ARTUR KRATZ

A NEW METHOD OF STONE RESTORATION

Every kind of stone decay caused by a foreign substance which decomposes the stone, splits up its crystalline structure, creates cracks, has other destructive effects on the stone. An ideal restoration must aim at freeing the stone from all foreign substances, purifying it throughly, saturating and hardening it. This must be done also to the very core and not only on the surface. A treatment of the surface cannot stop decay, it can merely exert a temporary influence in its conspicuous results. It seems to delay decay, but it cannot prevent it.

No matter which means of restoration one decides to apply, none of them has up to now succeeded in penetrating the stone further than just a few millimetres. Penetration of the whole stone is the basic demand for every restoration.

Considering this state of affairs, I have endeavoured to find out a method, which would enable the restorer to saturate the stone in all its pores with every kind of solvent.

The method of watering stones with a large common salt content has been known for many years. It is based on the knowledge that a work of art cannot be saved from total decay, unless the salt damaging the structure of the stone is removed. This method, however, involves both considerable expenditure and substantial dangers for the stone. It is placed into a bigger or smaller vat of water for as long a period of time as it takes to leach out all the salt of the stone. With big stones it will take at least 1 or 2 years, in the course of which a complete removal of the salt cannot be obtained. Besides the stone is subjected to considerable strain. Even if the stone concerned is fairly well preserved, one will not easily make up one's mind to expose it to influence of water for a period of years, for in the end, it will in any case show more or less substantial damage. Stones having a coat of paint cannot be watered without their colour being destroyed.

Another method to free stones of salt consists in casing them with paper pulp. It is applied when a stone is too big or too damaged by the influence of salt to stand watering. The salt dissolves, it is taken into the pulp when the water evaporates and there it settles. During that process however, only a few millimetres under the surface of the stone are cleaned of salt. The method is incomplete and is not worth the expenditure.

The problem is to substitute those tedious and insufficient treatments by a method which is as simple as possible and will show satisfactory results. Thus I took the following starting-point for my considerations:

Stone is porous. Non-porous stone, marble-stone e.g., does not contain any salt. Because of its porosity the stone can absorb water. The water in a stone rises according to the principle of capillary attraction. It rises higher, the narrower the capillary tubes are. If I thus case the stone with an air-tight and water-proof layer, leave an opening at the upper part of the layer for the air to escape, place the stone with its open bottom into a tub of water, the water will rise to a certain height within the stone. If I connect a vacuum with that upper opening, the water will be forced to go on rising and to run off through the vacuum tube. If I steadily create a vacuum on the top of the stone, the water continually escapes from the tub — which I can fill up time and again — through the stone, and runs off through the vacuum tube. Salts and other soluble substance contained in the stone are dissolved thereby and taken away by the water flowing through. In this way it must be possible to completely wash out all foreign substances contained in the stone, as the water is forced to flow through all its pores.

In order to get a positive proof of the correctness of these considerations, a small white sandstone, having a basal surface of 10 × 10 cm. and a height of 30 cm., was covered with an impermeable layer. A small hole was left in the base and the stone was placed in a flat tub of blue water. As early as a few hours later the stone was filled to capacity and the water ran off through the vacuum tube into a container kept ready for that purpose. As expected, blue water, light blue at first, then dark blue, appeared at the tap connection. After that the stone was taken out of the casing and it was broken asunder. The blue water had infiltrated all its pores, the stone was equally blue to the core. That, however was not the end of the test. The stone was cased anew and saturated with pure water. Some time afterwards the blue colour was leached out of the stone. It had become white again. No blue pigmentation was to be seen any longer. The whole test took five days.

