

What Were the Missing Leeuwenhoek Microscopes Really Like?

Brian J. Ford, Mill Park House, 57 Westville Road, Cardiff CF2 5DF

Summary

Antony van Leeuwenhoek died on 26 August 1723. He bequeathed to the Royal Society a collection of silver microscopes, each with a specimen attached, contained in little cases which were packed into a lacquered cabinet. There were 26 instruments, and they were documented shortly after arriving in London by Martin Folkes, then Vice-President of the Royal Society. About a century later, the collection was lost. Enquiries during the nineteenth century failed to find them, and it is possible that the collection is still in existence. There is much confusion about the appearance of the microscopes, and some of the surviving accounts have been misunderstood. A study of contemporaneous accounts and correspondence (some of which have since been misattributed) reveals how the microscopes would probably have appeared, and this reconstructed view is presented in the context of the history of the collection.

Background

Leeuwenhoek's microscopes were of a pattern first described by Robert Hooke, a decade before Leeuwenhoek began to make microscopes of his own. Hooke's description is given in a frequently-overlooked paragraph in the introduction to his *Micrographia* (1665):



Brian J. Ford was brought up in London and now lives in Wales, where he is Visiting Research Biologist at University College Cardiff and a Member of the Court of Governors. His published research covers haemostasis, locust reproduction, image analysis and forensic work. He is an authority on the origins of microscopy and a popular lecturer and keynote speaker at meetings around the world. His books and papers have been published internationally, and he is also well known for his broadcasts on radio and television.

If you take a very clear piece of a broken Venice Glasse, and in a Lamp draw it out into very small hairs or threads, then holding the ends of these threads in the flame, till they melt and run into a small round Globul, or drop, which will hang at the end of the thread; and if further you stick several of these upon the end of a stick with a little sealing Wax, so as that the threads stand upwards, and then on a Whetstone first grind off a good part of them, and afterward on a smooth Metal plate, with a little Tripoly, rub them till they come to be very smooth; if one of these be fixt with a little soft Wax against a small needle hole, prick'd through a thin Plate of Brasse, Lead, Pewter, or any other Metal, and an Object, plac'd very near, be look'd at through it, it will both magnifie and make some Objects more distinct than any of the great Microscopes.

Fig. 1. Hooke's original description of the type of microscope made famous by Leeuwenhoek occurs in this portion of the Preface from *Micrographia* (1665).

This is a remarkably close description of the kind of microscope Leeuwenhoek made so prolifically. The reason why Hooke did not use them for his own research is explained in the following sentence, which appears after the above extract: 'These, though exceedingly easily made, are yet very troublesome to be used, because of their smallness and the nearness of the object . . .' So Hooke turned away from simple microscopes and concentrated instead on the larger, compound instrument. This was manifestly easier to use, and it was better adapted to the use to which Hooke put it — namely, the demonstration of different specimens for the membership of the Royal Society to examine at their meetings. It was on April 1st 1663 that Robert Hooke was given the task of bringing in one new microscopical demonstration for each meeting and he responded on 8th April with a specimen of moss in the drawings of which (published in *Micrographia*) cell-walls are visible. On 13th April he demonstrated fine sections of cork, cut both transversely and longitudinally; it was in this important demonstration that his term the 'cell' was coined.

The compound microscope conferred several advantages for these demonstrations. First, it was large enough to be stable when handled by the members. Secondly, the working distance was greater than with the high-powered single lensed microscopes described earlier, so that focusing was less critical and the image was less likely to be disturbed by one member before it was examined by the next. Hooke's remark that simple microscopes were tiresome to use 'because . . . of the nearness of the object' shows why he used low magnifications, since magnification varies inversely with focal length. The illustrations Hooke prepared for publication show magnifications around x25, whilst Leeuwenhoek — using the more 'troublesome' lenses with higher magnifications — was able to observe structures and forms of life that were beyond Hooke's range.

Leeuwenhoek's Microscopes

The simplest type of microscope made by Leeuwenhoek was certainly based on the design of Hooke, q.v. (Ford 1981). It consisted of a lens fixed into the perforation of a metal holder, against which the specimen could be held. However, microscopes in which he fixed two lenses have been described, and the celebrated mezzotint portrait by Verkolje which appears as the frontispiece of Dobell's biography of 1932 portrays Leeuwenhoek holding a three-lensed microscope in his left hand.

