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A
PRACTICAL ESSAY

ON A

Cement and Artificial Stone,

Justly supposed to be THAT of

The GREEKS and ROMANS,

LATELY RE-DISCOVERED

By Monsieur LORIoT,

Master of Mechanics to His Most Christian Majesty,

FOR THE

Cheap, easy, expeditious and durable Construction
of all Manner of Buildings;

AND

The Formation of all Kinds of Ornaments of Architecture,
even with the commonest and coarsest Materials.

Translated from the *French* Original, lately published, by the express
Orders of the above-mentioned Monarch.

Ruinarum urbis ea maximè causa, quòd furto calcis sine ferrumine suo,
cœmenta componuntur. Plin. Hist. lib. 36. cap. 23.

THE THIRD EDITION.

D U B L I N:
PRINTED BY J. CHAMBERS,

F O R

JAMES WILLIAMS, [No. 21] SKINNER-ROW.

M.DCC.LXXVI.

ERRATA
THE HISTORY OF THE ROMANS
BY THE REV. JOHN BISHOP
LONDON: Printed and Sold by J. B. ROBERTSON, in Pall Mall, 1790.

TO THE
K I N G.

SIRE!

THE original of this Essay having been published in France, by the special Command of the French King; it seems but natural, that the translation of it should make its appearance, here in England, under the auspices of Your Majesty. Indeed, the importance of the Subject might alone suggest to me the propriety of seeking, for it, the patronage of a Monarch, whose knowledge of,

D E D I C A T I O N.

and acquaintance with, all the means of making His subjects happy, can only be surpassed by His zeal to employ them. May I, therefore, Sire, most humbly beg leave to lay it, for that purpose, at Your Majesty's feet, and subscribe myself, with the warmest affection and most profound veneration,

May it please Your Majesty,

Your Majesty's

most dutiful

and most obedient subject,

The Translator.

A

PRACTICAL ESSAY, &c.

Notwithstanding the great degree of perfection, to which the arts have attained within a few centuries, it cannot be denied, that, in looking over the writings of the ancients, and examining their monuments, we meet with certain signs of their having been acquainted with some secrets, to which we, moderns, are utter strangers. We are, no doubt, very rich without them; but that is no reason why we should not endeavour to recover them; and, instead of trusting to chance, employ both observation and experiment for that purpose.

Of this, one of the most important branches of architecture is a striking proof. Though the genius of our modern masters in that art, formed by the study of those monuments left us by the ancients, has succeeded so far, as to produce edifices capable of vying with their patterns, it may be fairly said, that we are still at a great remove from the Greeks and Romans with re-

spect to the running up of buildings with the degree of rapidity they used to do; and yet bestowing on them that degree of solidity, which seems to defy time itself; and all this, with almost every kind of materials they could lay their hands upon.

It is, no doubt, an easy matter to raise lasting edifices, by piling, one upon another, enormous blocks of stone: But, then, there are several countries, of very considerable extent, in which no such materials are to be had; and there are others, in which, though these materials abound, they are of too loose a texture to resist, for many years, the vicissitudes of the weather. Besides, this way of going to work is monstrously expensive. It is what very few simple subjects can pretend to; and, accordingly, few of the houses built by them are of any duration. Nay, states themselves are now often obliged to renounce the execution of the most useful works, on account of the enormous expence attending them in the modern method.

But the Romans, it is plain, generally employed, especially in those public works in which usefulness was more to be attended to than ornament, a far less expensive mode of construction. The principal parts of such works, if not the whole of them, usually consisted of materials of a very small bulk, but kept together by a mortar or cement of a very binding quality.

lity. What a fine method! one can hardly sum up all the advantages attending it. In it, they could make use of every kind of stuff already existing on the surface of the earth, and even stones every where almost to be met with in the beds of rivers and torrents, though worn round, nay, and polished, by their constant attrition against each other or other bodies. (1) They had no occasion for the unwieldy apparatus of heavy carriages to bring their materials to the spot, or cumbrous engines to raise them; consequently, they lost neither time nor labour in the execution of those tedious operations; all went directly to the forwarding of the work itself, which, of course, must have shot up with uncommon rapidity. How, otherwise, could they have executed, even with their numerous armies, those immense piles; those aqueducts of several leagues in length, and sometimes rising to the level of mountains; and all this often, merely to supply some middling town with water, not only for the necessary, though common, purposes of life; but even those of luxury and abundance; such as baths, fountains, &c.

(1) Of this we have an instance in the ruins of an ancient Roman building on the banks of the Rhone at Lyons, a little above St. Clare's quay. It is easy to see, that even the pebbles found in the bed of this river make a part of the work; but they are so strongly bound together, that it is much easier to break them, than to make them let go their hold of the cement, which fills all the interstices between them.

These considerations did not escape Monsieur Lorient, so deservedly celebrated for his many very useful mechanical discoveries and inventions; and it was in consequence of them he made these enquiries and researches, the fruits of which I am now going to communicate to the public. Ever taken up with the thoughts of serving his country and mankind, by cultivating and improving the fine and the useful arts, the great number of those vast remains of Roman grandeur, scattered over our southern provinces, could not fail of suggesting to him, that the solidity, so conspicuous in them, could not be owing to any secret confined to any one portion of mankind, nor to any merely local advantages, nor to any peculiar excellency in the quality of the materials; but that it must be the result of some common and easy method, within the reach of every man of the world of workmen, employed in these erections. But, perhaps, we had better follow the example of Monsieur Lorient; and, like him, particularly analyse these stupendous monuments, and thence regularly deduce the manner, in which it may be presumed the Romans constructed them.

Most of these monuments exhibit nothing but enormous masses in point of thickness and height, the heart of which, but just faced, with an almost superficial coating, evidently consists of nothing but pebbles and other small stones, thrown

thrown together at random, and bound by a kind of mortar, which appears to have been thin enough to penetrate the smallest interstices, and so form a solid whole with these materials, which ever kind was first laid to receive the other, when poured into it.

