THE DONNERUPLAND ARD

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Summary

This paper presents the results of a current research programme designed to examine by replication the construction, function and wear patterns of the Donnerupland ard. The research programme is being carried out by the author at the Butser Ancient Farm Project Trust near Portsmouth in Hampshire, England. The original ard is described in detail from the evidence recorded by P.V.Glob with further observations of the critical elements of wedges and the bracing of the foreshare against the stilt. The manufacture of the replica focuses attention upon the most vulnerable parts of the ard and indicates the probable age of the timbers necessary for its construction. The roles of the various component parts of the ard are detailed and the hypothesis that ards of this type are capable of producing the so-called ard marks is questioned in the light of empirical testing. The further postulated practice of tilting such ards to increase their potential in furrow depth and soil inversion is examined and rejected.

Introduction.

Any timberwork which survives from the prehistoric period is vitally important in fundamentally extending our knowledge and understanding. There can be little doubt but that wood formed the prime resource for the manufacture of houses, fences, implements, tools, boats, carts, sledges – the list is unending. In effect, wood was so commonly used that there is every reason to believe that silviculture represented a major industry and that craftsmen in wood formed an integral component in a complex society. Certainly such a condition existed by the Iron Age and Roman periods. Nor is a reliance on wood exclusive to the remote past. It was not until some time after the Industrial Revolution that metal became comparatively abundant and not until the advent of plastics that wood was largely replaced as a modern resource. The surviving fragments of metalwork which formed the fittings for vehicles, the blades for tools, rims for wheels give tantalisingly small insights into this major industry. It is not without point to put into context that most abundant and frequent of artefacts, the pottery sherd, which has so concentrated the minds of archaeologists in the general absence of other materials. Although its role within a society is fundamental it can hardly be described as diagnostic of an economy or representative of an industry outside its own production. It is, beyond a minor decorative role, a utilitarian product. In contrast a tool of almost any kind is indicative of not only its own potential but also of its product and the inevitable relationship of that product with other tools and other products.

Thus it is that wooden ploughs or ards, primarily those recovered from the Danish peat bogs, have attracted so much attention and, apart from the boats of all sizes and types, are perhaps the most celebrated wooden objects in North-West Europe. The fascination lies not only in the implement itself but also in the economy it represents. The basic economy of the prehistoric period was agriculture. That this economy, certainly by the late Iron Age, was extremely successful is beyond reasonable doubt with references by Caesar (De Bello Gallico Bk. IV) to an export trade including cereals and leather. The implication is of surplus production, presently being supported by the recovery of evidence of more and more intensive occupation on all soil types, more extensive field systems, reassertion of hill towns rather than forts in Southern England at least and complex storage systems which can best be described as warehousing facilities. Consequently to have evidence, and remarkably good evidence of the tool or implement which plays a significant role in the production of that surplus raises the practical questions of how does it work and how efficient is it. These questions have inspired a number of archaeologists to attempt to discover answers within the restrictive parameters of the subject. In fact, it is the asking of this type of question concerning the specific economy of the Iron Age which caused the creation of the Butser Ancient Farm Project Trust in 1972. This project, a unique open air research laboratory, is devoted primarily to carrying out empirical trials seeking to provide the boundaries of probability of the overall economy (Reynolds 1979).

The most recent comprehensive survey of the prehistoric ards is that written by P.V.Glob (1951) which complements the important publication of P.Leser (1931). Irregularly new finds of potential ard parts are reported like that of the Abingdon share (Fowler 1978). The other major finds of ard parts outside the Scandinavia are from Scotland, the ard beam from Loch Maban (Fenton 1968) and the ard share from Milton Loch (Piggott 1952-53).

The most notable trials carried out to date are those of Aberg & Bowen (1960) in England and Hansen in Denmark. The former selected the Donnerupland ard, the latter the Hendrikemose ard. The major difficulty encountered by both research enterprises was the lack of trained cattle. Hansen's experiments were the most extensive and complex, and included questions about the effects of the ard upon the subsoil surface vis â vis the so-called ard marks now regularly recovered in archaeological excavations and the effects of soil attrition upon the ard itself. The basic problem, also experienced by the author in earlier experiments (Reynolds 1967), which afflicted both these sets of trials was the lack of regular replication and, most of all, acquired skill in execution and recording.

It is from these earlier trials that a complex research programme has been developed at the Butser Ancient Farm. The overall purpose is to examine the whole range of ard types for which there is adequate evidence. The objectives are to assess their construction, efficiency, effect upon soil and subsoil and the wear patterns upon the ards created during their use. The methodology of the programme is to select the best surviving example of a type, replicate it as accurately as possible and to restore where necessary including increasing in size but retaining approximate shape of heavily worn elements. Thereafter it is to test it in a real and full agricultural cycle measuring and recording carefully all the required data. Finally, given its successful use as an implement, to correlate the wear patterns of the replica with those of the original and thus not only to confirm or deny the manner of its use in the experimental milieu but also approach conclusions concerning its life expectancy as an agricultural implement. Already a great deal of fascinating material evidence has emerged from this programme, the most notable being the normal operational depth of the ards, their basic design determining their optimum efficiency, and the probability that the range of design, principally through two types, is not necessarily diagnostic of sequential development through time but rather of different functional roles (Reynolds 1981). Similarly the programme has focused attention upon an ard type, as yet missing from the artefactual record but arguably present in the iconography.

This paper is an interim statement of but one ard type, the beam ard and specifically the Donnerupland ard, within the overall research programme. It presents the distillation of the results of some ten years of experience, practical work and thought. The Donnerupland ard has always attracted the greatest interest in so far as of all the ards recovered to date it is the most complete and probably the best preserved. It is this particular ard which has received the focus of attention in empirical trials particularly in Britain in all probability because the Loch Maben ard beam, the prime British survival, is clearly comparable. There is no doubt whatsoever that of all the ards, the Donnerupland is the one most commonly selected to illustrate the beam ard type and indeed the basic 'light plough' of the Iron Age. Despite the only trials to date being those of Bowen and Aberg and the author, its potential and limitations are remarkably well postulated and an intimate if unsubstantiated knowledge of it is entrenched in the literature. Within the overall research programme devoted to cultivation at the Ancient Farm it is but one of a range under examination. Others include the crook ards represented specifically by the Hvovslev ard (Plate 1) and the Dabergotz ard, the beam ards by both the Donnerupland and the Dostrup ards, the hypothesised rip ards (see below) like the Aspeberg ard (for the foregoing types and examples see Glob 1951), and the stone ard tips from the Orkney and Shetland islands (Fenton 1976), particularly those from Somborough (pers. comm.. R.G. Lamb).

