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Dr. Derek Linstrum

REF: TC/73/7

12th October, 1973

N E W S L E T T E R No. 5

1. GENERAL POINTS

1.1 B.A. Meeting in Canterbury

The ABSTRACT of the paper for the meeting of the British Association for the Advancement of Science, held in Canterbury on 22nd August, was sent out on 1st August as "TC/73/5". This was numbered in error and I shall be glad if you will kindly correct the number to TC/73/6. Anyone who wants a copy of the Abstract of this paper should apply to me.

There was not much discussion actually at the meeting but there has subsequently been much interest in discussing what happens to coatings during weathering. This information is still under discussion and it will be summarised in News Letter No. 6. "Double glazing" systems will be discussed in News Letter No. 7.

1.2 Visits between conservation workshops in Europe

The first of a series of visits between experts from conservation workshops has taken place. Mr. Peter Gibson, Superintendent of the workshop of the York Glaziers Trust, received a grant from the Radcliffe Trust Scheme for the Crafts to visit three European stained glass restoration centres. On 28th-30th May he visited the Laboratoire des Monuments Historiques, near Paris. He met Professor Dr. Louis Grodecki, M. Jean Taralon, Ir. J. M. Bettembourg, M. J. J. Burck, and Mme Françoise Perrot and visited three studios of M. Chevalier, M. Durand and M. Gruber together with a fourth which is directed by M. Chamoix, to discuss methods of conservation. Several churches in Paris were also visited.

On 1st to 5th June he visited the Osterreichische Bundesdenkmalamt in Vienna, where Frau Dr. E. Frodl-Kraft and Dr. Bacher showed him the technique of installing isothermal protective glazing in the church of St. Maria am Gestade, and he also saw the experiment in progress on the East window on the use of protective resin coatings; further details of these are being sought.

A visit was made to the workshop of Ignaz Durr and photographs were made available of the isothermal protective glazing in use at the LeechKirche in Graz (these were used during the BA Lecture, see item 1.1). Visits were also made to see the glass at St. Stephens' Cathedral, and in the monasteries at HeiligenKreuz and at Lilienfeld.

On 6th to 8th June he visited the restoration workshops of Dr. Gottfried Frenzel in Nuremberg, to see the techniques used for cleaning the Augsburg Prophet Windows and for fixing friable paint. Visits were made to the churches of St. Sebaldus and St. Laurence to inspect the isothermal protective glazing techniques and anti-theft devices in use there. Visits were also made to Regensburg and to Ingelstadt.

1.3 Chairmanship of the Technical Committee of the CVMA

At the CIHA general meeting held in Granada recently, Frau Dr. Eva Frodl-Kraft was appointed Chairman of the Technical Committee of the CVMA. She deserves our congratulations on receiving this honour.

1.4 Next Meeting of the Technical Committee of the CVMA

Professor Hans Hahnloser has informed me that Professor Nieto Alcaide has suggested that the Technical Committee, if not the whole CVMA, should meet in Segovia in September or October 1975, with excursions to Toledo and Leon.

1.5 Sheffield Cathedral "Spanish" Window

This window, reputedly of the 15th Century, was examined recently and it was concluded (for several reasons) not to be older than the 19th Century. A partial analysis of the glass showed it to be a soda glass with 20% of lime. Such an analysis suggests a date of manufacture in the first half of the 19th Century but there is a shortage of analyses of 18th and 19th Century glasses (compared with earlier centuries). Does anyone possess analyses of dated sheet glass from these centuries?

1.6 Bibliography notes

Section 3 of this News Letter contains some more bibliography i.e., item Nos. 128 to 145 . The earlier item numbers can be found as follows:-

Item Nos. 1 to 26 are in the bibliography dated 13th April 1972
" " 27 to 49 " " " " " 22nd May "
" " 50 to 70 " " " " " 21st August "
" " 71 to 127 are in News Sheet No. 4, dated 28th June 1973

Further bibliography items will be included in subsequent News Letters.

