By diagrams and other means we endeavored to determine whether the back-firing took place at the end of the stroke or at some intermediate time and concluded that it was at the beginning, and for the time we fell back on the hypothesis that the heated valve chamber caused ignition of the combustible mixture during the early part of the inlet stroke.

Finally we took stop diagrams with a light spring, and full diagrams with the ordinary spring, but with the back-lash in the indicator motion. These showed unforeseen conditions during exhaust and led to the true solution. It was found that the pressure in the cylinder immediately after the opening of the exhaust valve was above atmospheric, as might be expected, and that it remained there for a certain fraction of the exhaust stroke. For the remainder of the exhaust stroke, however, the proportion varying with load and cylinder from the last two-thirds to the last half of the exhaust stroke, there was a very slight vacuum in the cylinder instead of the positive back pressure which had been expected. This was found to be due to the wave set up in the long straight exhaust pipe by the first vigorous puff at release.

From this it immediately became clear that on the opening of the inlet valve explosive mixture began at once to enter the valve chamber, even though the piston had not yet finished its exhaust stroke, and that this inflow became more and more vigorous as the valve opened farther, the incoming mixture mingling with the outgoing exhaust gases and in part passing out with them through the exhaust port. The explanation of the back-firing was entirely rational. We did not have to assume that the exhaust gases were hot enough to pass through a slightly open, relatively cool port and still retain the temperature required to ignite explosive mixture, nor did we have to assume walls so hot that a rapidly whirling and eddying blast of incoming mixture impinging upon them was thereby ignited.

It was then assumed that a large number of incipient ignitions took place which did not propagate fast enough backward along the incoming gas stream to reach the mixing chamber and were blown out as the velocity of induction increased. Accepting this hypothesis and also recognizing the fact that a perfect mixture fires more easily and propagates flame faster than others, it was apparent why a rich slow-burning mixture prevented most of the trouble.

It was all along recognized that the use of an unduly rich mixture besides being wasteful was objectionable because it increased the luminosity of the flame and hence the radiation, besides coating the interior of the cylinder with a carbon deposit which tended to reduce the efficiency of the water jacket and to increase the skin temperature of the interior of the valve chamber.

While the matter was being analytically investigated a series of diagrams had been taken running with various mixtures and ignition settings and it had been decided that on account of the extremely heavy reciprocating parts the maximum stresses on the journals would not be greater with pointed than with round-top diagrams, since apparently the largest component in maximum journal pressure was that due to inertia rather than that due to the explosion. This last conclusion was borne out by the fact that the bearings ran much hotter on no load than on full load.

On account of the apprehensions of the station attendants these experimental settings were not at first maintained very long, but since they bore out the conclusions just mentioned, we finally changed the operation of all the engines as to both the mixture and the ignition settings. The mixture was adjusted for a slight excess of air over theoretical requirements and the ignition was timed materially earlier, producing a pointed rather than a round-top diagram and materially reducing the temperature of the gas at the moment of release when the explosive mixture mingled with it. After these changes were made the marked improvement in operation became so apparent as to convert even the more skeptical of the station men. Back-firing was not wholly eliminated, occurring occasionally in all cylinders and particularly in certain ones, despite the changes, but the improvement was distinctly greater than we had expected. The changes also enabled us to increase the engine output and to materially cut down the amount of gas used per kilowatt-hour. The reduction in fuel consumption was so marked that it was not merely observable by the methods of the test but was noticed by the producer men during a period when the engines were carrying considerably more load than was previously customary.

It was interesting to note that some analyses of the exhaust gas showed that if samples were taken as usual from a point a few feet below the top of the exhaust pipe, the analysis indicated a rather large excess of air in the mixture at a time when it was practically certain that such an excess did not exist. This might easily have misled previous observers and was, of course, due to the regurgitation of air into the exhaust pipe during the recession of the wave set up in the pipe by the "puff" occurring at release, as well as the loss of combustible mixture into the exhaust.

RAILWAY MILEAGE OF THE WORLD.

According to statistics in the Archiv fur Eisenbahnivesen, the railway mileage of the world in 1909 was 625,698 miles. This was divided as follows:—

	Miles.		Miles.
Europe	204,904	North America	277,014
Asia	61,800	South America	42,329
Africa	20,809	Australia	18,849
Total	625,698		

Of the total mileage 54 per cent. is in the Western hemisphere and 10,000 more in North America than in Europe and Asia together, although the latter geographical division has 1,280,000,000 inhabitants, against 115,000,000 in North America.

During the four years ending in 1909 the mileage added to the different continents has been the following:—

	Miles.		Miles.
Europe	12,359	South America	8,273
Asia	11,197	Australasia	1,306
Africa	4,518		
North America	25,057	Total	62,800

The world's total investment in 1909 amounted to about $51,000,000,000 which is about $33 per inhabitant.

TIMBER STATISTICS FROM QUEBEC.

The following comparative statement of timber, measured and culled to date, is furnished by the Supervisor of Cullers, office, Quebec, under date of July 5th:—

	1909 Cub. Ft.	1910 Cub. Ft.	1911 Cub. Ft.
Waney White Pine	583,000	236,240	440,720
White Pine	51,240	9,640	......
Red Pine	5,400	4,760	6,240
Oak	408,160	67,040	14,120
Elm	61,880	224,680	158,960
Birch and Maple	45,080	40,680	58,800
Ash	480	720	80