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KENWOOD HOUSE, UXBRIDGE, LONDON AN INVESTIGATION OF THE MUSIC ROOM WINDOW GLASS

TECHNOLOGY REPORT

David Dungworth



INTERVENTION
AND ANALYSIS



ENGLISH HERITAGE

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Kenwood House, Kenwood House, Uxbridge, London

An Investigation of the Music Room Window Glass

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SUMMARY

The investigation of historic window glass from the Music Room (originally constructed 1793–97) at Kenwood House was undertaken using complimentary laboratory-based equipment and a portable XRF instrument to determine glass composition and type. The glass falls into two groups: a potassium-calcium-silicate glass and a sodium-calcium-silicate glass. The former is extremely rare in England but is paralleled at Walmer Castle, Kent. This glass was probably imported from Bohemia or Germany at considerable expense. It is not immediately apparent why such expensive glass was used in this context (blind windows) but the context may help to explain why this glass has survived for over two centuries.

ACKNOWLEDGEMENTS

Roger Wilkes carried out initial sample preparation and analysis of the broken glass in 2010.

ARCHIVE LOCATION

The material and samples analysed are archived at Fort Cumberland (address below).

DATE OF ANALYSIS

2010–2013

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INTRODUCTION

Kenwood House is a Grade I listed detached villa that was originally built in the early 17th century but was remodelled in the middle of the 18th century by Robert Adams (Cherry and Pevsner 1998). The windows which have been investigated in detail belong to the northern wings which were added in the 1790s and served as Music Room and Dining Room.