2. RESULTS FROM THE RESEARCH PROGRAMME

A. Tests on protective coatings

The second synthetic glass has been used for a number of tests; it has about one quarter of the durability of glass No. 1 and the results for some coatings are given below. The sputtered Corning 7070 glass (100 μm thick), referred to in item A.2 on page 3 of News Letter No. 3, failed to adhere to glass No. 2 and hence gave no protection at all. An easily-fusible lead borosilicate glass has so far given complete protection when it is used as an over-fusion for the poor glass.

Readers of TC/73/6 (the Abstract of the British Association paper, wrongly numbered TC/73/5) will have seen from "Problem No. 7" on page 5 that I raised the question as to whether poorly durable glasses are valid substrates for testing protective coatings intended for use on glasses with higher durability. One way of trying to answer this question is to use three poorly-durable glasses, and a third (Glass No. 3) has therefore been devised, having a durability lying between that of No. 1 and No. 2. The weight-compositions and molar compositions of the three glasses are given below:-

	WEIGHT PERCENTAGE COMPOSITIONS			MOLAR PERCENTAGE COMPOSITIONS		
	Glass No. 1	Glass No. 2	Glass No. 3	Glass No. 1	Glass No. 2	Glass No. 3
SiO_2	42.9	43.9	50.6	50.0	50.0	55.5
CaO	19.9	20.5	21.2	25.0	25.0	25.0
K_2O	22.8	29.6	24.3	17.0	21.5	17.0
Al_2O_3	5.1	3.7	3.9	3.5	2.5	2.5
Fe_2O_3	2.3	2.3	-	1.0	1.0	-
P_2O_5	7.1	-	-	3.5	-	-
TOTAL	100.1	100.0	100.0	100.0	100.0	100.0

When these glasses were coated and extracted in a Soxhlet apparatus, the weights of K_2O (in mg) extracted from the standard sample (a disc 5 mm thick and 16 mm diameter) in 100 hours were:-

Extraction of K_2O in mg/100 h

Coating used	Glass No. 1	Glass No. 2	Glass No. 3
None	8.8	34.2	12.1
Vycoat	1.2	2.0	2.1
Acrylek	5.0	15.2	(?)

There are, as yet, too few results to draw any useful conclusions, as to whether the "apparent durability" of the coated samples, compared with the base glass, is constant or not, and many more coatings should be tested, but the results will be awaited with interest even though it seems likely (see Ref. 140 in section 3) that no organic coating will provide protection, or perhaps be other than harmful in the long term.

B.1 Non-destructive analysis of medieval glass

A report on the use of the "Isoprobe" has been issued as YG/73/4 on 17th August. Anyone who wants a copy should apply to me.

B.2 Rapid partial analyses

The easy identification of early medieval (high-potash) glass (see item B.2 on page 3 of News Letter No. 3) has been confirmed inside a building, by attaching radiation-monitoring films to glass in the "Norman Medallion" in the central lancet of the "Five Sisters Window" at York Minster. A report will be produced in November.

C. Environmental studies

The theoretical studies of "isothermal protective glazing", reported in item C on page 4 of News Letter No. 3, will now be extended to study the conditions inside the airspace between a medieval window and ventilated external protective glazing.

G. Cleaning

A report, (YG/73/3, dated 10th May 1973) has been prepared on the use of the ultrasonic bath for cleaning painted and enamelled glass. Anyone who wants a copy should apply to me.

H. Adhesives

Answers to Janet Notman's questionnaire have now been obtained for several adhesives, and they will be set out in a subsequent News Letter.

3. BIBLIOGRAPHY

Eighteen additional references are given on pages 6 onwards They have been numbered 128 to 145 to follow-on from the 57 items given in News Letter No. 4.

