ABSORPTION REFRIGERATION SYSTEMS

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1. GENERAL

1.01 This section covers the recommended procedures for safe, economical operation and maintenance of absorption refrigeration systems in Telephone Company buildings.

1.02 When this section is reissued, the reason(s) for reissue will be given in this paragraph.

1.03 General descriptions, terminology, basic fundamentals of absorption unit controls, and energy source equipment are covered in this section along with limit and safety controls.

1.04 This practice is composed of four major parts. The first part covers the operation of the equipment, the second part covers routines, the third part describes troubleshooting, and the fourth part explains various service problems and procedures.

1.05 It is not intended that this section serve as operating instructions for any given absorption system. Due to the wide variety of makes and types of equipment used throughout the Bell System, it will be necessary to supplement this section with the manufacturer's maintenance and operating data and with specific written operating instructions for each system your are responsible for. This material should be called for in the architect's or engineer's specification and should be furnished to the Building Operations Force as a requirement for the completion of the initial installation and for any subsequent rearrangements and changes.

1.06 This section will not include related components associated with air conditioning operation and routines of the burner.

1.07 Before any new air conditioning equipment is accepted for operation by Building Operations Forces, a final (or acceptance) inspection must be completed and all faulty items corrected. A Building Operations Force representative should participate in this inspection, along with planning, design, construction, architect's representative, contractor, and others, as appropriate. In addition to determining that all equipment called for is furnished and installed in accordance with the plans and specifications, all controls (both operating and limiting) should be tested in accordance with this practice.

1.08 Generally, the completion of these initial tests and the correctness of the installation are certified in writing and made part of the permanent air conditioning log.

1.09 Safety is covered throughout the practice in the various divisions. In addition, there are several sections that discuss specific precautions that apply when working on particular components of the heating system.

1.10 The procedures in this practice require a competent and trained individual. If you have not been properly trained, you must verify with your supervisor whether or not you can use this practice. The supervisor in charge of building maintenance may use this practice as a check or guideline when evaluating an on-the-job performance of an outside firm.

2. BASIC SAFETY PROCEDURES

2.01 Safety consciousness applies to absorption equipment operation the same as it does to other phases of telephone work and should always be foremost in the minds of personnel whose duties involve the operation and maintenance of absorption systems. Adequate supervision must be provided whether work is being done by Telephone Company personnel or by outside contractors. In all cases, only properly trained, qualified personnel may perform work on or operate mechanical equipment in Telephone Company buildings. It is the responsibility of the Telephone Company supervisor in charge to determine that all work is conducted in a safe manner and that necessary tests and inspections are carried out upon completion of repairs or modifications.

2.02 Always wear safety glasses; use proper tools for the job; use the right instruments to run amperage checks, voltage checks, phase balancing, and check operating pressures. Be sure that all piping identification is accurate and complete.

2.03 The maintenance of a neat, clean condition in the equipment room and associated quarters is essential to safe and economical operation. The equipment room should be kept free from all material and equipment not necessary to the operation of the air conditioning system. House service procedures should include routines to maintain the desired level of cleanliness. Good lighting is also necessary.

2.04 Floor drains in the equipment rooms can be a source of combustible gases. To prevent sewer or other gases from entering the equipment room, the traps in the floor drains should be periodically sealed by pouring water into them. In locations where there is a possibility of freezing, an antifreeze mixture should be used.

2.05 Adequate protection of personnel and property can be assured only through the proper operation and maintenance of the air conditioning plants. In many locations, laws or ordinances require that permits or certificates of inspection be obtained for certain equipment. Some states and municipalities require licensing or certification of personnel who operate and/or maintain absorption refrigeration equipment. It is the responsibility of the supervisor in charge of a given installation to ascertain that all laws and ordinances are being complied with.

3. GLOSSARY OF TERMS

3.01 ***Absorbent:*** A substance readily capable of taking in and retaining moisture from the atmosphere.

3.02 ***Absorber:*** A vessel containing liquid for absorbing refrigerant vapor.

3.03 ***Concentrated Solution:*** A solution with a large concentration of absorbent and only a small amount of dissolved refrigerant.

3.04 ***Concentrator/Generator:*** A vessel containing a solution of absorbent and refrigerant to which heat is supplied for the purpose of boiling away some of the refrigerant.

3.05 ***Condenser:*** A vessel in which vaporized refrigerant is liquefied by removal of heat.

3.06 ***Dilute Solution:*** An absorbent solution diluted by a large amount of dissolved refrigerant.

3.07 ***Evaporator:*** A vessel in which refrigerant is vaporized to produce a refrigerating effect.

3.08 ***Heat Exchanger:*** A device used to transfer heat between two physically separate fluids.

3.09 ***Heat of Condensation:*** The heat released when a vapor condenses to a liquid.

3.10 ***Heat of Dilution:*** The heat released when two liquids are mixed. This is sometimes referred to as the heat of absorption since in the mixing process one liquid may absorb the other.

3.11 ***Sensible Heat:*** Heat used to raise or lower the temperature of a substance.

4. ABSORPTION REFRIGERATION CYCLE

A. Basic Principles of the Cycle

4.01 Basically, the absorption refrigeration system is not too different in operation from the more familiar, mechanical compression refrigeration system. Both machines accept heat to evaporate a refrigerant at low pressure in the evaporator, and thereby create a cooling effect. Both also condense the vaporous refrigerant at a higher pressure and temperature in the condenser in order that the refrigerant can be reused in the cycle.

4.02 In both cases, the capacity of the machine depends upon the pressure that exists in the evaporator since this determines the evaporator temperature.

4.03 In mechanical compression systems, the vapor formed, when the liquid refrigerant absorbs heat to provide the refrigerant effect, is drawn to a lower pressure area created by the mechanical movement of the pistons. In an absorption machine, this vapor is also removed to a lower pressure area. However, the low pressure area in the absorption machine is created by controlling the temperature and concentration of a water lithium bromide solution (Fig. 1).

> ***Note:*** Lithium bromide, a nontoxic salt with a high affinity for water, is the absorbent.

4.04 Low pressure inside an absorption machine is the key to its refrigerating ability. The degree of vacuum at the low side is of major importance. To illustrate, a pressure increase of only 1 inch of water, equivalent to 0.036 psi, will increase leaving chilled water temperature by approximately 10°F.

B. How It Operates

4.05 In a compression system, the refrigerant vapor is mechanically compressed and moved from the low pressure to the high pressure side of the system (Fig. 2). In an absorption system, the vapor is first condensed and mixed into a solution of lithium bromide. This solution is then pumped to a higher pressure area and heat is applied. Heat causes the solution to boil, driving off the refrigerant vapor at the higher pressure.

4.06 The refrigerant used in many systems is water. Normally, water must be heated to 212°F to boil at 14.7 psia (sea level). If pressure is reduced, water boils vigorously at lower temperatures. For example, water boils at 199°F in Denver due to the reduced atmospheric pressure at Denver's altitude. With very low pressure, 1/100th of normal atmospheric pressure, water will boil at about 40°F (Fig. 3).

4.07 It is therefore evident that exactly the same function, that of taking low pressure refrigerant vapor from the evaporator and delivering high pressure refrigerant vapor to the condenser, has been performed in both the compression and absorption cycles.

C. Operational Cycle

4.08 The operational pressure throughout the absorption system cycle, using lithium bromide and water, will operate under a near perfect vacuum at all times. The absolute pressure within the generator and condenser, when on cooling, is of the order of 50 to 60 mm of mercury absolute, and the pressure within the cooling coil and absorber is 6 to 9 mm of mercury absolute. As a comparison, standard atmospheric pressure is the equivalent of 760 mm of mercury absolute. Therefore, it is quite evident that the entire system operates under a fairly high vacuum.

4.09 The four major components are the evaporator, absorber, generator/concentrator, and condenser. Refer to Fig. 4 for a pictorial representation of the following explanation:

(a) ***Evaporator:*** The refrigeration cycle begins in the evaporator with the evaporation of liquid refrigerant, the same as in conventional air conditioning systems. Liquid refrigerant at relatively high pressure passes through an orifice in the condenser to the low pressure region of the evaporator. As the pressure of the refrigerant falls, a portion flashes to a vapor, causing the temperature of the remaining liquid refrigerant to drop. The flashing continues until the refrigerant cools to the saturation temperature corresponding to the comparatively low pressure in the evaporator. The heat needed for evaporation comes from the refrigerant itself as it enters the evaporator. The passage of refrigerant through the orifice can be compared with the passage of refrigerant through the expansion valve of a conventional system.

(b) As the cool refrigerant (at approximately 40°F) drops onto the tube bundle containing the warmer system water, the refrigerant begins to evaporate. Heat for vaporization comes from the system water. The cooling effect thus obtained lowers system water approximately 10°F in a typical system.

(c) ***Absorber:*** The refrigerant, now a vapor, passes to the absorber where the pressure is the lowest in the system. In the absorber, the refrigerant vapor is absorbed by a concentrated salt solution. This absorption process causes the salt solution to become diluted. The diluted salt solution is pumped to the concentrator/generator where the temperature and pressure are the highest in the system. In the concentrator, heat is applied to the salt solution causing the refrigerant to be boiled off. While the refrigerant is a vapor at low pressure, when in the absorber and evaporator, it is a vapor at high pressure after being boiled off in the concentrator.

(d) Hence, the primary purpose of absorbing the refrigerant vapor in the absorber and then changing it back to a vapor in the concentrator/generator is to raise its pressure. The absorption process accomplishes the same thing as the compressor in a conventional system. By being absorbed in the salt solution, the low pressure vapor can be pumped to the high pressure region of the concentrator or generator.

Note: Concentrator and generator are the same.

(e) ***Generator/Concentrator:*** To regain its absorbent capacity, the lithium bromide is pumped to another vessel—the generator. This generator is where heat, provided by a heating coil, raises the temperature of the lithium bromide which boils off the absorbed water vapor. This reconcentrates the solution which returns to the absorber to maintain the cycle. (The heating coil may use steam or hot water generated from a gas- or oil-fired boiler or waste heat boiler, or it may utilize heat from gas engine or gas turbine exhaust.)

(f) ***Condenser:*** The high pressure refrigerant vapor passes into the condenser, releases its heat of vaporization to cooling water flowing through a tube bundle, and falls as a liquid to the bottom of the condenser. The cycle continues as the high pressure liquid refrigerant is forced through the orifice to the evaporator.

4.10 That, basically, is how an Absorption Cold Generator operates. The refinements in the system required in practice to ensure efficient and dependable operation are shown in Fig. 4 and explained in the discussion in Part 5.

5. THEORY OF THE ABSORPTION CYCLE

A. The Lithium Bromide Equilibrium Chart

5.01 With the basic principles of operation clearly in mind, the changes in pressure and temperature that occur throughout the absorption cycle can be discussed with the aid of the Lithium Bromide Equilibrium Chart, Fig. 5.

5.02 The chart is a plot of the various equilibrium points for lithium bromide solutions at different temperatures and corresponding vapor pressure. The chart can be used to determine the concentration of the solution.

