THE GUNDESTRUP CAULDRON IDENTIFICATION OF TOOL TRACES

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Abstract

The silver cauldron from Gundestrup Mose, a bog in northern Jutland, Denmark, is a unique piece of chased silver work, probably from the time around the birth of Christ. The decorations on the richly decorated cauldron have been embossed in very high relief and tooled to finish with a variety of punches. This paper is based on the identification and documentation of imprints of pattern punches occurring on the surface of the Gundestrup Cauldron. Silicone rubber impressions of tool marks on the vessel's surface have been the basis of the study. By identifying and comparing the individual tool marks, we can in certain instances verify or invalidate a stylistic/iconographic evaluation. Perhaps one day we shall finally be able to establish the provenance of the cauldron by comparing its tool marks with those of tools represented on other objects.

Fig. 1. The Gundestrup Cauldron after reconservation.

Fig. 2. Inner plate depicting the horned deity Cernunnos. Inv.no. C.6571.

Introduction

The Gundestrup Cauldron, that strange and unique Celtic masterpiece from Himmerland in northern Jutland, was in 1977 dismantled and reconserved in connection with the National Museum of Denmark's reorganization and the refurbishing of the exhibition of Danish prehistory. At this stage I had the opportunity of making a large number of partial silicone rubber casts of its surface, with a view to registration and identification of traces of tools employed in its production.

All sixteen parts of the cauldron are chased work of very high quality. The voluminous underpart has been chased in one piece. The richly decorated plates showing over one hundred figures of gods, men and animals have all first been embossed from the back and then neatly tooled from the front.

The Gundestrup Cauldron has, since it was found in 1891, been investigated by a large number of Danish and foreign art historians and archaeologists. Probably no

Table I. Different views on the dating and provenance of the Gundestrup Cauldron.

Authority	Year	Provenance	Dating
Müller	1892	Nordic work	100 BC—100 AD
Bertrand	1893	Cimbrian peninsula	1 AD
Reinach	1894		400—600 AD
Steenstrup	1895	India	620 AD
Drexel	1915	Danube, East Celtic	100 BC
Müller	1933	Gaul	80—50 BC
Arbmann	1948	Gaul, West Celtic	100—1 BC
Klindt-Jensen	1950	Gaul, West Celtic	100—1 BC
Norling-Christensen	1954	Balkans	200—400 AD
Holmqvist	1962	Balkans	1—100 AD
Nylén	1967	Scandinavia, Celtic exile work	100 BC
Powell	1971	Carpatho-Danubian Europe	100 BC
Olmsted	1979	North-western Gaul	80—50 BC

Fig. 3. Outer plate with male deity holding two deer in his outstretched hands. All outer plates are partially gilt. Inv.no. C.6568.

other Danish museum object has been treated in so many articles and monographs, with little agreement among their authors, in a discussion which has been going on for nearly a century.

The first to introduce the Gundestrup Cauldron into the literature was the then director of the National Museum of Denmark, Sophus Müller, who in 1892 in *Nordiske Fortidsminder* held that the cauldron is Nordic work, dating to the time around the birth of Christ. This view was challenged three years later by Japetus Steenstrup, who dated the cauldron to 620 AD and placed its origin in India. Later Friederich Drexel placed it in the 1st century BC and the Danube area. And so the discussion goes on. I give a survey of the most important theories on dating and provenance in Table I.

Fig. 4. Inner plate with female bust surrounded by elephants and griffins. Inv.no. C.6573.

The Gundestrup Cauldron has mainly been analysed from stylistic and iconographic points of view. On this basis, Sophus Müller distinguishes in 1892 three, perhaps four, different craftsmen involved in the making of the cauldron. Thus he writes: »Particular importance must be placed on the fact that the cauldron is obviously not the work of one man. Plates VI, IX, XII,2 and XIII,1 must derive from one and the same worker, who has had nothing to do with the other plates ... Plate XI,1 has been executed by a worker who, judging by the modelling and treatment of the details, has hardly done anything else. Finally, all the other plates must have been produced by one or possibly two artists«. Sophus Müller's conclusion on this point was later supported by such important Gundestrup scholars as Ole Klindt-Jensen and Garrett Olmsted. There are, however, variations with respect to the attribution of the individual plates. The discussion is again based on arthistorical appraisal.

Scrutiny of the literature reveals how remarkably little has been written on manufacturing technique, and proper technological investigations have never been carried out.

