REF: TC/74/1

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NEWS LETTER No. 6

1. GENERAL POINTS

1.1. Visits between conservation workshops in Europe

Some new grants have been made to encourage the exchange of information between workshops.

1.1.1. Mr. Paul Jefferies, from Dennis King's workshop in Norwich, has been awarded the Radcliffe Trust Scheme for the Crafts Travelling Scholarship for Stained Glass. It is expected that he will give special attention to lamination procedures.

1.1.2. Mr. Ian Addy, from the York Glaziers Trust Workshop in York, has been awarded a special grant by the Radcliffe Trust Scheme for the Crafts. It is expected that he will give special attention to "isothermal" glazings, including the constructional and aesthetic problems and the relative costs of the various systems.

1.2. An "Isoprobe" at the University of York

Professor Heavens, of the Department of Physics of the University of York, has received a grant of £14 347 from the Science Research Council to purchase an "Isoprobe" instrument (similar to the one described in report YG/73/4), for use in studying the relationship between type of weathering and composition of the glass, in the medieval glass from York Minster. This will provide a wonderful opportunity for investigating a wide range of medieval glass in relation to its durability, and it is evident that "York", which already has a lecturer in Medieval British Art as Dr. Peter Newton, will become a centre of excellence for the conservation, art and science of medieval glass.

1.3. Grant for preparing News Letters

The Union Academique Internationale has made a grant of BF 50 000 for the preparation of these News Letters and other documents for the Technical Committee.

2. LAMINATION OF STAINED GLASS AT COLOGNE

Miss Anne Moncrieff, of the Victoria and Albert Museum, visited Dr. Wolff, Architect to the Cathedral at Cologne, to study the lamination process invented by Dr. Jacobi. Her six-page report (with the title given above) shows that the conservation technique is an interesting one. The cover glasses, used to protect the medieval glass, are not visible from the ground; the cleaned and treated windows are much brighter than the dirty and untreated windows alongside them. The removal of mending-leads also made the original design easier to understand.

The glass is cleaned by scraping with knives and the mild use of abrasive papers. Cracks in the glass are mended with a special Hoechst adhesive and any excess is trimmed away. (This was not done in 1958-60 and the excess adhesive has yellowed.) Epoxy resins were tried but they react with the interlayer. The moulding of the 2 mm cover plates is as described in Jacobi's papers (Bibliography references 14, 33(d), 44, 98, 99, 100). The maximum size of glass so treated is 300 mm^2 but this needs care and the process is best suited to windows containing many small pieces.

The advantages are:- the medieval glass is protected from moisture, air pollution, and windborne grits (in 1958 the thicker parts of the glass were not laminated but 15 years later these are now corroded and only half as thick); the process is fully reversible. The disadvantages are the cost (not stated); the increase in weight and the possibility of physical damage (not yet observed).

3. FAILURE OF DOUBLE GLAZING

See the note and illustration on page 3.

4. COATINGS FOR PROTECTING MEDIEVAL GLASS AGAINST WEATHERING

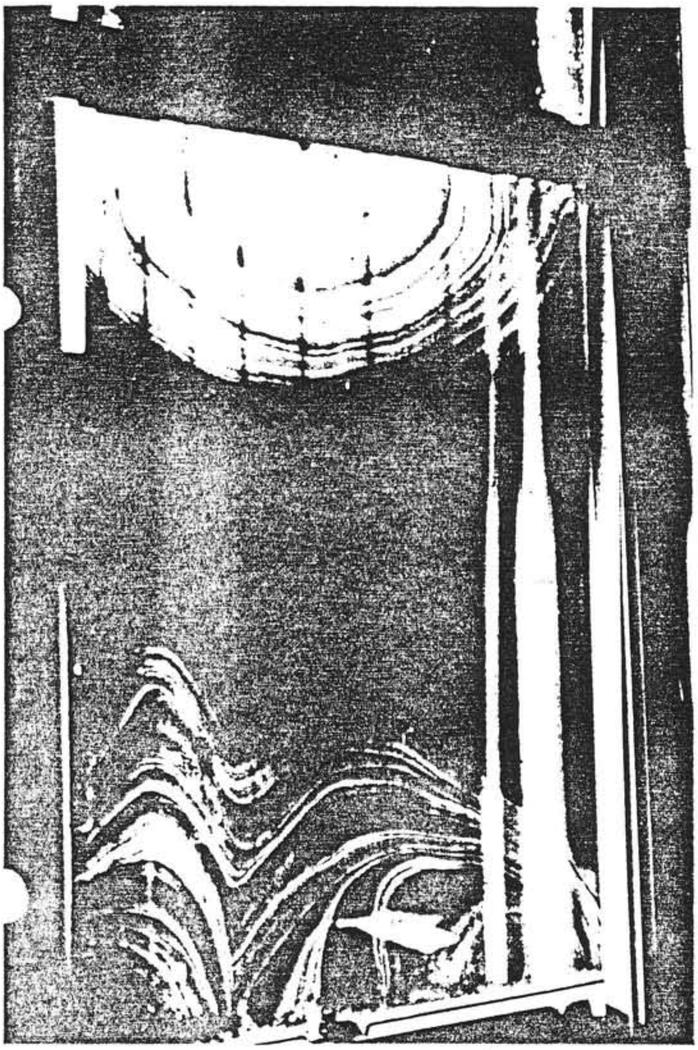
(It has been suggested by a reader that some News Letters should be devoted to a summary of the present situation with a particular technique. In this News Letter there is a summary of the present position of coatings; it is intended to be provocative and I shall be glad to hear from any outraged reader!)