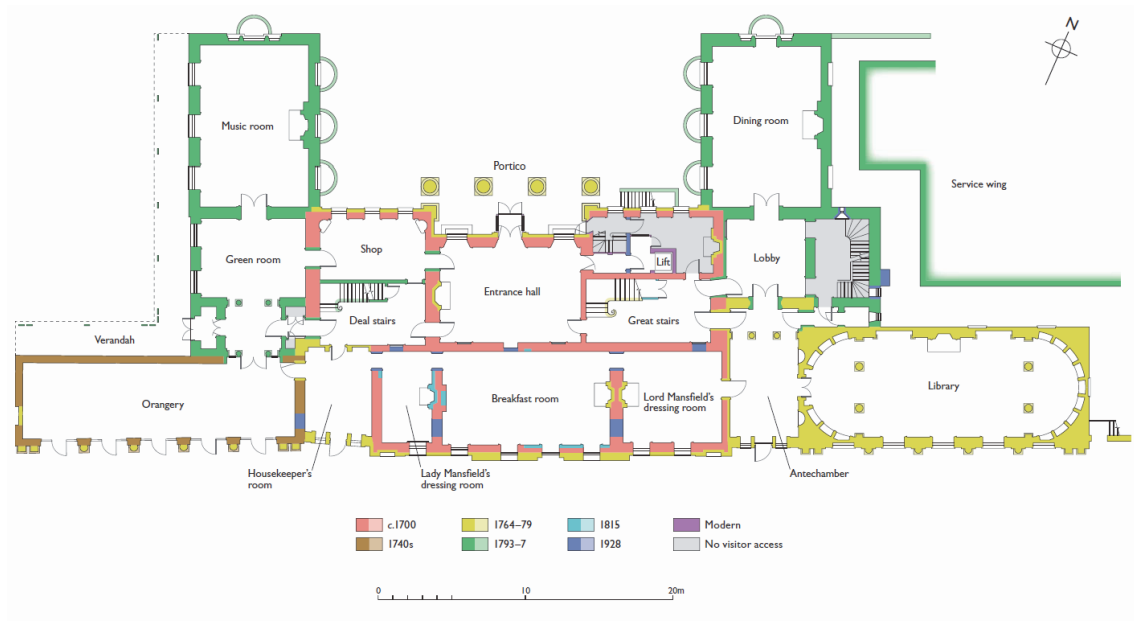


Figure 1. Plan of the ground floor of Kenwood House showing building phases

The first house on the site was probably a brick structure built by John Bill, who bought the estate in 1616. The house changed hands several times in the years that followed and in 1746 John Stuart, 3rd Earl of Bute, acquired Kenwood and added the Orangery to the west of the south front. William Murray, 1st Earl of Mansfield (1705–93), acquired Kenwood in 1754 and commissioned Robert Adam and his brother James to remodel the house from 1764 to 1779. Adam added a new entrance on the north front in 1764, a Library on the east side (designed in part to balance the Orangery) and modernised the existing interiors. In 1793 the house passed to Mansfield's nephew, David Murray, who commissioned George Saunders to build the north-east and north-west wings, providing Kenwood with an elegant dining room and music room. Saunders also added a service wing partially hidden behind the north-east wing. The house remained with the Mansfields although they preferred to live on their Scottish estate. In 1925 Edward Cecil Guinness, 1st Earl of Iveagh (1847–1927), bought the house and surrounding land and in 1929 bequeathed the house and its contents to the nation. It was taken over by English Heritage in 1986.

The decision to investigate the nature of the window glass in the Music Room was taken in 2010 after a window was accidentally broken by a member of the public and the

samples were sent to the author. The initial chemical analysis of the glass showed that it was of a type (a potassium-calcium-silicate) which had not been identified before in British windows (Dungworth 2011). The same glass type was subsequently identified at Walmer Castle, Kent (Dungworth and Girbal 2011) which prompted further investigation of unbroken windows at Kenwood (in 2013).

METHODS

The glass was analysed to determine its chemical composition. The fragments of broken window were all prepared for laboratory analysis but only the first five were analysed (initially it was assumed that all fragments came from different windows). The five fragments of broken glass were mounted in epoxy resin and ground and polished to a 3-micron finish to expose a cross-section through the glass. The samples were inspected using an optical microscope (brightfield and darkfield illumination) to identify corroded and uncorroded regions. None of the Kenwood House samples exhibited any substantial corroded surfaces. The samples were analysed using two techniques to determine chemical composition: SEM-EDS and EDXRF. The energy dispersive X-ray spectrometer (EDS) attached to a scanning electron microscope (SEM) provided accurate analyses of a range of elements while the energy dispersive X-ray fluorescence (EDXRF) spectrometer provided improved sensitivity and accuracy for some minor elements (in particular manganese, iron, arsenic, rubidium, strontium and zirconium) due to improved peak to background ratios (Table 1).

Table 1. Minimum Detection limits (MDL) and analytical errors (two standard deviations) for each oxide

	SEM-EDS			EDXRF	
	MDL	Error		MDL	Error
Na ₂ O	0.1	0.1	MnO	0.01	0.03
MgO	0.1	0.1	Fe ₂ O ₃	0.01	0.03
Al ₂ O ₃	0.1	0.1	CoO	0.02	0.02
SiO ₂	0.1	0.2	NiO	0.02	0.03
P ₂ O ₅	0.1	0.1	CuO	0.02	0.01
SO ₃	0.1	0.1	ZnO	0.02	0.01
Cl	0.1	0.1	As ₂ O ₃	0.01	0.01
K ₂ O	0.1	0.1	SnO ₂	0.1	0.05
CaO	0.1	0.1	Sb ₂ O ₅	0.15	0.07
TiO ₂	0.1	0.1	Rb ₂ O	0.005	0.005
BaO	0.1	0.1	SrO	0.005	0.005
			ZrO ₂	0.005	0.005
			PbO	0.02	0.02

The SEM used was a FEI Inspect F which was operated at 25kV with a beam current of approximately 1.2nA (polished samples were coated in carbon to ensure they were earthed). The X-ray spectra generated by the electron beam were detected using an

Oxford Instruments X-act SDD detector. The quantification of detected elements was achieved using the Oxford Instruments INCA software. The EDS spectra were calibrated (optimised) using a cobalt standard. Deconvolution of the X-ray spectra and quantification of elements was improved by profile optimisation and element standardisation using pure elements and compounds (MAC standards). The EDXRF used was an EDAX Eagle II which was operated at 40kV and 1mA with a 300µm capillary. The EDXRF spectra were deconvoluted and quantified using the Vision32 software.

The chemical compositions of the samples are presented in this report as stoichiometric oxides with oxide weight percent concentrations based on likely valence states (the exception being chlorine which is expressed as element wt%). The accuracy of the quantification of all oxides was checked by analysing relevant reference materials (NIST and DGG) using both SEM-EDS and EDXRF. A number of elements were sought but not detected: titanium, vanadium, chromium, cobalt, nickel, copper, zinc, tin, antimony, barium and zirconium.

