

# THE USE OF TIN ON MYCENAEAN VASES

(PLATES 92-93)

A group of twelve vases from a large Mycenaean chamber tomb on the north slope of the Areopagus has led to an examination of an enigmatic class of Mycenaean pottery previously noted at Knossos, Ialysos, Mycenae, and Dendra.<sup>1</sup> Of all the Mycenaean tombs found during the Agora excavations, this, the Tomb of the Bronzes (M 21 :2), was second only to its neighbor, the Tomb of the Ivory Pyxides (N 21-22 :1), in size and in wealth of contents.<sup>2</sup> It contained three burials made over a short span of time; the third, that of a man, was equipped with a low wooden table on which rested a long bronze rapier and a short sword, each with gold-riveted hilt, a bronze razor and a fragmentary bowl (Pl. 92, a). There were also thirty-eight gold foil rosettes, probably to be associated with a shroud or cloak, and some ivory rosettes and ornaments perhaps adorning the table. Compared with this ostentatious display, the pottery as it appears today is disappointing and contrasts markedly with the fine painted jars and alabastra from the neighboring tomb. Of the sixteen vases from the three burials (Pl. 92, b), only three had painted decoration: a small pilgrim flask (P 17,753) with concentric circles and a tangential spiral band beneath the handles, a miniature pithoid jar with net pattern (P 17,767), and a large three-handled jar with ivy-leaf and palmette decoration in early Myc. III A style (P 17,757). The first, although found in the center of the tomb and therefore not associated with any specific burial, has close parallels among the sherds from Tell el-Amarna and affords a secure dating of the tomb to the second quarter of the fourteenth century, and the other two painted vases are not inconsistent with this date.<sup>3</sup>

<sup>1</sup> This article has developed from a paper entitled "Imitation Metal Vases from Mycenaean Tombs," read at the Sixty-Fourth General Meeting of the Archaeological Institute of America in Baltimore, December 28, 1962. A first version, written in 1963, has been revised for this issue of *Hesperia* in honor of Carl W. Blegen, to whom we owe much in inspiration and scholarship. If we have made suggested emendations to his admirable publication of the Mycenaean vases from the Argive Heraion, it is with the thought that he too will share our interest in this problem.

The study of the Agora prehistoric collection was begun in the summer of 1961 under a fellowship from the American Association of University Women. I should like to thank Homer A. Thompson and the Agora staff for their helpfulness, Miss Marie Farnsworth for her chemical analyses and the note she has written, Mr. Reynold Higgins of the British Museum for arranging for chemical analyses of the Ialysos vases, and Dr. Stephen Foltiny of the Institute for Advanced Study for discussing with me possible Mycenaean connections with Central Europe.

<sup>2</sup> Tomb of the Ivory Pyxides, *Hesperia*, IX, 1940, pp. 274-291; Tomb of the Bronzes, *Hesperia*, XVII, 1948, pp. 154-158. Their respective numbers N 21-22 :1 and M 21 :2 refer to the Agora grid.

<sup>3</sup> The Tell-el-Amarna connections of P 17,753 were noted by Thompson in *Hesperia*, XVII, 1948, pp. 157 f. P 17,767 should be contemporary, whereas P 17,757 is slightly earlier in style (Myc. III A :1). Found near the entrance, it contained fragments of charred bone and vitrified

The remaining thirteen vases were undecorated. One of these, the large three-handled jar (P 17,766), does not belong to the class we are considering. Although completely unornamented, it has a smooth buff surface and is paralleled by similar undecorated jars from the tombs at the Argive Heraion.<sup>4</sup> The other twelve vases, comprising six kylikes of four different shapes, a beaked ewer with stirrup handles, two shallow bowls with ribbon handles, and three handleless shallow bowls, have a very different appearance. Although the shapes of the kylikes are elegant with good early parallels,<sup>5</sup> technically they are inferior or unfinished. The surface, in most cases, has been given a preliminary smoothing, but has not received the technical slip through final polishing. Furthermore, they are all characterized by irregular black patches of varying size, which at first suggested a deposit from soil contamination. Closer examination showed that this was a deliberate incrustation consisting of a thin blackish or gray layer adhering to a whitish substance underneath. The fact that it was applied inside and out on open shapes, but often not under the foot, likewise suggested some sheathing material intended to give the vases a very different and more splendid appearance.

In searching for parallels, it soon became apparent that these vases were not a unique phenomenon, but belonged to an apparently rare class of funeral vases, first recognized by Evans in his publication of the chamber tombs of Zafer Papoura at Knossos. A kylix from Tomb 7, which is similar to our P 17,755, he described as "of plain clay originally covered with a kind of black varnish, which seems, however, to have been imperfectly fixed,"<sup>6</sup> and he made further reference to a "black imperfectly fixed varnish" for seven more vases from various tombs, which we list below in the catalogue. After noting the metallic resemblances of the kylix shape, with reference to the bronze example from the Tomb of the Tripod Hearth and the silver kylix from the Royal Tomb at Isopata, he then concluded, "It seems possible that the curious black varnish with which . . . cups of the same class had been coated may have been intended to produce the illusion of metal work for funeral show."<sup>7</sup> His theory of imitation metal vases became somewhat confused in his publication of further examples

potsherds, presumably the remains of a sacrificial pyre; perhaps it was moved from the first burial to this secondary position. It would appear that all three burials took place in fairly rapid succession within the first and second quarters of the fourteenth century.

<sup>4</sup> Carl W. Blegen, *Prosymna*, II, Cambridge, 1937, figs. 260, no. 1053, 438, no. 174, 536, no. 1038.

<sup>5</sup> P 17,754: cf. kylix P 21,249 from the Ares Tomb (*Hesperia*, XXIV, 1955, pl. 74,15) and kylix no. 44 from Tomb 10 at Dendra (Axel Persson, *New Tombs at Dendra*, Lund, 1942 [hereafter *NTD*], fig. 103:4) which should be about 1400 B.C. P 17,764: cf. kylix no. 45 from Dendra T.10 (*NTD*, fig. 103:5). For P 17,756, 17,760, and 17,765 cf. kylikes nos. 42 and 43 from the same tomb (*NTD*, fig. 103: 2 and 3), and for P 17,755 cf. an example from Zafer Papoura, Tomb 7 (Arthur J. Evans, *The Prehistoric Tombs at Knossos*, *Archaeologia*, LIX, 1906 [hereafter *PTK*], p. 124, fig. 118, 7f).

<sup>6</sup> *PTK*, p. 26.

<sup>7</sup> *Ibid.*, p. 125.

“coated with a kind of black varnish” from the cemetery at Isopata,<sup>8</sup> owing to the occurrence in the same tomb of four ritual goblets with elaborate polychrome decoration in unfixed pigments,<sup>9</sup> for which he claimed a specific funeral use “since they could not have stood the wear and tear of daily handling.” This led him to the suggestion that the black varnished vases may have been “accompanied by polychromy that has disappeared” or “may have been wholly or partly covered with gold foil . . . and this may have been peeled off by early plunderers of the tomb.”<sup>10</sup>

Evans' observations led to the recognition of further examples in this technique among the Mycenaean vases in the British Museum from the older excavations at Ialysos. Forsdyke, in publishing these, referred to a “thick plaster-like gray paint which has largely perished,” or to a “thick unfired gray pigment which has mostly flaked off but shows white under the handles.”<sup>11</sup> He compared them with Evans' vases from Zafer Papoura, but then confused the technique with the survival of polychromy for funerary practice as in Tomb 5 at Isopata.