B. Temperature and Pressure Changes Throughout Cycle

5.03 To understand the use of the Lithium Bromide Equilibrium Chart, consider the absorption cycle plotted on the chart, Fig. 5. The plot is typical for an absorption unit operating fully loaded on 12 psig steam and 85°F cooling water entering the absorber.

5.04 Point 1 is the dilute solution in the bottom of the absorber shell. The temperature of this solution is 105°F and its concentration is 59.5 percent. This solution is picked and pumped through the heat exchanger to the concentrator. (See Fig. 4.)

5.05 Point 2 is the outlet of the heat exchanger. Notice that the solution picked up 65° as it flowed through the heat exchanger. The vapor pressure also rose and the concentration of the solution consequently remained at 59.5 percent.

5.06 Point 2 also represents the solution as it enters the concentrator/generator. Line 2 to 3 indicates additional heat added to the 59.5 percent solution to bring it to its boiling point. This additional heat is obtained from the steam being condensed in the concentrator tubes.

5.07 Line 1-2-3 gives a graphic illustration of the importance of the heat exchanger. If a heat exchanger were not used, the dilute solution would have to be heated from Point 1 to Point 3 with steam. The heat exchanger reduces considerably the steam rate of the unit.

C. Equilibrium Disrupted

5.08 Point 3 represents the boiling point of the dilute solution. Notice that the vapor pressure at this point is 2.75" Hg. As soon as enough heat is applied to the dilute solution to raise its vapor pressure to the condensing pressure, equilibrium is disrupted. At this point, the number of water vapor molecules leaving the solution is greater than the number of water vapor molecules reentering the solution because the water vapor leaving the solution is no longer confined. It can pass into the condenser. The temperature and vapor pressure at which equilibrium is disrupted is determined by the pressure and temperature in the condenser section. When the solution pressure becomes greater than the condensing pressure, water vapor begins to leave the lithium bromide solution and pass into the condenser.

5.09 As water vapor leaves the solution, the solution becomes more concentrated. The more heat added, the more water vapor removed from the solution and, consequently, the more concentrated the solution becomes. Line 3-4 represents the latent heat of vaporization. If the amount of heat added is controlled, it follows that the final concentration of the solution leaving the concentrator can be controlled. The heat available in the steam at 12 psig steam pressure will bring the solution equilibrium point to Point 4 on the chart.

5.10 Point 4 then represents the outlet from the concentrator and the inlet to the heat exchanger. Point 5 represents the outlet from the heat exchanger. Notice that the heat exchanger has cooled the solution from 210° to 135°F. Much of the heat which the concentrated solution lost from Point 4 to 5 is picked up by the dilute solution from Point 1 to 2.

5.11 The concentrated solution from Point 5 is now allowed to mix with some of the dilute solution from Point 1, resulting in an intermediate solution. This is the solution which is sprayed over the absorber tube bundle and absorbs the refrigerant from the evaporator.

D. The Intermediate Solution

5.12 There are several reasons for mixing dilute and concentrated solutions together to form an intermediate solution.

(a) One reason is to prevent salt crystals from precipitating out of solution. Notice how close Point 5 is to the saturation or crystallization line. If the solution at Point 5 were sprayed onto the cool absorber tubes, undoubtedly some crystals would form.

(b) Another reason for mixing the two solutions is that the less concentrated solution covers the absorber tube surface more completely than the concentrated solution at Point 5. This is because of the difference in viscosity between the two solutions. The higher the concentration, the more viscous the solution.

E. Why Concentrate and Then Dilute?

5.13 At first, it would seem that an excess of water vapor is removed in the concentrator. However, the reason for concentrating and then diluting the solution is the fact that the absorber requires a higher rate of solution flow than the concentrator. Therefore, to obtain the desired flow rate to the absorber, it is necessary to recirculate some of the dilute solution from the absorber. This necessitates concentrating the solution in the concentrator to a higher value than actually is required to spray into the absorber.

5.14 The intermediate solution is sprayed into the absorber section. As the spray droplets come in contact with the relatively cool absorber tubes, equilibrium again is disrupted as it was at Point 3. However, the solution is cooled to lower its vapor pressure below the pressure in the evaporator. The solution now has the ability to absorb water vapor from the evaporator. The more water vapor the solution absorbs, the more dilute it becomes until it reaches Point 1 where equilibrium is again established. The cycle is now complete.

6. OPERATIONAL PROCEDURES

6.01 Because of the variations in equipment design and function, the manufacturer's literature should be consulted and followed for all start-up and shutdown procedures.

7. STEAM, HOT WATER, AND CONDENSATE PIPING

7.01 Steam and condensate piping should be in accordance with present standards and codes. For maximum operational performance, the pressure drop in the modulating valve and steam line should be given special consideration. Systems should be designed to provide 12 psig steam at the concentrator/generator flange for one-stage machines.

7.02 On start-up, the absorption machine will draw approximately 150 percent of its full load steam rate. Piping should be sized to handle the load. If boiler capacity is insufficient to handle the start-up load, a steam demand limiting device such as a steam pressure controller should be used.

7.03 Some absorption cold generators use steam throttling capacity control. Therefore, only float and thermostatic traps should be used to allow gravity drainage of condensate during operating periods of low steam pressure in the concentrator. The concentrator outlet piping should allow the maximum positive head at the trap to promote gravity drainage.

7.04 Refer to your building prints and the factory service manual to check on requirements for your system. The manual should show a steam valve capacity table which should indicate the steam flow rate for various size valves at valve inlet and outlet pressures. Normally, a 2- to 3-pound pressure drop will result in the most economical valve.

7.05 The temperature of hot water supplied to the machine should be limited to 270°F. Typical piping for temperatures up to 270°F and high temperature hot water systems above 270°F are shown in your building prints and service manual.

8. DIRECT FIRED ABSORPTION UNITS (SINGLE COIL)

8.01 Figure 6 shows the flow diagrams for the cooling cycle. The system is charged with lithium bromide and water. The water being the refrigerant on the cooling cycle, and the lithium bromide solution being the absorbent.

8.02 Referring to Fig. 6 and considering the cooling cycle only, the generator contains a solution of lithium bromide in water. As heat is applied in the combustion chamber of the generator, it causes the refrigerant (water) to be boiled off. As this water vapor is driven off, the absorbent solution is raised by vapor lift action through tube (2) into the separating chamber (3).

8.03 Here the refrigerant vapor and the absorbent solution are separated by baffles. The refrigerant vapor rises through tube (4) to the condenser; the absorbent solution flows down by gravity through tube (6), through the heat exchanger, and then to the absorber. This circuit will be described in more detail after the refrigerant circuit is described.

8.04 The refrigerant (water vapor) passes from the separating chamber to the condenser through tube (4), where it is condensed to a liquid by the action of cooling water flowing through the condenser tubes. The cooling water is brought from an external source, such as a cooling tower, city main, or well.

8.05 The refrigerant vapor, thus condensed to water within the condenser, then flows through tube (5) into the cooling coil. Tube (5) contains a restriction which offers a resistance and, therefore, a pressure barrier to separate the slightly higher absolute pressure in the condenser from the power pressure within the cooling coil. The refrigerant (water) entering the cooling coil vaporizes due to the lower absolute pressure (high vacuum) which exists within it. The high vacuum within the evaporator lowers the boiling temperature of water sufficiently to produce refrigeration effect.

8.06 The evaporator or cooling coil is constructed with finned horizontal tubes and the air being cooled flows over the coil surface. Evaporation of the refrigerant takes place within the cooling coil. The heat of evaporation for the refrigerant is extracted from the air stream, and cooling and dehumidifying are accomplished.

8.07 In the absorber, the solution absorbs the refrigerant vapors which are formed in the evaporator directly adjacent.

8.08 To explain the presence of the absorbent at this point, it is necessary to divert attention back to the generator. The absorbent was separated from the refrigerant by boiling action. The absorbent then drains from the separator (3) down to the liquid heat exchanger and then to the absorber through tube (8). The flow of solution in this circuit can actually exist by gravity action alone because the absorber is slightly below the level of the separating chamber. It is also aided by the pressure difference existing between the separator and the absorber.

8.09 The absorber is a cylindrical shell which contains a coil through which cooling water is circulated. The solution flowing into the top of the absorber is distributed over the entire outside surface of the coil so that a maximum area of absorbent solution is exposed to the refrigerant vapor which is flowing into this chamber from the evaporator.

8.10 It must be understood at this point that cool lithium bromide, in either dry or solution form, has a very strong affinity for water vapor. It is because of this principle that the refrigerant vapor is absorbed back into solution again. The rate of absorption is increased at lower temperatures; therefore, a cooling water coil has been provided within the absorber shell. The resultant mixture of refrigerant and absorbent drains back through the heat exchanger through tube (9) to the refrigeration generator, where it is again separated into its two component parts by boiling action, to repeat the cycle.

8.11 Because of the slightly higher absolute pressure in the separator as compared to the cooling coil or evaporator, absorbent solution rises through tube (17), through the liquid trap (7), and up into tube (16), thereby forming a liquid seal so that refrigerant vapor cannot flow through tube (15) from the separator chamber. In this manner, the cooling cycle is maintained.

9. PUMP MOTOR COOLING AND LUBRICATION CIRCUIT (See Fig. 7)

9.01 The refrigerant, solution pumps, and motor are cooled and lubricated by refrigerant water. A portion of the refrigerant leaving the discharge side of the evaporator pump is diverted through a strainer and into the pump motor cooling and lubrication circuit. The return line is directed back to the float chamber, completing the circuit. Today, most pumps are hermetically sealed and require no lubrication.

A. Motor Temperature Control

9.02 Pump motor cooling and lubrication are dependent upon a continuous flow of cool refrigerant through the cooling and lubrication circuit. If, for some reason, the motor is not receiving adequate cooling, the Motor Temperature Control opens its contacts, stopping unit operation.

B. Liquid Level Switch

9.03 To assure an adequate volume of refrigerant for pump motor cooling and lubrication, the refrigerant in the float chamber must be maintained above a certain minimum level. If the refrigerant falls below this level, the contacts of the Liquid Level Switch open, stopping pump operation.

10. HEAT EXCHANGER

10.01 To improve the economy of the system, a heat exchanger is added between the absorber and concentrator. The cool diluted absorbent from the absorber passes through the heat exchanger in one direction and hot concentrated absorbent passes through a separate part of the heat exchanger in the opposite direction. The resulting exchange of heat is beneficial to both solutions. The diluted absorbent takes on heat and, therefore, requires less heat in the concentrator to reach its boiling point. The intermediate solution, on the other hand, resulting from the mixing of concentrated and diluted solutions, requires less cooling water in the absorber to lower its temperature and vapor pressure to increase its absorbing qualities. The flash tank, shown in Fig. 8, permits the pressure of the concentrated solution to equalize before the dilute and concentrated solutions mix and form the intermediate solution.

HEAT EXCHANGER BYPASS

10.02 The heat exchanger bypass tube, connecting the concentrator/generator sump directly to the absorber, serves to limit the solution level in the concentrator by bypassing excess solution directly back to the absorber.