It is enough therefore to consider these ruins, with the smallest degree of attention, to be convinced, that all the secret of this mode of construction consisted in the method of preparing and using this strange kind of mortar; a mortar not liable to any decay; bidding defiance equally to the perpetual erosions of time, and heaviest strokes of the hammer and pick-axe. At least, when any little stone, and it must be a round one, gives way to them, the mould of cement left by it is found equally hard with the compleatest petrification.

How different, then, must this ancient mortar be from the best of our modern! the latter, one would imagine, never dries perfectly but to fall to dust again at the least touch. Of this the remarkable crumbling away of our most recent buildings is an evident proof.

Another of the extraordinary qualities of this Roman cement, is its being impenetrable to water. This is not a mere conjecture. It is a fact, which the aqueducts of theirs, still in being, leave not the least room to doubt of; for, in these works, they never employed either

ther clay, mastich, or any other resinous substance, to prevent the waters making their way through them. The areas of these canals, resting sometimes on the ground, sometimes on a wall, and sometimes on arches built for the purpose, as well as their roof and sides, consisted of the same kind of small stones bound together by this extraordinary cement; with this difference, that the inside surface was composed of finer and smaller ingredients; which, at the same time that it does not look any thing like a coating made at second hand, and of course capable of being scaled off, carries evident marks of its being the result of a peculiar operation, which it may not be impossible to imitate by attending to the observations, that will occur in the course of this Essay.

Thus, then, it plainly appears, that these works were carried on by means of caissons. The trenches made for the foundation formed, of themselves, the lowest tire; and, surely, nothing could be easier than to fill these with the materials ready prepared for that purpose; tho' the Romans, no doubt, did it with their largest and heaviest stones. After bringing the work to the surface, they had recourse to planks made to fit into each other, successively extending them in length and in height, and binding the opposite ones at such a distance from each other, as to form the thickness of the wall; and

and withal with sufficient strength not to deviate ever so little, from the perpendicular, on either side.

It was, thus, that they formed, as it were in a mould, these enormously massive walls, composed, as we have already seen, of every species of pebbles and other small stones, which our modern architects know not what to do with for want of a mortar qualified to constitute with them one solid compact body.

We may easily conceive, at what a great rate, even a small number of hands, if well supplied with materials, must have been able, by this means, to push on any work in the building way. For this purpose, nothing more was requisite than to have in readiness a sufficient number of troughs full of the proper mortar; throw at random into the cassoons, the pebbles and other small stones; and then saturate the latter with the former; all which might be perfectly well done, by the smallest degree of attention to get as much stones as possible into the cassoons; and then make the mortar fill up all the interstices between them; and, with regard to vaulting and arching, they had their centers, as well as the moderns. When they had an aqueduct to build, then, as the interior surfaces of its channel required a coating of that peculiar cement, which is still observable in them to a certain thickness, and
which

which we have already taken notice of, they began by laying it on the planks of the interior casing and the centers, previous to the throwing in of the coarser materials; and thus formed a crust, which effectually kept the water from any stones of a spongy nature, that would otherwise have imbibed it.

Without this method of casing, they would never have been able to construct, either walls of so prodigious a thickness, or channels of so surprising a thinness. In a word, the effect of this cement must have been very quick, to coalesce, and set as readily as our gypses and plasters, and directly resist the pressure of the other materials laid upon it. In fact, the least shrinking or swelling must have proved fatal to works of this kind, not one of whose parts, perhaps, yielded a solid and horizontal basis to any other.

This fixedness and perseverance within the same volume constitute another important quality, which the slenderest observation must convince us the Roman cement is endued with; and being the last as yet discovered, we may proceed to sum up all the excellencies peculiar to this extraordinary composition.

In the first place, then, this cement, from a liquid, turned very quickly to a solid state, and hardened with time as plaster does.

Secondly, it acquired a surprising degree of tenacity, and laid such hold of the smallest stones,

stones, it came in contact with, as scarce to bear being parted from them.

Thirdly, it was impenetrable to water.

Fourthly, it continued always of the same volume or bulk, without either swelling or shrinking.

One would imagine, that so many extraordinary qualities should have secured this composition from the effects of violence and time, and kept the secret of it alive to the latest posterity. Yet, it may be safely affirmed, that this valuable secret has been lost to all intents and purposes; and that, notwithstanding the continued and hearty sifs and researches of all Europe, nothing like it, till now, has been discovered by the moderns. For, if, in some parts, the buildings are more solid than others, it is merely owing to the extraordinary goodness of the lime, sand, and other materials employed in them.

No doubt, Monsieur Lorient was not the first to examine the nature of the still existing remains of Roman grandeur. Nay, many other lovers of antiquity may have been equally careful to compare all the circumstances of these monuments, from which any insight into their construction could be derived; and many have even analysed more methodically the cement in them; but no one, besides himself, that I know of, has as yet been bold enough
to

to affirm, that, with all his reflections and trials, he had been able to recover the long lost secret of its composition.

Is it possible, then, that these gentlemen should have concluded, along with the vulgar, that the Romans, not finding any materials in their country fit for such cement, brought them to Italy; or, if they found any, that the veins, which then supplied them, have been long since exhausted? Absurd, however, as such conjectures must be, they are not of so discouraging a nature as those of the wine-dressers in the environs of Besançon, who make no scruple of telling each other, that the aqueduct of Arcier(2) is indebted for its solidity, to the using of bullocks blood in the making of its cement; a circumstance, they, no doubt, infer from the reddish and bricky clouds in it. But these clouds are of no weight with observers better qualified to judge of the matter, who, whether they abide by the evidence of their eyes, or have recourse to analytical decomposition, can find no ingredients in it, but such as are to be found in the commonest mortar now in use.

(2) *Quin et aquæ superest ductus per millia quinque,
Ad mea qui quondam mœnia vexit aquas.*

Despotots apud Chiff. Vesont.

