Besides the usual excellent assortment of literary matter, Belford's Magazine for July contains an article on Storms and Earthquakes, by Dr. Felix L. Oswald, and one on Sexagesimals and the Origin of Hours and Minutes, by James McCarroll.

The Western Engineer for June—published by the Pond Engineering Company—has a very practical article on Steam Boilers for Stationary Power, by William Lowe, which is worth reading.

Reference has heretofore been made to the Lomb prize essays of the American Public Health Association. The prize this year was awarded to an essay on Practical Sanitary and Economic Cooking, as adapted to persons of small and moderate means. The essay was written by Mrs. Mary Hinman Abel, who has fairly earned the prize by a very good and practical treatise, which the Association has just published in book form.

An account of the presentation of portraits of Generals Grant, Sherman and Sheridan to the United States Military Academy at West Point, by Mr. George W. Childs, of Philadelphia, has been issued in a very neat pamphlet form. It is prefaced by some very interesting personal recollections of General Grant by Mr. Childs, who was, as is well known, a very intimate friend of the great commander.

## EXPERIMENTS SHOWING THE RATE OF COMBUSTION IN LOCOMOTIVES ON THE BALTIMORE & OHIO RAILROAD.

EXPERIMENTS were made some time ago on the 17-mile grade of the Baltimore & Ohio Railroad by George B. Hazlehurst, now General Superintendent of Motive Power of that line, to show the maximum quantities of coal burned per square foot per hour in the grates of locomotives. The grade referred to begins at Piedmont, and has an ascent of about 117 ft. per mile for 17 miles. This grade is often combined with sharp curves, so that it is a continuous hard pull for the whole distance, and it gives an excellent opportunity of making a test of the quantity of fuel which can be burned in locomotive grates.

One experiment was made with a ten-wheeled engine and a train weighing 352,000 lbs. The running time was just 60 minutes, and the total coal consumed was 3,391 lbs. = 148.1 lbs. per square foot of grate per hour.

A second test was made with the same engine on September 20, 1889. Total weight of train, 380,000 lbs.; running time, 67 minutes; coal consumed, 3,809 lbs.; consumption per square foot of grate per hour, 133.2 lbs.

In both of these tests there was a dry rail and an average steam-pressure of 143\frac{3}{4} lbs. The dimensions of the engine were as follows: Weight in working order, 114,500 lbs.; on driving-wheels, 91,000 lbs.; cylinders, 19 × 24 in.: diameter of driving-wheels, 60 in.; total heating surface, 1,899 sq. ft.; size of grate, 33 × 100 in. = 22.9 sq. ft.; diameter of tubes, 2 in.

Another test, still more remarkable, was made with an American type of engine. The weight of the train was 378,900 lbs.; coal consumed, 5,316 lbs.; coal consumed per square foot of grate per hour, 193.7 lbs.; running time, 59 minutes.

While the last experiment was made the rail was dry; the average steam pressure was 148.1 lbs.; the dimensions of this engine were: Total weight in working order, 107,-700 lbs.; weight on driving-wheels, 73,400 lbs.; cylinders, 20 × 24 in.; diameter of driving-wheels, 66 in.; total heating surface, 1,511 sq. ft.; size of grate, 34 × 120 in. = 28.3

The coal used on these engines was broken gas coal from the Pittsburgh Division of the road, part of it having been in the tender some time. The experiments were made by running the distance from Piedmont to Altamont, about 17 miles. There can be no doubt of the accuracy of the tests, and they show that the maximum rate of combustion in locomotive fire-boxes is considerably greater than is ordinarily supposed. Rankine gives this rate, "with draft produced by a blast-pipe or fan," at 40 to 120 lbs. per square

foot per hour. The latter amount has generally been accepted as the maximum quantity burned. Probably 200 lbs. of coal are often burned per square foot per hour in locomotives in this country.