In publishing the chamber tombs at Mycenae, Wace noted five occurrences of this technique.<sup>12</sup> For Tomb 515, no. 48, he remarked that the kylix was unpainted “but incrustated all over except under the base of the foot with a dull gray substance which may be traces of a paint applied to the vase when placed in the tomb to give it the appearance of metal, or the remains of a paste or gum for affixing gold leaf so as to imitate actual gold cups of this shape,” and in summarizing, he referred to the probable intention “to give these clay vases the appearance of vases of metal, *perhaps silver . . .*” (italics mine), and he regarded them as “substitutes *in usum mortuorum* of valuable metal vases.”<sup>13</sup> He made no mention of a connection with the polychrome examples.

Wace's final remarks, and particularly his reference to imitation silver vases, were prophetic, for in 1939 during the Swedish excavations of the chamber tombs at Dendra, Persson discovered a series of five vases in this technique in an offering shaft (No. II) in Tomb 10, a shaft which also produced costly silver versions of the same shapes. This immediately led to his acceptance of Wace's imitation silver theory and his rejection of the alternative that the grayish substance was an adhesive for gold leaf.<sup>14</sup>

Against this background of unsubstantiated hypotheses it seemed advisable, in

<sup>8</sup> Arthur J. Evans, *The Tomb of the Double Axes . . .* (*Archaeologia*, LXV, 1914 [hereafter *TDA*]), p. 24, fig. 35.

<sup>9</sup> *Ibid.*, pl. IV and fig. 37, a and b.

<sup>10</sup> *Ibid.*, p. 26.

<sup>11</sup> E. J. Forsdyke, *Catalogue of Vases in the British Museum*, Vol. I, part 1, London, 1925 (hereafter *BMCat*), pp. 151 (A 850), 153 (A 860).

<sup>12</sup> Alan J. B. Wace, *Chamber Tombs at Mycenae* (*Archaeologia* LXXXII, 1932 [hereafter *CT*]), pp. 8 (T. 502, no. 17), 60 (T. 515, nos. 43, 49, 51, 52).

<sup>13</sup> *Ibid.*, p. 182.

<sup>14</sup> *NTD*, p. 92, fig. 103 (T. 10, nos. 41-45), pp. 135-136.

the summer of 1961, to have flakes of the grayish incrustation on one of our vases analyzed chemically, for there seemed little doubt that ours belonged to the same group.<sup>15</sup> The results of Miss Marie Farnsworth's first analysis were startling, and far exceeded most previous suggestions as to the *trompe l'oeil* effect these clay vases would have produced in their respective tombs. From the presence of tin oxide, she concluded that the surface was covered with a layer of tinfoil; in funerary usage this would certainly take the place of a silver vase. Only one sample was tested in 1961, but nine others from vases in this technique from the Tomb of the Bronzes, along with two from kylix fragments from the Tomb of the Ivory Pyxides, were taken in the spring of 1963.<sup>16</sup> All revealed a pure tin oxide spectrum in the spectographic photograph, and as Miss Farnsworth's note (Appendix II) will show, this compound is what would remain after the tin-incrusted vases had been subjected to cleaning in dilute hydrochloric acid. Although insufficient traces of incrustation remained on our P 17,738 and P 17,756 to warrant samples being removed, they have been included in the catalogue because of their similarity in surface treatment to the other vases in this technique. As a control group, three of the Ialysos vases (A 850, 860, and 861) were analyzed through the kindness of the British Museum Laboratory, and these likewise tested as pure tin oxide.<sup>17</sup> It therefore seems likely that we are dealing with the same sheathing material in all cases. A catalogue of known, but not necessarily tested, examples is presented in Appendix I. These are arranged according to shapes, which are illustrated in Figure 1.<sup>18</sup>

From the catalogue it is immediately apparent that all known tin-incrusted vases were found in tombs, and with the exception of the "pit caves" nos. 7, 66, and 67 at Zafer Papoura, which may be considered local deviants, these were all of the standard Mycenaean chamber tomb type. None were found in tholoi. In other words, the tin-incrustation was a specific funerary practice, as Evans had long ago correctly recognized, in imitation of more costly metal vases, and the latter would have been restricted to the royal tholoi or to exceptionally wealthy chamber tombs.<sup>19</sup> The occur-

<sup>15</sup> I am indebted to Mrs. Evelyn Smithson of the Agora staff for the information that Prof. Persson had commented on the identical appearance of our vases to his from Dendra, and for the suggestion that we send flakes from one of our vases to Miss Farnsworth for chemical analysis.

<sup>16</sup> These other samples were collected by Prof. Eugene Vanderpool and Mrs. Andreas Demoulini.

<sup>17</sup> Mr. Reynold Higgins reported by letter of March 12, 1963 that analysis of the deposits on A 850, 860 and 861 revealed tin oxide.

<sup>18</sup> The classification by shape number follows that of Arne Furumark, *The Mycenaean Pottery: Analysis and Classification*, Stockholm, 1941 (hereafter *MP*). Figure 1 was drawn by Miss Jean S. Stark; on it the false-necked jars from Knossos have been omitted (see below note 32).

<sup>19</sup> For example, the new Warrior Graves from Knossos: R. W. Hutchinson, *B.S.A.*, LI, 1956, pp. 68 ff. (Silver and Gold Cup Tomb); M. S. F. Hood, *B.S.A.*, LI, 1956, pp. 81 ff. (Gold Cup Tomb). From the ground plans and from the wealth of weapons, these are best interpreted as the graves of Greek settlers (cf. also F. Schachermeyr, "Forschungsbericht . . . 1957-1960," *Arch. Anz.*, 1962, cols. 152-154; Emily Vermeule, *Greece in the Bronze Age*, Chicago, 1964, pp. 146 f.).

