Glyn Walsh BSc, MSc, PhD, FCOptom

Spectacles through the ages and period inaccuracies

One of the most annoying errors made in historical entertainment, at least for the optical profession, is the use of spectacles which are inappropriate for the period being depicted.

Not all producers of historical shows require the same degree of accuracy. For example, a battle re-enactment society or a theatre company may only need to look authentic at a distance. However, a considerable proportion of re-enactors, along with period cinema and television producers, require props that look correct close up. At the same time, a smaller number of purists will require an item which is as close as possible to being exactly correct for the period.

A major problem with period spectacles is that many of the activities for which they are used are hazardous. This puts the practitioner in an awkward situation – modern safety spectacles are unacceptable. How many times have we all seen workers in historical theme parks breaking protective eyewear regulations on television. However, there are no period safety spectacles meeting current regulations. The position of a practitioner supplying something, which is better than the only alternative of nothing, is unclear – although any pretence that they offer a worthwhile degree of eye protection (even if they do) is probably unwise.

Most re-enactment, and indeed theatre, represents periods in which spectacles were available. It would be easy to flood the market with a small number of designs – every spectacle-wearing re-enactor I have ever met has asked whether an appropriate pair can be made for them. Potentially, there is an untapped market here possibly running into the tens of thousands.

Although many will not require spectacles or will wear contact lenses, the number for whom spectacles are more convenient, safer or even mandatory (but at present ignored) remains significant. For theatre and television, the figures are much less predictable as it depends on what is being produced and where – but must be considerable nonetheless.

The author is wearing wooden spectacles fastened with earloops

Potted history

It is believed an unknown 13th century glass worker in Italy originally invented spectacles (circa 1260). Evidence for spectacles in the UK at this time is scant although their first description here is usually attributed to Roger Bacon in 1267 or 1268. Similarly, evidence for the use of simple magnifiers is also poor, although Alhazen (962-1028 AD) described the optical principles used. So on the available evidence, there is no justification for wearing spectacles in the UK when representing periods prior to 1268, and little for probably half a century after that (except perhaps for specific characters). The same applies to single lenses, although it is possible to stretch the date back a bit for these.

For those not too bothered about accuracy, some very dubious, and some much older, objects and texts are often cited:

1. The "Nineveh lens" (7th century BC), which can be seen in the British Museum[1], and a few other less famous "lenses". There may be examples of lenses dating to 2000 BC or even earlier[2,3] (almost as old as glass-making itself). Although there is no evidence that they were used as a visual aid, there is none to the contrary either.
2. A burning glass is mentioned in Act II of "Comedy of the Clouds" (Aristophanes, circa 257-180 BC).
3. Pliny (23-79 AD) describes the Emperor Nero viewing the gladiatorial contests through or in emerald and water-filled globular glass vessels used as burning glasses[4].
4. Recent press reports have claimed that the Vikings had spectacles between 700 and 1000 AD. This is unjustified press exaggeration as the lenses were single, optically good, very high powered aspherics and dated from the 10th or 11th century[5,6] (**Figure 1**). Their purpose is unclear.
5. There are suggestions that spectacles were used as far back as 400 AD[7], but there is no real supporting evidence of this.

1300-1629

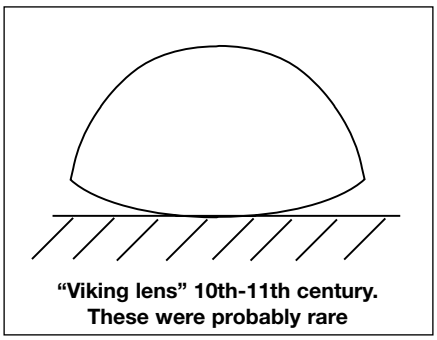
At the beginning of this period, spectacles were rare – although between July and September 1384, 1,151 pairs of spectacles were recorded as being imported through the Port of London[8]. At the end of this period, mass production was underway in earnest, particularly in France and Germany. These spectacles were used almost exclusively for reading. However, there is no reason to believe that hypermetropes could not have used them for viewing distant objects, as reading glasses would be adequate for this. By the end of the 15th century, spectacle pedlars were common in most of Western Europe and they often bought German spectacles by the dozen or by the basketful – 1d for a pair of leather spectacles (**Figure 2**), 9½d for "gilt horn"[9].

There were several hundred paintings and drawings showing spectacles being worn by, amongst others, shoemakers, clockmakers, tailors, hermits, doctors, alchemists, usurers and school masters displayed in an exhibition in 1929[2] - these were principally from the later part of this period. In Britain, the earliest recorded spectacle maker was Spyke Dowd (1485) in London.

