(CV MA) NEWS LETTER 12

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CONTENTS

1 GENERAL

1.1 PROFESSOR HANS HAHNLOSER

The death of Professor Hans Hahnloser on 7th November 1974, after a protracted and very painful illness, has robbed the CVMA (and also CIHA and other organisations) of an inspired and energetic leader. His passing has caused great sorrow in all quarters and it will be difficult to replace him. Our deepest sympathy goes to his brave wife and the rest of their family.

I understand that Professor Louis Grodecki will temporarily assume the duties of Acting President of the CVMA until a new President can be elected.

1.2 EXHIBITION OF YORK'S CONTRIBUTION TO STAINED GLASS

Readers of these News Letters in Great Britain may wish to make a note in their diaries that an important exhibition will be mounted in York during the week beginning 7th April 1975, on the occasion of an International Congress to be held in the University by the Chemical Society. The exhibition is expected to be staged in the foyer of the Department of Physics and it will cover four different aspects of York's contribution to stained glass:-

(a) Photographs of important windows in the Minster, and in some of the churches in York, and actual panels from the Minster both before and after restoration.

(b) Examples of the conservation activities of the York Glaziers Trust, probably to be shown as film on TV monitors in the exhibition area.

(c) Explanatory examples of the part played by the University in iconographical research which assists the proper restoration of a window. Dr Peter Newton's study of the Angels window at All Saints' Church, North Street will be one of the examples.

(d) Examples of the scientific work carried out by the University on the chemical composition of the Minster glass in relation to its remarkably varied durability patterns. Other examples of scientific aids to conservation will be displayed, such as the recovery of lost images, the use of radiation monitoring to establish the authenticity of pieces of early medieval glass, and a study of the humidity existing around the old glass when protective glazing is used.

Fuller details of this exhibition, with times of opening, will be given in later News Letters.

1.3 PAUL JEFFERIES' REPORT

In News Letter No.6 (item 1.1.1) it was stated that Mr Paul Jefferies, of Mr Dennis King's workshop in Norwich, had been awarded the Travelling Scholarship for Stained Glass offered by the Radcliffe Trust Scheme for the Crafts. He made the journey between September 13th and October 6th and visited Rouen, Evreux, Paris, Sens, Chartres, Troyes, Strasbourg, Ulm, Munich, Vienna, Regensburg, Altenburg, Augsburg, Straubing, Nuremberg, Linnich, Cologne, Aachen and Gouda.

At the laboratory at Champs-sur-Marne he saw glass fragments cleaned by M. Bettembourg's processes (see N.L. No.7, item 2.4); the glass was matt and translucent but it improved when coated. He also saw the mastics referred to in item 169 on p.7 of N.L. No.11; the resins used for coatings referred to in item 170; and the use of Viacryl VC363 referred to in the same item both for sealing freshly-cleaned surfaces and fixing loose paint.

In Munich, at the Frauenkirche, much of the old glass which was cleaned in the period 1950-60 is now said to be badly corroded. The Scharfzandfenster was in better condition than most.

At St Maria am Gestade in Vienna he noticed that some light penetrated between the widened medieval panels and the sides of the mullions in the isothermal glazing system there, but it was visible only from the sanctuary area.

In Nuremberg, at the workshop of Dr Frenzel, he saw the restoration of the Augsburg Prophet windows, any loose paint being fixed with Araldite AY101. The backs of the windows were washed with distilled water and any loose corrosion was scraped away with a scalpel while it was still wet. Araldite, thinned with acetone, was used for fixing any loose paint. Fractures were edge-bonded with Araldite and any gaps were filled with Araldite and afterwards toned down with a suitable cold paint.

Dr Frenzel made a statement that, in the 19th Century, some medieval glass had been repainted and refired. (RGN - see also item 3 below.) Dr Frenzel is also experimenting with electrically-heated copper wires in the cavity of an isothermal glazing system, to keep the interspace 1 degC. warmer than the interior of the building. (RGN - it will be important to learn more about this interesting experiment; how far the wires are separated; what current is used; and how the temperature is controlled.) When the exterior appearance of an isothermal system is important (as at Altenburg) the outer glazing is leaded to copy the main lead-lines of the medieval glass.

At Cologne he visited both the Dom and St Kunibert's Church and helped to clear up a criticism of the 'Jacobi process'. At St Kunibert's there was much discolouration of the bonded joints of the St Catherine window due to the use of an earlier technique. In the Dom a revised process is in use and no discolouration has occurred. (RGN - A party of art-historians and scientists who went to Cologne and saw only St Kunibert's have been very critical of the Jacobi process and it seems that their view may now need to be revised, but a photograph of the St Kunibert's window is not available for reproduction in the News Letter.)

1.4 STORAGE OF VALUABLE GLASS DURING THE WAR

Miss Judith Scott, lately of the Council for Places of Worship, has kindly drawn attention to the existence of war-time records regarding the storage of religious treasures of all kinds. Many of these, including stained glass from Exeter, Salisbury, Tickenham, Weston in Gordano and Walton, were stored in the crypt of Wiveliscombe church in Somerset, and some church treasures were apparently damaged by the flood which occurred there in 1947. These records will need time for study but Mr John Smith has drawn my attention to a pamphlet issued in 1940 by the Central Council for the Care of Churches entitled "How to protect a church in war time". On page 13 it states that panels of glass which have been removed should "be tightly packed in strong boxes or crates with dry sawdust between each panel. The crates should be removed to a safe place and stored so that the panels are in <u>an upright position</u>".

