

EXPERIMENTAL ARCHAEOLOGY

by JOHN M. COLES, F.S.A.SCOT.

THE term experimental archaeology is a convenient way of describing the collection of facts, theories and fictions that has been assembled through a century of interest in the reconstruction and function of ancient remains. This paper is an attempt to provide an explanation of some of the theory and principles involved in experimental archaeology, and a brief description of some experiments done in this country and abroad which can serve as examples to show the advantages and disadvantages of various approaches to the subject.

A. THEORY

Experimental archaeology can be divided into two sections, one concerned with the imitative aspect, the duplication of products of the industry of early man, the other utilising such products in determining their functional capabilities. Basic to both aspects is the production of copies of prehistoric objects, of wood, stone, bone or metal, either to be studied as replicas in themselves, or to be tested in some way. By making these copies, the archaeologist can gain some insight into how things were produced in ancient times, and often these experiments yield hints that aid in the interpretation of otherwise incomprehensible parts of objects or marks upon them. Casting seams and hammer scars on metal artifacts, for example, are most easily understood by attempting to duplicate them experimentally. This imitative aspect involves a considerable amount of specialised experience in arts and crafts, and, as usual, the archaeologist must draw heavily upon the knowledge of others. Often the entire experiment will depend upon the ability of the craftsman to make accurate copies of ancient objects, copies that are not only identical in appearance to the original but are also put together with the same view towards their eventual function. As an example, a wooden copy of an ard may closely resemble the ancient object (fig. 2) but the type of wood used, its age and its condition, and its grain, all must be considered carefully in the light both of the wood-worker's knowledge of stresses and of the condition of the ancient material. Here the value of examination and analysis of the material will be important, not only to yield information about the marks of production and wear on the object but also to determine the exact composition of the basic material. The obvious example of this is the reproduction of ancient metal artifacts, where spectrographic and other analyses can yield essential data about the composition, and therefore the properties, of the material. Specialists, present during the actual experiment, will also be valuable to the archaeologist to help him understand what is happening during the progress of his attempt to reproduce ancient objects.

The conduct of an experiment on archaeological material may be compared with an excavation, where the archaeologist has set a problem and draws upon the specialised information of others to help him determine his course of action and to

draw conclusions about the finished product. It is not necessary, nor possible, for the archaeologist to possess all the details of the scientific processes and theories involved, but it is necessary for him to appreciate the scope and potentialities, and, more important, the limitations of such scientific aids as he may be able to bring to bear upon the problem. I believe this statement applies equally to an archaeological excavation or an experiment.

In the copying of an object, the primary difficulty facing the archaeologist is the determination of the processes to be employed. It may fairly be said that in theory only those methods should be used that are presumed to have been available to prehistoric man. Most experimenters in practice have tended to avoid this problem and have made a small part of the object by using simple methods, such as cutting a piece of wood for a structural reconstruction with a stone axe, and thereafter using modern equipment. For the purposes of making a quick copy, such a procedure is self-evident, but the amount of information we can gain about the finished product is severely reduced. No estimate of the time involved in the manufacture can be made, as extrapolations are notoriously misleading in such cases, and the essential factor of 'prehistoric need' is unknown (see p. 7).

In addition to the loss of information about the time involved in the production of objects, through the use of modern methods, there is also a danger that the modern product will possess characteristics different from those of the ancient artifact. For example, the crushing and compression of surface areas of wood and bone through the use of high quality steel tools have not been considered, nor perhaps the effects of sophisticated methods of heating and casting of metals. Similarly, the breaking-up and shovelling of chalk with modern equipment may have a different effect upon the compaction of an experimental earthwork, when the latter is compared with a structure built entirely by methods more within the reach of prehistoric man. Another disadvantage of the use of modern methods to complete any copy lies in the total lack of information about the effects of the processes upon the tools employed, a corollary which could be of the greatest interest. Here the amount of information obtained through microscopic examination of edge wear on prehistoric tools¹ could be profitably compared with work traces on material used in experiments; for example, the ancient use of flint blades as whittling knives has been determined both through examination of striations on their edges (fig. 1) and by experimental reproduction.

In determining the methods to be employed in making duplicates, the rule of thumb used by experimenters is generally that of inefficient, because inexperienced, use of primitive unspecialised objects such as flint flakes, stone axes, wooden punches and mallets, bone shovels and scoops. These in many cases are second-best, because they too easily replace intelligent consideration of the degree of technological advances that prehistoric people had made. Block-and-tackle, shear legs, sledges and rollers, all were without doubt available to many prehistoric groups, to aid in transportation and erection of large objects, just as specialised pottery and metal equipment was available to comparable people making small artifacts. With such

¹ e.g., S. A. Semenov, *Prehistoric Technology* (1964).

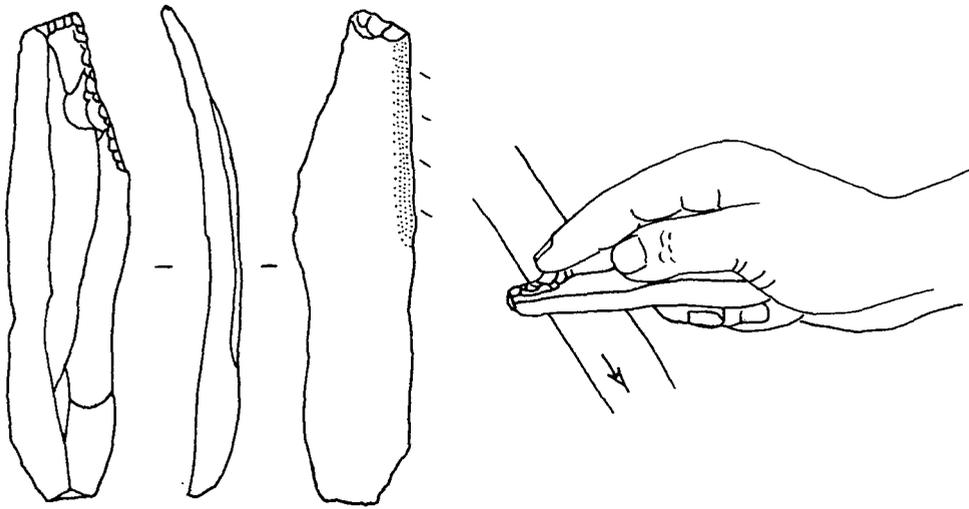


FIG. 1. Use of flint blade as whittling knife, with retouched edge for finger support. The stipple indicates the area of wear-striations, and lines show their direction. (After Semenov, 1964, fig. 45)

a range of equipment, allied to centuries of experiment and experience, it would be easy to devise and carry out relatively sophisticated methods of handling and manufacture. The experimental archaeologist, therefore, should have a detailed knowledge of the technological methods available, or presumed to be available, to the prehistoric peoples with whom he is concerned; such knowledge will be based upon estimates of prehistoric time, surviving materials, economy and environment.