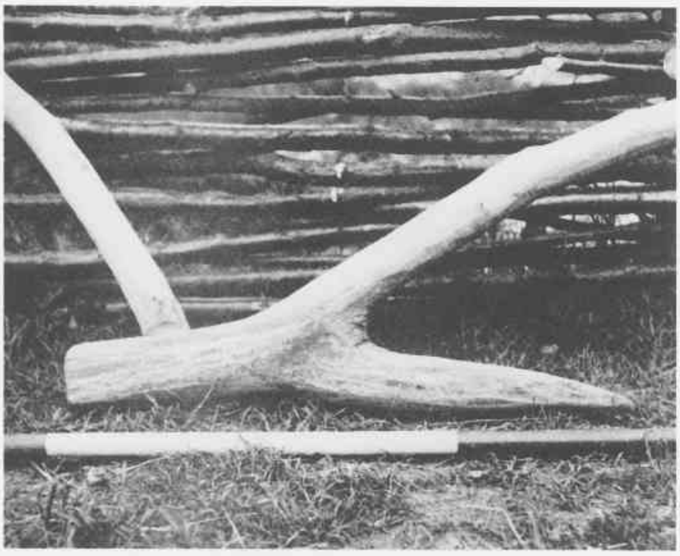

Plate 1. Replica of the Hvovslev Ard.

The Donnerupland Ard – the archaeological evidence.

The Donnerupland ard was discovered in 1944 in a little upland saucer-bog in Denmark. It comprises four main parts, the beam, the foreshare, the arrow shaped main or undershare and the stilt or handle. The beam is of birch (*Betula sp.*) and the remaining parts are of oak (*Quercus sp.*). The beam is roughly finished probably with an adze so that it is generally rectangular in section with rounded edges. The undershare and stilt are, in contrast, finely finished with hardly any traces remaining of the preliminary shaping. The beam has a small square horizontal hole *c.* 3 cm x 3 cm cut into it some 8 cm from the fore-end and in the foot, which is damaged, is a rectangular hole *c.* 5 cm x 17 cm maximum through which the shares and stilt pass (Figure 1).

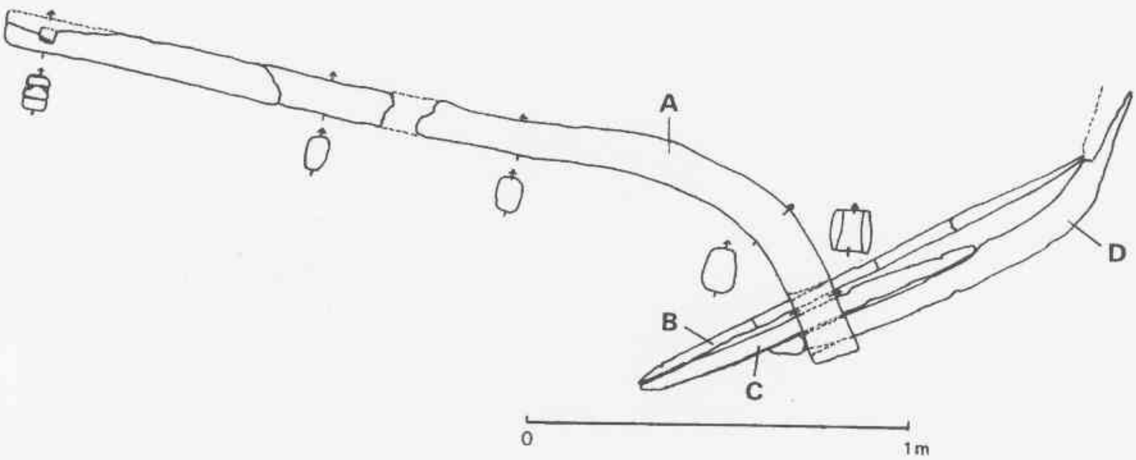

Figure1. The Donnerupland Ard. (After Glob).
A=beam; B=foreshare; C=undershare; D=stilt.

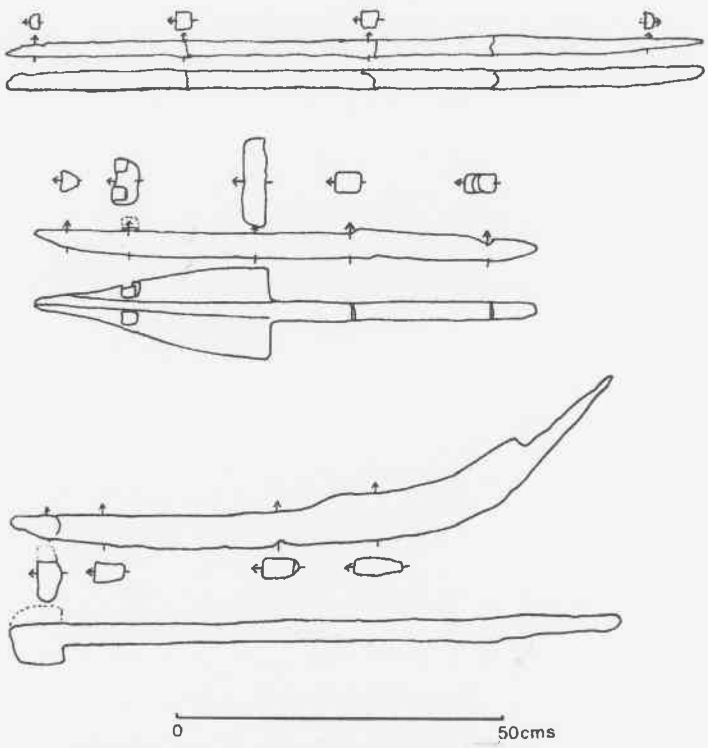

Figure 2. The foreshare, main or under share and stilt. (After Glob.)

The foreshare, arrow shaped undershare and stilt are represented in Figure 2. The foreshare shows clear signs of wear at each end indicating that both ends have been used as the share point. The undershare has on its upper side two four sided chiselled holes cut into it. Part of one original wooden peg survives in one indicating that their function was to hold the foreshare firmly in place along the line of traction. At the rear end on the upper side of the undershare is a notch which corresponds with a further notch on the underside of the stilt indicating a tie or lashing point to hold these elements tightly together. The stilt is broken at the rear where in all probability there was a provision for a smaller handle at right angles to the stilt. Estimations of the original shape of the stilt can be gained from rock carvings. The fore-end of the stilt has a spatulate terminal, subsequently described as the stilt head, half of which has split away.

