THE TECHNICAL EDUCATION OF CLAY-WORKERS.

BY EDWARD ORTON, E. M.

Mr. President and Gentlemen of the Institute:

It is with a feeling of some diffidence that I address you to-day on the subject which I have just announced. To some of you, if not to all, it may seem a subject foreign to those which you have assembled to discuss. I hope, however, to point out sufficient bonds of mutual interest between the miners and clay-workers to excuse me for occupying your time.

Clayworking, if not strictly a mining, is at least a mineral industry. Its crude material and supplies are wholly drawn from the mineral kingdom, and its products are most of them valuable by reason of their inorganic and imperishable nature.

Ohio is not commonly considered as one of the mineral states of the union. Our most painstaking efforts at Philadelphia in 1876, at New Orleans in 1884, and at Chicago in 1893, produced a mineral display mainly interesting to a student or a scientist. The vast majority of sight seers passed us by with scarcely a glance, while the rich displays of the northern and western states were constantly crowded. We have no gold or silver, no copper, lead or zinc, and I may almost add we have no iron, for the discovery of the vast deposits of rich and pure ores of the Lake Superior region has destroyed the vitality of our industries, established on the low grade and impure ores of our coal measures.

The only Ohio furnaces now running are such as by fortunate geographical location can obtain favorable freight rates on the ores from the northwest, and the cokes of Pennsylvania and West Virginia.

But while our minerals are lacking in the glitter and attractiveness of those of the mountain states, it must not be thought that we are without some claims to mineral importance. Our wealth lies in those common and homely supplies which fill our first and nearest wants. Our coals, clays and building stones, are the source of great present and future revenue, and the Ohio Institute of Mining Engineers has before it a field of great usefulness in their developement. The duties of the Institute should be interpreted in their broadest sense, and its

efforts should be directed towards the dissemination of knowledge in every branch of the mineral industry which is represented in our State, as well as in the mining of coal.

The position of Ohio as a clay working state is flattering to every enthusiastic Buckeye. We rank well to the front in every line of comparison with the other states, but in clay working we are *first*. In no other field of mechanical or technical progress do we hold so high a place.

Look at the Pottery industry. We possess almost all of the china factories in the United States. We manufacture over one-half of the white ware, eclipsing New Jersey, which is the home of the American pottery industry. In yellow wares, though they are a feeble and contracting branch of pottery making, we have ten large factories with over one-half of the country's output. In stoneware, Ohio goods are sold in every state in the union, even on the remote Pacific coast. We have thirty-five large potteries and innumerable small country shops, whose aggregate capacity is not far from twenty-five million gallons per year. A new field of usefulness for Ohio clays has been recently introduced in a handsome line of decorated earthenware, and lastly, to Ohio belongs the credit of supporting the first and only art pottery in America, which has achieved financial success at home and the critical endorsement of its rivals abroad.

In the lower grades of clay ware, like sewer pipe and paving brick, our standing is equally high. We are the center of the sewer pipe production of the country, with a list of thirty-five magnificent factories, among which are the three largest in the world. In paving brick we are not only the leaders, but the pioneers as well, and our forty factories have an annual capacity of three hundred millions.

In fire brick we stand second only to Pennsylvania, whose enormous iron industries support a larger home market than Ohio can find. Also in building brick, which are a commodity too cheap to transport, those states surpass us which have the large cities of the country for their markets.

But in every other branch of the building material supply, like fine pressed and ornamental brick, roofing, flooring and decorative panel tiles, fire proofing, building and foundation blocks, chimneys, flues, and terra cotta ware, Ohio's goods are known everywhere, and everywhere accepted as the standard.

Although accurate statistics, or even unofficial estimates entitled to credence, can not be furnished, enough is known to show that the various clay industries now produce articles of an aggregate value fully equal to the total present coal production of the state, and the day is close at hand when Ohio's richest

and most important mineral industry will be in the mining and manufacture of clay.

The colleges and universities of the country offer good courses in all branches of engineering science. To obtain the best of training in mechanics, electricity, mining, surveying, agriculture, or any of the sciences of animal or vegetable life, is to-day an easy matter. In every state free colleges have been established where these subjects are taught at only a nominal expense to the student, from whom time and dilligence only are exacted. But so far as is known to me, no American school offers any course of special instruction in the science of ceramics.

Ceramics, or more plainly speaking the science of clay working, is a complex study which requires in its explanation the aid of nearly every branch of engineering science. No college course or degree covers exactly the range of work needed to successfully prosecute this study, though the degree of Engineer of Mines gives more nearly what is wanted than any other.