A major problem in experimental archaeology is the subjective element, the fact that the experimenter comes from a different cultural body with a different approach to existence; he cannot hope to reproduce the mentality, and spiritual background, obtaining in prehistoric time. Everything in the experiment should be aimed at neutralising or eliminating the experimenter's personal influence on the experiment, through the incorporation of as many natural factors as possible. The several experiments in recent years with ploughing devices are cases in point. Although the natural conditions, soil structure, season and weather, can be chosen so that they may be presumed to reproduce the prehistoric conditions as closely as possible, the other subjective elements, the plough or ard, the choice of animal traction, the ploughman, are less reliable; the ard may reproduce exactly a prehistoric specimen, but it is necessary to consider carefully the need to train animals and men to pull and guide it (fig. 2, left). Tractors, and probably horses, are not suitable for such experiments if the soil marks, or wear on the ard, are to be examined. Clearly, such an experiment involves a great deal of research into the *modus operandi*.

The second aspect of experimental archaeology, the study of the function of ancient materials, requires that these materials should be accurately duplicated. In theory, this functional approach should assist the archaeologist in deducing the precise use of artifacts in prehistoric times, and this approach, allied to that of

microscopic examination for wear traces, may allow us, in time, to describe material in terms of actual function rather than shape alone. Metal axes, flint scrapers, bone points may then be seen to have served as chisels, knives and drills, respectively, functions which in fact have already been established for some of these general classes through both methods noted above.

In experimenting with actual ancient materials, or their copies, it is essential to determine the purpose of the experiment, so that the suitability of the environment, and the fitness of the material can be assessed. In ploughing experiments, for instance, the soil, crop, season and weather must be assessed accurately if valid comparisons are to be made, and the human elements strictly controlled. In the case of experiments in the destruction of houses, the natural factors must be allowed to act without human and subjective interference, so far as is possible. If the house is to be burnt (Pl. II, 2), then, providing the structure has been built according to an assessment of prehistoric building methods, the fire once started will act entirely naturally, dependent only upon natural factors of wind and damp.

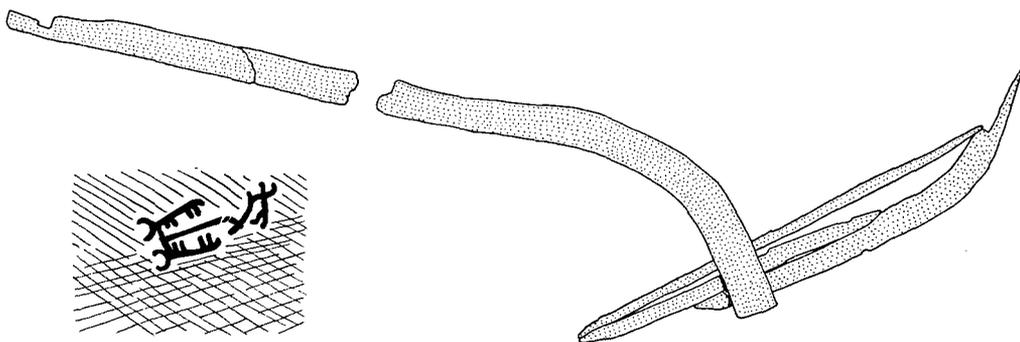


FIG. 2. (right) The Donnerupland ard. Length of foreshare *c.* 130 cm. (After Glob, 1951, fig. 29)
(left) Reconstruction of cross-ploughing. (After Skalk, 1958)

The decay of structures through other natural agencies which are not induced is eminently suitable for experiment, but such processes as rainfall, snow, frost and wind are generally of long-term effect. Provided that the experiment is carried out in a suitable environmental setting, where such agencies will be of comparable strength and effect to those of early times (bearing in mind any long-term alterations in climate), the human element can be, in theory, entirely eliminated. The main problem is that of the long-term nature of the experiment, because it is not possible to accelerate the effects of weather without distortion. Already the Overton Down experimental earthwork has yielded interesting results of rapid silting and slumping, but the total significance of the structure can only be revealed in terms of decades of years.

Almost entirely opposed to the example of house decay by natural agencies is that of the effects of human occupation upon a similar house. In this case, no useful experiment can be carried out, as there are too many human, too few natural, factors

involved. The habits of the occupants of the experimental house would in all probability bear no resemblance to those of the original occupiers, and any decay of the structure or deposition of debris through occupation would not necessarily be applicable to traces of decay or deposition in prehistoric structures.

A source of information about the production and function of ancient objects is available through the study of existing primitive societies. Such recourse to living events has tended to be ignored by the archaeologist, rightly in the case of society structure and religion, but the material culture of primitive groups may yield important information for our understanding of prehistoric artifacts. The superficial resemblance of special ovens for the extraction of iron in the Sudan and adjacent areas of Africa to those recovered from Iron Age sites in Denmark has led to experiments on reconstructed Iron Age ovens which indicate that the similarity in shape is a measure of the similarity in the method used in these unconnected areas.¹ On a different line, the observation of a specialised percussion method for flint flaking in Angola today has suggested that the term 'pressure-flaking', so often applied to the products of many Stone Age peoples, is misleading.² A clear guide is provided in this case for careful experimental duplication of 'pressure-flaked' objects through both controlled percussion and pressure; the significance of such work might be of far-reaching consequences in indicating that technological developments need not be considered to mark cultural change.

It is important to realise that environment plays a part in this functional approach to archaeology. By this I mean that the testing must be carried out with materials and under conditions approximating to those of prehistoric times. An obvious example for portable material is that of bronze and leather shields, which must be 'tested' by exact copies or actual specimens of Bronze Age spear and sword (Pl. II, 1). Examples for outside activities such as house building or ploughing are immediately apparent. Of course the reproduction of original circumstances can be overdone, and it is not considered necessary to dress in animal skins before flaking flints, although such a garb seems to be generally popular among some 'experimenters'.

The Historisk-Arkaeologisk Forsøgscener at Lejre in Denmark represents at the moment the best example of this environmental approach to experimental archaeology.³ The Center was established in 1964 on approximately 75 acres of land which includes arable land, moor, a small lake, and which is bounded on all sides by hills or forest. The aim of the Center is threefold, to conduct experiments, to collect data from other groups and individuals for an archive of experiments, and to make available the results both to science and to the public. The public are allowed to view the experiments in progress, and thereby contribute their interest and finance to the undertaking. More than 50,000 visitors attend the Center each year. The experiments planned include cultivation and animal husbandry as well as house building and a host of smaller experiments. Such large scale organisation of experimental

¹ O. Voss, 'Gammelt Jern', *Skalk* (1963) no. 2, 4; O. Voss, 'Jernudvinding i Danmark i forhistorisk Tid', *Kuml* (1962), 7.

² J. D. Clark, *Prehistoric cultures of northeast Angola and their significance in tropical Africa* (1963), 171.