The disparate wear on the undershare, the right side being worn to the extent that the wooden guide peg would hardly have been functional, is suggested by Glob to be the result of tilting the ard during ploughing allowing the undershare to act as a kind of mouldboard turning the greater part of the soil to the one side. This hypothesis is discussed below.

All the indications, the considerable wear on the undershare, the doubtful strength of the guide peg on the right side, the broken stilt head and handle, the damaged foot of the main beam suggest that the ard had fulfilled its useful life and had been disposed of, whether ritually or otherwise is of little account.

The basic dimensions used in the replication have been derived from the scale drawings by Glob and personal examination by the author of the original in the National Museum in Copenhagen. In analysing the extant evidence in order to replicate the ard the most critical element has been found to be the hole cut into the foot of the main beam. The crook ard being of unitary manufacture is totally inflexible and entirely dependent upon selection of natural timbers in order to achieve an

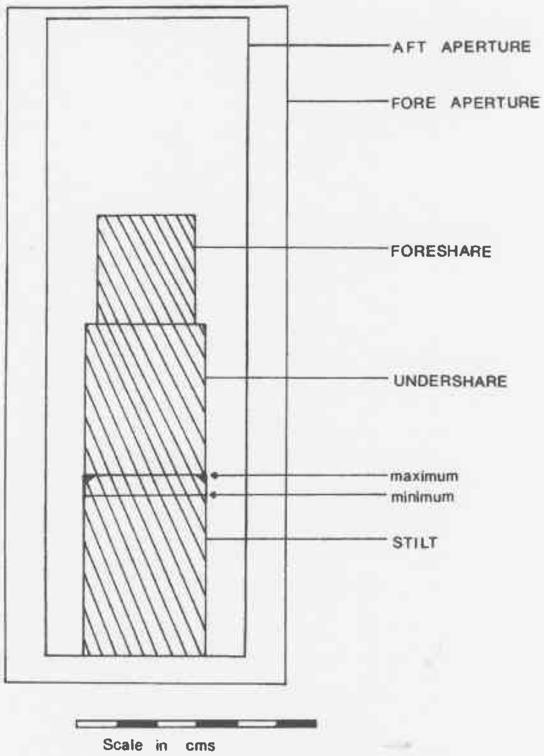

Figure 3. Schematised section of the hole set in the foot of the beam with shaded section of foreshare, undershare and stilt.

angle which will allow penetration of the soil by the foreshare attachment to the yoke, the point of traction. This last allows a minimum amount of flexibility, perhaps as much as 20 cm in the vertical plane. On the other hand, the Donnerupland ard not only has the above flexibility at the point of traction but also a great deal of flexibility at the foot. The hole chiselled out of the beam and the relative sizes of the component elements of the ard which pass through it are shown in diagrammatic form in Figure 3. It is quite clear that the disparity in size between the fore to the aft aperture is quite deliberate with distinct lowering or sloping of the hole from aft to fore. Secondly the component parts do not fill the hole and cannot of themselves be at all stable without wedges of some kind. None were discovered with the ard but it is an obvious missing element. In fact, empirical trials have demonstrated beyond doubt that at least two wedges are required. The space available, which needs to be locked with wedges, has a minimum depth of *c.* 5 cm in aft aperture and *ca* 11 cm in the fore aperture. Necessarily the wedges cannot be juxtaposed because they cannot exert pressure on each other. Consequently the obvious system to yield the maximum range of angle for the component elements against the beam is for one wedge to be driven into the base of the hole from the rear and the other into the top of the hole from the front. Instability results if any wedge is introduced between the elements of foreshare, undershare and stilt (see below)

Construction of the Replica

The major difficulty experienced in the whole construction process was the actual acquisition of timbers of the right variety and basic shape. The curvature of the main beam is such that although it appears at first sight to be common, in reality it is rather unusual. Birch (*Betula sp.*) is a tree which proliferates easily on acid sandy heathland, typical of most of Denmark but it normally grows quickly and straight. The ard beam has to come from a mature timber rather than a sapling and the original beam clearly utilised the natural strength of the grain as the tree grew into that basic shape. To achieve the same end product the tree itself almost necessarily came from the edge of a woodland

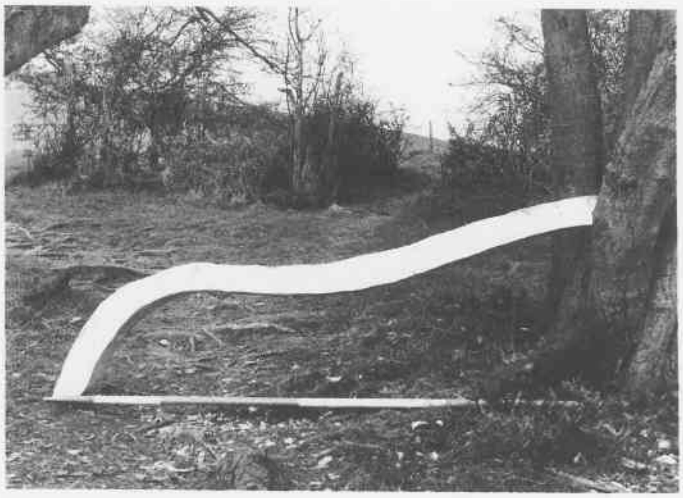

Plate 2. The main beam under construction

exposed to the prevailing wind or alternatively in an isolated position where the constant pressure caused it to bend away. The beam finally selected was 40+ years old (Plate 2).

The stilt or handle caused almost as much difficulty because the greatest width in the original, some 10 cm, suggested either the main stem or a branch of a maturing tree of some 30-35 years old. Similarly the undershare was made from an oak main stem of over 40 years old. The foreshare was the least difficult being split out of the heart wood of the same trunk which provided the undershare. The foreshare and undershare only were made from oak air seasoned over a period of three years. Both beam and stilt were made from freshly felled timber.

