Consideration must also be given to the power requirements for refrigeration while the car is standing or running at slow speeds. The electrical energy required for the ice-activated, steam, and internal combustion engine drive mechanical systems is easily supplied from the storage battery. Steam for the steam system can be supplied from the locomotive or from a stationary plant. The majority of the electro-mechanical systems are equipped with A. C.—D. C. motors. While standing in the yards and stations the A. C. motor is connected to a 220-volt, 3-phase circuit. The majority of these equipments are so ar-

TABLE 2. LOCOMOTIVE POWER DEMANDS FOR DIFFERENT AIR CONDITIONING SYSTEMS

SYSTEM	DRAWBAR HORSEPOWER PER CAR REQUIRED AT TRAIN SPEEDS			
	30 MPH	50 MPH	70 MPH	90 MPH
For Continuous Operation				
Electro-Mechanical	20.9	22.2	25.4	31.6
Direct Mechanical	16.8	19.5	29.5	42.6
Internal Combustion Engine Mechanical	3.4	4.6	7.0	11.9
Steam-Ejector[a]	7.6	9.3	12.5	19.0
Ice-Activated	3.2	4.5	6.8	11.6
For Non-Operation				
Electro-Mechanical	5.0	6.4	9.0	14.4
Direct Mechanical	5.2	6.3	8.7	13.5
Internal Combustion Engine Mechanical	2.2	3.5	5.8	10.6
Steam-Ejector	3.7	5.4	8.4	14.8
Ice-Activated	1.9	3.2	5.5	10.2
For Average Condition of 56 Per Cent Continuous Operation and 44 Per Cent Non-Operation				
Electro-Mechanical	13.9	15.2	18.2	24.0
Direct Mechanical	11.7	13.7	20.3	29.6
Internal Combustion Engine Mechanical	2.8	4.1	6.5	11.4
Steam-Ejector[a]	5.9	7.6	10.7	17.5
Ice-Activated	2.6	3.9	6.2	11.0

[a] In addition, steam is required from the locomotive to the extent of 230 lb per hour during the time the equipment is in operation.

ranged that, while operating on A. C. power, the D. C. motor may be used as a generator for battery charging. If an auxiliary circuit is not available the D. C. compressor-motor may be operated from the storage battery for short periods of time. The direct drive mechanical compression systems are, also, equipped with A. C. motors for operation from auxiliary circuits. As these equipments can only be operated when connected to the auxiliary circuit or while the train is running above the cut in speed of the drive, many cars are equipped with an auxiliary hold-over system by which reserve cooling is available. Due to the characteristics of the direct drive, the air conditioning system operates at reduced capacity when the car is moving at speeds below 42 mph.

COST OF RAILWAY AIR CONDITIONING

The cost of railway air conditioning is usually expressed in terms of 1000 car-miles. The actual costs for the different systems, however, are dependent upon a number of variables. Based upon a survey of the most prominent railroads in air conditioning, and upon extensive tests, the values given in Table 3 are indicative of the present costs of air conditioning to the railroads.

TABLE 3. AIR CONDITIONING COSTS FOR RAILWAY AIR CONDITIONING

SYSTEM	GROSS INSTALLATION COST	COSTS PER 1000 CAR-MILES[a]			
		Fixed Charges	Maintenance Cost	Operation Cost	Total
Electro-Mechanical	$6,484.00	$ 8.65	$3.33	$0.99	$12.97
Direct Mechanical	8,515.00	11.35	2.33	0.93	14.61
Internal Combustion Engine Mechanical	5,750.00	7.67	3.30	1.99	12.96
Steam-Ejector	8,475.00	11.30	2.15	1.02	14.47
Ice-Activated	3,982.00	5.31	0.97	5.29	11.57

[a] For an average cooling season of 5 months, an average train speed of 50 mph and an average car mileage of 150,000 miles per year.

Gross Installation Cost

The gross installation cost, from which the fixed charges are derived, may be amortized on this basis:

1. Depreciation, at the rate of 12.5 per cent.
2. Interest, at the rate of 6 per cent.
3. Taxes and insurance at the rate of 1.5 per cent.

The fixed charges per 1000 car-miles for any type of system are:

$$FC = \frac{1000}{m}(0.20A) \qquad (1)$$

where

FC = fixed charges, dollars per 1000 car-miles.
A = gross installation cost, dollars.
m = total number of car-miles traveled in one year.

Maintenance Cost

The average maintenance cost is based upon the experience of the railroads in maintaining several hundred air conditioning units. The maintenance cost per 1000 car-miles is:

$$MC = \frac{1000B}{m} \qquad (2)$$

where

MC = maintenance cost, dollars per 1000 car-miles.
B = total annual maintenance cost, dollars.
m = total number of car-miles traveled in one year.