The surface of one sample of glass was examined using the SEM to provide information on the topography of the surface. In this case the glass was coated in a thin layer of gold to ensure that it was earthed and the images produced using a secondary electron detector.

The *in situ* analysis of the window glass at Kenwood was undertaken using a Niton XL3t portable X-ray fluorescence (pXRF) spectrometer which was operated following procedures developed for the *in situ* analysis of historic window glass at Walmer Castle (see Dungworth and Girbal 2011 for further details). For the analyses at Kenwood, the pXRF was not operated with a helium flush and no attempt was made to detect or determine the concentration of light elements.

Table 2. Minimum Detection limits (MDL) and analytical errors (two standard deviations) for each oxide (pXRF)

	MDL	Error
SO ₃	0.05	0.1
Cl	0.05	0.1
K ₂ O	0.1	0.5
CaO	0.05	0.5
TiO ₂	0.02	0.05
MnO	0.02	0.05
Fe ₂ O ₃	0.02	0.05
As ₂ O ₃	0.02	0.02
Rb ₂ O	0.002	0.01
SrO	0.002	0.01
ZrO ₂	0.002	0.01

RESULTS

The five samples from the broken window all share the same chemical composition (Table 3) — as all fragments had originally formed part of a single pane of glass this is to be expected.

Table 3. Chemical composition of Kenwood House Music Room glass (all samples from the same pane)

	Na ₂ O	MgO	Al ₂ O ₃	SiO ₂	P ₂ O ₅	SO ₃	Cl	K ₂ O	CaO	MnO	Fe ₂ O ₃	As ₂ O ₃	Rb ₂ O	SrO
1	3.09	0.41	0.23	69.15	0.18	0.10	0.27	16.19	9.11	0.018	0.155	0.090	0.051	0.017
2	3.18	0.41	0.24	69.13	0.18	0.09	0.28	16.19	9.06	0.017	0.156	0.086	0.046	0.018
3	3.08	0.40	0.23	69.18	0.19	0.13	0.29	16.29	9.08	0.015	0.160	0.089	0.048	0.014
4	3.02	0.41	0.28	69.26	0.16	0.14	0.28	16.20	9.14	0.010	0.156	0.085	0.046	0.012
5	3.08	0.39	0.24	69.08	0.19	0.13	0.28	16.27	9.14	0.018	0.163	0.093	0.055	0.015
mean	3.09	0.40	0.25	69.16	0.18	0.12	0.28	16.23	9.11	0.016	0.158	0.089	0.049	0.015
sd	0.06	0.01	0.02	0.07	0.01	0.02	0.01	0.05	0.03	0.004	0.003	0.003	0.004	0.002