The construction process followed as faithfully as possible the evidence of the original. The tools used were an adze, an axe, one chisel and a mallet. These were, of course, modern tools and since the exercise involved neither time study nor observation of wear upon the tools themselves, it is of little consequence. Lack of basic skill was in part compensated for by painstaking accuracy. It seems to this writer that many experiments which seek to record the time taken to achieve a product when the operative is often unskilled and inexperienced, and then to utilise those time parameters as an indication of the time taken in the remote past not only distort the value of experimentation but deny the presence of skill and experience at that time. There is little doubt even from the scanty evidence which we have that a full range of highly skilled craftsmen plied their trade certainly in the Iron Age. It is further beyond doubt that such individuals, for example, wheelwrights, wainwrights, smiths both of black and precious metals, represented an industrial service element in a complex and successful society.

In the manufacture of the main beam of the ard, great care was taken to utilise the heart wood and to employ the line of the grain to preserve the greatest strength potential. Apart from the chiselled hole at the foot of the beam and at the yoke end, the only tool employed in its construction was the adze. The original beam was copied as exactly as possible. The most critical process in the whole construction was the chiselling out of the hole in the foot of the beam. It was tackled from both sides to avoid splitting along the grain. The original would appear to have been created in this way since it is almost impossible to avoid the slight narrowing in the side walls in the central part of the hole. (Figure 1).

The construction of the undershare utilised all the tools: the adze for crude shaping, the axe for the rough finish and initial creation of the shoulders and the chisel for the final shaping and smoothing and cutting the foreshare guide peg recesses. The pegs were carefully cut to be slightly oversize and then hammered into place on the clear understanding that any increase of moisture content in the wood would cause increased binding

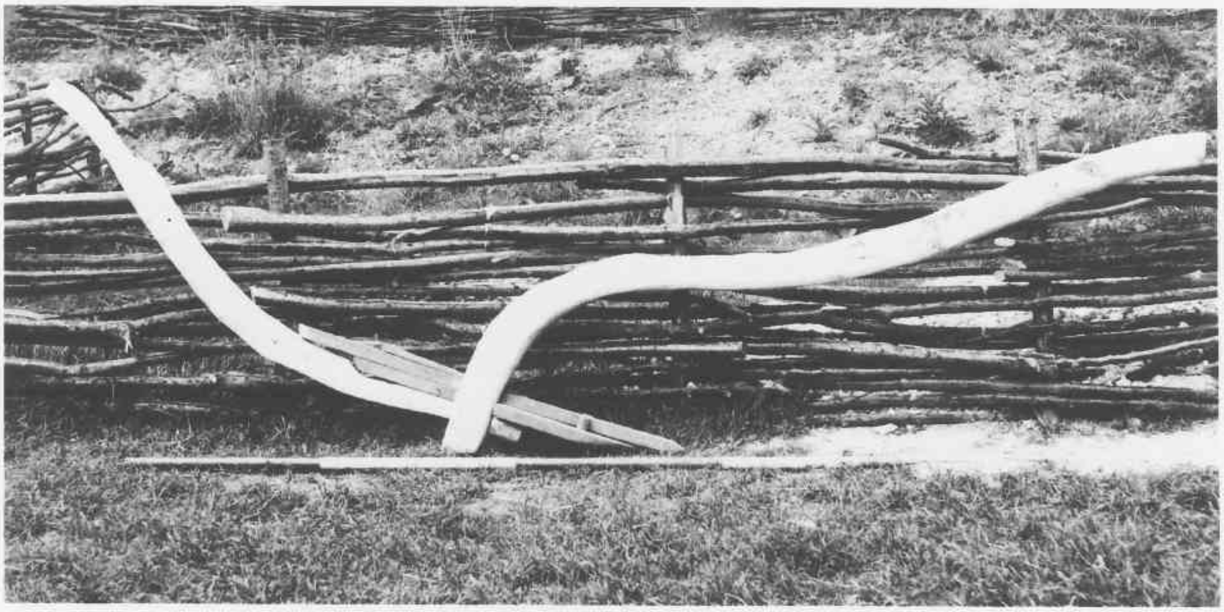

Plate 3. The completed replica of the Donnerupland Ard

The stilt proved the most difficult of all the elements. The first, two similar blanks were carefully and with forethought obtained, was almost complete when the head split not just on the one side as in the original but on both sides. The problem lay in the widest part of the handle in one plane, and the width of the stilt head in the plane at 90° to it. Effectively the branch required had to be taken from a maturing tree as stated above and then the majority of it adzed away. The whole of the handle apart from the head itself has to pass through the foot of the main beam which consequently dictates its maximum dimensions. Ironically the second stilt had a knot at virtually the same position as the break on the original. The third trial saw this handle break in an identical manner, so much so that it could be most interesting to examine the grain of the original next to the break. Since the handle exerts enormous pressure on the rest of the implement in keeping it in the vertical plane and the foreshare biting into the soil, it should ideally be made entirely from heart wood and to be free of knots and other imperfections. The third version fulfils these criteria and to date has lasted over two seasons.

Plate 4. Detail of the foreshare and main or under share and fore wedge.

Oak wedges of various sizes were made from waste pieces during the construction to allow for maximum flexibility at assembly. The early trials of 1964-65 (Reynolds 1967) had shown that the three elements had to lie tightly together in that any attempt to wedge between foreshare and undershare and undershare and stilt caused instability and weakness. In addition, despite the obvious weakness, trials were carried out with wedges set between the foreshare and undershare which led to a gap between them and a consequent trap for earth and stones. The resultant steadily increasing pressure caused the upper wedge to be forced forward and out. On one occasion the foreshare actually broke at its junction with the main beam having been lifted out of its seat between the guide pegs in the undershare. Some idea of the forces at play can be appreciated since the foreshare is *c.* 2.7 cm x 2.5 cm in section of seasoned oak at this point. Similarly a wedge between undershare and stilt was slightly more stable but because the stilt head protrudes only a short distance to the fore of the beam, longitudinal stability was disrupted, the point of the notches for lashing referred to above being denied, and the wedge itself regularly worked loose. As argued above, the only places for the wedges not only to give maximum stability and strength but also greatest choice of angle for the foreshare to engage the soil were above the component elements to the fore of the beam and below to the rear. These findings were repeated with every new replica of the Donnerupland ard. The replica here reported upon is, in fact, the fourth in this present series. The completed replica can be seen in Plate 3 and a detail of the shares and fore wedges in Plate 4. It will be noted that the undershare is not an exact copy of the original in that the shape is broadly similar but increased slightly in size to monitor and to test for differential wear.

