for a large amount of engineering knowledge and engineering work in the design and construction of the locomotive itself.

What are the conditions which we wish our locomotives to fulfill? They are to draw our trains at as high a speed as is consistent with safety, and to do this with the least expenditure for coal, for water, for repairs, etc., also to fulfill all the special conditions of the particular service which they are to perform, such as going around sharp curves, going up steep grades, hauling heavy trains, etc.

Of course, it is necessary that they should have the requisite strength and stiffness. Now, we have here at once questions of mechanism, questions of strength of materials, and questions of steam engine economy.

[To be continued.]

NOTE ON PEMBERTON'S METHOD OF PHOSPHORIC ACID DETERMINATION AS COMPARED WITH THE OFFICIAL METHODS.*

BY WM. C. DAY AND A. P. BRYANT.

Having occasion to make a series of determinations of phosphoric acid in Florida phosphate rock, we have used the method recently described by Mr. H. Pemberton, Jr.,† and incidentally have made a number of comparisons between it and the official method. The following are the results:

GRAVIMETRIC DETERMINATIONS.

- No. 1. From 0.7867 grms. $\text{Na}_2\text{HPO}_4 + 12\text{H}_2\text{O}$, obtained 0.2426 grms. $\text{Mg}_2\text{P}_2\text{O}_7$
- No. 1. From 1.1100 grms. $\text{Na}_2\text{HPO}_4 + 12\text{H}_2\text{O}$, obtained 0.3433 grms. $\text{Mg}_2\text{P}_2\text{O}_7$
- No. 2. From 1.0000 grams Florida rock, obtained 0.5828 grams $\text{Mg}_2\text{P}_2\text{O}_7$
- No. 3. From 0.3807 grams Florida rock, obtained 0.0262 grams $\text{Mg}_2\text{P}_2\text{O}_7$
- No. 3. From 0.4831 grams Florida rock, obtained 0.0333 grams $\text{Mg}_2\text{P}_2\text{O}_7$
- No. 4. From 1.0036 grams Florida rock, obtained 0.0227 grams $\text{Mg}_2\text{P}_2\text{O}_7$

* Read at the stated meeting of the Chemical Section, held February 20, 1894.

† *Jour. Frank. Inst.*, **136**, 362.

DETERMINATIONS BY PEMBERTON'S METHOD.

No. 1 used 1'0737 grams $\text{Na}_2\text{HPO}_4 + 12\text{H}_2\text{O}$ and 22'80 cubic centimeters KOH solution and 1'85 cubic centimeters acid.

No. 1 used 1'0370 grams $\text{Na}_2\text{HPO}_4 + 12\text{H}_2\text{O}$ and 21'30 cubic centimeters KOH solution and 0'80 cubic centimeter acid.

No. 2 used 1'0000 grams Florida rock and 41'85 cubic centimeters KOH and 5'05 cubic centimeters acid.

No. 3 used 1'0000 grams Florida rock and 7'55 cubic centimeters KOH and 3'10 cubic centimeters acid.

No. 4 used 1'0000 Florida rock and 6'75 cubic centimeters KOH and 5'50 cubic centimeters acid.

Strength of H_2SO_4 used 1 cubic centimeter = 0'015998 grams H_2SO_4 .

Strength of potassium hydrate solution 1 cubic centimeter = 0'01847 KOH.

The percentages of P_2O_5 , calculated from the foregoing determinations, are :

<i>Substance.</i>	<i>Gravimetric.</i>	<i>Pemberton.</i>
No. 1, sodium hydrogen phosphate,	19'72	19'73
No. 1, sodium hydrogen phosphate,	19'78	19'99
No. 2, Florida rock,	37'28	37'22
No. 3, Florida rock,	4'40	4'53
No. 3, Florida rock,	4'41	—
No. 4, Florida rock,	1'45	1'32

It is evident from the above figures that the agreement between the results of the two methods is as close as could be desired. Inasmuch as the Pemberton method is of extreme accuracy, is very easily carried out and effects a great saving of time and labor over the official method, it is well worthy of extended use. We have found that the author's statement of the time required for a single determination, namely, thirty to forty minutes from the time the solution is measured out for titration, is entirely reasonable. Omitting filtration of silica makes no difference in the accuracy of the results.

SWARTHMORE COLLEGE, PA.,

February 20, 1894.