1629-1666

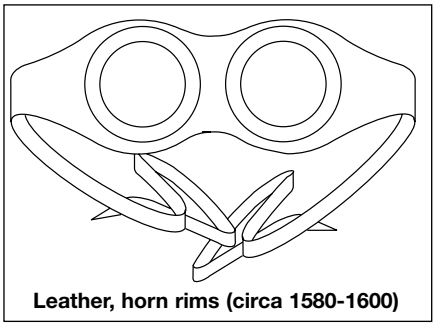
During this period, Germany was the centre of spectacle production. The specific period 1629 to 1666 is only of real significance in Britain, particularly London. In 1629, the Worshipful Company of Spectacle Makers (SMC) was set up in London. However, this much celebrated element of optical history may not be quite the wonderful event that it is usually believed to be. Any GCSE student of English history will tell you that Charles I (1600-1649) was

Figure 1

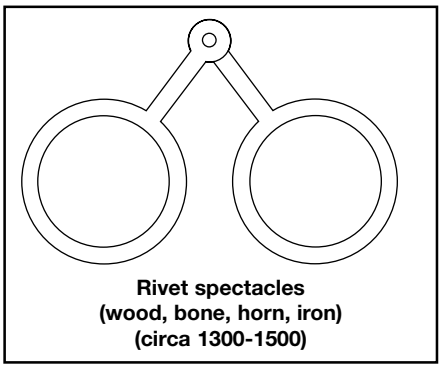


"Viking lens" 10th-11th century. These were probably rare

Figure 2



Leather, horn rims (circa 1580-1600)



Rivet spectacles
(wood, bone, horn, iron)
(circa 1300-1500)

Figure 3

beginning to set up monopolies and sell patents at this time for his own financial ends. There is little reason to believe that the SMC was not initially another such enterprise. In 1666, all the SMC's records were destroyed in the Great Fire, so we are never likely to know the truth. It is likely that spectacles continued to be imported and produced in ever-increasing numbers, as was the case throughout the rest of Western Europe, as evidenced by the SMC being empowered to judge the imported as well as the home product.

1666-1900

From this point onwards, the SMC does have records, although for much of their existence, most of the London guilds have had little influence outside London[13] and so the SMC might not have been particularly influential at this time. Spectacles have never really been a luxury item in the past 350 years, although the price of the cheaper types possibly rose a little in real terms in the 18th and 19th centuries. English (seldom differentiated from London) spectacles did become relatively expensive. Run-of-the-mill spectacles were priced from about 5d to 2s.1d per pair in the late 17th century[10,11], and from 1s.6d to 3s in 1800[12].

By the end of the 17th century, the price of imports had fallen to 3s 4d (wholesale) for "a number of boxes of spectacles", each apparently containing more than a dozen pairs of (possibly German) spectacles[12] – perhaps 1d a pair retail[9]. Goldsmiths[1] "the Vicar of Wakefield" (1766) is a much cited example of the low value of later (imported) spectacles; £3.5s.2d (about 5½d each) was considered much more than the value of a gross of (possibly tinned) copper spectacles with shagreen cases. In 1773, a pair of German metal spectacles cost 1d (wholesale) – less in real terms than they cost now.

Prescriptions and lens designs

Positive powered spherical lenses for near vision have been around since about 1268. Hypermetropia could be readily corrected with the same sort of spectacles that were used as reading glasses. Myopia correction may have become possible in at the end of the 15th century, but was rare until well into the 16th. By the early 17th century, spectacles for myopia were readily available, but still only accounted for a small proportion of the total market[14].

Astigmatism was very rarely corrected until the last quarter of the 19th century, although Thomas Young designed lenses for its correction shortly after he discovered the condition in his own eyes in 1799. The first record of their production is 1825 (Fuller of Ipswich)[4]. Bifocals were introduced in about 1780. This is usually attributed to Benjamin Franklin, although it is unlikely that he was their inventor. If one wants to stretch a point, a split lens (not really a spectacle lens) was described by Zahn in 1685 and later by Hertel in 1716[4,10,15].

Contact lenses did not exist prior to 1887, and were very rare prior to 1945. Obviously they can be worn, but should not be seen to be worn for representation of dates before 1900.

