Scientific American Supplement, Vol. XXI., No. 526.
Scientific American, established 1846.

NEW YORK, JANUARY 30, 1886.

{ Scientific American Supplement, \$5 a year.
{ Scientific American and Supplement, \$7 a year.

PRESERVATION OF BUILDING MATERIALS BY THE APPLICATION OF A PARAFFINE WAX COMPOUND, AS RECENTLY USED UPON THE EGYPTIAN OBELISK, CENTRAL PARK, N. Y.*

By R. M. CAFFALL.

IN discussing the subject of waterproofing and preserving building materials, it will be necessary first to consider the causes of decay in such materials, and how it may be prevented.

The most powerful natural agent that disintegrates stone and other similar building material is undoubtedly water, especially when it freezes after it has entered into the interstices of the stone, as it then exerts a force that is irresistible.

Mr. Dexter A. Hawkins has told me that he had seen in the New England States immense boulders of granite near the roadside which had been so powerfully acted upon by freezing water that it was the custom of those living there, when they required material for repairing roads, to back their wagons up to one of these apparently indestructible masses of rock, and by simply striking it with a pick, it would crumble into small pieces, which were then shoveled into the wagon, drawn away, and spread where required. He also mentioned having seen in the cañons of Colorado and elsewhere in the West immense banks of debris, one hundred feet or over in height, formed of matter forced off by frost from the face of the rock cliffs above.

The evidence that water is the most destructive agent can be seen on any building where the exposed stone remains the longest in a wet state, as, for instance, the base of the wall near the ground, the stoops, the stonework under balconies, porticoes, window sills, etc.

But there are also other causes of decay, the chief one, in my opinion, based on long and careful observation, being the white salts which are so often seen upon our best buildings, those of brick more particularly. They are especially ruinous to building materials, are most difficult to overcome, and hence deserve extended notice.

(1.) *As to their origin.*—These salts exist naturally in the clay from which the bricks, terra cotta, etc., are made; also in the lime used for mortar or cement. It is a well-known fact that many of the salts that are present in clay are insoluble while the clay is in its raw or natural state, but that the action of fire renders them soluble. The same result also follows the admixture of lime with the clay.

Hence, agriculturists apply lime to the clay soils to render them more fertile, because the salts are made soluble by the action of the lime, and the plants are then able to assimilate them.

(2.) *As to their elements.*—These salts consist of carbonates, sulphates, nitrates, and chlorides of sodium, potassium, calcium, magnesium, etc. Sometimes several of these salts are associated in one sample taken from a building, and in nearly every instance that has come to my notice, I have found a difference of constituents and proportions; so much depending upon the clay and how it is burned, and the character of the limestone used for the mortar or cement. Hence arise the apparently contradictory statements and opinions expressed by chemists and others as to what these salts are composed of, some claiming one thing and some another; and I have no doubt that each may have been correct in his analysis, though, perhaps, widely differing from the others. I have taken two samples from the same building, and found them dissimilar. I believe that every kind of brick, cement, and mortar contains soluble saline ingredients.

(3.) *The causes of their appearance.*—This is wholly due to moisture in the masonry. This dissolves the salts, forming a weak brine, which, upon coming to the surface, loses its water by evaporation, and leaves the salt to crystallize and form the objectionable efflorescence.

The presence of the moisture may be due to the water used in mixing the mortar or cement, or in wetting the bricks; or it may be absorbed from the rain falling against the walls. Hence the drier the walls are kept during the erection of a building (consistent with making the work good), the less chance will there be for the salts to show themselves; and if the walls can afterward be kept perfectly dry, the salts remain inert and do no harm, because water is the agent that renders them active and effective in their resolving powers. It may sometimes be seen which parts of a building were built in dry weather and which in wet, by the appearance of the mortar joints at different elevations, especially on old brick structures.

