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Air conditioning and lighting: two engineering facilities that can help money museology.

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Conservation of cultural heritages asks suitable environments not to compromise the unstable chemical and physical equilibrium that characterises the materials by which they are made: from this general point of view, the problem is the same in preventing a stone or a metallic object.

Keeping the objects far from any pollutant, for example in a passive atmosphere, no problem would arise, but what would be the meaning of the conservation itself if these things are not accessible at least to those who are interested in the mankind development during the earth's existence, that is to say students of our history whose reconstruction must be based only on cultural heritages?

So it is necessary to keep any cultural heritage accessible to people, possibly in the best conditions of visibility and in a comfortable environment: in these conditions, in general the principal enemies in preserving any cultural heritage are heat, moisture, gas, dust and light.

Generally speaking, a coin represents only the last moment of a series of cultural events, the result of a preparing activity going from a political and economical decision to the artistic creation of types, till the die engraving and than manual or mechanical act of minting: sometimes the activity goes on feeding the fantasy of painters and sculptors.

So money museology can interest the most various items: from ethnic pre-monetary objects to metallic coins, paper money, books, hand or print written documents, paintings, engravings, minting machines, and so on.

This is the reason why money museology involves every kind of problem faced while exposing cultural heritages in a suitable environment: points out some idea to meet this goal.

AIR QUALITY

The two main environmental parameters that we must control are air quality and microclimatic conditions of the atmosphere near the objects, but they must not be kept alone: other big problems come from radiant heat and light.

Related to the first one, it seems interesting to classify the materials as follow:

- MATERIALS SENSIBLE TO GASEOUS POLLUTANTS Leather tanned with vegetable products (ante 1850), Silver and Copper alloys, some mineral like Pirite.
- MATERIALS SENSIBLE TO SOLID POLLUTANTS (DUST): Oil paintings, Painted objects, Paper Papyrus, Parchment, Dresses, Tapestry, Skin, Fur, Straw and similar, Ethnological findings, Alabaster and Marble objects, Weak objects in general

The presence of gaseous pollutants joint or not with the presence of water (furthermore in the status of steam) may cause chemical reactions and even an air-tight show-case cannot, in many situations, solve the problem, as it is the material itself by which the case is made that releases chemical substances (typically this can happen with some quality of wood).

In the following table are collected some data about the maximum air pollutants concentration allowed in air for preservation purposes.

SO_2	**O_3**	**$N0_2$**	**CO_2**	**formaldehyde**	**dust**	**NH_3**	**VOC**	**Source**
1	2	5	4.5	-	-	-	-	(1)
2.5	25	5	-	4 ppb	-	-	-	(2)
1	25	5	5	-	75	-	4 ppb	(3)
12.5-25	-	-	-	-	-	-	-	(4)
1	5	5	-	-	-	-	-	(5)
10	2	10	-	-	-	-	-	(6)
1	25	5	4.5	-	-	-	-	(7)
-	50	-	1.8	30	60	20	200	(8)
1	25	5	-	-	-	-	-	(9)
10	2	10	-	-	-	-	-	(10)
12.5-25	10-20	10-20	-	-	-	-	-	(11)

(1) Parufil, D.P.C.P. Dutch Gov.
(2) Archives II, Adelphi, Maryland
(3) California State Archives
(4) Cenacol, Milano
(5) Minnesota State Archives
(6) Thomson G.
(7) U.S. Dept. of Commerce
(8) I.A.Q.
(9) *N.B.S.*
(10) Newberry Library
(11) *Nat. Inf. Standard Organ (USA)*

MICROCLIMATIC CONDITIONS

The microclimatic conditions may be represented by temperature and moisture content or relative humidity, the last defined as the real moisture content divided by the maximum weight of water as steam that the air can keep, depending on temperature; in table 1 the most common materials are split into five groups of different sensibility to humidity and temperature.