To be able to cope with the problems which the clayworker meets, the student should have instruction in the following subjects:

1st. Geology, especially in its economic aspect, which can contribute much that is directly useful. From this study we learn the origin of clays, and to what influences they owe their present location and structure. It teaches us where to look for clays, how to trace them from place to place, how to estimate their probable extent and how to identify different deposits when separated by a distance.

2d. Mineralogy instructs us in the composition and character of clay as a mineral. It shows us that really pure clay is a mineral of very rare occurrence, and that what we are accustomed to call clay is a mixture of a number of different minerals. It explains how the proportions of these minerals vary in different clays, and which by their effect on the clay as a whole deserve to be entitled impurities or fluxes.

3d. The great science of chemistry is really more than any other the foundation of all the science of ceramics. In its first and most immediate use, it shows us how to analyze and determine what our clays really are. Geology and mineralogy unite to show us what they are likely to be and what impurities to expect, but chemistry tells us definitely what our particular clay is and what its character is likely to be in working and burning.

And while this knowledge is wellnigh indispensable, the most important thing that chemistry can do for the student is to

thoroughly imbue his mind with the great laws of chemical union and combination which link together the atoms which make our wonderful world, and that of other worlds only known to us through astronomy.

4th. These studies are carried still farther under the name of metallurgy. Accurately speaking, metallurgy is the science which deals with the extraction of metals from their ores, but incidentally it includes much that is of especial and direct value to ceramics. The formation of silicates, their fusion and thermal properties, the nature of fluxes and how they are applied, the nature of refractory materials. and much other information which constitutes the heart and core of clay burning is here discussed. Also the use of fuels and the nature and appliances for combustion, together with the construction of kilns, furnaces and apparatus for carrying on metallurgical work is treated, so that it may be seen that metallurgy, as far as it affects the study of ceramics, is really the study of applied technical chemistry.

5th. The engineering sciences, civil and mechanical, both contribute much that is useful. Civil engineering is the great art of construction. It teaches how to measure and survey, how to draw and calculate, how to make a plan on paper and carry it into execution in wood, stone and iron. Not only is such knowledge useful to any clay worker in his own business, but it enables him to keep his products abreast of the progress in all kinds of construction.

6th. Mechanics teaches us the use of steam and power. We learn how to generate force, how to carry it, and how to apply it. We learn how to design and construct machinery, and how to repair and alter it to improve its imperfections.

7th. Manual training, only lately introduced into collegiate work, is able to do much to assist the clay worker. To a manager of men, nothing is more useful than direct, personal, practical knowledge of how to do hard work. No good manager wastes his time in doing hard labor himself, for it is the poorest economy to try to accomplish by personal effort and versatility that which belongs to others duties. But knowledge of the work to be done enables him to correctly estimate the industry and skill required to do it, and gives him a fair idea of its proper reward.

This list of sciences whose study would benefit the student in ceramics, might still be greatly extended, but enough has been said to indicate the most important studies which unite to equip him for his work.

The extent to which scientific or technical knowledge is actually used by clay workers is extremely small. The great

majority consider their commercial success and present prosperity as evidence of their skill, and they see no reason to expect technical education to still farther raise their standards, simply because nothing of the kind has yet been brought before their notice.

Of course if their present manufacturing processes were not conducted on substantially correct principles, commercial success could not be had; but those who work by rule of thumb, and who do not know any other laws but practical ones, are sure to stray from the straight and narrow path of success, not only occasionally, but frequently, scientists make mistakes also, but while a practical man is groping in the dark to find out which of natures laws he has violated, the scientist can usually at once see where the error is.

For instance, look at the problems with which the white-ware potter has to deal. He has to make from kaolin, silica and feldspar an artificial clay, which shall form a white, strong and partially vitrified silicate when burned at a proper heat. In addition he has to compound a glaze which shall not only fuse at the proper heat to a clear, transparent glass which flows and covers the surface of the ware, but it also must contract in cooling at substantially the same rate as the body, so that it shall not crack or craze and ruin the appearance of the article.

Now to make such a body and adjust the glaze to it is not really beyond the limits of even an untrained experimenter. But when a batch of several tons a day is to be made up, and when the various ingredients are all certain to fluctuate in composition more or less, it is plain that if the glaze is accurately adjusted for the body at one time, that it will be wrong for the body made when fresh lots of supplies are used. To maintain this fine adjustment between the composition of body and glaze is a problem only capable of solution by use of skillful chemical investigation into the quality and strength of every ingredient before its use.

At one time the iron business was conducted just as the pottery business is now. Blast furnaces were in charge of foundrymen, whose policy was to keep secret and mysterious everything connected with the management of the furnace.

Iron was sold by its appearance and grain, and ores were bought on the judgment of the eye alone. Some few furnaces are still trying to run along in this same old way, but the great majority are either dead and gone, or are waiting for the better times which will never come again to them.

