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XIV. *On a Mode of rendering Substances incombustible.*By ROBERT ANGUS SMITH, *Ph.D., Manchester* *.

I HAVE often been surprised that, considering the number of materials which will not burn and the small number which do burn, we should be compelled to build houses so liable without constant watchfulness to instantaneous destruction; that we should go also to sea in vessels made of a most combustible substance filled with enormous fires, frequently under the care of ignorant men. I think, therefore, I may be excused when I endeavour to add to a knowledge of the mode of rendering substances incombustible, or the theory of the mode to be sought after, even if the addition which I make be but a very small one.

Silicate of potash has been considered good. It is a soluble glass which was expected to cover the fibre of cloth or wood, and so protect it from heat. This does act to some extent, probably in the same manner as stones do when put into a fire of wood or coal; they take heat but give none, and are also bad conductors. If silicate of potash remained as a glass, it would act also by keeping out the air; but this does not seem to be the case, as it falls after a time to a powder.

It struck me that the mode of preventing combustion was not by protecting the wood from the fire merely, as heat must cause combustible gases to rise from wood, whether there be incombustible substances mixed with it or not, and these gases will force their way to the surface where there is no longer any preventive to burning. My object then was to find a substance which would render the wood unfit to burn, and would cause it to give out gases which would not burn; so that whilst the wood itself was being preserved, except where in contact with the fire, the gases would assist in extinguishing the fire.

I first tried phosphate of magnesia and ammonia, thinking the ammonia given out would be of use in extinguishing the fire; but this was of no value, as a piece of calico required to be made quite stiff with it before it was rendered incombustible. The calico was prepared by dipping in a solution of phosphate of magnesia in muriatic acid and then in ammonia. It seemed to me that the earthy salts are of little use for the purpose required, and that the amount of solid matter incapable of evaporation left on the cloth, assists in a very small degree.

Sulphuric acid, however, seemed to present the most promising characteristics of a substance incapable of burning, and of acting so strongly on vegetable substances as to make them

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incapable of burning. Sulphuric acid itself is a body perfectly burnt, or we may say overburnt, having an atom of oxygen given to it by artificial means, so to speak, which atom is difficult to separate, and therefore not resembling the oxygen of many highly oxidized bodies. It requires a high degree of heat to raise it to vapour; and the vapour formed is sluggish and heavy, remaining long where formed, and quenching flame wherever it is. It destroys the texture of wood also and other vegetable substances, causing them to give out after a time gases which do not burn, mixed with some which do burn; but if there be enough of acid, forming a mixture which does not burn. The wood also cannot be again induced to become combustible until it be heated to redness, so as to remove all the sulphuric acid, leaving only charcoal.

If sulphuric acid then could be introduced into wood just at the time that the fire was going to take place, the fire would cease to take place; and this we can do easily by saturating the wood with sulphate of ammonia. When there is no fire present there is no sulphuric acid present, as such; but as soon as the heat rises, ammonia goes off, and sulphuric acid is instantly presented to the wood. The ammonia does not come off quite pure, it is mixed with nitrogen and sulphurous acid; and this disengagement of gases is of advantage in extinguishing fire; when the heat rises to 536° , the sulphuric acid is then left to act on the wood in part and to volatilize in part, and that which I have mentioned takes place. The outside of course would first undergo the change, and the inside would be protected by the incombustible outer part; if the fire continued to act long, the inner layer would undergo a similar change. I imagine, then, the acid acts in a double manner; it makes the wood refuse to burn and it puts out fire. As sulphurous acid is given off in this process, the action is also similar in one point of view to that of sulphur, which has long been used for putting out fire in chimneys.

I have no doubt that a house built of wood prepared in this manner might have a fire lighted on the wooden floor without danger, burning only on the spot to which the fire was limited. A ship also would be safe, even if the cinders did fall from the grate in stormy weather.

