CVMA NEWS LETTER 15

British Technical Committee, Corpus Vitrearum Medii Aevi

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CONTENTS

1 GENERAL

1.1 VISIT TO BRITISH WORKSHOPS BY FRÄULEIN JULIANE RAUSCH

Juliane Rausch, from Dr Frenzel's restoration studio at Nuremberg, came to England with British Council support for the period 10th-27th March 1975, visiting Canterbury, York and Norwich. Her report covers similar ground to those by Dr Bacher (N.L. No.11, item 1.4) and Ir Bettembourg (N.L. No.13, item 1.2) and will not be repeated here. Dr Frenzel has, however, made some comments on her report and his views are summarised in the next item below.

1.2 COMMENTS BY DR G. FRENZEL ON FRÄULEIN RAUSCH'S REPORT

Cleaning: Before cleaning the painted glass should be stabilised with a brass frame, as the use of isothermal protective glazing means that there is no longer a bond with the building. The principle of supporting painted glass with a solid frame was already used in the Middle Ages, when the frames were strengthened by willow wands inserted in the leads, or were made of iron. We recommend cleaning with glass fibre brushes, as these make it possible for the restorer to treat each piece separately. We do not recommend cleaning by airbrasion as experiments which we have carried out in conjunction with the Bavarian Ministry of Works have shown that the presence of even small irregularities in the surface will cause the original material to be damaged (see J.C. Ferrazzini, Ref.187 in this News Letter).

On principle, we only half clean, i.e. weathering products are only removed to an extent which will not damage the glass. Basically, we are against methods of cleaning which are based solely on aesthetic considerations (cf. conference of the International Expert Committee in Regensburg, 22.11.74). In general we cannot recommend ultrasonic cleaning; it may, however, be a suitable method for experiments. Our own experiments have shown that the glass is severely damaged; particles of glass are moved against each other, cracks occur; or if cracks are present the glass disintegrates. (RGN - no damage occurred to the glass during the comprehensive series of experiments at York.) We do not yet know of any scientific methods of predicting ultrasonic damage (experiments and discussions with Prof. Oel, Institute of Materials Science of the University of Erlangen).

Plating broken glasses by means of cover glasses applied loose and dry is in principle good and does not damage the original. However, experience has shown that in the long-term it is not possible to seal such a plated glass perfectly. As soon as the bond becomes permeable moisture gets in, which is fatal for the glass (cf. e.g. the relatively severe corrosion of the painted glass of St Lorenz', Nuremberg, which was plated in 1935; see also Pfister: The preservation of the Kunhof window at St Lorenz' in Nuremberg, in Deutsche Denkmalpflege, 1939, pp. 66-78). (RGN - experience at Canterbury gives the opposite results - the plating glass (and hence presumably also the medieval glass) suffered no damage! See News Letters No.12 (item 1.4) and No.13 (item 2.4).)

We are not yet in a position to comment on cleaning by acid polishing as we have had no experience in this field. However, we shall be carrying out our own experiments in accordance with the specifications of Mr Cole and Professor Newton. (RGN - This is a misunderstanding! Frederick Cole does not clean with hydrofluoric acid but he regains the brightness of the surface, which was rendered matt by airbrasive treatment, when he polishes that surface only with hydrofluoric acid.)

We are preparing our own paper on the subject of external protective glazing which, besides a list of all the examples, will also include representative measurements. We mainly use the system of isothermal external protective glazing, often even before the restoration of the painted glass.

As a rule we do not consider it necessary to remove all the leads of a panel, since stabilising the painted glass in a solid frame is usually sufficient. Our experience has shown that removal of the leads produces numerous new cracks which place the original at risk.

Basically, cleaning with water is not harmful, provided that loose black enamel is fixed first (cf. Frenzel: Note in catalogue of exhibition on the problems of conservation and restoration of medieval painted glass in Freiburg in June 1975).

The method of replacing severely damaged medieval glasses by other medieval pieces cannot be recommended for aesthetic reasons, since the original appearance is altered. (RGN - how do we know what was the original appearance?) Even glasses which have almost disintegrated can be saved by modern restoration methods (plating with Araldite) "(Doublieren mit Araldit)" and even a restoration method which is not 100% satisfactory is better than removing the original.

We reject grinding the back of the glass because the slightest damage of the natural surface produces areas which are extremely susceptible to further weathering (See J.C. Ferrazzini, Ref.187 in this News Letter).

1.3 DANGERS TO PERSONNEL OF USING HYDROFLUORIC ACID

Some conservators of medieval stained glass are using hydrofluoric acid to polish the matt surface which remains after the airbrasive has been used for cleaning the outside surface, and especially for removing the deposits from any pits. Polishing with this acid will restore the transparency and make the glass "bright" again. (RGN - Here I should remark that Dr Eva Frodl-Kraft has seen some of this acid-brightened glass and comments that its colour-values have been changed in the process. This is true, but do we know the original colour values?)

Anyone using hydrofluoric acid is reminded that the acid is one of the more-dangerous ones to use. It differs from other acids in its action on living tissue because it can "fix" calcium in the tissues and cells. One result of this is that a preponderance of potassium occurs in the tissues, and this is probably responsible for the severity of the pain (potassium stimulation of nerves). Fluoride ions can also pass through apparently uninjured tissue (such as skin and finger nails) and cause pain and damage to tissues beneath!

Proper precautions must therefore be used. Always wear rubber or plastic gloves and work in a well-ventilated space. If any gets on the skin, in the eyes or in the lungs, immediate first aid must be taken.

The skin: wash continuously with plain water; remove all contaminated clothing; and apply calcium gluconate gel liberally to the affected area until all pain has disappeared.

The eyes must immediately be flushed with water continuously until the pain is subsiding and then 10% calcium gluconate should repeatedly be instilled into the eyes until all pain has subsided. Local anaesthetics should NOT BE USED. Betnovate drops should then be instilled every 5-10 minutes for an hour.

Inhalation of the fumes is particularly dangerous and hospital treatment is necessary (to prevent pulmonary oedema with laryngeal necrosis).

If large areas of skin are affected, e.g. greater than 12cm x 12cm, special calcium gluconate treatment (orally and intravenously) is needed in hospital.

Thus a supply of paper towels, and calcium gluconate gel, should be available whenever hydrofluoric acid is used, together with a copy of these first aid instructions.

1.4 IX CVMA COLLOQUIUM IN PARIS, 8-12 SEPTEMBER

This Colloquium is by invitation only and all the invitations have now been sent out! The numbers have had to be severely limited partly for financial reasons (N.L. No.13, item 1.1) and partly because space is limited in the workshop where the Chartres windows are being restored. The technical sessions will be concerned with composition of glass and its corrosion; cleaning; stabilisation of the painting; protection of windows; and the communications will be reported in a future News Letter.

1.5 EXHIBITION OF STAINED GLASS IN YORK

The exhibition was held in York on the occasion of the Annual Chemical Congress of the Chemical Society and the Royal Institute of Chemistry (7th to 11th April) and was so successful that those who wish to plan other exhibitions may care to know what it comprised.

