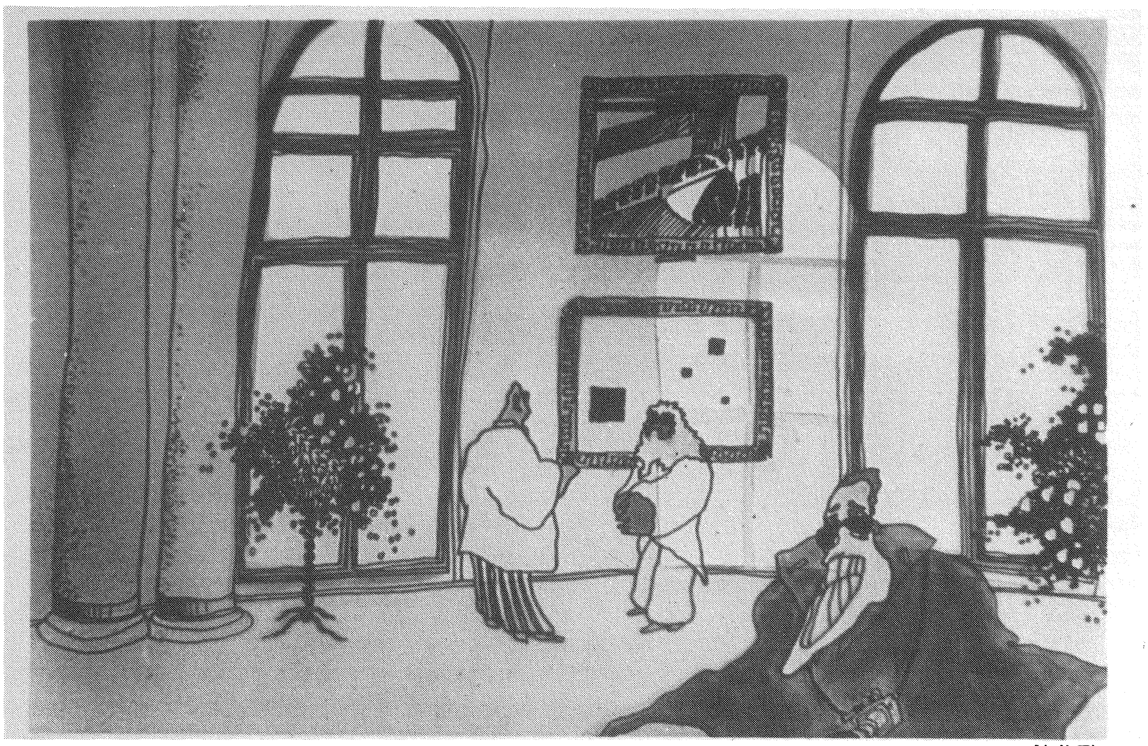
Control and Monitoring of the Environment

Notes of a Lecture
G. Thomson



Neil Thomson

Figure 1. Art lovers and art objects basking in the sunlight

Light

The radiation from the sun, the sky and artificial museum light sources can be divided into three regions according to wavelength (Fig. 2):
Visible light in the middle, from 400 to 760nm.
Infrared radiation at the long end, from 760nm.
A band of ultraviolet (U.V.) between 300 and 400 nm, most of which penetrates glass.

Infrared radiation may cause heat problems but is not responsible for the photochemical deterioration which is our primary concern. This is all caused by U.V. and visible radiation. The U.V. is more potent, but there is less of it. Overall, for a mixed collection, we can suppose that the blame for damage can be about evenly divided between U.V. and visible radiation. We therefore have to deal with both U.V. and visible radiation.

Ultra-violet. We need a filter to remove all U.V. radiation while allowing visible light to pass through without colour distortion. No glass can do this effectively, but plastic materials are available.

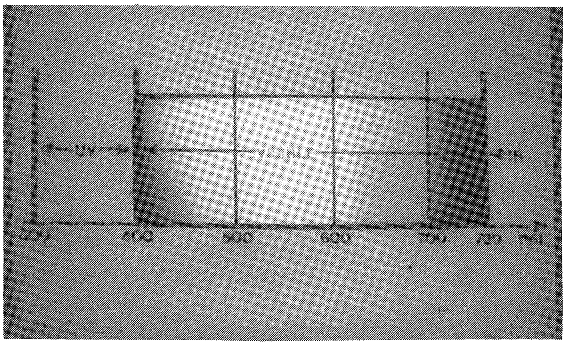


Figure 2. Spectral regions of museum light sources.
1 nm = 10^{-9}m or one millionth of a mm.