I know that muriate of ammonia has been used, and that it acts very well; but I think the sulphuric acid is superior, the ammonia being merely to keep it innocent; any other volatile base might do. I am sorry, however, that this is not perfect; its solubility in water is a great disadvantage, as it cannot be applied to clothes to be frequently washed. True, it is so cheap that it might be applied every washing where

there are peculiar dangers; but if a person were standing very near the fire, the ammonia would in part be evaporated, and the acid remaining would be enough to injure the fabric. There are however cases, such as curtains, to which this could not apply, and where it would be valuable.

Sir William Burnet's liquid is chloride of zinc: he uses it for preserving wood and canvas, and also for preventing fire. I am certainly surprised that more use has not been made of it, being, as far as I have seen it, so efficient. I believe the manner in which the chloride of zinc acts is very similar to that of the sulphuric acid, destroying the organic matter on the approach of heat, and rendering it incombustible. It can be introduced into wood at a specific gravity of 2000, I believe; sulphate of ammonia cannot easily be used above 1200. By heating the solution more may be attained. Sulphate of ammonia is cheap and easily procured and used, not hurting anything with which it may come in contact, and therefore more easily managed in households.

The chloride of zinc is said to unite with the fibre. This cannot be said for the sulphate of ammonia. It would not, however, come from the centre of a beam of wood, even if immersed in water, as the water enters with great difficulty into wood; and the solution itself cannot be introduced without forming a vacuum in the saturating vessel, and so removing all the air from the wood.

The first time I used this solution I found a large quantity of mould formed, and indeed it contains all the elements to increase its growth. The second time the solution was boiled in an iron vessel, and no mould formed on it; on the contrary, mould was destroyed by it. The sulphate of ammonia dissolves iron rapidly, and forms a double salt which is deleterious to such growths. I imagined any other metallic salt would do, and used ordinary chloride of manganese prepared in the laboratory, which killed all such fungi rapidly, and no more have grown after standing eleven months in contact with organic matter.

I believe there are many ways in which this may be used. My wish was to find a substance suited for building fire-proof ships, and I believe this would do; at any rate the ships would be fire-proof, experience could alone tell if any other objection followed. It does not render the wood hard, heavy or brittle.

I believe it would be of the greatest advantage in mills, which now suffer so much from fire, diminishing or rather entirely removing the expense of insurance. It does not hurt colours; so that even coloured goods might be dipped when kept long in one place, or when sent in vessels abroad. Possibly some

delicate colours may be attacked, but this must be a rare case.

I am more desirous of seeing ships built of an incombustible material, the means of escape at sea being few, and confined to few; and whilst there is any hope of doing it easily, I scarcely think it proper for any one to neglect what information may exist on the subject.

XV. *On a system of Triple Algebra, and its application to the Geometry of three Dimensions.* By the Rev. CHARLES GRAVES, A.M., Professor of Mathematics in Trinity College, Dublin*.

WHETHER we can directly evolve out of the ordinary double algebra such a more general algebra as will answer all the requisitions of the geometry of three dimensions, is a question into which I am not about to enter at present. But Mr. Cockle's discussion of it in the last Number of the Philosophical Magazine, and his use of an imaginary whose square is equal to positive unity, have reminded me of a system of triple algebra which I devised some time ago, and which, I am inclined to believe, will find more favour with others than it has done with myself. The outline of it was stated in a letter addressed by me to the late Professor MacCullagh in April 1845, since which time I have suffered it to lie without further development or application. For my own part, I commend the superior power, symmetry, and flexibility of Sir William Hamilton's quaternion theory, of the excellence of which use has only more and more convinced me. I find, however, that there are mathematicians who continue to object to it on the ground that they cannot conceive the nature of the operations by which his symbols i, j, k transform extra-spatial, scalar quantity into directed linear magnitude; and who protest against the sacrifice of the commutative character of multiplication. To those who cannot bring themselves to waive these objections, I submit the following system. It has the advantage of being easily and completely interpreted; and I may add that, in the treatment of some geometrical questions, it has proved itself not inferior even to the quaternions.

1. Imagine an operation denoted by the symbol (s) , and of such a nature that—

1. $s(1)$ is a quantity not homogeneous with the real unit, so that no equation of the form $s(a) + b = 0$, where a and b are real, can subsist, unless a and b be separately equal to zero.

* Communicated by the Author.