10.03 At the time of start-up, the solution level in the concentrator has a tendency to rise until the pressure difference between the concentrator and absorber is established. During this initial stage of operation, solution may flow through both the heat exchanger and heat exchanger bypass tube, holding the solution in the concentrator at the design level.

10.04 A second function of the bypass tube is to conduct the full flow of heated solution directly back to the absorber should crystallization block the return passages of the heat exchanger.

10.05 This direct return of hot solution to the absorber increases the temperature of the dilute solution returning to the concentrator through the tubes in the heat exchanger, providing the necessary heat to break up the crystals freeing the blocked passages.

10.06 The lower part of the bypass tube remains filled with solution at all times, thereby forming a liquid seal between the high and low pressure sides of the system. (See Fig. 8.)

11. COOLING TOWER BYPASS VALVE

11.01 In all cases, a cooling tower is used in the condensing water circuit and the water temperature is controlled at 85°F. When this is done, it is necessary to install a cooling tower bypass valve. This arrangement is shown in Fig. 9.

11.02 The cooling tower valve diverts some of the warm water from the condenser so that it mixes with some of the cool water from the cooling tower and a temperature of 85°F is maintained.

12. TYPICAL CONTROL SYSTEM (For Fully Automatic Systems)

12.01 Once the chilled water pump is started, operation of the Absorption Cold Generator is completely automatic. The unit goes into operation and remains in operation so long as the load on the machine is at least 10 percent of its nominal capacity.

12.02 Sensing changes in chilled water temperature, the pneumatic temperature control system automatically throttles the solution control valve quantity of steam or hot water supplied to the concentrator, modulating capacity from 10 to 100 percent, as required, to keep pace with changing system requirements. When cooling is no longer required, the unit automatically dilutes the absorbent solution before shutting down the system, thus preventing crystallization when the solution cools to ambient temperature.

12.03 All of the system motor starters, capacity modulation controls, and safety devices are consolidated into a single electrically interlocked system. This interlocking arrangement assures proper sequence of operation and provides complete protection against mechanical failure and improper operating procedure.

A. Control Operation

12.04 Figure 10 illustrates a typical absorption system control arrangement. The chilled water pump is started by pushing the START button on the Push Button Station (PB).

12.05 Interlocked with the Chilled Water Pump Starter (MS-2) through a set of auxiliary motor starter contacts and a Flow Switch (FS) in the chilled water circuit are the Pneumatic Electric Switch (PE) and the Condenser Water Pump Starter (MS-3).

12.06 A need for cooling, as indicated by the temperature of the chilled water leaving the unit, causes the branch line pressure of the Pneumatic Chilled Water Temperature Control (TC-1) to rise. The rising branch line pressure closes the contacts of the Pneumatic Electric Switch (PE) starting the condenser water pump through its starter, MS-3.

12.07 The Cooling Tower Fan Starter (MS-4) is interlocked with the Condenser Water Pump Starter (MS-3) permitting the cooling tower fan to start. Once started, the operation of the cooling tower fan is cycled on and off automatically by the Cooling Tower Thermostat (TC-3). Once the chilled water pump and the condenser water pump are started, the absorption machine can be operated. Turning the system Shutoff Switch (S-1) to the ON position energizes the Time Delay Relay (TR).

12.08 This supplies control voltage through the contacts of the Low Temperature Control (LTC), Motor Temperature Control (MTC), and the Liquid Level Switch (LLS) to the Unit Pump Starter (MC-1), starting the unit pumps.

12.09 The Solenoid Air Valve (SAV) is energized through a set of interlocking contacts in the Unit Pump Starter (MC-1). The energized air valve supplies thermostat branch line pressure to the pneumatic steam or hot water valve, allowing the valve to function.

B. Accurate Load Control

12.10 Variations in branch line pressure operate the pneumatic valve, controlling the flow of solution steam or hot water to the concentrator. This governs the rate of vaporization and concentration within the unit, enabling the Absorption Cold Generator to hold a stable chilled water temperature over a wide range of load conditions.

12.11 When lowering chilled water temperature, as sensed by TC, indicates that cooling is no longer needed, the reduced branch line pressure causes the contacts of the Pneumatic Electric Switch (PE) to open. This stops the condenser water pump, which in turn de-energizes the Time Delay Relay (TR), the Solenoid Air Valve (SAV), and the Cooling Tower Fan Starter (MS-4), thereby stopping the fan. De-energizing the SAV causes the pneumatic valve to close, stopping the flow of steam or hot water to the concentrator.

C. Low Temperature Control (LTC)

12.12 Should the temperature of the refrigerant in the evaporator approach the freezing point, the Low Temperature Control (LTC) will open its contacts, thereby de-energizing the Pump Starter (MC-1) and stopping the pumps, thus cutting off refrigeration. At the same time the interlocking contacts of the starter open, de-energizing the Solenoid Air Valve (SAV), causing the heat source pneumatic valve to close, thereby stopping the operation of the concentrator. The remainder of the system continues to operate normally, to raise the temperature in the evaporator thus warming the refrigerant. This warming continues until the temperature of the refrigerant rises above the cut-out setting of LTC, at which time the contacts of the control close, returning the unit pumps and pneumatic valve to service.

D. Flow Switch (FS)

12.13 The Flow Switch is installed in the chilled water line. In the event chilled water flows through the evaporator stops, the switch opens and the machine should stop before going through the dilution cycle.

E. Dilution Cycle (Refer to your manual for length of cycle on your machine.)

12.14 Prior to complete shutdown, the unit pumps continue to function for approximately 7 minutes under the control of the Time Delay Relay (TR), bringing about a mixing of the dilute and concentrated solutions.

12.15 Temperature of the cooling water is controlled by means of a pneumatic valve installed in a cooling tower bypass arrangement. A thermostat, sensing the temperature of the water supplied to the absorber, positions the valve to mix proper proportions of recirculated and tower water to hold the temperature of the water within design limits.

13. METHODS OF CAPACITY CONTROL (GENERAL)

A. Solution Control

13.01 An automatic 3-way solution valve proportions the flow of the generator pump. It sends one portion to the generator and diverts the remainder to the generator solution return connection where it mixes with the return flow. Heat input is reduced with this control by reducing the amount of generator heat transfer surface which is submerged.

B. Steam Control

13.02 An automatic steam valve reduces steam pressure and temperature. Heat input is reduced temperature difference between steam and solution.

13.03 An automatic steam valve regulates the temperature in the generator thereby controlling the strength of the solution which will determine the output of the machine.

14. THE EFFECT OF NONCONDENSABLES ON SYSTEM OPERATION

14.01 Noncondensables cause a loss of capacity and, in extreme cases, crystallization.

14.02 The evaporating temperature of the machine is dependent on the vapor pressure in the absorber. The greater the volume of noncondensables in the unit, the higher the vapor pressure in the absorber and the temperature in the evaporator. The end result is an increase in the leaving chilled water temperature and a decrease in system capacity.

A. Crystallization

14.03 The increase in absorber pressure and evaporator temperature has the dual effect of reducing the load on the evaporator and, in turn, on the absorber. Normally, a reduction in load on the absorber will result in a decrease in absorber temperature. Under normal conditions, when the unit is not operating under the influence of noncondensables, this is not harmful since the input to the unit also is reduced and the unit operates with lower solution concentrations.

14.04 However, when the reduction in capacity is the result of noncondensables, the temperature controller will be calling for a full load, and with full input to the machine, the solution concentrations will be at a maximum. With an abnormally low temperature in the absorber, the temperature of dilute solution entering the concentrator will be low enough to cool the strong solution leaving the concentrator below the saturation point and crystallization will occur in the heat exchanger.

B. Causes

14.05 There are always some noncondensables being generated in the absorption unit. If the purge unit is or is not operating properly, these noncondensables can, in time, accumulate in sufficient quantity to cause a reduction in capacity.

14.06 The most common cause of noncondensables is a leak somewhere in the unit. If the purge unit is found to be operating properly, the absorption unit should be leak tested to determine the source of the leak. Then repairs must be made as necessary.

15. PURGE SYSTEMS

15.01 The purpose of the purge unit is to remove all noncondensables and maintain a low pressure in the absorption machine. Basically, there are two kinds of purge units. One is a mechanical type and the other is a nonmechanical type.

A. Theory of Operation

15.02 Noncondensables travel from an area of high pressure to an area of low pressure. Therefore, the purge suction tube is located in the lower section of the absorber. Figure 11 illustrates the path that noncondensables follow in the machine and indicates the absolute pressure which exists when the machine is at full load operation.

B. Nonmechanical Purge Unit

15.03 A typical nonmechanical purge unit is shown in Fig. 12. The following paragraphs describe the operation of this unit. (Refer to your service manual for more details on your equipment.)

15.04 The lithium bromide is circulated through the purge while the machine is in operation. Referring to Fig. 12, solution supplied from the solution pump discharge line enters the purge and splits into two streams. One stream enters the transfer tube creating a lower pressure and picks up noncondensables entering from the absorber (as illustrated). The other steam sprays into the storage chamber creating a lower pressure which causes noncondensables to flow from the condenser to the storage chamber.

15.05 Noncondensables accumulate until the solution is forced out of the vent, drain tube, and separation pot. This causes the float and reed switch contacts to close, energizing the purge exhaust light on the control panel. This indicates the purge needs to be manually exhausted.

15.06 ***Exhaust Procedures:*** This applies only to Fig. 12. If your equipment is of a different type, refer to your manual.

(a) Close the purge return valve.

(b) Wait 10 minutes for storage chamber to pressurize.

(c) Open purge exhaust valve slowly. If level in container drops, close valve and wait 2 minutes. Reopen valve. When bubbles appear, leave valve open until bubbles stop. When level in container rises, close exhaust valve. With return valve in open position, open exhaust valve and allow part of the solution in container to be drawn into the purge. Close the exhaust valve before solution level in container nears the end of the tube. Do not allow air to be drawn into tube.

C. Mechanical Purge Unit

15.07 ***STARTUP:*** With the manual shutoff valve closed, start the vacuum pump and allow it to operate approximately 1/2 hour (Fig. 13). Check the oil level when the oil is at operating temperature with the pump running. The gurgling noise, which is characteristic of mechanical vacuum pumps operating at high pressures, should disappear after a few seconds. If it does not, check to see if the oil level is too low or if there is a leak in the connecting lines.

15.08 ***VENTED EXHAUST VALVE ADJUSTMENT:*** (Refer to your service manual for additional details.) The vented exhaust valve has a hollow stem. The lower part is a metal ball enclosure leading into a conical seat in the valve port housing. The upper part is a needle valve for metering the proper amount of air into the second stage of the pump. The air passage through the stem contains a check valve to prevent back flow of air during the final compression stage.

15.09 To adjust the valve, open the lower valve by loosening the large knurled locknut and turning the large valve stem one or two turns counterclockwise. Tighten the knurled locknut. The needle valve at the top of the stem on two stage pumps should be fully open.

15.10 ***PURGING:*** With these checks and procedures completed, open the manual purge shutoff valve to purge the machine.