The best is acrylic sheet with a U.V. absorber specially added (ICI VE Perspex or Rohm & Haas Oroglas UF3) (Fig. 3). Thin acetate sheets, varnishes and plastic sheets sandwiched between glass are also available. For UK suppliers see Information Sheet No. 6. *Conservation and Museum Lighting,* from the Museums Association, 87 Charlotte Street, London WIP 2BX.

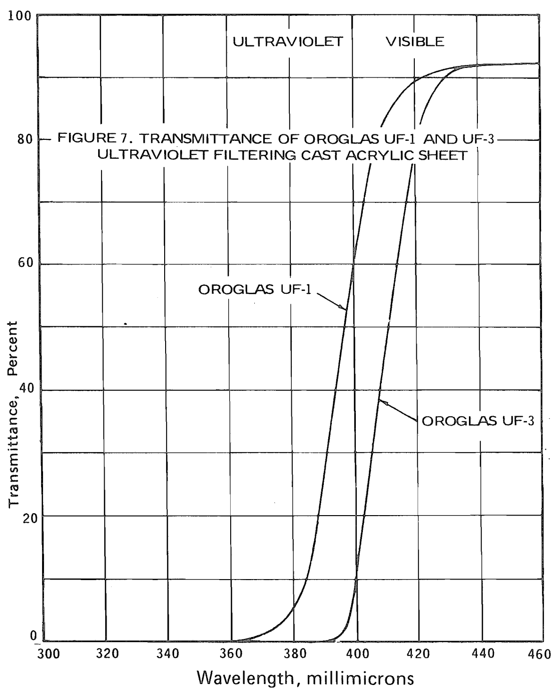


Figure 3. Spectral transmittances of oroglas UF1 and UF3.

If all the light can be reflected from a white-painted wall before reaching the exhibits its U.V. will be satisfactorily removed (Fig. 4).

Daylight contains the most U.V. The following table gives an idea of relative amounts (measurements are in microwatts of U.V. radiation per lumen):

Blue sky	1600
Light overcast	800
Direct sun	400
Fluorescent lamps	40–250
Philips 37 lamp	40
Tungsten iodine through glass	up to 130
Normal tungsten	60–80

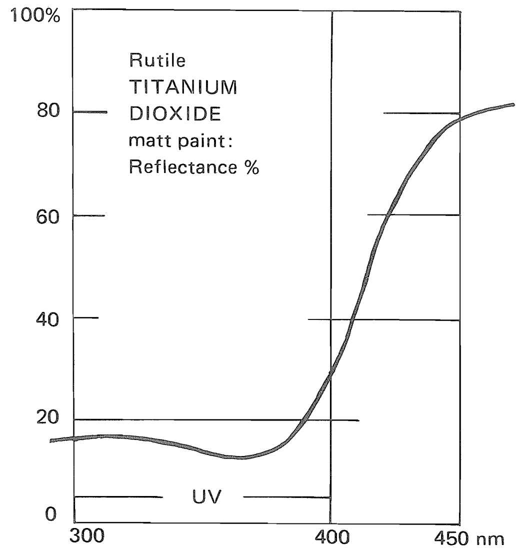


Figure 4. Reflectance of titanium dioxide paints

Standard advice is that U.V. should not exceed that from tungsten lamps (80 microwatts/lumen). Tungsten iodine (quartz halogen) are hot concentrated sources difficult to filter with plastics and should be acceptable unless run at the upper limit (short life, high colour temperature). But they do require glass to cut out a small quantity of very short but very potent U.V. of wavelength shorter than 300 nm.

We need an instrument to check whether U.V. is present and filters satisfactory (Fig. 5 and 6).

Visible Radiation. In devising guidelines for control of visible light we assume the "reciprocity law": damage is proportional to light intensity multiplied by time of exposure. Thus we assume that the damage is the same under 400 lux for 1 year as under 50 lux for 8 years.

The international unit of measurement is the "lux". The older UK/USA unit, the foot candle or lumen per square foot is equal to about 10 lux.

It may be possible to programme time of exposure but it is simplest and very essential to control light intensity by limiting illuminance (Fig. 7). To do this every museum must obviously have a light meter.