However, the microscope we associate with his name is of the type illustrated (fig. 2.). It was constructed of a rounded pair of rectangular brass plates, fixed together by riveting, bearing a specimen stage in the form of a block of brass, from which the specimen pin itself projects. A screw running downwards from the specimen stage enables the user to adjust the height of the specimen relative to the microscope, and a screw normal to this passing through the stage provides the focusing control. If this screw is tightened, the specimen is moved away from the lens, whilst if the screw is loosened instead the specimen moves closer to the lens by virtue of the elasticity in the right-angled bracket of the base of the microscope, transmitted through the long screw.

The reason this picture is familiar to us is not because this 'block-stage' microscopes the only type of microscope Leeuwenhoek made. It so happens that an orig-

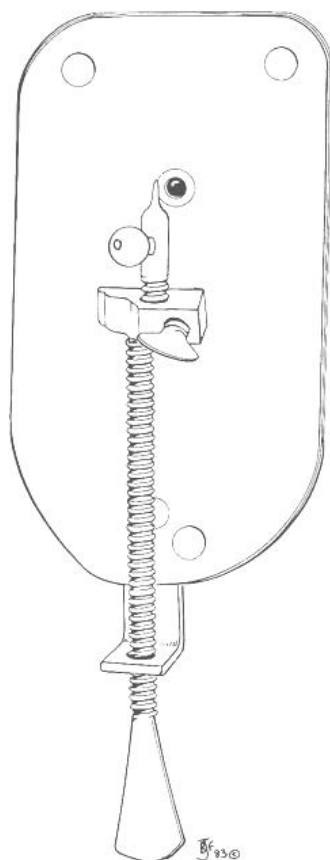
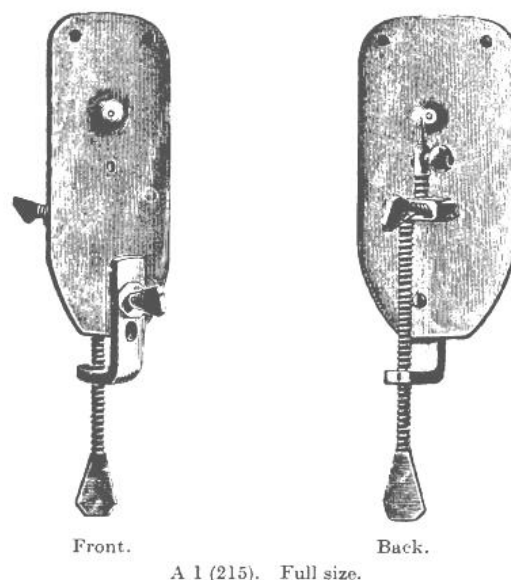


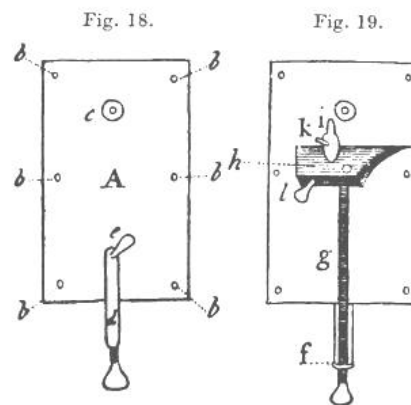
Fig. 2. Diagram showing the 'typical Leeuwenhoek microscope' based on the type in the Utrecht University Museum collection. Note the characteristic block stage.

inal microscope preserved in the collections of the University of Utrecht boasts the highest magnification of any of the known Leeuwenhoek microscopes, and has in consequence become the best known of them all. The process has been aided by the fact that the finest of the Victorian engravings of a Leeuwenhoek microscope showed this instrument, and the clarity of these representations was such an improvement on the earlier diagrams that there was an instinctive tendency to prefer these to their predecessors (see figure 3).

For these reasons, we have been taught that the Utrecht microscope — which is in fact just one of the types Leeuwenhoek made — is the 'typical Leeuwenhoek microscope' and alternative versions have consequently been disregarded. The earliest representation of a Leeuwenhoek microscope was published by Henry Baker and this was subsequently reproduced by Samuel Hoole in his *Select Works of Antony Van Leeuwenhoek* (1798, 1807). In consequence, Baker's diagrams have been referred to, incorrectly, as 'Hoole's figures' (Disney, Hill and Baker, 1928) and when his drawings have been published



A 1 (215). Full size.