We do not know the actual tools employed in the making of the Gundestrup Cauldron, whereas there are thousands of marks of tools on every plate. By studying such traces with the same precision as is used in forensic science, we have the possibility of identifying and comparing the traces of working on the basis of individual characteristics. This affords us in many cases the chance to see, and document, how an object has been made, step by step. In other cases, we may even be so fortunate that several objects can be linked, because they bear traces of the same identified tools.

Metal-working tools a brief classification

Tools used in metal-working may be broadly classified into three main groups according to the actual working process and the movement governing the contact between the tool and the raw material, which is also apparent in the tool traces we can document in the surfaces of metallic objects recovered in an archaeological context:

A) Scraping tools, e.g. scriber
B) Cutting tools, e.g. graver
C) Pressing tools, e.g. punch

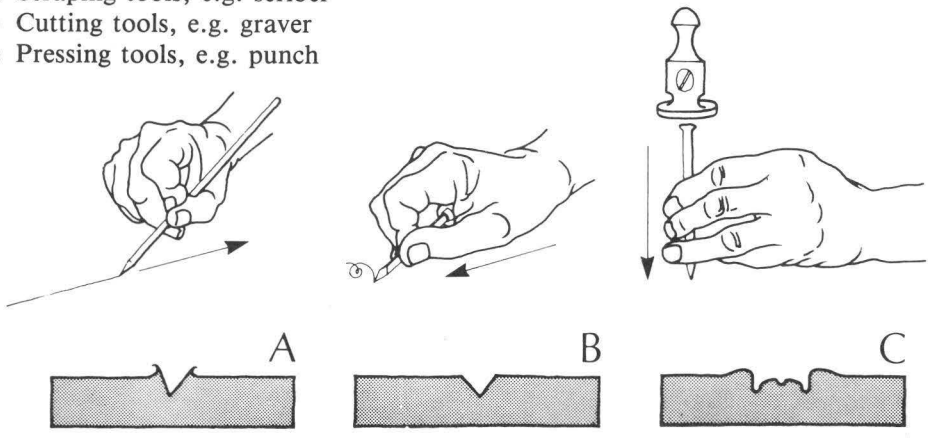

Fig. 5. Schematic drawing of three main kinds of metal-working processes.

Every tool within these three groups will leave, in the working of a given surface, traces containing individual microdetails. The possibilities of identification are greatest for pressing tools, since, unlike the two other groups, these do not require sharpening before use: sharpening alters the individual geometrical character of a tool. Thus in any

investigation of this nature where the individual character of working traces is involved, traces of pressing tools are highly suitable, and traces of scraping and cutting tools suitable with qualification, and it is this circumstance which has caused me to concentrate this investigation around traces of pressing tools. Within this group we find tools like hammers, matrices and patrices, and punches.

The decorations of the Gundestrup Cauldron have primarily been executed with pressing tools, and it will be appropriate here to look at the concept of punching a little more closely. Punches of different kinds are associated with many different craft processes. Processes such as planishing, modelling and matting all require punches adapted to the particular process. Ordinary and fancy pattern punches form a special group, and it is within this group that we find tools of the type which have been used in chasing large parts of the Gundestrup Cauldron's depictions of men and animals. The object to be punchdecorated is first bedded in pitch. The punch is driven with the aid of a small hammer into the surface of the metal and the ornament of the punch hereby transferred to it, as a negative of the tool's geometry, reproducing all its micro-details, like a fingerprint.

Fig. 6. Example of areas of an inner plate selected for making silicone rubber casts of all the different tool traces. Detail of Cernunnos figure. Inv.no. C.6571.

Investigation and documentation of tool traces

As a starting point for the investigations, I have made partial casts of all interesting areas over the whole surface of the Gundestrup Cauldron. The casting material found to be the most accurate and effective for the purpose is a two-component silicone rubber from Dow Corning: Silastic 9161, an extremely accurate casting material, which does not require the use of a release agent. Tool traces are in this way reversed from a negative in the surface of the silver to a positive impression, accurately reproducing every detail. A uniform material is obtained, since silicone rubber is chalky white in colour, which is considerably better to document than the often confusing tones of the metal.