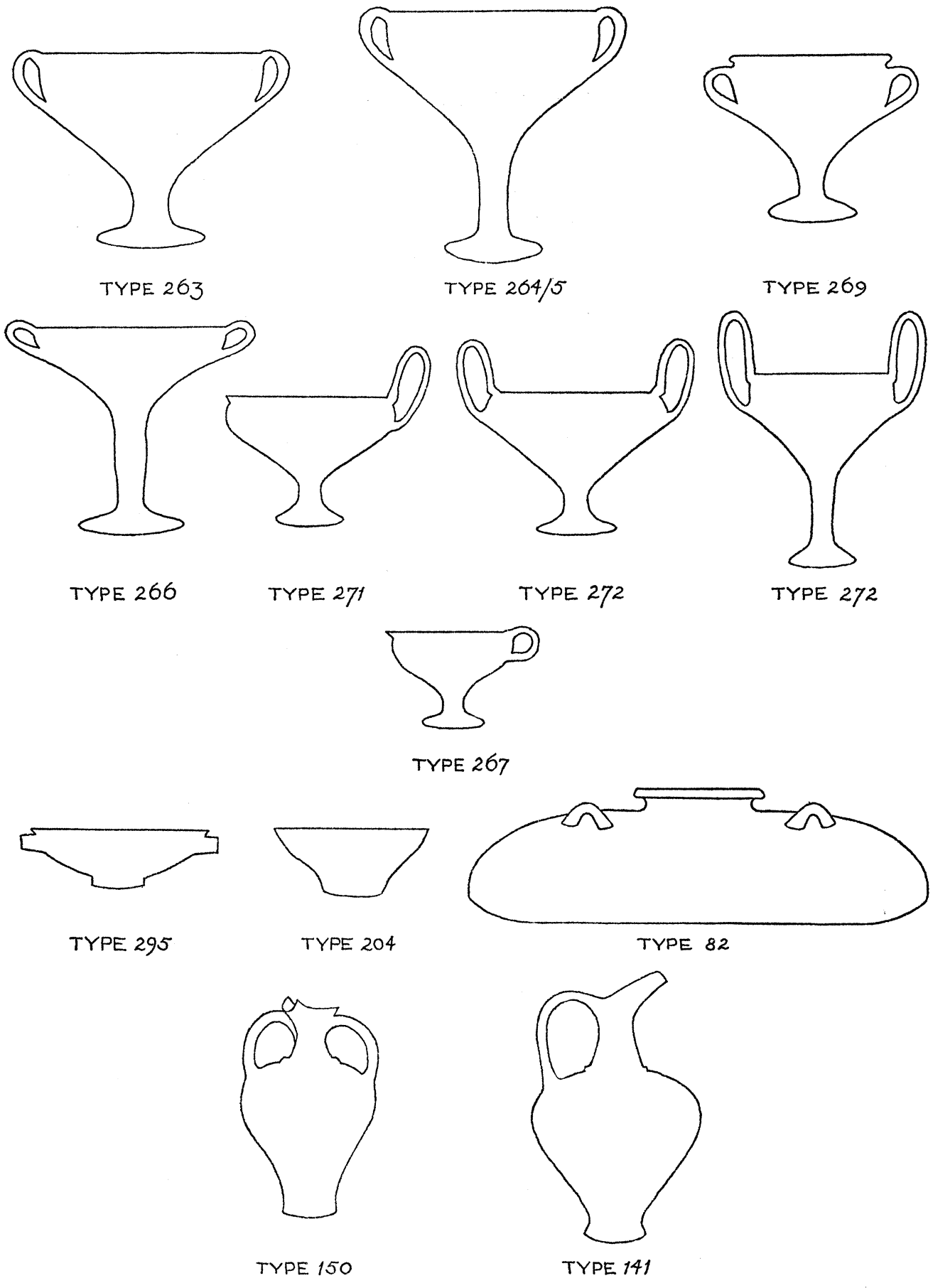


FIG. 1. Shapes of Vases with Tin Incrustation (ca. 1:4)

rence of both types in the same shaft of Tomb 10 at Dendra is unusual. Nonetheless, the tin-sheathing seems not to have been a mere poor-man's substitute for the more costly article, since most of the tombs in which these were found have pretensions of grandeur in their bronze weapons, ivories, fine painted vases, etc. As we shall see, tin, albeit in lieu of solid silver, carried considerable prestige owing to the relative scarcity of this metal.

Furthermore, the shapes on which the tin-incrustation occurs are all important in funerary ritual (Fig. 1). The kylix, in its various forms, comprises well over half of all known examples, and it was the standard shape for offerings of wine, either those drunk and poured by the relatives in the dromos or those left within the chamber for the enjoyment of the departed.<sup>20</sup> The shallow bowl either handleless or with horizontal ribbon handles, the second most prevalent shape, was, I suspect, the container for food offerings—grain, olives, figs, etc.—and its resemblance to the ideogram for the smallest measure for dry commodities on the Linear B tablets is suggestive.<sup>21</sup> Rarer shapes are the two alabastra and the two stirrup-vases from Isopata and Knossos, shapes which must have served as containers for perfumed oils and unguents, likewise important in the cult of the dead.<sup>22</sup> The two ewers, from Athens and Isopata, may also be considered part of a funerary service, useful for pouring wine from a large container, such as the three-handled pithoid jar (P 17,766) in our tomb.

How much the practice of tin-sheathing owed to the original metallic derivation of the shapes is debatable. Although the kylix in its various forms does occur in metal examples,<sup>23</sup> and significantly in the set of silver vases from Dendra, no metal alabastra or stirrup-vases have ever been found, and for the first a stone or alabaster origin seems likely in the light of Egyptian parallels.<sup>24</sup> The conical bowl shape, al-

<sup>20</sup> See Blegen, *Prosymna*, I, pp. 228-263, esp. pp. 237-238; George E. Mylonas, "Homeric and Mycenaean Burial Customs," *A.J.A.*, LII, 1948, pp. 56-81, esp. pp. 72-74.

<sup>21</sup> Michael Ventris and John Chadwick, *Documents in Mycenaean Greek*, Cambridge, 1956 (hereafter *Documents*), p. 50, ideogram no. 110, pp. 58 ff. with discussion of absolute values of symbols for volume. The smallest unit—our cup with or without a handle—is assigned a value of one-half liter or approximately a pint, on the basis of the Pylos Ab tablets. Only one of our cups approximates this postulated volume, P 17,763 with 450 grs. P 17,761 holds 250 grs. and the other three could not be measured at this time, but seems closer to the smaller variety.

<sup>22</sup> Cf. Hood's discussion of the alabastra from the new Warrior Graves and his opinion that they probably contained unguent or oil for anointing the body (M. S. F. Hood, "Late Minoan Warrior-Graves from Ayios Ioannis and the New Hospital Site at Knossos," *B.S.A.*, XLVII, 1952, pp. 243-277, esp. pp. 254-255). The stirrup-vase may have served the same function, but in a somewhat different chronological range.

<sup>23</sup> Bronze kylix from the Tomb of the Tripod Hearth (*PTK*, fig. 33, n) and silver kylix with one handle from the Royal Tomb at Isopata (*ibid.*, fig. 139). Furumark's discussion of the origins of the "stemmed cups" seems to me to minimize the metallic connections (*MP*, pp. 56-59).

<sup>24</sup> *MP*, pp. 39 f. for the alabastron shape and its derivation from Egyptian alabaster examples. For the stirrup-vase and its derivation from MM II ovoid jars, cf. *MP*, p. 19, notes 5 and 6. Evans believed in the existence of metal stirrup-vases because of the occurrence of metallic-type

though occurring in a bronze example from the Tomb of the Tripod Hearth, seems too purely utilitarian to propose more than a ceramic origin for it, and the type with ribbon handles is equally prevalent in simple clay examples from habitation sites.<sup>25</sup> Therefore, although the tin-sheathing would suggest a costly silver service, it would probably not be intended for pure deception so much as a "dressing-up" of simple clay containers for funeral display.<sup>26</sup>

It is interesting to note that almost all the recorded examples of this technique fall within a fairly narrow time range, from the late fifteenth through the first half of the fourteenth century, i.e. from shortly before the destruction of the Palace at Knossos through the Amarna period. The earliest examples, perhaps significantly, come from Crete; the two alabstra from Tomb 5 at Isopata should be dated LM II before the destruction of the palace.<sup>27</sup> This need not imply, however, that the technique was a specific Minoan invention. In the same tomb two of the four polychrome goblets bore representations of shields and helmets,<sup>28</sup> which remind one of the boar's tooth helmet depicted on the Palace Style jar from the new chamber tomb at Katsamba near Herakleion.<sup>29</sup> These representations of armor coincide with the advent of the new militarist dynasty at Knossos, which introduced many Mycenaean features, and may have kept a ready supply of tin for use in its armaments. The next two sets of tin-incrusted vases come from the wealthiest chamber tombs of our series, both on the mainland, Tomb 10 at Dendra and the Tomb of the Ivory Pyxides at Athens. These share many common features in their pottery, and should be dated about 1400 B.C. They seem to be followed shortly by Mycenae Tomb 515 and Knossos Tomb 7.<sup>30</sup> Our Tomb of the Bronzes with the most complete service in this

decoration on certain LM II stirrup-vases (Arthur J. Evans, *The Palace of Minos*, IV, London, 1935 [hereafter *PM*], pp. 300 ff.).