> ***Caution: If the absorption machine is under light load and cycles off automatically, close the manual purge shutoff valve. The purge pump has to handle excessive water vapor if the machine is not running, and this may result in contamination of purge pump oil with water vapor.***

15.11 ***TEST FOR SATISFACTORY PURGE:*** Normally, 1 to 2 hours of purging will free the unit of any accumulation of noncondensable gases.

15.12 A simple test may be performed to determine if the purging operation has progressed to a satisfactory point.

(a) Close the vented exhaust valve.

(b) Connect one end of a rubber hose to the vacuum pump exhaust port and place the other end in a container of water. The appearance of bubbles indicates the presence of air or other noncondensables and continued operation is required.

> ***Note:*** Reopen vented exhaust valve for continued purging. Never operate purge pump with vented exhaust valve closed except to test for satisfactory purge.

(c) If no more bubbles appear, continue with shutdown procedure.

15.13 ***SHUTDOWN:***

(a) Close the manual shutoff valve.

(b) Reopen the vented exhaust valve. Bubbles appearing in the container of water when the manual shutoff valve is closed indicate that the vented exhaust valve is open.

(c) Continue operating pump for 1 hour with the vented exhaust valve open. This is necessary for the removal of condensed water vapor from the oil.

> ***Caution: Remove tube from water to prevent siphoning when pump is stopped.***

(d) Stop the purge pump.

(e) Check the oil for discoloration and replace, if necessary, following the instructions under "Purge Pump Oil Change."

> ***Note:*** If pump is going to be out-of-service for a prolonged period, drain oil and fill to top of filler hole with new Duo-Seal oil to prevent corrision.

16. ROUTINES, TESTS, AND INSPECTIONS

16.01 Periodic tests and inspections of all absorption water chiller plants are required to maintain them in good working condition and to assure complete safety. Described in the following paragraphs are procedures that should be followed in making the indicated tests. Suggested frequencies for tests and inspections are covered in Part 17. Safety precautions should be exercised at all times to protect both personnel making the test and other occupants of the building.

16.02 In addition to the routine inspections covered in this section, additional service is available from Marsh and McLennan, Incorporated, our insurance consultants, for checking out the direct fired units. This includes both fire and safety inspections and annual boiler inspection service by the Hartford Steam Boiler Inspection and Insurance Company. This is covered in Section 760-650-150.

A. Test Equipment

16.03 The following paragraph outlines the routine steps necessary for normal preventive maintenance on the Absorption Refrigeration Machine. It is recommended that these steps be performed and that an accurate log be kept to aid in diagnosing any troubles. To ensure the continued satisfactory performance of the absorption machine, the suggested schedule must be closely adhered to.

B. Strainers

16.04 Service the magnetic strainer monthly and at seasonal shutdown. Clean all strainers and traps in the steam or hot water supply, condensate return, and cooling water circuits 2 weeks after seasonal startup, at midseason, and at seasonal shutdown.

16.05 Clean the magnetic strainer in the unit pump motor cooling circuit as stated in your service manual.

> ***Note:*** Some manufacturer's have two condensate weep holes which are located in the bottom of the pump motor housing. To prevent motor damage, make certain these holes remain free and clear.

C. Adding Octyl Alcohol

16.06 Octyl alcohol is usually required when the leaving chilled water temperature starts to rise above design (providing the control set point has not been altered). Check manufacturer's specifications to determine the amount and frequency for adding octyl alcohol. Unless your service manual has other instructions, use the following procedures.

16.07 Remove a sample of solution from solution pump service valve. If solution has no odor of alcohol (very pungent), then octyl alcohol should be added. Amount to be added depends on machine size. (Refer to your service manual for correct charge.) The alcohol is charged into the system in the following manner:

(a) Connect a charging line to the access valve located near the concentrator outlet (Fig. 14).

(b) Raise the open end of the tube and fill it with distilled water.

(c) Loosen the connection at the access valve and allow a small amount of water to drain from the tube. This will free the tube of any trapped air.

(d) Refill the tube with distilled water and place the open end of the tube in a flask containing the alcohol charge.

(e) Put the unit into operation and slowly open the access valve, allowing the alcohol to be drawn into the system. As soon as the last of the alcohol leaves the flask, close the access valve immediately.

> ***Caution: To prevent the entry of air into the system, close the access valve before the charging tube becomes empty.***

D. Inhibitor (Check your service manual to see if it applies to your equipment.)

16.08 It may be necessary to partially replenish the inhibitor charge after several thousand hours of machine operation. It is recommended that a sample of machine lithium bromide solution be analyzed on a yearly basis. Results of an analysis will indicate any inhibitor depletion and will also give an indication of machine tightness.

> ***Note:*** Lithium bromide is toxic as used in the machine because of the inhibitors added.

16.09 Inhibitor analysis service is provided by the manufacturer's representative for your equipment.

E. Absorber and Condenser Tubes

16.10 The absorber and condenser tubes should be cleaned annually.

16.11 To ensure maximum efficiency, the cooling water circuit must be kept free of both sludge and scale. Even a very thin coating of scale will greatly decrease the heat transfer capacity of the absorber and condenser tube bundles.

16.12 Two methods for cleaning the tubes are:

(1) Mechanical

(2) Chemical.

16.13 The mechanical method is used to remove sludge and loose material from the tubes.

16.14 Access to the tubes is obtained by removing the absorber and condenser water headers.

16.15 To loosen the material, work a nylon or bristle brush through the tubes (a brass, 20-gauge shotgun brush is recommended). After the material has been loosened, flush the tubes with clear water.

16.16 Scale deposits are best removed by chemical means. The cooling water circuit is composed solely of copper, steel, and cupronickel.

F. Cleaning the Cooling Water Circuit

16.17 Figure 15 illustrates a typical cleaning hookup. The cleaning hookup is made to pipe fittings installed in the absorber supply and condenser return piping.

16.18 All materials used in the external circulation system, quantity of solution, duration of cleaning period, and any required safety precautions should be approved by the company furnishing the materials or performing the cleaning.

16.19 The chilled water circuit is a closed circuit and, normally, will not accumulate an appreciable amount of sludge or scale. However, if cleaning should be required, use the same method outlined for cleaning the cooling water circuit.

G. Water Treatment

16.20 It is recommended that the supervisor in charge either have a person trained or engage the services of a qualified water treatment specialist to make tests and recommend the treatment necessary to remove any contaminating material from the water.

> ***Note:*** Manufacturers do not assume any responsibility for equipment failure resulting from untreated or improperly tested water.

H. Reclaim Solution (Does not apply to all systems.)

16.21 ***Reclaim Solution:*** During normal operation, some lithium bromide solution may be carried over into the refrigerant. To determine if contamination exists, remove a refrigerant sample per manufacturer's instruction and measure its specific gravity. If specific gravity value exceeds 1.02, the solution must be reclaimed. (Confirm this with your service manual.) This is an automatic or later model machine.

I. Evaporator Water Charge

16.22 ***Check Evaporator Water Charge:*** Tube leakage or excess refrigerant is indicated if reclaim valve is energized continuously during normal machine operation.

16.23 Reclaim valve should energize at full load, which is approximately 59.5 percent lithium bromide solution concentration in the absorber. To check this, operate the machine at full load with design entering condensing water temperature and design leaving chilled water temperature. Remove an evaporator water sample from refrigerant pump service valve and check its specific gravity. If valve is below 1.02, check absorber loss. (Follow instruction in your service manual if this test pertains to your system.)

J. Solution or Refrigerant Sampling (See Fig. 16)

16.24 A solution sample is taken periodically to check its temperature and specific gravity in order to determine absorber loss. To remove a sample, proceed as follows:

(a) Install a hose adpater to solution service valve.

> ***Note:*** Do not use copper or brass fittings. Copper oxides will form causing contamination of samples.

(b) Attach plastic tubing to adapter, fill tubing with water, and place other end of tubing in a container filled with water.

(c) Open service valve slightly. Be sure tubing end is under water. When water level in container rises, raise tubing and fill sample container.

> ***Note:*** Before sampling, be sure machine is operating without side variations in load or without recent reclaim valve operation. A more detailed vacuum test procedure is available from the Building Technical Training Center, Newark, N.Y. 14513.

16.25 Check manufacturer's specifications to determine the permissible amount of absorber loss. If it is more, purge air from machine. If specific gravity value is greater than 1.02, reclaim solution until specific gravity value falls below 1.02. Then absorber loss can be checked.

16.26 Check reclaim line by feel. If line is already cold with audible flow, remove refrigerant until reclaim valve closes (audible click) and refrigerant flow ceases.

16.27 When machine is operating at partial load, lithium bromide solution must be concentrated to 59.5 percent before checking evaporator water charge. This is done by raising entering condensing water temperature, then lowering control point adjuster setting to below design leaving chilled water temperature.

16.28 Continual removal of water indicates tube leakage. Report the problem to your supervisor.

K. Machine Tightness (Use only as a guide. Refer to your service manual.)

16.29 The most important maintenance item on the absorption machine is maintaining vacuum tightness by determining the noncondensable accumulation rate.

16.30 ***Determine Noncondensable Accumulation Rate (Fig. 17):*** Operate the machine approximately one week before determining noncondensable accumulation rate. Then proceed with the following instructions unless your service manual has other instructions.

(a) Connect a flexible length of tubing to the purge exhaust connection. Fill tubing with water and insert into a container of water. Close purge return valve; wait 10 to 15 minutes, then open purge exhaust valve slightly. If the liquid level in container recedes, close exhaust valve. Wait several minutes, then repeat this step. Purge is exhausting when bubbles rise through liquid to surface. Leave valve open until bubbles stop and liquid level rises. Then close valve. Purge is now exhausted.

(b) Open purge return valve and allow machine to operate for 24 hours.

(c) Fill a 1000-cubic centimeter (or equivalent) bottle with water and invert it in a clean container filled with water.

(d) Insert water-filled hose into bottle.

(e) Exhaust the purge following step (a). Noncondensables will displace water in the inverted bottle. Continue until bubbling in bottle ceases and only solution flows from exhaust tubing.

(f) Close exhaust valve and mark liquid level on inverted bottle. Remove bottle from container.

(g) Open purge return valve.

(h) Measure amount of noncondensables removed. If a graduated bottle was used, the amount (volume) of noncondensables removed is indicated by mark on bottle. If a nongraduated bottle is used, empty the bottle, then fill bottle with liquid to exhaust mark. Pour liquid into a graduated container to measure volume displaced.

(i) Refer to the manufacturer's table in your service manual (if available) for your machine's maximum allowable noncondensable accumulation leak rate. If accumulation rate exceeds allowable leak rate for your machine, then machine must be leak tested.

L. Exhaust Vertical Purge

16.31 Exhaust vertical purge weekly or when liquid level in storage chamber reaches the 6-inch level. Many machines with low leak rates will not require exhausting weekly. Follow the procedure in your manual.

M. Purge Systems

16.32 ***Once a Month:***

(a) Check pulley alignment and V-belt tension. The bolt should depress about 1/2 to 3/4 inch under light hand pressure applied midway between the pulleys. Belt adjustments are made by loosening the motor hold-down bolts and sliding the motor toward or away from the vacuum pump as required.

(b) Clean the purge drive belts with a cloth dampened in an approved cleaner. Refer to your service manual for more details.

