extend to other facilities beyond the equipment being discussed here, it is important that only an equitable share of the group's time be charged to maintenance.

Extraordinary repairs are quite often handled by separate maintenance divisions and the expense charged back to air conditioning, heating, and ventilating. In other cases, all maintenance is handled by outside service firms and the cost considered as maintenance. These costs vary to such an extent that the type and cost of the purchased equipment may determine the amount of maintenance necessary. Therefore, any forecast of maintenance costs should include consideration of the equipment as a part of the engineering study. The charges should be based upon the entire period under study rather than the early years of operation when repairs may be expected to be at a minimum.

The accounting practices of the owner and the rules of the *Bureau of Internal Revenue* affect the charges for major overhauling or complete replacement which may restore the capital value of certain equipment items. In these cases the expenditure may not necessarily be charged as maintenance but will become a fixed charge spread over the remaining years of equipment life. Table No. 4 gives some approximate costs for maintaining large air conditioning installations using high quality equipment.

TABLE 4. APPROXIMATE MAINTENANCE COST FOR LARGE AIR CONDITIONING INSTALLATIONS, USING HIGH QUALITY EQUIPMENT

	Dollars per (Ton)(Year)
Repairs for refrigeration machinery	0.96
Refrigerant	0.40
Oil and grease	0.11
Painting (Water boxes and dehumidifiers)	0.40
Filters, clean and re-oil 4 times per year	1.36
Controls, outside service	0.24
Cleaning air conditioners	1.19

LABOR FOR OPERATION

In some cases with the installation of automatic equipment, operating labor may be non-existent, but where such labor is required, the cost is readily calculated. Where operators are required, the expense is often considered maintenance, but since they may have other functions which are not properly charged to operation of the air conditioning, heating, or ventilating installations the charges should be properly allocated. The cost of experienced and competent operators is well justified in medium and larger plants by economies that can be achieved in maintenance and energy costs.

ENERGY AND WATER COSTS

Energy 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:

$$\text{annual power cost} = \frac{0.746(\text{bhp})HR}{\eta} \qquad (1)$$

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.

TABLE 5. EQUIVALENT FULL LOAD OPERATING HOURS OF REFRIGERATION EQUIPMENT USED FOR SUMMER COOLING MAY 15 TO OCT. 15[a]

Application	Hr Open for Business	Atlanta	Boston	Chicago	Detroit	Los Angeles	New Orleans
Barber Shops	1280	1010	650	720	720	680	1080
Department Stores	940	840	560	610	610	580	890
Drug Stores	2100	1630	950	1060	1060	980	1790
Funeral Parlors	600	440	300	330	330	310	470
Offices	940	870	560	620	620	580	900
Restaurant (Short Hour)	1290	970	535	620	620	570	1060
Restaurant (Long Hour)	2100	1510	820	930	930	850	1690
Specialty Shops (5 & 10)	1090	800	530	590	590	560	860
Theaters—Continuous	1500	1010	700	750	750	720	1080
Theaters—Neighborhood	900	640	420	450	450	430	650

Application	Hr Open for Business	New York	Philadelphia	Oklahoma City	St. Louis	Washington D.C.
Barber Shops	1280	830	860	1020	890	940
Department Stores	940	700	720	840	750	780
Drug Stores	2100	1280	1330	1650	1420	1530
Funeral Parlors	600	370	380	440	400	410
Offices	940	710	740	880	770	810
Restaurant (Short Hour)	1290	760	800	980	830	880
Restaurant (Long Hour)	2100	1170	1210	1530	1300	1400
Specialty Shops (5 & 10)	1090	670	690	810	720	750
Theaters—Continuous	1500	850	870	1020	910	950
Thearers—Neighborhood	900	500	520	650	550	580

[a] Modern Air Conditioning, Heating and Ventilating, by W. H. Carrier, R. E. Cherne and W. A. Grant (*Pitman Publishing Corp.* 1940, p. 73).

Operating Refrigerating Equipment

In an air conditioning system the refrigerating equipment is usually the largest power consuming item to be considered. Also, the prediction of operating cost is more difficult because the power required for summer cooling is affected by many factors of a variable nature.

Table 5 gives the equivalent full load operating hours of refrigerating equipment used for summer cooling for the period of May 15th to October 15th. This table was calculated from the following equation:

$$H_e = m(b + cf) \qquad (2)$$

where

H_e = equivalent full load operating hours of refrigeration equipment used for summer cooling during period May 15 to October 15.