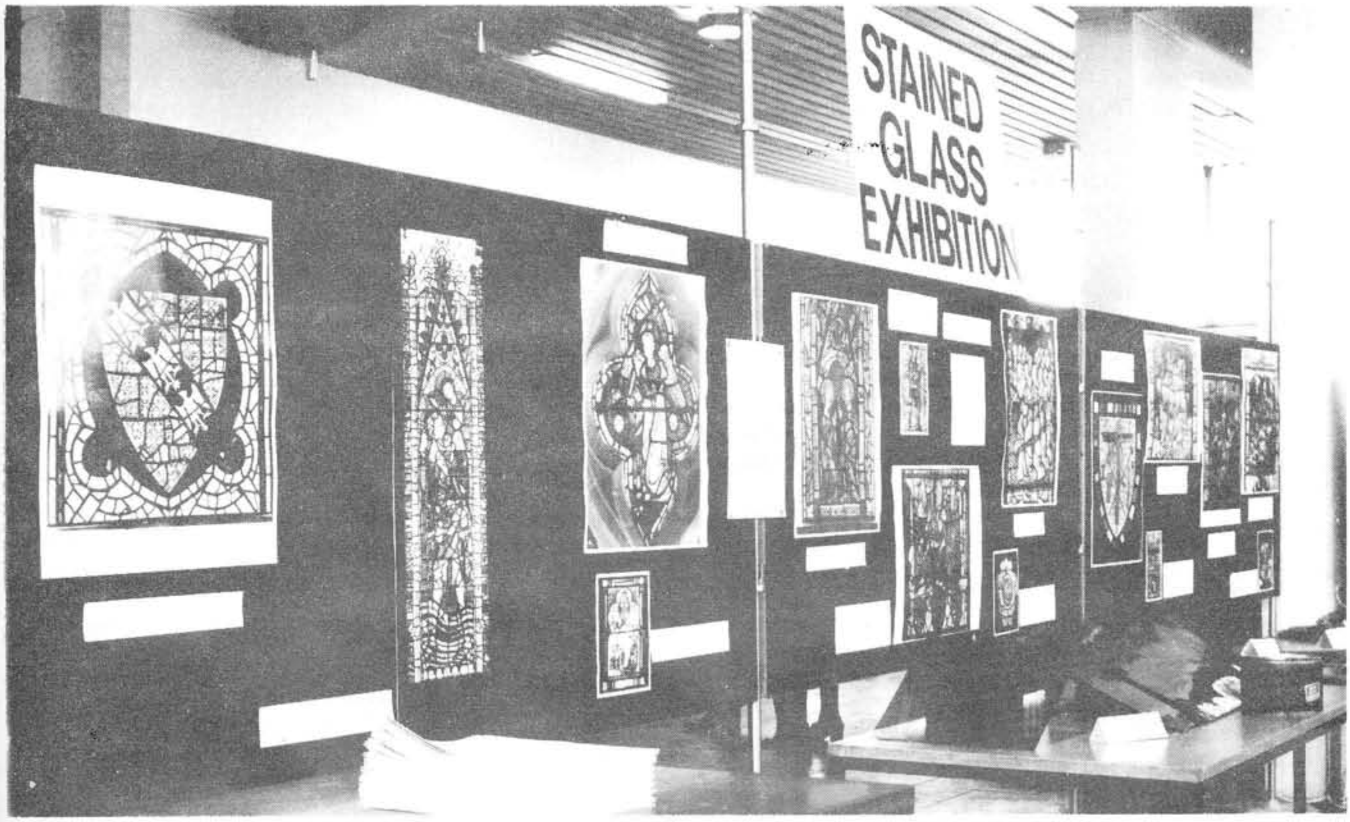

Fig. 1 Part of the Exhibition of Stained Glass, held in York from 7th to 11th April, which attracted much interest.

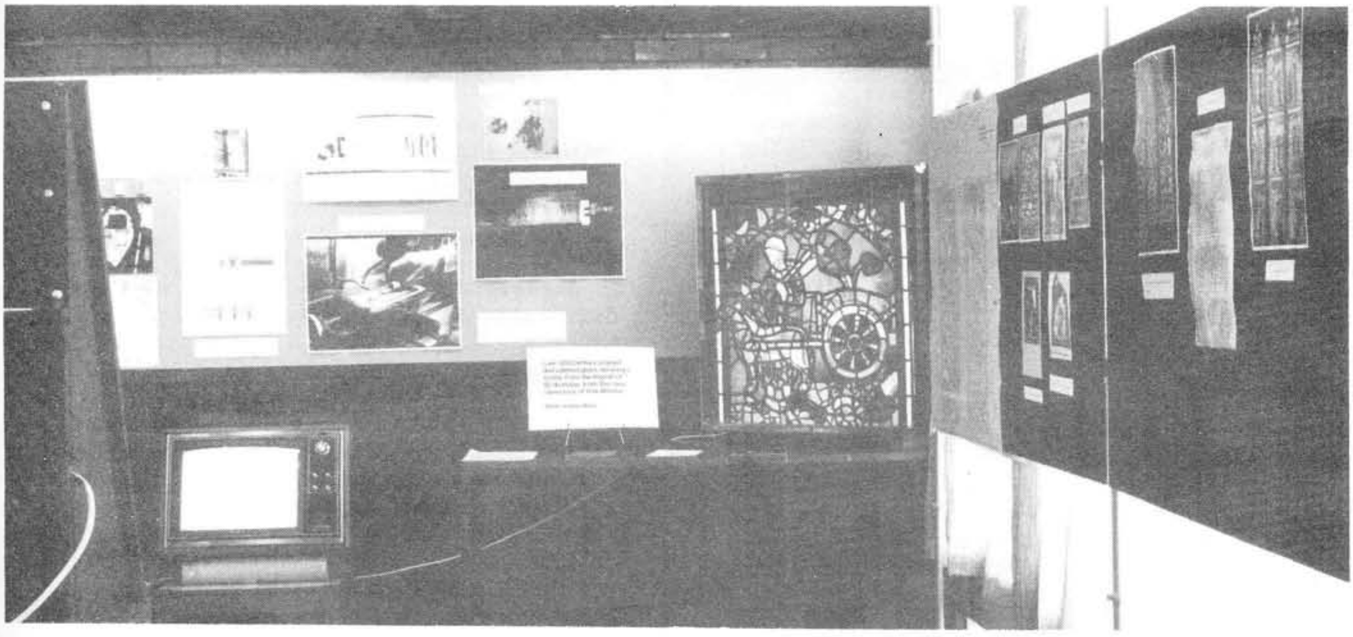

Fig. 2 Another part of the same Exhibition, showing some of the scientific exhibits and one of the television monitors which continuously showed a closed-loop film of the activities of the York Glaziers Trust.

Fig.1 shows how photographs of panels were displayed and Fig.2 shows one of the television monitors (see below), together with some of the exhibits of the way in which science can help the conservator.

The displays were arranged to tell the story in four stages, (a) to (d) below.

(a) Why stained glass has to be restored included photographs and illuminated panels showing badly weathered and fragile glass, before and after restoration. Other photographs showed how neglect by the authorities in the 18th and 19th centuries, coupled with the incompetence of jobbing plumbers, led to the existence of "jumbled windows".

(b) How the art-historian makes his contribution, by Dr Peter Newton, FSA, gave three examples to illustrate the problems: (i) A 12th c. window from York Minster, which seemed to have three figures in it, was eventually shown by comparison with the 12th c. St Albans Psalter (now at Hildesheim in Germany) to be the "Supper at Emmaus", and confirmed by comparison with a 12th c. English leaf (now in the Victoria and Albert Museum). (ii) A panel of 12th c. glass from York Minster which had been described as "a hermit in a cave" was correctly reconstructed, by comparison with the 12th c. illustrated life of St Benedict from Monte Casino in Italy, as the legend of St Benedict being supplied with food by a monk. (iii) A panel from the parish church of All Saints, North Street, York had previously been described as "a religious procession preceded by angels" or as "the coronation procession of Edward IV in York in 1463", but careful study, and a lucky discovery, showed that it was really the "Nine Orders of Angels", probably based on a 13th c. treatise by Bartolomeus Anglicus.

(c) How the scientist can make a contribution, with a series of illustrations showing (i) the recovery of lost inscriptions, (ii) the non-destructive chemical analysis of glass using the Isoprobe, (iii) the mechanism of weathering of glass, (iv) the identification of 19th c. replacement glass by using radiation monitoring films and (v) systems of isothermal glazing.

(d) How the craftsman carries out restorations. A television film had been made in the workshop of the York Glaziers Trust, showing all the operations of restoration, and a closed-loop version of the film was continuously shown on several closed-circuit television monitors throughout the exhibition area. These television monitors were kindly supplied by the Audio-Visual Unit of the University of York.

(e) In addition, a fine series of 18 photographs of important stained glass in the City of York was kindly supplied by the Royal Commission on Historical Monuments.

1.6 REVERSIBILITY OF AN EPOXY RESIN

Mr Frederick Cole has kindly reported some results from his research programme at the Canterbury Glass Restoration Studio concerning the removal of cured epoxy resins when used to "fix" loose paintwork. Two pieces of badly-fired 19th c. glass were used. The original painted line was over-painted with coloured epoxy resin (Araldite AY103 hardened with HY951) and cured for 24h at 70°C. Soaking in acetone produced some loosening of the resin after 5 minutes but there was little change after another 15 minutes and it was concluded that acetone does not remove this cured epoxy resin. The second sample was treated with Nitromors (Green Label, Wilcot Ltd, Fishponds, Bristol) and after 10-20 minutes the resin could readily be wiped from the glass without disturbance to the painted line. The line-work of the hair on a 19th c. painted head was then over-painted with the dark-coloured epoxy resin and cured as above. A line was drawn across the head and the lower part was treated with Nitromors; after 20 minutes the epoxy resin was removed by wiping. Finally, some float glass was painted with resin and cured. After treatment with Nitromors the pattern was wiped off and the "polished" surface of the glass was quite unimpaired.

