the mechanical properties which make yew an excellent reservoir of strain energy are seriously impaired at temperatures above 35⁰C (Gordon 1978, 78-9). In composite bows, however, the wooden core played only a minor part in storing the energy induced by the archer stringing and drawing the bow : instead, this energy was stored partly under tension in the sinew surface moulded to the back of the stave and partly under compression in the horn strips on the belly. Both of these materials function more effectively as energy stores than does yew and lose none of their efficiency up to c. 55⁰C, provided they are kept dry.

A more important advantage enjoyed by the composite bow over the self bow lay in the fact that a greater amount of energy could be stored in the bow during the stringing process. Gordon (1978, 80-3) outlines the principles involved as follows : the energy available to dispatch the arrow is dependent on the distance by which the string is drawn (normally

a maximum of 0.6m) and the force applied to it (usually not more than 350 Newtons or 80lb); Fig. 54 expresses diagrammatically the means by which the maximum energy available for storage in an unstressed bow⁽¹²⁾ can be calculated at c. 105 joules, that is, about half the input of the archer. In contrast, composite bows are, as already explained, reflexed when strung, so that a more significant amount of strain energy is already stored in the bow before the archer begins his pull (Fig. 54); in this instance about 170 joules of energy are available at the moment the arrow is fired. An alternative method of comparison is given in Fig. 55, in which 'force-draw' curves are shown for various types of bows : A represents a short simple bow, in which even small variations in the length of draw produce large variations in the arrow velocity; B is a one-piece long bow of simple construction; C demonstrates the advantage gained by adding ears to a short bow and D indicates the optimal qualities of the reflexed bow. (The amount of energy stored in each bow with a draw of 28 inches and a drawing force of 60lbs is proportional to the area under the respective curves.) In weapons of similar size the composite bow would clearly have a considerable advantage in range over the self bow, but in practice this advantage was used in making composite bows of smaller and more manageable size.

While the horn strips clearly represent the most vital element in the composite bow to be made of the materials under review, pre-medieval examples seem not to have survived. Only one bow incorporating horn has been noted in the publications surveyed and nothing of certainty can be said about its age : this example, said to have been formed from a single horn,⁽¹³⁾ was found in the fens between Ely and Waterbeach

around the middle of the last century; the only details published, apart from the above, are that it was 1.08m long and was broken at one end (Archaeol. J. 13 (1856) 412; 14 (1857) 284; 27 (1870) 76).

The bone or antler 'splints' in which the nocks were cut are better represented, at least in the Roman period : six of these were found in the fort at Bar Hill on the Antonine Wall (MacDonald 1934, 282-5; Robertson et al. 1975, 56, Fig. 18, 8-10), where they are generally associated with the presence of Syrian troops of the Cohors I Hamiorum Sagittariorum; a collection of about fifty splints came from the destruction levels of a 3rd-century building, evidently an armourer's workshop, in the legionary fortress at Caerleon, Monmouthshire (Nash Williams 1932, 94-6; Boon 1972, 54) and a single example of approximately contemporary date was recovered at Silchester (Boon 1974, 68, Fig. 8, 7); other unstratified examples in the Museum of London are illustrated in Pl. 25. Similar splints are common finds in the German limes (von Groller 1901, 131, Taf XXIV, 25-5; Stade 1933, 110-114; Rausing 1967, 65-7). Although all the above-mentioned examples were found singly, a complete 'ear' from a Roman-period composite bow found at Belmesa, Egypt, and illustrated by Balfour (1921, Fig. 14), shows that in practice they were used in pairs, one fixed to either side of the wooden ear.

In the post-Roman era the composite bow enters a period of obscurity in northern Europe. There is no reason to believe that its popularity declined in the east Mediterranean, however, and well-dated physical remains have been found as far north as central Europe : several graves in the Migration Period cemetery at Környe in Hungary produced splints of the type discussed above (Salamon and Erdélyi 1971, 149); other finds

are listed in Stade 1933, n 1. Although composite bows are illustrated in the 9th century Utrecht Psalter (reproduced in Rausing 1967, Fig. 23a) no physical remains of Frankish bows have yet been noted (op. cit., 61, n 90). It seems premature to conclude, however, as Werner (quoted in Rausing 1967, 61-2) has done, that they were not made by the Franks. In Anglo-Saxon England the occurrence of the term hornbogen, 'horn bow', in Beowulf has been taken to equate with bows of this type (Archaeol. J. 13 (1856) 412; Rausing 1967, 64); even if the reference was not to the material of which it was made but rather to the shape of the bow, comparison with a pair of cattle horns is perhaps more apposite for the shape of a composite bow than for the simple curve of a self bow. Physical remains are, however, entirely lacking.⁽¹⁴⁾ A number of (apparently unrecognised) splints published from Viking graves in the Ukraine (Arne 1931, Abb 10a, Abb 61a-b), while probably representing locally acquired weapons, offer the possibility of a reintroduction at this time.

For further evidence of the possible currency of composite bows in post-Roman Britain, reference must be made to the question of the use of crossbows (pp. 155-62); while it is possible to construct a crossbow with a one-piece bow, the small size which is desirable in such a weapon would certainly favour a composite structure. Medieval crossbows were invariably made in this way, as were (to judge from the representations discussed below) those of Roman date.

Catalogue

- 21.1 The Fens, Cambridgeshire
Archaeol. J. 13 (1856, 412; 14 (1857) 284; 27 (1870) 76

CROSSBOWS (Fig. 56)

Two elements in the crossbow are of relevance to the present enquiry : one is the bow, constructed in composite fashion in the manner just described, and the other is the nut.

The earliest evidence for any kind of crossbow is the description of the gastrophetes or belly-bow contained in the handbook of Heron of Alexandria who, although writing in the second half of the 1st century AD, relied to a great extent on the works of an earlier Alexandrian writer who was active in the middle of the 3rd century BC (see Marsden 1969 for an account of this early form of 'non-torsion catapult'). Although the basic elements of later crossbows are represented in this early form, it seems to have suffered something of an eclipse towards the end of the 3rd century BC, when larger torsion catapults relying on springs rather than conventional bows came to the fore (op. cit.). Smaller hand-weapons no doubt survived alongside these larger field pieces, perhaps covered by the rather ill-defined category of manuballistae (Webster 1969, 233, n 1). Whatever the precise form of these early hand guns, the record in the 4th century of a weapon called the arcuballista certainly implies by its name that it incorporated a bow, no doubt of composite form. Although no detailed descriptions of the arcuballista survive, it may be that this is the weapon illustrated on two Roman bas-reliefs from Aquitaine : the first of these (Espérendieu 1908, no 1679),

a cippus from Salignac-sur-Loire, illustrates a hunting assemblage, including a crossbow with reflexed (ie composite) bow; the second (op. cit., no. 1683), a fragmentary slab found among the ruins of a Gallo-Roman villa at Espaly, has a more ambitious composition showing a hunting scene in which one of the huntsmen carries an unmistakable crossbow and has a quiver at his belt. Whatever the precise name applied to these weapons by the Romans, their currency in Britain by the 4th century seems highly likely on the above evidence, even though they may by then have been used exclusively as sporting rather than as military weapons.

As already mentioned, the bow on any crossbow found in Britain is likely to have been of the composite structure described above (pp.150-1), incorporating horn springs and, perhaps, bone, antler or horn splints which formed the nocks.⁽¹⁵⁾ So far, however, only those splints mentioned on p.153 have been found in this country, all of them being Roman in date. With the second crossbow element normally executed in skeletal materials, the nut, we are better provided with archaeological remains.

Payne-Gallwey (1903, 95-7, Figs. 48-55) describes in detail the function of the nut in the crossbow : cradled in a socket lying across the top of the stock, it was secured by an axial pin or by strands of catgut threaded through an axial perforation; the sear of the trigger engaged in a notch cut in the underside of the nut, which was usually protected from undue wear by the insertion of a steel wedge; the bow-string was held under tension in a second notch cut in the upper side, slotted transversely to form twin projections, between which lay the arrow, fitted to the string. Pressure on the lower end of the trigger mechanism disengaged the sear from its notch, leaving the nut free to rotate in its cradle under the tension of

the bow-string until the string was freed and the arrow released.

Both the sculptured representations of Roman crossbows illustrated by Espérandieu (1908, Nos. 1679, 1683) exhibit what could be taken to be nuts of this type. Early excavations at Carnuntum in Upper Pannonia produced one example indistinguishable in form from later medieval nuts (von Groller 1909, 64, Fig. 22), but unfortunately the stratigraphic context of this piece is quite unknown and the possibility of contamination of the Roman layers by later material can not be ruled out. A second piece (Fig. 56), of unusual form, was found in a chalk-cut grave at Burbage, Wiltshire, towards the end of the last century, and has also been claimed as being of Roman date (Goddard 1896, 87-90, Fig. 5). This example is quite unlike the normal lathe-turned cylindrical nuts of the medieval period (see below) in being rather flat in section and having a trigger-notch extending across the entire width of the nut. Other items of bone or antler contained in the grave included a stock or pommel, a lathe-turned collar and a strip ornamented with incised border lines and with ring-and-dot motifs; the latter piece was pierced by a number of iron rivets and is of the same character as the ornamental casket mounts described below (pp. 304-9), although Goddard (1896, 88) records the opinion that this example may have decorated the stock of the crossbow; an iron hammer-head was also included. Precise dating evidence is entirely lacking : a Roman or Saxon date might be acceptable for a formal burial with grave-goods, though the manner in which the body was thrown in (it was found face-downwards, with the skeleton apparently twisted, with the feet about three feet lower than the head) might suggest clandestine interment.

A few years earlier, another nut of unusual form had been found, this time at Buston Crannog, Ayrshire (Munro 1882, 217). The Buston nut (Fig. 56) is made from a sawn section of antler beam, the original periphery of which has been smoothed on one side and cut away to form the string and trigger notches on the other side. There is an axial perforation, 4mm in diameter; an earlier attempt at perforating the nut, by drilling from either side with a pointed implement, has been abandoned at an early stage, presumably when it was realised that the resulting hole would be considerably off-centre. An arrow-slot 6mm wide has been cut through the uppermost quadrant. It is clear from the irregular outlines of the piece that it has been shaped entirely by hand; many small facets grooved in various directions by the action of a file or other abrading implement can be detected on the bearing surface and show no signs of having been smoothed away by subsequent wear from use. Like the Burbage nut, the trigger-notch on the example from Buston extends across the entire width of the nut. The seating for the string has an inadequate look, not having been undercut to provide a more secure hold in the manner usual in medieval nuts. On the evidence for currency of crossbows in the pre-Norman period given below (p. 160), the 8th-century date generally accepted for the bulk of the material from Buston might also be applied to the nut, although it should be noted both that there is a certain amount of residual Roman material on the site (Munro 1882, 190) and that the crannog survived as a small island until the 19th century; it was described at this time as the resort of numerous waterbirds, and could continually have attracted the attentions of wildfowlers. A definite date can not, therefore, be assigned to this piece as yet, although its aberrant form may yet provide the basis greater precision.

A further important find, whose significance seems not to have been recognised, has been made at the Butte d'Isle Aumont (Aube) : amongst the bone and antler finds from this site (which was devastated in the 10th century, is an unmistakable crossbow nut (Scapula 1956, Fig. 112). This would seem to represent the earliest definite archaeological evidence for its use in Western Europe at this time.

Whatever its status beforehand, the crossbow enjoyed greatly increased popularity from the time of the Norman Conquest, as can be seen from surviving remains as well as numerous literary references. A nut of the typical lathe-turned cylindrical form favoured in the medieval period has been recovered from Goltho Manor, where it was found in a late 11th-century context (MacGregor, forthcoming). Renn (1960, 61, Fig. 19c) describes a similar example from Wareham Castle, Dorset (Fig. 56), dated to the first half of the 12th century. An unstratified nut which may, however, belong to the period under review, was recovered from early excavations at Urquhart Castle, Inverness-shire (MacGregor 1976, 318-9, Fig. 1B); this latter example incorporates the oxidised remains of an iron wedge which had once protected the trigger slot, a feature also seen on a 13th-century nut from Castel-y-Bere, Merioneth (Butler 1974, 93, Fig. 6). An unstratified nut, thought to be of medieval date, was found towards the end of the last century near Sidney Street, Cambridge (Hughes 1895, 37, Pl. IX, 76); another from London, of equally equivocal date, is illustrated by C. R. Smith (1859, Pl. XXIV, II).

Two interesting historical references to the collection and use of antler for the manufacture of crossbow nuts appear in the Close Roll of Henry III :

Mandatum est Hasculf de Adhelakeston quod omnes perchias
de cervo quas penes so habet de foresta nostra que est in
custodia sua habere faciat Philipo Converso
balistario ad nuces balistarum faciendas

(Rotuli Litterarum Clausarum II, 50)

Precipimus tibi quod habere facias Magistro Petro Balistario
dimidiam marcam pro nucibus nervis et cornu que emit per
preceptum nostrum ad balistas nostras de Corf reperandas ...

(Rotuli Litterarum Clausarum II, 63)

Together these represent the only historical record of the deliberate gathering of antlers for manufacturing purposes. It is of interest to note that the word perchia (also written perticha) refers to the beam rather than the whole antler (Turner 1899, 146) : perhaps it was permitted to remove the tines (which were of no use in crossbow-making) before the antlers were rendered up to the crown.

It is well known that crossbowmen are conspicuous by their absence on the Bayeux Tapestry, a fact which has been taken in the past to imply that these weapons did not enter the Norman armoury until after the Conquest. Morton and Muntz (1972, 115) have observed that the stance and accoutrements of one of the archers shown on the tapestry are much more appropriate to a crossbowman, however, and suggest that the weapon itself may have been discreetly omitted from this highly propagandist work since it was generally considered to be barbarous (its use against Christians later being banned by the Second Lateran Council in 1139. Guy of Amiens, in his Carmen de Hastingsae Proelio, written within two years of the Conquest, twice (vv 338 and 411) mentions crossbowmen within the Norman force (Morton and Muntz 1972, 113) while we find that some of the tenants in chief recorded in Domesday as holding land in Yorkshire, Norfolk and Wiltshire (listed in Ellis 1833, 373-4) are given the title arbalistarius, confirming the existence of these weapons in England within a few years of the Conquest.

Secondary evidence for the use of crossbows in the pre-Norman period is limited to a few passing references in continental written sources (summarised in Morton and Muntz 1972, 113-4), and to a series of important representation on Pictish stones (Allen and Anderson 1903, Fig. 69, 120, 344, Pl. 350B), the significance of which has recently been reviewed by Gilbert (1976, 316-7). Although the details are unclear, each stone illustrates a kneeling hunter pulling the string on his bow with one hand while the other grips not the bow but the base of what appears to be a stock attached to the bow. Gilbert states that an arrow can be seen outlined on the flat stock of the crossbow illustrated on the Drosten stone (Gilbert 1976, Pl. 23b). He concludes that the weapon represented must be a primitive type without a trigger mechanism, the archer simply pulling back the arrow and releasing it by hand. Far from being, as Gilbert says, 'ideal for stalking ... since it would require less strength, less space and less movement to fire', such a weapon would be totally impractical, presenting no mechanical advantage to the kneeling archer; furthermore, the manner in which the figure on the Drosten stone is gripping the string makes it clear that this is not what is being portrayed. In any case, the identification of the nut from Buston Crannog, if it is indeed contemporary, would render such a hypothesis unnecessary.

In each case the Pictish crossbows are portrayed as hunting weapons : Anderson (1881, 123) may well be correct in his assertion this was the principal role of crossbows among the Picts while conventional bows were used as weapons of war.

Catalogue

- 22.1 Buston Crannog, Ayrshire (Fig. 56C)
Munro 1882, 217
- 22.2 Wareham Castle, Dorset (Fig 56D)
Renn 1960, 61
- 22.3 Goltho Manor, Lincolnshire
MacGregor, forthcoming
- 22.4 Burbage, Wiltshire (Fig 56E)
Goddard 1896, 87-90

HORN HELMETS (Fig. 57)

The qualities of lightness and toughness possessed by horn recommended it for use in defensive helmets. These were costly articles, however, and were worn only by the uppermost echelons of Anglo-Saxon society. Keller (1909, 15) notes that the word galea is glossed leðerhelm in some sources, and we may conclude that any battle helmets worn by the rank and file would usually have been of leather. Wilson (1971, 122) observes that on the Franks casket (Pl. 49) only the principal figures wear helmets with nasals and neck guards and there is a corresponding scarcity of these items in contemporary graves. By the 11th century, however, helmets of one form or another were more generally worn; the Anglo-Saxon Chronicle for 1008 records that each eight hides of land had to provide a helmet and a corselet (Plummer and Earle 1892, 138).

Only one helmet bearing evidence of having incorporated horn plates survives in this country, the well-known example found in the middle of the last century at Benty Grange, near Buxton (Bateman 1861, 28-33). The helmet came from a grave, said to contain no trace of a body save

for the hair, but which produced a silver rim (thought to be from a leather cup), some champlevé enamelwork and fragments of silk, as well as the helmet fragments (loc. cit.). The helmet has recently undergone conservation and exhaustive research at the British Museum, from which the following details of its structure have emerged (Bruce-Mitford and Luscombe 1974, 230-3). It consists of an iron framework based on a horizontal brow band 25mm wide and 1-2mm thick. From this brow band rises an openwork crown of which the two principal members are arranged at right angles to each other : one of them projects at the back to form a curved neck guard and at the front (where it had an applied silver cross) to form a nasal; the other projects at either side over the ears, the extensions perhaps originally carrying ear protectors or anchorages for cheek pieces. The quadrants formed by these major strips were each subdivided by a narrower tapering iron band, also running from the brow band to the crest. On the inside of this framework would have been a cap of cloth or, more probably, of leather, while on the outside it was covered with strips of horn. Traces of these strips survive as a mineralised pattern on the outer surface of the iron strips, the pattern reproducing the structure of fine parallel lines established above (p. 25) as being typical of horn. The horn has clearly been applied as a series of riveted plates, softened and bent into shape, with the 'grain' of each arranged obliquely to the iron framework and at right angles to that of the adjacent plate, resulting in the chevron pattern visible in the corrosion products. The junctions between the plates, marked by a small ridge of corrosion along the centre of the iron bands, were covered with strips of horn, cut to the same width as the underlying iron bands and fixed to them with silvered rivets (Fig. 57). Impressions detected in the corrosion

products on the neck guard suggest that further horn plates were fixed between it and the ear pieces to give additional protection. The material used was judged to be cattle horn, presumed to be from Bos longifrons. The frame of the helmet was surmounted by a bronze crest in the form of a boar. A date in the latter half of the 7th century would seem to be appropriate (Bruce-Mitford and Luscombe 1974, 242).

An excellent parallel for this helmet comes from the grave of a princely youth found under Cologne Cathedral and dating to the 6th century (Doppel-feld 1964, 170-4, Abb 10-11). In this instance the helmet was thought to have been constructed as follows. First of all, a stiff leather skull-cap was made, either in one piece or from a series of wedge-shaped panels, probably on a mould. Twelve strips of horn were then cut as sectors of a single circle; for each of these a corresponding but slightly oversized leather lining was cut. A brow band of horn was mounted on the skull-cap and the leather-lined horn plates were glued to it, with a strong leather disc applied to the crown. The assembly was then stitched firmly together, using, at least in parts, bronze wires which passed through the leather edgings of the horn plates. Strips of bronze were then applied to the helmet, one passing around the outside of the horn brow band and the others arranged radially to cover the joints between the horn plates, terminating under a finial on top. A meshed neck guard and a pair of cheek-pieces were finally suspended from the rim.

The richness of the Cologne burial serves to emphasise the rarity of these helmets. To describe it as a 'child's version of the Spangenhelm' (Lasko 1971, 54), with (presumably) the implication that being constructed of horn rather than sheet metal it should be considered as little more than

a toy, seems misleading. Bearing in mind the evidence of the Benty Grange helmet, it is more appropriate to see the Cologne helmet (for all that it was made for a child) as a miniature version of an adult type and not as a useless substitute. The work of fracture for horn has been calculated at an impressively high value, and it would clearly have been quite effective in this role.⁽¹⁶⁾

Catalogue

- 23.1 Benty Grange, Derbyshire (Fig. 57)
Bateman 1961, 28-33; Bruce-Mitford and Luscombe 1974,
223-49

AMULETS AND PENDANTS (Figs. 58-9)

A number of small items, although of disparate forms and materials, may be considered together as amulets or charms. Some have been purposely shaped but most retain something of their original forms, occasionally simply having been perforated or provided with a mount for suspension. Others, for example the human teeth found at Dunstable (C. L. Matthews 1962, 28, 30) are quite unworked and may have been carried around in a small bag or pouch. In the case of this second group, the qualities for which they were treasured were obviously intrinsic and bound up with the source of the raw material, no added significance having been gained by carving in a particular form. They may be compared with the use made of certain parts of animals, notably the paws, jawbones and teeth of wolves, in the incantation of charms and the preparation of salves during the Anglo-Saxon period (Storms 1948, 85, 155). Almost all those listed are of Early or Middle Saxon date, only the pendants from Jarlshof and York indicating a survival into the Viking period.

Amongst the teeth which form the most numerous category in the catalogue below, there is a marked preponderance of those of the beaver. Evidently it was an animal held in some esteem,⁽¹⁷⁾ but we have no way of knowing what special significance it held for the pagan Saxon people (mostly women, it would seem) by whom its teeth were worn and with whom they were buried. The fact that the beaver teeth from Ducklington and Wiggleslow are mounted in gold while ^{that} from Dunstable was found on a necklace strung with amethysts (C. L. Matthews 1962, 31) and another from Castle Bytham came from a grave containing a jewelled brooch (Archaeol. J. 10 (1853), 81-2), all point to these teeth being considered as rather rare and special. (Bear teeth, which appear to have been favoured among contemporary communities on the continent (eg Martin 1976, 95; Sage 1973, 228) have not yet been recognised in this country.)

The boars' tusks listed belong to a long-established tradition, although their occurrence in late Roman warrior graves on the continent (see, for example Werner 1949, 248-56; Böhme 1974, 324) and in the Roman forts of Richborough, Silchester and Segontium (Boon 1975, 62-3), is in contrast to their occurrence in Anglo-Saxon England : among the twelve examples recorded by Swanton (1966, 286) is one from an Anglo-Saxon grave at Camerton, Somerset, containing the skeletons of a woman and a fully formed foetus (Horne 1933, 44-6) which he regards as providing an archaeological complement to the ethnological observation that such amulets were held to have some power as parturition charms.

Of the other groups, little indication of cohesion can be found. There is no duplication of any species among the animal bones listed. The fish bones from Dunstable (C. L. Matthews 1962, 31-2), although

unusual in this country, find an interesting parallel from Hedeby : there, a perforated vertebral centra was identified (Lepiksaar and Heinrich 1977, 107) as belonging to halibut which became the particular fish to be eaten during fasting (Heilbutt - holy fish) and may even have had some special pre-Christian significance. A number of perforated fish vertebrae have also been noted from hitherto unpublished excavations in York (MacGregor, forthcoming) and Norfolk (A. K. Jones, personal communication), so that the type promises to become much better known in the future. Many others may have gone unrecognised. One possible example from Southampton appears in the published catalogue (Platt and Coleman-Smith 1975, 271, Fig. 247, 1920) as a gaming piece.

Some of the more formalised pendants may be related to others beyond the British Isles : a 5th-6th century pendant (said to be of ivory) from Lackford (Lethbridge 1951, 36) belongs to the numerous 'Hercules club' series discussed by Werner (1964, 176-97), while the related prismatic pendants from Souldern (Kennett 1975, 207-9) and Wallingford (Fig. 58) also find numerous counterparts in Werner's series. The Wallingford pendants, at least, are made from antler tines which, in view of their natural shape, may be expected to form the normal raw material for the manufacture of pendants of this type.

A further group of pendants, although of later date than those considered so far (all of which belong in the early or middle Saxon period where any dating evidence can be adduced), are also made of antler, although in this case it is the tines which are utilised. With the exception of

one example from London (Fig. 58) all of those found so far come from Viking period levels in York. They include four examples from early excavations in the city (Waterman 1959, Fig. 19, 1-4) and one from more recent investigations at Lloyds Bank, Pavement (MacGregor, forthcoming). Some of the earlier finds (Fig. 58) incorporate zoomorphic decoration, while the Lloyds Bank piece, which is cut from the palmate end of a fallow deer antler, is recessed on its inner faces as though to take an insert of some other material. Auden (1909, 171) suggests they were hunting amulets.

Although it is not a common type in bone, the 'heckle-shaped pendant' described by Hamilton (1956, 123) from a Viking or late Norse period context at Jarlshof, may be one of the 'Thor's hammer' pendants well-known among the metalwork of the period.

Shed antler burrs were used in the manufacture of a series of pendants of the Roman period which were embellished with a phallus in relief on the flat, discoid base (see, for example, Corder 1948, Pl. XXVIa). A related form was ornamented with bulls' heads (Roes 1956, 57-63). While neither of these forms of decoration survived the Roman period, antler burrs continued to be used for the production of pendants in the form of flat discs, sometimes perforated, usually decorated with incised ring-and-dot motifs. Three good examples come from Burwell (Lethbridge 1931, 62-5; Hull Museum 1506, 42), two of them centrally perforated (Fig. 52), while others may be noted from Spong Hill (Hills 1977, 30, Fig. 136); they find parallels in the Allier region (Vertet 1958, 241-4) and in Frisia (Roes 1963, Pl. LVI, 3). An early representative of this type, judged to date from the 2nd century or earlier, was

recorded from a Romano-British farmstead in the Hambledon Valley, Buckinghamshire (Cocks 1921, 195).

To judge from one example, which is perforated for suspension and inscribed with a compass-drawn cross, and was recovered from a Frankish grave at Rittersdorf near Trier (Böhner 1958, Taf 23, 13), pendants of this type maintained something of their efficacy even after the introduction of Christianity. Indeed, until the 17th century and later, many benefits were held to derive from potions made from various parts of the anatomy (particularly the antlers) of stag, which animal was described as 'a world of remedies, of commodities and advantages, for men' (D. Murray 1904, 58). The pharmacy of the Elector of Saxony, for example, contained fifty-one preparations from stags horns (loc. cit.).

Yet another group of antler objects may be considered here as they seem to have possessed prophylactic powers, although they fulfilled a practical role as well. These are large annular rings of sufficient diameter to have been considered as bracelets for children or even adults (Roes 1958, 325), although they may equally have been worn as pendants or as girdle rings. They too are made from the burrs of shed antlers, in which the whole of the central area was cut away, leaving little more than the peripheral coronet. The inner surface is very often found polished from wear on some soft and pliant material such as textile or leather, while the denticulated outer edge commented on by some writers is no more than the natural surface of the coronet,

channelled and guttered by the presence of blood vessels running over it during the formation of the antler (p. 13). As an alternative to wearing these rings as bracelets, Roes (1958, 323-5) has suggested that some may have been tied round the necks of cattle or horses although she also notes some from human graves of the 7th century.⁽¹⁸⁾ Examples from cremations of the 5th or 6th century in this country may be noted from Lackford (Lethbridge 1951, Fig. 14, 50.127) and from Newark on Trent (Fig. 59). An unstratified example from Vichy is illustrated by Vertet (1958, 241, Fig. 72). The suggestion that some at least may have been used as girdle rings is enhanced by the occurrence of one at Whitby Monastery, in which one side is cut as though to take a strap or belt (Fig. 59), while another illustrated in the Guildhall Museum Catalogue (1908, 121, Pl. LII, 13), although described as a pendant is seemingly a simpler version of this type of buckle. Lagore Crannog has produced a squarish version of this type (Hencken 1950, 198, Fig. 108, 120).

A group of annular brooches cut from antler burrs in the same manner as described above may also be noted here. They include examples from Londesborough (Swanton 1966, 283), Yelford (^{38 (1870) pl. II, n)} ~~Archaeologia~~ and elsewhere.

Although varying from each other in detail, the above groups of objects cut from antler burrs are linked by their common raw material which, it may be suggested, had a particular significance for the wearers. Roes has stressed the prophylactic powers of antler, which were such that quite plain pendants as well as elaborately decorated ones have been found on the continent (Roes 1963, 71-3).⁽¹⁹⁾ All the above objects, while sometimes serving perfectly practical purposes, might therefore be held to possess common talismanic powers.

Catalogue

Teeth

- 24.1 Dunstable, Bedfordshire
Beaver. C. L. Matthews 1962, 27, 31 (2)
- 24.2 Dunstable, Bedfordshire
Human. C. L. Matthews 1962, 28, 30 (2)
- 24.3 Abingdon, Berkshire
Dog. Leeds and Harden 1936, 45, Pl. XV
- 24.4 Burwell, Cambridgeshire
Beaver. Lethbridge 1931, 47; Fox 1923, 262
- 24.5 Wigberlow, Derbyshire
Beaver. Ozanne 1963, 29 (published as pig)
- 24.6 Castle Bytham, Lincolnshire
Beaver. Archaeol. J. 10 (1953) 81-2
- 24.7 Sleaford, Lincolnshire (Fig. 588)
Carnivore. G. W. Thomas 1887, 401
- 24.8 Cassington, Oxfordshire
Pig. Leeds and Riley 1942, 65, Fig. 15 (2)
- 24.9 Ducklington, Oxfordshire (Fig 58A)
Beaver. Chambers 1975, 193-5, Fig. 11, 10
- 24.10 Wheatley, Oxfordshire
Unidentified. Ashmolean Museum
- 24.11 Bidford-on-Avon, Warwickshire
Beaver. Humphreys et al. 1923, 103
- 24.12 Londesborough, Yorkshire
Pig. Swanton 1966, 285

Talons

- 24.13 Alfriston, Sussex
Griffith 1914, 25, 39

Animal bones

- 24.14 Kingston, Kent
Sheep? G. B. Brown 1915, 450, Pl. CVII, 6

24.15 Nassington, Northamptonshire (Fig. 58F)
Cattle. Leeds and Atkinson 1944, 110, Pl. XXX, 30

24.16 Petersfinger, Wiltshire
Large feline. Leeds and Shortt 1953, 28, 51

Fish bones

24.17 Dunstable, Bedfordshire
C. L. Matthews 1962, 31-2

24.18 Wallingford, Berkshire
Leeds 1938, 99, Pl. IV

Shaped pendants

24.19 Barrington, Cambridgeshire
Foster 1886, 32, Pl. IX, 1

24.20 Burwell, Cambridgeshire (Fig. 58D)
Lethbridge 1931, 62-5 (2)
Hull Museum 1506.42

24.21 Kingston Down, Kent
C. R. Smith 1856, 43, 74 (2)

24.22 Souldern, Oxfordshire (Fig. 58E)
Kennett 1975, 207-9, Fig. 2, 5

24.23 Jarlshof, Shetland
Hamilton 1956, 123

24.24 Lackford, Suffolk
Lethbridge 1951, Fig. 14, 50, 71

24.25 Alfriston, Sussex
Griffith 1914, 35-6

24.26 Driffield, Yorkshire
Mortimer 1905, 280, Fig. 795

24.27 York, Yorkshire (Fig. 58H)
Waterman 1959, 91, Fig. 19, 1-4

Antler rings

24.28 Beginnish, Co. Kerry
O'Kelly 1956, 178, Fig. 4, 1

24.29 London (Fig. 59C)
Guildhall Museum Catalogue, 121, Pl. LII, 13

- 24.30 Lagore, Meath
Hencken 1950, 198, Fig. 108, 120
- 24.31 Spong Hill, Norfolk
Hills 1977, 30, Fig. 136
- 24.32 Newark on Trent, Nottinghamshire (Fig. 59E)
Newark Museum, unpublished
- 24.33 Cloonfinlough, Roscommon
Wood-Martin 1886, 144, Pl. XXXV, 5
Munro 1890, Fig. 117
- 24.34 Whitby, Yorkshire (Fig. 59D)
Peers and Radford 1943, 72, Fig. 18, 2

IVORY 'BAG RINGS' (Fig. 60)

The series of ivory rings occurring in a number of early Anglo-Saxon cemetery sites has long posed problems on two fronts : the first is concerned with function, the second and more important with the origin of the raw material.

In general, these rings are of comparatively large size, reaching some 150mm or more in diameter; they are usually sub-rectangular or D-shaped in section, having a maximum width in the region of 25mm. A surface examination of the structural features of the ivory shows that each ring represents a single transverse section, probably cut near the root where the tusk is developed to its maximum diameter and where the pulp-cavity forms a natural internal void (R. Owen 1856, 65-7). Ivory having a tendency to delaminate with time and an adverse environment (see below), the majority of these rings survive only in fragmentary form. On occasion, as in the case of a discovery at Mitcham, Surrey, delamination has been so complete as to lead the excavators to believe that the ring had originally been built up from a number of individual sections

(Bidder and Morris 1959, 117), but this is certainly erroneous. Evidence of contemporary repairs suggests that in some instances this process of disintegration may already have begun before burial : one example from Beckford, Worcestershire (Fig. 60), incorporates two pairs of thin bronze plates each joined by radially-set rivets; quite possibly they were intended to clamp together the constituent lamellae already showing a tendency to split apart, although they could equally well have been designed to repair accidental breaks.

The widely-held opinion that they were used as bangles seems no longer tenable. One example, found with a skeleton in a grave at Mitcham, Surrey, was said at one point to have been discovered 'on the left fore arm' (Bidder and Morris 1959, 74), but elsewhere is stated as having been found 'where the left arm should have been' (op. cit., 117); another, from Driffield, Yorkshire, occurred 'near the right wrist' of the skeleton of a young woman (Mortimer 1905, 279). In both instances the implication is that the rings were found alongside the hips and this accords with the position most frequently noted elsewhere and with the contention that they were worn suspended from the waist, either as part of a chatelaine or in association with a bag.⁽²⁰⁾ A convincing reconstruction (Fig. 60) is offered by Myres and Green (1973 102-3, Text Fig. 3) who note that these objects are almost invariably found with the remains of women (op. cit., 101). On the continent a number of rings have been found associated with bronze discs (G. B. Brown 1915, 400; R. Koch 1967, Taf 28; Vogt 1960, Taf 31-2) which may have served as closing flaps for similar pouches to that reconstructed here, but no associations of this kind have been noted

in England. Vogt's researches (op. cit.) make it clear that the bags concerned were worn suspended from the waist band.

With regard to the source of the ivory, the possibilities have already been discussed elsewhere (p. 41). It may simply be reiterated here that utilisation of locally obtained fossil ivory should not be ruled out at this stage. Furthermore, Mr. David Brown has pointed out to me (personal communication) that although exotic imports from the Mediterranean can be found in a considerable number of Anglo-Saxon graves, they tend to be associated with burials of later date than those of the 5th to 7th century which produce these rings. Myres and Green (1973, 101) may be correct in their assertion that ivory rings were imported from this area, perhaps through the agency of Byzantium (in a finished condition, to judge from the absence of other contemporary artefacts in this material), but it is clear from Mr. Brown's observation that they must have arrived by some quite different commercial mechanism from that which introduced the other Mediterranean material.

Catalogue

- 25.1 Leagrave, Bedfordshire
G. B. Brown 1915, 400, Pl. XCII; Archaeologia 50 (1887)
383-4
- 25.2 Barrington, Cambridgeshire
C. Fox 1923, 255; Lethbridge and O'Reilly 1935, 141-2
- 25.3 Burwell, Cambridgeshire
Lethbridge 1931, 57
- 25.4 Shudy Camps, Cambridgeshire
Lethbridge 1936, 6
- 25.5 Soham, Cambridgeshire
Lethbridge 1933, 158-9

- 25.6 Waterbeach, Cambridgeshire
Lethbridge 1927, 145, Fig. 4, 8
- 25.7 Fairford, Gloucestershire
Wylie 1852, 15
- 25.8 Kingston Down, Kent
C. R. Smith 1856, 47, 66-74 (2)
- 25.9 Glen Parva, Leicestershire
R. A. Smith 1907, 231
- 25.10 Loveden Hill, Lincolnshire
Fennel 1964
- 25.11 Sleaford, Lincolnshire
G. W. Thomas 1887, 393, 398-9, 402 (4)
- 25.12 Caistor-by-Norwich, Norfolk
Myres and Green 1973, 100-3 (5)
- 25.13 Nassington, Northamptonshire
Leeds and Atkinson 1944, 110, 112
- 25.14 Millgate Cemetery, Newark, Nottinghamshire
Newark on Trent Museum, 42/51.70; 63/11.66 (2)
- 25.15 Brighthampton, Oxfordshire
Akerman 1860, 86, 89
- 25.16 Holywell Row, Suffolk
Lethbridge 1931, 23
- 25.17 Lackford, Suffolk
Lethbridge 1951, Fig. 5; Fig. 11; Fig. 14 ('13')
- 25.18 Mitcham, Surrey
Bidder and Morris 1959, 117, 128
- 25.19 Alfriston, Sussex
Griffith 1914, 32, 46, 48 (3)
- 25.20 Bidford on Avon, Warwickshire
Humphreys et al. 1923, 104
- 25.21 Devizes, Wiltshire
G. B. Brown 1915, 400, Pl. XCII
- 25.22 Petersfinger, Wiltshire
Leeds and Shortt 1953, 30
- 25.23 Beckford, Worcestershire (Fig. 60 B-C)
Birmingham City Museum (3)
- 25.24 Driffield, Yorkshire
Mortimer 1905, 279

- 25.25 Sancton, Yorkshire
Myres and Southern 1973, 34, 60, 74 (3)
Hull Museum Bc48 (1)
- 25.26 Staxton, Yorkshire
Hull Museum 1938
- 25.27 Hornsea, Yorkshire
Hull Museum

BUCKLES AND STRAP-ENDS (Fig. 61)

Despite the fact that they perform less well in tension than in compression, skeletal materials were nonetheless sufficiently strong to have been used on occasion in the manufacture of girdle rings, as discussed above (p. 169) and also buckles, in which form they would have been subjected to not-inconsiderable strains.

Roes (1963, Pl. LIX, 9) illustrates a simple plaque of bone with an oval perforation at one end which she interprets as an unfinished buckle. The presence of two rather similar but more decorative plaques from York (Waterman 1959, 91, Pl. XX, 2-3) and Saxon Southampton (Holdsworth 1976, 47, Fig. 21, 9), provided with rivet holes at the opposite ends, suggests that they may in fact represent a simple but well-established form of strap-end functioning as a primitive buckle.

Two basic types of true tongued buckle may be distinguished. The first of these is manufactured in a single piece : the tongue which engages with the strap hole is cut as a projection on the loop, pointing back towards the base plate. The type appears among the Frisian terps (Roes 1963, 78, Fig. 27) and, on the evidence of one find from Greenland (Roussell 1941, 264, Fig. 164), survived well into the medieval period, so that it cannot be considered exclusively as an early type. Whereas the belt or strap

seems merely to have been wrapped around one end of the Frisian buckle (Roes, loc. cit.), the example from Greenland is transversely slotted at the base for the insertion of the strap (Roussell, loc. cit.) which, on the evidence of two small holes, was riveted in position. One example (Fig. 61), possibly from England, is in the collection of the Duke of Northumberland at Alnwick Castle (G. B. Brown 1915, 293, Pl. II, 4). Another bone buckle, this time a simple loop with metal pivot and tongue (?) from Ozengel, Kent is illustrated by the same author (op. cit., Pl. LXXIV, 3).

The other form corresponds more closely to the better-known metal prototypes, having a distinct loop, a pivoted tongue and a base-plate which is often slotted in the manner described above for the insertion of the strap : Roes (1963, Pl. LIX, 8) illustrates an unfinished buckle of this form which has been broken through the strap slot in the course of manufacture. The most impressive example of this type (Fig. 61) was found with the Lewis chessmen discussed on p. 275 : like the chessmen, the buckle is made of morse ivory. The buckle comprises a deep, pointed loop and a rectangular plate, the latter slotted at the base for the strap, which was held in position by four rivets inserted from the rear; the tongue pivots on a bronze pin. The entire front surface is covered with an incised interlace design within a reserved border. An origin in the 12th century is suggested by the art style of the accompanying chessmen.

A 10th-century date may be suggested for a buckle of bone or antler (Fig. 61) found at Goodmanham (R. A. Smith 1912, 77). A deep, pointed loop is combined in this example with an elongated plate, broken at the

base through a transverse slot with holes for four (or five) rivets which, to judge from surviving green stains, were of bronze; the tongue is also of bronze and is wrapped around an integral crossbar, cut out of the bone. The obverse of the plate is ornamented with incised interlace in the Borre style.

Of two bone buckles from Clifford Street, York (Fig. 61), one incorporates an ovoid loop and a slotted base plate with two rivet holes, but lacks its tongue. The second has a tongue which pivots on a pin of the same material and has a notched projection at its base instead of the usual slot. On the obverse surface is an incised interlace knot, suggesting a date for this piece in, perhaps, the 10th or 11th century.

A number of later medieval bone or antler buckles from York (MacGregor, forthcoming), Goltho (Beresford 1975, 77, Fig. 36, 4-5) and elsewhere - for example the medieval Norse settlements of Greenland (Roussell 1941, 256, Fig. 161) - demonstrate the survival of the type beyond the period under review.

Strap-ends of bone (Fig. 61) would have formed a natural complement to the buckles described above and indeed a few examples of these can be cited although, in general, they seem to be of earlier (late Saxon) date than most of the buckles. Brøndsted (1924, 159, Fig. 132) describes one example of 9th-century date from Leicester, with incised ornament in the form of opposed beasts and masks in acanthus foliage (see also R. A. Smith 1907, 228; Fox 1933, 303-4). A further example from London, probably of similar date and seemingly made of morse ivory, also displays opposed animals (and, perhaps, birds) but without accompanying foliage, and has

four holes for fixing-rivets at the base (R. A. Smith 1909, Fig. 22).

An unfinished strap-end of similar form and with only rudimentary incised ornament is in the British Museum (unpublished). From Lund comes one example with low relief decoration in Borre style (Blomqvist and Mårtensson 1963, 190-2, Fig. 205), which must be considered on the basis of its decoration to be a near-contemporary of the Goodmanham buckle.

Catalogue

Buckles

- 26.1 Ozengel, Kent (Fig. 61B)
G. B. Brown 1915, Pl. LXXIV
- 26.2 Lewis, Outer Hebrides (Fig. 61C)
Dalton 1909, 73, Pl. XLVIII
- 26.3 Goodmanham, Yorkshire (Fig. 61D)
R. A. Smith 1912, 77
- 26.4 York, Yorkshire (Fig. 61E-F)
Waterman 1959, 91, Fig. 19, 6-7
- 26.5 Unprovenanced (Alnwick Castle Museum)(Fig. 61A)
G. B. Brown 1915, 293, Pl. LII, 4

Strap ends

- 26.6 Leicester, Leicestershire (Fig. 61G)
Brøndsted 1924, 159, Fig. 132; Fox 1933, 303-4
- 26.7 ?London (Fig. 61H)
British Museum, unpublished, 79.5.20

PINS (Figs. 62-5)

Dress pins formed in antiquity one of the principal means of fastening clothing; others included brooches, buttons, toggles, straps and ties.

Each of these groups is more or less appropriate to a particular kind of garment : the pins discussed here, for example, would not be well suited to use with tight-fitting clothing but are more likely to have been associated with loose cloaks and tunics, presumably made in fairly open-weave material. It is clear, however, that quite radical differences in clothing styles may fail to register any changes in the pins themselves. Some attempts to infer variations in clothing styles in this way have nonetheless been made : Schwarz-Mackensen (1976, 68-9) has suggested that the occurrence of bronze or bone pins in certain Viking-period graves on Gotland and their absence from contemporary graves at Birka suggests a different (or additional) element in the dress worn on Gotland at this time. She has further noted (loc. cit.) that, with one exception, the women buried at Hedeby in Scandinavian-style dress (represented by a pair of oval brooches at the shoulders), never have accompanying pins. In analyses of this kind, however, the possibility that different burial practices rather than different modes of dress may be represented must be borne in mind (cf. G. R. Owen 1976, 16). Using pins derived from settlements rather than cemeteries, Laing (1973, 60) postulates that pins fell from popularity as dress fasteners in the southern parts of Scotland from the 7th century onwards, though whether this reflects changes in contemporary dress or merely the adoption of an alternative method of dress fastening is not established. By about 1200 the advent of tight, buttoned styles of clothing saw the final demise of the dress pin. (A number of later medieval bronze pins with large globular heads and slender shanks are known, but these seem to be hair or hat pins.)

The possibility that some bone pins too were used as hair pins must be borne in mind. The remains of a Roman matron discovered at York included a bun of hair at the back of her head, held in place by a number of polygonal-headed pins of jet (RCHM 1962, 83). The same function has been noted for metal pins of the Roman and Merovingian period on the Continent (Schwarz-Mackensen 1976, 67). In Anglo-Saxon England the position in which certain pins have been found in inhumation burials also suggests some use as hair pins (G. R. Owen 1976, 121), but there is no evidence for this practice in the Viking period (Schwarz-Mackensen 1976, 69).

It is interesting to note that the Roman hair pins mentioned above, along with many other jet pins of the Roman period, are identical in form with contemporary examples in bone. The same is true of certain metal (mostly bronze) pins, but in this case the relationship may have been a technological rather than a purely stylistic one : the likelihood that bone originals were used for preparing moulds for casting bronze pins has been borne out by the discovery at a number of Scottish sites, including Dunadd and the Mote of Mark (Stevenson 1955, 285-6; Laing 1973, 67), as well as Birsay (unpublished), of clay moulds with impressions made by associated bone pins.

Materials

Whereas it has been noted already that antler was favoured above bone in the production of many categories of artefact, it seems that limb bones were more popular for making pins. With the exception of the pig fibula pins discussed below, in which one end of the whole bone is used without

a great deal of alteration, most pins are cut from the sides of limb bones of large ungulates, mostly horses and cattle. Since all identifying characteristics are usually lost in this process, little can yet be said with any greater precision about patterns of utilisation. Occasional traces of residual spongiosa or the occurrence of other features identifying the raw materials as limb bones are all that we have to guide us : the small perforation in a pin from York Minster (Pl. 4), for example, is the natural nutrient foramen of such a bone, connecting the periosteum with the medullary cavity (p. 10).

Production

In view of the ready availability of raw materials and the comparatively simple preparative processes necessary for some of the plainer pins, many of these may have been manufactured by the individual as required. It seems likely that many of the pig fibula pins, for example, would fall into this category. At the other end of the scale, some highly competent pins, such as those with zoomorphic heads carved to very high standards (p. 189), seem to speak of professional production. Possible workshops are hard to find, though one candidate was identified at Hedeby by the concentration there of seven pins, all of the same type, within a 50 x 90cm area (Schwarz-Mackensen 1976, 70). Elsewhere, only stray examples of unfinished pins can be found to suggest on-the-spot preparation : examples of roughly-whittled blanks for pins have been found at York (Fig. 62) Buston Crannog (Munro 1882, 216) and Jarlshof (Hamilton 1956, 124). All show traces of working with knives only. No pins of this period have been found to be lathe-turned : indeed, lathe-turning seems to provide an almost infallible

indicator that the object in question will prove to be a parchment-pricker rather than a pin (p. 135).

Classification

Two principal components may be considered in classifying dress pins : the shank and the head. Some pins lack heads of any kind, the upper end of the shank simply terminating in a straight cut or, occasionally, a rounded or slightly pointed end. In the case of these headless pins the shank is either straight (parallel) sided and tapered only at the tip or else it tapers smoothly along its entire length. On the other hand, while some pins with distinct heads have shanks which fall into one or other of these categories, many of them also taper from the centre towards the head, resulting in a marked swelling in the middle of the shank. This swelling would have had the effect of holding the pin more securely in position when it had been thrust through the weave of the material (or, indeed, through the hair). Some pins of this type have bands of incised lines or cross-hatching (Fig. 63) around the shank which, in addition to any decorative value, would have had the further virtue of impeding any tendency for the pin to slip out of position. Another more effective measure designed to keep the pin in place was the development on the shank of distinct hips (Fig. 62), formed by a sharp expansion about two-thirds of the way towards the tip. Stevenson (1955, 285) has suggested a late Roman or 5th-century origin for these hipped pins, but so far none has been found in a context demonstrably earlier than the 6th century. Those few that are known on the Continent (Roes 1963, 65) appear to be no earlier than the British examples and indeed are thought

(loc. cit.) to have derived from them. One author (Lethbridge 1952, 187), in describing a pin from South Uist, declared himself convinced that they were 'almost certainly used, among other things, for picking winkles out of their shells', but this must certainly have been a rather deviant secondary use and not the primary function for which they were designed.

While some differentiation between pins can therefore be made on the characteristics of the shank, it is the head which undoubtedly offers the most promising means of classification. Apart from the headless skewer pins mentioned above, the head usually had more attention paid to its form and decoration than did the shank. It is therefore on the basis of the head that the principal divisions have been drawn up below.

Ball headed pins (Fig. 62)

These are in origin the classic dress pins of the Roman period. They were popular all over Roman Britain and occur throughout the period of Roman occupation. Although they decline in popularity within the former Empire from the 5th century, it is clear that the type survived after this time and, particularly in Scotland beyond the former frontier, took on a new and vigorous lease of life. There was also some continuity south of Hadrian's Wall : the pins from Little Wilbraham (Lethbridge 1931, 72) and Sarre (Payne 1892, 21), combining ball heads and hipped shanks, date from the 6th or 7th century, which is about the time when the Scottish series appears to get under way, most of them apparently belonging to the 7th or 8th century. The ball headed pins which are thought to have secured the sack containing the Cuerdale treasure belong to a slightly

later period, being dated by the hoard to c. 903^{*} (T. D. Kendrick 1941, 163). A number of bronze pins with ball heads, several of them with hippled shanks, may also be noted from Southampton (Addyman and Hill 1969, 68, Fig. 26, 1-3), York (Waterman 1959, 78, Fig. 11), Whitby (Peers and Radford 1943, 63, Fig. 14) and Orkney (MacGregor 1974, 99, Fig. 24), all probably of 7th or 8th century date.

Polygonal headed pins

These too are well known in the Roman period in bone and jet and are well attested in bronze in the Anglo-Saxon period, appearing in the pagan Saxon cemetery at Lackford (Lethbridge 1951, 20-1, Fig. 28), the monastery at Whitby (Peers and Radford 1943, 63, Figs. 13-4) and from various sites in the cities of York (Waterman 1959, 78-9, Fig. 11) and Southampton (Addyman and Hill 1969, 68, Fig. 26, 5-8). A few bone pins from York have heads shaped in the same way as those of bronze (ie they are basically cubes with chamfered corners) but the heads are smaller in relation to the shank; they seem to belong to the Anglo-Scandinavian period. A contemporary example in wood is noted by Jankuhn (1943, 143) from Hedeby. A few have been found in post-Roman contexts under York Minster (MacGregor, forthcoming), but in each case there has been so much residual Roman pottery in the same layers that it is impossible to be certain as to the date of the pins.

Nail headed pins (Fig. 62)

An origin for nail headed pins can also be demonstrated in the Roman period, when the type is fairly common. An early representative in the

* The date of c. 905 given by Kendrick has been revised to c. 903 by more recent scholars: cf. R.H.M. Dolley, The Hiberno-Norse Coins in the British Museum (London, 1966), 49.

north comes from broch-period levels at Clickhimin, Shetland (Hamilton 1968, 114). In the post Roman period they show little sign of development except in the case of two Norse pins from Jarlshof (Hamilton 1956, 148, 151) which are provided with plain collars about 10mm in depth below the head. Two nail headed bronze pins, including one with a blue glass inset in Roman fashion, were found at Buston Crannog (Munro 1882, 228, Figs. 242-3) and others are known from the Broch of Burrian (MacGregor 1974, 99-100, Fig. 24) and Cahercommaun, Co. Clare (Stevenson 1955, 286).

Segmented head pins

Few representatives of this type have so far been noted, yet despite their apparent rarity they clearly form a well-developed type of which more representatives may yet be expected. Comparable examples in bronze have been noted from Culbin Sands, Morayshire, and Birsay by Laing (1973, 70, Fig. 6, 40, 42). Their form seems to recall the segmented glass beads occasionally found in Anglo-Saxon graves;⁽²¹⁾ the example from Driffield was itself found in a barrow interment where, the excavator suggested, it may have fastened a shroud (Mortimer 1905, 279).

Disc headed pins (Fig. 62)

There appear to be no Roman models on which these might be based, despite claims to the contrary by Laing (1973, 70) and Stevenson (1955, 282-7). It seems most likely that the scarce bone pins in this series evolved from the better known disc headed bronze pins of Anglo-Saxon date in which the heads were formed by hammering out the end of the shank into a large flat field or by fitting a separately wrought disc head.

Examples of the former type, stamped with ring-and-dot motifs, are known from York (Waterman 1959, Fig. 11, 1-3), Whitby (Peers and Radford 1943, Fig. 13, 1, 7, 7a) and Southampton (Addyman and Hill 1969, Fig. 26, 11). A more ambitious example with composite head ornamented with a cruciform design (originally one of a suite of three linked pins) was found at Birdoswald (Cramp 1963, 90-3) while a similar pin, bearing a representation of two confronted winged beasts comes from York (Cramp 1967, 11, frontispiece). Perhaps slightly earlier in date is a bronze pin with flattened shank and expanded cruciform head, found on Breach Down, Kent (G. B. Brown 1915, 371, Pl. X, 5). Scottish metal pins with disc heads include a group in silver found with the late 9th-century hoard from Talnotrie, Kirkcudbright (Stevenson 1955, 286) and a more modest but beautifully executed pin from the Broch of Burray, Orkney (*ibid.*, fig. A, 17).

The 8th- or 9th-century date suggested by these metal pins agrees with that postulated for the few bone pins of this type from the continent, all of them from the Frisian terps (Roes 1963, 66). The only stratified example of this type from England, however, came from an 11th-century context at Lincoln. An unprovenanced example now in the British Museum is illustrated by Jessup (1974, Pl. I, 3).

Small disc headed pins (Fig. 62)

A group of short pins with flattened heads, sometimes forming a complete disc and sometimes cut away on the underside to form a fan shape, seems at present to have a predominantly Scottish distribution and to be absent

in the Roman period. A few examples are now known in the south, however, including one from York (MacGregor, forthcoming) and a group from Swindon;⁽²²⁾ one example in bronze was found at Whitby (Peers and Radford 1943, Fig. 14). Several bone pins of this type are also known from the Frisian area (Roes 1963, Pl. LIII).

Zoomorphic headed pins (Fig. 63)

This group, as represented by the few examples so far recognised, is extremely heterogeneous. The earliest pin in the series (Fig. 63), from the Broch of Burrian, is perhaps of 7th-8th century date : it features two addorsed horses' heads and finds its only parallel in the British Isles in a bronze pin in the National Museum of Ireland (E. C. R. Armstrong 1922, 81, Fig. 4, 6). A bone pin surmounted by opposed birds, now in the Groningen Museum, is comparable in style if not in detail and is probably of similar date (Roes 1963, 66, Pl. LIII, 1). An unstratified pin from North Uist (National Museum, Edinburgh, unpublished) may also be considered to be of broadly contemporary date on account of its bird-like head arranged at right angles to its swelling shank.

A styliiform object from York has been considered in a number of earlier papers : noting its similarity to a bronze styliiform pin or stylus from Canterbury (Radford 1940, 506-7), Ward Perkins came to the conclusion that this piece was itself a stylus (Ward Perkins 1949, 207-9); writing ten years later, Waterman (1959, 82-3) again referred to it as a styliiform pin or stylus. Here it has been included among writing materials (p. 134), although the evidence for pre-Conquest bone styli^{is} extremely slight.

The Jarlshof pins (Fig. 63) are all closely related to each other and might well be the products of a single craftsman. The heads on these examples, like that on the pin from York already discussed, are aligned with the axis of the pin, a fact which Hamilton (1956, 115) has contrasted with the normal practice on 'native' pins on which the heads tend to be arranged at right angles to the shank (see above). The high standard of workmanship displayed by all these pins strongly suggests that this group may have been professionally produced.

Axe headed pins

Only three axe headed bone pins have been noted in this survey, all of them from Jarlshof. Although there exist Roman axe-headed pins and there are on the continent a number of Merovingian examples (Roes 1963, 68-8), the type is most commonly found in the Viking period. Those from Jarlshof are all related stratigraphically to the zoomorphic pins already discussed.

Cruciform headed pins (Fig. 63)

Jarlshof has also produced two of the cruciform headed pins so far noted, of which one from the more recent excavations at the site is shown in Fig. 63; . . . a more elaborate example^{is} now in the Ashmolean Museum. An unpublished cruciform headed pin from Roscommon (now in the British Museum) has a markedly expanded upper arm and smaller cross bars, strongly reminiscent of a bronze styliform pin from Whitby Monastery (Peers and Radford 1943, Fig. 15, 3). It is possible that they have some Christian significance.

Thistle headed pins (Fig. 63)

Two groups may immediately be distinguished within this class all of which come from Scotland : short pre-Norse pins including those from the Broch of Burrian, Buckquoy and Buston Crannog on the one hand and more robust pins such as those found at Jarlshof on the other. The Buston pin (Fig. 63) has a shank ornamented with bands of cross-hatching (see p. 184), while there are three circumferential grooves on the Burrian pin (Fig. 63). Those from Jarlshof are all similar in style, although one of them is from pre-Norse levels and the others are of Viking date.

Loose ring headed pins (Fig. 64)

Although this type is undoubtedly best suited to production in metal and the bone representatives are unlikely to be numerous, two finds have already been made. Although it is possible that the York pin (Fig. 64) may have been used simply as a model in the casting of metal pins (and there is no particular reason to think that it was), the fact that another pin from York now in Norwich Castle Museum (423/76.94) is fitted with a bronze ring would certainly have excluded it from this purpose. The type is well known in bronze and iron in Ireland (E. C. R. Armstrong 1922, 71-86) and the fact that half a dozen metal pins as well as the single example in bone have been found in York is perhaps an indication of the close relations which existed between York and Dublin in the Viking period.

Expanded head pins (Fig. 64)

Although their shape seems to have been inspired by the natural form of the pig fibula pins discussed below, the expanded heads of these larger pins are not conditioned in the same way by the bones from which they were made. Instead they have been cut from the shafts of limb bones, as can be seen from occasional surviving features (p. 11). The flat expansion at the top of these pins presented a broad field which invited decoration and this opportunity was grasped on a number of examples, most notably in the case of a large paddle-shaped pin from London, decorated with Ringerike style ornament (Fig. 64). The type is at present known only from the Viking period in England and finds good parallels in Scandinavia (Grieg 1933, 241-2, Fig. 207-9) and northern Germany (Schwarz-Mackensen 1976, 40-1, Abb 14). The resemblance to certain late Saxon bronze styli from Whitby, however, suggests that earlier examples may yet be forthcoming.

Pig fibula pins (Fig. 65)

Pins of this group present an interesting illustration of the way in which specific bones were chosen for specific functions. The fibulae of pig (Fig. 65) present a shape which immediately recommends itself as a pin : the diaphysis or shaft is neither too thin to be over-fragile nor so thick that it needs thinning down : at the proximal end it expands to form a natural head while around the middle of the shaft a second area of expansion can either be trimmed off at a stroke while pointing the tip or, by slicing it slightly lower, can be incorporated in the shank of the pin so that it impedes any tendency to slip out of place (cf. p. 184).

The head may be perforated or left intact but, so far as we can tell, there need be no difference in function between the two types. Those with perforated heads have sometimes (Hamilton 1956, Fig. 69, 3-4; Brodribb et al. 1972, 129) been claimed as needles, but in most cases this seems unlikely to have been the case as the perforations rarely show any sign of wear and they often occur together with untrimmed heads which would be inconveniently wide for most sewing purposes. Some wear has, however, been noted in the perforations on pins from Feltrim Hill (Hartnett and Eogan 1964, 24). In most cases the perforations may simply have had a retaining cord passed through them, the pins being used to secure an article of dress in one of two ways : they could have been paired - one at each shoulder - as in some inhumation burials of the Migration Period on the continent (Nerman 1935, Textfig 108) and joined by a cord in the manner of certain Anglo-Saxon union pins (Leeds 1936, 109); alternatively, they could have been used as a primitive form of safety pin, with a cord passed through the perforation and tied around the tip.

Pig fibula pins seem to have been mundane, everyday objects and frequently display no great degree of elaboration beyond occasional trimming of the head. This ornamentation is usually limited to cutting down the natural expansion of the articular end to form a distinct head, either squarish in outline or with jagged indentations (Fig. 65). These latter pins, which appear to be limited to the Viking period, are the last efflorescence of the type, which can be traced back to the pre-Roman Iron Age in this country. They seem to have been particularly common in Ireland during

the Early Christian period - there are 131 from Lagore (Hencken 1950, 194) and 82 from Cahercommaun (Hencken 1938, 38) - and they are well represented on contemporary sites in England.

Globular pin heads (Fig. 65)

In addition to the pins made entirely of bone, as described above, an interesting group of pin heads made of ivory or bone may be noted here, most of them from Scotland and Ireland. Three principal types may be distinguished : (1) - a solid variety (probably of antler) known from three Orkney and two mainland brochs and from Buston Crannog; (2) - a hollow type cut from the shaft of a long bone (probably sheep), distributed in the northern and western isles and in Ireland (where there are numerous examples from Ballinderry Crannog 2 (Hencken 1942, 53) but with one outlier from Corbridge (Stevenson 1955, 292-3); (3) - a series made from animal teeth, all at present from Orkney. Stevenson (loc. cit.) has suggested an origin in the series of Roman pins with large heads of jet.

Catalogue

Ball headed

- 27.1 Dún an Fheurain, Argyll
J. N. G. Ritchie 1971, Fig. 2, 14-16
- 27.2 Buston Crannog, Ayrshire
Munro 1882, 215-6, Figs. 201, 208-9, 211
- 27.3 Freswick, Caithness
Curle 1939, 98, Pl. XLVIII, 7-9
Stevenson 1955, 285, Fig. A23.
- 27.4 Little Wilbraham, Cambridgeshire
Lethbridge 1931, Fig. 38, 2
- 27.5 Ronaldsway, Isle of Man
Neely 1940, 82, Pl. XIII

- 27.6 Sarre, Kent
Payne 1892, 21
- 27.7 Cuerdale, Lancashire
T. D. Kendrick 1941, 163
- 27.8 Broch of Burray, Orkney
Stevenson 1955, Fig. A18
- 27.9 Broch of Burrian, Orkney (Fig. 62 E-G)
MacGregor 1974, 70, Fig. 5, 1-7
- 27.10 Brough of Birsay, Orkney
Unpublished - information from Mrs. C. Curle
- 27.11 Buckquoy, Orkney (Fig. 62 H)
A. Ritchie 1977, 192, Fig. 4, 10-15
- 27.12 Foshigarry, North Uist, Outer Hebrides
Scott 1948, 75
- 27.13 Sithean a Phiobaire, South Uist, Outer Hebrides
Lethbridge 1952, 187
- 27.14 Á Cheardach Mhor, South Uist, Outer Hebrides
Young and Richardson 1960, Fig. 13
- 27.15 Rosemarkie, Ross-shire
Stevenson 1955, 286, Fig. A, 21
- 27.16 Jarlshof, Shetland (Fig. 62 I)
Hamilton 1956, 125-6
- 27.17 Swindon, Wiltshire
Swindon Archaeological Project, unpublished
- 27.18 Whitby, Yorkshire
Peers and Radford 1943, 71, Fig. 21, 114
- 27.19 York, Yorkshire
Waterman 1959, Fig. 14, 33

Polygonal headed

- 27.20 York, Yorkshire
Waterman 1959, 83, Fig. 12, 7-9
Further material from York Minster unpublished

Nail headed

- 27.21 Dunadd, Argyll
Stevenson 1955, 285-6
- 27.22 Buston Crannog, Ayrshire
Munro 1882, 215, Fig. 202

- 27.23 Ronaldsway, Isle of Man
Neely 1940, 82, Pl. XIII
- 27.24 Mote of Mark, Kirkcudbrightshire
Stevenson 1955, 285-6
- 27.25 Broch of Burrian, Orkney (Fig. 62J)
MacGregor 1974, Fig. 5, 8-11
- 27.26 Buckquoy, Orkney
A. Ritchie, 1977, 194, Fig. 4, 18-19
- 27.27 Jarlshof, Shetland (Fig. 62K-M)
Hamilton 1956, 148, Fig. 69, 5-9

Segmented headed

- 27.28 Drifffield, Yorkshire
Mortimer 1905, 279, Fig. 775
- 27.29 Whitby, Yorkshire
Peers and Radford 1943, 71, Fig. 21, 113

Disc headed

- 27.30 Unprovenanced (British Museum) (Fig. 62N)
Jessup 1974, Pl. I, 3
- 27.31 Lincoln, Lincolnshire
Unpublished, Lincoln Archaeological Trust

Small disc headed

- 27.32 Culbin Sands, Morayshire
Stevenson 1955, Fig. A, 20
- 27.33 Broch of Burrian, Orkney
MacGregor 1974, 70, Fig. 6, 30-6
- 27.34 Buckquoy, Orkney (Fig. 62O)
A. Ritchie, 1977, 192, Fig. 4, 7
- 27.35 Dun Cuier, Barra, Outer Hebrides
A. Young 1956, Fig. 14, 28
- 27.36 Swindon, Wiltshire
Swindon Archaeological Project, unpublished

Zoomorphic headed

- 27.37 Lagore, Meath
Hencken 1950, 193, Fig. 103, 74, B; Fig. 105, 853, 1306
- 27.38 Buckquoy, Orkney
A. Ritchie 1977, 194, Fig. 5, 24-6
- 27.39 Broch of Burrian, Orkney (Fig. 63 G)
MacGregor 1974, 71, Fig. 6, 39
- 27.40 North Uist, Outer Hebrides
National Museum, Edinburgh, NA 283
- 27.41 Jarlshof, Shetland (Fig. 63 A-D)
Hamilton 1956, 115, 124, Fig. 58
- 27.42 York, Yorkshire (Fig. 63 E-F)
Waterman 1959, 82-3, Fig. 12, 6; 105, Fig. 25, 7

Axe headed

- 27.43 Jarlshof, Shetland
Hamilton 1956, 115, 124f, Pl. XXII, c

Cruciform headed

- 27.44 Lough Aconnick, Co. Roscommon
Unpublished - British Museum
- 27.45 Jarlshof, Shetland (Fig. 63 H)
Curle et al. 1954, Fig. 4
Hamilton 1956, 148, Fig. 69, 2
- 27.46 Unprovenanced,
Ashmolean Museum, 1909, 835

Thistle headed

- 27.47 Buston Crannog, Ayrshire (Fig. 63 J)
Munro 1882, 215-6, Fig. 212
- 27.48 Broch of Burrian, Orkney (Fig. 63 I)
MacGregor 1974, Fig. 5, 24
- 27.49 Buckquoy, Orkney (Fig. 63 K)
A. Ritchie 1977, 194, Fig. 4, 14-16
- 27.50 Jarlshof, Shetland
Hamilton 1956, 115, 125

Loose ring headed

- 27.51 York, Yorkshire (Fig. 64A)
Norwich Castle Museum, unpublished, 423/76.94
Waterman 1959, 80, Fig. 12, 1

Expanded headed

- 27.52 London (Fig. 64F, H)
Bjørn and Shetelig 1919, Fig. 59
Wheeler 1927, 49-50, Figs. 27-8
- 27.53 York, Yorkshire (Fig. 64B, E-G)
Waterman 1959, 83-5, Figs. 12, 14

Pig fibulae

- 27.54 Sutton Courtenay, Berkshire
Leeds 1923, Fig. 2, a-d
- 27.55 Cahercommaun, Co. Clare
Hencken 1938, 38
- 27.56 Feltrim Hill, Co. Dublin
Hartnett and Eogan 1964, 24
- 27.57 Lagore Crannog, Co. Meath
Hencken 1950, 194
- 27.58 Broch of Burrian, Orkney
MacGregor 1974, 71, Fig. 8, 94-100
- 27.59 Buckquoy, Orkney (Fig. 65C)
A. Ritchie 1977, 192, Fig. 4, 1-3
- 27.60 Oxford, Oxfordshire
Henig, in Durham 1977, 163, Fig. 37, 2; Fig. 38, 12-14
- 27.61 Shakenoak, Oxfordshire
Brodribb et al. 1972, 129
- 27.62 Jarlshof, Shetland
Hamilton 1956, 126
- 27.63 York, Yorkshire (Fig. 65D-E, Pl. 4)
Waterman 1959, Fig. 14
MacGregor, forthcoming

Globular headed

- 27.64 Dún an Feurhain, Argyll
J. N. G. Ritchie 1971, 103, Fig. 2, 19
- 27.65 Buston Crannog, Ayrshire
Munro 1882, Fig. 214-5
- 27.66 Freswick, Caithness
National Museum, Edinburgh, unpublished
- 27.67 Kettleburn Broch, Caithness
National Museum, Edinburgh, unpublished
- 27.68 Ballinderry Crannog 2, Co. Offaly
Hencken 1942, 53
- 27.69 Broch of Ayre, Orkney,
Stevenson 1955, 292
- 27.70 Broch of Burray, Orkney
National Museum, Edinburgh, unpublished
- 27.71 Broch of Burrian, Orkney (Fig. 45 F-H)
MacGregor 1974, 71-6
- 27.72 Broch of Howe, Orkney
Stevenson 1955, 292
- 27.73 Broch of Midhowe, Orkney
Stevenson 1955, 292
- 27.74 Oxtrow Broch, Orkney
Stevenson 1955, 292
- 27.75 Brough of Birsay, Orkney
Stevenson 1955, 292
- 27.76 Bac Mhic Connain, Outer Hebrides
Stevenson 1955, 292
- 27.77 Foshigarry, Outer Hebrides
Callander 1931, 339, Fig. 8, 2

COMBS (Figs. 66-82, Pls. 26-33)

Throughout the period under review, toilet combs were articles of everyday use at almost every level of society. Hence, from the most

modest of Anglo-Saxon cemeteries to the flourishing urban centres of the Viking and early medieval periods, combs of various types form one of the commonest classes of finds.

Many were clearly valued for their decorative as well as their functional values and evidence survives that they occasionally formed the subject of exchanges of gifts. A comb accompanied the important letter from Boniface to Æthelburh c. 625, imploring her to strive to 'kindle the spark of the true religion' in her husband, Edwin of Northumbria : the papal message (Bede XI, 106) concludes as follows :

'As well as the blessing of St. Peter, chief of the apostles and your protector, we send a silver mirror and an ivory comb adorned with gold. We beseech your Majesty to accept it in the same kindly spirit in which it is sent.'
(Colgrave and Mynors 1969, 175)

Alcuin too was the recipient of an elaborately-wrought comb and, in a letter of c. 794, eulogises on its properties to his benefactor, Archbishop Riculf of Mainz :

De vestra valde gaudeo prosperitate, et de munere caritatis vestrae multum gavisus sum; tot agens gratias, quot deutes in dono numeravi. Mirum animal duo habens capita et dentes sexaginta non elephantinae magnitudinis, sed eburneae pulchritudinis. Nec ego huius bestiae territus horrore, sed delectatus aspectu, ne me frendentibus illa morderet dentibus, timui; sed blanda adulatione capitis mei placare capillos advisi. Nec ferocitatem in dentibus intellexi, sed caritatem in mittente dilexi, quam semper fideliter in illo probavi.
(Dümmler 1895, 67)

'I rejoice greatly in your prosperity, and
 I have rejoiced much in your loving gift.
 As many thanks as the present has teeth!
 It's a remarkable animal with its two heads
 and sixty teeth - and such beautiful ivory,
 though it's not as big as an elephant!
 The beast didn't frighten me - its appearance
 is delightful; I had no fear those gnashing
 teeth might bite me, but there gentle
 caresses smoothed the hair of my head
 beautifully. I did not look at the
 ferocity of the teeth but loved the
 affection of the sender ...'
 (MGH 4, No. 26, translated in Allott 1974,
 152 (letter 154))

In the Anglo-Saxon period in particular, combs seem to have had a potent symbolic significance : their remains were often burned and deliberately broken in cremation burials (p. 211); symbolic miniature combs were sometimes made especially for interment (p. 211) and representations of combs are occasionally found stamped on cremation urns (Vierck 1972, Abb 8, 2.3, 7). A representation on a Frankish grave slab from Niederdollendorf, North Rhine Westphalia, showing (apparently) the deceased combing his hair, is thought (Lasko 1971, 88, Pl. 82) to represent an affirmation of life after death. During earthly existence too, hair could have a very particular significance : long hair was a sign of nobility and perhaps even of magical power among the Franks (Wallace-Hadrill 1962, 156-7, 245-6) and combs no doubt acquired a special significance by association. A more down-to-

earth explanation of their widespread use at a time before hygiene had acquired any significance in everyday life might be that they performed a useful role in the control of lice (Grohne 1953, 159).

In the Pictish realms of Scotland, lying outside the area of strong Germanic influence, combs again held some powerful meaning, as may be judged from their frequent appearance on symbol stones. C. Thomas (1963, 81) postulates that the combs represented (frequently in association with a mirror) on the stones are womanly attributes, perhaps referring to a female in relationship to a person otherwise commemorated on the stone. Forty-four examples of double-sided combs in association with mirror symbols are recorded by Allen and Anderson (1903, 105) and others have been found since (see, for example, Webster and Cherry 1978, Fig. 3), the latter example clearly representing a composite structure. Even on later medieval funerary sculpture in Scotland, combs remained a favoured symbol in some areas (Steer and Bannerman 1977, 177). Rectangular symbols looking like decorative wallets which have been noted on fifteen stones have been interpreted (Calder 1947, 4) as representing comb cases.

The extent to which comb-making was at any time in the hands of craftsmen who engaged solely in this trade is part of a wider problem discussed above (pp.66-8). A number of instances may, however, be cited in which

comb production can be shown to have been carried out by specific individuals (or workshops). One of the earliest of these is a sizeable group of roughly-shaped antler comb blanks found at Grossjena (Kr Weissenfels), dating from the 3rd or 4th century (Bicker 1936, 294-5). Many waste fragments and half-finished bone combs found within the old cathedral precinct at Münster clearly derive from a flourishing industry and have been taken to indicate the activities of professional craftsmen (Winkelmann 1977, 111-5). West Stow in Suffolk has also produced manufacturing evidence from this period (West 1969, 13-16). In the Viking age the evidence is more prolific : Dublin (Ó Ríordáin 1971, 75, Pl. VII) and York (MacGregor 1978, 46-8) have been particularly prolific in this country, but many centres have produced scattered evidence to demonstrate some level of activity. The most impressive collection of waste and half-finished material, however, comes from Hedeby : Ulbricht (1978, 117-9) has computed from surviving workshop debris that as many as 37,000 combs might have been manufactured on the site; on the other hand, the evidence is scattered over most of the settlement, which flourished for some 200 years, and Ulbricht comes to the conclusion that even this impressive body of material can not be taken as proof that specialist craftsmen were employed throughout the year exclusively on the manufacture of combs. In the face of this rigorous interpretation we must stop short of identifying the comb-makers as professionals in the sense that they worked exclusively on their manufacture. The distinction may be one purely of semantics, however, and it seems unnecessary to deny that craft activities were compartmented merely because the compartments were not always watertight. At any rate, from the point of view of the standard of production,

the comb-makers show themselves as being perfectly worthy of the epithet 'professional'.

Composite combs

The evidence provided by manufacturing remains clearly demonstrates the way in which the task of producing a composite comb was tackled. (An explanation of the terminology used is given in Fig. 66 : it differs somewhat from that recently proposed by Galloway (1976, 154-6) but is not in conflict with it.) As mentioned elsewhere, true bone combs are exceedingly rare, the normal raw material being red deer antler. The normal practice, as demonstrated by remains from the centres mentioned above, was first of all for the tines and terminal burr of the antler to be sawn off, leaving the thick main beam intact. The beam was then sawn into appropriate lengths for the long side plates and shorter tooth plates, before being cut or split lengthwise into strips. The cancellous tissue in the centre of the beam was cut away and the resulting billets of dense outer tissue sawn and shaved with a draw-knife to the required thickness - about 3mm for the tooth plates and 6-10mm for the side plates. Tempel (1970, 220-1, Abb 1) has calculated that six side plates and twenty-eight tooth plates might be won from a single antler from a ten-point head and eight side plates and thirty-six tooth plates from an antler from a fourteen-pointer. A pair of strips was selected to form the side plates : these were cut and filed into the desired shape, smoothed and polished, and the decoration (if any) incised on the prepared surfaces. To facilitate symmetrical shaping and decoration of the side plates they may have been riveted or pegged together temporarily at this stage : a number of unmounted side plates with single rivet holes at either end have been found at Hedeby

(Ulbricht 1978, 51, Taf 29-30) and interpreted in this way; it must be remembered, however, that such plates might equally derive from comb-cases (p. 243).