The preliminary investigations of silicone rubber impressions are carried out under the microscope at a magnification of 10—40×. In this phase all characteristic features are registered for each sample. The impressions are photographed with an Optica process camera with a special objective allowing up to 10× enlargement in the negative. A Schott illumination unit is attached to the camera's exposure timer. Sidelighting of the white silicone rubber impressions at an acute angle reveals many new features,

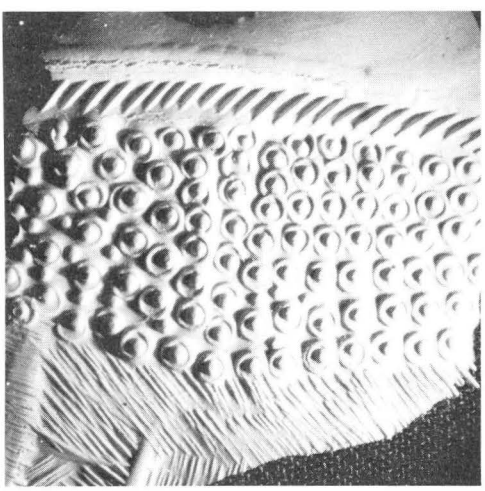

Fig. 7. Silicone rubber impression of a punched area from the surface of the cauldron. See Fig. 6, zone 7.

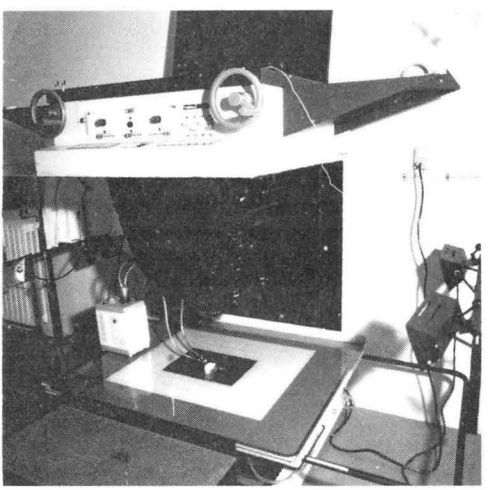

Fig. 8. Optica process camera used for photographing the silicone rubber impressions.

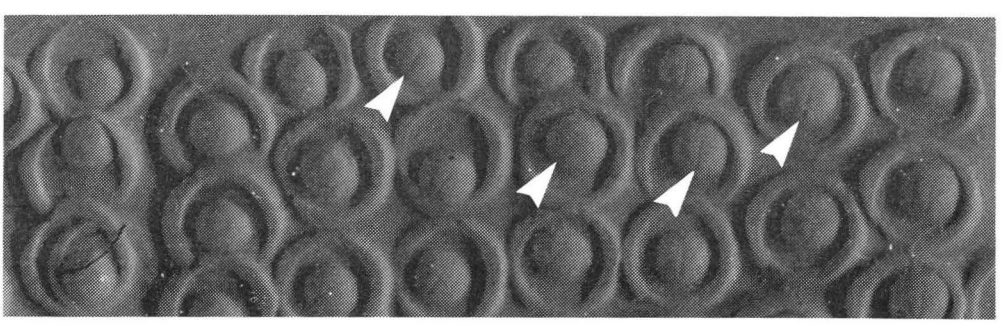

Fig. 9. Silicone rubber impression photographed with the Optica process camera. See Fig. 7.

this incidence forming highlights and shadows in the surface microtopography. A hard lithographic film, e.g. Kodalith Estar sheet film 6 ASA, is employed. If this film is over-exposed and shock-developed, the emulsion forms a tone negative with very high contrast. The cost is low, and details from the individual impressions of this survey documentation are reproduced with such accuracy that those portions of the surface offering the optimal conditions for documentation of the individual details of each pattern punch may be selected.

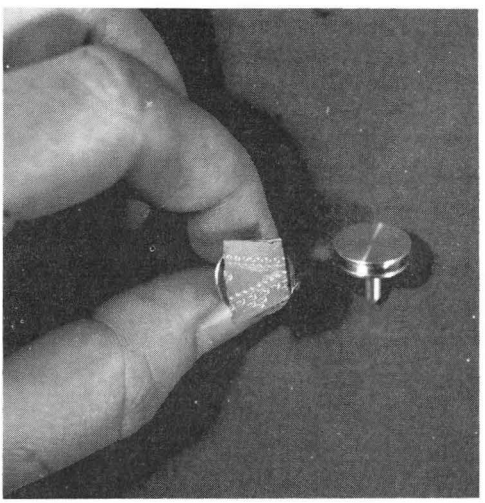

Fig. 10. Fragment excised from a silicone rubber impression, mounted on a stub of aluminium, and goldcoated in an Edwards sputter coater.

