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The black bronzes of Burma

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Summary Following the donation of 25 Burmese lime boxes to the British Museum in 2005, selected boxes were treated and a technical study was carried out. The boxes are made of silver, copper, brass, cupro-nickel and black-patinated copper alloy, or combinations of these materials. Three types of different alloy compositions (copper with 1.8% silver and 1.2% gold, copper with 10% silver or copper with 0.9% arsenic) were found for parts that are suggested to have been patinated originally. The use of black-patinated copper alloys and details of the construction of the boxes are described. The techniques encountered on these boxes include engraving, chasing and the use of niello; silver braze and copper alloy wires used as inlays were also found. The analyses of the alloy compositions indicate that some areas which now have a copper colour were originally intended to be patinated. The condition of the boxes, and conservation treatments that removed surface dirt, corrosion and lime deposits, encourage reconsideration of the original appearance of the objects and form a basis for discussing the desired appearance of the objects for future display. The ethical issues surrounding restoration of the patina on some of the objects are discussed.

INTRODUCTION

Although the patina on ancient bronzes is now a much admired aspect of their appearance, it seems that originally metals were usually kept in a polished metallic state [1]. An exception to this is the family of black-patinated and inlaid copper alloys containing small quantities of gold, silver and sometimes arsenic. The term ‘family’ is used advisedly, for it seems likely that the manufacture and appreciation of this most sophisticated of materials has been linked through the millennia and across the continents from the Mediterranean world of the third millennium BC to present-day Japan [2].

As Japanese *shakudo* alloys are still in production, there is a much greater knowledge of their methods of treatment and the nature of the patina; these are taken as representative of other black patinas on copper alloys [3, 4]. The copper is alloyed with small quantities of gold and/or silver, typically between about 0.25 and 2%. Although rarely mentioned in the recipes, small amounts of arsenic are often present in quantities significantly above those found in contemporary alloys. The metal can be cast or forged to shape before being inlaid with precious metals; alternatively the alloy itself can form the inlay. The finished piece is then carefully cleaned and polished. As with all surface treatments, the physical condition of the surface is crit-

ical to the appearance following the subsequent chemical treatment. After polishing, the surface is first treated with certain fruit or vegetable juices before the piece is placed in boiling water containing small quantities of buffered copper salts including blue vitriol (copper sulphate), verdigris (copper ethanoate) and saltpetre (potassium nitrate) or alum (aluminium potassium sulphate). Dense purple-black patinas are formed that contrast well with the adjacent metals. The principal mineral present in the patina, as detected by X-ray diffraction, is copper(I) oxide [3].

The first studies on the use of these alloys outside Japan concentrated on the earlier, occidental occurrences, exemplified by the *hympty km* of the Egyptians, the *kyanos* of the Greeks and, most famously, the *Corinthium aes* of the Romans [2, 5]. Scholars across several disciplines have known about these ancient black bronzes, or bronze alloyed with small quantities of gold and silver, but links have not been established between the descriptions from these different places and periods, nor with traditional patinated Japanese *irogane* alloys, especially *shakudo*. The British Museum is extremely well placed to examine these interconnections, as not only are objects from each of these cultures present in the collections, but also there are in-house facilities to undertake scientific examination and experimental replication of the alloys [6], allowing factual information to replace speculation as to the nature of these materials.



FIGURE 1. Map showing some of the locations where the black-patinated alloys have been produced in south east Asia

Japanese *irogane* metals have been appreciated for over a century in the west, but more recent work has shown that similar patinated alloys were being made in many centres in east and south east Asia, Figure 1 [7, 8], and that some, notably the *sawasa* wares, seem to have been made in the seventeenth and eighteenth centuries especially for sale to the west [9]. The number of regional varieties and centres of

production now known to have been in operation, mainly in the post-Mediaeval period, is steadily increasing.

A recent donation to the British Museum of a collection of highly decorated polychrome metal boxes has significantly contributed to this increased knowledge. This contribution describes the manufacture of these boxes, together with an account of their conservation and some discussion as to whether those that have lost their original decorative surfaces should be repatinated.