For the insertion of the tooth plates, the side plates were separated and the blank tooth plates inserted between them. Although they might by this time have been filed to a blade-like point along their longitudinal axis, the tooth plates would not yet have any teeth cut in them. It is well known from frequent cut marks found on the side plates that the teeth were usually, probably invariably, cut after the entire assemblage had been riveted together. Examples of assembled combs with uncut tooth plates may be noted from Dublin (Fig. 67) and Lund (Blomqvist 1942, Bild 78). It may also be noted, however, that there is rarely any unevenness of spacing at the junctions of the plates, so that we may assume that they were cut to widths representing whole numbers of teeth before being riveted in position. Most probably, this would have been achieved by testing the individual plates against templates or examples known to be of satisfactory size and is unlikely to have involved accurate gauges or finite units of measurement. Just how many teeth would be cut on any given plate would be conditioned by the dimensions of the raw material (see above). The prepared tooth plates would then have been riveted in position, the normal practice being for one rivet to be inserted at every second join; usually it was only the end plates which were actually pierced, the intervening plates generally being found to have only half a rivet hole notched on one edge, although this was not invariably the case. Iron rivets were much more commonly used than bronze, except perhaps on some late combs of Scandinavian type. As mentioned above, the sawing of

the teeth in situ at this stage often resulted in cut marks extending on to the under side of the side plates; in some cases these marks are purely haphazard but in others the cuts have been carefully and deliberately executed in a more or less decorative manner. To judge from recent practice among horn comb makers, the final shaping and polishing of the teeth may have been a more lengthy and elaborate process than can easily be detected; in workshops still operating in 20th-century York no fewer than seven separate stages were involved in the preparation of the teeth (Wenham 1964, Fig. 11).

Just why such a complex method of manufacture should have been developed and remained popular for around a thousand years is not immediately clear, but the primary reasons are almost certainly bound up with the limitations imposed by the raw material. Remembering that all but a handful of composite combs are made from antler rather than bone (the reason for which is discussed on p. 59), two basic methods of production would have been open to the manufacturer: either he could slice off a longitudinal plaque of material and cut the teeth across the 'grain' or he could cut a very much shorter length and have the teeth in line with the principal axis of the antler. The first of these options has two disadvantages, namely that the width of such a comb would be limited by the curvature of the outer surface of the antler on one side and the presence of the central core of cancellous tissue on the other, while the teeth, being cut at right angles to the axis of greatest strength, would be comparatively fragile (see p. 60). While the second option, with the teeth cut in the vertical axis, would certainly be more robust, the length of the comb in this instance would be limited to a few centimetres. A solution was found by uniting a number of these vertically-cut tooth plates by riveting

them between a pair of horizontal bars which, incidentally, always have the grain running in the direction of their long axis.

An alternative explanation, offered by Wilde (1863, 271) was that this composite method of construction became popular as it allowed damaged tooth plates to be replaced without the necessity of buying an entire new comb, but while this may have some validity it seems less satisfactory than that given above. Individual tooth plates certainly could, however, be replaced without too much difficulty and, if carried out competently, any such repairs would be difficult to detect. Traces of repair in the form of redundant rivet holes and of extra saw marks on the undersides of the side plates from recutting the teeth have nonetheless been noted on a composite comb from Castell-y-Bere, Merioneth, (occupied c. 1231-95) (Butler 1974, 93, Fig. 6, B4); similar saw marks from repairs are seen on a comb from Oslo (Wiberg 1977, Fig. 3). It is of interest that fragmentary combs found at Sarre (Brent 1865, 168-9) and Kingston Down (C. R. Smith 1855, 62, Fig. 2), both in Kent, have been mended in a different way, both combs having had individual teeth replaced by small bronze pins (Fig. 67).

Combs made from the strong columnar limb bones of cattle and horses are not so well represented in the period under review, but the morphology of these bones would have imposed the same sort of limitations as antler on composite combs : in the case of limb bones, the marrow cavity would have had the same effect as the cancellous core of the antler in imposing a certain pattern of utilisation. (On the mechanical advantages of antler, however, see p. 61). A workshop specialising on the production of composite combs from the limb bones of horses has been found in Münster :

the style and method of production of the combs manufactured in this workshop, which has been dated to the 8th century (Winkelmann 1977, 111-5, Fig. 7-8), are consistent with those outlined above for antler combs. Paulsen (1967, 22) writes of combs commonly being made with antler side plates and bone tooth plates, but this practice would seem to have little to recommend it. One such comb has, however, been firmly identified at Hedeby (Ulbricht 1978, 65, Taf 34, 3), where five other composite combs of bone were noted (loc. cit.).

Ignoring the diminutive one-piece Anglo-Saxon combs for the moment, only a few true bone combs can be cited from Britain before the 13th century : double-sided bone combs from Ford, Wiltshire, and Kingston Down, Kent, are mentioned below, each having all the teeth cut on a single billet cut from a scapula, but these are exceptional. Split ribs were occasionally used for the side plates (eg MacGregor 1978, 48, Fig. 29, 10). The flat cross-section of the ribs dictated a rather more slender profile for these combs than was encountered on any of those with antler side plates. A large group of split ribs, some of them decorated, from a rubbish pit in Leadmill Lane, York, has recently been referred to as a collection of comb fragments (Addyman 1974, 217), but detailed examination suggests that all are derived from comb cases rather than combs. Perhaps the fact that the side plates on comb cases are not subjected to the same strains as are imposed on the combs themselves meant that the craftsman could accept material with comparatively poor mechanical properties for this function, or conceivably it may reflect no more than different preferences within different workshops.

True horn combs (as distinct from those made of antler) are rare indeed in this period, but this may be at least partly due to the comparatively poorer survival qualities of horn; a few examples recently found in Dublin (Dunlevy 1969, Nos. 346-54) suggest that they might have been more common than has hitherto been suspected and give hope that more will be forthcoming.

Just as the majority of 'horn' combs mentioned in the archaeological literature turn out on examination to be made of antler, so too do most of those described rather hopefully as ivory. True ivory combs from this period are occasionally found, however, the majority of them being so-called 'liturgical' combs (p. 241). Many of these are indeed made of walrus or elephant ivory, the remainder frequently being of cetacean bone. (Wooden combs of this type are also known in some quantities.) The skeletons of large cetaceans would have been the only generally available source of bone of adequate dimensions to provide suitable raw material for liturgical combs; being larger and heavier than everyday combs, and often being embellished with ornate low-relief carving, they are invariably made from a single block of material and are never of composite construction.⁽²³⁾ In its fresh state, ivory is fairly strong in every dimension, but it has been noted (Rackham, in Hall 1975, 124-5) that later (post-medieval) combs of ivory often have the teeth cut at an angle so as to minimise the weakening effect of its laminar structure.

Combs of wood, perhaps boxwood most commonly, were quite usual in the Roman period and occasionally the use of wood is recorded in the post-

Roman and pre-medieval era; apart from the liturgical types mentioned above, most of the 'native' examples are also made from a single piece, like that from Buston Crannog, Ayrshire (Munro 1882, Fig. 218), but an interesting example of composite type with a handle imitating the shape of the more usual antler tine handles (see below) may be noted from the Thames (Winter 1906, Taf 28, 84). The well-established series of iron combs from northern Germany (S. Thomas 1960, 114) is represented in the British Isles by one example from Sutton Courtenay (Leeds 1923, 182), although the excavator was of the opinion that this example was originally fitted with a handle. A few miniature bronze combs are known from Roman contexts (Neville 1855, 112; Todd 1969, 90, Fig. 38, 6), but with a single exception from Whitby, Yorkshire (Yorks. Archaeol. J., 29 (1929) 350) there seem to be no later examples from this country. (The Whitby comb finds a very close parallel from the Frisian terps, however : cf. Munro 1890, Fig. 100, 14.) Jankuhn (1953, 37-45) describes a series of composite combs with bronze side plates, distributed sparsely from Frisia to southern Sweden. The forms of the bronze side plates are identical to the contemporaries in antler, from which they clearly derive.

Single-sided combs of the Anglo-Saxon period

Miniature one-piece combs (Fig. 68)

As already mentioned, the toilet comb was by no means an innovation of the Anglo-Saxon period, but has an ancestry which can be traced beyond the Roman period to one-piece prehistoric examples. In form at least, the miniature one-piece combs which are commonly found in Anglo-Saxon cremation cemeteries are perhaps most closely related to these pre-Roman

types, but their simplicity has probably got less to do with any conscious conservatism than with purely practical considerations, for the role they had to play was a particularly ephemeral one. With the single exception from West Stow mentioned below, every one of these combs has been found in a funerary context and the evidence suggests that many, if not all of them, were made specifically as tokens for deposition with the dead. While some have been manufactured with a certain amount of care, the majority were only roughly shaped, the coarsest of them being much too crude ever to have served any practical purpose. Two of those from Abingdon (Leeds and Harden 1936, Pl. III) and one from Lackford in particular have short v-shaped teeth of no useful value whatever, while in one instance (*ibid.* 1936, 14, Pl. 10) only four of the teeth are actually cut, the remaining five being merely indicated by grooves. It seems, therefore, that these miniature combs (along with other scaled-down implements such as shears, tweezers and knives, which are also common in Anglo-Saxon cremations) were manufactured specifically for burial with the dead. It has been noted that these miniature combs, like many of the (apparently) deliberately broken full-sized combs which also occur in cremation cemeteries, have rarely been burnt in the funeral pyre (Lethbridge 1951, 12). Some of these combs, however, have been subjected to the fire and in some areas on the continent it is the unburnt combs which are unusual (Myres and Green 1973, 92). Representations of combs of this type in the form of stamped impressions on funerary urns (Vierck 1972, Abb 8, 2, 3, 7) reinforce this impression of a ritual role.

Catalogue

- 28.1 Abingdon, Berkshire
 Leeds and Harden 1936, 12-25, Pls. III-IV (10)
- 28.2 Wallingford, Berkshire (Fig. 687)
 Leeds 1938, 97

- 28.3 Cambridge, Cambridgeshire (Fig. 68G-H)
Hollingworth and O'Reilly 1925, Pl. V, 3
- 28.4 'Near Cambridge', Cambridgeshire
Ashmolean Museum, unpublished, 1909, 308
- 28.5 Loveden Hill, Lincolnshire
Noted in Myres and Green 1973, 97; Fennel 1964
- 28.6 Caistor-by-Norwich, Norfolk (Fig. 68D)
Myres and Green 1973, 97, Pl. XXIII, c, e (2)
- 28.7 Castle Acre, Norfolk
Norwich Castle Museum, unpublished, 131, 11 and 50, 962 (2)
- 28.8 Lackford, Suffolk (Fig. 68A-B, F)
Lethbridge, 1951, 16-22, Figs. 1-35 (7)
- 28.9 West Stow, Suffolk
Noted in Myres and Green 1973, 97
- 28.10 Bidford-on-Avon, Warwickshire (Fig. 68C)
Humphreys et al. 1923, 104, Pl. XVI, 2c

A number of miniature one-piece combs are also known from Ireland and from Scotland, but these are unrelated to those of ultimately Germanic origin discussed here. The Irish and Scottish combs include examples from Lagore Crannog, Co. Meath (Hencken 1950, 189, Fig. 102a) and a number of broch sites in northern Scotland (MacGregor 1974, 80).

Triangular-backed composite combs (Fig. 69, Pl. 26)

Combs in the triangular-backed series are among the earliest to make an appearance in the Anglo-Saxon period, most examples apparently belonging in the 5th and 6th centuries. The earliest representatives from the British Isles, indeed occur in Roman contexts as at Colchester (Hull 1958, 79, Fig. 35) and Richborough (Bushe-Fox 1928, 47, Pl. XXI 43; 1932, 81, Pl. XIII, 35; 1949, 148, Pl. LIV, 226, LVI, 265, 270). The cemeteries

at Girton College, Caistor-by-Norwich, Castle Acre and Lackford are, in general, early in the Anglo-Saxon period, and such datable finds as occurred with individual finds tend to confirm this picture : all the datable urns containing these combs at Caistor-by-Norwich (Myres and Green 1973, 95-6) and Lackford (Lethbridge 1951, 17, 21-2, Fig. 6, Fig. 34) were judged to be of 5th or 6th century date. Some of those from West Stow, Suffolk, however, may be as late as the early 7th century (Myres and Green 1973, 96).

On the Continent, similarly early dates are demonstrable for combs of this type and an origin in the early 4th century has been demonstrated (S. Thomas, 1960, 99-104). As Biddle (1970, 313) has observed, combs of this type form a component of the so-called Laetenhorizont, more usually recognised by its distinctive metalwork. This connection is most readily seen in the zoomorphic treatment of the crests of combs from Lackford (Lethbridge 1951, 17, Fig. 6) and Loveden Hill (Pl. 26) and on a more fragmentary example from Sancton, East Yorkshire (Myres and Southern 1973, 56, Fig. 12). The Lackford comb, in particular, may be compared with one from the 4th-century Laetenfriedhof at Furfooz, Belgium (Nenquin 1953, 69, Pl. IX), which has a crest fashioned into horses' heads and to those from Cortrat (Böhme 1974, 313, Figs. 117, 120) and Garvan-Dinogetia (S. Thomas 1960, 182, Abb 74), for example. Several of the Furfooz combs have openwork crests in the manner of those from Winchester (Biddle 1970, 313, Pl. XLVIII, b) and Castle Acre, Norfolk (see catalogue) (cf. also Fremersdorf 1928, Taf 141). As well as this projecting crest, formed by the tops of the tooth plates, greater scope is provided for decoration on the broad triangular side plates, which more often than not carry multiple incised borders and ring-and-dot

decoration.

Combs of this type are occasionally referred to as 'triplex' combs, but this is a misleading term and not to be encouraged. The tooth plates on composite combs of triangular outline are made in exactly the same way as those described above, so that instead of consisting of three pieces, as this term suggests, the entire assembly is likely to consist of five or more individual plates of antler.

Catalogue

- 28.11 Girton College, Cambridgeshire (Fig. 69D)
 Hollingworth and O'Reilly 1925, Pl. V, 2, 4 (2)
- 28.12 Colchester, Essex
 Hull 1958, 79, Fig. 35
- 28.13 Winchester, Hampshire (Fig. 69E)
 Biddle 1970, 313, Pl. XLVIII, b
- 28.14 Richborough, Kent
 Bushe-Fox 1928, 47, Pl. XXI, 43; 1932, 81, Pl. XIII, 35; 1949, 148, Pl. LIV, 226, Pl. LVI, 265, 270
- 28.15 Ancaster, Lincolnshire
 Trollope, 1870, 4
- 28.16 Loveden Hill, Lincolnshire (Pl. 26)
 Fennel 1964
- 28.17 Caistor-by-Norwich, Norfolk
 Myres and Green 1973, 95, Pl. XXII, c (1 complete plus several fragments)
- 28.18 Castle Acre, Norfolk
 Norwich Castle Museum, unpublished, 131, 11.
- 28.19 Eye, Suffolk
 Akerman 1855, 44, Pl. XXII, 2
- 28.20 Lackford, Suffolk (Fig. 69A, c)
 Lethbridge 1951, 17, 21-2, Figs. 6, 34 (4 complete plus 2 fragmentary examples)
- 28.21 West Stow, Suffolk (Fig. 69E)
 West 1969, Fig. 10, 1-2 (2)

- 28.22 Malton, North Yorkshire
G. B. Brown 1915, 391, Pl. LXXXV, 1
- 28.23 Sancton, East Yorkshire
Myres and Southern 1973, 56, Fig. 12 (several
fragmentary examples)
- 28.24 York, North Yorkshire
Stead 1958, 434, Fig. 4, 3

Round backed combs (Fig. 70)

Although their origins on the Continent may be even earlier than those of the triangular backed combs described above (S. Thomas 1960, 77), composite combs with round backs were carried into this country on the same wave of cultural traits which brought most of their more angular counterparts. Numerically, however, they are much less well represented : perhaps the fashion was already beginning to wane in favour of the triangular back by the time that the main influx got under way. Some early triangular backed combs (eg that from Richborough - Bushe-Fox 1928, Pl. XXI, 43) have the apex rounded, so forming an intermediate type. The Lackford comb, with its vertical-sided end plates represents the more 'normal' shape, the outswept profiles of those from Caistor-by-Norwich and Lower Warbank being less common, although a number of parallels may be cited from the Frisian area and from Central Germany (Myres and Green 1973, 94).

Catalogue

- 28.25 Cambridge, Cambridgeshire
Unpublished - noted in Myres and Green 1973, 94, n 12
- 28.26 Lower Warbank, Kent (Fig. 70c)
Philp 1974, Fig. 49, 477
- 28.27 Caistor-by-Norwich, Norfolk (Fig. 70E-F)
Myres and Green 1973, 94-5, Pl. XXII, a-b (2 complete
plus several fragments)

- 28.28 Lackford, Suffolk (Fig. 70 D)
Lethbridge 1951, 21, Fig. 33 (plus 1 fragment)
- 28.29 West Stow, Suffolk (Fig. 70 A)
West 1969, Fig. 10, 3
- 28.30 Sancton, East Yorkshire (Fig. 70 E)
Myres and Southern 1973, 62, Fig. 2353

Barred combs of Frisian type (Fig. 71)

An interesting and easily identifiable group of early combs is that known as the barred Frisian type. These are characterised by having, instead of the normal symmetrically arranged side plates, a broad flat plate on one side and two plano-convex bars on the other, the width of the two bars together being equal to that of the single plate. They are sometimes provided with a small central handle on the back, flanked by inward-facing zoomorphic terminals cut from the projecting end plates; occasionally, the handle is reinforced by an additional antler plate riveted on either side.

In the Caistor-by-Norwich cemetery, two urns produced combs of this class while in another were incomplete sections of two combs or, perhaps, a comb and its case (Myres and Green 1973, 92-3). The cemetery at Spong Hill, North Elmham, has produced twenty in recent excavations (Hills 1977, 28-9, Figs. 129-31). Two have been found on sites in Suffolk, one of them, from Grimstone End, Pakenham, from a possible Saxon hut (Owles and Smedley 1965, 188-9, Fig. 25a) and the other, from the Lackford cemetery (Lethbridge 1951, 16, Fig. 1), although this latter example is unusual in having a pair of plano-convex bars on either side. Two

further representatives of this type come from York, one of them found in the last century and the other during excavations in 1975 (MacGregor 1975, 195-8, Fig. 76, 1-2). One final example has recently been found during excavations at Peterborough (MacKreth 1978, 219, Fig. 65).

All the dating evidence which can be mustered for combs of this type points to their having a late 4th- or 5th-century introduction to this country. At Caistor-by-Norwich (Myres and Green 1973, 92-4) and Lackford (Lethbridge 1951, 13, 16), all the urns containing combs of this type were of 5th-century date, while the recent find from York was from a late Roman or immediately post Roman level (R. A. Hall, personal communication). The little information accompanying the other finds also suggests early Saxon dates. The presence of opposed zoomorphic terminals on these combs immediately brings to mind the late 4th- and 5th-century belt fittings usually associated with the presence of Germanic Laeti, both in England and on the continent. With a single exception, from Issendorf, Niedersachsen (Janssen 1972, 49f, Taf 34b), all those occurring on the continent are from the provinces of Friesland and Groningen in the Netherlands and have similarly early dates wherever they can be independently established (see, for example, Boeles 1951, Pl. XXVII).

Catalogue

- 28.31 Caistor-by-Norwich, Norfolk
Myres and Green 1973, 92-4, Fig. 28, Y17, M53
- 28.32 Spong Hill, Norfolk (Fig. 83A)
Hills 1977, 28-9, Figs. 129-31
- 28.33 Peterborough, Northamptonshire
MacKreth 1978, 219, Fig. 65

- 28.34 Lackford, Suffolk
Lethbridge 1951, 16, Fig. 1
- 28.35 Pakenham, Suffolk (Fig. 71c)
Owles and Smedley 1965, 188-9, Fig. 25a
- 28.36 York, North Yorkshire (Fig. 71A-B)
MacGregor 1975a, 195-8, Fig. 76, 1-2

Other combs with 'Frisian' features (Fig. 72)

A number of combs incorporate features which link them stylistically with the products of the Frisian area. This is not to say that they demonstrate conclusively the ethnic origins of their owners but collectively they do reflect something of the distribution of Frisian traits already established for Britain.

One feature which may be considered in this context is the provision of an extra side plate. An elongated angular-backed comb with 'winged' end plates of the type discussed below (p. 220) came from Hayton, East Yorkshire : the depth of the upper side plates on this comb (Fig. 72) seems perfectly adequate for them to perform their normal functions but an additional D-section plate has been added at a lower level. The shortness of the teeth and the multiple saw cuts on the lower edge of the lower side plates show clearly that they were an original feature and were not applied secondarily for strengthening or repair.

In three other combs with extra pairs of side plates one plate follows the outline of the back while the other is straight, leaving an expanse of the tooth plates exposed inbetween them. On a comb from Cambridge (Pl. 27) and one from a well-appointed double inhumation grave dated c. 600 at Dunstable (Fig. 72), this intervening area has been decorated with

inscribed vertical lines; the Dunstable comb also displays curiously looped terminals, perhaps debased zoomorphic elements. The third comb in this group, from Garton Slack, is undecorated on its central reserve, although the side plates (like that on the Cambridge comb) carry incised ornament; it was found among the remains of what was thought to be a purse frame (Mortimer 1905, 251).

Angular backed combs with extra pairs of side plates are well known in the Frisian area (see, for example, Roes 1963, Pls. VII, 2; XX, 1-5); they also occur on round backed and curved backed combs from the same area (op. cit., Pls. IV, 2; XX, 3-5). Combs with a space between the two pairs of side plates are also known from Frisia (op. cit., Pl. XX, 1-2). Extra side plates are a feature unknown on Scandinavian combs of this period, although they do occur occasionally in Germany : the presence of such combs at Thaining in Upper Bavaria (Dannheimer 1962, 412, Abb 5, 12), Donaual-Regensburg (U. Koch 1968, Taf 8, 12) and at Pfullingen (Cabrol and Leclercq 1938, Fig. 100040, 2) implies, perhaps, some popularity in this area.

Another peculiarity of certain Frisian combs (Roes 1963, Pl. XXIX) is an asymmetrical outline⁽²⁴⁾ with one end curved and the other terminating in a squared end plate, the latter frequently not cut with teeth but merely decorated with incised ornament. On the continent only a few are known outside the Frisian area (op. cit., 24, n 1; Cabrol and Leclercq 1938, Fig. 10040, 4; U. Koch 1968, Taf 10, Taf 65). A single example of this type has been recovered from Saxon Southampton (Fig. 72), an important port of the period with established Frisian connections (Addyman and Hill 1969, 81, Pl. VII, b).

The close correspondence between a single end plate from a composite comb found at Dorestad (Roes 1965, 62, Pl. XXVIII, 216) and another from York (Fig. 72) has been commented upon elsewhere (MacGregor 1978, 37) as a further indication of contact between the British Isles and the Frisian littoral at this time.

Catalogue

- 28.37 Dunstable, Bedfordshire (Fig 72A)
 C. L. Matthews 1962, Fig. 2, 4
- 28.38 Cambridge, Cambridgeshire
 Ashmolean Museum, unpublished, 1909, 307
- 28.39 Southampton, Hampshire (Fig 72B)
 Addyman and Hill 1969, 81, Pl. VII, b
- 28.40 Garton Slack, Yorkshire
 Mortimer 1905, 251
- 28.41 Hayton, Yorkshire (Fig 72C)
 Britannia 7 (1976) 316
- 28.42 York, Yorkshire (Fig 72D)
 MacGregor 1978, 37, Fig. 29, 5

Hogbacked combs (Fig. 73, Pl. 27)

A distinct group of combs may be recognised in the long hogbacked variety, often provided with large 'winged' end plates. The majority have been recovered from inhumation graves but two are from domestic contexts. Of the three combs of this type found at Burwell, one (Lethbridge 1931, 65, Fig. 34) was found at the chest of a (probably middle-aged female) skeleton, where it had been suspended by a cord with a red and a green bead at either end; a second comb (op. cit., 67, Fig. 36, 5)

had originally been placed in a casket at the feet of another female inhumation. Another of these combs, from Kingston Down cemetery, Kent, had also been deposited in a casket in an exceptionally rich grave, containing twelve amethysts, eighty-six beads, pendants and jewels (C. R. Smith 1856, 66-8, Pl. XIII, 2). Of the two combs from non-funerary contexts, one came from a hut at West Stow (West 1969, 14-5, Fig. 10, 8) and the other from Saxon Southampton (Addyman and Hill 1969, 75-6, Pl. VIIa).

A number of other hogbacked combs may be noted which lack the characteristic flaring end plates of those described above. Since many of these lack ends of any kind, however, the distinction may be more apparent than real. One small hogbacked comb of this type with deep side plates is, however, complete (Walker 1912, 125-6, Pl. XII); it was found in Cambridge with the skeleton of an inhumed girl. A date in the 7th or 8th century may be suggested for the group as a whole.

Catalogue

- 28.43 Lowbury Hill, Berkshire
 Evison 1963, Fig. 27a
- 28.44 Sutton Courteney, Berkshire (Pl. 27)
 Leeds 1923, Pl. XXVIII, Fig. 1, a
- 28.45 Burwell, Cambridgeshire (Fig. 73c)
 Lethbridge 1931, 52, 65, 67, Figs. 25, 34, 36
- 28.46 Cambridge, Cambridgeshire (Pl. 27)
 Walker 1912, 125-6, Pl. XII
- 28.47 Southampton, Hampshire
 Addyman and Hill 1969, 75-6, Pl. VIIa
- 28.48 Kingston Down, Kent
 C. R. Smith 1856, 66-8, Pl. XIII, 2

- 28.49 West Stow, Suffolk (Fig 73A)
West 1969, 14-5, Fig. 10, 8
- 28.50 Kingston Down, Kent
C. R. Smith 1856, 91-3, Pl. XIII, 4; Akerman 1855, 64, Pl. XXXI, 2
- 28.51 Whitby, North Yorkshire (Fig 73B)
Haigh 1873, 279-81

High backed 'Celtic' combs (Fig. 74)

A group of small combs made with high backs in which the tops of the tooth plates extend well above the side plates seems to have a distribution within the late Celtic rather than the Anglo-Saxon realms. Various authors (eg Dunlevy 1969, 32-6; Laing 1975, 300) have, however, compared the zoomorphic treatment found on the backs of some of these combs with that on late Roman 'Germanic' metalwork; the comb type is, on the other hand, never found in Anglo-Saxon contexts.

Zoomorphic treatment of the type mentioned occurs on composite combs from Carraig Aille II, Lagore Crannog and Dun Cuier (Fig. 74). Dunlevy also notes its appearance on a one-piece comb from Lagore (Hencken 1950, Fig. 102B), although it could be argued that the resemblance to Anglo-Saxon motifs here is an accidental result of the way the back has been perforated with a pelta design, which could equally well derive from the Pictish world, where it is well known.

In this same general class may be included a number of combs without zoomorphic treatment but featuring the same extension of the back above the side plates : this projecting crest may take the form of a series of arches, as on certain Irish examples; others have backs in the form of a simple or sinuous curve.

The side plates on this series are frequently short and flat, often bowed outwards along their long edges; sometimes they terminate well short of the margins of the end tooth plates while others extend for the entire length of the comb. The type as a whole seems, on the evidence of its find-spots, to have survived as late as the 8th century. A derivation in the 5th century would be necessary to account for the correspondences with late Roman military metalwork mentioned above (if such correspondences were to be accepted as valid) and possibly earlier if a derivation for the curved-back variety from one-piece combs of the late Iron Age is admissible, as has been suggested (MacGregor 1974, 80).⁽²⁵⁾

No doubt future research and further finds will result in this type being more precisely dated and sub-divided. For the purposes of this exercise all these combs may stand together on the basis of the structural peculiarity of their prominent crests.

Catalogue

- 28.52 Carraig Aille, Limerick
S. P. O'Riordáin 1949, 81, Fig. 13, 13H
- 28.53 Lagore, Meath (Fig. 74E)
Hencken 1950, Fig. 99, 777; Fig. 102, B, C
- 28.54 Buckquoy, Orkney (Fig. 74A)
Ritchie 1977, 194, Fig. 7, 47
- 28.55 Burrian, Orkney (Fig. 74C-D)
MacGregor 1974, 80, Fig. 11, 149-50
- 28.56 Burwick, Orkney
Anderson 1883, 240, Fig. 213
- 28.57 Dun Cuier, Barra, Outer Hebrides (Fig. 74B)
Young 1956, 316-9, Fig. 13, 1

Handled combs (Fig. 75)

Handled combs, that is, those with a side handle (or 'whip handle') enjoyed a certain popularity from, perhaps, the 8th until the 10th centuries; securely-stratified examples are scarce, however, and these dates must remain tentative for the present.

The problem of fitting a comb with a suitably robust handle was, it seems, overcome in either one of two possible ways : the most common solution was to take an antler tine and to cut a longitudinal slot through it, starting from the narrower end and occupying about half the entire length, into which the tooth plates were riveted in the usual manner; alternatively, two elongated plaques of antler were cut so that, when placed together, there was a space into which the tooth plates could fit at one end while at the other the plaques were riveted directly together, so forming a rigid composite handle. In every case so far noted, iron rivets were used. The majority of those with one-piece handles have been manufactured either from fairly straight tines or from tines sufficiently large to be shaped into straight lengths. One or two retain the characteristic and attractive curve of the tine, however, and whenever this is the case the teeth are invariably on the inside of the curve. Sometimes the tines have been faceted to give them a hexagonal cross-section; an interesting example of this type, found in the Thames, while having all the morphological characteristics of an antler comb, is in fact made of wood (Winter 1906, Taf 28, 84), surely a classic example of the way in which the raw material can influence the design of an artefact, even when the limitations imposed by that material are no longer applied.

On the Continent, one example of (perhaps) Frankish date may be noted from Belgium (de Loe 1939, 154-6) and three found in the Frisian town of Dorestad may be dated tentatively within the period c. AD 700-850 (Roes 1963, 23). A handled comb of Viking date came from the important trading ~~settlement~~ of Birka (Arbman 1943, 238, Taf 74) while early medieval examples are known from Bergen (Grieg 1933, Fig. 183) and Lund (Blomqvist 1942, Fig. 10). The initial impetus behind their widespread distribution has been attributed to the activities of Frisian merchant seamen from emporia such as Dorestad (Waterman 1959, 90). The fact that decoration is often confined to one side only of the handle is a feature noted on composite combs from Frisia by Tempel (1972, 57). Independent evidence for contacts with Frisia can certainly be produced for centres such as York and Southampton, and the early combs from Ipswich and Whitby could owe their inspiration, at least, to the same source. The Southampton example, however, with its teeth on both sides of the handle, finds parallels in Scandinavia (Herteig 1969, Fig. 423) as well as Holland (Trimpe-Burger 1965, Pl. XXX, 5).

Catalogue

- 28.58 Bedford, Bedfordshire (Fig. 75A)
Proc. Soc. Antiq. London, ser. 2, 12 (1887-9), 115
- 28.59 Southampton, Hampshire (Fig. 75B)
Addyman and Hill 1969, Pl. VIIa
- 28.60 Canterbury, Kent
Unpublished, Canterbury Archaeological Trust
- 28.61 Rochester, Kent (Fig. 75G)
Harrison and Flight 1969, Fig. 18, 2
- 28.62 London
Winter 1906, Taf 28 (see also Taf 28, 84 for handled comb of wood)
Wheeler 1935, 152, Fig. 30
Proc. Soc. Antiq. London, ser. 1, 4 (1856-9), 188

- 28.63 North Elmham, Norfolk (Fig. 75c)
Wade-Martins 1970, 17, Fig. 21
- 28.64 York
Waterman 1959, 89-90, Fig. 17, 1-2
MacGregor 1978, Fig. 28, 7, 9

Scandinavian-type single-sided combs (Fig. 76-8)

As much as any other single category of artefact, composite combs of distinctive form may be regarded as the characteristic type-fossil of Scandinavian settlements in the British Isles. Most of these combs are fairly easily distinguished from those which preceded them, although the number of variables by which they are characterised makes the task of expressing succinctly how much and in what particular ways they differ from Anglo-Saxon types rather a difficult one. It may be helpful, therefore, to treat the various elements individually in the first instance and then to compare the ways in which they occur together.

Length. One of the most striking characteristics of some, at least, of the Norse combs is their unusual length. The most extreme examples, reaching over 300mm in length, are greater than any other combs to be found at any time in the British Isles. One advantage of the composite method of construction is, of course, that the number of teeth can be increased simply by riveting more and more tooth-plates between the side plates, the available length of raw material for the side plates being the only limiting factor.

The terms 'long' and 'short' are nonetheless totally subjective, and in fact there is a continuous spectrum of lengths from one extreme to the other.

Outline. Several sub-groups may be recognised by the outline of the side plates, among which are those with concavo-convex backs similar to the Anglo-Saxon hog-backed combs considered above, plano-convex backs which form the most numerous category of Norse-type combs and those with straight backs. A small number of high arched back combs is also noted. One comb from York (Fig. 76) with an elongated angular back, is of a type characterised by Tempel (1972, Taf 8, 10) as being of a distinctively late 8th- and 9th-century type.

Terminals. Two principal methods of decorating the extremities of combs are recognised, one involving carving the ends of the side plates and the other concerned with the outline of the end tooth plates. Amongst the former may be noted three very similar examples, two from Jarlshof (Curle *et al.*, 1954, 18, Fig. 2) and the other (Waterman, 1959, Fig. 16, 1) from York, both with 'snouted' ends to the side plates. Both form and decoration link these to 9th-century combs on the continent. A development may be noted from early Viking period combs with upswept ends on the side plates to a later variety in which the end tooth plates retain this outline while it is lost on the side plates. End tooth plates may simply be expanded in a manner similar to that found on Anglo-Saxon 'winged' combs as discussed above or they may be drawn up into distinct crests or terminals or carved into elaborate zoomorphic shapes as with one comb found in London (Wheeler, 1935, 190, Pl. XX).

Side plate cross sections. D-shaped cross sections are by far the most common, increasing in average roundness from the late 8th until the 10th century, those with chamfered edges forming the next most numerous group. Flat (ie thin, rectangular) cross sections are rare and when they do occur

(eg MacGregor 1978, Fig. 29, 10) the side plates are found to be made from split rib bones which would be incapable of producing the thicker profiles encountered with antler cross sections; in other words, they form a further illustration of the way in which raw material can affect stylistic considerations. Some side plates, particularly on combs with straight backs, are gouged along their entire length to produce complex profiles to the cross section : these tend to belong to the 12th and later centuries rather than to the floruit of the Viking period.

An interesting group of high arched back combs, well known in Scandinavia (see, for example, Blomqvist 1942, Bd 26-35), is represented in this country by only three examples; these have broad, flat side plates with a rib running along the bottom edge; although made to look separate, the rib is invariably carved in one piece with the rest of the side plate (see below, p. 230).

Rivets. Although iron rivets remain in common use on Scandinavian type combs, bronze rivets are found much more frequently than at any earlier period. When bronze is used, the rivets tend to be smaller and more closely set, often in two parallel rows, occurring particularly on straight backed combs and those with high arched backs. At Trondheim, it has recently been noted that the appearance of close set bronze rivets is a late (early 13th-century) phenomenon, as are the two types of combs just mentioned, (Long 1975, 27) so that we may expect there to be similar chronological implications in the occurrence of these in this country.

Decoration. Although there is considerable variation in detail, the decorative schemes incised on the side plates (and, occasionally, the

end plates) of these combs may be reduced to three basic types : linear motifs (which may be saw-cut or knife-cut), ring-and-dot motifs (cut with a small scribing tool or centre-bit, never stamped as some authors would have us believe) and free-style (often interlace) decoration. A range of motifs occurs which are based on various combinations of incised lines : among these are bands of multiple lines, opposed Vs or triangles, saltires, diamonds, hexagons, checquers and chevron patterns; any of these may be accentuated by cross hatching.

Ring-and-dot motifs may be scattered in random fashion or linked in rows by series of tangential lines; a common Scandinavian motif consisting of a recumbent figure-of-eight or S-shaped design executed in ring-and-dot occurs twice in the British Isles, once in fairly classic form in a comb from South Uist (Grieg 1940, 73-4, Fig. 42) and once in a rather debased style incorporating dots only at Lagore Crannog, Co. Meath (Hencken 1950, 187, Fig. 98, 1044). Combinations of two or more of the above motifs are frequent, perhaps the most common involving the marking off of a central area with bands of multiple lines, the resultant panel being filled with crosses or diamonds. Occasionally a central band of interlace is found, flanked on either side by tapering, elongated panels : this arrangement is commonly linked with snouted ends to the side plates. Perforations in the form of T-shapes, sometimes (or perhaps invariably) backed by sheet bronze, are mostly confined to the series of high arched back combs discussed below, but occur at least once (Waterman 1959, 87, Pl. XVIII, 2) on a long comb with a plano convex back.

Crests. Decorative crests, cut from the protruding tooth plates along the back of the comb are known in the Scandinavian homeland and in Ireland

(Dunlevy 1969, Figs. 80-2; Hencken 1950, Fig. 98, 681, 1044), but so far none has been noted in Scotland or England.

Date. Too few of the combs listed below have been found in contexts with sufficiently clear dates for more than a tentative assessment at the moment of their chronological span. At Jarlshof, for example, long straight backed combs came from contexts ranging in date from c. 9th century to c. 13th century, and combs with plano-convex backs came from contexts with a similar date range (Hamilton 1956, 134-68, Fig. 77, Pls. XXX, XXXII). No precise date can be given to the large number of combs from York published by Waterman (1959, 87-90, Fig. 16, Pl. XVIII), although newly-excavated examples from Coppergate and elsewhere will prove more useful. By way of comparison, recent excavations at Trondheim have produced a majority of plano-convex backed combs from the earliest (11th century) levels, those with long straight backs with grooved decoration beginning about 1200 (Long 1975, 27, Fig. 9).

Combs with high arched backs (Fig. 78)

A group of small single-sided combs falls outside the range hitherto discussed. Two of these combs, one from London and one from Northampton, are related to each other by their high arched backs, wide and flat side plates with a false rib along the bottom and by T-shaped openings piercing the flat areas; both make use of close set bronze rivets. The London comb (R. A. Smith 1909, 164-5, Fig. 27) is said to be made of only three plates of material, all the teeth and the zoomorphic terminals being cut on a single tooth plate. The T-shaped openings are stained green 'as though originally filled with bronze' (loc. cit.). The comb from Northampton is

said (R. A. Smith 1902, 233) to have been 'associated with an urn burial'; the association can hardly have been a meaningful one, however, and may indicate that it belonged to a secondary Norse burial in a Bronze Age barrow. A third comb (Fig. 78), from Freswick Sands, belongs to this same group, although it lacks the perforated decorative technique of the others.

Although Baldwin Brown (1915, 391) suggests Anglo-Saxon origins for these combs, there can be little doubt that they are in fact of Scandinavian derivation. Arched profile combs of this type are assigned to the 13th century at Trondheim, where they occur with zoomorphic terminals of a type similar to those found on the London comb (Long 1975, 27, Fig 9h); an example dated to the second half of the 12th century from Oslo is illustrated by Molaug (1975, Abb 17, 2). Combs with T-shaped perforations, backed by sheet bronze in the way that these two almost certainly were, date from the early 12th to the 13th century in Bergen and Oslo (Grieg, 1933, 223-4, Fig. 186; Wiberg 1977, Fig. 14), while in Lund a similar date is suggested for a series of combs with high perforated side plates with false ribs but without animal terminals (Blomqvist 1942, 1945-6, Bd 26-36). Floderus (1934, Fig. 10) illustrates a rather longer comb from Västergarn, Gotland with the same cross sectional profile, in which the side plates are pierced with cruciform perforations backed with sheet metal. An 11th-century origin would be historically acceptable for the two English combs, both of which might well be Norwegian imports. Only one other instance of the use of this type of perforated decoration has been noted on a comb from England : one of the long concavo-convex combs from Clifford Street, York (MacGregor 1978, Fig. 29, 4) combines T-shaped

openings with incised interlace panels in its decorative scheme. An attempt is made in Fig. 79 to summarise in schematic form the chronology of all the single-sided combs so far discussed.

Catalogue

Long concavo-convex combs

- 28.65 Northampton, Northamptonshire *28.65a London (Fig. 77c)*
Williams 1979, 310, Fig. 137, 34
- 28.66 Jarlshof, Shetland
Hamilton 1956, 153, 167, Fig. 77, 6, Pl. XXX, 4 (2)
- 28.67 York, North Yorkshire (Fig. 77A-B; Fig. 78D)
Waterman 1959, Pl. XVIII, 2

Long plano-convex combs

- 28.68 Jarrow, Durham
Professor Cramp, personal communication
- 28.69 South Uist, Inverness-shire (Fig. 76D)
Grieg, 1940, 73-4, Fig. 42
- 28.70 Caistor, Lincolnshire
F. H. Thompson 1954, 77, Fig. 1
- 28.71 London
Wheeler 1935, 190, Pl. XX
Winter 1906, Taf 28, 85
- 28.72 Lyking, Mainland, Orkney Is.
Grieg 1940, 80, Fig. 44
- 28.73 Orphir, Mainland, Orkney Is.
Grieg 1940, 148, Fig. 66
- 28.74 Sanday, Orkney Is.
Grieg 1940, 150, Fig. 68
- 28.75 Jarlshof, Shetland
Curle *et al.* 1954, 18, Fig. 2 (2)
Hamilton 1956, 134-5, 148, 167-8, Figs. 69, 77, Pls. XXX-XXXII
- 28.76 York, North Yorkshire (Fig. 76E, C)
Waterman 1959, 87-90, Fig. 16, Pl. XVIII (Over 70 examples)
Richardson 1959, 83, Fig. 17, 16
Wenham 1970, 167, Pl. V

Long straight backed combs

- 28.77 Freswick, Caithness
Curle et al. 1954, 49f, Fig. 19 (2)
- 28.78 Jarlshof, Shetland Is.
Curle et al., 1954, 22, Fig. 7; Hamilton, 1956, 148, 160,
Pl. XXX, 3, XXXII, 4

Short combs

- 28.79 Skaill, Orkney Is.
Grieg 1940, 81, Fig. 45
- 28.80 York, North Yorkshire (Fig. 76c; Pl. 10)
Hall 1976, Fig. 12
MacGregor 1978, Fig. 29, 11

Short combs with high arched backs

- 28.81 Freswick, Caithness (Fig. 78c)
National Museum, Edinburgh, unpublished
- 28.82 London (Fig. 78A)
R. A. Smith 1909, 164-5, Fig. 27; Archaeol. J. 34 (1877),
450-1
- 28.83 Northampton, Northamptonshire (Fig. 78B)
R. A. Smith 1902
Victoria County History of Northampton 1, 233.

Double sided composite combs (Figs. 80-2, Pls. 28-9)

Double sided combs enjoyed some popularity throughout the period under review, some of the plainer examples being impossible to assign stylistically to any one century or another. Alcock (1963, 154-6) has pointed out that double sided combs of the Roman period are invariably made with coarse teeth on one side and fine on the other; indeed, this was presumably the whole point of having two sets of teeth in the first place. Many of those listed below, however, have teeth on one side which are indistinguishable in size and spacing from those on the other so that, for some reason,

presumably no more than that of taste, the form survived the Roman period but the reasoning behind it was, to some extent, lost. Differentiated teeth never entirely disappeared, however, and isolated examples occur scattered throughout the period. With the introduction of new traits from Scandinavia in the 9th century onwards, differentiated teeth once again became the norm.

The earliest group to be taken into account usually occur in late Roman contexts, but their composite construction and occasional display of zoomorphic ornament clearly mark them apart from the classic one-piece Roman combs as 'barbaric' Germanic objects which deserve mention here. The wide tooth plates on these combs may be connected by a single side plate or by a pair of side plates running parallel to each other at some distance apart (Fig. 80). The end plates are invariably cut with complex outlines as in the examples from Alchester (1932, 64, Pl. xvii, 2) ^(Illife) and Keill Cave (JNG Ritchie 1967, Fig. 2, 4), some of them, as from the Langton and Beadlam villas having zoomorphic treatment which is immediately reminiscent of that found on metalwork associated with Germanic laeti of the 4th and early 5th century (cf. Hawkes and Dunning 1961, 1-68). Another feature prominent on the combs from Askrigg and Beadlam is the use of 'key hole' cut-outs, a feature commonly found on continental combs of the same series (Haupt 1970, Bild 31).

A one-piece wooden comb published among the medieval finds from the Custom House site in London (Tatton-Brown 1974, 199, Fig. 42) should probably be considered as contemporary with this group on the basis of its cut-out decoration, which closely resembles that on the combs discussed above.

Most numerous among the double-sided combs are those with rectangular ends and with a length distinctly greater than their width. There is little or nothing to distinguish those of this category from the early Saxon period, as from Bantham or from Upton , for example, from middle Saxon examples as from Whitby , Anglo-Scandinavian examples as from York or even those of early medieval date as found at Thetford (Knocker 1969, Fig. 15, 8). All the ornament displayed on these combs is limited to incised lines and ring-and-dot motifs, equally unhelpful in making chronological distinctions.

More promising from this point of view is the manner in which the end plates on some combs have been decoratively elaborated. An end plate from a composite comb (Fig. 80) found in an Anglo-Frisian urn of 5th-century type at Lackford has been given a markedly concave outline : it finds contemporary parallels in the Frisian area to which it is said (Roes 1963, 14) otherwise to be restricted. Other Anglo-Saxon combs with decoratively outlined end plates come from Newark on Trent (Pl. 28) and Abingdon (Pl. 29).

Two Anglo-Saxon double-sided combs merit individual notice here : those from Kingston Down and Ford (Fig. 81) are distinguished from all other composite combs so far considered in having their teeth cut on a single plaque of bone instead of several plates of antler. Both may have been manufactured from scapulae, as claimed for the Ford comb by Musty (1969, 108); scapulae do provide large expanses of flat tissue of even thickness, but their laminar structure (p. 10) would not be particularly appropriate for tooth cutting. The inherent fragility of the large expanses of bone

from which these combs are made has been compensated for by the addition of side plates, not to fasten the tooth plates together as is usually the case but simply to add strength and rigidity. Both are likely to be of c.7th century date.

A single example of a handled double sided comb comes from a Saxon context at Southampton (Fig. 75). That the type survived into the medieval period is demonstrated by examples from Aardenburg, Holland (Trimpe-Burger 1965, Pl. XXXI, 5) and Bergen (Herteig 1969, Pl. 42).

An analysis of double-sided combs taking into account a comparison of length to width ratios shows that, while long combs are distributed throughout the British Isles, there is a group of comparatively short and wide combs with flat side plates which have a distribution corresponding with that of the 'Celtic' single sided combs mentioned above (p. 222) : that is, they occur almost exclusively in Ireland and around the Atlantic coast of Scotland. The vast majority come from Ireland (Class C in Dunlevy's classification) where they seem to range in date from about the 3rd to the 9th century (Dunlevy 1969, 38-41). In comparison with Anglo-Saxon combs, the area left in reserve at the extremities of the end plates is rather narrow. Many combs of this type display sinuous outlines to the end plates, while some incorporate a perforated convexity in the centre of the end plate : one of these , from Lough Corcreevy Crannog, Co. Tyrone, is threaded with a bronze ring. Outside Ireland the type can be recognised at Buston Crannog (Munro 1882, Figs. 217-9), Dun Cuier (Fig. 81), Buckquoy (A. Ritchie 1977, 196, Fig. 7, 50) and the Broch of Burrian (MacGregor 1974, 80-4, Fig. 11). From Wales a comb found at Dinas Powys (Alcock 1963, 158, Pl. VII) displays

the ogival outline commonly encountered on these combs. An easily recognisable outlier was found in Victoria Cave, Settle (Fig. 81) : its proportions, flat side plates and perforated bulbous end plate all mark it clearly as belonging to this class of 'Celtic' comb.

Double sided combs of Scandinavian type are less numerous in Britain. Of those which have been noted, some from York have wide flat side plates which clearly relate them to the long single-sided combs with plano convex backs described above (p. 227). Others, for example from Freswick and from Jarlshof (Fig. 82) have close-set bronze rivets and side plates with complex cross-sections comparable with other groups of single sided combs already mentioned (p. 228). Both these groups of double sided combs contain examples in which the row of fine teeth extends for only part of the length of the comb (Fig. 82). The re-establishment of well differentiated coarse and fine teeth as the norm rather than the exception is a feature of this period.

Straight end plates such as are found on Anglo-Saxon combs continue to occur, but a new type with a double convex profile also appears (Fig. 82). Single sided combs with a simple convex end are known in Scandinavia (eg Long 1975, 27, Fig. 9f) but as yet are not represented here : the double sided combs with double convex outline look very much like two of these single sided combs placed back to back, an impression which is enhanced when those with an abbreviated set on one side are considered (Fig. 82).

A further type of Scandinavian origin,⁽²⁶⁾ with two pairs of widely spaced side plates (Fig. 82) is represented by examples from Lagore

(Hencken 1950, Fig. 98, 1338; Dunlevy 1969, 57-8) and fragments from one or two other Irish sites (Dunlevy, loc. cit.), while Hamilton (1956, 186, Pl. XXII, 5, 7) mentions two from 13th-14th century levels at Jarlshof. Scandinavian combs of this type occur in early medieval Lund (Blomqvist 1942, Bild 65-6), Bergen (Herteig 1969, Pl. 42) and Oslo (Wiberg 1977, Fig. 27-8). Decorative perforations cut in the area between the pairs of side plates are a feature of many of these combs.

Catalogue

Pre-Norse double sided combs

- 28.84 Abingdon, Berkshire (Pl. 29)
Leeds and Harden 1936, 33, 47, Pl. VII
- 28.85 Sutton Courtenay, Berkshire
Leeds 1924, Fig. 1
- 28.86 Burwell, Cambridgeshire
Lethbridge 1931, 62, Fig. 30, 5
- 28.87 Bantham, Devon
A. Fox 1955, 60-1, Fig. 3, 1-2. (2)
- 28.88 Southampton, Hampshire
Addyman and Hill 1969, 75, Pls. VI-VIII ('many examples')
- 28.89 Carisbrooke Castle, Isle of Wight
G. B. Brown 1915, 390, Pl. LXXXV, 3
- 28.90 Darenth, Kent
Philp 1974, Fig. 46, 45
- 28.91 Kingston Down, Kent
C. R. Smith 1856, 93-4, Pl. XIII, 1
- 28.92 Harston, Leicestershire
Dunning 1952, 49-51, Fig. 2, 1, Fig. 4, 1
- 28.93 Normanby-le-Wold, Lincolnshire
Unpublished; information from J. B. Whitwell
- 28.94 Thealby Mine, Lincolnshire
Dudley 1949, 235, Fig. 81, 3
- 28.95 London
R. A. Smith 1909, Fig. 25

- 28.96 Upton, Northamptonshire 28.96a Dun Cuier, Outer Hebrides (Fig. 81A)
Jackson et al. 1969, 212, Fig. 6, 4
- 28.97 Alchester, Oxfordshire
Iliffe 1932, 64, Pl. XVII, 2
- 28.98 Chadlington, Oxfordshire
Leeds 1940, 27-8, Pl. VIb, 1
- 28.99 Lackford, Suffolk (Fig. 80D)
Lethbridge 1951, 17, Fig. 7, Fig. 10 (2)
- 28.100 West Stow, Suffolk
West 1969, Fig. 10, 5-7 (3)
- 28.101 Bow Hill, Sussex
H. Smith 1870, 60, Fig. 1
- 28.102 Ford, Wiltshire (Fig. 81D)
Musty 1969, 108, Fig. 5e, Pl. XXVIII, a
- 28.103 Askrigg, Yorkshire (Fig. 80E)
Manby 1966, 343, Fig. 2, 7
- 28.104 Beadlam, Yorkshire (Fig. 80A)
Stead 1971,
- 28.105 Drifffield, Yorkshire
Mortimer 1905, 281, Pl. C, 799
- 28.106 Garton Slack, Yorkshire 28.106a Langton, Yorkshire (Fig. 80C)
Mortimer 1905, 252, Pl. LXXXIX, 701
- 28.107 Victoria Cave, Yorkshire (Fig. 81E)
Swanton 1969, Fig. 63
- 28.108 Whitby Monastery, Yorkshire
Peers and Radford 1943, 70, Fig. 20
- 28.109 York, Yorkshire
Waterman 1959, 88-9, Fig. 17, 3, Pl. VIII, 10-11 (3)
For double-sided combs see Appendix 1, p. 322A
- Horn combs of the period 400-1200 (Pl. 30)

By the opening of the medieval period, the workers in skeletal materials were already being displaced (p. 88) by horners. The poorer survival properties of horn have no doubt led to the loss in the ground of many horn combs, but with more and more urban waterlogged sites now being excavated an increasing number may be expected : several examples from early medieval Dublin are described by Dunlevy (1969, 75).

The use of horn for the manufacture of combs is not, however, exclusively a medieval phenomenon. Three combs deserve notice here, all of them having the peculiarity of being basically one piece combs with all the teeth cut on a single plate of horn but being provided with riveted bone or antler side plates as though they had been of composite construction. In this feature they resemble two bone combs from Ford and Kingston Down referred to above (p. 235), although there seems to be no correspondence in date. The first of these combs formed part of a grave group found at York in the 19th century; a double pointed pin beater was found in the same grave (p. 101). This example (hitherto unpublished) has always been assumed to be of Roman date : the combination of a pin beater of primarily Anglo-Saxon type (p. 235) with a comb made in the manner of Anglo-Saxon composite combs might make a date at least in the 5th century more acceptable. Of the other two examples, both in the Museum of London, one is an undated 19th century find from Queen Victoria Street and the other (Pl. 30) was recovered from a 9th or 10th century pit at Milk Street (information from Mr. John Clark). Hopefully, further excavated finds will in due course throw more light on this intriguing and seemingly long-lived type.

Catalogue

- 28.110 Dublin, Co. Dublin
 Dunlevy 1969, 75
- 28.111 London (Pl. 30)
 Museum of London, unpublished (information Mr. J. Clark) (2)
- 28.112 York
 Yorkshire Museum, unpublished

One-piece combs (Pl. 31)

Although composite combs survived, therefore, at least until the 13th century, they were rapidly being replaced by that time by one-piece combs of bone and horn as well as wood. (The demise of antler as a raw material is commented upon on p. 31). Typical continental combs of this period have an H-shaped outline with a height greater than the width : typical examples can be seen from Lund (Blomqvist 1942, Bild 49-51), Bergen (Herteig 1969, pl. 42), Oslo (Wiberg 1977, Fig. 21), Visby (Nihlén 1925, Fig. 68) and Hedeby (Ulbricht 1978, 66-7, Taf 34, 8). Some of these combs can be quite large and heavy. It is possible that some may have been intended for use with animals such as horses and dogs, as illustrated in a manuscript of c. 1440 (Bibl. Nationale ms 619, folio 42, reproduced by Thieraux (1974, 25)). Few one-piece combs of bone or antler are yet known from Britain, although a diminutive example from Wallingford may be noted : it is, however, horizontally aligned. The comb was found at the same time as the seal matrix of c. 1050 discussed above (p. 141), but the association is indefinite.

For catalogue see Appendix 1, p. 322A

'Liturgical' combs (Pls. 32-3)

One group of one-piece combs which has so far not been discussed is that generally referred to as 'liturgical' combs. Lasko (1956, 342-4) provides a full airing of the question of the liturgical function (if any) which these combs may have performed in the pre-medieval period, which need not be repeated here, except to say that the case for their employment in any liturgical role is far from proven. Wealthy ecclesiastics may well have been amongst the most enthusiastic purchasers of these combs and, perhaps,

the recipients of them as gifts (cf. p. 200), but this is not to say that they had any special significance in church ritual. The influence of Rome and the Mediterranean world in general might, on the other hand, explain the survival of one-piece manufacture for these combs as opposed to the composite construction of northern 'barbaric' combs.

From a technological point of view, the type is generally characterised by fairly massive construction combined with ornate ornament, often deeply cut and even, in the case of an elaborate 12th-century comb now in the Victoria and Albert Museum (Goldschmidt 1926, 13, Pl. VII), completely a jourée. As a result of their considerable thickness the teeth, which are reasonably fine in outline but wide in profile, present elongated cross-sections at right angles to the main axis of the comb.

Apart from a comb formerly in the treasury at Nivelles and thought to be of English origin, Lasko (op. cit.) mentions only one Anglo-Saxon comb of this type made in ivory : this example, said to have been found in Wales (Dalton 1909, 38, No. 40, Pl. XXI), can be dated stylistically to the last quarter of the 11th century. Two more recent finds may be mentioned here. The first (Pl. 32) has been the subject of a discussion by Wilson (1961, 17-19) : it is of walrus ivory and is cut with coarse teeth on one side and fine on the other; on one face two felines confront each other within a divided rectangular frame and on the reverse an interlaced snake occupies an undivided panel. The ornament, which is knife-cut and badly worn, incorporates Anglo-Saxon, Romanesque and Scandinavian elements and is dated by Wilson to the late 10th or 11th century. The second comb (Pl. 33) was recovered during recent excavations at York Minster : it is cut from a plate of cetacean bone and bears carved ornament featuring

collared beasts with back-turned heads and lip lappets suggesting a date for it in the 11th century.

For catalogue see Appendix 1, p. 322A

Comb cases (Fig. 83)

Many composite combs were provided with protective cases to minimise the danger of breakage to the teeth. The cases were quite often elaborately decorated, normally matching the ornament on the comb itself. It is possible that the plainer, everyday combs were normally sold without cases. An alternative form of protection was provided for one comb found in a grave at Birka (1074), which was enclosed in a leather bag (Arbman 1943, 447, Taf 136,1; Taf 161, 2) : perhaps this was the common practice with plain combs.

From a constructional point of view, cases again reflect the character of the combs for which they were designed. Antler is the principal material used and iron is the normal medium for the rivets. Cases for single-sided combs commonly consist of a pair of wide side plates or two pairs of narrower plates, separated in either case by spacer plates at the ends. The extremities of the spacer plates project beyond the upper edge of the side plates, their upper edges forming a continuous line with the back of the comb when it is inserted fully into the case. The side plates of the comb and those of the case form triple matching bars when they are in contact. Sometimes one end plate of the comb has been drilled through so that a pin pushed through a corresponding hole in the case engages with the comb and holds it in place.

Variations on this basic theme are found. Cases made with two side plates on one side and a wide flat plate on the other (Fig. 83) in the manner mentioned above (p. 216) as characterising barred combs of Frisian

type, have been found in association with such combs, as at Spong Hill (Hills 1977, 29, Figs. 129-31) and, on two occasions, without matching combs, as at Girton College, Cambridge (MacGregor 1975a, 197, Fig. 76) and Lackford (Lethbridge 1951, 16, Fig. 1). The form of the case cannot, however, be taken as an invariable indicator of the form of the comb : triangular backed combs were found in association with cases of this type at Spong Hill (Hills 1977, Fig. 132), while a long triangular backed comb found with such a case at Obermollern, Thuringia, is illustrated by B. Schmidt (1961, Taf 82, h-i).

In the British Isles cases for single-sided combs are most numerous in the Viking period, when they are often associated with short combs of c. 10th-century type : examples come from Orkney (Grieg 1940, 81-2, Fig. 45), York (Hall 1976, Fig. 12; MacGregor 1978, Fig. 29, 11), and an unassociated case from Liverpool Street, London (Fig. 83). A comb case from Lincoln bears an inscription in incised runes reading 'Thorfast made a good comb' (British Museum Anglo-Saxon Guide, 117, Fig. 150).

A group of fragments from York are exceptional in that they are made from split ribs rather than antler : it has been suggested (MacGregor 1978, 48) that this mechanically inferior material may have been thought suitable for cases even though it was rarely used for combs (p. 208), since the side plates on cases would rarely be submitted to the same strains as those on combs.

Double sided combs require double sided cases. For these (Fig. 83D) the two pairs of side plates are located at opposite extremities of the spacer plates, the gap between them being filled by the side plates of the comb

when the assemblage is complete. Access for the comb is arranged by pivoting one pair of side plates at one end, the other end being free; the spacer plate at the other end also pivots, its free end being notched to engage with a rivet joining the side plates so holding the case shut. A continental example with a perforated extension to one of the spacer plates (presumably for suspension) is illustrated by Neuffer-Muller (1966, Taf 11). An Anglo-Saxon case found in a barrow at Driffield (Mortimer 1905, 281, Pl. C, Fig. 200) has a decorative scheme of double arcades containing ring-and-dot motifs which links it to a series of such cases on the continent, for example from Köln-Müngersdorf (Fremersdorf 1955, Taf 11, 72; Taf 14, 88), Nordendorf (Franken 1944, Taf 15, 4) and several sites in Württemberg (Veek 1931, Taf 11-12).

A few oddities occur amongst the numerous comb-cases found in Migration Period graves on the continent; such as the case made to receive a pair of single-sided combs (one inserted from each side) found at Weilbach (Schoppa 1959, Taf 32). One comb case of Migration Period date found along with its comb at Stössen, Kr. Hohenmölsen, (Schmidt 1970, 31, Taf 22, h) explains a curious feature noted on some single-sided combs from elsewhere (eg Arbman 1943, Taf 159, 15; 162, 2, 6) : both comb and case are provided with loops on their backs, through which a thong might have been passed to hold them together.

Catalogue

- 29.1 Freswick, Caithness
Curle et al. 1954, 50-1, Fig. 20
- 29.2 Cambridge, Cambridgeshire
Hollingworth and O'Reilly 1925, 12, 20, Pl. V, 1

- 29.3 Dublin, Co. Dublin
Viking and Medieval Dublin, Pl. IX
- 29.4 Lincoln, Lincolnshire
 British Museum Anglo-Saxon Guide 117, Fig. 150
- 29.5 London (Fig. 83C-D)
 R. A. Smith 1909, Figs. 26-7
- 29.6 North Elmham, Norfolk
 Wade-Martins 1970, 67, Fig. 21c
- 29.7 Spong Hill, Norfolk (Fig. 83A)
 Hills 1977, 29, Figs. 129-32
- 29.8 Northampton, Northamptonshire (Fig. 83E)
 Williams 1979, 309-10, Fig. 136, 33
- 29.9 Skaill, Orkney
 Grieg 1940, 81-2, Fig. 45; Winter 1906, Taf 29, 92
- 29.10 Jarlshof, Shetland
 Hamilton 1956, 167-8, Fig. 77, 8
- 29.11 Lackford, Suffolk
 Lethbridge 1951, 16, Fig. 1
- 29.12 Driffield, Yorkshire
 Mortimer 1905, 281, Pl. C, Fig. 800
- 29.13 York, Yorkshire (Fig. 83B; Pl. 6)
 Hall 1977, Fig. 12
 MacGregor 1978, Fig. 29, 11
 Stead 1970, 160, Fig. 9B

STRINGED INSTRUMENTS (Fig. 84)

Evidence derived from archaeological excavations for the form and development of stringed instruments during the period under review is slim indeed. In the British Isles, the remains of only two categories of bone fittings from such instruments have been identified : the tuning pegs or 'wrest pins' around which the strings were coiled and by which their tension was adjusted and (in one instance only) a mount from the peg arm or yoke of a lyre. One other element recorded in bone from else-

where may yet be expected to appear : the 'Black Earth' at Birka produced a bridge (Fig. 84), variously described as bone or horn (presumably antler), over which seven strings had been stretched, dating perhaps to the 9th century (Crane 1972, 14; Salmen 1970, 8). Other examples of bridges are known in metal and, more numerous, in amber (Roes 1965, 45-6, Pl. XIX; Salmen 1970, 8; Bruce-Mitford and Bruce-Mitford 1974, 193, Fig. 23), mostly notched for six or seven strings.

The remains of any stringed instruments dated earlier than about the 10th century would probably be derived from lyres. The reconstructed Sutton Hoo lyre (Bruce-Mitford and Bruce-Mitford 1974, Pl. 40) gives a good impression of the appearance of the Anglo-Saxon instrument : the hollow sound box and partially hollowed arms are covered by a thin sound board and are connected to the symmetrical yoke by mortice and tenon joints; the six strings are anchored to a tail piece at the base of the instrument, pass over the bridge which rests on the sound board and fan out to the pegs set in the yoke. (It should be noted, however, that no tail piece and no bridge were actually found at Sutton Hoo, while the pegs in this instance were made of wood, probably willow or poplar.) The remains of three further lyres have been found in Germany (op. cit., 191).

In contrast to the lyre, in which the strings pass over the sound board (to which the vibrations are transmitted by the bridge), the true harp has strings rising directly from the sound board, to which they are anchored. Furthermore, while lyres are invariably symmetrically shaped, harps are generally asymmetrical instruments, either rectangular or triangular in outline. The earliest evidence for the introduction of

true harps dates to the 9th century (Bruce-Mitford and Bruce-Mitford 1974, 195; Fry 1976, 139); representations on stone monuments of this period in Scotland show them as tall as the player, while a smaller variety, played on the knee, is illustrated in the Bodleian Caedmon manuscript Junius XI, possibly produced in Northumbria and dating to the late 10th century. No material remains of harps such as these have yet been identified, although it is possible that some of the pegs mentioned below may have come from instruments of this type.

Apart from the Sutton Hoo lyre (which, as mentioned above, had no bone fittings) the remains of only three stringed instruments have been noted from contexts of Anglo-Saxon date in England. One of these, from a 7th-century grave at Taplow, Buckinghamshire (J. Stevens 1884, 66, Fig. 10) although excavated almost a century ago, was only recognised for what it was when the reconstruction of the Sutton Hoo instrument as a lyre (instead of a harp, as originally postulated) had been completed : its two bird-headed decorative escutcheons (found with a few fragments of maple wood) form a good match for those from Sutton Hoo, but as with the latter instrument, no fittings of bone were recovered. A further lyre, again without fittings, has recently been recovered from Bergh Apton, Norfolk (Lawson 1978a, 87-87). A 5th-century grave at Abingdon, on the other hand, produced two curving strips of antler (one fragmentary), originally perforated by five regularly-spaced circular holes and united by long rivets (Leeds and Harden 1936, 39, Pl. IX, b).⁽²⁷⁾ Although their significance was not recognised at the time of excavation, these fragments are now accepted as being a set of mounts from the wrest plank

or yoke of a lyre (Bruce-Mitford and Bruce-Mitford 1974, 192). Pegs protruding through the perforations would have engaged the ends of the strings; since no such pegs were found in the grave we may presume that they were of organic material, no doubt wood, as seems to have been the normal practice at this time (Lawson 1978b, 139-41).

Increasing numbers of bone pegs of this type are now known. Previous claims for an Anglo-Saxon currency, largely based on unstratified finds from Whitby monastery (Peers and Radford 1941, 71, Fig. 21, 110-2; Fry 1976, 137-9) have not, however, been substantiated by recent discoveries. Besides examples of uncertain date listed in the catalogue, evidence from stratified finds can now be brought to bear on the problem and in no instance can an origin earlier than ^{the}medieval period be demonstrated. The earliest securely dated piece is that from Wallingstones, Hereford (Lawrence 1978b, 139, Fig. 7e), assigned to the late 12th century; the same author quotes further examples of the 14th century from Winchester and the 15th century from Gloucester (op. cit., Fig. 7, f-g), while others of the 14th or 15th century have been recovered in Oxford (Henig, in Durham 1977, 163-6).

All those found have in common a small transverse perforation (or, in some instances, a slot) close to one end, through which the string was passed. The proximity of these holes to the tip of the peg in many examples indicates that they were inserted in the wrest plank from the rear, and not in the manner indicated in the Sutton Hoo reconstruction.⁽²⁸⁾ Occasionally, as on the Castle Bellingham peg (Lefroy 1870, 292), the friction of the string has resulted in some lateral grooving on either side of the hole. Fry (1976, 139) has taken the general absence of

metallic staining in the region of the perforations as an indication that strings of organic material such as gut or horsehair were used. Lawson (1978b, 139-41), on the other hand, while conceding that organic strings would have been more appropriate for Anglo-Saxon instruments fitted with soft wooden pegs, notes a correlation between the first appearance of metal strings and the introduction of bone pegs c. 1100.⁽²⁹⁾

At the opposite end, the circular-section shank may expand to form a spatulate grip (expanded into a T-shape in the case of a 16th century example from Lincoln and another possible peg from York), which would allow the tuning to be adjusted by hand; alternatively, it may taper to a square-section terminal, implying the use of a key or tuning wrench. Several of the Whitby pegs display some wear on the heads from the use of such a wrench (Fry 1976, 138), as does one of those from Oxford (Henig, in Durham 1977, 164). A number of manuscript illuminations exist showing tuning wrenches in use (Fry 1976, 139, n 33), although none has yet been recognised from archaeological sources.

Considering the comparatively late currency of bone tuning pegs as outlined above, it is possible that they were used on a much wider range of instruments than the harps and lyres with which they have hitherto been associated : fiddles, lutes, psalteries and rebecs would all be possible candidates.

Catalogue

Wrest planks

- 30.1 Abingdon, Berkshire (Fig. 844)
Leeds and Harden 1936, 39, Pl. 1xb; Bruce-Mitford and
Bruce-Mitford 1974, 192.

Tuning pegs

- 30.2 Meols, Cheshire
Hume 1863, Pl. XXX 11
- 30.3 Gloucester, Gloucestershire
Lawrence 1978b, Fig. 7, G
- 30.4 Winchester, Hampshire
Lawrence 1978b, Fig. 7, F
- 30.5 Wallingstone, Herefordshire
Lawrence 1978b, 139
- 30.6 Lincoln, Lincolnshire
Lincoln Archaeological Trust, unpublished
- 30.7 Castle Bellingham, Louth
Lefroy 1870, 292, Fig. 3
- 30.8 Oxford, Oxfordshire
Durham 1977, 163-6
- 30.9 Ardakillen Crannog, Roscommon
Wood-Martin 1886, 125, Fig. 171
- 30.10 Strokestown Crannog, Roscommon
Wilde 1863, 340
- 30.11 Ludgershall Castle, Wiltshire
MacGregor, forthcoming
- 30.12 Hull, Yorkshire
P. Armstrong 1977, 70, Fig. 29, 138
- 30.12 Whitby, Yorkshire (Fig. 84B-E)
Peers and Radford 1941, 71, Fig. 21, 110-12; Fry 1976,
137-9; Lawrence 1978b, 139-41
- 30.14 York, Yorkshire
MacGregor, forthcoming

WHISTLES AND FLUTES (Fig. 85)

From as early as the Upper Palaeolithic period (Megaw 1968, 335) hollow limb bones have been utilised to produce pipes and whistles. Notwithstanding the range and variety of music which must have been

played on these instruments until the medieval period, when they finally declined, they seem never to have developed technically beyond a fairly rudimentary form. While many examples can be found from as late as the 13th century, from which time the history of woodwind instruments is fairly well documented, they contributed little or nothing to the musical developments of this period, which were taking place on a variety of more versatile and sophisticated instruments. The bone flute, it seems, remained to the end of its days a folk instrument, the plaything of the rustic and the urban poor.

All those considered here are end-blown instruments, in which the player's breath was ducted by a block or fipple inserted at the upper end of the pipe and directed against a narrow ledge or voicing lip cut in the blow-hole, so setting up the essential vibrations in the column of air within the pipe. No fipples of the era under examination have been found in this country but a number of examples, all of wood but used originally with bone instruments, have been noted from Holland, Norway and Sweden by Crane (1972, 29-35). The same author suggests (loc. cit.) that many flutes may originally have been fitted with fipples of beeswax while Megaw (1961, 177) postulates clay as an alternative. No evidence for cross-blown bone flutes has ever been found.

Long bones of various mammals, particularly sheep (Brade 1975, 31; Crane 1972, 25; Megaw 1968, 338) but also cattle, pig and dog (Brade 1975, 31) were used in the manufacture of continental flutes and whistles of the period reviewed here. In England sheep tibia whistles are known from

medieval sites at Lyveden (Bryant and Steane 1971, 68, Fig. 19,b) and Ludgershall Castle (MacGregor, forthcoming) and utilised deer metapodials have come from 12th-13th century levels at White Castle (Megaw 1961, 176-80) and a 13th-14th century context at Keynsham Abbey (Barrett 1969, 47-50).

The pneumatic limb bones (particularly ulnae and tibiae) of large birds were also favoured, their long, thin-walled hollow shafts suiting them admirably for this purpose. Particular concentrations of bird-bone flutes have been noted among coastal-dwelling communities on the continent (Brade 1975, 32), presumably corresponding with a special importance in the diet of these communities of such birds. Bird-bone flutes are by no means limited to these lacustrine settlements, however : examples from England include those of Saxon date from Thetford (Megaw 1960, 10) and Southampton (Holdsworth 1976, 47, Fig. 21, 4), along with two from York likely to date from the Viking or early Norman period (Waterman 1959, 91, Fig. 19, 10-11). Others of the early medieval period (12th-13th century) are known from Canterbury (Megaw 1969, 149-50), Ludgershall Castle (MacGregor forthcoming) Lydney Castle (Casey 1931, 254, Pl. XXXVI), Norwich (Norwich Survey, unpublished) and Southampton (Megaw, in Platt and Coleman-Smith 1975, 252-3); an undated bird-bone pipe from Lincoln is mentioned by J. Clarke (1855, 228-9). The bones in question, where identifiable, are all tibiae or ulnae from crane or geese.

Considerable variation in the quality of workmanship is displayed by these whistles, but there is no suggestion that they were ever made on any professional basis.⁽³⁰⁾ The best made seem to be those from Canter-

bury (Megaw 1969, 149-50) and from White Castle (Megaw 1961, 176-80). Particular care has been taken with the voicing lip of the latter instrument : it is a finely-cut ledge only 0.5mm thick, set within a rectangular aperture measuring 8 x 5mm. The number of finger holes displayed by the complete pipes listed below varies from three to five, but Brade (1975, 36-46), in an examination of all known flutes from the northern European mainland, notes examples with up to seven holes. The most commonly-encountered number is three, which Megaw (1960, 12) observes is the largest number which can be controlled with one hand.⁽³¹⁾ A range of up to an octave and a half was achieved with the Keynsham Abbey whistle, which has five finger holes and a thumb hole at the rear (Barrett 1969, 50). One particular refinement on the Canterbury flute is that the three finger holes are each recessed (Megaw 1969, Fig. 39), a feature paralleled in Britain only on a wooden instrument, thought perhaps to be a reed pipe, from 10th- or 11th-century levels at Hungate, York (Richardson 1959, 85). Although not uncommon on the continent, thumb holes appear only rarely on English instruments : the flute from White Castle has two, however, a refinement which has important implications for its tonal range (Megaw 1961, 178-80); similar flutes with two thumb holes are noted from the continent by Brade (1975, 46-8).

Megaw (1968, 338-9) has experimented widely by playing on these instruments and determining their tonal range, but little evidence for the use of consistent scales could be found : some flutes are evidently pentatonic in scale while others correspond more closely with the diatonic; yet others are non-modal. Megaw concluded that to attempt to explain any correspondence between the notes produced by these pipes and those of our present day

scales as evidence of the early currency of these tonal systems would be to start from a false premise : more probably, our scales evolved as the result of generations of such instruments being fashioned to similar patterns on standard raw materials which naturally resulted in the repeated production of a certain range of notes. Brade (1978, 24), on the other hand, reminds us that the playing technique employed with these instruments may have been quite different from that of the present day, using different methods of fingering etc.

In addition to the instruments described above, simple whistles lacking finger holes to modulate the note produced are also known : one example from Ludgershall Castle (MacGregor, forthcoming) is identified as a simple signal pipe while Hamilton (1956, 123, Fig. 57, 6) suggests that a perforated bone from Jarlshof may have been an otter whistle.

Catalogue

- 31.1 Abingdon, Berkshire
Parrington and Balkwill 1975, 48, Fig. 37, 15
- 31.2 Lydney, Gloucestershire
Casey 1931, 254, Pl. XXXVI
- 31.3 Southampton, Hampshire
Holdsworth 1976, 47, Fig. 21, 4
Megaw, in Platt and Coleman-Smith 1975, 252-3
- 31.4 Canterbury, Kent (Fig. 85A)
Megaw 1969, 149-50
- 31.5 Folkestone, Kent
Crane 1972, 38
- 31.6 Lincoln, Lincolnshire
J. Clarke 1855, 228-9
- 31.7 White Castle, Monmouthshire
Megaw 1961, 176-80
- 31.8 Kings Lynn, Norfolk
Clarke and Carter 1977, 314, Fig. 143, 19-20

- 31.9 Norwich, Norfolk (Fig. 85D)
Norwich Survey, unpublished, BGN 72, 158
- 31.10 North Elmham, Norfolk (Fig. 85C)
Wade-Martins 1970, Fig. 20, I
- 31.11 Thetford, Norfolk
Megaw 1960, 10
- 31.12 Thorpe next Norwich, Norfolk
Crane 1972, 38
- 31.13 Lyveden, Northamptonshire
Bryant and Steane 1971, 68, Fig. 19,b
- 31.14 Seacourt, Oxfordshire
Biddle 1962, 184
- 31.15 Jarlshof, Shetland
Hamilton 1956, 123, Fig. 57, 6
- 31.16 Keynsham Abbey, Somerset (Fig. 85B)
Barrett 1969, 47-50
- 31.17 Ludgershall Castle, Wiltshire
MacGregor, forthcoming
- 31.18 Salisbury, Wiltshire
Crane 1972, 38
- 31.19 York, Yorkshire
Waterman 1959, 91, Fig. 19, 10-11

BLAST HORNS AND DRINKING HORNS

A number of horns have been recognised from Anglo-Saxon and later sites in England, Scotland and Ireland. In most cases only the decorative metal mounts have survived, but actual horn fragments were recovered from Taplow (J. Stevens 1884, 65-8), Broomfield (G. B. Brown 1915, 462) and Sutton Hoo (Bruce-Mitford 1975, 442). The former presence of others is attested by metal mounts at Sarre (Brent 1865, 167), Alton (Evison 1963, Fig. 20) and Burghead (Graham-Campbell 1973, 43-51). G. B. Brown (1915, 462), however, mentions that similar mounts were occasionally

applied to the rims of wooden drinking cups, a possibility which should be borne in mind when speculating on the significance of remains like these in the absence of the original associated organic material. There seems to be no way at present of distinguishing blast horns from drinking horns on the appearance of the rim : Graham-Campbell (1973, 50) suggests that the presence of a suspension loop on the Burghead mount might indicate that it was not a drinking horn, though he does cite other drinking horns which do have loops. To those he mentions may be added an important find from Cologne (Doppelfeld 1964, 178-80), found together with remains of its carrying strap.