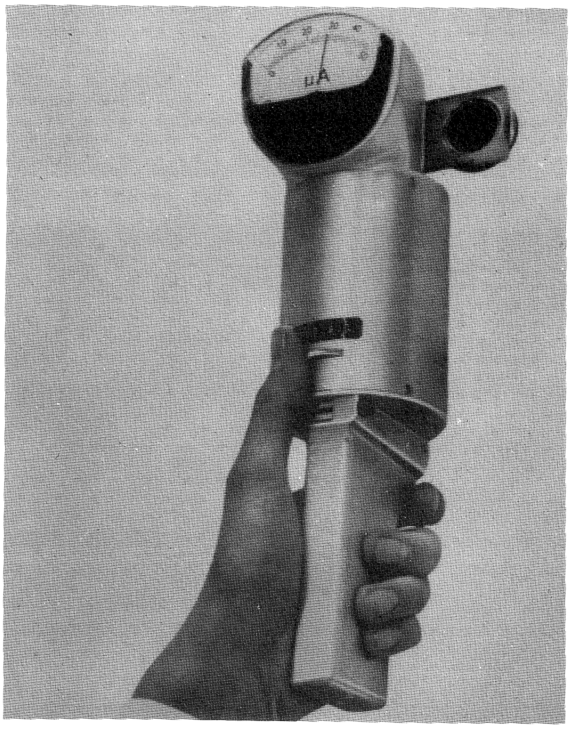


Figure 5. The Elsec UV Monitor. From Littlemore Scientific Engineering, Railway Lane, Littlemore, Oxford, England.

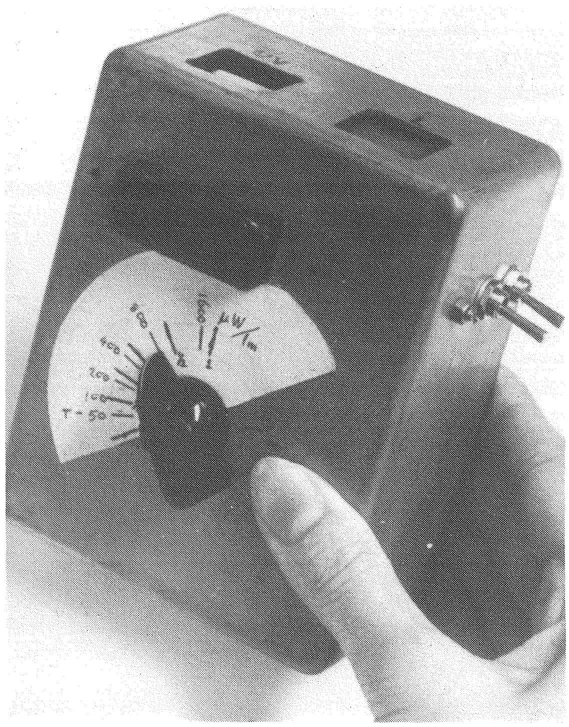


Figure 6. Prototype by Crawford for a new UV monitor to be made by Littlemore.

Reduction of illuminance

The following are recommended as values which *should not be exceeded* for the categories listed:

Oil and tempera paintings, undyed leather, lacquer (Oriental and European). Wood, horn, bone and ivory (where surface colour is important).	150 lux
Costumes, watercolours, tapestries, furniture, textiles, prints and drawings, stamps, manuscripts, miniatures, wallpapers, dyed leather, many natural history exhibits.	50 lux

UK Illuminating Engineering Society, French National Committee of ICOM, Russian Ministry of Culture, etc.

Figure 7. Recommended illuminances

Limiting daylight to a set level of illuminance is costly and not completely satisfactory so far, since photocell control of blinds or other light-limiting devices renders the light uniform in both time and space, thus eliminating much of the essential quality of daylight. However, daylight is often required, and the National Gallery, London, now has many galleries with daylight limited to 150 lux by photocell control.

It is not practical to limit daylight to 50 lux. But the warmer more controllable artificial light can be entirely satisfactory and appears apparently bright. One is not likely to come across many exhibits which are smaller and of lower contrast than historic stamps (Fig. 8). But great care must be taken to apply the following rules:

Ensure viewers' eyes are fully adapted.

Avoid glare.

Avoid veiling reflections.

Avoid strong contrasts in brightness of exhibits and surroundings.

Humidity

First aid and improvisations to avoid acute dangers of mould growth (over 65-70% R.H.) and embrittlement (below 40-45% R.H.) can be provided by free-standing room humidifiers or dehumidifiers. Only the one or the other will usually be required for this basic need. Countries with cold winters need humidifiers to combat winter dryness due to heating. The wet tropics and monsoon areas need dehumidifiers. Both humidifiers and dehumidifiers must be switched on and off automatically with humidistats. These are the equivalent of thermostats and consist of a sensor which responds to changing R.H. by operating a relay switch.