(c) Change the purge vacuum pump oil according to the instructions given under "Purge Pump Oil Change" in your manual.

16.33 ***Once a Year:*** Lubricate the purge pump motor with a good grade of machine oil.

16.34 ***Purge Pump Oil Change:***

(a) Warm the oil by operating the pump for approximately 15 minutes with the intake closed. Stop the pump and remove the oil drain cap. Most of the oil will drain out freely. ***Use extreme care***—the oil will be hot. The small residue remaining in the pump can be forced out by turning the pump pulley by hand, with the exhaust port closed and the intake open. The oil will spurt out suddenly and should be deflected into the drain pan. Avoid extensive operation with the exhaust port sealed; excessive internal pressure may loosen the shaft seal.

(b) After removing all oil, close the drain and pour 3 or 4 ounces of clean Duo-Seal oil into the intake port. Open the exhaust port and run the pump for a short period to completely circulate the new oil. Drain the flushing oil and force out the residue as previously indicated. Repeat flushing with new Duo-Seal oil until flushing remains clean and free of color and foreign matter.

Caution: Do not use solvents or light flushing oils. Their complete removal is difficult and their higher vapor pressures would prevent the attainment of high vacuum.

(c) If the oil has thickened or contains sludges, it is advisable to remove the oil reservoir case and thoroughly clean it with clean, lint-free rags. In replacing the oil case, varnish a new gasket and position it on the pump case. Tighten all screws uniformly.

(d) After the oil is completely flushed, refill by pouring new Duo-Seal oil into the exhaust port. Fill to the level indicated on the sight glass. Replace the dust cap. Start the purge pump with the manual hand valve closed and allow it to operate 1 hour to warm the oil. Recheck the oil level with the oil at operating temperature.

Note: Duo-Seal is a trade name; it is a nonmechanical type. Follow your service manual on suggested routines.

N. Refrigerant Pump

16.35 ***Check Solution and Refrigerant Pump Starters:***

(a) Place solution and refrigerant pump switches in OFF position; starters will de-energize.

(b) Inspect condition of contacts.

(c) Check wiring connection for tightness.

16.36 ***Check Solution and Refrigerant Pump Rotation:*** Install compound pressure gauge on solution or refrigerant pump service valve. Start pump and check pump discharge pressure per manufacturer's specifications.

Warning: Do not check pump rotation before solution and/or refrigerant is charged into machine. Serious damage could result to the bearings.

O. Service Valve Diaphragms

16.37 The requirement to replace valve diaphragms is determined by valve usage or number of machine operating hours. Less frequent usage of valves and lower number of machine operating hours results in longer life span for valve diaphragms. With minimum usage, the requirement to replace diaphragms might be 2 years. With maximum usage, they will need to be replaced in approximately 1 year. To replace valve diaphragms, break machine vacuum with nitrogen procedure according to your service manual instructions. Otherwise, follow instructions below.

16.38 Remove all solution and refrigerant from machine if the job requires that this be done.

16.39 Store solution in clean containers for recharging. Remove old valve diaphragms and replace. Torque valve bolts to 3 ft · lb (confirm with your service manual). Retest all affected connections for leakage. Replace solution and refrigerant in machine. The same quantity of solution and refrigerant removed must be replaced. Reevacuate machine after servicing. Machine evacuation procedures are given in your service manual.

P. Hermetic Pumps

16.40 ***Inspect Hermetic Pumps:*** Pumps used on hermetic absorption machines are hermetic and do not require seals. Pump motors are cooled by the fluid being pumped and are thermally protected with high temperature cutouts (Klixons).

16.41 Inspect hermetic pumps and motors every 7 years or 30,000 hours, whichever comes first.

Q. Pneumatic Steam or Hot Water Valve

> *Note:* Pneumatic controls are the most common type used. However, other types also work well.

16.42 Service the pneumatic steam or hot water valve in accordance with the valve manufacturer's recommendations.

16.43 For pneumatic machines, ensure 18 psig air supply to control panel (Average).

R. Controls (Use only as a guide. Refer to your manaul for specific details on your controls.)

16.44 Once a year, observe the setting and operation of each of the system controls and make the necessary adjustments in accordance with the instructions in your service manual.

16.45 ***Check Dilution Thermostat(s):*** Dilution thermostat(s) should open when strong solution temperature drops to 140°F. If thermostat contact point is not at 140°F, adjust by inserting screwdriver in slot on face of thermostat (located on strong solution line). Adjustment procedures vary with different uses; therefore, check your manual for more details.

> *Note:* For system using timers or time delay relay, follow instructions in your service manual.

16.46 ***Check Low Temperature Cutout:*** Remove control sensing element from low temperature cutout well(s) on evaporator shell. Place in an ice bath and check cutout point. Control should trip at 5°F below design leaving chilled water temperature or at a minimum of 34°F.

16.47 Cutout point is dial setting less 3°F differential. When control trips, the machine will shut down immediately without going through a dilution cycle.

16.48 Chilled water pumps will continue to run if standard wiring arrangement is used.

> ***Caution: Hot circuit; use insulated jumper.***

S. Safety Control Checkout

16.49 These checkout procedures are for semiautomatic control systems. There are two procedures given. Select the procedures for your machine size and follow the checkout sequence. Use wiring diagram located inside control panel door for reference to components. Machine must be charged with solution and refrigerant before control checkout.

16.50 ***Check Capacity Control Valve:*** Check the leaving chilled water temperature. If temperature is not being maintained at design, adjust electronic or pneumatic capacity control as follows:

(a) ***Electronic Control Adjustment:*** Move control point adjuster clockwise to increase temperature or counterclockwise to decrease temperature.

(1) If this fails to bring leaving chilled water temperature within design, replace vacuum tubes in control motor and clean relay contacts with stiff paper. Be sure new tubes are installed properly. Instructions differ on solid state. Refer to your manual for additional details.

(2) If this fails to correct the problem, contact your supervisor or the manufacturer's representative.

(b) ***Pneumatic Control Adjustment:*** Reset control point setting to design. If this fails to correct the problem, contact your manufacturer's representative.

16.51 ***Check Cooling Tower Bypass Control:*** If control is not maintaining design entering condensing water temperature, recalibrate the control thermostat. For additional information, contact the valve (or control) manufacturer.

17. MAINTENANCE, INSPECTION, AND TESTING SCHEDULE

17.01 Listed below are suggested frequencies for the various routines and tests to be performed in connection with inspection and maintenance of an absorption air conditioning system. Local conditions, laws, or ordinance may require changes in the intervals listed.

17.02 ***Daily:*** (Absorption unit in service)

(a) Observe operating pressure, solution, and refrigerant level.

(b) Observe operating temperature of the absorption system and related equipment.

(c) Observe energy to generator.

(d) Observe the general condition of the equipment and report any unusual noise or condition.

17.03 ***Weekly:*** (Absorption unit in service)

(a) Check energy supply.

(b) Manual purge operation.

(c) Observe operating pressure.

(d) Record amperage of components.

Note: Schedules denoted with an * are subject to manufacturer's exceptions. Refer to your service manual for guidelines.

17.04 ***Monthly:*** (Absorption unit in service)

(a) Reclaim solution*.

(b) Run vacuum test (same as tightness test).

(c) Add Octyl alcohol*.

(d) Determine absorber loss* (often referred to as noncondensable accumulation rate test).

17.05 ***Every 2 Months:***

(a) Check out dilution cycle.

(b) Check purge high level safety probe*.

(c) Check low temperature cutout.

17.06 ***Every 6 Months:***

(a) Check evaporator water charge.

(b) Check setting on capacity control.

(c) Check cooling tower bypass control*.

(d) Lubricate motors*.

(e) Lubricate valve motor linkage*.

17.07 ***Annually:***

(a) Lubricate evaporator and solution pump motor*.

(b) Lubricate purge pump.

(c) Replace vacuum tubes in electronic control motor*.

(d) Check absorber and condenser tubes; clean as required.

(e) Clean purge tank*.

(f) Check operation of the purge valve.

17.08 ***Every 2 years:***

(a) Replace valve diaphragms.

(b) Replace check valves.

(c) Inspect and clean solution spray header, if accessible.

(d) Replace seal in water pump*.

(e) Replace evaporator and solution pump seal.

(f) Clean or replace slight glass.

17.09 ***Every 7 Years/30,000 Hours*:***

(a) Inspect hermetic pumps.

18. TROUBLESHOOTING GUIDE

SYMPTOM		POSSIBLE CAUSES
18.01	Lithium bromide solidifies a start-up.	(a) Condenser water too cold. (b) Air in machine. (c) Improper purging.
18.02	Lithium bromide solidifies during operation.	(a) Condensing water too cold. (b) Steam pressure or hot water temperature above design. (c) Vapor condensate temperature too low. (Temperature should never be below 112°F at full load.) (d) Machine requires octyl alcohol. (e) Improper purging. (f) Air leakage.
18.03	High absorber loss.	(a) Leakage in vacuum side of machine. (b) Inhibitor depleted.
18.04	Low capacity.	(a) Air in machine. (b) Condenser tubes dirty. (It can be noted by continually rising vapor condensate temperature at full load.) (c) Improper purging. (d) Machine needs octyl alcohol. (e) Improper setting of capacity control valve. (f) Insufficient condensing water flow or temperature too high. (g) Solution temperature leaving generator below 220°F at full load. Note correct temperature at full load.
18.05	Machine shuts down on safety control.	(a) Motor overloads. (b) Hermetic pump thermo-overload tripped. (c) Shutdown on low temperature cutout.
18.06	Solidification during shutdown.	(a) Dilution cycle less than 7 minutes. (b) No load during the dilution cycle. (c) Condensing water pump off during dilution cycle. (d) Improper closing of capacity control valve. (e) Machine shut down with air in it.
18.07	Suspect air leakage.	(a) Leakage into vacuum side of machine.
18.08	Loss of vacuum at shutdown.	(a) Leakage into vacuum side of machine.
18.09	Failure to keep machine purged.	(a) Leakage above the pumping rate of vertical purge. (b) Vertical purge is not performing properly.

19. SERVICING PROCEDURES (GENERAL)

A. Solution Charging (See Fig. 18.)

19.01 Refer to your service manual for the proper charge. Use the following procedures for charging the solution:

(a) Connect flexible hose to 1/2-inch pipe. Fill both pipe and hose with water.

(b) Add inhibitor per manufacturer's instructions to first drum of lithium bromide; stir for proper mix.

(c) Insert pipe in drum and connect flexible hose to solution pump service valve. On some machines, they can be charged through either solution pump service valve.

(d) Open service valve. Continue charging until the solution level is near the bottom of the drum, then close the valve. Do not allow air to be drawn into the machine.

B. Refrigerant Charging

19.02 Repeat steps (a), (c), and (d) of paragraph 19.01 to charge water (refrigerant) through the refrigerant pump service valve. Most machines can be charged through either refrigerant pump service valve.

C. Charging for Conditions Other Than Nominal

19.03 When the chilled water temperature, condensing water temperatures, or flow differ from the nominal values, the solution quantity can be adjusted to compensate for these other-than-nominal conditions. The solution quantity can be increased or decreased up to a total of 10 percent of the nominal charge as shown in your service manual.