The occurrence of decorative metal terminals from the other (narrow) end of the horn must, of course, be indicative of drinking horns. (No metal mouth-pieces from drinking horns have yet been recognised). Seventeen drinking horn terminals found in Norway, many of them zoomorphic in form and all thought to have been imported from England, are listed by Petersen (1940, 41-172). A plainer example with a spherical finial comes from Fetter Lane, London (Antiq. J. 28 (1948) 179, Pl. XXVIIb).

It is clear from the numbers of mounts found that both classes of horn were much more commonly used than the few surviving horn fragments would otherwise indicate. Little can be said of the beasts from which the horns were derived, except that most were probably Bos longifrons. The Cologne horn is from a goat, however, (Doppelfeld 1964, 178), so that possible sources other than cattle should not be excluded.

Catalogue

- 32.1 Taplow, Buckinghamshire
 J. Stevens 1884, 65-8

- 32.2 Broomfield, Essex
 G. B. Brown 1915, 462
- 32.3 Sutton Hoo, Suffolk
 Bruce-Mitford 1975, 442

GAMING DICE AND PLAYING PIECES (Figs. 86-7)

Tests of skill, guile and intelligence have no doubt complemented those of strength and endurance from the earliest times. One of the ultimate expressions of this matching of oponents against each other lies in formalised board games with elaborate sets of rules, which remain to this day an important social phenomenon. Games of chance are no less popular in our era and there is no reason to doubt that their antiquity is any less lengthy. As far as the British Isles are concerned, games of hazard played with dice may be detected several centuries before the appearance of board games played with counters, which in turn might or might not involve dice in the determination of play.

Skeletal materials began to be used in the manufacture of dice some centuries before the opening of the period reviewed here and were still used for this purpose within living memory. Today only ivory survives in use for the production of prestige gaming sets.

Dice (Fig. 86)

The earliest known British dice are from Iron Age contexts and are parallelepiped rather than cubical. At least ten pre-Roman sites have produced dice of this type (see D. Clarke 1970, 217 for references), while the latest example in the south, from Coygan Camp, Carmarthen,

may be dated to the 2nd century AD (Wainwright 1967, 183-4, Fig. 48, 8). D. Clarke (op. cit., 218) suggests that the later absence of parallelepiped dice from the highly Romanised south may be explained by the wholesale adoption there of the Roman six-sided cubical die along with other facets of Roman material culture. In those regions lying beyond the limits of intense imperial influence, however, the type lingered on for several centuries and, indeed, may not even have gained currency in the first instance until around the 2nd century AD, by which time they were already disappearing from the south.

In Scotland parallelepiped dice occur on a number of broch and wheel-house sites with lengthy post-Roman occupation, although any association with the later rather than the earlier phases is in every instance probable rather than demonstrable. In Ireland, on the other hand, several examples from Ballinderry Crannog 2 (Hencken 1942, 55, Fig. 22, 17, 45) and Lagore Crannog (Hencken 1950, 196, Fig. 106, 1000) clearly do belong to the post-Roman period, all of them dating perhaps to the 6th-8th centuries.

The choice of raw materials used in the manufacture of parallelepiped bone dice varies to some extent from that noted below for the cubical variety : the majority are made from the shafts of small long bones, comparable to the metapodials of sheep, and indeed their characteristically elongated shape may be seen as resulting from this repeated selection. A corollary of this choice is that the ends are usually open and hence the values are normally restricted to the four elongated sides, the numbers 1 and 2 normally being omitted (Fig. 86). Antler is also used on occasion, however, as well as entire small bones, but even the solid ends of these dice do not normally carry values.

The manner in which dice of this type were used is unclear, but several plausible suggestions have been made : Wheeler (1943, 310-11), for example, thought they might have been used as multiple dominos; S. P. Ó Riordáin (1940, 156) thought they might have been covered by one player while his opponent had to guess the score on the upper faces; D. Clarke (1970, 226) drew an interesting parallel with certain North American Indian games, in which four 'stick dice' were thrown up together, the score being kept by passing counters between players. No direct connection between parallelepiped dice and counters can be drawn in this country, however, and in view of the frequency with which these dice occur in groups we may perhaps conjecture that a win or loss was decided on the outcome of a single throw, so that there may have been no call for an elaborate scoring system.

The dice in use throughout England and Wales in the period under review were the direct descendants of the Roman cubical type, from which they are often indistinguishable. Bone and antler are the materials most commonly used in their production. The comparatively large areas of dense tissue offered by antler would seem to have made it a more attractive substance than bone for producing large cubical shapes of uniform appearance : in particular, the base of the antler near the burr and the pedicle which supports it are excellent sources of dense tissue, at least during certain seasons (p. 14) and evidence for their utilisation for the production of dice has been found at Hedeby (Pl. 9). Dice of skeletal bone, when they do occur, tend to be rather smaller in size. The most readily available ivory, in the form of ungulate teeth, is neither as uniform in structure nor as easily worked as antler. No post-Roman elephant ivory dice have yet been confirmed, many early identifications being erroneous.

Most Roman dice are fairly regularly-shaped cubes and two of the dice from the pagan Saxon period illustrated here (Fig. 86), from the Gilton Town cemetery near Sandwich (C. R. Smith 1856, 7), conform closely to this Roman model. In later times, however, total symmetry was apparently thought less important (or perhaps, at times, even undesirable), so that dice are not infrequently found with one axis distinctly and presumably deliberately longer than the others. Scandinavian dice are frequently of this type (Petersen 1914, Figs. 19-22; du Chaillu 1889, Fig. 1338; Müller-Wille 1978, Abb 6, 11), and it may be that the type is exclusively Scandinavian in origin. A die from Lincoln with this characteristically elongated shape appears to be made of walrus ivory, both factors suggesting that it derives from the Viking period. Other dice show the opposite bias, with one axis markedly shorter than the others : one example from York Minster (MacGregor, forthcoming) is shaped in this way; the trait is carried to such an extreme on a 12th- or 13th-century die from Botolph Street, Norwich (Fig. 86) that throwing any values other than those on the flat sides must have been extremely difficult. In every case the values are marked with dots or with ring-and-dot motifs.

On irregularly-shaped dice of these types, certain patterns may be detected in the method of numbering : an elongated die from a Viking period ship burial in Brittany has the values 1 and 2 on the two small ends, which would have been most difficult to throw (du Chatellier and le Pontois 1909, 149, Fig. 15), a feature echoed on certain dice from Scandinavia (Petersen 1914, Fig. 20).⁽³²⁾ The Norwich die mentioned above is so marked that 1 and 2, on the smallest sides, would be most difficult to throw, followed by 3 and 4 on the intermediate sides and 5 and 6 on the largest and most readily-thrown faces. It seems possible

therefore, that variations in shape may prove to be useful indicators of date.

On cubical dice of the Roman period (or, for that matter, of the present day) the values are arranged so that the values on opposite faces always total seven : thus 6 is opposite 1, 5 is opposite 2 and 4 is opposite 3. Deviations from this pattern do occur but mostly, it would seem, within the medieval period from the 13th century onwards : during this period an alternative method of numbering was commonly used, in which 1 appeared opposite 2, 3 opposite 4 and 5 opposite 6. Nine examples of this numbering system have been noted from Winchester on dice dating from the 13th to the 15th century (D. Brown, forthcoming), thirteen from Dublin (Viking and Medieval Dublin, 13) - though the dates of these are not given - one from Southampton (Platt and Coleman-Smith 1975, 271, Fig. 247, 1927) dated 1200-1250, one 16th-century example from Streatley, Bedfordshire (Dyer 1974, 19-20, Fig. 4), one unstratified die from Water Newton, Huntingdonshire (C. Green 1964, 80, Fig. 5, 12) and individual unpublished examples from Lincoln and York. Interesting as this phenomenon may be, for the purposes of this enquiry these characteristics only serve to exclude otherwise undated dice from inclusion within the chronological limits being examined.

It is established that certain board games current in the British Isles within the Roman period depended on dice for determination of the movements of the pieces on the board (see below). Then as now, not all board games involved the use of dice, however, and neither did all dice games involve playing men. Cubical dice of the Anglo-Saxon period are so scarce and our knowledge of contemporary board games is so scanty that only minimal conclusions about the use of dice can be drawn. The dice from the Gilton

Town grave (see above) were unaccompanied by playing pieces and are so nearly identical in size that they could easily have formed a pair for the casting of lots, without any involvement in board games. Some Anglo-Saxon associations of dice and playing men have nonetheless been noted : a 'decayed bone object resembling a die' was found with 56 plano-convex playing pieces in a grave at Shudy Camps (Lethbridge 1936, 23); two dice in Grave 198 at Sarre were accompanied by 40 plano-convex counters (Brent 1868, 308); a pair of dice along with 46 bone playing pieces were recovered from a grave at Keythorpe Hall, Tugby (R. A. Smith 1907, 239). Near-contemporary finds with similar associations on the continent include those from Hemmoor-Warstade, Niedersachsen, where one grave produced three dice and nine playing pieces (Waller 1959, 12, Taf 10), Gudendorf, Niedersachsen, where two dice were found with three counters (op. cit., 25, Taf 34) and Hemmoor-Westersode, Niedersachsen, where a number of counters, some of white glass and some of black, were accompanied by a die (op. cit., 11, Taf 3). A number of associations of sets of playing pieces accompanied by dice may also be noted from the Viking period : of several sets of playing pieces found in the Birka graves, one (from Grave 581) was accompanied by three dice (Arbman 1943, Taf 147), while the two dice from the Ile de Groix ship burial in Brittany were found with 19 playing pieces (du Chatellier and le Pontois 1909, 149-51). It seems fairly certain, therefore, that the moves in at least some of the board games played during these periods were determined with dice.

The casting of lots with dice is recorded in the Norse sagas : in St Olaf's Saga, for example, ownership of a tract of land is decided on the throw of a pair of dice :

The kings agreed to cast lots about the possession thereof, and throw dice, and that he should have it who threw the highest. The Swedish king threw two sixes, saving that King Olaf need not throw; but he replied, shaking the dice in his hand, 'There are yet two sixes on the dice, and it is easy for God, my Lord, to let them turn again'. He threw, and got two sixes. Olaf King of Sweden threw again and got two sixes. Olaf King of Norway threw and there was on one die six, but the other burst assunder, and then there were seven. He then took possession of the district.

(du Chaillu 1889, 356)

Dice games have long attracted the displeasure of moralising authors, an indication perhaps of their widespread popularity : Strutt (1876, 403) records that ten different dice games of the 12th century are known by name and that even the bishops and clergy were not immune to their appeal.

Gaming pieces (Fig. 87)

As with the six-sided cubical dice of the period, the earliest Anglo-Saxon playing pieces owe a clear debt to Roman types; Beck (n.d., 452), indeed, attributes the introduction of board games into northern Europe to the Romans. Whereas most bone counters of the Roman period are either flat or plano-concave in section, however, plano-convex counters of the period are occasionally found (eg MacGregor 1978a, 33, Fig. 17, 345), and it is to these that most Anglo-Saxon counters most closely conform. Although some groups may have adopted this pattern after settlement in England, the occurrence of counters of this type in certain continental cemeteries as at Klietzen, Halle (Laser 1965, 164, Taf 32), Hemmoor-Warstade, Niedersachsen (Waller 1959, 12-13, Taf 6, 10, 11) and Gudendorf, Niedersachsen (Waller 1959, 25, Taf 34), demonstrates a currency there at least as early as in England. Several writers have commented on the

regular profiles of these pieces, which have been likened to slices cut from a billiard ball (eg Lethbridge 1951, Fig. 7); the implication seems to be that they were lathe-turned and indeed many of them have a pair of holes or indentations in the base (Pl. 34) which have been interpreted as keying holes for attachment to the lathe (British Museum Anglo-Saxon Guide, 82); others have been noted with single holes or with three holes, however (Myres and Green 1973, 99), while yet others display no holes at all, so that their true significance is not entirely clear. The assertion by Ozanne (1963, 37) that any early Saxon playing pieces which were made on the lathe would of necessity be imported, even if it were true, is therefore neither proven nor disproven by the presence of these holes. (For a discussion of early lathes see p. 72.)

While many of these plano-convex counters are quite plain, others are ornamented with incised dots or with ring-and-dot decoration, the number of dots varying between one - for example on a counter from Kingston Down (Fig. 87) - and ten in the case of some of the twenty-eight counters from a cremation barrow at New Inns, Derbyshire (Bateman 1861, 179-81). As Bateman (loc. cit.) observed, the number of motifs on the most prolifically-decorated pieces is too great for them to have been counted easily, so that the number present is unlikely to have had any significance in the game.

Several of the (fifteen or so) sites on which these counters have been found (see Ozanne 1963, 37 for a list) have produced large groups of them : Leeds (1924, 118) records ten or more from Asthall Barrow; fourteen came from a cinerary urn (2321) at Sancton, Yorkshire (Myres and Southern 1973, 84, Fig. 26); twenty-eight were found with an 'interment of calcined human

bones' at New Inns (Bateman 1861, 179-8); a cremation urn at Lovedon Hill, produced forty-five (Pl. 34), while among the fifty or sixty counters accompanying the burial in Grave VI at Sarre were many of plano-convex outline (Brent 1865, 157-8). These large numbers clearly imply that whole sets of counters were being interred, a suggestion supported by the fact that twenty-two counters of white bone in Urn N59 at Caistor-by-Norwich were accompanied by eleven of a black material, probably shale (Myres and Green 1973, 160). About half the bone counters from an urn at Lackford, Suffolk (Lethbridge 1951, 17, Fig. 8) appear to have been deliberately blackened (Myres and Green 1973, 100).

As mentioned above, many counters of this plano-convex shape come from cinerary urns, including examples of 5th-century date as at Lackford (Lethbridge 1951, 17), Caistor-by-Norwich (Myres and Green 1973, 100) and Spong Hill (Hills 1974, 87-9) while others, including the examples from Sarre (Brent 1865, 157-8) come from inhumation graves as late as the 7th century (see Ozanne, 1963, 37 for find spots).

A second type of playing piece commonly found in Saxon contexts is that made by modifying a horse's molar tooth, so that the grinding surface becomes the base and the root is rounded off to form a high dome or conical shape. Their contemporaneity with plano-convex counters is demonstrated at Sarre, where both types occurred in Grave VI (Brent 1865, 157-8). A large series of these pieces in the British Museum (Pl. 35) is thought to have come from Faversham, Kent (British Museum Anglo-Saxon Guide, 48); the slightly ambivalent wording of the Guide's description has led several writers (eg Wheeler 1935, 154) to believe

that similar teeth were found in Taplow Barrow, Buckinghamshire, while Murray (1952, 58) has further conflated finds from the two sites in his statement that Taplow, Faversham and Basingstoke have all produced playing men in the form of short hollow cylinders made from horses' teeth with the opposite ends closed by discs united by a silver pin; the playing men from Taplow (see below) have nothing in common with those from Faversham, however, and are certainly not made from horses' teeth. An unstratified example of a horse's tooth playing man, from Cheapside, is in the collection of the Museum of London (Wheeler 1935, 154) and another (Fig. 87) was found in recent excavations in York, but is again unstratified. Continental parallels may be noted from the Frisian terps (Roes 1963, Pl. XLIV, 25-6) and from Scandinavia (Wheeler 1935, 154).

In contrast with the above, the cylindrical pieces from Sutton Hoo were, to judge from the written description of their laminar structure (Bruce-Mitford 1975, 573-6), of elephant ivory

The Taplow playing men mentioned above are, as yet, unique. Found with a rich burial of the 7th century (J. Stevens 1884, 65-8) were thirty cylinders turned from the hollow shafts of ungulate long bones, each about 20mm high and 30mm in diameter; the ends of these cylinders were closed by discs of the same material, linked by a central bronze pin (Fig. 87). To judge from additional finds of loose bronze pins from the barrow, ninety or more pieces may originally have been buried (Bruce-Mitford 1975, 574). No other pieces of similar composite construction are known from the British Isles, nor from the continent.

Another instance of the natural shape of certain animal bones recommending themselves for utilisation as playing men is that of astragali or 'knuckle bones'. One astragalus was found with a plano-convex counter in an urn (N10) at Caistor-by-Norwich (Myres and Green 1973, 150), while a second urn (N59) from the same site, mentioned above (p. 266) as containing 33 plano-convex pieces also produced 35 astragali, 15 or

more of them from sheep and at least two from roe deer (op. cit., 98, 160); one roe deer astragalus was distinguished from the others by its large size and dark brown colouring, and also by having an inscription in runes on one face (cf. Wrenn 1962, 306-20).

Phalangeal bones formed a common alternative to astragali, their natural shape allowing them to be stood on end with ease. A single phalanx from the Saxon port of Hamwih (Southampton), inscribed with Frisian runes and published as a trial piece (Addyman and Hill 1969, 86-8, Pl. VIIIc), may conceivably have been a playing man, and the same interpretation has been proposed for two phalanges from the Broch of Burrian, North Ronaldsay, one of them bearing an undoubted Pictish symbol and probably dating to the 7th or 8th century (MacGregor 1974, 88, Fig. 16, 210-11). Several examples have been recovered from the Frisian terps, while 20th-century village communities in Friesland are said to have amassed large numbers of them; these were used in games in which the bones were placed in long rows on the ground (or on frozen river surfaces), the object being to strike the furthestmost phalanx with a throwing stick or long bone (Roes 1963, 55-7, Pl. XLVI, 1-4). It has been suggested (MacGregor 1974, 88) that the presence of large numbers of bovine phalanges in the absence of other parts of the skeleton on the Dark Age site of Á Cheardach Mhor, South Uist, may reflect similar practice, though the possibility cannot be overlooked that this apparent selection is merely the result of some quite different practice, such as skinning cattle and leaving the foot-bones in the skin until they are later discarded together.

The use of knuckle bones for a variety of children's games survived until the last century : these were the 'small bones of calves' feet, from which jelly was made before modern science taught the cooks to make it of glue' (Micklethwaite 1892, 323-4). Micklethwaite mentions that pottery playing pieces were being manufactured in the shape of bone originals in his day, while a recent Roman find from London is of a bronze playing piece, the original model for which was certainly an actual astragalus (Ferretti and Graham, in Bird et al. 1978, 156, Fig. 62, 6).

The influx of new cultural traits which accompanied the arrival of large numbers of Norse settlers in the 9th and 10th centuries brought a new form of playing piece, onion-shaped or domed with a flat bottom, often provided with a basal peg-hole. Although some of these domed pieces have shapes reminiscent of the horses' teeth playing pieces mentioned above (p. 266), they are often of considerably larger size, a factor linked to a new source of raw material, namely large cetaceans. These provided dense and heavy bone in quantity, without the inherent limitations of ungulate bone which, for all its potential size, tends to be arranged either in hollow tubes or as a layer of dense cortical tissue over a spongy internal mass (p. 10). Red deer antler bases still provided a satisfactory alternative, of course, but there does seem to be a strong correlation between the appearance of this new type of playing piece and this hitherto unencountered raw material to which Scandinavian (particularly Norwegian) communities had greater ease of access.

Four playing pieces of this type in the National Museum in Dublin may well have originated in the well-known Viking cemetery at Kilmainham (Bøe 1940, 53-4, Fig. 36); a further example, with the classic onion shape mentioned above, was found at Jarlshof, Shetland (Curle et al. 1954, 19, Fig. 5) and another was recovered from a long-house on Drimore Machair, South Uist (MacLaren 1974, 17, Fig. 2). A more recent discovery, from Goltho Manor, Lincolnshire, is illustrated in Fig. 87.

Another specifically Viking age playing piece is the piriform variety, in which a bulbous bottom is surmounted by a knob; the base is again often drilled to take a pin. A single example from Jarlshof (Hamilton 1956, Pl. XXXVII, 8) may be compared with a series of fourteen found at Boge, Gotland (Proc. Soc. Antiq. London 15, (1893-5), 273).

Within a few decades of the Norman Conquest a new class of gaming counter was beginning to make its appearance - flat, discoid, averaging about 40mm in diameter and about 10mm in thickness.⁽³³⁾ Three groups may be isolated in terms of raw material, the respective qualities of which impose quite marked stylistic differences in the treatment accorded to each group. Antler discs are among the most numerous of these, usually transversely cut from the thick beam of the antler, although instances are also found of them having been cut longitudinally, as demonstrated by the direction of the spongy tissue : in transversely-cut pieces the cancellous tissue, which consists of a limited area of closely-set pores, usually runs axially from the centre of the upper surface to the centre of the lower surface (Pl. 36), while in longitudinally-cut discs it may sometimes be distinguished running diametrically from one side of the disc to the other. Discs cut in either axis from near the base may show little evidence of any spongy tissue (p. 13) and in any case the bulk

of an antler disc always consists of solid tissue. Examples are known from York (Benson 1906, Pl. III), Goltho (MacGregor, forthcoming) and London (Pl. 36). Bone discs are also fairly plentiful, usually cut from the conveniently thick mandibles of horses and cattle; others (Pl. 37) are known in cetacean bone and yet others are of composite form, built up from several discs of (presumably mammalian skeletal) bone,⁽³⁴⁾ some of them being fairly ornate.⁽³⁵⁾ Those cut from mandibles are often from the angle of the jaw; in addition to the characteristic sandwich effect of the cancellous tissue seen in section, they are often perforated by a larger hole, the mandibular foramen (Pl. 5), which is often mistaken for an artificially drilled hole, the discs then being taken for pendants. In the early medieval town of Schleswig, numerous jaw bones have been found with circles neatly excised from them for the production of discs of this type (Pl. 16). In most instances, decoration on bone and antler counters of this type is limited to ring-and-dot motifs or compass-drawn petal designs incised lightly on the surface (Fig. 87). Cetacean bone permits a more deeply-cut treatment, however, as on a counter from London (Pl. 37) and another from Iona Abbey, carved with the figure of a mermaid (Proc. Soc. Antiq. Scot. 87 (1952-3), 203, Fig. 6).

Discs of elephant or morse ivory are much less numerous : they would have been more expensive in the first instance and thereafter often had deeply-cut decoration lavished on them, as was permitted by the uniform structure and excellent working properties of the material. Few of the beautifully carved ivory counters in the national collections (eg Dalton 1909, 74-83, Pls. XLIX-LII) have any provenance and many are known to have been imported from the continent by collectors. A few early medieval

examples have been found in the British Isles, however, among which may be noted one example in walrus ivory from Melrose Abbey, decorated with a representation of a bird (Archaeol. J. 9 (1852), 297), one found in a garden in Leicestershire and showing, perhaps, Jeremiah being cast into the pit (Proc. Soc. Antiq. London 11 (1885-7), 316-7) and a third from London carved with the figure of a man, perhaps Bacchus (Dunning 1932b, 177-8). A series of uncarved discs in the British Museum display the typical structure of morse ivory (Pl. 38).

The only similarly-shaped pieces in other materials which can be compared with those mentioned above are a few examples in bronze, showing some signs of having been enhanced with enamel; all of these come from Ireland, where the best provenanced of them was 'found by Mr. Patrick Donohue while preparing his garden for planting potatoes ... near Durrow, Co. Laoighis' (Roe 1945, 156-9).

At some point in time, as yet imprecisely defined but perhaps in the 11th century,⁽³⁶⁾ a whole new series of playing pieces makes an appearance in England. They show a certain amount of stylistic resemblance to each other and indeed are generally thought to have been used together in a single game, namely chess. Although there may be some scope for dissension from this view, the individual identities normally ascribed to these pieces are retained here for convenience of discussion (see p. 278 for a discussion of the evolution of these shapes). Simplest among them are the cylindrical 'pawns', represented here by early medieval examples from Ludgershall Castle (Fig. 87) and two others in the British Museum (Pl. 39); these are paralleled in jet at the Mote Hill, Warrington

(J. Kendrick 1853, 62-7). Whereas the British Museum pieces are naturally solid, being made of antler, it is interesting to note that the Ludgershall Castle piece has been manufactured from an antler tine, plugged at the end with a second piece of antler to disguise the cancellous core. A further interesting feature of this piece is that the concentric circles which have been incised on the plugged upper end contain traces of red colouring matter, no doubt to distinguish the men of one set from those of the opposing side. Of two cetacean bone pawns found with more elaborate playing pieces at Witchampton, Dorset, one pawn (and several other pieces) had been 'purposely blackened by the action of fire in order to distinguish them from the uncoloured men' (Dalton 1927, 77, Pl. VI, Fig. 3).⁽³⁷⁾ The use of jet as a common alternative to bone in the manufacture of pieces of this type presumably also reflects this desire to distinguish opposing men.

Found with the cylindrical piece at Warrington was a representative (again in jet) of a second group of these playing men, usually identified as knights. These may be circular or sub-rectangular in section and are usually provided on the upper edge with a single projection, often fashioned into a stylised zoomorphic head. An example in antler from Helpstone (Pl. 40) has had the cancellous tissue removed from its centre and replaced by a plug of solid material in the manner already described. Two knights were among the collection of pieces found at Witchampton (Dalton 1927, 77).

Closely related to this latter group is a series of pieces distinguished by having two projections or heads instead of one and normally described as bishops. An example of this type is in the collection of the Museum

of London (Pommeranz-Liedtke 1964, 57, Taf 3) and two more are in the British Museum (Archaeol. J. 39 (1882) 422), all of them from London. Others come from Northampton Castle (loc. cit.), Beverley (H. J. R. Murray 1913, 766) and Witchampton (Pl. 41).

The 'castles' in this series are again represented in jet (Waterman 1959, 94, Fig. 21, 1; Dunning 1965, 61, Fig. 8; Norwich Castle Museum 103, 945) as well as bone : two examples made from plugged sections of long-bones are in the Museum of London (Pl. 42), one of them found in Tokenhouse Yard, London. Another from Woodperry, Oxfordshire is illustrated in Archaeol. J. (1846, 122, Fig. 15). All are characterised by a wide V-notch cut in the uppermost surface.

Finally, we may consider those pieces identified as kings : these are basically cylindrical in shape with a slightly projecting lower half or a rebated upper half (Pl. 43). An example of this type in the British Museum is mentioned by H. J. R. Murray (1913, 766) and another from Rievaulx Abbey is illustrated by Dunning (1965, 60, Fig. 7). More elaborate versions have a separate head projecting from the top of the cylindrical body as one example in the British Museum (Pl. 43) and others from Old Sarum, Wiltshire (F. Stevens 1933, 308-10) and South Witham, Lincolnshire : the latter piece has lost most of its head, but part of it survives in its socket, held in place by a transverse antler pin (MacGregor, forthcoming). A 12th-century date has been suggested for the Old Sarum king (F. Stevens, loc. cit.), while that from South Witham was found in a 13th century context. Apart from this latter piece, however, none of them comes from a context which can be dated with any degree of precision, although dates in the 11th and 12th centuries are most widely favoured for them.

A number of more ornate chessmen retain something of the basic outlines described above while displaying much more elaborate decoration : among these may be included a king from Kirkstall Abbey, for which a 12th century date has been suggested (Way 1849, 170-2), and several continental pieces (Dalton 1909, 74-83), many of them in morse or elephant ivory.

Perhaps the best known chessmen from the British Isles are those found in 1831 on the Isle of Lewis. In sharp distinction to the schematised pieces described above, the Lewis men are wholly naturalistic in their execution : of the 78 pieces found (presumed to belong to several sets) the identity of each is immediately apparent to any present-day chess player, except perhaps for that of the castles, represented here by helmeted warders carrying a sword and shield. All are carved in a simple but powerful style : the outlines are uncomplicated, with facial features, details of dress etc., represented either in low relief or with incised lines and dots. The raw material is identifiable as walrus ivory from the marbled dentine structure visible on the bases and, in some instances, in the longitudinal axis (Pl. 45). The carver has made maximum use of these irregularities of structure, the marbled 'graining' being used, for example, to enhance the flanks of the knights' horses (Pl. 45) or to heighten the effect of folds in the vestments of some of the bishops (Pl. 44).

Games and gaming boards

Before considering the range of games in which all the various types of playing men considered in this thesis may have been used, a brief review of gaming boards from the period under consideration will be useful.

These are very rare indeed, however, and add little to our understanding of the games in which most of the playing pieces were involved, especially as direct associations between the two are entirely lacking. The gaming boards employed in the Roman world were of two principal types : one of these, used in games like duodecim scripta, and its later variant, tabula, is laid out in three rows of twelve stations arranged in two columns, the game being in effect an early form of backgammon; the second type of board, used in games like ludus latrunculorum, is in the form of a simple grid of squares. Both types are known from Romano-British contexts (see MacGregor 1976, 3-4 for references). One important feature of duodecim scripta and tabula was that players were allowed to 'promote' pieces by piling one on top of the other (Murray 1952, 31); not only are suitable boards quite unknown from the post-Roman period, but there are no playing pieces which are remotely suitable for piling until the introduction of the large discoid counters mentioned above (p.270-2), for which an origin around the time of the Norman Conquest was suggested. Simple squared boards are scarce indeed and the range of games which might have played on them is enormous, so that these are hardly more illuminating : two fragments of squared 'boards' of stone were found during the excavation of a Norse site on Unst, Shetland (Small 1966, 244, Fig. 16) along with some simple pebble counters, while more recently three similar and contemporary boards were discovered at Buckquoy, Orkney (A. Ritchie 1974, 30; 1977, Fig. 9). An edge fragment from a squared board has come from Viking levels on the current excavations in Coppergate, York (York Archaeological Trust, unpublished). Dornan (1975, 122-57) lists a number^{of} stone and fragmentary wooden boards from Ireland, but pre-eminent among these Irish boards is the magnificent example from Ballinderry Crannog 1 (Hencken

1937, Pl. XXV), ornamented with motifs suggesting a 10th-century origin and provided not with squares but with holes arranged in seven rows each way for use with pegged playing pieces of the type discussed above (p. 269).

Early gaming boards are equally scarce on the continent, but two important examples must be mentioned : the first, thought to date from the Roman Iron Age, is from Vimose, Fünen, and is marked with at least 18 squares in each direction (H. J. R. Murray 1952, 58, Fig. 21); the second and more interesting board came from the Gokstad ship burial and is marked with 13 x 13 squares on one side, the second and fifth columns from each edge being hatched (op. cit., Fig. 22); the reverse of the Gokstad board is marked out for merels. A number of graves at Birka have been shown on the evidence of iron mounts to have contained gaming boards, although these have not survived (Selling 1940, 134-44).

Murray (1952, 56) states that tafl (and its later variant hnefatafl) was the only board game played by the Saxons and that it remained popular until the introduction of chess in the 11th century, so that (if he is correct) all the above-mentioned boards may well have been used for games of this type. There are two players in tafl, one having a king surrounded by a number of supporters in the centre of the board⁽³⁸⁾ and the other with double the number of men ranged around the edge of the board. A hnefatafl board indicating the disposition of both sides (on the intersections of the lines) is illustrated in a 10th-century manuscript dating from the reign of Athelstan (J. A. Robinson 1923, 69-71) and the rules of play are given by Bell (1960, 80-1).

The game of merels enjoyed enormous popularity in the middle ages, but the date of its introduction into the British Isles is, as yet, conjectural. A Neolithic or Bronze Age date claimed for a board from Co. Wicklow (Murray 1952, 44) must be treated with suspicion, but the occurrence of a merels layout on the reverse of the Gokstad board mentioned above makes a currency in Britain by the Viking period quite likely. The practice of having boards marked for chess on one side and merels on the other remained common throughout the medieval period (Murray 1952, 44). Precise dates for early merels boards are not yet available from Britain : 13th-century origins have been claimed for examples from Dryburgh Abbey and Arbroath Abbey in Scotland (Robertson 1966, 321-3), however, and a 12th-century or earlier date is possible for at least one stone board from the Isle of Man (Cubbon 1960, 66-70). Whether formal playing pieces (rather than mere pebbles) were used with these early merels boards has yet to be proven.

No early chess boards have yet been identified. As mentioned above, a considerable number of playing men are now known, dating from the 11th to the 13th centuries and generally identified as chess pieces. The ancestry of their respective forms has been traced through Islamic intermediaries to Indian originals by H. J. R. Murray (1913) and may usefully be summarised here. Hindu chess was essentially a war game in which the various pieces represented the armed host : the king and his vizier or second in command both rode elephants, while a charioteer, an elephant, a horseman and a foot soldier stood for the chariot, elephant, cavalry and infantry corps respectively. Since naturalistic representations of this sort were proscribed in the Islamic world, each of these

pieces suffered radical schematisation at the hands of Arab craftsmen when the game was adopted in that part of the world, so that only the broad outlines of the originals survived to be transmitted ultimately to northern Europe. Thus, the king and the vizier (who were distinguished from each other only by size) became reduced to stepped blocks, the projecting part representing the elephant's head and the higher part the howdah on top. The charioteer became a block with a wide V-shaped depression on top, one apex recalling the heads of the horses and the other the charioteer himself, while the elephant was transformed into a simple cylinder with two projections, representing either the tusks or perhaps the warrior and his driver. Closely similar to the latter but with only one projection was the cavalryman, while the foot soldier became a plain cylinder. On reaching northern Europe each of these pieces became re-identified in terms of contemporary feudal society : hence the vizier re-emerged as the queen, the charioteer as the castle, the elephant as the bishop and the horseman as the knight; only the infantryman retained his character intact as the pion or pawn.

This, at least, is the currently accepted explanation given to these schematised pieces. On the other hand, in view of the sophistication of some contemporary sets of undoubted chessmen, such as those from Lewis (Madden 1832, 203-43)⁽³⁹⁾ or the numerous pieces of 13th-century and later dates found elsewhere, one may be forgiven for speculating whether all (or even any) of these stylised pieces may have been used in chess. Although plausible pedigrees can be traced for the simpler pieces to the undoubted chessmen of the Islamic world, it remains at least possible that some of these could have been used in the game of hnefatafl : the three barbaric 'kings' described above (p. 274; Pl. 43)

would probably seem quite at home on a tafl board, perhaps as the cynningstan discussed by Page (1969, 1-4), and the bone 'castle' from Woodperry, along with the 'pawn' and 'knight' of jet from Warrington have all be identified elsewhere as pieces for hnefatafl (Murray 1952, 60). This hypothesis is likely to remain unproven, however, until the discovery of one or more complete sets of pieces demonstrates the true relationships of these pieces to each other.

Catalogue

Dice

- 33.1 Keiss, Caithness
D. V. Clarke 1970, 229
- 33.2 Southampton, Hampshire
Platt and Coleman-Smith 1975, 271, 274, Figs. 247, 249
- 33.3 Water Newton, Huntingdonshire
C. Green 1964, 79, Fig. 5, 12
- 33.4 Dalcross Castle, Inverness-shire
Proc. Soc. Antiq. Scot. 31 (1896-7) 80
- 33.5 Gilton Town, Kent (Fig. 86A-B)
C. R. Smith 1856, 7
- 33.6 Tugby, Leicestershire
R. A. Smith 1907, 239
- 33.7 Lincoln, Lincolnshire
Lincoln Archaeological Trust, unpublished (Flaxengate)
Lincoln Museum, unpublished (Carlbon Coll. 23a)
- 33.8 Lagore, Meath
Hencken 1950, 196, Fig. 106, 1000
- 33.9 Kings Lynn, Norfolk
Clarke and Carter 1977, 314, Fig. 143, 18
- 33.10 Norwich, Norfolk (Fig. 86C)
Norwich Survey, unpublished (BS 170N)
- 33.11 Ballinderry Crannog 2, Offaly
Hencken 1942, 55, Fig. 22, 17, 45
- 33.12 Broch of Ayre, Orkney
D. V. Clarke 1970, 230

- 33.13 Broch of Burrian, Orkney (Fig. 86F)
MacGregor 1974, 86-8
- 33.14 Broch of Gurness, Orkney
D. V. Clarke 1970, 230
- 33.15 Broch of Lingro, Orkney
D. V. Clarke 1970, 231
- 33.16 Eac Mhic Connain, Outer Hebrides
D. V. Clarke 1970, 229-30
- 33.17 Dun Cuier, Barra, Outer Hebrides
Young 1956, 319-20, Fig. 13, 5-10
- 33.18 Jarlshof, Shetland
Hamilton 1956, Pl. XXXVII, 8
- 33.18a York, Yorkshire (Fig. 86 C-D)
MacGregor, forthcoming
- Playing pieces
- 33.19 Iona Abbey, Argyll
Proc. Soc. Antiq. Scot. 87 (1952-3) 203
- 33.20 Harlington, Bedfordshire
Proc. Soc. Antiq. London 11 (1885-7) 311
- 33.21 Taplow, Buckinghamshire
J. Stevens 1884, 65-8
- 33.22 New Inns, Derbyshire
Bateman 1861, 179-81
Howarth 1899, 192-3
- 33.23 Witchampton, Dorset (Pl. 1, Pl. 41)
Dalton 1927, 77-86
- 33.24 Gloucester, Gloucestershire
Hassal and Rhodes 1974, 73, Fig. 28, 30
- 33.25 Southampton, Hampshire
Platt and Coleman-Smith 1974, 271, 274, Fig. 247
- 33.26 Winchester, Hampshire
Cunliffe 1964, 152, Fig. 52, 1-4
- 33.27 Faversham, Kent (Pl. 35)
British Museum Anglo-Saxon Guide, 48
- 33.28 Kingston Down, Kent (Fig. 87B)
C. R. Smith 1856, 52
- 33.29 Sarre, Kent
Brent 1868, 308

- 33.30 Tugby, Leicestershire
R. A. Smith 1907, 239
- 33.31 Unprovenanced, Leicestershire
Proc. Soc. Antiq. London 11 (1885-7) 316-7
- 33.32 Goltho Manor, Lincolnshire (Fig. 27 D, G, H)
MacGregor, forthcoming
- 33.33 Lincoln, Lincolnshire
Archaeol. J. 14 (1857) 278-9
Lincoln Museum, unpublished
- 33.34 Loveden Hill, Lincolnshire (Pl. 34)
Fennel 1964
- 33.35 Searby, Lincolnshire
Lincoln Museum, unpublished
- 33.36 South Witham, Lincolnshire
MacGregor, forthcoming
- 33.37 London (Pls. 36-7)
Dalton 1909, 84-6
Dryden 1882, 421, Pl. 5
Dunning 1932b, 177-8
Pommeranz-Liedtke 1964, 57, Taf 3
Wheeler 1927, 46-9, Fig. 26; 1935, 154
- 33.38 Lagore Crannog, Meath
Hencken 1950, Fig. 107, 910, 833
- 33.39 Trim Castle, Meath
Sweetman 1978, 184, Fig. 24, 10-11
- 33.40 Rug, Merioneth
Dalton 1909, 83
- 33.41 Caistor-by-Norwich, Norfolk
Myres and Green 1973, 98-100
- 33.42 Kings Lynn, Norfolk
Clarke and Carter 1977, 314, Fig. 143, 16
- 33.43 Pensthorpe, Norfolk
British Museum Anglo-Saxon Guide, 82
- 33.44 Spong Hill, Norfolk
Hills 1974, 87-91; 1977, 29, 1047
- 33.45 Helpston, Northamptonshire
Dryden 1882, 421, Pl. 2; Dalton 1909, 85

- 33.46 Northampton Castle, Northamptonshire
Dryden 1882, 421, Pl. 5
- 33.47 Ballinderry Crannog 2, Offaly
Hencken 1942, 55, Fig. 22, 407
- 33.48 Broch of Burrian, Orkney
MacGregor 1974, 88, Fig. 16, 207-12
- 33.49 Lewis, Outer Hebrides (Pls. 44-5)
Madden 1832, 203-91
- 33.50 Tettsworth, Oxfordshire
M. Robinson 1973, 104
- 33.51 Woodperry, Oxfordshire
Murray 1952, Fig. 24c; Archaeol J. 3 (1846) 122, Fig. 15;
Dalton 1909, 86
- 33.52 Jarlshof, Shetland (Fig. 87E)
Hamilton 1956, Pl. XXXVII, 8
Curle et al. 1954, 19, Fig. 5
- 33.53 Lackford, Suffolk
Lethbridge 1951, 17
- 33.54 Ludgershall Castle, Wiltshire (Fig. 87F)
MacGregor, forthcoming
- 33.55 Old Sarum, Wiltshire
F. Stevens 1933a, 308-10
- 33.56 Salisbury, Wiltshire
F. Stevens 1933b, 310-12
- 33.57 Beverley, Yorkshire
H. J. R. Murray 1913, 766-7; Dalton 1909, 85
- 33.58 Kirkstall, Yorkshire
Way 1849, 170-2
- 33.59 Methley, Yorkshire
I. H. Goodall, in le Patourel 1973, 93, Fig. 37, 10
- 33.60 Rievaulx, Yorkshire
Dunning 1965, 60, Fig. 7
- 33.61 York, Yorkshire (Fig. 87A,C)
Benson 1906, Pl. III
MacGregor, forthcoming

BONE SKATES (Fig. 88, Pl. 46)

For more than a century, bone skates have formed part of many museum collections, while intensified archaeological activity in recent years has produced a considerable number of additional specimens. Although earlier writers disagreed among themselves about the origins of these skates,⁽⁴⁰⁾ they were rarely in any doubt about their function, chiefly because bone skates had survived in use within living memory in a number of communities in central and northern Europe. More recently, however, a growing confusion arose concerning them, as skates of this type disappeared from use in contemporary communities and also as the direct result of a number of publications which have attempted to refute the earlier identification.

Even before the end of the last century, Tergast (1879, Fig. 49) had recorded a bone, 'polished on one side, for smoothing textiles', from Grimersum in Friesland. Further doubt as to their use was expressed in print by Kjellberg (1940, 74-8) in a study concerned primarily with the care of linen : finding no medieval smoothing implements which corresponded with known earlier and later examples, Kjellberg turned his attentions to the 'so-called bone skates'; after a test run on the ice and an inspection of the wear marks sustained in the process, he decided, perhaps a little precipitately, that these bones could not have been used originally as skates and that they might, therefore, be identified as linen smoothers. A further and more damaging blow to their pedigree was dealt by Semenov in his influential work Prehistoric Technology (1964). Semenov's objections to the identification of these objects as skates were fivefold :

- (1) Many of the bones have no perforations through which they might be tied to the feet;
- (2) the action of the ice would have marked the flat base in a recognizable manner and rendered it irregular, dulling the characteristically sharp angles along its edges;
- (3) the striations on the base are mostly parallel to the axis of the bone and therefore do not reflect the true movements of a skater (by comparison with the wear marks on steel skates, which cross the main axis of the blade at an angle of 70 to 80 degrees);
- (4) real skates always have additional (non-linear) abrasions and dents;
- (5) many of these bones are not upswept at the 'toe' and would, therefore, have caught in every irregularity in the ice.

Semenov also concluded that they were probably used in textile preparation or perhaps in leather working (Semenov 1964, 191-3). This view became widely held, even by those who conceded that some of these artefacts are indeed skates (eg Jacob-Friesen 1974, 690). In 1976 the present writer re-stated the case for identifying these objects as true skates (MacGregor 1976), a premise which has received general approval since that time.

The vast majority of bone skates are made from selected limb bones of large animals, almost exclusively horses and cattle. Metapodial bones (metacarpals and metatarsals) were most commonly used and skates made from radii, although less common, also occur fairly consistently (Mac-

Gregor 1976, Table I). A few utilized leg bones of deer also occur.

The widely-held belief that tibias were most frequently used may perhaps stem from a statement to this effect in the British Museum's Guide to the Mediaeval Antiquities (1924, 27), which is erroneous. The Latin texts of William fitz Stephen and Olaus Magnus (see below) both use the word tibia, but apparently without the precise anatomical meaning which it has today.⁽⁴¹⁾ Further etymological evidence linking skates with limb bones may be adduced from the Icelandic term isleggir used to denote these objects, for it has the literal meaning of 'ice leg-bones' or 'ice-legs' (Cleasby et al. 1957, 319). Another interesting link is contained in the modern Dutch word schinkel or schenkel, which can be used to denote either the blade of an iron skate or the shank bone from which its ancestors were most commonly fashioned (van Dale 1976, 2151). In 18th-century Holland, peasant children learned the first principles of skating on rib bones of cattle (Wichers 1888, 72), a practice apparently known in Iceland and in Westphalia (Balfour 1898, 252-3) and in more recent times in this country.⁽⁴²⁾ The use of horse jaw bones for skates and sledges has also been recorded in the 19th century (Balfour 1898b, 251-2), a wooden platform being fixed over the teeth (Fig. 88).

In the case of the leg bones considered here, it was almost invariably the anterior side of the bone which formed the contact surface with the ice. While some skates show only slight abrasion of the naturally rounded surface, others are flattened and worn to such a degree that the medullary cavity is exposed. Such excessive flattening is not, however, always entirely the result of prolonged use, for on some examples (MacGregor 1976, Pl. IVB) traces of preliminary grinding or cutting have survived

the polishing action of the ice. Deliberate grinding of a flat surface on the base of the skate is a practice mentioned in the 16th century by Olaus Magnus (see below) and it was still favoured in 19th century Germany : one contemporary account of skate-making in eastern Germany is by the son of a miller, whose especial task it was to grind his friends' skates on his father's millstone.⁽⁴³⁾ This treatment obviously improved the comfort and performance of the skate but was not essential : some early skates show very little flattening indeed. Of two pairs made by the writer in co-operation with Mr. D. J. Rackham, the underside of one pair was given only minimal preparation, but they still performed quite satisfactorily. A fine polish, which is a feature of most skates (but which has in the past been taken to indicate that they could not have been used as such), began to develop on the base after only a few hours' use, and was particularly noticeable on a pair made from immature (and therefore softer) bones. Microscopic scratch marks which were formed by abrasion on the ice were entirely consistent with wear patterns noted on skates from archaeological contexts (MacGregor 1975b, 385-90, Figs. 2-3).

The upper surface of the skate was usually flattened to some extent. Rough transverse cuts were sometimes made to improve the foothold (MacGregor 1976, Pl. IVA). In Scandinavia and Finland, flattening was sometimes carried to such an extent that the medullary cavity was exposed for its entire length (see, for example, Berg 1943, Figs. 7-9; Hyltén-Cavallius 1868, 464; Vilppula 1940, Fig. 3).

Pointing and bevelling the front of the skate were further optional refinements. Skates with upswept toes would obviously be less affected by surface irregularities, but for use on smooth ice no such treatment

would be necessary. Shaping the front end to a point would not have altered the performance but may conceivably have proved useful in light snow. Narrowing the front of the skate in this way would have made the drilling of a strap-hole less troublesome, but not all pointed skates have toe holes and neither have all those with strap-holes at the toe been pointed (MacGregor 1976, Table I). Toe strap-holes are most commonly transverse, but a few skates with vertical perforations are known; Fig.88 shows an example of how the natural cleft between the condyles of a bovine metapodial has been worn by the action of the bindings. Holes for heel fastenings, where they occur, are either transverse or, much more commonly, axial. Vertical holes at front and rear indicate sledge-runners rather than skates : the suggestion (Schuldt 1960) that some vertically-perforated runners originally had a wooden platform pegged to the top of them is unsupported by any evidence. Cords or straps were never passed through axial heel holes, none of which penetrate the entire length of the bone; instead, a peg was driven into the hole to form an anchorage for an ankle loop or (when combined with a toe hole) to provide a strainer point by which the skate could be more securely fastened. Several such pegs have been found in situ.⁽⁴⁴⁾

A marked correlation between axial heel holes and horse metapodials will be noted in Table I. This may be explained by the fact that the proximal ends of these bones (which invariably form the heel end of the skate) present a naturally weak point which can easily be penetrated; this is particularly true of the metatarsals, which have a small natural foramen in the centre. Bovine metatarsals, which have no central foramen, do not lend themselves naturally to this treatment and skates made from

them less frequently have true axial heel holes;⁽⁴⁵⁾ when such holes are present, the structure of the bone dictates some rather aberrant compromises (MacGregor 1976, Pl. IVE). Iron loops occasionally occur in place of perforations; a skate from an 11th-century context at York Minster incorporates a vertical loop at the toe (MacGregor, forthcoming), while two examples in the British Museum (one of them 'found with samian pottery at a depth of twenty-five feet' in Tokenhouse Yard, London) have iron loops at the heel. Some axial heel holes are so small that they must have been made to take iron nails rather than wooden pegs, and indeed a few have been noted with the remains of nails still within them. Berg (1971, 5) notes that some perforations, on more recent skates at least, were for straps used purely for hanging them up when not in use or for convenience in carrying them.

Many skates have no holes whatever and could not have been tied to the feet, one of the features which led Semenov to conclude that it would have been impossible to skate on them. The technique of bone skating, however, is quite different from that used with steel-bladed skates and the use of bindings is entirely optional. The skater stands with his knees slightly flexed and with his feet some way apart. Pushing back on the ice between his feet with a spiked pole he moves forward, keeping his weight evenly distributed; the feet are not shuffled to and fro and are never lifted. Since the friction between the ice and the skate is lower than that between the skate and the foot (particularly when the upper (posterior) surface of the bone skate has been artificially roughened), the body weight of the skater is normally enough to keep the skates in position. On the indoor ice-rink where the recent experi-

ments took place, even novice skaters had little trouble in staying on their skates in this way, but on uneven outdoor ice they would certainly have preferred those with a full set of bindings.

The earliest extant description of the technique described above is also one of the most obscure : into his work, Tabā' i' al-hajawān ('The Natural Properties of Animals'), written c. 1120, Sharaf Al-Zamān Tāhir Marvazī inserted a variety of information gathered from Muslim merchants who traded with the peoples of the Volga basin and beyond, among which is the following description :

At a distance of twenty days from (the Bulghārs), towards the pole, is a land called Isū, and beyond this a people called Yura; these are a savage people, living in forests and not mixing with other men, for they fear that they may be harmed by them. The people of Bulghār journey to them, taking wares, such as clothes, salt and other things, in contrivances (lit. 'utensils') drawn by dogs over the heaped snows, which (never) clear away. It is impossible for a man to go over these snows, unless he binds on to his feet the thigh-bones of oxen, and takes in his hands a pair of javelins which he thrusts backwards into the snow, so that his feet slide forwards over the surface of the ice; with a favourable wind (?) he will travel a great distance by the day.
(Minorsky 1942, 34)

In 1253, while on a mission to Mongolia, William of Rubruck recorded in his Itinerarium that in the region of what is now the Irkutsk, to the west of Lake Baikal, lived the Oengai ...

who tie polished bones under their feet, and propel themselves over the frozen snow and on the ice, with such speed that they catch birds and beasts.
(Rockhill 1900, 198)

Much better known and closer to home is the account by William fitz Stephen of skating on Moorfields, included in the preamble to his Life of Thomas Becket, written 1170-83 :

... Others, more skilled at winter sports, put on their feet the shin-bones of animals, binding them firmly round their ankles, and, holding poles shod with iron in their hands, which they strike from time to time against the ice, they are propelled swift as a bird in flight or a bolt shot from an engine of war. Sometimes, by mutual consent, two of them run against each other in this way from a great distance, and, lifting their poles, each tilts against the other. Either one or both fall, not without some bodily injury, for, as they fall, they are carried along a great way beyond each other by the impetus of their run, and wherever the ice comes in contact with their heads, it scrapes off the skin utterly. Often a leg or an arm is broken, if the victim falls with it underneath him; but theirs is an age greedy for glory, youth yearns for victory, and exercises itself in mock combats in order to carry itself more bravely in real battles.

(Douglas and Greenaway 1953, 961)

Olaus Magnus (1555) illustrates in two woodcuts this same method of propulsion (Pl. 46)⁽⁴⁶⁾ and gives a fascinating description of the competitions which took place at the time when iron skates were beginning to achieve some popularity in the north :

There is another type of competition in which the contestant, using flat, polished lengths of iron, or flat deer or cattle bones, tibias in fact,⁽⁴⁷⁾ which have a natural slipperiness because of their inherent greasiness, measuring one foot and fastened to his feet, races at high speed over slippery ice only. He maintains his speed over the flat surface of the ice by a continuous sliding movement. Where this sort of competition is held, you will everywhere see men enthusiastically racing to and fro competing for prizes : the length of a lap over the frozen, mirror-like lakes is set at eight or twelve Italian miles or less, each way. The prizes are silver spoons, brass pitchers, swords, new clothes, and young horses - the last most frequently. The competitors who outstrip the others are the ones who wear, fastened to their feet, deer shins which they have filed down to a broad surface and greased with pork fat, because, when the shin bones are greased like this, there is no possibility of their being impeded or clogged by those frozen drops of water (which rise up as though through holes in the ice in conditions of severe cold) in the way that iron is, however much it is polished and oiled. Certainly there is no lubricant for iron which suits it better than grease suits deer or cattle shin bones, already slippery with their own matching fattiness. And so, whenever the ice is clear, and not covered with snow, and two or three fingers thick, then it is that these sports can be held with comparative ease and safety.

(Olaus Magnus 1555, Book I, Chapter 25)

Prowess on the ice was evidently a valued accomplishment, something worth boasting about : in the man-matching between Sigurd Jerusalemfarer and his Brother Eystein, described in Heimskringla, Book XIII, Chapter 24, Eystein boasts that :

... I could swim as far as you, and could dive as well as you; and I could skate so well that nobody could beat me, and you could no more do it than an ox.
(Laing and Foote 1961, 298)

A number of other references to descriptions of skating in Norse texts are occasionally cited (see, for example, Munro 1897, 297-8) but none are supported by present-day scholars.

The origins of bone skates are still obscure. Various claims for a prehistoric ancestry stretching back as far as the Neolithic were made in the last century. These were summarized and subsequently dismissed by Munro (1894, 185-7). While Munro's incisive approach makes refreshing reading after the highly speculative theorization of his predecessors in the field, his rejection of a prehistoric introduction was apparently a little premature. A few years later, Herman (1902, 222) published an 'undoubtedly prehistoric pair' made from horse metacarpals and found at Verebely in Hungary, a metal-working site of Bronze Age date. Another allegedly Bronze Age pair, made from horse radii, is known from the village of Hüngheda in Thuringia (Sellman 1911, 68-70), and together these form the earliest examples which can be dated with any degree of certainty. The Bronze Age skates from the Swiss Pfahlbauten mentioned by Tschumi (1949, 621) seem to be the same items whose significance Munro had half a century earlier placed 'on a par with the finding of an exploded gun-cartridge at the bottom of a prehistoric cairn' (Munro 1894, 197), implying that conta-

mination by later material could not be ruled out. If skates were, however, introduced by the Bronze Age, then some at least from these lake-dwelling sites may not be entirely out of context. Another lake-side settlement, at Donia Dolina in Bosnia, has produced a skate for which a late Hallstatt date has been claimed (Čurčić 1912, 534-6).

Well-stratified Iron Age examples from the La Tène period are known from Mühlhausen in Thuringia (Sellman 1911, 68-70) and others of late 2nd-century to early 4th-century AD date come from a habitation site near Frankfurt (Marschalleck 1940, 302). A number of skates of uncertain date have been noted from Austria (Vohnicky 1933, 85). They are known in the Roman Iron Age in Saxony (Enderle 1977, 137) where they are common in settlements of the Slavic period (c. 600-900; Jacob 1911, 220; Jacob-Friesen 1974, 690, Abb 862) and in Poland, for example from Gniezno (Kostrzewski 1949, 350-1), Kołobrzeg (Rulewicz 1958, 353, Fig. XI-XII), Szczecin (*ibid.*, Fig. II; Leciejewicz *et al.* 1972) and Wolin (*ibid.*, Fig. VI-VII; Filipowiak 1956, Tab. II, 1), and occur in Russia from the last millennium BC until the 12th century AD (Semenov 1964, 191). In the Netherlands large numbers have been found, particularly in the Frisian terps, but none is demonstrably pre-Carolingian in date (Roes 1963, 57-9). A number of later examples may also be noted from Holland (Glazema 1950, 23-5; van de Heide 1956, 116; Trimpe-Burger 1957, 137-8). From Belgium comes one skate supposedly of Frankish origin, found in a terp at Vlissegheem in western Flanders (de Loë 1939, 178), and three more have been excavated from a 12th century context at Grimbergen, Brabant.

In Scandinavia the earliest bone skates so far recovered are from Sorte Muld, Bornholm, dated by associated coins to the 5th or early 6th century

AD (Klindt-Jensen 1951, 20; 1957, 140-1), and from the migration period settlement at Vallhagar, Gotland (Stenberger 1955, 857-8, 1105-7).

Skates of Viking date have been found on the latter island at Ihre (Stenberger 1961, 18-20) and contemporary examples come from Trelleborg (Nørlund 1948, 135) and Birka (Arbman 1943, 38, 187, 284; Stenberger 1955, 1106). An interesting example, carved with a rudimentary human face, was found during excavations at Viborg (Nielsen 1968, 38). They are well represented in the medieval cities of Oslo (Grieg 1933, 264-5), Bergen (loc. cit.), Lund (Blomqvist and Mårtensson 1963, 207), Trondheim (Grieg 1933, 264; Long 1975, 25) and Århus (Andersen et al. 1971, 141-2). Others of medieval date come from a farmstead at Fole, Gotland (Bohrn 1942, 68).

Many skates have been recovered from early excavations in this country (MacGregor 1976, Table 1), particularly in London and York : over fifty skates in various collections can be ascribed with certainty to each of these cities and a similar number of unprovenanced examples may well have come from either one of them. Lincoln too is said to have been prolific (Allen 1896, 36) but the skates seem to have been largely dispersed. Virtually all of these early finds from England must be regarded as unstratified, but a good many of those from York at least may be of Anglo-Scandinavian or early medieval date (Radley 1971, 55-7). One example, again not securely stratified, came from the Saxo-Norman kiln site at Torksey, Lincolnshire,⁽⁴⁸⁾ and others, perhaps of Tudor date, were found at Crowland, Lincolnshire (M. W. Thompson, in Semenov 1964, 191, n 1). A rather poignant find was made in Ipswich during re-building in College Street in 1899, when a pair of bone skates was found with the remains of a female skeleton embedded in the mud of the former river

course (Layard 1900, 183-8). More recently-excavated examples show an ancestry stretching back in this country at least to the 8th century, as at Bedford (Miss J. Hassal, personal communication), Ipswich (Smedley and Owles 1963, 304-35) and York (MacGregor 1976, 71).

The archaeological and historical evidence outlined above is complemented by several accounts from the last two centuries of skating on bones. Herman (1902, 218-22) provides an account of their use in the 19th century, illustrating various methods of skating, including the use of two spiked poles instead of one; he shows too the technique of fitting a small sail between the two poles, for effortless skating with a following wind. Lewicki (1953, 395) and Čurčić (1912, 536) both mention the use of two poles in recent times in Bosnia, but in the north a single pole was normally used. Confirmation that the binding of skates to the feet was entirely optional comes from Hungary (Herman 1902, 220-2; see also MacGregor 1975b, Fig. 1), the Sudetenland⁽⁴⁹⁾ and from Sweden, where traditionally only children and beginners made use of bindings (Berg 1943, 82). The same was true in some areas of Finland, while in others no one ever used bindings (Vilppula 1940, 52). Berg records that in parts of Sweden bone skates were not merely worn for sport but were used as an everyday means of travelling over the frozen rivers and lakes. They were also used for fishing over thin, transparent ice when pike and other fish could be followed, stunned through the ice with a blow from a club and subsequently retrieved with a fish spear through a hole hacked in the ice with an axe (Berg 1943, 82-3). A 10th-century grave at Ihre, Gotland, containing the remains of a youth with a pair of bone skates and a pair of bone sledge-runners at his feet and also (among other items of fishing gear)

an ice axe (Stenberger 1961, 18-20), suggests that the practice had a considerable antiquity. In the coastal regions of Finland, bone skates remained in use until only a generation ago (Vilppula 1940, 51-8), and in Estonia they survived until recently as playthings for children, particularly in Swedish settlements (Berg 1943, 86). An English antiquary purchased a pair which had been in current use from a small boy in Iceland in 1878 (Allen 1896, 33-4). In England their later history is not well documented, but they are reported to have survived in London until the latter half of the 18th century (C. R. Smith 1848, 169), in Birmingham until the 1880s (Balfour 1898a, 35), and in the East Anglian fens until about 1900 (Porter 1969, 43).

The National Skating Palace in London was the scene of some experiments with bone skates in the 1890s, in which some success was achieved without using a spiked pole. N. Brown (1959, 18) concluded that because it was then found possible to strike off from the toe, there was some chance that bone skates had been used in this manner in the past. There is, however, no evidence to suggest that this was the case; the lack of binding holes on many skates, the frequent absence of upswept toes and the invariably flat underside, all indicate conclusively that the skates always remained flat on the ice. Wherever skating on bones was practised in recent years a pole was used; modern examples of skating poles from Finland are illustrated by Vilppula (1940, Fig. 2), from Sweden by Berg (1971, Fig. 2) and from Hungary by Herman (1902, Taf. V, 1). No poles nor iron tips which may have served them have yet been recognized in Britain, although there exist many socketed bone points of a type (Fig. 43) which has been thought in the past to have been used as tips for skating poles (Layard 1908, 74; Guildhall Museum Catalogue, 154). No

record survives of bone having been used for this purpose, however, and it has been suggested elsewhere (p. 119) that these points are too diverse in size and shape to have fulfilled this function satisfactorily.

Geographical considerations

Bone skates, naturally, are not found further south than the normal occurrence of winter ice. The northern limit is also, to a large extent, set by climatic factors, in that skates are only really useful in areas where there are long periods of icy weather with very few heavy snow falls (Berg 1971, 4). Such climatic considerations may also affect local distribution within these limits : in Norway, for example, over four hundred skates recorded from Oslo compare with only four from Bergen (Grieg 1933, 264-5). Even allowing for a possible difference in the intensity of archaeological activity in these two cities, the more temperate climate of Bergen may have been a factor in determining this disparity (Herteig 1969, 198).

Theorization on past climatic conditions on the evidence of bone skates is highly speculative. Radley's suggestion that the large number of skates from York must imply that the Anglo-Scandinavian period was characterized by winters which were frequently long and hard, and during which the river was frozen for long periods (Radley 1971, 57) seems reasonable enough, but no corroborative evidence has so far been found among contemporary biological remains from the city; I have recently suggested (in Addyman et al. 1976, 227-8) that the undoubtedly good skating conditions were probably created by more complex climatic and geographical considerations than are allowed for in Radley's hypothesis.

Between their initial introduction and their final displacement by steel skates (a process which began on the continent in the 14th or 15th century but which was, on the evidence cited above, only completed within living memory), a great deal is known about them from historical and archaeological as well as ethnographic sources. Far from being shrouded in obscurity, therefore, bone skates may be counted among our better-known antiquities and should henceforth be treated with the certitude merited by several millennia of widespread use.

Catalogue

- 34.1 Bedford, Bedfordshire
Miss J. Hassal, personal communication
- 34.2 Dublin, Co. Dublin
Viking and Medieval Dublin, Cat. Nos. 147-9
- 34.3 Durham Castle, Co. Durham
M. O. H. Carver, personal communication
(see Medieval Archaeology 23 (1979) 24, fig. 14)
- 34.4 Waltham Abbey, Essex
Huggins 1972, 39-127
- 34.5 Winchester, Hampshire
MacGregor, forthcoming
- 34.6 Huntingdon, Huntingdonshire
R. Smith, personal communication
- 34.7 Lincoln, Lincolnshire
Lincoln Archaeological Trust, unpublished
- 34.8 Torksey, Lincolnshire
M. W. Barley, personal communication
- 34.9 London (Fig. 83 C-D)
MacGregor, forthcoming
- 34.10 Thetford, Norfolk
Norwich Castle Museum, unpublished

- 34.11 Northampton, Northamptonshire
Williams 1979, 315, Fig. 140, 75-6
- 34.12 Oxford, Oxfordshire
Henig, in Durham 1977, 160-3, Fig. 37, 1
- 34.13 York, Yorkshire (Fig 88B)
Radley 1971, 55-7
Richardson 1959, 100
Wenham 1970, 165-8
MacGregor, forthcoming

SLEDGE RUNNERS (Fig. 89)

Two distinct types of sledge runners may immediately be distinguished on the basis of raw material : the first and most numerous consists of runners made from long bones, principally the metapodials and radii of horses and cattle, while the second is derived from the jaw bones of the same animals.

Of these two groups, long-bone runners are the best-known and most widely distributed. In appearance they resemble the bone skates already discussed, except that they invariably have fixing holes aligned from top to bottom (ie, in the dorso-palmar plane). These holes were used in fixing the runners to the sledge. Although no more than the runners of these sledges have ever been found in archaeological contexts, the survival of the type into the 19th century in various parts of central and northern Europe provides illustrations of the kind of superstructures with which they would have been associated. The simplest form consists of a plank base, pointed or rounded at the front, to the bottom of which the runners were nailed or pegged. An illustration of a sledge of this type in use is given by Herman (1902, Abb 135). A common refinement of this type was the addition of a three-legged stool on which the user could sit, with his feet on the baseboard . This practice was not as precarious

as it might seem, for sledges of this type were not (necessarily) used for downhill tobogganning : normally they would be used on the frozen surfaces of lakes, the motive power being provided by two iron-tipped poles wielded by the sledger in much the same way as those used by bone skaters (p. 296). Sledges of this type are illustrated by Balfour (1898, Figs. 2, 6), Goldstern (1921, Taf XXVIII, 7-8) and Herman (1902, Abb 136-40), while a verbal description of the use of such in the mid 19th century in Gotland is given by Berg (1971, 9). A refinement of this type took the form of a four-legged stool with the legs fitted directly to a pair of bone runners. In sledges of this type the feet usually fitted into a perforation cut in the upper surface of the bone only (Balfour 1898, 249), as distinct from the holes on sledges of the base-board type which had perforations running right through them, sometimes countersunk on the underside to accommodate the head of the nail or peg. In addition to the simplest types illustrated by Čurčić (1912, Fig. 57) and Moszyński (1929, Fig. 514) are more elaborate examples with cross-braced legs (Balfour 1898, Fig. 5) or with ornately carved seats (Goldstern 1921, Taf XXVIII, 1-4).

None of these sledges could be considered as more than childrens' playthings, but the possibility that some runners from archaeological contexts could have fulfilled a more serious role is underlined by observations made on the Fens towards the end of the last century. Goodman and Goodman (1882, 27) describe sledges mounted with bone runners used by wild-fowlers to get within range of their prey over frozen water : the gunner lay prone on the sledge which had in front of it a framework camouflaged

with reeds, through which the duck-gun protruded. The wildfowler approached the birds by manoeuvring the sledge with a pair of spiked sticks. Balfour (1898, 247) saw such a sledge on the Fens in 1882, and an illustration of one in use is given by Porter (1969, Pl. I). Such an arrangement could also have been useful with a crossbow, although it would have been less satisfactory for conventional archery.

A few bone sledge-runners are known from England, although none can be securely dated. One was recovered at Stixwold Ferry, Lincolnshire, during construction work on the Great Northern Railway in 1848 (Proc. Archaeol. Inst. 1848, XXXII); another was found at a depth of 2m in peat at Ramsey, Huntingdonshire (Munro 1897, 300), and a third at a depth of 2.5m on Mildenhall Fen, Suffolk (The Field 1893, 990). An unpublished 19th-century find from Billiter Street, London, is shown in Fig. 89. Continental finds serve to indicate the chronological limits within which these finds may fall. A few claims have been made there for a prehistoric introduction : Herman (1902, 231) places a number of Hungarian runners in the late Neolithic or early Bronze Age, though the secure stratification of these early finds cannot be guaranteed; Ćurčić (1912, 535-6) presents evidence for late Hallstatt sledges of this type in Bosnia. Kostrezewski (1949, 350-1) finds indications of their use in (perhaps) Slavic levels in Gniezno, and a single pair was found in a grave of the Viking period at Helvi, Gotland (Stenberger 1961, n 6, Abb 51) along with a pair of skates already mentioned (p.295). Sledge runners of 11th- or 12th-century date come from Potzlow (Herman 1902, 231), Kūpenick (Herrmann 1962, Taf 4) and Teterow (Schuldt 1960, Abb 5; Unverzagt and Schuldt 1963, 116, Abb 45), and others of medieval

date come from Wolin (Rulewicz 1958, 353; Tab VII, 5), Szczecin (ibid., Tab II, 2), Oslo and Bergen (Grieg 1933, 264) and the former island of Schokland, Zuiderzee (van de Heide 1956, 116, Fig. 7, f-g). On this evidence, it would not be unreasonable to propose an introduction into the British Isles of this type of sledge from as early as the Middle or Late Saxon period, with a proven survival until the early years of the present century, corresponding closely with the chronological distribution of the related bone skates (p. 294).

In the second group of sledges considered here, the mandibles of horses and cattle formed the raw material for the runners. Once again, much of the evidence relating to them comes from ethnographical sources, but a currency at least as early as the medieval period can be demonstrated.

In their simplest form they consist of an entire lower jaw with a plank seat fitted over the teeth. Some illustrations show the user facing in the same direction as the jawbone, as in a well-known engraving after Pieter Breugel the Elder (reproduced in Ijzereef 1974, Pl. XXVI, 2), while another after Hendrik Avercamp shows the jawbone reversed (op. cit., Fig. 5); in either case the sledge is propelled with two spiked sticks, although eye-witness accounts survive of their use in downhill tobogganning (Berg 1971, 8). One variation on this method of construction involved splitting the jawbone at the front and mounting the two halves parallel to each other on a wooden base (Balfour 1898, 251, Fig. 9), while another apparently employed two jawbones mounted side by side in catamaran fashion (Ijzereef 1974, 183-4, Fig. 4b). Evidence for the existence of the latter type of sledge rests entirely on a study of the wear marks on one half of

the jawbone from Dordrecht : from the angle at which the wear marks crossed the sliding surface of the Dordrecht mandible, Ijzereef (loc. cit.) calculated that it was probably mounted in this way, while the fact that the vertical ramus had been removed concurred with his suggestion that the innermost ramus of each jawbone would have been cut off for this type of sledge.

Apart from the Dordrecht sledge runner, which is perhaps of 14th-15th century date (Ijzereef 1974, 181), only one other example has been noted from an archaeological context : from excavations at the Ebor Brewery site in York, a fragment of a similar runner has been recovered from a medieval context (MacGregor, forthcoming).

Contemporary illustrations provide useful proof of their currency and method of use : the earliest of these appears as an incidental illustration in the margin of a Flemish manuscript of the first quarter of the 14th century held in the Bodleian Library, Oxford (Randall 1966, Pl. XCVII : 471); two more sledges appear in paintings by Pieter Bruegel the Elder, one entitled The St. George Gate at Antwerp, dated c. 1555, and the other an Adoration of the Magi of two years later (reproduced in Ijzereef 1974, Pl. XXVI, 1-2); a print after van der Borcht of c. 1560 shows three examples of jawbone sledges (Wichers 1888, Pl. following p. 64), while an illustration by Avercamp of c. 1620 provides the only evidence for their being used in reverse (reproduced in Ijzereef 1974, Fig. 5).

Their survival into the 19th century is testified from Brandenburg (Herman 1902, 231-2) and Pomerania (Balfour 1898, 251), but the period of their initial development has not yet been established before the Middle Ages.

Catalogue

- 35.1 Ramsey, Huntingdonshire
Munro 1897, 300
- 35.2 Stixwold Ferry, Lincolnshire
Proc. Archaeol. Inst. 1848, XXXII
- 35.2 a London (Fig. 89A)
Pitt Rivers Museum, unpublished
- 35.3 Mildenhall Fen, Suffolk
The Field 1893, 990
- 35.4 York, Yorkshire
MacGregor, forthcoming

CASKET MOUNTS (Fig. 90-1, Pl. 47)

The material in question may be divided into two groups; firstly, decorative strips or plaques which were applied to caskets or boxes made of wood, and secondly, small caskets which were themselves made entirely of bone.

By far the majority of the surviving pieces belonging to the former group are simple rectangular or mitred strips. Very few plaques with any attempt at representational carving are known and, for the most part, decoration is limited to simple linear or geometrical devices. The origins of the series appear to lie in the late Roman period : examples of Roman date are known from Lydney Park (Wheeler and Wheeler 1932, 91, Pl. XXXI) and Gloucester (Hassal and Rhodes 1974, 33), Richborough, Kent (Bushe-Fox 1926, 47, Pl. XV; *ibid.* 1949, 152, Pl. LVII) and Leicester (Hebditch and Mellor 1973, 52, Fig. 21), while that from the Anglo-Saxon cemetery at Caistor-by-Norwich was thought to be perhaps of late 4th or 5th century date (Myres and Green 1973, 85-7, 191-2, Pls. XX-XXI). Similar dates may be postulated for other examples from Illington (*ibid.*, 86), Abingdon (Leeds and Harden 1936, 18, 27) and, perhaps, from Dover (T. D. Kendrick

1937, 448, Pl. XCVII). Rather later in origin are some fragments from a 7th-century cremation in Asthall Barrow, (Leeds 1924, 118, Fig. 4), and a number of decorative bone plaques said to have come from the crannogs of Ballinderry and Strokestown (Munro 1890, 361-2, Fig. 112) may also belong to about this time. Among the later caskets found in England may be included one from a pit at South Cadbury Castle, represented by a number of strips with incised ring-and-dot decoration and a plaque incised with a crude interlace design, datable to about the early 11th century (Greene, in Alcock 1970, 22-3). Three further caskets of the 11th and 12th centuries include one from Ludgershall Castle, in which the wood had decayed but the strips which decorated the lid were found in their original relationships (Medieval Archaeol. 10 (1966), Pl. XV), as well as two from Coppergate in York : the first of these was found during rebuilding of the corner block of Castlegate and Coppergate at the beginning of the century (Benson 1906, 73, Pls. II-III) and the second in 1978 at 16-22 Coppergate (Fig. 90). A third example from York was found in a Saxo-Norman context under York Minster (MacGregor, forthcoming).

On the Continent, several mounts of this general type are known from late 4th- or 5th-century contexts, including one from a Laetengrab of c. 400 at Fécamp, Seine-Maritime (Werner 1962, 150, Taf II, 9; Böhm 1974, 316, Taf 122, 13); others of Frankish date come from Maroeuil, Pas de Calais (Loß 1939, 161-3, Fig. 132) and Weilbach, Main-Taunuskreis (Schoppa 1953, 44-50, Taf 9; ibid. 1959, 27-8, Taf 16-7). One example, incorporating a chi-rho monogram in its decorative scheme came from Heilbronn, Baden-Württemberg (Goessler 1932, 294-9); there were several fragments

of decorative strip among the contents of a 7th-century grave in the cemetery at Junkersdorf near Cologne (La Baume 1967, 78-9, Taf 7); another, virtually intact, and thought to be of 8th- to 10th-century date, was found at Stebbach, Nordbaden (Lutz 1970, 104, Abb 67). Goldschmidt (1918, Pls. LIV, LVI, LVIII) illustrates a number of other caskets dated on stylistic grounds to about the 8th to 10th centuries. Some fragments from the Frisian terps, although lacking precise dates, will no doubt fall within the limits established above (Roes 1963, 79-80, Pl. LXIII).

In some cases, as in the majority of the fragments from York Minster and in a single piece from Goltho Manor (MacGregor, forthcoming), the raw material used in the manufacture of these strips is antler. Rib bones were also used, however : the Frankish casket from Maroeuil was said to be ornamented with strips of split bovine ribs (de Loë 1939, 161-3); the lids from Ludgershall Castle, Coppergate and a variety of strips from various sites in Lincoln (unpublished) are of the same origin, as betrayed by the structure of the cancellous tissue on the back of the strips (p. 11, Pl. 6). Amongst the mounts from York and Perth, those pieces for which bone rather than antler has been used are the large flat plaques illustrated in Pl. 47 : the dimensions of these pieces are such that only one bone from the normally-available mammalian skeleton could have been used - the broad and flat expanse of the scapula. This source is confirmed by the presence of a band of exposed cancellous tissue on the back of one of the plates (Pl. 47) marking the site of the projecting spine (p. 11). The mounts from Lydney Park (Wheeler and Wheeler 1932, 91) and those from Asthall Barrow (Leeds 1924, 118) have

both been published as being of ivory, but confusion between ivory and bone has been frequent in the past and it is not unlikely that a fresh examination would prove that both were of bone or antler. Decorative strips of ivory were commonly used on caskets of Byzantine origin, however, particularly in the 9th and 10th centuries (Talbot Rice 1968, 438), so that the possibility of this medium being used or being imported into the British Isles cannot be ruled out.

