REF: TC/74/2

7th March 1974

NEWS LETTER No. 7

1. GENERAL POINTS

1.1. Visits to conservation workshops in Europe

1.1.1. Mr. Ian Addy. As a result of the grants mentioned in item 1.1.2 of News Letter No. 6, Mr. Ian Addy is in May expecting to visit the workshops of Konrad Vetter in Berne, Dr. Frodl-Kraft in Vienna and Dr. Frenzel in Nuremberg for the express purpose of studying all aspects of "isothermal" glazing. I expect to accompany him for part of his journey. See also item 3.

1.1.2. Mr. Brian Clarke, a free-lance stained glass artist and restorer, has been awarded a Winston Churchill Memorial Fellowship to study stained glass in Europe for three months. He is at present arranging his itinerary.

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1.1.3. Dr. J. C. Ferrazzini (see item 1.3) will be visiting England during the period 3rd to10th March. He expects to go to the Victoria and Albert Museum, Mr. Dennis King's workshop in Norwich, BGIRA in Sheffield, and the York Glaziers Trust.

1.1.4. The British Council is trying to make arrangements to support visits to England by Continental experts in the restoration of medieval glass.

1.2. Conservation workshop at Canterbury

Mr. Frederick Cole tells me that his new workshop at Canterbury is now complete. It has been constructed within an old building in the Cathedral precincts and has two floors, but one-third of the upper floor has been removed to give extra height to the lower floor at this point. The equipment comprises an Airbrasive unit; a transistorised ultrasonic cleaner; two stereo-microscopes; a de-ionising unit; and two electric motors with flexible drives for use with rotary brushes. There is a strong-room, controlled for humidity and temperature, for the storage of windows awaiting treatment. There are ample facilities for the repair of windows and the photographic studio has a ground glass screen illuminated by three pairs of fluorescent tubes.

1.3. Swiss Technical Sub-Committee

Two new members have been appointed, Dr. J. C. Ferrazzini of the Kristallographisches Institut der ETH, Sonneggstrasse 5, CH 8006, and Dr. Gerhard Bayer, of the Eidgenössische Technische Hochschule, Zürich, with the same address. I understand that, among the usual activities, they will make attempts to monitor the environment within Berne Cathedral.

1.4. Use of laser beams for cleaning medieval glass

Laser beams were recently demonstrated at the Victoria and Albert Museum as a means of cleaning sculptures and suggestions have been made that the beam might also be used for cleaning medieval glass. Details are being sought and will be reported in a subsequent News Letter. (See also 2.4 for other methods of cleaning.)

1.5. My retirement

I shall be retiring as Director of Research of BGIRA on 30th June 1974, but I hope still to be able to produce these News Letters after my retirement. I shall be much involved in work on medieval glass with the York Glaziers Trust and with the University of York.

2. RESEARCH PROGRAMME

2.1. Standard synthetic medieval glasses

In addition to the three standard medieval glasses used in Britain (see p.3 of News Letter No. 5), Ing. J. M. Bettembourg has adopted five glasses for use in France. Their compositions are:-

	Weight percentages					Molar percentages				
	E	F	G	H	I	E	F	G	H	I
SiO_2	50	48.4	63	61.0	69.5	52.7	51.3	66.4	64.8	70.3
K_2O	17	16.4	12.5	12.0	1.5	11.4	11.1	8.4	8.1	1.0
Na_2O	3	2.9	1.5	1.5	14.0	3.1	3.0	1.5	1.5	13.7
CaO	16	15.4	12	11.6	12.0	18.1	17.5	13.5	13.2	13.0
MgO	7	6.9	4	3.9	-	11.0	10.9	6.3	6.2	-
Al_2O_3	1.5	1.5	1.5	1.5	1.5	0.9	0.9	0.9	0.9	0.9
Fe_2O_3	0.5	0.5	0.5	0.5	0.5	0.2	0.2	0.2	0.2	0.2
MnO	1.0	1.0	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.9
CuO	-	3.0	-	3.0	-	-	2.4	-	2.4	-
CoO	-	0.10	-	0.10	-	-	0.1	-	0.1	-
P_2O_5	4.0	3.9	4.0	3.9	-	1.8	1.8	1.8	1.8	-

