honor by offerings of gold and silver, frankincense and myrrh.

It is by such persistence as his, in following the directing compass of an o'er mastering faith, that science and its argosy will make discoveries of new lands under skies and stars to us unknown. On such a voyage science will permit of art no suggestion of turning, and when doubt shakes its skeptical head, and fear asks timorous questions, the reply of science will be as sternly decisive as was that of Columbus, when

" Behind him lay the gray Azores,
Behind, the gates of Hercules,
Before him only ghosts of shores ;
Before him only shoreless seas,
The good mate said : ' What shall I say
If we sight naught but seas at dawn,'
Why you shall say at break of day ?
' Sail on—sail on—sail on—and on.' " *

COMMENTS ON THE DETERMINATION OF PHOSPHORIC ACID BY TITRATION OF THE "YELLOW PRECIPITATE" AS DESCRIBED BY MR. HENRY PEMBERTON, JR.

BY W. J. WILLIAMS, F.I.C., F.C.S., etc.

[Read at the stated meeting of the Section, held November 21, 1893.]

On September 19, 1893, at a meeting of the Chemical Section of the Franklin Institute, I heard with great interest Mr. Henry Pemberton's, Jr., paper on the determination of phosphoric acid by titration of the yellow precipitate with standard alkali.

For some time I have been seeking a *reliable* volumetric method for the determination of phosphoric acid. The well-known uranium nitrate method is sufficiently accurate for most purposes on an aqueous solution of phosphoric acid, but is entirely unreliable if the phosphatic material is dissolved in mineral acids or even in acetic acid.

* Joaquin Miller.

After some conversation with Mr. Pemberton on the subject, subsequent to hearing his paper, he very kindly sent me by letter some valuable hints and instructions on the details of the process, with the help of which I began my investigation.

The first trials were made on ordinary mixed fertilizers, containing ammoniates and potash salts, and the result showed an almost exact agreement with previous results obtained by the usual gravimetric method.

	<i>Phosphoric Acid by Pemberton's Vol. Method. Per Cent.</i>	<i>Phosphoric Acid by Gravimetric Method. Per Cent.</i>	<i>Difference Per Cent.</i>
Ammoniated phosphate,	15.475	15.480	0.005
Acid phosphate with ammonia and potash,	13.175	12.980	0.195
Acid phosphate with ammonia and potash,	13.730	13.820	0.090
Acid phosphate with ammonia and potash,	11.100	11.000	0.100

These I consider to be highly satisfactory results, and such as justified further investigation as to the reliability of the method on substances rich in phosphoric acid, such as Florida phosphate rocks, and on the other extreme of substances low in phosphoric acid, such as the "insolubles" in a well-made fertilizer.

High-grade Acid Phosphate.—Working on 0.2 gram for the "total phosphoric acid," and on 0.5 gram for the phosphoric acid "insoluble in ammonium citrate," I found

	<i>By Volumetric Method.</i>	<i>By Gravimetric.</i>	<i>Difference.</i>
"Total" No. 1,	16.830	16.57	0.26
No. 2,	16.750	16.89	0.14
"Insolubles" No. 1,	0.24	0.32	0.08
No. 2,	0.36	0.32	0.04

On ordinary mixed fertilizers.—

"Totals" No. 1,	15.28	14.78	0.50
No. 2,	14.60	14.14	0.46
No. 3,	12.29	11.45	0.84
No. 4,	13.83	13.43	0.40
"Insolubles" No. 1,	1.90	1.79	0.11
No. 2,	4.35	4.22	0.13
No. 3,	2.06	2.17	0.11
No. 4,	1.82	1.79	0.03

Here, again, I consider the results highly satisfactory.

I next worked on high grade Florida phosphate rocks, using in each case 0.1 gram of substance. To insure a fair sample, however, I first dissolved five grams of rocks in hydrochloric acid, and made up to 250 cubic centimeters and mixed thoroughly by shaking and decantation. Of this solution I took fifty cubic centimeters equal to one gram of rock, diluted to 250 cubic centimeters, and again mixed thoroughly by shaking and decantation. I then took twenty-five cubic centimeters of this second dilution equal to 0.1 gram rock, brought it to alkalinity with ammonia, and acidified with nitric acid, adding a little ammonium nitrate.

	<i>By Volumetric Method.</i>	<i>By Gravimetric.</i>	<i>Difference.</i>
Florida rock No. 1,	32'33	33'00	0'67
No. 2,	30'66	30'89	0'29
No. 3,	31'55	31'54	0'01
No. 4,	31'37	31'34	0'03
No. 5,	33'17	33'33	0'16
No. 6,	33'24	33'14	0'10

The greatest variation is in No. 1, where it reaches 0.67 per cent., but this is small compared with the variation in results from different analysts. For instance, No. 3 was analyzed by four chemists of repute, and the results were 31.54 per cent., 31.61 per cent., 31.86 per cent. and 34.56 per cent. The chemist who reported 34.56 per cent. was requested to revise his figures and reported the second time 34.44 per cent. These show a greater divergence from the results of the three first analysts than is found in the case of No. 1.

I think, therefore, that Mr. Pemberton's method followed carefully according to his instructions is entirely reliable, for high grade rocks, for plain acid phosphates and for mixed fertilizers, in the hands of careful and competent analysts. But with careless or unskilful manipulation the chances of serious error are very great. For instance, incomplete washing of the yellow precipitate would lead to very serious errors and misleading results but in careful hands the method is accurate and reliable.

WILMINGTON, DEL, November 21, 1893.