Several of the above strips carry traces of iron corrosion from the rivets which held them in place. On others bone or antler pegs were used in place of iron rivets. The latter were not only less unsightly than their iron counterparts but they also allowed decorative schemes to develop without interruption (the incised ornament being carried over the heads of the flush-fitting pegs after they were inserted). It should be noted that the strips were secured to the flat surface of the wood by the pegs and were not, it seems, inlaid as some writers have suggested.⁽⁵¹⁾

A rather limited repertoire of decorative schemes is found on these mounts, being confined for the most part to linear and compass-drawn motifs of the simplest kind. The designs were evidently executed on the strips before assembly, the individual lengths being then cut to fit the space available without regard to the incised patterns. This may be seen clearly on the caskets from Ludgershall Castle (Medieval Archaeol. 10 (1966), Pl. XV) and 16-22 Coppergate (Fig. 91). These examples also incorporate

what seems to be an otherwise uncommon form of decoration in which the strips are pierced with large-diameter holes, which were backed with sheet metal in a more or less decorative manner : the gilded sheet copper on the

Coppergate casket (Waterman 1959, 86) must have looked quite attractive, but in the case of the Ludgershall box the backing of lead can have added little to its appearance. A richer example from Emden, Ostfriesland, with gold leaf backing to its bone plates, is dated by P. Schmidt (1969, 273-4) to c 11th century. Waterman (loc. cit.) compares this backed openwork treatment to that found on a number of Irish shrines, particularly of the 11th and 12th centuries, and it is also found on a number of composite combs of similar date (p. 230). Large-diameter holes are also to be found on the strips decorating the caskets from Stebbach (Lutz 1970, Abb 67) and St. Gereon's, Cologne (Goldschmidt 1918, Pl. LVI), but no mention is made in those publications of metal backing.

Most of the examples cited above have been recovered from what are clearly secular - in some instances even pagan - contexts, although one or two of the continental examples have survived in church treasuries and several have elements of Christian symbolism in their decorative schemes : two of those illustrated by Goldschmidt (1918, Abb 31, Pl. LVI) include plaques with incised equal-armed crosses, as does the gold-backed Emden casket (P. Schmidt 1969, Fig. 5), while the Weilbach casket carries a composite cross on the lid (Schoppa 1953, Taf 9). The Heilbronn casket displays an alternative Christian symbol in the form of a chi-rho (Goessler 1932, Abb 1). There seems no reason why the type as a whole should be invested with any particular ecclesiastical significance, however, and there can be little doubt that the majority were used for storing small items of personal value rather than as reliquaries, as has been suggested. The remains of small wooden boxes without bone decorations are common finds in Anglo-Saxon graves, where they frequently contain trinkets and jewellery,

combs and shells (see, for example, Lethbridge 1931, 53-7, 61; *ibid.*, 1936, 17, 25; C. R. Smith 1856, 66-8). No doubt most of the decorated examples performed a similar sort of role.⁽⁵²⁾ Their more elegant counterparts in the Byzantine world, in which panels of figure sculpture are often surrounded by strips ornamented with repeating rosettes (all executed in ivory or bone) (eg Dalton 1909, 16, Pl. XI) fall into two broad groups : Talbot Rice (1968, 438) has suggested that those members of this 'rosette group' which carry secular ornament were probably marriage gifts while those with religious scenes may have contained relics or church treasures.

Catalogue

- 36.1 Abingdon, Berkshire
Leeds and Harden 1936, 18
- 36.2 Dover, Kent (Fig. 90 E-C)
T. D. Kendrick 1937, 448
- 36.3 Goltho Manor, Lincolnshire
MacGregor, forthcoming
- 36.4 Lincoln, Lincolnshire
Lincoln Archaeological Trust, unpublished
- 36.5 Caistor by Norwich, Norfolk
Myres and Green 1973, 85-7
- 36.6 Illington, Norfolk
Myres and Green 1973, 86
- 36.7 Northampton, Northamptonshire
Williams 1979, 315, Fig. 141, 83
- 36.8 Ballinderry, Offaly
Munro 1890, Fig. 112
- 36.9 Asthall, Oxfordshire
Leeds 1924, 118, Fig. 4
- 36.10 Strokestown, Roscommon
Munro 1890, Fig. 112
- 36.11 Ludgershall Castle, Wiltshire
MacGregor, forthcoming

- 36.12 Cadbury Castle, Somerset (Fig. 90D)
K. T. Greene, in Alcock 1970, 22-3
- 36.13 York, Yorkshire (Fig. 90A, C ; 91)
Benson 1906, 75
Waterman 1959, 86-7
MacGregor, forthcoming

CASKETS (Fig. 92, Pls. 48-51)

As well as the decorative bone and antler casket mounts mentioned above, which were used merely to ornament boxes otherwise constructed of wood, a number of boxes made more substantially of cetacean bone panels must be considered.

Some of these, such as the Fife casket (Anderson 1886, 390-6), rely to some extent on metal fittings to hold them together. Four riveted bronze bands encircle the Fife casket, incorporating the hinge and lock mechanisms; the end panels are dovetailed into the sides, but in addition the vertical corners are covered with decorative metal strips and each is clamped by a pair of right-angled riveted clasps, with an additional vertical strip in the centre of the panel. The five fields so formed on the long sides and the lid are filled with carved angular and curvilinear ornament, which also embellishes the end panels. All the panels except the base (which was judged (loc. cit.) to be a later addition) display some traces of red staining. Stevenson (1955a, 94) draws attention to certain stylistic parallels which can be detected between the Fife casket and Anglo-Scandinavian stone sculpture. The free rings occurring in the interlace and the hatched pellet-like pattern which fills some of the interstices in the ornament would certainly be consistent with a date in the Viking period.

The so-called Eglinton casket shares many constructional features with the Fife casket, including the use of dovetail joints on the end panels (Callander 1926, 110). Whether or not it falls within the date range to which this survey is restricted is, however, open to doubt.

The cetacean bone box known as the Franks Casket stands as the supreme example of its type, not only because of its early 8th-century date but more particularly because it is manufactured without the use of functional metal bindings of the kind described above. The constructional details of the Franks casket (Fig. 92, Pls. 48-51) presumably reflect contemporary carpentry techniques : the method of jointing is so masterful as to be inconceivable that it could have been developed in response to this particular need and, in the absence of comparably constructed bone caskets, we may assume that the technique was evolved in the production of wooden boxes. The casket, which measures some 23 by 19 by 10.5cm, is made of bone, seemingly derived from the jawbone of a whale. The key to its construction lies in the complex upright members found at the four corners (Fig. 92, Pl. 51). These are slotted vertically on two adjacent sides to receive the rebated ends of the side plates; in addition, within each of these slots is a pair of rectangular sockets, cut to receive corresponding tenons projecting from the ends of the side plates. (These are best seen on the panel now in Florence, illustrated by Ross 1970, Pl. XII.) The uprights and the side plates are also channelled horizontally to receive the edges of the base. Once the four sides and the base had been assembled, the mortice and tenon joints at the corners were secured by rivets or pegs, originally no doubt of bone or, perhaps (G. B. Brown 1930, 20), of wood, driven through drilled holes which intercept each other in pairs at common points on the insides of the uprights; in this

way, only two holes (instead of four) are visible on the inside of each upright. Undecorated areas have been left in reserve on the outer edges of the side panels where these pegs emerge; originally they were covered with decorative silver mountings, now lost (G. B. Brown, 1930, 20). To judge from residual metal staining, mounts which were lozenge-shaped rather than rectangular had been fitted to the casket, but Leslie Webster has expressed doubt as to whether these were original.⁽⁵³⁾ Traces of small feet have been noted under the four corners.

The lid (Pl. 50), now fragmentary, originally sat on a rebate running around the top edge of the box and was secured with a lock on one side. The lock itself was evidently renewed on at least one occasion, to judge from the many fixing holes which survive (Pl. 48), although it is possible that some of these were connected with the fixing of a conjectural metal lock plate (G. B. Brown 1930, 22-3). The fact that the lock was an original feature of the box is shown by the way in which the carved ornament respects the square field around the keyhole. Curiously, no similar provision was made for the hinges at the opposite side of the casket, so that inevitably they must have concealed part of the carved decoration. This fact has led to doubts as to whether the hinges represented now only by rivet holes (Pl. 49) could have been original; if, however, they were not and there were no original hinges, then it is difficult to see how the lock could have been effective.

The surviving central panel of the lid is rebated along the upper edges of its long sides and would have been overlapped by the flanking panels. An undecorated strip (doubtless a late repair) to one side of it is correspondingly rebated on its underside and is morticed at the ends to

engage with the (now missing) edge plates, perhaps reflecting an original feature. Mrs. Webster has suggested that the missing lid panels might have been of wood covered with decorative plates of precious metal : this could account for their disappearance as the casket is known to have been stripped of its metal mounts in the late 18th or 19th century (G. B. Brown 1930, 20). An undecorated circular field in the centre of the lid was presumably covered originally by another metal plate, possibly incorporating a handle. From a constructional point of view, Mrs. Webster finds the closest parallel in the so-called Brescia casket.

The knife-cut ornament of the casket is of the highest calibre. It incorporates a runic inscription relating the circumstances in which the whale from whose bones the casket is made was stranded :

Hronaes ban fisc flodu ahof on fergen berig,
 Warth gas ricg rorn thaer he on greut giswom

The British Museum Anglo-Saxon Guide gives the translation :

The fish-flood (sea) lifted the whale's bones on to the
 mainland; the ocean became turbid where he swam aground
 on the shingle.

TRIAL PIECES (Fig. 93)

A final category of material to be considered is that generally labelled trial pieces : while some of these do seem to represent first essays by carvers, in which the details of schemes ultimately to be executed on other pieces (or in other media) were worked out, it will be seen that others are finished to a higher standard which renders the accepted terminology less satisfactory. The motifs used in both categories indicate a currency

during the Viking period.

Amongst the first category, designs are found cut on bones of a wide variety : scapulae have been found decorated in this way in York (York Archaeological Trust, unpublished) and in Ireland (Wilde 1863, Fig. 228; Hencken 1950, 181); ribs were used in London (Guildhall Museum Catalogue, Pl. 11, 17) as were the jawbones of cattle (Cottrill 1935, 69). The rather more suitable medium of long bones of horses and cattle appear at York (Grove 1940, 285-7) and in Ireland at Lagore (Hencken 1950, 181-3, Figs. 95-6), Dublin (Ó Ríordáin 1971, Fig. 21a) and elsewhere (Laing 1975, 249). Amongst the latter group are many of the more finished pieces in which small panels of ornament are executed to very high standards. The effort expended on these pieces to bring them to this degree of refinement demands an explanation other than that offered for the foregoing. Two possibilities suggest themselves : one is that casts were taken of these panels in clay or models were constructed from them in wax (cf. p. 144), to be used in the casting of decorative plaques in bronze, lead alloy or precious metal; the second is that thin sheet metal could have been moulded directly on to the bone to produce similar panels in a repoussé-like technique. Current work on the numerous trial pieces from Dublin may provide more conclusive answers to this hitherto unresolved problem.

Catalogue

- 37.1 Dublin, Co. Dublin
 O'Riordain 1971, Fig. 21a
- 37.2 Lagore, Meath (Fig. 93 A-E)
 Hencken 1950, 181-3, Figs. 95-6

- 37.3 London (Fig. 93F; Pl. 52)
Cottrill 1935, 69; Guildhall Museum Catalogue, Pl. LI, 17
R. A. Smith 1909, 162.
- 37.4 Strokestown, Roscommon
Munro 1890, 369, Fig. 118
- 37.5 York
Grove 1940, 285-7
Waterman 1959, 91, PL. XX, 1
York Archaeological Trust, unpublished

THE ARTIFACTS : NOTES

- (1) In the interests of brevity and in the hope of avoiding confusion, the county boundaries adopted here are those which existed before the local government reform of 1974. The Greater London area is referred to simply as London and no distinction is made between the Ridings of Yorkshire.
- (2) An interesting bone object with a hooked end found in London (Dennis 1978, Fig. 179, 133) may be a spindle of a type described by Patterson (1956, 201-2), having a slotted end for attaching the wool.
- (3) An attempt was made to find evidence of particularly favoured weights among the forty-three whorls from the Broch of Burrian (MacGregor 1974, 88-9) but without success. Oakley and Hall (in Williams 1979, 286-9) were able to distinguish some clustering around 10-16gm and 20-34gm among whorls of various materials found at Northampton. In considering bone whorls it should be noted that the consistent selection of femur heads as already noted would automatically result in some clustering, even though the particular weight of the femur head may have been only one factor in its original selection.
- (4) I was able to examine the Lincoln whorls through the kindness of Miss Jenny Mann, Lincoln Archaeological Trust.
- (5) An alternative form of tensioning, employing a second beam instead of weights is illustrated in a Monte Cassino manuscript of Rabanus Maurus De Originibus, dated c.1023 (reproduced in Salzman 1964, 195).
- (6) A 6th-century sword with this same feature, now in the Bergen Museum, is illustrated by Hoffmann (1964, Fig. 112).
- (7) In Norway the warp-weighted loom also survived until recent times, but only for the specialised task of weaving coverlets, whose manufacture did not require this particular tool.

- (8) Examples are held in the collections of the British Museum and the Museum of London, but in no instance can a British provenance be demonstrated.
- (9) The horizontal loom had, it seems, made its appearance in Poland by the 10th century.
- (10) Unlike the metapodials of even-toed ungulates (such as cattle and deer), which consist of fused pairs of originally-separate bones and which retain traces of their former dual nature (Fig. 10), horse metapodials derive from a single bone and are more regular in section, having no central septum.
- (11) I am grateful to Mr. Brown for allowing me to read his reports on objects from Winchester in advance of publication.
- (12) A self bow, being almost straight in its unstrung form, is invested with only a small amount of strain energy during stringing.
- (13) It seems unlikely that this could have been the case : the objections are the same as those raised by Balfour over fifty years ago to claims that the Homeric bows of Odysseus and Pandarus were of one horn only, namely that they would be hopelessly weak (Balfour 1921, 291-5). Indian bows constructed from a single buffalo horn are known, however : conceivably the Waterbeach bow could have been a recent introduction from the Far East.
- (14) The only bow to have survived from the Anglo-Saxon period was found at Chessel on the Isle of Wight (Clark 1963, 89), a self bow some 1.50m in length. A Viking age self bow was recovered from Ballinderry Crannog I (Hencken 1937, 139, Fig. 80).
- (15) It is not, of course, essential that the bow should be of composite structure but, for the reasons given on p. 152, composite bows could be made of a small size appropriate to these weapons.

- (16) Unpublished information from Professor J. D. Currey.
- (17) In this context it is interesting to note that the Sutton-Hoo lyre was stored in a beaver skin bag (Bruce-Mitford and Bruce-Mitford 1974, 196).
- (18) On classical references to amulets worn by animals, see Boon 1975, 62.
- (19) A disc of bronze immitating the form of the antler burr and found at Krastatt in Alsace (Roes 1963, 73-4) suggests, however, that the form as well as the material may have been considered important.
- (20) In a grave at Cassington, Oxfordshire, an iron ring of comparable size to those discussed here was found. Its cross-section is too sharp for it to have made a practical bangle and its position, together with the distribution of associated objects, gives support to the identification of both this and its ivory homologues as bag rings (Leeds and Riley 1942, 65, 69, Fig. 15; see also D. Brown 1977, 95-9).
- (21) Laing (1973, 70) actually refers to these as 'bead-headed pins'.
- (22) Details of these pins, found in association with a number of Grubenhauser on Swindon Hill in 1975, were kindly sent to me by Miss Caroline Washbourn.
- (23) On the significance of this fact, see p. 242.
- (24) This asymmetry seems to result from whole tines being used to form the side plates, a further example of stylistic influence being exerted by the form of the raw material.
- (25) It should be noted, however, that this suggestion has not met with universal acceptance (cf. A. Ritchie 1977, 188).
- (26) This form is also represented in the Anglo-Saxon cemetery at Dover (British Museum, unpublished), however, so that it cannot be regarded as exclusively Scandinavian. The Dover comb finds a late Roman parallel from Altenstadt in Upper Bavaria (Keller 1971, Taf. 33, 2).

- (27) Two Iron Age objects identified as possible wrest planks should also be noted : one from Dinorben, Denbighshire (Gardner and Savory 1964, 169-70) and the other from Dún an Fheurain, Argyll (Megaw, in J. N. G. Ritchie 1971, 106-7).
- (28) The perforations on the Sutton Hoo pegs (which are of wood) are at the shoulder rather than the tip as on most of the bone pegs discussed here, and clearly were fitted in the reverse manner. The same is true of a number of the 15th-century pegs from St Aldates, Oxford (Henig, in Durham 1977, Fig. 39).
- (29) The tuning pegs too were sometimes made of bronze : several examples found in Ireland are now in the British Museum.
- (30) Crane (1972, 27-8), however, has suggested that whistles of a particular type, so far found only in Frisia, may have been professionally made.
- (31) The other hand could then have been employed in playing a drum.
- (32) The Lincoln die already mentioned is aberrant in having 3, 4, 5 and 6 on the long sides and 4 and 5 on the ends.
- (33) The contemporary introduction of spindle whorls of similar forms and raw materials is discussed on p. 97. It is not impossible that some centrally-perforated discs may yet be playing pieces rather than whorls.
- (34) A riveted discoid counter was found during excavations at Trim Castle, Co. Meath, where it was identified (Sweetman 1978, 184) as being made of antler and having been mended in antiquity after splitting. The structural organisation of antler makes the possibility of it splitting in this way unlikely, however, and it is more probable that this is an example of original composite construction. Another example, found in Cologne, is in the British Museum (Dalton 1909, 83).

- (35) An interesting example of this type (Binding 1961, 73-6, Abb 21, 100), from an 11th or 12th century context at Schloss Broich (Rüthr) had a sheet of bronze interposed between its two riveted discs; this plate was exposed through decorative perforations cut in the upper disc in the manner also encountered in combs (p. 229) and casket mounts (pp. 307-8). The British Museum counter referred to in Note 34 has been similarly treated : Dalton (1909, 83) notes the angular perforations on the upper disc which he mistakenly assumes to have held inlays.

- (36) Similar pieces make their appearance on the continent in the 10th or 11th century : see Binding 1968, 73-6 for discussion and references.

- (37) Wilson (1970, 41), however, describes it as dyed.

- (38) The fact that the central intersection on the Ballinderry board is emphasised by a number of concentric circles suggests a connection with tafl.

- (39) Wilson (1970, 41) has suggested that even the Lewis men may not have been used in chess.

- (40) Various earlier opinions are summarised in Munro 1894, 185-97, reproduced later as Chapter 6 in Munro 1897.

- (41) The fact that the shin bones of these animals are the metapodials, whereas in man they are the tibias, may also have added to the confusion.

- (42) A Mr. Hartshorn of Tickhill, South Yorkshire, recalled using skates made from rib bones in his youth, about the turn of the century (P. C. Buckland, personal communication).

- (43) Zeitschrift für Ethnologie 4 (1872) Verhandlungen, 42.

- (44) See MacGregor 1976, n. 7, Appendix I.

- (45) A number of axial heel holes in bovine metapodials listed in MacGregor 1976, Table I, are set at an oblique angle, however, so that they penetrate the upper (posterior) surface of the bone rather than the medullary cavity. Skates with perforations of this type would not have required heel pegs, since thongs or cords could have been strung through the holes.
- (46) The representation of the skates themselves, however, is inaccurate. Olaus Magnus, sometime archbishop of Uppsala, left Sweden some thirty years before the publication of his volume and the Italian blockmakers who illustrated the Historia (and also the earlier Carta Marina by the same author) almost certainly had no first-hand experience of their subjects. Many of the illustrations are indeed known to be derivative (Professor Gosta Berg, personal communication).
- (47) See Note 41. By going on to talk of 'shin bones', Olaus Magnus makes it clear that the bones he describes are metapodials, as we should expect, and not tibias in the strict sense of the term.
- (48) Professor M. W. Barley, personal communication.
- (49) Zeitschrift fñr Ethnologie 4 (1872) Verhandlungen 3, 42.
- (50) The earliest representation of iron-bladed skates is in the Vita Lydvinae of 1498 (reproduced in N. Brown 1959, Pl. 2). St. Lydwi (born c. 1380) suffered an accident on the ice from which she never fully recovered and subsequently became the patron saint of skaters.
- (51) A casket found at Vermand, however, had its lid decorated with strips of wood embedded in a clay matrix, giving the effect of inlay.
- (52) The caskets illustrated on some West Highland sculptured monuments are further pointers to a secular function (Callander 1926, 116).
- (53) I am grateful to Mrs. Webster for providing me with the text of a paper on the Franks casket read by her at a symposium in Münster in 1967, from which the comments reproduced here are drawn.

Table 1

	Bending strength (MN/m ²)				Modulus of Elasticity (GN/m ²)			
	longitudinal		transverse		longitudinal		transverse	
	wet	dry	wet	dry	wet	dry	wet	dry
Bone (cattle tibia)	199	299	98	96	25	16	20	9
Antler (red deer)	178	343	82	123	21	13	4	8
Ivory (elephant)	155		72.5		6.8		2.6	
Horn (sheep)					3.8			

Table 2

	A Bending strength (MN/m ²)		B Work per unit area (arbitrary units)	
	longitudinal	transverse	longitudinal	transverse
Bone	299	96	39	7
Antler	343	123	117	16

Appendix 1

Double-sided composite combs of Scandinavian type

Catalogue

- 28.113 Freswick, Caithness
National Museum of Antiquities, Edinburgh, IL 676
- 28.114 London
R A Smith 1909, 164, fig 25
- 28.115 Lagore, Meath
Hencken 1950, fig 98, 1338
- 28.116 Burrian, Orkney
National Museum of Antiquities, Edinburgh, GA 111
- 28.117 Jarlshof, Shetland
Hamilton 1956, 186, pl XXII, 5, 7
- 28.118 York, Yorkshire
Waterman 1959, pl XVIII, 7-8, 10-11

One-piece and 'liturgical' combs

Catalogue

- 28.119 Durham, Co Durham
Lasko 1956, 336-55
- 28.120 Wallingford, Oxfordshire
British Museum, ~~SI.4.4.2~~
- 28.121 'Wales'
Dalton 1909, 38, pl XXI
- 28.122 York, Yorkshire
MacGregor, forthcoming
- 28.123 Unprovenanced
Wilson 1961, 17-9

22

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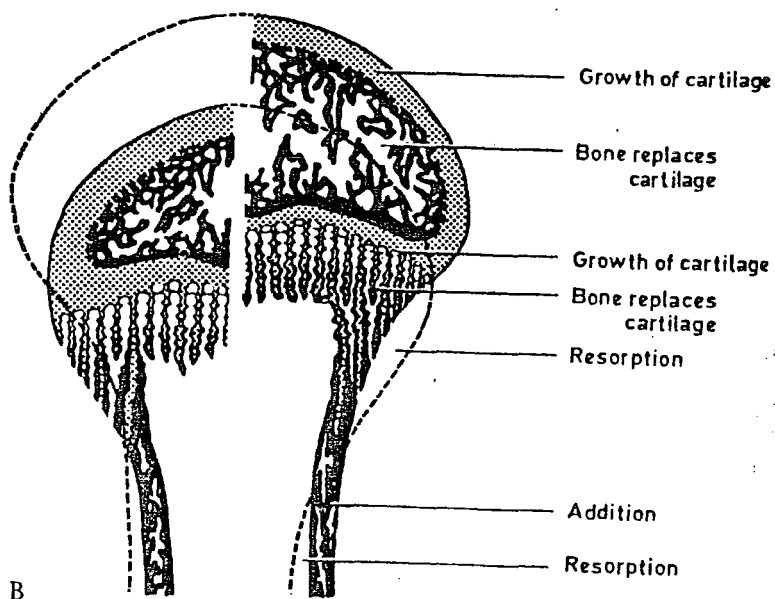
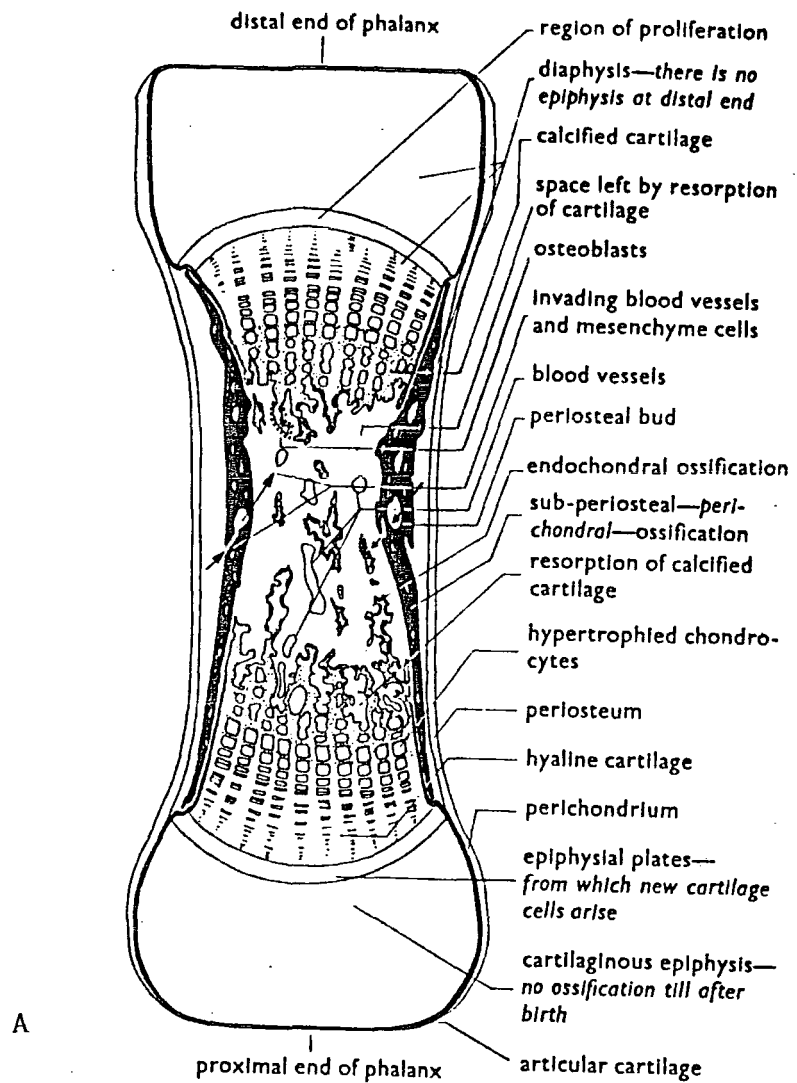


Figure 1. Cartilage bone. A Endochondral ossification of human phalanx (after Freeman and Bracegirdle). B Extension of long bone by endochondral ossification (after Ham).

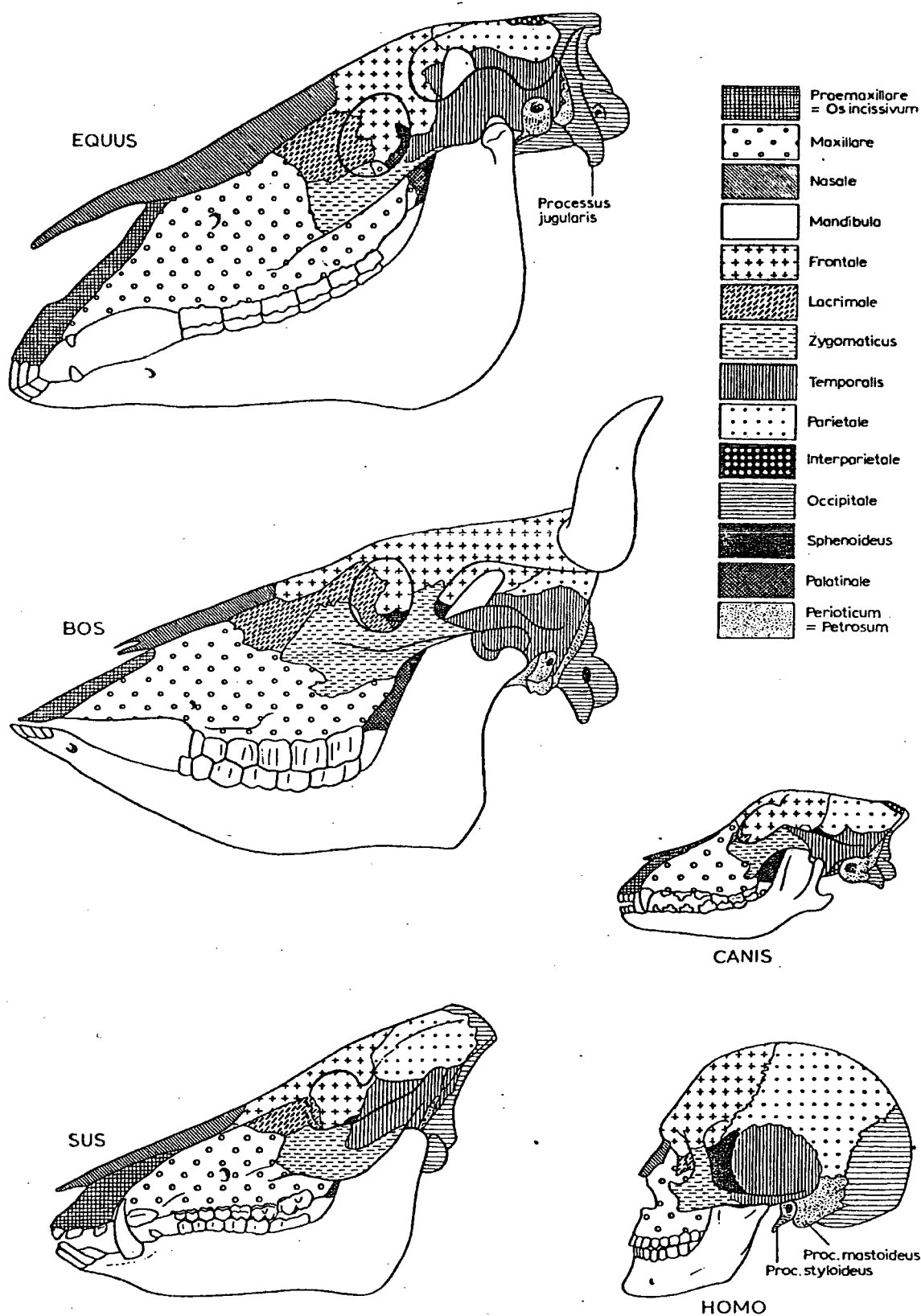


Figure 2 Membrane bone: comparison of skull morphology in different species (after Schmid).

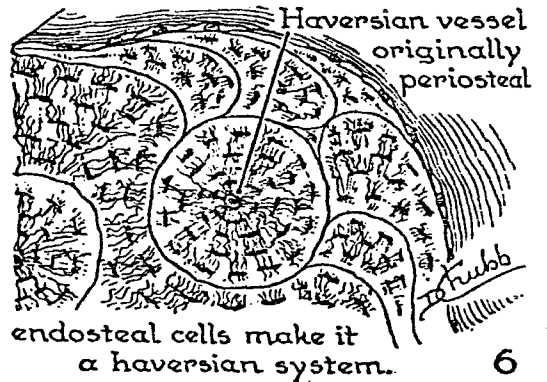
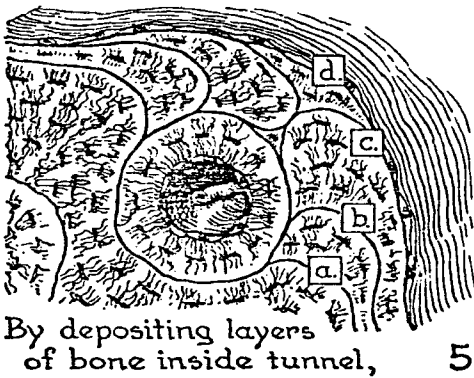
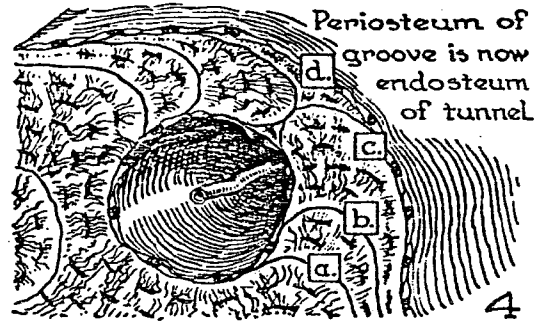
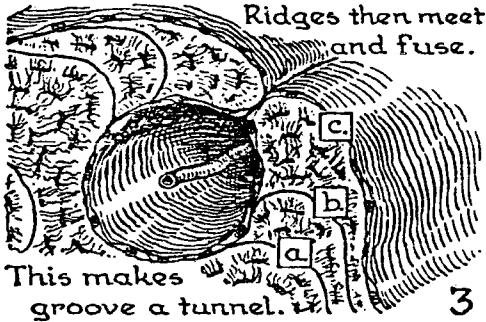
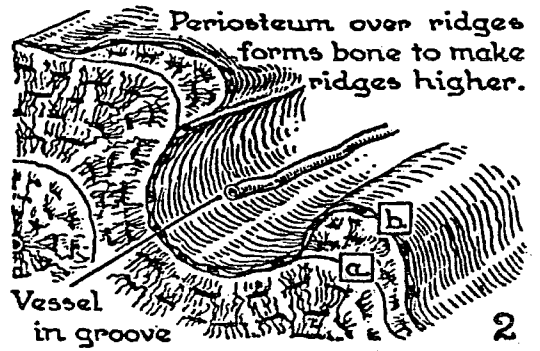
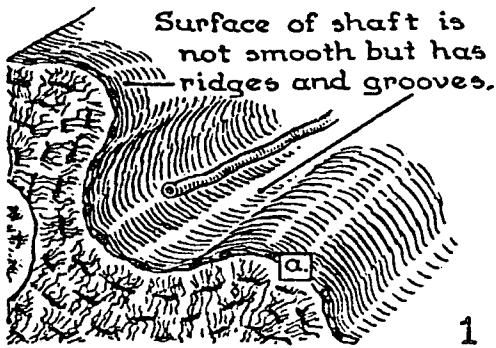


Figure 3

Three-dimensional diagrams showing how the longitudinally-disposed grooves on the exterior of a growing shaft become roofed over to form tunnels and how these become filled in to form Haversian systems, which thereupon are added to the exterior of the shaft. These diagrams also show the blood supply of a long bone which, when fully grown, is derived to a great extent from the periosteum by means of vessels which have been buried in the bone substance. (After Ham).

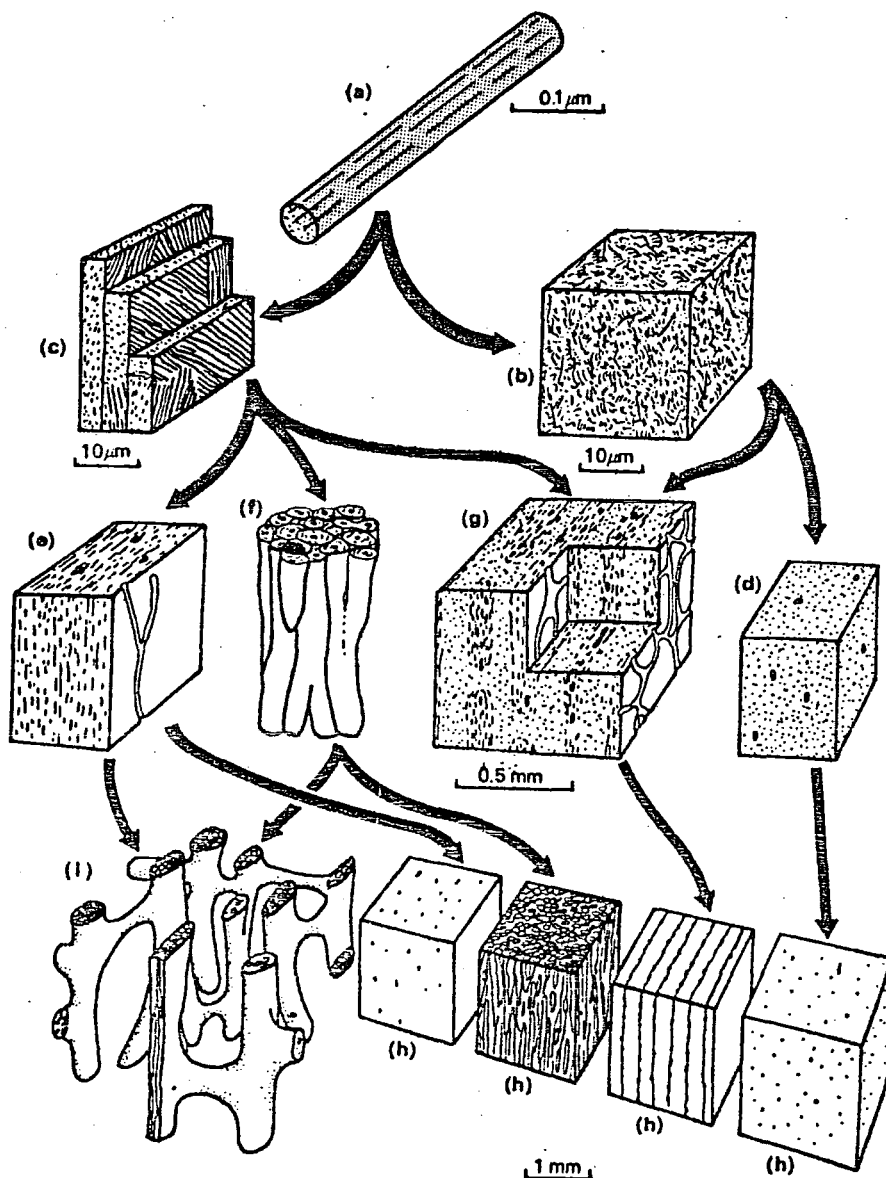


Figure 4

Structure of mammalian bone at different levels (after Currey).

The arrows show what types may contribute to structures at higher levels.

- (a) Collagen fibril with associated mineral crystals.
- (b) Woven bone. The collagen fibrils are arranged in random fashion.
- (c) Lamellar bone. There are separate lamellae, and the collagen fibrils are arranged in domains of preferred fibrillar orientation in each lamella.
- (d) Woven bone. Blood channels shown as large black spots. At this level woven bone is shown by light dotting.
- (e) Primary lamellar bone. Lamellae are indicated by light dashes.
- (f) Haversian bone. A collection of Haversian systems, each with concentric lamellae around a central blood channel.
- (g) Laminar bone. Two blood channel networks are exposed. Note how layers of woven and lamellar bone alternate.
- (h) Compact bone, of the types shown at lower levels.
- (i) Cancellous bone.

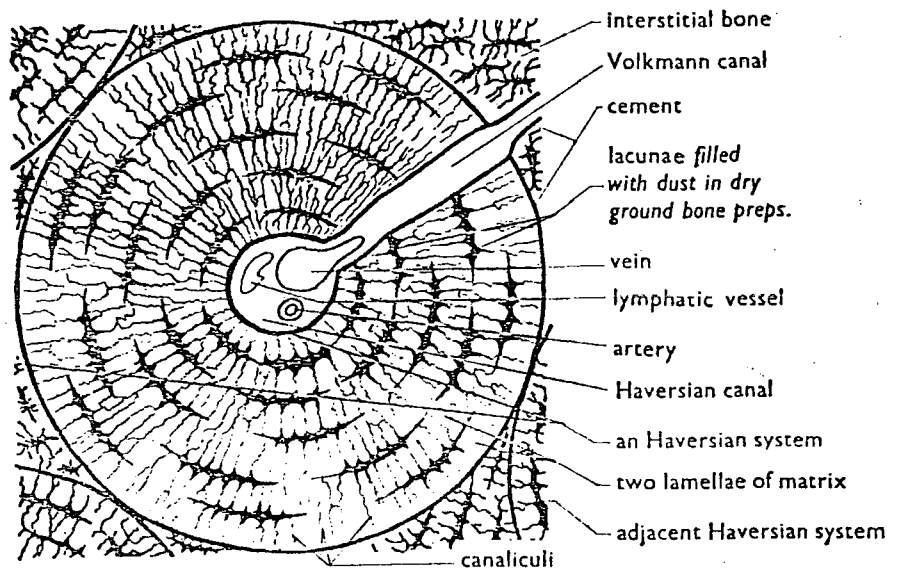


Figure 5. Transverse section of an Haversian system (after Freeman and Bracegirdle).

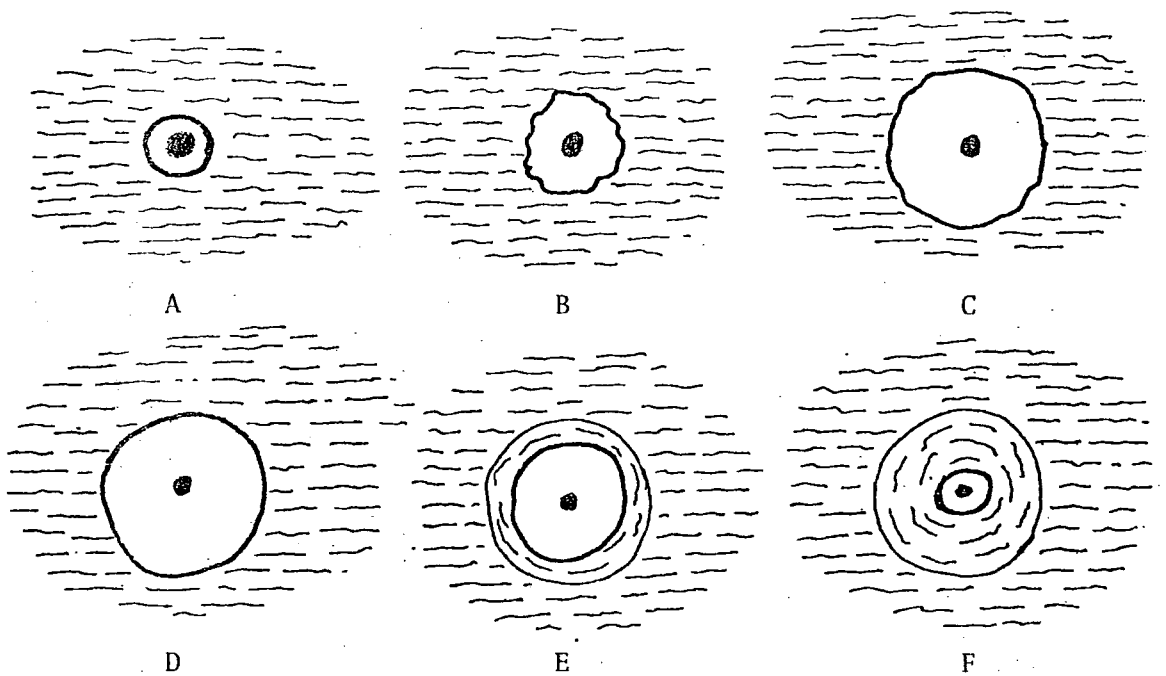


Figure 6. Formation of an Haversian system (after Currey).

A Blood vessel running in a channel in the bone, shown in cross-section. B An erosion cavity forms round it. C The cavity increases in size. D The surface is smoothed off. E New bone is laid down on the surface. F The Haversian system is complete.

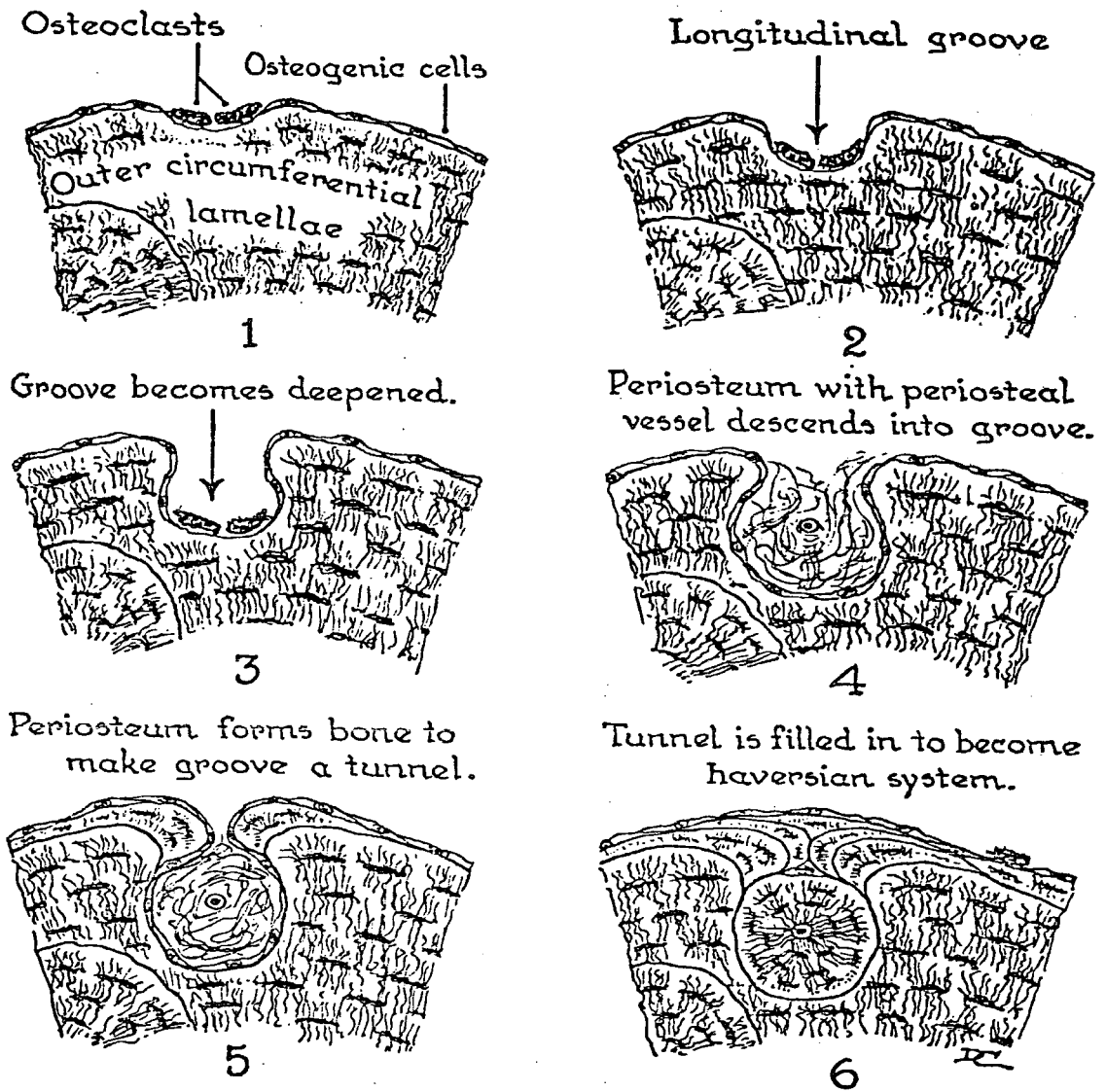


Figure 7

Digrams of cross-sections of the shaft of a bone showing how Haversian systems are laid down under the periosteum in older bones to replace outer circumferential lamellae (after Ham).

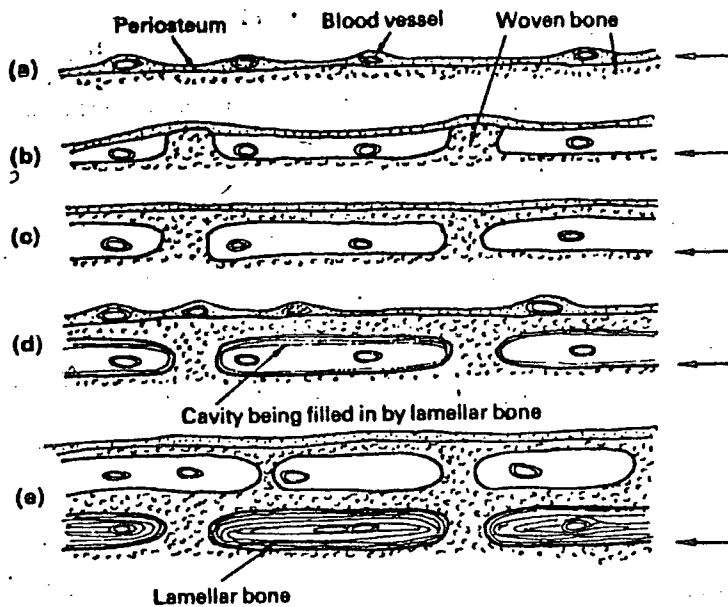


Figure 8 Growth of laminar bone (after Currey).

a resting surface; periosteum has blood vessels between it and woven bone at surface, b. c scaffolding of woven bone with cavities. d cavities filled with lamellar bone. e process repeat

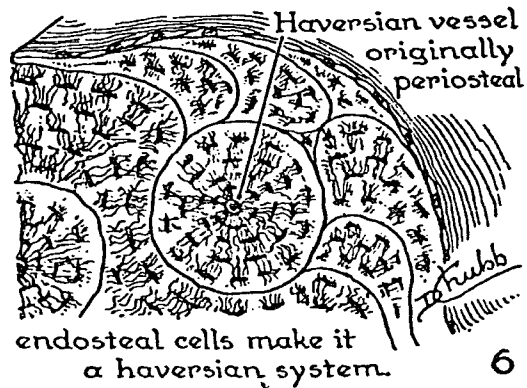
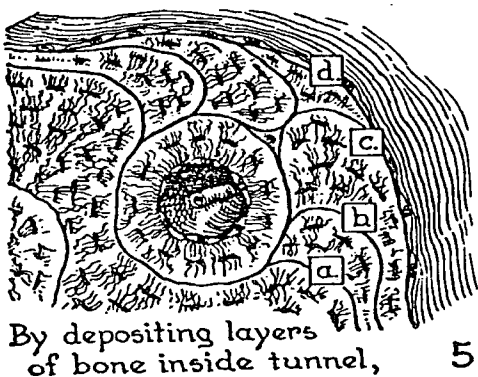
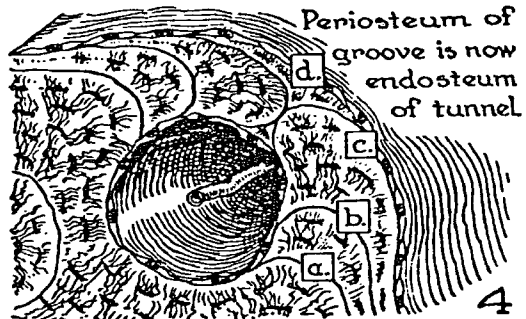
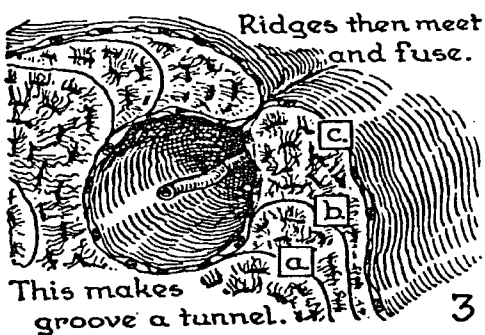
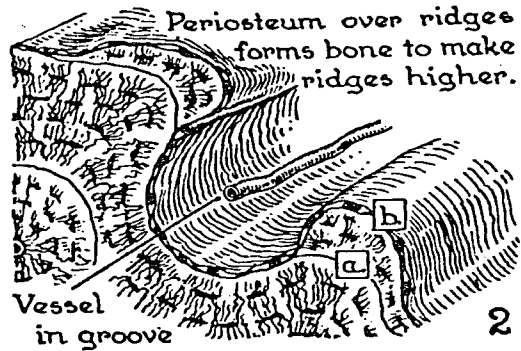
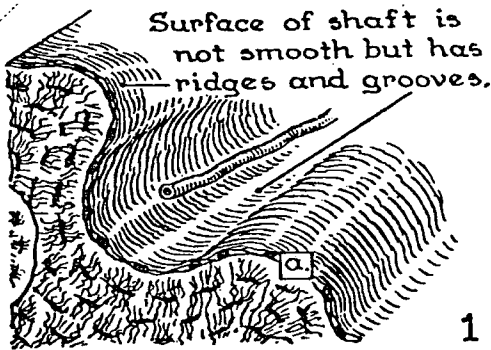


Figure 9 Growth of laminar bone (after Ham).

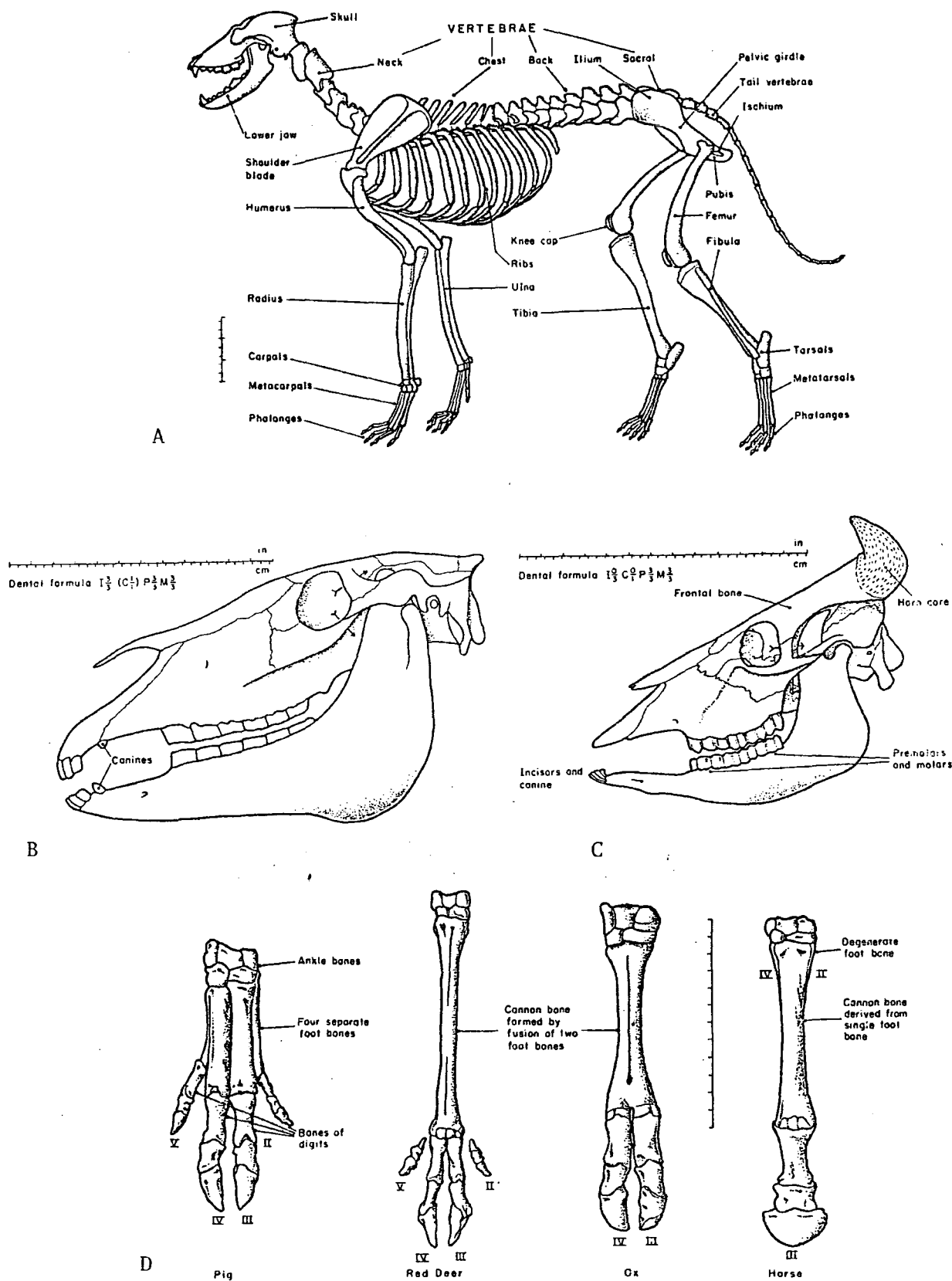


Figure 10. The mammalian skeleton (after Ryder). (A) Principal bones. (B) Horse skull. (C) Cattle skull. (D) Comparison of bones of the lower limb in four species.

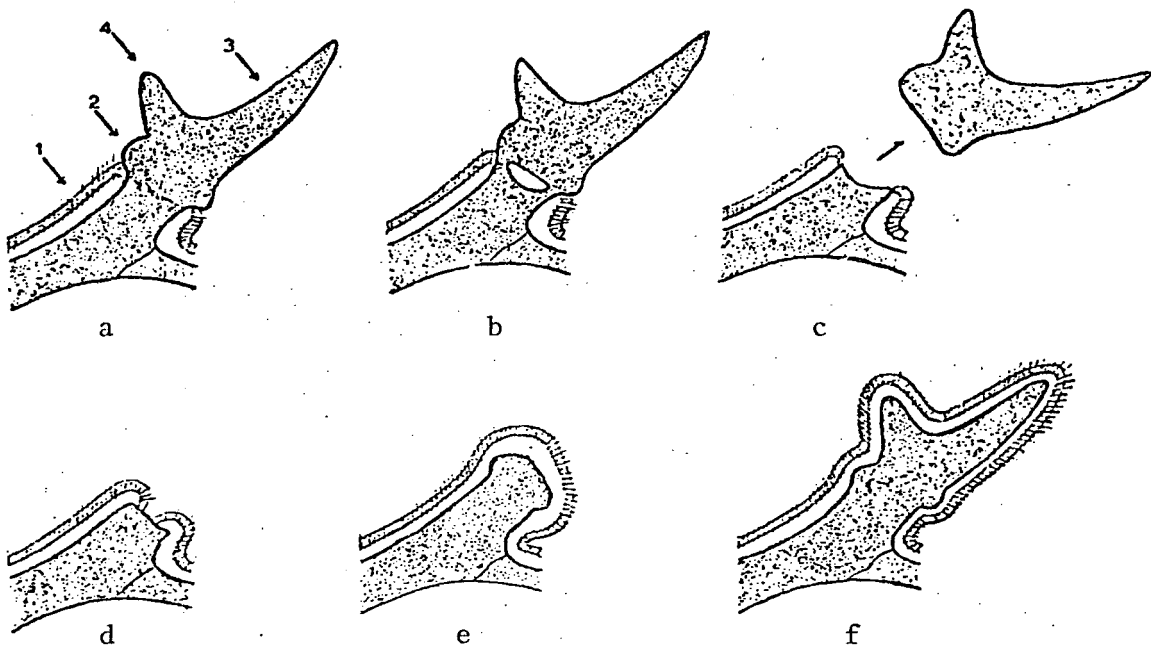


Figure 11 Shedding and growth sequence in antler (after Schmid).
1 velvet, 2 burr or coronet, 3 beam, 4 tine.

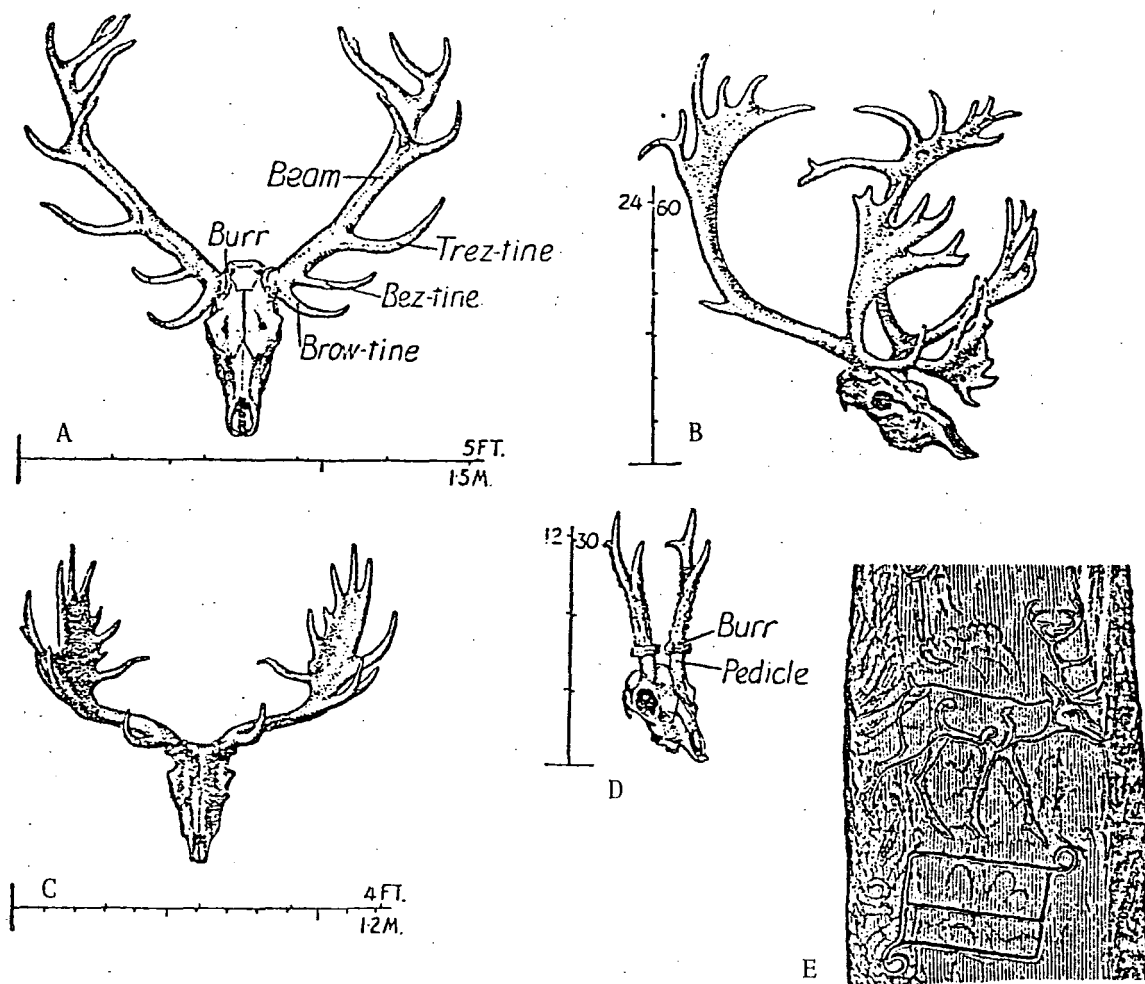


Figure 12 Antler morphology (after Cornwall).
A red deer, B reindeer, C fallow deer (Clacton), D roe deer,
E slab incised with representation of a deer, Grantown.

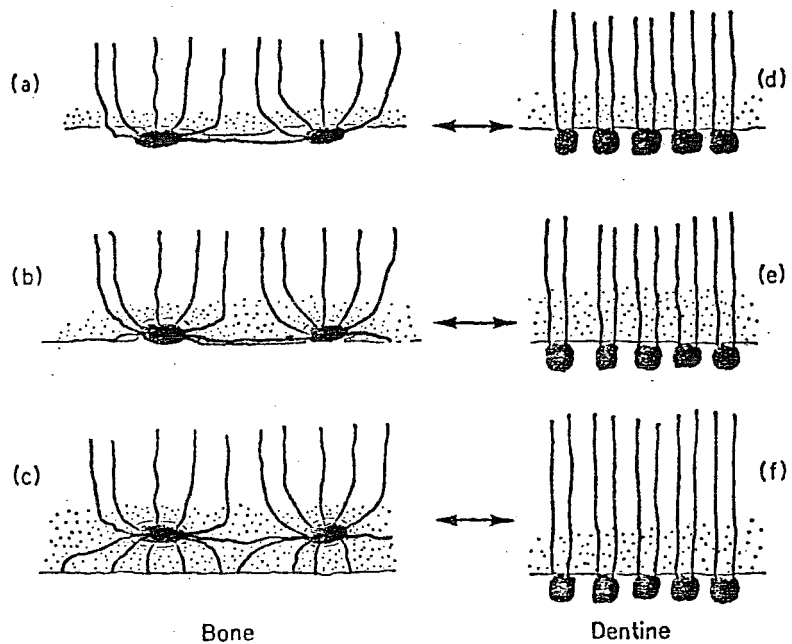


Figure 13. Comparison of development in bone and dentine (after Currey). As new bone is laid down, bone cells gradually become engulfed in the matrix while maintaining contact with each other and with the free surface. In contrast, dentine cells maintain their closely-packed positions on the surface, their process extending back into the dentine as it is laid down.

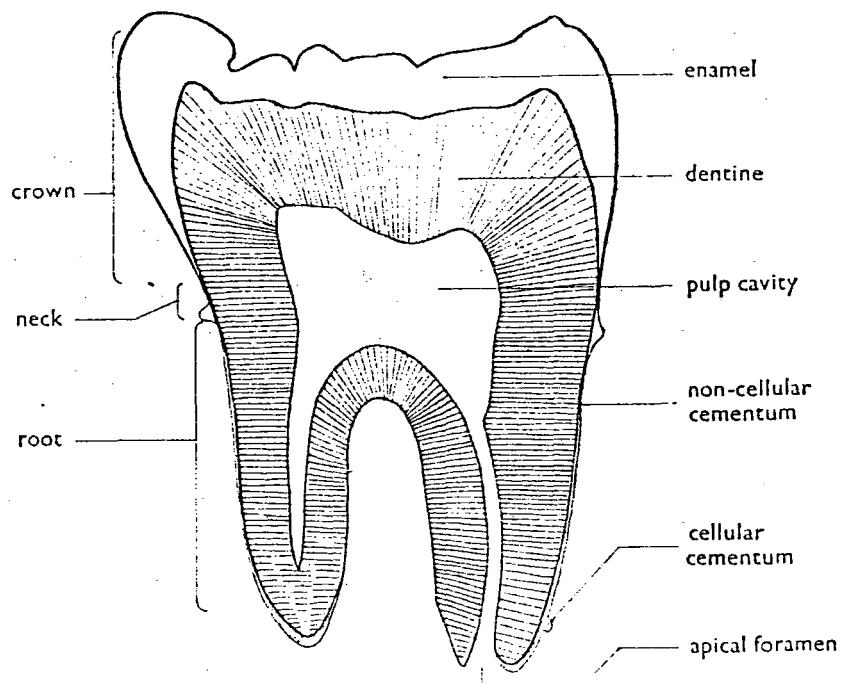


Figure 14. Cross-section through a tooth (human molar), showing principal components (after Freeman and Bracegirdle).

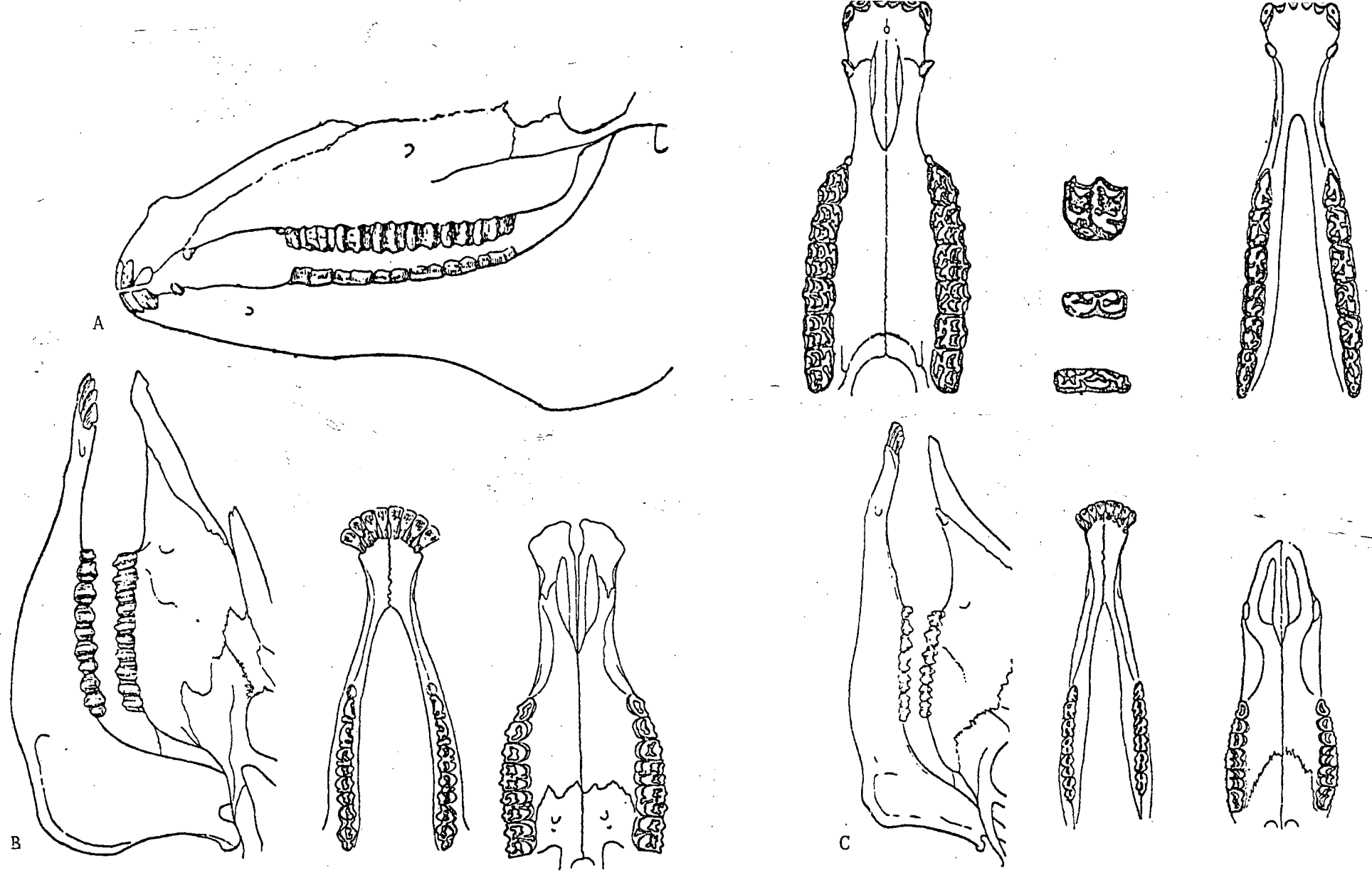


Figure 15 Tooth morphology in different species. A horse, B cattle, C deer. Not to scale.

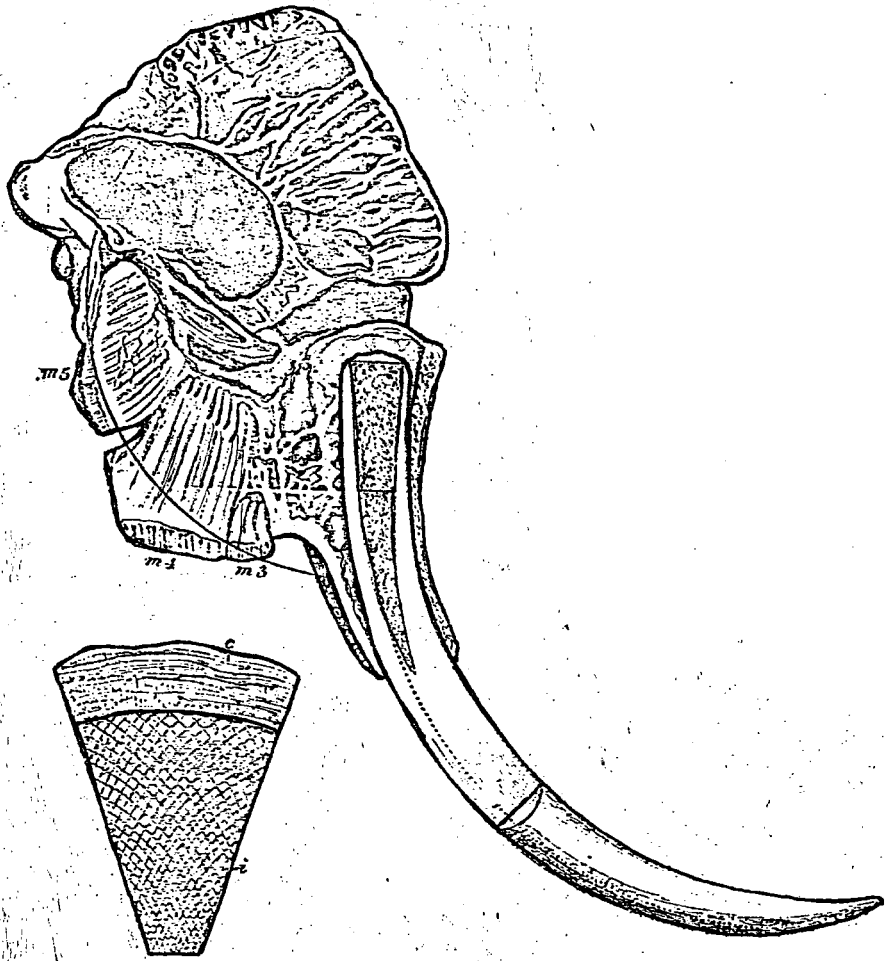


Figure 16 Dentition of the elephant (after Owen).

In addition to the two long tusks (i), one in each of the premaxillary bones, there are large molars in each jaw (m3, m4, m5). Of the latter there is never more than one wholly or two partially in place and use on each side at any given time, the series continually being in the process of formation and destruction, shedding and replacement. In elephants all the grinders succeed one another horizontally, from behind forwards.

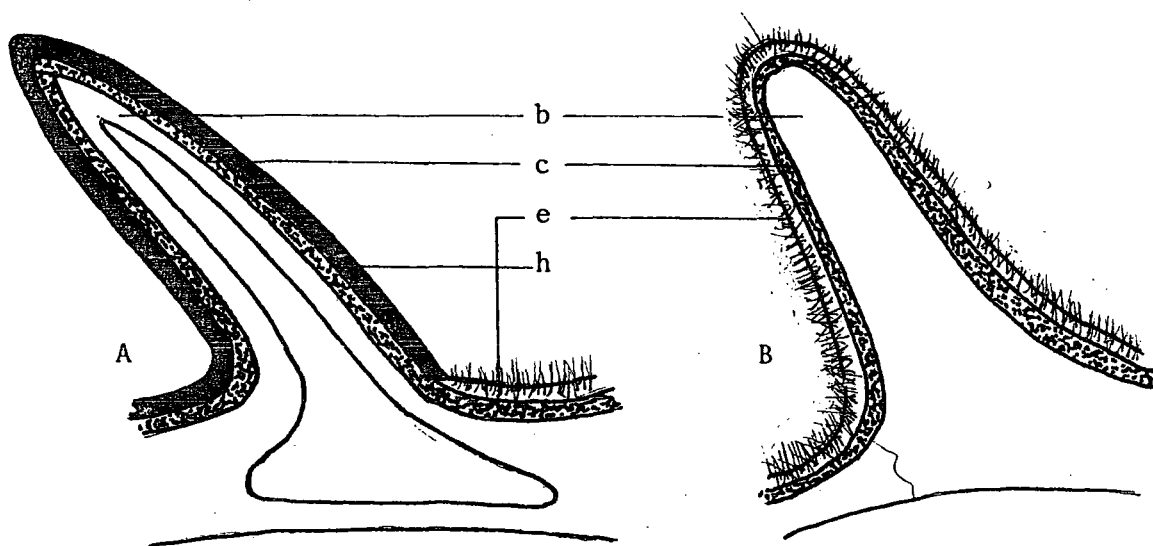


Figure 17A Comparison of horn (A) with growing antler (B).
b bone, c cutis, e epidermis, h horn.

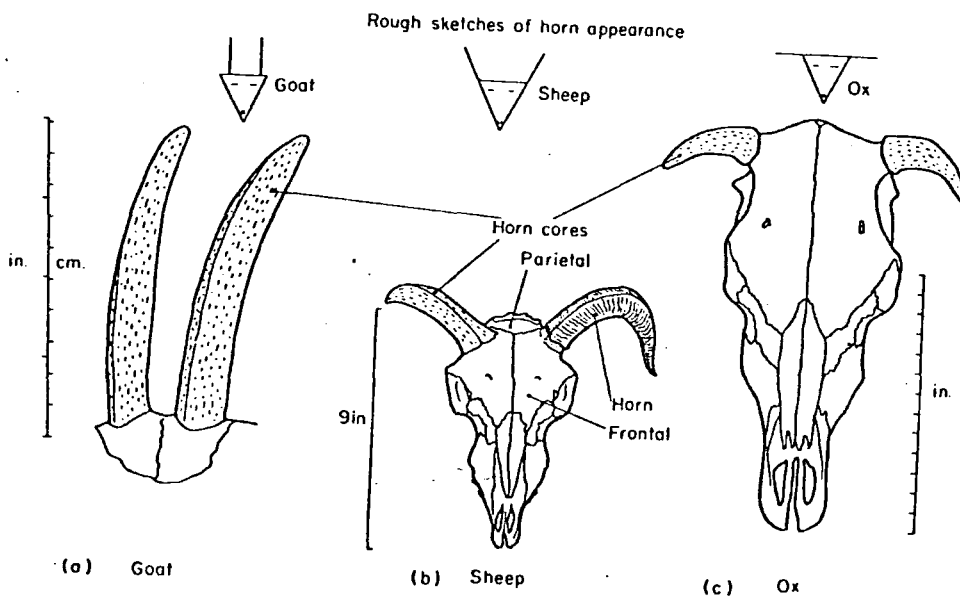


Figure 17B Horn morphology in different species.

