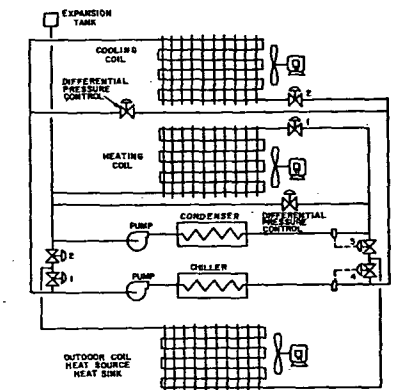




* To provide simultaneous heating and cooling with fixed refrigerant circuit. Suitable for centrifugal compressors and other factory assembled fluid coolers.

Fig. 2 Air-to-Liquid Heat Pump Cycle*

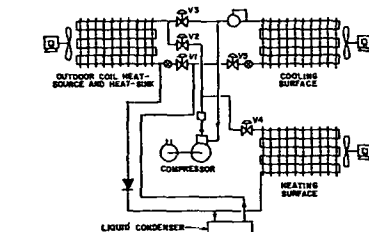
The well water can be supplied directly to the condenser and chiller instead of by means of an exchanger, as illustrated by Fig. 1, thus eliminating one heat transfer surface. This direct supply of well water in this manner is generally used on small systems, but may be used on larger systems, providing the well water is chemically acceptable and does not unduly contaminate the heat transfer surfaces.

The operation of the air-to-liquid cycle shown for Fig. 2, is identical to that described for the well water system of Fig. 1, except that outdoor air instead of well water is the heat source and heat sink.

Fig. 3 uses air as the heat source and heat sink, and as the heating and cooling medium, by changing the direction of the refrigerant flow.

The use of direct-expansion type heat transfer surfaces in this manner will also provide either independent or simultaneous heating and cooling. Also, the heat removed from areas requiring cooling may be transferred to the zones needing heating in a similar manner to that described for the indirect systems. One advantage of the direct type system is the elimination of the additional heat transfer surfaces. This advantage may be offset in some installations by the precautions which must be observed to assure proper refrigerant flow and to obtain the desired capacity modulation. Each installation must be evaluated to determine which cycle is the most practicable and, at the same time, provides the most satisfactory performance. Such an analysis particularly applies to a multi-zone installation or to a system in which the heat source and heat sink equipment must be located a considerable distance from the compressor.

A further improvement in efficiency with a corresponding lower operating cost frequently can be achieved by incorporating a storage tank in the system, as illustrated by Fig. 4. A double-circuit condenser (two sets of tubes in a single shell) is used to avoid contaminating the heating circuit with dirt from the cooling tower circuit and, at the same time, to localize the cooling tower water treatment and to enable maintaining independent water pressures in the two circuits. In this



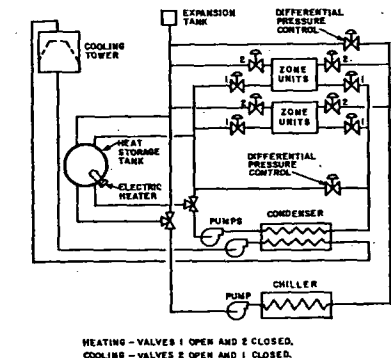
OUTDOOR COIL-HEAT SOURCE: VALVES V-1, V-2 AND V-3 OPEN, V-4 IS OPENED AS REQUIRED TO PROVIDE SIMULTANEOUS COOLING. OUTDOOR COIL-HEAT SINK: VALVES V-5 AND V-6 OPEN, V-4 IS OPENED AS REQUIRED TO PROVIDE SIMULTANEOUS HEATING.

* To provide simultaneous heating and cooling by changing direction of refrigerant flow.

Fig. 3 Air-to-Air Heat Pump Cycle*

cycle the excess heat from the internal zone (over that required by the exterior zone) may be stored in the tank for use as supplemental heat when the structure heat loss exceeds the internal heat gain. Storage tanks permit off-peak direct electric heating, as well as off-peak cooling during the summer period, in order to take full advantage of the lower electric energy rates available from many utilities.

The operating cycle of the arrangement illustrated by Fig. 4 is similar to that described for Figs. 1 and 2, except that the excess heat from the structure either can be transferred to the storage tank, or rejected to the cooling tower. Generally, the modulating valve in the condenser circuit maintains a predetermined supply water temperature to the zone units. As the water temperature rises above this setting, the valve is positioned to divert the warm water to the top of the storage tank and to use the lower temperature make-up water from the bottom of the tank. When the excess heat from the struc-



* To reclaim internal heat for heating of perimeter area and ventilation air. Heat rejected from the system is stored in the tank for use as supplemental heat when structure heat loss exceeds the internal gain. Storage tank permits off-peak direct electric heating, as well as off-peak cooling during the summer period.