These results confirm Mr Cole's belief that over-painting can be reversed and I understand that he will now be extending the experiment to 12th c. glass with defective paintwork.

1.7 REWORKED OLD-LEADS OR NEW ONES?

One of the abstracts in Section 6 of this News Letter (No.188) comments on the advantages of re-using the original leading but, if the practice in a particular workshop is to replace the leading, then there is the question as to whether the older lead should be re-milled or whether modern (purer) lead should be milled to form the leads.

One well-known restorer does not use reworked old lead because the old alloy contains tin and it is then rather stiff to use, being tiring for the craftsmen. Mr Cole at Canterbury has been looking into this question and has kindly passed on the results of his researches. The Lead Development Association analysed some of his older lead (? originally made in AD 1200) and found that it contained 0.004% silver (and hence of no value for the silver content) but it contained 13.4% tin. The old lead was thus a hard, strong alloy which has a higher breaking strength and a much smaller extension before it breaks (eg 16% instead of 60% stretch at breaking point).

This result raises an interesting question about the way in which some windows "bulge" and "sag" under their own weight. Does the bulging occur only when new lead is used or can it also happen with the original leads (see also Ref.188)? Please write to me about these points.

2 PROTECTIVE GLAZINGS

2.1 RESULTS FROM THE ISOTHERMAL WINDOW AT SHEFFIELD

2.1.1 General points

The basic details of this important experiment were given in Section 3.1 (p.4) of N.L. No.13 and a 33-page report was prepared for the Department of the Environment, who sponsored the work. They have now given permission for the following brief summary to be published, and readers will see that it provides data about isothermal glazings which were not known before.

The experiments were carried out between 10th September 1974 and 15th January 1975 but this winter was exceptionally mild and little or no condensation was encountered, at least during those periods when experimental measurements were being made. Thus, in this respect, the experiment was slightly disappointing. Nevertheless, many basic data were collected and it will be possible to use the results to predict whether condensation would have occurred on the inner glazing (the simulated medieval glass) in any particular weather conditions, especially if we know the temperature and the humidity inside the building.

The chart from the recorder could contain up to 1152 results in a 24-hour period, depending on whether the condensation gauges were registering or not. The individual readings were transcribed into a notebook, all the results from each half-hour cycle being written on one line. These results were then plotted in groups on "transparent" graph paper, so that any set of graphs could be compared with any other by placing one sheet on top of the other. Thus it became easy to obtain any temperature differences by comparing the appropriate lines.

So many results were available that many conclusions could be drawn. In this summary the discussion will generally be restricted to the conditions in the space between the two glazings and the relationship between the temperature of the inner glazing to those of the air inside and outside the building.

2.1.2 Results with an unheated building

Three different spaces were used between the fixed outer glazing and the movable inner glazing: 240mm, 120mm and 80mm. The unheated building and the interspace became warmer during the day even though no direct sunshine fell upon it (the window faces N.W.), the interior of the building being some 2 to 7 deg.C warmer than the outside air depending on the weather and the time of day (see columns X in Table I). There were strong flows of air down the interspace, becoming faster as the space was made narrower (see Table II) until, with the 80mm gap, the flow was of the order of 1 m/s; the air velocity figures suggest that the volume flow rate may have been the same with all three gaps. As the window was about 6m tall, this rate of ventilation of the interspace corresponded to about 600 changes of air per hour.

Data for the unheated building at different times of the day are given in Table I and it is evident that the temperature of the medieval glass falls further below that of the air in the building as the gap is made narrower. With a gap of 240mm the inner window is rarely more than 0.5 deg.C colder than the building and 48% of the temperature drop, from inside the building to the outside air, occurs across the gap; at 120mm the inner window is sometimes more than 1 deg.C colder and 32% of the temperature drop is across the gap; and at 80mm the inner window is often more than 1 deg.C colder and only 20% of the loss occurs across the gap. Hence, if it is desired to keep face 3 (counting from the outside) as warm as possible in an unheated building, the gap should be kept wide, preferably more than 100mm, but this clearly increases the aesthetic difficulties of excluding light, etc. Table II shows the average data for the three widths of gap. In these experiments the inner window was made of clear glass but some experiments in which stained glass was used in the inner glazing suggest that, during the daytime, any stained glass would be about 1 deg.C warmer still, and hence, even with an unheated building, isothermally-glazed medieval painted glass could be 2.0 to 5.8 deg.C warmer than the outside air.

TABLE I UNHEATED BUILDING AT DIFFERENT TIMES OF THE DAY

GMT	240mm gap		120mm gap		80mm gap	
	X	Y	X	Y	X	Y
15.00	2.5	0.1	5.5	0.2	3.5	0.1
18.00	2.9	0.4	5.1	1.0	6.8	1.7
21.00	4.5	0.2	5.0	0.7	7.1	1.3
24.00	4.3	0.4	4.1	0.6	6.0	1.4
03.00	4.0	0.4	4.9	1.7	5.8	1.5
06.00	5.3	0.7	6.4	1.0	4.5	1.2
09.00	5.3	0.5	6.3	0.9	1.7	0.7
12.00	5.0	0.1	5.9	0.4	1.7	0.3

$X = t_i - t_o$, or the temperature of the air inside the building, near the ceiling, minus the temperature of the air outside the building, in degC.

$Y = t_i - t_g$, or the same temperature of the air inside the building minus the temperature at the top of the inner window; it shows the amount (in degC) by which the inner window gets colder than the building.

TABLE II UNHEATED BUILDING

Width of gap (mm)	Minimum outside air temperatures (degC)	Horizontal temperature differences (degC)		Air velocities (m/s)
	(1)	(2)	(3)	(4)
240	3.6	3.3	1.6	up to 0.3
120	2.1	4.4	1.6	up to 0.9
80	2.7	3.0	1.1	0.6 to 1.2

TABLE III HEATED BUILDING

Width of gap (mm)	Minimum outside air temperatures (degC)	Horizontal temperature differences (degC)		Air velocities (m/s)
	(1)	(2)	(3)	(4)
240	-1.2	15.0	5.8	0.2 to 0.7
120	1.0	16.2	6.4	0.6 to 1.1
80	1.5	17.3	3.8	0.7 to 1.2

NOTES:

(1) These are the minimum outside air temperatures encountered on those days in January 1975 when each experiment was carried out. The daily range in outside air temperature was about 5 to 7 degC.

(2) These are the average differences in temperature between the air in the building and the outside air. The values in Table II are lower than those in Table I which apply to the top of the building. The values in Table III are much higher than those in Table II because the building was heated.

(3) These are the average differences in temperature between face 3 and face 2.

(4) These air flows down the interspace were exceedingly turbulent and only the extreme values are quoted.

2.1.3 Results with a heated building

A 2 kW electric heater with a circulating fan was used to supply heat to the small temporary building, measuring 6.44 x 2.67 x 1.30 m (see Figs 1 and 2 of N.L. No.13) and this raised the temperature to a maximum of about 21°C. The situation in the heated building is, of course, markedly different from that in the unheated one, all the temperature gradients being increased. The same three spacings were used and the results are summarised in Table III, in the same way as in Table II, and the same notes apply to both tables. In the centre of the space the air flows were again strongly downwards and were all highly turbulent. As the gap was made narrower the flow rates increased and they again exceeded 1 m/s with the narrower gaps.

No condensation occurred during the experiment but the appreciable temperature differences across the space will help to keep face 3 free from condensation. The figures in Table III probably do not emphasise the situation well enough because the minimum temperatures encountered anywhere on face 3 were:- 240mm gap, 10.5°C; 120mm, 12.5°C; 80mm, 10.6°C, and dew points of this order did not occur during the period October 1974 to January 1975. Dew points in excess of 10°C occurred on five occasions in September 1974 but the minimum air temperatures were also in excess of 10°C so that the temperatures on face 3 would still have been above the dew point.

2.1.4 Remarks

These experiments make two points quite clear.

(a) Isothermal systems will function even in an unheated building and will keep the medieval glass about 3 to 4 deg.C warmer than the outside air.