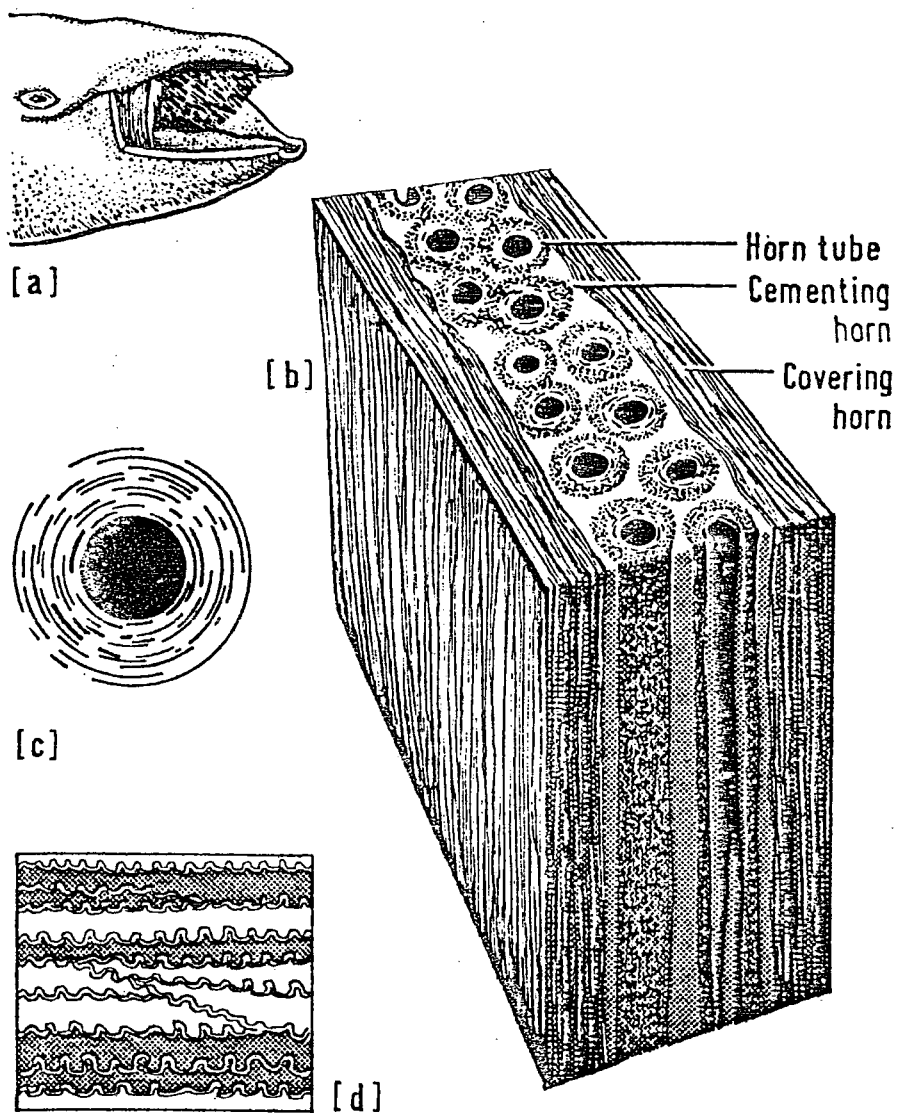


Figure 18 Baleen (after Halstead): (a) head of whalebone whale with plates of baleen hanging from the roof of the mouth; (b) block diagram of baleen; (c) section of horny tube with areas of calcification indicated; (d) drawing based on electron micrograph of keratinized epidermal cells, those shaded being mineralized.

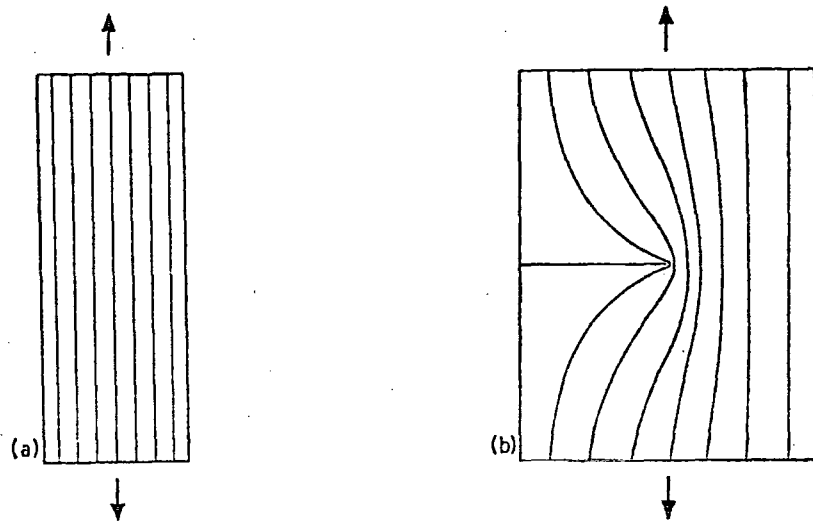


Figure 19. Stress concentrating effect of a narrow slit. In (a) the lines of force run from one end of the stressed material to the other. In (b) the lines of force have to make their way round the end of the crack, causing a concentration of force at the tip. (After Currey).

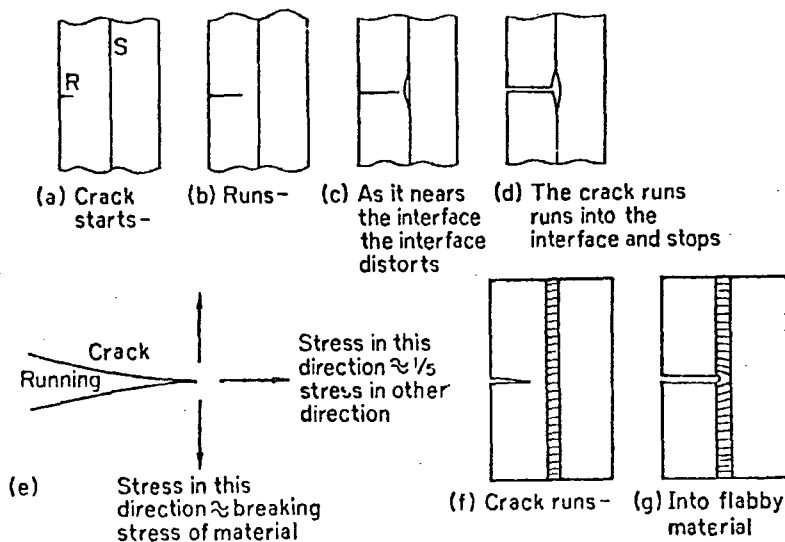


Figure 20. Blunting effect of an interface. In (a) to (d) the progress of a crack R is shown as it runs across a crystal. As it approaches the longitudinal crack S the latter opens up at right angles to it under the influence of a tensile stress running just in front of the crack, effectively dissipating the stress in R and halting its progress. A similar effect is obtained by interposing a layer of flabby material, as in (f) to (g), a function performed by the collagen in bone. (After Currey).

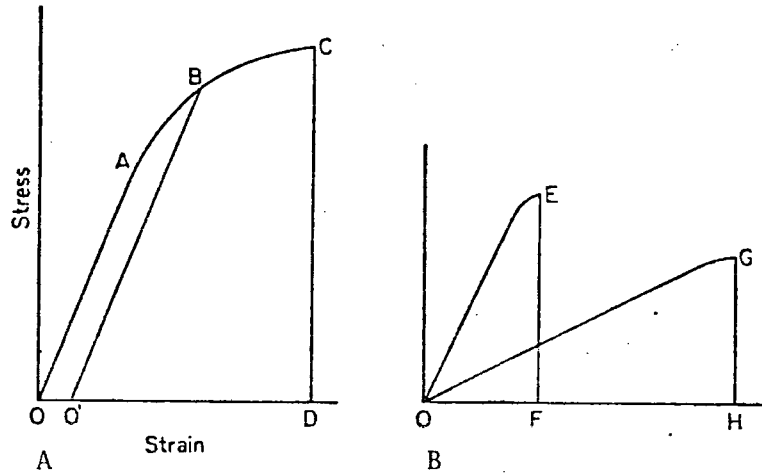


Figure 21. Stress-strain curves (after Currey). In Curve A, in the region OA the strain is directly proportional to the stress, and in this region if the stress is removed the strain will return to zero (elastic strain). Beyond point A, the material does not lose all its strain: if the stress is removed at point B the material remains deformed by the extent $O-O'$. With increasing strain the material finally breaks at C, the value CD representing the ultimate stress of the material. The area under the curve, up to any particular stress, is a measure of the work per unit volume that has to be performed on the material in order to achieve that stress. The highest amount of energy is not necessarily absorbed by the material with the highest ultimate stress: this is shown by the curves in B, in which the ultimate stress in OEF is greater but a larger area is contained within OGH.

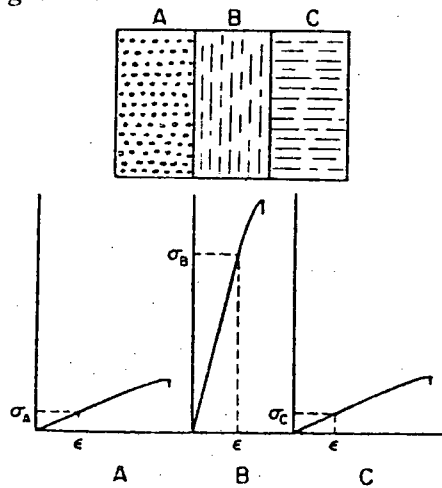


Figure 22. Stresses in woven bone (after Currey). A, B and C are three blocks of bone with their fibres oriented in the directions indicated. The whole block is pulled in tension from top to bottom and the corresponding stress-strain curves are shown below. The strain (which is the same for all three blocks because they are united together) and the corresponding stress σ (which is not the same) are indicated by dotted lines.

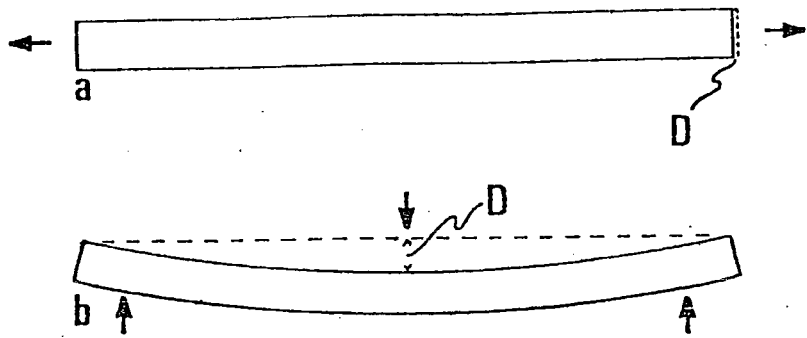


Figure 23. Comparison of the tension (a) and bending (b) tests for E (after Currey). In each case the deformation D must be measured, but in the bending test it is much bigger than in the tension test.

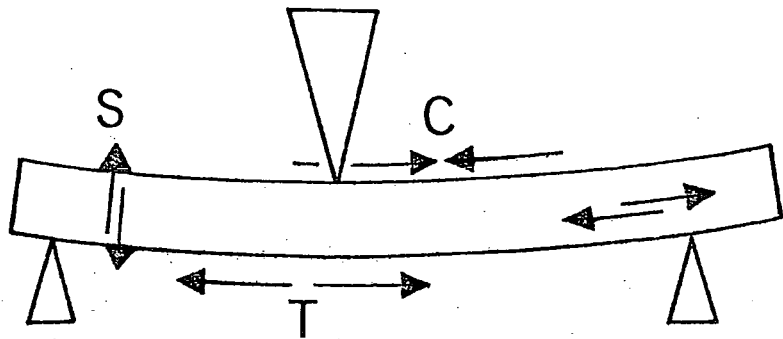


Figure 24. Forces acting on a beam in static bending (after Frost). S : shear C : compression T : tension.

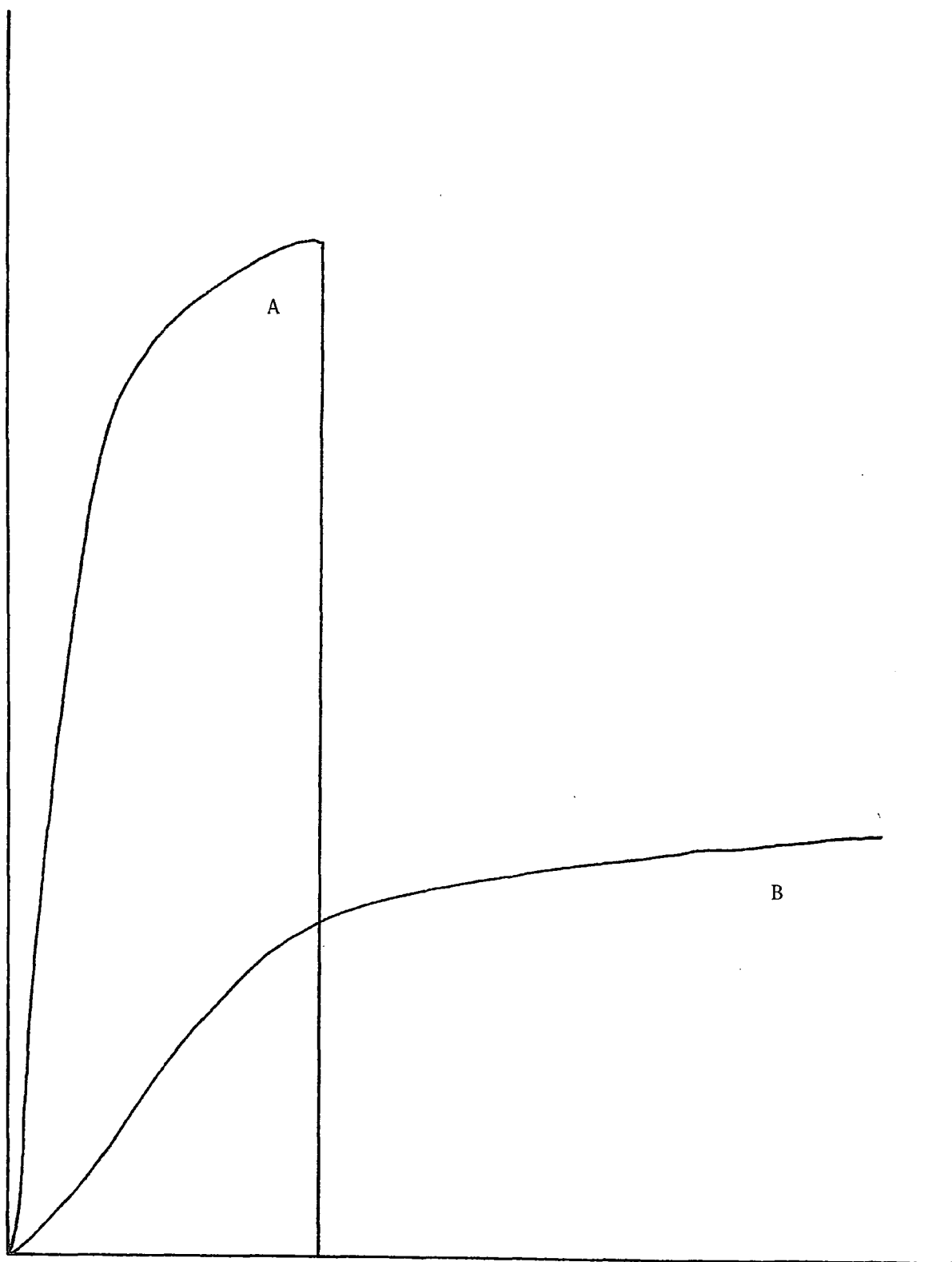


Figure 25. Stress-strain curves for (A) dry and (B) wet antler.

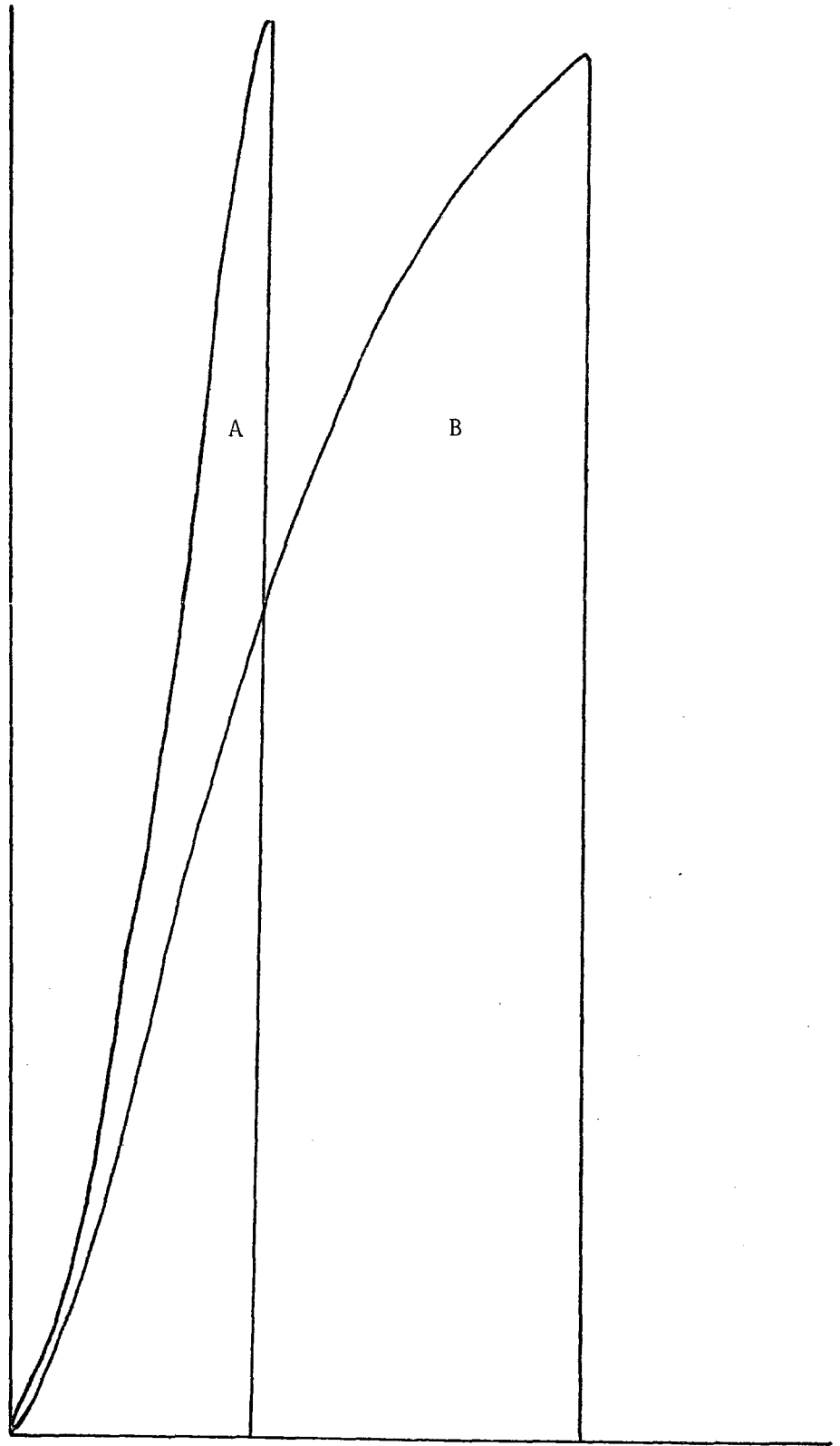


Figure 26. Stress-strain curves for (A) bone and (B) antler. Although the values for ultimate stress are similar, the area contained within curve B is markedly greater (cf. Figure 21b).

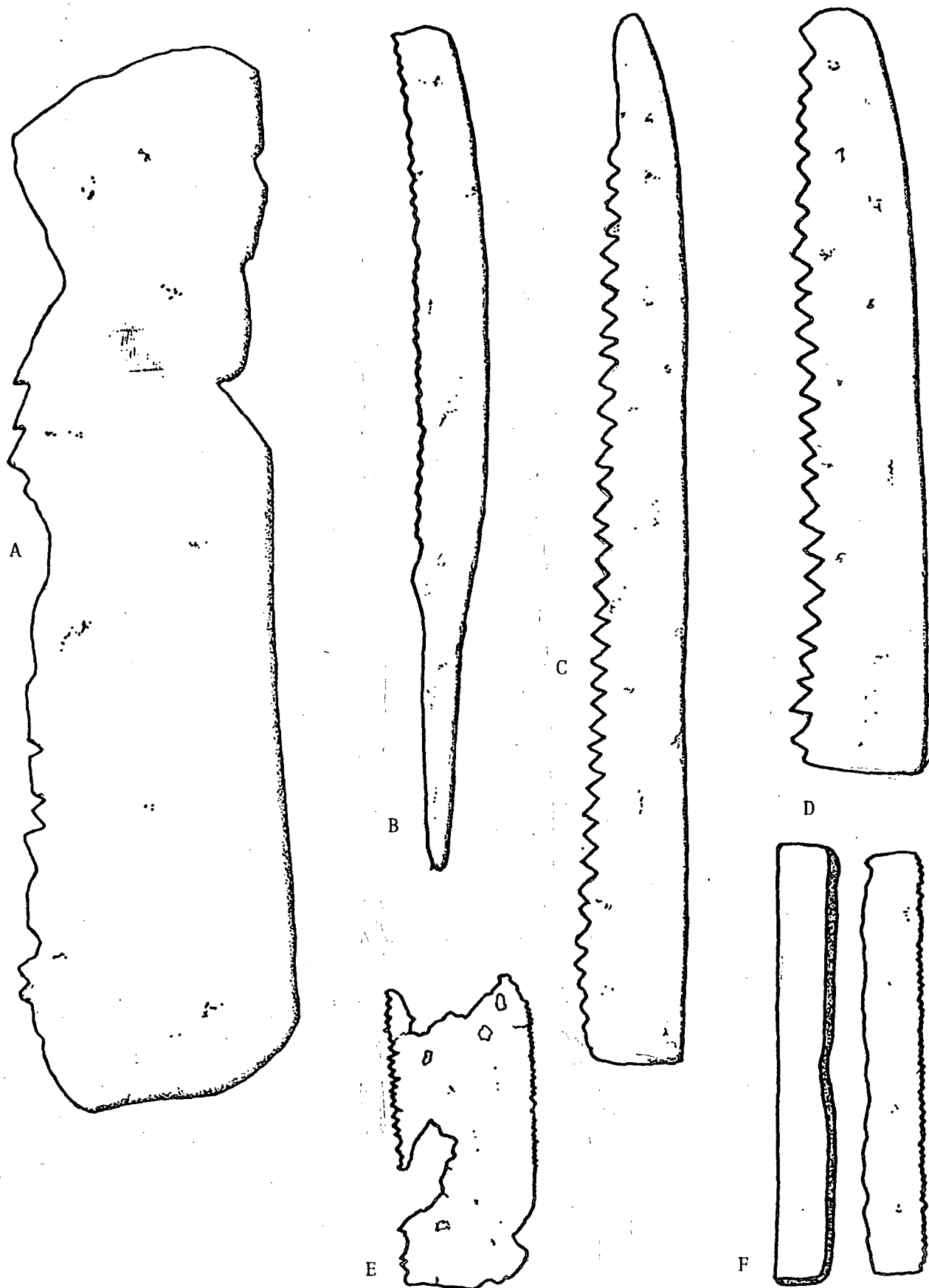


Figure 27 Saw blades from (A) Lochlee Crannog, (B) Oslavany, (C-D) Novgorod, (E) Thetford and (F) Icklingham. Scale (C-F) 1:1.

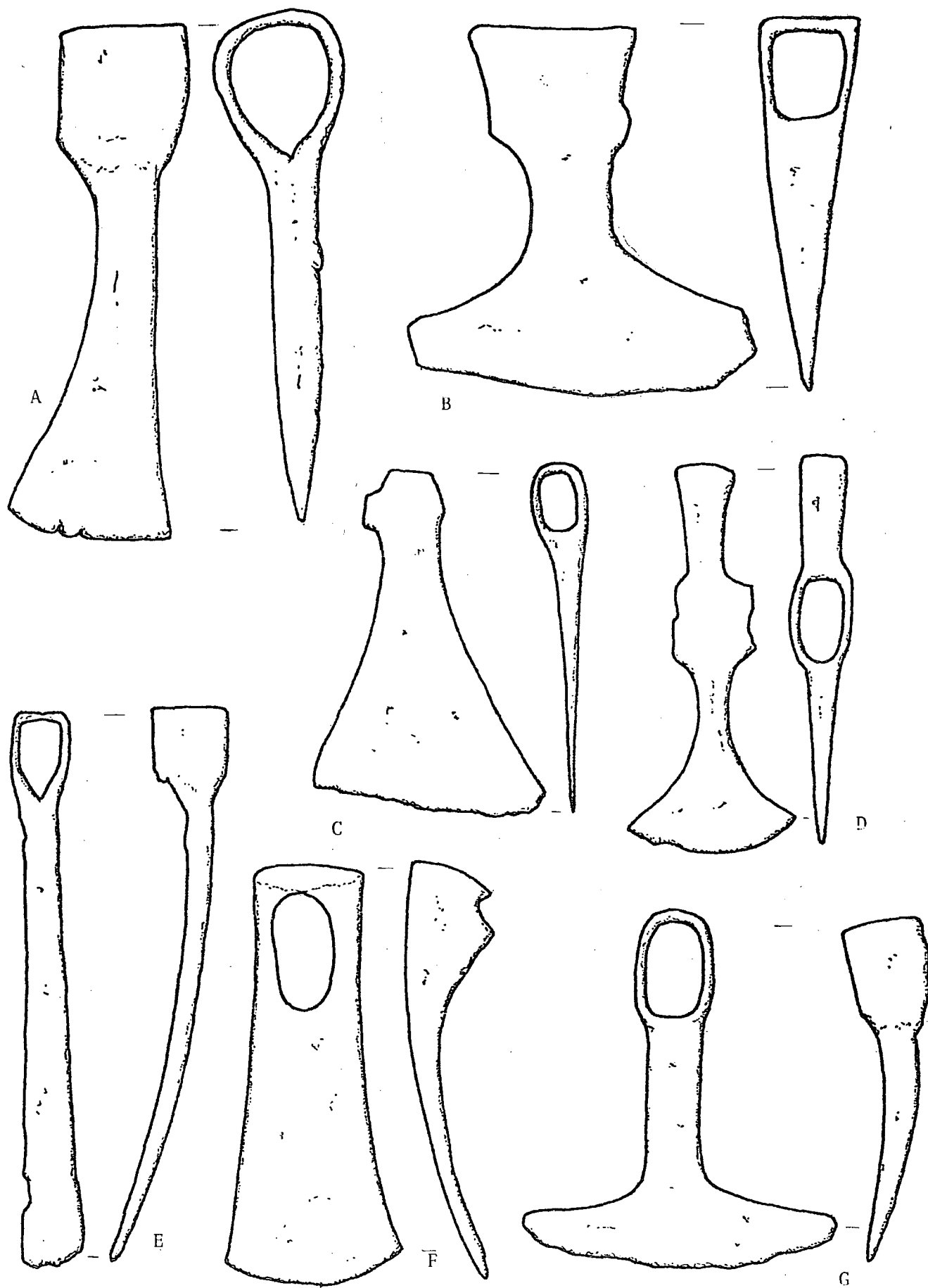


Figure 28 Axes (A - D) and adzes (E - G) of late Saxon date (after Wilson). Scale 1:2.

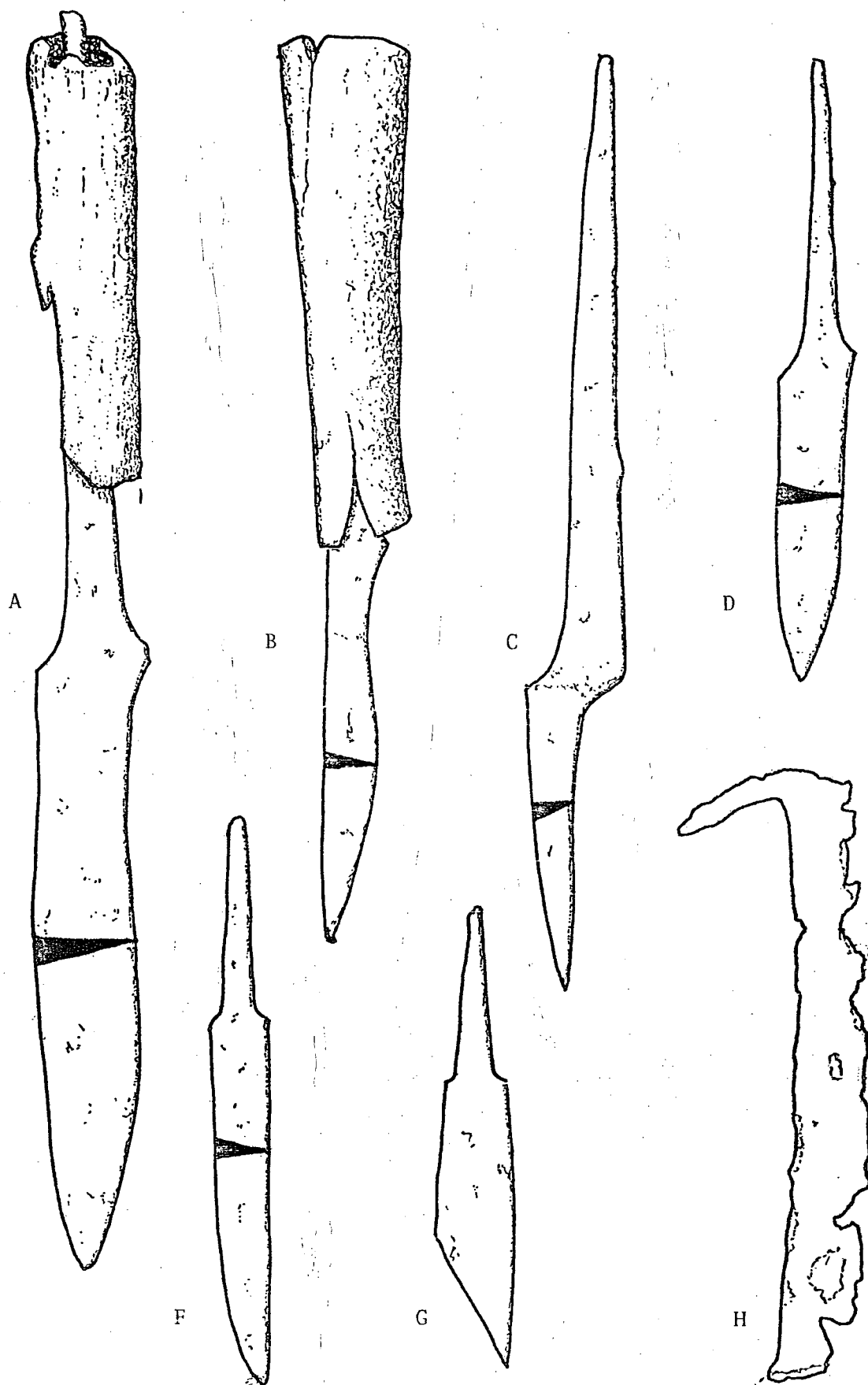


Figure 29 Knives (A - G) and draw-knife (H) of late Saxon or early medieval date. A -G Scale 1:1, H (after Wilson) not to scale.

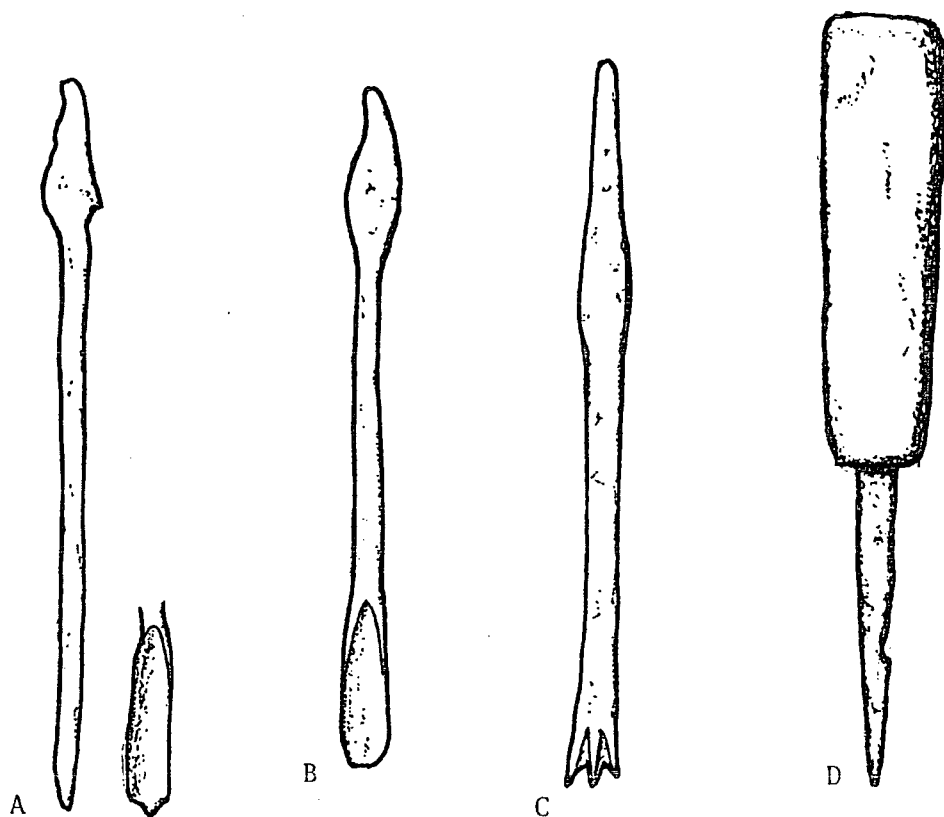


Figure 30 Drills from (A) Brundall, (B) Thetford; ring-and-dot scribe (C) from Stare Mesto; awl (D) from York. Scale 1:1.

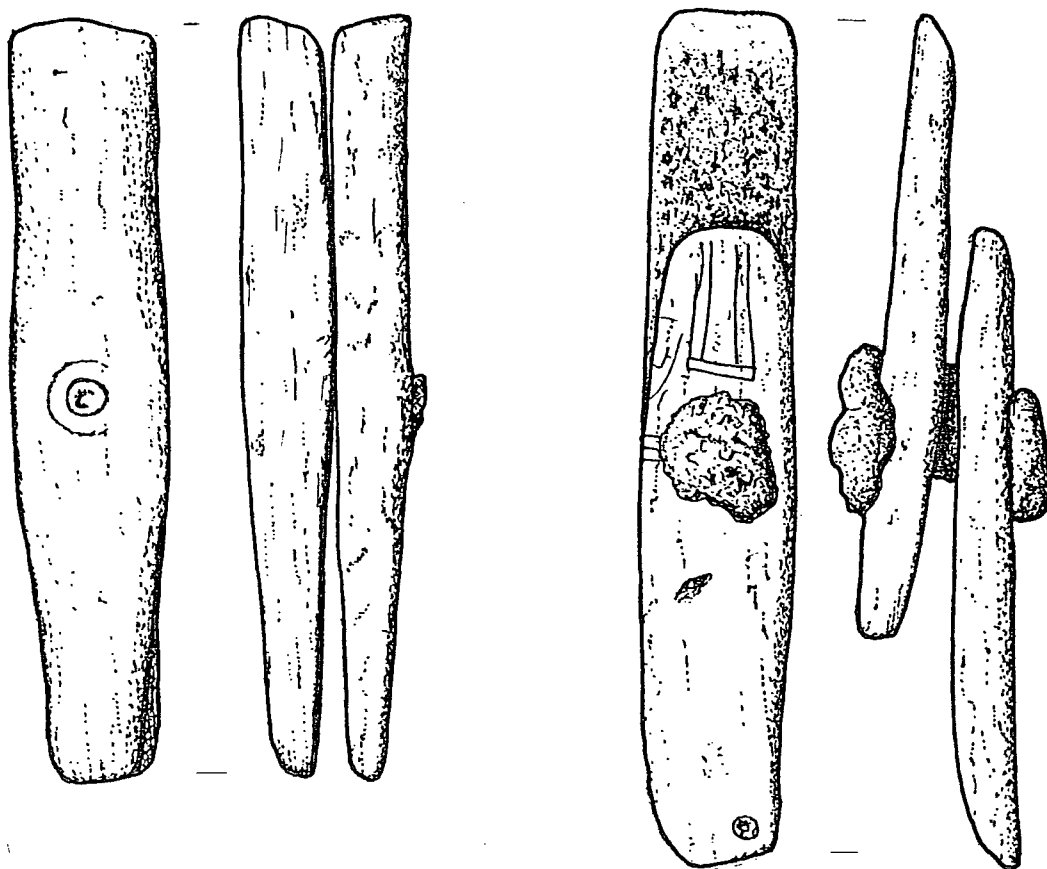


Figure 31 Antler clamps from Hedeby. Scale 1:1.

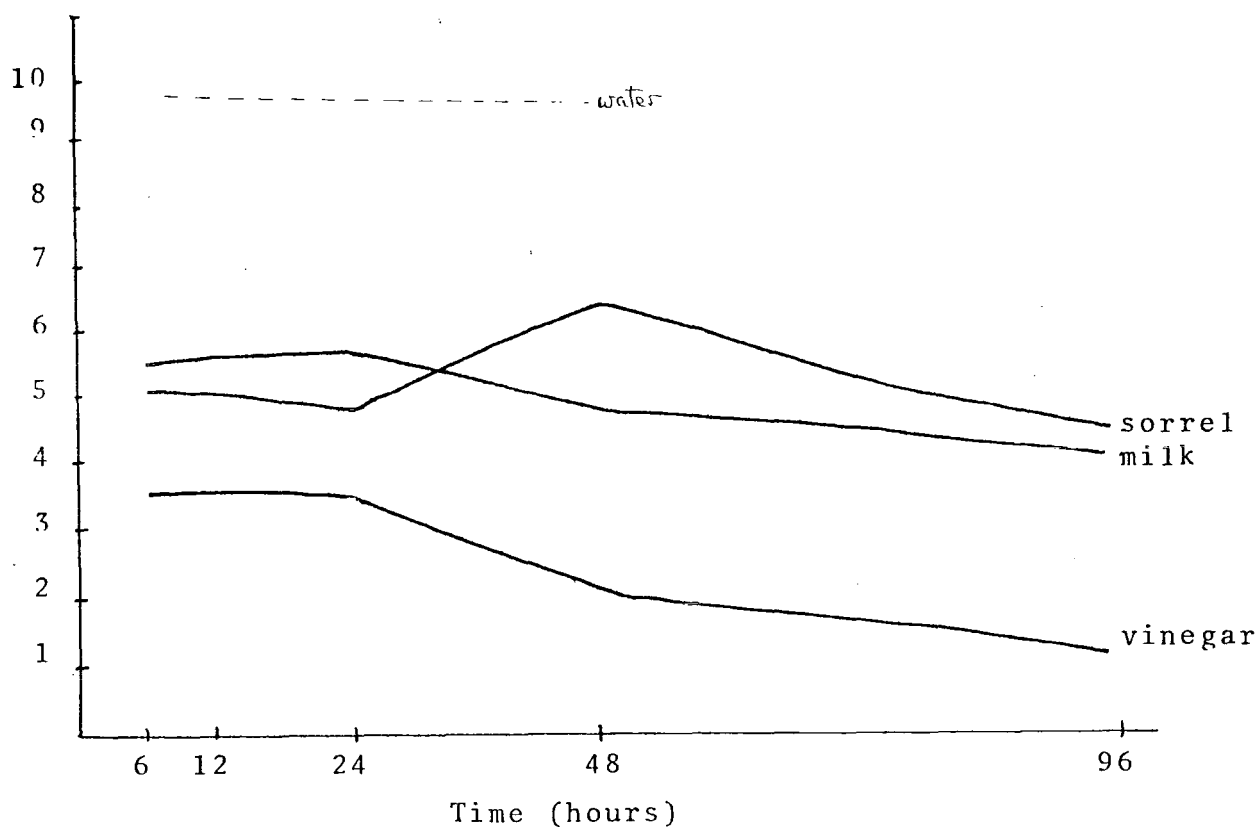


Figure 32 Graphs showing the effect on modulus of elasticity (E) of soaking in organic acids.

It will be seen that sorrel (oxalic acid), milk (lactic acid) and vinegar (acetic acid) had varying effects on the antler samples, with vinegar producing the most marked result. In these particular experiments the results gained with sorrel were anomalous: further tests should show that it too is capable of inducing a marked softening effect, which is the practical outcome of this process.

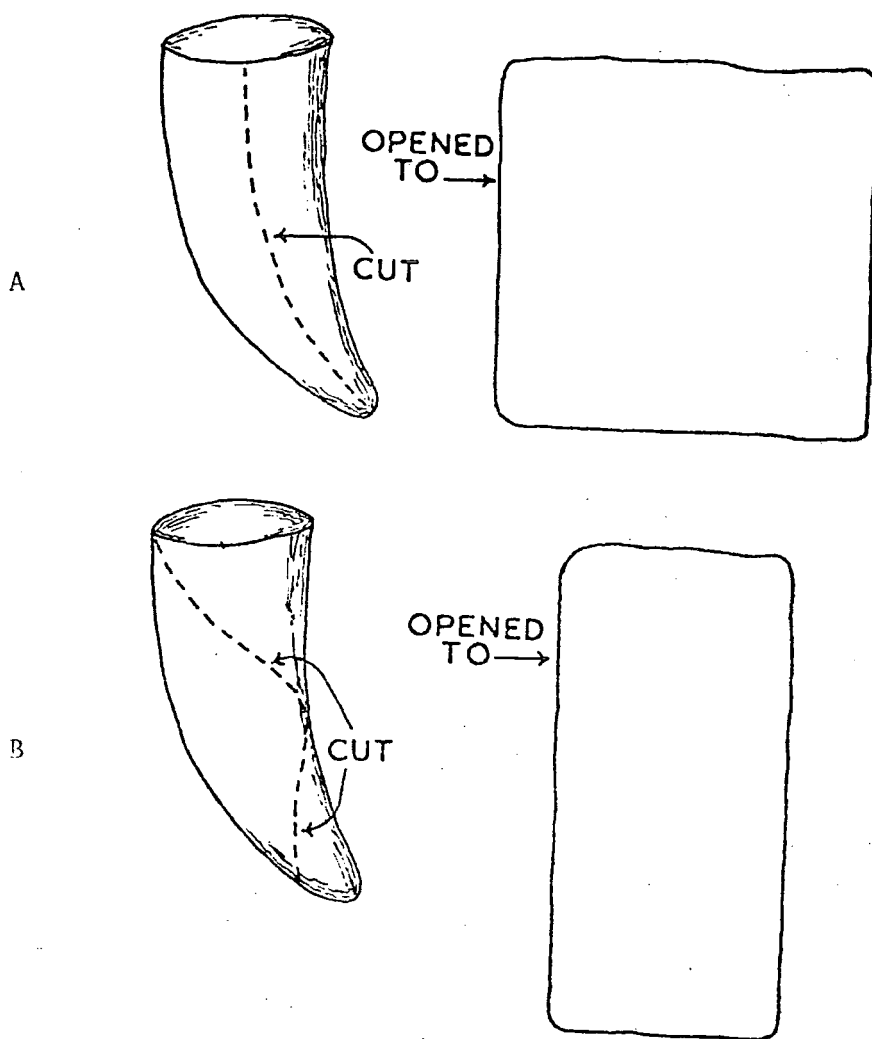


Figure 33.
Methods of horn breaking (after Wenham). A straight cut, to produce a squarish sheet; B corkscrew cut, to produce a more elongated format.

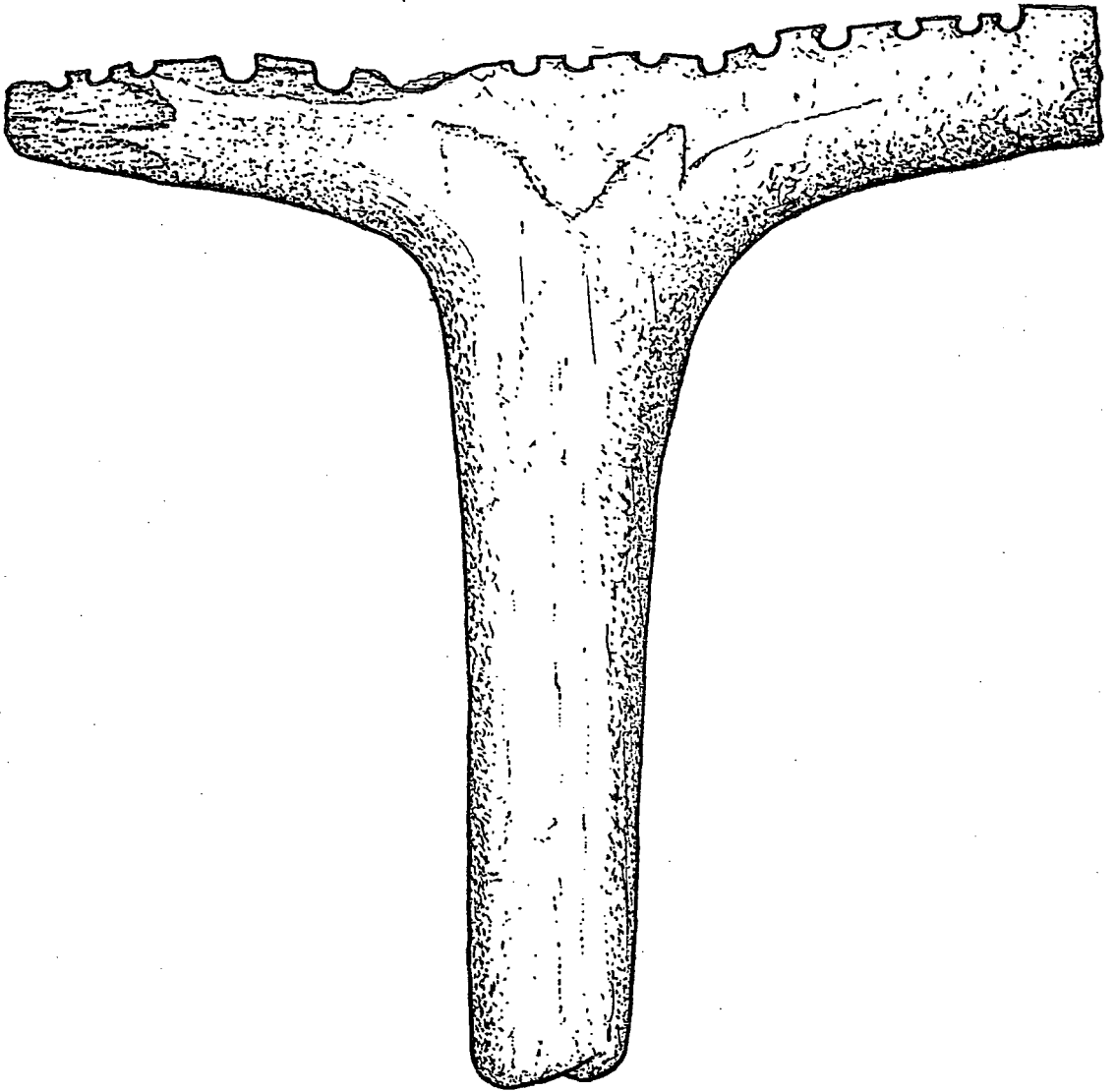


Figure 34

Antler wool comb or heckle from Jarlshof, broken through perforations for first row of (iron) teeth. Scale 1:1.

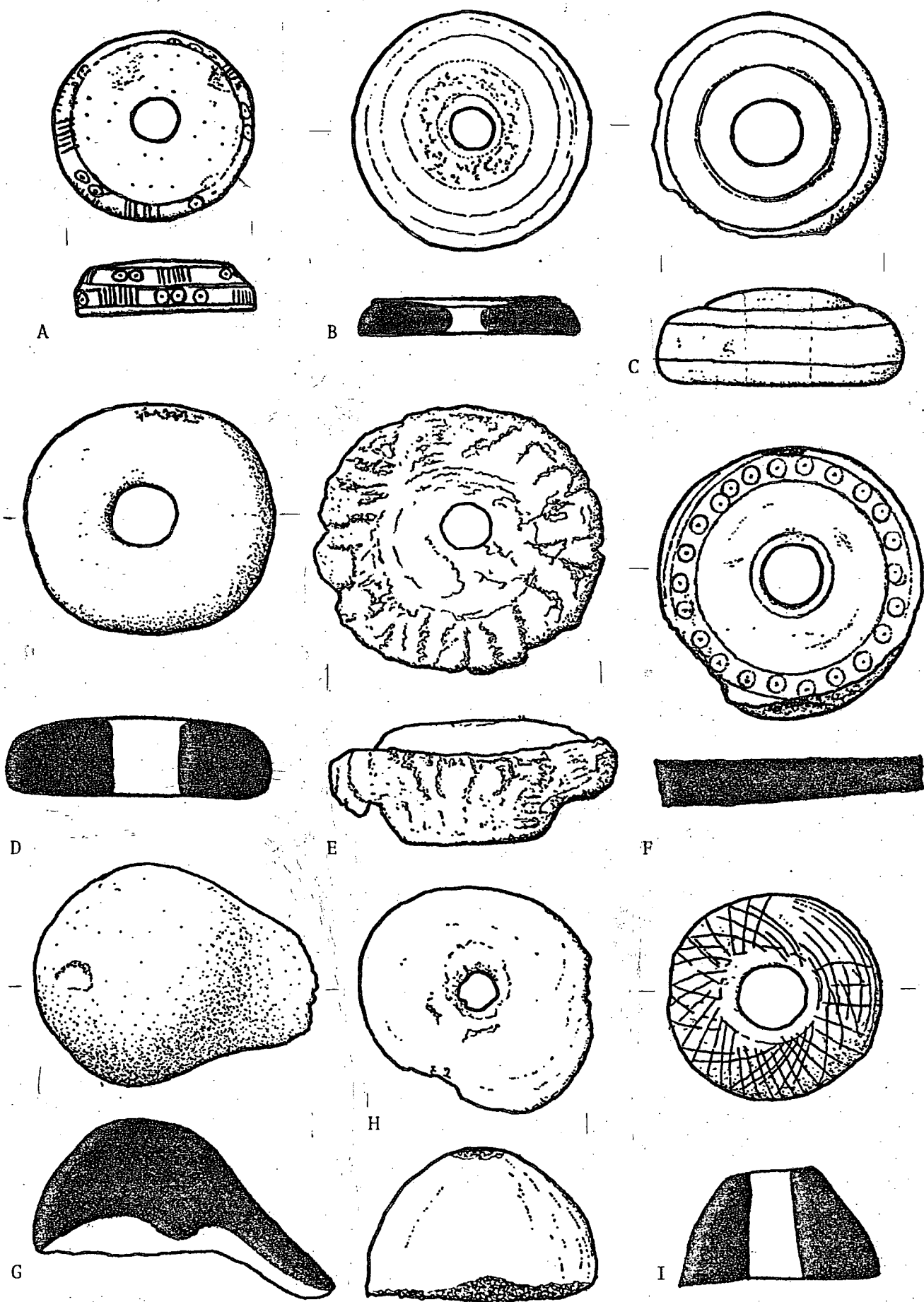
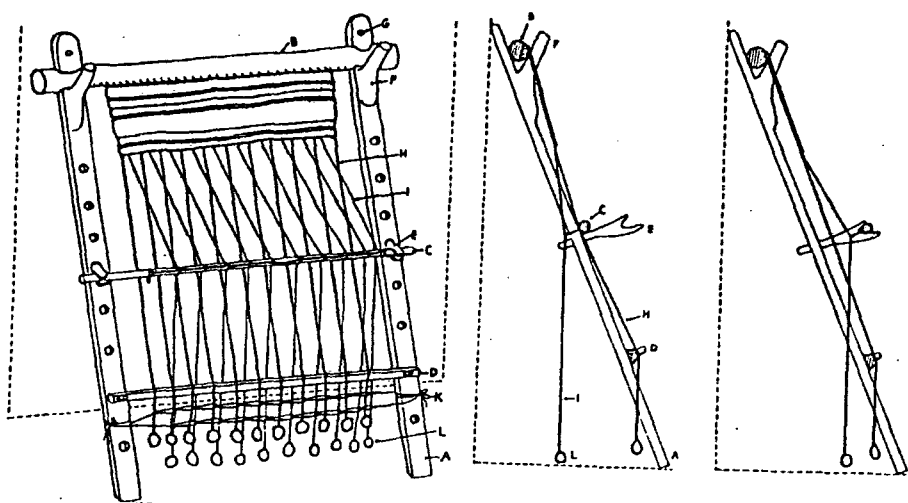
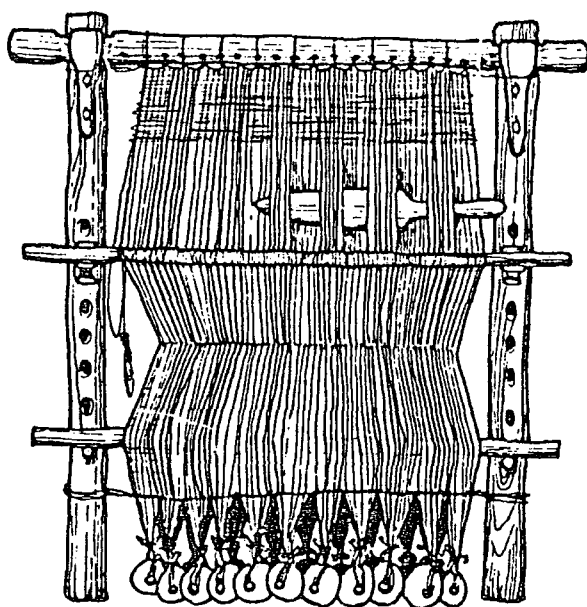


Figure 35 Spindle whorls. Antler from (A) Kingston Down, (B) Sibbertswold, (C) unprovenanced, (D) Beckford, (E) Lackford; jawbone from (F) from London; (G) unfused femur head; (H) femur head whorl from York; (I) stone whorl imitating femur shape. Scale 1:1.



A



B

Figure 36 Warp-weighted looms. A Simplified diagram of the loom (after Hoffmann). A upright, B beam, C heddle rod, D shed rod, E supports for heddle rod, F crutches for the beam, G hole for securing upright, H front threads, I back threads, K chained spacing cord, L weights.

B Generalised reconstruction of loom (after Howarth).

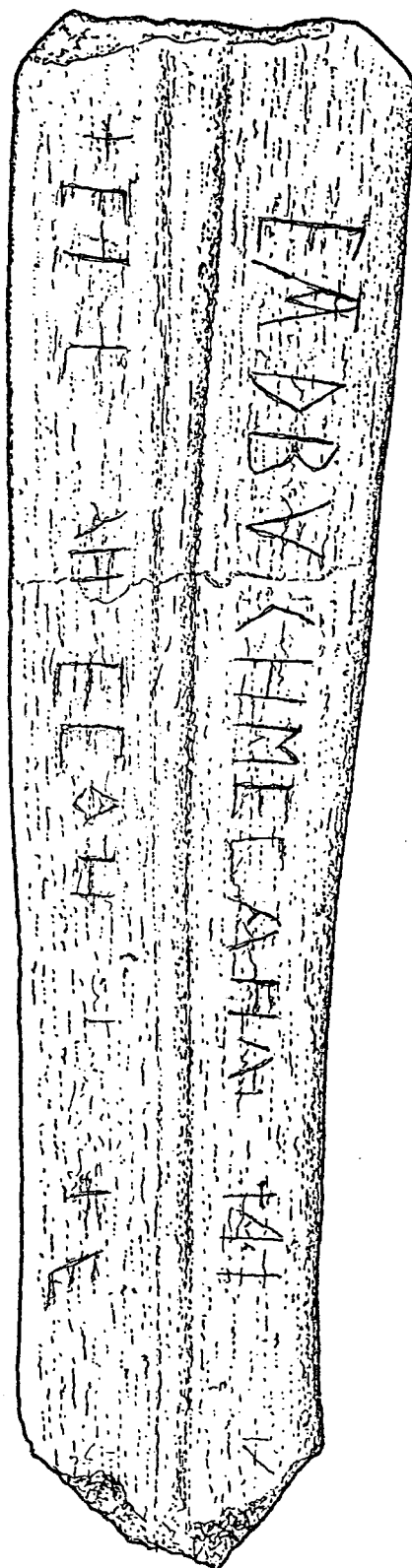


Figure 37 Cetacean bone weaving sword from Wallingford, inscribed
 - EADBVHMECAHA(....)-AE(....) and - EADBVH(M)ECAH(AH)E(....)
 - AE(....). Scale 1:1.

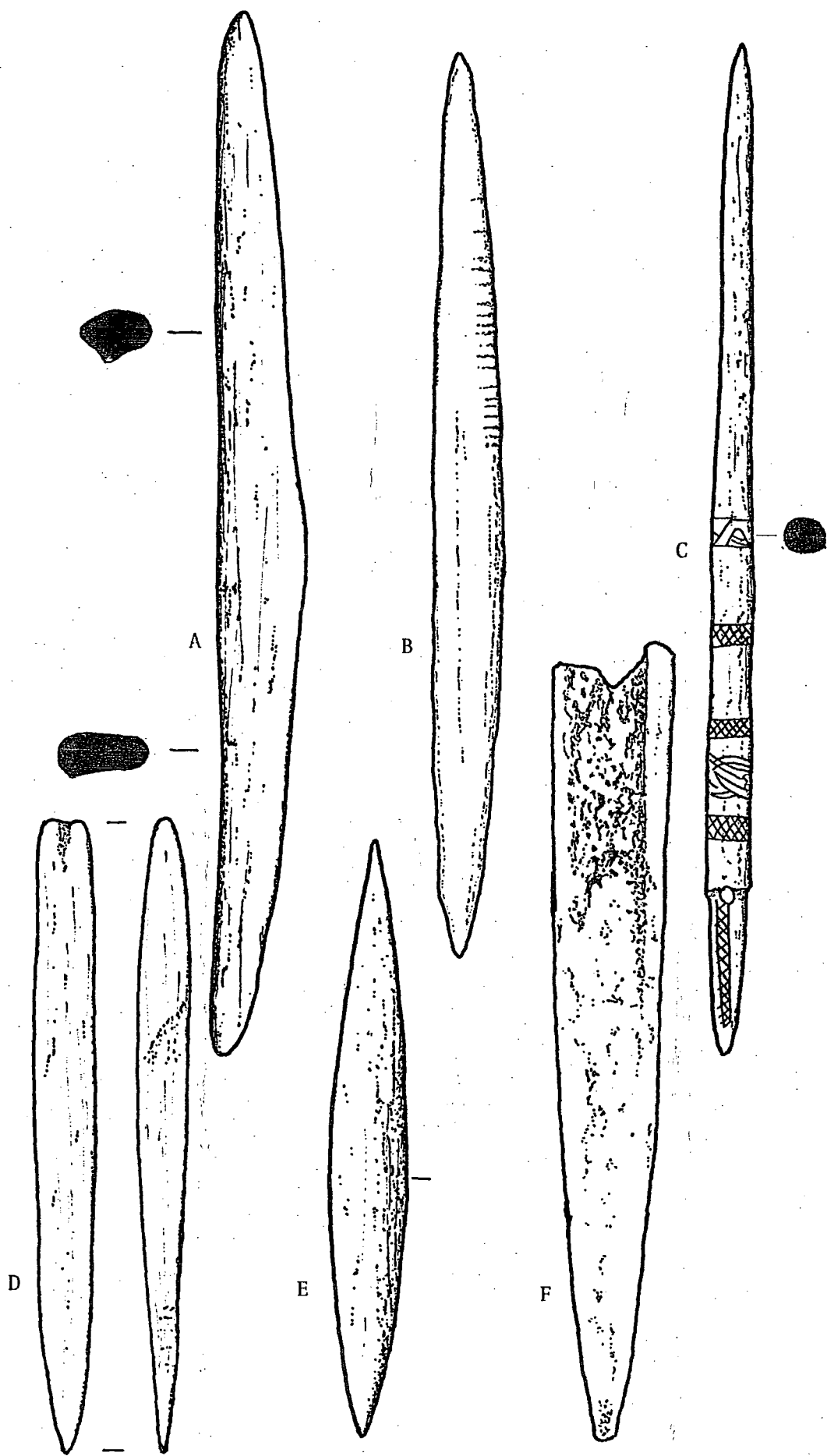
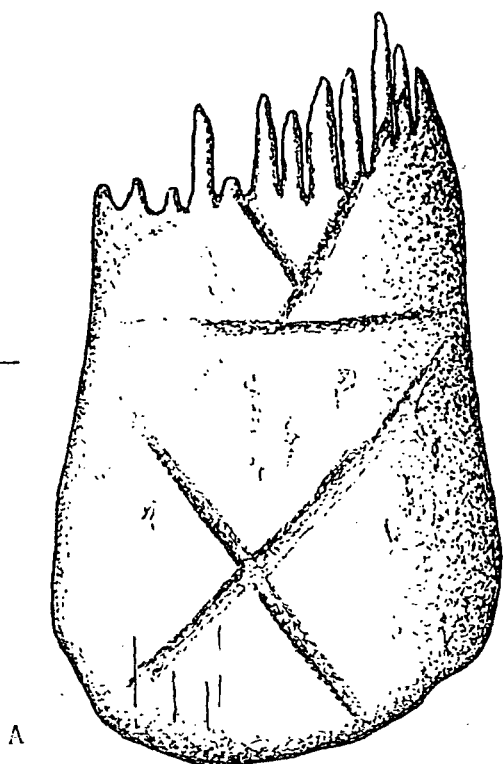


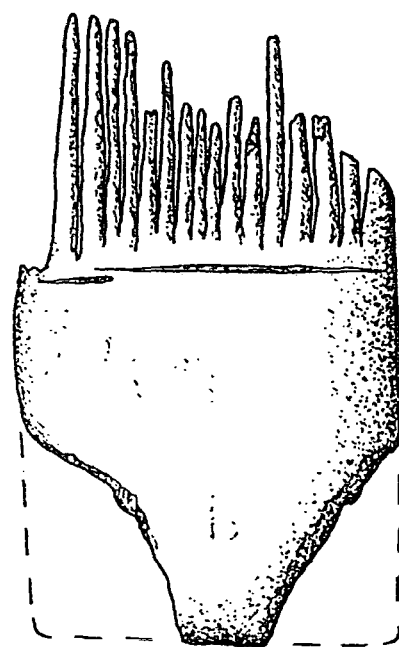
Figure 38 Pin beaters. A-B Hamwih (Southampton), C York, D Goltho Manor, E Sutton Courtenay, F York. Scale 1:1.



A



C



B



D

Figure 39 Weaving combs of (A-B, D) cetacean bone and (C) antler, from the Broch of Burrian. Scale 1:1.

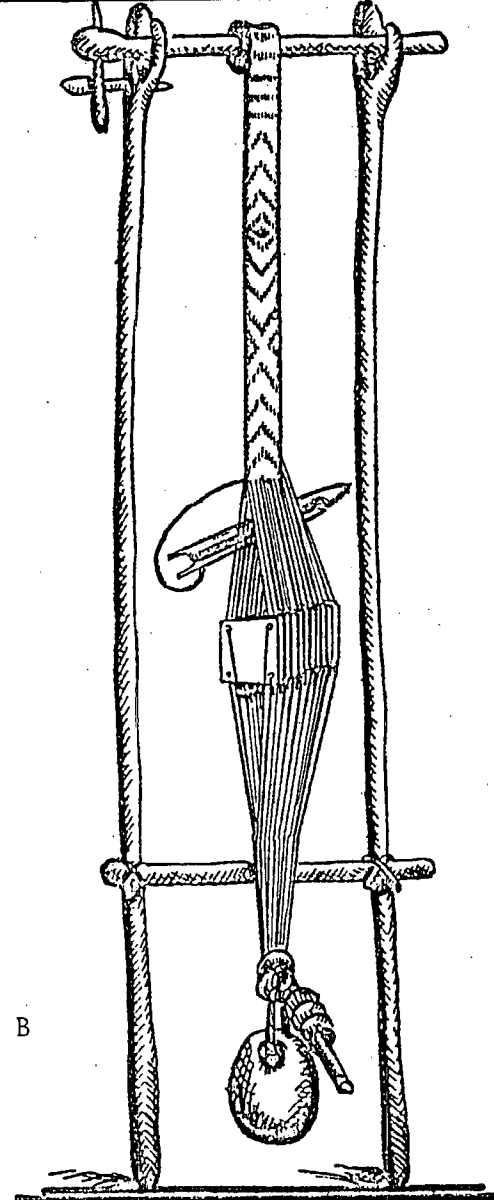
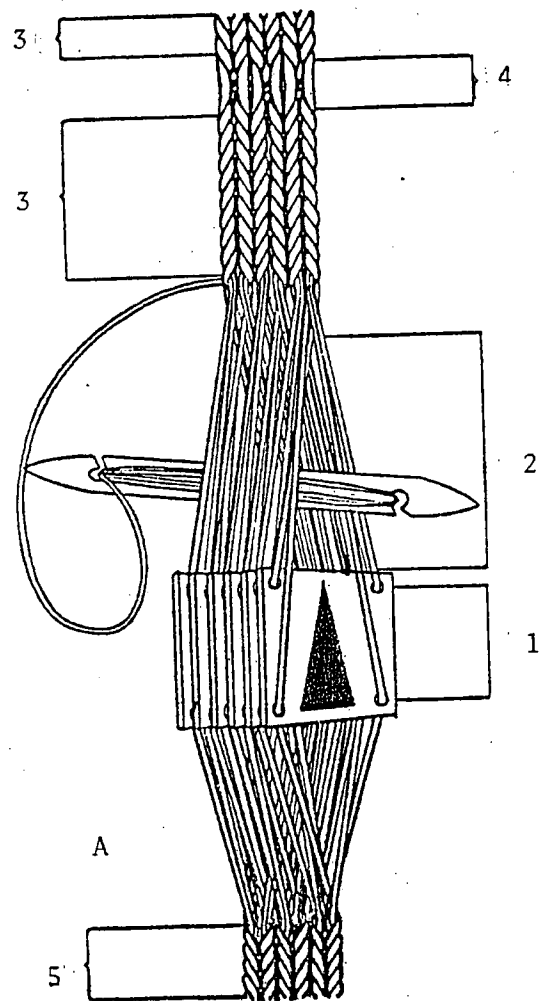
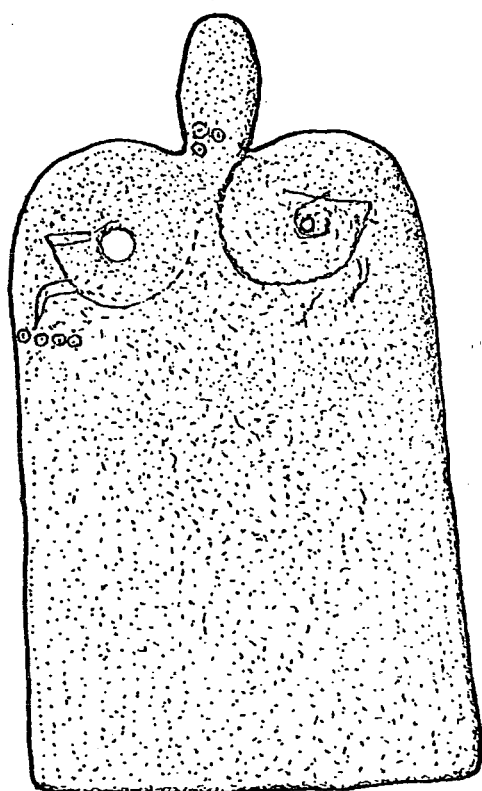
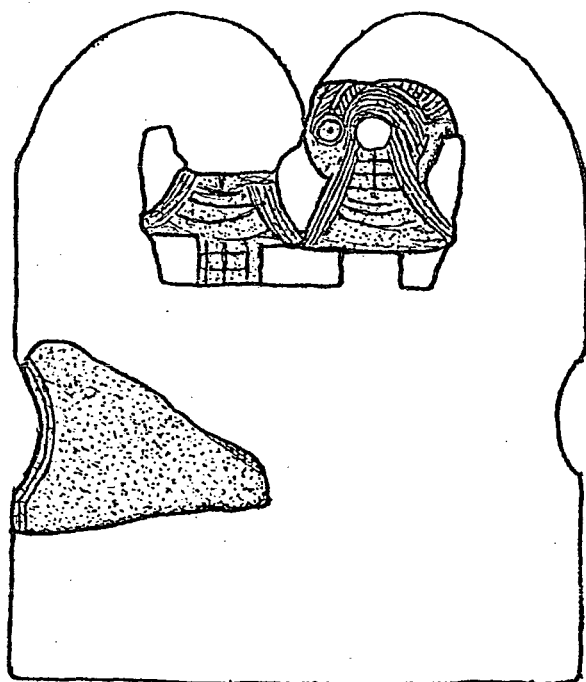


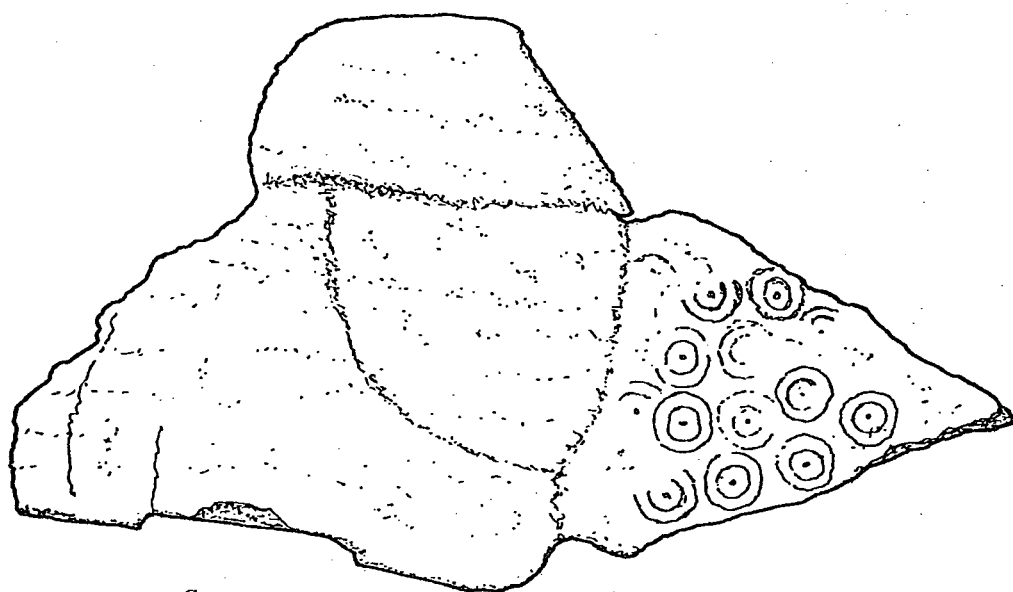
Figure 40 Tablet weaving (after Schlabow). A 1 tablets, 2 shed, 3 pattern from paired tablets, 4 reverse; B vertical frame for tablet weaving.



A



B



C

Figure 41 Cetacean bone smoothing boards. (A) with unfinished decoration, from Ely; (B) fragmentary, restored, from Ireland; (C) fragmentary, from Arran. Not to scale.

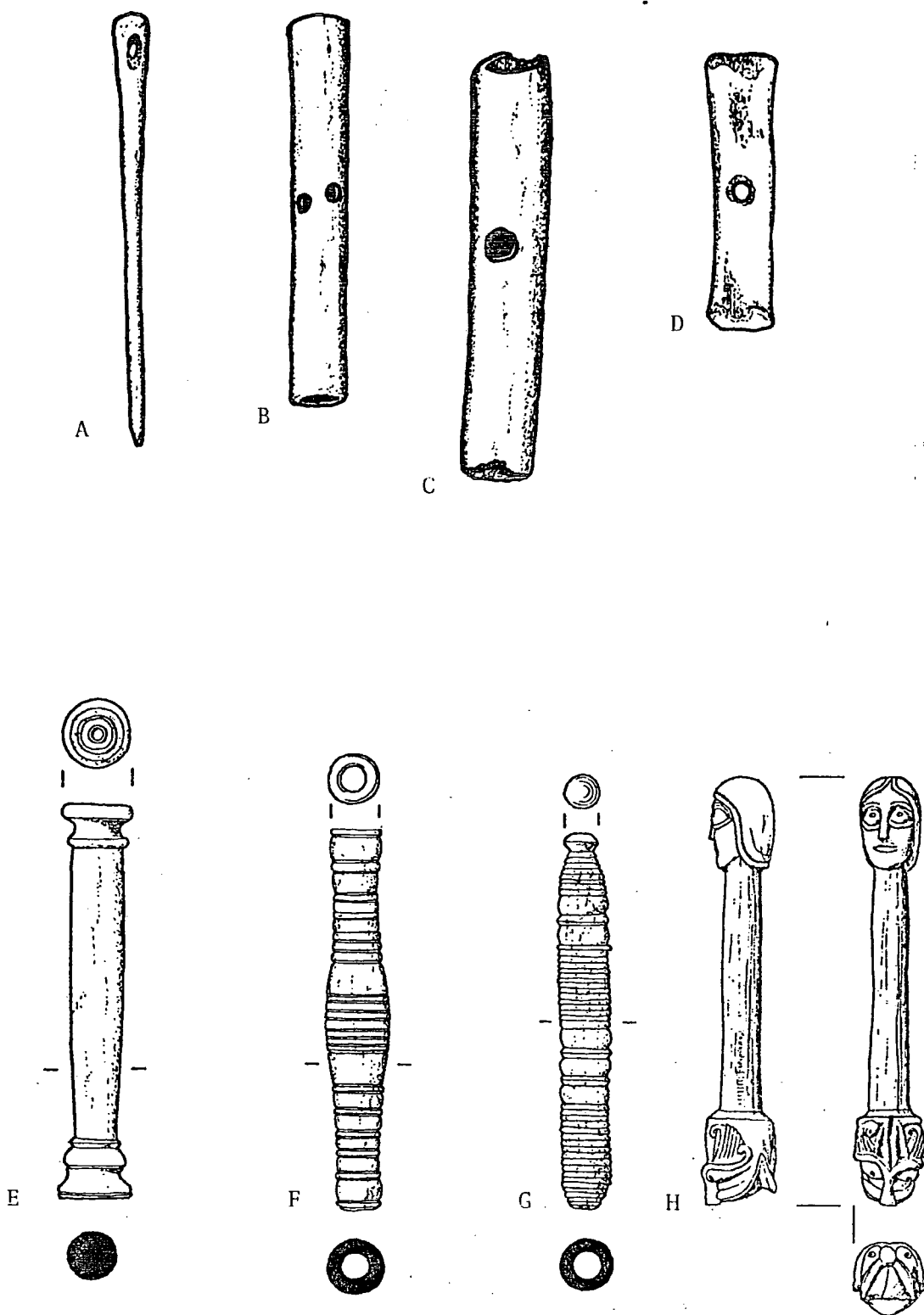


Figure 42 Miscellaneous textile equipment. A needle, Whitby; B-C needle-cases, Jarlshof; bobbins of bone (D) from Jarrow, turned antler (E-G) from York and walrus ivory (H) from Norwich. Scale 1:1.