To make sure that even within a big stone the water would flow through all parts equally, the following experiment was made:

A red sandstone, very solid and tight, basal surface abut 30 cm × 50 cm, height 80 cm, was covered with that impermeable skin. Several tap connections were installed for placing the vacuum. Once again the base was left uncovered, and the stone was placed in a flat tub filled with water. It took 14 days until the first drops of water escaped from the stone. After the water had escaped from all tap connections and several litres had flowed through the stone, blue water was used again. As expected, the blue colour showed at the lower tap connections first, then, rising, it escaped from the upper ones as well. Since we could suppose that approximately three quarters of the stone would be filled with blue water, the experiment was stopped and the stone was opened. The lower part was totally intermingled with blue water, the blue colour had saturated all pores equally. Proof was furnished that uniform rising of water took place in a stone, in the core as well as close to the surface. My suspicion that veins might be formed in the stone by means of which the water might reach the tap connections turned out to be groundless. Indeed the rising of the water took place in all parts of the stone equally.

The test stone described above had been worked on around 1920. It was part of a tomb cleared away in 1950. Since that time it had been left among other stones on the ground in the open air. Some parts had grown brittle. It began to decay. Narrow cracks formed, the common sign of decomposition. On the whole it was still in rather good condition. The water, tapped off before the colour test, was a darkbrown-reddish, partially brownish-green colour. Since all

pores of a stone are saturated when the above method is applied the solution was accordingly concentrated. The whole process took a rather short time. The chemical analysis read as follows:

The amount of inorganic substances was found by heating the dry residue at 1000 °C. As heating residue it amounted to 2,75%.

The amount of organic substances amounted to 7,85%.

The metals formed were tested by spectroscopic analyisis.

The main substance was zinc beside some larger quantities of aluminium manganese and magnesium.

As far as acid residues are concerned the presence of sulphates and a small amount of chlorides was proved.

The tests made in order to find the varieties of organic substances had the following results:

1. organic nitrogen compounds	proved
2. organic suphur compounds	proved
3. carbohydrates	not proved
4. natural resins	not proved
5. albumin products (amido acids)	proved

A small quantity of the test material was poured into ether, the ether extract was dried up, and was tested with the help of an infra-red spectral photometer. From the spectrum we could conclude the presence of carbonic acid.

This result shows that even such stones, which have been in the open air for only a short period of time, do take up destructive substances. Thus the problem of how to clean stones of their salt content does not only concern works of art from older epochs but also all those monuments from later and latest periods, if they show signs of inside decay.

Up to now the question of how to clean stones of salt has only been understood in the sense of freeing the stone from destructive common salt. That however, is only part of the problem. The method of watering, which was applied so far, was only useful for stones with a large common salt content. The new method however, grants permanent restoration, as it enables the restorer to purify all stones from inside when they show signs of decomposition.

I am now going to report on a restoration done according to the method described above. It concerns the statue of an enthroned Isis with a horus boy on her knees. The material is a soft narrow-pored limestone. The figure was excavated in Egypt and was acquired in 1961 by the Department of Sculpture at the « Staatliche Museen » (Stiftung Preußischer Kulturbesitz).

The stone was soft and brittle like chalk. Crumbs of soil were still in its folds and it was impossible to remove them, as the stone would have dissolved to pulp in water. In some places small blisters were to be seen. Pieces had fallen off the socle during transportation. A small piece of the stone was tested and showed a large common salt content. Later on, it was found that the true amount of common salt surpassed the result of the test tenfold. To prevent it from falling into pieces the stone was at first hardened with a « Fluat ». (Fluats are salts of silica fluor-hydrogen acid. Combined with metals they turn into different kinds of salts. These metal silicofluorides are put on the market under the general name of « Fluat »). The chemical reaction, the transmutation from lime to calcium took place with a slight effervescence. Small bubbles appeared and they did not stop rising until the process was completed. It is important to permeate the stone to the core, whether you apply a treatment with fluats or prefer any other kind of saturation method. The chemical reaction has to take place everywhere quite uniformly. The saturation with fluats cannot be compared with conventional saturation methods. The point is the transmutation from lime into a rather constant calcium fluoride and into silicic acid, which fills up the pores of the stone as a solid crystalline structure.

This process took two days. About two weeks later the whole chemical process had come to an end. Within that time the hydrous silicic gel had changed into solid silicid acid. Afterwards it was possible to remove the particles of soil and some stains from the surface with the exception of those parts wich were completely amalgamated with the stone. It could be washed and scrubbed with a strong brush without any danger. Now the actual operation, the leaching out of the inner structure of the stone could begin.