(b) The rapid downward flows of air ventilate the cavity very rapidly (600 changes of air per hour).

2.1.5 Postscript

When this fast air flow rate was pointed out to the British Cathedral Architects, at their triennial meeting held in Exeter on 11th April, fears were expressed that dirt and dust would be carried into the cavity by this flow of air and be deposited in the interspace. By a happy chance, Mr Derek White, of the Canterbury Glass Restoration Studio, was due to visit Europe, on a Radcliffe Trust Travelling Grant, in May and I was able to arrange for him to see the oldest isothermal glazing system which exists anywhere, that installed in Bern Minster by Konrad Vetter in 1945. Thanks to the kindness of Konrad Vetter, Kirchmeier Dr Marchand and the Minster architect Peter Indermühle, the bottom right-hand panel of the first window on the north side of the Apse was taken down on 21st May and the cavity was inspected by Derek White and Konrad Vetter.

The window is about 4.6m high and the space between the two glazings is 30mm wide. Thirty years had elapsed since the isothermal glazing had been installed (in 1945) and a film of dust had collected on the inside of the outer glazing (face 2). Face 3, however, was surprisingly clean and uncorroded! (RGN - any dust will be deposited preferentially on the colder surface, i.e. face 2.) No cobwebs were found, and only one dead fly!

A test of the air flow was made by introducing some smoke from Konrad Vetter's pipe into the interspace at the bottom of the second panel. This smoke travelled upwards for the remaining 3.65m in 15 seconds (0.24 m/s) but attempts to introduce this smoke into the cavity of another window failed because the smoke travelled up face 4 instead (as at Sheffield). There is therefore a new mystery, as to why the smoke from the pipe went up the cavity at all instead of downwards (perhaps because it was hot smoke from the pipe!) and this is a further reason why tests should be carried out with the cold smoke generators (see section 2.2 below).

The alternative conservation system, of using external protective glazing and ventilating it to the outside, now being studied in York Minster, may prove to be equally useful for protecting medieval glass from both rain and condensation and the results of those experiments, also sponsored by the Department of the Environment, will be awaited with great interest.

2.2 "VENTILATION" WHEN WINDOWS HAVE EXTERNAL PROTECTION!

The pocket smoke generators, mentioned in column 2 of page 5 of N.L. No.14, have been put to remarkably good use by demonstrating quite conclusively that some of the outer protective glazings on the windows of York Minster have not been sealed as effectively as had been thought to be the case, even though they were last put into good order as recently as 1953!

Readers will remember, from item 4.2 (p.8) of N.L. No.12, that we had come to the conclusion that the humidity in the space between the two glazings of the Great East Window at York Minster was influenced by the changes in weather outside the building, and hence the outer protective glazing seems to have been "leaky" to the outside. This conclusion was reached by placing a hair hygrometer in the space and recording the reading three times per day. This experiment with the hair hygrometer was then repeated on a south-facing window (No.17 in the South Choir Aisle, second from the west) with similar conclusions although the results have not yet been reported.

That circumstantial evidence has now been confirmed by the use of these very small, but intense, smoke generators. The tip of a smoke generator has been moved up and down the pointing on the outside of the mullions, and even up and down some of the diagonal leading of the external diamond-quarry glazing, and at several points smoke could be seen entering the space between the two glazings!

What is even more surprising is the behaviour of one specially-sealed panel containing early 14 c. glass. This type of externally-protective glazing was described (N.L. No.7, last paragraph of p.5) in the discussion of all types of externally-protected windows and it is one in which the outer modern glass has been leaded in such a manner that the main lead-lines of the medieval design have been followed by the modern leading and, in consequence, the space between the two glazings must be kept small to avoid parallax, being only 3mm wide. Because the space is so narrow the two panels can be soldered together at the edges (tack-soldered) and the interspace had confidently been expected to be fully sealed! We now find that this is not necessarily the case! In one of these panels in window No.20 (south transept, east wall) a thin stream of smoke could be seen to appear inside the cavity through the leading at either side.

Thus we are beginning to think that none of the windows at York may be completely sealed! Perhaps this is a good thing, because the slight ventilation to the exterior will help to keep the windows dry. (Here it should be remarked that the experiment at present being carried out at York has shown that the medieval window is some 2 deg.C warmer than the outer window, even during the night, and it can become quite warm during the day. In sunshine, a temperature of 46°C was recorded on 20th April and there is sufficient temperature differential to cause air to flow through extremely small gaps.

3 WAR-TIME STORAGE OF GLASS

3.1 GLOUCESTER CATHEDRAL

News Letter No.13 carried an item (1.6 on p.2) to the effect that the glass from the Great East Window (the "Crecy Window") of Gloucester Cathedral had been stored in three different ways during the war, part being stored in the dry cellars of Miserden Park about 12 miles to the S.E., part in the damp crypt of the Cathedral and part was left in the window. In that news item it was stated that it was hoped that a further investigation of the situation might be possible, because it seemed that this window might provide an "experiment" as to whether damp war-time storage caused the glass to suffer worse after the war than the similar glass stored in dry cellars.

I am now happy to say that the Cathedral Architect, Mr B.J. Ashwell, MC, Dipl.Arch, FSA, FRIBA, and his deputy, Mr C.B. Comely, Dipl.Arch, RIBA, have been to a great deal of trouble to discover what actually happened, including interviewing the retired stonemason, Mr Harry Pearce, who was responsible for taking the window out, and for re-installing it. Mr Pearce is now aged 94 but his memory is quite clear and some of his recollections have been confirmed independently. I am greatly indebted to Messrs Ashwell and Comely for the following notes.

The glass in the window is probably dated to 1347-1350 and nothing is known of its treatment until 1861 when the window was removed to repair the deteriorating stonework. It was replaced, apparently only with relead- ing, in 1862. The window consists of three parts, a centre section of six tiers of 6 lights and two sections (one to the north and one to the south) each of 6 tiers of 4 lights, but the centre section is actually two tiers taller than the side sections because the entrance to the Lady Chapel occupies the two bottom tiers. The side sections are inclined at an angle to the centre section. In 1940 timber scaffolding was erected in order to remove the six centre top panels. Three months later, after the scaffolding had been taken down, orders were received for the removal of four upper panels on the north side of the window and the whole scaffolding operation was repeated. After yet another four months, orders were received to remove all the remaining stained glass and the scaffolding was erected for the third time!

All the panels from the three main centre tiers were labelled, crated, and removed to Miserden Park about mid December 1940. The remainder of the stained glass in the North and South side windows was packed in boxes and stored in the crypt; here they were sandbagged and the environment was so damp that mould started growing on the case in which was stored the Coronation chair from Westminster. The sandbagged enclosure in which the glass and the Coronation Chair were stored was then provided with through-ventilation and no further trouble with mould was experienced during the remaining years. The clear glazing at the top of the side windows was left in the window, as were small areas of glass at the top of the centre section. When the glass was unpacked in 1947/48 it was found that the adhesive labels had fallen off and were lying at the bottom of the crates.

I visited Gloucester Cathedral on Monday, 14th April and inspected the outside with binoculars from the roof of the Lady Chapel. There was a surprising amount of outside painting (matting) on the subject and canopy panels in the centre section which is in remarkably good condition, and I felt sure that the North and South sections had weathered worse than the centre section. I took a number of photographs with an ordinary lens, and with a telephoto lens, but the light was poor and rain was falling most of the time so that the photographs are not of good quality. Nevertheless, Mr Peter Gibson has kindly examined my photographs and he states that, in his opinion, the North Section has weathered worse than the centre section, and the four upper panels worst of all; he finds no difference between the centre and Southern sections. The tracery glazing, which remained in situ during the war, was too high to photo- graph satisfactorily. Thus there is a suggestion that some of the glass which was stored in the damp crypt has weathered margin- ally worse than that stored at Miserden Park. Perhaps other experts may like to examine the Crecy Window to see whether they find any overall difference in weathering behaviour!

3.2 BERE FERRERS CHURCH, DEVON

The Rector of Bere Ferrers, the Rev. A.J.C. Beddow, has written to tell me that the glass was stored during the war in the cellar of the Rectory, and not buried in the garden as had previously been believed (see item 3.1, col.2 of N.L. No.14). Thus it seems that this is not now an example which might throw light on the effects of adverse war-time storage especially as Mr Beddow tells me that the glass "is in no way spoilt".

