The design of museum showcases

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Abstract

A description of the various techniques for sealing boxes and the effectiveness of relative humidity buffering within these isolated spaces.

This is a digital facsimile of the article first published as: Tim Padfield, 'The design of museum showcases', Preprints of the London Conference of the International Institute for Conservation 1967, edited by G. Thomson. pp 119 – 126.

THE DESIGN OF MUSEUM SHOW-CASES

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INTRODUCTION

It seems to me that more attention should be paid to the design of show-cases and picture frames. The show-case could be the greatest single aid to conservation. In this article I hope to show that we can apply the results of research done in other fields and thereby increase the protection afforded by the museum show-case to its contents.

The best conservation treatment for most museum objects is simply to keep them in an environment as uniform and unchanging as possible. The atmosphere should contain only the historic ingredients - water, carbon dioxide, oxygen, nitrogen and a trace of the inert gases.

Unusual environments must be avoided until we know more about the various processes of decay. Extreme dryness, cold, absence of oxygen, total vacuum - all these 'scientific' environments prove to be hazardous in unexpected ways.

THE AIRTIGHT CASE

A pre-requisite for any attempt at atmosphere control is a well-sealed show-case. Most attempts at sealing show-cases (usually in order to remove the air) have been unsuccessful. An early model was Simpson's patent show-case (1), designed during a period of controversy over the effect of light on water colours. It is inconceivable, and probably fortunate, that the case could have held a vacuum for more than a few hours and the designer was apparently so doubtful of its performance that he left out the promised pressure gauge.

More recently an ancient piece of cloth was enclosed in a sealed frame with a perspex front and an inert gas filling. But the permeability of perspex is so great that within a few days the atmosphere inside the case must have been indistinguishable from that outside.

This permeability of plastic materials seems to be not sufficiently well known. In one natural history museum a deliquescent mineral from a salt deposit was sealed in a small perspex container. The mineral has steadily absorbed water from the air so that the container is now almost filled by a dilute solution of the salt.

All chemists must be familiar with the custom of putting a small canister of silica gel drying agent in a corner of the balance case but they may not know that the flow of air through any balance case is so great that the dessicant has no detectable effect on the relative humidity.

I give these examples to show how people have persistently underestimated the difficulty of maintaining a controlled environment in glazed cases.

Nevertheless an airtight case can be made. The National Bureau of Standards approached the problem of sealing up a museum specimen in a thoroughly scientific manner (2). The frame they made holds the Declaration of Independence and the Constitution of the United States in an atmosphere of helium and water vapour. All the materials and joints are of absolutely impermeable metals and glass, and a leak detector is provided.

This frame cannot be opened without destroying the seal, so the design is not suitable for normal museum use. Furthermore the use of an inert gas to replace air cannot be recommended for general use in show-cases (3).

It is extremely difficult to make a show-case which can be repeatedly opened and yet remain impermeable. The case would have to be made entirely of metal and glass without any organic materials, which are all more or less permeable to gases. The glass and the seals would have to withstand the fluctuations of atmospheric pressure and the pressures and stresses of thermal expansion and contraction.

THE VENTILATED SHOW-CASE

A less demanding approach to show-case design is to allow air to enter the show-case, but only through a small hole provided with dust filters and pollutant absorbers.

This system also has positive advantages. An absolutely airtight show-case is probably not an ideal container for art objects because the volatile constituents and the products of decay of the objects and furnishings inside the case may themselves be corrosive. Polyvinylchloride for example decomposes in light, giving off small amounts of hydrogen chloride. Many conservators will have come across isolated examples of damage probably caused by volatile materials released within the frame. This may have happened to the pastel illustrated at the end of this article.

Fortunately the constant alteration of atmospheric pressure and temperature causes an ebb and flow of air in a show-case and provides an entirely automatic method of gentle ventilation.

The ventilation hole should be well away from the objects inside the case because the climate near the hole is much less stable than that in the interior of the case.