To attempt to wash the salts off only results in their

England, nearly 150 years old, still active and troublesome. In Philadelphia, on October 4, 1882, I noticed the peculiarly white appearance of a great number of the houses, and I asked if they had been whitewashed. I then learned that the whiteness was wholly due to an extraordinary quantity of these salts on the surface of the walls, caused by a three days' rainfall that had occurred a few days before, and had completely saturated the brickwork, which upon drying out had produced the efflorescence. It by no means follows that the brick, cement, and lime severally are not good because they contain these salts, however undesirable these salts may be; in fact, I have constantly observed them in the very best qualities of each.

(6.) *Responsibility of the profession and trades.*—Architects and builders are often blamed and held amenable for discolorations on buildings, and most unjustly so, when they are no more responsible for dirt settling upon and staining the walls, or for the salts that appear thereon, than are the shoemakers for our shoes getting soiled when we walk in a muddy street, or glaziers for our windows getting dirty from rain and dust.

Water will penetrate an ordinary brick; it will dissolve the salts in the walls, it will bring the same to the surface and evaporate and leave the salts to crystallize. Dust will float in the air and settle on exposed surfaces, and, if rain can fall upon them, it will most assuredly penetrate and permanently stain them. These are natural causes and effects, and no one can be justly and reasonably blamed for such things happening.

About a year ago, I was requested to examine a large new building in this city; the front was of a light yellow brick. The owner was moving his goods into it. It had become, as usual, stained, and the owner was retaining a part of the money, refusing to pay either architect or builder because of these stains. After a careful examination, I told him that neither of them was responsible; that the front faced the north, had been very wet, vegetable germs had settled upon it and grown, and the rain had washed floating particles of dust into it; and that the architect and the builder ought to have their dues. I asked him if he had withheld payment from the glazier because his windows had become dirty. His reply was, "Well, I will take good care that you don't see those parties." I said, "You asked for my opinion on your building, and I have given you a true and honest one."

Here are for your inspection some pieces of brick taken a few days ago from a new building on 58th Street, near Sixth Avenue. You will see it had

been painted, and though the paint used was of good quality, as shown by its toughness, yet the destruction of the face of the brick and the forcing off of the coating of paint was wholly due to the caustic alkaline properties of these salts, which were brought to the surface and into contact with the paint by water. This effect can be seen, more or less, almost without an exception, on every brick house that had been painted with ordinary linseed oil paint. And if the paint thus perishes, so does linseed oil when applied alone, though the effect is not so readily seen. It is therefore neither durable nor effective. How often do we see the paint on a building peeling off the mortar joints and leaving them quite bare! This is due, as I have said, to the action of the lime salts in saponifying the oil.

Terra cotta shows these salts very much, in some buildings even more than the brickwork. This is noticeable on the new Produce Exchange Building. It is there caused, probably, by the liberal, though, perhaps, necessary backing of cement or mortar used to fill up the hollow spaces behind it, the salts of which come to the surface as before described.

Stone, especially in contact with brickwork, is damaged by the same cause. The water, no matter how it reaches the cement or mortar in a wall, will permeate through a stone, and bring with it these destructive salts, which quickly eat away the surface.

The late Mr. Francis D. Lee, a well-known architect of St. Louis, Mo., said he believed that the damage to

THE PRESERVATION OF THE OBELISK.

being dissolved and absorbed by the bricks, to reappear as the bricks dry. Rain does not wash them off, but into the surface of a building.

(4.) *Other causes of production.*—Salts of lime are produced by acids and alkalis contained in rain water, especially that falling in cities. Some twelve years ago an eminent English scientist estimated the quantity of sulphurous acid gas given off by the coal consumed in London at 300,000 tons annually. The carbonic acid gas from the same source must have been many times greater. These two gases have a great affinity for moisture, and are readily taken up by the rain which falls against and is absorbed by the brickwork, and are the most active agents in producing soluble salts of lime, and so causing it to dissolve, to appear afterward on the surface as previously described. Nitric acid, and also the alkali ammonia, act similarly. Their destructive effect on the mortar and cement joints is especially noticeable on the brickwork of the tops of chimneys that are in contact with the outflowing gases resulting from the fires beneath.