19.04 The procedures are as follows:

(a) Increase (decrease) the nominal solution charge by 1 percent for each degree that chilled water temperature is below (above) 44°F.

(b) Increase (decrease) the nominal solution charge by 1 percent for each 2 degrees that condensing water temperature is above (below) 85°F.

(c) Increase nominal solution charge by 1 percent for each 10 percent reduction in condensing water flow below nominal 100 percent.

19.05 Do not adjust the nominal charge for changes in steam pressure or hot water temperatures. If the solution charge is increased (decreased), decrease (increase) the refrigerant water charge by an equal amount.

D. Care and Handling of Lithium Bromide

19.06 This solution is nontoxic, nonflammable, nonexplosive, and chemically stable. It can easily be handled in an open container and will not undergo any noticeable change in properties even after years of usage.

19.07 If lithium bromide solution is spilled on parts or tools, they should be rinsed and wiped off as the solution is corrosive when exposed to air. Coat tools with a light film of oil after rinsing. Empty metal containers used for solution storage should also be rinsed.

19.08 Lithium bromide solution can be irritating to the skin, eyes, and mucous membranes. Wash off with soap and water. If it gets into the eyes, wash with fresh water and consult physician immediately.

19.09 Do not, under any circumstunces, charge the solution into the machine until the unit is ready for operation.

19.10 Do not start any pump motors until the machine has been charged with solution and refrigerant water (refer to your manual) or serious damage can result.

E. Inhibitors

19.11 Inhibitors are used to suppress corrosion in the machines. A charge of inhibitor will be effective for approximately 7,000 machine operating hours.

F. Breaking Vacuum With Nitrogen

19.12 Air must never be allowed to enter the machine. Any time that the vacuum must be broken, either for service work or extended shutdown, it must be broken with nitrogen. Nitrogen prevents any air from entering the machine and, in this way, protects the interior of the machine against corrosion. If service work is being performed and the machine will be opened to atmosphere, the vacuum should first be broken; then, the pressure regulator should be set at 1 psig pressure and nitrogen should be constantly bled into the machine. Blind flanges or temporary covers should be used to cover the openings during service work. See Fig. 19 for connecting the nitrogen bottle, regulator, and line to the alcohol charging valve. For winter shutdown, 1 psig should be left on the machine.

G. Machine Evacuation

19.13 Evacuation is required to lower the absorber pressure in the machine and to remove noncondensables after the machine has been opened. Determine mercury gauge pressure in absorber. Check room temperature. From Equalibrium Diagram, find corresponding pressure. This pressure should match the mercury gauge pressure; if not, air or noncondensables exist in the machine and purging (evacuation) is necessary before start-up.

19.14 ***Auxiliary Evaluation:*** Due to the critical nature of machine operation on some jobs, it may be desirable to provide an auxiliary device. This may be accomplished with a steam jet, water jet, or vacuum pump. A 1-inch coupling is provided on the generator for this purpose. If a vacuum pump is provided, precautions must be taken to prevent oil from inadvertently entering the machine (Fig. 20).

H. Solution Desolidification

19.15 During a long unscheduled shutdown period without proper dilution due to prolonged power failure, solidification may occur. If solidification is to the extent that the solution pump will not rotate and the motor overloads trip out, desolidify by using the following procedures (unless your manual states something different).

(a) Heat the pump casing and adjacent lines with steam until the pump will rotate. Be careful not to allow steam and condensate to enter the pump motor or controls. Special precautions must be taken with hermetic pumps. The pump casing may be warmed with steam, but, under no circumstances, should heat be applied directly to any flange connection as the very high temperature will deteriorate the gasket material used.

(b) Confirm pump rotation. Rotation of a hermetic pump cannot be viewed directly. Install a compound pressure gauge on the solution pump service valve. With correct pump rotation, the gauge will indicate a positive reading above atmospheric pressure. If the pump is solidified, the gauge will indicate atmospheric pressure. If the casing is partially desolidified and the pump will not turn, the pressure gauge should indicate a deep vacuum. Continue to heat the casing until the pump is desolidified. Desolidification of the heat exchanger will take place automatically once the pump starts functioning.

(c) Refer to Troubleshooting in your service manual for cause and correction of solidification.

20. RECORDS AND LOGS

OPERATING AND MAINTENANCE INFORMATION

20.01 Proper operation and maintenance of absorption units requires that certain records and logs be kept. All drawings (including control wiring diagrams, specific written operating instructions, manufacturer's maintenance and operating instructions, and other related material) should be kept permanently in the equipment room or other suitable location so that it will be readily available to persons who operate and maintain the equipment. Where space permits, drawings and diagrams should be framed or sealed in plastic and hung adjacent to the related equipment. Other material should be assembled in brochure form and enclosed in a suitable binder. Maintaining duplicate copies of this material at an appropriate location, such as a BOCC, is desirable. When changes or additions are made, the maintenance data and all drawings must be revised accordingly. Initially, the furnishing of this material and its revision, as required, should be a condition for the acceptance of the equipment for operation by the Building Operations Forces.

20.02 A permanent logbook should be provided in each absorption room to record maintenance work inspections, certain tests, and other pertinent data. Brief details of any repairs or other work done on the system (including the time started, time completed, and signature of the mechanic or person in charge) should be recorded. Performance and results of all tests and inspections or other routines required by codes or laws (including insurance company inspections and initial acceptance tests) must be recorded.

20.03 Log sheet readings are valuable for three reasons. They familiarize the operator with the machine operation; they may be of assistance when planning maintenance work; and they are beneficial in diagnosing trouble. For these reasons, it is recommended that log sheet readings be taken periodically.

20.04 A form similar to Fig. 21 shall be used to record maintenance work, inspections, tests, and other pertinent data pertaining to the equipment. This shall also include any repair work (including time started, time completed, and signature of who performed the work). (See Fig. 21.)

20.05 Figure 21 lists the basic minimum checks and routines that shall be completed. In addition, the manufacturer's manual may describe additional checks and/or records that should be completed. The frequency of these routines shall be determined with the aid of the manufacturer's manual or this practice.

20.06 The Absorption Refrigeration Log shall be retained for a period of 2 years. This will provide a means for comparison which will enable you to solve many of your heating and cooling problems.

20.07 There may be items that do not apply to your equipment. These should be lined out.

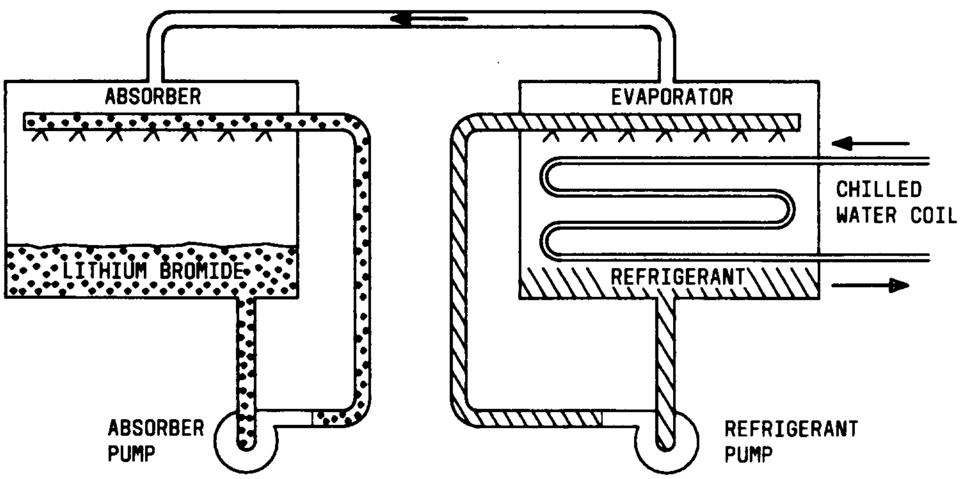

Fig. 1—Basic Cycle Schematic

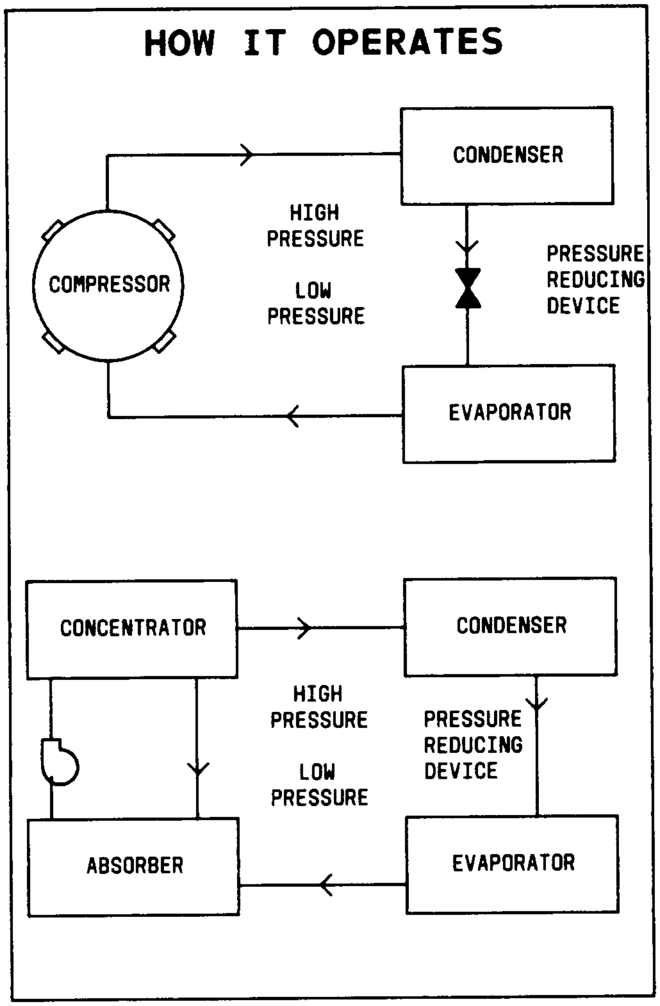

Fig. 2—Comparison of Mechanical Refrigeration Cycle and Absorption Refrigeration Cycle