Description:-

E Corrosible - colourless
F " - blue
G Durable - colourless
H " - blue
I Soda effect

Glasses E and F would be expected to be less durable than any of the three British glasses whereas H & G would be expected to be more durable. I shall carry out comparative trials with our equipment at Sheffield to ascertain whether these predictions are correct and to obtain more information about possible "acceleration" factors for glasses with graded durabilities (see p. 5 of News Letter No. 6).

2.2 A simplified method of comparing glass compositions

The published chemical analyses of medieval glasses may quote 20, or even 30, components and the mass of figures tends to bewilder even experienced technologists. There is therefore a need to condense the analyses into a manageable form, and a method has been devised for grouping the many constituents of a glass under three headings only:- the silica and the other oxides which form the network; the alkalies which make the glass easier to melt but which, in excess, reduce the durability to water; and the alkaline earths which make the glass more stable but which, in excess, reduce the durability to acids and sulphur dioxide.

The detailed calculations for making the adjustments are described in Report YG/74/1; please ask me for a copy if you wish to have one.

2.3 Identification of early medieval glass

Sometimes there may be difficulty in distinguishing between early medieval glass and clever 19th century reproductions. The ancient glass is, however, slightly radioactive and it can be identified by attaching a radiation monitoring film for two months. The details are given in Report YG/74/2; if you wish to have a copy, please ask me for one.

2.4 Cleaning of medieval glass

M. Bettembourg tells me (22.2.74) that he has been using two methods (a) and (b) below for cleaning medieval glass. Method (b) is suitable for removing a crust composed of sulphates and carbonates and its action is more rapid than method (a). The choice between the two depends on the porosity of the weathering crust and the extent of cleaning which is desired.

2.4(a) Use of a solution of thiosulphates and pyrophosphates.

An aqueous solution of 10% sodium thiosulphate ($Na_2S_2O_3.5H_2O$) and 5% sodium pyrophosphate ($Na_4O_2O_7.10H_2O$) is applied with successive pads of cotton wool, each being left on the weathering crust and then replaced with a freshly-soaked pad. The method is useful when the weathering crust is porous and allows the solution to permeate the crust. If the corrosion consists of pits, the action of this solution is too slow to permit them to be cleaned out properly and the technique is therefore recommended for cleaning windows where the weathering is quite uniform.

2.4(b) Use of a solution of EDTA and ammonium bicarbonate.

An aqueous solution of EDTA (the sodium salt of ethylene diamine tetra-acetic acid) 30 grams per litre, and ammonium bicarbonate ($NH_4.HCO_3$) also 30 g/l, has a more rapid cleaning action than (a) and it should be used on weathering crusts which are very adherent and non-porous. It is particularly suitable for cleaning out pits. Cleaning is carried out by soaking the panels (apparently still in their leads) in baths of the solution for two or three hours, or until the required degree of cleaning has been achieved. This procedure was used for the first time on the Jesse Tree window at Chartres, with good results, after three successive treatments of the outer face and one soaking of the internal face.

3. ISOTHERMAL GLAZING

The UK Department of the Environment has offered a contract to BGIRA of £8000 to make an experimental study of isothermal glazing situations, and of means of predicting the long-term durability of glasses, especially in a polluted atmosphere. This section of the News Letter is therefore devoted to a review of the current knowledge about isothermal glazing.

3.1 Definitions

There has been much confusion about terminology, especially as the word "Aussenschutzverglasung" can mean both "external protective weathershield" and "isothermal glazing". I suggest the following:-

(a) The term "double glazing" should no longer be used in connection with stained glass because it is an architectural term for glazings intended to increase personal comfort in buildings, and the air space between the panes is intended to be permanently sealed.