Even though "dry sawdust" was recommended, it would not remain "dry" for very long. For example, in a cellar with a temperature of 10°C and a relative humidity of 90% the sawdust would probably have a moisture content of 28% (depending somewhat on the type of wood from which the sawdust was made). Fortunately, moist sawdust tends to be slightly acid (rather than alkaline which would tend to damage the glass), Scots pine having pH values of 4.3 to 4.6, spruce 4.8 to 5.0 and beech 4.5 to 5.9; oak is distinctly acid (3.3 to 3.9) but it would probably not have been used for sawdust. However, the question should be investigated in an experiment at the York Glaziers Trust. Some simulated medieval glass (British Glass No.2) will be packed in sawdust and stored in a damp cellar to see whether any damage occurs.

1.5 DEPOSITS INSIDE THE PLATING OF THE HEAD AT CANTERBURY

In Section 2 of N.L. No.10 an account was given of the condition of the modern glass inside a plated head at Canterbury Cathedral. In the fourth paragraph of p.2 it was stated that Dr N.J. Bridge would be studying the white and black deposits found on it. He has now reported that the white material was gypsum and the black material was probably a mixture of graphite and silica gel. The graphite presumably came from soot in the atmosphere. The gypsum and the silica gel might also have been airborne (eg from stonework, etc.) but may have come from glass, in which case they would have come from the ancient glass because the modern glass was shiny and unaffected.

2 DOES CLEANING AFFECT WEATHERING ?

There are suggestions in the literature that the crust, or the patina, on weathered medieval glass may have a protective action against further weathering (see, for example, Abstract Nos. 45, 49 and 50 in the British Academy Bibliography).

On the other hand there have been suggestions that a porous crust might harbour moisture, or alkaline solutions, or even micro-organisms and thus enhance further weathering (Ref. 126).

Yet again, Dr R.H. Brill (Ref. 14) has suggested that any vigorous cleaning of the glass will remove the protective fire-finished surface (which is known to be specially durable in newly-made articles) and hence will enhance further weathering.

Moreover Klaus Kühne (Ref. 84) has claimed that polishing of the surface with acid improves the durability of the glass because it reduces the alkali content of the glass surface (fire-finishing has the same mechanism, the alkali being reduced by volatilisation in the flame).

Thus the problem clearly needs some experimental study but there are many difficulties in carrying out suitable experiments, especially as accelerated weathering must be used to obtain answers in a reasonable time and the acceleration procedure may introduce some distortion in the answers. However, a start must be made somewhere, somehow, and the following brief notes of two experiments being carried out at BGIRA in Sheffield are included in the hope that they may encourage someone to comment and perhaps inspire somebody to carry out a better experiment!

Brill (Ref. 14) claimed that loss of a fire-finished surface would enhance weathering and hence the first experiment used a poorly durable simulated medieval glass (British simulated glass No.2) having a freshly-melted fire-finished surface. A 17mm diameter disc was cut from the cast slab of glass and a narrow stripe was airbraded across the flat surface. After exposure for 50 hours to distilled water in a Soxhlet apparatus the airbraded stripe had turned a deep red because the iron in the dark green glass had been attacked where the durability of the glass had been lessened by the airbrasive treatment. The rest of the surface was still green and shiny but the sides of the disc, where it had been cut from the slab of glass with a diamond core-drill, had also turned red.

A second stripe was then airbraded at right angles to the first one and the sample was again exposed for 50 hours in the Soxhlet. The red deposit was lost from the first stripe but another developed on the second stripe. These effects can be seen in Figs. 1 and 2. Fig.1 shows the disc and the red deposit on the second stripe shows up as an irregular white mark (presumably the airbrasive grit blew across the disc towards the left and produced the ragged edge). Fig.2 shows an enlarged view of the central portion taken with extreme oblique illumination and the position of the original stripe can be seen as a groove with a shadow in it.

Thus the airbrasive undoubtedly reduces the durability of a freshly-melted fire-finished surface, but the process of accelerated weathering seems to confer fresh durability on the initial stripe because it does not form a second red deposit. Moreover, we do not know how long a fire-finished surface can remain as a protection against corrosion when exposed to the weather. In order to answer this second question (at least in part) the next experiment used a small piece of 12th century glass from York Minster, by kind permission of the very helpful Dean and Chapter. Mr Peter Gibson carefully selected a piece of glass having the following characteristics: (i) it should be as similar as possible to the piece of 12th Century green glass described in Ref. 129 and hence likely to have a poor durability, (ii) it should be completely covered in a coherent crust, including the edges, (iii) there should be as little paint on the surface as possible, and it should show no evidence of ever having been broken (i.e. apart from grozing it should have the original surface), and (iv) it should be small enough to fit inside the Soxhlet apparatus; the actual dimensions were 26 x 18 x 3 mm.

