ISSN: 0308-2237

CV NEWS LETTER 24

Comité Technique du corpus Vitrearum

Physics, University of York

18 February 1977

CONTENTS

1 GENERAL

1.1 DEATH OF DR NEVILLE WILLIAMS

The untimely death of Neville Williams on 29th January of a heart attack, while he was visiting the British Institute in Eastern Africa, in Nairobi, has robbed the British Committee of its new Secretary so soon after his predecessor, Derek Allen, had died (N.L.15, Section 8).

Neville Williams had had an earlier heart attack in October 1976, after his visit to Russia, but as soon as he was out of hospital he threw himself into his work again with his accustomed energy, and this proved too much.

The part which he played at the Public Record Office from 1950 to 1973 (he was Deputy Keeper for the last three years), his skilled authorship of historical books of the Tudor period and his many other academic achievements will be recorded in other places. Here I shall only say how very sad it is to lose a kind friend and a wise counsellor. The British Academy, and hence the British Committee of the Corpus, will find it hard to replace him.

1.2 FUTURE OF THE CV-NEWS LETTER

Section 2.1 contains some adverse remarks on the News Letters by M Jean Taralon. In order to clear the air for a sober discussion I have resigned as Editor of the News Letters, to take effect on 27th May when the Corpus has its full meeting in Freiburg. It is thus likely that No.25 may be the last CV-News Letter to appear under my Editorship.

1.3 10th COLLOQUIUM OF THE CORPUS VITREARUM

The provisional programme shows that this will be an exceptionally interesting meeting, with several papers on stained glass of the period between 1150 and 1250, and visits to Esslingen, Lautenbach, Walburg, Strasbourg and Freiburg.

1.4 CRAFTS ADVISORY COMMITTEE SYMPOSIUM IN YORK

This meeting, held from 9th to 11th January, was extremely successful. It was heavily over-booked and the list of participants had to be closed when it reached 70 so that many applicants were disappointed, especially from overseas. The programme of lectures and visits stimulated much discussion which will be reported in the Proceedings of the meeting. There were six discussion groups which had their own topics from the following list:-

1.4.1 Conservation: Should we always conserve medieval glass or allow some to decay; should post-medieval glass be conserved; if so, are different techniques required; are special techniques needed for museum display of stained glass?

1.4.2 Restoration: How much restoration should be done; how much repainting is allowable; how can loose paint be re-fixed; what are safe cleaning methods from the point of view of further weathering; should protective coatings be used, or external glazings; what resins are suitable as adhesives or as fillers; how can medieval colours be matched; should copies be made of important windows; what are the best anti-vandal techniques; what records should be kept; how can anyone learn whether, and when, particular medieval windows are being restored; how can would-be restorers gain experience?

1.4.3 Technical questions: Why does medieval glass have an unusual chemical composition; will modern stained glass windows be durable, or should we protect them; why is the paint-work sometimes durable and sometimes not; why does medieval glass sometimes show surface-crazing?

1.4.4 Congratulations

Miss Cherry Ann Knott of the Crafts Advisory Committee must be congratulated on conceiving such a valuable meeting and Mrs Vivien Lawson for organising it in such an excellent manner. Also we must congratulate Mr David Rymer, of the Institute of Advanced Architectural Studies, for having made such effective administrative arrangements in York to everyone's satisfaction.

1.5 EUROPEAN SCIENCE FOUNDATION ANNUAL REPORT

Section 1.1 of N.L. 19 contained a brief note about the meeting of a group of stained glass experts in Munich on 25th February 1976, under the aegis of the European Science Foundation. This meeting has now been reported on pages 24-25 of the ESF Annual Report for 1976, and I have received permission to reproduce it in full, as follows, and to add a short note of my own.

"1.12 Preservation of mediaeval stained glass

The deterioration of the mediaeval glass in the great cathedrals and churches of Europe is a matter of increasing concern. Stained glass windows are an important part of a European cultural heritage and they are also historic reminders of the traditions from which present-day glass industries have sprung.

Some research work is in progress in a small number of institutions throughout Europe aiming both at understanding the causes and the mechanisms of the corrosion of the glass and at the elaboration of suitable procedures for cleaning and preservation. An increased scientific effort and a better co-ordination of on-going work is, however, important in order to ensure rapid progress in the development of appropriate techniques so that conservation can be effected at a satisfactory rate.

At present art historians and scientists studying the different aspects of mediaeval stained glass have a common form in the Corpus Vitrearum which formally is a commission of the International Academic Union (IAU), and it was from representatives of the IAU, of the Corpus Vitrearum and especially the Technical Committee of the Corpus Vitrearum that the proposal emerged for ESF involvement in the field.

To explore possible actions a small meeting with experts was held in Munich in February 1976. (The participants in the meeting are listed in Appendix 1). The meeting, which was chaired by Professor Gentner (Heidelberg), agreed on the skeleton of a rather extensive research programme to be carried out jointly by several European laboratories. The main items of the programme were:

1. a detailed study of the ability of different coating materials to protect the glass, including the crucial question of what happens to the glass under the coating;

2. the specification and fabrication of a number of "simulated" mediaeval glasses to be used by researchers all over Europe, thus providing common standards in their work;

3. an account of older restoration work describing methods and results;

4. an increased, broadened and more co-ordinated research effort aiming at a better understanding of the fundamental mechanisms of the corrosion of glass.

It transpired that the second part of the programme was the easiest to implement. The specification of the glasses was made by the Technical Committee of the Corpus Vitrearum and through the good offices of the ESF, the Nuffield Foundation in London decided to award a grant of £500 to the Chairman of this Committee (Professor R. Newton, Sheffield), for the actual fabrication. For the other items, however, the ESF has not yet been able to reach entirely satisfactory solutions. Some draft research programmes which were drawn up following the meeting in Munich have had a certain impact on the on-going work but it has not yet been possible to start the envisaged major research programmes on a co-operative basis."

Note by RGN: item 3 does not fully describe what had been agreed at the meeting in Munich, because the objective of the study of earlier restorations was to identify any damage visible today which could have been attributable to faulty conservation procedures many decades ago. Thus it was hoped that the study would help to provide a much-needed time scale for the rate of development of damage to glass. There are likely to be so few examples where this could be done that it is essential to conduct the study on a European scale.

The Secretariat of the ESF was represented at the CAC Symposium in York (Section 1.4 above) and it is clear that there is still great interest in the idea of trying to launch a joint European research programme in this field.

1.6 CORRIGENDUM - CLEANING GLASS WITH CALGON AND EDTA

I am grateful to Dr J.C. Ferrazzini for pointing out that N.L.23 contains a misunderstanding about his researches on the effects of Calgon and EDTA on medieval glass.

Dr Ferrazzini pointed out that these chelating agents, which can convert insoluble weathering products such as gypsum and syngenite into soluble compounds, cannot necessarily distinguish between the calcium in the weathering crust and the calcium which forms an essential part of the unaltered glass. Hence the glass can be attacked by these agents. This is confirmed by the work of Ernsberger abstracted as No.254 in this News Letter because he used EDTA to etch modern glass.

In N.L.23 I stated that Figs. 1 and 2 showed how medieval glass was damaged by EDTA and Calgon, respectively, but this is misleading because such visible attack occurs only on freshly fractured surfaces. But there is also another form of attack which is invisible to the naked eye. Weathered medieval glass which has been cleaned with Calgon or EDTA has a surface which apparently has a reduced content of metal ions and is about twice as susceptible to corrosion as is glass which has been cleaned by mechanical methods. (RGN - we do not yet know how thick is the surface layer which has been affected by EDTA. If it is very thin, this doubled susceptibility to further attack may not persist for too long a period of time.) To repeat: the invisible damage which has been caused by the EDTA is rendered visible when the glass is subsequently exposed to further weathering, and Fig.3 of N.L.23 shows the damage which occurs after further weathering of the cleaned surface.

Thus it was wrong of me to suggest (on page 12 of N.L.23) that there was a conflict between Dr Ferrazzini (on the one hand) and Dr Bauer and M Bettembourg (on the other hand). All three agree that glass which has been freshly-cleaned with EDTA shows no signs of attack which are visible to the naked eye, but Dr Ferrazzini found that subsequent weathering reveals the damage. Dr Bauer and M Bettembourg did not continue their researches to discover what happened to the cleaned glass when it was again exposed to weathering, but Dr Bauer did envisage the need to make further studies of the nature of the cleaned surface (see p.64 of Verres et Réfractaires 1976, 30).

1.7 PROFESSOR L.L. HENCH

Professor L.L. Hench, of the Department of Materials Science and Engineering, University of Florida, has been doing much work on the durability of glass which is of interest to scientific conservators, see, for example, abstract 232 in N.L.21 and abstracts 238, 239 and 243 in N.L.22; two more articles of his will be abstracted in N.L.25. In a recent letter to me he says:

"I am currently working very hard with my students on completing the writing of a series of investigations on the weathering of glass using the instrumental tools of infra-red reflection spectroscopy, Auger electron spectroscopy and electron microprobe. I think there is considerable hope from our studies to be able to develop the infra-red reflection technique as a means of non-destructive evaluation of the extent of deterioration of historical windows and identification of the processes needed to restore the windows. We are also completing an investigation (Mr Morris Dilmore's PhD dissertation) which may give some clues as to how to apply a surface preservative to the glass without destruction of optical properties. Mr Dilmore's work is now in the final draft stage and I should be able to send you copies of those papers within the next three months."