MYLAR AND THE BURMESE LIME BOXES

In 2005 the British Museum received a collection of 25 metal lime containers (*hton bu*) used in the preparation of the betel quid [10], presented by Ralph and Ruth Isaacs, who collected them in Burma in the early 1990s. Stylistically, the boxes (registration numbers 2005,0115.1–25; Figure 2) are purely local and were certainly made in Burma, probably mainly in the Shan States in the north east, bordering the province of Yunnan in China. Several of the pieces are dated, usually to the first part of the twentieth century and bear the owner's name; one box is dated to 1959, but this need not necessarily be the date of manufacture. The production of patinated boxes had long ceased by the time the Isaacs made their collection and Fraser-Lu made her study of Burmese crafts in 1994 [11].

The collection comprises boxes manufactured using a range of techniques and materials, including silver, various copper alloys, either embossed or engraved with inlays of niello or lacquer. Thirteen boxes in the collection use a black-patinated alloy, locally known as *mylar* [12]. From the outward appearance of the boxes, it was immediately



FIGURE 2. Selection of lime boxes with *mylar* from Burma that are part of the Ralph and Ruth Isaacs gift to the British Museum. Top left to bottom right, respectively registration numbers: 2005,0115.10, 12, 14–17



FIGURE 3. Selection of ink boxes formerly in the Collier collection, made of *wu tong* with silver braze alloy inlays, dating to the nineteenth or early twentieth century: 1992,1109.1–6

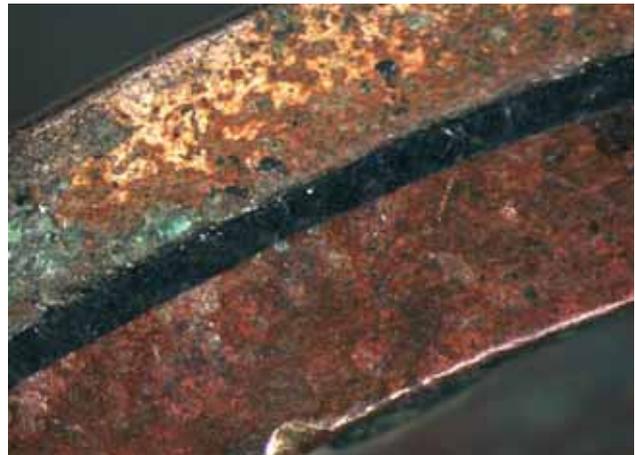


FIGURE 4. Detail of the rim of the bottom of lime box 2005,0115.12 showing the laminated construction; untreated. From the top downwards the metals are white metal (raised strip) but with some corrosion, *mylar* and copper: image size 6 × 4.5 mm

apparent that there were parallels with the *wu tong* boxes produced in the province of Yunnan in China and this has been confirmed by scientific study, Figure 3. All these boxes were made with the black-patinated copper alloy and some had inlays of silver brazing alloy. A number of the lime boxes show a greater range of techniques and materials in their construction and many are polychromic, with reds and yellows of copper and brass inlays used together with the black-patinated alloy and silvery metals.

The boxes have been built up from sheet components brazed together to form outer and inner jackets, Figure 4. The outer sheets are usually of the black-patinated alloy with an inner jacket of copper. Raised strips of silver or cupro-nickel were added at the edges as decoration and to conceal the brazed joins on the outside; a construction that

is very similar to the use of silver strips on *wu tong* boxes. The decorative channels on two boxes in the collection were engraved (Figure 5) or chased (Figure 6) and inlaid with molten silver brazing alloy, again similar to *wu tong* boxes, Figure 7; note the sharp points typical of engraved lines in Figures 5 and 7. Additionally, on one box sheets of silver and copper were brazed into recesses made by chasing, Figure 5. The colour difference between both the copper and silver sheets and the silver braze surrounding them is noticeable. Other boxes were built up from outer sheets of cupro-nickel or copper and flat lids with complex annular polychrome decorative schemes have been built up linearly, Figure 8. On these lids there is no underlying metal base plate into which the elements were set – the components were simply brazed to each other. The chevron patterns were made by twisting



FIGURE 5. Detail of the lid of lime box 2005,0115.12 after treatment. The inset to the upper left shows a detail of the inside where the shape of the chased decoration and remnants of lime can be seen. The inset to the bottom right shows a detail of the triangular shape of the engraved lines filled with silver braze: main image size 12 × 9 mm



FIGURE 6. Detail of the lid of lime box 2005,0115.13, made of black alloy, silver braze alloy inlay and silver strips, after treatment. The inset is a detail of the inside where the shape of the chased decoration and remnants of lime can be seen: main image size: 30 × 22 mm