Most lenses in the UK up to about 1820 were biconvex or biconcave (usually with the same curve on both surfaces), but cheap lenses were often made from glass which had been flattened on one surface for mirrors (often French made), hence they had one flat surface and one curved. Although these may not have been well made, in principle it is an optically better form[16], despite the SMC's criticism of them at the time. After the mid 19th century, the more modern "curved" lenses became less rare, although not the "norm" until the 20th century.

The earliest bifocal type was the "Franklin split" (circa 1780). Cemented bifocals were introduced in the 1880s, in which a small near vision segment is cemented to the surface, or more rarely inset (with cement) into the lens. The cement used was Canada balsam, although modern cement is more stable and is indistinguishable from it. A few other types of bifocals were around between 1820 and 1900[16], but they are not readily available today and therefore their use as a prop is probably not viable.

Spectacles with supplementary lenses for reading that fold in front of the distance lenses have been available since at least the 1820s. Tinted lenses (particularly dull green) became popular in the 17th century (Samuel Pepys is usually cited), and their use has continued since then, although the fashionable colours have varied.
Anti-reflection coatings are very much a phenomenon of the late 20th century.

What is available?

Prior to 1900, all lenses were either glass (usually similar to crown) or "pebble" (quartz). Pebble lenses are no longer available, but glass is. Fortunately, it is very difficult to tell the two apart in use. Quartz is harder (hence was often preferred) and double refracting. Biconcave and biconvex lenses are no longer readily available, although some prescription houses can still produce them at a price. There is an exception to this – a very limited range of spherical powers is available from suppliers of laboratory equipment. These need edging to shape, but are quite cheap and usually quite small giving a nice finished job for positive powers without having to be surfaced.

Plano-convex and plano-concave lenses are less difficult to obtain, but are no longer a standard form, and can still be relatively expensive. Cemented and Franklin split bifocals are available, with the provisos given for the basic lenses above.

Acceptable alternatives

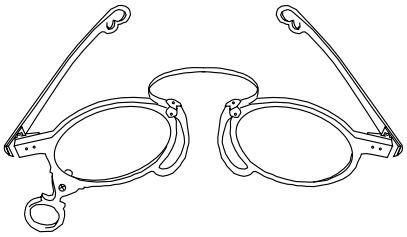
It is often difficult to tell glass and plastic lenses apart, particularly in the small lens sizes used pre-1900. If the spectacles are not handled, it is impossible. From the safety aspect, if any fighting, hammering, grinding etc, is being done, plastics lenses (ideally polycarbonate) are obviously preferable regardless of historical accuracy.

If the lenses are not in the correct form, it is still unlikely that the audience will notice. This is particularly so with a thick frame and plus or low minus prescriptions – the most common spectacles would have a convex front surface, as do most modern ones. Again, this is assuming that the spectacles are not handled.

One additional point is that most re-enactors, who will be close enough to the public for minor anachronisms to be noticed, usually like talking to the public, and will often explain the problem if they are aware of it. For theatre, television and cinema, anti-reflection coatings may often be advisable due to the unnatural lighting conditions and the frequent need to see the eyes. However, the visible coloured surface reflections they occasionally give are definitely wrong. Ideally, anti reflection coatings should never be used for re-enactors.

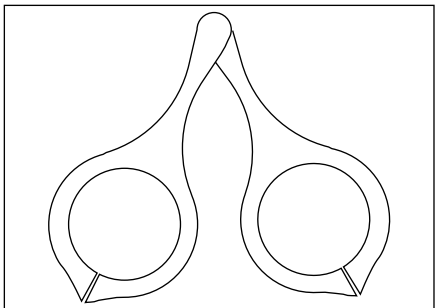
For low and even moderate degrees of astigmatism, the public would be unlikely to see the cylinder, so it does not really matter. If noticed, it could be attributed to poor workmanship. It is hard to explain away otherwise except for the late 19th century onwards. A significant problem encountered in the correction of astigmatism is that in many frame styles, such as rivet spectacles (**Figure 3**) and most spring bridge spectacles of the period (**Figure 4**), the axis changes as the distance between the lenses increases. A correction for this must therefore be obtained for each patient – and an indication of the correct centration given.