<sup>25</sup> Early Myc. III A examples from the palace at Mycenae (*B.S.A.*, XXV, 1921-23, fig. 33, b and d) and III B examples from the Potter's Shop at Zygouries (Carl W. Blegen, *Zygouries*, Cambridge, Mass., 1928, p. 158, fig. 150).

<sup>26</sup> A similar practice of offering relatively cheap articles intended to give the effect of objects of greater value occurs in later tombs. I am indebted to Miss Lucy Talcott for reminding me of the near solid lekythoi from Attic tombs, and to Mrs. Phyllis Lehmann for calling to my attention the fake jewelry from certain Samothracian tombs (see the lead-sheathed wooden crown with gilded bronze leaves and gilded terracotta berries from a fourth century B.C. tomb, *Archaeology*, VI, 1953, p. 34).

<sup>27</sup> Evans' date of LM I is too early (*TDA*, p. 30). Furumark (*MP*, p. 12, note 7, p. 40, note 4) dates the tomb to LM II (?), and the resemblance of the armor on the polychrome goblets to the helmets on the Palace Style jar from Katsamba (see below, note 29) strengthens this dating.

<sup>28</sup> *TDA*, p. 27, fig. 37, a and b.

<sup>29</sup> S. Alexiou, "The Boar's-tusk Helmet," *Antiquity*, XXVIII, 1954, pp. 211-213, pl. VIII.

<sup>30</sup> Mycenae Tomb 515 (*CT*, pp. 50-63) was a complicated tomb with 21 burials ranging from Myc. II through the Granary period. The lowest stratum in the chamber (burials IV-VI) to which our vases belong should be early in Myc. III A:2 (cf. A. Furumark, *Chronology of Mycenaean Pottery*, Stockholm, 1941 [hereafter *CMP*], p. 60). Tomb 7 at Zafer Papoura contained a painted three-handled jar (*PTK*, fig. 23) which, on the basis of its shape and decoration, should be early in the fourteenth century.

technique falls in the second quarter of the fourteenth century, and probably with it should be placed Knossos Tombs 66 and 67, Mycenae Tomb 502, and Tomb 37 at the Argive Heraion (see addendum to the catalogue, Appendix I). The Ialysos examples, although from the older and unscientific excavations of Biliotti,<sup>31</sup> are of early type and were found with other early Myc. III A vases; they should therefore be roughly contemporary with Dendra Tomb 10 and the Tomb of the Ivory Pyxides. Only Knossos Tomb 99 is later than the Amarna period, and one wonders whether the stirrup-vases are actually in this technique.<sup>32</sup>

It is curious that no other examples have been noted which would point to the continuation of this technique into the later Mycenaean period. One might argue that other occurrences have gone unnoticed by their excavators, either through too thorough cleaning of the pots in hydrochloric acid solution or through failure to recognize the black patches as anything more than soil incrustation. Indeed, as we have suggested in Appendix I, this must have been the case with some of the pottery from the tombs at the Argive Heraion, although the majority of kylikes and shallow bowls were apparently simply covered with glaze or left undecorated.<sup>33</sup> It is significant that only two of the forty-one Mycenaean tombs and graves from the Agora produced this class; they were by far the wealthiest and belonged to the crucial period in which this technique is found. Likewise at the Argive Heraion, if our surmises are correct, Tombs 37, 38, 41 and 2 follow the same pattern with costly offerings and deposits of the Myc. II-III A:2 period. In our other Athenian tombs the most characteristic type of kylix is the short-stemmed Ephyraean shape (Type 263) covered with red or brown glaze, which may also be imitative of metal,<sup>34</sup> but was surely within the reach of the humblest family.

Significantly, the tin-incrusted vases belong to the specific period in which metallic tin first became generally available as an article of international trade. Although bronze had been produced in the Mediterranean from some time in the third millennium, the ratio of tin to copper varies, and metallurgists have postulated that its manufacture took place merely by smelting together the natural tin-stone (cassiterite) and copper ores without reducing the cassiterite to metallic tin.<sup>35</sup> Not until the

<sup>31</sup> Published in Adolf Furtwängler and Georg Loeschcke, *Mykenische Vasen*, Berlin, 1886, pp. 1-18, pls. 1-11; also *BMCat*, I, 1, A 801-970.

<sup>32</sup> *PTK*, fig. 100. Dated to LM III B:1 by Furumark, *CMP*, p. 105. Both in shape and in chronological range, these are so out of line with the other examples that one wonders whether the "black varnish" Evans speaks of was not just the ordinary dark glaze. This proved to be true of the unusual kylix with horizontal handles (A 862) from Ialysos which Forsdyke had connected with A 850, 860, 861, and 863 in technique.

<sup>33</sup> See addendum to the catalogue for probable examples of tin-incrustation at the Argive Heraion. For a discussion of the occurrences of our specific shapes in the pottery there see *Prosymna*, I, pp. 413-414 (F 204), 425 (F 295), 432-434 (F 267, F 263-264, F 271, F 272), 440-441 (F 150).

<sup>34</sup> Frank Stubbings, "Mycenaean Pottery from Attica," *B.S.A.*, XLII, 1947, pp. 27 ff., 62 ff.

<sup>35</sup> The fullest account of the technology of ancient bronze manufacture that is intelligible to



XVIIIth dynasty are tin objects found in Egypt, and the tin content of the bronzes points to the steady importation of tin to a country in which cassiterite is lacking. At the same time we have evidence for the new controlled manufacture of bronze from the prepared metals in scenes in XVIIIth dynasty tombs. In the Tomb of Rekhmire, vizier of Thothmes III, Wainwright has recognized what he considers the first representation of this new method.<sup>36</sup> In the scene depicting the manufacture of bronze doors for the Temple of Amon at Karnak, a large ingot of oxhide shape and two baskets of small cake-shaped objects are represented, presumably the components of a crucible of molten metal which is being poured into the casting moulds. The ingot is easily recognizable as copper from its resemblance to the actual copper ingots found at many Mediterranean sites in the Late Bronze Age,<sup>37</sup> and Wainwright concluded that the small cakes must be tin. At the time of his writing (1944), no industrial tin had been found, but in the 1960 exploration of the Late Bronze Age wreck off Cape Gelidonya in Turkey, a number of piles of white powdery tin oxide were found.<sup>38</sup> They presumably comprised cakes of metallic tin of undetermined form, and along with the copper ingots and other tools of trade found in the wreck made up the smith's complement for the industrial production of bronze.

The tin trade, even in the Late Bronze Age, is elusive, since the metal traveled mainly as industrial tin for bronze production. Nonetheless, there are a few significant objects of metallic tin, the most famous of these being the pilgrim bottle found by Petrie in an XVIIIth dynasty grave at Abydos and now in the Ashmolean Museum.<sup>39</sup>

the layman can be found in R. J. Forbes, *Metallurgy in Antiquity*, Leiden, 1950, pp. 248 ff., esp. p. 251. See also A. Lucas, *Ancient Egyptian Materials and Industries*, 2nd ed., London, 1934, pp. 209-215.

<sup>36</sup> Norman de Garis Davies, *Paintings from the Tomb of Rekh-mi-re at Thebes*, New York, 1943, I, p. 54; II, pl. 53, row 3. G. A. Wainwright, "Egyptian Bronze-Making Again," *Antiquity*, XVIII, 1944, pp. 100-102. In the inscription above the casting scene the metal is referred to as "Asiatic copper which his majesty captured in victories in Retenu" (James H. Breasted, *Ancient Records*, II, Chicago, 1906-7, p. 292, no. 755), but this may have been the sobriquet for bronze (G. A. Wainwright, "Egyptian Bronze-Making," *Antiquity*, XVII, 1943, pp. 96-98).