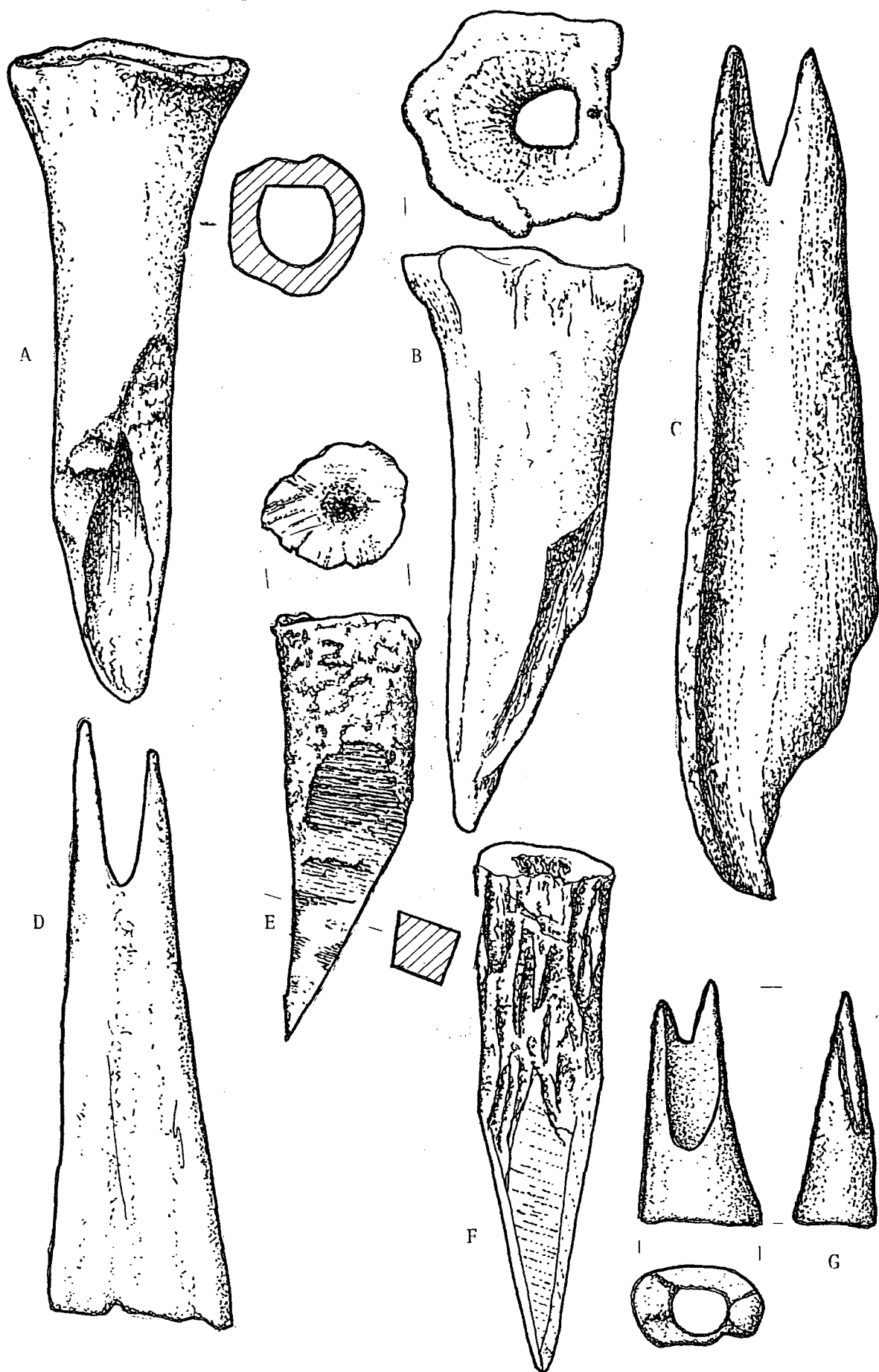


Figure 43 Points: socketed bone from (A) York and (B) Northampton; bovine nasal bones from (C) Lochlee and (D) York; antler tines (E) (transversely grooved) from York and (F) from Aberdeen; double point (G) Waltham Abbey. Scale 1:1.

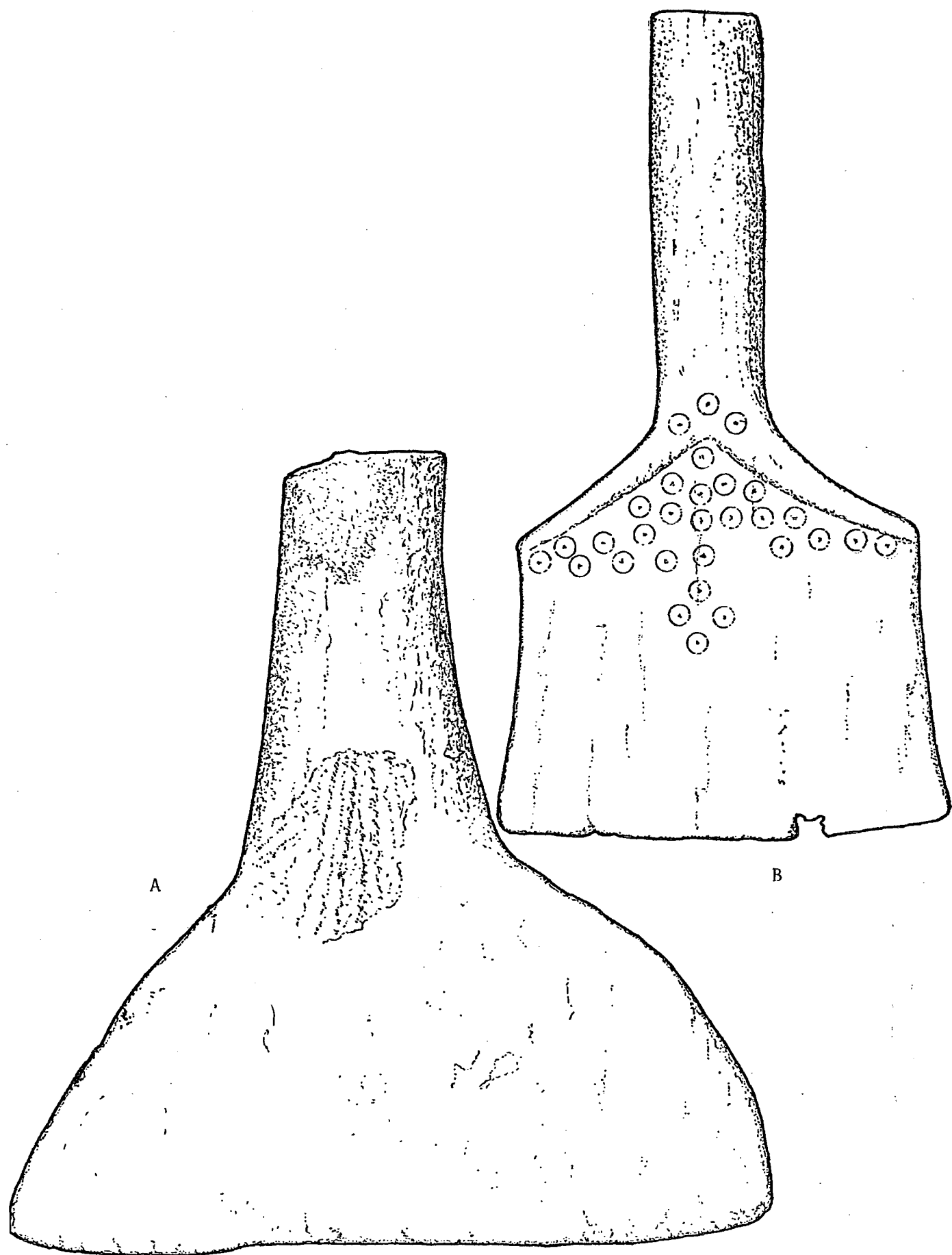


Figure 44. Cetacean bone cleavers from (A) Drimore and (B) Dublin. Scale 1:1.

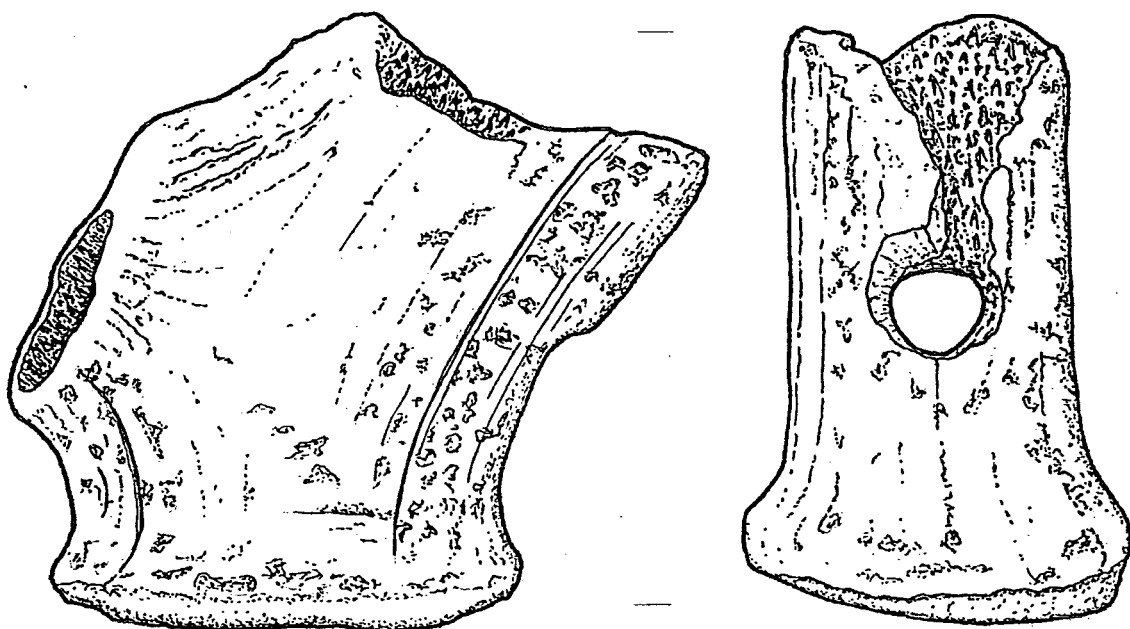


Figure 45 Antler hammer, transversely drilled, from Jarrow. Scale 1:1.

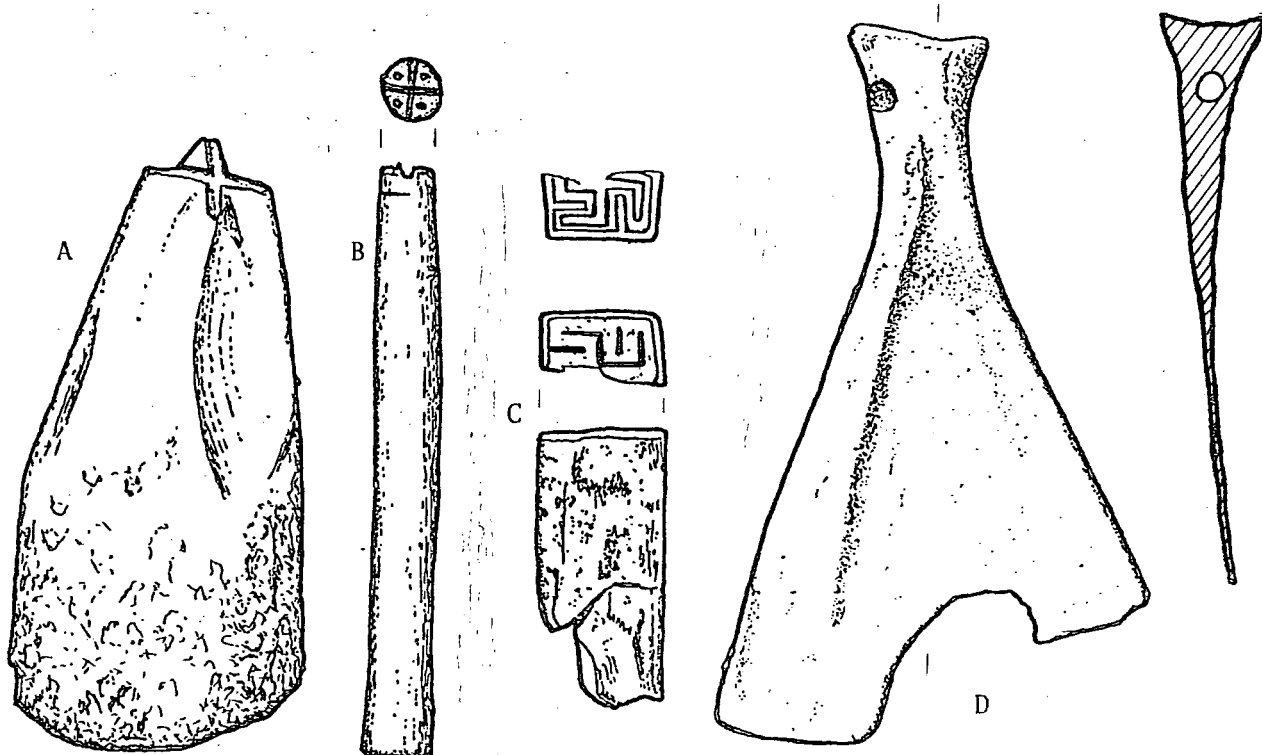


Figure 46 Stamps from (A) West Stow, (B) Dun an Fheurain, (C) Jarrow and scapula scoop (D) from York. Scales (A) after Myres, not to scale, (B) 1:1, (C-D) 2:1.

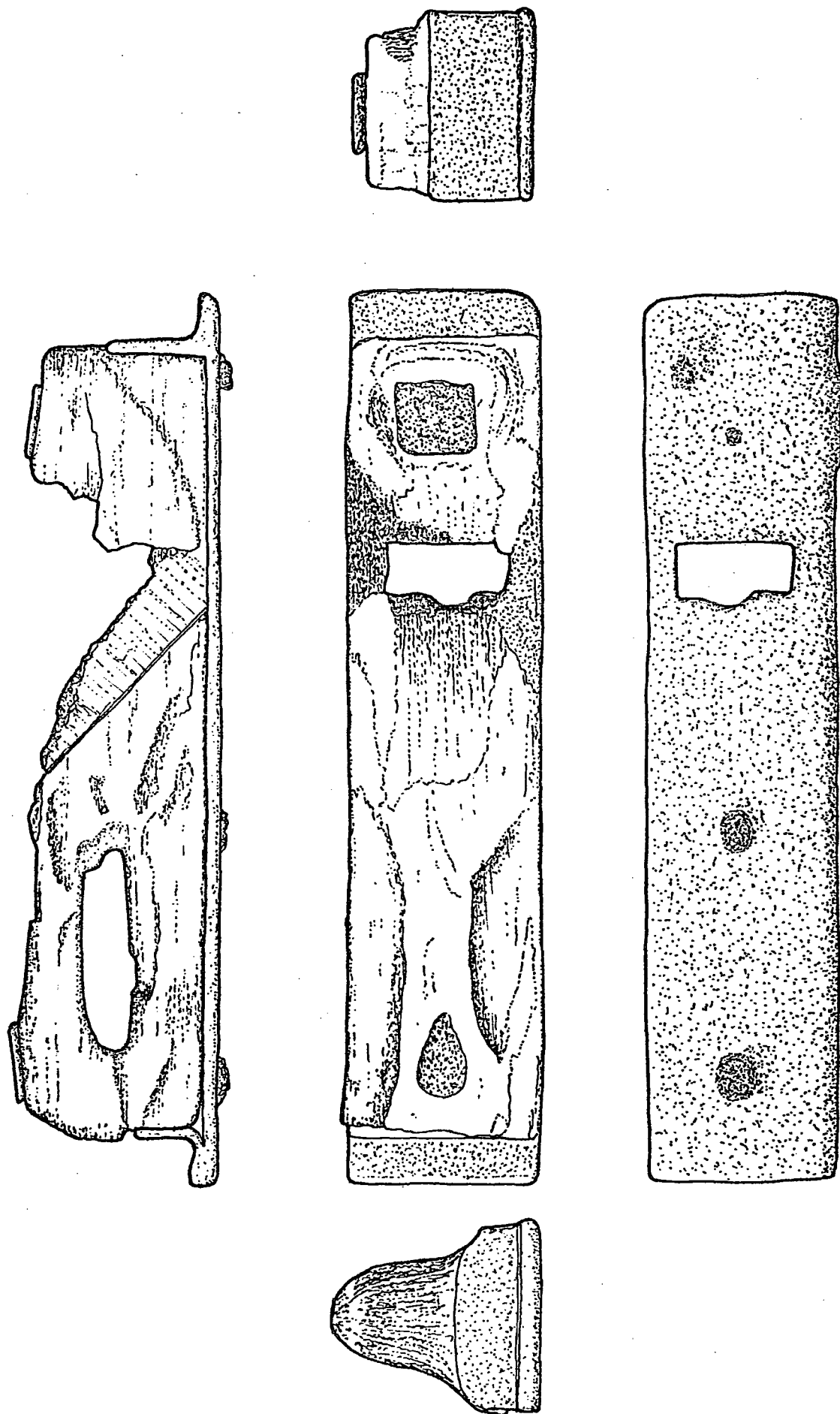


Figure 47 Plane, with antler stock and bronze sole-plate,
from Sarre. Scale 1:1.

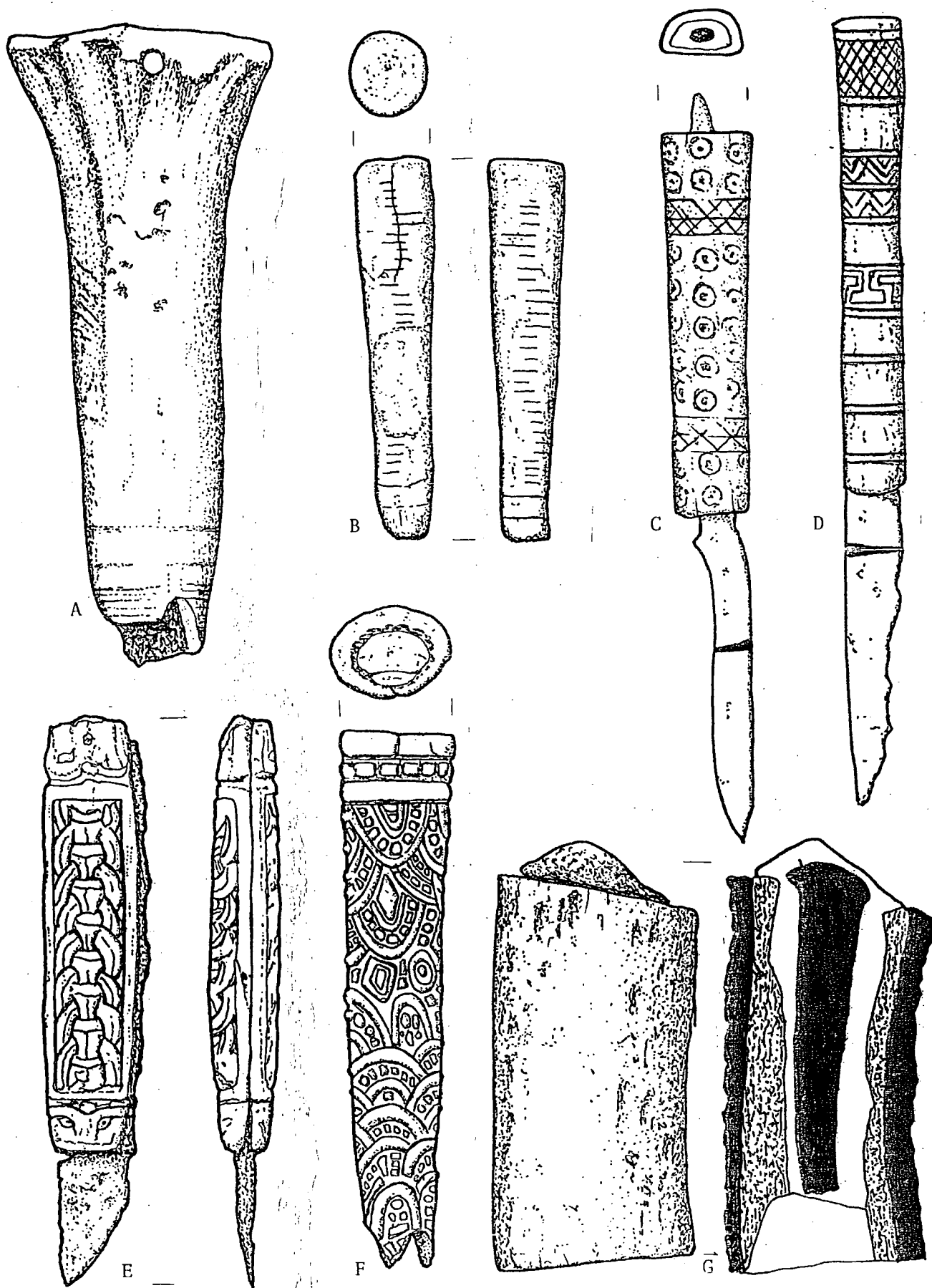


Figure 48 Handles. A A Cheardach Mhor, B Weeting, C - D York, E Canterbury, F London, G Southampton. Scale 1:1.

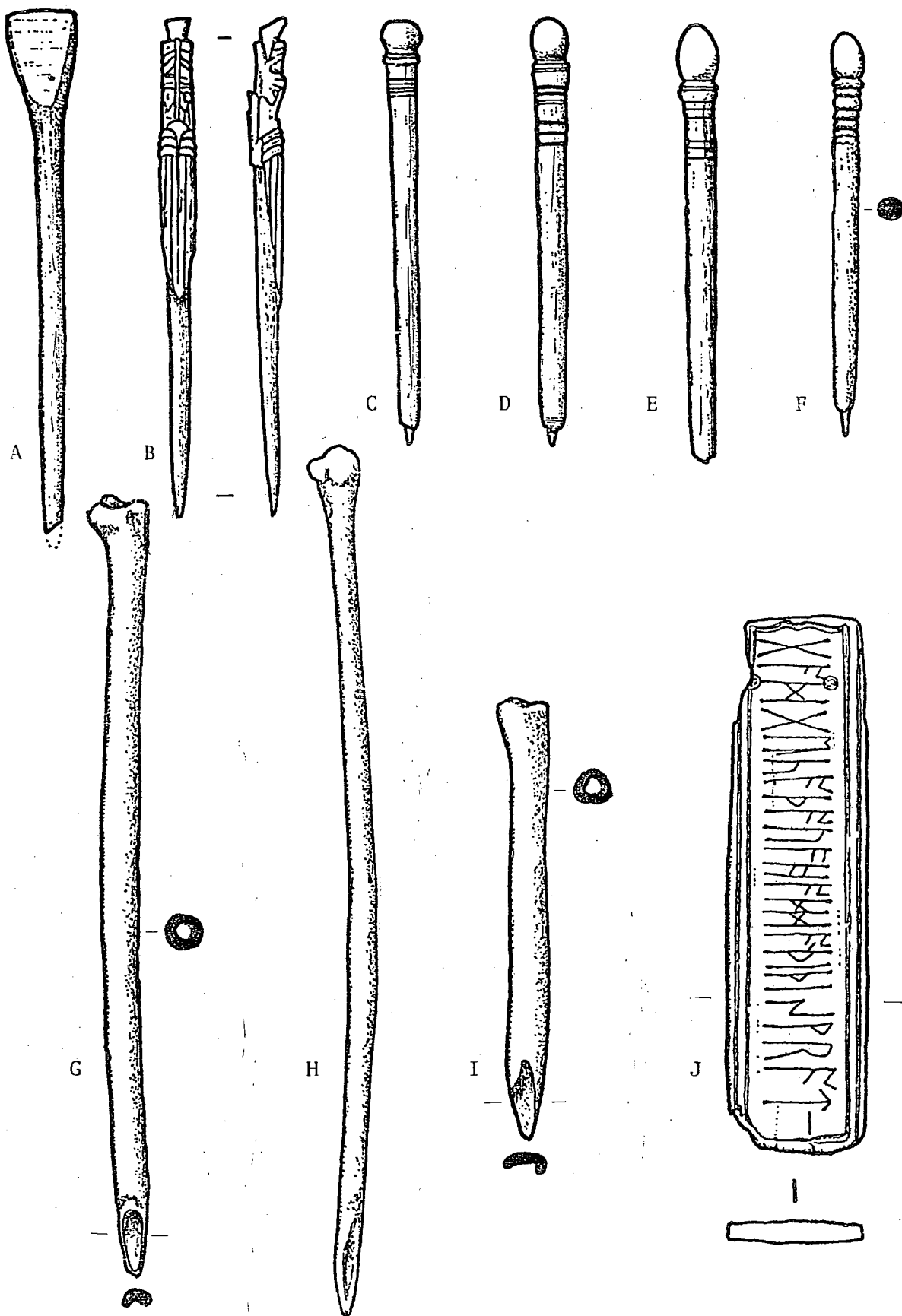


Figure 49 Writing equipment: styli from (A) Whitby and (B) York; prickers from (C-D) Whitby, (E) York and (F) Jarrow; pens from (G-H) Coventry and (I) Norwich; plate (J) from Derby. Scale 1:1.

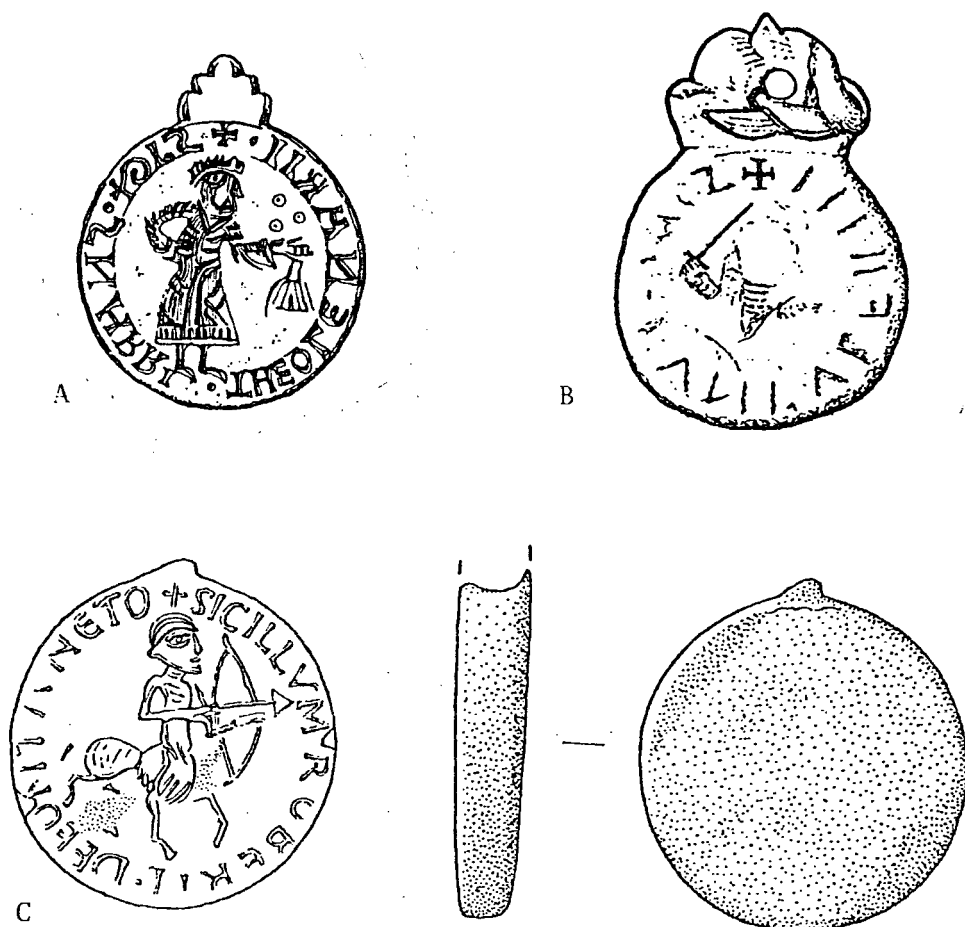


Figure 50 Seal matrices: A from York, B from Siltingbourne, C (after N Griffiths) from Witney (the obverse of C shown as an impression). Scale 1:1.

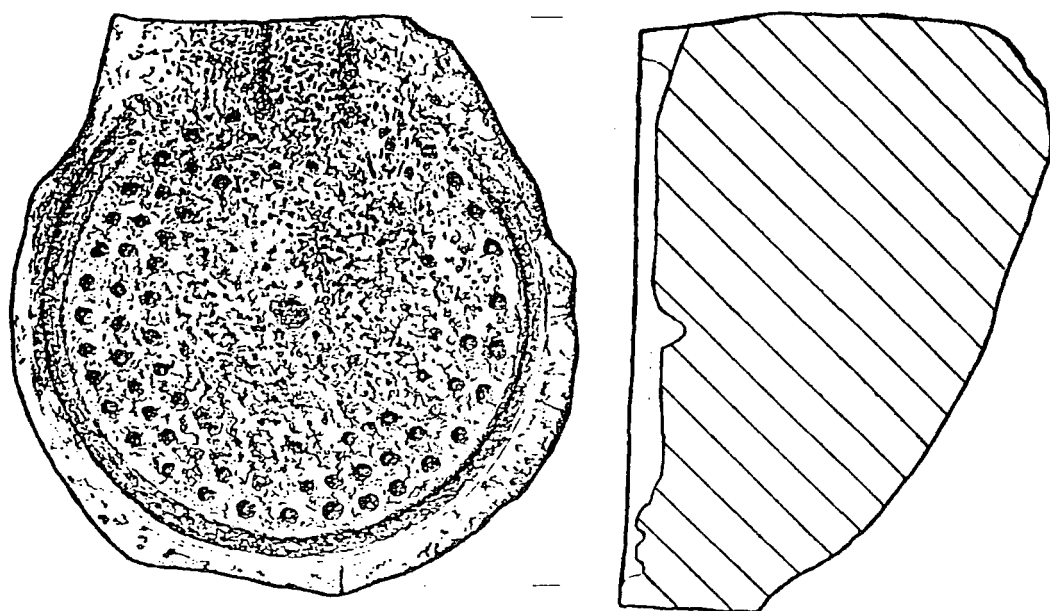


Figure 51 Brooch mould cut from antler burr, Southampton. Scale c. 2:1.

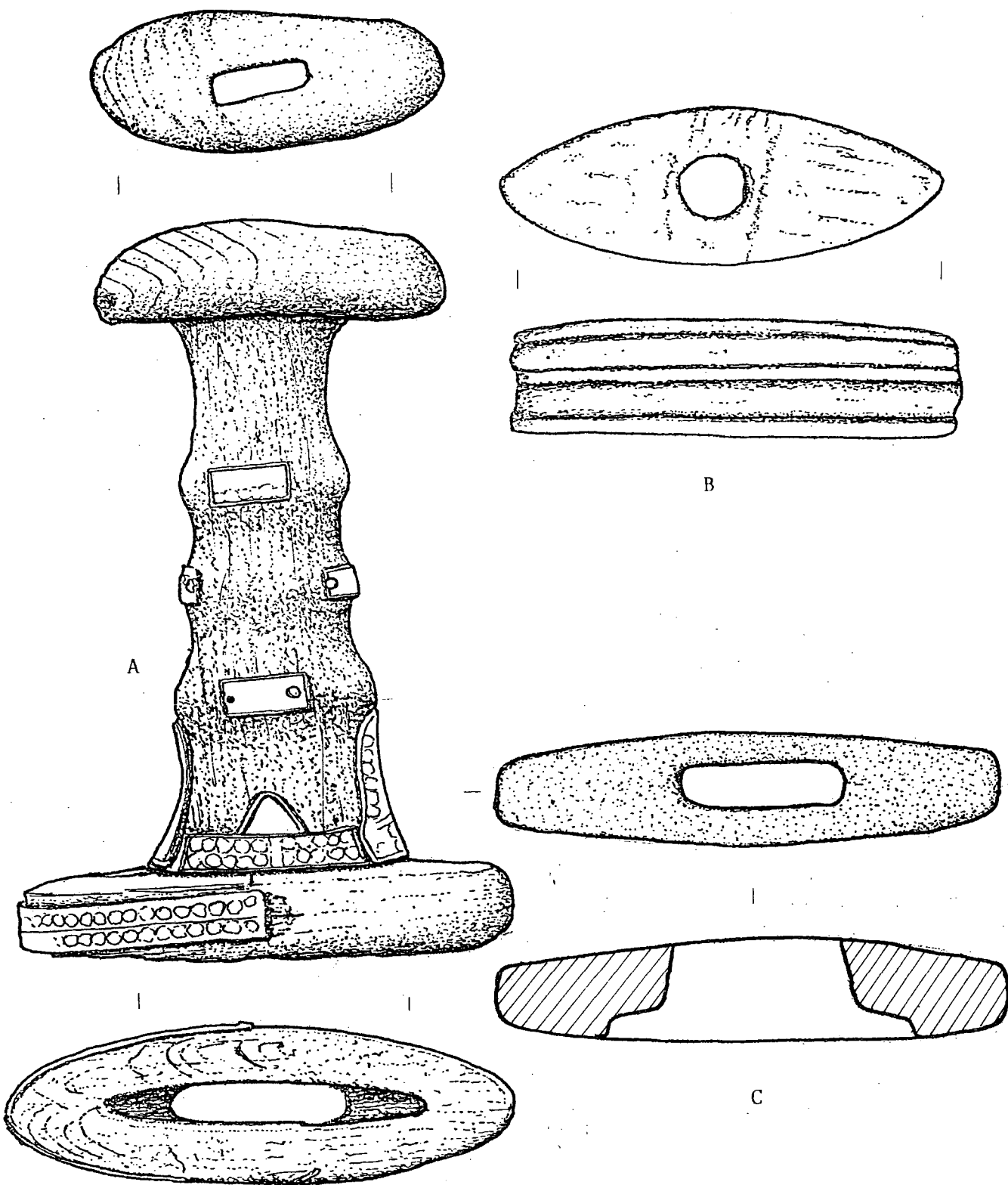


Figure 52 Sword hilts. A Cumberland, B Lakenheath (pommel), C York (guard). Scale 1:1.

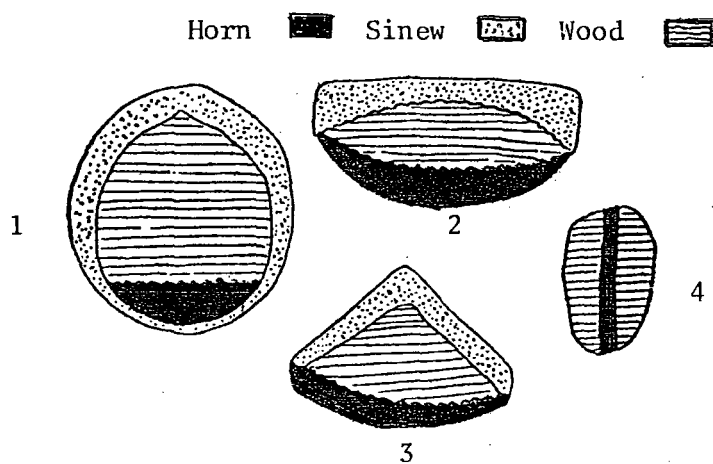
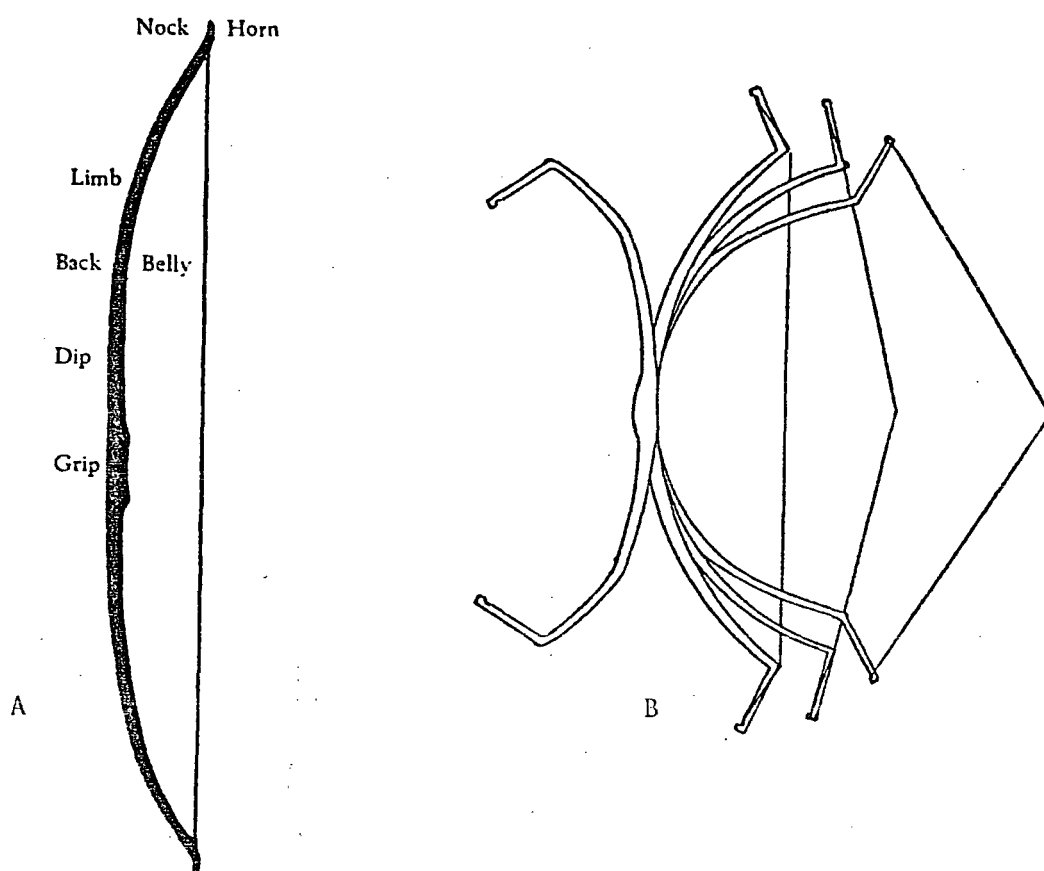


Figure 53 Composite bows: structure (after Rausing)
 A Principal parts of the bow
 B Conformation of bow from unstrung to fully extended
 C Sections through (Turkish) composite bow: 1 Handle, 2 Limb, 3 Limb below ear, 4 ear.

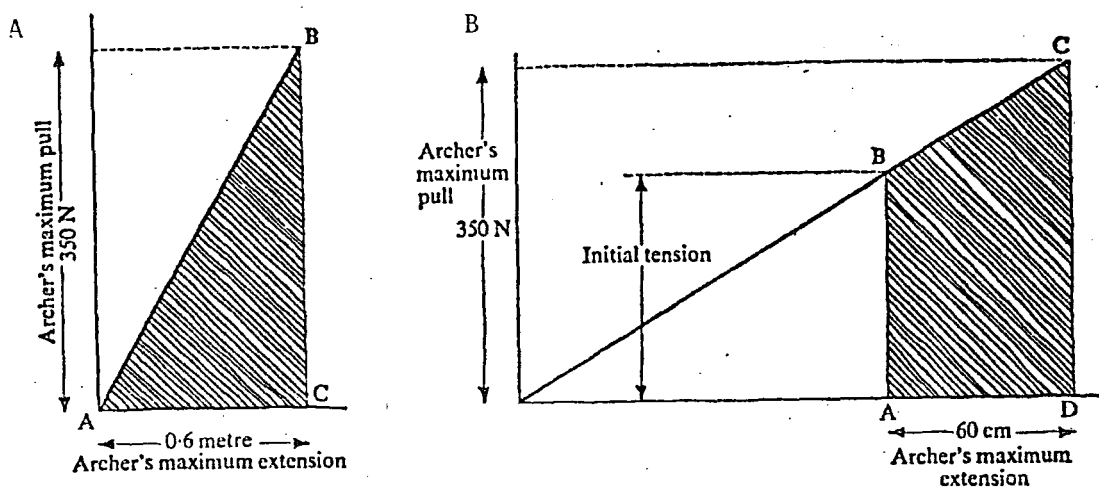


Figure 54 Bows: schematic energy diagrams (after Gordon).

- A Self bow: energy stored in bow (ABC) = $\frac{1}{2} \times 0.6 \times 350 = 105$ Joules
 B Pretensioned composite bow: energy stored in bow (ABCD) = 170 Joule

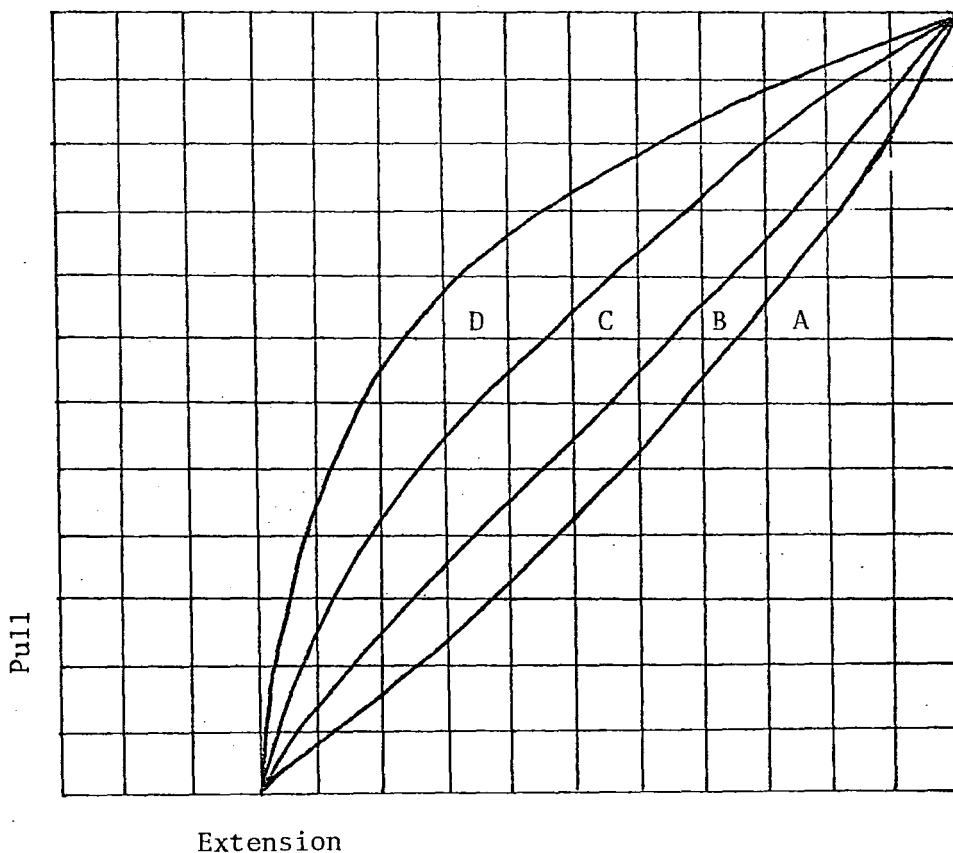


Figure 55 Bows: schematic energy diagrams (force-draw curves) for typical bows with 60lb pull (after Rausing). A short (four-foot) one-piece bow; B long (six-foot) bow; C short bow provided with rigid ears; D short reflexed bow. The amount of energy stored in the bow is represented by the area enclosed by the curve, the perpendicular and the base line. The area contained within D is 57% greater than in A.

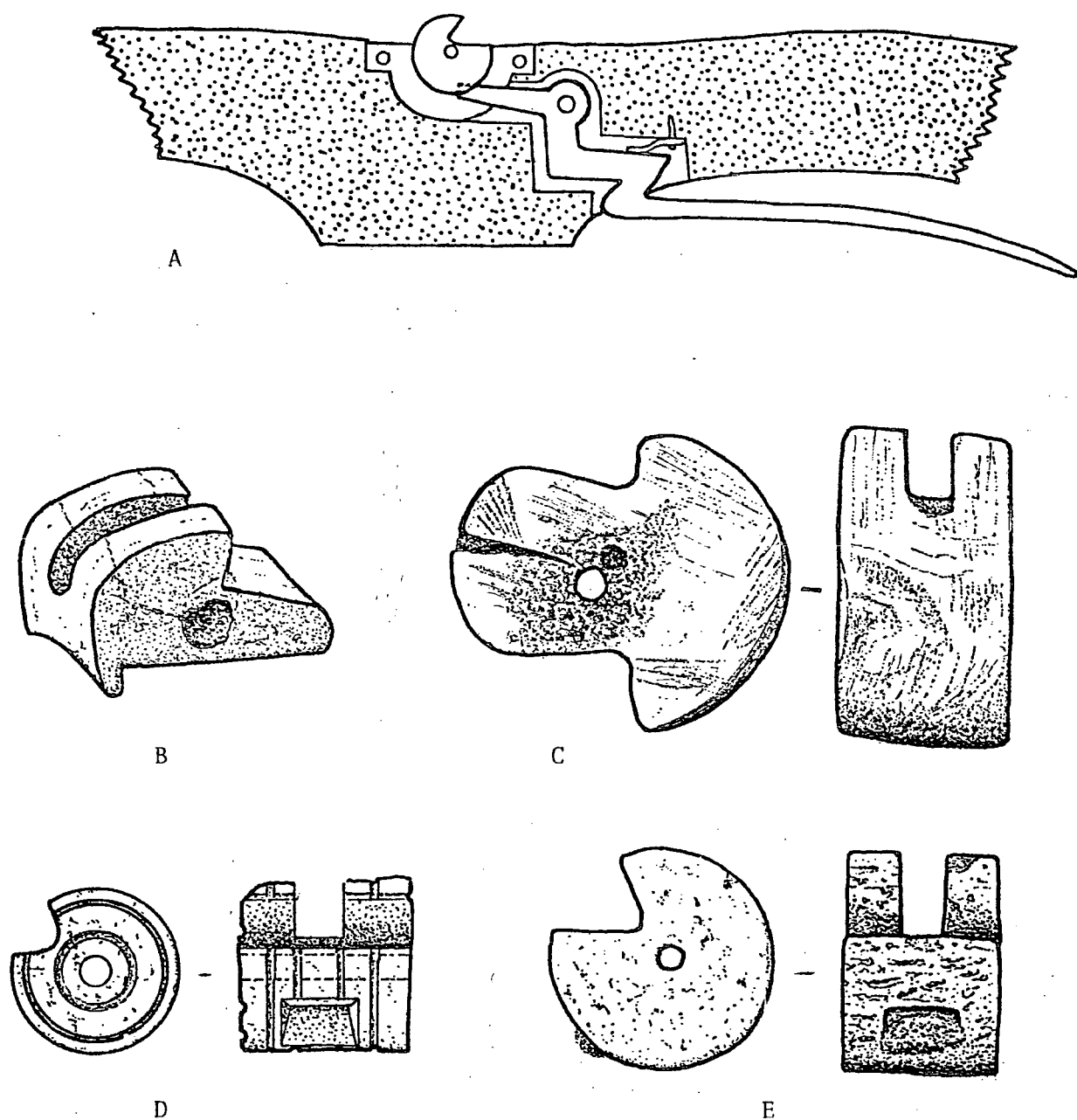


Figure 56

Crossbow nuts. A location of the nut within the crossbow mechanism (after Payne-Gallwey); B Burbage, C Buston Crannog, D Wareham Castle, E Urquhart Castle. Scale 1:1

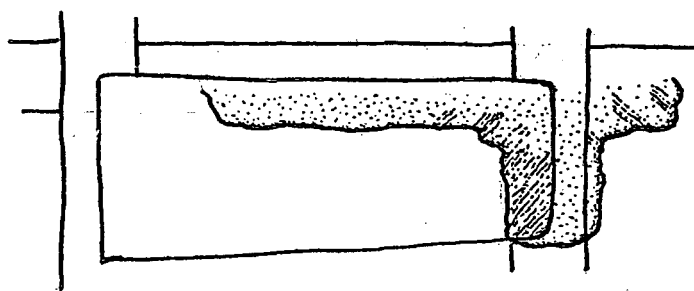
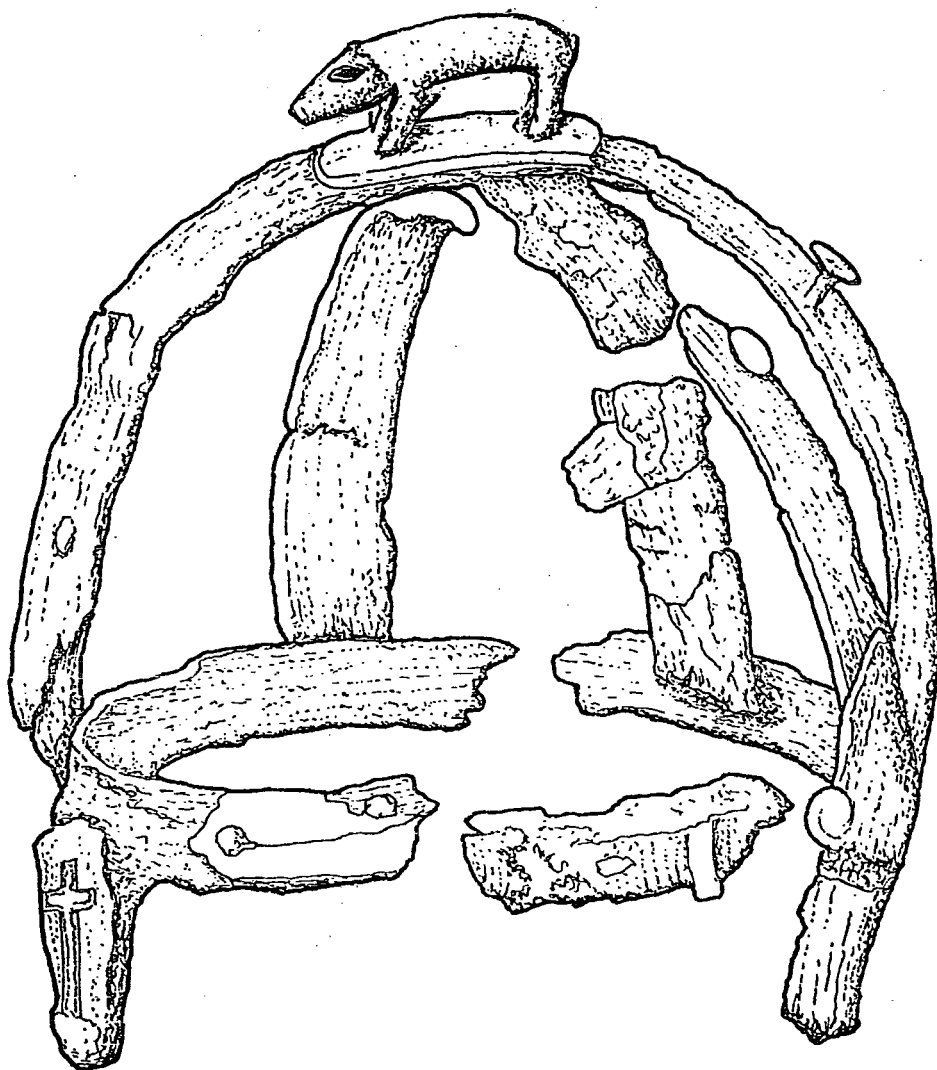


Figure 57 Helmet from Benty Grange (after Bateman and Bruce-Mitford). Inset, reconstructed detail of neck guard (after Bruce-Mitford).

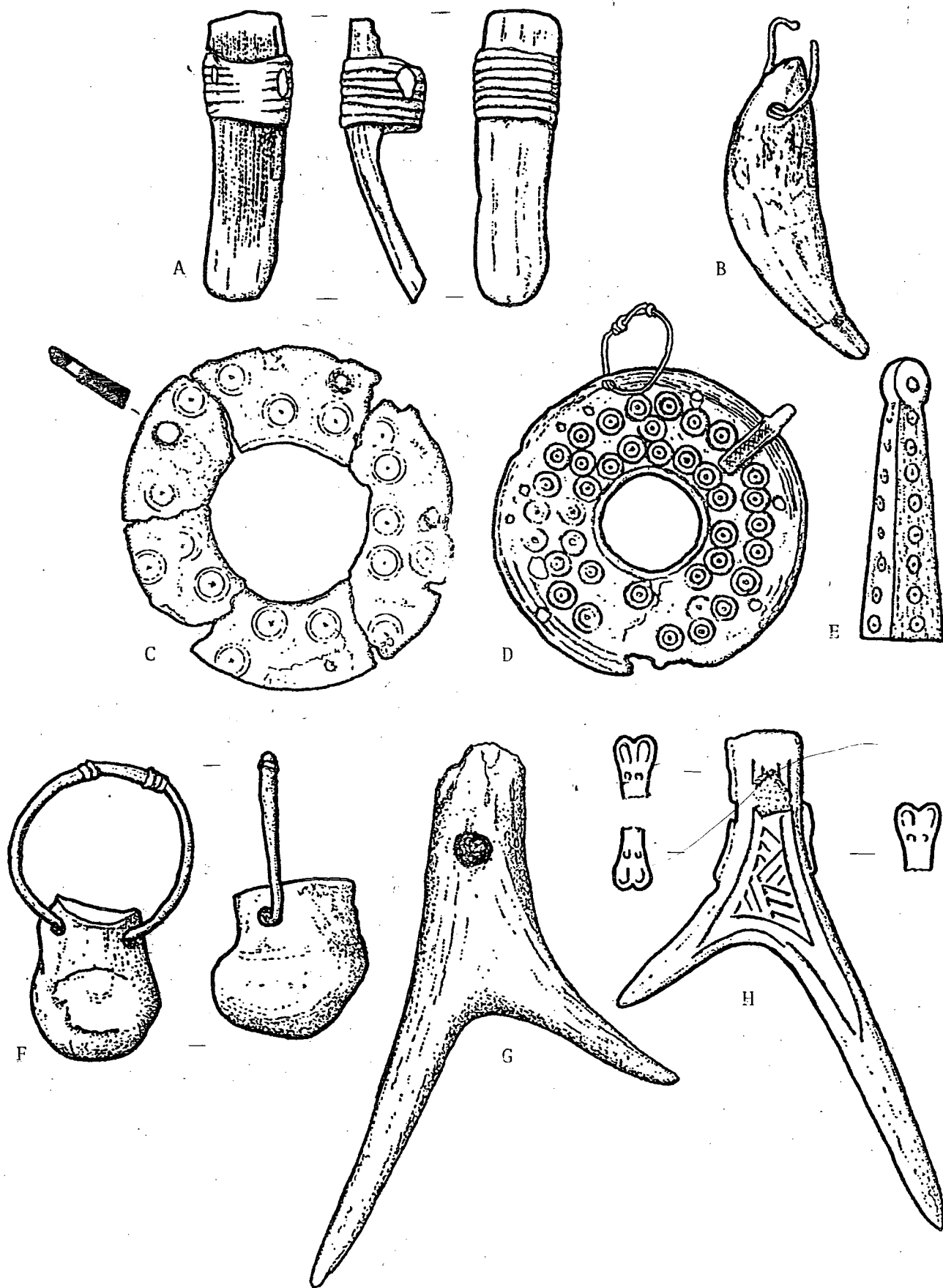


Figure 58 Amulets: beaver tooth (A) from Ducklington; tooth (B) from Sleaford; annular, of antler, from (C) Kent and (D) Burwell; prismatic, of antler (E) from Souldern; bone (F) from Nassington; antler tines from (G) London and (H) York. Scale 1:1.

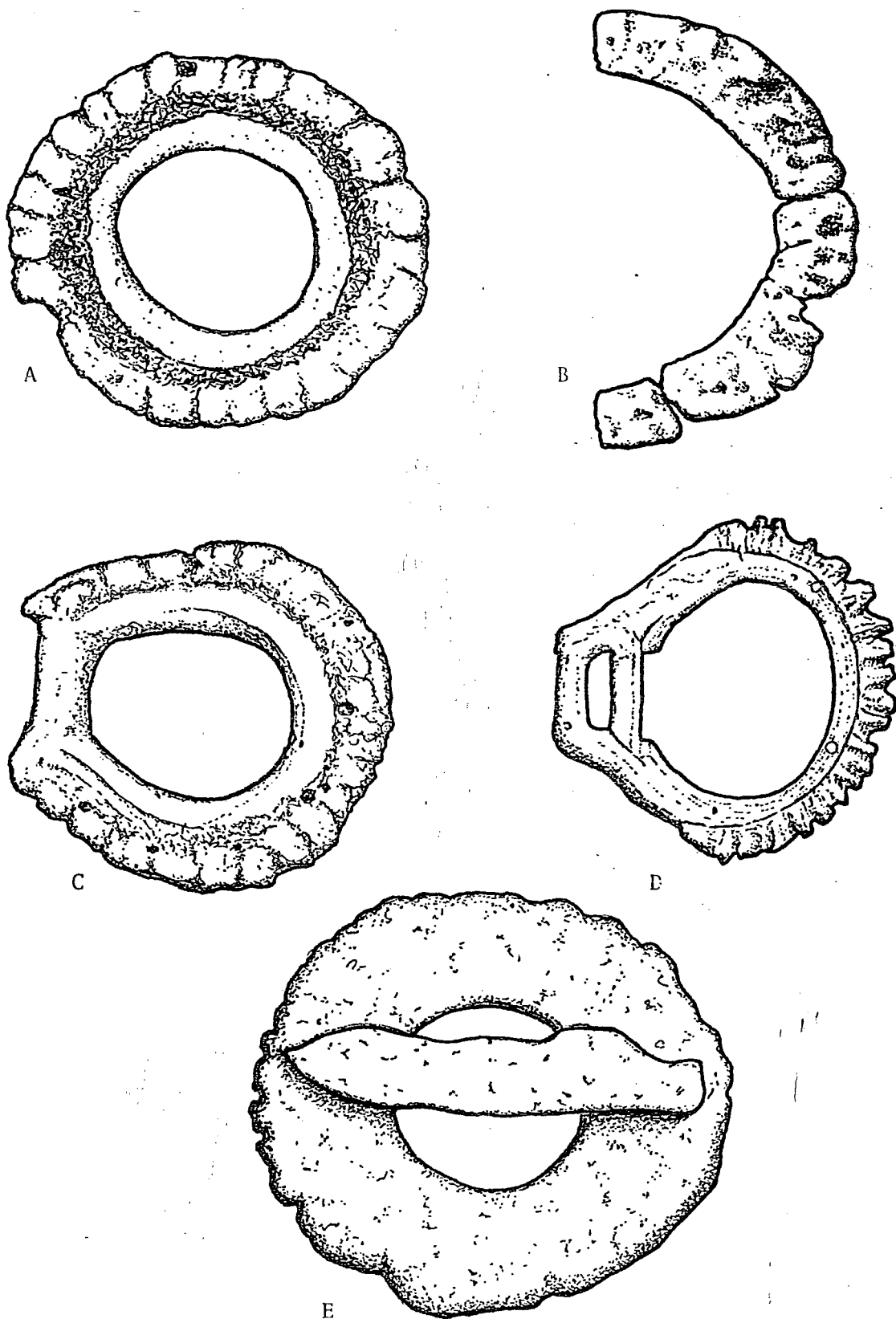


Figure 59 Girdle rings, buckles and brooches made from antler burrs: A unprovenanced, British Museum, B Newark on Trent, C unprovenanced, Museum of London, D Whitby, E (with iron pin) Londesborough. Scale 1:1.

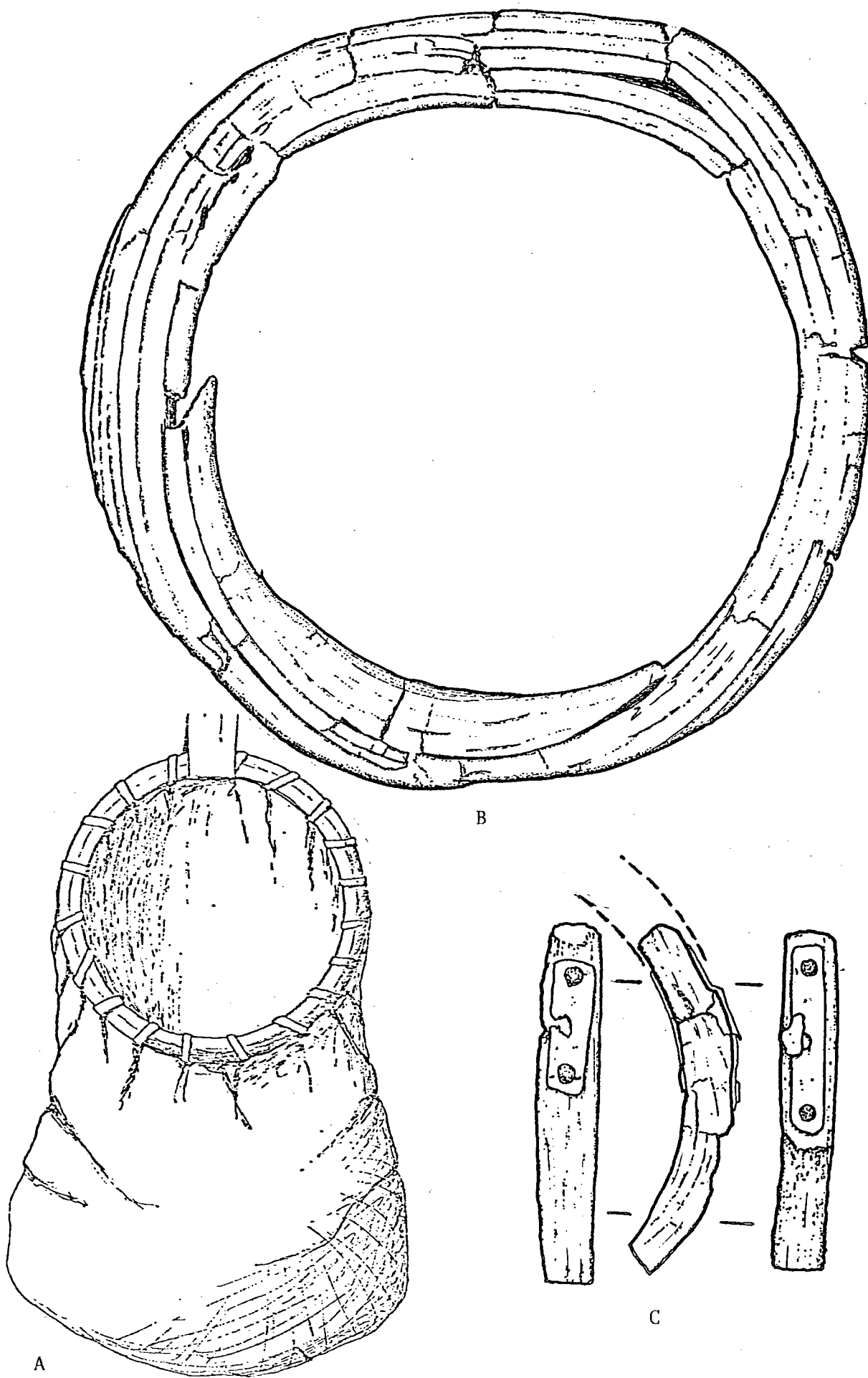


Figure 60 Ivory bag rings. A reconstruction of method of use (after Myres and Green), B - C Beckford. B - C scale 1:1.



Figure 61 Buckles and strap ends. A Alnwick Castle Museum, B Ozengel, C Lewis, D Goodmanham, E - F York, G Leicester, H London. Scale 1:1.

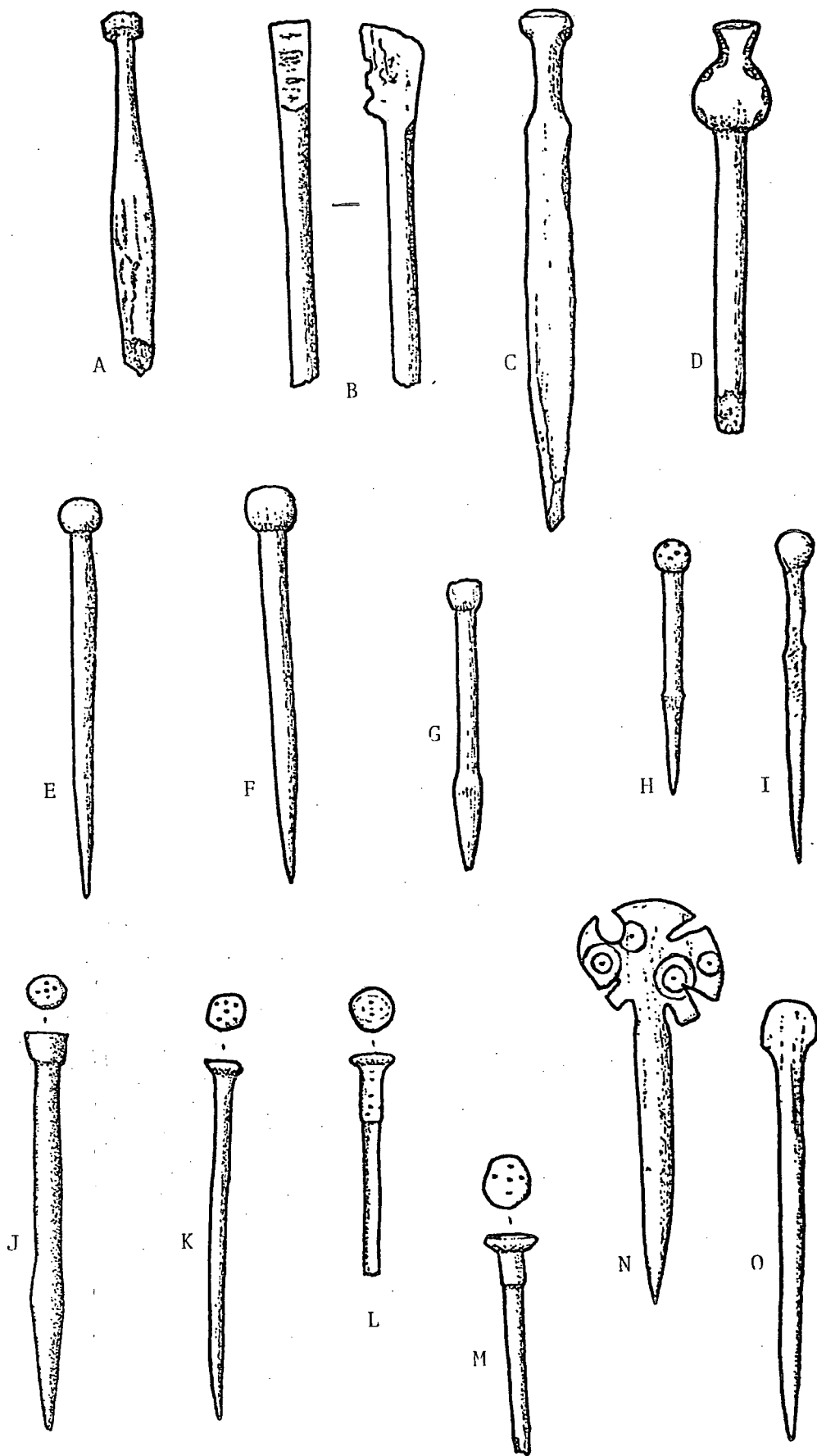


Figure 62 Pins. Unfinished, from (A) Buston, (B) York, (C) Ronaldsway, (D) Jarlshof; ball-headed, from (E - G) Burrian, (H) Buckquoy, (I) Jarlshof; nail-headed, from (J) Burrian, (K - M) Jarlshof; disc-headed, (N) unprovenanced, (O) Buckquoy. Scale 1:1.

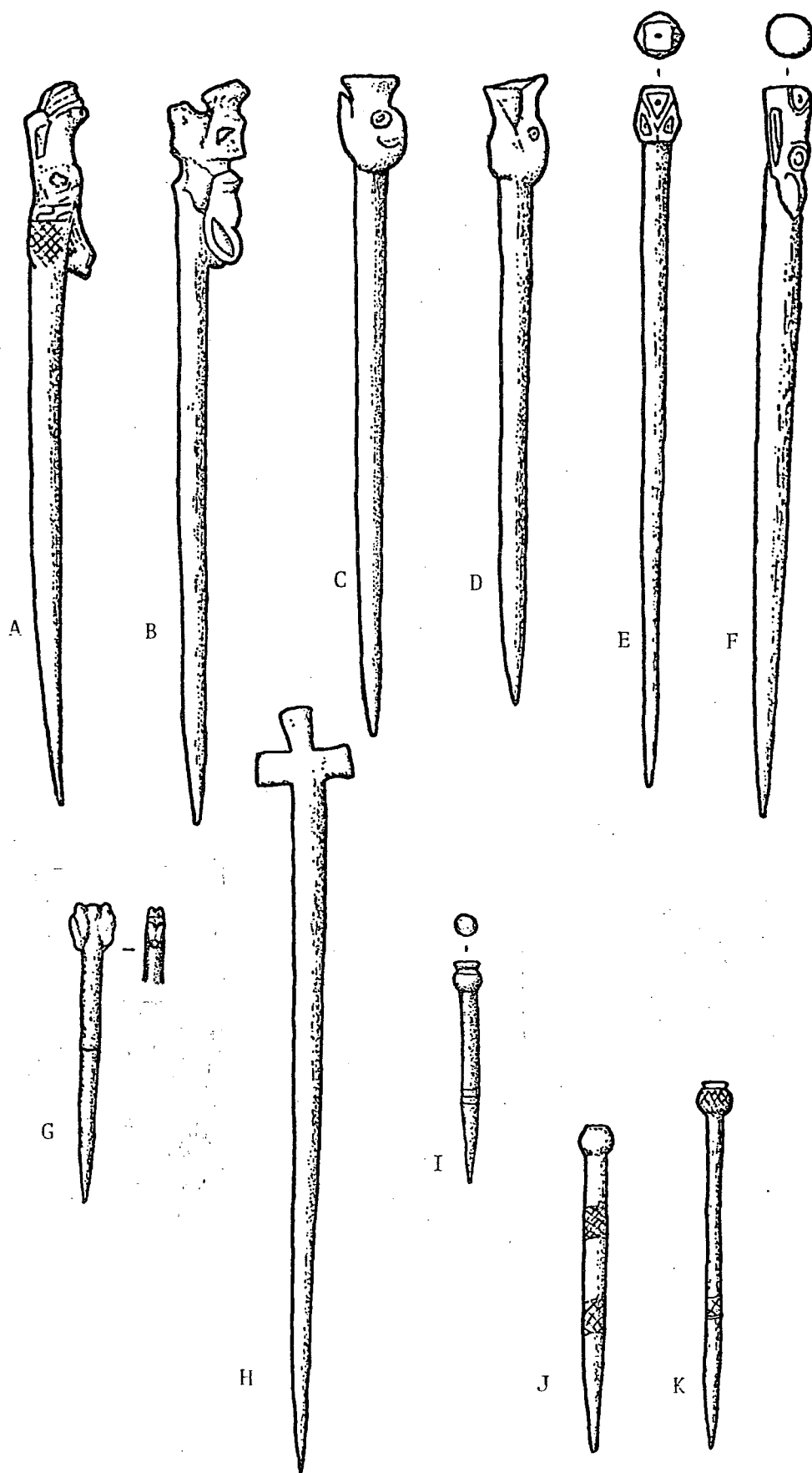


Figure 63 Pins. Zoomorphic, from (A - D) Jarlshof, (E - F) York and (G) Burrian; cruciform from (H) Jarlshof; thistle-headed from (I) Burrian, (J) Buston and (K) Buckquoy. Scale 1:1.

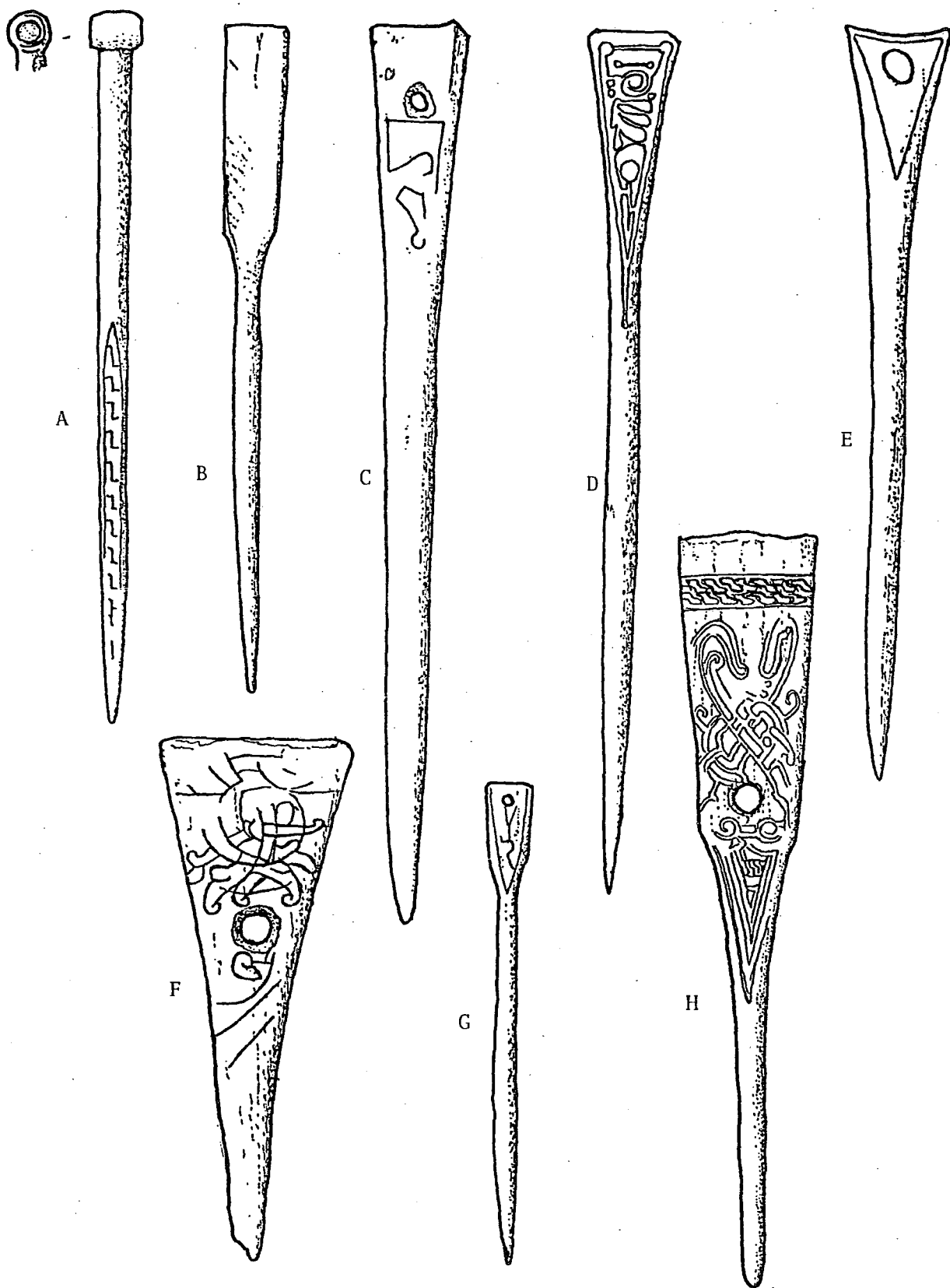


Figure 64 Pins. Loose ring headed (A) from York; expanded headed from (B-E, G) York and (F, H) London. Scale 1:1.