Traction.

In any simulation study which involves movement the variables increase almost exponentially. Various methods of traction have been utilised in the early trials with replicas of the Donnerupland ard. These have ranged from the forwards from a rugby team to the winch gear on the front of a landrover. While it is much easier to calculate speeds and pressures with a purely mechanical traction unit the simulation of cattle pulling was rather remote. Similarly it is extremely difficult to create the correct angle of pull without a range of support tripods and hawser wire. Consequently the early trials tended to use human traction. With the creation of the Butser Ancient Farm in 1972 (Reynolds 1979) the ideal conditions for this type of study were created. In the very early stages of the farm's development a pair of long-legged Dexter cattle were purchased. They were selected as being the nearest equivalent to the Celtic shorthorn (*Bos taurus*), bones of which are regularly recovered from Iron Age sites. In practical terms these Dexters have the same shoulder height and body weight and presumably, therefore, the power ratio as their prehistoric ancestors (Plate 5). The training of a pair

Plate 5. The Dexter Cattle

of cattle proved to be a long term undertaking although reports exist of full training being given within the space of a few months. In fact, it took some two years before the pair of cows were thoroughly under control and able to work together successfully. Their work capacity is quite considerable and certainly in excess of eight manpower! Again this is an area of study which is currently in process at the farm. It is planned to reconstruct a further replica of the Donnerupland ard fitted throughout with electronic sensors which will feed back to a microprocessor all the data concerning the strength of pull, the interaction of the elements of the ard and the rate of soil flow past the implement. These data should allow greater insight into this complex area and ultimately should provide a full picture of the tensions and pressures involved and give a swifter understanding of the rate and nature of wear upon the ard.

While the animals themselves present possibly the greatest variable within the trials their yoking together presents just two options, a yoke across the necks and one tied across the horns. There is a slight difference in angle of pull dependent upon which system is selected but not sufficient to be practically significant. Both have been tried and the latter, the horn yoke, is preferred. Unfortunately the iconographic evidence is not at all clear although the majority of examples seem to indicate the use of a horn yoke. It has distinct practical advantages in that it holds the animals' heads firmly apart. In any pairing of animals there is a dominant beast, and when neck yoked, occasionally there are problems with one seeking to exert dominance over the other. In addition the horn yoke equates the pull of the two beasts more effectively. These are the findings at the farm although in north west Spain both systems of yoking are to be found even on adjacent farms and the subject has adherents, some of whom are quite vehement in their support, for both systems.

The average speed of traction of these Dexters compares favourably with the Spanish cattle used for the same purpose and ironically still pulling a version of a Roman sole ard, at some 4 kilometres per hour. They are capable of working for five hours without a significant break although the normal work pattern at the farm is measured by area rather than time. It is quite normal to cross plough a Celtic type field of approximately a fifth of an hectare within three hours given the right conditions for work. It is perhaps as well to underline the fact that a large range of agricultural processes are dependent upon the weather and the conditions of the ground. While this combination of conditions gives rise to the traditional gloomy and jaundiced view of the farmer, it is often beyond the experience and comprehension of the majority of people of an urbanised and industrial economy. Nonetheless it is the experience of the author that in every agricultural season there is a moment when all conditions are favourable for ploughing. This is the occasion when the ground is not too wet, not too dry, not too soft or not too hard. This applies to all soil types including the heavy clay and marl soils which are so fertile and rewarding. The real skill or gamble of farming is first to recognise the moment and second to capitalise upon it.

One final comment needs to be made concerning the cattle. Inevitably one pair is different to another in detail and it would be quite wrong to suggest otherwise. Although, therefore, the results are to a certain extent dependent upon the traction element and consequently are affected by it, the purpose of simulation of prehistoric practice is better fulfilled by using cattle than any other system. Their interaction with the implement is more sympathetic and observations of that interaction are of more value in that the trace evidence was created by animal power. A case can be made for mechanical traction especially with regard to wear patterns upon the implement hypothesised as being caused by a specific system of usage.

The component parts and their functional role.

The foreshare.

As described above, the foreshare, a straightforward length of oak with an average section of 2.6 cm^2, had evidence of wear at both ends. There has been considerable discussion as to whether the share was actually fitted into a notch cut into the stilt (Steensberg 1960). Detailed examination by the author of the actual ard in Copenhagen National Museum brought to light no clear indication of such a notch despite the break in the stilt occurring at a seeming critical point. In fact, although the ard when discovered had the foreshare in this position (Figure 1), the other end of the foreshare did not protrude beyond the point of the main or undershare and thus denied it a clear functional role. Nor indeed were any wedges recovered, the obvious need for which is discussed above. One possible explanation for the foreshare to be in this position on discovery is that by locking it into the broken stilt it exerts sufficient pressure through the hole in the foot of the beam and against the undershare to prevent the parts falling out of the main beam. With the insertion of a wedge into the hole in the foot of the main beam to lock together the elements of the ard, the stilt, the undershare and the foreshare, the angle of the foreshare is lowered quite significantly. Empirical trials carried out by the author in 1964 and 1965 with a crude replica of the Donnerupland ard beam but precise simulation of the oaken elements recorded that a foreshare of seasoned oak was literally worn away on average by some 2.5 cm per half hectare of working on the light stony soil overlying the oolite capping of the Jurassic limestone in the Cotswolds. During ploughing it became necessary to adjust the main share usually twice a day. Any need for it to be locked into the stilt was found to be unnecessary and, indeed, undesirable since such a requirement would have needed actual replacement rather than adjustment. Clearly such wear would have been been obviated by sheathing the tip of the foreshare with metal but there were no indications of such a technique on the original and the fact that it was worn at both ends suggests that it was not contemplated. One further interesting point which has emerged from several years of trials has been the need to sharpen the foreshare occasionally. The wear effectively blunts it and thus reduces its penetration qualities. In practical terms the foreshare has a minimum length of 70 cm. This allows it to be locked in place by the wedge within the hole and to protrude the critical distance beyond the undershare. Its maximum length of *ca* 1.40 m is dictated by the curve of the stilt.