DUST AND POLLUTION

Dust and pollutants can easily be removed as the air enters the case. Glass-fibre filter paper is very suitable for removing dust, and filters made from this material, pleated to increase its surface area, are commercially available (4).

Because of the slow rate of ventilation - about five volumes per year (5) - it is also quite easy to absorb pollutant gases as they enter the show-case. Ready-made active-carbon filters are available (4) and 500 g of carbon per cubic metre of show-case volume should last for several years, even in the city air into which most of the finest works of art have now been moved.

Active carbon absorbs vapours with an avidity which increases with their molecular weight and critical pressure. It is therefore a non-selective absorber of all pollutants in the air.

It must be remembered however that the process is reversible and small concentrations of pollutant gases in the air will be in equilibrium with the adsorbed pollutant. If the art object reacts with the pollutant, as marbles does with sulphur dioxide, it will slowly mop up the pollutant and more will be released by the carbon. For complete protection from gases coming from inside as well as outside the case it is wise to have chemicals in the case which react with the pollutant. Reagents are more specific in their action than active carbon so complete purity of the atmosphere would require numerous reagents, but many acid pollutants, such as sulphur dioxide, can be removed by putting into the case paper or cloth impregnated with magnesium carbonate by the method used to de-acidify paper. The effectiveness of placing insoluble carbonates within a picture frame is strikingly illustrated by the photograph at the end of this article.

The Raphael Cartoons in the Victoria and Albert Museum are provided with clean filtered air by the methods described above (Fig.1).

HUMIDITY CONTROL

With the slow movement of air through the almost air-tight case humidity control becomes much easier.

A stable relative humidity is simply achieved by putting plenty of absorbent material inside the show-case. Unvarnished wood, parchment, paper, cotton, silk and woollen cloth are all suitable materials. The relative humidity in the case will drift slowly towards that in the gallery, but all rapid variations due to changes of temperature and atmospheric relative humidity will be efficiently smoothed out.

The quantitative description of this buffering effect has been the subject of several recent articles (5,6,7) so I will only give here a brief account of the principles of the process.

The effect of atmospheric moisture on art objects is always a function of relative humidity (RH) (8) rather than of water-vapour concentration. The dimensions of absorbent materials change with the RH of the surrounding atmosphere. Mould growth, the deliquescence of some glasses and minerals and the corrosion of metals are also governed by RH.

It is important therefore that a show-case should be maintained at both a constant and a moderate RH.

This involves continual adjustment of the water-vapour concentration of the air because, as Figure 2 shows, the water vapour concentration of air changes with temperature <u>at constant RH</u>. Conversely in an empty show-case, which is an almost isolated volume of air with a constant water vapour content, the RH will vary with temperature. This is a dangerous situation and in an almost sealed case some control over RH is essential.

Fortunately the absorbent materials affected by RH changes are also very efficient RH stabilisers.

CHANGE OF RH WITH TEMPERATURE

The moisture content of absorbent materials, unlike that of air, depends mainly on the RH and is only slightly affected by temperature changes, at constant RH (Figs. 2 & 3). It is evident that as the temperature changes, absorbent material in the case will automatically adjust the water vapour content of the air to maintain a constant RH. This process is shown diagrammatically in Fig.3.

CHANGE OF RH DUE TO LEAKAGE OF AIR

The RH inside a ventilated case will slowly drift towards the average RH (averaged over several weeks) in the gallery. This drift is slowed by absorbent materials within the case. The reason for this is that the moisture content of cotton, for example, is very large compared with the moisture content of an equal volume of air. As the air space loses or gains water vapour the cotton in the case will absorb or emit water to counteract this change without very much change in the equilibrium RH in the case.