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128. BACHER, E. (1973 a) "Aussenschutzverglasung" (External protective glazing) OZKD, 1973 27 (1/2) 66-68

This is an important paper on the subject of isothermal protective glazing and it is one of the few where engineering-type drawings are published. Fig. 74 shows, in both vertical and horizontal sections, exactly how the ancient glass is hung inside the building so that the warm internal air can circulate on both sides of it; it is unfortunate that there are two errors in the dimensions shown, the figures 650 and 150 should be 65 and 15 mm respectively.

The objectives of isothermal protective glazing are reviewed but no clear distinction is drawn between (1) sealed double-glazing, (2) ventilated exterior protective glazing and (3) true "isothermal" glazing; in fact the Aspis window at Lindena, installed in 1897, is referred to as "one of the first conservation projects of this kind" (Eine der ersten Konservierungsmasznahmen dieser Art) even though it was probably intended as a protection against damage. Nevertheless, the Lindena window is said to have weathered only slightly in the 75 years and non-isothermal glazing is clearly protective against deterioration.

The Austrian examples are then reviewed; two have been completed (the Wassen-kirche at Leoben in 1969/70 and the Leech-kirche at Graz in 1971/72, see Ref. No. 35 in the bibliography dated 22.5.72) and two are being carried out at present (the chancel window of St. Maria am Gestade in Vienna and the cloister windows at Lilienfeld Monastery). The technique was developed by the firm of Emil Bergmann and was based on the experience gained at Nuremberg and at Berne.

Panes of window glass 4 mm thick are installed in the original glazing grooves and the medieval glass is then hung some 60 to 80 mm further inside the church. The existing tee-bars are strengthened and two to four screwed bolts 80 to 100 mm long are welded to them. The medieval panels are then rested on the bolts and fastened with nuts. Because the mullions are sculptured, the panels need to be made slightly wider to prevent light shining through at the sides. This is done by using U-shaped strips of metal and details are given in the paper. The stability of the structure has proved adequate for the moderate weight of the new glazing system and there is no need for elaborate strengthening of the medieval panes because they are no longer subject to wind pressure. If strong winds are likely the modern window glass can be made more rigid by soldering some struts, of the window bar type, to the framing strip on the outside. The sheets of modern glass are protected against irregularities of the glazing groove by using strips of "Styropor".

In discussing the ventilation of the space between the two sets of panels he remarks that leaded glass can never be relied on to remain sealed, and hence the cavity must be ventilated ("...musz für ausreichende Belüftung gesorgt werden,....") whereas it seems to RGN that the essential feature is to encourage the flow between the windows of as much air from the warmed building as possible, so that the ancient glass does not become chilled below the condensation point. Ventilation slits are, however, left between the medieval glass and the sill so that air can circulate; at the top the last of the medieval panes is tilted so that air can escape through the gap. These procedures, and the means for preventing too much light from passing through all the gaps, are discussed in the paper. The space between the windows may become dirty but the medieval panels can easily be removed for cleaning by unscrewing the nuts.

Finally, he refers to the aesthetic problems created by reflections in the exterior glass, as seen from the outside the buildings. This will have to be dealt with in some way, but it was not important in the case of the two Steier churches due to the closeness of the surrounding buildings.

129. BACHER, E. (1973 b) "Das VIII Colloquium des Corpus Vitrearum Medii Aevi in York and Canterbury, 25th September - 1 Oktober 1972" (The VIIIth Colloquoum of the CVMA in York and Canterbury, 25th September - 1st October 1972)

This is a brief account of the meeting which took place during that week. He comments that there was an opportunity to look at medieval windows in York, Cambridge and Canterbury, and that the recent tendency for more of the papers to deal with technical and restoration problems was again evident. Four themes emerged:- 1, everyone must take some interest in technical solutions; 2, there are special technical problems which require fuller discussion; 3, the progress of the work of CVMA; and result of the work of the Corpus.