Fig. 11. The SEM apparatus employed at Denmark's Technical University (Philips 505).

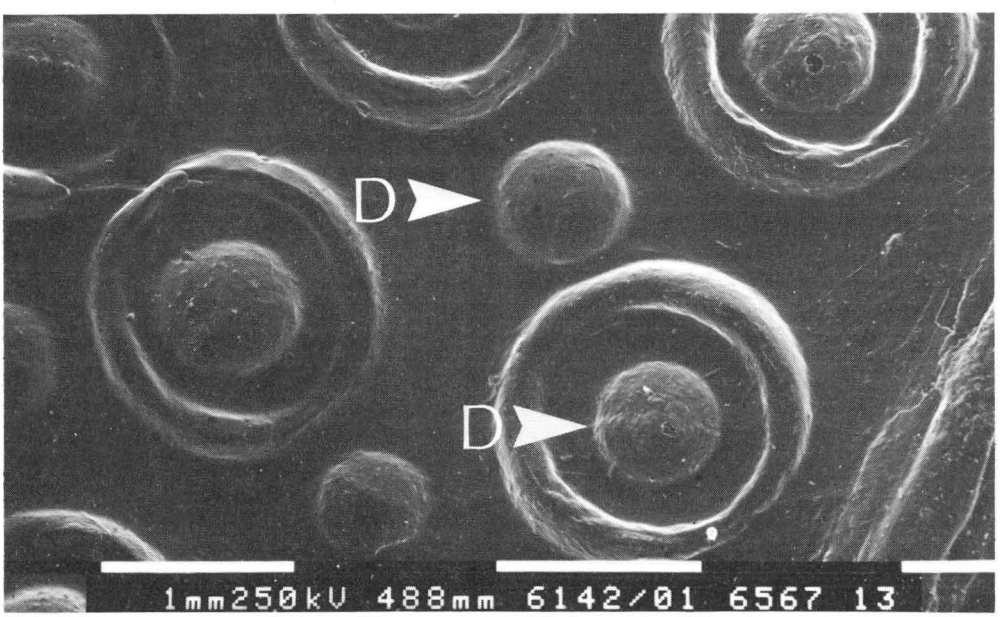

Fig. 12. SEM micrograph showing impressions of the punched area Fig. 6, zone 7. That two tools have been used is seen in the variation in the dot's position within the ring. The same dot punch is seen also to have been used outside the ring (D).

The final documentation is then made using scanning electron microscopy to give greater precision to the observations. A fragment is cut from the silicone rubber impression, mounted on a stub of aluminium and coated by evaporation with a very thin layer of gold (300—400 Ångstrøm) to make the surface electrically conductive, which is essential for scanning electron microscopy. In this way all the different punch marks have been identified and documented. The scanning pictures can now be compared, and tool marks deriving from the same punches be distinguished on the basis of individual features.