And,

And, indeed, how can the Romans, with all their power, be supposed to have brought from so great a distance the mountains of materials necessary for so many and such vast constructions! and, surely, it is equally absurd to think, that they should have discovered, precisely at the time when, and on the spots where, they wanted these materials, such precise quantities of them, as not to leave their successors the least opportunity of doing the great things they did. No, such ideas might be justly deemed extravagant, even though their cement, on being decomposed, were to yield any extraordinary substance, or exhibit any phenomena the moderns were yet unacquainted with.

But, Monsieur Lorient, after examining, in the course of his travels, almost all the monuments of this kind left by the Romans in France; after considering all the materials nature afforded in the places where they erected them; after, in short, comparing and combining all their possible local resources; found himself obliged to confess, from the clearest conviction, that they employed no materials but what we still employ; that their cement owed all its excellency to the lime, sand, brick-dust, and other materials of that kind, with which they made it; but that they had another method of mixing up these materials, and using the mixture.

This

This system, uncommon and bold as it might then appear to be, not only kept possession of his mind; but sunk deeper into it from day to day, in consequence of the new observations he had frequent opportunities of making, till, at length, in the beginning of the year 1765, he took upon him, for the first time, to present the Royal Academy of Architecture a memorial, in which he gave his opinion, and laid down his reasons for it, with regard to both these points; to wit, the sameness in the substance of the materials, and difference in the manner of mixing them. And, having already convinced himself of the inertness and sufficiency of lime that had been slaked for any considerable time, he scrupled not to assert, that the Romans used quick-lime on their scaffolds; and that it was to its vivifying quality we were to attribute all the wonderful effects of this cement.

The Marquis de Marigny, director and surveyor-general of the king's works, having received a copy of this piece, condescended to read it with all that zeal for his majesty's service, the advancement of the arts, and the welfare of the public, for which he is so distinguished. He immediately saw that the fine prospects it afforded, were far from being visionary; and he no sooner saw it, than he did Monsieur Lorient the honour of writing to him,

to encourage him in the pursuit of so promising a scheme. His letter is dated the 13th of February, 1765; and contains a great number of observations, analogous to Monsieur Lorient's system on the use of quick-lime in Italy, and particularly at Naples, in conjunction with what they call *rapillo* and *pozzolana*.

This letter gave room to another memorial; and both were presented together to the same academy. But this body, then, it may be, taken up with objects more worthy of its attention, or biased perhaps by the report made to it concerning these memorials, received them with a great deal of coolness. But, however mortified Monsieur Lorient must have been at this treatment, he was not discouraged by it. Instead of imputing it to the academy in general, he attributed it to some of its members in particular, from whom he knew he had no favour to expect; and to a prejudice against his opinion, which he could not but allow to be pretty natural, and tolerably well grounded, since it is countenanced by the two only ancient writers upon the subject, whose works are come down to us.

In fact, these gentlemen did not forget to object to him the testimonies of Vitruvius and Pliny; especially that of the first, who, in his architecture, bestows the greatest praises on the lime which has been the longest slacked; so as

to leave but little hopes to any future artists of being able to introduce the use of quick-lime, or at least lime slacked in the very act of using it. Monsieur Lorient, therefore, thinks it incumbent on him to discuss the passages in those authors, which have been alledged against him; and shew, that all the proof, which could be drawn from them to the prejudice of his system, is at best of a negative nature, and withal so very confined, as not to deserve being put in competition with such well attested facts, as he produced in support of it.

In the first place, with regard to Vitruvius, it does not appear, that he has any where condemned the use of quick-lime; for, when, in the second chapter of his seventh book, he recommends that which has been long slacked, it is merely for the making of plaster, on account of its being then too well dissolved, to contain any grains or lumps, which might spoil the work.(3) There is, besides, some reason to suppose, that Vitruvius was by no means as well acquainted with the practice of architecture, as with the theory of it; for, he

(3) De maceratione calcis ad albaria opera: such is the title of this chapter, which is the second of the seventh book. Tum de albariis operibus est explicandum. Id autem erit rectè, si glebæ calcis optimæ, ante multo tempore quàm opus fuerit, macerabuntur. Namque, cum non penitus macerata, sed recens sumitur. habens latentes crudos calculos pustulas emittit. Qui calculi dissolvunt et dissipant tectorii positiones.

does not cite a single building as of his own erecting; and, in this case, it is very possible, he might have overlooked an operation confined to the scaffold.

Pliny, indeed, seems to have affirmed more clearly, in the twenty-third chapter of the thirty-sixth book of his history, that the older lime is, the better.(4) But, unless we take particular care to distinguish, in this passage of his, the two propositions it contains concerning lime; and, first, make ourselves thorough masters of the first proposition; we shall strive in vain to understand the second. This author, who wrote from a collection of materials, in conformity to which, he digested his chapters with such peculiar precision, as often leaves his readers in the dark, in this place evidently speaks of lime in two different states; one, in which it is possessed of all its strength, all its activity, all its *ferrumen*, which Monsieur Lorient, in his first memorials, stiles its *gluten*; and it is the absence of this quality, which Pliny, in the first part of the foregoing passage, means by the words, *calcis sine ferrumine suo*.

(4) Ruinarum urbis ea maximè causa, quod, furto calcis, sine ferrumine, suis cœmenta componuntur. Inrita quoque quò vetustior, eò melior. In antiquarum (*antiquis*) Ædium legibus invenitur, ne recentiore trimâ uteretur redemptor; ideo nulla (*nullæ*) tectoria eorum rimæ scævare. Plin. Hist. lib. 36. chap. 23.

