An orderly arrangement of the various components of owning and operating costs, which will also serve as a check list to forestall inadvertent omissions, is illustrated in Table 6. The formulae for computing amortization and interest are given in the table. Interest should be computed on the undepreciated portion of investment only.

MAINTENANCE COSTS

Maintenance costs include replacement parts and the labor required for making repairs, replacing parts, cleaning, painting, etc. It should be noted that major overhauling or complete replacement may restore the capital value of certain items of equipment, and in such cases the costs incurred may not necessarily be charged as maintenance costs. Generally, routine labor requirements will be the function of an operating engineer or staff and the responsibility of this group may extend beyond the equipment being discussed here; hence, it is important to include only an equitable share of the time of this group. Extraordinary repairs involving special machinery will usually be covered by contract with equipment service divisions and should be accounted for on that basis.

Many of the items included in maintenance costs are highly variable and depend on the type and quality of the purchased equipment. For large air conditioning installations, using high quality equipment, some approximate costs per ton are given in Table 7.

In addition to the costs listed in Table 7, consideration should possibly be given to other items such as: water treatment for boilers; other boiler and heating plant cleaning and repairs; repair and replacement of heating plant valves, traps, and vents; water treatment for cooling tower or chilled spray water; drive belts, possible damage due to freezing weather; cleaning of air ducts; and repairs to insulation.

SERVICE COSTS

Service costs include the costs for power, water, steam, coal, oil, etc., consumed to operate the system.

From the selected equipment and type of installation, it is possible to segregate the relatively constant power loads and the total brake horsepower. Annual power cost can then be figured from the following formula:

$$\text{Annual power cost} = \frac{0.746\,(\text{bhp})\,H\,R}{\eta} \tag{1}$$

where

bhp = Brake horsepower.
H = Annual operating hours.
R = Power rate, dollars per/kwhr.
η = Motor efficiency (decimal).

In using Equation 1 it must be pointed out that the electric rate, R must reflect the proper combination of energy and demand rates. These vary widely between the utility companies, and sometimes the rate structure is such that it is largely the demand charge which determines the proper value of R to use in Equation 1.

Refrigerating Equipment Operating Cost

In an air conditioning system, the refrigerating equipment is usually the largest power-consuming item to be considered. Also, the prediction

TABLE 7. APPROXIMATE MAINTENANCE COST FOR LARGE AIR CONDITIONING INSTALLATIONS, USING HIGH QUALITY EQUIPMENT

	DOLLARS PER TON PER YEAR
Repairs for refrigeration machinery	0.60
Refrigerant	0.25
Oil and grease	0.07
Painting (Water boxes and dehumidifiers)	0.25
Filters, clean and reoil 4 times per year	0.85
Controls, outside service	0.15
Cleaning air conditioners	1.15

of operating cost is more complex, since the power required for summer cooling is affected by many factors which are of a variable nature. Among these are solar radiation, temperature difference between outside and inside, sensible and latent heat brought in with outside air, sensible and latent heat from people, heat released by electric lights, and, in some cases motor-driven equipment, cooking devices, and other equipment used in the conditioned spaces. Some of these factors vary with the weather while others are substantially independent of it. The relative proportion of each factor varies widely even among installations of the same application, depending on building layout and location, the size and quality of the establishment, the personal idiosyncracies of the owner, and other items.

In a strict sense, it is necessary to evaluate the effect of all such factors in order to predict the operating cost of a refrigeration plant. In most cases this procedure will prove to be too tedious, or it may not be possible because the exact breakdown of load data is unknown. The use of a simplified semi-rational formula, Equation 2, which takes into account for each application the number of hours open for business and the geographical location, will provide a value of H which may be used in Equation 3 to determine the *Season Power Cost.*

$$H_e = m\,(b + cf) \tag{2}$$

where

H_e = Equivalent full load operating hours of refrigeration equipment used for summer cooling during period May 15 to October 15.
m = Total hours during period May 15 to October 15 that the establishment is open for business.
b = Fraction of maximum load from internal heat under average operating conditions.
c = Fraction of maximum load which is due to external sources at maximum design conditions.
f = Ratio of the number of hours for a particular city, when the outside wet-bulb exceeds 65 F, during the period June 1 to October 1 to the total number of hours during that same period. Total hours are assumed as 8 hr per day period for barber shops, department stores, funeral parlors, offices, short hour restaurants, and specialty shops and 12 hr per day period for drug stores, long hour restaurants, and theaters.

Table 8 was calculated from Equation 2. It should be pointed out that certain southern cities may have seasons longer than the 5-month period indicated in Table 8. If it is desired to consider a longer season of operation, the ratio of full load operating hours to hours open for business is smaller; in other words, the *refrigeration load factor* is lower. This is true because the extra increment of days added will be at relatively light load, since the table already includes the more severe part of the season.