4 ISOPROBES AND X-RAY ANALYTICAL TOOLS

It is well known that X-ray fluorescence has been employed in a useful manner for analysing medieval window glass but it will not detect any soda in the glass and consequently its usefulness was dependent on the assumption that the soda (Na_2O) content was less than about 2% by weight. Fortunately the vast majority of samples of medieval glass, from Britain or Continental Europe, are potash (K_2O) glasses, the K_2O contents being in the region of 13 to 20 per cent by weight.

About a year ago, when the first radiation monitoring experiment was in progress (see N.L. No.8, Ref.168) a piece of blue 12th c. glass in the Five Sisters window at York Minster gave an unexpected answer, as if the glass was much more recent and containing rather little potash. It was then discovered that five European samples, of the 100 or so already analysed, contain more soda than had been expected for their age. One piece, like that from the Five Sisters, contained 12.4% Na_2O and the other samples were from Houdun (16th c.) with 5.9% Na_2O; two from Amiens (13th c.) with 10.2 and 14.4%, one from Avignon (AD 1423) with 16.7% and also four from Asia Minor, i.e. Istanbul (AD 1125) in the range 13.8 to 14.9% Na_2O.

For these rather rare samples other methods of non-destructive analysis must be sought and, fortunately, one has recently become available. It is the Link Systems MECA (Multi Element Computerised Analyser) 10-6, which can detect soda at 1 part in 10,000 and will also analyse many elements at 1 part in 1 million. Thanks to the kindness of Mr M. Jocelyn of Link Systems Ltd, 35 Spring Gardens, Buxton, Derbyshire it has been possible to examine the soda-rich 12th c. glass from York Minster using the MECA (see Figs. 3 and 4).

A fuller report will be presented in a later News Letter but, briefly, Fig.3 shows the peaks which result when an aluminium target is used, which enables sodium, magnesium and many other elements to be analysed, but NOT aluminium or chromium (because these are "functional" parts of the apparatus when an aluminium target is used). However, if the target-selection switch is turned, and a titanium target is used many elements, including aluminium and chromium, can be analysed but NOT sodium, magnesium or titanium. Fig.4 shows the difference in appearance of the peaks when a germanium target is used. Thus this apparatus opens up many new possibilities which will be explored in the coming months and a fuller account will be included in the next News Letter.

5 AIR-POLLUTION, SULPHURDIOXIDE AND MEDIEVAL GLASS

There is much diversity of opinion as to whether air pollution and/or sulphur dioxide causes harm to medieval stained glass and I have prepared this note to stimulate the discussion! It will be clear that I am personally of the opinion that sulphur dioxide (SO_2), when present in the same concentrations as in polluted air (say 500 $\mu g/m^3$), does not harm medieval glass and it may even have a protective effect! Anyway I hope that my remarks will provoke a lot of replies!

I have chosen my title deliberately, to separate air pollution (smoke, hydrocarbons, carbon monoxide, etc.) from sulphur dioxide because some sulphur dioxide has been present in the atmosphere as long as the glass has, whereas air pollution (as defined above) is much more recent.

Some studies have been made of the origins of sulphur dioxide (5, 6, 7) and it seems that, on a world-wide basis, about two thirds of the sulphur dioxide comes from natural sources and only one-third from man-made sources (6, 7). Moreover, sulphur dioxide is continually being destroyed by many surfaces and the concentration in the air in Britain has not increased in the last 20 years (5); some figures show that it has decreased by 45% in Britain between 1958 and 1970 (9).

It is absorbed by the sea and hence the concentration of SO_2 may be as low as 11 $\mu g/m^3$ (8) around the British sea coasts on the west of the Island, where the prevailing winds are from the Atlantic and considerable reduction of the sulphur dioxide content can occur. In inland areas the average concentration may be as high as 125 $\mu g/m^3$ (9) whereas in the heavily-industrialised areas in the north-west of England the concentration may rise to 500 $\mu g/m^3$ on a few days when the weather conditions fail to disperse the concentration (e.g. in November). Very occasionally the concentration may exceed 1000 $\mu g/m^3$ (1 mg/m^3) for one day only but it falls again the next day to a more usual value (8). We do not know what the concentration of SO_2 was in inland cathedral cities in medieval times, but I believe it was of the order of 100 $\mu g/m^3$! If anyone can give me reasons for believing that the value was less than this, will he please write to me!

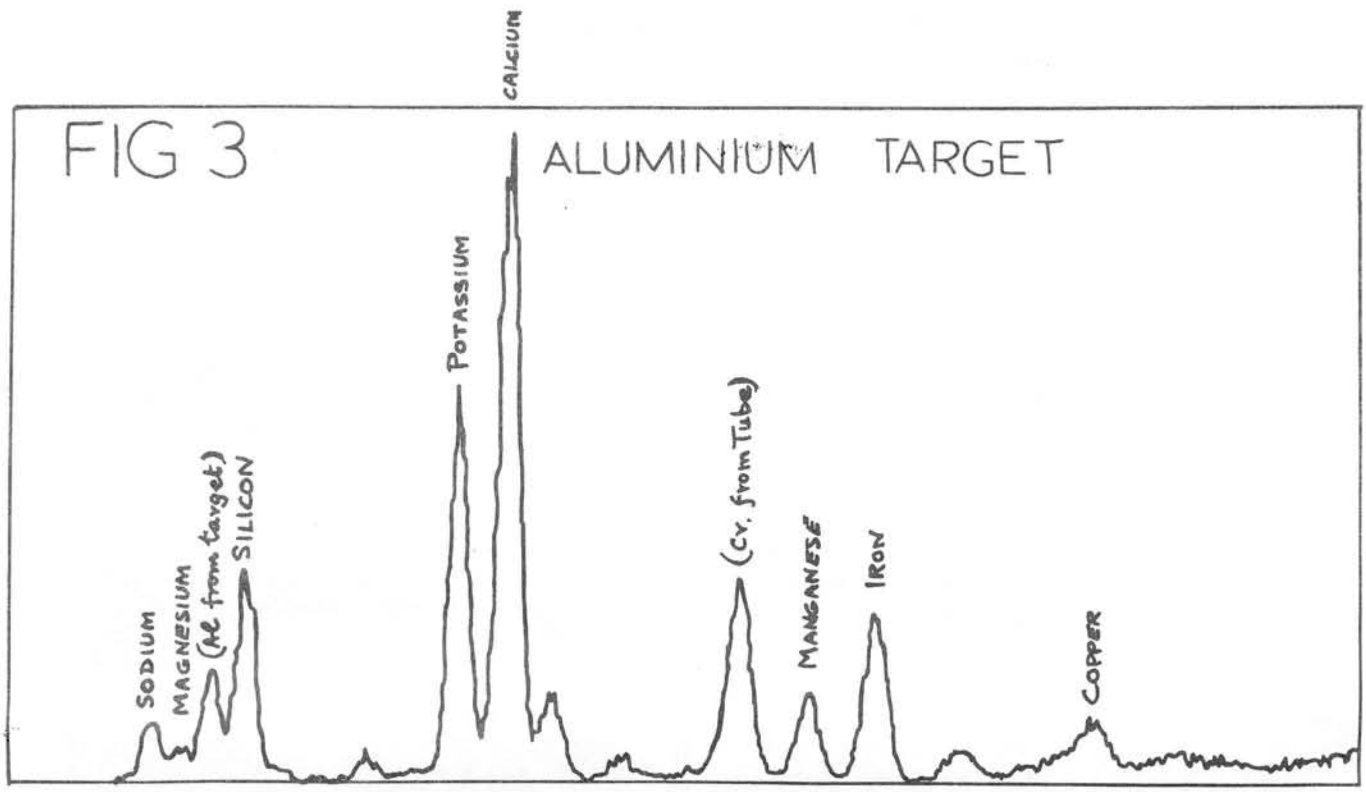

Fig. 3 A piece of 12th C. glass from York Minster was unexpectedly found to contain more soda than potash in its composition. It can be analysed non-destructively by means of Link System Ltd.'s MECA 10-6 X-ray analyser. The composition of the glass was:— silica, 61.7; lime, 8.5; magnesia, 2.2; alumina, 2.8; potash, 6.4; soda, 12.4; iron oxide (Fe_2O_3), 1.0; manganese oxide (MnO_2), 0.9; copper oxide (CuO), 0.15%. When the aluminium target is used, the MECA will detect soda, magnesia, silica, potash, lime, manganese, iron and copper, i.e., all the major constituents except alumina (because the 'target' is made of aluminium). The sizes of these peaks are by no means simple indicators of the amounts present (there is less potash than soda, and much more silica than any other constituent) but they are related to the way the apparatus is used. Different elements respond in different ways (see also Fig. 4).