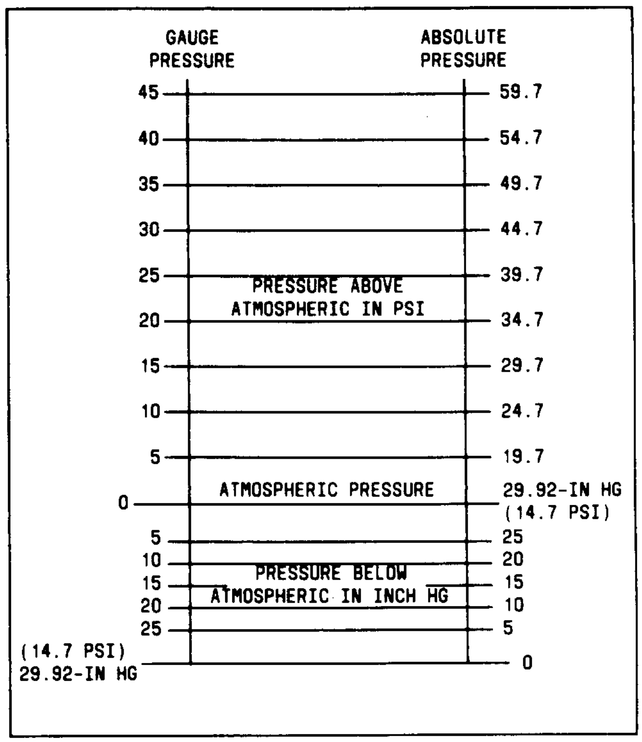

Fig. 3—Relationship Between Absolute and Gauge Pressures

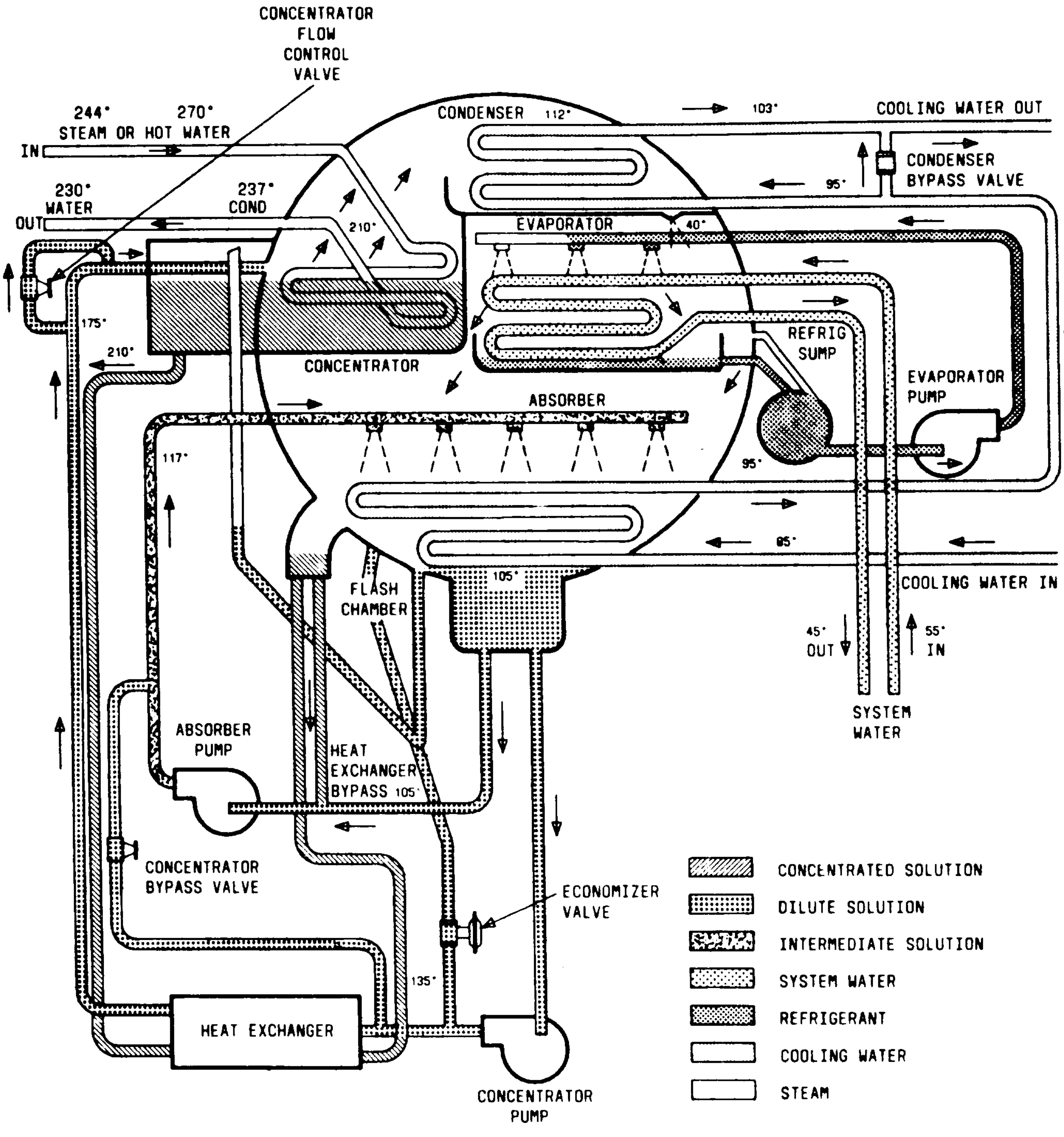

Fig. 4—Schematic of Absorption Cycle

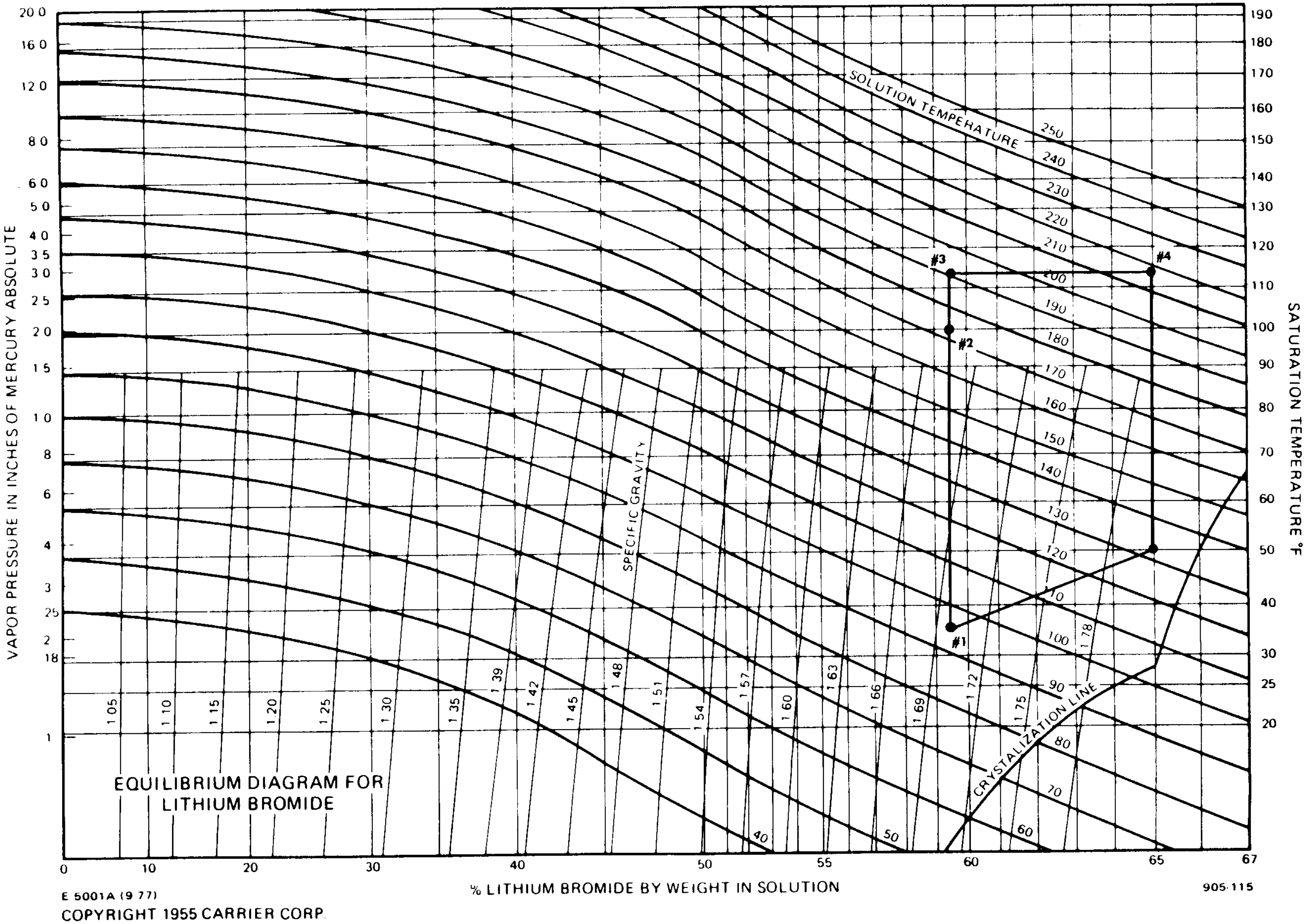

Fig. 5—Lithium Bromide Equilibrium Chart

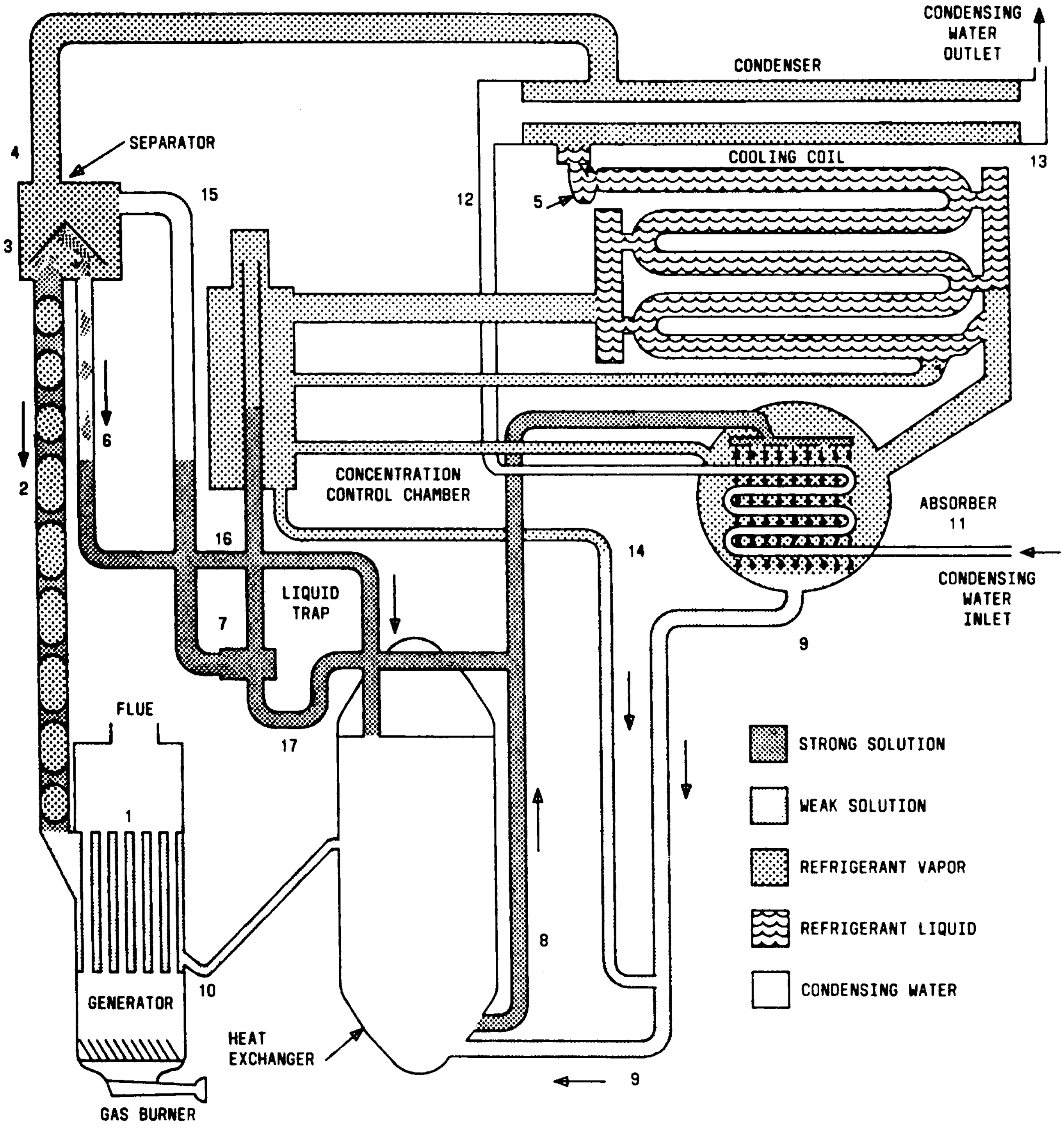