GROUP A	**MATERIALS THAT NEED STRICT RELATIVE HUMIDITY CONTROL**
	Inlayed, veneered wooden Furniture, Wooden musical instruments, pictures on Wood, Wooden sculptures, manuscripts on Paper or Parchment (if exposed to light), oriental Lacquers, Gypsum, Japanese Screens
GROUP B	**MATERIALS THAT CAN TOLERATE SOME FLUCTUATION IN RELATIVE HUMIDITY**
	Textile and Clothes, oil pictures on Canvas, paper and Parchment, Papier maché, materials of Vegetable origin, Wood and Wooden objects and Furniture, Bone, Ivory and Horn objects, lacquered Wooden objects, non metallic Armatures
GROUP C	**MATERIALS THAT CAN TOLERATE HIGH FLUCTUATIONS IN RELATIVE HUMIDITY**
	Stone, marble, Ceramics, Glass, Alloys with Gold and Silver
GROUP D	**MATERIALS THAT NEED DRY ATMOSPHERE**
	Iron, Steel, Brass, Bronze, Copper and alloys, Lead, Tin and alloys, common Silver, common Gold, archaeological Bronze, iridescent Glass, Textiles with some metal wire, Mummy and Mummified findings
GROUP E	**MATERIALS THAT NEED LOW TEMPERATURE**
	Furs, Pelt, Animal findings

Table 1 - Sensibility to Temperature and/or Relative Humidity

To achieve a satisfying level of air quality in presence of sources of pollutants and/or moisture, the only way one have is to change indoor air with pure air coming from outdoor, and this is possible with an air conditioning plant that filters outdoor air and modifies the igrothermal characteristics of air to meet the required conditions for indoor.

HUMIDITY

The moisture content can be represented in two ways, depending on a different point of view: absolute and relative. Any change in temperature of a certain volume of dry air that does not change the weight of moisture kept within, changes also the relative humidity value, and this is a big problem in humidity control.

The absolute content is obviously the weight (in grams) of water steam that is mixed with one kilogram of dry air: usually we live well in an atmosphere where there are about 8 g/kg in winter and 17 g/kg in summer, while in very hot and humid days it is possible to have till 25 g/kg.

Humans and objects are sensible to changes of relative humidity (r.h.), but not so sensible to changes of absolute humidity if also temperature changes: for well being this r.h. figure must not change during the day and in less measure also during the seasons.

So, to maintain the requested value of r.h. it is necessary to add moisture in winter and subtract moisture in summer (but also when people enter in a show room): therefore, to achieve this result we need some technical apparatus, and technical apparatus are always characterised by two factors, reacting time and accuracy.

AIR CONDITIONING

These two factors represent the big problem of air conditioning for preservation purposes, in particular when cultural objects like paper money must be shown to public.

During past centuries, when cultural objects where kept in castles or big monumental buildings, the problem was automatically solved by the concurrence of many factors as the high thermal inertia of the walls, the reduced dimension of the windows, the permeability of masonry and windows to the moisture, the reduced number of visitors, last but not least, the low artificial lighting level.

Nowadays, even if we keep cultural objects in monumental buildings, the problem arises from the high number of visitors, that suddenly bring in a lot of moisture and heat: then they go out often before the air conditioning plant has the time necessary to balance these new environmental conditions. Immediately, sometime before that a new stock of visitors can attain the room, the H.V.A.C. plant brings in fresh and dry air: as a consequence, a series of rising up and going down in temperature and relative humidity in the surroundings of the objects compel them to a continuous movement of constraining and dilating, surely not present in the past.

Furthermore, the regulation mechanism is based on two different kinds of devices, the sensor, that reacts to a physical stimulus, and the actuator, that reacts to an electrical one: so, both are characterised by a soil under which the apparatus is insensible.

The sum of these two soils represents the accuracy of the regulation system: this accuracy may be improved, but it will never be possible to lower the soils under a value that depends from the selected parameter: as for the temperature, it is quite impossible to get values under 0,1 °C each, so the system will react only after that the temperature is raised up of a minimum of 0,2°C.

As far as the humidity is concerned, this minimum cannot go under 0,5%.

Another limit refers to the spatial uniformity of the value, as we can measure only in one or some point but it would be possible to have the same value everywhere in the controlled space only if we realise a perfect mixing of the air, that is to say only if we move violently and accurately the air in the whole space interested, so causing another kind of problem to things (for example, curtains cannot stand vertically) and humans.