³ S. Nielsen, 'Eksperiment', *Skalk* (1966) no. 3, 13.

archaeology is unmatched elsewhere; in the British Isles, experiments have generally been individual efforts.¹

The last point to be noted is probably the most important of all, and is concerned with the limitations of the subject. The value of experimental archaeology must not be over-emphasised. It is the task of the experimenter to obtain new knowledge to add to that gained through other archaeological disciplines. By observation of materials and sites, theories about functions and past events may be formulated, and experiments can be made to test some of such theories. In the natural sciences, the experimental method of proof is vital; the scientist is dealing with existing things and events which are observable and which can be repeated and measured. In archaeology, the events are past, gone forever, and cannot be observed or measured. The experiment in the last resort is based upon conjecture, the idea of the archaeologist who believes that a specific object was made in a certain way and performed a certain function. What he sets out to do is to prove or disprove his theory, but it is in the nature of the situation that he cannot be certain of the result. It is too easy in experimental archaeology to fall within the compass of that damning definition of prehistory, the unwarrantable deduced from the unverifiable. He can only assure himself that certain objects are very unlikely to have successfully served certain specified purposes, but he cannot be as certain that they were used solely for another function. An example of this is the beaten bronze shield which has been shown by experiment to be physically unsuitable as a defensive weapon; it is unlikely, therefore, that Bronze Age warriors, if there were such people, would carry such objects into armed combat. They might however have served as ornamental gear up to a time immediately preceding a battle, or they might have been made as gifts of ostentation, or as ritual or ceremonial objects. We cannot know their precise function, but we have probably eliminated one possibility from the list.

Another example will serve to amplify this point. A prehistoric object such as a horn of the Irish or Scandinavian Bronze Age by experiment can be shown to be capable of yielding from one to twelve or more notes, depending on the instrument (fig. 10), but modern analogues in primitive societies show that the potentiality of an instrument need not indicate its precise range when in use. We cannot know if prehistoric man was capable of producing as many as 12 notes from one instrument or if he could do so, whether or not he used all or any of them, or for what purpose. Other prehistoric objects could be treated in the same way, potentially serving several purposes, and all the experimental archaeologist can do is eliminate some of these. This is perhaps an over-gloomy assessment of the value of experimental archaeology, but I believe that the limitations inherent in the material and the method must be constantly in mind.

Although experimental reproductions of archaeological material were first made a century ago, it is only in the past two decades or so that serious attempt has been made to test the functions of prehistoric tools. These and other experiments may conveniently be divided into three groups, one dealing with the production and consumption of food, another with the manufacture and decay of buildings and

¹ J. M. Coles, 'Flere Forsøg', *Skalk* (1967) no. 1, 26.

structures, and a third with the production and function of tools, weapons and other artifacts. It is not possible to describe here more than a few examples in each of these groups.

B. EXPERIMENTS

1. *Food Production*

Clearance and Cultivation

Most experiments on the processes from forest clearance to cultivation have been carried out in Scandinavia. Jorgensen and Iversen have recorded experiments on the clearance of forest by stone and flint axes, hafted according to surviving prehistoric examples¹; in one experiment, 2000 sq. yds. of forest were cleared, leaving oak trees of over 14 in. diameter girdled. Oaks of less than 12 in. diameter were felled in half an hour, and three men cleared 500 sq. yds. in four hours. Comparisons have been made between the felling of trees by these stone axes and by iron axes. Using the former, it has been estimated that in one week one man could clear half an acre of forest compared with one acre of clearance through the use of the metal axe. Yet in Upper Canada, where the latter rate of clearance was recorded,² the essential point is that although on this reckoning one man could clear 52 acres per year, he in fact averaged only 4 to 5 acres annually, leaving stumps in the ground. In addition to factors of seasonal weather, and basic subsistence, the 'need factor' is surely worthy of more consideration than it is generally given. I believe that it is wrong to consider that the time available to prehistoric man was virtually limitless, and it is almost certain that he would be constantly attempting to reduce his activity load by streamlining his actions and by planning ahead. Prehistoric communities must have been well enough organised to make provision for future arable land under the land exhaustion process of cultivation. Trees in a suitable new area could easily be ringed and left to wither well in advance of the season and year of first cultivation. In addition, time-saving devices such as windrow-felling on slopes would cut the time by almost one half.

Following the experiments on forest clearance in south Jutland, the felled trees and brushwood were burnt so that the ground was thoroughly heated.³ In western Europe the only suitable method of forest clearance was probably burning because of the heavy undergrowth which would inhibit other forms of clearance, yet Neolithic man must also have been aware of the need to keep felled areas small to allow forest regeneration quickly, and to avoid the development of heathland. The area was then sown with Neolithic varieties of wheat and barley, by sprinkling and raking with a stick. An unburnt area of cleared forest was also sown as a control, and both areas were weeded and hoed. A strong crop of grain grew on the burnt area in the first year, hardly any on the unburnt control area, but this primitive slash and burn

¹ S. Jorgensen, 'Skovrydning med Flintøkse', *Fra Nationalmuseets Arbejdemark* (1953), 36; J. Iversen, 'Forest Clearance in the Stone Age', *Scientific American*, 194 (1956), 36.

² E. C. Guillet, *Early Life in Upper Canada* (1933).

³ A. Steensberg, 'Mit Braggender Flamme', *Kuml* (1955), 63.

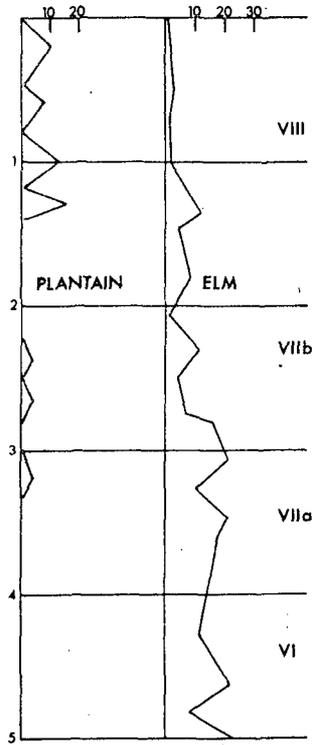


FIG. 3. Extract from pollen diagrams for Dalnaglar. Depth in metres below surface
 (left) Plantain: percentage of total non-tree pollen
 (right) Elm: percentage of tree pollen
 (After Durno, 1961-2)