The same compromises are possible if a Franklin split or cemented bifocal is wanted. If you want a safer lens, then an "E" style bifocal looks very similar to a Franklin and round solids look similar to period cemented (although older cemented bifocals frequently had the segment on the back, whilst most



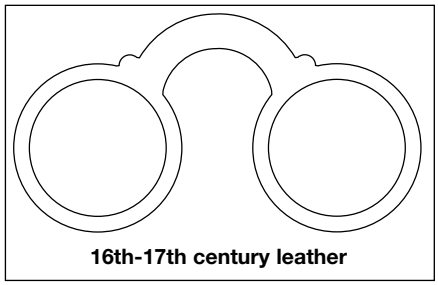
Hard rubber with steel bridge (circa 1890)

Figure 4



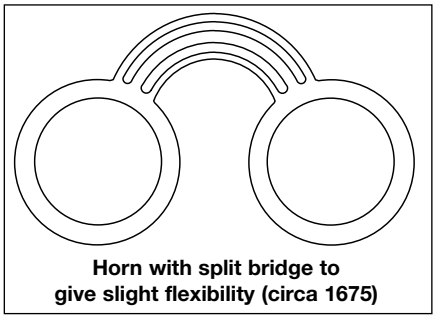
Wood, mid 15th century

Figure 5



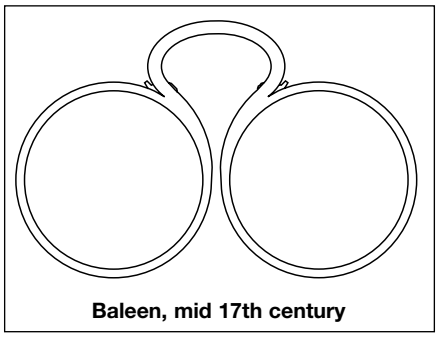
16th-17th century leather

Figure 6



Horn with split bridge to give slight flexibility (circa 1675)

Figure 7



Baleen, mid 17th century

Figure 8

plastics solids have them on the front). These are only available in a curved form, but as they are made from a single piece of glass or plastic they are less likely to break.

Varifocals lenses are very modern but to the public they look like single vision lenses. Most historically correct European frames are very small, and do not give enough depth for such lenses to work properly, but they may occasionally be worth considering (set high for the really desperate).

Frames to 1900

Frame styles have always been much more varied than lens types. To go into sufficient detail would occupy several weighty volumes[17,18]. A brief précis of this therefore follows.

Most of the materials from which modern spectacle frames are made are also modern. Both the plating and the underlying metal of modern frames are both late 19th century (and later) introductions to the spectacle industry.

Similarly, plastics materials are a 20th century innovation. Fortunately, spectacles were made from almost every conceivable material that there was, and most are still readily available – wood, leather, bone, baleen, horn, ivory, tortoiseshell, rubber, ferrous metals, copper and its alloys, silver, gold, lead, tin, etc.

Up to 1600, a high proportion of spectacle frames were made from perishable materials, and few have survived. It is very surprising how slender frames made from these delicate materials can be. From 1800 to 1900 the majority of spectacles were metal.

Materials

Wood

Until quite recently, this was thought to be an unusual material, but opinions have begun to change, and it is now thought that many of the light coloured spectacles in portraits once thought to be bone may actually have been wooden. It was either worked from a single piece or laminated as plywood. There is little information available on the type of wood that was used, although Obstfeld[19] has suggested box, beech, and lime (presumably the native small-leaved type). It was probably used mostly in the earlier days of spectacles, say up to 1550, but was still in occasional use as late as the mid 19th century (**Figure 5**).

Bone/ivory

Bone was used for a similar period and for similar frame styles as wood. It is less perishable, harder to work and does not come in such large pieces. It has been suggested to the author by modern bone workers that the forehead of cattle may be most suitable. However, the metacarpal bone of a bull was suggested as the only bone large enough when the "Trig Lane" spectacles were reported[20]. Ivory was seldom used for spectacles, is almost indistinguishable from bone and is probably not worth considering for re-enactment even if you can get hold of it.

Leather

This has probably been used since the invention of spectacles. It was common in the early 16th and early 17th centuries, although, as with wood, it probably continued in use much later (**Figure 6**). Leather rims with a spring steel bridge were used in the period from 1700 until the 1760s. Leather is readily available, but it often underwent a complex (and very smelly) treatment to harden it for spectacles.

Horn

This was in common use from the invention of spectacles, and remained common until the end of the 18th century, although in that century there was often a spring steel bridge (**Figure 7**). Its use continued to a lesser degree through the 19th century. Horn is still readily available.

Baleen (whalebone)

This is very flexible when heated and springy when cold. It was used occasionally, particularly in the late 17th and early 18th centuries as a single piece bent similarly to the mass produced German wire spectacles described later (**Figure 8**). It is no longer available new.