Thus, then, the naturalist, as no stranger to the abuses which in his days already began to creep into the building art, chiefly attributes the quick decay of the then modern buildings at Rome, to a defalcation her architects now began to make in the composition of their mortar; (5) a defalcation, which he styles a theft, *furto*; and the subject of this theft was a lime, the withholding of which deprived the mortar of that tenacity and strength it used formerly to derive from its presence: *furto calcis sine ferrumine suo, cœmenta componuntur.*

Pliny does not say, that the abuse consisted in making mortar without lime; for, we are not to imagine, that, in his days, the Roman architects were wild enough to entertain any such thoughts; or, if they were, that he would not have contented himself with the mention of this subtraction in absolute terms; and not have dignified with the name of *cœmenta* the paltry compounds adopted in the room of them. No, he speaks of the withholding of a species of lime, which alone could confer on the mortar those valuable properties, every builder must wish to find it possessed of; and this we cannot allow to have been slaked-lime, since the least experience is sufficient to convince us,

(5) It is well known, that the word *cœmentum* is not always used by the Latin authors to signify cement or mortar. But, in this passage of Pliny, it can signify nothing else.

that, let such flaked-lime be ever so old, and used in ever so great a proportion, though in one degree of combination it may afford a somewhat better mortar than in another, it will never afford a mortar, in any respect equal to the good mortar of the Romans.

There may be, therefore, according to Pliny, a theft of lime, a criminal thriftiness with regard to it, to which we are to attribute the badness of the mortar, which about this time began to be used in Rome, and proved the source of those ruins that disfigured her. But this theft cannot be that of lime, which has been long flaked, since there is no mending mortar by restoring it to ever so large a quantity of such long-flaked lime.

The consequences, therefore, arising from Pliny's assertion, and our own experience, are very obvious. In the first part of the passage in question, he cannot possibly mean that lime which has been flaked, but a medium, to which the mortar is indebted for its strength and efficacy.(6) This truth will appear more and more evident, in proportion as Monsieur Lorient's discovery unfolds itself; and we shall,

(6) In the beginning of this chapter, Pliny, it is evident, speaks of the employment of quick-lime, which he calls *calcis quam vehementissimæ*; so that every thing he says, till we come to those words *intrita quoque, &c.* which shew that he is going to consider lime in another state, is to be understood of the quick-lime.

of course, be apt to ask ourselves, how it could come to pass, that, instead of looking into Pliny for authorities in support of a blind and bad routine, we did not immediately perceive, what is, in fact, the principle of a wise practice, well known in his days, and which his writings, with a little more reflection on the side of the reader, were sufficient to perpetuate? But the mischief of it is, there are few readers who know how to read as they ought to do; and sit down to their books with all the dispositions requisite to get the better of old prejudices.

The second part of Pliny's text, *intrita quoque*, &c. evidently means another species of lime, or another state of it, different from that which made the subject of his first; he sets them in opposition, as it were, to one another. In the first place, with regard to their names, he calls the first *calx* simply, or *calx cum ferumine suo*, *calx quam vehementissima*; and gives the second an epithet sufficient to indicate the new state, in which he has been considering it, calling it *calx intrita*, (7) lime dissolved and flaked. Secondly, with regard to their effects,

(7) *Intrita*. Can this word be understood of air-flaked, as well as water-flaked lime? if it may, Pliny must be allowed to have left room for a double construction by using this expression. We shall have hereafter occasion to shew, that air-flaked-lime is not deprived of all the qualities observable in water-flaked-lime.

it is the first, which bestows on mortar its strength and consistency, if you withhold it, you deprive the work of the solidity it ought to have: the second is valuable on account of its having been long flaked, and being of course perfectly dissolved, by which means the works in which it is used are not liable to any cracks or flaws; advantages, he adds, "enjoyed by our fore-fathers, in consequence of their laws relating to building: which forbade the use of this kind of lime, within three years after the flaking of it."

But let the authority of Vitruvius and Pliny be what it will; and, by the bye, it is plain, these authors have not been well understood; it is of little consequence to Monsieur Lorient; he has facts to speak for him; sad experience, indeed, has convinced him, that he must, notwithstanding, engage with prejudice and jealousy, much more formidable enemies, it must be allowed, to a man, who professes to invent and reform, than any detached passages in authors, who have long since paid the tribute of nature, have now no longer any friends of cabal in their favour, and may, in an enlightened age like this, be safely contradicted, as often as there appear any substantial reasons for doing it.(8) Monsieur Lorient therefore pro-

(8) The author here means the persecution Monsieur Lorient suffered with regard to the machines of his invention constructed at Pompean.

tests, that he will employ no other weapon against his enemies, but his success; nor any means to convince his detractors, or at least silence them, but that of bidding them come and behold with their own eyes the trials, in great, of his method, which he is actually making, in the sight of mankind, in those works, with which the king has been pleased to charge him.(9)

But, to return to our history of Monsieur Lorient's interesting discovery, the enquiries begun by him on the plan he had laid down to himself in 1765, having suffered interruption, as well from some journies he was obliged to undertake, as from some private works for the king's use,(10) the Marquis de Marigny, whose zeal to forward every undertaking he has once found of consequence to the improvement of the arts, and that of building in particular, knows no bounds, took advantage of a tour which Monsieur Lorient had occasion to make to his estate of Menars, in 1769, to engage him to recollect and pursue his ideas

(9) Monsieur Lorient is actually lining with his cement the vaulted roof of the orangery at Versailles, where every body is free to come and see with what rapidity the work goes on, and with what quickness his cement takes without the betraying the least disposition to crack or flaw.

(10) Viz. The models of some flying tables, (*tables volantes*,) which are to be executed at Trianon, and which every connoisseur in the capital has seen and admired.

with regard to the cement of the Romans; and withal make such trials, as might speedily bring his scheme to that degree of perfection, of which it might be capable, and which he thought it so well deserved.

This request had the force of a command with Monsieur Lorient; but a command so much the more easy to obey, as the Marquis at the same time gave orders for supplying him with every thing necessary to perform the task he had imposed on him; being determined, that all the trials, both in the great and in the small, should be made entirely at his own risk and expence; a noble instance of disinterestedness, such as is rarely to be found even amongst those, who would be considered as first-rate patrons and protectors of the fine arts!

