R. R. Bennett and S. N. Hawks: *Tobacco Curing* (*University of North Carolina Extension Circular* 332, January 1949).

L. S. O'Bannon: *Principles of Burley Tobacco Barn Operation* (*University of Kentucky Bulletin* 501, May 1947).

E. M. Matthews, M. H. McVickar, and R. B. Davis, Jr.: *Fuels for Curing Tobacco* (*Virginia Agricultural Experiment Station Bulletin* No. 396, May 1946).

N. C. Teter and E. G. Moss: *Heating Tobacco Barns with Stokers* (*North Carolina Agricultural Experiment Station Bulletin* No. 352, May 1945).

Irvin Lavine and O. D. Sutherland: Revised psychrometric chart assists high temperature design (*Chemical and Metallurgical Engineering*, April 1928, p. 226).

C. R. Wilkie and O. A. Hougen: Mass transfer in the flow of gases through granular solids extended to low modified Reynolds numbers (*American Institute of Chemical Engineers Transactions*, Vol. 41, 945, p. 445).

W. R. Marshall: *Current Status of the Theory and Practice of Drying* (University of Wisconsin, *Engineering Experiment Station Reprint* No. 265).

CHAPTER 54

OWNING AND OPERATING COSTS

Fixed Charges: Amortization, Interest, Taxes, Insurance, Rent; Maintenance Costs; Labor for Operation; Energy and Water Costs: Operating Refrigerating Equipment, Condenser Water, Heating

THE total cost for the use of heating, ventilating, and air-conditioning systems may be divided into two classifications. The first of these is the relatively fixed and unvarying expense of ownership, and the second is the variable and somewhat controllable expenditure for actual operation of the equipment. Owners and prospective purchasers of this equipment are particularly concerned with both since the actual expenditure is generally predicated upon the possible return on the investment resulting from increased patronage, greater efficiency on the part of the employees, meeting of competition, or the improvement and maintenance of quality in a manufactured product. These costs may be grouped under four headings: (1) *Fixed Charges*, (2) *Maintenance Costs*, (3) *Labor for Operation*, and (4) *Energy and Water Costs*.

FIXED CHARGES

Fixed charges are the annual expenses arising from the ownership of the installation, including use of the owner's money, and protection of the equipment in the form of insurance. Such costs are usually unchanged from year to year regardless of whether the equipment is in or out of service. Fixed charges may be grouped under five headings: (1) *Amortization*, (2) *Interest*, (3) *Taxes*, (4) *Insurance*, and (5) *Rent*.

Amortization

As air-conditioning equipment becomes older, its ability or capacity to perform present and future service is reduced. Provision must be made for the owner to recover each year a portion of the initial value of the equipment as an expense to be charged against revenue, or to amortize the cost. This decrease in the value of property is usually determined by an accountant or engineer using some theoretical method and will depend upon (1) the total first cost, and (2) the amortization period.

The total first cost of an installation is the actual capital expenditure required to buy and install the air-conditioning, heating, or ventilating system ready for operation. It represents the first cost of the equipment combined with additional costs incurred because of the installation of the system.

The first cost of air-conditioning, heating, or ventilating systems includes the following:

1. Heat producing equipment including boilers, burners, controls, etc.
2. Heat distributing equipment including direct radiation, piping, etc.
3. Air handling equipment including fans, air heaters, air conditioners, filters, controls, etc.
4. Air distribution system including ducts, outlets, grilles, etc.
5. Refrigerating equipment including piping, pumps, etc.
6. Water conservation devices including towers, evaporative condensers, etc.
7. Insulation of pipes, ducts, and equipment.
8. Building alterations, furring-in ducts and pipes, structural work, etc.

To estimate the first cost of any system prior to installation, the best procedure is to determine the heating and cooling load, and then after thorough engineering study, select the type of system. The installed cost of systems will vary widely, depending upon the type of equipment selected, and the design of the distribution system, equipment and labor costs in the locality, demands for the particular installation, etc. A reasonably approximate cost may be determined for a selected design in a given locality from the sum of the estimated unit costs of the component parts of the system. A reasonably precise estimate of the cost of the components may be obtained from cost records of recent installations of a comparable design, or from quotations submitted by manufacturers and contractors.

Approximate costs are given in Table 1 for mechanical air-handling systems including heating and cooling coils for distributing 1½ cfm per square foot of floor area and refrigeration equipment based upon a requirement of one ton for every 333 sq ft of floor area. Different types of service demand may change the floor area per ton of refrigeration and air volume per square foot between wide limits and, consequently, the table should be used with caution.

Other first costs may be incurred because of the installation of the air-conditioning or heating and ventilating system. These will include such items as electrical work, plumbing, miscellaneous piping, building alterations, cutting, patching, furring-in of ducts or pipes, foundations, structural supports, remodeling or redecorating after installation, consulting engineer's fees, licenses, and permits. As these costs vary widely no approximations are practicable. Therefore, each case must be considered individually. If a quotation can be secured from a manufacturer or contractor covering the complete job, it will usually include the items that have been mentioned.

The length of the amortization period to be used depends upon (1) the type and remaining life of the building or