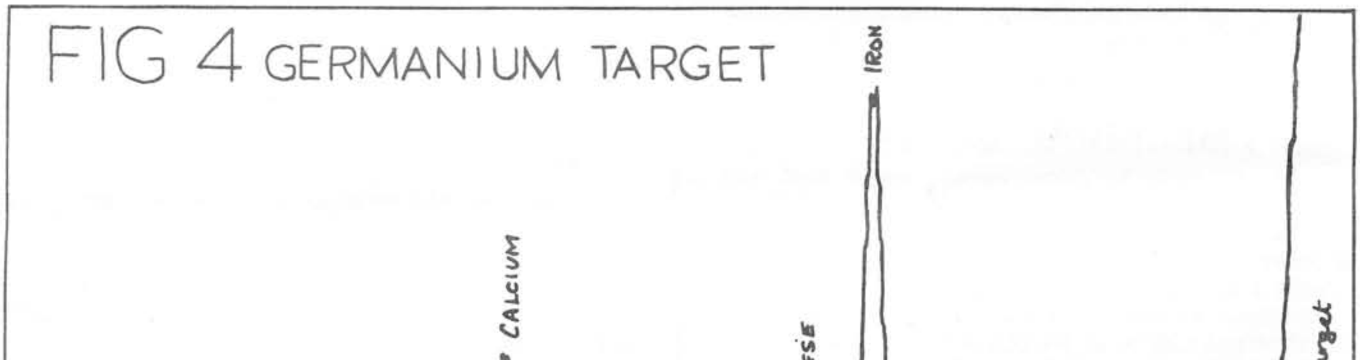

Fig. 4 This shows the peak-height display for the same piece of 12th C. glass when a germanium 'target' is substituted for the aluminium 'target'. The lighter elements do not now respond so well; sodium and magnesium do not respond at all and the silicon peak is much lower than in Fig. 3, as are the potassium and calcium peaks also. But the manganese, iron and copper peaks are now much larger, because these elements are activated more intensely by the radiation from the germanium. The peak for copper is well-marked, even though only 0.15% is present, and the presence of zinc is now clearly indicated, even though less than 0.05% of zinc oxide is in the glass ! Five different 'targets' can be 'switched in' to the apparatus, thus enabling it to provide an effective analysis over the band required. The alumina content of the glass can be determined by using a titanium target.

If I am correct, then 12th c. glass could have been exposed to about 800 "microgramme-centuries" of SO_2 before the war (8 centuries at 100 $\mu g/m^3$) compared with 100 "microgramme-centuries" of SO_2 in the period since the war even if we assume that average concentration of SO_2 had been as high as 300 $\mu g/m^3$ for the 30 years since the war ended. As the concentration of SO_2 in Britain has been decreasing since the war (9), this figure is certainly an overestimate, but it seems likely that early medieval glass had been exposed to at least 8 times as much SO_2 as it has since the war!

There have not been many experiments on the attack of SO_2 on medieval glass. It is clear that dry SO_2 does NOT attack glass (1, 3) and thus we can forget about dry SO_2. The glass has either to be wet or the air has to contain moisture (50% humidity will permit the attack to occur; 1), but moisture and damp air alone will also attack glass and it could well be argued that the destructive agency is really the water, and that the SO_2 merely reacts with the alkali hydroxides which are formed in the water when sodium and potassium ions are exchanged for protons from the water.

It is not easy to carry out direct experiments on the effect on glass of sulphur dioxide at "air-polluting" levels for two reasons:- (a) the concentration of the gas in the air is so low and (b) moist air alone causes a comparable amount of damage. For example, some work sponsored by the Department of the Environment and carried out by BGIRA in Sheffield gave the following results.

Samples of the three poorly-durable British simulated medieval glasses were exposed to air at 55°C which had been freed from "acid gases" (both sulphur dioxide and carbon dioxide) by bubbling through sodium hydroxide solution, and then moistened by bubbling through water also at 55°C. Visible dulling of the surface of all three samples was produced after exposure for 130 hours. Examination with the Nomarski differential interference contrast microscope confirmed that surface deterioration, including crazing of the glass, had been produced by moist air alone.

A mixture of sulphur dioxide and nitrogen was obtained but the makers of the compressed gases would not attempt to supply less than 3 parts per million (about 9000 $\mu g/m^3$) of sulphur dioxide but this is about 70 times the average concentration in industrial NW England. Samples of the same three poorly durable glasses were exposed to this mixture at 55° after bubbling through water and the visible dulling of the surface then occurred after 67 hours' exposure. Microscopic studies of the surfaces gave results which were variable but, on average, they were not worse than those with the air which was free of acid gases. Thus at present the hypothesis is that, at 55°C and 100% relative humidity, exposure to 70 times the average concentration of sulphur dioxide might be equivalent to twice as long an exposure to wet "pure air". If this is so, a pollution level of about 35 times the normal might be needed to produce a noticeable effect!

I am indebted to Dr A. Paul, of the Department of Ceramics, Glasses and Polymers of the University of Sheffield, for pointing out that sulphur dioxide in the atmosphere may actually exert a protective influence on medieval glass, rather than an aggressive one, when present in air-polluting concentrations (as distinct from laboratory conditions using high concentrations of SO_2, see below). He points out that, as noted above, the initial attack on the glass is by water, to produce an alkaline solution containing NaOH and/or KOH. This can then be reacted upon by the "acid gases" in the atmosphere carbon dioxide (CO_2) and SO_2.

Attack by CO_2 will lead first to the formation of $NaHCO_3$ which is not particularly soluble in water, and then to the formation of the soluble Na_2CO_3. Both of these are "alkaline salts" because carbonic acid (H_2CO_3) is a weak acid (for the physical chemists among my readers, I should remark that the logarithms of the ionisation constants are:- $H_2CO_3 = -6.4$; $HCO_3^- = -10.3$ so that the solutions will attack glass, where the corresponding values are:- $H_2SiO_3 = -5.2$; $HSiO_3^- = -10.0$), and they give alkaline reactions with pH values of 9.8 or larger. This alkalinity is enough to attack the silica linkages (the "building blocks" in the glass) and the glass will deteriorate.

If, on the other hand, the attack on the alkaline water had been by SO_2 (or, more probably SO_3 because in moist air the chemisorbed SO_2 is easily oxidised to SO_3), the resultant Na_2SO_3 or, more probably, Na_2SO_4, are "neutral salts" with nearly neutral reactions (the logarithms of the ionisation constants are:- $H_2SO_3 = -1.9$; $HSO_3^- = -7.3$; $H_2SO_4 = +2$; $HSO_4^- = -2$). Thus the sodium sulphate formed will not attack the glass and it could well form a protective solution on the surface instead of leaching out the silica as would be done if carbonates remained there. One way of protecting glass would be to ensure that enough SO_2 were present to convert all the carbonates to sulphates.

There are some strong suggestions that attack by CO_2 occurs first, and that this is followed by a second phase of reaction with the SO_2 in the atmosphere. The excellent electron microprobe photographs of a section through a pit in the surface, in the paper by Collongues and Perez y Jorba (2), show (their Fig.5) that the sulphur tends to be present near the top of the pit, rather than at the bottom of the pit where reactions are occurring with the surface of the glass. The contents of the pit comprise silicon, calcium, aluminium and sulphur but there is no potassium nor magnesium (although these are present in the glass) no doubt because they have soluble carbonates and sulphates. There are many interesting features but the ones of importance here are that the sulphur is concentrated at the top of the pit and away from the glass. The calcium is also relatively deficient at the bottom of the pit and is richest at the top, where silicon and aluminium are absent. The top seems to consist entirely of gypsum and this seems to me to support my view that attack by SO_2 occurs only in the final stages of the process.

