CAR WEIGHTS AS AFFECTING OPERATING COST.*

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When it is suggested that a decrease in the weight of cars might be brought about without sacrificing carrying capacity or safety, the question is at once raised: "Will it pay?" In other words, will not the increased cost of building such lighter cars more than offset any saving to be effected in operating expenses?

This investigation was undertaken with the hope of throwing some light on the question of the relation between the weight of cars and operating expenses. It has been conducted by means of correspondence with car manufacturing companies, operating companies, and various gentlemen who were known to be interested in the subject; also by the consultation of text books and authorities in the effort to obtain theoretical data applicable to the matter.

The effort to obtain information based on actual tests or operating data has been largely barren, and therefore the theoretical discussion occupies the larger part of the paper.

Probably no argument is needed to show that an increase of car weights will cause an increase in the following items of expense:

(1) Cost of power; (2) cost of car repairs; (3) cost of track repairs; (4) fixed charges of power plant, and (5) fixed charges of distribution system.

While it is evident that these items will increase with car weights, it is not obvious that they will increase proportionately thereto. An attempt has been made in the following discussion to show the manner in which these various costs vary with the weight of cars.

Power Consumption.

In Fig. 1, O A B C D is a typical speed-time curve, figured for a car of 50 tons' weight, making a schedule speed of 30 m.p.h., with a stop every 5,710 ft., and stops of 10 sec. duration.

The slope of the coasting line, B C, is determined by the train resistance, taken in this case at 14 lb. per ton. If instead of weighing 50 tons the car were very much lighter, the train resistance per ton would be greater and the slope of the coasting line would be steeper, like the line B_1 C_1.

In the figure the areas under the curves O A L N D, O A B C D, and O A B_1 C_1 D are equal; therefore in each of these speed-time curves the car travels the same distance in the same time. In the computations which follow, when cars of different weights are assumed to be operated on the same schedule, the calculations are based on speed-time curves like O A B C D and O A B_1 C_1 D; that is to say, the curves of acceleration and braking are kept the same, but the slope of the coasting line is changed to correspond with the calculated train resistance.

The energy required to propel the car on the speed-time curve O A B C D is equal to:

(1) The energy to accelerate to the speed at the point B.

(2) The energy to overcome train resistance to the point B.

(3) Motor and rheostatic losses, proportional to (1) and (2).

The energy used in accelerating from point L to point B is all used in overcoming train resistance to point M, at which the speed is the same as at point L. Therefore, the energy required for this speed-time curve may be re-stated, as equal to:

(1) Energy to accelerate to point L.

(2) Energy to overcome train resistance to point M.

(3) Motor and rheostatic losses, proportional to (1) and (2).

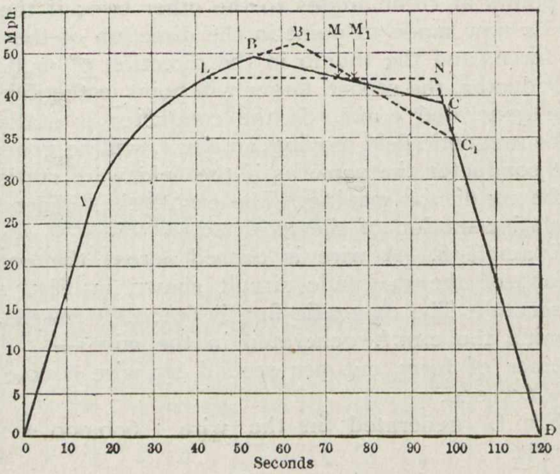
If we draw a series of speed-time curves for the same schedule, for cars of different weights, the point M shifts, as shown by the distance between M and M_1, but the total movement of this point is small, and in the computations which follow the point M is assumed constant for all cars on the same schedule. In computing the power consumption for cars of various weights, operating on the schedule, Fig. 1, the following quantities are calculated:

(1) Energy required to accelerate one ton to speed of point L, 7 per cent. being added to allow for the effect of rotating parts. The formula for this calculation is

$$E = .0205\ S^2$$

where E = energy in watt hours, and S = speed in miles per hour.

(2) Distance traveled by car before reaching point M.



Car Weights—Fig. 1.—Typical Speed-time Curves for 50-Ton Cars, Speed 30 M.P.H., 10-Second Stops Every 5,710 Feet.

(3) Average effective train resistance for the car in question. Then (2) × (3) × .000278 = energy in watt hours to overcome train resistance. These figures give the energy per ton for the schedule in question, for the distance covered by the speed-time curve.

The curves of Fig. 2 are calculated for cars of various weights operating on the schedule of Fig. 1. Vertical distances correspond to watt hours per car mile and horizontal distances and to ton weight of cars. Curve A shows the energy required for acceleration only, for cars of all weights up to 50 tons. Curve B shows corresponding values of energy to overcome train resistance only. Curve C is the sum of A and B. Curve D shows the total energy including motor losses to operate cars of all weights up to 50 tons on the schedule in question.

Curve B is calculated with the aid of Armstrong's formula for train resistance:

$$F = \frac{50}{\sqrt{W}} + .03\ S + \frac{.002\ a\ S^2}{W}$$

Where W = weight of car in tons; S = speed in miles per hour; a = area of car end in sq. ft. Throughout these computations a is taken at 92 sq. ft.

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