1.8 SIMULATED MEDIEVAL GLASSES

In Section 1.6 of N.L.20 it was stated that the Nuffield Foundation had awarded a grant which would enable ten new synthetic medieval glasses to be made, for use in experimental work on conservation. These glasses have now been made by Pilkington Brothers Ltd, and all have been carefully analysed so that they can also be used for calibration of analytical equipment.

Full details of the analyses will be given in N.L.25 and limited quantities will be available to genuine experimenters. Will anyone interested please register their interest with me, stating:-

(a) the purpose for which they need the glass,
(b) the form in thich they want their test pieces, eg 15mm disc, 50mm disc, 20x50mm rectangles, etc,
(c) the minimum number of test pieces required.

My address is:- Professor R.G. Newton, 5 Hardwick Crescent, SHEFFIELD, S11 8WB, England.

1.9 MORE 12th CENTURY BLUE SODA GLASS

The rather unusual highly-durable 12th century blue soda glass which has been found at Chartres Cathedral, at the Abbey Church at St Denis, at L'Aube, and at York Minster (72 pieces only), would be expected to occur also at other places which have 12th century glass. Somewhat similar glass (but not blue in colour) has been found at Phrygia, in Turkey. Searches for this glass have been made at Canterbury Cathedral but so far none has been found. However, quite unexpectedly, some has been found at two places in the south of England.

I am indebted to Suzanne Keene, of the Winchester Research Unit, for drawing my attention to some highly durable glass which had the same lovely blue colour as that at York. It came from the excavations of the old Minster there, and I am grateful to Mr Martin Biddle, MA, FSA, Director of the Unit for allowing me to make tests on two of the samples (Nos. 514 and 515).

Similarly, I am indebted to Mrs Eleanore Saunders, of the Salisbury and South Wiltshire Museum, for showing me similar glass from the excavations of Old Sarum, and I am grateful to Mr Peter Saunders, BA, AMA, Curator of the Museum, for making two samples (Nos. 516 and 517) available for tests.

Analyses of these new samples were kindly carried out on the XRF equipment at York University by Mr Mark Pollard, and I am grateful to Dr G.A. Cox for permission to use these results. We now have analyses of nine 12th century high-soda glasses and the seven most-interesting constituents are listed in the table below. All are blue glasses except the two from Phrygia, No.97 being green and No.98 yellow.

The two samples from Winchester have remarkably similar compositions but they differ from all the others in containing surprisingly little potash, and having by far the highest soda contents. The two samples from Old Sarum differ sufficiently to suggest that they were not made at the same time. The sample from L'Aube differs from all the other European ones in its lime content and the virtual absence of lead.

At the moment all we can say is that the four new glasses are very interesting in being not dissimilar from the others from England or northern France (the analyses of the glasses from Chartres and St Denis have not yet been reported in full) and all conservators, archaeologists, museum curators and art historians should draw my attention to any more glass of this kind. In the meantime we await the results of the Neutron Activation Analysis being carried out on the four new glasses at the University of Bradford.

Table of analyses of 12th century high-soda glasses

Origin of glass	York	L'Aube	York	Phrygia		Winchester		Old Sarum	
Analysis No.	2	57	93	97	98	-	-	-	-
Sample No.	228	6	2	-	-	514	515	516	517
Silica	61.7	68.7	68.2	67.0	70.0	70.7	70.5	70.6	66.6
Soda	12.4	13.7	12.8	14.3	12.8	16.7	17.6	14.9	13.9
Potash	6.4	1.3	1.2	1.3	1.2	0.7	0.6	1.7	3.7
Magnesia	2.2	0.07	1.8	2.3	2.2	0.4	0.4	0.5	1.4
Lime	8.5	12.1	7.9	9.0	10.5	7.2	6.8	7.9	9.1
Copper oxide	0.15	0.39	0.22	2.5	-	0.31	0.29	0.24	0.26
Lead oxide	0.31	0.005	0.46	-	-	0.61	0.46	0.61	0.74

2 CONTRARY OPINIONS

For the first time we have three "contrary opinions".

2.1 FRENCH TECHNICAL COMMITTEE

M Jean Taralon, Inspector General of Historic Monuments in France and Chairman of the French Technical Committee of the Corpus, has asked me to insert the following note in this issue of the News Letter. I have also reproduced his letter and note in facsimile form so that there shall be no doubt about what he says.

Translation

The last issue of the News Letter included papers which were more polemic than scientific in character, being aimed solely at attempting, by every means, to discredit in the opinion of the public the research and the work carried out in France on the conservation of stained glass windows, and in this way obstructing the policy which our Minister is pursuing in this field.

The French Technical Committee of the Corpus Vitrearum considers such attacks to be contrary to the objectivity which should be observed by a bulletin bearing the seal of the Corpus Vitrearum (CV), whose authority it is thus misusing for ends incompatible with its true purpose.

Consequently, the French Technical Committee has decided not to reply in the News Letter to the attacks made on it. In future, the Committee will only publish its results in an international journal of a universally acknowledged scientific character.

2.2 EXTERNALLY-VENTILATED 10mm CAVITY

The "kite-flying" exercise in Section 2 of N.L.22 has attracted some valuable attention. Two architects have written to point out that the use of zinc in conjunction with copper in Fig.2 is unsound on electrochemical grounds.

Mr Martin Caroe ARIBA has kindly written: "If it is necesary for the material to have rigidity in order to provide adequate strength to the top of the panel, I would suggest an attempt to obtain similarly perforated copper sheet of perhaps 22-24 gauge. If rigidity is not important, why not use ordinary copper fly wire normally fixed in larder vents? .... Do not use the very fine meshes .... as I have found these completely clogged after 20 years' service.".

Dr Bernard Feilden, CBE, FSA, the architect to York Minster, has made some modifications to the proposal so that it can be tested in a window of the workshop. His main modifications are to introduce a spacing

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le 29 janvier 1977

Prof. Dr. Roy Newton
Directeur des News Letter
5 Harwick Crescent
SHEFFIELD S11 8WB

Monsieur le Directeur,

Usant du droit de réponse, je vous prie de bien vouloir publier dans le prochain numéro des News Letter le texte ci-joint.

Avec mes remerciements, veuillez agréer, Monsieur le Directeur, l'expression de ma considération distinguée.

Jean Taralon
Directeur du Comité Technique Français
du Corpus Vitrearum

NOTE

Il a été publié dans le dernier numéro des News Letter des communications à caractère plus polémique que scientifique n'ayant d'autre but que de tenter de discréditer par tous les moyens devant l'opinion les recherches et les travaux entrepris en France pour la conservation des vitraux, et de mettre ainsi en échec la politique que poursuit notre ministère dans ce domaine.

Le Comité Technique Français du Corpus Vitrearum estime que de telles attaques sont contraires à l'objectivité que devrait observer un bulletin portant le sigle du Corpus Vitrearum (CV), dont il utilise de cette façon abusivement la caution à des fins incompatibles avec sa vocation.

En conséquence, le Comité Technique Français a décidé de ne pas répondre dans les News Letter aux attaques dont il a été l'objet. Il se réserve de ne plus publier désormais les résultats de ses recherches que dans une revue internationale à caractère scientifique universellement reconnu.

Le Comité Technique Français
du Corpus Vitrearum

Slightly reduced facsimille copy of the letter from M Jean Taralon block of wood, 10mm wide, at the bottom of the window and a vertical lip on the T-bar to stabilise the outer panel. The ventilation slot at the top of the window will have a lead shield to exclude driven rain.

The experiments will also involve the use of different treatments of the external glazing to improve its appearance, both from outside and inside the building. Thus the "kite-flying" has amply justified its purpose in getting people to think about ways of producing really narrow interspaces.

2.3 DURABILITIES OF SODA- AND POTASH-GLASSES

This "contrary opinion" is by me against myself! It is well known that in simple (alkali-silicate) glasses, those containing potash (K_2O) are much less durable than the corresponding soda (Na_2O) glasses, by a factor of 10 or more, depending on the attacking agent used (see, for example, Douglas, R.W. and El-Shamy, T.M., J.Amer. Ceram. Soc., 1967 50 p3 and Hench, L.L., J. Crystalline Solids, 1975 19 p32).

However, in complex glasses where appreciable amounts of lime and magnesia are also present, in addition to potash and silica, the durability is greatly improved (see El-Shamy, T.M., Phys. Chem. Glasses, 1973 14 1-5). The lime and magnesia stabilise the network and the difference in durability between a complex soda glass and the corresponding potash glass will be greatly reduced, so much so that I have argued that the difference will be negligible even though El-Shamy did not study complex soda glasses. It now seems that I was wrong.

I have recently been examining the analyses of about 200 glasses from York Minster, carried out by Mark Pollard at the Physics Department of the University of York. If unweathered medieval glasses are considered, and the high-soda glasses are ignored, there is an indication (not yet a proof) that the glasses which contain soda and potash are more durable than those which contain mainly potash and little soda.

Here I should forestall those persons who will point to the "mixed alkali effect" by remarking that my studies were based on molar compositions, and that L.L. Hench (ibid, p32) showed that there is no evidence of a "mixed alkali effect" on the durability of glass, provided the compositions are compared on a molar basis. The "well-known" mixed alkali effect has been a false conclusion based on the comparison of glass compositions on a weight-percentage basis, where the molar proportion of silica had been inadvertently changed when the alkali had been changed from soda to potash.