(b) The term "external protective glazing" should be used where an external shield of glass or plastics material is employed to protect the medieval glass against the weather and damage by stones, etc. The space between the two panels should not be sealed but should be ventilated to the outside so that any moisture which may collect in the space can dry out when the sun shines and warms the air in the space.

A special case of (b) exists at Lindena (see also 3.4) where the medieval glass has been moved into the building but it is not ventilated to the inside. Thus it is not "isothermal" glazing.

(c) "Isothermal" glazing is essentially a system intended to protect medieval glass from contact with both forms of moisture (rain and condensation) at all times. It is generally used with heated buildings (see the table in Section 3.2.2) and corresponds to placing the ancient glass in a "museum-type atmosphere", where little or no further deterioration is likely to occur because the glass is kept dry. This type of glazing consists of removing the ancient glass from the glazing grooves and re-hanging it inside the heated building in such a way that the warm air in the building can pass both sides of the ancient glass. Modern glass is placed in the glazing grooves. The fact that the warm air in the building can reach both sides of the stained glass means that the temperature can be nearly the same on each side; we have isothermal (= equal temperature) conditions. It is probable that the system can also be used with an unheated building, provided a wide enough ventilated gap exists between the two panels. The system is known as the "Swiss system" because it seems to have first been used in Switzerland, although Professor Marchini claims to have invented it in Florence at the end of 1969 (1). There are also claims that it was first used in a church in Lindena (Brandenburg) in 1897 (2), but this seems to have been a special kind of external protective glazing (3).

3.2 Advantages and disadvantages of external glazing

3.2.1 Addition of modern glass to the outside of the glazing groove.
The first advantage of using modern glass on the outside is to protect the ancient glass against damage by weather, stones, pigeon droppings, etc. There seems little doubt that some protection of the ancient glass against corrosion is provided because the glass at Lindena is

still in good condition after 75 years. It also seems that some of the windows in Nuremberg which have been cleaned, but were left unprotected, have deteriorated again (2).

If the ancient glass is left in the glazing grooves, the external glazing should be ventilated to the outside so that any condensation in the space between the glazings can dry out (6, 7). Nevertheless, on cold nights <u>some</u> condensation will occur on the medieval glass and some damage by the water must be assumed to occur while the glass is wet and especially during the drying out. An additional reason for ventilating the cavity is to avoid buckling of the medieval glass due to expansion of the air in the cavity when the sun shines.

If the modern glass is hung to the outside of the glazing groove there will be loss of the architectural and aesthetic value of the Gothic moulding of the mullions. Some architects regard this loss as being serious*, particularly in strong sunlight, but it would not occur if an isothermal glazing (Type c) system were used.

A disadvantage which is common to both external protective glazing, and isothermal glazing, is the harsh nature of the flat modern glass on the outside of the building with its tendency to produce reflections of the sky or of the surrounding buildings. In extreme cases this effect makes the cathedral resemble a shop-front These reflections can largely be removed by dividing the glass with lead-lines, because the different pieces then cease to be exactly parallel, or the surface of the glass could be etched or sand-blasted with an attractive design. JWC

In the Great East Window at York Minster there is a space some 70-80 mm wide between the two sets of glazings and the external protective glazing has been disrupted by diamond leading. This provides a satisfactory appearance from the outside of the building but in strong sunlight the straight diagonal lines of the diamond glazing can produce an aesthetically unpleasant effect when viewed from the inside.