There is much interest in the possibility of using a transparent coating material to protect ancient glass against the effects of its environment, chiefly because a satisfactory permanent coating would probably be easy to apply and be much cheaper than the other methods under discussion for protecting the glass, such as laminating or "double glazing".

It is not yet possible to state that any coating would be satisfactory to protect glass for 100 years, nor might it ever be possible, but the following notes are set out to summarise the present position, to indicate what is now being done experimentally and to suggest what researches might be undertaken. Laminating procedures are not discussed here (see item 2 above).

Many kinds of coatings have been advocated, organic or inorganic, which can be applied from solution, by fusion or by sputtering. An excellent summary of the historical situation was prepared in 1963 by Dr. Eva Frodl-Kraft (1).

A false impression of security may be engendered by the fact that some plastics materials seem to give satisfactory protection to modern glass when exposed to the weather for a few years. For example a coating of Acrylek was sprayed on a conservatory window in Sheffield in August 1972, and Dr. Bacher applied Viacryl VC 363 to a panel in the east window of the chancel of St. Maria am Gestade in Vienna in December 1971 (see Fig. 67 of Ref. 2). In both cases these coatings have remained glossy, adherent, colourless and apparently protective to the glass. The Sheffield conservatory window is made from modern sheet glass (perhaps 30 years old) and the window in Vienna is medieval, but it seems to be a fairly durable example of such glass. Both experiments have been in progress for less than 2½ years.



FAILURES OF DOUBLE-GLAZING

It is well-known that the failure of the seal in a double-glazing unit can lead to condensation of moisture in the space between the two panes, and that this water can in the course of a few years (less than five) lead to permanent etching of the glass; such an etched pane was demonstrated at the CVMA meeting in York in September 1972.

There is also a view that condensed moisture in a "leaky" double-glazing situation can be removed by ventilating the cavity to the outside atmosphere. For example, R. M. E. Diamant (1971) states on p. 60, with reference to "leaky" double-glazing, "It is essential, therefore, that the rate at which water vapour is allowed to diffuse from the air cavity to the outside is always much faster than that at which water can diffuse into the cavity from the inside. This means ventilation towards the outside and hermetic sealing towards the inside....... It is far better to have converted double-glazing systems where the extra frame is hinged loosely to the outside of the existing windows." Again, on p. 104 "To cure condensation... light (glazed) frames... are hinged loosely to the outside of the existing windows....".

Mr. George Linsley, of Pilkington Brothers Limited, has drawn my attention to a remarkable occurrence in connection with a sealed double-glazing unit. The sealed unit had been installed for some six years when condensation was noticed in the cavity, indicating that the seal had failed somewhere. The pattern of condensed moisture was the well-known one lying at the bottom of the cavity and extending partly up the sides. The panes of glass were 6 mm thick, and the cavity was 6 mm wide.

Within three weeks of noticing the condensation, the decision was taken to bore three holes 6 mm diameter, through the outer pane (one in the middle of the top edge and the other two near the bottom corners) in order to (1) dry out the cavity by blowing dry air through the unit from one hole to the others and (2) leave the cavity "ventilated" to the outside.

After less than four months after drilling the holes the glass was found to be attacked in the patterns shown in the illustration. The three "concentric" patterns of corrosion are each centred on one of the three holes and all the damage was on the outer face of the inner pane (ie glass surface No. 3, counting from the outside). The reason for the attack, and for the concentric pattern, is by no means fully understood but the whiteness is due to silica-rich material and the occurrence is a warning as to what can happen when double-glazings are ventilated to the exterior.

Any prediction which might be made about the condition of these coatings in 100 years, or even in 10 years, will depend on (a) intelligent anticipation and (b) accelerated testing. As regards (a), fears have been expressed that sunlight or ultraviolet light may cause darkening and crosslinking of the resin (3) but modern stabilised polymethyl methacrylate has not darkened after 10 years' exposure and it has even become slightly depolymerised (4).

At any time in our 100-year period unauthorised cleaning agents could hasten the deterioration of glass and plastics. Glass has been spoiled by the use of hydrofluoric acid and by strongly alkaline detergents (5). Similarly, the plastic laminates of car windscreens were damaged in February 1973 in the Emden area of Germany when a new type of lubricant was used for inserting windscreens into new cars. The adhesion between the resin and the glass could become impaired, especially in the presence of moisture, as was the case in the Winston Churchill panel at Dudley (6) and in the experiments on adhesives carried out by J. M. Bettembourg (7). Even if the adhesion remained secure, there is still the risk that water vapour may diffuse through the coatings and react with the glass (8).