A 1 (215): Hoole's figures.

Fig. 3. The Victorian engraving which popularised the Utrecht design, reproduced by Disney *et al* with Baker's diagrams (here attributed to Hoole, who merely reprinted Baker's original figure).

alongside the more aesthetic Victorian engravings, there has been a natural tendency either to dismiss them as amateurish and inaccurate portrayals (op. cit., plate 1, facing p. 160), or as 'drawn from memory' and 'not accurate as to details', (van Zuylen 1981).

However, if we look closely at Baker's first-hand account we may be able to reconstruct the appearance of Leeuwenhoek's missing 26 microscopes. His description does not merely include those diagrams as an aide-memoire, or as rough drawings, for his account includes the words:

The curious will be pleased to see a drawing . . . taken, *with great exactness*, from those in the Repository of the Royal Society, which are all alike in form, *and differ very little in size from this drawing*, or from one another.' [Author's italics]

I therefore conclude that these historic diagrams are accurate in terms of dimensions and construction. In this light it is possible to discard our preconceptions, and set out to rebuild a Leeuwenhoek microscope from Baker's diagrams.

Reconstruction of the Missing Microscopes

The Royal Society collection of microscopes were of a type that is clearly different from the Utrecht version in many respects. The lens is in a different (higher) position, the plates are proportionately broader, they are more sharply rectangular, rather than being rounded; and the focusing screw and specimen stage are different in shape and configuration.

a) The Plates

The typical Leeuwenhoek microscope has plates made of brass and conspicuously rounded at the corners. The missing microscopes had plates of silver measuring 22mm x 35mm with square corners. Whereas the Utrecht microscope is held by two conspicuous rivets at the upper corners with a third rivet situated centrally in the lower apex of the shaped plates, the Baker diagrams clearly reveal that the silver plates of the Royal Society microscopes were secured with six rivets, situated one at each corner and with two additional rivets above the mid-point of the two long sides.

b) The Screws

Baker's diagram does not show the screw threads with any great precision, and it is arguable that the pitch of the thread is not portrayed accurately. The number of turns of the thread he shows in the long vertical screw is approximately 85 in 30mm. However, close scrutiny of the engravings shows that many of the lines portrayed seem to be set in pairs, as though corresponding to the *two* faces of each turn in the thread. If this is so, then the number of turns is actually 42 per 30mm, giving a pitch of $30 \div 42 = 0.7$ mm.

It is noteworthy that the focusing screw through the stage seems to be smaller than the one on the Utrecht type of microscope, and that the specimen holder screw is fitted with a rod-like attachment, rather than the

