PHW:JHMc
V-1

DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
WASHINGTON, D. C.

Letter
Circular

LC 288

(September 23, 1930).

PAINTING PLASTER

There is more trouble with paint failure on plaster than on all other structural materials combined. It is the only material on the interior of a dwelling or office building on which paint does not stick. On wood, if in a north room where no direct sunlight falls on the surface, ordinary interior varnish which will fail utterly in a few months outdoors, is generally in excellent condition after twenty or more years. On plaster, modern paint frequently utterly fails in a few years. The failures generally occur on ceilings, and since the failure is most often a flaking off in more or less large areas and such flaking is easily brought about by water back of the film, the painter can generally lay the trouble to water. He is, however, very often wrong in this conclusion. Paint, either the ordinary flat wall paint or long-oil stipple paint, will in time come off in large flakes from ceilings that have never been wet after the plaster was applied. In numerous instances, of paint failures (flaking off) on walls and ceilings, a laboratory examination of that side of the flake which was next to the plaster has demonstrated the presence of plaster. Such flakes collected from ceilings that had never been wet after the paint has been applied, consisted of four or five times as much powdery plaster as of paint.

While gypsum plaster has been known for many centuries, the white coat plaster used in America until within the last 50 or 75 years was lime-white sand or lime-marble dust plaster, with no gypsum. The ordinary white coat plaster today is made from lime putty (hydrated lime and water), in which a varying amount of plaster of paris is mixed shortly before spreading. The ratio of hydrated lime to plaster of paris varies from equal parts to 3 lime and 1 plaster. Hence, the white coat seldom contains less than 25 per cent of plaster of paris and may contain as much as 50 per cent.

The old type of white coat contained no plaster of paris but consisted of approximately equal quantities of hydrated lime and white sand or marble dust. The change that takes

place in lime-sand or lime-marble dust plaster is first a simple drying out accompanied by some conversion of the hydrated lime into calcium carbonate by reaction with the carbon dioxide in the air. This reaction continues slowly for a long time, gradually converting more and more of the hydrated lime into carbonate ($Ca(OH)_2 + CO_2 = CaCO_3 + H_2O$). While of course the same conversion to carbonate occurs with the hydrated lime in the more commonly used lime-plaster of paris plaster, the important reaction which gives the quick setting is the hydration of the plaster of paris with the reformation of gypsum, $(CaSO_4)_2 H_2O + 3H_2O = 2(CaSO_4 2H_2O)$.

Calcium carbonate is a very stable substance that can be gently ignited without decomposition. It is also very slightly soluble in water (0.0065 g at 20° and 0.002 g at 100°C in 100 g H_2O).

Gypsum ($CaSO_4 2H_2O$) is not only much more soluble in water than $CaCO_3$ (0.241 g at 0° and 0.222 g at 100°C in 100 g of water) but it loses its water of hydration if exposed to dry air at ordinary room temperature. If a clear crystal of gypsum is put in a desiccator over a reasonably good dehydrating agent, for example concentrated sulphuric acid, and observed from time to time, a gradual change in the crystal will be seen after three or four weeks. It will no longer be transparent but will be covered with a white powder of $(CaSO_4)_2 H_2O$ (plaster of paris). Similar changes can take place in gypsum plaster. It is known that no paint coating is impervious to air and water vapor, and therefore a paint coating can only somewhat retard such changes. It can not prevent them. It might be possible to cite some ancient plaster that is known to be gypsum plaster and is known to be in good condition at the present time, but such an example would not refute the above reasoning, because the conditions prevailing in our buildings never prevailed in olden times and do not prevail anywhere except in America today. Today in Europe and less than 40 years ago all over the world a house was considered comfortable in winter if the temperature was 60°F and few houses were ever that warm in cold weather. Today in the United States 70°F or more is generally demanded. Temperatures are measured only slightly above the floor level, but they are notably higher at the ceiling. It is an exceptional case when adequate steps are taken to increase the water content of the air in our buildings. When the outside air is at 32°F and saturated with water vapor, on heating it to 60°F it will be

36.5% saturated, on heating to 70°F it will be only 26.2 per cent saturated, on heating to 80°F only 19.1 per cent saturated, and on heating to 90°F only 14.2 per cent saturated. The corresponding figures for outside temperatures of 0°F are 8.1, 5.9, 4.3, and 3.2 per cent for outside temperatures of -10°F, 5, 3.5, 2.5, and 1.9 per cent. It is therefore evident that in many, if not most, heated buildings there is very dry air, particularly next to the ceilings, during several months each year. Dehydration when it has progressed to a considerable extent will result in the plaster becoming powdery, and if the plaster is not covered with paint there will be simply a gradual falling off of dust. If gypsum plaster gets wet and then dries out, it is also weakened by the solution and recrystallization of $CaSO_4 2H_2O$. It is therefore apparent that unless gypsum plaster is kept under conditions where it never gets too dry and never gets actually wet, it will become powdery on the surface. On the other hand, lime-plaster is not injured by dry air and on account of the lower solubility of calcium carbonate and calcium hydroxide will be injured less by occasional wetting and drying than gypsum plaster.