The removal of 3.5 g of water from one cubic metre of air at 20°C will alter the RH from 60% to 40%. The removal of the same amount of water from 200 g of cotton will cause the same change of RH around the cotton. This weight of cotton, roughly that of three glass cloths, is therefore equivalent in its moisture relations to one cubic metre of air. This means that one complete change of air in a case of this volume containing about 1 Kg of cotton would produce the same effect on the RH as changing one sixth of the air in an empty case and then remixing. In other words the change of RH in the stabilised case would be one sixth of the change in the empty case. Other absorbent materials are even more effective in stabilising the RH.

The subtler effects of temperature dependence and hysteresis in absorbent materials have been studied by Thomson (6) and by Stolow (7). These effects can be neglected in museum show-case design : they become important in packing for transport or storage in extreme climates.

LIGHTING

Electric lamps generate heat: even fluorescent lamps give out nearly as much heat as light. Lamps should be outside the show-case and in enclosures with good convective ventilation. Illumination from below a show-case through a glass floor generates a dangerously high temperature and consequent low RH within the case. If illumination from below is wanted the light can be reflected from lamps placed at the side of the case or alternatively forced-air ventilation of the lamps can be used, with a safety device to cut the current to the lamps when the fan fails.

The heating effect of the light itself must not be neglected. Direct sunlight generates a high temperature inside a glazed case. It also causes photochemical damage. For both these reasons sunlight, or any other bright light, must not be allowed to shine upon a showcase containing organic materials.

SUMMARY OF A SHOW-CASE SPECIFICATION

I propose this specification for a museum show-case or picture frame. It should be sealed against air flow under pressures up to half a millibar, but not constructed to such high (and expensive) standards that diffusion of gases into the interior is prevented. There should be one small hole, about 5 cm diameter for each cubic metre of air space, through which air can move into and out of the case. This air should pass through a dust and pollutant filter before entering the case. The inside of the show-case should contain an abundance of absorbent materials such as unvarnished wood, parchment, paper, cotton, silk and wool to stabilise the atmosphere against relative humidity changes. All light sources should be outside the case but not below it.

GLOVE BOXES

These requirements can be met by adapting the designs for the glove boxes used to handle toxic or highly reactive chemicals.

These boxes are similar to show-cases in appearance but they have long rubber or neoprene gloves saled into the front window so that an operator outside the box can handle apparatus within (9).

The efficiency of modern glove boxes is such that they allow the safe handling of chemicals which are dangerously toxic in concentrations below one part in a million of air.

Anyone who has watched the dust gather on the glass shelves of a show-case will concede that we are more adept at keeping material inside boxes than at keeping it out!

METHODS OF CONSTRUCTION

The construction of the rigid parts of glove boxes is not complicated and it should be no more expensive to make an airtight case than to make the smart metal-framed show-cases which grace our richer museums.

Various ways of making airtight joints between glass or perspex sheets and a metal frame are illustrated in Fig. 4. This does not illustrate the most important difference between the design of glove boxes and the usual show-case construction: the close spacing of the screws holding the glass down on to its gasket. The fastening screws or other devices should be placed not more than 15 cm (6 inches) apart, or even closer if thin glass is used. This prevents the glass bowing away from its gasket.

An all-glass, frameless show-case can be sealed by using modern silicone-rubber adhesives to join the glass edges. Small cases can be arranged to lift off their bases. In this case the weight and rigidity of the glass provides a good seal between base, gasket and glass. The only fastening needed is a security lock.

In all other designs a multiplicity of fastenings is needed. This raises the difficulty of removing the glass to change or handle exhibits. There are various answers to this problem. Some quick-release fastenings are shown in Fig. 4 and many other varieties are available. Fig.1 shows the fastenings used for the back boards of the Raphael Cartoons.

Then there is the problem of security. It is customary to use locks as the only closing devices for show-cases. But the lock must only prevent the case from being opened, it need not form part of the sealing system. Besides, dozens of quick release fastenings might prove a better deterrent than a couple of locks!

