thought, was quite sufficient for the cultivation of almost any crop except rice; and taking into account the fact that, in a large valley, such as the Henares, there must always be a great variety of crops, many of which would only require irrigation every twenty or thirty days, it was evident that ½ a litre per second was a good dotation for a canal. This, in English measure, amounted to 1 cubic foot per second for every 140 acres. The quantity allowed in India varied, it was believed, from 120 to 200 acres per cubic foot per second. The canon fixed by Government for the Henares canal was equivalent to 3s. 9d. per irrigation of 450 cubic metres, and for the Esla canal, 2s 9½d. for the same quantity; the lower price, in the latter case, being due to the less expensive character of the works. Some particulars of the price of water in Spain were then furnished.

Several modes of measuring the water to be supplied to the landowners were then described, including the system adopted by the Moors, the Milanese module, the plan followed on the Marseilles canal, and a new method, by Lieutenant Carrol, of the Indian army, which had been tried on the Ganges canal. The principal objects to be sought in a module were, simplicity of arrangement of the different parts, freedom from friction or any similar deranging cause, constant discharge under varying heads, and of course, an exact measure of quantity. It was of great importance that there should be no concealed machinery, and also that the measure should be capable of being easily inspected by the landholders. The module adopted on the Henares and the Esla canals could not lay claim to novelty; but it was believed it would fulfil its purpose practically. The water was measured by being discharged over a knife-edge iron weir, without any perceptible velocity, and when perfectly still. On the wall of the outer chamber was fixed a scale, whose zero point was at the level of the edge of the weir, and by means of this scale any person could satisfy himself that the proper dotation of water was flowing into the distribution channel. By arranging the sluice the guard could regulate to a nicety the height of water to be passed over the weir. Experiments were being made to ascertain the proper co-efficient for these weirs under varying heads.

As regarded the probable losses by filtration and evaporation, it was difficult to arrive at any reliable calculation, as different authorities gave such contradictory results. During the month of July, the water evaporated from the Henares Canal was equivalent to nearly ¾ per cent. of the whole volume. Another important point to the irrigation engineer was the principle followed in the distribution of the water. In the Henares Valley the ground was divided into plots of from 750 to 850 acres, each plot being served by one of the primary channels taken off direct from the main canal, one of the modules previously described being fixed at the point of departure.

May, 1868.—The Paper read was on *The Durability of Materials*, by Mr. Edwin Clark, M. Inst. C.E.

The Author expressed the opinion, that a series of Papers devoted, not so much to the special application of those philosophical principles which formed the basis of practice, as to the consideration of the principles themselves, would be of great interest, as numerous questions occurred which could be more effectually discussed in their abstract capacity, than in connection with the practical applications out of which they arose. Well-established fundamental principles had been arrived at on many subjects, which it was advisable should be definitely recorded.

The list of materials used by the engineer was small. It included stone and timber among natural productions, and bricks and cement and the metals among artificial products. It was difficult to state, even approximately, the positive life of either of these articles. The durability of any material depended, not only on its own inherent properties, but principally on the agencies to which it was exposed; as, for instance, the effects due to climate.