Some exterior protective glazings at York Minster have been leaded in such a manner that the main lead-lines of the design of the medieval glass are followed by lead-lines on the outer glass. In this case, however, the two panels are soldered together at the edges, so that the space between the two pieces of glass is only about 3 mm and any displacement of the shadow of the outer leading, relative to the leading of the medieval glass, is quite negligible. This arrangement would not be suitable for "isothermal" glazing because there must be

*<u>Footnote</u> Dr. Bernard Feilden, the architect to York Minster, points out that the depth of a window in its reveal is of fundamental importance to the appearance of a building and designers consider this carefully because it can give either an impression of flatness or of sculptural relief, indicating either a thin wall or a thick one. Any changes in the apparent depth of the reveal are material alterations and it must not be tampered with if the principles of conservation are to be respected.

a clear space through which the (warmed)-air from the building can move. It is, however, not yet known what is the minimum spacing between the glazings which will allow satisfactory movement of the warmed air to provide the isothermal conditions needed to prevent condensation. It is hoped that the experimental programme at BGIRA will provide information on this point.

3.2.2 Isothermal glazing, the modern glass being placed in the glazing groove, and the ancient glass moved inwards. The big advantage of this system is that the medieval glass does not become wet. Mr. R. E. Lacy, of the building Research Establishment, has done some calculations of the frequency with which condensation is likely to occur on the medieval glass, during the winter months, for three types of "external glazing" (8). The calculations were carried out for windows of three types, A, external protective glazing; B, "isothermal" glazing and C, a sealed double-glazed window, as if they had been installed in King's College Chapel Cambridge, with an interior temperature on average 7 degC above the exterior temperature. Subsequently (9) he repeated the calculations for the conditions in York Minster, with an interior temperature assumed to be constant at 15°C in winter. These are D, for single-glazed windows and A* for one with an outer rainshield. He has calculated the percentage of the time, for different months of the year, when condensation might be expected to occur on the ancient glass. The figures are:-

Estimated frequency of condensation (percentage of all hours) on inner leaf of double windows in churches, with three different arrangements

Month	Outer rainshield of modern glass A	A*	B: ancient glass free-standing within church	C: sealed double-window	D: single-glazed windows in the heated building
January	22	2	6	14	15
February	23	1	3	12	18
March	16	1	3	11	15
April	7	1	1	3	10
October	11	6	2	7	25
November	16	2	3	10	18
December	22	2	6	15	18

He comments that the figures in column B are probably all zero and that the values listed may represent occasions when the air in the building became saturated, or nearly so. As can be seen from the column A*, the figures become much smaller for a heated building.

The disadvantages of isothermal glazing are the cost (see Section 3.3) and the fact that the modern glass on the outside needs to be treated in some way to reduce the "shop front effect" described above. One of the ways of doing this, without producing aesthetically unpleasant effects when viewed from the inside, would be to insert a diffusing screen between the medieval glass and the external leaded glass. This would increase the weight to be supported on the cross bars, and by the mullions, and would also make the assembly more complicated and more expensive but it will now be studied experimentally at BGIRA. The extent to which this is a problem depends much on the surroundings of the building. With many cathedrals in England there is a wide area surrounding the building but, as Bacher (10) remarks, the two Steier churches already treated by the Austrians are so hemmed in by surrounding buildings that the reflections are not serious.

Other, more sophisticated, ways might be found for avoiding the reflections. One sure way, but far too expensive, would be to "bloom" the surface as is done with anti-reflective coatings for optical lenses. Other possibilities, which would need to be investigated, would be to fire-on matt designs which simulate the appearance of medieval windows but which need not cast hard shadows on the ancient glass. Any treatment, however, would still further increase the cost of the installation.

The isothermal glazing system depends on the use of heated air (or at least a building which is warmer than the external environment) to equalise the temperatures on each side of the ancient glass. If the building is not heated, tubular electric heaters could be placed on the sills, and perhaps even a forced-air circulation might be used.