3 VIACRYL AND SAWDUST

In N.L. No.20, Section 6.2 pages 8-9, I gave an account of the first part of an experiment intended to learn whether Viacryl resin might protect poorly durable glass from deterioration in a particular accelerated weathering test. Accelerated weathering tests are notoriously difficult to devise, and each test proposed has been criticised in some way or another because some feature (e.g. the liquid or the temperature) must be made more aggressive than in normal weathering. The aggressive agent used in this accelerated test was wet English oak sawdust and the temperature was lower than normal; it is by no means an ideal test but it has the advantage of producing a definite effect on unprotected glass in a period of about half a year, perhaps without being excessively aggressive.

To remind readers of the first phase of the experiment, part of the Canterbury Glass Restoration Studio research programme was concerned with the protective capacity of Viacryl. In this test Mr Derek White air-braded a sample of Glass No.2 for 30 seconds using No.3 powder. The sample was then sent to Sheffield so that the surface roughness could be measured with the Talysurf instrument. In order to be able to locate the exact region where the Talysurf measurements were to be made, scratches were made on the glass: crosses at A and B (in Fig.1) and linear marks at C and D. The "central" measurements (line 1) were made between the bar of the cross at A and the line at C, and the other two measurements (lines 2 and 3) were made as shown in Fig.1.

After these first measurements were made (in September 1975) the sample was returned to Canterbury to be coated with Viacryl and then sent to York to be placed in the wet sawdust for 4½ months. The coating was then removed with Cital 12-12 (it was easily removed) and the Talysurf measurements repeated (in February 1976). It was found that the roughness of the surface had decreased (see Tables I and II on p.8 of N.L. No.20), suggesting that (as in the experiment without Viacryl reported in Section 6.1 of N.L. No.20) the slightly "acidic" liquid from the wet sawdust could have etched some of the surface away.

It was pointed out that, in that experiment, the Viacryl had been applied in one coat only and thus it was possible that "pin holes" might have been present in the coating and might have allowed the liquid to pass through and reach the glass. The same piece of glass was therefore returned to Canterbury in order to have two successive coatings applied, the first being allowed to harden for 3 days before the second coat was applied. It was then returned to the wet sawdust for 10 months (316 days). Unfortunately, as will be seen below, the sample had not been leaded and hence the border was not protected below the Viacryl coating.

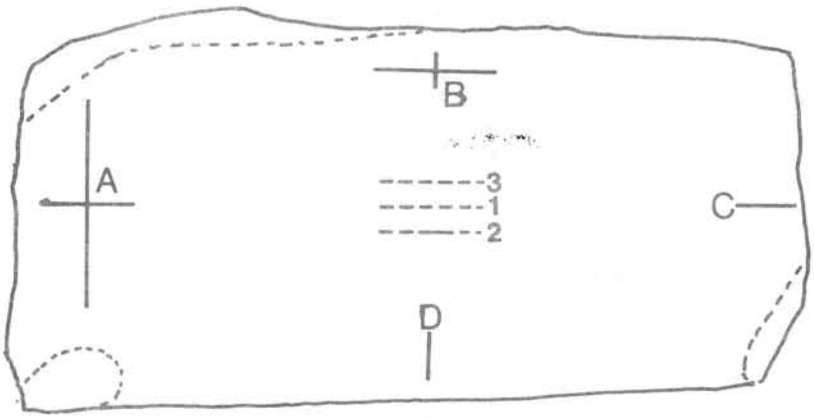

Fig. 1 This shows the positions of the original reference marks, scribed on the airbraded surface of the glass in September 1975. Lines 1, 2 and 3 show where the three 'Talysurf' measurements were made on each of the three occasions.

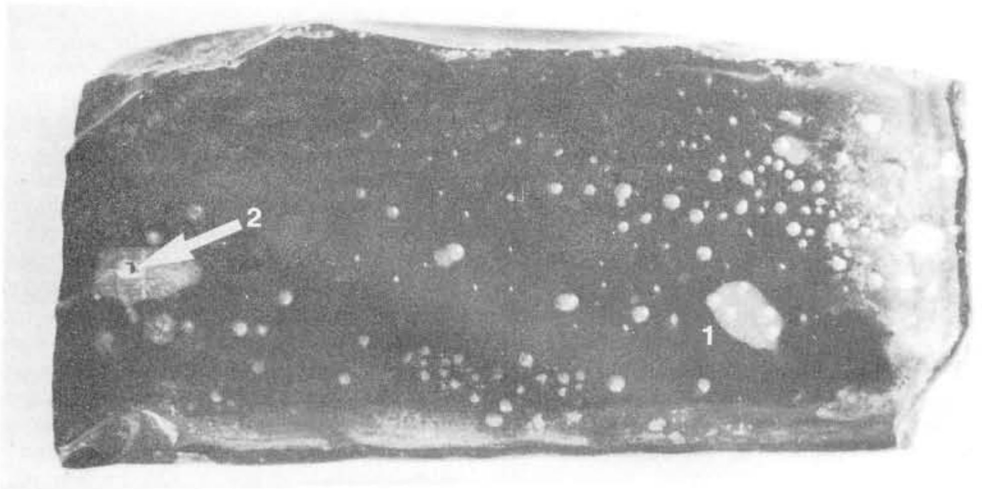

Fig. 2 This shows the many blisters which had developed in the Viacryl coating after exposure to wet sawdust for 10 months (316 days). Each blister has a white area below it, and the group of four blisters at (1) have one large white area beneath them all. When the hole was made in the resin at (2), the white area became larger but no liquid came out and it is assumed that there was only air beneath the blister.

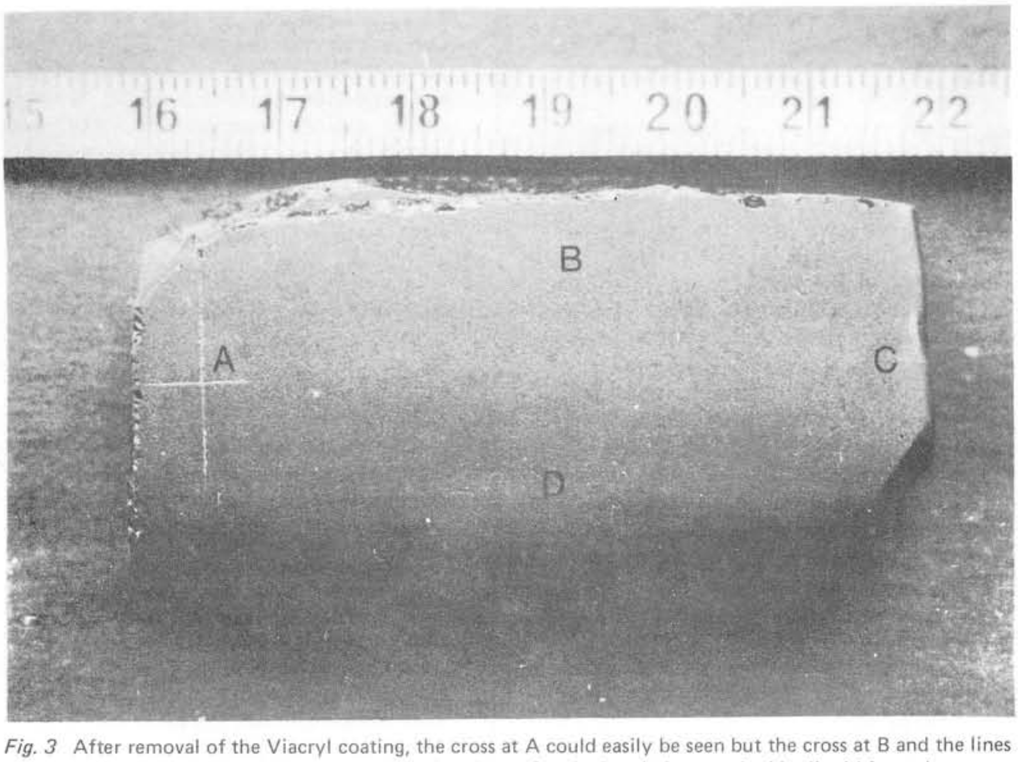

Fig. 3 After removal of the Viacryl coating, the cross at A could easily be seen but the cross at B and the lines at C and D were difficult to locate, suggesting that the surface had again been etched by liquid from the sawdust which had penetrated the Viacryl. It is possible that the cross at A had not been attached as much as the other marks because it had been under the large blister at (2) in Fig. 2.

When the sample was removed from the sawdust, on 6th January 1977, it was found that the surface of the Viacryl was no longer smooth, but was covered in raised blisters where the adhesion between the glass and the Viacryl had been impaired by this exposure to wet sawdust. Glass No.2 is very dark in colour but there was a white area under each blister (see for example area 1 in Fig.2). When a blister was pierced (as at 2 in Fig.2) the white area increased in size but no liquid came out and it seems that there was air beneath it. It is not known how the air came to be there. The sample was shown, in this condition, to the members of the Stained Glass Symposium in York on 9th January.

Mr Peter Gibson then kindly removed the Viacryl coating with Green Label Nitromors (it was again easily removed) and the members of the meeting could see that the airbraded surface did not show any obvious visible signs of damage, in particular there were no marks on the surface corresponding to where the blisters had been.

The sample was then taken to Sheffield to be measured on the Talysurf, and it was only then realised that three of the index marks had nearly disappeared. The cross at A could still be seen (see Fig.3) but the marks at B, C and D were extremely difficult to locate, suggesting that the surface had again been etched by the liquid, presumably because it had penetrated the Viacryl because it was unlikely that pinholes in each of the coatings would have been opposite to each other.