There is still a need to find a "common language" regarding the principles of conservation, and also of restoration, because various schools have diametrically-opposed views. The papers by R. H. Brill, E. Frodl-Kraft and G. Frenzel did, however, bring the opposing views together. Particular attention was drawn to the paper by G. F. Linsley on the possibility of protecting corroded glass by depositing a thin layer of durable glass.

He then comments on the "feeling of helplessness" felt by the participants when faced with the weathering damage to the glass at Canterbury Cathedral.

130. BURMAN, P. A. T. (1973) "Corpus Vitrearum Medii Aevi. Canterbury meeting 30th September 1972: Canterbury Cathedral glass". J. Brit. Soc. Master Glass Painters, 1972-3 XV (1) 27-33.

This is a detailed account of the lecture by Dr. G. Frenzel and the discussion which followed. Mr. Frederick Cole opened the proceedings by discussing the history of the Canterbury glass since 1793 (when the position of the genealogical windows was changed), and 1878 (when much repair and rearrangement was carried out by the younger Caldwell). Significant changes also took place following the removal of the windows during the 1914-18 and 1939-45 Wars, but Caldwell destroyed virtually all of his tracings and drawings so that identification of his restorations has been rendered difficult.

Steps are being taken to set up a new stained glass workshop in Canterbury which will be situated within the Cathedral precincts.

Dr. Frenzel described the conditions of the Canterbury windows as "catastrophic" because the pitting had progressed to the stage of complete removal of the surface. In his opinion the glass was unlikely to survive for more than 20 years. Dr. Eva Frodl-Kraft was also of the opinion that the panel "Adam Delving" on display in the Crypt dare not be replaced in its present condition.

Dr. Frenzel then read his paper on "The preventative and conservational methods used in preserving the Prophet Windows (ca 1130) at Augsburg" and he illustrated the decay which had occurred between 1909 and 1972, with photographs and photomicrographs, special emphasis being placed on the increased rate of decay which has occurred since 1945 and which he attributed to increased concentrations of carbon dioxide and sulphur dioxide (Note by RGN - but CO_2 does not increase by more than 1.4% per annum.). He recommended the use of external protective glazing (if it maintained dry conditions). The cleaning of the five Prophet windows cost 300 000 DM; mechanical cleaning (80%) with glass fibre brushes was used, together with chemical cleaning (20%) to dissolve atmospheric deposits. He stressed that there were still many problems to be solved regarding cleaning, restoration and preservation of medieval stained glass.

During the discussion several of the Continental delegates commented that they had not previously seen windows in such a bad state of preservation. There was also a discussion of "double-glazing" and Professor Hahnloser commented that, since the end of the last war, all the medieval glass in Switzerland had gradually been double-glazed and, because of this, no damage had occurred to any of it. Dr. Maercker remarked that an important window in East Germany had been double-glazed in 1897 yet it looked as though the glazing had been done only recently. That window was said to be fully sealed, but Dr. Frenzel's windows at Augsburg had some ventilation to the outside; his windows at Nuremberg had protective glazing systems of the isothermal type. Mr. Dennis King commented on the problems and suggested that the use of reinforced translucent acrylic sheeting would provide a valuable temporary protection. Dr. Brill considered that some of the windows had deteriorated too greatly to be protected by double glazing and needed to be kept in museum conditions.

Dr. Eva Frodl-Kraft commented that any application of "protective coatings" could be considered only when the surface of the glass (either the inside or the outside) had been made absolutely clean, but she could see no way of doing this without destroying some of its quality and, more especially, some of the painting. In summararising the meeting, Professor Hahnloser emphasised that the recommendations were that protective glazing should be installed.

131. CRAWFORD, A. S. (1973) "A study of the internal environment of cathedrals with particular reference to St. Paul's" Paper given to the British Association for the Advancement of Science at Canterbury, 23 August 1973. 8 pages and 5 charts. (Copies can be obtained from Freeman, Fox & Partners, 25 Victoria St., London, SW1.)