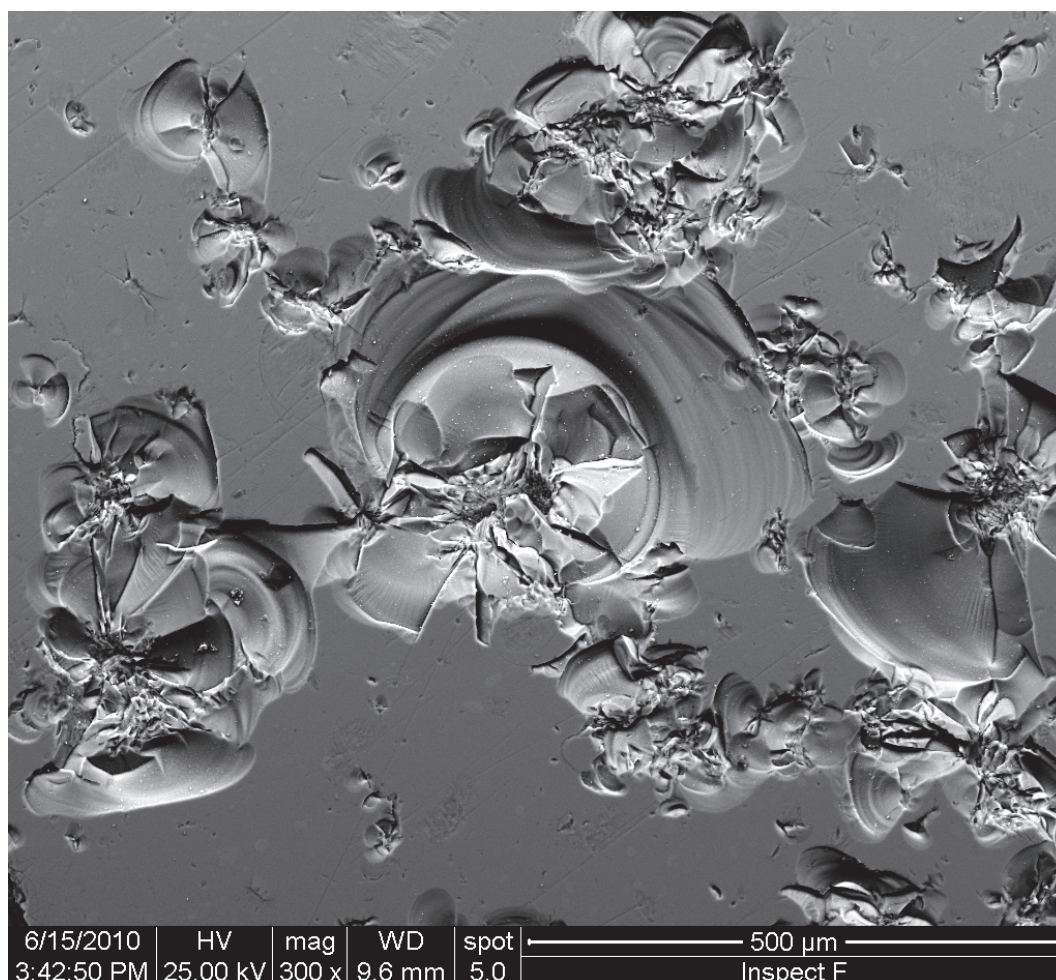


Figure 2. SEM image of the surface of the broken pane from the Music Room

The fragments of broken window submitted for analysis displayed a 'frosted' appearance on parts of one surface which consists of thousands of small impact fractures (Figure 2). The same surface was observed on several of the remaining panes at Kenwood and is believed to have been accidentally produced when the adjacent brickwork was cleaned (shot-blasting).

The pXRF analyses of the Kenwood windows included the lowest (and so most accessible) 18 panes from the three windows on the east side of the Music Room (Figure 3). All of the ground-floor windows on this side of the Music Room are 'blind' — behind the glass is a brick wall and the windows do not serve to admit light but merely to provide an architectural balance with the west wall of the Dining Room (whose windows are not blind). MR18 was the pane which was replaced in 2010 following the breakage. For comparison with the Music Room windows, 12 panes from two windows of the west wall of the Dining Room were also analysed using pXRF (Table 4).



Figure 3. East side of the Music Room showing the three windows analysed.

Thirteen of the analysed panes from the Music Room share similar compositions which are distinguished by high levels of potassium ($15.7\% \pm 0.8$) and are comparable with the fragments of the broken pane (Table 3). Such high levels of potassium are unusual in English historic window glass (Dungworth 2011). Medieval window glass did contain comparable levels of potassium but Kenwood was built long after manufacture of that glass type ceased. In addition, medieval glass usually contains much higher levels of a range of elements (manganese, iron, strontium, zirconium, etc) compared to this glass type. This glass type is comparable with window glass at Walmer Castle and is believed to have been imported from Bohemia or Germany (further discussion below). It is assumed that this glass type represents the original glazing for this room.

Table 4. Chemical composition of Music Room glass (in situ analysis using pXRF)