The Talysurf "Centre Line Average" figures in micrometres were:-

	Sept 1975	Feb 1976	Jan 1977
Line 1	3.1	2.0	2.7
Line 2	2.5	2.1	2.5
Line 3	2.8	2.5	2.5

and they showed that the surface had become slightly rougher but it is believed that appreciable etching had occurred, because the scratches on the surface had nearly been obliterated. If a lead border had been applied in February 1976 there would have been the possibility of having had a protected edge and of measuring the depth to which the face of the glass had been etched below it.

This experiment is open to challenge, if only on the grounds that wet sawdust is not a typical weathering agent (but it might be no worse than pigeon dung!) and that the surface became rougher during this exposure for 10 months whereas it became smoother during the previous 4½ months. However, the presence of the blisters in the surface of the resin, and the loss of visibility of marks B, C and D, suggest that something unexpected had happened both to the coating itself and to the glass beneath the resin coating.

The sample was again sent to Canterbury where Mr Cole extended and deepened the scribed markings using a diamond point. He then leaded the glass all around the edges and cemented the leads, using a wooden tool in order to avoid damaging the reference surface. The whole specimen was then thoroughly degreased with acetone and the resin coating (80% Viacryl and 20% Desmodur w/w) applied with a brush to cover both the lead and the glass, on the prepared surface only. After drying for 24 hours at 21°C a second coat of resin was applied but on this occasion the mixture was diluted with ethyl acetate (to make it more fluid) because the original mixture was very viscous and entrapped many air bubbles which still remained after it had dried.

Mr Cole also remarks that two 12th century border panels were coated with Viacryl in May 1975 and placed in the clerestory at Canterbury Cathedral. These were removed for inspection early in January 1977 and close examination showed a wide distribution of small cracks surrounded with a whitish area where the membrane had detached from the glass.

4 CONDENSATION

4.1 MEASUREMENT OF CONDENSATION - PART II

In Section 1.8 of N.L.22 doubts were expressed as to whether the condensation gauge described therein might not "dry out" as quickly as the window does after condensation has occurred; in other words the response from the condensation gauge might be too slow compared with the disappearance of condensation from the window. Mr Stephen Moehr, of the Physics Department of the University of York, has now succeeded in making a very thin condensation gauge, which is only 0.8mm thick and has a response time of less than 10 minutes. When no condensation was present on the window the resistance was of the order of 500,000 ohms. As soon as light condensation was visible the resistance had fallen to 46,000 ohms, and as condensation increased over the next 16 minutes the resistance fell to 10,000 ohms. A ventilation fan was then switched on and visible condensation had disappeared in 8 minutes, the resistance then being 26,000 ohms. The fan was kept on and, in the next 10 minutes, the resistance had increased to 400,000 ohms. This speed of response is regarded as satisfactory.

Also, in the Physics Department, Mr J.S. Scott has devised an electronic counter which can be adjusted to start when condensation is present and stop when it disappears. This is now being used to test the performance of the new gauge under a variety of conditions. Details of these tests can be found in the York Glaziers Trust Research Report YGT/77/1, and copies are available from Mr Peter Gibson, 3 Deangate, York YO1 2JJ, at a cost of 75p.

4.2 CONDENSATION IN FREIBURG MINSTER

Münsterbaumeister Klaus Geis has prepared a report on the interior climate and condensation in Freiburg Minster, dated October 1976. The title is "Raumklima und Schwitzwasserbildung im Freiburger Münster" and I have pleasure in summarising it here.

The document starts with a discussion of the causes of deterioration of medieval windows and it goes on to state that since 1970 there has been a 10-year programme to fit external protective glazing to the Minster windows in collaboration with the State, the Diocese, and the Town.

The thick panes of glass are fitted in the former glazing grooves of the stained glass windows; the stained glass panels are moved inwards about 50mm and fixed by means of metal lugs; an airspace of 5 to 10mm is left open between the masonry and the brass frame of the stained glass panels in order to ventilate the interspace. Since condensation also has a harmful effect on stained glass windows it was important to establish whether condensation occurs on the windows under the conditions prevailing in Freiburg Minster. From March 1974 to September 1975 the climate in the main aisle was automatically recorded and the microclimatic conditions between the external protective glazing and the stained glass panels were investigated.

Condensation: The relative humidity in a room is determined by its air temperature. Given a water vapour content of e.g. 8g water per m^3 (absolute humidity 8 g/m^3), then at an air temperature of 17° the relative humidity will be 55%; if the air temperature then falls to 7.9°, the absolute humidity remains 8 g/m^3 but the relative humidity rises to 100%; this is the dew point; condensation forms on all the colder surfaces in the room. From the records of the relative atmospheric humidity and air temperature in Freiburg Minster it is possible to calculate the absolute humidity; if there is a sharp fall in the air temperature while the absolute humidity remains constant a relative atmospheric humidity of up to 100% (the dew point) can be reached. Measurements of the relative atmospheric humidity and the air temperature in the Minster, and subsequent measurement of the temperature of the inside surfaces of the windows, make it possible to assess whether the dew point is reached and consequently the risk of condensation occurring.

1st series of measurements: The air temperature and relative humidity were recorded continuously at two points inside the Minster for 1½ years: one measuring point was in the south aisle near the Schuster window, 4m above the floor; the other was 18m high in the nave. There was an unexpectedly close agreement between the air temperatures and relative humidities measured at these two points; in the main, the difference did not exceed 1°; the circulation from the newly installed hot air heating functioned satisfactorily up as far as the 27m high roof of the nave; the Minster heating comes on between 12° and 13°C. These uniform space temperatures occur not only when the heating is on, because there is no temperature stratification in the summer either.

Measured interior temperatures:

Mean values for the measuring periods 1974/1975	16.9/17.4°
Maximum monthly mean (in August 1975)	22.5°
Minimum monthly mean (in October 1974)	13.6°
Maximum hourly mean (in August 1975)	27.0°
Minimum hourly mean during the heating period	12.0°

(for 90% of the time the measured values were between 13° and 21°)

Relative atmospheric humidity measured in the interior:

Mean values for the measuring periods 1974/1975	54/55%
Maximum monthly mean (in September 1975)	65.7%
Minimum monthly mean (in February 1975)	37.1%
Maximum hourly mean (in June 1975, a rainy period)	80.0%
Minimum hourly mean (in March 1975)	28.0%

(for 85% of the time the measured values were between 43% and 67%)

Absolute humidity (calculated) in the interior:

Mean values for the measuring periods 1974/1975	7.9 g/m^3
Maximum monthly mean (in September 1975)	12.2 g/m^3
Minimum monthly mean (in February 1975)	4.9 g/m^3

2nd series of measurements: From September 1974 to September 1975 the temperatures were recorded continuously on two inside window faces: 2 x 2 temperature gauges were installed at the same height on the Schuster window - on the inside of the outer window (face No.2) and on the back of the painted glass window (face No.3) - in order to determine the surface temperatures of the glass in the space between external protective glazing and inner glazing. On the basis of the climatic data for the interior of the building the dew point was calculated for the coldest glass temperature measured in the course of a day.

Even the temperature on the outer window never reached the dew point; no condensation at all was observed during the measuring period. In general, it can be said that the temperature of the outer glazing slowly follows the temperature outside the church, while the temperature of the stained glass window - the Schuster window - is always close to that of the interior of the church. In winter the danger of condensation is kept at bay by the heating inside the church; but the temperature should not fall below that of the 12° - 13°C maintained so far. No additional electric heating of the space between the inner and outer windows is then needed to prevent condensation.

The measurements also showed that panes of different colours are heated differently by the sun - there are warm and cold colours. The space temperature follows the external temperature relatively slowly, especially in view of the fact that at Freiburg the window areas are not large compared with the heavy masses of masonry; there is little air circulation through the entrance doors and the installation of the external protective glazing without any leads reduces the heat transfer through the windows. Today, the leads of the inner stained glass windows act as heating bridges between the room temperature inside the church and the temperature of the interspace; before the installation of the external protective glazing they were cooling bridges, and that is why there was previously a greater danger of condensation forming on the stained glass.

The frequent climatic variations, typical of Freiburg, have only a gradual effect on the interior; even the atmospheric moisture inside changes only slowly and it usually remains in the medium range. Similarly, the art treasures - wooden carvings, oil paintings, stained glass windows - expand and contract slowly. The fairly constant interior climate is a contributory factor in the good condition of the interior of the building - stonework, decorative work. It may be assumed that even before the installation of the Minster heating, which is background heating to a moderate temperature, the interior temperature was fairly even. The climate in the chancel of Freiburg Minster, with its large areas of glass, which is possibly quite different, has not yet been investigated. Investigations into interior climates at Augsburg and Nuremberg are being carried out by Dr Frenzel.

These investigations were made possible through the generosity of Dr G. Rönicke and Dipl.Ing.arch. R. Rönicke, who worked without any fee to a total cost of 8000 D.M. and carried out the measurements themselves. The present report is based on their data and graphs of the temperature and dew point gradients; they can be seen at the Freiburg Münsterbauverein.

4.3 EFFECTS OF REPEATED CONDENSATION - PART 2

In Section 6 of N.L.22 there was a discussion of the possible effects of repeated condensation, and it was concluded that this might not be as dangerous for the glass as had been generally supposed. A search has been made of the literature for reports on this problem but no direct experiments have been found. However, a comparison can be made between two papers, abstracted as No.244 in N.L.22 and No.260 in this News Letter.

