LIMITED CUT-OFF APPLIED TO LOCOMOTIVES

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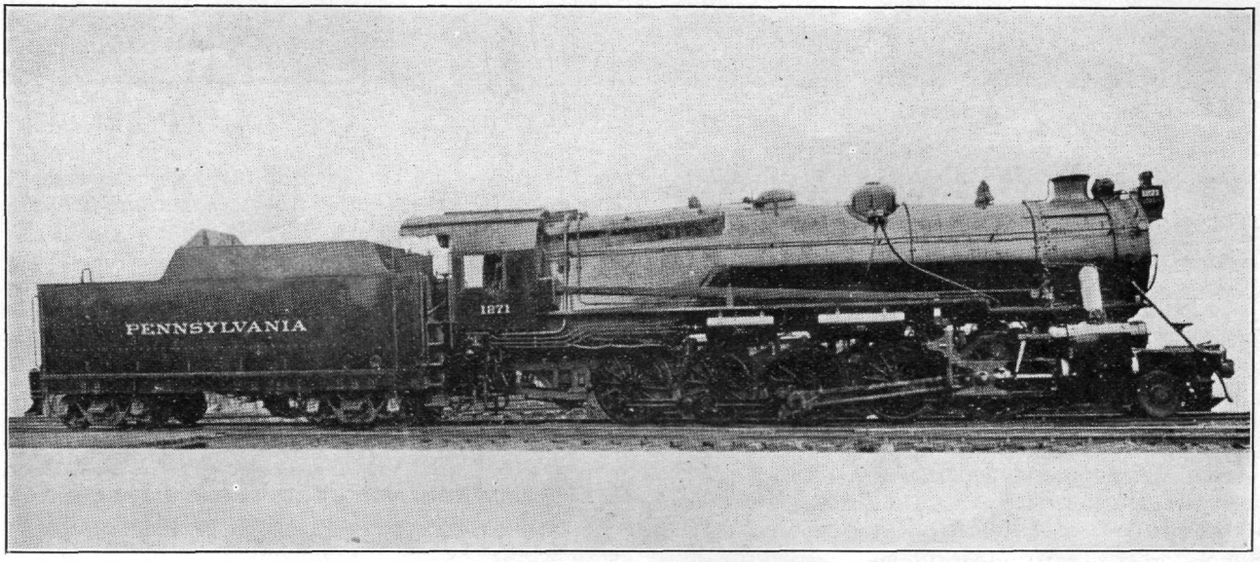
During the early years of railroad development in the United States, the main interest of mechanical officials of the various roads was to design locomotives capable of hauling heavier trains, to keep pace with the development of our present industrial age. When coal could be loaded on the locomotive tender at a cost of $1.25 per ton, many roads serving coal fields getting it for less, little thought was given to economies in operation. However, with the tremendous increase in the cost of fuel and labor during and since the World War, it has become necessary to make each engine haul more revenue tons of freight per ton of coal burned, and at the same time get it over the road in scheduled time. That is, the objective now is an engine that will pull heavy loads at high speed.

With this object before them, the mechanical engineers of the Pennsylvania Railroad began in 1916 experiments and tests on freight engines, the result of which is the class Ils locomotive. One of the peculiar features of the engine of this class is that it is designed to operate at a cut-off of 50 per cent of the stroke when running at full gear. This is a Decapod type 2-10-0, which means two truck wheels under the pilot, ten driving wheels, five on each side, and no trailer truck. The total wheel base is twenty-two feet six inches. Such engines, running East out of the Canton, Ohio yard over a division of heavy grades, are hauling trains of one hundred loaded cars. Before engines of this class were placed in service, the standard practice was to operate trains of fifty to sixty cars hauled by class Lls, Mikado-type engines. These Lls engines were the heavy freight engines designed for a similar service just preceding the class Ils engines.

The table (page 22) shows how the locomotive compares with the class Lls in certain leading dimensions. The total heating surface is about 12 per cent larger than that of the class Lls, and the total weight about 16 per cent greater. The grate areas of the two locomotives are alike.

The main difference between the class I1s and L1s and the greatest improvement over the L1s is that the I1s operates at 50 per cent cut-off. The principles of limited cut-off, or the utilization of the expansive properties of steam after cutting off the supply from the boiler, has long been known and applied by engineers in stationary and marine engine practice. Limited cut-off is not unknown in locomotive operation but is used in a slightly different manner, as the cut-off is controlled by the engineman by means of the reverse lever in the cab. It was always necessary to take steam at full stroke in starting, then after gathering speed the valve travel was shortened and an average cut-off of 90 per cent could be used. In high-speed passenger service cut-offs of less than 50 per cent are not uncommon.