CONCLUSIONS

The measures proposed here to improve the efficiency of the show-case in preserving its contents are, I believe, safe and non-controversial. The difficulty seems to lie in the construction of show-cases of sufficient airtightness for dust and pollutant filters to be effective. Air must find no other way into the interior. Some orthodox wooden-framed show-cases which I tested suffered about one change of air per day. In a more scientifically constructed case this air flow could easily be reduced to less than one change of air in a month, with great benefit to the contents.

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Relative Humidity is the water vapour content of air expressed as a fraction, or more usually a percentage of the maximum possible water vapour content at that temperature.
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Fig.1
Dust filter (top), active carbon pollutant absorber (immediately below) and one of the quick release fasteners fitted to the back-boards of the Raphael Cartoons in the Victoria & Albert Museum. Reproduced by courtesy of Mr. N.S. Brommelle, Keeper of the Conservation Department.

Fig.2
The range of moisture content of air and of cotton between 10^{o} and 30^{o}C. for relative humidities between 30% and 70%. The graph shows that at any given RH the moisture content of air is much more sensitive to temperature than that of cotton.

Fig.3
The moisture content / RH / temperature relations of 5 m^3 of air (top) and of 1 Kg of cotton. If the air is in an empty, sealed case the RH will change from 50% to 35% when the temperature rises from 18^{o} to 25^{o}C (horizontal arrow in top graph). If the cotton is in the case it will release water into the air to raise the RH. The vertical arrows, of equal length and opposite directions, indicate a movement of water from cotton to air until an RH of 42% is attained. Thus the change in RH caused by the temperature change has been halved by the influence of a fairly small amount of absorbent material.

Fig.4
Some ways of sealing glass and perspex panes to metal frames. The shaded material is neoprene gasket. A, The 'Clatonrite' system. B, D & E are for permanently fixed glass. C is a bell jar seal, held closed by the weight of glass bearing vertically on the gasket. F, G & H are quick-release fastenings. In F the T-section strip is jammed in place by the elastic O ring.

Figs. 5a and 5b
Photographs of a pastel (5a) and of the reverse side of the paper support (5b). The pattern of the grain of the wooden back-board has printed itself on the paper except where calcium carbonate is present on the surface of the pastel. Possibly some volatile constituents of the wood have reacted with substances in the paper except where the alkaline carbonate pigment has inhibited the reaction. For these pictures I am indebted to Miss Joyce Plesters of the National Gallery Laboratory.