FIGURE 7. Detail of a lid of *wu tong* ink box 1992,1109.4 before treatment: image size: 30 × 22 mm



FIGURE 8. Lid of lime box 2005,0115.16, decorated with concentric bands of red and white, chevrons of red, white and black, brown-red and white bands and 16 circles of white and brown-red; untreated

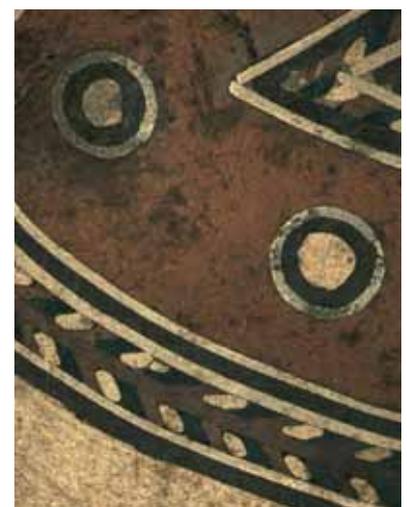


FIGURE 9. Detail of the lid shown in Figure 8. The chevrons comprise *mylar* (black), copper (red) and cupro-nickel alloy (white). The parallel bands of copper-arsenic alloy and cupro-nickel alloy are brown-black and white in colour respectively: image size: 15 × 11 mm



FIGURE 10. Detail of the chevron pattern on lime box 2005,0115.14; untreated. The left shows the outer surface of the twisted wire, at the right the wires were filed down to the middle causing a change in the pattern to rectangles: image size 30 × 22 mm

together combinations of wires of different metals, such as silver, copper, black-patinated alloy or a copper-arsenic alloy (Figure 9), to make a cable with a helical seam. In one instance it is clear that the inlaid twisted wire was filed down to the centre of the twisted wires revealing changes in pattern, Figure 10. The use of the different alloys – copper, cupro-nickel, *mylar* and copper-arsenic alloy – in and next to the chevron patterns creates an attractive colour scheme and the minor differences in alloy composition are clearly intentional.

CONDITION AND CONSERVATION

The condition of the collection was assessed upon its arrival at the British Museum. Although the general condition was considered stable, 10 of the boxes were judged to require surface cleaning and, to improve the fit of the lids, the removal of corrosion and lime deposits from the rims of both the boxes and the lids.

Little information was available on the methods employed for the maintenance of the patina during use in Burma, although it is clear that the boxes were used and would have been handled frequently. The suggested method of patination for the *wu tong* boxes is through handling, which initiates reactions between perspiration and the metal to promote the formation of the patina [8, 13]. In the case of Japanese *shakudo*, application of a wax after the chemical patination process is often suggested [14].

The following information was provided by Mr Isaacs regarding maintenance of the collection of boxes while they were in his ownership:

No wax or other coating was used after cleaning. Many of the boxes were really dirty. They were not washed, because I wanted to keep the lime inside them. But water and soap or detergent were used. Boxes of silver

were cleaned and polished with a domestic silver cleaner or at least an impregnated cloth. Copper boxes were polished with a brass cleaner, which might well have contained an abrasive. 'Black' boxes were wiped, the silver keel(s) cleaned with silver polish. The black surfaces may have had a wipe with a metal cleaning cloth. And I think it possible that some light mineral oil was used as well. The processes employed were used in order to see the decoration patterns and various inlays.

Tarnish and remnants of old cleaning compounds were removed from two silver boxes using successive swabs of white spirits, Silvo® silver polish in white spirits, industrial methylated spirit and distilled water on cotton swabs. A steam cleaner was used to remove traces of chalk or clay when possible. Finally the surface was given a general polish with cotton wool. The rims of the boxes and lids were mechanically cleaned with a scalpel to remove excess lime, providing a better fit.