Once again the stone was covered with the air-tight skin mentioned above and it was connected with a vacuum. The isolation layer is put on in liquid condition and hardens to a gumlike foil, which fits the stone like a skin. At the end of the process it is easily removed. By action of the vacuum the skin is pressed close to the stone and thus it protects its surface. It is important to fix all loose particles before the work begins, otherwise they might fall off when the foil is removed. The size of a figure does not matter. These operations can be done everywhere and in any room. No special outfit is needed. It cannot be foretold how much time will pass until the first drops fall into the tub. It depends on the size and the constitution of the material. A widepored stone needs much less time than a narrowpored one. In our case it took two days before the first drips could be tapped. For big figures several tap connections must be installed, as we did. Of course the water first escaped from the lower tap connections, rising slowly to the upper ones as well, and gradually it streamed through the stone into the container. During the first days about 1 litre per 24 hours was tapped off through the stone, through its fine and finest pores. After that the consumption of water amounted to about 3 litres a day. The whole operation took six weeks. On the whole, 90 litres had flowed through the stone. The salt content of the water tapped was rather large in the beginning. Six days later it increased approximately tenfold. Another four weeks later it rapidly decreased, and at last the test formed only a small amount of salt, not more than can be found common tap water.

The working period of six weeks is rather short for a narrowpored stone of such a size ,the more so when one considers that total purification is obtained. It is advisable to use distilled water, as unclean particles contained in tap water might disturb the purification process.

The question whether painted stones can be purified it this way without endangering the colour must — as a matter of principle — be answered in the affirmative. Proof was furnished as to the correctness of statement this However special care must be taken when removing the foil. A painted sandstone, a head fragment from the 14th century (19 cm high, 14 cm wide, 17 cm deep) whose coat of paint had been preserved in great part, was purified in the manner described above. After the paint had been fixed with casein the stone was inserted and connected with a vacuum. Five hours later the first water was tapped off. Three

weeks later the process was completed. The colour had neither changed nor was the coat of paint loosened. Not the slightest particle was lost.

Let us recapitulate: The method of stone restoration presented here provides a means of penetrating, impregnating and, if necessary, even saturating all limestone and sandstones which show signs of decomposition, even to the core. This can be done with every kind of solvent. Even brittle stones which could fall into pieces can be treated without any risk. The working process takes only a short time. The expenditure is small and costs are low. No special equipment is needed. The operations can be done everywhere and in any room. The method has been registrated at the Federal patent office.

ARTUR KRATZ

NOUVELLE METHODE DE RESTAURATION ET DE CORSERVATION.

RÉSUMÉ.

Aucune des méthodes appliquées à ce jour n'a donné un résultat durable par le fait qu'il est impossible de pénétrer complètement à l'intérieur de la pierre ,infectée à coeur. Le but de la restauration serait de libérer la pierre des corps étrangers, de la purifier à fond et de la saturer afin de la durcir d'une manière homogène à l'intérieur et non seulement en surface.

Un traitement externe ne peut pas arrêter la désagrégation car il n'exerce, sous de résultats visibles, qu'une influence temporaire. Il ne peut donc que retarder en apparence la destruction mais ne peut jamais la prévenir. Il est indubitable que, quels que soient les moyens de saturation adoptés, il n'a pas été possible jusqu'ici de pénétrer dans la pierre, en profondeur, à plus de quelques millimètres seulement.

J'ai essayé de trouver une méthode qui soit capable de restaurer en pénétrant complètement dans la pierre et de toutes parts au moyen d'un liquide et j'ai réussi.

Cette méthode est basée sur la propriété de capillarité des pierres poreuses: On revêt la pierre d'une substance imperméable, sauf à la base et au sommet où l'on ménage un orifice relié à un tube de vidange.

Si l'on immerge la pierre dans l'eau, elle est complètement drainée à cause du phénomène d'absorption capillaire qui se produit de bas en haut, et elle expulse l'eau de lavage par le tube.