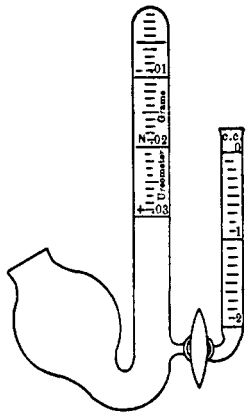
tus shown in the accompanying figure. A tube graduated to tenths of cc. is attached on the side opposite the bulb, and the two tubes are connected by a stopcock. The instrument is filled with the test liquid in the usual way and then the small tube is filled with the urine. Exactly one cc. is allowed to run in through the stopcock, and then the nitrogen is measured in the larger tube. The instrument gives as great accuracy as can be attained with the small quantities dealt with. The hole in the stopcock should be filled with the urine. This can be done by running in a drop or two of urine before filling with the test liquid.



The instrument is conveniently held with the left hand while the stopcock is being operated with the right.

CUMBERLAND UNIVERSITY,
LEBANON, TENNESSEE.

CHEMICAL CONSIDERATIONS ON THE POTTERY INDUSTRIES OF THE UNITED STATES.

BY KARL LANGENBECK.

Received Nov. 16, 1893.

PART I.

OUR pottery industries have developed so purely on an empirical basis, that very little of a chemico-technical character has found its way into English literature concerning them.

Our potters are, almost without exception, innocent of chemical knowledge, and American chemists have had little opportunity of working in their manufactories, or have not felt at liberty to publish their experience in such lines of work.

As, however, the diligence of our many geological surveys causes many thousands of clays to be annually collected, described, and analyzed, it is unfortunate that such extensive

work brings industrially no fruit, because the chemists so employed seem to have no knowledge of the potter's needs and present data that even to the pottery expert are valueless, stopping short, as they do, of the point at which their analyses would prove of use.

It is with the hope that this diligent and extensive effort of the chemists of our geological surveys may be directed into serviceable channels, that a description of the main branches of our American pottery industry will be attempted.

The most important domestic products of our markets, are fire clay goods, terra cotta, red ware, yellow ware, stone ware, C. C. (*i. e.*, cream colored), and white granite ware. The manufacture of bone china and to a limited extent of feldspar porcelain have also been begun, but are not as yet, industrially as important as the former.

Concerning the first two classes, fire clay products and terra cotta, it is not the purpose of the writer to consider them in the course of this article; not because they lack interest from the point of view of the chemist, but because the manufacturer of these wares stands in no such need of the chemist, as the manufacturer of glazed wares, and considerations applying to the examination of the raw materials of the latter, apply equally to those of the former.

Red Ware.—The simplest and cheapest of glazed pottery is called from its color, "red ware." It is ordinarily formed from the same materials used for making red brick; alluvial mud found in the river valleys and weathered ferruginous shales. It is important that the material contain but little lime, which if present in any considerable amount, destroys the bright red color imparted by the oxide of iron, giving unsightly ware.

At a heat sufficient to melt a wire of pure silver to a bead, the clay should bake so hard, that it can barely be cut with a knife. The specimen baked at that heat should adhere, when touched to the tongue and be of a bright red color.

The clay must be of such composition, that with the hardness attained at the given temperature (from the melting point of silver to not exceeding that of an alloy of seventy-five per cent. silver, twenty-five per cent. gold), it will have practically the

same co-efficient of expansion, and hence bear without fracture, a glass fusible at that heat.

A glass or "glaze" of this character would be one having a chemical formula lying between 1. PbO 0.1 Al_2O_3 1. SiO_2 and 1.0 PbO 0.15 Al_2O_3 1.5 SiO_2 made by grinding together

129.7 parts white lead,

13.0 to 19.5 parts china clay,

24. to 21. parts quartz.

In order to absolutely resist the action of acids on cooking utensils of "red ware," it would be desirable to use more acid glazes, but such is not the practice in this industry; although there is a practice that should be absolutely condemned and against which chemists should throw their influence, namely, that of using litharge or galena alone as the glazing substance and depending on its taking up sufficient alumina and silica from the body of the ware, during fire, to form the glass. A "glaze" so formed is certain to be basic on the surface, and is sure to be attacked by the weakest acids used in cookery.