As for temperature and moisture content, we must remind that in general any material is well kept in air with about 50% of relative humidity, with a span of plus or minus 5% from summer to winter. The natural gradient of temperature in ancient buildings is of about 0,25° C per week, so our plants must realise at most values of 0,5'C/week, spanning from 19°C in winter to 23°C in summer, (FIG. 1)

The trend is now towards maximum energy conservation, so it is costume to switch off the thermal plant when people is not present or, in residences, during night time: this kind of behaviour is absolutely forbidden for the conservation of cultural objects in general: even metallic objects, like coins, may be submitted to sudden and repeated movements that can physically damage the object itself.

The thermal plant can be general, as it is usually in coin exposures, or particular, as it is usually for big objects like painting, artistic windows, tapestry and so on.

LIGHTING

Another environmental problem is related to the light, that is indispensable while examining little artistic objects like coins, but even a big enemy of the conservation, due to direct (electromagnetic) and indirect (heat) effects on other items: table 2 presents a general sensibility scale to light.

VERY SENSIBLE	Textiles (in particular Silk), Paintings on Paper (in particular water colour), Books and Manuscripts, Leather, Plumage, Ethnologic materials coloured with vegetable products, Tempera painting not varnished, some Modern picture made by unstable colours, Lacquers, Alcoholic colours
SENSIBLE	Oil paintings, varnished Tempera paintings, Organic materials of Vegetal origin
QUITE INSENSIBLE	Metal, Stone, Ceramics, Glass not coloured

Table 2 - Sensibility scale to light exposure

MATERIAL	EFFECT OF LIGHT	SUGGESTED
COLOURS	Water colours suffer chromatic changes as they are mixed with a weak vehicle not enough protective	40 - 50 lux
TEXTILES	Vegetable and animal fibres are not coloured, so being insensible, but if coloured they undergo chemical reactions that mechanically weaken the staples	40 - 50 lux
PAPER	Paper of good quality is quite stable to light but, in presence of resins, weakening and yellowing can accelerate	40 - 50 lux
WOOD, IVORY	Wood changes colour (mahogany and walnut fade, oak and rosewood yellow, teak darkens). U.V. rays change moisture content in wood and ivory, wood warps, ivory can also break	75-120 lux
LEATHER, PARCHMENT	Moderately sensible to light, painted leather is more delicate	75-150 lux
VARNISH, BINDERS	They are sensible to U.V. and can fade, oils and resins loose volatile substances, with surface erosion and constrains. Varnishes became less sensible to solvents	75-150 lux
METALS, CERAMICS, STONES, GLASSES	Insensible to light, but glasses can sometime change colour	300 lux

Table 3 - Lighting suggested values and consequences of excessive light level

We have different kinds of lighting for different kind of objects, but surely we must minimise the quantity of liqht that we send on the object, obviously without reducing the possibility of appreciate any detail of the object itself.

As the lighting system brings also thermal energy, the air conditioning plant must be chosen having in mind the selected kind of lightening system.

Little objects like coins are usually exposed in show cases and here it is now possible to obtain good results with very little electrical power, so reducing the thermal shock, always present when the lighting system is switched on or off.

Generally speaking, the lighting level on the object must not exceed the values of table 3, where the lighting value is associated to the material. Following the most recent researches, it is recommended not to exceed annual light doses as presented in table 4; these proposals seems as interesting as practicable for the management of sections of a museum or temporary exhibitions.

VERY SENSIBLE MATERIALS	**SENSIBLE MATERIALS**	**Source**
54.000 lux hour/year (no U.V.)	500.000 lux hour/year (no U.V.)	III. Engng. Society, North America
50.000	500.000	AIDI (It. III. Society)
-	600.000	National Gallery
200.000	500.000	CTI (Thermotechnical Italian Society)
125.000	1.120.000	PHILIPS

Table 4 - Recommended values for annual light dose

When one faces the problem of preparing a presentation of coins, the first problem arises from the choice of presenting only one face or both. If the choice is to present obverse and reverse, having available only one coin, it is necessary a particular attention on lighting (usually coming from the top) as it is not possible to lie down coins: in this case a reinforcement from the bottom can solve the problem, so better underlying the design with light and shadows (see figure 2) without any dazzling effect.

Another problem is linked to the lack of space when we have many coins to show; a situation to be avoided, as many coins cannot be lighted in the same way when exposed in the same show-case.