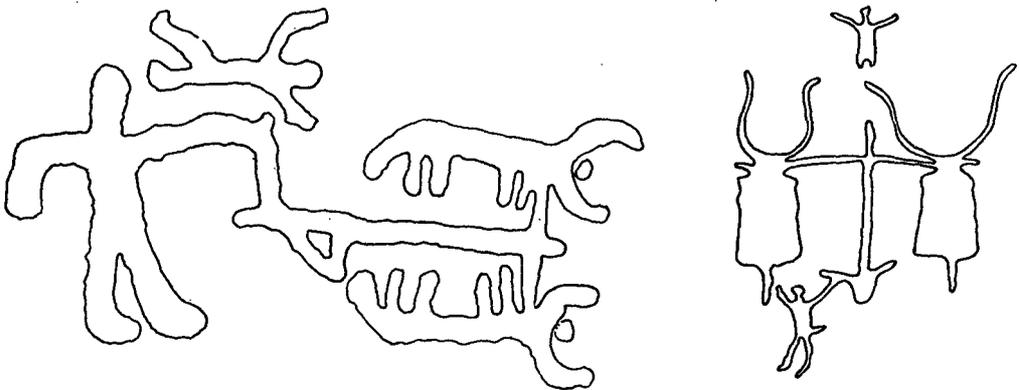


FIG. 4. Cultivation scenes in Bronze Age rock art
 (left) Finntorp, Bohuslan, Sweden. Scale $\frac{1}{8}$. (right) Val Fontanalba, Italy. Scale *c.* $\frac{1}{4}$.
 (After Glob, 1951)

method was only effective for one year. In the second year, the crop was much smaller.

The experiments also demonstrated that the weeds returning to the area differed both on the unburnt and burnt ground; colonising plants in the burnt area included dandelion, thistle and plantain, and it is just such plants that are recorded in pollen diagrams from the third millennium B.C. in Scotland (fig. 3). The diagram from Dalnaglar in Perthshire¹ must indicate Neolithic occupation in the area at this date, and may help to explain the situation and grouping of Neolithic barrows in parts of Perthshire, as well as pointing to further fieldwork and excavation.

The Danish experiments continued with cattle grazing, an activity also recorded in pollen diagrams through the decline of elm pollen, the leaves and shoots of which tree were used as winter fodder. The diagram from Dalnaglar neatly illustrates this correlation between the elm decline and the appearance of weeds of cultivation (fig. 3).

The essential fact emerging from these experiments is the short-lived nature of the successful grain crop in newly cleared ground, a fact which must indicate a general mobility of Neolithic peasantry in cultivated fields if not in settlements.

Ploughing experiments have been carried out in several countries, but those in Britain and Czechoslovakia have been hampered by the absence of trained traction animals. Near Reading, a full scale model of the Donnerupland ard (fig. 2), of late first-millennium date, was pulled over various soils by horse and tractor.² Two fragments of wooden ards are known from south-west Scotland.³ Earlier evidence of ards or ploughs comes from rock art in both northern and southern Europe, and these tend to show that paired oxen were used (fig. 4).⁴ At Lejre in Denmark, experiments are now being carried out using trained oxen, and the results both in terms of the soil marks and the wear on the ard should be of greater value than those so far achieved. An interesting aspect of ploughing experiments would be the measurement of the time necessary for traces of plough marks on subsoil to disappear if they were not covered by a barrow. It would be essential to carry out such an experiment in areas similar in local environmental conditions to those where barrows with preserved ploughing marks have been recognised. The results would help to settle the debate about the ritual nature of such prehistoric ploughing.

A number of experiments have been carried out on the harvesting of grain, but those of Steensberg in Denmark are the most objective and are well recorded.⁵ Most of the experiments have been concerned with the reproduction of the gloss on sickles, now known to be produced by the reaping of corn or other siliceous grasses. Steensberg attempted to show which prehistoric and early historic implements served as reaping tools (fig. 5). Flint blades, unretouched or with serrated edge, bronze and iron sickles and iron scythes were used to cut two crops, one drill-sown barley and

¹ S. E. Durno, 'Pollen Analysis of Peat', *PSAS*, xciv (1961-2), 154.

² F. A. Aberg and H. C. Bowen, 'Ploughing Experiments with a reconstructed Donnerupland Ard', *Antiquity*, xxxiv (1960), 144.

³ A. Fenton, 'Early and Traditional Cultivating Implements in Scotland', *PSAS*, xcvi (1962-3), 264.

⁴ P. V. Glob, *Ard og Plov i Nordens Oldtid* (1951).

⁵ A. Steensberg, *Ancient Harvesting Implements* (1943).

oats on a clay soil, the other hand-sown barley and oats on sandy loam. A number of small plots were sown in these ways and the matured grain was then cut by gripping a bunch of straws below the head and cutting with the implement, then gripping another bunch and so on until a handful was collected. The number of cuts required to obtain a handful was recorded, as well as the number of uprooted straws taken as a percentage of the total, and the time taken to reap the 50 sq. m. plots. All of these

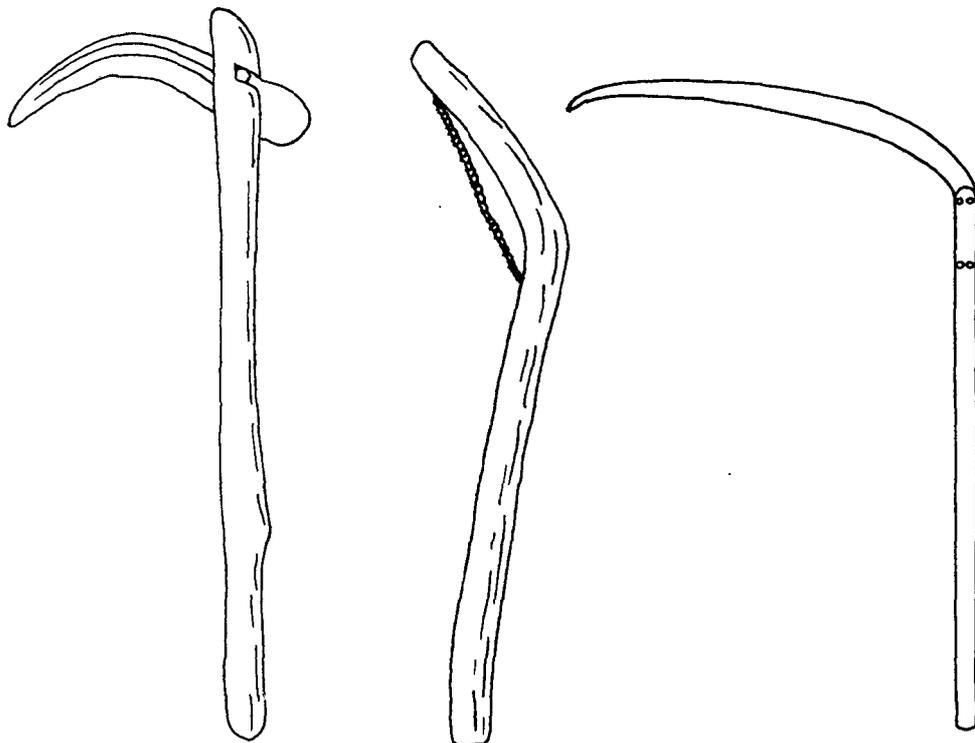


FIG. 5. Harvesting implements
 (left) Bronze knob sickle. (centre) Flint saw-edged sickle. (right) Iron Viking scythe
 (After Steensberg, 1943)

represent functions of the efficiency of the various implements. The experiments also indicated the best method of using the implement, some cutting in a sweep near the ground, others cutting in an inclined sweep. Taking the percentage of uprooted straws as the criterion of efficiency, a Viking scythe (cf. fig. 5, right), and a Roman Iron Age scythe were the best, followed by a modern sickle, also of iron. But an unhafted unretouched flint blade was next, demonstrating once again the impossibilities of deducing the function and efficiency of material by its typology alone. Bronze sickles (fig. 5, left) were also suitable implements when measured by this method, followed by less satisfactory flints (fig. 5, centre).