A piece was found which met these exacting requirements and it weighed 3622 mg; its volume was about 1.4 ml and its surface area was about 1200 mm^2. The first experiment (a) was to wash it well in order to extract any alkali (potash) which may have collected in the crust; this was done by washing for 30 minutes in hot distilled water at 60°C. A substantial amount (0.73 mg) of potash (K_2O) was washed out from the crust, representing 0.020% of the weight of the sample (the period of immersion was too short to permit any attack on the glass). Next (b) the crusted sample was put in the Soxhlet apparatus for 50 hours at about 85°C and it was found that a further 0.78 mg of K_2O was extracted (0.022%) or about 0.6 µg K_2O per mm^2 of surface in 50h. Some of the crust became detached during this prolonged extraction, so that the new weight of the sample was 3556 mg (thus about 64 mg of crust was probably lost).

Next (c) the crust on both sides and all four edges was cleaned off with the airbrasive (using No.3 grit) and the cleaned sample weighed 3200 mg. It is not known how much glass was removed during the cleaning process but the loss in weight of 356 mg (about 10%) probably represents mostly crust. The cleaned sample was then put in the Soxhlet for 50 hours and 0.66 mg of K_2O was found in solution in the extracting water (0.021% of the new sample weight). The sample lost a further 4.4 mg in weight which possibly represented loss of adherent alumina grit from the airbrasive and perhaps other losses of glass, crust, etc. Up to this point the apparent durability of the glass could be represented by a loss of about 0.022% of its weight as K_2O in 50 hours at 85°C whether the crust was present or not.

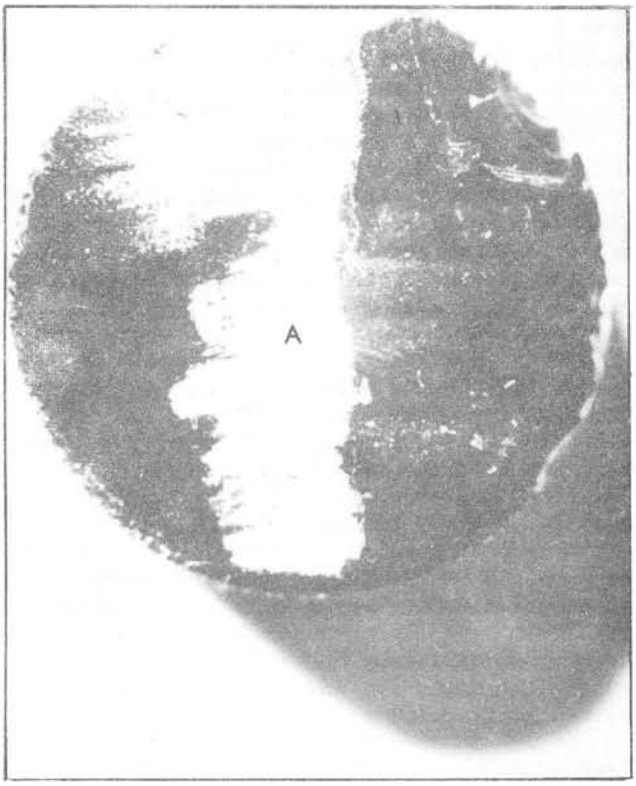

Fig. 1 The circle is a 17 mm diameter disc of poorly-durable dark green glass with a fire-finished surface which has had a stripe airbraded across the vertical diagonal. After accelerated weathering, the iron in the glass weathered to give a red deposit which appears white in the photograph. It was therefore concluded that airbrasion of a fire finished surface reduces the durability of the glass.

The letter A indicates the same spot in both Figures.

Thus it seems from (a) that the crust (which at most weighed 420 mg) contained 0.73 mg of K_2O or 0.17%, and this may be evidence of the crust "harbouring" alkaline solutions. Moreover, from (c) it seems that cleaning with the airbrasive did not change the apparent durability of the glass.

Next (d) the sample was ground smooth using Carborundum grades 220, 320 and 600, and then polished mechanically using "Cerirouge" 688, Grade 90. This reduced the weight considerably (to 1708 mg) and the new dimensions were 24 x 16 x 2 mm, or about 0.7 ml, with a surface area of about 950 mm^2. It was again given a Soxhlet extraction for 50 hours but only 0.21 mg of K_2O was extracted (0.012 of the new weight or 0.2 µg K_2O per mm^2 of surface). The conclusion is that the apparent durability of the surface has been greatly increased, being doubled on the basis of percentage loss of K_2O (only half as much lost) or increased about 3 times on the basis of loss of K_2O per unit area of surface.

From this it could appear that the crust present at stage (b) did not have a protective action and that polishing of the glass (stage d) enhanced the durability, probably by reducing the total effective surface roughness and possibly also by bringing about some loss of alkali from the heating of the surface during wet grinding.

The experiment is not yet completed because stage (e) is involved with the production of a flame-finished surface, and the results will be reported in the next News Letter. (The first part of this study is supported by the Royal Society and the second part by the Department of the Environment.)

The results to date are summarised in the table on page 5 for convenience.