In Fig.4, on page 43, of No.260 a much lower attack occurred on the glass when there was "water run off" than when there was "condensation recycling", and the author comments that the reaction products had probably been washed away in the second case. However, Fig.3 on page 144 of No.244 seems to suggest that one month's storage in a "damp basement" followed by 2 months' "condensation recycling" (curve B) produced 3 to 4 times as much "haze" (permanent damage to the glass surface) as did 2 months' condensation recycling alone (curve A).

If this interpretation is correct, then 1 month in the damp basement seems to have produced more damage (or perhaps initiated the possibility of more damage) than two months of condensation recycling.

Moreover Fig.1 of No.244 suggests that 20% of haze is produced by 2 months of condensation recycling whereas Fig.4 of No.260 suggests that 90% of haze is produced by 1 month of condensation recycling. Thus the situation is rather confused and there is clearly a need for one of the well-equipped laboratories to carry out a proper programme of research into this vexing question.

An important fact brought to light in No.244 is that the higher durability of the original "fire-finished" surface skin on newly manufactured glass is destroyed by storage for only one month in the "damp basement".

5 MORE ANALYTICAL RESULTS

Many more analyses of medieval glasses are now being carried out, in several different laboratories. Moreover, a few glasses have been analysed in more than one laboratory and some disturbing differences have been found. This section of the News Letter discusses these differences (5.1) and also gives the results for 25 more analyses (5.2).

5.1 ACCURACY OF THE FIGURES

Chemists are accustomed to the idea that there are errors in their results, despite the usual tendency to express them with much greater precision than they warrant! But laymen may well assume that the figures are accurate ones, and I should therefore comment on the position.

First, there is the number of "significant" figures which are quoted in the result. For example, two of the laboratories habitually send me figures for the silica contents which contain four numbers, such as 55.69%; there are many examples of these in N.L.21, pages 10-14! However, the statistical "confidence limits" for these silica determinations are only about 0.3 on the percentage

ANALYSIS NUMBER	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150
Laboratory	CORNING MUSEUM OF GLASS						UNIVERSITY OF YORK DEPARTMENT OF PHYSICS																		
Origin of glass	CANTERBURY CATHEDRAL																	Hartley Wood		Buxted Park	St. Michaelskirche Vienna			Dennis Hall.	East Mersea
Lab. Reference	2400	2401	2402	2403	2404	2405	381	382	383	384	385	386	387	388	389	398	399	159	163	177	378	379	380	176	162
Colour	Colourless		Green	Dark Blue		Ruby	Dark Blue		Green			Pink	White				Green	Ambitty	Smoke	White	Green M.1	Purple M2	Ruby M4	White	Blue
Weathering *	#	#	#	△	△	#	△	△	△/#	△	#	△	△	△	△	o/△	o/△	o	o	o				o	#
Date	(12)						(12)											1886	1877	c.1700	(14)	(14)	(14)	1770	(14)
WEIGHT PERCENTAGE																									
SiO_2	47.9	49.2	48.5	53.0	50.6	47.8	51.7	51.8	49.1	54.3	53.4	50.6	53.0	55.7	48.8	50.6	52.5	67.5	72.0	56.2	44.9	46.7	47.9	67.7	59.0
Na_2O	1.3	1.2	1.7	0.9	1.0	1.4	1.4	1.1	1.3	1.4	2.0	1.4	1.2	3.3	1.1	1.2	2.0	12.6	11.3	1.2	1.1	0.90	0.38	7.3	2.9
K_2O	15.6	16.9	16.2	14.2	15.9	17.6	16.2	16.4	17.2	13.7	14.2	14.7	13.2	11.7	14.5	17.3	13.7	0.70	0.83	6.3	24.9	25.3	25.4	3.7	5.1
MgO	6.0	6.1	5.7	5.0	5.1	5.9	5.0	5.0	4.3	4.2	4.0	5.4	4.5	7.1	4.0	3.9	4.9	0.11	0.05	3.3	3.7	3.9	3.5	5.5	3.1
CaO	18.8	17.4	18.2	16.4	16.4	18.1	15.6	15.7	17.6	16.9	16.7	18.1	18.9	14.8	22.3	15.7	17.3	15.1	11.8	23.5	19.0	18.4	17.4	11.4	23.0
MnO	0.79	0.72	0.61	0.68	0.74	0.61	1.2	1.2	0.79	0.83	0.84	2.0	0.96	1.2	1.1	0.84	0.72	1.6	2.2	0.92	0.89	1.1	1.0	0.14	1.1
CuO	0.41	0.005	1.7	0.28	0.28	0.36	0.26	0.25	1.6	2.0	1.9	0.27	0.02	0.02	–	0.42	2.1	0.10	0.55	0.09	0.03	–	–	–	0.02
ZnO	–	–	–	0.74	0.71	–	0.25	0.24	0.21	0.23	0.22	0.06	0.05	0.05	0.02	0.78	0.29	0.02	0.03	0.03	0.05	0.05	0.03	0.02	0.03
PbO	0.005	–	0.05	0.10	0.10	0.02	0.74	0.69	0.24	0.17	0.17	0.05	0.17	0.04	–	0.82	0.19	0.71	0.17	0.78	0.44	0.34	1.0	0.10	0.03
Al_2O_3	1.1	0.98	1.0	1.1	1.0	0.98	1.5	1.5	1.4	1.1	1.2	1.3	1.5	1.1	1.4	1.7	1.3	–	–	2.9	1.6	1.6	1.5	1.5	1.0
Fe_2O_3	0.51	0.50	0.63	0.96	0.96	0.56	0.75	0.74	0.52	0.40	0.41	0.36	0.41	0.57	0.36	1.1	0.38	0.32	0.37	1.0	1.7	0.20	0.24	0.51	0.36
TiO_2	0.20	0.20	0.20	0.20	0.25	0.16	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
P_2O_5	7.0	6.3	5.0	5.9	6.3	6.2	5.4	5.4	5.7	4.8	5.0	5.8	6.1	4.4	6.4	5.7	4.7	0.82	0.68	3.7	1.7	1.6	1.6	2.1	4.3
Others	BaO 0.2 CoO – SnO_2 .005	0.2 – –	0.25 – 0.15	0.2 0.07 0.005	0.2 0.15 0.005	0.15 – 0.01	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
TOTAL	99.8	99.5	99.5	99.5	99.7	99.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	100.0	100.1	100.0	100.0	99.9
MOLAR PERCENTAGE																									
SiO_2	51.4	52.8	51.9	56.9	54.9	51.4	55.8	56.0	53.3	57.8	57.0	53.8	56.3	57.6	52.1	55.5	55.6	68.5	72.7	58.4	49.4	50.8	52.5	68.0	60.2
Na_2O	1.3	1.3	1.7	0.9	1.1	1.5	1.5	1.2	1.4	1.4	2.0	1.5	1.2	3.3	1.1	1.2	2.1	12.3	11.1	1.2	1.2	0.9	0.4	7.1	2.9
K_2O	10.7	11.6	11.1	9.7	11.0	12.1	11.2	11.2	11.9	9.3	9.7	10.0	8.9	7.8	9.9	12.1	9.2	0.4	0.5	4.2	17.5	17.5	17.8	2.4	3.3
MgO	9.6	9.7	9.1	8.1	8.2	9.4	8.0	8.0	6.9	6.6	6.4	8.6	7.1	11.0	6.5	6.5	7.7	0.2	0.1	5.2	6.0	6.3	5.8	8.1	4.8
CaO	21.6	20.0	20.9	18.9	19.0	20.9	18.0	18.2	20.5	19.3	19.1	20.6	21.6	16.4	25.5	18.5	19.7	16.4	12.8	26.1	22.4	21.5	20.4	12.3	25.2
MnO	0.7	0.6	0.5	0.6	0.7	0.6	1.1	1.1	0.7	0.7	0.8	1.7	0.9	1.1	1.0	0.8	0.6	1.4	1.9	0.8	0.8	1.1	0.9	0.1	1.0
CuO	0.3	–	1.4	0.2	0.2	0.3	0.2	0.2	1.3	1.6	1.5	0.2	–	–	–	0.4	1.7	0.1	0.4	0.1	–	–	–	–	–
ZnO	–	–	–	0.6	0.6	–	0.2	0.2	0.2	0.2	0.2	–	–	–	–	0.6	0.2	–	–	–	0.1	–	–	–	–
PbO	–	–	–	–	–	–	0.2	0.2	0.1	0.1	0.1	–	0.1	–	–	0.2	0.1	0.2	0.1	0.2	0.1	0.1	0.3	–	–
Al_2O_3	0.7	0.6	0.6	0.7	0.7	0.6	1.0	0.9	0.9	0.7	0.7	0.8	0.9	0.7	0.9	1.1	0.8	–	–	1.8	1.0	1.0	1.0	0.9	0.6
Fe_2O_3	0.2	0.2	0.2	0.4	0.4	0.2	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.5	0.2	0.1	0.1	0.4	0.7	0.1	0.1	0.2	0.1
TiO_2	0.2	0.2	0.2	0.2	0.2	0.1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
P_2O_5	3.2	2.9	2.3	2.7	2.9	2.8	2.5	2.5	2.6	2.1	2.3	2.6	2.8	1.9	2.9	2.6	2.1	0.4	0.3	1.6	0.8	0.7	0.8	0.9	1.9
Others	BaO 0.1	0.1	0.1	0.1	0.1	0.1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
TRIANGULAR VALUES																									
"SiO_2"	56.5	57.5	56.1	61.9	60.2	56.1	60.9	60.9	58.1	61.6	61.2	58.3	61.2	61.3	57.1	61.3	59.6	69.1	73.3	64.4	53.6	53.6	55.5	71.0	63.6
"RO"	32.4	30.4	32.0	28.5	28.8	31.2	27.8	27.9	29.7	28.5	28.0	31.3	29.7	28.5	33.0	26.9	30.0	18.2	15.2	32.4	29.4	29.0	27.4	20.6	31.0
"R_2O"	11.1	12.1	11.9	9.6	11.0	12.7	11.3	11.2	12.2	9.9	10.8	10.4	9.1	10.2	9.9	11.8	10.4	12.7	11.5	3.2	17.0	17.4	17.1	8.4	5.4

* o = shiny & unweathered, △ = pitted, # = crusted

scale (i.e. the limit would be 0.6% of a silica figure quoted as 50.00%)- Hence four numbers are certainly not justified, and even the third figure would not be completely accurate because the "confidence limits" are ± 0.3 and the correct figure would lie between (say) 49.7% and 50.3%. In Section 5.2 of this News Letter I have therefore rounded all the data to three figures at the most.