<sup>37</sup> See especially H.-G. Buchholz, "Der Kupferhandel des zweiten vorchristlichen Jahrtausends," *Minoica, Festschrift zum 80. Geburtstag von Johannes Sundwall*, Berlin, 1958, pp. 92-115. Also George Bass, "The Cape Gelidonya Wreck: Preliminary Report," *A.J.A.*, LXV, 1961, pp. 267-276. The fact that the actual ingots when tested are always copper, not bronze, is against the theory that bronze was imported in ingot form. Cf. the analysis of the ingot from the Library at Ras Shamra, which was 98% pure copper with 0.88% tin and smaller traces of lead, iron, zinc, and sulphur, all counting as impurities (Claude F. A. Schaeffer, *Missions en Chypre*, Paris, 1936, p. 99).

<sup>38</sup> *A.J.A.*, LXV, 1961, p. 273. Bass doubts that the bun-shaped objects in the casting scene in the Tomb of Rekhmire are tin because they are painted the same color as the oxhide ingot (*ibid.*, p. 273, note 31); nonetheless tin had to be added at some time to the mixture, unless the ingots were already of the alloy, which we have seen reason to doubt (above, note 37).

<sup>39</sup> E. R. Ayrton, C. T. Currelly and A. E. P. Weigall, *Abydos*, III (The Egypt Exploration Fund, 1904), p. 50, pl. XVII. I am indebted to Miss Farnsworth for this reference and for the report of a spectrographic analysis made for her by the Ashmolean Museum, which revealed the bottle to be metallic tin. Also *PM*, II, London, 1928, p. 178, fig. 91.

Contemporary objects of tin are rare elsewhere in the Aegean, or have not been noted. The large ivory pyxis from the Tomb of the Ivory Pyxides in Athens had a tin lining,<sup>40</sup> and a folded sheet of tin was recovered from the Cape Gelidonya wreck, perhaps for some sheathing purpose.<sup>41</sup> Consequently, our fifteen certified examples of tin-incrusted vases and the probability that others were similarly treated have substantially increased the inventory of Late Bronze Age tin objects.

Tin was valuable because of its relative scarcity in the eastern Mediterranean.<sup>42</sup> Even in Homer it is mentioned several times for decorative inlay work in bronze, perhaps as a substitute for silver, and in Neo-Babylonian times its value was eight times that of copper and next to that of silver.<sup>43</sup> Although in later antiquity the tin fields of Spain and Cornwall were the most productive centers, it is unlikely that these were the source of our Mycenaean tin. Two possible Mediterranean sources have been proposed: Krisa near Delphi by Davies<sup>44</sup> and Byblos in Syria by Wainwright.<sup>45</sup> However, doubts have been expressed concerning both.<sup>46</sup> On the other hand, the tin fields of Bohemia and central Europe may have contributed to the knowledge and supply of tin from quite early times, and may have been responsible for the tin bangle from Thermi IV (*ca.* 2700-2350 B.C.) and the high tin content of the weapons from the Troy II treasure.<sup>47</sup>

<sup>40</sup> References to objects of tin in standard publications of prehistoric Aegean sites are practically nil. The ivory pyxis (*Hesperia*, IX, 1940, p. 286 f., figs. 27-29) preserved traces of a metal lining, analyzed as tin by Miss Farnsworth.

<sup>41</sup> Not mentioned in the preliminary report. I am indebted to Mr. Bass for supplying me with this information by letter.

<sup>42</sup> For a discussion of the location of tin deposits important in antiquity, see the chapter on "Tin, Antimony and Arsenic in Antiquity," in Forbes, *op. cit.*, pp. 231-271, esp. pp. 238-244.

<sup>43</sup> Forbes, *op. cit.*, pp. 254-255. Homer, *Iliad*, XI, 25 (breast plate of Kinyras), XI, 34 (shield of Agamemnon), XVIII, 474, 565, 574 (shield of Achilles), XXIII, 503 (chariot of Diomedes).

<sup>44</sup> O. Davies, "Two North Greek Mining Towns," *J.H.S.*, XLIX, 1929, pp. 89-99. Also G. A. Wainwright, "Early Tin in the Aegean," *Antiquity*, XVIII, 1944, p. 59. L. Dor, J. Jannoray, H. and M. Effenterre, *Kirra*, Paris, 1960, make no claims for tin-mining. Also S. Benton, "No Tin from Kirra in Phokis," *Antiquity*, XXXVIII, 1964, p. 138.

<sup>45</sup> G. A. Wainwright, "Egyptian Bronze-Making," *Antiquity*, XVII, 1943, pp. 96-98.

<sup>46</sup> Against Krisa, see Forbes, *op. cit.*, p. 244 ("the local provenance of the ore is doubtful"); against Byblos, *ibid.*, pp. 239-240, 253. His argument is that since Egypt was in contact with Byblos from early times but does not use bronze until the New Kingdom, the exploitation of tin in the Byblos region cannot have been early.

<sup>47</sup> Tin bangle from Thermi IV (Winifred Lamb, *Excavations at Thermi in Lesbos*, Cambridge, 1936, p. 171, fig. 50, pl. XXV, no. 30.24). See also the discussion by Wainwright in *Antiquity*, XVIII, 1944, pp. 57 f. On the tin fields of Bohemia and the possibility of their early exploitation and connection with the Troad, see Forbes, *op. cit.*, pp. 243, 251. Also V. Gordon Childe, *The Danube in Prehistory*, Oxford, 1929, pp. 239 ff., 414 ff.; Childe, *The Dawn of European Civilization*, 6th ed., New York, 1958, pp. 128 ff.; Childe, *The Bronze Age*, Cambridge, 1930, p. 140.

The current opinion seems to hold that the knowledge of bronze came later to Central Europe than to the Near East, but that once the supplies of alluvial tin-stone (in the Caucasus, Iran and Anatolia), which made possible the early development of true bronze in Mesopotamia (Ur dynasty), were exhausted or no longer accessible, metallurgists from Anatolia began to discover and exploit

Despite earlier sporadic contacts with tin-producing regions, it was apparently not until the XVIIIth dynasty that the tin content of bronze became stabilized at about ten percent and that tin objects and industrial tin began to circulate over the eastern Mediterranean. The sea-faring Keftiu may have been important in this trade, for the tin pilgrim bottle from Abydos has Aegean affinities,<sup>48</sup> and the same Tomb of Rekhmire with its scene of improved bronze casting represents elsewhere the famous Keftiu or "Cretan" envoys.<sup>49</sup> In this connection, one remembers that the earliest tin-incrusted vases come from the LM II Tomb 5 at Isopata. But should Crete alone be considered the main center of diffusion? Perhaps a more likely explanation would connect the tin trade with the Mycenaean element of the Keftiu, which by the mid-fifteenth century had already asserted its strong influence in Crete. This would be even more plausible if we knew for certain that the European tin fields of Bohemia were the source of supply in this period, since a series of Northern features—amber, boar's tusks, menhirs and stelai, as well as a barbaric abundance of gold—distinguishes Mycenaean from Cretan civilization even from the time of the Shaft Graves.