SAMPLE	Comment	SO ₃	K ₂ O	CaO	Fe ₂ O ₃	As ₂ O ₃	Rb ₂ O	SrO
MR01	Bohemian	0.08	14.8	9.6	0.18	0.09	0.023	0.013
MR02	Bohemian	0.11	15.4	9.4	0.17	0.11	0.039	0.013
MR03	Bohemian	0.33	16.6	9.1	0.18	0.13	0.062	0.011
MR04	Bohemian	0.38	17.5	9.2	0.15	0.14	0.078	0.009
MR05	Bohemian	0.20	15.0	9.1	0.18	0.11	0.041	0.013
MR06	Bohemian	0.28	16.7	9.2	0.17	0.13	0.064	0.011
MR07	Bohemian	0.22	15.9	9.3	0.14	0.10	0.055	0.011
MR08	Bohemian	0.19	15.6	9.5	0.13	0.09	0.060	0.011
MR09	Bohemian	0.17	14.8	8.9	0.17	0.18	0.053	0.011
MR10	20th century?	0.14	0.58	8.5	0.15	<0.02	<0.002	0.005
MR11	Bohemian	0.18	15.3	9.2	0.15	0.15	0.055	0.011
MR12	20th century?	0.17	0.59	8.3	0.15	<0.02	<0.002	0.005
MR13	20th century?	0.17	0.40	8.4	0.09	<0.02	<0.002	0.024
MR14	Bohemian	0.30	16.2	9.1	0.16	0.12	0.064	0.011
MR15	Bohemian	0.17	14.8	9.1	0.17	0.12	0.039	0.011
MR16	20th century?	0.18	0.41	8.3	0.09	<0.02	<0.002	0.025
MR17	Bohemian	0.24	15.5	9.6	0.13	0.08	0.062	0.011
MR18	19th/20th century?	<0.05	<0.1	9.2	0.06	<0.02	<0.002	0.007
DR01	19th century?	0.32	<0.1	10.9	0.11	0.08	<0.002	0.007
DR02	19th century?	0.38	<0.1	10.3	0.10	0.08	<0.002	0.005
DR03	19th century?	0.39	<0.1	10.9	0.11	0.08	<0.002	0.007
DR04	19th century?	0.28	<0.1	10.9	0.10	0.08	<0.002	0.007
DR05	19th century?	0.27	<0.1	11.0	0.09	0.07	<0.002	0.007
DR06	19th century?	0.28	<0.1	10.9	0.10	0.08	<0.002	0.007
DR07	19th century?	0.33	<0.1	10.9	0.11	0.08	<0.002	0.007
DR08	20th century?	0.12	0.51	8.5	0.10	<0.02	<0.002	0.004
DR09	19th century?	0.40	<0.1	10.6	0.10	0.08	<0.002	0.007
DR10	20th century?	0.10	0.49	8.5	0.09	<0.02	<0.002	0.005
DR11	20th century?	0.06	0.48	8.5	0.09	<0.02	<0.002	0.005
DR12	19th century?	0.27	<0.1	11.0	0.11	0.08	<0.002	0.007

The remaining five panes from the Music Room that were analysed, and all of those from the Dining Room, have compositions which are consistent with the sorts of window glass manufactured after the introduction of Leblanc soda in the 1830s (Dungworth 2011). These panes can be divided into two groups (with one outlier — MR18). The first group comprises nine of the Dining Room panes; this glass group has slightly higher levels of calcium and contains traces of arsenic (but no potassium). The second group (four from the Music Room and three from the Dining Room) has lower calcium and contains traces of potassium (but no arsenic). The first group is likely to have been manufactured in the 19th century and the second group in the 20th century (and after 1930). The first group could represent the original glazing of the Dining Room but the second group comprises later replacements and repairs. The outlier (MR18) contains neither arsenic nor potassium and has rather intermediate levels of calcium and so is difficult to place in the sequence of post-1830 window glass. Nevertheless, it is known that this pane was broken and replaced in 2010.

DISCUSSION

Most of the glass used to glaze the blind windows on the east side of the Music Room is a potassium-calcium-silicate glass. When the fragments of the broken pane were first analysed (2010), the glass type did not match any known historic window glass in England (Dungworth 2011). The subsequent analysis of window glass from Walmer Castle (Dungworth and Girbal) and the pXRF *in situ* analysis of Music Room window glass (2013) has confirmed the use of this glass type (Table 5). The glass at Walmer Castle displayed some small differences compared to that at Kenwood. Firstly much of the Walmer Castle glass was deliberately coloured using manganese to achieve both pink and purple colours. Secondly, the Walmer glass either contained no arsenic (<0.01wt%) or much higher levels (0.6–1.0wt%) than seen at Kenwood. The third group of Walmer contains lower levels of potassium glass and probably also contain sodium, however, the analytical technique employed (pXRF) is incapable of detecting this element.