Humidifiers are of two kinds, atomizing and evaporative. Atomizing humidifiers send out a cool spray of very fine water droplets which disperse to vapour within a short distance from the machine.

Figure 8. The National Postal Museum, London, illuminated throughout at 50 lux.

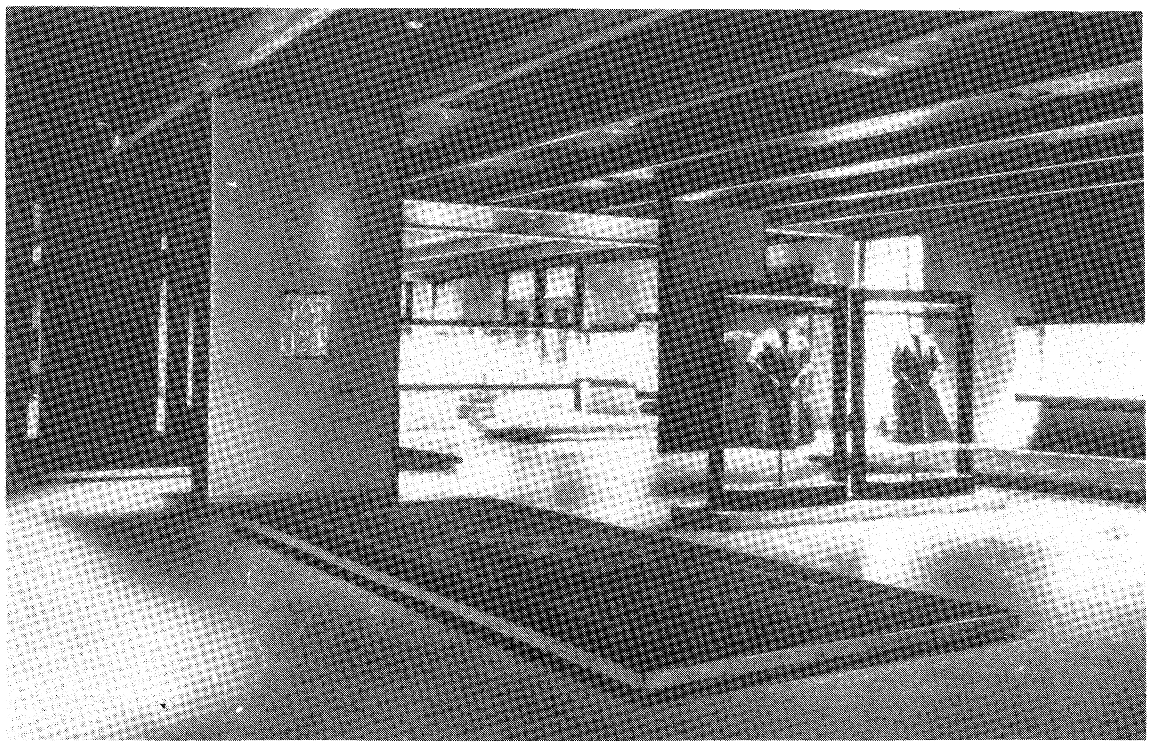


Figure 9. The Gulbenkian Museum, Lisbon. 50 lux. Side windows afford view of garden, but their glare is reduced with grey glass and net curtains.

Evaporative humidifers blow room air through a moisture-laden blanket usually of plastic foam. There is a strong preference for the evaporative type, since the older atomizing type has two disadvantages: (a) all the salts in the water are dispersed into the room, forming quite soon a grey deposit, unless deionized or distilled water is used; (b) if the humidistat sticks in the "on" position the room can become saturated with moisture. A failed humidistat on an evaporative humidifier will bring humidity to about 70-80%: bad enough but not so disastrous as 100%.

Room dehumidifiers are also of two types: the refrigerant and the desiccant. The refrigerant dehumidifier uses a heat pump closely similar to that in the domestic refrigerator. Room air first passes over the cooling coils, is cooled below its dewpoint and therefore deposits moisture. It is then reheated by passing over the warm "condensing coils" normally to be found at the back of the refrigerator. The desiccant dehumidifier makes use of a salt (e.g. lithium fluoride) which can be dehydrated by heat and is then in a condition to absorb moisture from air passed over it. A drum containing the salt slowly rotates, passing in turn a region where hot air drives moisture from it through a duct and out of the room, and then a region where the room air is passed through it and thus dehumidified.