The red ware potter has no china clay at his disposal, and usually makes his glaze by grinding the lead preparation with a loamy sand.

The glaze then has frequently some such composition as this—

$$1.0\ PbO \begin{cases} 0.09\ Al_2O_3 \\ 0.03\ Fe_2O_3 \end{cases} 1.4\ SiO_2$$

(taken from practice). This glaze would be of a yellowish color, which is not objectionable.

The co-efficient of expansion of the clay depends on the amount and fineness of the uncombined silica and feldspathic detritus it contains, which constituents, are in the analysis, determined by the "rational analysis" of Seger and Aaron.

A practical "red ware" clay, burning at the indicated temperature to the required hardness and color, and bearing the glaze without suffering fracture ("shivering") or the glaze itself cracking ("crazing"), being of sufficient plasticity and having from the clay to the baked condition a linear shrinkage of one-sixteenth, is a weathered shale of the following analysis:

TOTAL ANALYSIS.

	Per cent.	Insol. in H_2SO_4 and Na_2CO_3.
Silica	74.75	57.20
Alumina	12.55	0.62
Ferric Oxide	5.28	0.70
Lime	1.28	0.77
Magnesia	0.85	0.00
Alkalies	2.27	1.80
Combined Water	3.23	
	100.21	61.09

RATIONAL ANALYSIS.

	Per cent.
"Clay Substance"	39.12
Quartz	52.54
"Feldspathic detritus"	8.55

PERCENTAGE COMPOSITION OF THE "CLAY SUBSTANCE."

	Per cent.
Silica	44.86
Alumina	30.50
Ferric Oxide	11.71
Lime	1.30
Magnesia	2.17
Alkalies	1.20
Combined Water	8.26
	100.00

The following, a highly plastic red colored clay, proved unsuitable. It was too plastic and would twist and crack in the fire; it burned to a dark brownish red, instead of a light bright color, shrinking one-eighth linear measure in the fire. It contains insufficient uncombined silica to bear a glaze suited to the red ware fire, without the latter's "crazing."

TOTAL ANALYSIS.

	Per cent.	Insol. in H_2SO_4 and Na_2CO_3.
Silica	61.93	28.98
Alumina	19.87	0.53
Ferric Oxide	7.83	1.57
Lime	1.61	0.16
Magnesia	0.77	0.08
Alkalies	2.38	1.08
Combined Water	5.91	
	100.30	32.40

RATIONAL ANALYSIS.

	Per cent.
Clay Substance	67.90
Quartz	21.57
Feldspathic detritus	10.83

PERCENTAGE COMPOSITION OF THE "CLAY SUBSTANCE."

	Per cent.
Silica	48.53
Alumina	28.48
Ferric Oxide	9.22
Lime	2.14
Magnesia	1.02
Alkalies	1.92
Combined Water	8.70

The wares manufactured in this industry are flower-pots and other unglazed terra-cotta articles; of glazed articles, brown door-knobs, milk crocks, bean pots, and other cooking vessels, pots for corroding white lead, jardiniers, umbrella-stands, spittoons, etc., which latter ornamental pieces are often decorated on the outer unglazed surface with oil colors.

The chemist in order to determine the suitableness or unsuitableness of a clay for this industry should make a "rational analysis" of the same. He should determine by kneading, in a general way, the plasticity of the material and the coarseness of the admixed quartz.

Cakes several inches square and about $\frac{3}{16}$ inches thick, should be formed and dried and placed in a muffle with a wire of pure silver; on one or two of the cakes such a glaze-mixture as described before should be painted to the depth of about $\frac{1}{32}$ inch. The muffle is then fired with a gradually increasing heat until in the course of three hours, the silver wire melts, when firing is discontinued.

It goes without saying that an oxidizing fire must be maintained throughout the burning, in order to insure a bright red color of the clay by complete oxidation of its iron and to prevent a reduction of the lead of the glaze.

When cold the pieces are withdrawn and the color and hardness of the unglazed ("biscuit") pieces and the character of the glazed sherds, and whether in the course of some weeks the latter bear the glaze without defect, are noted.

ZANESVILLE, O., Nov. 15. '93.