Another interesting point from Professor Collongues' paper is that most of the 50 glasses which he studied do contain sulphates (gypsum and/or syngenite) and hence have reacted with SO_2 at some time, but there were two groups of glasses in which no sulphates were found and the weathering products were either crystallised silica or calcite ($CaCO_3$). In these cases it seems that the SO_2 failed to react with the decomposition products! ("Aucun sulfate n'est présent et la couche de silice même cristallisée qui subsiste en surface protège le verre sous jacent d'une attacque eventuelle." - bottom of p.8.) In connection with the presence, or absence, of syngenite, I am indebted to Dr H. Marschner, of the University of Erlangen-Nürnberg, for pointing out to me that syngenite is unstable in moist air and decomposes to form gypsum.

The enhanced attack which has occurred on some medieval windows since the war, compared with the relatively slight attack before the war, can, I believe, be explained by adverse war-time storage when the windows were removed from the buildings during the war (4), and the fact that sulphates are present on the surface of these windows is evidence only that there has been enough SO_2 present to convert the carbonates or hydroxides to sulphates. It seems that there was always enough SO_2 present in the atmosphere to bring this about without any air pollution.

Another point to be considered is why the corrosion is generally so much less on the inside face of the glass than on the outside face. The concentration of SO_2 will certainly be less inside a cathedral than outside but it seems possible that the concentration may still be 30% of that outside (10). Again, the circumstantial evidence seems to be against SO_2 as a primary agent of weathering.

Two aspects have not been considered in this note:- (a) whether any other aspects of air pollution (soot, hydrocarbons, carbon monoxide, etc.) have had a deleterious effect on the windows and (b) Dr H. Marschner tells me that windows at Cologne Cathedral which where cleaned after the war have developed a thick corrosion layer in only 15-20 years but it is not exactly clear what has happened there. Will anyone who has any evidence on this or any other point please get in touch with me?

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2. COLLONGUES, Professor, and Mme PEREZ Y JORBA (1974) "Sur le phénomène de corrosion des vitraux." See Abstract No.171, in News Letter No.11.

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9. WARREN SPRING LABORATORY (1972) "National Survey of Air Pollution 1961-1971. Vol.I Introduction, United Kingdom South East, and Greater London. HMSO London. 195 pp. (see British Academy Bibl. Ref.No.121)

10. WILSON, M.J.G. (1968) "Indoor air pollution." Proc. Roy. Soc., 1968, A307 215-221 (see Abstract No.194 in this News Letter).

6 NEW ABSTRACTS

186-192 (also 156, 157, 169, 174, 179, 185)

The papers for the 1975 Stockholm Congress of the IIC "Conservation in Archaeology and the Applied Arts" have now appeared and those concerned with stained glass are abstracted here.

(179) ASMUS, J.F. "Use of lasers in the conservation of stained glass" see 179 on p.7 of N.L. No.13, is now published as pages 139-142.

(169) BETTEMBOURG, J.M. "Etude de mastics élastomères - le masticage des panneaux de vitraux anciens" pp 137-138. This is exactly the same as that abstracted as 169 of N.L. No.11.

(185) NEWTON, R.G. "Conservation of medieval windows (isothermal glazing)". See item 185 of N.L. No.13 - now published as pages 109-114.

186. BRILL, Robert H. "Crizzling - a problem of glass conservation" pp 121-131.

This paper will be of particular interest to those who are concerned with the safe storage in museums of Renaissance goblets and decorated hollow-ware, in fact it goes far to explain the phenomena of "crizzled", "weeping" and "sick" glasses which had previously been a matter for speculation since the middle of the 18th c. These phenomena are shown to be due to the attack by atmospheric moisture on glasses which have an "unstable" chemical composition, and further damage can be halted by storage under suitable conditions. However, there is an urgent problem concerning glasses which show "incipient crizzling"; they have become stabilised towards humid environments and the damage becomes noticeable only when they are brought into centrally-heated or brightly-lit environments. This kind of damage has also been noticed in a roundel of 15th c. German glass which has been hung near a heater for 10 years.

Chemical analysis of these glasses showed that most of them contained less than 4 (weight) % of lime, and more than 17 (weight) % of soda or potash and they are thus unstable. (RGN - the molar percentages are even more striking, the "RO" being 0.8 to 4.6% and the "R_2O" being sometimes as high as 21.0% - see abstract No.167 of N.L. No.8). These compositions are so different from medieval stained glasses that readers are referred to the original paper for further information, but experiments with the electron microprobe confirmed that extensive de-alkalisation of the surface had occurred but there were cases where it was not complete; the depletion rate was of the order of 0.3 μm per year. It is recommended that these unstable glasses should be stored in conditions of 40-60% relative humidity.

187. FERRAZZINI, J.C. "Reaction mechanisms of corrosion of medieval glass" p.135.

He points out that inhomogeneities in the glass and surface defects such as scratches and cracks can lead locally to more rapid deterioration. Some changes in composition may occur even in the thickness of the glass if it is heated for some time, but these changes do not extend below a depth of 7 to 10 μm. A protective layer on the surface of the glass can be produced by heating to 400-900°C.

The replacement of alkali ions in the glass by protons enables the divalent calcium ions to escape also (the "tunnel effect") but none of this will happen if the glass is kept free from water (below 60% relative humidity), for example by isothermal glazing, perhaps with heaters in the cavity. He states that the total removal of old corrosion layers will encourage and even accelerate a new phase of weathering. (RGN - but this is not confirmed by the experiments reported in N.L. No.13 (item 2.1) and N.L. No.14 (item 4).) He also states: "Restorers applying such cleaning methods should consider that they are killing the glass. They not only seriously damage the natural protective coat of stained glass but remove most of the whole skin. A conscientious restorer only removes loose and porous weathering products from the surface. He never indiscriminately removes compact, patently genuine, glass layers as is to be expected using radical cleaning methods". (RGN - one question to be asked is whether acid-polishing of the wholly-cleaned glass will renew the "natural protective coat"!)

188. FRODL-KRAFT, Eva "Mediaeval stained glass corrosion - conservation - restoration" pages 105-110.

She points out that the question of the best, and the least harmful, methods of restoration and conservation cannot be answered in isolation but only in relation to the work in hand and the type of weathering which it displays. If stained glass has to be kept at a relative humidity below 33% (RGN - this figure may be much too low, see items 186 and 187 above) then there could be a conflict between preserving the glass and preserving the wood in a building! She refers to what happened in St Michael's Church, Vienna (see item 180 of N.L. No.13) and also discusses the experiments on protecting the glass with a resin coating or by isothermal glazing and mentions the problems presented on the exterior of the building by the treatment of the external glazing. She illustrates (her Fig.3) the exterior of St Walpurgis Church in Styria with its pleasing array of leaded hexagons in the external glazing.

The profiles of medieval leads "are definitely superior to modern profiles with thin cores and broad flanges as far as resistance to wind pressure is concerned. The bulbing panels of the famous West Windows at Chartres Cathedral with their modern leading ..... make it quite obvious that modern profiles are mechanically unsuited, in particular for large panels.". (RGN - but see also item 1.7 of this News Letter.)

Other practices recommended are the edge-bonding of cracks with silicone adhesives and the use of moulded cover glasses for plating (used successfully in Austria for 30 years). She also discusses the considerable problem of judging what was the "original appearance" of a stained glass window.

189. LOWE, John "The conservation of stained glass" pages 93-97.

He discusses (1) restoration in terms of the double function of stained glass (to please the eye and be part of the architectural fabric of the building) and sets out to provide a background to the subject for those at the Congress who are specialists in other fields. He therefore deals with (2) the history of the techniques of glass painting, especially the introduction of enamelled glasses in the 16th C. until the revival of the medieval type in the first half of the 19th C. (3) Cleaning: he recommends the use of a detergent (such as Lissapol N) in water; cracks in the glass should be kept free of soap; if the glass is greasy, 5% ammonia in water is recommended. (RGN - many conservators of medieval windows would disagree with all of these, and with his comments that painting on the outside of the glass is rare.) (4) Deterioration and decay: he discusses the removal of loose enamel and the possibility of repainting the missing parts, and lacquers are discussed for restoring the brightness to corroded glass. He makes the surprising remark that "areas of glass covered by yellow stain are invariably freer from corrosion than areas without stain". (RGN - there are many cases where the stained areas have corroded more than the unstained.) (5) Corrosion removal: he recommends Dennis King's (of Norwich) procedure for grinding and resurfacing the outside of the glass; pits can be cleaned with dental burrs or with acids and the holes filled with coloured resin. The cavitron or the airbrasive can also be used for cleaning pits. (6) Restoration: he discusses the various approaches for the treatment of "missing heads". (7) Releading is recommended every 100 years.