The surface cleaning of the other boxes was carried out with white spirits on cotton wool swabs. Some corrosion on the silver-braze inlays was removed mechanically with a scalpel (Figure 11), and with Silvo® in white spirits on cotton wool swabs while working under a stereomicroscope at ×20 magnification. On some black surfaces it was found that the sheen was slightly altered. This was thought to result

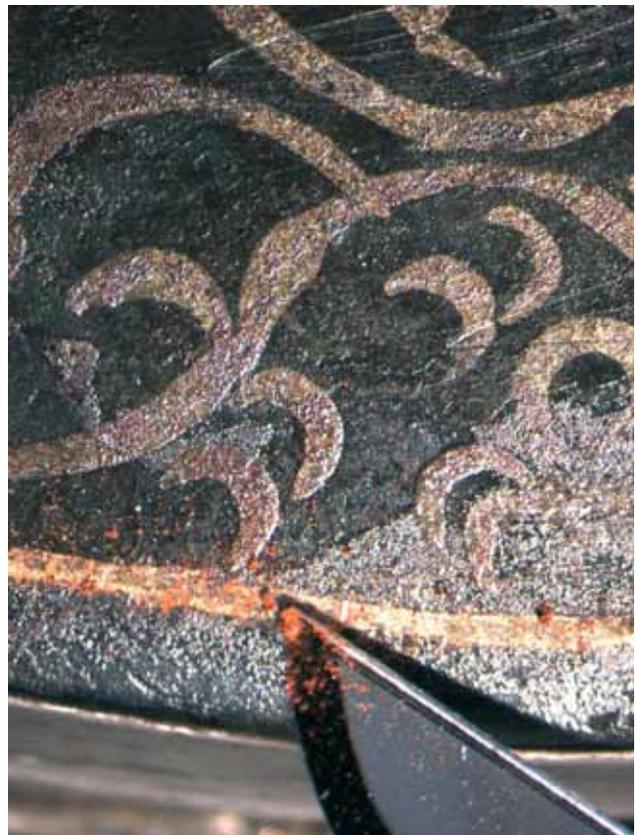


FIGURE 11. Detail of the lid from lime box 2005,0115.13, showing the removal of a corrosion layer on the surface of the silver alloy decoration: image size: 6 × 4.5 mm

from partial removal of surface dirt or possibly a wax layer; these would saturate the patination layer and thus deepen the colour and sheen. This layer was analysed by Fourier transform infrared (FTIR) spectroscopy, but gave inconclusive results. The necessity of either further cleaning of the grime or wax layer (possibly not without risk to the patina) or applying a microcrystalline wax to the surface to create a more uniform appearance of the surface was considered. It was decided not to undertake any further treatment, since the appearance of the surface was variable, depending on the light under which the surface was viewed.

During analytical investigation of the boxes, it became evident that some that now appear to be made of copper may originally have been patinated. The surface has a copper colour and it is impossible to differentiate visually between pure copper and alloys with small amounts of other metals that were intended to be patinated. Chemical analysis is essential to establish the composition of the alloy and subsequent original appearance. These analyses have also been used to inform a series of experiments that has been carried out to investigate patination methods and possible conser-

vation or restoration methods for patinated materials; the results of these experiments are presented elsewhere [6].

COMPOSITION

Some of the colonial period accounts of Burmese metal crafts suggest that various metals were imported by the European maritime trade [15]. This may have been true in the late nineteenth and early twentieth century, but other sources were also available [16]. The Bawdwin mines in the Shan States of north east Burma, for example, were a major source of silver when worked by the Chinese up to the mid-nineteenth century and were an equally important source of zinc when worked by the British in the twentieth century; these mines also produced significant quantities of lead and copper [17]. So-called *baw* silver from those mines, with a purity of at least 95%, was favoured by some silversmiths [11]. In the province of Yunnan in China (adjacent to Burma), major deposits of copper, tin, gold, silver, zinc and