(5.) *Effects of these salts on building materials.*—The alkaline property of some of these salts is very destructive to brick, stone, cement, and mortar, completely disintegrating them, as may be seen by careful examination of the places where they show; nor can linseed oil, paints, or similar compositions withstand them, the oil being saponified by the alkali and rendered useless, so that the paint is destroyed and falls away. I have seen these salts in the walls of buildings in

* From a paper recently read before the N. Y. Academy of Sciences.

property, caused by the weather and these salts, was at least \$500,000 per annum in that city alone. If that was a correct estimate, who can compute the enormous loss to property owners in such a city as New York? The fact is, a certain amount of deterioration in house property is looked upon as a matter of course, as something inevitable, and therefore to be borne, like taxation, as philosophically as possible.

The question before us is, Can this disintegration be arrested or prevented? Can this natural law of decomposition be stayed? I believe it can, by shutting out or keeping off that destructive and ever active agent—water.

For the preservation of these building materials by waterproofing, the paraffine compound process is the most effective and lasting yet discovered. This statement is based, not on mere theory, but on many years of extensive application in varying climates, and on nearly every known kind of stone and building material.

I have had nearly twenty years of experience in this matter, sparing neither trouble nor expense to ascertain what is really the best thing to do. I have tried oils, varnishes, gums, rubber, and silica compounds, and made numerous experiments, but found no substance to have so many advantages and accomplish such perfect results as paraffine combined with creosote, applied with the aid of heat. It is imperishable, invisible, insoluble, impenetrable to water and gases, and it does not evaporate or waste away. It prevents the disintegration of stone, the weathering of brickwork, the crumbling of mortar-joints, the growth of moss and other destructive and unsightly vegetable organisms, the efflorescence of salts, and, in a word, it keeps buildings in a fresh, clean condition.

It renders the interior walls of hospitals, etc., impervious to the infectious emanations from the sick, thus keeping the wards healthy.

Although this may seem a large claim, yet every statement can be verified by accomplishment of successful work, extending over a long period and in many places.

The enemies of the exterior walls of our buildings are legion, but the strongest and, as I have shown, the ally of all is unquestionably water. The particular deduction from this established fact therefore is: Keep your house dry; it will last longer, look better, cost less to keep in repair, and be more comfortable and healthy for those who live in it. Each and all of these advantages are worthy of the fullest consideration of all owners of house property.

The proper time to treat a building is immediately after its erection, and before it becomes permanently stained and spoiled. But it is difficult to make owners or builders appreciate this. The following incident is one of many similar experiences. I saw in this city a very fine building in process of erection, white brick with brownstone trimmings. I knew it would quickly stain and be ruined. I brought this process to the attention of the owner; the front looked very fine indeed, though even at that time stains were beginning to show at the ends of the window-sills and other projections. The owner said the building was new, only just finished, and clean, and he did not see why it was necessary to do anything more to it. I replied, now was just the time to do it, and to keep it clean. He said he would wait a year or two to see if it stained, and if it did, then he would have something done to it. I need scarcely say that "then" will be too late, for there is no known process that will clean and restore a white or light-colored brick front to its original appearance. It is permanently ruined. "Prevention is better than cure," for in this case, if a decent-looking wall is desired, after it has stained, it must be coated with paint or color, and that forever prevents the brickwork from being seen again, except in spots, in a dilapidated condition, where the paint peels off.

The discoloration of the terra cotta of the new New York Cotton Exchange is rapidly taking place in spite of its coatings of linseed oil, and its light yellow bricks will ere long look like those of the building on the opposite corner, William and Beaver Streets, and those of the "Post" building, on Beaver Street and Exchange Place, which are stained beyond the possibility of restoration.