It must not be forgotten that a new building or even an old building that has been replastered contains an enormous amount of water. Even under the most favorable conditions it takes a long time for plaster to become dry enough for the application of the ordinary oil paints. The demand of the owner or builder for haste in finishing is very liable to cause the painting to be done over walls that are not dry. Even with dry plaster the common method of applying full pigmented oil paints giving a distinct layer of paint over the plaster seems illogical. If such coatings must be applied, probably the best preliminary treatment is to first be sure that the plaster is dry and then slightly roughen the surface by sandpapering, dust thoroughly, and apply a size coat of water-resisting varnish thinned with turpentine or mineral spirits. After this is dry, use a first coat paint containing considerable boiled oil and use the fewest possible number of coats to give the desired appearance.

It would generally be much better to avoid using full paint coats but to roughen and dust the surface as above and use one coat of thin oil stain, the idea being to have this penetrate and stain the plaster. Of course only lime-proof pigments should be used here.

The best and most durable of all methods of painting new plaster is the oldest, and while it seems particularly well adapted to our modern demand for speed in finishing a new building it is one seldom heard of. This is the fresco process.

In this process hydrated lime is the only white pigment used, and finely divided lime-proof pigments suspended in pure water, with or without the addition of hydrated lime, are applied to the wet plaster. The old masters always applied the fresco painting the same day the plaster was laid. The painter avoided retouching except when absolutely necessary and the whole operation was completed before the plaster had time to dry. What takes place is that the pigment suspended in water partially penetrates into the plaster, and the solution of calcium hydroxide in the plaster during the process of drying is drawn to the surface, surrounds the particles of pigment on the surface, and by reaction with the carbon dioxide in the air is converted into calcium carbonate, thus binding the pigments on the surface. In other words the paint becomes part of the plaster. While large areas can be uniformly colored by this process, it is best adapted to the popular irregular finishes, such as "sponge effect", "crumple roll", etc. The paint which, as mentioned above is a suspension of lime-proof pigment in water without binder, may if desired contain alkaline or neutral volatile dispersing agents. For example, with some lots of ultramarine a little ammonia has been found to be a desirable addition to the water. While such paint can be applied with brush or sponge, spraying and then mottling with sponge or paper is certainly one of the best methods of application. With this method of painting the decoration of the walls can be completed within twenty-four hours after the last of the plaster is applied.

While such a paint will be more durable than oil paint on any kind of white plaster, if the opinion is correct that gypsum plaster is less durable than lime plaster, it follows that the fresco painting on gypsum plaster will be less durable than that on lime plaster. No records of very old painting on gypsum plaster are known, but there are some very celebrated frescoes on lime-sand or lime-marble dust plaster that have stood for centuries. In citing one such, it may be instructive to bear in mind some comparative dates. Ponce de Leon was the first white man to record landing on any part of what is now the United States. He landed in Florida in 1513. Michael Angelo started work on the frescoes in the Sistine Chapel at the Vatican in 1508 and finished in 1512. They have, therefore, lasted longer than the whole period of United States history. The unusual artistic ability of the masters, such as Machael Angelo, and the fact that they considered it necessary to use thick

coats of plaster, to complete the painting the same day that the plaster was laid, and to do the work right at the first painting - no retouching, may be the reason that true fresco work is now seldom used. If, however, it is applied to present-day decorative methods that do not involve pictures of terrestrial and celestial beings there appears to be no reason why it can not be used by any competent decorator with saving in cost of material, labor and particularly time. The decorator may be sure that the paint will outlast any oil paint on plaster and that when redecoration is desired the plaster will be in a better condition for the application of oil paint than it would be if it had been originally painted with oil paint.

To sum up the following suggestions are worthy of serious consideration:

(1) Use no oil paint on new plaster; but use water color without binder and do the painting as soon after the plaster is laid as possible; always before the plaster has dried.

(2) With old plaster that can not be thoroughly soaked in water for the water-color painting, roughen the surface and use an oil stain instead of paint.

(3) Only when neither of the two preceding methods can be used should oil paint be applied. When this is done, see that the plaster is dry, roughened and clean, and size with a varnish. Use the smallest possible amount of paint.