Tortoiseshell (real shell)

This is the shell of the hawksbill turtle (a protected species) and was relatively commonly used from the 17th century until the first half of the 20th (**Figure 9**), although it has been imported into Europe since the time of the Roman Empire. For most purposes it is similar to horn, although it is less likely to delaminate, and it is possible that some earlier "horn" spectacles could be "shell" and vice versa.

Ferrous metals

Unfortunately, the literature seldom distinguishes between the many ferrous metals. Heavy, often heavily oxidised, old spectacles are usually called iron (**Figure 10**), whilst more recent, fine ones are called steel. Where the metal is obviously a spring (e.g. as used for bridges), the metal is always referred to as steel. Ferrous metals were in constant use in the period under consideration, and were the standard material in the 19th century. Later, steel frames were often "blued" – a heat treatment applied to carbon steels, giving a springier finished product. This may also have been the case earlier, but corrosion has invariably removed the visible evidence.

Copper and its alloys

Again, there is no serious attempt in the

literature to distinguish between copper alloys. If it is yellow, it is usually called brass; if it is reddish, then it is called copper. Occasionally the term bronze is used. They have been in use from the invention of spectacles to the present day (**Figure 11**).

Gold
This has always been expensive, and although very expensive spectacles were made from it, it is unsuited to the purpose because of its weight and softness. For practical purposes, gold plating only appeared on spectacles at the end of the 19th century although mercurial gilding (vermeil) has been possible for many centuries.

Silver, tin
Silver was in steady, but uncommon, use throughout the period under consideration. It represented the expensive end of what could be considered "ordinary" spectacles. Cheap copper alloy frames have often been "tinned" (tin-plated) so that they looked like silver. Both have a much greyer appearance in use than most modern silver-coloured plating materials.

Nickel
This was first isolated in a relatively pure form in the late 18th century, but its alloys have been in use from very early times. Nickel and its alloys are best avoided because of potential allergy problems[21-24].

Antimony
This should no longer be used in spectacle frames, but may be present in "white metal" late 19th or early 20th century antique frames. This can cause problems should a patient wish to have one glazed. It was a common irritant when it was in use[25].

Rubber (vulcanite, ebonite)
Spectacles made from this material were an American phenomenon of the period 1866 to 1900. The material was not rubbery, but relatively hard with high sulphur content (25-50%).

Shagreen
This is shark or ray skin, which was frequently used to decorate cases. Cetorhinus and Rousette are less common types of shark skin. The terms are included here simply because they are very frequently mentioned, without explanation, in articles on the history of spectacles.

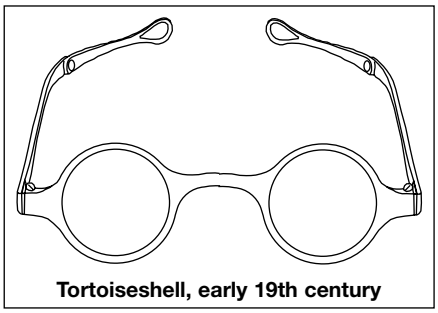
Styles
There have always been an innumerable number of variants of styles and unusual materials can occur in unexpected contexts. This section will be restricted to the more common styles. The rims of almost all frames up to the present century have been grooved to hold the lens.

Centration
Most lens apertures prior to 1900 were small, typically 30-35mm in diameter, often less. This can make distance centration with many styles a problem for large modern faces. As smaller centration distances are necessary for near vision spectacles, particularly if worn near to the end of the nose, it is reasonable to assume that most (particularly the "nose-clip" styles) were used principally for near vision or with inaccurate centration for distance. Better control of distance centration is possible with rigid frames, as these can be made to match the inter-pupillary distance[26]. With rivet spectacles (if not clipped onto the nose) and some other folding designs, the centration distance is under the control of the wearer. It is unfortunate that few if any of the many published texts and catalogues give the dimensions of the spectacles illustrated, hence discussion of size must be limited to those measured by the author. Typical centration distances for early (pre 1800) nose clip spectacles were about 56mm before being pushed onto the nose, the optical centres being at the geometrical centre of the lens. The optical centration of rigid frames tends to correspond to the geometrical centration distance, although some lenses are decentred out by a small amount.

1270 to 1500
Wood, bone, iron and horn were the most frequently used materials in this period, often in the form of rivet spectacles (**Figure 3**). The adjustable rivet allows the frame to be clamped to the nose and often to be folded for storage. Some rigid ones were made from the same materials and also of leather. Most portraits show the spectacles as if they were principally for holding in the hand. Although ear-loops and headbands do not seem beyond the ingenuity of the average wearer, there is little evidence in the UK for them or any of the more complex attachment methods since devised. Single lenses were also commonly used for reading. Frames similar to the "Nuremburg" wire ones (**Figure 12**) have been around since the early 15th century.