The role of the foreshare is critical to the successful operation of the ard. It is, in effect, the mode of entry into the soil for the ard hence the reasons for its regular sharpening and the method by which it is held in the soil. The ard itself is designed to operate in the horizontal plane, the foot being just below the soil surface and to a maximum of 15 cm. The disturbance of the soil is achieved by the undercutting and lifting of the soil by the undershare and the furrow is created by the flow of the soil on either side of the foot of the main beam. Once the foreshare becomes disengaged from the soil the ard ineffectively skips along the surface. On the other hand, since the ard as a unit is locked and wedged together it is virtually impossible for it to dig into the soil. If this were to occur the ard would pivot on the foreshare, raising the stilt at the rear and, more critically, forcing the end of the beam at the tie point to the yoke downwards and instantly stopping any further forward motion. Throughout the trials this condition has never obtained. The greatest difficulty has, in fact, been to arrange the foreshare at precisely the right angle of some 29-30° to maintain the foot of the ard within the soil.

The undershare or main share.

The role of the under or main share is to undercut and lift the soil. Various attempts have been made to use the ard without the presence of the foreshare. All such have failed because of the extreme difficulty encountered in penetrating the soil surface and holding the share within the soil. Even when the share is carefully set at a suitable depth before traction is exerted, within two or three metres and usually less, it is pulled out of the soil. In normal usage the foreshare causes the ard to dig into the surface, thereafter the undershare causes it to stabilise within the soil very much after the pattern of a plane landing. Once at its operational depth it is extremely easy to maintain balancing the angle and pressure upon the stilt against the drag of the foreshare in the soil.

The original undershare showed clear signs of differential wear. The right hand side was worn away to the extent of reaching the hole which supported the foreshare guide pin. Indeed it is doubtful whether this undershare would have been usable and it is most likely a contributing factor for its abandonment. The guide pins are absolutely critical in that they hold the foreshare in place in the line of traction. The length of the hole in the foot of the beam is itself insufficient to hold the foreshare firmly in place and in line. The differential wear pattern, however, has posed a major question which to date the trials have failed to answer. One theory regularly proposed for this type of ard, inspired to a certain extent by the original wear evidence, is that the ard was used tilted at an angle so that the undershare could partially fulfil the role of a mouldboard (Steensberg 1957-58). Fragments of wood bearing differential wear have been tentatively identified as parts of Donnerupland ard type on this very basis. There are, however, significant problems to be overcome if this theory is to be substantiated in any way. The greatest problem is the nature of the ard itself. It is a solid entity given the necessary addition of wedges. To tilt it to one side or the other from the vertical has two distinct and immediate effects. The first is caused by the foreshare which is now set at a divergent angle from the line of traction. It no longer maintains the undershare and the foot of the ard within the soil since its plane has been radically altered and, more importantly, it causes the ard to veer away in the opposite direction to the tilted angle. The second difficulty is caused by moving the beam off its vertical alignment. If the ard is tilted at a 45° angle, sufficient to invert the soil a little although a steeper angle is preferable, the curve of the beam would physically touch the traction animal on that side. Such a problem could be obviated by increasing the length of the yoke thus setting the animals further apart. In practice this causes difficulties in control but is not insurmountable. Another factor which militates against tilting the ard is the nature of the stilt. In the vertical plane it is extremely strong but away from vertical it becomes vulnerable to breaking at the notch where the undershare is lashed to it.

Given the complexity of the construction of this ard, it seems rather odd to imply that it should be tilted to improve its operation. There is little doubt that if the implement was required to throw the soil to one side and in the process invert the soil, it could easily have been designed to do precisely that. It would need the foreshare to be independent and in advancement of the undershare to avoid the condition described above. Further its operation would be enhanced by the provision of a coulter in advance of the foreshare. In other words the hypothesis proposed for tilting the ard is not simply based upon the wear pattern but is influenced by later ploughs and the assumed need to invert the soil and to bury unwanted weeds and brush on the soil surface. That this last is desirable is undeniable but in a labour intensive process it is not unlikely that the preparation of a seed bed was not simply achieved by the ard alone. Considerably more work is required to complete the preparation of the tilth for seeding, and hand weeding, especially of such persistent weeds like couch grass (*Agropyron repens*), would be of advantage. It is most likely that the soil of arable fields both of prehistoric and historic time prior to the advent of agrochemicals had an average organic content of some 18% in contrast to modern plough soil of approximately 2-3%. In fact, the ard itself is too efficient an implement to be regarded as the last phase of the cultivation process (see below under furrows).

One hypothesis, as yet unproven by any of the trials, which apart from those referred to above, have been carried out on the lighter chalk downland soils, could offer an explanation for differential wear on the undershare. The reason for drawing attention to the soil type is simply a direct reference to the common sandy soils of Denmark. The attrition of sand upon wood is considerably greater and wear would become apparent far more quickly there than on the soil type of the trials to date. It is a major variable within the context of this study and one which is occasionally overlooked. The hypothesis involves the manner of ploughing. Given the two basic systems of ploughing, in parallel ridges and round and round for the mould board plough (Bowen 1961) where the plough always turns the soil to one and the same side, if one were to adopt a similar procedure for the Donnerupland ard where one side of the implement was always offered to the 'undisturbed soil' or 'land side' while the other consistently traversed the loosened soil from the previous furrow, differential wear would be likely. On a sandy subsoil where compaction occurs more readily than on the puffy friable redzinas of the chalklands the effect would be more pronounced. As stated above this has not yet been indicated as an effect during the trials to date but it is intended to examine this variable in the future. One further observation that can be made at this point is that one would expect the wear on the undershare, were the ard to be tilted, to be further back on the broader cheek where there is greater friction rather than as it is on the forward section near the point. Given verticality in its forward motion and the above conjecture, the wear is precisely as would be expected.

Plate 6. The long or extended draw.

The stilt or handle.

The upper part of the stilt or handle is unfortunately broken on the original and to date a complete version has not been discovered. One can, however, postulate the nature of it from the rock carvings of ploughing scenes from Scandinavia (Glob 1951) and the Val Camonica in Italy (Anati 1965). It seems from this evidence that the handle curved almost to the vertical and was fitted with a further small handle. The objective which emerges from the trials and thereafter in the rock carvings is to provide sufficient leverage to control the whole implement. The part of the stilt head which prevents it from pulling through the hole in the foot of the beam is half broken away on the original. This is the direct result of the run of the grain and the extreme thinness of the stilt itself (see above under construction). This particular element is very much protected by the undershare and wear is minimal beyond regular smoothing. The loss of half of the stilt head is not too critical provided the wedges are firmly in place.

The ard in use.