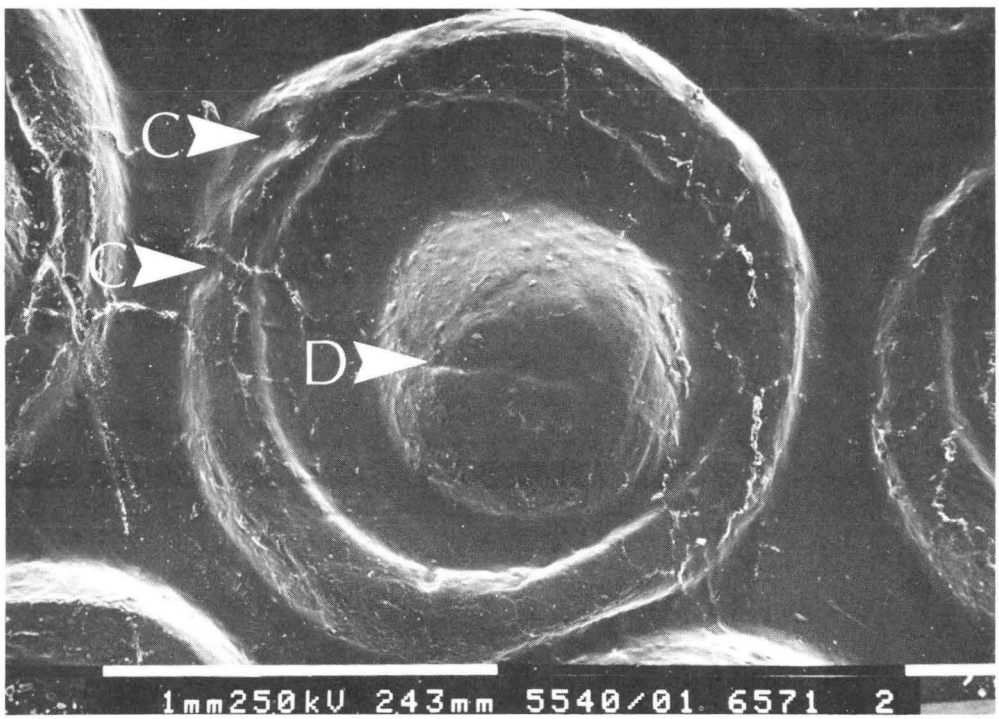

Fig. 13. SEM micrograph at a greater magnification of the ring and dot punch marks in Fig. 12. The individual microgeometry of the tools used is clearly visible in the tool marks (C and D).

Results

Using the method described, it has been possible to identify 15 different punches, on the basis of 34 silicone rubber impressions from selected areas of the Gundestrup Cauldron's decorated plates. In Fig. 15, the 15 different punch traces are drawn on the same scale.

Based on the distribution of the punchmarks in the individual plates, the plates may be grouped as shown in Fig. 16.

From the diagram we can see that three different sets of pattern punches can be distinguished. Two plates cannot be assigned, since they lack pattern punch marks; it may be possible to place these with further investigations of other types of tool traces. It is worth remarking that marks of the same tools are found on both outer and inner

plates in both set I and set II. Similarly, we have marks from the same tools in both male and female divinities on the outer plates.