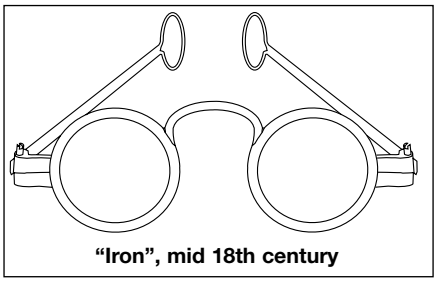
1500 to 1700
This was a period of very rapid change. In the 17th century, the German metal spectacle frame industry began to take off, particularly around Nuremburg and rivet and other older types of spectacles declined. At the end of this period, factories had begun to produce metal frames in numbers that would set many modern frame manufacturers trembling. A number of very fancy fretwork spectacles are illustrated in most books, and proudly exhibited in museums. These were never intended for use, being apprentice's "masterpieces" (**Figure 13**).

1700 to 1800
From about 1720, even general guidelines are at best vague, as fashion began to take over in



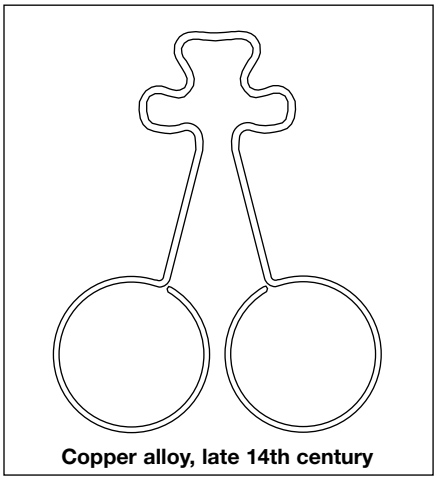
Tortoiseshell, early 19th century

Figure 9



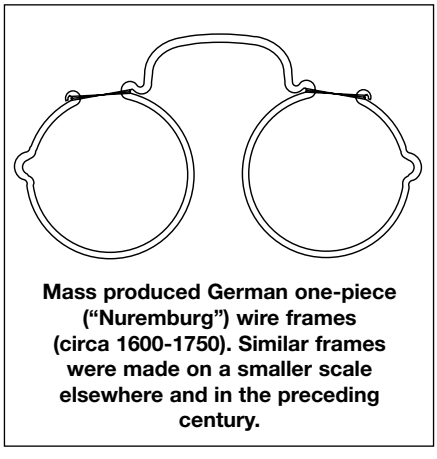
"Iron", mid 18th century

Figure 10



Copper alloy, late 14th century

Figure 11



Mass produced German one-piece ("Nuremburg") wire frames (circa 1600-1750). Similar frames were made on a smaller scale elsewhere and in the preceding century.

Figure 12

a big way. Generally, frames were beginning to look much more modern, although the lenses were still quite small. Short sides with curly loop ends (not quite reaching to the ears) for tying or more probably insertion into a wig came in about 1700. Scarlett claimed to have invented them in 1728, but a similar idea is shown in earlier continental portraits.

From about 1750, longer loop-ended sides, hinged in the middle became popular. The single piece German wire spectacles continued to be imported until the end of the 18th century. Plain leather had died out by about 1720, but leather with a spring steel bridge continued to be quite common (imported) until around 1780.

The proportion of metal frames (steel, brass, silver) increased dramatically throughout the century, being probably in the majority by 1800. Fixed bridges were generally aesthetic rather than for comfortable fitting, but with small lens sizes, this does not give a problem with comfort. Shapes other than round, particularly ovals, became more popular as the 18th century progressed.

Single lenses, worn as a pendant on a cord around the neck ("quizzers" or "quizzing glasses") became common among the more fashionable members of society, as did a variety of concealed telescopes, "scissors" spectacles, etc.

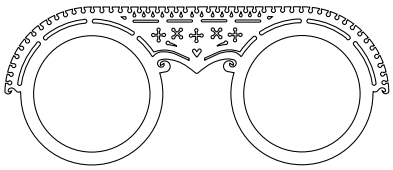
From the mid 18th until the early 19th century, a peculiar phenomenon in England (and to a lesser extent elsewhere) was the popularity of "Martin's Margins", lenses of reduced aperture, with a horn margin, in an ordinary sized frame (**Figure 14**). These strange lenses were intended to reduce the damage to the eye from the excessive light, although Martin's (1704-1782) reasoning was somewhat questionable, as he appears to have thought that the spectacle frame rather than the wearer's pupil was the limiting aperture of the system[27].