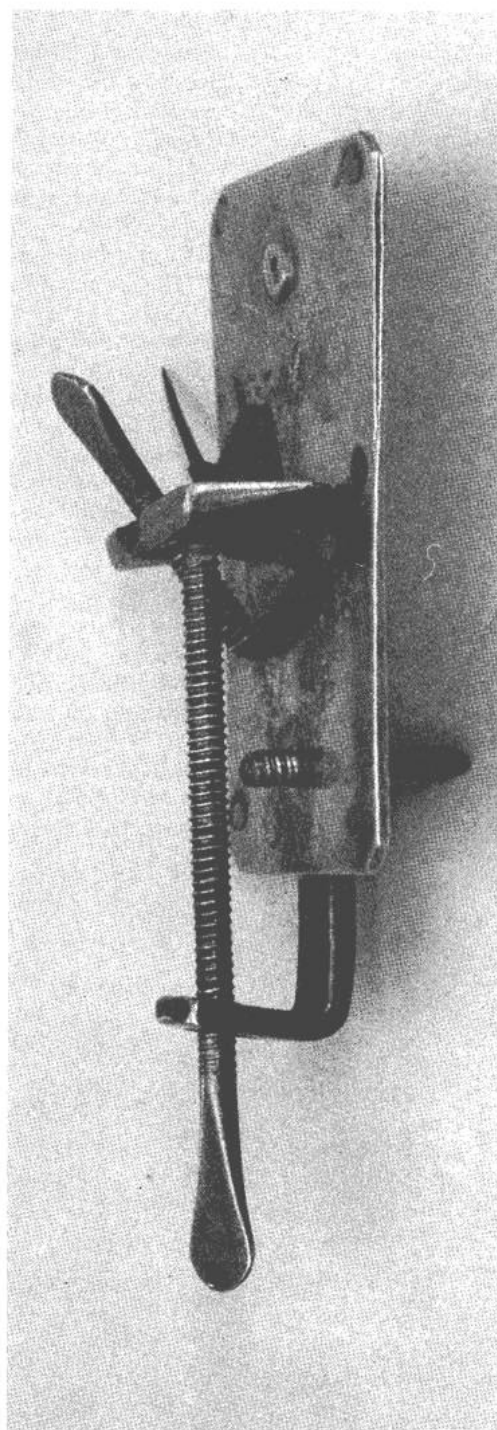


Fig. 4a. Oblique view of the silver microscope in the Deutsches Museum collection, Munich, showing some structures in common with the type figured by Baker.

rounded knob which is a prominent feature of the Utrecht instrument.

c) The Lens

The diagrams suggest that the lens is fixed 7mm from the upper extremity of the microscope body plates, i.e. $35 \div 7 = 20\%$ of the overall length from the upper extremity. The diameter of the perforation in the plate

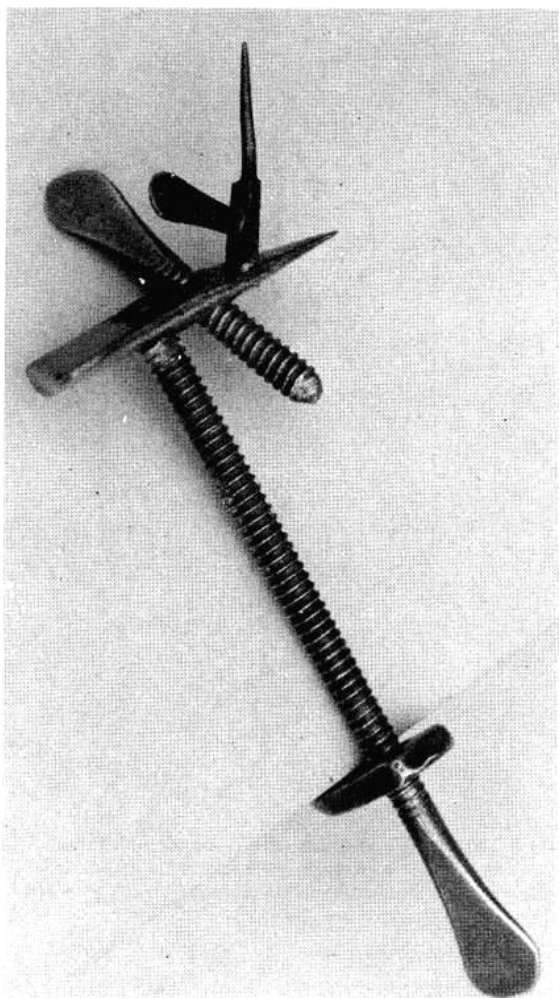


Fig. 4b. Main screw and tapering silver stage from instrument in previous figure. Note also solid steel specimen pin and oblique focusing screw.

is shown as 1mm, hence the lens would have been substantially greater in diameter than this. The diameter of the lens mount (i.e. the region of brass worked into a dome in order to retain the lens) is shown as 3mm, and the lens itself must have had a diameter of about 2mm in order to fit.

d) The stage

Here we are faced with an unusual structure. The stage portrayed by Baker seems to be tapering in cross-section, measuring perhaps 2mm in thickness at the (observer's) distal edge to less than 0.5mm at the edge nearest the microscope plate. The stage also tapers in plan view, for although the broadest 9mm are perhaps 4 or 5mm wide, the remainder tapers through a curve to a point. This is very different from the block stage represented by the Utrecht instrument.

e) Construction

The Baker drawings show clearly that the focusing screw is on the observer's *right*, whereas the typical

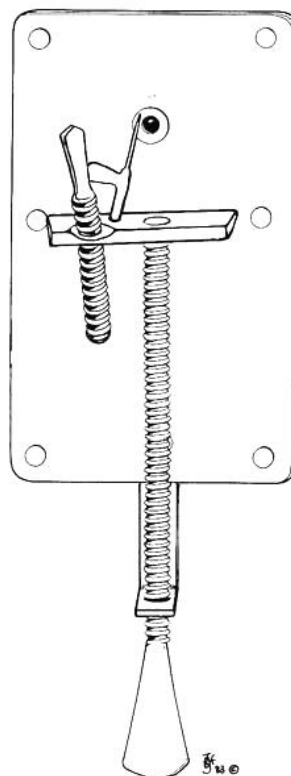


Fig. 5. Diagram showing the layout of the Munich instrument (Fig. 4a). The oblique focusing screw is unusual, and the tapering stage can be contrasted with the block stage with which we are more familiar.

