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.
- 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.

It should be pointed out that certain southern cities may have seasons longer than the 5-month period indicated in Table 5. 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 a relatively light load, since the table already includes the more severe part of the season.

The season electrical power cost for refrigerating equipment is then given by the following equation:

$$\text{season power costs} = \frac{0.746\,(\text{bhp}_t)\,T H_e R}{\eta} \qquad (3)$$

where

- bhp_t = brake horsepower per ton (see Fig. 1) for *average* load during period. (Due allowance should be made for poorer compressor efficiency at light load.)
- T = maximum refrigeration design load, tons.
- H_e = equivalent full load refrigeration operating time, hours (from Table 5).
- R = power cost, including demand and energy charges, dollars per kwhr.
- η = motor efficiency at average load (decimal).

In considering refrigeration power consumption, it should be noted that the use of weather records for a specific year may lead to large inaccuracies in estimating operating costs, since there may be wide variations from year to year, and therefore, average yearly weather records should be used rather than those for any individual year.

If the refrigeration compressor is steam turbine driven, the same general method can be followed, taking into account average water rate per brake horsepower-hour and the cost of steam.

Condenser Water

Condenser water cost estimates can also be based on equivalent full load operating hours of the refrigeration equipment. The varying temperature of the water at its source, as well as the temperature of the discarded water, must, however, be taken into account. In general, when water is purchased, control is provided to hold the leaving water temperature (or condensing temperature) constant; and in such case the entering water temperature becomes the major variable, and the gallons per minute per ton can readily be calculated for any water temperature rise.

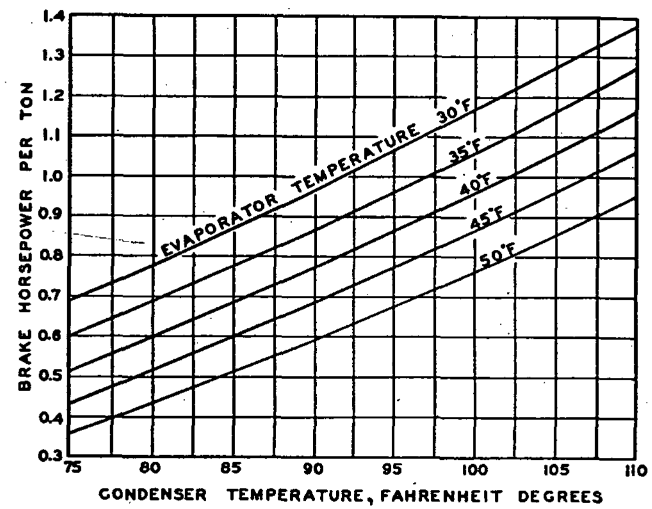

FIG. 1. TYPICAL BRAKE HORSEPOWER REQUIREMENTS FOR REFRIGERATION[a]

[a] Values given are representative of dichlorodifluoromethane reciprocating machines of about 25 tons capacity in air conditioning applications. Requirements of smaller machines are usually higher, and for larger machines may be lower. Values shown are for liquid refrigerant at condenser temperature (no subcooling). Subcooling of the liquid may decrease these values approximately 0.3 percent to 0.5 percent for each Fahrenheit degree the liquid temperature is lowered.

The following equation for cost of condenser water is useful:

$$B = 0.060\,a\,T\,H_e\,C \qquad (4)$$

where

- B = cost of water for refrigeration during period, dollars.
- a = average gallons per (minute) (ton).
- T = tons of refrigeration at maximum design load.
- H_e = equivalent full load refrigeration operating hours (Table 5).
- C = water cost, dollars per 1000 gal.

The average gallons per minute per ton must take into account the variable water temperature. When well water is used as a source, and entering and leaving temperatures are considered constant, the average gallons per minute per ton obviously are equal to the design gallons per minute per ton. However, when the source is river or lake water, its maximum seasonal temperature will generally be reached at the same time that