TABLE 1. XRF results for alloy compositions on a selection of lime boxes

Box	Ag	Au	Cu	Pb	As	Zn	Sn	Fe	Co	Ni	Cr
2005,0115.1											
Side of box	98.8	0.2	1.0								
2005,0115.5											
Lid of box	88.6	0.3	11.0	0.2							
Interior of lid	85.7	0.3	14.0	0.1							
Niello	present		present	present							
2005,0115.12											
Silver	99.2	-	0.8	-	-	-	-	-	-	-	-
Silver braze	80.1	0.3	13.4	0.6	-	5.7	-	-	-	-	-
CuAgAu	1.6	1.4	96.1	-	0.2	0.5	-	0.2	-	-	trace
Copper	-	-	99.4	0.1	0.1	0.3	-	0.1	-	-	trace
White metal	-	-	74.2	0.4	0.1	9.7	-	0.2	-	15.4	-
CuAgAu - underside of lid	1.7	3.6	94.0	-	-	0.5	-	0.2	-	-	-
Copper interior	-	-	99.5	0.2	0.2	-	-	0.1	-	-	-
2005,0115.13											
Silver braze	62.3	0.1	28.5	1.1	-	8.2	-	-	-	-	-
CuAg 1	9.2	-	87.0	0.2	0.4	2.9	-	-	-	-	-
Silver edge	94.2	0.3	5.0	0.3	-	0.2	-	-	-	-	-
2005,0115.16											
Copper	0.05	-	99.3	0.24	0.12	0.31	0.15	0.05	-	0.04	-
CuAgAu	3.90	0.83	94.5	0.04	0.10	0.34	0.30	0.04	-	-	-
CuAs	0.05	-	98.8	0.02	0.65	0.31	0.06	0.04	0.02	0.08	-
White metal	0.06	-	59.6	0.56	0.04	24.6	0.56	0.45	0.1	14.4	-
Copper	0.05	-	99.3	0.24	0.12	0.31	0.15	0.05	-	0.04	-
2005,0115.17											
Brass	0.43	-	69.5	1.34	0.29	23.5	4.24	0.10	0.02	0.46	-
Copper	0.06	-	98.9	0.34	0.185	0.31	-	0.04	0.02	0.12	trace
CuAg	1.74	0.12	96.2	0.18	0.3	0.615	0.73	0.08	0.02	0.26	trace
CuAgAu	0.58	0.47	98.1	0.18	0.19	0.25	0.45	0.10	-	0.16	trace
White metal	0.12	-	61.6	0.53	0.12	26.8	0.30	1.27	0.23	9.1	trace

Note: '-' indicates that the concentration was below the detection limit.

nickel have been worked since antiquity [18]. Therefore, all the metals found in the *mylar* and *wu tong* alloys could be obtained locally.

Analysis was carried out on the unprepared surfaces using X-ray fluorescence, see Table 1 and the experimental appendix. The *mylar* components are usually of copper with between about 1.7 and 2.2% (average 1.8%) silver and 0.8–1.8% (average 1.2%) gold, with only traces of other metals, including arsenic. Some of the box components were of copper with about 10% silver and 0.4% arsenic but no gold, reminiscent of some Roman *Corinthium aes* alloys [2]. A third alloy that appeared to be patinated intentionally is the brown-black alloy of copper with 0.9% arsenic. This appears to resemble the Japanese alloy *Kuromi-do*, which comprises copper with 1% arsenic [19]. The inlays of silver brazing alloy that had been melted into place contained approximately 60% silver, 30% copper and 10% zinc.

The cupro-nickel components are copper with very variable quantities of nickel and zinc, but both average about 10%. The alloy also contains between about 0.5 and 1% iron, significantly higher than in the other copper-based components. The production of cupro-nickel may well have started in Yunnan and certainly its production formed a major commodity for trade with Europe in the eighteenth century [20, 21]. It was known as *paktong* and usually contained variable quantities of nickel, typically about 10%, and considerable quantities of zinc, typically between 20 and 40%. *Paktong* was made by co-smelting the iron-nickel sulphide ore pentlandite, $(\text{Fe,Ni})_3\text{S}_8$, with copper ores to produce an impure copper-nickel *matte*. This had to be further purified and zinc added, but even so the resulting *paktong* almost invariably contained 1% or more of iron. Cupro-nickel was produced in Europe from the 1820s, but by mixing metallic copper, nickel and zinc, the resulting alloys containing only traces of iron. The cupro-nickel components of the lime boxes have approximately the same nickel content as *paktong* but much less zinc. This could be because this material was intended to be worked as sheet metal and too much zinc might embrittle the alloy and make it unworkable. The average iron content is somewhat less than the average for *paktong*, but still much higher than in European cupro-nickel, suggesting that the source of the metal was Yunnan.