design — so-called — has this screw on the *left*. This is not, as one might assume, a consequence of the user being right-or left-handed, for both versions are as easy to use as each other. A further discrepancy is that the Utrecht microscope has the right-angled bracket offset to the observer's right, so that the positioning screw can be oriented vertically, allowing the offset specimen pin to lie adjacent to the lens. If the bracket and the positioning screw were central, then the screw itself would have to be positioned at a slight angle, so that the specimen screw could take up this position.

In Baker's drawings, however, this is not the case: the bracket is exactly in the centre of the plate and for the specimen pin to be brought to the lens centre, the long screw would need to be offset to the observer's left.

Precedents for this Design

The construction of this version of a Leeuwenhoek microscope is different from the Utrecht type that is now so widely known. However, although we have Baker's assurance that the diagram is accurate, both in respect of design and dimensions, there is a further source of information, namely the design of lesser-known Leeuwenhoek instruments. It is possible to take the separate design considerations and relate them to different microscopes in the European collections. At the present moment these are collected together in a temporary exhibition (Englesman 1982) which makes it possible to compare the differences, though this means they are unavailable for close examination. For the

purpose of the present paper, Leeuwenhoek microscopes have been examined on the bench and, where necessary, carefully disassembled for measurement.

a) The Plates

Three of Leeuwenhoek's microscopes (in the collections at Munich and Leiden) are made of silver plates that are almost rectangular, and show a shape that is similar to that of Baker's drawings. The dimensions of the silver microscope in the Boerhaave Museum collection at Leiden, are close to the Baker figures, and the instrument owned by J. Willemse of Rotterdam closer still:

	Leiden microscope	Baker's drawings	Rotterdam microscope
WIDTH	19mm	22mm	22mm
LENGTH	32mm	35mm	39mm

The Utrecht microscope, and others like it, have plates that are approximately 24mm x 46mm.

b) The Screws

The length of the main positioning screw shown by Baker is 30mm (i.e. the length of the threaded section). The Utrecht thread is longer than this, approximately 40mm. However, the microscope at Rotterdam in the possession of W de Loos has a thread measuring 28.5mm.

Furthermore, there is a 22mm screw on the silver microscope in the Leiden collection — now, sadly, held in place with model-maker's glue — and so a screw measuring 30mm is well within the range of the known instruments, even if it is markedly shorter than the example from Utrecht. In the same way, the pitch of the screw of the Utrecht microscope, at 0.86, is significantly different from Baker's figure which can be measured at 0.70. It may be — since this detail is so small in Baker's drawing — that the pitch of this screw is not accurately portrayed, and it is not necessary to assume that such fine detail should conform exactly to the original instrument. If we take Baker at his word, and insist that even this feature *was* accurately measured, then what other Leeuwenhoek microscopes can match this?

Two of the microscopes that still exist have a pitch that is within 0.04mm of this figure. They are the silver microscope at Munich (0.66) and the brass microscope in the same collection (0.67). Other Leeuwenhoek microscopes range on both sides of the figure obtained from Baker's drawing, the finest pitch being 0.60mm on the long screw of the Rotterdam microscope possessed by Willemse, and the coarsest 0.97mm on the brass microscope at Antwerp. Several of the microscopes also lack the round knob for focusing, which is present in the Utrecht version.

c) The lens

Baker's dimension for the diameter of the lens aperture, 1mm, compares favourably with the other

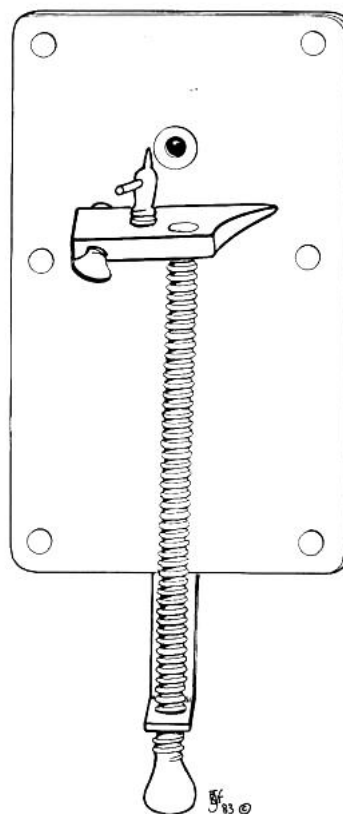


Fig. 6. Utilising the evidence described in the text, this reconstruction shows the type of microscope which features in the collection lost from the Royal Society. Actual size of rectangular plates = 22mm x 35mm.