Monsieur Lorient, being by this means made as easy as he could wish, prepared the materials for his different mixtures, in the intervals of leisure left him by a mechanical work, which he had undertaken for the purpose of raising water at Menars; and, in the course of the year 1770, had the happiness to discover a kind of mystery in nature, which, for several ages past, had not, it is most probable, manifested itself to any body but himself; a mystery, on which all the merit of his discovery is founded.

Taking some lime, which had been a long time flaked, out of a pit covered with boards,

and

and a considerable quantity of earth over them again, by which means the lime had preserved all its original freshness, he made two parts of it, and plashed and beat them both perfectly well.

He then put one of these parts, without any addition, into a glazed earthen pot; and, in that condition, set it to dry, of itself, in the shade. Here, in proportion as it lost its moisture by evaporation, it cracked and split in every direction; parted from the sides of the pot; and crumbled into a thousand pieces, all of them equally friable with the bits of lime dried up by the sun, which we usually meet on the banks of our lime pits.

With regard to the other part, Monsieur Lorient just added to it one third of its quantity of powdered quick-lime, and then had the whole well kneaded, in order to make two kinds of lime perfectly incorporate with each other. This done, he put this mixture likewise into a glazed earthen pot, as he had done the first; when, behold, it soon began to heat, and, in the space of a few minutes, acquired a degree of consistence equal to the best plaster, when prepared in the best manner. In short, it set and consolidated almost as readily, as metals in fusion, when taken from the fire; and turned out a kind of instantaneous lapidification, having dried completely within a very small space of time, and that too, without the least crack or flaw.

flaw. Nay, it adhered so strongly to the sides of the pot, as not to be parted from them without breaking it.

The result of this addition of the quick-lime, surprising as at first sight it may seem, is, notwithstanding, so easily explained and accounted for, that it seems somewhat strange, that Monsieur Lorient should be the first to suspect and discover it. In fact, what can be plainer, than that the sudden setting and consolidating of these two substances, when thus united, must necessarily arise from the quick-lime's being carried, by a perfect amalgamation or admixture into the inmost recesses of the flaked lime, saturating itself with the moisture it there meets with, and thereby effecting that instantaneous and absolute desiccation, which, because we are so well accustomed to it, we so little mind in the use of gypses and plasters.

But, the most valuable of all the extraordinary qualities in this composition is, its not being liable to any cracks or flaws, when the ingredients are in the exact proportion they ought to be; or to give way in any sense, either by shrinking or swelling; or, in short, ever undergo the least alteration from that state, in which its fixation left it; a phenomenon we may account for on the same principles with the foregoing. Whereas mortar, or common cement, never dries but by the evaporation of its moisture;

ture; Monsieur Lorient's cement becomes perfectly solid without the least evaporation; its moisture continues in, and makes part of it; the desiccation is altogether intestine; and, as the mass continues the same, and moreover the component parts of it are brought so near each other, it is impossible any cracks or flaws should ensue; for, cracks and flaws can arise from nothing but the evaporation of a superfluous moisture, and the approach to each other of those parts, which that moisture had till then kept asunder.

Monsieur Lorient had likewise the satisfaction to see, that his composition was endued with the surprising quality of being and continuing impenetrable to water. For this purpose, he made new trials; he formed, with his cement, some vessels of a form proper to hold water; weighed them, filled them, and, after the water had stood in them a considerable time, emptied them; when, on weighing them a second time, he could not find that they weighed either more or less than before he filled them.

After several repetitions of these trials, and always with the same success, it now only remained to find out what effects, if any, time, or rather the vicissitudes of the weather, might have on this mixture of the two kinds of lime, as well as on several other compositions, in which Monsieur Lorient had made it up with
other

other materials fit for mortar; but, after making for this purpose a great number of new experiments, all the conclusion he could draw from them was, that not only the original mixture of the two kinds of lime, but every other to which he added it, instead of giving way to greatest dryness or moisture, heat or cold, in the air, encreased with age in solidity and compactness.

Monsieur Lorient now no longer made any scruple to affirm, that the mixing of powdered quick-lime with any kind of mortar or cement made with slaked lime, was the best way to give it all the perfections builders could wish to see it possessed of. This is the key to the discovery advertised by him; and the most interesting consequences flow spontaneously from it. However, I shall proceed to point out the chief of them. Further reflections and trials, nay chance itself, may, in the course of time, bring to light a great many more.

From the two kinds of lime so forcibly laying hold of and embracing each other, as it is plain from experience they do, so as to constitute but one solid body, it naturally follows, that they must likewise be able to seize and shackle several other kind of substance, that may be mixed up with them, according to their greater or lesser degree of suitableness to each other in point of surface and texture;

so as to add considerably to the mass we are about to employ.

Now, sand and brick-dust are the foreign bodies which have as yet been found to answer best for this purpose.

Take, therefore, any quantity of very fine brick-dust, and twice as much fine river sand, the former well sifted, and the latter well screened, with a sufficient quantity of old flaked lime to form, with water, an amalgama as usual, but withal, wet enough to flake a quantity of quick-lime equal to one fourth of the brick-dust and sand taken together; then add the quick-lime in powder to the brick-dust and sand; incorporate them well without loss of time, and use them directly, as the least delay may render the use of them defective or impossible. (11)

A coating of this mixture, applied to the bottom and sides of a canal, basin, or any other kind of building, which is to contain or stand over water, has the most extraordinary effects, though laid on ever so thin. What wonders, therefore, might we not expect from this cement, were such buildings to be originally constructed with it.

The dust of charcoal incorporates very kindly with the same materials, in a quantity

(11) See the observations hereafter to be made on the quality of the quick-lime.

equal to that of the quick-lime; and, though the lead colour, which arises from this addition, makes no essential part of the mixture, it may still have its uses on certain occasions; but, it is otherwise with regard to the bitumen contained in the charcoal; since this substance cannot but form a rampart extraordinary against the water, no way inferior to that afforded by the other materials with which it is made up.