Another, apparently minor, difficulty with isothermal systems arises from the displacement of the medieval glass further into the building. The tapering of the mullions, and the sloping of the reveals, means that the panels no longer fill the space. Light can shine around the sides, over the top, and under the bottom unless the window is fitted with wider edges, with "skirts", etc. The difficulty can be overcome but the additional frames, edges, skirts, etc. add to the expense. Dr. Bernard Feilden remarks that the alteration of the depth of the internal reveal is of less importance than when it occurs outside the building because the inside is more likely to be viewed with a limited field of vision and the distortion of the designer's intentions is much less; moreover it is less likely to be seen in the sharp relief of sunshine and shadow.

Another disadvantage of the isothermal system, with its circulation of air, is that dust and dirt can be carried into the interspace, but the medieval windows can be taken down relatively easily for cleaning by unscrewing the nuts.

3.3 Mechanics of isothermal systems

It seems that only two engineering-type drawings of isothermal systems have yet been published, one by Bacher (10) and one by Hahnloser (11). The former uses a gap of 60-85 mm and the latter does not give any figures. It is understood that Dr. Frenzel used gaps of 20 mm to 50 mm in the Lorenzkirche at Nürnberg. Nowhere is the optimum gap discussed, from the point of view of achieving equal temperatures yet avoiding the high cost of an unnecessarily wide gap. This point will be studied under the DOE contract at BGIRA. Nevertheless, Bacher's paper (10) gives an excellent amount of detail about the way that the isothermal glazing system is installed in Austria.

Little has been published about the costs of installing either external protective glazing or isothermal glazing. Some figures quoted by Dr. Frodl-Kraft (12) are 9750 Austrian Schillings per sq. m., say 1350 DM/m^2 or £15 per ft^2 for installing isothermal glazing at the Leechkirche in Graz, and Dr. Frenzel (13) has quoted 60 DM/m^2 for the extra cost of arranging for the free flow of air around the medieval glass. There seem to be discrepancies between these figures and more detailed costings are needed. In the systems described by Bacher and Hahnloser, the medieval panels are held in place on the cross-bar by means of nuts on screwed bolts. Once the bolts are in position the medieval panes can be put in place relatively easily, and also be taken down again for periodical cleaning. In fact it is now so easy to take them down that it has been necessary to instal anti-theft devices on the assemblies.

3.4 Lindena Church

I am greatly indebted to Professor Maercker of Halle in the DDR for some up-to-date information about Lindena, which shows that the installation is not isothermal, yet it is also not a simple external weather shield.

Lindena is a little village, lying about half way between Berlin and Dresden, close to the small town of Kirchain-Dobrilugk, at about $51^{\circ}38'$N and $13^{\circ}34'$E. Dr. Maercker visited it in 1969 and again in January 1974. As can be seen from Figure 1, this painted window is a small lancet on the north side of the Apse and it was restored in 1897 by Oidtmann in the Rhineland and put behind external protective glazing. No doubt the primary object was to protect the medieval window, which is rather near the ground, from damage by stones, etc.

In 1974 the window made the same impression on Dr. Maercker as it did in 1969. The wooden surround (1897) to the external protective glazing, which is at the original position of the medieval glass (see Figure 2), seems to Dr. Maercker not now to be tight enough to prevent some circulation of the external air although, in 1969, he seemed to think that there was no entry of air from the outside.

The painted glass, from the middle of the 13th century (see Figures 3 and 4), is apparently in good condition on both sides and the painting on the outside is still clearly visible. The frame for the medieval glass is placed some 6 to 8 cm behind the original position of the window. It, and the stabilising saddle-bars of 1897, are still secure in the reveal and, as far as Dr. Maercker could observe, no air from inside the church can enter the space between the glazings.

Dr. Maercker remarks that the window has needed no maintenance since 1897 although the medieval panels, with their leading of 1897, have bent a little. He says he does not know of any 13th century window in the DDR which is in such a good state of preservation as regards both the glass and the paintwork. He attributes this to the protection afforded by the external protective glazing, even though there was probably no ventilation of the cavity for the first few decades.
(Note by RGN: This would seem to be a case where a nominally-sealed cavity gives adequate protection for 75 years but it would be interesting to know whether the 13th century glass happened to have a particularly durable composition, such as that possessed by the piece of pink 12th century glass from York Minster discussed in Report YG/73/4.)