Secondly, some samples have now been analysed more than once, and the results are never exactly the same! Sometimes there are quite big differences. Examples in N.L.21 were analyses 2 and 3; 6 and 7; 13 and 14, 99 and 100. But the window glass from Dennis Hall, in Stourbridge, built in 1770 has now been analysed in four ways. The first two occasions were analyses 99 and 100 in N.L.21, the quoted silica contents being 73.3% and 68.84%. The glass has been tested again at York (analysis No.149 in this News Letter), using a different computer program to process the results, and the silica content is now quoted as 67.7%. However, Dr Paul at the University of Sheffield has kindly determined the silica content by wet chemistry and he obtained the figures: 65.8, 66.0, 65.6 and 65.7.

It seems clear that the figure of 73.3% (No.99) is wrong but there is still a range of 3.4 between the other results, which is statistically significant. Thus all the figures have to be treated with caution, despite the optimistic feelings of those who supply them! If any other laboratory wishes to test this same sample of 18th century window glass, please let me know, stating the quantity of glass required.

Thirdly, there are some gaps in the data. For example, York University does not have a "standard glass" with a known amount of titania, and hence there is always a gap for TiO_2. As will be seen from the other analyses in this News Letter and in N.L.21, there is usually some TiO_2 present (sometimes about 0.2% but occasionally as high as 0.4%, as in analyses Nos. 17 and 28). The computer program in use at York automatically adjusts the total to 100.0% and hence the presence of titania in the glass would mean that all the other results would be given slightly too large a figure.

5.2 CHEMICAL ANALYSES OF MEDIEVAL WINDOW GLASSES - PART 2

The first list, of 125 analyses of medieval glasses, was given in Section 5 (pages 9-14) of N.L.21, and the next 25 analyses are set out in the table here. The first 17 glasses are all from Canterbury Cathedral, by the kindness of Mr Frederick Cole of the Canterbury Glass Restoration Studio.

Samples 143-145 supplement the data about window glasses of different dates, given in Table IV of N.L.18. No.145 is the same glass as the Buxted Park sample in Table IV, but the results are slightly different. Samples 146-148 are from St Michaelskirche in Vienna, and can be compared with Nos.89-91 on p.13 of N.L.21.

Sample No.149 is the same as that previously analysed (by different laboratories) as Nos. 99 and 100.

6 BOOK REVIEW

Most of us who are concerned with the Corpus - as craftsmen, master-glaziers, scientists, restorers, art-historians, or glass painters - tend to live in compartments which are too narrow for our own best work. We generally do not know enough about each other's ideas, problems or points of view, and perhaps too often we do not even care about them. This is bad for co-operation and bad for our-selves. We should welcome opportunities for learning something about the other man's viewpoint.

A book has just been published on "The Appreciation of Stained Glass" by Lawrence Lee (118 pages, 74 illustrations, including 8 in colour, ISBN 0-19-211913-3 Oxford University Press, London, 1977, £5.50) which is very penetrating, powerfully written and thought-provoking. It deserves careful reading by all peraons who want to understand the special problems of stained glass as an art form.

There are eight main chapters in the book: the framework, the glaziers, the spectator, scale and structure, line, colour - the "sound" of light, painting and design. Lawrence Lee discusses all of these with great perceptivity and considerable good humour. (RGN - He does not discuss conservation but I know that he admires the original beauty of an early window and deplores the loss of colour-balance which can occur with age.)

Stained glass is unique in being the only art form which depends on the transmission of scattered light for its portrayal. For example, it would never be possible to enjoy a stained glass window if we were to live on the moon, which has no atmosphere to scatter the light from the sun. But there are also several other respects in which stained glass differs radically from other forms of art. It is "monumental" in size and must conform to the architecture of the building which houses it. Thus no one can have a "collection of windows" but only small portions of windows, such as roundels, and this is why display in a museum is generally a poor substitute except in rare cases, such as the "Cloisters" near New York, where the museum has been specially designed for the display of whole windows.

In addition, a peculiarity of medieval stained glass is that it was virtually restricted to displaying a single religion, and even then in a rather restricted part of the world. It requires a special technique of painting, using a loaded brush used with a confident single sweep on a slippery surface; no touching-up can be done. And an over-riding importance was given in medieval windows to depicting the human appearance and facial expression.

Finally, and what is really obvious, it depends on the proper use of colour and of lead lines. These two points are fully discussed in Chapters 1, 6 and 7 with a nice treatment of "halation" and the perception of a multi-coloured image as a single visual impact. All of these special characteristics have a bearing on the artist's approach to making a window, and the observers' appreciations of it but, in addition, the general observer encounters some extra difficulties, such as the almost complete anonymity of the artist, a general lack of information about the craft of using coloured glass, and an even more remote understanding of the making of coloured glass (pot metal, not "stained" glass).

The interesting illustrations have been carefully chosen to illustrate all these various points (although, in my view, page 27 does not do justice to the Great East Window at York Minster, and I should have liked the Chagall window at Tudeley to have been in colour because the interplay between blue and black in the original is completely lost on page 42). Moreover, in Chapter 9 he does not hesitate to illustrate and discuss some bad examples of 19th and 20th century glass.

There are a few minor errors in the book but the only one I will remark on here is that the Five Sisters window at York is dated to about 1260 and not 1400 as stated on page 23.

7 ABSTRACTS

251. BECKSMANN, R. (1976) "Probleme der Restaurierung Spätromanischer Glasmalereien" (Problems in the restoration of late-Romanesque stained glass" A report on the Colloquium held in Linnich on 29th and 30th March, 1976, published in Kunstchronik 1976 29 330-337.

At the time of the Colloquium the chancel glass from Bücken on the Weser, the Jesse window from St Patrokli in Soest and parts of the Jesse window from Freiburg Münster were at the Oidtmann workshops in Linnich, and Freidrich and Ludovicus Oidtmann were prepared to give a demonstration lecture.

After a general tour of the workshops, the 30 participants discussed the work in hand, which provided an excellent basis for the discussions of the second day. U.-D. Korn reported on the critical condition of the Bücken glass and the difficulties of restoration. G. Frenzel had circulated a report on the state of the Regensburg Jesse window, with criticism of the work being carried out at Regensburg, and U.-D. Korn gave an introduction to the problems of restoring the severely corroded Jesse window from Soest. A concluding paper was given on the condition of the Freiburg Jesse window and the plans for "de-restoration".

G. Frenzel used photographs to demonstrate the deterioration which had occurred in the Regensburg Jesse window since the thirties. Since 1940 almost all the half-tone work has disappeared, and the linework is now in great danger. This applies both to the black enamel and to the flashed red in the borders - a remarkable technical feature. This was obviously due to the extremely high level of moisture in the atmosphere of Regensburg cathedral. He had submitted proposals for restoration in 1974 which were discussed by an international committee of experts which recommended isothermal external protective glazing, which would provide protection without interfering with the glass. An aesthetic compromise had been attempted in that the external glazing had a simulated leaded appearance but this was not really successful. If the relative atmospheric humidity in the cathedral were more than 60%, then the heating of the window zone, suggested by Frenzel, would be absolutely vital to suppress further weathering. The specific interior climate would have to be measured over an extended period, as at Freiburg Münster (see Section 4.2 above). The committee also recommended "emergency fixing of the black enamel", but this is a term liable to misinterpretation. According to E. Frodl-Kraft it is not a stop-gap nor an economy measure but immediate action to fix loose black enamel by saturation with a synthetic resin solution after cleaning of the glass surface. A description of the work involved makes it obvious that the idea of treating 100 m^2 in three weeks is quite absurd. The reversibility usually demanded in such cases was claimed to be quite senseless in this particular case, and on this point there was complete agreement. Fixing black enamel with synthetic resin is a process which, regardless of whether a single or two-component adhesive is used, cannot be reversed without material loss, and this places the highest demands on the skill of the restorer. For this reason, it is not possible to carry out provisional fixing of loose black enamel before the glass is dismantled or transported to the workshop.