1800 to 1900

The vast majority of frames in the 19th century were made of metal. The use of thin steel frames continued to increase, as did that of oval styles. Nearly rectangular frames also became popular, although not the "norm". "Astigmatic clips" became increasingly common from the 1850s onwards. In fashionable circles, quizzers, lorgnettes etc, became increasingly popular, although as optical aids they were very impractical. Monocles were very much a 19th and early 20th century, upper class phenomenon. Spectacles continued to be worn by the majority of the population who needed and could afford them.

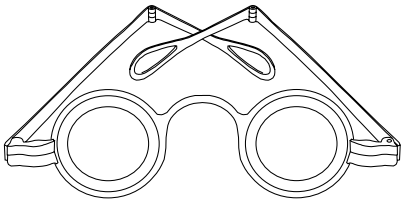
Working with the materials
(personal experiences)

Wood (worked from a single piece)
These caused problems in use as the lenses cracked when the frame warped in damp weather. For plywood, cherry or sycamore three-ply with "pearl" or "hoof & horn" glue works well, but should not get wet for prolonged periods. With modern waterproof PVA type glue, it is very satisfactory. Unfortunately, most commercial plywood is made from the wrong woods and looks awful (and the glues used are potentially dangerous).



German masterpiece. Although produced over a very long period, these are unsuitable for wear in any period!

Figure 13



Martin's Margins. Steel with horn inserts, late 18th century

Figure 14

Horn
This is difficult to work into a spectacle frame as it tends to delaminate, but it is very nice when completed.

Leather
This works surprisingly well, if you can stand looking like Biggles. It hides the lenses, and can be extremely comfortable in use. Oak tanned leather is good for a slimmer frame and can be soaked in beeswax to be almost correct for the period. All leathers become too soft for use when they get wet

Bone
This works well, but is difficult to use for anything other than early rivet spectacles, as large flat pieces can be hard to obtain in the UK.

Iron/steel
This is good, but it goes rusty and marks the nose, particularly in hot or wet weather.

Copper alloys
These are used for most modern frames. Be careful, as you can get allergic reactions, particularly if the alloy contains nickel. The author has used both nickel silver from dismantled frames (before the nickel directive and against his better judgement, but it is very difficult to obtain small quantities of grooved wire from any other source) and spring-bronze.

Plastics
The author has occasionally sacrificed his principles and used plastics materials. Acetate "shell" can be almost indistinguishable from the real thing. Imitation horn is a bit less convincing, but not bad. It may also be possible to find plastics which are a good approximation to baleen. Leather often becomes polished with use – to the extent that some extant ones are difficult to distinguish from horn or baleen. Off-white plastics are rather less convincing as imitation bone, as they lack the pores and colour variation present in the real thing.

Most period frame types are easily modified to tie to the head or ears if they do not have sides.

Frame manufacture

Anyone manufacturing spectacle frames must be registered with the Medical Devices Agency (MDA, 1994) and the product must conform to BS EN ISO 12870 (1998)[28]. Fortunately, most of the conditions of the standard do not apply to natural materials, although they would to metal or plastic ones. Discussion with the MDA indicates that it is unlikely the regulations would apply to a non-prescription theatrical prop, although the author has never obtained this in writing. There are a few professional traders in such products and some museums currently sell replicas of their exhibits – often made from unsuitable materials. If the patient presents with a frame for re-glazing and suitable advice is given and recorded at the time of glazing, this may be acceptable, as we need not customarily request evidence that a frame not supplied by the practice conforms to BS EN ISO 12870 (1998)[28,29]. Safety spectacles have been around at least since the mid 19th century[26], but these would probably not meet modern standards, so extreme caution must be exercised (and recorded) in any advice given to patients.

Contact lenses

For theatre, cinema and television productions, contact lenses are probably safe. However, the conditions on most re-enactment sites are such that contact lens wear can present a considerable risk to the eyes. This is both as a direct result of the dangerous activities taking place and of the rather unhygienic (both historical and modern) living conditions. Unfortunately, contact lens wear by the majority is necessary for overall historical accuracy, so this is a very obvious demand for extended wear lenses over the re-enactment season. Most shows only last a few days, hence three months of extended wear may not be necessary.