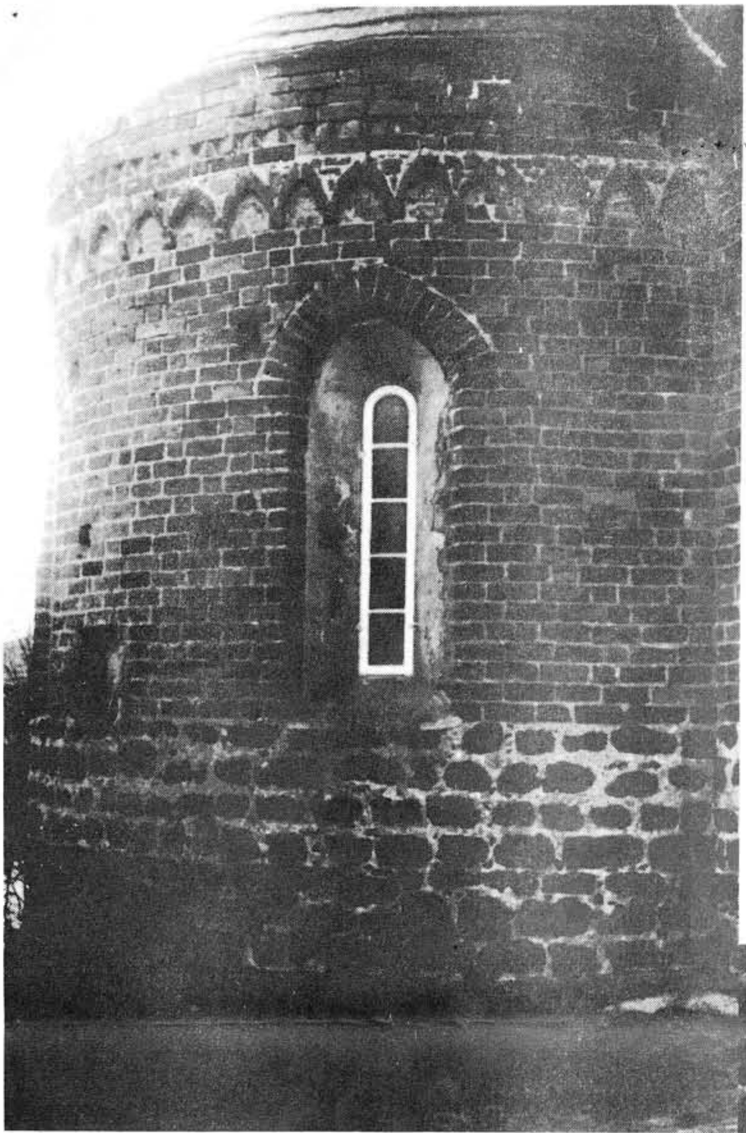

Fig 1 Exterior view of north side of Apse of Lindena Church.