The author reviewed the historical evidence about the temperatures in St. Paul's Cathedral, including sub-freezing temperatures in 1598 and 1833. The crypt windows were glazed, and heating installed, in 1840. Many gas jets were installed for the funeral of the Duke of Wellington in 1852. Hot water radiators were used from 1909.

The present proposals for producing an environment in the Cathedral, which will not harm the books or wooden furniture (16°C to 18°C and 50-65% relative humidity) are set out in some detail. The plans assume 3 000 visitors per hour and the air conditioning unit will supply 45 000 cu. ft. per minute of recirculated filtered air. Twenty gallons of perspiration per day will be removed from the air before recirculation and the equipment will be programmed to take account of the number of visitors present in the building.

132. DOLEZEL, B. (1972) "Vliv klimatickych faktoru na starnuti plastickych hmot" (Ageing of plastic materials as affected by climatic factors). Koroze Ochr. Mater. 1972 16 (2) 25-27.

This paper discusses the degradation of plastics materials in the presence of UV-light, oxygen, ozone, water and air pollutants. It seems that the simultaneous effect of oxygen and sunlight is greater than the total of their individual effects. High humidity greatly accelerates the ageing of plastics, especially in a hot climate. Ageing tests reported by manufacturers must be accepted with reservations because they are often performed without simultaneous exposure to mechanical stresses which normal usage produces.

133. DUKES, W. A., and GREENWOOD, D. (1972) "An adhesive system for an applique glass screen out of doors" Unpublished report from the Explosives Research and Development Establishment, Waltham Abbey, Essex. (See also No. 134)

The Winston Spencer Churchill glass appliqué memorial at Dudley, Worcestershire, which is 13 m wide and 3 m high, was made with pieces of broken coloured glass, bonded to each other and to a 12 mm toughened glass sheet with an epoxy resin system. The adhesive is said to have been a plasticised epoxy resin cured with a polyamide at room temperature but, within a few months of completion and exposure to the weather, the pieces of coloured glass began to fall off. The rate of failure increased with time and had become extensive after two years; examination of the panel showed that the failures had occurred at the interfaces between the glass and the resin.

An experimental study was made of various epoxy resin systems, using four types of hardener (polyamide, amine, polysulphide and Ajicure B 001) and two siloxane surface treatments, both of which are believed to form chemical bonds to both the resin and the glass. The joints were tested after standing at room temperature for 14 days and after then being placed in boiling distilled water for 1, 3 or 7 days. The polyamide- and amine-hardened resins failed after the boiling water tests, even though siloxane treatment had been used with the latter. Thus it is understood why the original panel had failed.

Further tests were made using the polysulphide- and Ajicure B 001-hardened epoxy resins, and the two siloxanes. The bonds were tested after heating in air at 100°C for seven days, or in water at 20°C for 25 weeks; 40°C for ten weeks; and 60°C for seven weeks. The Ajicure B 001 bonds had adequate shear strength (at least 1000 lbf/sq in or 7 MPa) after all these tests, but the polysulphide-hardened bonds showed some loss of strength (to 500 lbf/sq in or 3.5 MPa) after eight weeks in Water at 20°C.

It was therefore concluded that adequate strength would remain in the panel, even after 25 years' exposure to the weather if the glass was dipped in a 1% aqueous solution of Teepol, rinsed in tap water and then dipped in a fresh 1% aqueous solution of γ-glycidoxypropyltrimethoxy silane (Union Carbide A 187) and dried. The epoxy resin was cured with Ajicure B 001 (Epikote 827) for 24 hours at room temperature.

134. EXPLOSIVES RESEARCH AND DEVELOPMENT ESTABLISHMENT (1973) "How they saved the Churchill Window" Plastics and Rubber Weekly, March 9th 1973, p. 12. See also No. 133.