The modern blast furnace buys its ores on analysis, sells its iron on analysis, and runs its burden on regular chemical formulas,

and it goes ahead and makes more iron than ever, and sells it cheaper instead of crying of hard times.

Takeanother instance of what chemistry can do. The commonest loss in the sewer pipe and paving brick business is from bloating of the clay in burning. Some works lose more or less on every kiln. Some only get a bad kiln once in a while, but none altogether escape. The cause of bloating is a very simple chemical reaction, which is easily understood, and easily proved by anyone.

But in a recent tour of the State, in which almost every clayworks was visited, only two men were found who understood this bloating process. One of them was college trained, and the other, a sharp, practical man, admitted that he had saved hundreds of dollars in loss since his discovery. The sewer pipe men and paving brick makers are active minded, pushing, progressive men, but they simply have never yet had it borne in upon them that chemistry is likely to especially aid them in their difficulties.

Instances of this kind might be multiplied indefinitely, but enough has been said to illustrate my position. I have now called your attention successively to the value of our clay deposits, the high rank of Ohio as a clay working state, the constantly increasing importance which the industry is likely to enjoy in the future, the kind of knowledge which a clay worker needs in his business, and to what a very limited extent the clay workers have availed themselves of scientific assistance.

Lastly, I wish to suggest a means to improve this condition of affairs.

While the various branches of study needed are not found united in any one college course, that of Engineer of Mines offers most nearly the range that is desired, and if the clay-workers would send their sons and young men growing up in the business, and let them avail themselves of this full course which the state offers free, the infusion of the new blood and new ideas would soon make itself felt in the factories of the country. But as the course is somewhat long, and requires some considerable education before beginning it, it is not likely that any great or sudden change can be brought about by this means.

But the miners of the state have, by their efforts, and especially by the influence of this Institute, obtained for their free instruction, a short mining course at the State University, which is designed to offer to those of bright and vigorous minds among the working miners, a chance to educate and enlighten themselves in the scientific part of their business, without

exacting from them either a long course of study or a high standard of previous education.

No more beneficent use has yet been devised for the educational machinery of the state. In every branch of technical work, active minded and energetic young men are found, whose lack of education is the only thing which prevents their rapid rise to positions of responsibility. To give these men a chance to learn what they need most to know, with as little delay and hindrance with things which they can do without, is a departure in educational ideas as wise as it is novel.

In agriculture, also, a short course has been established, and is in most useful and efficient operation. Young farmers can get in two years the essential part of the longer course, and they go back to their farms with new and higher ideas of the dignity and possibilities of their calling.

Now why should not the clay workers be eqnally favored by the state? The industry is certainly important enough, and this kind of education is certainly needed badly enough.

Especially is such a course needed in ceramics, for none of the long courses exactly fill the needs which even a short course, properly selected, could be made to supply.

No one could master in two years the various sciences mentioned in the earlier part of this paper, but it is perfectly possible to pick out from each that which bears most nearly on the study of ceramics. The bulk, of course, would be in chemistry, theoretical and applied, and in this subject the facilities of the University are unsurpassed.

Every pottery and clay works contains one or more young fellows who ought to take such a course. They already know the most that what experience can teach them, and they already have the skill of hand so hard to acquire later. Their minds are at the most receptive age, and though they would have many prejudices to overcome, and wrong opinions to unlearn, still they would rapidly absorb what they need most to know.

There are really few clay works in the state that could afford to employ, or who would even profit by the work of a skilled technical chemist. But what they all need, and what each one can afford to employ, is a superintendent or manager or foreman who knows the theory of the business, and who could use the chemical work of others. A mere analyst to do testing under supervision is a cheap man, whose work only becomes valuable in the hands of a competent manager. But when an analyst adds to his chemical knowledge the practical knowledge and skill of the factory, he then is no longer cheap, for he is fit for promotion.

If the clay workers of the state would unite in demanding the endowment of such a short course in ceramics at the State University, there is small room for doubt but that their efforts would be attended with speedy success. Both of the other short courses were obtained in just such ways, and their respective constituents now appreciate more than ever the value of the work they have inaugurated. It rests with the clay workers to go and do likewise. The Lord helps those who help themselves.

THE CHAIR: Gentlemen, you have heard Mr. Orton's paper. It is now before you for discussion. That is a matter which I can hardly speak about personally because I am connected with the university, but I think the university, upon a proper request from those interested in this work, would be glad to set about the inauguration of such a course. I have always believed in the University connecting itself as closely as possible with all the industries of the state. It is closely connected with the agricultural and mining industries of the state and I don't see why it should not be with the clay working industry which, as Mr. Orton has said, is among the largest in the state.

We will now proceed to the next paper on the programme, by Mr. Ede, on "The Development of No. 2 Coal in Jackson County, Ohio."