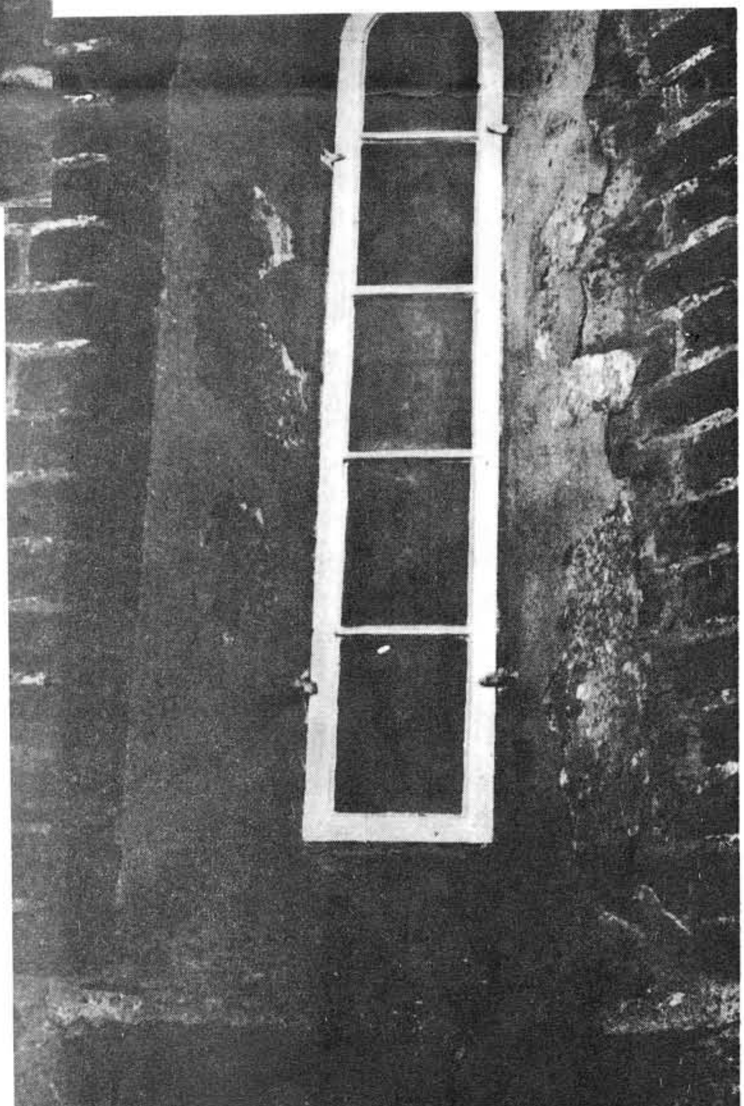

Fig 2 Closer view of lancet window, showing 1897 glass inserted in the glazing grooves.