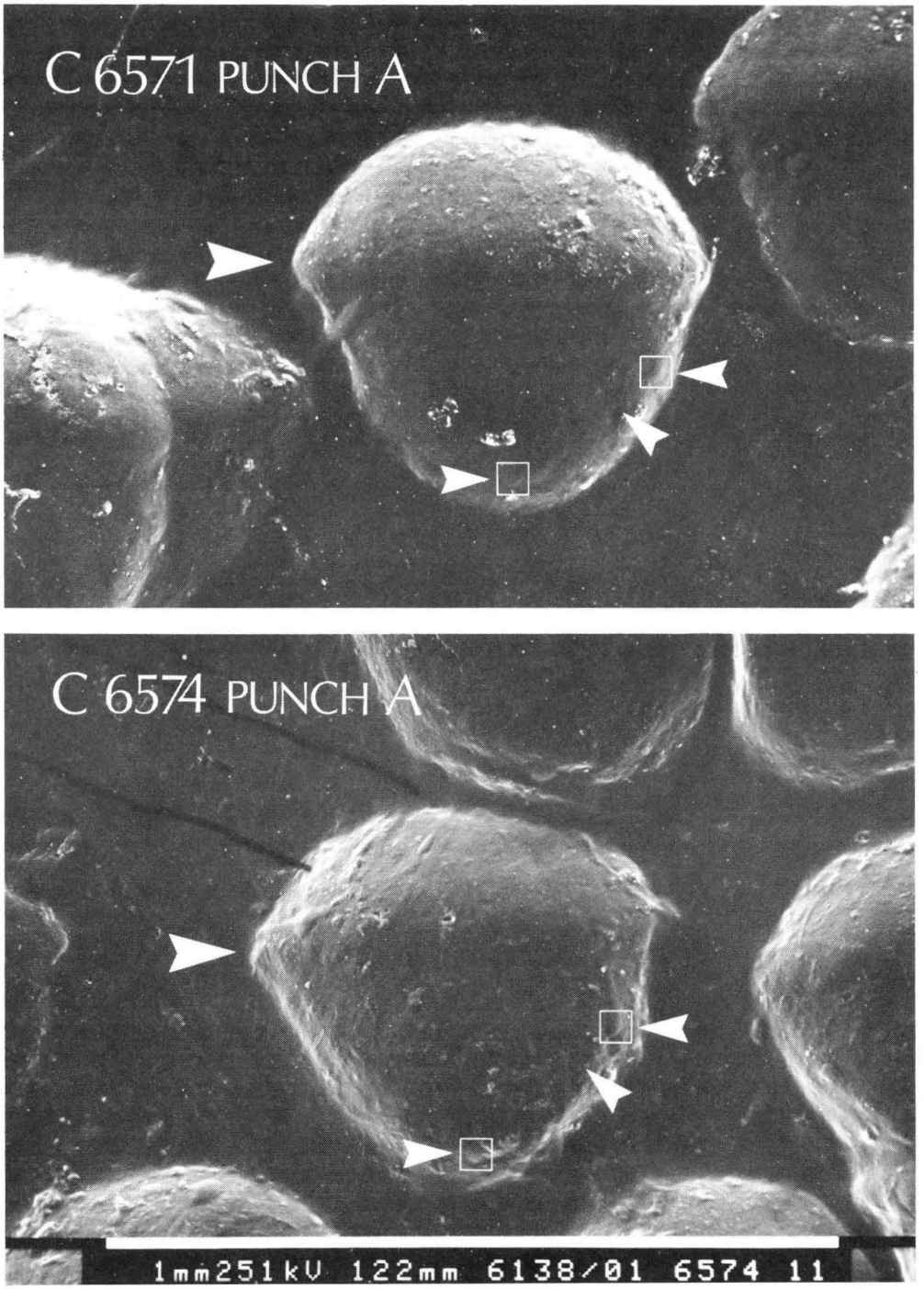

Fig. 14. Comparison of punch marks from two different plates. The SEM micrographs show them to be identical. All tests included in this study were documented in the same manner.

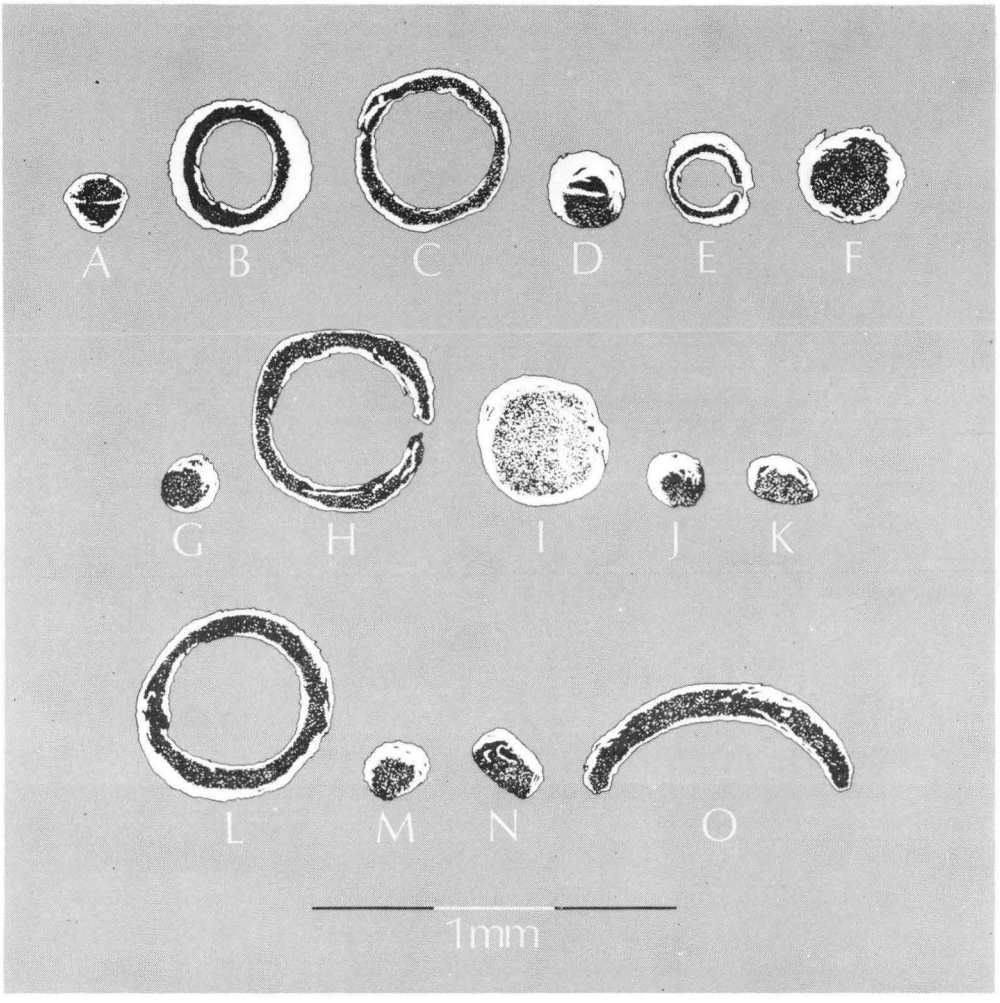

Fig. 15. Drawing of the 15 different impressions of pattern punches in the surface of the Gundestrup Cauldron, drawn at exactly the same scale. Based on SEM micrographs.