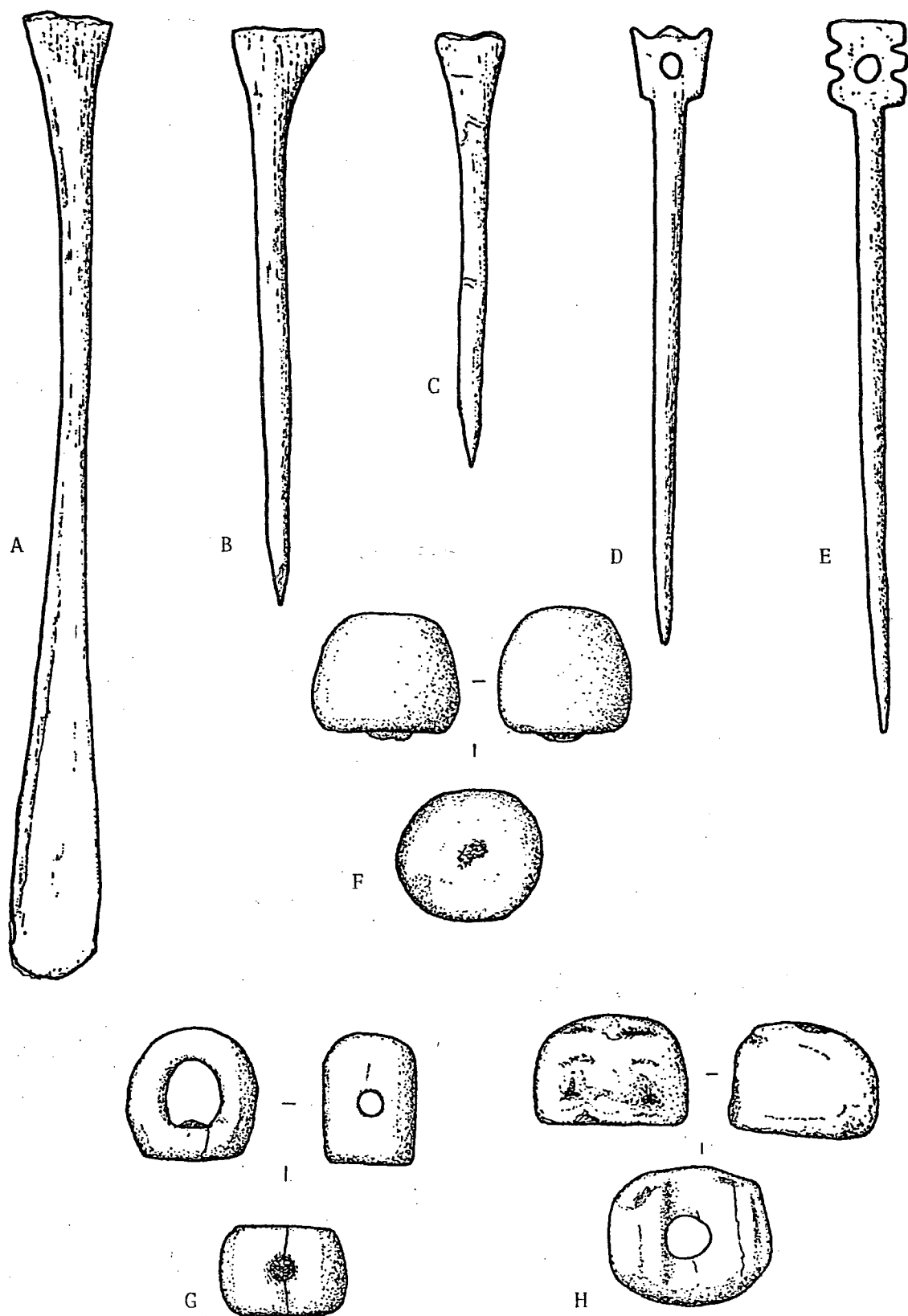
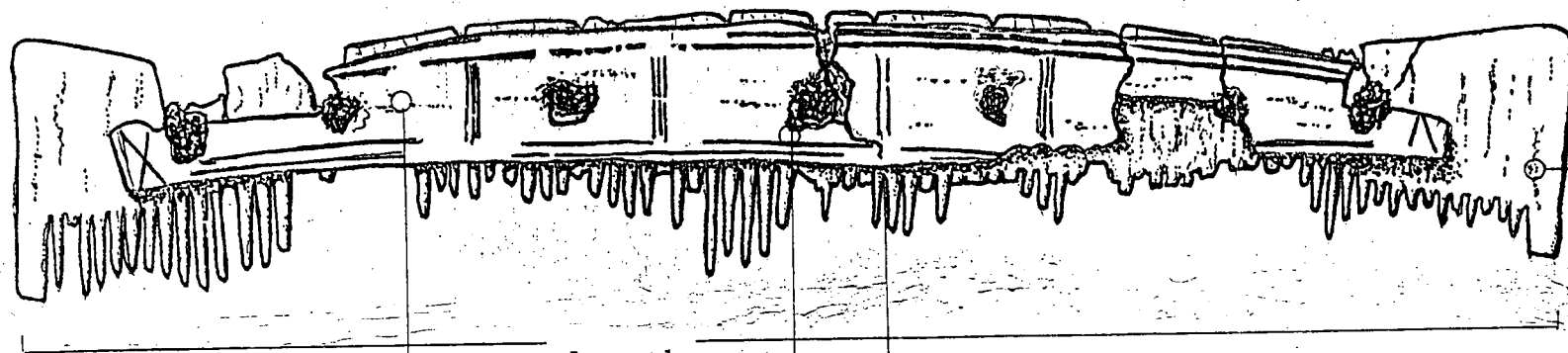
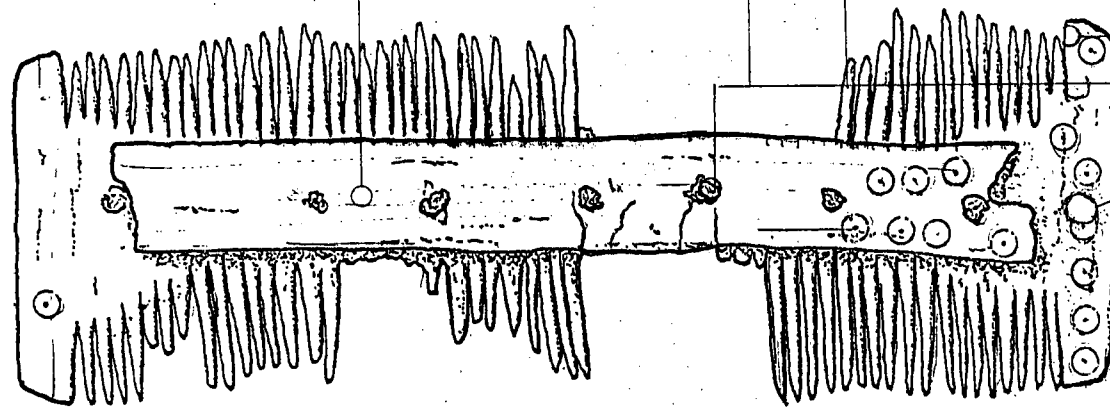


Figure 65 Pins. (A) uncut pig fibula; pins cut from pig fibulae from (B) Busto, (C) Buckquoy, (D - E) York; pin heads of (F) antler, (G) bone and (H) tooth, from Burrian. Scale 1:1.

Single-sided



Double-sided



Length

Side plate

Tooth plate

End plate

Rivet

Suspension hole



Height



Figure 66 Composite combs: explanation of terminology.

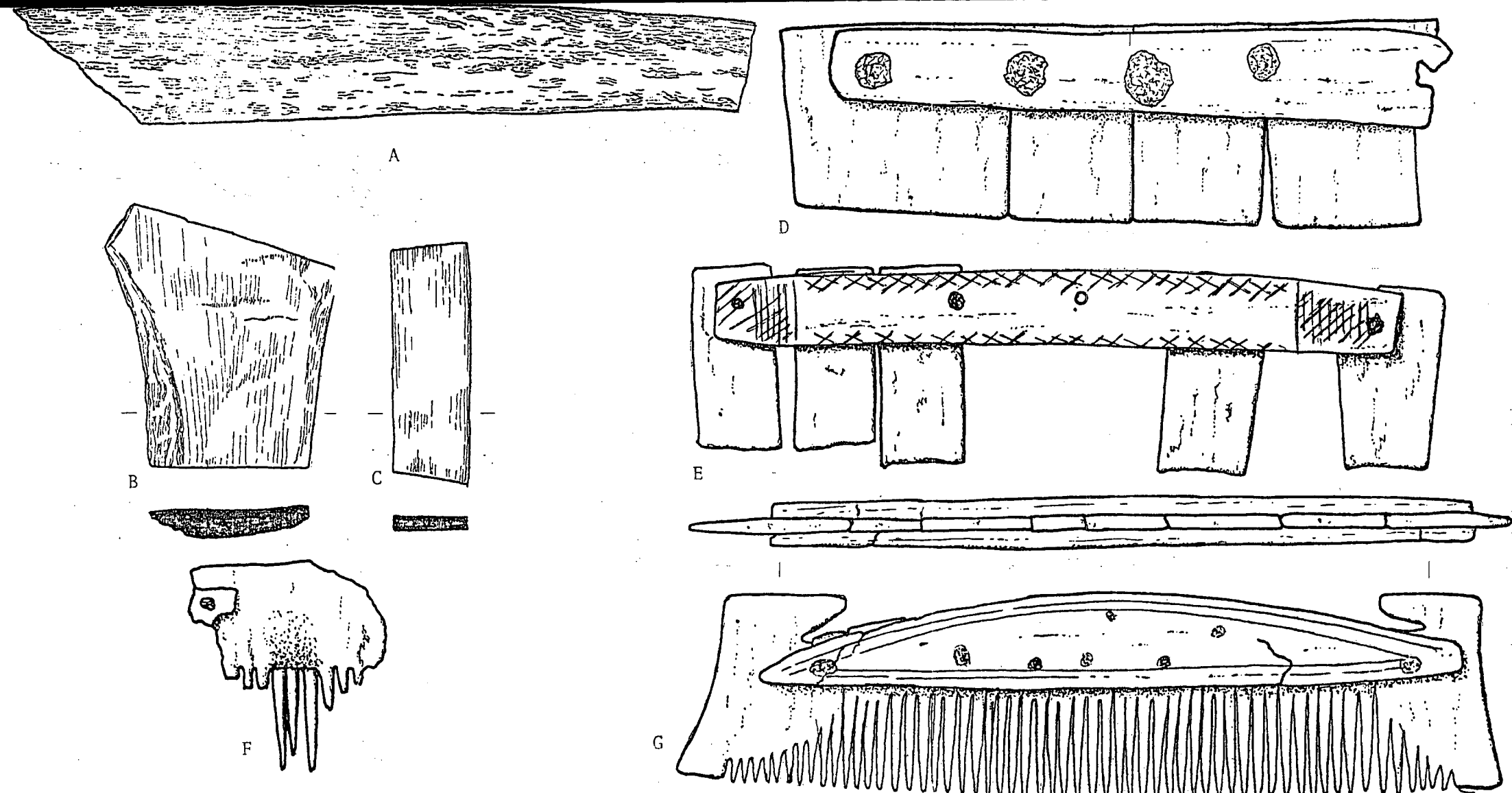


Figure 67 Composite combs: construction. Antler blanks for (A) side plate and (B - C) tooth plates; assembled combs with uncut teeth from (D) Dublin and (E) (after Dunleavy) Groningen Museum; tooth plate (F) with replacement bronze teeth, from Sarre; fully assembled comb (G) from West Stow. Scale 1:1.

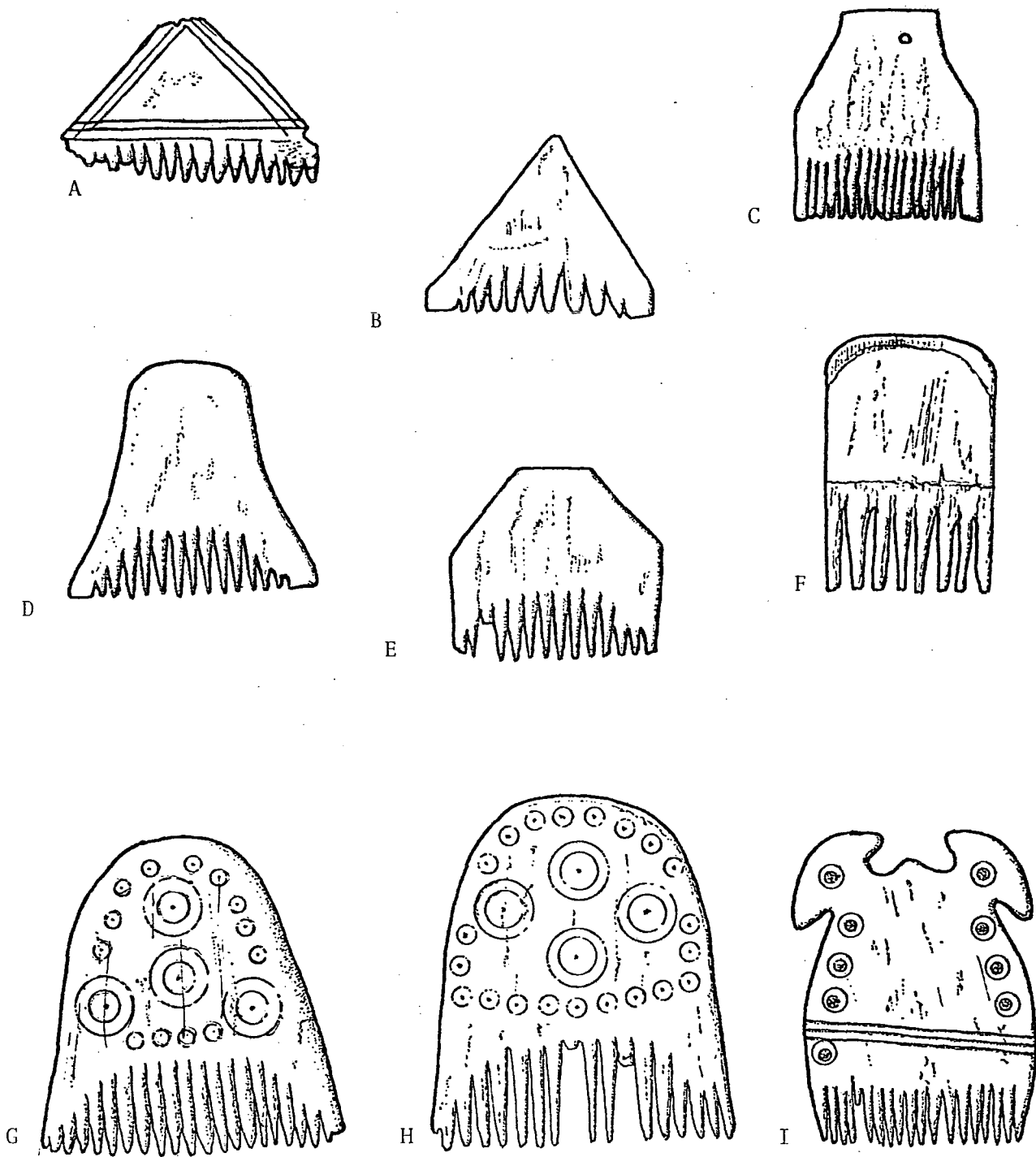


Figure 68 Miniature one-piece combs. A-B, F Lackford, C Bidford-on-Avon, D Caistor-by-Norwich, G-H Cambridge, I Wallingford. Scale 1:1.

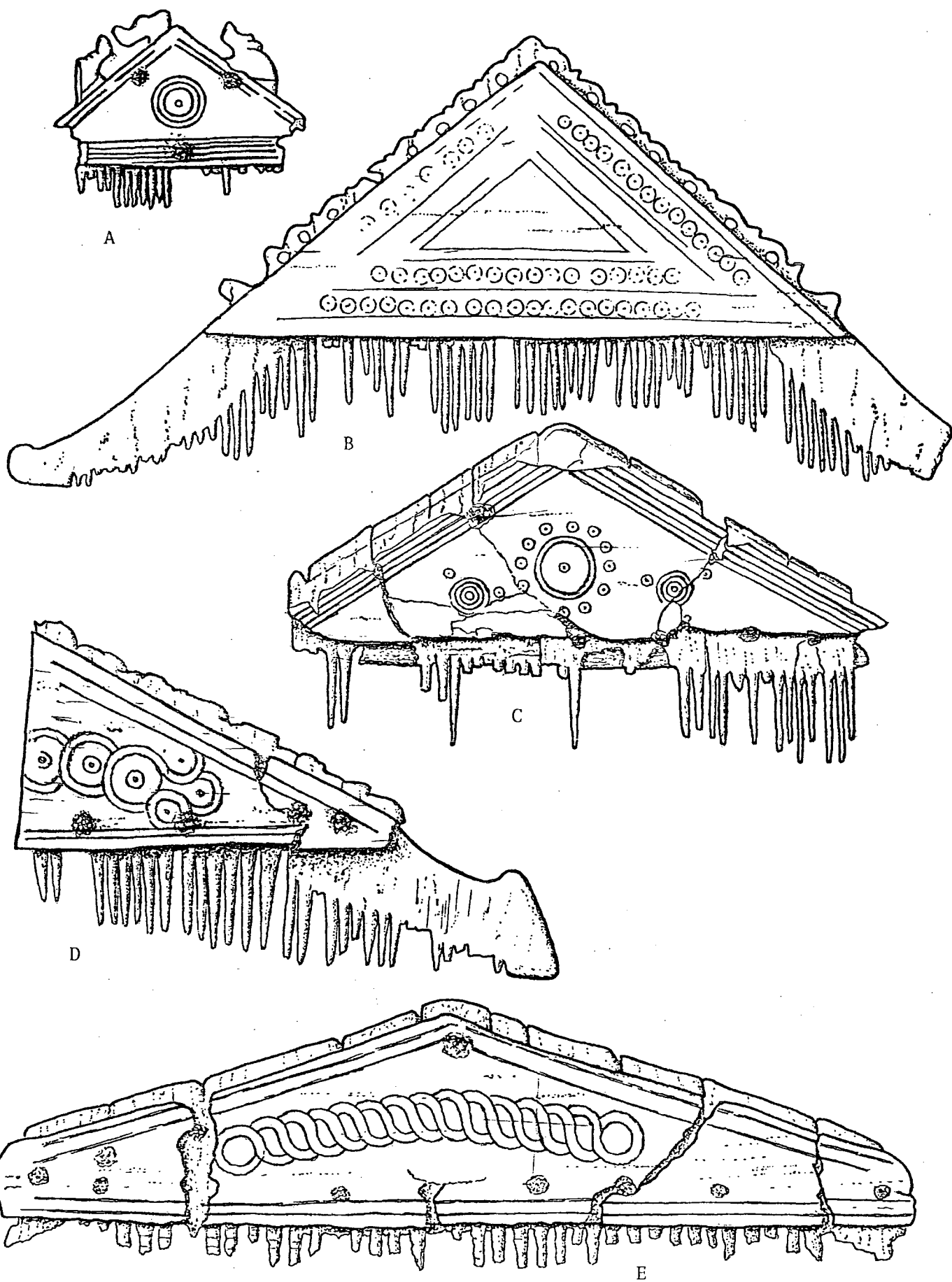


Figure 69 Triangular-backed combs from (A, C) Lackford, (B) Winchester, (D) Cambridge, (E) West Stow. Scale 1:1.

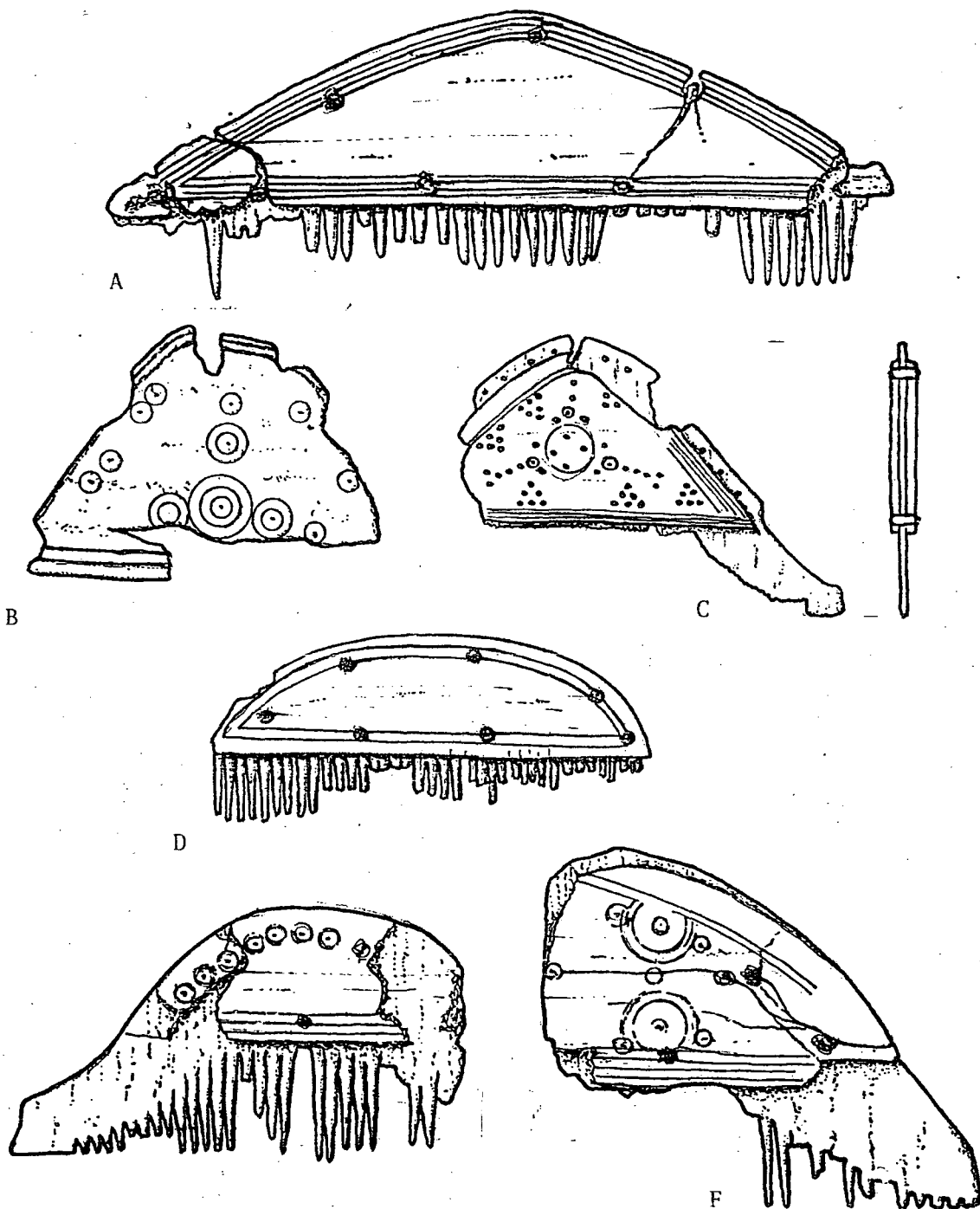


Figure 70 Round-backed combs. A from West Stow, B from Sancton, C from Lower Warbank, D from Lackford, E-F from Caistor-by-Norwich. Scale 1:1.

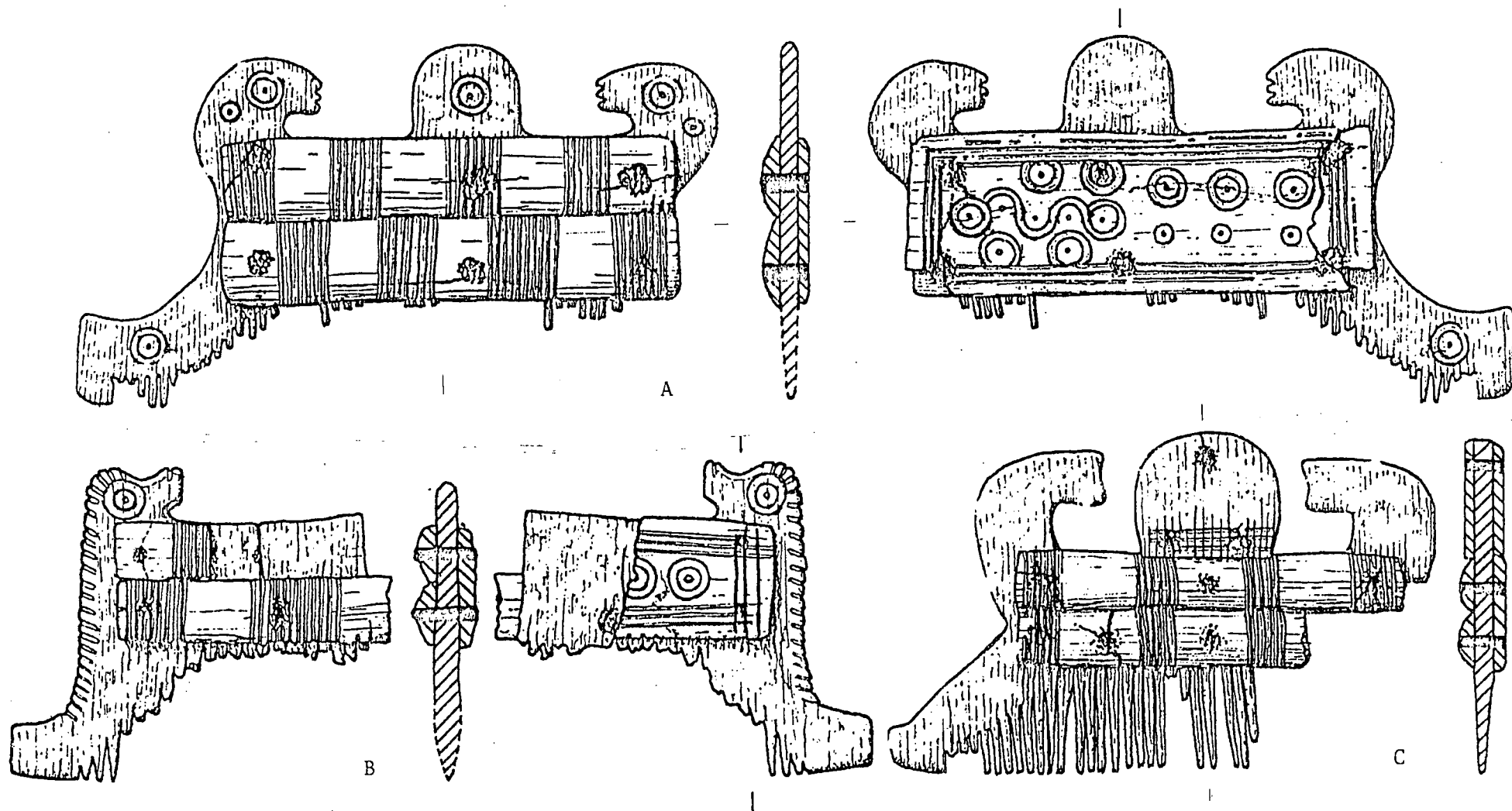
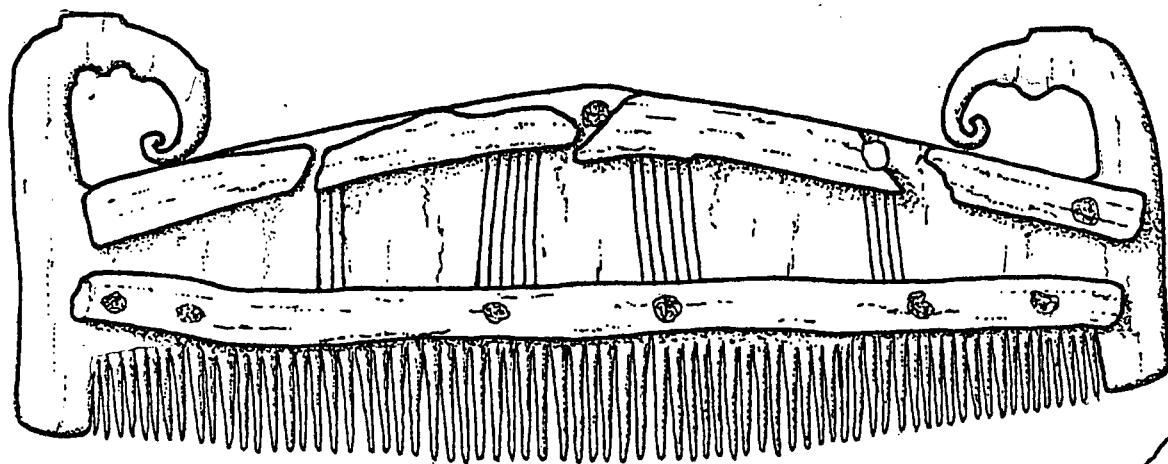
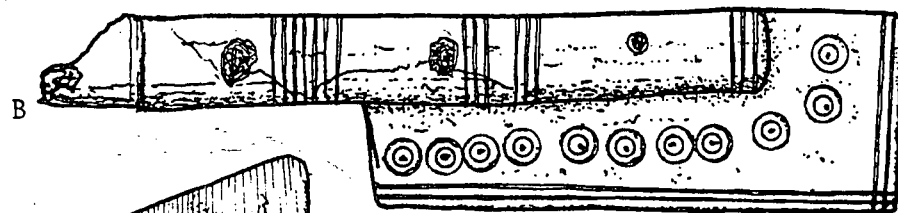


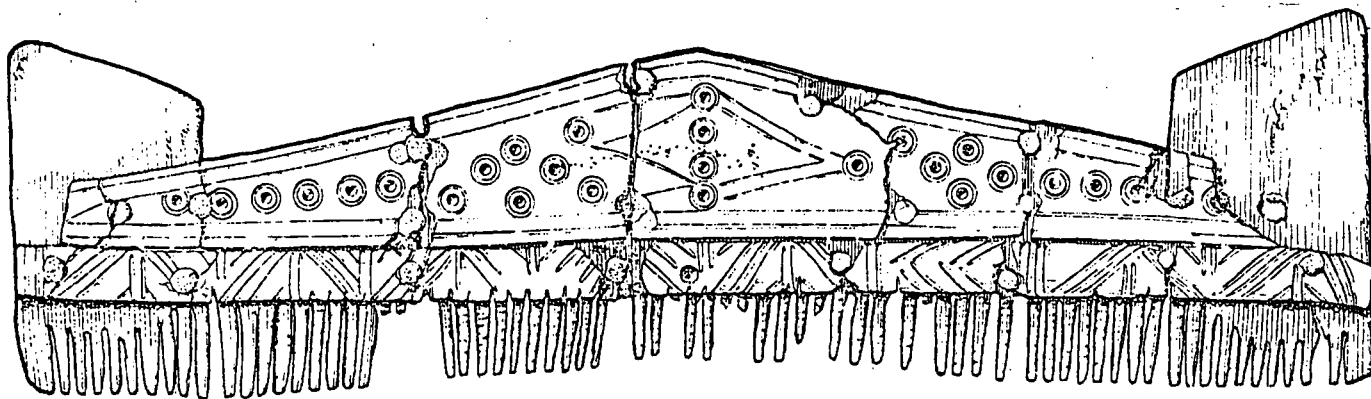
Figure 71 Barred combs of Frisian type. (A - B) from York; (C) from Pakenham. Scale 1:1.



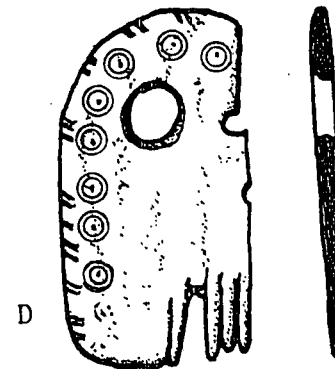
A



B



C



D

Figure 72 Combs with Frisian affinities from (A) Dunstable, (B) Southampton, (C) Hayton and (D) York. Scale 1:1.

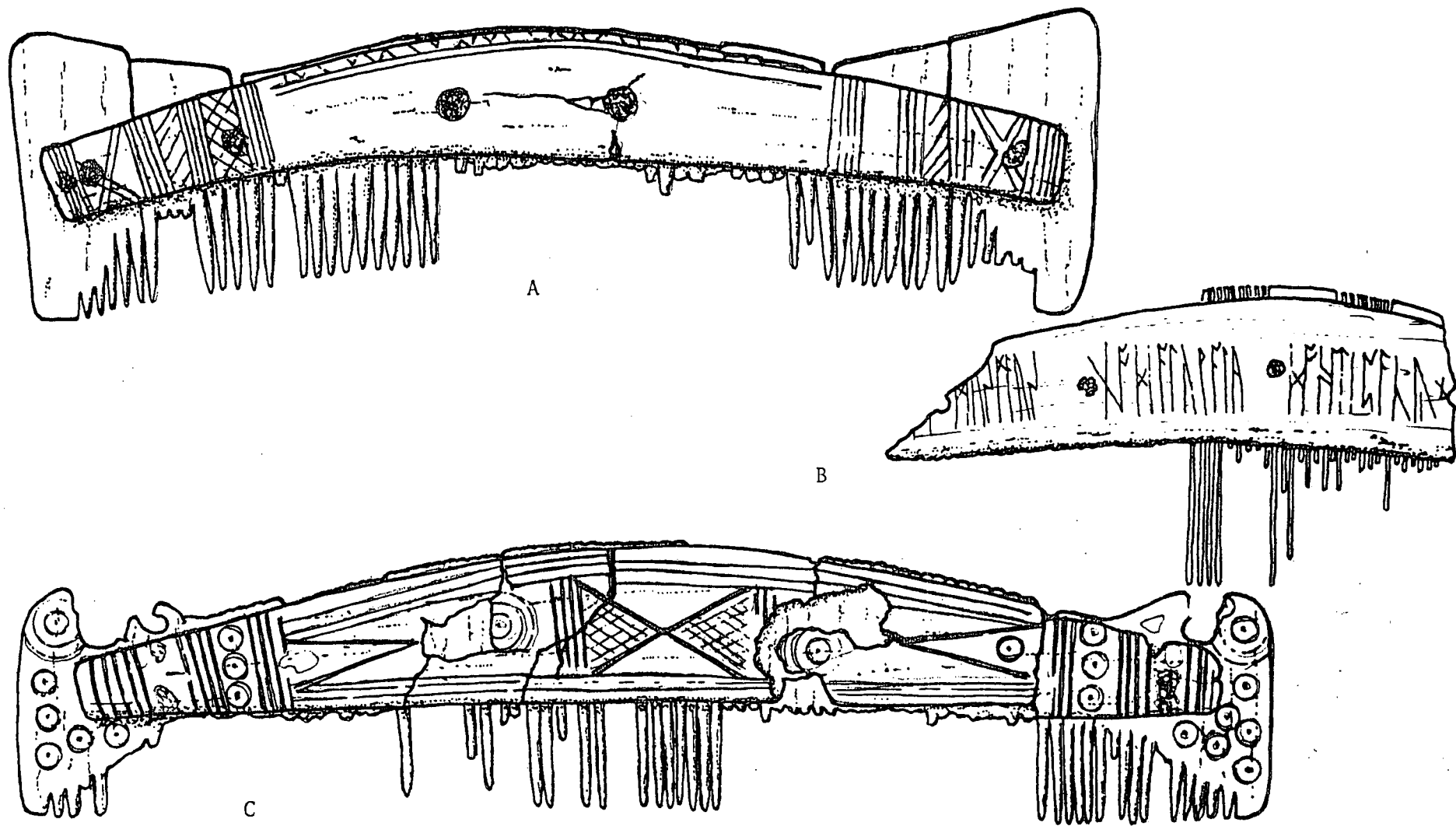


Figure 73 Hog-backed composite combs from (A) West Stow, (B) Whitby and (C) Burwell. Scale 1:1.

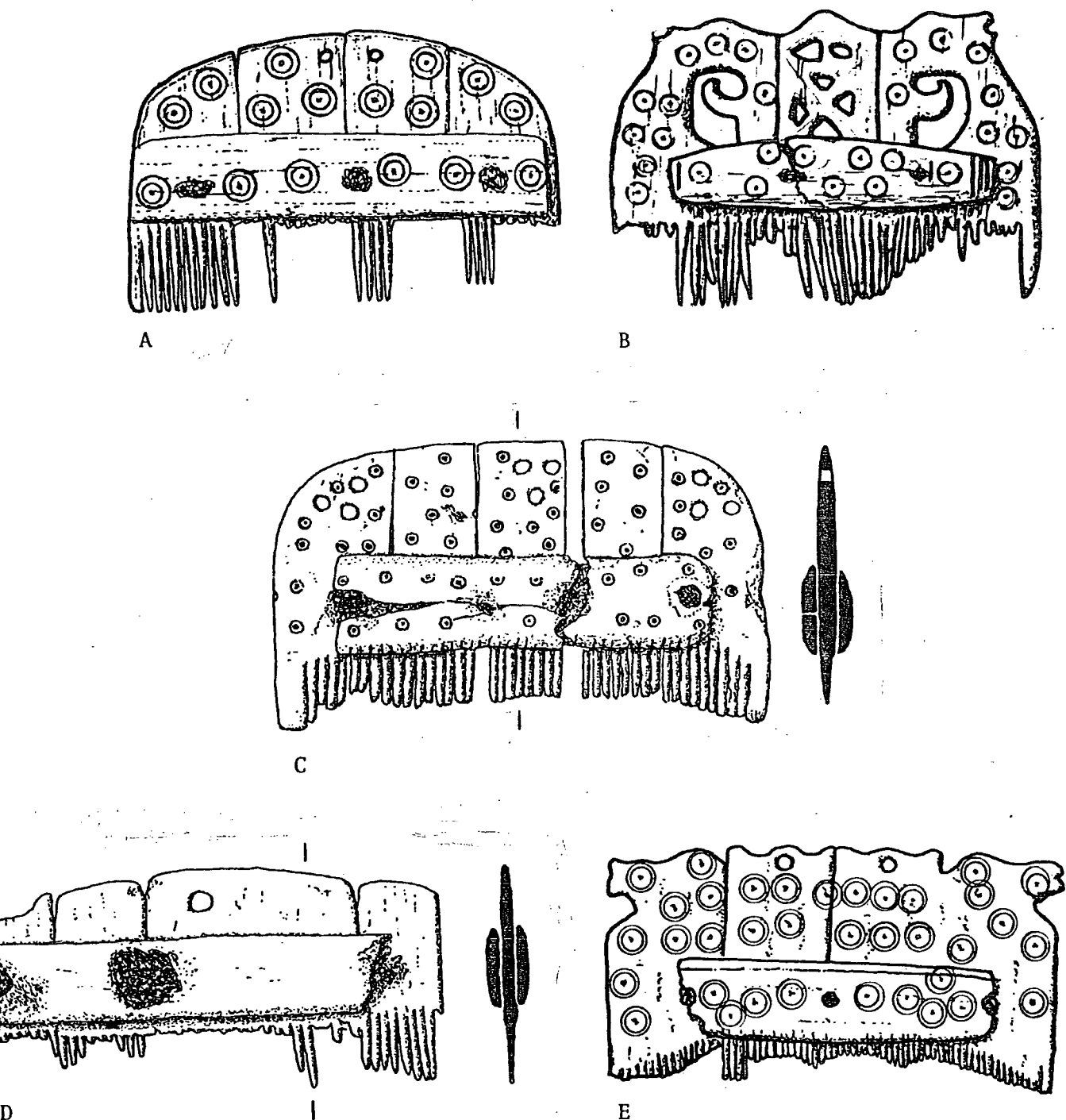


Figure 74. High-backed 'Celtic' combs from (A) Buckquoy, (B) Dun Cuier, (C-D) Burrian and (E) Lagore. Scale 1:1.

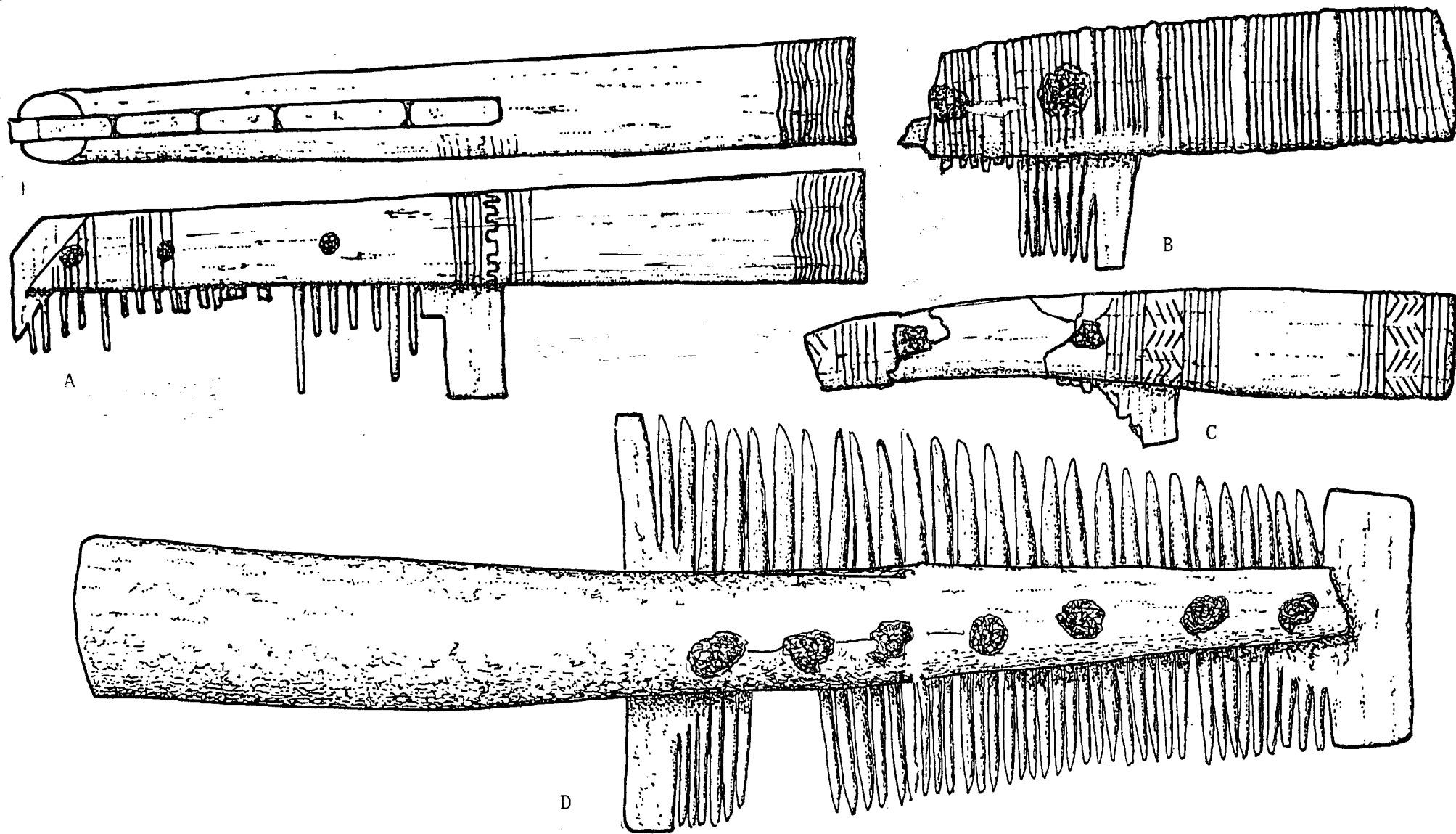


Figure 75 Handled combs from (A) Bedford, (B) Rochester, (C) North Elmham, (D) Southampton.
Scale 1:1.

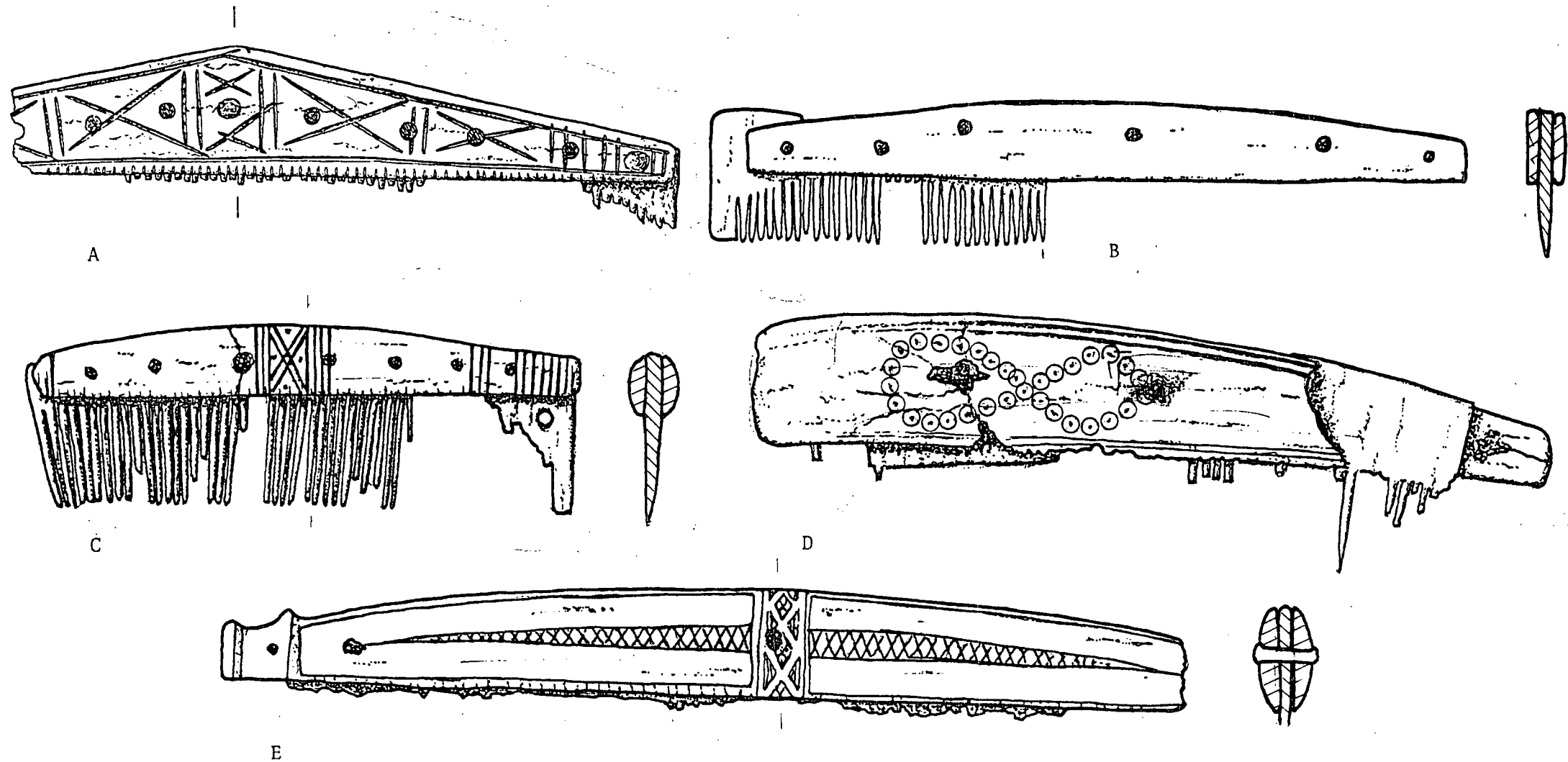


Figure 76 Scandinavian type single-sided composite combs from (A-C, E) York and (D) South Uist. Scale 1:1.

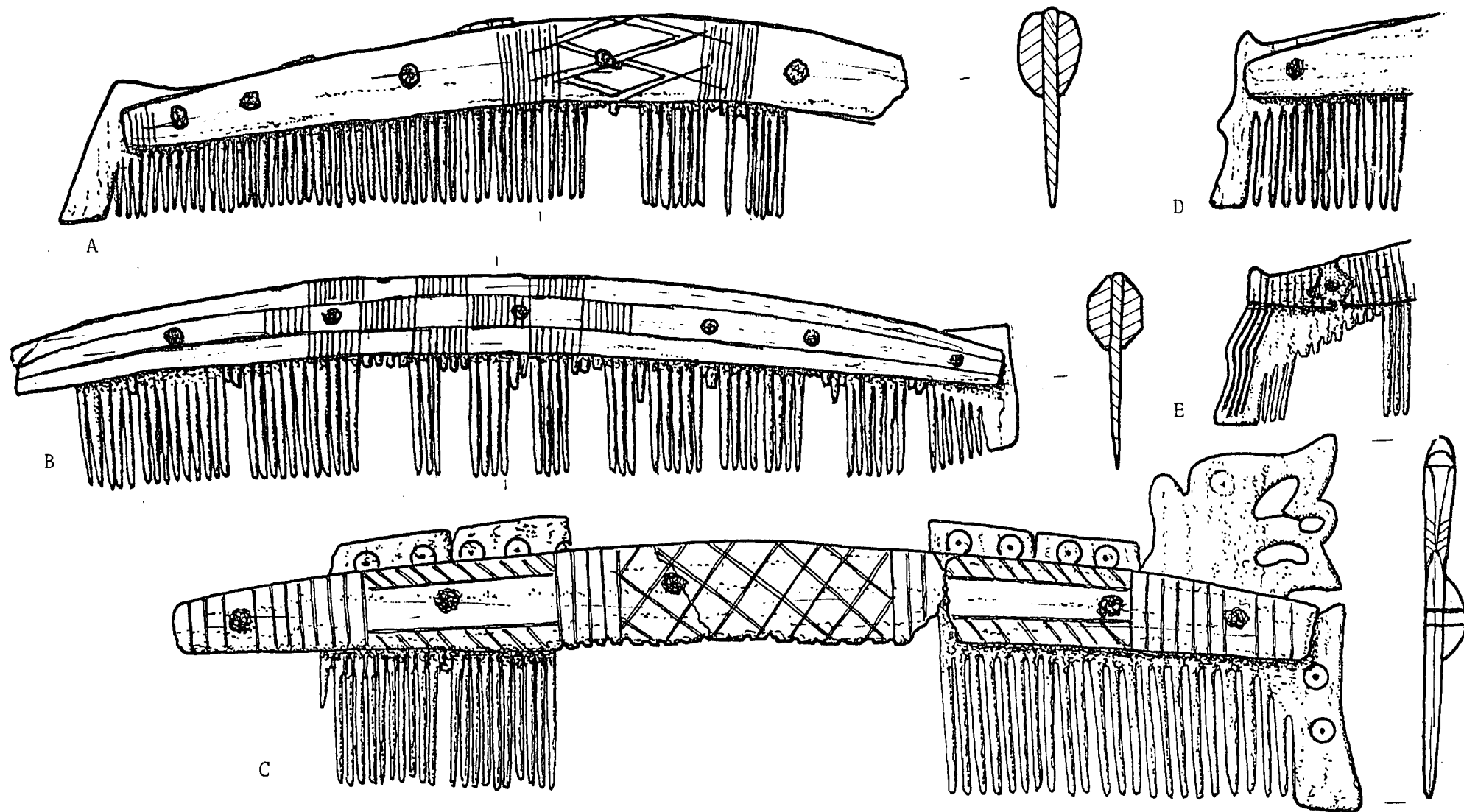


Figure 77 Scandinavian type single-sided composite combs from (A-B) York and (C) London; complex terminals from (D) York and (E) Hedeby. Scale 1:1.

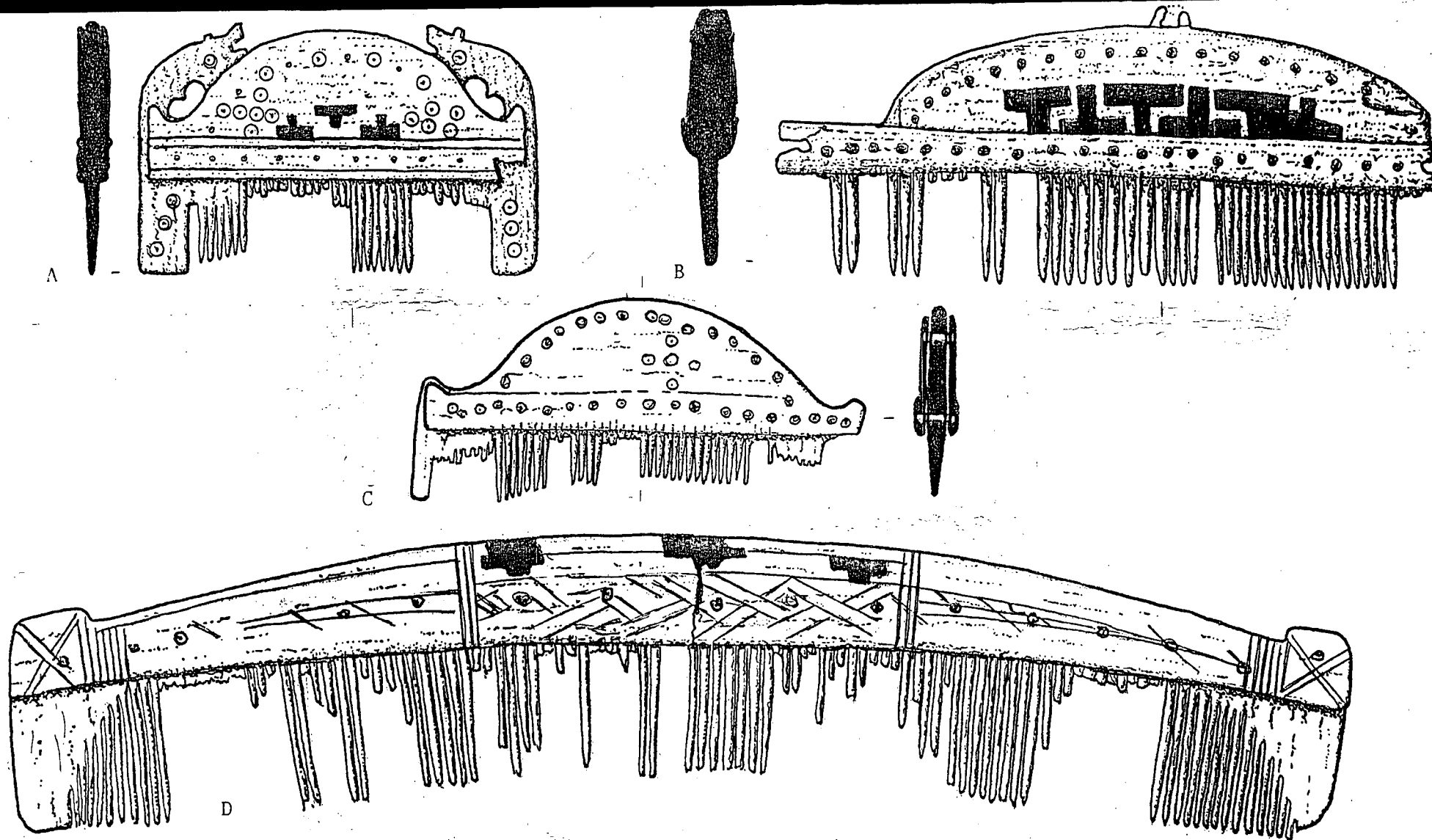


Figure 78 Combs with high arched backs and false ribs from (A) London, (B) Northampton, (C) Freswick; long comb with T-shaped openings from York. Scale 1:1.

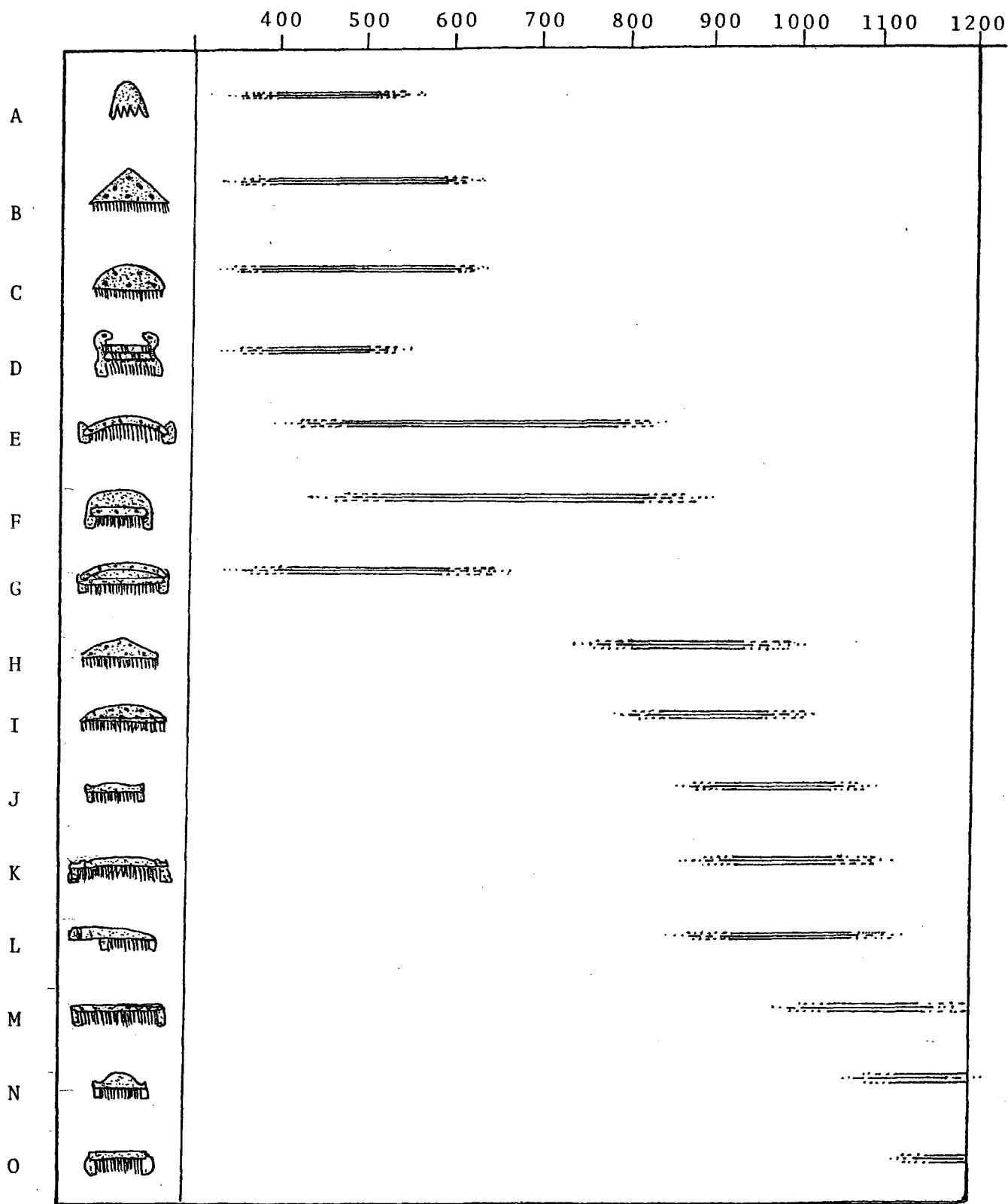


Figure 79 Chronological sequence of comb types. The small numbers of closely-dated combs available for consideration do not allow for a definitive statement and all currencies shown here are necessarily provisional. A one-piece miniature, B triangular-backed, C round-backed, D barred Frisian type, E hog-backed, F high-backed Celtic, G combs with Frisian affinities, H-K Scandinavian types, L handled, M-O later combs of Scandinavian-derived types.

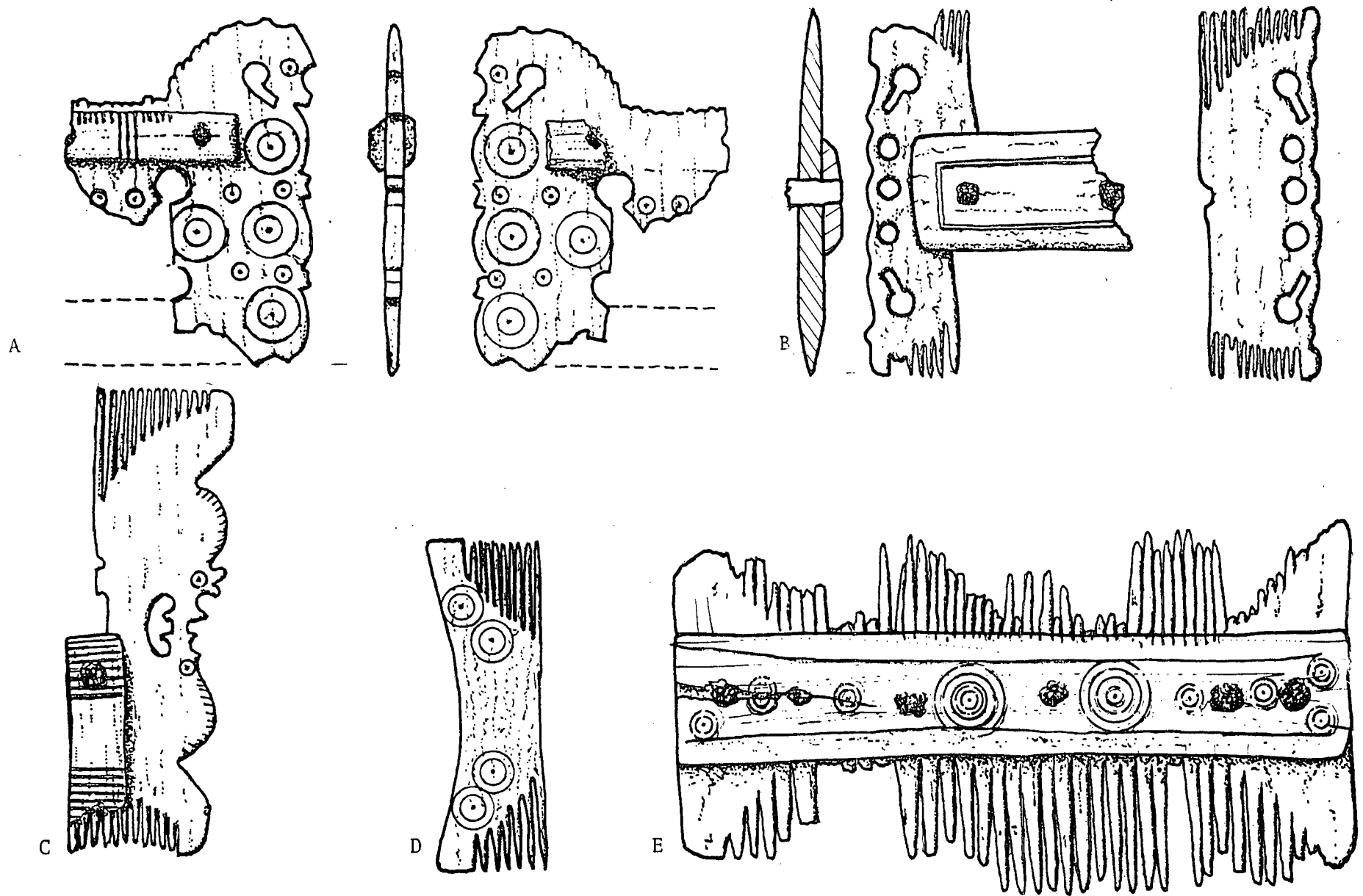


Figure 80 Double sided composite combs of Late Roman and Early Saxon date.
 A Beadlam, B Askrigg, C Langton, D Lackford, E unprovenanced, Liverpool City Museum.
 Scale 1:1.

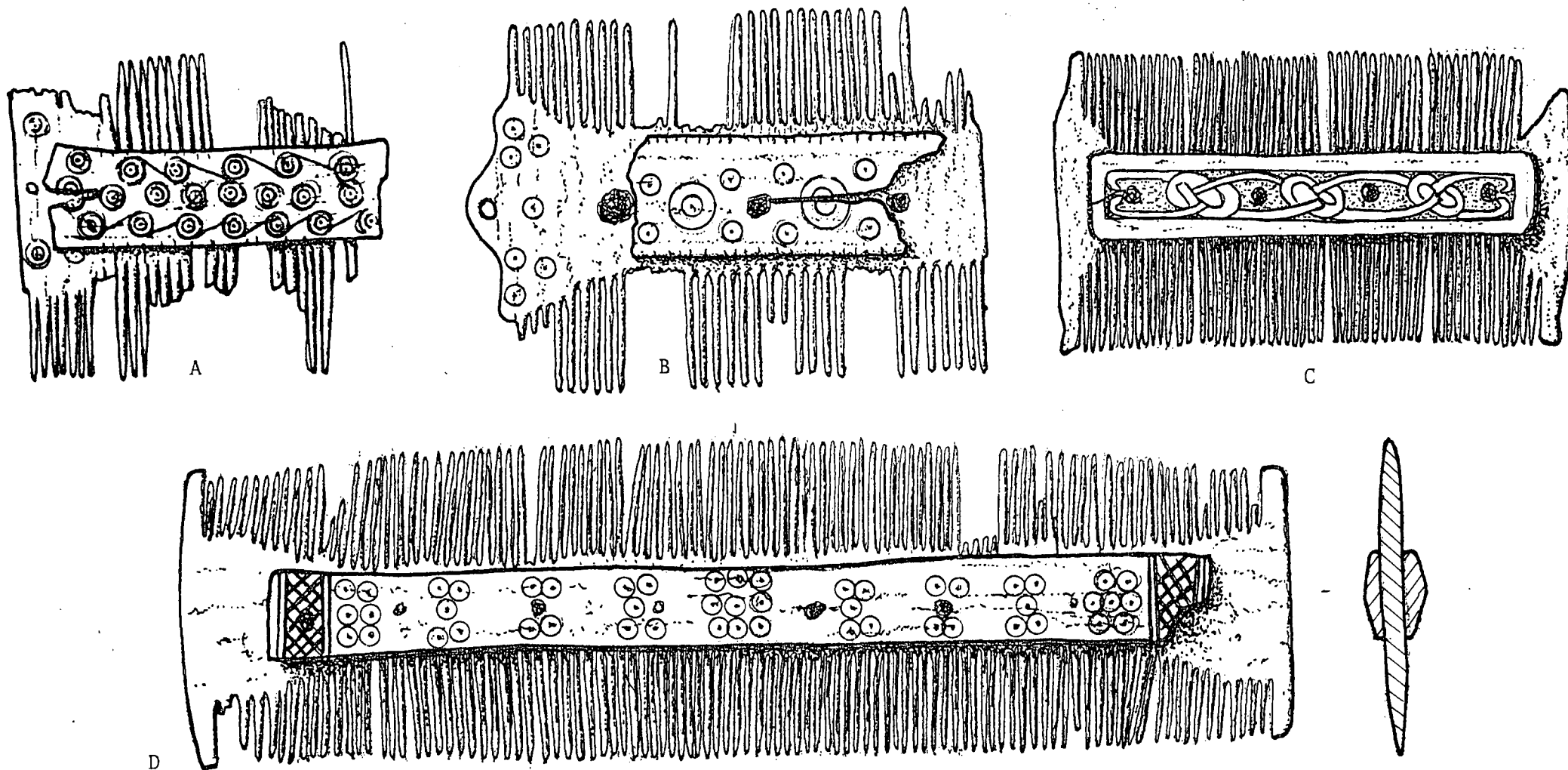


Figure 81 Double-sided composite combs: A Dun Cuier, Barra, B Victoria Cave, Settle, C Ardglass Castle, D Ford. Scale 1:1.

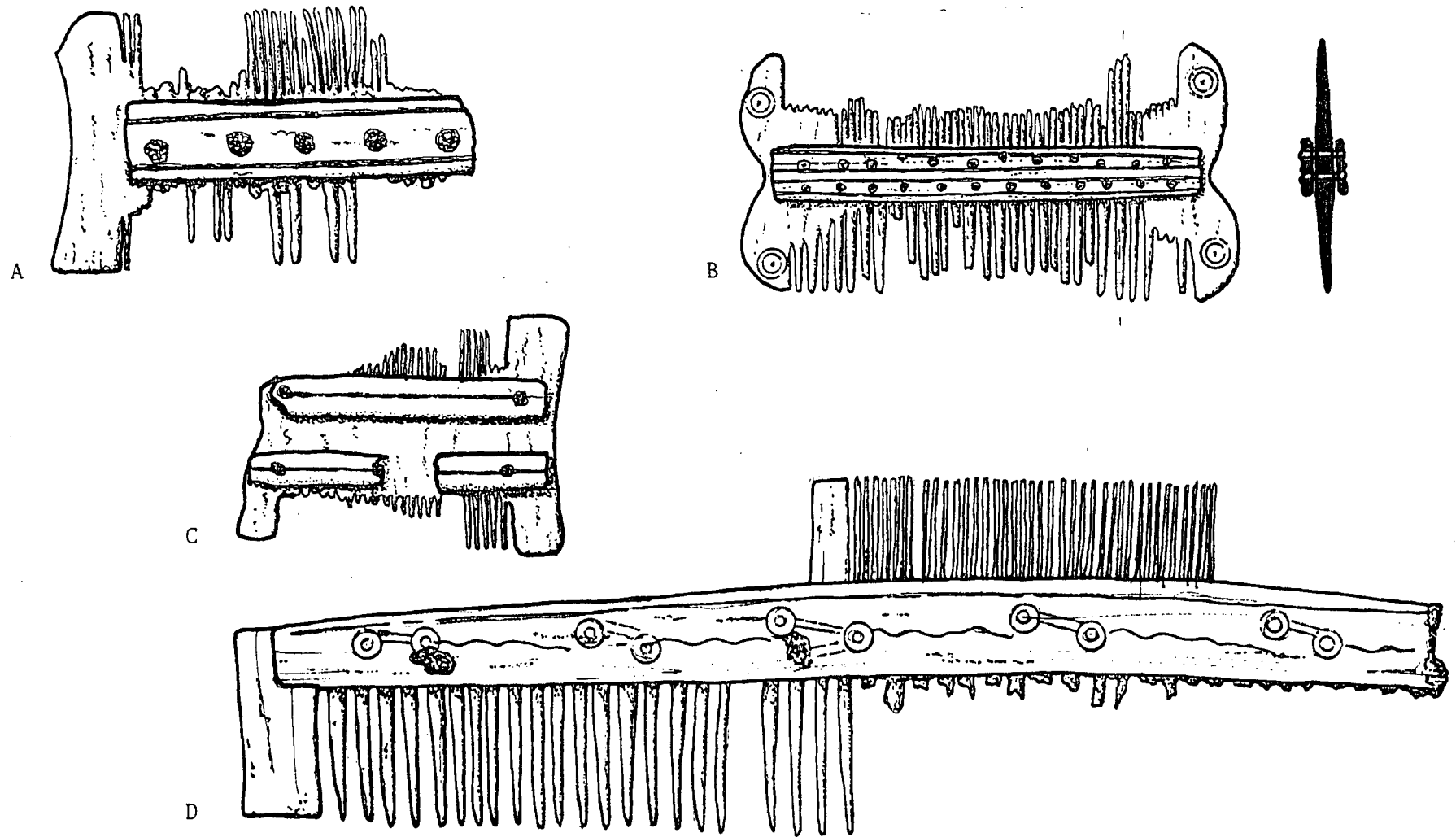


Figure 82 Double-sided composite combs of Scandinavian type, from (A, C) Jarlshof, (B) Freswick and (D) York. Scale 1:1.

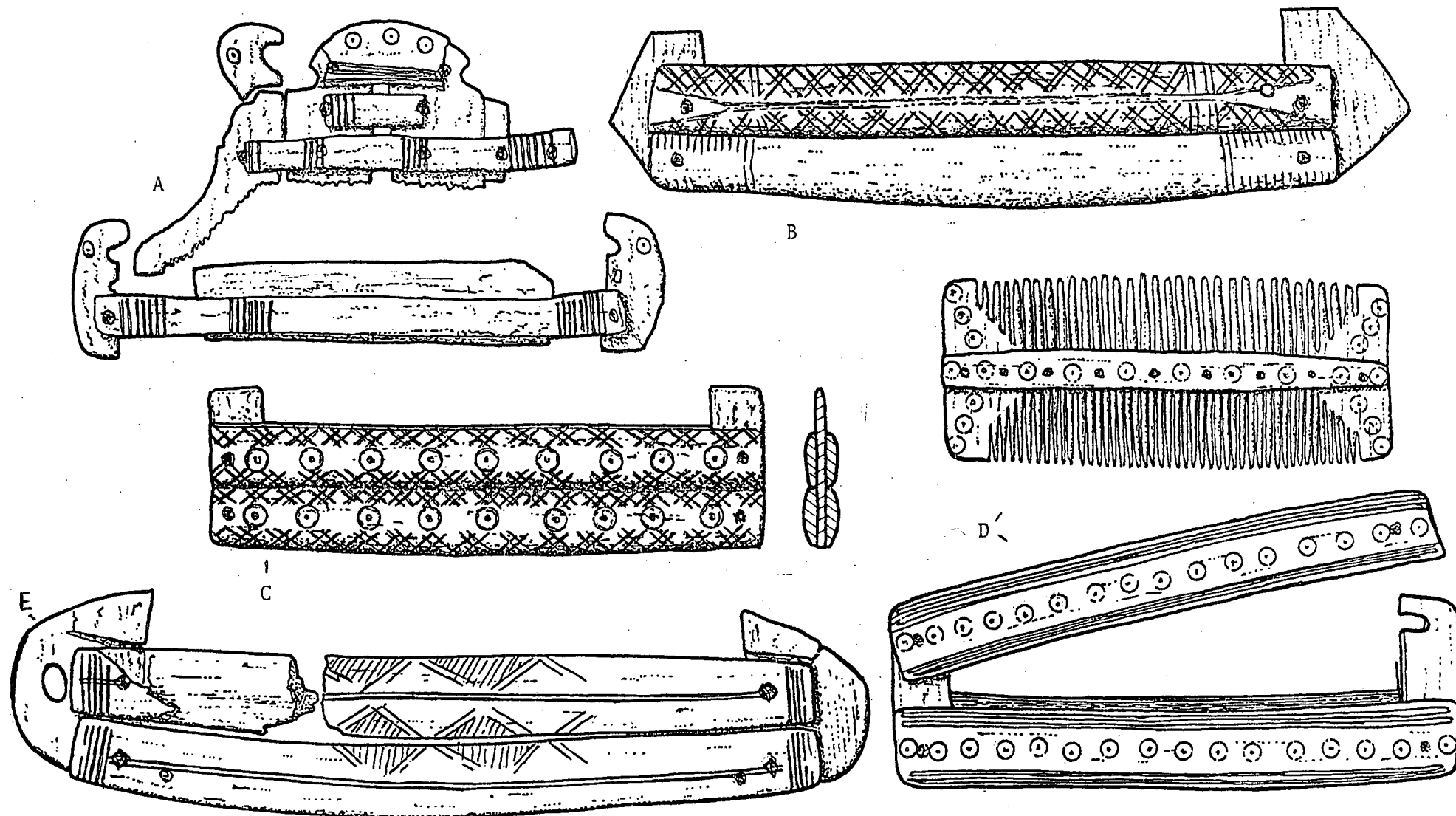


Figure 83 Comb cases. A (with comb) Spong Hill, B York, C - D (with comb) London, E Northampton. Scale 1:1.

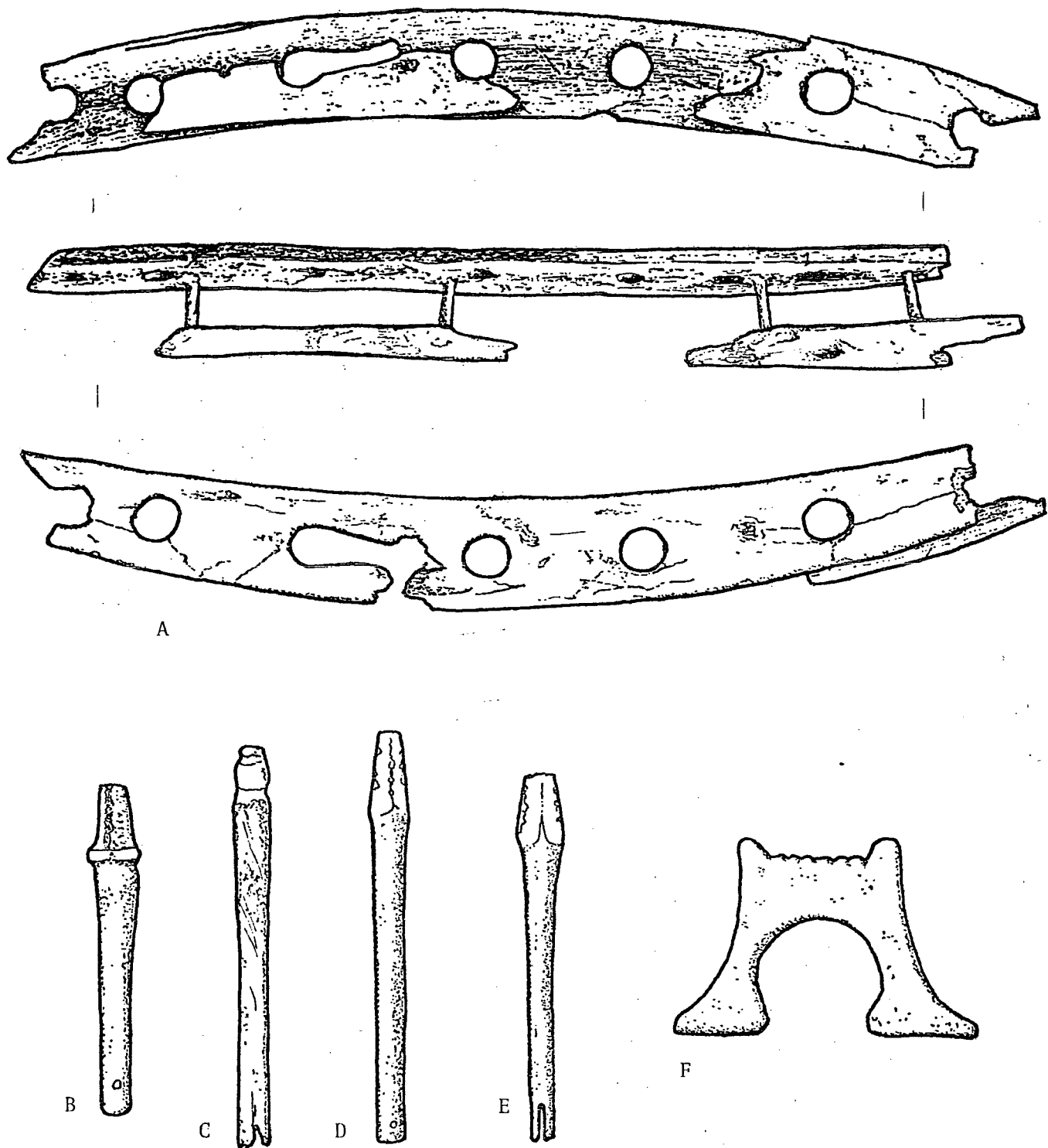


Figure 84 Stringed instruments. A wrist plank from Abingdon, B-E tuning pegs from Whitby, F bridge from Birka. Scale 1:1.