The principal objective in the ploughing trials at the Butser Ancient Farm has been to determine whether the Donnerupland type of ard is capable of simulating the prehistoric scores in the subsoil so regularly attributed to it. The secondary objectives include the efficiency of the ard in stirring the soil and effect of soil movement over the ard in terms of wear patterns. With regard to wear patterns, there has been insufficient time to date to assess critically the wear patterns on any individual parts of the ard beyond the earlier trials referred to above concerning the foreshare. The major problem of such a trial is exactly the same as that which afflicts all the agricultural experimentation at the Ancient Farm, the basic requirement of time. In practical terms to reach any kind of conclusion which is supported by statistically valid data some twenty years of work are needed. On the other hand, that the ard is an efficient implement is a conclusion which can be reached relatively quickly.

It has been used successfully for the past five years in the cultivation of fields on the two basic soil types of the farm, the friable redzina and the hill wash soils. Various positions have been employed for the ard in relationship to the cattle. Examples of the 'long draw' and 'short draw' can be seen in Plates 6 and 7. The 'long draw' was favoured in the Bowen & Aberg trials (Bowen 1969) with the same results of instability and lack of control. By far the best is the 'short draw' both from the point of view of the ploughman (or woman in this case) who has greater control of implement and the animals who are more aware of the process in hand. The 'long draw' poses problems of

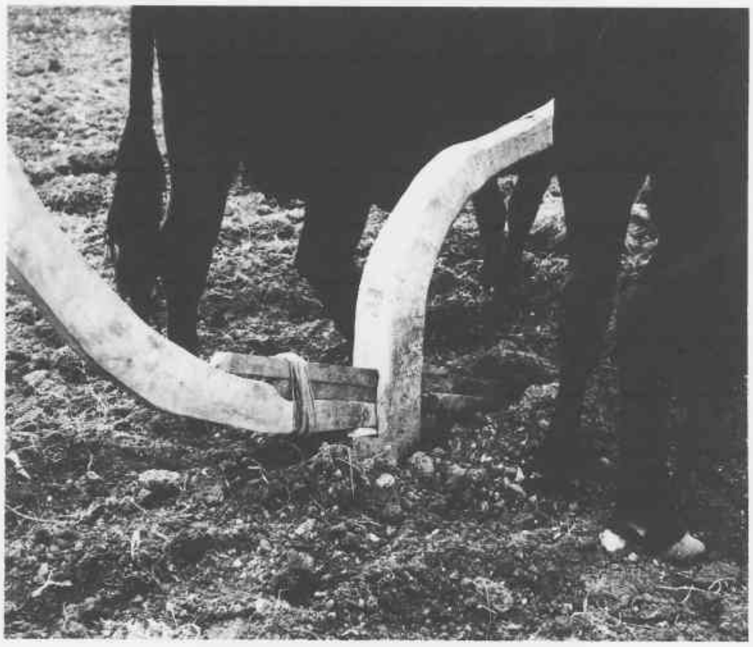

Plate 7. The short or close draw

maintaining verticality and hence the line of traction of the ard. Its relative remoteness from the animals causes them to be less conscious of working and they are more prone to wander off course.

The full effect of the undershare lifting the soil can be seen in Plate 8. The marks around the foot of the main beam show the height at which the soil occasionally flows around it. The wedge which dictates the angle of penetration and the leather lashing around the stilt and the rear of the undershare are similarly quite clear. The reverse wedge at the rear of the beam is shown in Plate 6. In all the plates it can be seen how the three elements, the stilt, the undershare and the foreshare are laid tightly together. The foreshare is wedged in place while the lashing maintains the position of the other parts. It became clear during the trials that unless this condition of maximum strength prevails, breakages occurred on the one hand, and on the other the penetration angle was unstable and efficiency was impaired.

Plate 8. The bite of the foreshare and lift of the undershare.

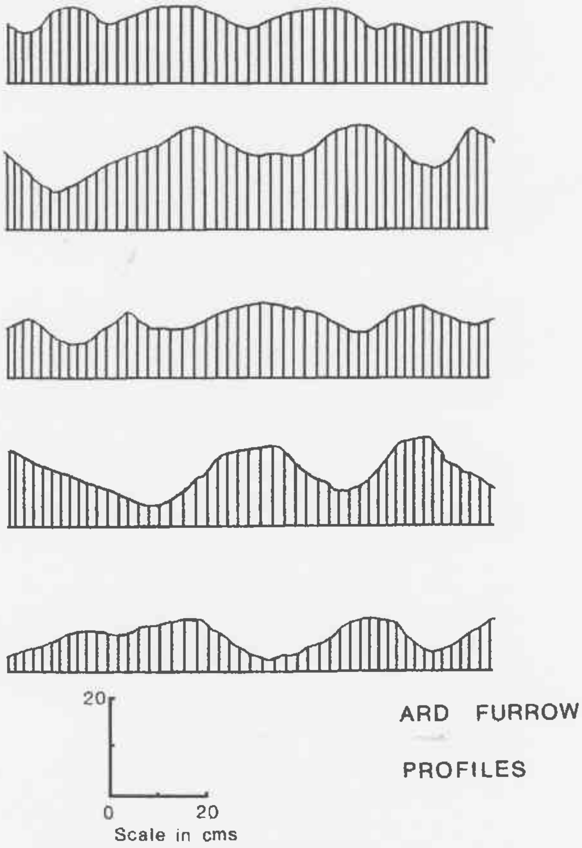

Figure 4. Profiles of furrows created by the replica ard in typical hillwash chalk soil.

The capabilities of the ard in production of furrows is undeniable (Figure 4). While it cannot be used for ploughing up established grassland or very old fallow, it is quite equal to the task of dealing with a field which has lain fallow with stubble and weeds overwinter or alternatively has been rested for a season. Indeed, while the majority of trials with the ard here described have been on light soils, several trials were carried out by the author on the heavy clay and marl soils of the west Midlands. As commented above, there regularly occur the ideal conditions for ploughing, and given those conditions the Donnerupland ard under human traction, which was considerably less than the power of the team of Dexters (traditional folklore suggest one human power equates to one eighth horsepower and presumably, therefore, *circa* one fifth cow power), was perfectly capable of dealing with the heaviest of soils. The assumption that because it is seemingly of light construction it is incapable of a heavy work load is quite erroneous. Throughout all the trials its maximum penetration, that of the tip of the foreshare, never exceeds 20 cm and it averages at 15 cm. The depth of furrow from trough to crest averages out at some 30 cm. This, in turn, causes problems in that such a furrow is too deep for direct sowing of cereal seeds. The ideal seed drill is no more than 5 cm deep when compacted. Thus the ard represents only one phase of the cultivation process, further operations include the levelling of the tilth, drawing of seed drills if such are probable (Reynolds 1981b) and finally compaction of same.