Experiments on the storage of corn have recently been carried out in Britain,¹

¹ H. C. Bowen, 'Corn Storage in Antiquity', *Antiquity*, xli (1967), 214.

based on pits which occur frequently in Iron Age sites in the south, but which are also known from Neolithic times in England and Scotland. The experimental pits had narrow mouths and were lined with basketry. A large storage pit, 5 ft. deep, would require a basketry strip of the order of 15 ft. long by 5 ft. wide, and would hold over 40 bushels of corn. The pits were aired for six weeks before filling, and after filling were sealed to exclude air and to allow carbon dioxide to develop. After six months, the corn, whether dried or not, had been successfully preserved apart from some loss at the edges and top. Corn in an unsealed pit was completely ruined. More recent attempts to provide adequate sealing with puddled clay and chalk on wicker have indicated that this may have been the primary difficulty in this method of preserving corn.

In Denmark, some experiments have recently been carried out on the preparation of corn, involving querns and clay ovens,¹ but of perhaps greater interest is a public experiment carried out by the B.B.C. some years ago involving the preparation and consumption of a 'prehistoric meal'.² Examination of the contents of the stomach of the strangled man from Tollund in Denmark revealed that his last meal had consisted of a soup containing barley, linseed, camelina seed (mustard), persicaria (a pale pink flower), with traces of other plants; sphagnum moss was also present, as well as some fine sand. For the experimental meal, most of these ingredients were boiled slowly to make a grey soup which tasted strangely to those archaeologists accustomed to more 'civilised' dishes. In fact, Pliny records that the gruel of peasants consisted of barley, linseed, coriander seed and salt, a comparable recipe.

Animal husbandry and cooking

The experimental reconstitutions of beasts externally resembling *Bos primigenius* through selective breeding is well-known to archaeologists,³ and the building-up of small flocks and herds at Lejre, for purposes of husbandry practices and for training of beasts for traction, has also been noted. Two experiments in Britain have been concerned with the preparation of meat for consumption. Recently an attempt has been made to reproduce a method of cooking that is attested in the sixteenth century A.D. in Ireland, involving the boiling of meat in an animal skin over an open fire.⁴ Scottish troops on the retreat in 1327 are reported to have left behind 'more than four hundred cauldrons made of hide with the hair left on, full of meat and water hung over the fire to boil'. The experiments were performed with a 5 lb. sheepskin holding one gallon of water in which the meat lay. The fire, however, could not boil the water and by shrinkage of the skin through heat and loss by evaporation, most of the water was lost. A repeat of this experiment, using a larger skin, or perhaps pot-boilers such as are attested in certain societies, would be valuable.

More successful from the standpoint of the finished product was an experiment carried out some years ago in Ireland.⁵ Excavations at Ballyvourney in Co. Cork

¹ Nielsen, *op. cit.*

² P. Johnstone, *Buried Treasure* (1957), 97.

³ F. E. Zeuner, *A History of Domesticated Animals* (1963), 204.

⁴ M. L. Ryder, 'Can One Cook in a Skin?', *Antiquity*, XL (1966), 225.

⁵ M. J. O'Kelly, 'Excavations and Experiments in ancient Irish Cooking-Places', *JRSAL*, LXXXIV (1954),

revealed traces of a structure comparable in plan to that of historically-known deer-roasting places (fig. 6) The site, of the mid-second millennium B.C., was reconstructed to form a wooden hut containing a meat-rack and table or butchery block, a boiling trough dug into the peat and surrounded by two major hearths, and a roasting pit. In the experiment, the hut was employed as the butchery area, where game was cut up prior to cooking, and the roasting pit, in which meat was covered by a corbelled

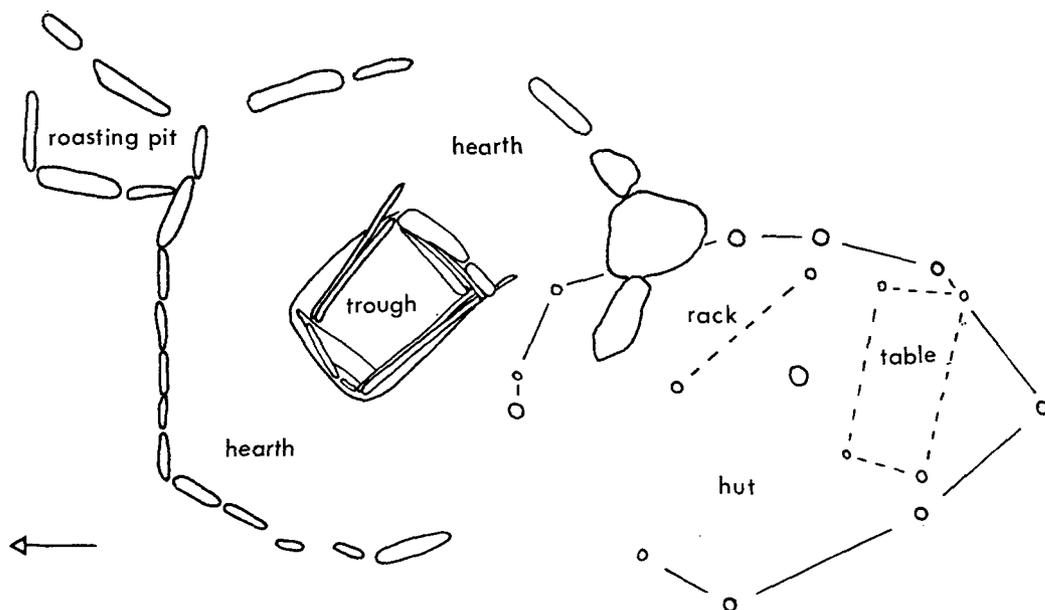


FIG. 6. Plan of cooking-place at Ballyvourney. Note post-holes of hut and internal furniture, and vertical slabs enclosing hearths and roasting pit; the trough is formed of stone and wood. Scale 1 in. to 7 ft. (After O'Kelly, 1954; most secondary structures omitted)

structure of hot stones, served as an oven. The trough, dug into the peat below the water-line, held 100 gallons of water, which was brought to the boil quickly by pot-boilers from the adjacent hearths, only thirty minutes being required to heat the water; few stones were needed to keep the water hot once the joint was placed in the trough. After nearly four hours, a leg of mutton was cooked to perfection, and was consumed by the archaeologists.