DECAPOD TYPE FREIGHT LOCOMOTIVE

Pennsylvania Railroad, Cless I 1s. A locomotive of the same class as No. 790, the one tested

Many freight locomotives, in helping service especially, are worked almost continuously with a cut-off near the end of the stroke; and if they were designed so as to work at but 50 per cent cut-off when in full gear, without a sacrifice of drawbar pull, there would be gained the difference between the coal and water rates at full-stroke cut-off and those at half stroke, that is, there would be a saving of approximately 25 per cent.

Both types of engines were tested on the Pennsylvania Railroad Company's testing plant at Altoona, Pa., and the comparisons of this article are from the results obtained. The testing plant is designed to reproduce as nearly as possible actual conditions when operating on the road.

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Limited Cut-Off Applied to Locomotives

(Continued from Page 8)

THE GENERAL DIMENSIONS OF LOCOMOTIVES OF THE I1s AND L1s CLASSES

	Class I1s	Class I1s	Per cent Increase of I1s over L1s
Weight in working order, total pounds	371,800	320,700	15.9
Weight on drivers, working order, pounds	342,050	240,200	42.4
Driving wheels, diameter, inches	62	62	—
Cylinders (simple), inches	30½×32	27×30	37.6 Vol.
Heating surface, tubes (water side), sq. ft.	4043.94	3715.71	8.8
Heating surface, firebox (including arch tubes) square feet—	290.20	301.51	3.8 Dec.
Heating surface, superheater (fireside), square feet—	1478.91	1171.63	26.2
Heating surface, total (based on water side of tubes), including superheater, sq. ft.	5810.25	5188.85	12.0
Heating surface, total (based on fireside of tubes), including superheater, sq. ft.	5423.12	4847.72	11.9
Grate area, square feet	70.0	70.0	—
Boiler pressure, pounds per square inch	250.0	205.0	—
Valves	12" Piston	12" Piston	—
Valve motion, type	Walschaert	Walschaert	—
Firebox, type	Wide	Belpaire	—
Tubes, number	244	237	—
Tubes (outside diameter), inches	2.25	2.25	
Flues (for superheater), number	48	40	—
Flues (outside diameter), inches	5.5	5.5	—
Tubes and flues, length, inches	228.32	226.51	—

Indicated Horsepower

The range of horsepower was between 766.6 and 3486.1. The highest power was obtained at a speed of 140 r.p.m., which is equivalent to 25.3 m.p.h.

The superheated steam used per i.hp.-hr. was between 14.9 and 21.6 lb. In twelve of the tests the steam used, per i.hp.-hr., was 16 lb. or less. On 16.6 lb. of steam per i.hp.-hr., an indicated horsepower of about 3500 was developed.

Dynamometer Horsepower

The dynamometer horsepower shows increases and economies closely following those for indicated horsepower.

Many tests have a coal rate of 2½ lb. and a steam rate of less than 18 lb. The minimum rate was 16.8 lb. of steam per d.hp.-hr. Results show that both the coal- and water-rate curves are below those of the class L1s for all dynamometer horsepowers.

The drawbar pulls obtained upon the Testing Plant were found to be favorable. To be 25 per cent greater than the pull of the L1s at 40 r.p.m., the I1s should have a pull of about 75,000 lb. and this pull was considerably exceeded.

The engines of this locomotive, compared with long cut-off locomotives as to economy in coal and steam, have yielded expected results. The tests have shown that the restricting of the cut-off has had the desired effect in that, in full gear, where the bulk of the work is done, this locomotive operates much more economically than the L1s. This advantage, as expected, is reduced as the engines are cut back, but it is not until we have gone below the most economical cut-off for both locomotives that the L1s becomes more economical, at a given horsepower, than the I1s. This, moreover, is the case only at the lower horsepower (in short cut-offs at low speeds), that is, for but a small portion of the work to be done by the locomotive.

In the beginning of this article it was mentioned that the objective of all locomotive improvement is to increase the weight of the trains to be pulled and reduce the cost. The class I1s operating at a limited cut-off meets this requirement. The Pennsylvania Railroad is the pioneer in this field, but other roads have since seen its advantage and are making use of it.