A suggestive link with Central Europe which may point to the exploitation of metal deposits in that area by the Mycenaeans has recently been furnished by Miss Sandars' study of later Aegean sword types.<sup>50</sup> In this important article, she shows

the European supply, introducing with them Anatolian metal forms to Danubian culture. Although true bronze does not become common at Troy until Troy V, the weapons from Schliemann's treasure of Troy II, when chemically analyzed, have been found to be real bronze, suggesting to Blegen that "they were imports from some foreign region metallurgically more advanced than the Troad" (Carl W. Blegen, *Troy and the Trojans* [*Ancient Peoples and Places*, vol. 33], New York, 1963, pp. 78-79). Blegen also comments (*op. cit.*, p. 87) on the distribution of the typical Trojan *depas* or two-handled goblet as far as Thrace and southeastern Bulgaria.

<sup>48</sup> *PM*, II, p. 178f. Although originally an old Oriental form, occurring in Troy II (Blegen et al., *Troy I*, Part 2, Princeton, 1950, fig. 386, no. 36.665), the type was taken over in the Middle Minoan period by Cretan potters, whence it was transmitted again to the Levant by Mycenaeans in the Myc. III A period. See also Furumark, *MP*, p. 32. On the other hand, the Abydos pilgrim flask is lentoid and baseless like the original prototype, so its Aegean affinities are not absolutely certain.

<sup>49</sup> For a recent study of the Keftiu and the probability that from the mid-fifteenth century on they comprised Mycenaeans rather than pure Minoans, see F. Schachermeyr, "Das Keftiu-Problem," *Jahresh.*, XLV, 1960, pp. 44-68. Against the theory that the over-painting of the dress in the Tomb of Rekhmire is of significance in distinguishing Mycenaeans from Minoans see E. T. Vermeule, *Greece in the Bronze Age*, pp. 148-151.

<sup>50</sup> N. K. Sandars, "Later Aegean Bronze Swords," *A.J.A.*, LXVII, 1963, pp. 117-153. Dr. Stephen Foltiny of the Institute for Advanced Study has also called to my attention the diffusion of Mycenaean sword types to Central Europe. Furthermore, he has noted the occurrence of a metal-incrusted vase from a grave in the Hungarian Banat (Szöreg near the confluence of the Tisza and Maros: Foltiny, *Dolgozatok*, Papers of the Archaeological Institute of Szeged University, XVII, 1941, pl. 18, fig. 6). The grave, dated to the Middle European Bronze Age (Toszeg C = Reinecke B or approximately 1500-1350 B.C.), is contemporary with our Mycenaean examples. Neither the shape, a typical Danubian mug, nor the manner of applying the metal to pick out plastic details conforms to our Mycenaean examples, yet the use of metal on pottery is significant.

that the Type C sword, that is the long horned rapier with midrib and riveted hilt which is the hallmark of the late fifteenth and early fourteenth century Mycenaean aristocracy, was diffused in a less luxurious version far to the North, occurring in Epiros, Jugoslavia, and Bulgaria, along with spear-heads of Aegean type. The farthest find-spots are situated close to the Danube river system, and hence not out of reach of the tin fields to the North, and one might well speculate that such swords of Aegean type were payment for one of the raw materials needed in their manufacture.

An interesting corollary of a study of the distribution of the Type C and D swords<sup>51</sup> of the luxury class may be noted. Their find-spots coincide almost exactly with the sites that have produced our tin-incrusted vases, for example, Knossos, Zafer Papoura, Dendra, Mycenae, the Argive Heraion, Athens and Ialysos. Furthermore, the chronological range coincides exactly. Luxury weapons along with metal or imitation metal vases were the appropriate paraphernalia of the Mycenaean warlords beginning with the late fifteenth century militarist dynasty at Knossos and continuing down through the first half of the fourteenth century, when weapons became more serviceable and mundane,<sup>52</sup> and the practice of the tin-incrusted vases apparently also ceases.

What can one conclude about the place or places of manufacture of the vases under discussion? The pots themselves are standard forms of the Myc. II-III A:2 repertory, and the sheathing material would have been available at any site where improved bronze was being produced from metallic copper and tin. The distribution of these vases and the coincidence of their find-spots with the distribution of the luxury class of C and D swords would suggest that this production was a palace monopoly, with an atelier centered at Knossos to account for the weapons in the Warrior Graves and the tin-incrusted vases at Zafer Papoura and Isopata, and with a contemporary or slightly later workshop in the Argolid at Mycenae. The latter could have been the distribution center for the weapons and vases at near-by Dendra and the Argive Heraion, and perhaps also for those at Athens. The remarkably high

Although the metal was not analyzed and has unfortunately now been lost through cleaning in hydrochloric acid, Dr. Foltiny felt quite certain that it was tin. Such tin-incrustation of pottery may have been a Central European tradition, for it survives in the later Alpine Urnfield culture as an accessory to incised decoration (see the large basin in C. Tsountas and J. I. Manatt, *The Mycenaean Age*, Boston and New York, 1897, p. 233, fig. 116, a reference supplied me by E. L. Bennett). Childe (*The Bronze Age*, pp. 210 f.) notes the dependence of the Alpine Urnfield Culture upon the Lausitz and Southwest Bohemian Tumulus culture. Can we assume that the Mycenaean learned the application of tinfoil to pottery in the region from which they may have imported their tin?

<sup>51</sup> The D-type swords with cruciform hilts are contemporary with the horned C type and have about the same distribution in the Aegean, but were not diffused to the North. Miss Sandars (*A.J.A.*, LXVII, 1963, pp. 126-128) considers the Class D sword the "Knossos sword *par excellence*" because of its frequency in the Warrior Graves.

<sup>52</sup> Sandars, *op. cit.*, pp. 130-132. She even goes so far as to suggest that with the destruction of the great workshop at Knossos at the end of LM II, the production of luxury weapons ended (*ibid.*, p. 127).

quality of the ivories and decorated pottery in the Tomb of the Ivory Pyxides, as well as its resemblance to the painted vases from Tomb 10 at Dendra, suggest that we are dealing with imports from the Argolid, and the same might be argued for the weapons and tin-sheathed vases from the neighboring Tomb of the Bronzes.<sup>53</sup> At Ialysos the situation is somewhat different. For two of the vases the tin-sheathing seems to have been an afterthought: A 860 had been previously covered with a red to black glaze and A 863 had a lustrous yellow surface. This would suggest local transformation at the time the vases were to be placed in the tombs, and the availability of tin can be assumed from the presence of a bronze industry at the near-by site of Trianda.<sup>54</sup>

In the thirteenth century we have documentary evidence for the palatial control of the bronze supply in the Jn series of Linear B tablets from Pylos. Here the tablets record the allotment by weight of metal to the various village smiths. Since the metal is described as *ka-ko* = χαλκός or "bronze" and no second metal is referred to, we may assume that the preliminary process of alloying the copper with tin had already taken place, probably at the palace itself.<sup>55</sup> That the Mycenaean palace was the repository for the raw materials needed in its economy seems preferable to the alternative theory that it imported finished bronze. However, the Cape Gelidonya wreck with its evidence for an itinerant smith as well as a merchant in copper ingots from Cyprus, and also the founders' hoards from Mycenae and Athens,<sup>56</sup> warn us that this rigid palace monopoly may have been collapsing at the close of the Mycenaean age.