In the light of the Bücken example it was obvious to all that the cleaning of the glass surface before the fixing of the black enamel is fraught with great problems. The three chancel windows of about 1250 from

St Materniani (see Hans Wentzel: Niederdeutsche Beiträge zur Kunstgeschichte) were in quite good condition when stored during the second world war. In late 1975 they were again dismantled for the installation of protective glazing. For reasons of cost it was not at first planned to carry out restoration work. However, careful examination at the Linnich workshop showed that they could not be re-installed in their existing condition. This can be seen from comparison of photographs of the condition at the present time (Fig.5a) and that in 1943 (Fig.5b).

A particularly worrying feature is the condition of the inside, possibly caused by incorrect storage during the war and by condensation, which has already led to significant loss of black enamel and has even extended to unpainted areas. There are also mould-like deposits, particularly on the heads, with the affected areas sometimes completely opaque (Figs. 5a and 6a). Such phenomena have not been encountered anywhere else and they require careful chemical investigation before treatment, on which a start has been made. There is also, especially on the flesh-coloured areas, some browning of the inside - this is frequently encountered on medieval glass but it has not yet been satisfactorily explained. In addition, the luminosity and transparency of the original parts have been impaired by severe corrosion of the outside, in the form of scaling of the glass. This process has already perceptibly reduced the thickness of the glass and almost completely destroyed the external paintwork. The severity of the corrosion is surprising because Bücken is not an industrial area and it was suggested that under certain weather conditions the atmospheric pollution of the Bielefeld and Osnabrück area 100 km away might drift that far.

Difficulties also arise from the parts restored in 1866, which make up more than half the total. The techniques available at that time were not good enough to give adequate fusion of paint and glass so that a major part has come away because of condensation. This spoils the overall picture and also means the loss of a historic document, because the restorer had copied fragments of the original which are now lost. It was therefore decided not to replace Welter's technically inadequate restoration work but to find ways of preserving it, probably by putting the lost paintwork on to cover glasses in the case of the figures and by cold painting on decorative parts.

All the participants agreed that careful conservation and restoration of both the original and the 19th century work was a matter of urgency. The following steps should be taken straight away: removal of loose weathering crusts on the outside wherever these severely impair the transparency and represent a source of further destruction; careful cleaning of the inside and fixing of the loose black enamel; replacing lost paintwork on the 19th century glass. The participants went so far as to address to the relevant authorities a resolution with detailed suggestions, which as far as the original glass is concerned have already been met. Any lasting success at Bücken, however, will only be achieved if the relative atmospheric humidity in the vicinity of the painted glass can be kept below 60%. In this connection, the question of supervision was also raised.

Quite different problems were raised by Korn's report on current restoration work on the Soest Jesse window; probably dating from before 1166, it was reinterpreted as a Mary window by additions by Baudri in 1863/64. Uniform weathering crust had formed as early as 1897, possibly because Baudri had etched the old glass on the outside. Photos in 1943 showed varying degrees of opacity, a negative effect being produced with most of the linework resisting attack. Damage had been caused by storage in a cellar which was sometimes under water. Amateurish restoration work after the war had sacrificed almost all the medieval leadwork. Since then efflorescence and soot deposits have reduced the window to a ruin. It has therefore been decided to remove the Jesse window, after careful cleaning and fixing, to the Rüstkammer Museum, which already holds the remaining parts of the main chancel windows, and to replace it by a copy.

In Freiburg, on the other hand, there is reluctance to remove the pre-1218 Jesse window to a museum, even though the nine medallions had already been moved from their original position and had thus lost much of their impact. Basically, the opinion was that all glass should be left in its original place, insofar as this is possible from the point of view of conservation. To this end, since 1971 there has been a planned installation of external protective glazing, which is further assisted by a relatively dry, balanced indoor climate. The windows of the south transept were given protective glazing right at the beginning of the ten-year programme, but restoration of the Jesse window was postponed until experience had been gained from work on the more recent glass. Fortunately the delay had no adverse effects. Since 1967 the state of weathering both inside and out has remained almost constant, thanks to the external protective glazing and the dry indoor climate. The Freiburg Jesse window does not therefore pose any special problems.

Although the so-called weathering crust here had, like Soest, been removed mechanically in the 1870s and the half-tone work possibly existing at that time had been destroyed, the relatively slow further deterioration of the outside is probably due to the above-average quality of the coloured glasses. Information about weathering in the past 60 years is provided by excellent photos before and after Geiges' restoration of 1911, showing that Geiges only removed weathering crust from the outside when it had begun to peel away by itself. In addition, Geiges used cold paint over any pieces which seemed too bright, such as the unweathered green glasses. He justified this by references to Viollet-le-Duc, who claimed that the 13th century glass painters applied a cold glaze to certain glasses in order to balance out errors in colouring. However, since this work significantly altered the artistic impression, this is a case where "de-restoration" should be welcomed. In view of the relatively good state of the black enamel, removal of the cold over-painting with an acetone solution would not seem to be too difficult.

It was agreed that the basic rule should be - Maximum preservation by means of minimum interference with the original material. As far as Regensburg, Soest, Bücken and Freiburg are concerned, the following technical problems dominated the discussion: the problem of fixing the black enamel, still unsolved after fifteen years. However unsatisfactory the fixing of loose black enamel by saturation with an Araldite or Viacryl solution might be, no better method is available at present. Just as important are the sense of responsibility, manual skill and artistic sensitivity of the restorer. Special problems are raised by the extensive restoration which has gone on since the middle of the last century - some want to remove all such insertions while there is a slow movement towards respect for such work, aimed at integrating it into the whole. Discussion of these problems proved very fruitful and there was a general desire for more meetings of this kind.

252. BRILL, R.H. (1963) "Analyses of some finds from the Gnalić wreck" J. Glass Studies 1963 15 93-97.

This is the third paper of a series on a connected theme which are printed together. The first paper, by Astone Gasparetto (pp 79-84) describes the discovery of a 16th century wreck off the (Jugoslavian) island of Gnalić and suggests that it was the ship Gagiana which had left Venice for Constantinople on 10 November 1583 with a heavy mixed cargo which included much glass. Some of the glass was flat (eg window) glass which "still had straw between the layers" after some 380 years.

The second paper, by Sofija Petricioli (pp 85-92) describes the 86 types of glass articles, with of course special attention to the decorated domestic glassware. Of the flat glass, there were 648 round window panes, together with "innumerable fragments". Of the lot, 205 are intact and the rest are slightly damaged. They are of 3 sizes, 205, 185 and 170 mm in diameter; several are illustrated. The simplest pieces of flat glass were irregular in shape, of varying sizes ranging from 220 x 180 mm to 300 x 380 mm. None of the flat glass was coloured, although some of the vessel glass was blue and the glass beads were white, blue or brown.

Six of the pieces of glass were analysed by the Corning Museum of Glass and the analyses form the subject of the third paper. One of the six samples was from one of the 156 mm pieces of circular glass but all six analyses "are generally quite uniform in composition, so much so in fact, that all appear to have been made in the same factory, the window glass being made in the same factory as the vessel glass". The analysis of the window glass is:- SiO_2, 71%; Na_2O, 13.7%; CaO, 6.53%; K_2O, 2.88%; MgO, 1.76%; Al_2O_3, 1.60%; Fe_2O_3, 0.75%; MnO, 0.94%; PbO, 0.28%; SrO, 0.18%; the next largest constituent was SnO_2, 0.08%, and seven others are quoted. This composition is, however, not at all like any of the compositions of medieval window glasses quoted on pages 10 to 14 of N.L.21.

253. DRACHENBERG, E. (1975) "Probleme der Erhaltung und Restaurierung mittelalterlicher Glasmalerei" (Problems of preserving and restoring medieval stained glass). Denkmalpflege in der DDR 1975 2 38-47.

The author explains the weathering of medieval glasses (especially 14th century) in terms of their high alkali contents, and then discusses in general terms the cleaning, fixing of loose paint, and conservation of the cleaned glass. He advises that commercial products, with well-defined compositions, should be used, and that all methods should be reversible.

He considers that by far the most difficult job is fixing the paint; it cannot be refired but coatings in the manner of lustre glazes are considered to be suitable. A solution of metal soap in oil and turpentine is applied with a paint-brush. After drying, "burning in" is carried out at temperatures of up to 250°C in an oxidising atmosphere. The organic components volatilise, leaving the oxide corresponding to the metals used - alumina and bismuth oxide have proved suitable. Both are colourless, have no optical effects and form a lasting protective layer. This does not solve the problem of the half-tones, which get darker and spoil the effect. Also, heating to only 250°C represents a threat to the glasses. Research has not yet yielded a definitive method of fixing black enamel.

Cleaning of the glass and fixing of the paint must always precede any process of preserving the glass itself if there is to be any hope of success. Various methods have been tried, such as plating with or without an interlayer of synthetic resin, but it proved to be unsuitable in the long term - either because it discoloured or the paintwork was damaged when removal became necessary. Or renewed penetration of moisture took place.

He also discusses the use of protective resins (which cannot always be removed without damaging the glass, as has been claimed); the sputtering of inorganic glasses (the glass was not coated uniformly and it is still susceptible to corrosion, but the coating is invisible and the method might be improved); isothermal glazing is therefore recommended as the best available prophylactic procedure. He discusses isothermal glazing in some detail (pp 44 and 45) and refers to the windows at Lindena (see page 8 of N.L.7), pointing out that they were not ventilated although the results (after 80 years) are favourable. He considers that the external window should be made of laminated safety glass, as a protection against stone throwing, and that it should be cut up and leaded "in the form of rectangles or diamonds which should not be too small". The medieval glass should be hung 50 to 100 mm in front of the external window and be stabilised by means of copper frames; he discusses three different ways of doing this. The recommended widths of the ventilation slots are 10-20 mm at the bottom and 20-30 mm at the top.

