Based on an average cost of coal, water and locomotive lubrication of \$0.001133 per pound of fuel burned and the following assumptions: generator and drive efficiency 80 per cent, locomotive mechanical efficiency (cylinders to tender draw-bar) 90 per cent, 3.5 lb coal per cylinder horsepower and 6 lb of water per pound of coal, the cost of generating 1 kw of electrical energy would be \$0.00738, and 100 lb of steam \$0.01888. This is based on the assumption that the cost of coal, water and locomotive lubrication would increase in direct proportion to the amount of coal burned. As the cost of locomotive lubrication would not increase in direct proportion to the amount of coal burned, the extra cost of lubrication included in the figure should offset the increase in cost of locomotive maintenance due to the additional load. Using an average capacity of 3.3 tons, the cost per hour of operation would be approximately \$0.04 for steam and mechanical compressor systems and \$0.55 for ice, using a price of \$4.00 per ton for ice.

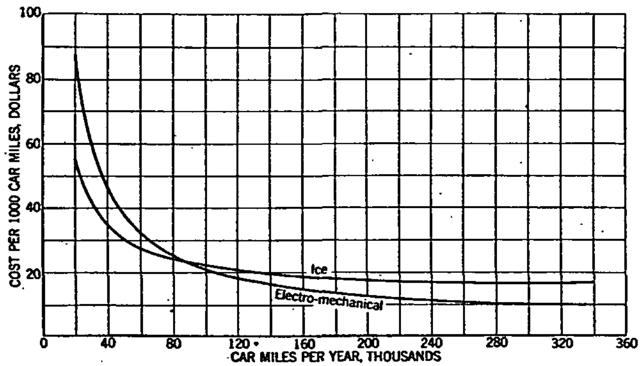

FIG. 2. COSTS RAILWAY PASSENGER CAR AIR CONDITIONING

These figures are based on the assumption that the motor driven compressor is receiving power direct from the generator and that the efficiency of the direct drive is the same as the combined efficiency of the axle generator, drive, and motor. Of course part of the current for the electric drive would be taken from the battery and therefore the battery efficiency would have to be taken into consideration. Likewise the lower efficiency should be considered of the direct drive at the higher speeds and it would be necessary to know the characteristics of the run under consideration to make an exact comparison.

For a given run the total kilowatt hours required for the electro-mechanical system would

$$= \frac{E_g \times I_g \times T_g}{1000} + \frac{E_b \times I_b \times T_b}{e_b \times 1000}$$

where

E_g = voltage with generator cut in.
E_b = voltage with generator cut out.

I_g = current with generator cut in.
I_b = current with generator cut out.
T_g = time generator cut in.
T_b = time generator cut out.
e_b = battery efficiency.

$$\text{Cylinder horsepower hour} = \frac{\text{kilowatt hours} \times 1000}{e_g \times e_d \times e_l \times 746}$$

where

e_g = generator efficiency.
e_d = drive efficiency.
e_l = locomotive mechanical efficiency.

With these formulae and the coal and water rates of the locomotive the total amount of fuel and water required to supply the power enroute can be calculated.

Fig. 2 shows the relation between the cost per thousand car miles and total miles run per year for the ice and electro-mechanical systems. These curves are based on the cost figures previously given and the following formula:

$$\text{Cost per thousand car miles} = \frac{A}{CM \times D} + M + \frac{1000}{45} C$$

where

A = Annual fixed charges (dollars) calculated as follows:

a. Depreciation	12.5 per cent
b. Interest	6.0 per cent
c. Taxes and insurance	1.5 per cent
Total	20.0 per cent

CM = thousand car-miles per day.
D = days in service per year.
M = maintenance cost per thousand car miles.
C = operating cost per hour.
45 = average miles per hour.

No charges for precooling are included. The curves for the steam and direct drive mechanical compressor systems would be between those shown for the ice and electro-mechanical compressor systems.

PROBLEMS IN PRACTICE

1 ● What item is the greatest among the cooling loads figured in the design of a summer air conditioning system for a passenger car?

The heat from passengers.

2 ● To what extent does bright sunshine increase the cooling requirements of a passenger car?

About one ton of refrigeration.

3 ● What is the total refrigerating capacity generally required in a passenger car?

5.5 to 7 tons per car.