Whatever the implications of this class of Mycenaean pottery, it has seemed worthwhile to present the evidence in full and to call it to the attention of field archaeologists. Only through careful scrutiny and through chemical analysis of suspicious surface incrustation, before vases are cleaned in hydrochloric acid solution,<sup>57</sup> can we know for certain whether the practice of tin-sheathing was restricted to a given period and to specific sites, as we have suggested, or whether it was more common and of longer duration. By increasing significantly the number of tin objects of the period, this class has contributed to our knowledge of the tin trade in the Late Bronze Age, and to the outside connections of the Mycenaeans, perhaps as far as the Bohemian tin fields.

<sup>53</sup> P 15,238 (*Hesperia*, IX, 1940, p. 281, fig. 19) cf. *NTD*, figs. 79, 83; P 15,237 (*ibid.*, p. 281, fig. 20) cf. *NTD*, fig. 81:1-2; P 15,239 (*ibid.*, p. 281, fig. 21) cf. *Prosymna*, II, fig. 704, no. 844; P 15,235 and 15,236 (*ibid.*, p. 281, figs. 22-23) cf. *NTD*, fig. 104: 1 a-b.

<sup>54</sup> Sandars, *op. cit.*, p. 128.

<sup>55</sup> *Documents*, pp. 351-358, also p. 135. See also Vermeule, *Greece in the Bronze Age*, pp. 166-167 on the function of the palace "as a safe deposit and central goods-exchange for most products."

<sup>56</sup> Sandars, *op. cit.*, pp. 135 ff.; Έφ. Ἀρχ., 1891, p. 25 and *B.S.A.*, XLVIII, 1953, pp. 6-7, pl. 2 (two hoards from Mycenae); O. Montelius, *La Grèce préclassique*, 1924, p. 155, figs. 481-499 (Athens, Acropolis).

<sup>57</sup> The usual practice of cleaning potsherds in dilute hydrochloric acid is deplored by Miss Farnsworth. She feels that a solution of Calgon would be sufficient and would not destroy evidence such as the tin-incrustation. See Appendix II.

## APPENDIX I

## CATALOGUE OF TIN-INCURED VASES

In each group examples are listed according to site, in what seems to be the correct chronological order. Examples tested in the laboratory are marked with an asterisk.

Form 79. "Stemmed Cup" (kylix). 25 examples.

Type 263: deep-bowled with low stem.

Dendra, N.T. 10, no. 41 (*NTD*, fig. 103:1)

Types 264-265: deep-bowled with medium stem.

Knossos, T. 7, f (*PTK*, p. 124, fig. 118, 7 f)

Mycenae, T. 515, no. 48 (*CT*, pl. XXXI)

\* Athens, T. M 21 :2, P 17,755 (Pl. 92, b)

Type 269: deep-bowled with handles below rim.

\* Ialysos, O.T. 5 (*BMCat*, I, 1, A 860, pl. X)

\* Ialysos, O.T. 5 (*BMCat*, I, 1, A 861, fig. 205)

Type 266: shallow-bowled with high stem.

Ialysos, O.T. 7 (*BMCat*, I, 1, A 863, pl. X)

Mycenae, T. 515, no. 49 (*CT*, pl. XXXI)

Type 271: deep-bowled with one high-swung handle.

Dendra, N.T. 10, no. 44 (*NTD*, fig. 103:4)

\* Athens, T. M 21 :2, P 17,754 (Pl. 92, b)

Type 272: deep-bowled with two high-swung handles.

Dendra, N.T. 10, no. 45 (*NTD*, fig. 103:5)

\* Athens, T. M 21 :2, P 17,764 (Pl. 92, b)

Mycenae, T. 502, no. 17 (*CT*, p. 8, not illustrated)

Type 267: low-stemmed with one handle, lightly carinated bowl.

Dendra, N.T. 10, no. 42 (*NTD*, fig. 103:2)

Dendra, N.T. 10, no. 43 (*NTD*, fig. 103:3)

Mycenae, T. 515, no. 52 (*CT*, pl. XXXI)

Athens, T. M 21 :2, P 17,756 (Pl. 92, b: insufficient remains)

\* Athens, T. M 21 :2, P 17,760 (Pl. 92, b)

\* Athens, T. M 21 :2, P 17,765 (Pl. 92, b)

Knossos, T. 66, h (*PTK*, p. 124, fig. 118, 66 h)

Knossos, T. 66, n (*PTK*, p. 72, not illustrated)

Knossos, T. 67, b (*PTK*, p. 73, not illustrated)

Knossos, T. 67, c (*PTK*, p. 73, not illustrated)

Uncertain form.

\* Athens, T. N 21-22 :1, P 27,100 (fragment: stem and foot)

\* Athens, T. N 21-22 :1, P 27,101 (high-swung handle)

Form 85: "Shallow Bowls with Flat Horizontal Handles." 5 examples.

Type 295: smaller type.

\* Ialysos, Tomb A (*BMCat*, I, 1, A 850, pl. X)

Mycenae, T. 515, no. 51 (*CT*, pl. XXXI)

\* Athens, T. M 21 :2, P 17,759 (Pl. 92, b)

\* Athens, T. M 21 :2, P 17,763 (Pl. 92, b)

Knossos, T. 67, a (*PTK*, p. 72, not illustrated)

Form 57: "Handleless Cup." 3 examples.

Type 204: plain.

- \* Athens, T. M 21 :2, P 17,758 (Pl. 92, b)
- \* Athens, T. M 21 :2, P 17,761 (Pl. 92, b)
- \* Athens, T. M 21 :2, P 17,762 (Pl. 92, b)

Form 16: "Alabastron." 2 examples.

Type 82

- Isopata, T. 5, b (*TDA*, p. 25, fig. 35)
- Isopata, T. 5, c (*TDA*, p. 25, not illustrated. Oxford)

Form 46: "False-Necked Jar." 2 examples (not certain, see note 32).

Type 178.

- Knossos, T. 99, 1 (*PTK*, fig. 100)
- Knossos, T. 99, m (*PTK*, fig. 100)

Form 42: "Amphoroid (Beaked) Jug." 1 example.

Type 150.

- Athens, T. M 21 :2, P 17,738 (Pl. 92, b: insufficient remains)

Form 40: "Tall Beaked Jug." 1 example.

Type 141.

- Isopata, T. 5, d (*TDA*, p. 25, fig. 36, which Evans says "also shows traces of a bright red pigment of a powdery nature").

#### ADDENDUM

The catalogue was compiled in 1963 when the original version of this paper was written. In the summer of 1964 it became apparent that the number of vases in this technique could be substantially increased from the pottery found in tombs at the Argive Heraion. At least nine clear examples were on display in the Argive Heraion case in the Mycenaean Room of the National Museum. These included six kylikes (Types 271, 1 example; 272, 3; 266, 1; 267, 1) and three shallow bowls (Type 204). Samples were not analyzed, nor were the vases removed from the case, but there was no doubt that they were identical in appearance to ours. Unfortunately, in only one case could the exposed number (the others were apparently N. M. inventory numbers) be reconciled with the numbering in *Prosymna*. This was the kylix with two high-swung handles no. 712 from Tomb 37 (*Prosymna*, II, fig. 297). From the other illustrations (figs. 294, 296) of the pottery from this tomb, it looks very much as if we have another "imitation silver" service consisting of four kylikes (nos. 720, 714, 712, and 713) and three shallow bowls (nos. 717, 719, and 718) corresponding very closely to those from our Tomb of the Bronzes. This is particularly interesting since Tomb 37 also contained a splendid horned rapier with gold plated rivets (*ibid.*, fig. 298) and belongs to the same chronological range (Myc. III A:1-2) as our tomb.