On examining all the facts, and seeking some common characteristic, it was found that among all the causes of decay, humidity held the first rank. The decaying influence of humidity was evidently dependent on other coincident circumstances. The mere pressure of water, or even of a saturated atmosphere, was not sufficient to induce rapid decay, which appeared to be caused by humidity only under peculiar conditions. One of these conditions was well known by the popular title of dampness. The decay caused by dampness, as in the case of dry-rot, was as effectually prevented by the presence of water as by a constant current of air, whether perfectly dry, or saturated to any degree of humidity. Damp, therefore, was not the mere presence of moisture in the ordinary form in which it was held in solution by the atmosphere. If an hygrometer were placed in a damp situation, it would simply indicate perfect saturation; no evaporation took place, but the cotton covering of the wet bulb was speedily covered by a peculiar mould, well known by its fungus-like odour, and in a short time it was converted into an impalpable powder, or ash. Under similar circumstances, timber, leather, paper, and all like materials, underwent the same rapid decomposition; vegetable gums and oils, that were insoluble in water, and even dry hard paints and varnish, became soluble and liquid. Massive timbers were rapidly disintegrated to the core, entirely losing their weight, though still retaining their form; and they were often totally free from apparent moisture, although at times dotted externally by drops of brilliant water. Damp spots were, moreover, peculiarly hygrometric, indicating atmospheric changes with remarkable precision, and temporary dessication in no way disturbed this process. The peculiar odour which always accompanied this condition was one of the best tests of its existence; and the expression that a room smelt damp was strictly correct. The effects were, within certain limits, intensified by increase of temperature and absence of light, and arrested by poisons destructive to vegetable life. If this phenomenon of decay were more closely examined, the process would be found to resemble, in many respects, a slow combustion. The ultimate results of combustion and decay were strikingly similar; the union with oxygen was slowly effected, and the residue was more or less diluted with foreign substances; but whether bodies were burnt or decayed, the remains in the ashes were substantially identical. Decay might thus, to a great extent, be looked upon as a decomposition, resulting from the slow chemical combination of oxygen with the matters decomposed. Now, if slow combustion were the cause of decay, and that particular state called dampness were so important an accessory, the inquiry naturally suggested itself, what connection existed between those agencies, or in what way could damp promote the absorption of oxygen? In the case of organic substances, the presence of vegetation in the form of fungus, or mould, was an invariable characteristic of decay, and the decomposing effect of all vegetable growth was beyond question. It might be said, that the vegetable growth alluded to was the effect rather than the cause of decay. Doubtless the spores of microscopic fungi followed the law of all other seeds in vegetating only under the peculiar conditions of soil, light and moisture which were adapted to their growth; dampness and partial darkness, and absolute quietude, and even decay, might be essential to their existence; and therefore it was only under such conditions that they appeared at all. But, nevertheless, when they did appear, their presence rapidly accelerated the decay, and they furnished a vital medium, capable of accomplishing the observed effect—combustion, or slow union with oxygen, of the substances on which they throve. It was probably by some such chemical vital action, the fact could be explained, that even the hardest rocks were rapidly decomposed by the growth of lichens, or that decay should be arrested by poisons which could exert no other influence than the prevention of vegetation. It was equally remarkable, that in the putrefaction, or rapid chemical decomposition, of animal and vegetable substances, the same profusion of the lower forms of animal, as well as vegetable, organisms characterized the phenomena.

Whatever might be the cause of decay, moisture was an indispensable element. Dry air was incapable of decomposition. Water was a carrier of oxygen in a potent form; and it was only from water, and more especially when in the form of vapour, that the oxygen necessary for decay could be obtained. The durability of tin and iron roofs in Geneva and St. Petersburg, was due to the absence of moisture; and the importance of some shelter for timber, and of thorough ventilation wherever it was employed in this moist climate, was a necessary corollary.

The durability of metals, like that of organized substances, depended mainly on the resistance they offered to combination with oxygen; and thus their decay might also be regarded as a slow combustion. But their durability further depended on the character of the oxides formed on their surface. Iron exposed to moisture was soon coated with rust, in the form of hydrated peroxides; and as these oxides did not adhere to the surface, additional flakes constantly formed and fell away, until the whole mass was destroyed. Wrought iron in a pure, dry atmosphere, suffered, practically speaking, no deterioration in any lapse of time. It was extremely durable in distilled water free from air; but it was slowly oxidized in a moist atmosphere, and with fatal rapidity in air or water containing free acids or other corrosive agents. It was, however, efficiently protected from such agents by paint, which adhered to clean iron with great tenacity. It was also a fact, not hitherto satisfactorily accounted for, that oxidation was to a great extent arrested by vibration. The painting of wrought iron girders and roofs, more especially in the neighbourhood of smoky towns, was a precaution of the utmost importance. Every care should be taken to expose the iron as freely as possible to the air, to leave no hollows where water could collect, to avoid the contact of damp earth, and especially of vegetation, and to throw the material into the form of heavy bars rather than thin plates. Painting was more economically performed, and was more effectual, when constantly attended to, than under the vicious practice of laying on three or four coats, and then leaving the work for years, till the paint all peeled off, with a layer of rust attached to it. The Britannia Bridge furnished a striking illustration of the value of this system. The maintenance had been effected by two or three men, constantly on the work, who attended to the slightest symptom of local discolouration. As a consequence, the author did not hesitate to express his firm belief, that the total loss from rust of the 10,540 tons of which the tubes consisted, did not in twenty years amount to a single pound weight.

Cast iron, when exposed to the action of sea water, slowly decomposed, the iron being dissolved, leaving behind a graphite or plumbago. The action, however, was superficial, and very slow. It could be preserved by painting, where accessible for that purpose, and by any pro-