The article describes how an appliqué window, constructed with the use of epoxy resins, failed within six months of the erection of the mural and pieces of glass started to drop off. The failure was investigated by ERDE and attributed to the ingress of moisture and thermal and mechanical movement. After carrying out an extensive programme of accelerated testing, and outdoor exposure trials, ERDE recommended that a siloxane primer should be applied to the glass and that a different epoxy resin (Shell Epikote 828) should be used with the curing agent Ajicure B 001. A life of at least 25 years is now predicted because Ajicure B 001 produces a flexible molecular structure when it cures the epoxy resin.

135. FISHER, Alfred. (1973) "An artist's look at CVMA" (A very personal report on the 8th Colloquium held at York and Canterbury from 25th September to 1st October 1972). J. Brit. Soc. Master Glass Painters, 1972-3 XV (1) 34-40.

This is a general account of the colloquium, special emphasis being placed on the marked national and personal differences which were expressed towards the cleaning, conservation and restoration of medieval stained glass, and on the extraordinary differences in funds made available in the different countries for preserving medieval stained glass (eg, £40 000 being spent in Germany for the conservation of the five small Augsburg prophet panels).

He asks several questions as to what is really required from a conservation programme, and concludes that a balanced approach towards the window is needed, with contributions of expertise from all the different disciplines.

136. JACOBI, R. (1973) "Zur Frage der Erhaltung alter Glasmalereien" (The problem of preserving old painted glass). Maltechnik Restauro 1973 2 114-120.

This paper is mainly a detailed account of the "safety-glass process" used for laminating the Kings' Windows in Cologne Cathedral, and anyone who wants to know exactly how this was done should consult the paper.

Page 114 also describes the "fixing" of loose black paint by using a polymerisable silicone dolution supplied by BASF; this is said to precipitate solid silica, producing a bond which is resistant to water and corrosion.

137. NEWTON, R. G. (1973 b) "Scientific methods and conservation of medieval 'stained' glass" Paper given to the British Association for the Advancement of Science at Canterbury, 23rd August 1973, 10 pages.

This is a revised version of the information given in Ref. No. 111, with the addition of detailed information about systems of isothermal protective glazing in use at Vienna, Graz, Nuremberg and Warwick. Questions are also raised regarding the validity of accelerated weathering tests using poorly-durable glasses.

138. NOTMAN, Janet, H. (1973) "The Restoration of a stained glass roundel. St. Anne with Virgin and child. Early 16th century. Flemish" Scottish Art Review 1973, XIV (2) 10-13.

This is an account of the restoration of a small panel which was found to be part of a roundel. All the steps are described in simple terms and various points of interest are the removal of a water-soluble glue used in an earlier restoration; the use of diamond burr to improve the adhesion of the epoxy resin used to make edge-to-edge joints; and the use of coloured acrylic to build up grozed edges.

139. RIEDERER, Josef (1973) "Die Wirkungslosigkeit von Luftverunreinigungen beim Steinzerfall" (The inefficiency of air pollutants in causing stone decay.) Staub, Reinhaltung, Luft, 1973 33 (1) 15-18.

Of all the air pollutants, only sulphur dioxide is said to attack buildings; hence automobile emissions do not harm buildings. Moreover, the sulphur dioxide concentrations in Munich have been decreasing, from 0.45 mg m^{-3} in 1955 to 0.15 mg $^{-3}$ in 1969 so there is no reason to fear a rapid decay of monuments. Nevertheless, it is difficult to explain why protected areas of limestone are often more corroded than exposed areas, nor why massive soot incrustations containing gypsum are found on intact limestone.

140. RITTER, J. E. Jr. (1973) "Stress corrosion susceptibility of polymeric-coated soda-lime glass" J.Amer. Ceram. Soc., 1973 56 (7) 402-3.

It was found that acrylic, epoxy, and silicone coatings had little, if any, effect on the susceptibility of glass to be weakened by moisture. It was concluded that these resin coatings do not stop the deterioration of glass surfaces caused by water.