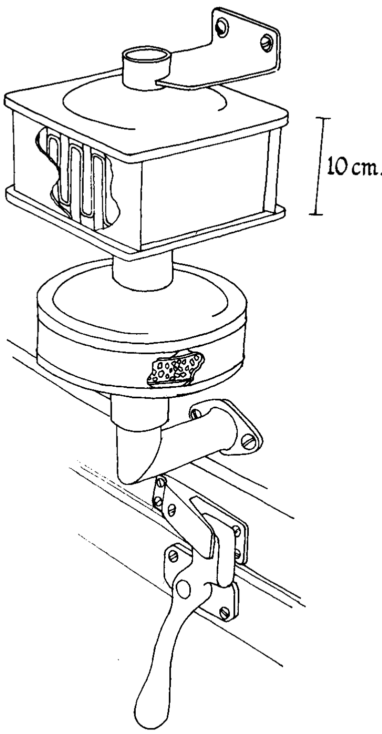

Fig. 1

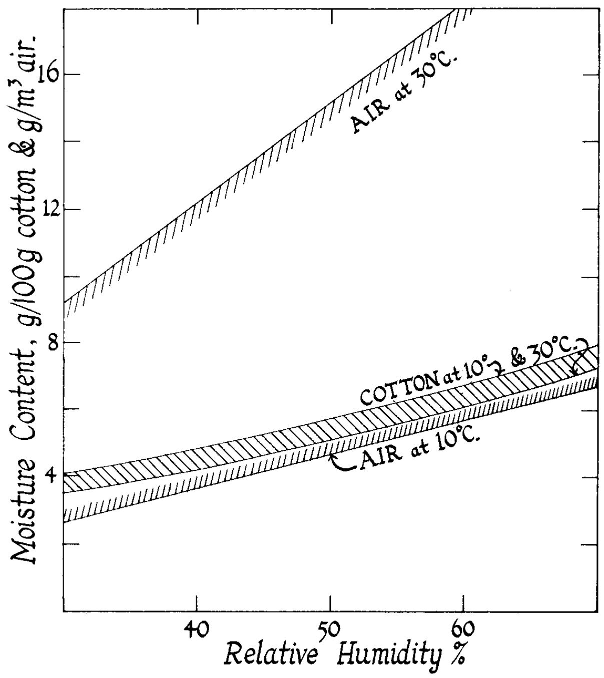

Fig. 2

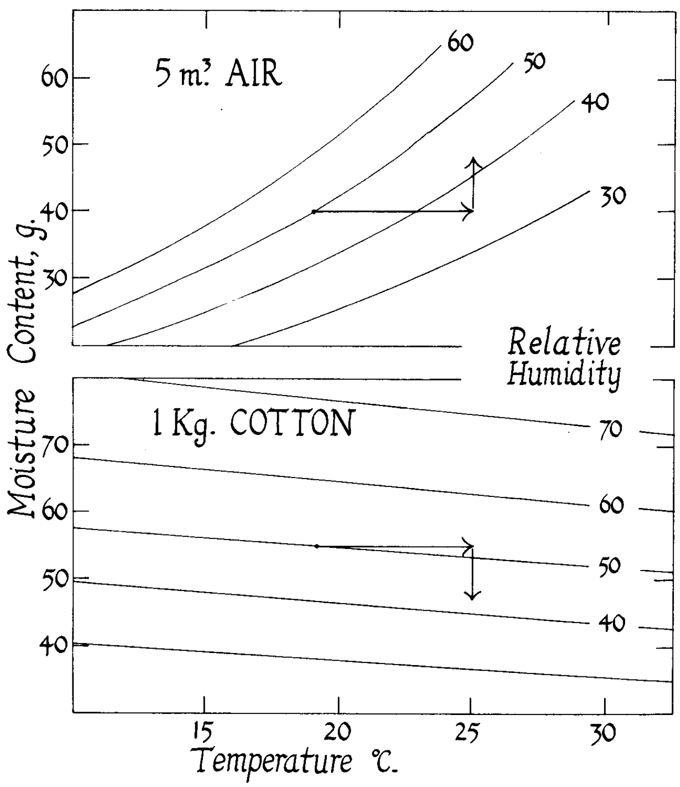

Fig. 3

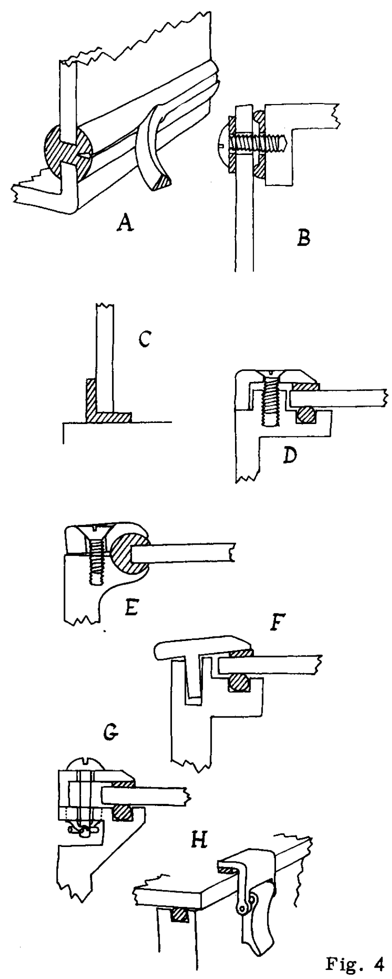

Fig. 4

Fig.5a

Fig.5b