A very important consideration with an architect, in designing a good building, is color—the proper blending of shades. But of what use is it for him to be so careful in selecting brick and stone of certain tints, and to see that the builder and mason execute good, clean work, when in a few months after it is finished the whole of the beauty is completely marred by unsightly discolorations?

If it is worth while to spend time and money, and to take so much care in designing and erecting a substantial and handsome building, surely it is wise to spend a further comparatively small amount to permanently preserve the whole from the ruinous effects of the weather, which will surely follow exposure.

Let us now briefly consider in this connection a few of the stones used in New York buildings.

Brownstone is a popular stone, and deservedly so. There is a very substantial look about a brownstone house. The stone has a beautiful grain and sparkle, and does not, on account of its color, readily show the weather stains which are sure to occur in a city. But the chief objection to it is its liability to decay. It absorbs water freely, and then the frost quickly disintegrates it. If bedded on a dry, waterproof foundation, and protected from the action of water and frost, there is no reason why it should not remain sound and good for an indefinite time, and the above objection to its use would no longer exist.

The entrance to the Greenwood Cemetery, at Brooklyn, a fine brownstone structure, is badly decayed. It is said that many things have been tried to save it, linseed oil and sundry solutions, but all useless, none lasting over a year; and the beautifully carved work, erected at a great cost, seems doomed.

The Carlisle or Scotch red sandstone, though very beautiful in its color and grain, is probably the most absorbent of all the building stones used in this city. It certainly stains very quickly and badly, and cannot stand the weather. Any one can see this who will carefully examine any of it that has been exposed a year or two. Among the finest exterior work in New York is that on the front of the Hon. S. J. Tilden's house, in Gramercy Park, where the principal part of the exquisitely carved stone is this same red sandstone. The discoloration and decay are very marked. In

some places the costly carving is rapidly disappearing, a salt appears in many spots, which is said to be due to the stone having been wetted by sea-water. Its extreme porosity, more than that of some kind of brick, is against its being able, unprotected, to withstand the attacks of this very trying climate.

The blue **Wyoming stone**, from Pennsylvania, is a very hard, substantial stone, less absorbent and consequently less liable to decay than the former stones; but even this is damaged where in contact with brickwork, the salts of the lime and brickwork being carried into and through the stone and so corroding away its surface.

The light-colored Ohio and Nova Scotia **sandstones** are good, sound, hard stones, but owing to their delicate color they show the weather stains and become very unsightly, and are sometimes almost covered with a green vegetable growth. A large quantity of Dorchester stone was used in Central Park, especially on what is called the "Terrace" at the north end of the Mall. Here, a few years ago, an enormous amount of money was expended in executing a great deal of fine sculpture, but, alas! its beauty is rapidly fading away. Some portions are almost obliterated, and there is scarcely any that is not seriously damaged.

There are many buildings here constructed of **marble** of various kinds. It stains badly, and perishes more readily than is generally supposed. The old building of the Mutual Life Insurance Company on the corner of Broadway and Liberty Street was cleaned last summer. It was in a very bad state, and the stone near the top very much decayed. Some pieces of it here exhibited speak for themselves. I could dig into it in places a half an inch with my pocket knife. I have taken fragments of marble from old buildings in this city, and rubbed them into dust in my hand. You will observe that this piece of marble from the upper portion of the "Stewart" building, obtained when the building was being altered two years ago, has quite perished.

Limestone, oolites, etc., are not much used in New York, but where they have been, they show stains on their white surfaces, and abundant evidences of decay.

Granite is undoubtedly the strongest and most durable of building stones. But even it is not proof against the disintegrating forces. The **obelisk** is, unfortunately, an illustration.

I saw the obelisk for the first time about six months after its erection in Central Park. Being interested in the preservation of stone, I examined it as carefully as I could from a distance, and saw how rough the western and southern sides were, but, being unable to approach it closely, could form little idea of the actual condition of the surface.

On many subsequent occasions, I examined it closely, and after a time found small pieces of the granite lying around the base, which, to me, clearly proved that it was being affected by the severe climatic influences.