Refrigerant dehumidifiers are the choice for warm climates, but frost up too readily in cool conditions. For cold climates desiccant humidifiers have the advantage.

Installation of a room humidity controller requires much work with a sling psychrometer or other R.H.-measuring device to ensure even mixing of air. Fans may be necessary and regular maintenance of these devices is important. Ducted air conditioning is the only complete answer to humidity control, and is essential for filtering out air pollution.

Air Pollution

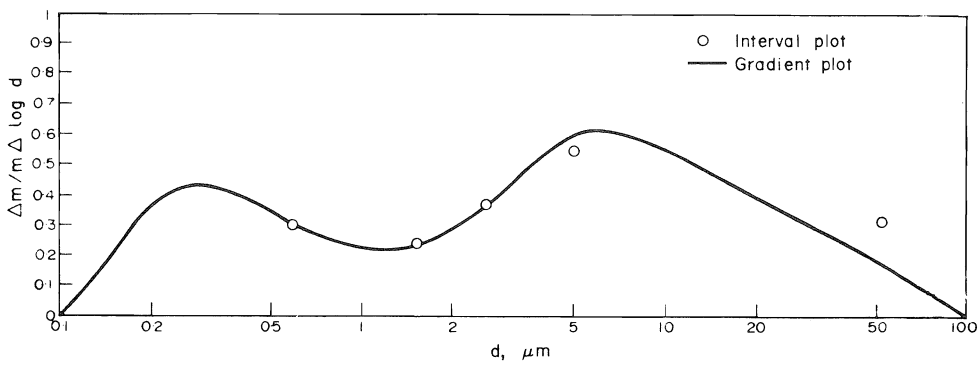
Particulates must be removed by passing the air through a fabric or plastic filter, and the choice of filter grade is determined by the size range of the particulates. We could if we wished take out 99.9% by weight of the particulates with "absolute" filters and with considerable extra cost, but they would be wasted in the relatively open situation of the museum.

It has been found quite recently that the size distribution of particulates is normally bimodal (Fig. 10), which is to say that particulars fall into two size groups, the dividing line being near 1 micron diameter (a thousandth of a mm). Dust greater than 1 micron is formed by direct mechanical action, e.g. abrasion, and is thus typed as "mechanical particulates." The particulates smaller than 1 micron have been formed in quite a different way — by combustion and by chemical processes occurring in the air. These sub-micron particulates comprise around 20% by weight of the total and are therefore important to us.

To test a filter we blow a standard dust through it and measure the proportion retained. British Standard Test Dust No. 2 is commonly quoted by manufacturers because it gives a high efficiency rating for even moderate filters. But it has nothing under 2 microns, so it will not do for us. British Standard Test Dust No. 1 (Methylene Blue) or the U.S. DOP (di-octyl phthalate) tests are finer and should be specified. At least 60% efficiency should be asked for. With recirculation in the air-conditioning system this will ensure that well over 95% by weight of the incoming particulates are trapped on the filter.

Removal of pollutant gases. Two methods are currently available: (a) Washing with plain or alkaline water. (In some plants humidity control is by continuous water spray at variable temperature.

Figure 10. Mass distribution of particulates in Melbourne.



Mainwaring and Harsha, *Atmospheric Environment,* 10 (1976), 60.

This can be an effective wash). (b) Absorption, usually on activated charcoal. Water-washing with recirculation of air can be effective for the acid gases sulphur dioxide and nitrogen dioxide. Activated charcoal (with recirculation) can be effective for all three of the dangerous pollutants, the above two and also ozone. Suggested specification for these systems are: (a) sulphur dioxide and nitrogen dioxide — each not more than 10 $\mu g/m^3$ (b) ozone — reduce to trace levels (0–2 $\mu g/m^3$).

A typical air-conditioning plant in diagrammatic form (Fig. 11) shows 90% recirculation of air. Fresh air is drawn through a roughing filter which need only be of moderate quality, its main purpose being to increase the lifetime of the main filter and keep the entrance duct clean. The main filter is according to specification above. Both humidity control and purification from gaseous pollutants is by continuous water spray. A more usual system today would require the addition of activated carbon filters.