## EXPERIMENTS ON THE TEMPERATURE IN LO-COMOTIVE SMOKE-BOXES.

## BY REUBEN WELLS.

THE experiments recently made on the Paris, Lyons & Mediterranean Railroad, to determine the variations in economy of locomotive boilers with different lengths of tubes, and which are discussed in an editorial on another page, will give a special interest to some investigations made by Mr. Reuben Wells some years ago on the Jeffersonville, Madison & Indianapolis, of which he was Superintendent of Machinery at that time. Through the courtesy of Mr. Wells we are enabled to give an engraving of the diagrams which he made to represent the results of his investigations. In his experiments the temperature in the smoke-box was taken from a pyrometer every quarter minute, and the steam pressure was taken simultaneously. In the diagrams the spaces between the vertical lines represent minutes and the spaces between the upper horizontal lines represent 20° of temperature. The spaces between the horizontal lines at the lower part of the diagrams represent 10 lbs. of steam pressure per square inch.

The wavy lines at the top represent the temperature observed in the smoke-box of different engines, as will be explained later on, and the steam pressure is shown by

similar lines at the lower part of the diagrams.

The experiments were made as follows: FIRST EXPERIMENT.—Was made on March 22, with engine No. 7, which had  $16 \times 24$ -in. cylinders, 5-ft. drivingwheels. The boiler had 114 tubes 2 in. diameter and 11 ft. 2 in. long;  $70\frac{1}{2}$  sq. ft. of heating surface in the fire-box and  $636\frac{1}{2}$  in the tubes, making a total of 707 sq. ft. The train consisted of  $26\frac{1}{2}$  loaded freight cars. The average speed was 16 miles per hour. The average steam pressure was 117 lbs. Size of exhaust nozzles,  $2\frac{7}{16}$  in. The temperature in the smoke-box is represented by the upper dotted line in fig. 1, and the steam pressure by the dotted line below.

SECOND EXPERIMENT.—Made March 26, with same engine, with 26½ loaded freight cars (three empty cars being rated as two loaded). The average speed while using steam was 17.5 miles per hour; average temperature in the smoke-box, 721° Fahr.; average steam pressure, 114 lbs.; exhaust nozzles, double, 2½ in. diameter. The evaporation on a run of 432 miles and an average train of 28.2 loaded cars was 5.54 lbs. of water per pound of coal, equal to 2.71 lbs. per car per mile. The temperature and steam pressure for this engine are represented in fig. 1 by light lines.

Third Experiment.—Made March 29, with engine No. 28, with 16 × 24-in. cylinders and 5-st. wheels. The boiler had 153 2-in. tubes, 10 st. 10 in. long; 90 sq. st. of heating surface in the fire-box and 830 in the tubes, or a total of 920 sq. st. The weight of the water in the boiler was 7,000 lbs. The train consisted of 29 loaded freight cars; the average speed while using steam was 14.52 miles per hour. Average temperature in smoke-box, 712°; average steam pressure, 128 lbs. Exhaust nozzles 2½ in. diameter. The evaporation on a run of 432 miles and an average train of 30.71 loaded cars was 6.20 lbs. of water per pound of coal, or equal to 2.17 lbs. per car per mile. The temperature and pressure are represented in fig. 1 by a heavy line.

FOURTH EXPERIMENT.—Made April 9, with engine No. 16, with 17 × 22-in. cylinders and 5-ft. wheels; exhaust nozzles, 3 in. diameter. The boiler had 158 2-in. tubes, 11 ft. long; 96 sq. ft. of heating surface in the fire-box, 868 in the tubes, making a total of 964 sq. ft. The train consisted of 27 loaded freight cars; average speed while using steam, 19.35 miles per hour. Average steam pressure, 129 lbs. Average temperature in smoke-box, 714°. The temperature and pressure are indicated by dotted lines in fig. 2. FIFTH EXPERIMENT.—Made April 11, with engine No.

30, with 14 × 22-in. cylinders, 5-ft. wheels, and 2\frac{1}{2}-in. exhaust nozzles. The boiler had 113 2-in. tubes, 10 ft. 11