Professor Doremus accompanied me, about a year ago last September, to examine the obelisk. We gathered quite a quantity of it from around its base. He showed the pieces we had picked up to the late Commander Gorringer, who could hardly believe they came from the monolith, and expressed the hope that some day it would be polished. Hence Dr. Doremus refrained from pressing the matter of its preservation with the park commission.

On his return last summer from Europe, the then President of the Board, Mr. J. D. Crimmins, wrote to Professor Doremus, requesting his opinion and advice, which resulted in his letter published last September.

The Hon. M. E. D. Borden was finally intrusted with the decision as to the proper treatment to be adopted. After consultation with Prof. Doremus, and a visit to the obelisk with him, Mr. Borden decided on the paraffine compound application. On September 22, 1885, we received a letter from the Park Commissioners, requesting us to treat the north side of the plinth as a specimen of our waterproofing process.

On September 25th, my son and I went to the obelisk, and commenced the work, when I discovered that I could remove quite large scales with my fingernails from the surface of the plinth, and also that there was a green vegetable growth behind each piece removed.

This was so serious that I thought it better to call the attention of the authorities to its condition before proceeding with the work.

It took my son and myself several hours to take off the decayed portions. We then applied the waterproofing compound. I watched very closely the effect of the heat upon the stone, as so much had been said against using it, and found that it stood the necessary temperature perfectly well, not being damaged in the slightest degree.

Prof. Doremus was present, and watched the operation and applied some of the melted compound himself, and thus saw how readily the warmed surface of the granite absorbed the melted compound.

This accords with Professor Doremus' experiment, the year before, with a large piece of the obelisk given to him by the late Commander Gorringer, which he heated and dipped in melted paraffine wax, and found to absorb it, the heat not damaging the stone.

I found, much to my surprise, that the stone absorbed the compound *very freely*, much more so than stone generally. This showed that there were many and large interstices into which water could pass; which, if frozen while there, would inevitably force off, with its resistless power, the surface of the stone. This confirms the experiments made by Professor G. W. Wigner, in 1878, respecting this stone, and published in the *Analyst*, which showed that "the absorbent power of the unchanged stone was at the rate of 7.8 grains per square foot; the weathered surface showed an absorbent power six times as great."

Some time afterward, we received the order to proceed at once with the scaffolding, cleaning, repairing, and waterproofing of the whole surface of the obelisk and its plinth.

We commenced on October 27, 1885, and the scaffolding was completed, in spite of bad weather and other hindrances, on November 2. We then began the cleaning of the stone, and discovered what a deplorable condition it was in, far surpassing our worst fears. Some large pieces were so loose that they would scarcely bear the hand on them without falling away. Walking around the monolith on a plank, I put my hand against one of the hieroglyphics to steady myself, when it came off in my grasp. We found the greatest disintegration

to be on the west side, very bad on the south, not so much on the north, and the least on the east, though decomposition had already progressed to a serious extent even on this side in certain places. We removed about two and one-half barrels of pieces, weighing altogether seven hundred and eighty pounds. Some of the flakes were so much decayed that even with the greatest care they would crumble to pieces when being removed. In quite a number of places we found the flakes, though separated from the stone and sounding hollow when tapped, yet seemingly firm in position. These we allowed to remain, if they would stand the heat. One especially large piece, which measured sixteen by seventeen inches, is on the base of the western face of the apex, or "pyramidion," and extending several inches down the western side. I consulted Commissioner Borden about it, and he said: "Don't remove any unless you are obliged to do so." I heated the piece carefully, and saved it. To have removed it would have seriously disfigured the top of the obelisk. This plan was carried out all through the work, and there is a great deal of the surface which, though hollow, will now stand for a great number of years, which, had it been left unprotected, would soon have fallen away. When the work of cleaning had sufficiently advanced, we proceeded to apply the waterproofing compound. This was on November 6, and we continued the work until November 13, when all was finished. Some part of the time, the weather was very boisterous; one could scarcely stand on the scaffolding, the wind had such force, especially on November 9 and 10.