2. Structures

Houses

A number of experimental reconstructions of prehistoric buildings have been carried out, again mostly in Denmark, although a copy of one of the Lough Gur houses in Ireland was built for the B.B.C.¹ Danish Television has also participated in the rebuilding of an Iron Age house at Roskilde, in this case so that it could be

¹ Johnstone, *op. cit.*

burnt down (plan, fig. 7, left).¹ All of the other Danish reconstructions have been attempted to allow study to be made of the techniques of building and the processes of decay. One of the first tasks of the Historisk-Arkaeologisk Forsøgscenter has been the reconstruction of a number of Neolithic and Iron Age houses, using plans supplied by excavators of prehistoric sites. An earlier rebuilding of a small Neolithic settlement has provided important information about the quantity of material required for even a small dwelling.² One of the houses measured 20 by 15 ft., and was made of wattle and daub with supporting posts. Nine tons of clay were required, as well as a load of hay, over 200 bundles of reeds, 48 posts up to 8 ft. long, 28 rafters 13 ft. long, 100 laths and tie-rods, 2000 hazel and osier twigs for wattle, and stones for the



FIG. 7. (left) Sketch plan of Iron Age house at Skørback. Note wall-posts in foundation trench, double row of roof-posts, opposed doors with paving, hearth at centre of (stippled) clay floor, and stall partitions (upper right). (After Skalk, 1966)
(right) Plan of burnt reconstructed Neolithic house at Allerslev. Note line of wall base and two hearths, single line of roof-posts, and charred wood of walls and roof. (After Hansen, 1961, fig. 11). Plans are not to uniform scale

floor. After the material had been collected, 12 men took 10 days to build this small house; this figure can be compared with a recorded 4 man-days in Upper Canada to cut and erect a log cabin measuring 20 ft. by 12 ft. Although stone axes would probably double this Canadian figure, the log-built houses were certainly a more economical proposition in prehistoric Europe if the wood and equipment were available. The building of a large mortuary house of logs might in the end have allowed a more imposing barrow to be erected with a saving in time.

The Danish wattle and daub house was occupied for a time, and records kept of rising damp and frost damage, and smoke blackening of the walls and roof. The experimenter reckoned that the latter fact was so well marked that even if the house had fallen down, archaeologists might have considered it to have been burnt. In actual fact, the house was accidentally set alight during the kindling of a fire and was thereafter excavated (fig. 7, right); it would be of interest to compare the deposits of destruction from this 'occupied' house with those from houses built and burnt before drying and weathering had occurred.

The Danish T.V. experimental burning of the Iron Age house (Pl. II, 2) was

¹ Nielsen, *op. cit.*

² H.-O. Hansen, 'Ungdommelige Oldtidshuse', *Kuml* (1961), 128.

recorded by marking all timbers with metal plates, and by placing thermocouples on the floor. The house collapsed after twenty minutes, and in thirty-five minutes it was almost totally destroyed except for heavy posts. The temperature at the centre reached 900°C, and was sufficient at the sides to bake some of the mud wall. The site was excavated after two days, and the plan of the collapsed timbers could be compared to that of the prehistoric house upon the plan of which the reconstruction had been made.

Walls and Banks

In Britain, a number of attempts have been made to reconstruct defences of hill-forts and other sites, mainly to obtain some idea of the time involved in building operations. A small area of the timber and earthen rampart at Bindon Hill, Dorset, was reconstructed,¹ as well as part of the rampart revetment-wall at Stanwick, Yorkshire.²

A more recent experiment in Britain has been the construction of an earthwork at Overton Down in Wiltshire.³ Two main purposes lie behind this attempt, first to record the methods and the time required to build an earthwork comparable in size to that of many prehistoric monuments in the south of England, a bank and a pitch separated by a slight berm, second to observe over a period of years the exact processes of decay and collapse that are at work on this structure. The earthwork was built in 1960, so that the observations are only just beginning, but already some important facts have emerged about the silting of the ditch and the decay of various samples buried in the bank.⁴

During the construction of the bank, and the digging of the ditch, some observations were made of the functional use of primitive digging and collecting implements. Among these, the red-deer antler picks, quite commonly found on prehistoric sites in the south of England, were found to be efficient for loosening the chalk blocks, but shovels made of the scapulae of horses were not at all successful, even as scraping tools; wicker baskets were employed for transporting the loads of chalk up to the bank.

These British experiments have prompted some estimates of the time involved in the erection of monuments in prehistoric times.⁵ A small ditched barrow of 40 ft. diameter, of a type found over much of southern Britain, would have involved ten people for one week; in north Britain, the comparable cairn would have taken less time if sources of material were close at hand. Such estimates as these are useful as a general guide, but it is not quite so easy to visualise the time allotted to the building of larger monuments. The Pitnacree barrow might have taken ten men fifty days to build on this reckoning, but for monuments of much greater size, such as Avebury and Silbury Hill, such estimates are really quite meaningless.

Another experiment on building structures was carried out in Scotland a number

¹ M. Wheeler, 'An Early Iron Age "beach-head" at Lulworth, Dorset', *Ant. J.*, xxxiii (1953), 13.

² M. Wheeler, *The Stanwick Fortifications* (1954).

³ P. A. Jewell (ed.), *The Experimental Earthwork on Overton Down Wiltshire 1960* (1963).

⁴ P. A. Jewell and G. W. Dimbleby (eds.), 'The Experimental Earthwork on Overton Down, Wiltshire, England: the first four years', *PPS*, xxxii (1966), 313.

⁵ P. Ashbee and I. W. Cornwall, 'An Experiment in Field Archaeology', *Antiquity*, xxxv (1961), 129.

of years ago, involving the erection of a timber-laced wall with a core of rock (fig. 8).¹ The purpose of the experiment was to determine if the burning of such a structure would produce the phenomenon known as vitrification. The vitrified forts of E. Scotland are too well-known to require description here. The experimental wall was 6 ft. wide and 6 ft. high, with horizontal timbers interlaced with stone slabs. After ignition through brushwood fires around the wall face, the wall began to burn and after three hours it collapsed. The core of basalt rubble became red hot, probably

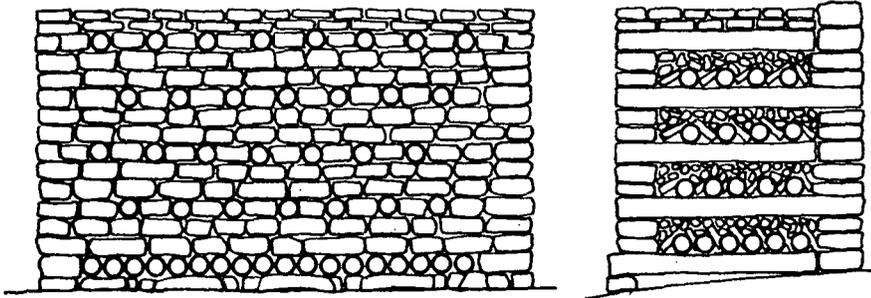


FIG. 8. Timber-laced wall at Plean, Stirlingshire. Note ends of horizontal timbers in elevation (left) and ends and sides of timbers in section (right). Scale $c. \frac{1}{8}$ (After Childe and Thorneycroft, 1937-8, fig. 1)

reaching 800 to 1200°C, and after excavation the bottom part of the rubble was found to be vitrified, with rock droplets and casts of timber preserved. The experiment proved that a timber-laced wall of this character could become vitrified through fire, but the explanation of the reasons for such widespread treatment of these Iron Age forts remains uncertain.

