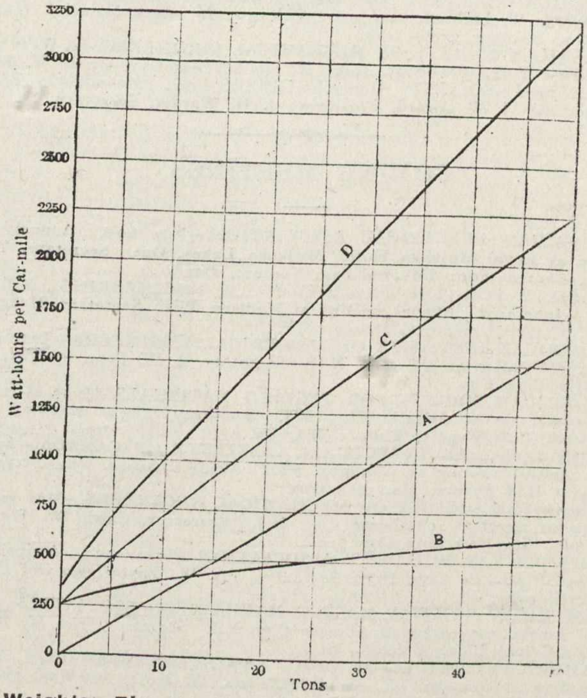
The important thing to notice about curve D is that it is substantially a straight line. If the energy were proportional to weight it would be a straight line through the origin, like line A. To show how closely this form of curve is followed under varying conditions, other schedules have been calculated.

Starting with Fig. 1 as a basis, other speed-time curves can be assumed, of the same shape, but of different sizes. Then all speeds and times will be proportional to the linear




**Car Weights—Fig. 2.—Energy Curves for Cars of Various Weights Operating on Schedules Shown in Fig. 1.**

dimensions, and all distances to the squares of the linear dimensions. By the aid of this proportionality, and a special calculation in each case for the train resistance, energy curves can be calculated for other schedules, corresponding to speed-time curves of the same shape. By assuming new speed-time curves of different shapes, further series of energy curves can be calculated in the same manner.

Such energy curves have been calculated for speed-time curves of the three shapes in Fig. 3. These were taken as illustrating widely differing characters of service, curve X requiring one stop every 3 minutes, curve Y one every 90 seconds, and curve Z one stop every 70 seconds, allowing 10 seconds duration for each stop. On the basis of these three curves, changing the dimensions in the manner above described, the energy curves of Fig. 4 have been obtained. These show the energy in watt hours per ton mile required for cars of various weights from 12.5 to 50 tons, operating on various schedule speeds, and on speed-time curves of shapes similar to the curves X, Y and Z of Fig. 3.

These curves are all very nearly straight lines represented by the equation

$$E = a + bW,$$

when E = the energy per car mile, a is the intercept of the curve on the Y axis, and b is the slope of the curve.

This equation will, therefore, be adopted as correctly representing the relation of weights of car to power consumption in all cases of like schedule, the constants a and b being dependent upon the frequency of stops and schedule speed attained.

This formula may be expressed:

$$P = \frac{p}{n}(ap + bpW).$$

where P = cost of power per car mile in cents; p = cost of power per kw-hour in cents; and n = efficiency of transmission, power house to car.

For ordinary frequent stop service, when the schedule speed is forced up to about the highest point permitted by frequency of stops, probably conditions intermediate between those of curves Y and Z would obtain, and the power consumption would be about that indicated by the broken line on Fig. 4. The equation of this line is:

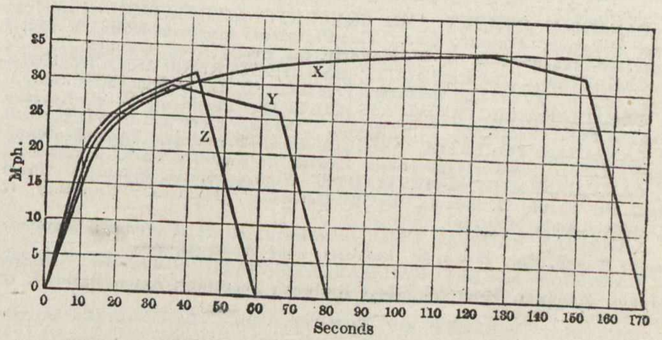
$$E = .500 + .075 = W$$

If we assume that the cost of power per kw-hour is one cent, and the efficiency of transmission to the car 75 per cent., this becomes:—

$$P = .667 + .1\ W,$$

which is believed to fairly represent the cost of power in cents per car mile under average conditions.

These equations indicate that the cost of power is divided into two portions, one of which is independent of the weight of car, and the other proportional thereto. In the case assumed the cost is 0.667 cent per car mile, irrespective of weight of car, plus 0.1 cent per ton of car weight. The value of both the constants a and b in the general formula is dependent upon the formula used in calculating train resistance. If train resistance were proportional to weight the constant a would disappear, making the power cost exactly proportional to weight. The formula used is believed to represent average conditions, as near as present information will permit, but would not be correct in some special cases.




**Car Weights—Fig. 3.—Calculated Speed-time Curves for Various Kinds of Service.**

The use of ball bearings, for instance, would give rise to a different formula, and would reduce the value of the quantity a. The figure 0.667 for a is undoubtedly too high for ordinary city conditions, which are more nearly represented by the line corresponding to the schedule of 10 m.p.h., curve Y, Fig. 4. This indicates but about 0.28 cent per car mile as the part of power cost independent of car weight. The curve chosen (the broken line) is more nearly that of elevated railway or frequent stop interurban service.

**Cost of Car Repairs.**

An increase in car weight involves an increase in the weight and cost of all replacement parts, this cost being nearly but not quite proportional to the weight. If the increase of weight is accompanied by proportional increase of strength and bearing surfaces, the life of parts should not be decreased, the sole increased cost of repairs being due to the greater cost of replacement parts. However, such proportional increase is not possible in many parts, such as trolley wheels, gears, brakeshoes and wheels, all of which wear out much faster with heavy cars than with light ones. On the other hand, some items of car repairs are independent of weight, such as painting and replacing broken glass.

(Concluded next week).