If all we want is a strong coating, then, by adding to the common mortar, consisting of flaked-lime and sand, one fourth its quantity of quick-lime, we shall have one, which, within four-and-twenty hours, acquires a greater degree of consistence, than the common kind in several months.

Two parts of air-flaked-lime; one, of sifted plaster; and a fourth, of quick-lime; made up into an amalgama of the consistence of common mortar, afford a coating, no less fit for the inside of buildings, than tenacious and incapable of cracking or flaking.

But then, we must, as in using the first prescribed mixture, not prepare above a trough full at a time of these new ones; and that only just as we want to use them.

Instead of sand, we may use loose earth for buildings that are to be run up in a hurry, as likewise for the coating of walls, both within
and

and without doors; but the more sandy this earth, the better.

If we cannot conveniently get brick-dust for those works, which are occasionally to receive, or constantly contain water, we may use the same kind of loose earth as a substitute to it. It is only making it up into little balls; then baking them in a lime-kiln, by putting them behind the lime-stones, or in a kiln by themselves; and lastly, reducing them to a powder, which they may easily be; for, this powder will do as well as brick-dust.

A dry and stony free-stone, well powdered and sifted, may be used instead of sand and loose earth; nay, it will answer better, on account of its extraordinary lightness, for any constructions that are to be supported by timber-work.

All kinds of marne, well washed, in order to destroy that unctuousness of theirs, which might otherwise prevent their taking to other substances, and carefully powdered, are equally proper to incorporate with both kinds of lime. Charcoal-dust;(12) and, in general, all the vitrified substances afforded by furnaces, as well as the refuse of foundaries and forges; in short, every kind of rubbish impregnated with metallic bodies altered by the fire, is equally

(12) Ashes are pernicious, and retard the setting of the lime.

subject to the fetters of the mixtures made with the two kinds of lime; and may, of course, be usefully employed to make cements of any colour we would chuse to have them.

Nor ought we in cases of necessity to overlook pounded stone; so that the hitherto so useless heaps of stone chips, and distressing mountains of old materials arising from the demolishing of buildings originally constructed with lime and sand, and which there is sometimes, in the old way, a necessity for removing to a great distance, may, in this new one, be disposed of on the spot to great advantage. The trials Monsieur Lorient has already made of them in the small, are sufficient to vouch for their success in the great.

It is, however, but fair we should warn those, who are to collect the materials for this new cement, or mix them up, that, on account of the difference, in point of strength, not only between the common kind of lime in one district and that in another, but even between different parcels of lime made of stones from the same quarry, according to the time elapsed since the burning of them, there is no assigning precisely the exact quantity of quick-lime, that is to be added to every mass of the common cement or mortar. In one place, we must use more; in another, less. It is for this reason, Monsieur Lorient has pitched upon a medium,

dium, in prescribing, for any quantity of sand and brick-dust taken together, one fourth of their quantity of middling lime, when used just as it comes from the kiln; for, if on the one hand, it happens to be of a superior quality; and, of course, capable of imbibing a greater quantity of water, in consequence of its being made a harder stone; a smaller proportion of it will do; as, on the other hand, a larger will be necessary, if it has been long flaked.

The works in the neighbourhood of Paris begin to shew, that one third of the best lime it affords is not too much; but, this lime is not of as good a quality as the best common lime in most other places; nor this last equal to that of Senlis, which is the best we have. It is of the greatest importance to be well acquainted with the condition and peculiar properties of the lime we are to use, as it is only from a just combination of it with the other materials we can expect a perfect whole. There is a quick-lime strong enough to drink up, before it is perfectly flaked, a great deal more water, than is to be found in the mortar already described; so that the mixture made with them, instead of coalescing into a good cement, burns up, and falls to dust; whilst, on the other hand, some quick-lime, on account of its opposite quality, shall meet, in the

the same mortar, with more water than it can imbibe; and so form with it a compound, which, on the evaporating of the superfluous moisture, shall crack to pieces. I cannot, therefore, too strongly recommend, even to workmen who have had the greatest success in other districts, the trying of the strength of the lime, they are about to employ. They ought, besides, to be convinced, that, independently of any local advantages or disadvantages in the nature of their lime, it ceases to be what it originally was, in proportion as it grows old, so as to require a proportionable encrease in the dose of it; and that sometimes even it may happen to be so bad, as entirely to spoil any work in which they should be indiscreet enough to employ it.

Therefore, to be always supplied with fresh lime, especially for large and constant works, we should have kilns like those in the neighbourhood of Chartres, which are so many furnaces in the forms of chimneys; filled at top with alternate beds of fuel, and stone broken into small pieces, and are to be emptied of their lime by a hole at bottom. Another equally considerable advantage, attending this method of making lime, would be that of enabling us to burn the stone, in a just proportion to its quality; for, we are not to imagine, that every kind of it requires so great a diminution of

its weight by that operation, as is generally prescribed, on the strength of certain particular trials; and, the degree of this diminution being once ascertained, all we should have to do would be proportionably to encrease or lessen our beds of fewel.

With regard to sand, there are some kinds of fossil sand preferable to river sand, on account of the grains of the latter being too much rounded and polished by the friction, it is in moving water liable to undergo.

There are two different ways of preparing Monsieur Lorient's cement. The first is, to mix up very well, with water and flaked lime, the sand, brick-duft, or other materials, you chuse to employ for the purpose, to the consistence already prescribed, that is somewhat thinner than usual; then sprinkle into the mixture your powdered quick-lime; and lastly, incorporate the whole well together, to be used directly.