Leeuwenhoek microscopes. They range from 0.55mm (the brass microscope at Leiden) to 1.45mm (the brass microscope at Antwerp). Apertures around 1mm are the brass microscope of de Loos at Rotterdam (0.92mm) and the silver microscope at Munich (1.06mm). The Baker figure has excellent precedents, therefore.

d) The stage

Most of the surviving Leeuwenhoek microscopes feature a block stage which is undeniably similar to the Utrecht example. However, two of the instruments have stages that are remarkable for their resemblance to Baker's portrayal. These are the two silver instruments in the respective collections of Carl Zeiss, Jena, and the Deutsches Museum, Munich. Both of them have stages that reveal a tapering, wedge-shaped configuration which is unlike the block stage of the better-known brass examples but which is clearly reminiscent of the Baker version.

The Fate of the London Microscopes

When Leeuwenhoek's collection of microscopes were received by the Royal Society in October 1723 they attracted considerable attention. An account of the cabinet in which the microscopes were fitted was provided, briefly, by Leeuwenhoek himself in his letter

dated 2 August 1701 and after they were received in London they were examined in detail by Martin Folkes (1724) and this was supplemented by Henry Baker in the early 1740's who measured the magnification of each microscope lens.

Two other such microscopes may also be lost in England. Leeuwenhoek presented a pair of silver microscopes to Queen Mary II (wife of William II) when she visited him in Delft. These are also missing, and Folkes stated that an individual who was familiar with these microscopes and with the Royal Society's cabinet of 26 claimed they were all virtually identical in size and appearance.

It appears that the Royal Society's collection were missing in the 1820's. Sir Everard Home, the distinguished if controversial surgeon, was known to have possessed them at one time and it is likely that he was the last individual to know of their whereabouts. It is possible they may have been destroyed by fire: Home posthumously published many of the papers of John Hunter as his own, and when pressed to give up the Hunterian manuscripts he eventually set fire to them. It may be that in the dangerous blaze which he claimed followed, the microscopes were destroyed. In a personal communication, Professor Derek de Solle Price of Yale tells me he attempted to resolve the mystery of the missing microscopes during the period 1950–1957 at the Whipple Museum in Cambridge, and concluded that they were probably destroyed by fire 'during Homes' time at the Chelsea Hospital'.

The matter was raised in April 1855, when Sir James South realised they were missing from the Royal Society collections. He wrote to the Secretary on 5 April 1855, protesting about the fact. However, the correspondence record suggests that he knew more of the matter than the bare words of his letter imply. When Sharpey, then Secretary of the Royal Society, replied to South, he wrote of 'these long missing instruments' and added: 'you stated that the microscopes bequeathed to the Royal Society by Leeuwenhoek were still in existence and that you knew in whose possession they were . . .'. It is clear that South had more background information on the instruments than he was admitting.

The reply South sent was terse in the extreme:

'I at present decline correspondence, except with the

President and Council, on any of these interesting objects.'

he wrote on 22 June 1855. Eventually he did reply, however, and stated that the last he knew they were in the possession of Sir Everard Home some years before. 'This, I grieve to say, is all the information that I possess,' he added.

The response of the Royal Society was not of great practical value. The Council minutes reveal that South's initial letter dated 5 April 1855 was read to Council, and it was resolved to appoint a committee:

'This committee . . . shall inquire and report on the state of the MSS belonging to the Society, [and] shall consist of the Officers, with Mr Tite, Mr Wheatstone, Mr de la Rue, Mr Bell, Mr Miers, and Mr Grove.'

Sir James South wrote again to ask to be kept informed of the results of the Committee's findings, and the Council minutes record that 'a letter from Sir James South . . . on the subject of the Leeuwenhoek microscopes' was read. South's final epistle on the subject was dated 10 May 1865, when he asked once again for the search to be concluded. However, no deliberations of the committee seem to have been published, and no final report was ever made known.