If we now correlate these observations with Sophus Müller's, Ole Klindt-Jensen's and Garrett Olmsted's groupings, we find an astounding agreement with respect to identification of the different artists, in which it should be remarked that each artist has used a set of tools that seems to have been his and his alone (Table II).

The following four figures, Fig. 17—20, show how the Gundestrup Cauldron's plates may be grouped on the basis of the individual geometrical details of each tool.

Conclusion

Simply by identifying the traces of the tools employed we can confirm or refute a stylistic/iconographic evaluation. The analysis described here is only part of a larger investigation of the Gundestrup Cauldron. It is my hope that coming analyses may contribute to the solution of some of the many questions which attach to this remarkable Celtic masterpiece. And perhaps one day it will be possible to finally establish the provenance of the Gundestrup Cauldron by comparing its tool traces with those of other objects.

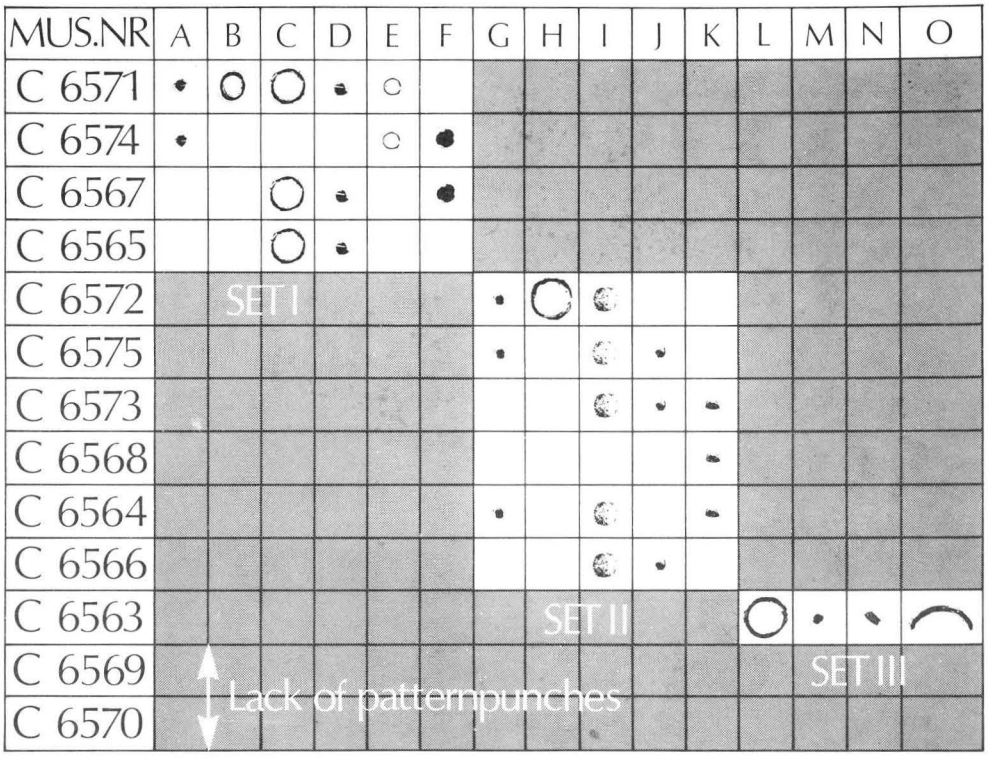

Fig. 16. Diagram showing three different sets of pattern punches used in the decoration of the Gundestrup Cauldron. The column on the left gives the inventory number of each panel. The rubric above with letters A to O indicates the 15 different identified marks of pattern punches, Fig. 15.

Table II. The result of the analysis set in relation to Sophus Müller's Ole Klindt-Jensen's and Garret Olmsted's stylistic/iconographic observations.