190. MONCRIEFF, Anne "Problems and potentialities in the conservation of vitreous materials" pages 99-104.

This is an extremely comprehensive paper, with 36 references, and it will provide food for thought for many conservators. It is so well-documented, and so concisely written, that all concerned should consult the original paper! The best which I can do here is to indicate the topics which will be found there! Cleaning: all methods are discussed very fairly, with special comments on the use of the airbrasive, acids, detergents (some can damage glazes), and lasers (very expensive but "may be able to do cleaning, without damage, that cannot be done by any other method"). Repair: all types of resins and adhesives are discussed in relation to discolouration, shrinkage, reversibility and loss of adhesion over the years (some epoxies have failed after many years); silicone adhesives may show promise here; an ultra-violet setting resin proved disappointing. Restoration: again all types, including types of package, are discussed; at the Victoria and Albert Museum epoxy resins coloured with dyes "have not stood the test of time" when exposed to museum lighting! Protection from deterioration: isothermal glazing, resin coatings, inorganic coatings, plating, revitrifying with lasers, and modifying the surface composition of the glass are all discussed.

191. OGDEN, Paul H. "A new glass adhesive" - this paper is available as a leaflet; it will be presented at the Conference but was not received in time to be included among the published conference papers.

This paper gives technical information about the new crack sealant (see N.L. No.14, item 1.6). It is an epoxy resin which has been modified to have a (polymerised) refractive index which matches that of modern window glass (= 1.52), in a double sachet with a polyamide hardener; a silane coupling agent is also present in order to improve the bond to the surface of the glass. When the sachet is squeezed the seal between the two compartments is broken and the hardener can be mixed with the resin. The mixture is quite fluid and will readily run into a fresh clean crack. It is possible for the manufacturers ("3 Ms") to modify the refractive index and advice is given as to how to determine the refractive index of the glass which requires mending, by allowing various mixtures of toluene and carbon bisulphide to run into the crack. The mixture has about one hour of usable life. Old cracks are more difficult to repair and, moreover, the refractive index (even for window glass) might be wrong because the refractive index of glass changes on weathering. (RGN - the sealant will readily enter a crack which reaches both sides of the glass because the air can then escape. If there is surface-fracturing (N.L. No.12, Figs 3 and 4) it may be necessary to use a reduced pressure to suck the air out.)

192. WOLFF, Arnold "The conservation of mediaeval stained glass according to the Jacobi method of lamination used at Cologne" pages 115-120.

This article gives full details of the procedure used for the "Jacobi process", with nine illustrations. The windows at Cologne compare with Koenigsfelden in area and artistic quality for early 14th C. glass but they are in a very poor state of preservation and the glass is badly cracked. (RGN - it is alleged that supersonic bangs from jet airfract have contributed to the damage but no evidence is given for this unexpected statement - see also N.L. No.11, item 173.) The weathering crust has made the windows opaque and this, coupled with the multiple fractures, has necessitated this particular restoration procedure.

The principle is to embed the old piece of glass in a soft plastic mass which is held between shaped cover plates of thin (1.3mm) modern glass, and "mass production" procedures have been introduced so that the total of 380,000 separate pieces of glass can be handled. No liquid is used for cleaning; loose paint is fixed with a silicone; gaps are filled with pulverised glass; hardening of the silicone is carried out at 50°C and curing of the interlayer at 80°C; the cover glass shaping is described in detail; the old leading cannot be used although it is kept for the records (the gaps fill with resin and are painted black); the process is reversible. Anyone who wants to use the process should consult this paper.

(174) SPITZER-ARONSON, Dr Martha - see N.L. No.11, 174, this paper has been published in Comptes-Rendus de l'Académie des Sciences, 1974, C278, 1437-1440. The original abstract omitted the words "or cuprous ions (Cu^+)" between "copper" and "which" in the seventh line.

(156, 157) NEWTON, R.G. - see N.L. No.8 156, 157, these papers have been published in the Proceedings of the Tenth International Congress on Glass, Kyoto, 1974, pages 9-49 to 9-54 and 11-32 to 11-38, respectively.

193. ANON. (1975) "Denkmalpflege in der Bundesrepublik Deutschland Geschichte. Organisation. Aufgaben. Beispiele" (Restoration of ancient monuments in Western Germany. History. Organisation. Problems. Examples) 1975 Heinz Moos, Munich.

This beautifully-illustrated volume of 127 pages is a contribution to the European Architectural Heritage Year. It contains about 150 illustrations, many in colour, illustrating various phases of Germany's restoration programme. The text is divided into 40 separate short articles about the restoration of towns or of materials. Pages 107 and 108 by Gottfried Frenzel are devoted to the restoration of stained glass, in particular the Augsberg Prophet Windows where the loose paint has been fixed with epoxy resin. It is stated that work is in progress on an instrumented window which will provide information about the temperature and humidity conditions existing there.

194. WILSON, M.J.G. (1968) "Indoor air pollution" Proc. Roy. Soc., 1968 A 307, 215-221.

This is an interesting paper because the author studies air pollution inside a building. He finds that sulphur dioxide (SO_2) is quickly destroyed, the "half-life" being only about 1 hour (i.e. the concentration falls to one half in one hour, to one quarter in 2 hours, one eighth in 3 hours, etc.). Of course, SO_2 continues to enter a building from outside, as well as being destroyed inside, and hence the equilibrium value of the concentration of SO_2 is about 20% of that in the outside air.

The SO_2 seems to be destroyed by the walls and ceilings, especially by new plaster, and hence the equilibrium value is higher in old houses and lower in new houses. On days when there was high outdoor pollution (440 $\mu g/m^3$) the rise of indoor SO_2 concentration could be detected if the windows were opened for a few minutes and then closed again, the values soon falling to an equilibrium value of 150 $\mu g/m^3$. Nevertheless, the lowest indoor concentration encountered in a normal room was 90 $\mu g/m^3$ (it could be reduced to 10 $\mu g/m^3$ by painting the walls with a strong solution of sodium carbonate).

Smoke as an air pollutant was not destroyed as rapidly as SO_2, the equilibrium concentration being about 80% of that found in outdoor air.

(Note by RGN. The author was concerned with domestic houses and not cathedral buildings, but the SO_2 was removed at surfaces and less-well by old surfaces. In cathedrals there is relatively less surface compared with the volume of the building, and the surfaces are very old; moreover the doors of cathedrals are opened more frequently than the doors of houses. All three features would seem to make the equilibrium concentration higher inside cathedrals, perhaps 30% or more of the outside concentration. Someone should make similar studies in an old cathedral, especially in a polluted area!)

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

7 CUMULATIVE INDEX TO NEWS LETTERS NUMBERS 1–15

The references are generally to the News Letter and the Section, e.g. 2(1.1.1) means News Letter No.2, Section 1.1.1, but three-figure numbers are to bibliography references, e.g. 8(150) means bibliography reference No.150 in News Letter No.8. (Note, these references are to bibliography items which were not in the British Academy bibliography, Occasional Papers Part I (price £4.00) obtainable from Oxford University Press.)

8 DEATH OF MR DEREK ALLEN, CB, FSA, FBA.

After this News Letter was ready for printing it was with great sadness that I had to report the sudden death of Mr Derek Allen on 12th June. When he was Secretary of the British Academy he was in a unique position to give great encouragement to studies of stained glass, both in Britain and Internationally. Thus, as Secretary of the British Committee of the CVMA, and as a close personal friend of the late Professor Hans Hahnloser, he was able to make international co-operation more effective; as a Delegate to the Assembly of the Union Académique Internationale he was instrumental in helping to obtain the main funds which pay for this News Letter.

After his retirement from the British Academy he became even more active and his wise counsels, coupled with his indefatigable energy, made him an invaluable source of strength. On the day he died he had attended a CVMA meeting in London, on a very hot day and despite a warning from his doctor that he was seriously ill, and gave us his unrivalled advice on the future evolution of the CVMA. He then travelled back to his beloved Charlbury and died while drinking a cup of tea that night.

He excelled in many fields and he made no concessions to slackness in any way; others will write about his contributions to numismatics, to the war effort, and in many diverse fields. For those concerned with stained glass in Britain his enduring personality will long be remembered and his widow has all our sympathy in her untimely bereavement.

Roy Newton

NOTES

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