141. SANDERS, D. M. and HENCH, L. L. (1973) "Mechanisms of glass corrosion" J.Amer. Ceram. Soc., 1973 56 (7) 373-7.

This paper is a highly technical one concerned with understanding the formation of silica films on glass surfaces when they are exposed to water; it should therefore be consulted by anyone who wants to investigate these topics. Among the various conclusions the authors discovered that scratching the surface of glass causes an unusually high release of silica and produces pits 0.5 μm diameter along the scratches because "chemically-active glass" is produced by scratching or grinding.

142. SCHAFFER, R. J. (1932/1972) "The weathering of natural building stones" DSIR Special Report No. 18, HMSO London, 1932. (This book is again available in a facsimile edition (1972) from the Building Research Establishment, Garston, price £2.)

Page 25, and Appendix I (pages 106-119), discuss the effects of air pollution on stonework, but the information is also of interest in connection with the deterioration of glass. Acid gases are the main cause of decay of building materials which contain calcium carbonate (RGN: the first decomposition product of glass is probably calcium carbonate). Deposits of soot can bring acidic materials into close contact with stone (or glass). Carbon dioxide is of little consequence to stonework but sulphur dioxide is more important. Although the SO_2 originates largely in towns it can be dispersed widely before it is destroyed by natural processes. This book, written in 1932, states (p. 107) that "sulphur gases are not naturally present in the air, except locally in the vicinity of volcanoes" (etc) and thus it conflicts with the statements in Refs: 116, 118 and 119, to the effect that, on a global basis, more than half of the SO_2 in the atmosphere comes from natural sources! The view (in this book) that SO_2 does not arise naturally leads to the statements (on p. 117) tnat SO_2 is widely distributed from the sources in towns and that the inverse ratio of soot to SO_2 still has to be explained. On p. 119 there is the comment that much decay of limestone from sulphate attack occurs in country districts.

There is an interesting remark on p. 113 that hoar frost contains 40 times as much soot, and 50 times the acidity, of average rain.

143. SCHRÖDER, H. (1973) "Comments on the paper by Adlerborn (71)" Letter dated 25th June 1973.

Professor Schröder comments that, although Adlerborn uses electron microscopy to demonstrate the presence of a faint deposit produced on glass by water vapour, this may not really be significant in relation to the practical deterioration of glass. He points out that, about ten years ago, he exposed various optical and technical glasses (including window glass) for two years to tropical conditions in the Amazon valley in Brazil. The relative humidity exceeded 70% for most of the time, but the samples were shielded from rain and condensation was excluded by ventilation. The samples could have been cleaned two or three times per year but no visible signs of weathering could be detected after the two years.

144. SILCOCK, Bryan (1973) "Leaning spires" Sunday Times 26th August 1973.

This is a rather brief account of the meeting of the Physics Section of the British Association for the Advancement of Science at Canterbury on 22nd August 1973.

It discusses the negligible effect of the buttresses of Winchester Cathedral and the changes which had to be made to the foundations of York Minster. At the end of the article there is a paragraph which draws attention to the importance of isothermal glazing for protecting medieval windows.

145. WERNER, A. E. (1966) "The care of glass in museums" Museum News Technical Supplement No. 13, June 1966, pp 45-99.

This paper is essentially similar to Ref. 49, but there are three interesting additions. One concerns a glass bell (Fig. 2) on which adhesive labels had accentuated the crizzling, thus emphasising the dangers of sticking labels to such unstable glass and enhancing the tendency for moisture to accumulate locally. (Perhaps pit-corrosion may occur in a similar fashion, if moisture collects in the pit.) The second item concerns the storage of the Kungsholm glass in dry argon (T. Boström, Särtryck ur Svensk Naturvetenskap., 1962 p. 405), and the third is a comment on the possible dangers of using "spotlights" in museum cases, with the risk of damage by local heating and thermal cycling.