Stone Erections

Another monument that has been the subject of experiment in Britain is Stonehenge. A replica of one of the bluestones, measuring 7 ft. 6 in. by 2 ft. by 1 ft. 6 in. and weighing about 2 tons was easily transported on water and overland.² Three canoes with a crew of four were used to float the stone, and the draught required was only of the order of 9 inches. On land a sledge proved less effective than rollers, and only a dozen men would have been required to pull and push the stone, with another group to move the rollers in turn. No experiments have yet been carried out on the transportation of the bluestones from south-western Wales to Stonehenge.

Even more impressive experiments have been made involving the movement of large stones on Easter Island.³ The statues on this island weigh up to 60 tons, although experiments have been tried only with 12-ton masses. It was found that 180 people could move the stone without much difficulty, and that it could be raised into a vertical position with a small labour force in about two weeks. The problems of difficult terrain and the superposition of up to 10-ton stones on top of the erect

¹ V. G. Childe and W. Thorneycroft, 'The Experimental Production of the Phenomena distinctive of Vitrified Forts', *PSAS*, LXXII (1937-8), 44.

² R. J. C. Atkinson, *Stonehenge* (1956), 95.

³ T. Heyerdahl, *Aku-Aku* (1958).

statues would have placed enormous strains on the strength and ingenuity of the original statue builders. This experiment, although not perhaps as rigorously observed as some others, nevertheless represents an impressive contribution to the whole problem of experimentation with original materials.

Scale-model experiments are generally of less value, particularly when ropes and levers are used, but the experimental work on the erection of stones at Stonehenge with a $\frac{1}{12}$ scale model has been accepted by both engineers and archaeologists.¹ At Old Keig, Aberdeenshire, the pointed asymmetrical bases of a number of the large standing stones have been explained in mathematical terms as aiding the thrust necessary to raise the stone into its erect position, but no attempt seems to have been made to duplicate the proposed method by experiment.²

3. *Artifacts*

Pottery

Among recent experiments has been the firing of pottery vessels under controlled conditions in reconstructed Romano-British kilns, partly to aid the understanding of archaeomagnetic dating, but also to gain knowledge of the techniques.³ A kiln was built on the basis of the Water Newton kilns, 4 ft. in diameter and turf-supported. The pottery was stacked inside, and layers of green grass placed on top of the stack. After firing up to 1000°C, the kiln was cooled for 30 hours. The whole procedure indicated that there were many difficulties to be overcome by the potter. Among these was the difficulty in moving unfired pots, suggesting that the pottery workshops must have been situated near the kilns. Observations on the amount of time and materials required for a kiln load were also made, and suggested that about 2 tons of wood were required for a successful firing. One potter plus an assistant could fill the kiln with unfired pots in about one week. Most of the kilns tested were severely damaged by the actual firing, and would have required substantial repairs before a second load could be fired. Other experimental work on coarse pottery was carried out on ware from Glenshee, Perthshire, but was primarily concerned with analysis of the content rather than with the technique of firing.⁴ Nevertheless, a number of trial firings, in wood fires and in kilns, were carried out and recorded in detail. The conclusions were that the clay of the prehistoric ware was local, and that the pots had been fired in a wood or peat fire at a temperature slightly over 500°C. Comparable work of more recent date has been intimately connected with thin-section examination of pottery.

Bone and Antler

Organic materials have also been tested by experiment. One of these tests was

¹ E. H. Stone, *The Stones of Stonehenge* (1924).

² H. E. Kilbride-Jones, 'Stone Circles: a new theory of the erection of the monoliths', *PSAS*, LXVIII (1933-4), 81.

³ P. Mayes *et al.*, 'The firing of a pottery kiln of a Romano-British type at Boston, Lincs.', *Archaeometry*, IV (1961), 4.

⁴ W. Thorneycroft, 'Observations on hut-circles near the eastern border of Perthshire, north of Blairgowrie', *PSAS*, LXVII (1932-3), 187.

designed to discover the functional efficiency of Mesolithic harpoons made of antler.¹ Reproductions of these perforated harpoon-heads, and unperforated heads of earlier date, were thrown at leather-covered pillows. As a result, it was possible to suggest that the reasons for the appearance of the perforation, and its movement from near the base to near the centre of the harpoon-head, were entirely functional (fig. 9). In

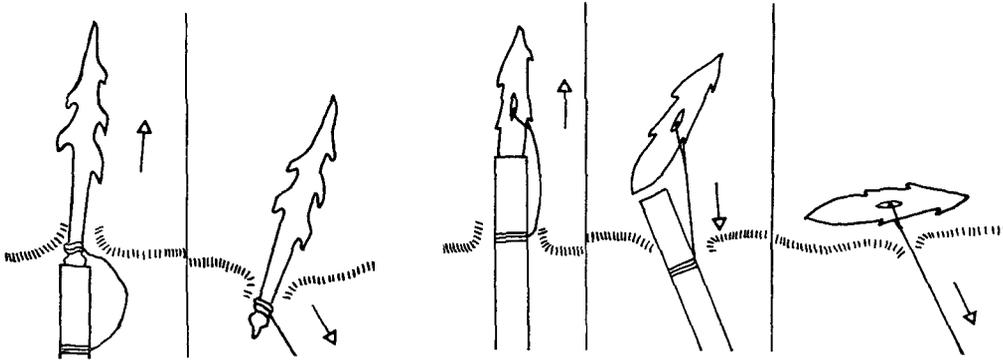


FIG. 9. Harpoons. Hatched line represents animal skin; arrows show direction of thrust and drag. (left) Magdalenian harpoon susceptible to withdrawal when shaft drags. (right) Azilian harpoon with central perforation swings and blocks withdrawal when shaft drags. (After Thompson, 1954)

early post-glacial times the spread and growth of forest vegetation in northern Spain and southern France forced Mesolithic man to adapt his hunting weapon, so that the harpoon-head, once lodged inside the animal's body, would not pull out if the shaft of the harpoon became entangled in the undergrowth. The central perforation of the harpoon-head functioned as a toggle, swivelling the head around against the animal's skin so that it could not pull out.