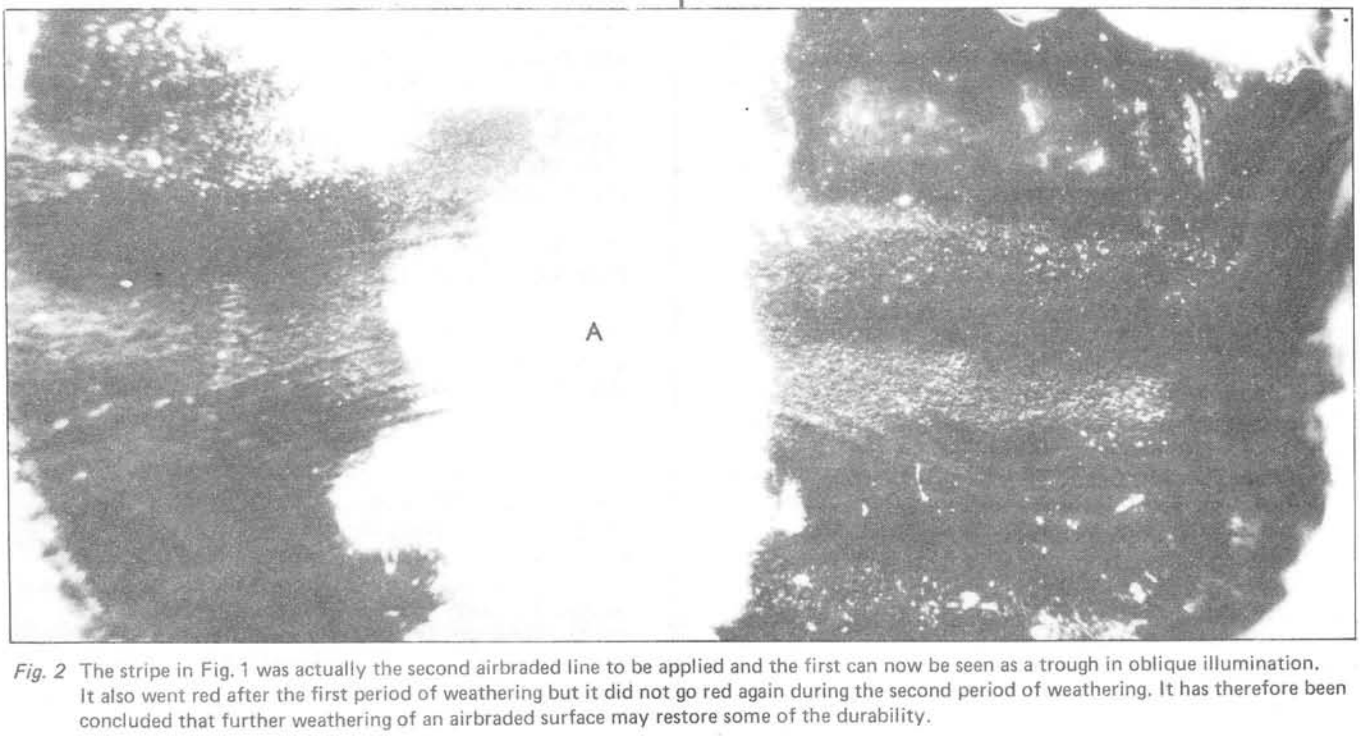

Fig. 2 The stripe in Fig. 1 was actually the second airbraded line to be applied and the first can now be seen as a trough in oblique illumination. It also went red after the first period of weathering but it did not go red again during the second period of weathering. It has therefore been concluded that further weathering of an airbraded surface may restore some of the durability.

Procedure	Weight of sample (mg)	Percentage loss of K_2O	Loss of K_2O per unit area ($\mu g/mm^2$)	Comments
(a) Washing	3622	0.020	0.6	Alkali held in the crust
(b) Extraction through the crust	3556	0.022	-	The crust is not protective against this type of weathering (64mg crust also lost)
(c) Extraction after airbrasion	3200	0.021	-	The airbrasive treatment does not reduce the durability of an ancient sample
(d) Extraction after polishing	1708	0.012	0.2	The resistance to this type of weathering is at least doubled by polishing the sample

3 HEATING OF MEDIEVAL STAINED GLASS !

I feel that the time has come to re-examine the validity of the widely-held view that most medieval stained glass should not be re-heated at all. Here I include the possibility of two types of re-heating, the "substantial" heating (e.g. to 200°C) which might be involved in "baking" a resin on to the surface and the "extreme" heating involved in refiring the glass, either to fire-on renewed painted lines or to produce an "enamelled" (or even a flame-fired) finish as a means of improving the durability of the glass.

Probably the first paper advising against the heating of renaissance glass was that by Miss Mavis Bimson and Dr Tony Werner in 1964 (see Ref. 9 of the British Academy Bibliography). They found that the surface of a 17th Century goblet became badly crazed by heating slowly to only 90°C over a period of 8 hours. As a footnote to the same paper Dr R.H. Brill commented that, at the Corning Museum of Glass, 23 samples of "ancient glasses" had been heated (first to 110°C for 60 hours and then to 175°C for 160 hours) and 30% of them were damaged.

These experiences with renaissance vessel glasses may not be wholly relevant to the question of heating early medieval window glass, if only because the medieval windows have been durable enough to remain extant (though damaged) for 500-800 years and it would be interesting to speculate on the fate of renaissance goblets if they were to be exposed continuously to the weather for a similar period!