Little is known of the history of *mylar* production. Scott and Hardiman recorded the production of lime boxes, including those with black patination, at the beginning of the twentieth century [15]. They noted that the production of the inlaid lime boxes was a speciality of the brass workers of the town of Pokokku in the Pakokku district of Burma, Figure 1. They clearly had some inkling of the patination process and stated that the finished boxes were placed in a clay pot, heated and then buried for some time. Presumably this is a half-understood reference to the patinating solutions being heated in a pot, to which the authors added the idea of burial. Patinas were popularly believed to have been created by burial, although there is no real evidence for this anywhere. Maryon, for example, included burial as a patination technique in the first edition of his well-

known book on metalwork, but it is omitted in subsequent editions [22]. Tilly, in an article on Burmese silverware, refers to this type of material, though his understanding of the process is less profound; he relates it to damascening and claims that the blackening is produced by melting the copper with 5% gold and a little sulphur [23]. The latter part of this is almost certainly incorrect. The patina contains no sulphides, though similar erroneous assumptions were made by others [2].

DISCUSSION AND CONCLUDING REMARKS

The boxes have now been examined, analysed, conserved and cleaned and the intricate designs can be better appreciated. Mr Isaacs very properly chose not to clean the boxes comprehensively when they were in his care. However, before they came to him, some of the boxes had obviously been vigorously cleaned, removing the *mylar* patina along with the dirt in some instances, so that now a coppery inlay is set in a copper background, instead of a black patina contrasting with red metal.

During their examination and treatment the question arose of whether the *mylar* should be repatinated. It is certain that the distinctive *mylar* alloy would originally have been patinated and the knowledge gained from recent experiments would enable the patina to be restored [6]. On the other hand, the present state of the boxes, still containing some of their original contents of lime, worn and missing some of their patina, is a record of their history and should be preserved. This is a dilemma that occurs with many museum artefacts; should they be restored to reflect how it is believed they would originally have appeared, or should they be conserved and cleaned only to the extent that this preserves all visible evidence of their history? It could be argued that the original patina was removed in ignorance, a mistake that should now be rectified, while others would argue that this very ignorance of the deliberate patination of these boxes is a poignant comment on the rapid loss of appreciation of the technique and should, therefore, be preserved.

How ought this dilemma be resolved? There are models available that can be used to guide decisions about conservation and restoration decisions [24]. A similar problem was addressed by a team at the Victoria and Albert Museum, London when considering the watered pattern of *wootz* steel used to make an Indian axe head dating from 1739 to 1753. The distinctive pattern had been inadvertently removed by over-polishing before it entered the Museum's collections. After lengthy consideration, the decision was taken to restore the *wootz* pattern by re-etching using swabs bearing dilute nitric acid [25]. What is the ideal balance between established ethics of conservation, like reversibility and preservation, and the desire to restore the intended original appearance? This dilemma has not yet been resolved in the case of these boxes, but the present work provides a greater

understanding of black-patinated alloys and the protection of the valued patina from inappropriate cleaning.

It comes as something of a surprise to discover that so many metalworking traditions around the world have survived into the recent past only to pass away without adequate record. If this is true for the descriptions of the objects and the style of their decoration, it is even more the case for the techniques used to make them.

At the time of completing (as was thought in the early 1990s) the work on the history of the black-patinated bronzes, south and east Asia were investigated for traditions that could provide a link between classical antiquity and Mediaeval Japan, and the discovery of the Chinese *wu tong* was regarded as highly significant. Since then, no less than four more varieties have come to light and almost certainly there remain still more to be discovered and recorded. It is very likely that there were contacts and technical inter-relationships in the production of such a distinctive and sophisticated material, and it is hoped that further research will uncover these.

EXPERIMENTAL APPENDIX

The alloy compositions were analysed using a Bruker AXS ARTAX micro X-ray spectrometer (X-ray tube settings: 50 kV, 800 μ A, collimator 0.2 mm with a collection time of 300s). Detection limits for the technique are of the order of 0.01% for Cr, Fe, Co, Ni, Cu, Zn, Pb, Sb, of the order of 0.02% for Ag, Sn and 0.05% for As. Precision for copper is ~1–2% and decreasing down to ~50% for elements at or near the detection limit. The analyses were performed on uncleaned patinated surfaces.

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MATERIALS AND SUPPLIERS

- Cotton wool, industrial methylated spirit, white spirits: VWR International Ltd, Magna Park, Hunter Boulevard, Lutterworth, Leicestershire LE17 4XN, UK. Email: info@uk.vwr.com
- Silvo® Duraglit metal polish wadding: Reckitt Benckiser plc, 103–105 Bath Road, Slough, Berkshire SL1 3UH, UK

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