Table 5. Summary of composition of Bohemian/German window glass with contemporary window glass (Dungworth 2011; Dungworth and Girbal 2011; Muspratt 1860; Smrcek 2005)

	Na ₂ O	MgO	Al ₂ O ₃	SiO ₂	P ₂ O ₅	SO ₃	Cl	K ₂ O	CaO	MnO	Fe ₂ O ₃	As ₂ O ₃	Rb ₂ O	SrO	ZrO ₂
Kenwood	3.09	0.40	0.25	69.2	0.18	0.12	0.28	16.2	9.1	0.02	0.16	0.09	0.049	0.015	<0.005
Walmer 1	NA	<1.5	<0.5	67.3	<0.2	<0.2	<0.2	18.0	10.6	0.34	0.07	0.78	0.024	0.006	<0.005
Walmer 2	NA	<1.5	<0.5	68.9	<0.2	<0.2	<0.2	16.8	10.1	0.83	0.12	0.73	0.023	0.011	0.028
Walmer 3	NA	<1.5	0.9	71.4	<0.2	<0.2	<0.2	6.1	5.6	<0.01	0.15	<0.02	0.022	0.006	0.006
Muspratt	3.0	NA	NA	73.0	NA	NA	NA	11.5	10.5	NA	NA	NA	NA	NA	NA
Smrcek	NA	NA	1.4	72.9	NA	NA	NA	18.0	8.7	NA	NA	NA	NA	NA	NA
Kelp glass	7.8	5.3	2.7	66.0	1.1	0.20	0.60	4.2	10.2	0.05	0.72	<0.05	<0.005	0.430	0.030
Soda glass	13.3	0.2	0.67	70.3	<0.1	0.5	<0.1	0.1	13.9	<0.05	0.24	0.31	<0.005	0.021	0.005

The glass type used for the Music Room at Kenwood House has close parallels with 'chalk glass' produced in Bohemia and Germany (Kunicki-Goldfinger *et al* 2003; Muspratt 1860, 210–212; Smrcek 2005). This was a high-purity glass (in particular with low levels of iron) using potassium (pearl ashes) and calcium (chalk) as the only additions to silica. This was developed in Bohemia in the 1670s (Douglas and Frank 1972, 18). Initially it was used for the production of tableware (Kunicki-Goldfinger *et al* 2005) but Smrcek's (2005) review of literature relating to the composition of window glass from 1830 to 1990, shows that essentially the same glass used in the early and mid 19th-century to make window glass in Bohemia and Germany (Table 5). Muspratt describes Bohemian glass as 'highly valued on the Continent for tableware, where it is also employed to make costly windows for fine buildings and carriages' (Muspratt 1860, 211).

While the use of this type of glass for windows (in continental Europe) appears to end in 1870s, its earliest use is not yet known. The Music Room was constructed in the last decade of the 18th century and it is most unlikely that the chalk glass windows pre-date this. The chalk glass at Walmer Castle were in a suite of rooms that are popularly

believed to have been installed when the Earl of Liverpool was Warden of the Cinque Ports (1806–1828, see Dungworth and Girbal 2011).

The analysis of window glass at Kenwood House and Walmer Castle indicates that chalk glass was imported to England for several decades around the turn of the 19th century. Chalk glass may have been desired due to its low iron content which would have ensured that it was colourless, especially compared to kelp glass (Table 4). Indeed Muspratt stresses that ‘the beauty and value of this glass depend upon its absolute limpidness’ (Muspratt 1860, 213). It is likely that this advantage was largely removed when English window glass manufacturers made the switch from kelp to synthetic soda during the 1830s.

The use of chalk glass at Kenwood House still poses several unanswered questions. The glass would certainly have been more expensive than most contemporary glass and the cost of shipping would have added greatly to the cost. This increased cost could be seen as justifiable as chalk glass was completely colourless and offered much greater transparency than most contemporary glass. Cast and polished plate glass could have provided a production with the same qualities as blown chalk glass, however, the plate industry in England had a slow start. A plate glass works was set up in 1777 but it does not seem to have operated successfully for many years (Douglas and Frank 1972). As the sole English producer, it operated for many years under near monopolistic conditions and plate glass prices remained high until the second decade of the 19th century (HMSO 1835).

The motivation behind the selection and use of an expensive, high-quality glass for the Music Room is additionally curious as the windows are blind and no one would ever have been able to appreciate their true quality. Given their specific architectural quality almost any quality of window glass would have served as well. It is possible that originally all of the windows in the Music Room were provided with this expensive glass but that it has only survived on the blind windows which are less likely to require repair or replacement.

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