However, what we really want to know is what actually happens to medieval window glass when it is heated. In 1971 Dr Gottfried Frenzel told me that there was rarely any danger in heating medieval window glass to "extreme" temperatures providing the surface did not already show signs of "micro-cracks". In fact, much medieval painted glass was heated to 500°C to 600°C when the "superfusion process" (see Dr Eva Frodl-Kraft, Ref. 44(b), for details) was in vogue for conserving stained glass and it came to no harm. In the St Lorenzkirche in Nuremberg 60 panes were heated to at least 400°C in 1919 and another 90 were so treated in 1938 without harm (see Ref. 36). Josef Schmitz repainted and refired glass in the St Sebaldkirche (Die Denkmalpflege, 1919 21, 97-99, 106-107) and Rudolf Pfister did the same in the St Lorenzkirche (Deutsche Denkmalpflege, 1939 66-78).

In Item 1-A of the Bibliography prepared for the 1972 CVMA Colloquium, and dated 21 August 1972, I enquired whether any practising restorers or any delegates to the Colloquium could provide any evidence of medieval glass being damaged by heating. Only Mr Dennis King of Norwich sent me a reply and he stated that there was generally no risk, but any glass which showed surface fracturing (such as that from St Michael's Cathedral, Coventry - see Fig.3) would be liable to damage by even moderate heating.

Modern adhesives used for edge-joining broken pieces tend to need some heat if they are to "cure" reasonably quickly and we therefore need to know whether there is any risk of heating medieval window glass, providing it does not already show signs of cracking such as that in Fig.4, and providing the surface has been carefully cleaned before heating (see Ref. 44).

I therefore renew my appeal; does anyone know of cases where glass has been damaged? Please write to me at 5 Hardwick Crescent, Sheffield S11 8WB.

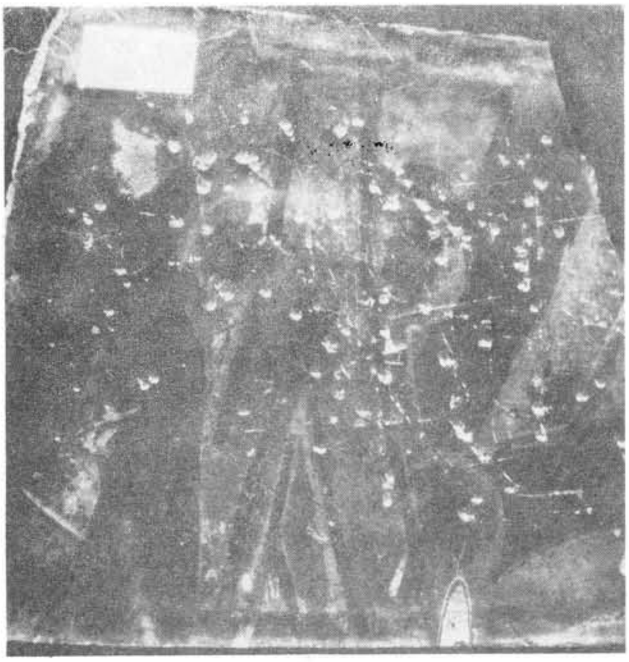

Fig. 3 This glass from St. Michael's Cathedral Coventry shows surface fractures which cause concave cavities to form; it would be damaged by heating.