Acknowledgements

The author would like to thank Henri Obstfeld and John Mitchell for their help with this article, as well as Neil Handley and the College of Optometrists museum, for access to museum specimens and records. The figures are stylised compounds based on the photographs of "Il Museo dell'Occhiale" (undated)[30], Orr (1985)[31], Poulet (1978)[17] and Winkler (1988)[32].

For those interested in further reading, the College of Optometrists' library has an extensive selection of historical references and of exhibition catalogues.

References

1. Barker WB (1930) Lens work of the ancients II: the Nineveh lens. *British Journal of Physiological Optics* 4, 4-6
2. Greef R. von (1929) Katalog Einer Bilderausstellung Zur Geschichte der Brille: Xlll *internationalen ophthamologischen Kongresses*, Amsterdam
3. Taylor HL (1907) The manipulation and fitting of ophthalmic frames. *J & H Taylor, Birmingham*
4. Levene J R (1977) Clinical refraction and visual science. *Butterworths*, London
5. Schmidt O, Wilms KH & Lingelbach B (1999) The Visby lenses. *Optometry and Vision Science*, 76, 624-630 (also http://www.fhaalen.de/sga/WER/MITARB /VISBY/START.HTM)
6. Schmidt O (2000) personal communication
7. Rosenthal JW (1996) Spectacles and other vision aids: a history and guide to collecting. *Norman publishing*, San Francisco
8. Dreyfus J (1988) The invention of spectacles and the advent of printing. *Bibliographic society offprint from the library 6th series*, 10, 93-106
9. McQuown S H (undated) A pair of eyeglasses. *Kelly and Kelly*, London
10. Rohr M von (1924) Contributions to the history of the spectacle trade from the earliest times to Thomas Young. *Trans. Opt. Soc.* London, 25, 4-71
11. Corson R (1967) Fashions in eyeglasses. *Peter Owen Ltd*, London
12. Rohr M. von (1924) Additions to our knowledge of old spectacles - A summary of papers published in 1923-1924 relating to the subject of the Thomas Young Oration of 1923. *Trans. Opt. Soc.* London, 26, 175-187
13. Thirsk J (1978) Economic policy and projects in the development of the consumer society in early modern England. *Clarendon*, Oxford
14. Bourgeois A (1923) Les besicles de nos ancêtres. *A Malone & fils*, Paris
15. Bennett, AG (1966)Trial lenses ancient and modern. *Ophthalmic Optician*, 6, 964
16. Jalie M (1974) The principles of ophthalmic lenses. *ABDO*, London

17& 18. Poulet (1978) Atlas on the History of spectacles Vol 1. *Wayenborgh*, Bonn. Also Vol 2 (1980) & Vol 3 (1980)

19. Obstfeld H (1997) Spectacle frames and their dispensing. *Saunders*, London
20. Rhodes M (1980) A Pair of late medieval spectacles from the Trig Lane site. *The London Archaeologist 4*, 23-2 of spectacles. Reprinted in: The arts and spectacles over five centuries. *Wayenborgh*, Bonn
21. ENV 14027:2001 (2001) Method for the simulation of wear before the detection of nickel release from coated metal and metal combination spectacle frames. *BSI*, London European Parliament and Council Directive (1994) 94/27/EC
22. European Parliament and Council Directive (1994) 94/27/EC, commonly called the "nickel directive"
23. BS EN 1811 (1999) reference test method for release of nickel from products intended to come into direct and prolonged contact with the skin
24. ENV 14027:2001 (2001) Method for the simulation of wear before the detection of nickel release from coated metal and metal combination spectacle frames. *BSI*, London
25. Taylor HL (1930) Lens work of the ancients: 1 lenses and the eye in ancient Egypt
26. Pflug A von (1925) Uber Eisenbahnbrillen zeitschrift für ophthalmologische Optik. *Julius Springer*, Berlin
27. Handley N (2000) Marginal development. *Focus*, Autumn 2000, p6
28. BS EN ISO 12870 (1998) Ophthalmic optics. Spectacle frames. General requirements and test methods
29. Anonymous (2001) MDA Climbs down on reglazing. *Optometry Today* July 13, p9
30. "Il Museo dell'Occhiale", catalogue (undated) Centro Servici Occhialerie Srl., 32044 Pieve di Cadore (Belluno), Via degli Alpini 35
31. Orr H (1985) Illustrated history of early antique spectacles. *H.Orr*, Beckenham, Kent
32. Winkler, W (1988) A spectacle of spectacles. *Carl Zeiss*, Jena