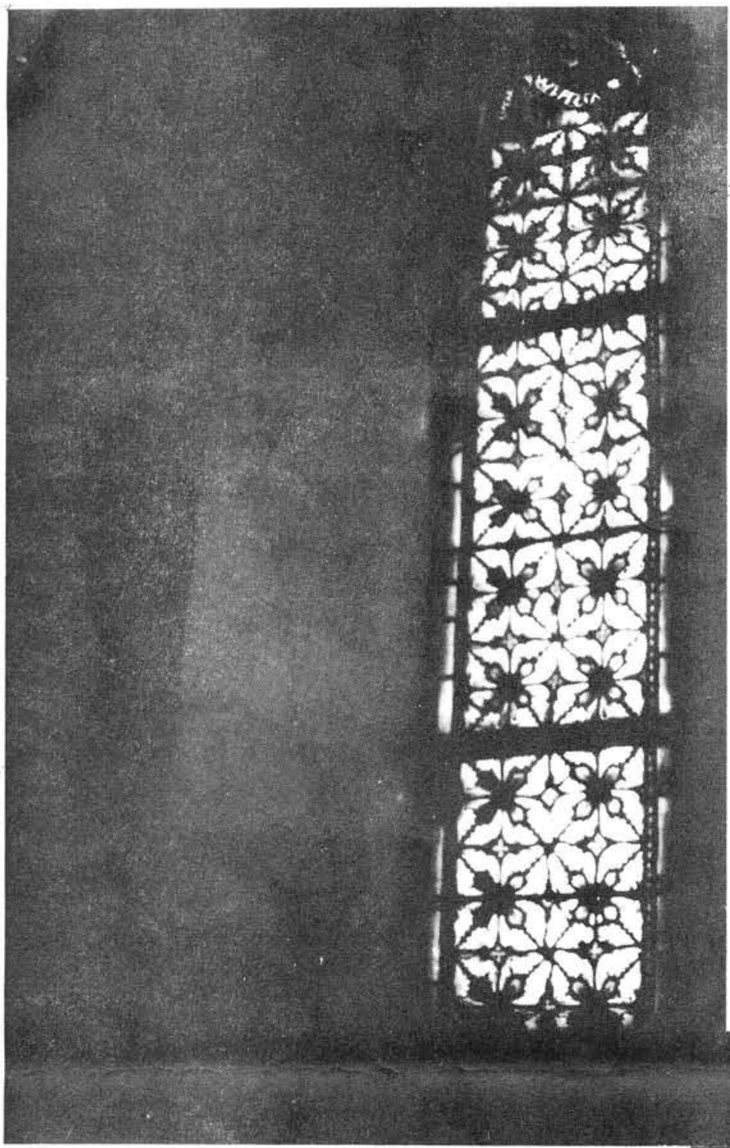

Fig 3 View of inside of the Apse lancet window where it has been rehung within the aperture but without circulation of air from the building into the space between the two glazings.

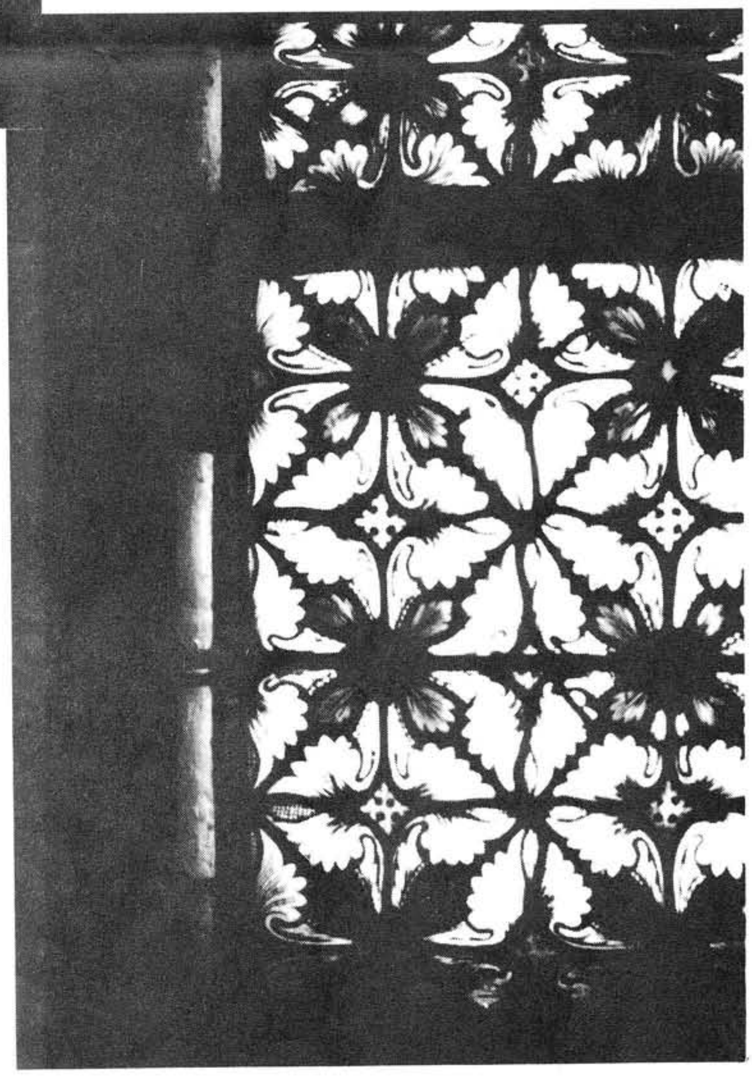

Fig 4 Closer view of the 13th Century glass, showing the absence of a gap through which air could circulate. and the absence of weathering of the glass.

3.5 References

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12. Frodl-Kraft, Eva, Private communication, dated 23rd March 1973.

13. Frenzel, G. Private communication, July 1972.