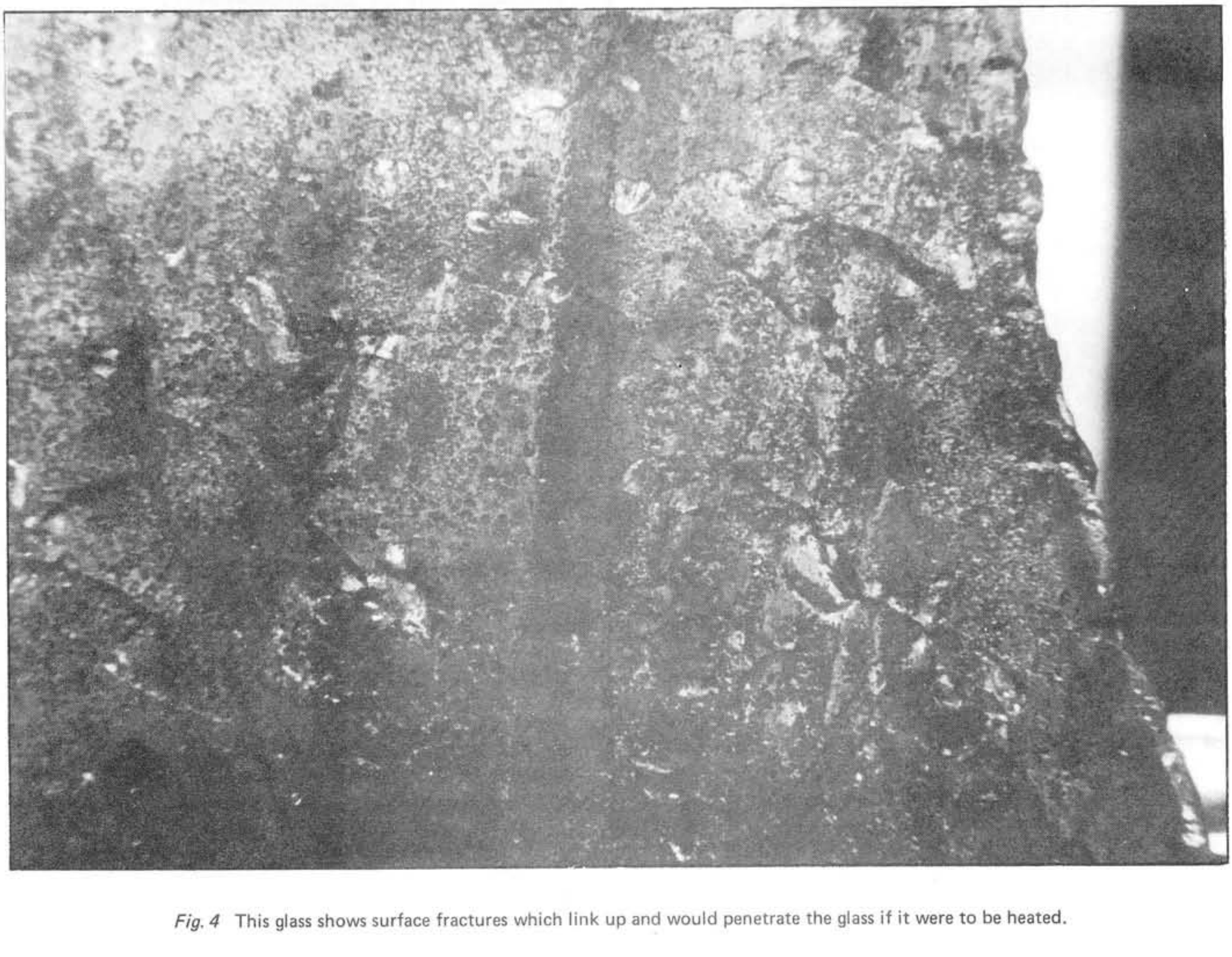

Fig. 4 This glass shows surface fractures which link up and would penetrate the glass if it were to be heated.

4 PROTECTIVE GLAZINGS

4.1 ISOTHERMAL GLAZING

News Letter No.10 contained, as item 3.1 (and as Fig.4 of that issue), some details of the isothermal glazing installation at the Church of Santa Croce in Florence, but no measurements were available at that time. Professor Marchini has now kindly sent me some measurements which are shown diagrammatically in Fig.5. They can easily be related to the photograph in N.L. No.10. The central ventilator with three apertures has a total area of 27 cm^2 and the two side ventilators, with five apertures, each have a total area of 45 cm^2. The piece of glass which forms the external glazing to this tracery is remarkably large, being 2.15m x 1.77m!