As before stated, 780 pounds of pieces of decayed granite were taken from the obelisk, which proves beyond question that the stone, though only exposed four and one-half years, could not withstand the destructive influences of this climate.

What I have recently accomplished clearly proves also that certain statements made in the public press are unreliable, viz., the calculation that "it would require 58,056 years to remove from the plinth a shell one centimeter in thickness, and weighing 631,652 grammes" (or 1,338 pounds avoirdupois), and that "the waste in a century would therefore be scarcely a perceptible amount," as well as the concluding summing up that "we need, therefore, be under no apprehension that the obelisk will seriously suffer from the effects of our climate."

Secondly, it proves that "the suggestions of certain foreigners, who had visited Central Park, and said that if the obelisk was not protected, the frosts and snows of our severe winters would soon make more of an impression upon the stone than the thousands of years under an Egyptian sun," were reasonable and well founded.

Thirdly, that "a hot compound could not be made to enter the stone, without the use of a greater heat than would be possible without injury to the stone," was a groundless fear, because the successful heating and applying of the hot melted paraffine compound to the surface has been actually done without causing any injury whatever to the stone. This is a fact, not an opinion or a theory, and it speaks for itself. But for these unfortunate expressions of opinions from high authorities, made through the public journals, doubtless the obelisk would have been treated years ago, and much of this valuable and interesting relic and record of the past, which has now been irretrievably lost to posterity, would have been saved.

It was feared by some persons, as I have just stated, that this waterproof compound could not be applied to the obelisk without serious risk of injury. The trial has been made and no damage at all has been done, for, by a careful method of application, acquired by many years of experience, it was safely accomplished, and I do not think that a single particle of solid, sound stone was displaced from the surface of the obelisk by the application of the heat employed to enable the stone to absorb the compound to an effective depth. There were many witnesses to the correctness of this statement, some of whom watched especially for it. There were even spaces that were hollow beneath that were successfully treated. In some few instances, where the pieces were very loose and had a green vegetable growth behind them, as soon as the stove had warmed the stone, the steam came out of the humble but audacious plant-life at the back of the loosened scale, and these pieces were removed.

I believe the compound penetrated to a depth of half an inch and deeper. The stone certainly absorbed it in considerable quantities, no less than 67½ pounds having been used. The surface treated—shaft and plinth—is about 220 square yards. An equal surface of brownstone would have taken from 40 to 50 pounds. The work was effectually accomplished, and nothing was spared to insure a satisfactory result.

We did most of the work when the wind was blowing a gale from the northwest, and one squall that passed left our top poles covered with ice, though below it was simply a cold rain.

DISCUSSION.

Mr. Caffall, in answer to inquiries, said that ordinarily one pound of the paraffine compound would cover two to three square yards of brick surface. The compound penetrates the stone only as far as the melting heat penetrates. If some of the liquid remains upon the surface, it demonstrates that the pores of the brick or stone are completely filled to the depth reached. Then a reheating causes the absorption of this excess, and leaves the surface clear. By this method, the thickness of the saturated layer is under control. The melting-point of the compound is 140° F. It consists of paraffine, containing creosote dissolved in turpentine. The use of creosote prevents organic growth upon the surface. The compound, in its constituents and its proportions, is the result of many experiments and long experience.

Prof. R. Ogden Doremus called attention to the statement of Prof. Persifer Frazer concerning the rock of the obelisk, contained in the eighth chapter of Commander Gorringer's work on "Egyptian Obelisks," and read as follows: "The first thing that strikes one is the freshness and soundness of the rock. No *maladie de granite* is observable, and this fact will answer the first and natural question as to why this rock was so much preferred by the Egyptians for monumental purposes." Again, on page 167 Prof. Frazer says: "The rock of the needle can, therefore, be regarded as unusually fresh and healthy, in spite of the honorable age which it possesses."