The second way is, to mix up the sand, brick-duft, and powdered quick-lime, by themselves, in the proportion prescribed; then, adding to them, just as fast as you want your cement, the proper quantity of flaked-lime and water, work the whole up well with the trowel. In this way, the sand, brick-duft, and powdered quick-lime, may be kept ready made up in sacks, large enough to fill one or two troughs,

so as scarce leave the workmen any room to fail in the operation, let them be ever so ignorant or careless about it.

But, I must own, that all I have been saying might be looked upon as an idle declamation in Monsieur Lorient's favour, intended merely to heat the imagination and excite the curiosity of my readers, without any reasonable prospect of my being able to satisfy it, did I not give some proofs, that the success of his cement in real works, of the most extensive and various kinds, has not fallen short of the merit attributed to it in consequence of a few confined trials.

The first thing the Marquis de Marigny thought it his duty to ascertain, with a view of rendering Monsieur Lorient's discovery useful to his majesty, and the state in general, both in civil and military, private and public architecture, was the surprising quality attributed to it of being impenetrable to water; of sustaining and containing that element; nay, of acquiring under it a perfect degree of consistence and tenacity; and all without flawing, or cracking, or shrinking, or swelling; and, with this view, he chose some works perpetually exposed to water for his first trials.

He had, it seems, to construct, in his gardens at Menars, a basin to supply a very considerable hydraulical machine; a canal, from forty to fifty toises long, to bring water to that

basin; and some subterraneous drains to carry off his waste water.(13)

Now, there was not one of these works, in which he did not make use of Monsieur Lorient's cement; in one part of them, by way of a simple coating; where nothing more was wanting; in another, to bind together common stones huddled promiscuously together; and in a third, to stop the sluice of a canal he wanted to drain, in order to coat it from one end to another. The effect of the cement used for the last of these purposes, after common mortar, clay, and every other simple or compound substance generally used on such occasions, had failed, proved extremely sudden and decisive. It had scarce time to fill up the sluice, when it withstood the water to such a degree, as to dry and harden completely, and in a very small space of time, whilst the contiguous stones were visibly sweating at every pore.

The dome of a fountain, of very curious construction, being found, in consequence of the spongyness of the stones of the country with which it had been built, to give way to all the waters which happened to light upon it, and thereby render the least stay under it disagreeable and dangerous, the marquis had it coped with a layer of this cement; and the effect

(13) The toise is equal to six French feet; and the French foot is almost three quarters of an inch longer than the English foot.

fect proved equally sudden and satisfactory with that just now related with regard to the sluice.

The bason we just now took notice of, situate for the most part on the arch of a vault, containing all the moving parts of the hydraulical machine supplied by it, exhibits another striking proof of the great advantages to be expected from this cement; and what adds to the wonder is, that all these trials were made in weather extremely unfavourable to them, viz. in autumn; in the beginning of the winter of 1772; and in the spring of the present year, 1773, during which the men were often obliged to work in the rain. In the latter end of October, 1772, they had scarce done coating a bason in a yard, where the marquis intended to keep some water fowl, when a violent shower filled it to the height of six inches and upwards; yet the work never suffered by this severe trial; not a drop of the water penetrated; what escaped, was merely by evaporation.

It will, no doubt, be asked, which of the foregoing compositions it was, that Monsieur Lorient gave the preference to in his several works at Menars; and it is but just I should satisfy him.

The cement used in the grand-canal of the kitchen garden, forty-seven toises long, seven feet broad, and three deep; in that of the back kitchen garden; in that of the yard to keep

water-fowl in; on the outside of a vault, over which there now stands a shrubbery; on the dome of the fountain I have already taken notice of; as likewise in the massy part of a building, which conveys water to the machine; and, rising seven feet within the basin it supplies, serves as a vent, as well as to carry off the water at top to prevent its over-flowing, when it is not to be let into the little basin of the machine; the cement, I say, employed in all these works, was that composed entirely of sand and brick-dust, with quick and slaked-lime. But, the coatings of this conduit, and the basin at which it terminates, were made with the addition of powdered charcoal, in the proportion already prescribed.

With regard to the coatings of the terrace walls, and some other parts of the building, the old plastering of which, yielding to the moisture and other affections of the weather, used to peel off, every winter, he employed nothing in the composition of them, but the already prescribed quantity of quick-lime added to common mortar made of slaked-lime and sand, but somewhat thinner than for common use.

He likewise employed the same kind of cement for the placcage of a subterraneous vault; and afterwards coated it over with the very white cement already spoken of, made with two parts of air-slaked lime, one of quick-lime, and

and one of plaster. And here it is proper I should observe, that lime flaked by the air alone, and in the shade, a circumstance easily known by its being found crumbled to an impalpable dust, may be used to advantage for the purpose of preventing the cement from setting as soon as it otherwise would; a thing of some consequence in coating, when the operation requires any extraordinary degree of time and precaution.

As often as Monsieur Lorient had occasion to lay his cement on the outside of any vaults, over which there might be a necessity of peoples walking, he had recourse in composing it, to coarser materials than brick-dust, sand, and the like; by which means, without losing any of its power to prevent the rain and wet from penetrating such works, it rendered the passage along the inclined sides of them less difficult and dangerous.

By what we have already said, the reader may easily guess, what a great number of useful purposes this cement must answer; and what uncommon advantages it must, of course, afford in every branch of every species of architecture.

To begin with the most obvious, let the building be of what nature it will; and let the materials of it, of themselves, afford each other ever so little hold by their sides; or firm footing,

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ing, if I may be allowed the expression, through the smoothness and inclination of their upper and lower surfaces; this cement will, notwithstanding, confer on them a degree of permanency and stability, which without it we could scarce expect from the best cut stone.

What arches, therefore, may we not expect from the use of it! how many useful and agreeable forms may we not now venture to give them! by means of this wonderful composition, we may make them almost as light as we please, and that, too, with the smallest, smoothest and roundest pebbles, without any apprehensions of their yielding, in any shape, to any reasonable degree of pressure.

Not only we may make aqueducts with it, but even pipes of any bore to raise water to any height, by just proportioning their thickness to the pressure occasioned by these two circumstances.