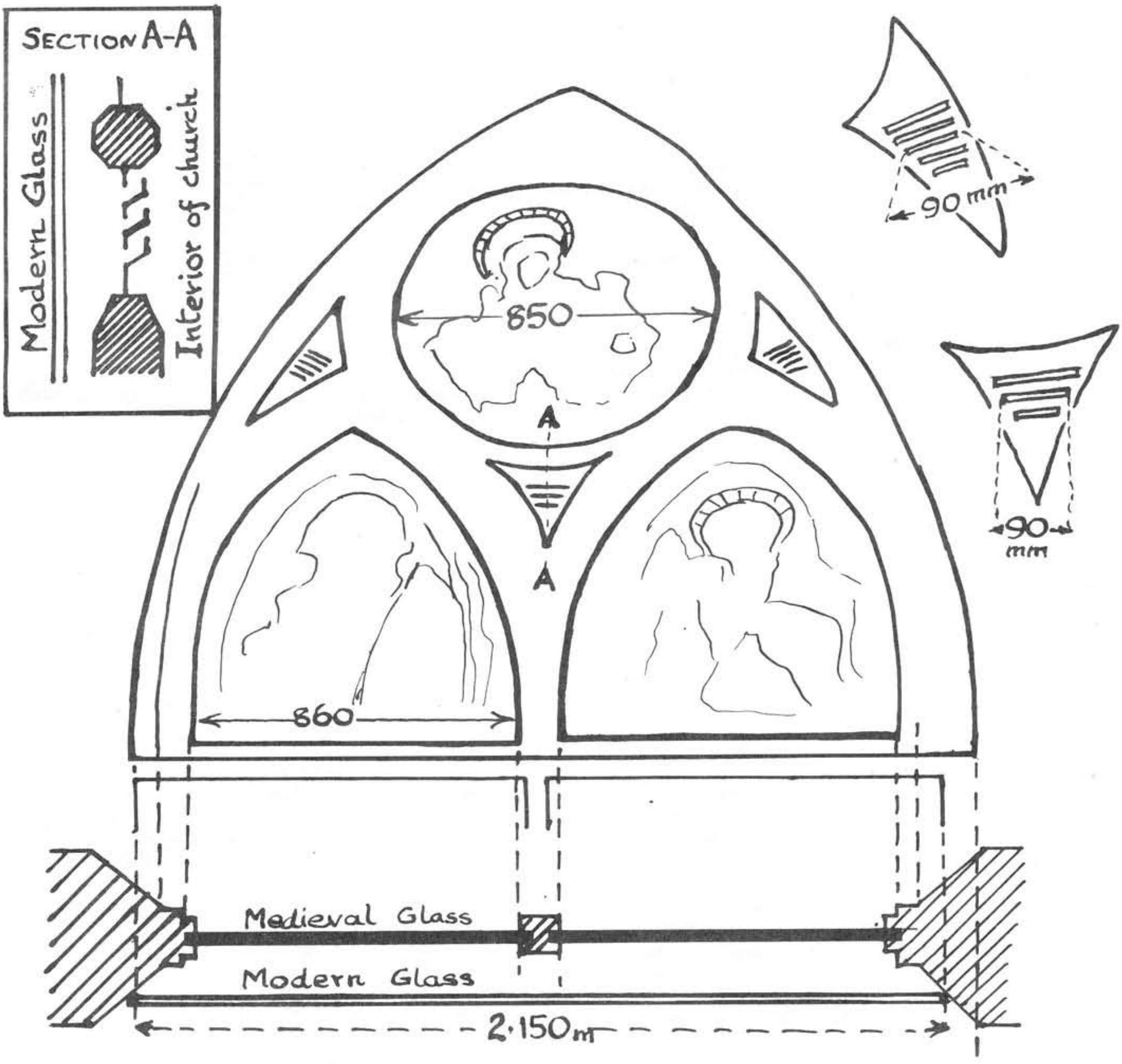

Fig. 5 Details of the isothermal glazing system on the tracery lights at Santa Croce Church, Florence.

4.2 EXTERNAL PROTECTIVE GLAZING AT YORK MINSTER

By kind permission of the Dean and Chapter, studies are being carried out of the changes in humidity inside the space between the medieval glass and the external modern diamond-quarry glazing of two windows at York Minster, a hair hygrometer having temporarily been inserted into the space.

The first window to be studied was the Great East Window and the following data were obtained:-

Date	Time	Weather conditions	Inside temp. (°C)	Outside temp. (°C)	RH (%)	Moisture content (g/m^3)
14 October	08.10	Dry, sunlight on window	8.9	7.8	67	(5.9)
	10.45	Dry, sunny*	9.4	10.6	70	(6.4)
	18.35	Dry, clear sky	8.9	8.9	75	(6.5)
15 October	08.04	Cloudy, light rain	8.3	7.2	95	7.9
	10.00	Cloudy	8.9	8.3	91	7.9
	18.36	Heavy cloud	8.9	7.8	89	7.8
16 October	08.08	Cloudy, light rain	8.3	6.7	94	7.9
	10.20	Cloudy, no sun	8.9	9.4	89	7.8
	18.10	Heavy cloud	8.9	7.8	85	7.4
17 October	08.03	Overcast	8.9	6.7	98	(8.5)
	10.25	Cloudy, intermittent rain	8.3	11.7	90	7.5
	18.20	Moderate rain	8.9	7.2	86	7.5
18 October	08.05	Heavy rain	9.4	6.7	98	(8.9)
	10.40	Overcast, light rain	8.3	12.8	89	7.3
	18.25	Light rain	8.3	10.6	86	7.1
19 October	08.15	Dry, sun on window	8.3	7.2	64	(5.2)
	10.40	Dry, sunny intervals*	8.9	10.0	71	(6.2)
	17.20	Light rain	8.3	8.9	81	6.8
20 October	09.20	Dry, weak sunlight on window	8.9	6.7	77	6.7
	12.45	Dry, cloudy, no sun	8.9	10.0	76	6.6
	18.30	Dry, cloudy	8.9	8.9	77	6.7
21 October	08.05	Dry, cloudy, no sun	7.8	5.0	91	(7.3)

* But the sun was not shining on the glass

The temperature inside the Minster was measured with a thermometer close to the stained glass at the position of the hygrometer; there was little variation, between 7.8° and 9.4°C. The outside temperatures were measured at the back of a nearby house in a comparatively sheltered position and the variation was between 5° and 12.8°C. The moisture contents of the air in the interspace were estimated on the assumption that the temperature in the interspace was that of the Minster; this could lead to the errors which are discussed below. The relative humidity in the early morning tended to be in the range 94% to 98%, unless the sun was shining on the window, when the value was 64% to 77%. However, the figures for the moisture content of the air are more informative. Except for the eight figures in brackets the values lie between 7.4 and 7.9 g of water per m^3 in the first part of the period but seem to fall to 6.6 to 7.3 g/m^3 in the second part; the corresponding dew-points would have been 7.5 to 6.5°C or 4.5 to 6.2°C. The five low values for 14th and 19th October (especially those of 5.9 and 5.2 g/m^3) occur when the sun was shining on the window or the sky was bright; in these circumstances the temperature of the air in the interspace would certainly have been higher than that recorded for inside the Minster. In fact, a moisture content of 7.9 g/m^3 and a relative humidity of 67% would correspond to an interspace temperature of about 13.5°C which is only about 4 degC above the temperature in the Minster.

Similarly, the three "high" values of 8.5, 8.9 and 7.3 g/m^3 correspond to rather cold nights and the interspace temperature on 17th October corresponding to 7.9 g/m^3 would have been about $7\frac{1}{2}$°C, between the values recorded for "inside" and "outside". It seems possible that some condensation may have occurred on "face 2" (the inside of the outer glazing) on the nights of 15/16th and 20/21st October. It seems likely that the moisture content of the interspace was actually lower in the second part than in the first part and, if this was so, it might correspond with the fact that the weather was rainy until 18th October and dry thereafter. This would suggest that there is some "leakage" of air from the atmosphere into the interspace. The data also indicates that there is no "reservoir" of condensed water (or rainwater) in the interspace or it would have increased the humidity on those days (14th and 19th October) when the sun was shining and the interspace was warm; this confirms the suggestion that the interspace is "leaky".

Further studies (to be reported in a subsequent News Letter) will be carried out on a south-facing window (No.17, in the South Choir Aisle, second from the west).