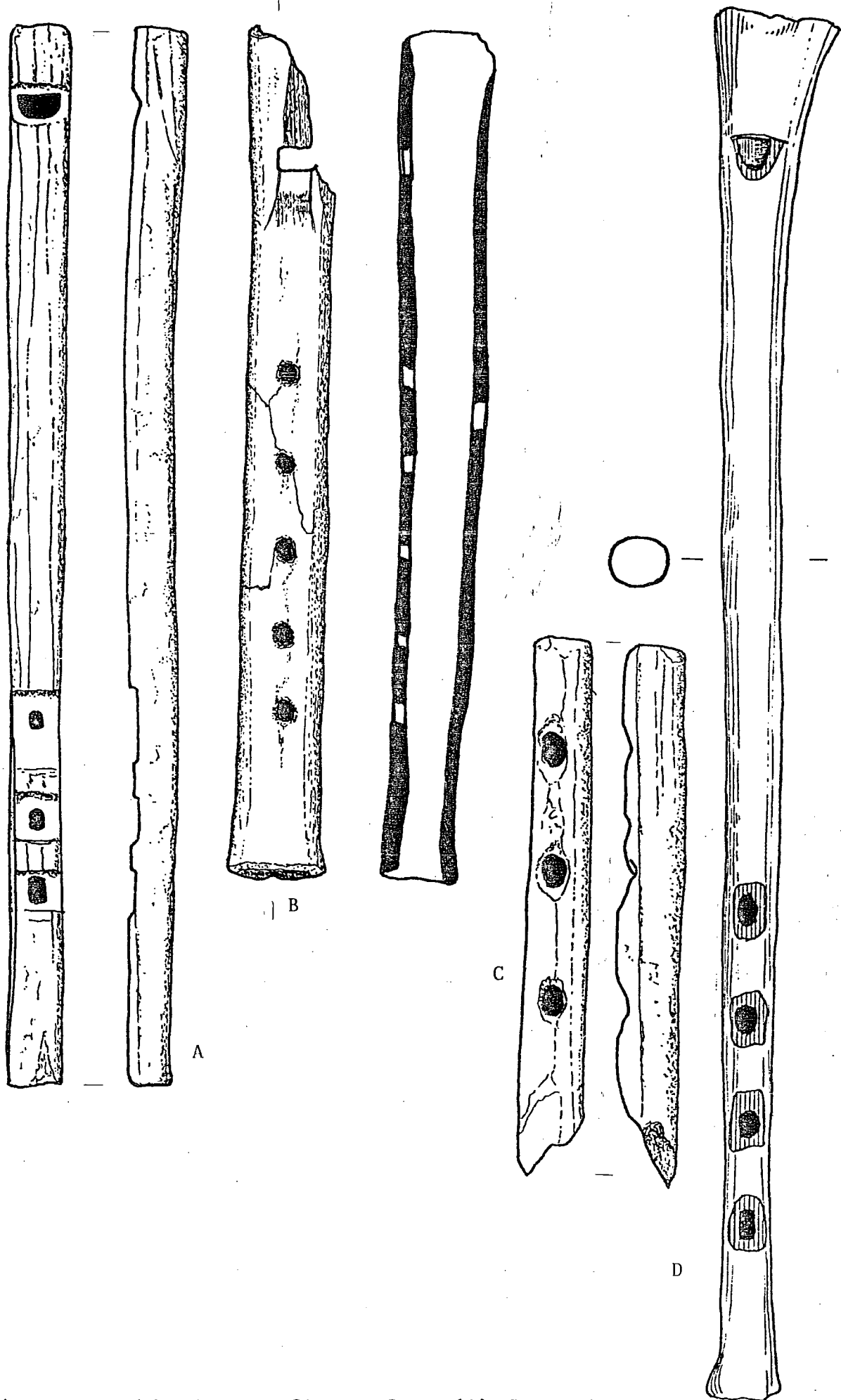


Figure 85 Whistles or flutes from (A) Canterbury, (B) Keynsham, (C) North Elmham, (D) Norwich. Scale 1:1.

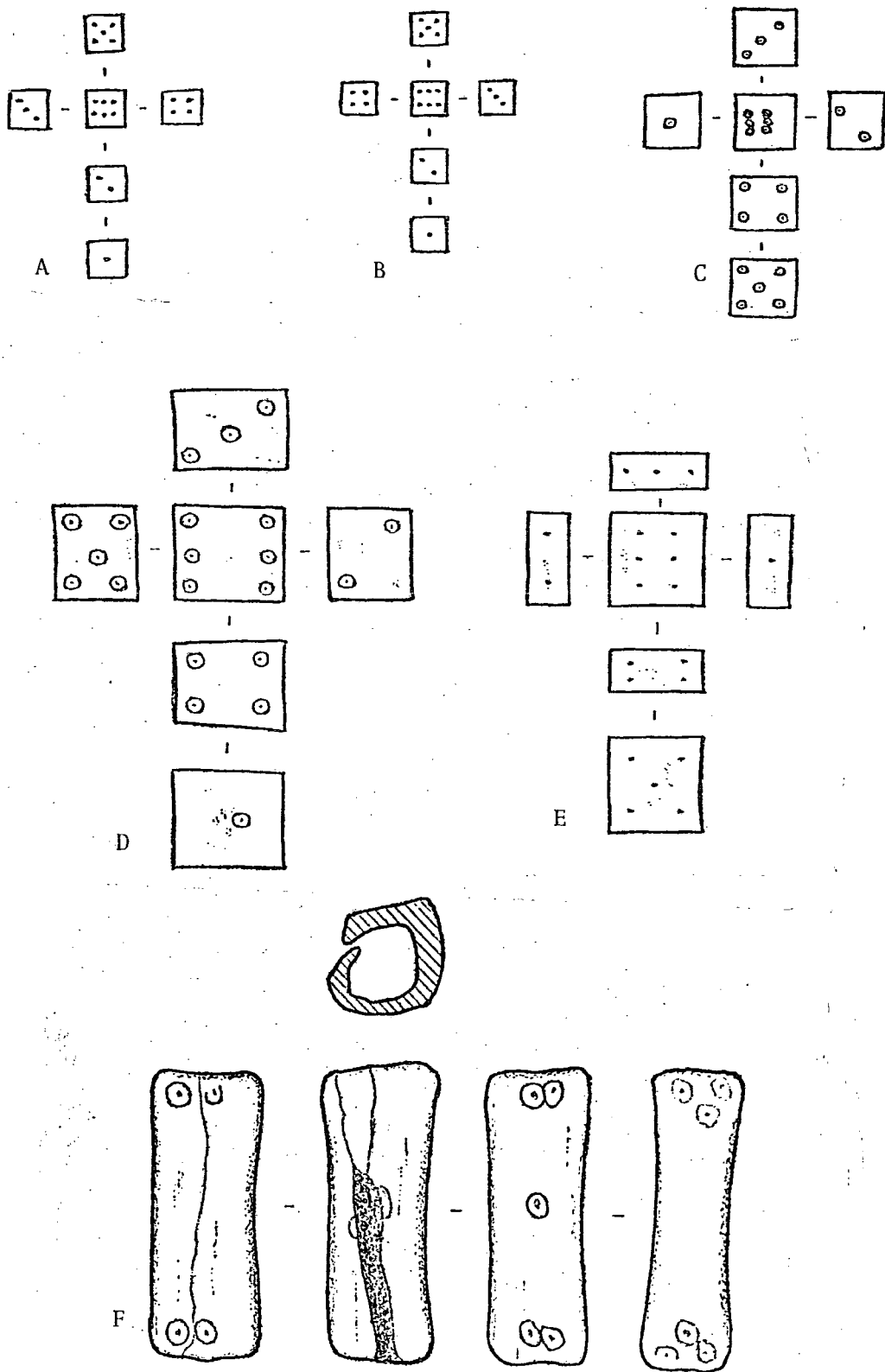
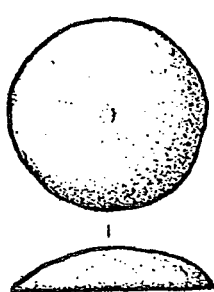
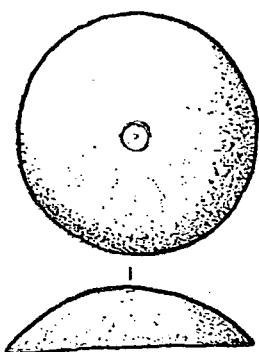


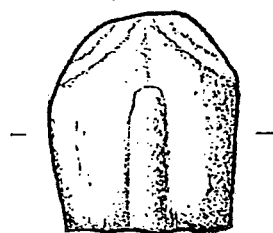
Figure 86 Dice. Regular cubes from (A-B) Gilton Town, (C-D) York Minster, irregular (E) from Norwich; parallelepiped (F) from Burrian. Scale 1:1.



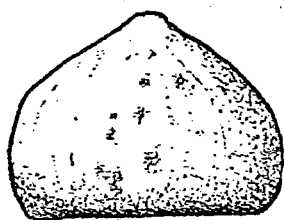
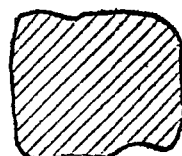
A



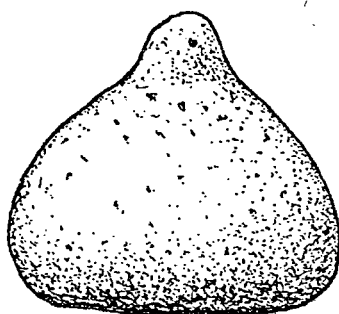
B



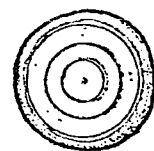
C



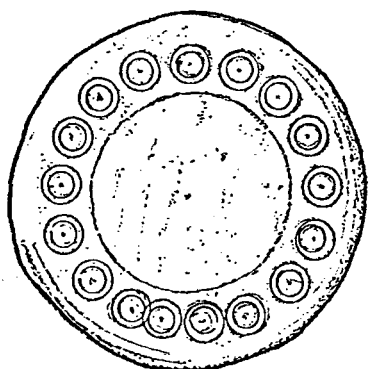
D



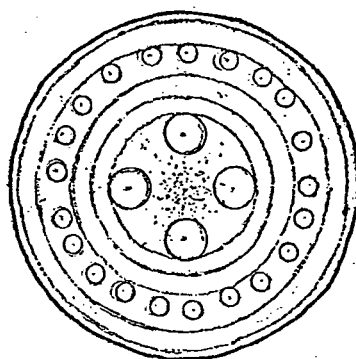
E



F



G



H

Figure 87 Playing pieces. Plano-convex from (A) York, (B) Kingston Down; Horse tooth (C) from York; cetacean bone from (D) Goltho and (E) Jarlshof; antler pawn (F) from Ludgershall; discoid, of (G) bone and (H) antler, Goltho. Scale 1:1.

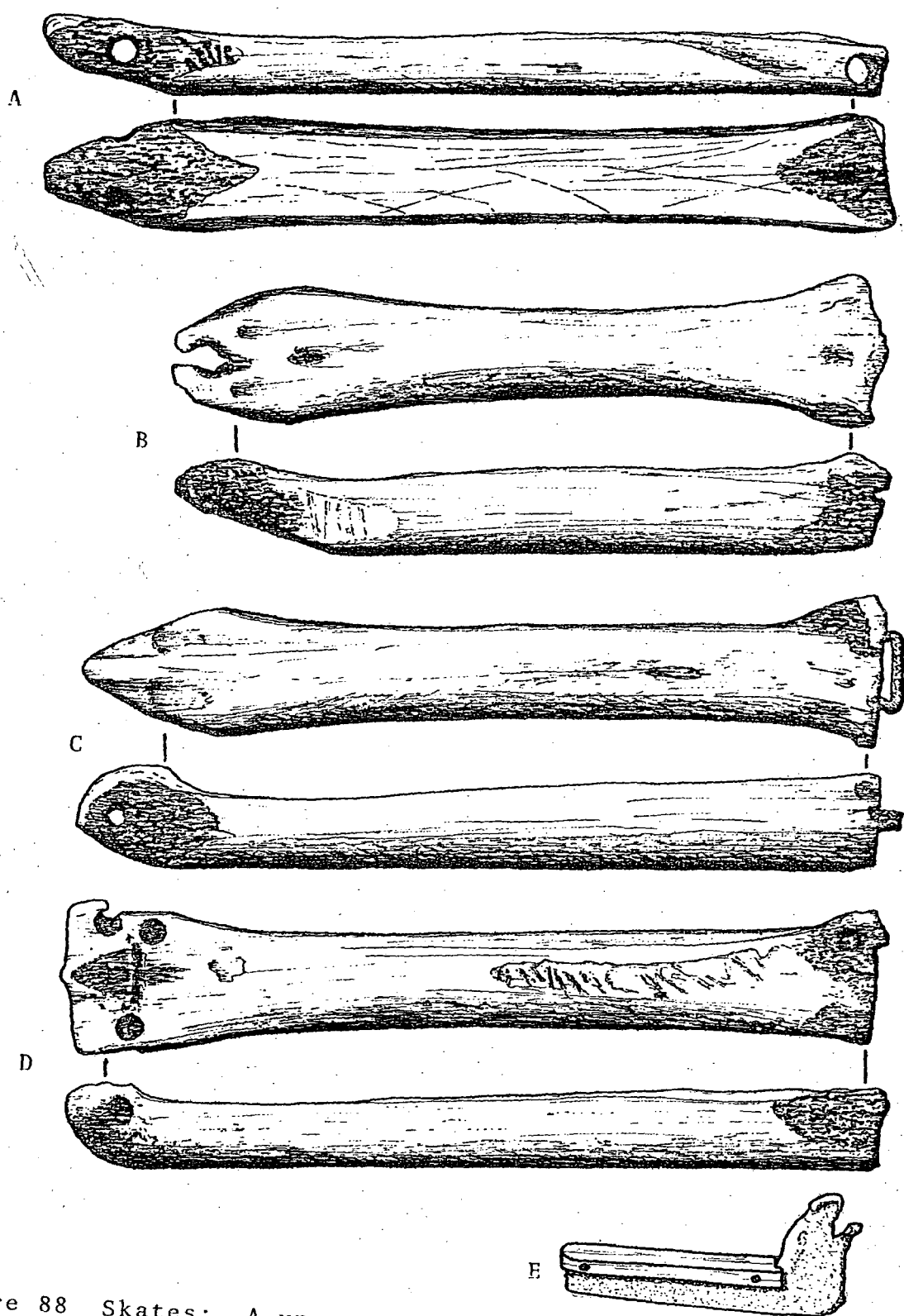


Figure 88 Skates: A unprovenanced, Museum of London, B York, C-D London. Also shown (E) is a representation of a jawbone skate (after Herman), a type not yet represented in the British Isles.

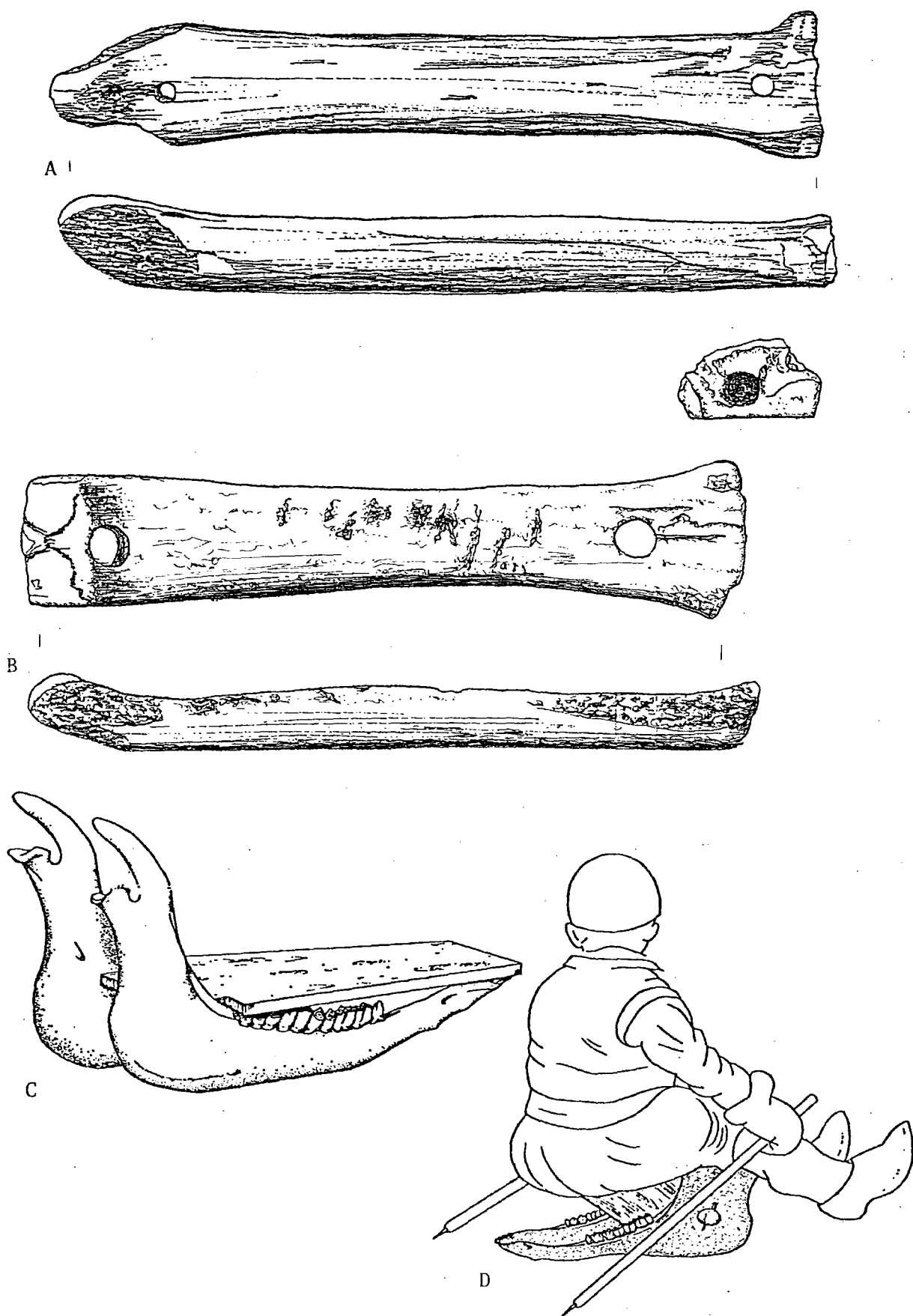


Figure 89 Sledge runners: A London, B unprovenanced, Pitt Rivers Museum, C jawbone sledge from Arnswalde, D sledge as illustrated by Avercamp (after Ijzereef). Not to scale.

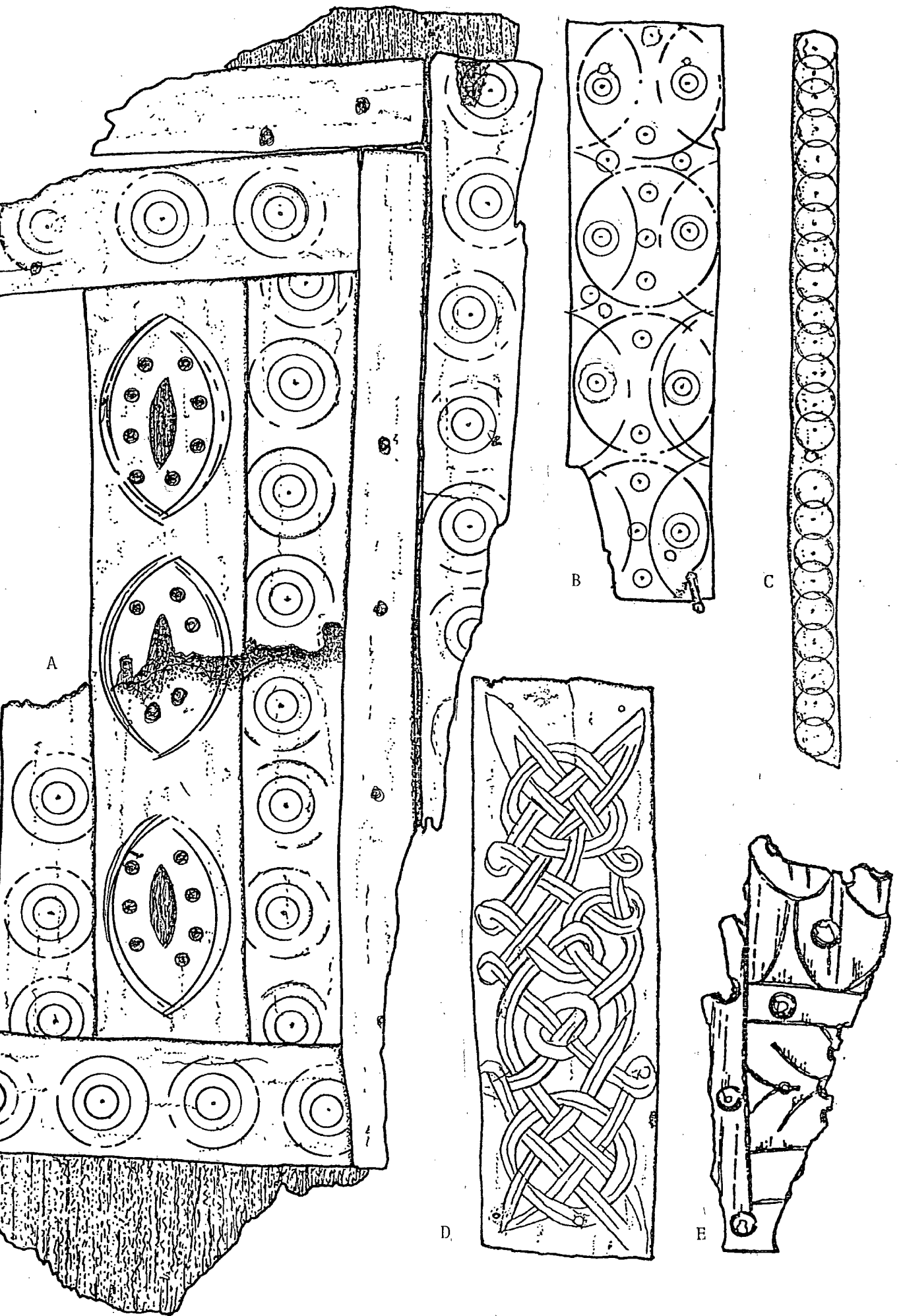


Figure 90. Casket mounts. A, E York, B - C Dover, D South Cadbury.
Scale 1:1.

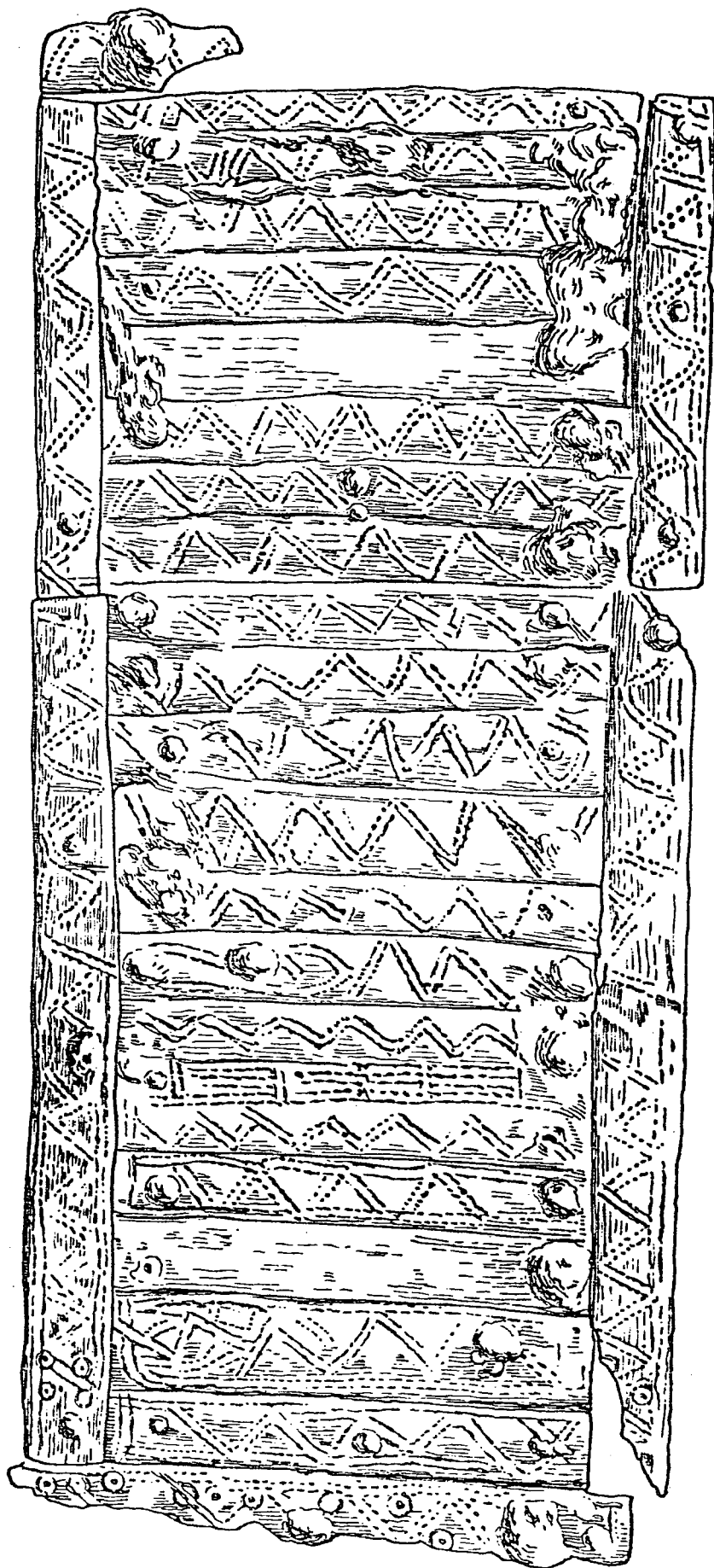


Figure 91 Casket mounts. Complete lid from Coppergate, York. Scale 1:1.

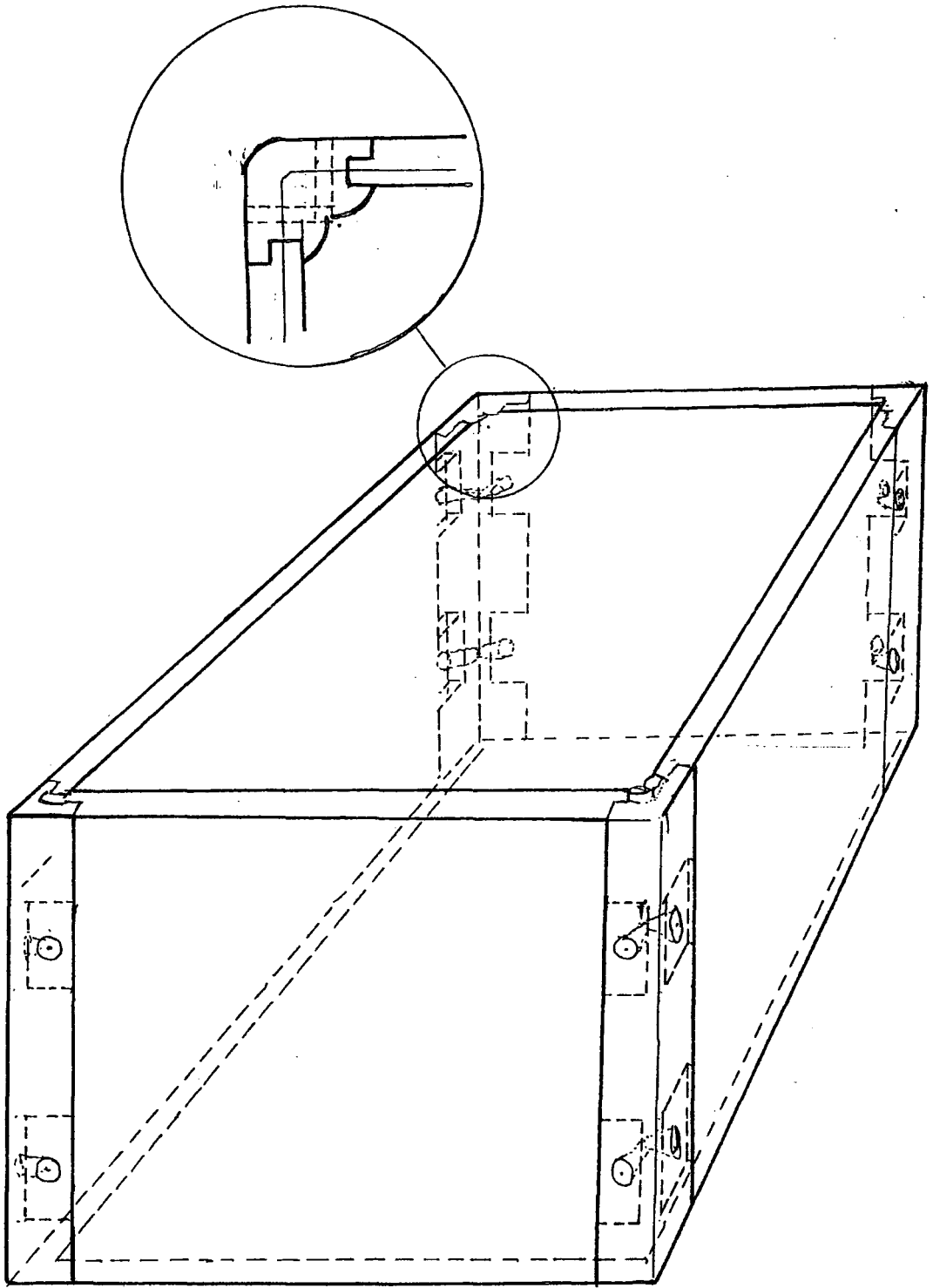


Figure 92 Simplified diagrammatic representation of method of assembly of Franks Casket.

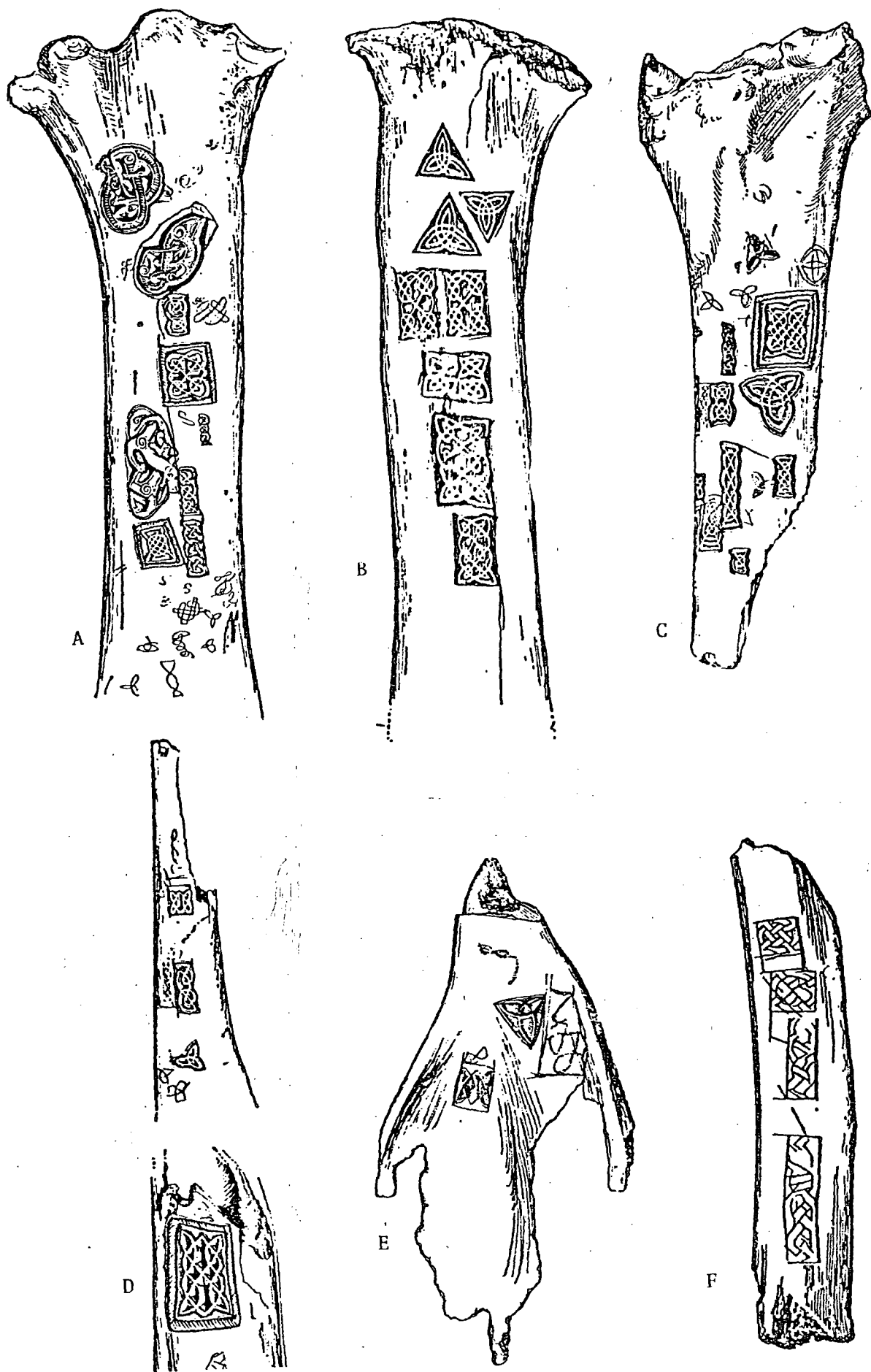


Figure 93 Trial pieces. A-E Lagore Crannog, F London.
Scale A-E 2:3, F 1:2.

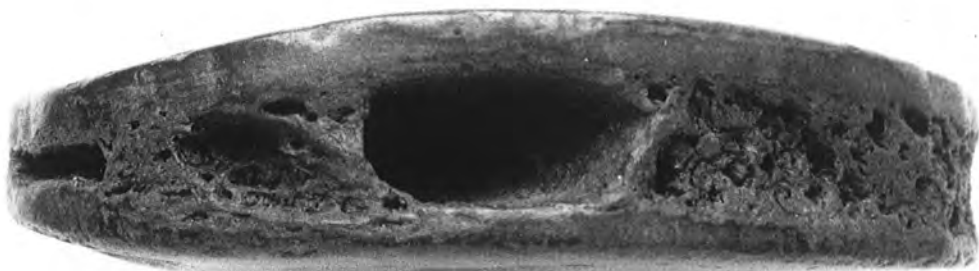


Plate 5 Nutrient foramen on bone gaming counter from Perth.
(By permission of Perth High Street Excavation Committee). These large natural perforations have led to counters of this type occasionally being identified as pendants. The source of the raw material can be located precisely on account of the natural features visible (cf. Plate 16a).

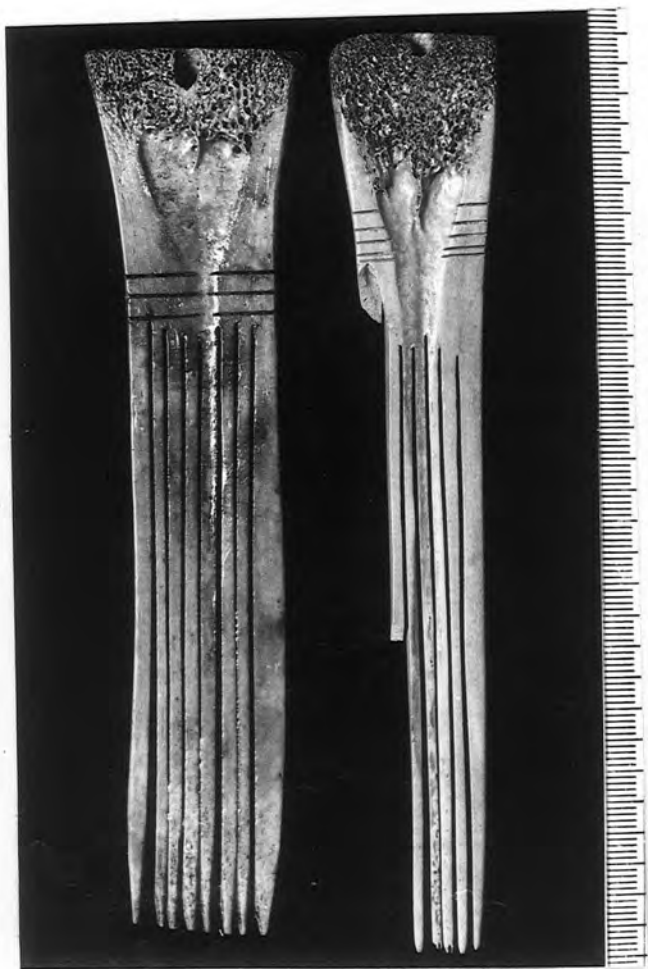


Plate 19 Long-toothed comb, exhibiting residual cancellous tissue and nutrient foramen.



Plate 20 Close-up view of pointed teeth of long-toothed comb as shown in Plate 19.

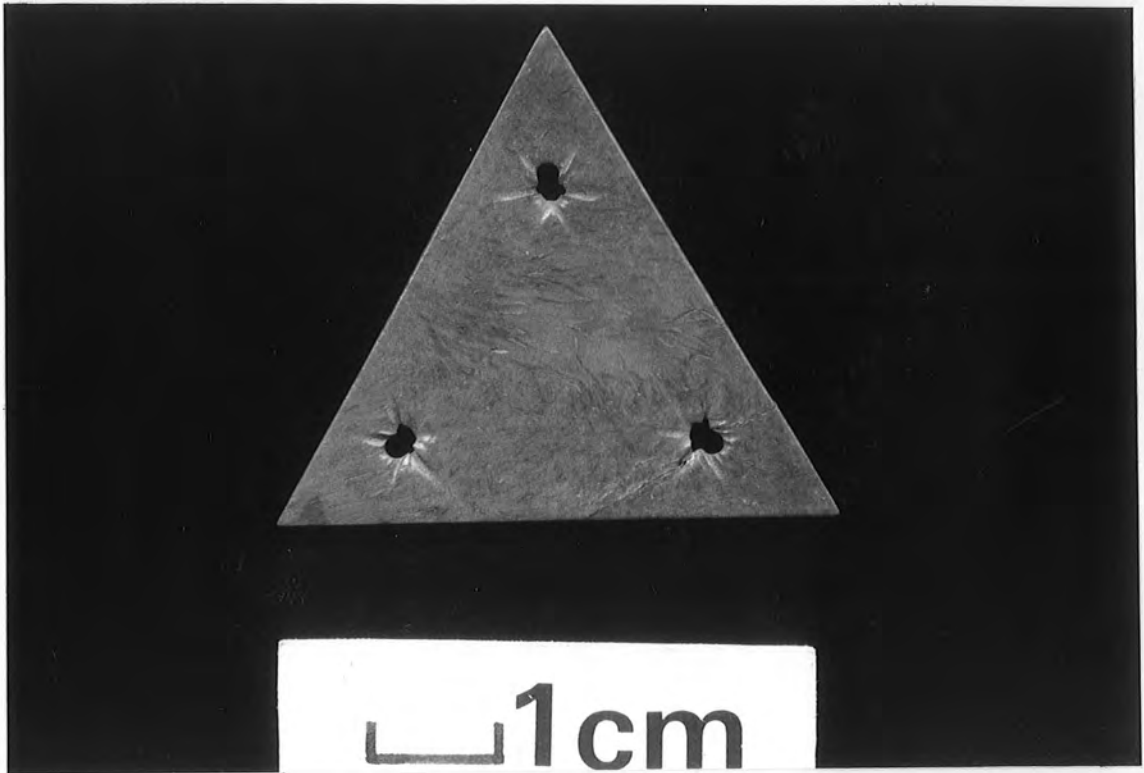


Plate 21 Weaving tablet of Roman period, from Malton.
The perforations exhibit characteristic radial wear marks
from the warp.



Plate 32 One-piece comb of Walrus ivory,
British Museum.



Plate 33 One-piece comb of cetacean bone,
York. (By permission of York Minster Archaeology
Office).



Plate 41 Chessmen: bishop of cetacean bone, from Witchampton.



Plate 43 Chessmen: king piece of antler, Museum of London.



Plate 52 Trial piece: decorated jawbone from London.

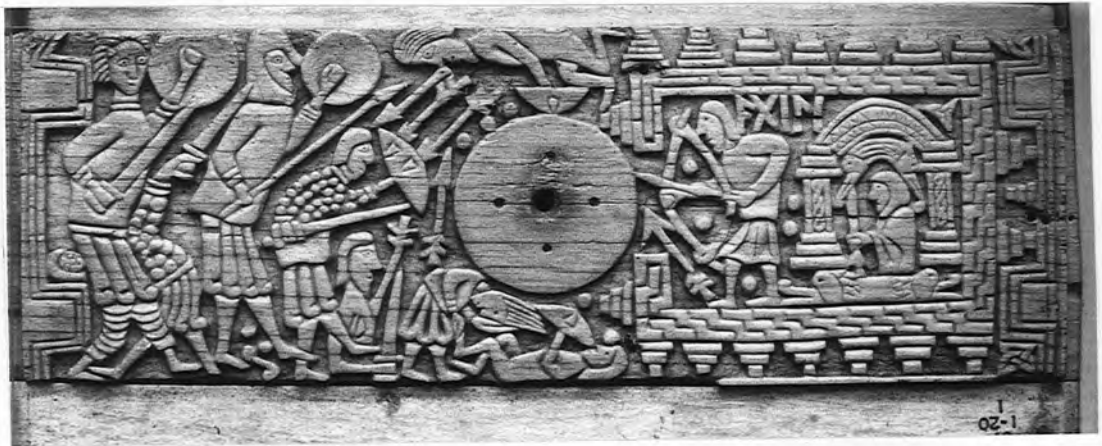


Plate 50 Franks Casket: view of lid from above.



Plate 51 Franks Casket: view of corner piece from above.



Plate 48 Franks Casket: front view showing site of lock.



Plate 49 Franks Casket: back view showing site of hinges.



Plate 46 The method of bone skating, using a spiked pole (after Olaus Magnus).



Plate 47 Casket mount from Perth. At the bottom of this rear view of the mount can be seen a strip of cancellous tissue, indicating the site of the *spina scapula* and hence identifying the source of the raw material.



Plate 44 Chessmen: bishop of walrus ivory,
Isle of Lewis.



Plate 45 Chessmen: knight of walrus ivory,
Isle of Lewis.



A



B

Plate 42 Chessmen: castle of antler, Museum of London. A side view, B top view.



A



B

Plate 40 Chessmen: knight of antler from Helpstone. A side view, B top view.

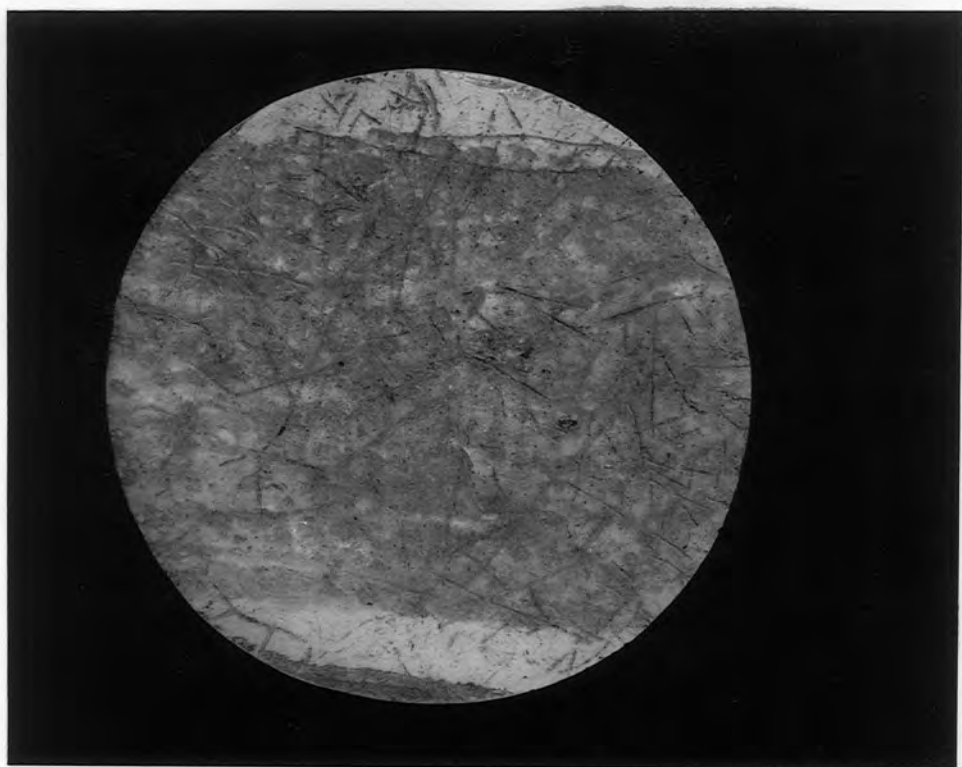


Plate 38 Discoid playing piece (? blank) of walrus ivory, British Museum.

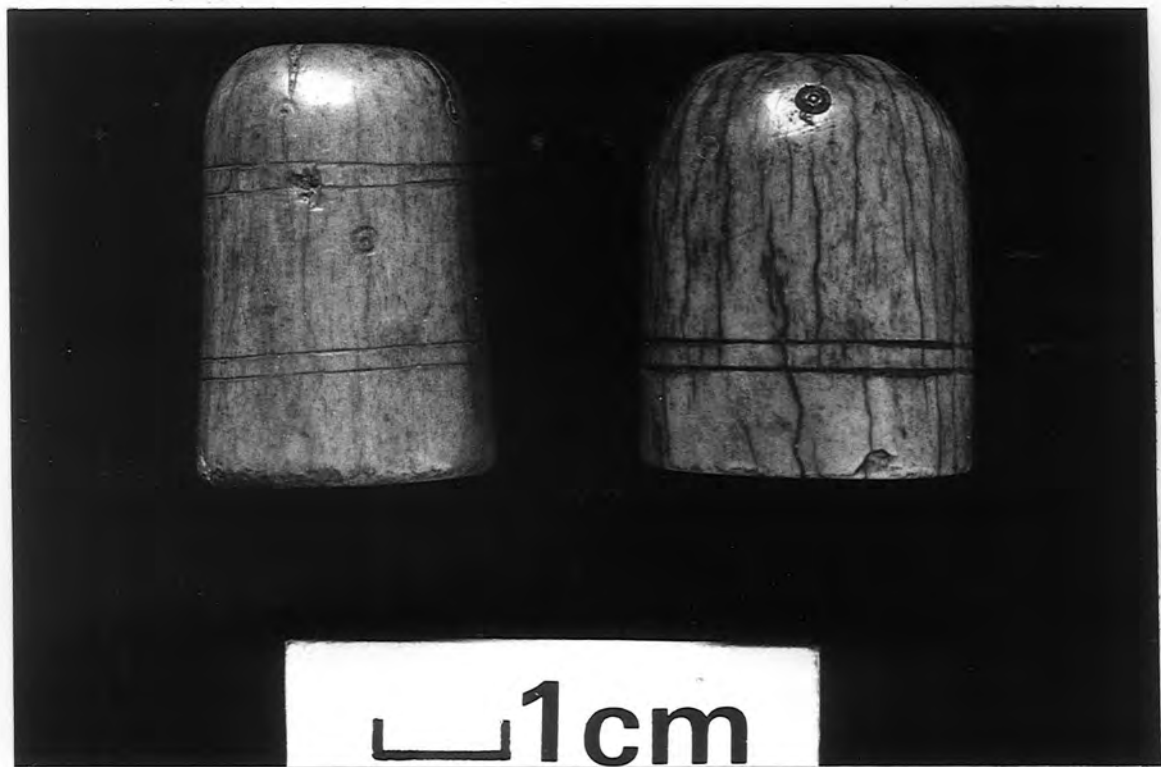


Plate 39 Chessmen: cylindrical pawns, British Museum.



Plate 36 Discoid playing piece or whorl of antler,
from London.



Plate 37 Discoid playing piece of cetacean bone,
from London.

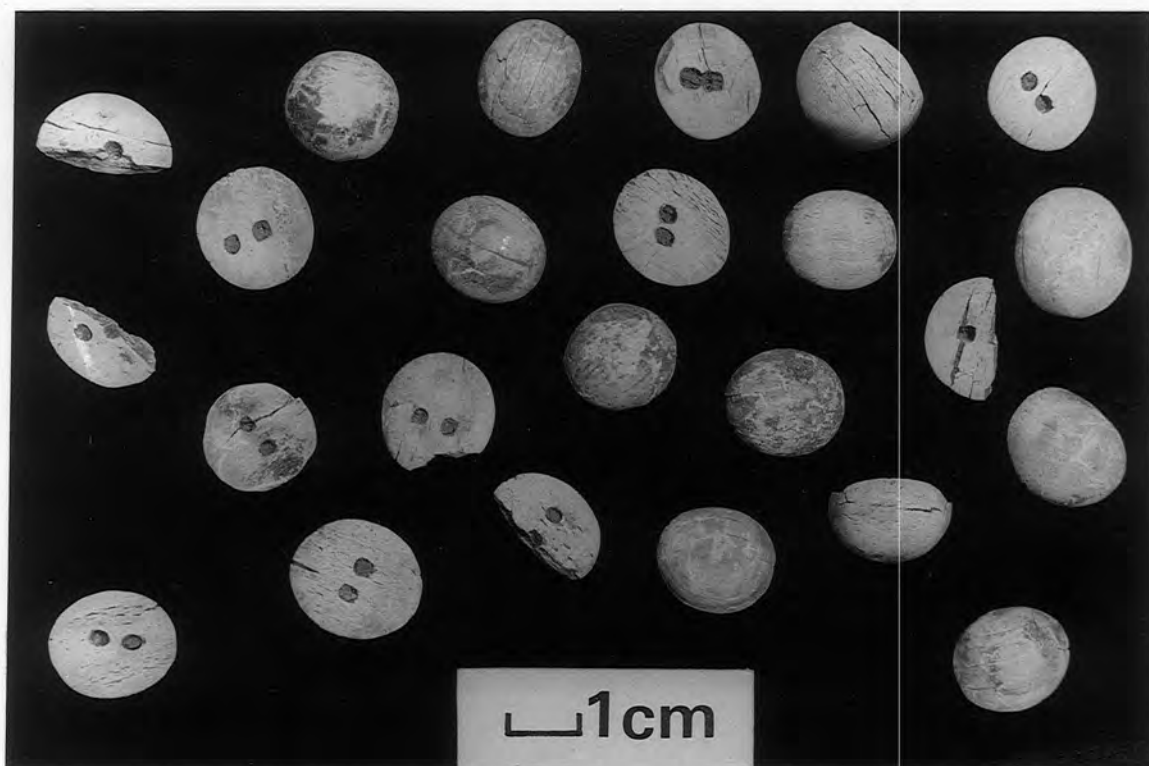


Plate 34 Plano-convex playing pieces of bone from Loveden Hill.

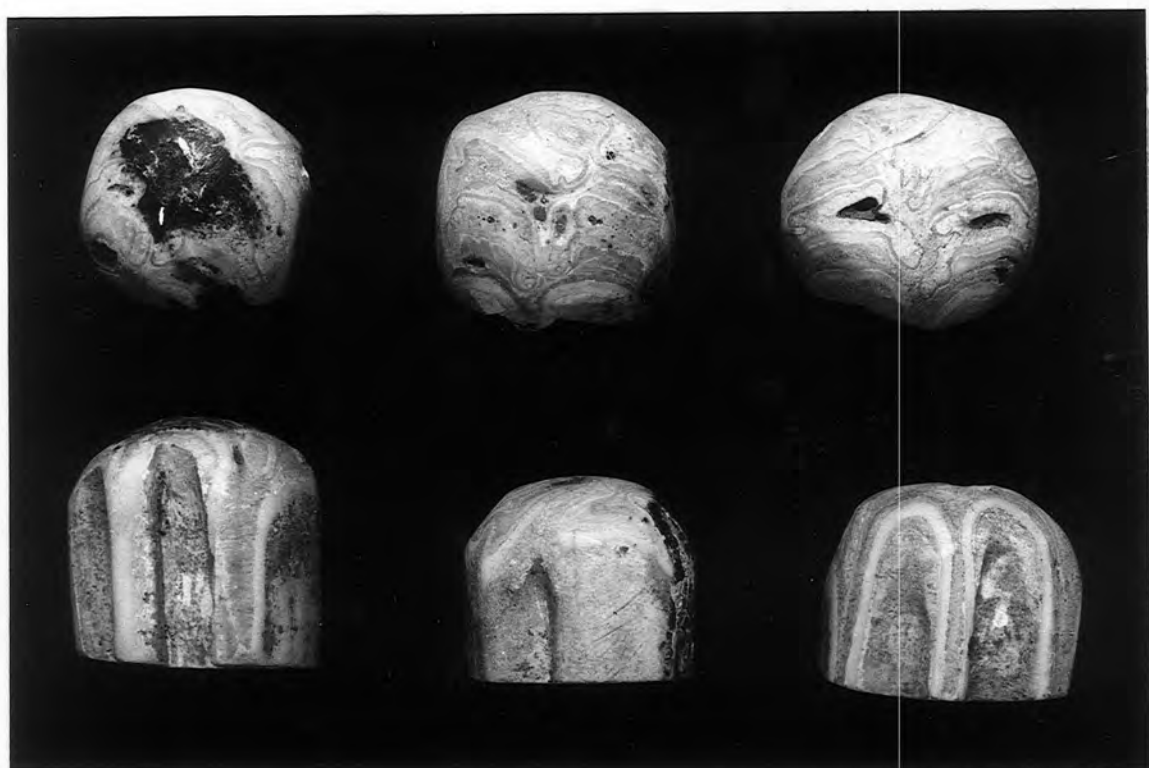


Plate 35 Playing pieces of horses teeth from Faversham.



Plate 30 Horn comb with riveted bone side plates, from Milk Street, London.

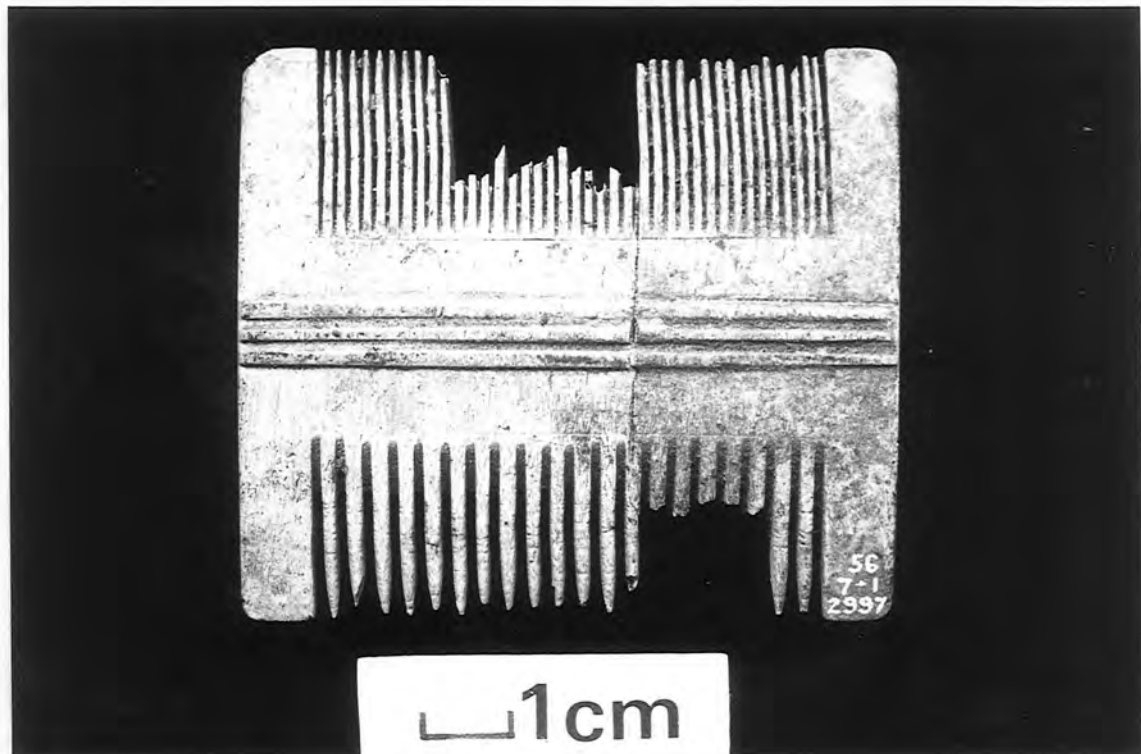


Plate 31 One-piece bone comb of the early medieval period, from London.



Plate 26 Triangular-backed comb and case from Loveden Hill.

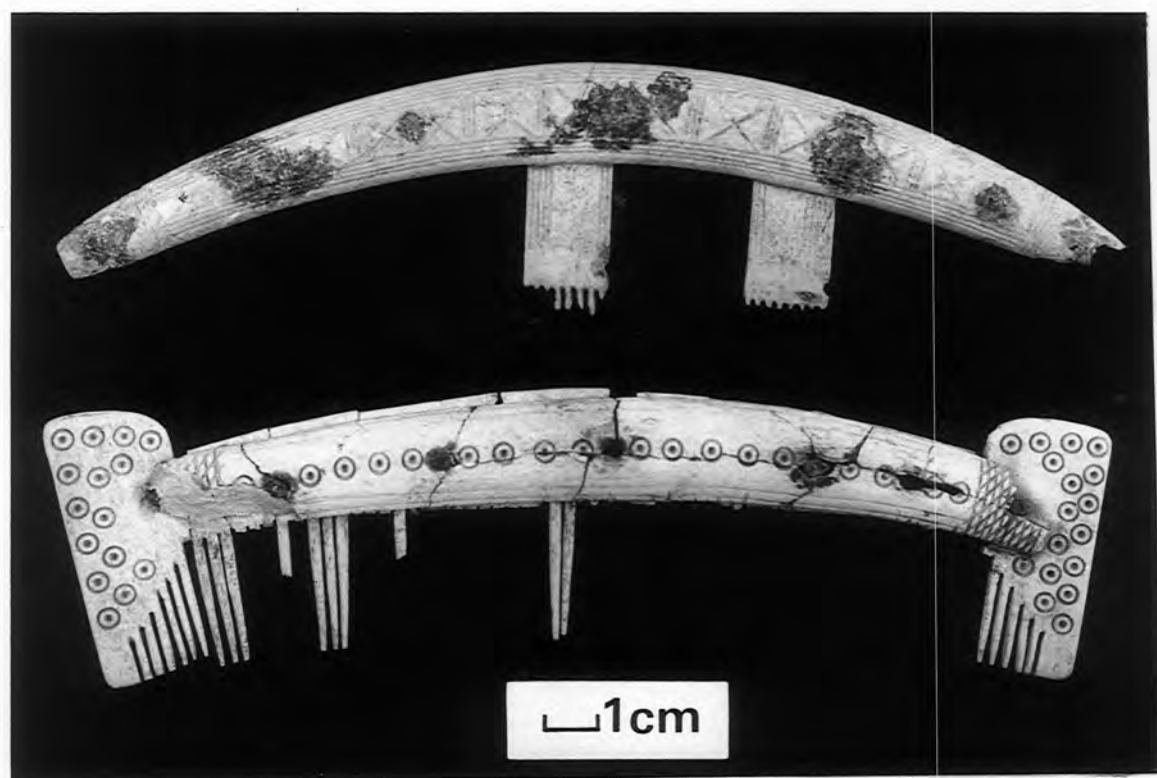


Plate 27 Combs from Cambridgeshire (above) and Sutton Courtenay.
The Cambridgeshire comb has originally had a second set of side plates.



Plate 24 Gold-mounted horn sword handle from Cumberland.



Plate 25 Antler splints from Roman composite bows, from London.



Plate 23 Obverse and reverse of walrus ivory seal matrix from Wallingford.

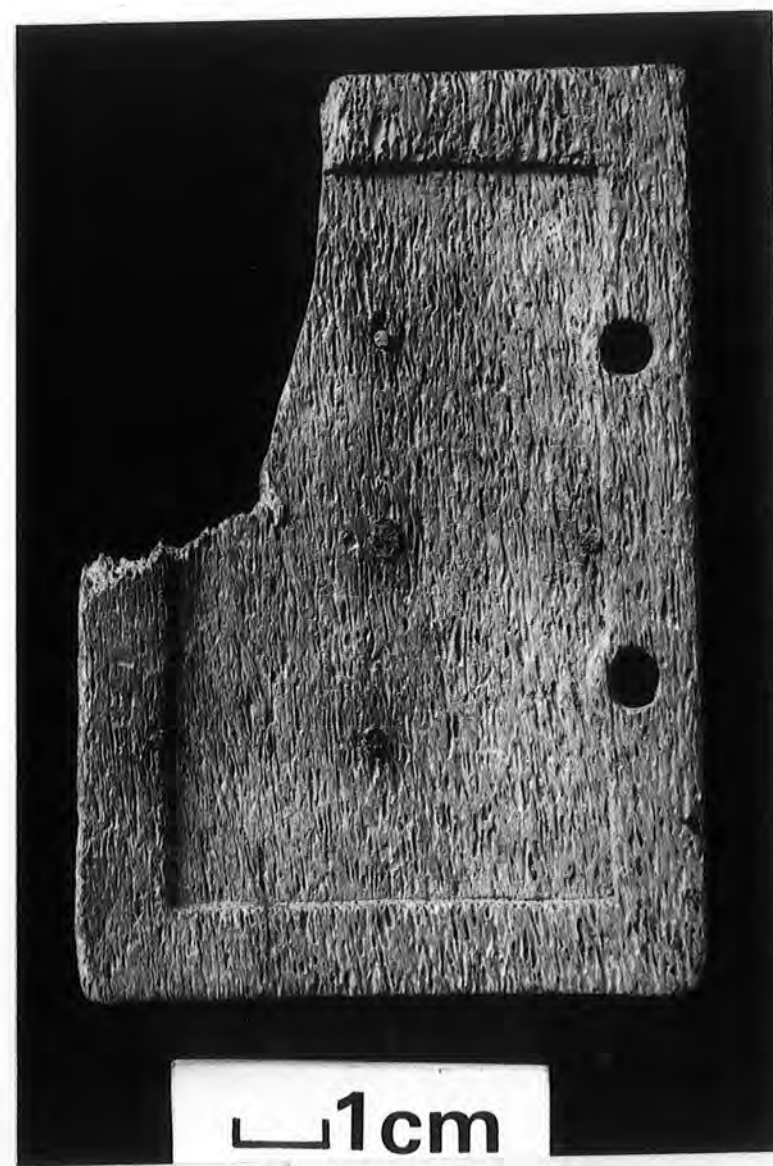


Plate 22 Obverse and reverse of cetacean bone writing tablet from Blythburgh, Suffolk.



Plate 17 Top and side view of antler playing piece, showing disposition of cancellous tissue running axially through the disc. (Little cancellous tissue is in fact visible on this piece, indicating that it was cut near the burr.



Plate 18 Top and side view of jawbone playing piece, showing disposition of cancellous tissue running transversely through the disc. On the right of the cross section is the mandibular foramen.



Plate 16a Jawbone drilled for production of gaming counter or spindle whorl, from Schleswig. The nutrient foramen (Plate 5) runs through the area from which the disc has been excised.

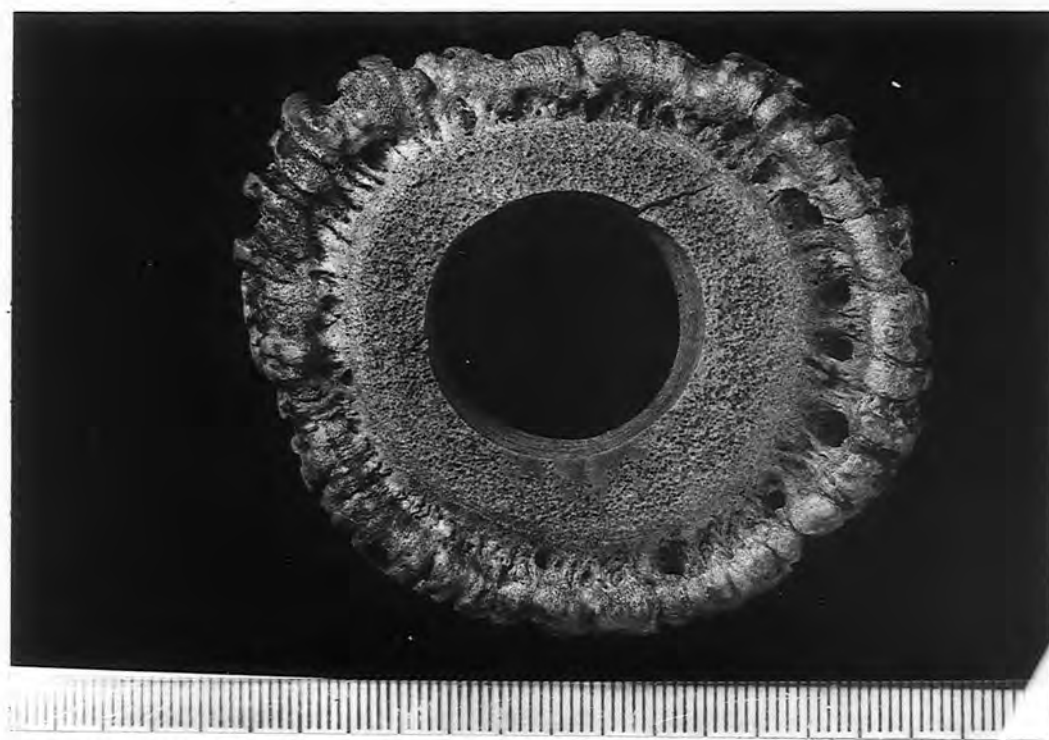


Plate 16b Drilled antler burr from Hedeby.

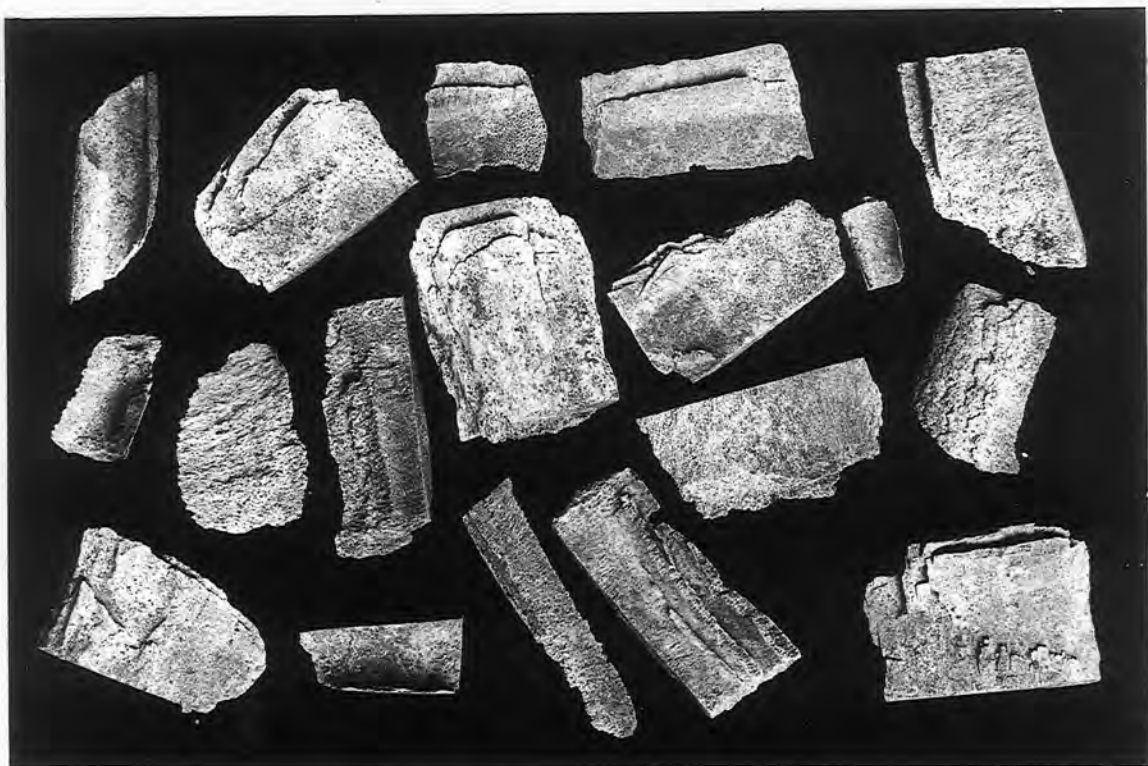


Plate 14 Antler shavings from Hedeby, produced by a draw-knife.



Plate 15 Chatter marks from shaping process on a long-toothed comb.



Plate 12 Antler tines, the tips of which have been sliced to a point with a knife.



Plate 13 Antler burr (brooch mould) with faceted sides, seemingly cut with a draw-knife.

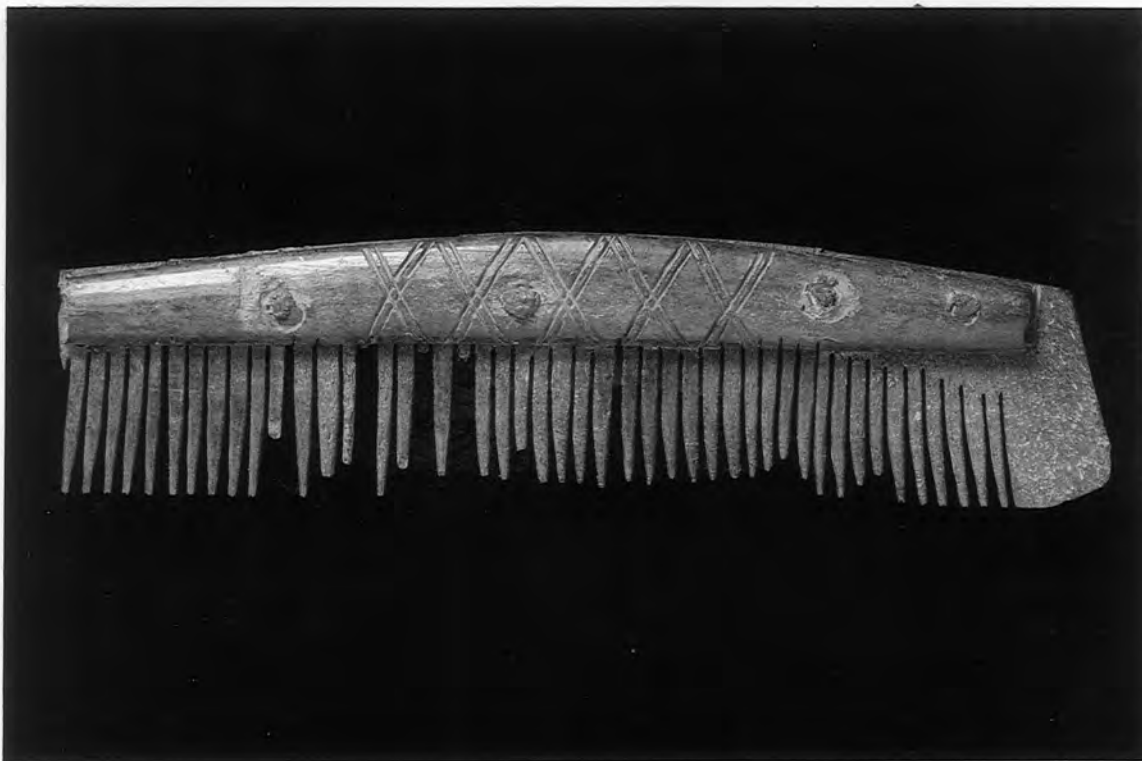


Plate 10 Antler comb from York decorated with incised ornament from a double saw.



Plate 11 Antler beam from Hedeby with a splitting wedge of antler driven into one end.



Plate 8 Antler burrs displaying saw marks from their initial separation from the beam.



Plate 9 Pedicle, cut and partially trimmed, perhaps intended for a die.

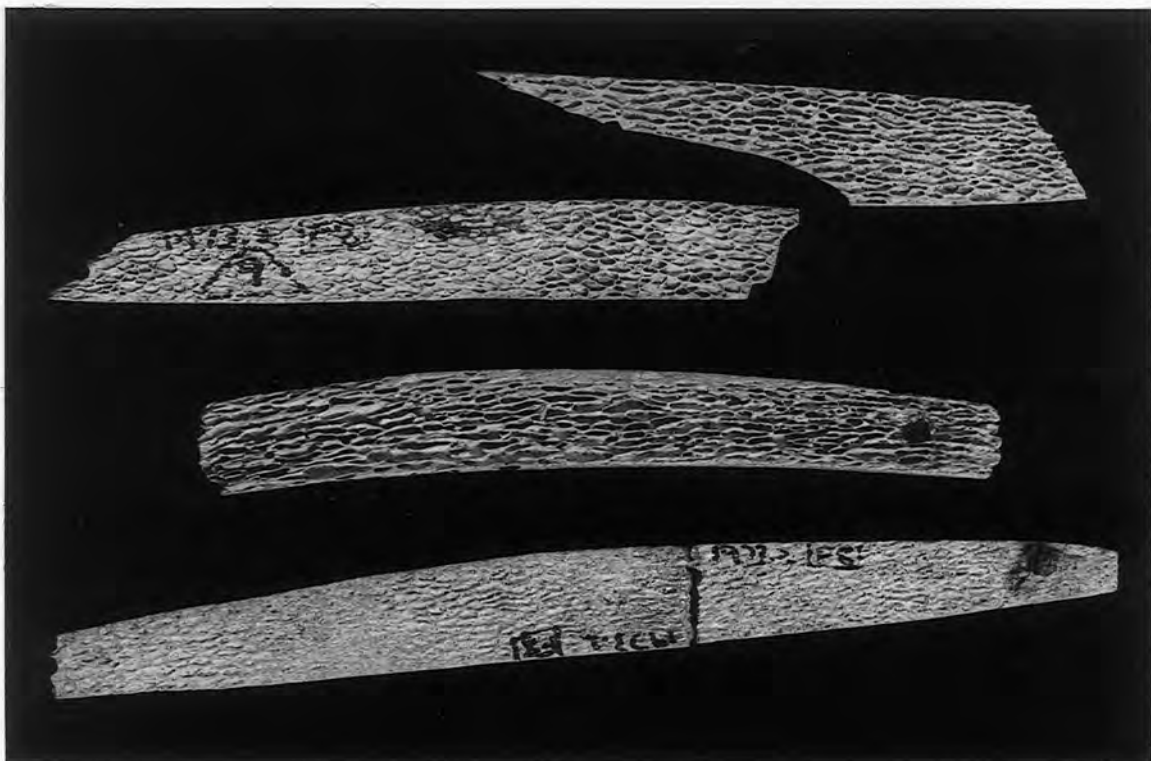


Plate 6 Cancellous tissue on split ribs (comb case fragments) from York.



Plate 7 Cancellous tissue on antler fragments (offcuts) from York.



Plate 3 Nutrient foramen (centre) on bone skate from Hedeby.



Plate 4 Nutrient foramen on bone pin from York. (By permission of York Minster Archaeology Office).

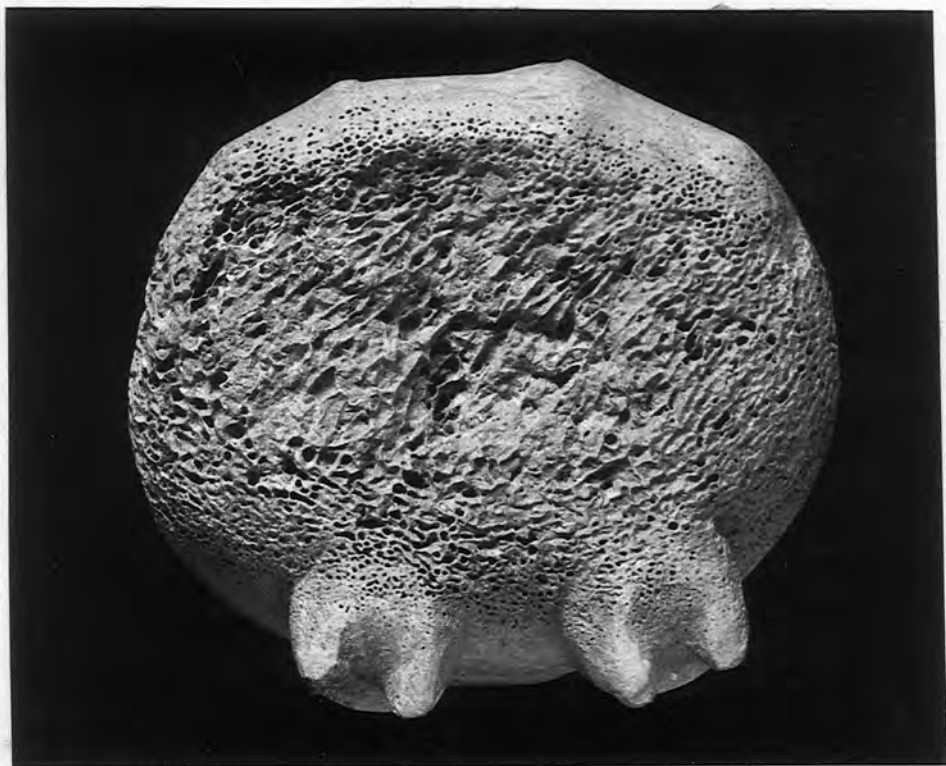


Plate 1 Cancellous tissue: top view of cetacean bone playing piece from Witchampton (cf. Plate 41).



Plate 2 Compact tissue: medieval crucifix from Lincoln, carved from a bovine metapodial.