Artist	Sophus Müller 1892	Ole Klindt-Jensen 1950	Garrett S. Olmsted 1979	E. Benner Larsen 1984	Toolset
Artist I	C 6565 C 6567 C 6571 C 6574	C 6565 C 6567	C 6565 C 6567 C 6571 C 6574	C 6565 C 6567 C 6571 C 6574	Toolset I
Artist II	C 6564 C 6566 C 6568 C 6570 C 6572 C 6573 C 6575 C 6563	C 6564 C 6566 C 6568 C 6570	C 6564 C 6566 C 6568 C 6570 C 6572 C 6573 C 6575	C 6564 C 6566 C 6568 C 6572 C 6573 C 6575	Toolset II
Artist III	C 6569	C 6569	C 6569		
Artist IV		C 6563	C 6563	C 6563	Toolset III
Unidentified				C 6569 C 6570	Unidentified

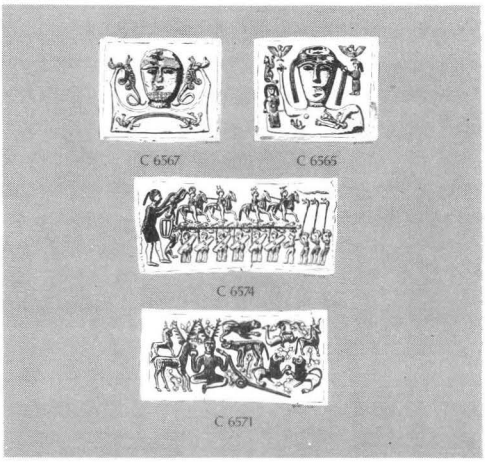

Fig. 17. Two inner and two outer plates decorated using pattern punches within tool set I (punches A-F).

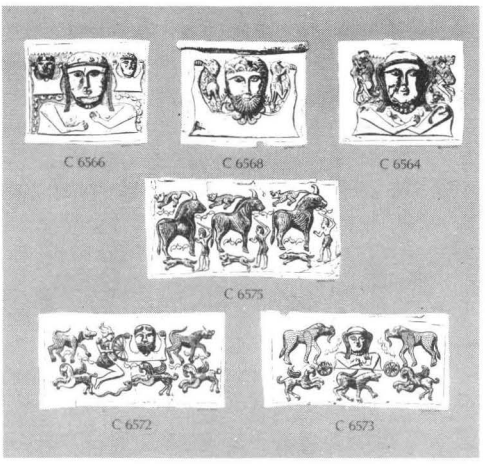

Fig. 18. Three inner and three outer plates decorated using pattern punches within tool set II (punches G—K).

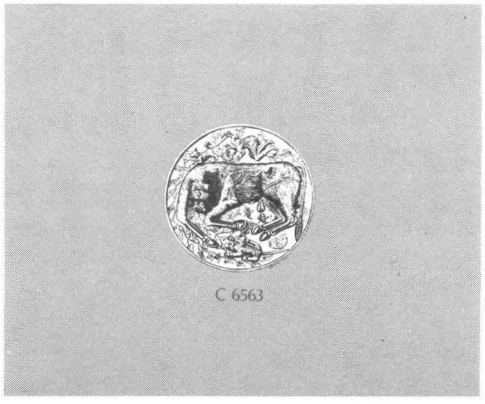

Fig. 19. The bull plate from the base of the Gundestrup Cauldron was decorated using punches within tool set III (punches L—O). These punches have been used only on the bull plate.

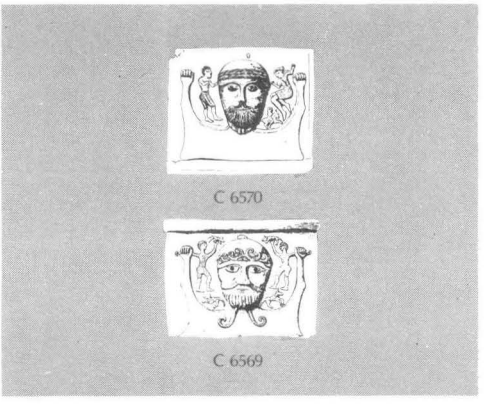

Fig. 20. The two outer plates inv.no. C.6569 and C.6570 could not be assigned to any of the three sets of tools mentioned, since they lack all traces of pattern punches.

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Special thanks are due to *dr. scient* V.F. Buchwald and scanning operator Inger Søndergaard, Institute of Metallurgy, Denmark's Technical University. Without their help and interest this work would not have been possible.

Fig. 21. The bull plate from the bottom of the Gundestrup Cauldron. The craftsmanship, the toolkit and artistic virtuosity make this a piece apart from the rest of the decorated plates. Inv.no. C.6563.

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