From a scrutiny of the plates in *Prosymna*, II other possible candidates for vases in this technique may occur in Tombs 38 (figs. 305, 307), 41 (figs. 353, 356, 357), 15 (fig. 425), 2 (figs. 433, 435, 438). However, without a thorough examination of the vases and some testing of samples, it seems unwise to add any of the *Prosymna* material to the catalogue.

## APPENDIX II

## SPECTROGRAPHIC ANALYSIS OF SAMPLES

By MARIE FARNSWORTH

In 1961 one sample of grayish incrustation from a Mycenaean vase (P 17,763) was sent from Athens and examined spectrographically. There was no doubt whatever that the material was tin oxide. Later (1963) eleven additional samples were examined in the same manner (Pl. 93). All were found to be quite pure tin oxide. Reading from the top of the plate down, the spectra are as follows:

iron, P 17,754, P 17,755, P 17,758, P 17,759, P 17,760, P 17,761, P 17,762, P 17,764, P 17,765, P 27,100, P 27,101, pure tin oxide (modern), spex mix

The three known substances, iron, pure tin oxide, and the so-called spex mix were added for comparison. We added tin oxide to the plate, for we knew from our first test that at least some, if not all, would probably be tin. Spex mix is a commercial product, a mixture of many metal oxides, to enable an unknown line to be identified by comparison. Iron is commonly added to spectrographic plates to line up the unknown plate with a standard.

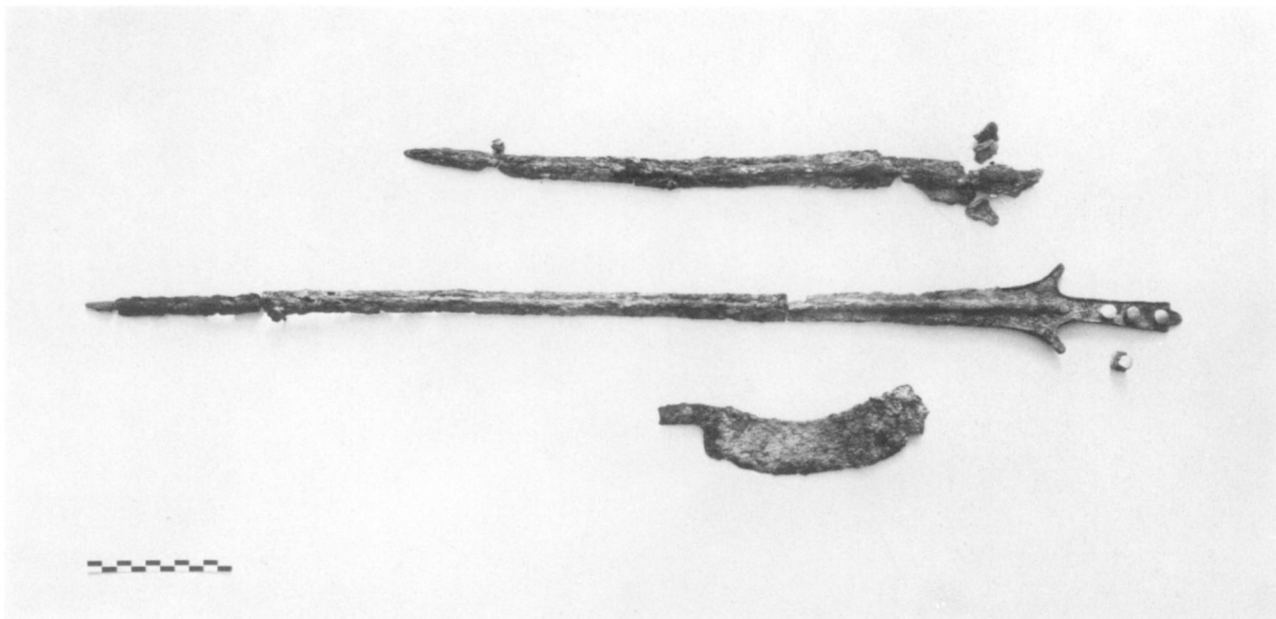
The results are qualitative, not quantitative. The entire sample was burned and the amount of sample, while consistently small, varied greatly. Some samples were undoubtedly twice as large as others. As one looks at the plate, there is no doubt that, with the exception of the top (iron) and the bottom (spex mix), all are tin and surprisingly pure tin, when one considers that some of the pot may have adhered to the incrustation and some soil may have been deposited in its porous structure. The question naturally arises: Did the Mycenaean use a tin of such high purity? As yet we have no way of knowing. Tin dissolves readily in dilute hydrochloric acid which, unfortunately, was used for cleaning these pots. As the acidity of the solution decreased, either by the acid being used up or, more probably, by dilution in the washing process, the tin hydrolyzed to insoluble tin hydroxide, adhered to the pot, and later dried to tin oxide, which is what we analyzed. The common impurities in tin, copper for example, would not hydrolyze to an insoluble product and would be washed away.

Examination of vases which have not been subjected to the acid bath would give some indication of the thickness and purity of the tin and possibly of the method of application of the metal to the pot.

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CHAPEL HILL, N. C.





a. Bronzes from Tomb of the Bronzes M 21 :2 : Sword B 781, Rapier B 778, Razor B 782.



P 17,762  
P 17,761

P 17,757  
P 17,754  
P 17,756

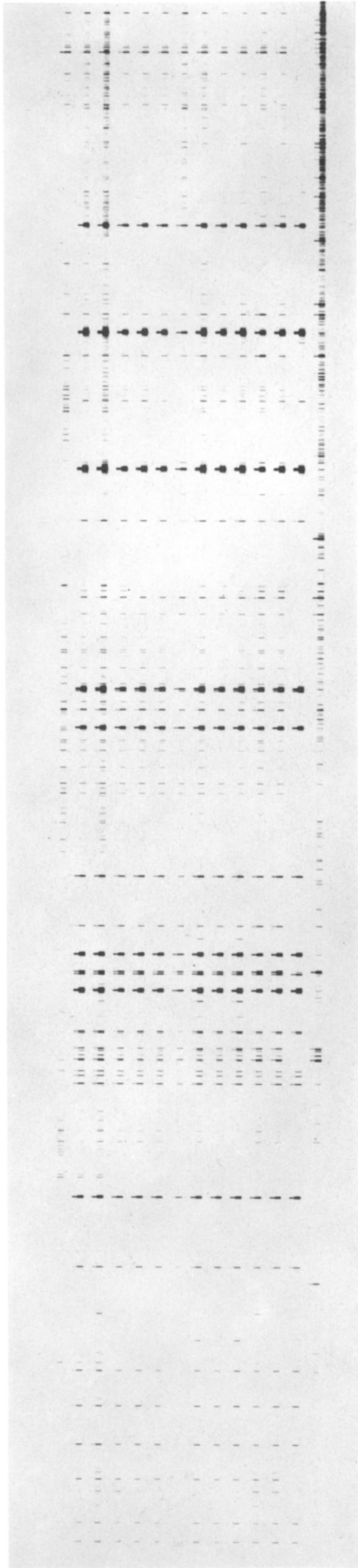
P 17,753  
P 17,755  
P 17,759

P 17,766  
P 17,764  
P 17,758

P 17,767  
P 17,765  
P 17,760

P 17,738  
P 17,763

b. Pottery from Tomb of the Bronzes M 21 :2.



Spectrographic Analysis of Samples.

Reading from top to bottom, the spectra are:

iron

P 17,754

P 17,755

P 17,758

P 17,759

P 17,760

P 17,761

P 17,762

P 17,764

P 17,765

P 27,100

P 27,101

pure tin oxide (modern)

spex mix