When light is coming from the top (see figure 3) it is necessary to avoid the reflex from the glass otherwise the observer sees oneself together with the exposed coins (figure 4).

In conclusion, there is not a general solution for lighting problems, but many solutions are analysed, for example, in bibliography to which readers are addressed for more details.

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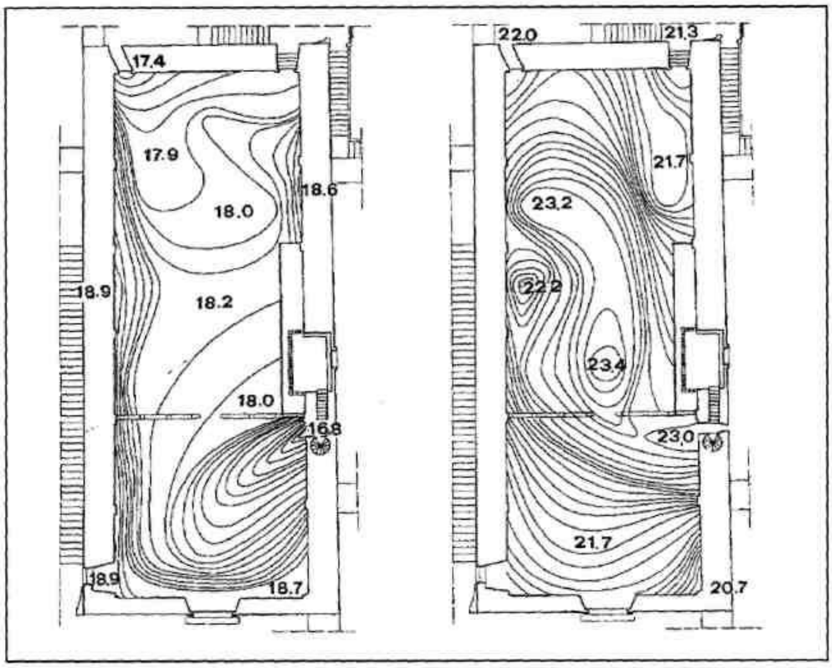
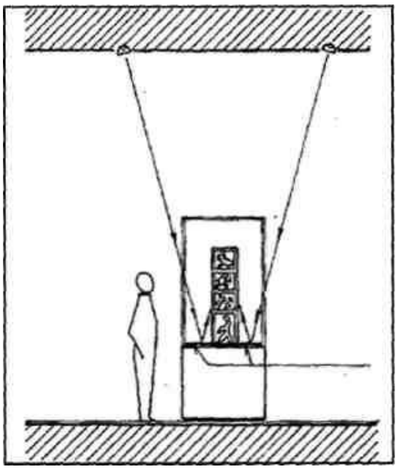


FIG. 1 Air temperature in a horizontal cross section of the Sistine Chapel when it is opened for cleaning (left) and after the entrance of visitors (right)

FIG. 2 A sketch of a possible solution of lighting both from the top (direct) and the bottom (reflected).



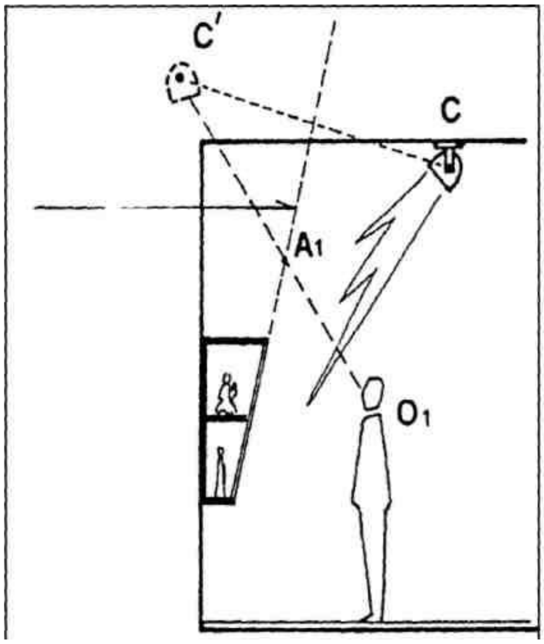


FIG. 3 A sketch of a possible solution of lighting from the top.

FIG. 4 A sketch of a situation that can create a reflected image on the glass.