As regards (b) the accelerated testing of the coating, various kinds of test are in use, such as cabinets where the humidity and temperature are cycled periodically, where intense illumination is added to humidity and temperature, and tests using hot water. The big problem is that different properties of the materials may be accelerated at different rates, or entirely new features may be introduced; for example, if heat is used to accelerate the test, quite a different answer might be obtained if the resin were to melt and run off, or if cracks produced in the hard resin by light and oxygen were to be "sealed" by a softening of the resin at an elevated temperature.

These problems may be minimised by grading the tests, for example by using hot water at intervals of (say) 10^{o}C and noting the time required to produce a relevant measurable effect. If, for a given effect, a straight line is produced when the temperature is plotted against the logarithm of the time, it is likely that the acceleration procedure is valid within the straight-line region.

One of the factors which may accelerate the test is the durability of the glass. If the glass has a poor durability, so that it is readily attacked by water, any water which diffuses through the resin coating will react with the glass to produce an alkali hydroxide which may tend to collect between the coating and the glass. This material may damage the adhesion or even rupture the coating, or the alkali ions may diffuse out through the coating and be detected in the water surrounding the coated sample, showing that some reaction has occurred, despite the presence of the resin. This kind of accelerated test is in use at BGIRA in Sheffield and the poorly durable glass is one which is rich in potassium. So far, potassium ions have been found in the surrounding water in the case of every type of resin yet examined (see, for example, the results given in page 4 of News Letter No. 5).

An accelerated test which has been in use for many years is that used by Pilkington Brothers Limited, at St. Helens, for the quality control testing of their float glass production. The test apparatus consists of a closed cabinet in which the relative humidity is maintained at 100% and the temperature is cycled between 35^{o}C and 75^{o}C in approximately six hours. The samples are placed vertically in the chamber with spacers so that air circulation and condensation can occur on all surfaces. The test-result is recorded as the number of cycles which the product withstands before a noticeable deterioration occurs.

When the simulated (poorly durable) medieval glass (No. 2) was used, none of the five resin coatings remained in place after only one cycle. Their conditions were:-

Vycoat ACA 60: coating became opalescent with loss of adhesion at the edges.

Acrylek: good adhesion but film had discoloured.

Bedacryl 122X: ditto

Bedacryl 123 AH: some loss of adhesion and marked discolouration.

SC 28: the coating had completely peeled away in a single brittle sheet.

The behaviour of all these resins was so disappointing that they were used again, but this time on a substrate of polished plate glass. The resins adhered very much better, but there was some deterioration, as set out below.

Vycoat ACA 60: after one cycle the coating had become opalescent and it began to peel away after eight cycles. After 35 cycles it was white and wrinkled.

Acrylek: slight mottling after one cycle, and some loss of adhesion after five cycles; much mottling of the surface after 120 cycles.

Bedacryl 122X: slight mottling after one cycle; becoming more severe after five cycles and unacceptable after 120 cycles.

Bedacryl 123 AH: ditto for one cycle; bubbles appeared in the coating after five cycles and became severe after 120 cycles.

SC 28: slight discololoration after one cycle; pitting of the edge after five cycles; complete detachment after 120 cycles.

Thus the behaviour of the coatings is quite different on the two substrates and a question to be asked is whether the poorly durable glass is a valid substrate for testing coatings intended for use on glass having a high durability? This question could be studied by carrying out tests with a series of glasses having graded durabilities. However, an inorganic easily fusible glass was tested on both substrates and the test ran for 120 cycles without the coatings becoming detached, so it seems that the poorly durable glass does not necessarily bring about detachment of vitreous coverings.

There is clearly a need for much more testing work but this note is a summary of the present position.

REFERENCES

1. Frodl-Kraft, E (1963) "Das Problem der Schwarzlotsicherung an mittelalterlichen Glasgemälden", Vienna 1963, 23 pages.

2. Frodl-Kraft, E. (1973) "Untersuchungen und praktische Erfahrungen in der Konservierung mittelalterlicher Glasgemälde", OZKD 1973 27 55-65.

3. Oel, H. J. A comment made at the colloquium on the conservation of the Augsburg Prophet Windows, Nürnberg, 1971 and referred to on p. 63 of reference 2.

4. A sample of PMMA sheet, exposed at Welwyn Garden City for ten years, facing south at an angle of 45°, RGN's sample No. 179.

5. Gresford church in N. Wales, suffered damage to the glass, Mostyn Lewis 1970 "Stained glass in North Wales up to 1850".

6. "How they saved the Churchill Window", Plastics and Rubber Weekly, March 9th 1973, p. 12.

7. Bettembourg, J. M. (1972) "La restauration de vitraux brisés. Vieillissiment acceléré de collés" eight pages of typescript, dated 3.11.72.

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

I send you all my warmest good wishes for another conservationally-effective year, in 1974

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