By means of it, we may, in our canals and basons, and all other works of that kind, save ourselves the expence of abutments, clays, mastichs, and such other works and substances, which, after all, decay with time, and of course stand in need of continual repairs. No doubt, the best way by far would be to use this cement, even in the solid and massy parts of such constructions; and, when they have been built in

in the common way, it will be necessary to look out for the joints, before we lay it on them.

Every kind of subterraneous constructions, whether civil or military, may, by means of this cement, be rendered, not only habitable, but even infinitely more healthy, than they generally are; and that, too, though surrounded by water; so that our cellars, especially those under court-yards and other open places; as likewise our necessaries; all now so subject, the former to be deluged on every rising of the neighbouring rivers, &c. the latter, to convey infection to a great distance, by their contents oozing through the adjacent earth; all these works, I say, may be easily cured by means of this cement, equally proper to keep water in or out.

In short, what is it we may not make of, or with the assistance of, this proteous matter, and that at one cast! watering troughs, ponds for stable and poultry yards, reservoirs against fire; wholesome cisterns in fortified and other places, where no running or well water is to be had.

What floors, what cieling, what copings, what terraces, and that of any form, may we not promise ourselves from this substance! We now need no longer such weighty gutters of stone or lead, and, of course, such massy walls to support them; precautions, which, though so very expensive, seldom answer the purposes for which they are intended. Instead of prov-
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ing effectually impervious to rain or even the common dampness of the weather, they often bring to the ground the buildings they were intended to defend. And, in point of ductility, surely, neither tiles, nor slates, nor milled lead, can pretend to compare with this cement, for rills, drains, sewers, capping for the ridges of roofs, and such other works as require a curve or irregular surface.

Nay, whole roofs may be formed with it, by just placing the laths a little closer to each other than usual, and then laying a coat of it on them; and, what is more, the slightest timber work will be strong enough to bear the weight of such a covering; a covering, which must be allowed of singular utility in places, where people are now obliged to put up with ponderous flag-stones; or a slight shingle, so liable to catch fire from every spark.

Both the exterior and interior ornaments of our buildings may likewise derive from this cement, not only the greatest solidity, but the most pleasing variety. But, in this use of it, care must, no doubt, be taken, not to apply it, either in the way of pargetting, or of ornaments in relievo, to any walls but such as are perfectly dry, lest it should concenter some destructive particle, which, in process of time, might make their way out; and such works
 themselves

themselves should have time to dry perfectly, before any frost can get at them.

Moreover, this cement, especially that kind of it, which has powdered stone in its composition; is, of itself, an artificial stone, which may be cast in a mould, and formed into balustrades and pilasters, for the support of terraces and platforms; and flights of stairs with all their appendages both useful and ornamental, straight and curvilinear; though, for greater safety, it may not be amiss to bestow a rude iron core on the pilasters, &c. whose slenderness and height may seem to require such an addition.

We might, likewise, make it, by casting it in moulds, or fashioning it on the potters' wheels, into flower-pots, and even other less residentiary vessels, for gardens and parterres, and that of any colour we like best.

There are several of our provinces, and several countries in Europe, where there is not a bit of plaster to be found; and where, of course, the dearthness of it has proved an insurmountable obstacle to the execution of a great number of the most useful works, particularly with regard to chimneys. But, henceforward, by means of this discovery of Monsieur Lorient's, any kind of work may be carried on, in any place, with the same cheapness and ease, as in districts where plaster is to be had in the greatest abundance.

There

There is, indeed, one very curious art, that of sculpture, to which Monsieur Loriot cannot as yet take upon him to affirm, that this cement of his may be made subservient, so far as to supply the place of plaster, clay, and other less solid substances, liable to shrink or swell. It is, however, already past doubt, that the cement is very proper to obtain the hollow moulds of such figures as we would wish to copy; and Monsieur Loriot hopes, that, with the advice and assistance of the famous artists of our capital, he shall, some day or other, be able to contribute something, on his side, to the service of the art, which they so assiduously cultivate. In the mean time, he will always be ready to answer any letters addressed to him, concerning the possibility or probability of applying his cement to any other purposes.

For our parts, we have nothing more at present to say concerning the discovery and composition of this cement, and the manner of using it. Monsieur Loriot has made no secret of any thing, not even of his private thoughts with regard to several particular uses, to which he can at present but just suppose it may be applied, as he has not as yet had any opportunity to make actual trials of it, in the great, for such purposes. But, if, on the one hand, he has had nothing more at heart, than to satisfy

tisfy the curiosity expressed by the public, as soon as it came to be known, that his majesty had ordered the secret to be published, that every one, who chose, should be able to take advantage of it; so, on the other, he hopes, that the same public will vouchsafe to value his discovery, not so much by the simplicity, as by the usefulness of it; not so much by the ease, with which it may be put in practice, as by the length, assiduity, and painfulness of the enquiries and researches of which it is the fruit, and of which, they are now enabled to reap the benefit at free cost.

It is, however, proper we should here warn such persons, as may have works to execute, in which Monsieur Lorient's cement can be useful, not to impute to him any blunders, that may be committed in the composition or use of it, by persons taking upon themselves to be masters of his method, without ever adding any practice to the theory they may acquire by the perusal of this essay; it being of the utmost importance, in every art, to unite them. For this reason, Monsieur Lorient, while he is employing, in his majesty's works, and those of the rest of the royal family, the workmen first formed by him at Menars, will not grudge the trouble of instructing all others, who may offer themselves for that purpose, provided they do not think it beneath them to put, themselves, a
hand

hand to the work; and then, as soon as he thinks them perfect, will give them a certificate of their having served this kind of apprenticeship, on sight of which any one may safely employ them. He will even render them capable of instructing others. And, should any province or town apply to him for persons ready for both these purposes, he will, to forward their patriotic views, make it his business to send them some of his best hands.

F I N I S.