5 NEW ABSTRACTS

175. CARLSON, W. (1956) "Interferometric studies of convective flow phenomena in vertical, plane enclosed air layers". PhD Thesis, University of Minnesota, April 1956. 298 + xvii pages of typescript.

This long thesis is highly technical but its conclusions can be of interest to architects and others concerned with the technical requirements of isothermal glazing.

The author determined the directions and extent of air flows in a tall narrow cavity when one side is hotter than the other. Many of his results are not appropriate for the situation of cathedral windows (e.g. the cavity was only 8 mm wide and the temperature difference was 83 degC) but some of his tests were made with a cavity 152 mm wide and a temperature difference of 8 degC, so these are of greater interest.

At the narrowest spacing (8 mm) the main heat transfer was by conduction and the temperature profiles across the interspace were linear, but as the interspace was made wider the mechanism of convection came into effect. Air flowed up the hotter surface and down the colder surface with horizontal flows at the top and bottom, and this became noticeable with the 8 mm spacing.

End effects were found at the top and bottom of the cavity and both of these effects became more pronounced when the temperature difference exceeded 20 degC.

Even at the widest interspace used (152 mm) the central core of the air layer had a temperature gradient, being warmer at the top than the bottom. In these cases the flow became turbulent.

176. OLBRICH, H. (1973) "Molasses as remedy at the renovation of the glass painting of a church window of St Lorenz in Nuremberg". F.O. Licht's Internationaler Melassebericht. International Molasses Report, 10 (6) pp1-3 (12 April 1973). This abstract is taken in its entirety from AATA Vol.11 No.1, Summer 1974 p.76 (Abstract 11-273) and there is as yet no further information.

The use of molasses in the conservation of a painted glass window (the Hallerfenster, made in 1480, by the Michael Wolgemut Workshop) is discussed. In 1939, as a temporary measure, broken fragments were joined using an adhesive made from molasses and a dextrin-protein glue, and the repaired pieces were protected on either side by two sheets of clear glass. The treatment is still considered satisfactory after thirty years.

177. PATERSON, M.P. (1974) "The atmosphere of the Royal Albert Hall - a study of the internal atmosphere of a natural draught building". Air Pollution Research Group, Mathematics Department, Imperial College, London S.W.7. 12 pages of typescript, 28th October 1974.

The atmosphere of the Royal Albert Hall in London is of interest to architects concerned with cathedrals because it is a large building ($10^5 m^3$) which can hold a large number of people (about 8000) and its atmosphere can be controlled by only two adjustable factors; (a) by opening outside doors and windows, etc. and (b) by turning on the heating system. There are no fans for forcing air through the building and no cooling system.

The height of the building (50 m) assists movement of the air by thermal convection (producing a pressure difference in the corona of about 0.02 mb per degC of temperature difference) and the thick walls produce a thermal inertia; when there were no occupants the inside temperature varied by 1 degC while the outside temperature changed by 9 degC. The study was made during the BBC Promenade Concert Season and an audience of 5000 persons and 100 performers were assumed to contribute 620 kW of heat and 412 kg/h of water vapour. There would be an average of 450 kW from the heating system during the winter (1500 kW at peak rates) and 1200 kg/h of water vapour brought in by the flow of outside air (assuming 60% relative humidity, 22°C and 1h residence time); the lighting during a performance contributes an extra 95 kW.

During an average performance of 2½ hours the temperature rises by about 2.5 degC (from 22.0 to 24.5°C) and moisture content by 2.8 g/m³ (the relative humidity from 60.0% to 64.8%). (RGN - he calculated that the moisture content might rise by 4.1 g/m³, and the true value probably lies between these two figures because hair hygrometers tend to give low values when the humidity is rising rapidly.)

(Comment by RGN - We can draw some interesting deductions from this paper about the way in which a large congregation would help to cause condensation on the inside of the windows of a cathedral. In London the average outside dew-point is 3°C, corresponding to 6 g/m³ of moisture in the air. The congregation would add 2.8 g/m³ and the resulting moister air (8.8 g/m³) would have a dew-point of 9°C; if we assume that the inside of the window is at the same temperature as the outside air, condensation would occur 90% of the time in an average January. In the summer, the average dew-point would be raised from 12°C to 16°C and, again making the same assumption, condensation would occur 40% of the time in an average July.)

Dr Paterson tells me that he would be glad to hear from any readers of the News Letter who have comments on the situation.

178. RYND, J.P. and RASTOGI, A.K. (1974) "Auger electron spectroscopy - a new tool in the characterisation of glass fibre surfaces". Ceram. Bull., 1974 53 631-634, 637.

This is a rather technical article about an expensive piece of equipment which uses electrons to study the surface composition of samples of glass. It is of potential interest in the scientific study of corrosion phenomena because it studies only the layer of atoms at the surface. The authors found that the compositions of the surface layers of two newly-formed modern glasses (glass fibre compositions E and S) differed from those of the bulk glass. The surfaces were, for example, found to be richer in some elements than in others but only aluminium (alumina) was richer at the surface in both glasses.

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NOTE: Will readers of these News Letters please draw my attention to any papers which should be abstracted here. It would be particularly helpful if photocopies of the papers could be supplied. My address is 5, Hardwick Crescent, Sheffield, S11 8WB, England.

NOTES

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