On page 46 he lists 21 churches, village churches and cathedrals in the DDR in which isothermal glazing has been installed.

254. ERNSBERGER, F.M. (1959) "Attack of glass by chelating agents" J. Amer. Ceram. Soc., 1959 42 373-375.

The author studied the attack on glass of chelating agents (agents such as EDTA which combine with insoluble materials, such as calcium compounds, to form soluble compounds), apparently with the intention of testing the materials for etching glass instead of using the rather aggressive ammonium bifluoride or hydrofluoric acid. These agents will also attack the weathering crust on glass and hence the paper is of interest in connection with the cleaning of weathered glass, but it was found that EDTA will attack the glass to produce a surface "indistinguishable from surfaces etched to a comparable depth by hydrofluoric acid". Hence the surface would seem likely to be liable to further attack by the atmosphere.

The author studied two chelating agents (sequestering agents) with quite different functions, EDTA and Catechol. EDTA will combine with calcium, magnesium and aluminium to form soluble compounds, and it forms the basis of J.M. Bettembourg's "Solution B" (see abstract 181 in N.L.13 and Section 2.4 of N.L.7). Catechol will form a soluble compound with silicon ions, and hence it might prove to be a useful additional reagent for removing those weathering crusts which contain silica. It does, however, have the disadvantage that it combines with oxygen and hence any cleaning of glass with it would have to be done in an inert atmosphere.

The paper shows that the chelating properties of EDTA and catechol were additive. The optimum concentrations were 0.2% EDTA and 0.4% catechol, and their effect was greatest in an alkaline solution. The maximum rate of attack was 12 fringes per hour at 100°C (say 2mm per month), or about 1/300th of the rate of attack of 1-molar ammonium bi-fluoride.

255. FERRAZZINI, J.C. (1976) "Vorteile und Technik der Anwendung von Cyanoacrylat-Monomer-Klebstoffen zur Sicherung der Malerei von Glasgemälden" (Advantages and techniques of applying cyano-acrylate monomer adhesives to protect the paint on stained glass). Glastech.Ber., 1976 49 264-268.

The author points out that in some cases the base glass has weathered while the painted lines are durable, but in other cases (all illustrated) the paint has weathered and is kept in place only by static charges and it can easily fall off. The Epoxy resins so far used have two disadvantages, they are not readily reversible and are visible to the naked eye.

Any fixing material for use when removing windows for transport must be rapid in its effect, safe, easily reversible, invisible in daylight, have good corrosion resistance, be easily diluted with safe solvents and be easily applied with a very fine paintbrush. About 20 materials were tested, and cyano-acrylate monomer adhesives were found to be the best. Four different commercial brands were used and the best was found to be Cyanolite 201 (from Minnesota Mining Products).

Full details are given for applying the diluted adhesive, depending on whether a thick weathering crust is also present in which case the crust should first be saturated with a toluene-acetone solution. Other features to be considered are whether corrosion has attacked otherwise sound paintwork from the side, etc. The paper (and/or No.256) should be consulted by anyone proposing to use the technique, because the Table on p.267 discusses the sources of error and methods of overcoming them. The hardened adhesive is removed with dimethyl formamide.

256. FERRAZZINI, J.C. (1976) "Die Anwendung von Cyanoacrylat-Monomer-Klebstoffen in der Glasrestaurierung" (The use of cyano-acrylate monomer adhesives in restoration of glass). The information Bulletin of the association of museums in Switzerland 1976 16 5-10.

This article is similar in content to No.255 but it also deals with mending cracks in glass. Cyano-acrylate monomer adhesives are colourless, rapid setting, invisible on the glass (refractive index = 1.4517), easily reversible using N.N. dimethyl formamide, and no surface preparation is needed. As far as cracks in the glass are concerned, Cyanolite 201 is recommended for clean fractures only; old fractures with crumbling edges should still be mended with epoxy resin adhesives because cyano-acrylates should be used in thin layers only (they form a surface layer which prevents the material underneath from drying out).

Details are given of strengths of bonds and there are six illustrations showing how to use the material. When fixing loose paint the adhesive sets in a few seconds. If a longer setting time is required, Cyanolite 202 is better. The shelf-life is limited to one year at most when kept at 5°C; at -20°C it is unlimited.

On pages 7-8 there is a discussion of reversibility because E. Bacher has expressed his doubts about reversible processes during which a paint fragment may become lost altogether (Linnich Symposium 29/30 March 1976, see 251 above). Ferrazzini's solution to this problem is to add a little Araldite to the Cyanolite so that there is a controllable reversibility; he found that 5-10% of Araldite (AW106/HV953U) in Cyanolite 202 was sufficient.

257. NEWTON, R.G. (1976) "First report to the Royal Society on cleaning stained glass with the airbrasive equipment" 26 pages of typescript and 60 colour photographs.

This report studied the use of various types of particle in the airbrasive apparatus and it was found that the harder types of grit such as Nos 7 and 8 (silicon carbide) could easily damage modern glass, producing a cavity 0.5mm deep in one second. The alumina powders (Nos 3 and 5) produced less damage and the hole made by No.5 powder was only 0.12mm deep after 4 seconds, plenty of time for the craftsman to stop the jet after the crust had been removed. Powder No.9 (glass beads) did not produce measurable damage on glass even after 8 seconds. The hardest weathering crusts can easily be removed using alumina powders, and even with glass beads if the crusted glass has first been kept in a dry store for some weeks before cleaning starts.

Some accelerated weathering tests were carried out on the airbraded surfaces, and they failed to confirm that the cleaned surfaces are more susceptible to weathering than were the original, uncleaned surfaces.

258. POLAK, Ada (1975) "Glass, its makers and its public" Weidenfeld & Nicholson. London. £7.50.

This well-documented book describes glass and glassmaking, from medieval times to 1870, with discussions of all its interactions as determined by geography, economy and fashion. Its scope is best described by listing the first seven chapter headings:- 1. Glass and glassmakers. 2. Glass and the Church. 3. Glassmaking in forests and towns. 4. Forest glassmaking in the north. 5. Mediterranean glassmaking in forests and towns. 6. Venice, the greatest of urban glassmaking centres. 7. The italians introduce glassmaking in the towns of the north. Chapters 8-22 deal with decorated glass or with post-medieval developments.

In the USA the same book has a different title:- "Glass - Its tradition and its makers", published by G.P. Putnam's Sons, New York, $15.95.

259. SCHMIDT, Christa (1976) "Zur Restaurierung der Glasmalereien in Mühlhausen" (The restoration of stained glass at Mühlhausen) Denkmalpflege in der DDR, 1975 2 42-51.

Descriptions (and illustrations) are given of four panels from the Marienkirche. These had been left in place during the war and survived without much damage occurring. But the medieval glass from Blasius church was removed during the war and stored in a cellar, and it is now completely destroyed.

In restoring the Marienkirche windows, any loose paint is fixed with Piaflex solution after which the weathering crust is removed by mechanical means. Details are then given of the various changes made in the window and restoration procedures such as firing-in missing paintwork. Mending leads are removed where possible and the cracks repaired with a special adhesive; these cracks are stabilised with lead plugs at intersections. (Lediglich an Kreuzungspunkten werden die geklebten Risse durch Bleiplomben stabilisiert.) The outer edges of panels are strengthened by tin soldering and inserted in a copper frame, but this is complicated by the fact that every panel is of a different size so that a special frame has to be made for each of the 150 panels.

260. SIMPSON, H.E. "Measuring surface durability of glass" Bull. Amer. Ceram. Soc. 1951 30 (2) 41-5.

Abstract No.244 in N.L.22 describes the results of many experiments on the treatment of glass surfaces, using a technique for measuring the "haze" (permanent surface damage) produced on the glass. This paper gives full details of the apparatus for carrying out these tests.

Some test results are also included; Fig.3 shows that more damage is caused to glass by repeated condensation and drying than by continuous condensation, apparently because the latter situation produced large amounts of water which ran off the surface carrying the reaction products with it. Fig.8 shows how two modern window glasses gave quite different results because they had different compositions. One was more than twice as durable than the other, and it contained 12.1% of soda whereas the less durable one had 13.2% of soda (the full compositions are given on p.45). Four optical glasses (compositions also given) behaved in quite different ways when subjected to the test.

261. TUMMALA, Rao (1976) "Stress corrosion resistance compared with thermal expansion and chemical durability of glasses" Glass Tech. 1976 17 145-6.

The author is primarily concerned with predicting the stress-corrosion-resistance of glasses (which is tedious to measure) and he points out that it is correlated with the coefficient of thermal expansion of the glass and with the chemical durability (towards water), which are correlated with each other. RGN - the paper is of interest for the theory of conservation, because it would indicate that the poorly durable medieval glasses automatically have a relatively large thermal expansion, which might make it difficult to use Acloque's proposed conservation process (see Section 2.3.5 of N.L.23). Medieval glasses are believed to have a coefficient of expansion of twice that of modern glass (see Section 3.6 of N.L.18). According to this paper, the medieval glass would have one tenth of the durability of the modern glass. Here again, the glasses in most urgent need of protection will be the most difficult ones to protect.

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