A more grisly experiment was that carried out many years ago on the trepanning of skulls.² Skulls from which a roundel of bone has been removed are known from many prehistoric cultures, and the experiment was devised to time the operation on an adult and a child's skull. Using a sharp flake of glass, the experimenter scraped a hole in the adult skull in 50 minutes, but the child's skull only took 4 minutes. The conclusion was that only a child could have survived the operation, and that no adult could have managed to remain alive after nearly an hour's work on his head. The theory has been proved wrong by clear evidence of the healing of certain adult trepanned skulls, the record apparently being survival after seven such operations. Nevertheless, the experiment indicated that such individuals must have possessed strong constitutions.

Metal

There have been many experiments made on metalwork of the Bronze and Iron Ages, both in this country and abroad. The recent iron-smelting experiment in

¹ M. W. Thompson, 'Azilian Harpoons', *PPS*, xx (1954), 204.

² Munro, *Prehistoric Problems* (1897), 220.

Denmark,¹ and comparable work in England,² have both indicated that reduction of ore could be done in a relatively simple bowl furnace. Casting and beating of copper and bronze objects such as axes and shields have also been carried out experimentally on a number of occasions. Few of these productions have been put to the test for function.

One element in bronze working has however been subjected to testing on many occasions, and this is the Bronze Age horn; two forms are known, the Scandinavian *lur* and the Irish bronze horn (fig. 10). One Scottish example is known. Musical

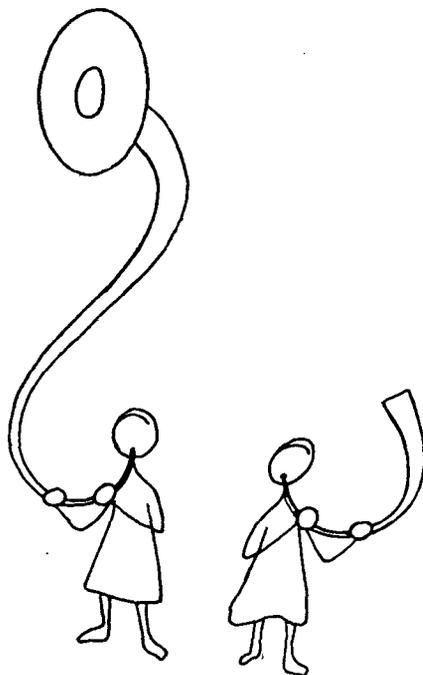


FIG. 10. Scandinavian *lur* (after Skalk, 1961) and Irish horn.

experiments with *lurer* have been made on several occasions, and the range of accessible notes has been shown to be quite long³; we can make intelligent guesses about which of these notes would have been available to Bronze Age musicians, but we cannot know which were in fact used. The smaller Irish end-blow horns present a different problem, in that they are only on rare occasions found with their mouthpieces. To be certain of the notes played by prehistoric man, it was necessary in the musical experiments to play these instruments without mouthpieces, as any improvisations might have falsified the evidence.⁴ The range of these instruments is re-

¹ Voss, *op. cit.*

² E. J. Wynne and R. F. Tylecote, 'An experimental investigation into primitive iron-smelting technique', *J. Iron and Steel Inst.*, 190 (1958), 339.

³ H. C. Broholm *et al.*, *The Lures of the Bronze Age* (1949).

⁴ J. M. Coles, 'Irish Bronze Age Horns and their relations with northern Europe', *PPS*, xxix (1963), 337.

stricted to only three or four notes, possibly five or six with proper mouthpieces.

Another group of Irish horns consists of side-blow horns, where the narrow end is closed; the form is comparable to that of the instruments of ivory and animal horn of parts of Africa, and must have been based upon the same idea, perforation of the horns of cattle, leaving the solid tip intact. Translated into bronze, the Irish side-blow horn is basically a one-note instrument, blown only with great difficulty because of the absence of any form of built-up mouthpiece. In the nineteenth century in Ireland attempts to blow these instruments proved to be both unsuccessful and, in one instance, fatal; Dr Robert Ball of Dublin apparently burst a blood vessel and died while trying to wrest a note from one of these side-blow horns.

Hide and Leather

Few experiments on hide and leather have been made, although ancient methods of preparing and tanning hides appear to be well understood. Analysis of surviving materials has also contributed to this. A recent experiment on leather-working involved the production of a shield comparable in appearance to a surviving Irish specimen.¹ The shield presented special problems, because it had to be ribbed and then hardened and made waterproof. After a cold soak to soften the leather, it was scrubbed to remove any excess tannin, then beaten into a wooden mould (Pl. I). The drying process took three days, with regular hammering to prevent shrinkage. After this the shield was functional, but would soften under damp conditions. In Ireland, and Scotland, it would without doubt be necessary to make some precaution against the damp, so that the shield would not collapse. Various methods of hardening and waterproofing were attempted, and the most practical were the use of boiling water either poured on to the shield or employed as a dip, and immersion of the shield in hot wax (beeswax could be used) for approximately 30 seconds, to allow penetration of the wax through the leather. Both methods were successful in producing stiffened shields capable of withstanding prolonged damp conditions, particularly the wax-impregnation method.

The experiment continued with the production of a metal shield of comparable thinness and hardness to the Late Bronze Age shields from Achmaleddie, Aberdeenshire, and Yetholm, Roxburghshire. This and one of the leather shields were selected for the final experiment to test their capabilities in standing up to blows and thrusts of sword and spear (Pl. II, 1).² The metal shield was cut and slashed to pieces by the first blows. The leather shield withstood repeated heavy blows of a copy of a Bronze Age sword specially sharpened for the occasion. The conclusion was that the metal shields were not suitable for actual physical conflict, but the leather shields could have served a useful function in battle.

It is the aim of archaeology to obtain more information and new sources of information to add to the foundations of knowledge upon which our culture is based. Experimental archaeology, when employed scientifically and with an awareness of

¹ J. M. Coles, 'European Bronze Age Shields', *PPS*, xxviii (1962), 175.

² J. M. Coles, 'Archaeology by Experiment', *Ill. Lond. News*, 2 March 1963, 299.

its limitations, can add materially to our sources of knowledge about the past, and may be considered as an important way in which archaeology can come to grips with the mental processes, plans and activities of prehistoric man.

ACKNOWLEDGMENT

I am grateful to Mr H.-O. Hansen, Director of the Historisk-Arkaeologisk Forsøgscenter, Lejre, Denmark, for comments on this paper.



Experimental production of leather shield in wooden mould

(top) Beating leather into mould with wooden punches.

(bottom) Shield ribbing and boss completed

Photos: L. P. Morley, University Museum of Archaeology and Ethnology, Cambridge



1. Experimental testing of shields of leather (left) and metal with bronze and iron swords. Note damage already done to metal shield by first sword slashes and thrusts

Photo by Ralph Crane. *Life* © 1963 *Time* Inc.



2. Destruction by fire of reconstructed Iron Age house at Roskilde
Photo reprinted from *Skalk*, 1966