So much for the involvement of Home, South and the Royal Society. We are still left uncertain as to whether they knew, by then, what they were looking for. In one of his letters, South pointed out that he had spoken to one of the possible possessors of the microscopes. 'He received me most courteously,' he wrote, 'showed me most unreservedly all his antique scientific curiosities, amongst them the microscopes which he had long greatly prized as having been the microscopes of Leeuwenhoek, but which I convinced him they never had been, by placing in his hands the sketch and model of those of Leeuwenhoek which I carry in my pocket-book.'

It is possible that this encounter was with Home himself. The sketch that South carried was based on Baker's drawing, and if Home possessed instruments that were totally unlike that description one could only conclude that they were not the original Leeuwenhoek microscopes.

Since 1865 the matter has remained unresolved and whether the microscopes still exist is a matter of conjecture. It is possible that the Royal Society cabinet is still in hands that are unaware of its importance. Lacquered boxes of the kind Leeuwenhoek presented were common in 17th century Holland, being imported from the routes through the Dutch East Indies, though a search through the collections of the Victoria and Albert Museum has not disclosed anything that might be used as a model of what we are looking for.

The two microscopes possessed by Queen Mary are not in the present Royal collections of works of art, I am informed by Geoffrey de Bellaigue, (surveyor of the Queen's Works of Art). Sir Robin Mackworth-Young, the Librarian at Windsor Castle, informs me that the only early optical instrument in the collections is a binocular microscope presented to HRH the Duke of Edinburgh by the Royal Microscopical Society when he was President. The other microscopes in the Royal Collections were put in care of King's College and are now on loan to the Science Museum, where there is no known record of the missing Leeuwenhoek microscopes.

Thus the mystery remains. It may be that, somewhere in this country, are 28 microscopes of silver made by Leeuwenhoek. If their rediscovery has been hindered by an erroneous preconception of their appearance, then the present reconstruction should remove this obstacle to their recovery. Nine Leeuwenhoek microscopes are known to exist (Dobell 1932, van Zuylen 1980, Engelsman 1982) and the find of nine packets in which he sent specimens to London has provided much valuable information about his methods and techniques (Ford 1981, 1982). But the restoration of the 26 microscopes sent to the Royal

Society, and the pair given to Queen Mary, would be a fitting recognition of the 350th anniversary of Leeuwenhoek's birth on 24 October 1632.

References

- Baker, H. An account of Mr Leeuwenhoek's microscopes, *Phil. Trans.*, XLI:503 (1740) [Note: the date is erroneous, for other evidence suggests this paper was published around 1744].
— *The microscope made easy*, 8°, London, 1742.
Disney, A.N., Hill, C.F., and Baker, W.E.W. *Origin and Development of the Microscope*, Royal Microscopical Society, 1928.
Engelsman, S.B. (ed) *Antony van Leeuwenhoek*, exhibition catalogue, Boerhaave Museum, Leiden, 1982.
Folkes, M., Some account of Mr Leeuwenhoek's curious microscopes . . . *Phil. Trans.*, XXXII: 446, 1724.
Ford, Brian J., The van Leeuwenhoek specimens, *Notes and Records of the Royal Society*, 36 (1): 37–59, 1981.
Ford, Brian J., Revelation and the Single Lens, *British Medical Journal*, 285: 1822–1824, 1982.
Hoole, S., *The Select Works of Antony van Leeuwenhoek*, 2 vols, 4°, London 1798 and 1807.
South, J., MSs correspondence in Archives of the Royal Society, file MC5. See also *Royal Society Minutes of Council*, vol 2, pp. 319, 360, 1846–1858; vol 3 p 162, 1858–1869.
Zuylen, J. van, The microscopes of Antoni van Leeuwenhoek, *Journal of Microscopy*, 121 (3): 309–328, 1981.

Acknowledgements

Helpful discussions in connection with this work have been held with colleagues in many countries, and I am particularly grateful to the following bodies for the advice and, in many cases, their invaluable assistance in providing facilities for examination and detailed measurement of the instruments in their care: the Utrecht University Museum, the Boerhaave Museum at Leiden, the Royal Zoological Society at Antwerp, the Technical University of Delft, the Deutsches Museum in Munich and the Royal Society, London. Funding in support of this work has been granted by the Kodak Bursary Scheme, the Appleyard Trust of the Linnean Society, and the Royal Society.