Fig. 4 Heat Pump Reclaiming Cycle*

Heat Pump Systems for Air Conditioning

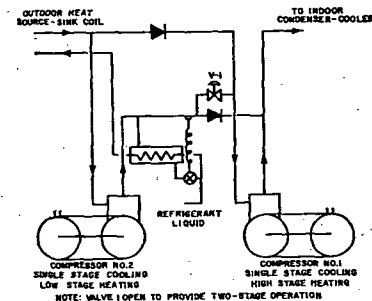
ture can no longer be transferred to the storage tank, the second condenser pump is operated and the excess heat is rejected to the cooling tower. During periods when more supplemental heat is needed than that available from the internal area, the 3-way valve in the condenser circuit is positioned to use the warmer water from the storage tank. When the temperature of the storage tank water is reduced below a level that is no longer applicable for direct heating, the 3-way modulating valve in the chiller circuit can be positioned to use the stored water as the heat source. A considerable quantity of additional heat can be recovered from the storage tank water by reducing its temperature to 40-45 F. The same operating cycle can be used to provide off-peak storage of cold water during the summer periods.

EQUIPMENT SELECTION

The heat source and heat sink surfaces, heating and cooling surfaces, compressors, and accessory equipment are sized and selected in accordance with current refrigeration and air-conditioning practices discussed in Chapters 28, 32, 33, 34, 36, 39, and 41 of the 1961 GUIDE AND DATA BOOK. The capacity of the system must meet both the design heating and cooling requirements. Normally, the refrigeration equipment is first selected to meet the cooling load and then checked with the heating load to see if the required temperature lift and balance can be obtained to operate successfully as a heating system (see Chapter 58 of the 1961 GUIDE AND DATA BOOK).

Supplemental Heating

The heating needs may exceed the capacity available from equipment selected for the cooling load, particularly if outdoor air is used as the heat source. When this condition occurs, consideration must be given to supplemental heating or to additional compressor capacity. The additional compres-



Some Possible Compressor Combinations

Low Stage	High Stage
Reciprocating	Reciprocating
Rotary	Reciprocating
Centrifugal	Centrifugal
Reciprocating	Centrifugal

* Provides two-stage compound compression for low outdoor air temperatures.

Fig. 5 Air Source Heat Pump with Series-Parallel Compressor Arrangement*

or capacity, or the supplemental heat, is generally used only in the severest winter weather and, consequently, will have a low usage factor. Each of the two possibilities must be evaluated to determine the most economical selection.

Heating and Cooling Load Estimates

Realistic winter outdoor design temperatures should be selected in order to obtain authentic heating requirements and to prevent installation of oversized supplemental heating equipment.

The winter design temperatures given in Column 6, Table 2, Chapter 25 in the 1961 GUIDE AND DATA BOOK, should be used unless experience and more authentic data for the particular locality are available. The experience of some utility companies has shown that values selected from Col. 7, Table 2, Chapter 25 of the 1961 GUIDE AND DATA BOOK, will give satisfactory results.

The use of heavily conservative heating requirements and lowering the nightly indoor temperature are not recommended, because the resulting additional heating capacity would unnecessarily increase both the first and operating costs of the system. Instead, consideration should be given to the use of operating cycles employing auxiliary equipment to provide higher operating efficiencies, and to all means of load reduction, including:

1. Employing the maximum, practical amount of insulation with proper vapor barrier in sidewalls, ceilings and floors of a structure. Windows and doors should at least be weatherstripped and properly caulked, and in most areas of the country storm windows and doors, or the equivalent, can be justified.

2. Utilization of available, dependable heat sources within the structures, such as lights, motors, heat producing machinery, and people.

3. Automatically closing the outdoor air intakes during nights, weekends and other unoccupied periods, so that the heat loss will be limited to transmission and infiltration.

4. Proper selection of the ventilation air. Because the ventilation air load is an appreciable part of the total, reasonable ventilation quantities, without sacrificing a healthful environment, should be selected. Minimum quantities of outdoor air may even be unacceptable, because of objectionable irritable and toxic odors in the atmosphere due to a high percentage of hydrogen sulfide, smog, and other chemical effluents from industrial processes. It has been found that physical and chemical odor removal units, such as activated charcoal in combination with a conventional or electric air filter, are effective in purifying and removing odor causing substances (see Chapter 10 in the 1961 GUIDE AND DATA BOOK, and Chapter 74 in this volume). The quantity of ventilation air can frequently be reduced considerably, resulting in savings in both first cost and operating cost.

Reciprocating or Centrifugal Compressors

Both the reciprocating and centrifugal types of compressors can be used for the central plant type of heat pump system. Present available experience does not permit an evaluation of the exact size for shifting from one type to the other.

Most air source installations have employed single stage reciprocating compressors, but also the use of multistage compressors has increased. The two-stage compound compression system is particularly applicable in the extremely northern climate where the frequent occurrence of low outdoor temperatures makes the single stage system impracticable. In the two-stage arrangement shown in Fig. 5, the compressors can be used in parallel during the cooling-cycle and in series during the heating cycle. The main advantage of staging is the resultant smaller heat-source, heat-sink surface (due to the larger possible air-refrigerant temperature difference) and the proportionally smaller auxiliaries needed to provide a given heating effect at the lower outdoor temperatures. At an outdoor temperature of approximately 15-20 F, the performance of the two-stage and single stage systems is