TABLE 4. HEAT PUMP HEAT SOURCES AND SINKS

HEAT SOURCE	AIR	CITY WATER	WELL WATER	SURFACE WATER	WASTE WATER	EARTH	SOLAR
Source Classification	Primary	Primary or auxiliary	Primary	Primary	Primary or auxiliary	Primary or auxiliary	Auxiliary
Suitability as Heat Sink	Good	Good	Good	Good	Variable with source	Usually poor	None
Availability (Location)	Universal	Cities	Uncertain	Rare	Limited	Extensive	Universal
Availability (Time)	Continuous	Continuous—except local shortages	Continuous—unless well runs dry	Continuous	Variable	Continuous, temperature level drops from a maximum to a minimum as heat is removed, slowly rises when pump is inoperative	Intermittent. Unpredictable, except over extended time
Expense (Original)	Low, less than earth and water sources except city	Usually lowest	High, result of drilling well	Low	Variable	High, usually less than the cost of drilling a well	Unexplored
Expense (Operating)	Relatively low	High, usually prohibitive	Low to moderate	Relatively low	Relatively low	Relatively moderate	Unexplored. Promising as auxiliary for reducing operating cost
Temperature (Level)	Favorable 75–95% of time in most of U. S.	Usually satisfactory	Satisfactory	Satisfactory	Usually good	Initially good—drops with time and rate of heat withdrawal	Excellent
Temperature (Variation)	Extreme	Variable with location (10 to 25 F Deg)	Small	Moderate	Usually moderate	Large—less than for air, however	Extreme
Design Information	Inadequate	Usually adequate	Usually adequate	Usually adequate	Adequate if source is constant in supply and temperature	Inadequate	Practically available
Size of Equipment	Particularly bulky	Moderate	Moderate (except well)	Moderate	Variable (usually moderate)	Moderate (except ground coils)	Probably bulky
Adaptability to Mass Production	Excellent, can be factory assembled and tested	Excellent	Excellent, (except well)	Excellent	Poor	Fair	Fair
Sources it may Augment		Air, earth				Air, water	Air, earth, water
Special Problems	Least heat available when demand greatest. Coils may become frosted requiring extra capacity, alternate source, or standby heat. May require duct work. Variable air temperature makes control difficult.	Scale on coils. Local use restrictions during shortages. Disposal. Water temperature may become too low to permit further heat removal.	Corrosion, scale may form on heat transfer surface. Disposal. Water location, temperature, composition usually unknown until well drilled. Well may run dry.	Water may cause scale, corrosion, and algae fouling.	Usually scale forming or corrosive. Often insufficient supply. Very limited application, hence requires individual design.	Limited by local geology and climate. Installation costs difficult to estimate. Requires considerable ground area, may damage lawns, gardens.	Probably will require heat storage equipment at either evaporator or condenser side.

installing a smaller refrigeration plant, augmented by a storage system, and by operating it for longer periods.

The Heat Pump

It has been almost 100 years since Prof. William Thomson (Lord Kelvin) first proposed the use of a compressor as a "warming engine" and as a means of heating buildings to replace equipment for direct burning of fuels. Several early working models were constructed, but the device has remained essentially of laboratory interest until the last 20 years.

Although frequently referred to incorrectly as the reverse cycle system, the heat pump cycle is identical with the ordinary refrigeration cycle, and differs only in the sense that the desired effect is rejection of the heat from the condenser rather than absorption of heat in the evaporator. A discussion of the coefficient of performance for the heat pump is found earlier in this chapter.

The first actual residential heat pump installation was probably made in Scotland in 1927 and since that time, a number of commercial and residential systems have been made in this country. Both progress and growth of interest have been particularly rapid in recent years and, consequently, at the present time there are several hundred residential installations and probably a greater number of commercial systems. However, much research is needed before the residential heat pump installation can successfully emerge to compete economically and with equal reliability with the more common forms of heating and fuels.

From an analysis of the equation for the coefficient of performance, it is evident that the economical adaption of the heat pump as a practical means of heating, requires that the temperature of the source from which the heat is extracted be as high as possible, and that the temperature of the sink to which the heat is rejected for heating purposes, be as low as possible. Thus, with a small temperature spread between the evaporator and the condenser, six or more times as much heat may be obtained theoretically (and three to five times practically) as the heat equivalent of the work necessary to operate the system. There are a number of limitations, however, the most serious of which is the lack of ready availability of a practical source of heat.

One of the major problems in the development of the heat pump involves research on, and the compilation of reliable design data for, the various heat sources and sinks available. The four principal potential sources of heat are air, water, earth, and solar energy. Of these, the first three are primary sources of heat which may be used alone. The fourth, solar energy, while of tremendous potentiality, will probably be developed in most localities as auxiliary to the other three. In addition, there are other minor sources such as process waste heat, sewage, etc., which may be used under special circumstance.

There are also a number of industrial applications of heat pumps, for purposes other than space heating, which are practical largely through economic considerations of the particular process involved. Table 4 presents a summary of the advantages and disadvantages of each of these major heat sources.

By reference to Table 4, it will be seen that, to date, the most satisfactory heat sources are air, water, and earth, and that air and water are the most satisfactory heat sinks. There are, therefore, six possible combinations of source and sink in application: air to air, air to water, water to air, water to water, earth to air, and earth to water. In addition, it should be recog-