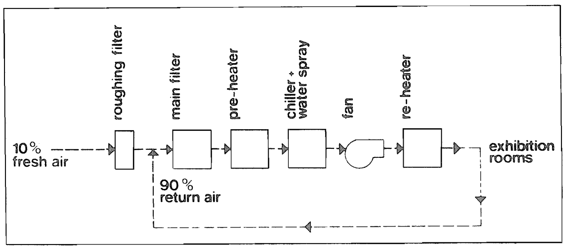


Figure 11. Diagram of an air-conditioning system.

Monitoring.

An air-conditioning plant is run by qualified engineers with their own instrumentation. However, the museum should ideally run independent checks on:

illuminance
U.V. protection
R.H. and temperature
particulate filtration
gaseous filtration

Hourly records need only include illuminance, R.H. and temperature (Fig. 12). For gaseous pollution, sulphur dioxide will serve as indicator and is best checked, not by an expensive continuous recorder (which in any case will have difficulty in dealing with these low levels) but by the old-fashioned lead peroxide cylinder which absorbs SO_2 over a month or two, or its more modern equivalent, a solution of sodium tetra-chloro mercurate (II) over a semi-permeable silicone membrane (West-Gaeke method) (Fig. 13). U.V. protection can quickly be checked with a monitor (Figs. 5 and 6), perhaps every 6 months. It can generally be arranged for an appropriate institution to check the particulate distribution, but this need only occur every other year or so.

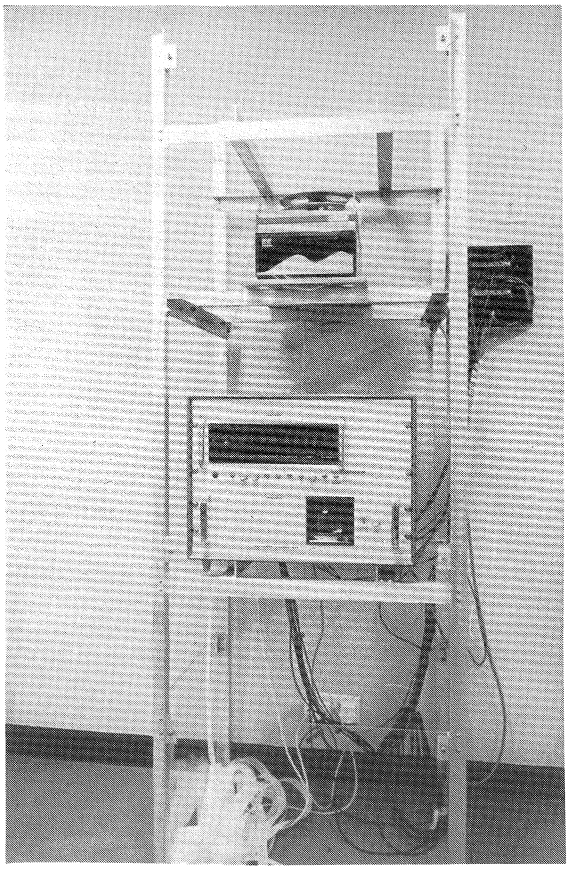


Figure 12. A pilot monitoring system covering the National Gallery Northern Extension for illuminance, R.H. and temperature. Hourly record on punched tape.

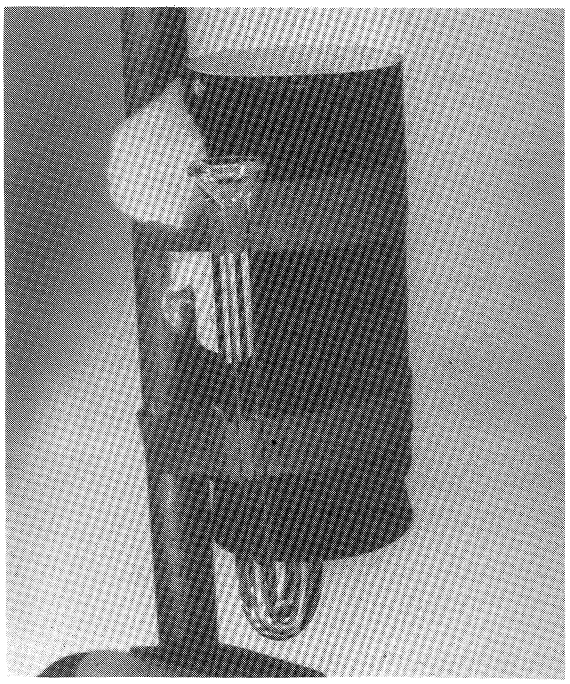


Figure 13. West-Gaeke type sulphur dioxide absorption cell.