The conclusion reached from all these trials is that if the topsoil depth in antiquity exceeded an average of 20 cm the so-called ard marks are unlikely to have been created by an ard of the Donnerupland type. Indeed the horizontal plane of the ard in action is such that the foreshare protrudes beyond the undershare to a maximum vertical depth of *ca* 3 cm. Any greater depth caused the ard to jam in place with subsequent lifting of the stilt and dropping of the yoke. Its optimum operational depth was *ca* 2 cm. In soil depths of less than 20 cm, especially on sandy subsoils it is not unreasonable to expect some scoring of the subsoil surface. Perhaps such a condition existed at Gwithian (Megaw, Thomas & Wailes 1961). However, where there are clear indications of one way ploughing or cross ploughing as evidenced by such score marks, there follows the problem of cultivation frequency. In practice a field can be ploughed several times a year under normal conditions. If a bare fallow was employed ploughing might well have occurred on six to eight occasions in one season. Were the same plough to be used, bearing in mind that its ploughing depth cannot be effectively adjusted, a plethora of score marks would be created. Ultimately this would lead to a self-cancelling effect with this top layer of subsoil becoming thoroughly mixed with the topsoil. The options, therefore, would seem to be threefold, first the ard marks as ascribed and observed are representative of the last pass of the ard prior to abandonment, second the field was in use only two or three times and third and most likely, the marks were not actually made by this type of ard at all. This last option has been explored by the author (Reynolds 1981) and prior to empirical trials including the replication of certain ards of the Aspeberg type (Glob 1951) the conjecture is that a specific implement, the 'rip ard', is missing from the artefactual evidence at this time.

Conclusion.

This paper has sought to report the reconstruction and testing of a specific wooden implement recovered from a peat bog in Denmark. The empirical approach adopted has focused far greater attention to functional detail than is normally possible in an archaeological context and the results have been validated by repeated physical testing. The conclusions, inconclusive in terms of wear patterns at this time but, given an adequate period of consistent and consecutive use even this problem may be answered, indicate that the implement cannot efficiently be tilted as has been hypothesised in order either to ridge a deeper furrow or to invert the soil, nor can it, with the above *caveat* concerning soil depth, create the so-called ard marks regularly attributed to it. On the other hand it is a most successful implement in stirring the soil and it does produce adequate and substantial furrows. There are no signs of appreciable wear upon its component parts after five seasons of regular use on the Ancient Farm, a period which is conjecturally commensurate to two seasons in antiquity. This observation suggests that its functional life as an implement is quite considerable and with regular replacement of foreshare it could well be in use for twenty years or more.

In more general terms the experiment underlines the lack of archaeological data of wooden implements which were undoubtedly the norm in prehistory. In an agricultural context it would be more significant to regard prehistory from the neolithic onwards as a continuum, the prime material timber and a straight-forward development of agriculture, which by the Iron Age, certainly embraced on the one hand arable and pastoral agriculture and on the other silviculture. Every opportunity to examine timber implements whether they are tools or boats should be eagerly taken, since it is a direct and positive way of investigating not only the construction techniques and the functional efficiency of these objects but also the prime resource they represent. There is clearly no conflict between the various disciplines involved in that boat archaeology has clear implications of timber husbandry on land. The only regret is the comparative dearth of timber objects which relate to agricultural practice.

References

Anati, E. 1965. *Canonica Valley.* Jonathan Cape, London, 1965

Aberg, F.A. & Bowen, H.C. 1960 Ploughing Experiments with a Reconstructed Donnerupland Ard. *Antiquity* 34, 1960, 144-47

Bowen, H.C. 1961. *Ancient Fields.* Reprint S.R.Publishers Ltd. London, 1970

Bowen H.C. 1969. The Celtic Background in *The Roman Villa in Britain.* A.L.F. Rivet (ed). Routledge & Kegan Paul, London, pl. 1, 2.

Fenton, A. 1968. Plough and Spade in Dumfries and Galloway. *Trans. Dumfriesshire and Galloway Nat. Hist. & Antiq. Soc.* XLV, 147-83

Fenton, A. 1976. *Scottish Country Life.* John Donald Publishers Ltd.

Fowler, P.J. 1978. The Abingdon ard-share in *The excavation of an Iron Age settlement, Bronze Age ring-ditches and Roman features at Ashville Trading Estate, Abingdon (Oxfordshire), 1974-76,* Oxfordshire Archaeological Unit Report 1, Council for British Archaeology Research Report 28.

Glob, P.V. 1951. *Ard and Plough in Prehistoric Scandinavia.* Aarhus.

Hansen, H.O. 1968. *Report of initiative ploughing experiments with copies of a prehistoric ard with passing through stilt (Dostrop type) 1962-68.* Reports from experiments in Lejre, 1968.

Leser, P. 1931. Entstehung und Verbreitung des Pfluges. *Anthropos,* B III, .Munster, 1931

Megaw, J.V.S., Thomas, A.C. & Wailes, B. 1961. The Bronze Age settlement at Gwithian, Cornwall. *Proceedings West Cornwall Field Club,* II, 1961

Piggott, C.M. 1952-3. Milton Loch Crannog 1. *Proceedings Soc. Antiq. of Scotland,* LXXXVII, 143-44.

Reynolds, P.J. 1967. Experiment in Iron Age Agriculture. *Trans. Bristol & Glos. Archaeol. Soc.*, 86, 60-73.

Reynolds, P.J. 1979. *Iron Age Farm: The Butser Experiment.* British Museum Publications, London.

Reynolds, P.J. 1981. 'The working agroscape of the Iron Age'. *Landscape Hist.* Vol. II.

Reynolds, P.J. 1981 b. *Les Techniques de conservation de grain à long terme,* Ed. Gast à Sigaut. CNRS, Marseilles.

Steensberg, A 1957-8. Parallel ploughing with alternately sloping and upright ard in Columella. *Folk-Liv,* 157-62

Steensberg, A.1960. Plough and field shape. *Selected papers of the 5th International Congress of Anthropological and Ethnological Sciences* (Sept. 1956), Copenhagen, 342-45