Fig. 6—Cooling Cycle—Schematic Flow Diagram—Single Coil, Direct Fired Unit

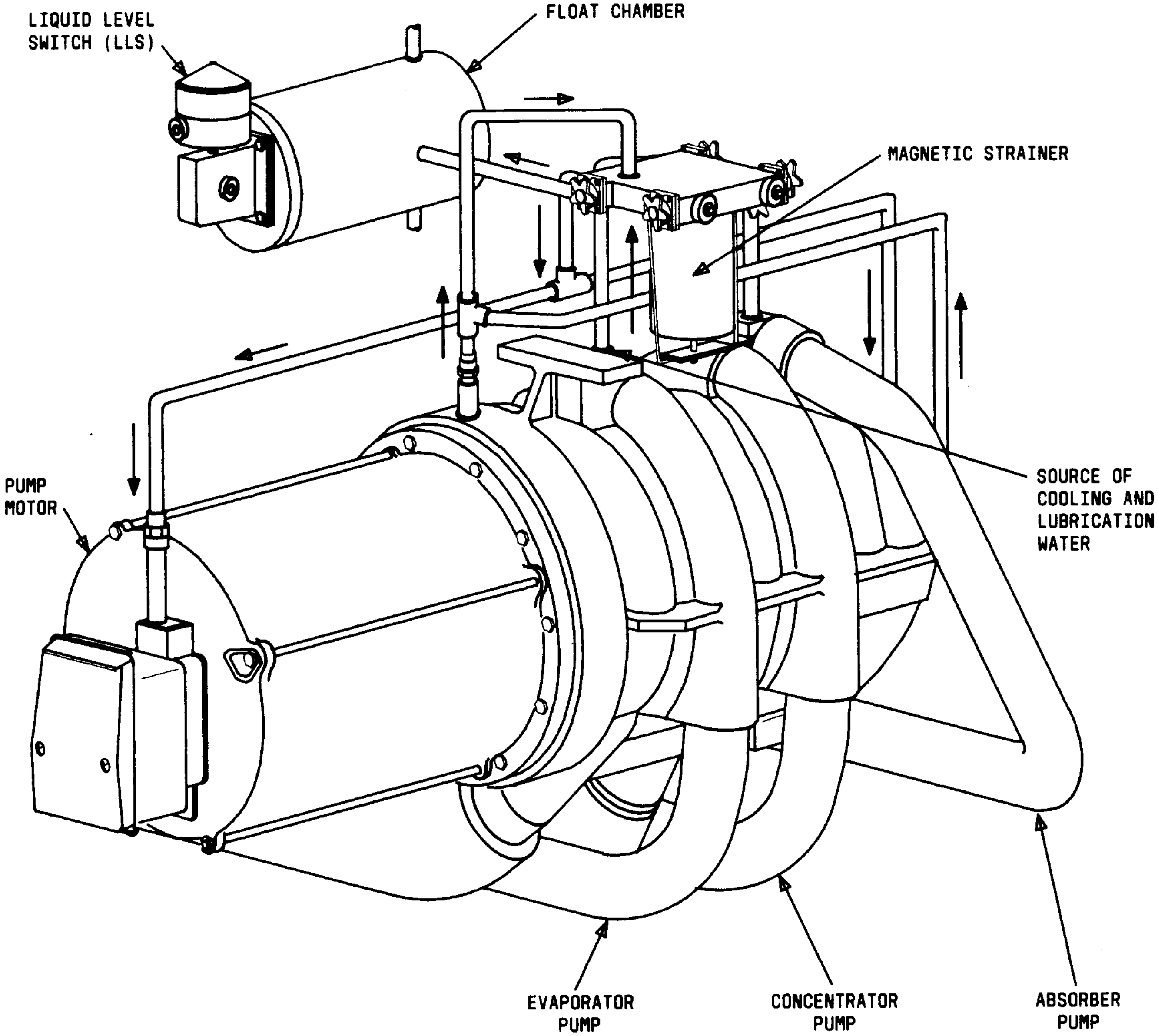

Fig. 7—Pump Motor Lubricating and Cooling Circuit

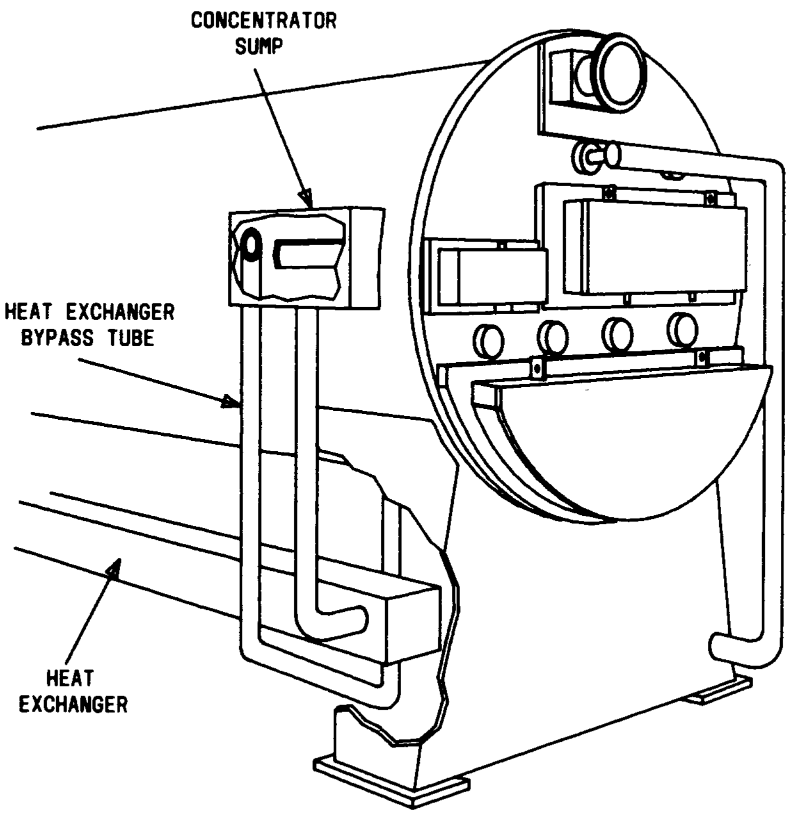

Fig. 8—Heat Exchanger Bypass

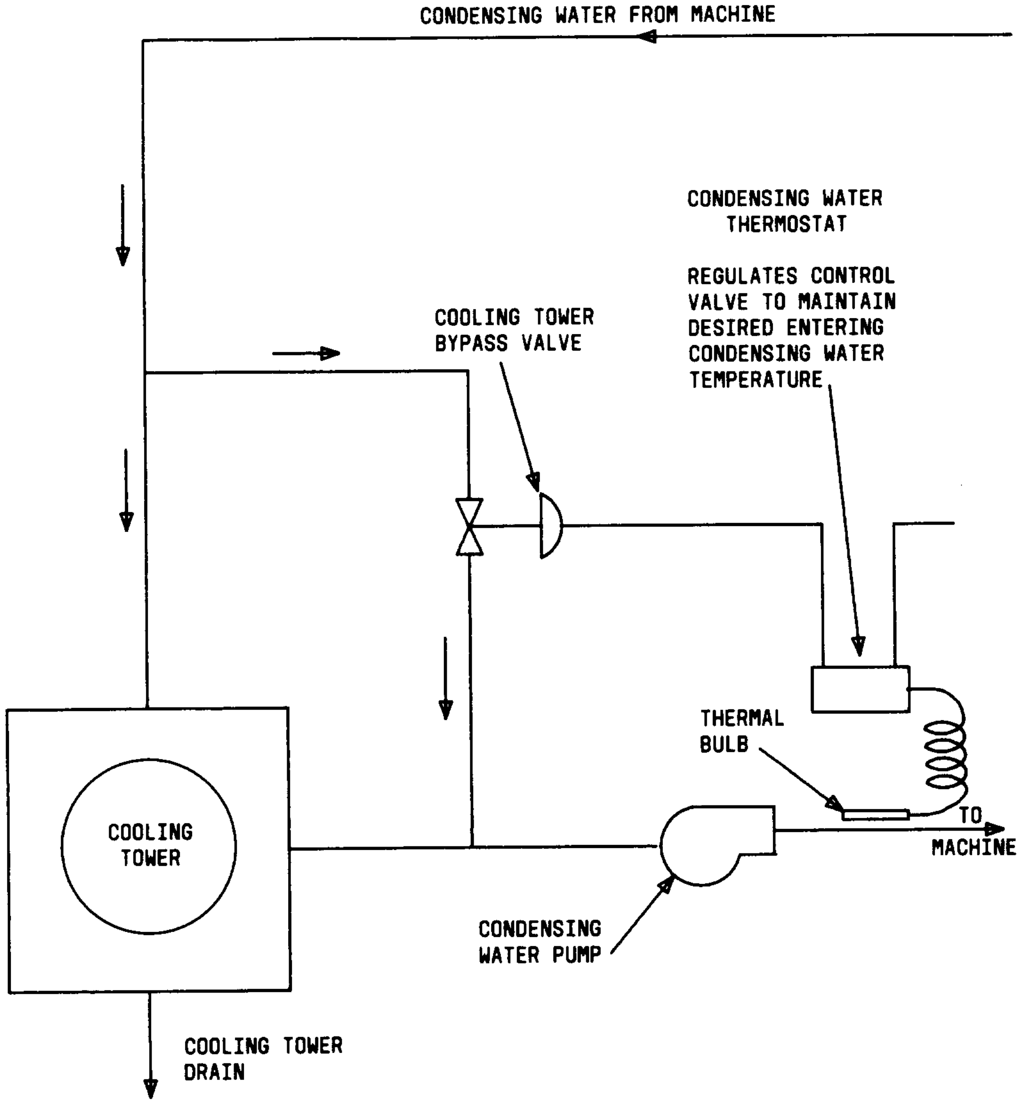

Fig. 9—Cooling Tower Circuit

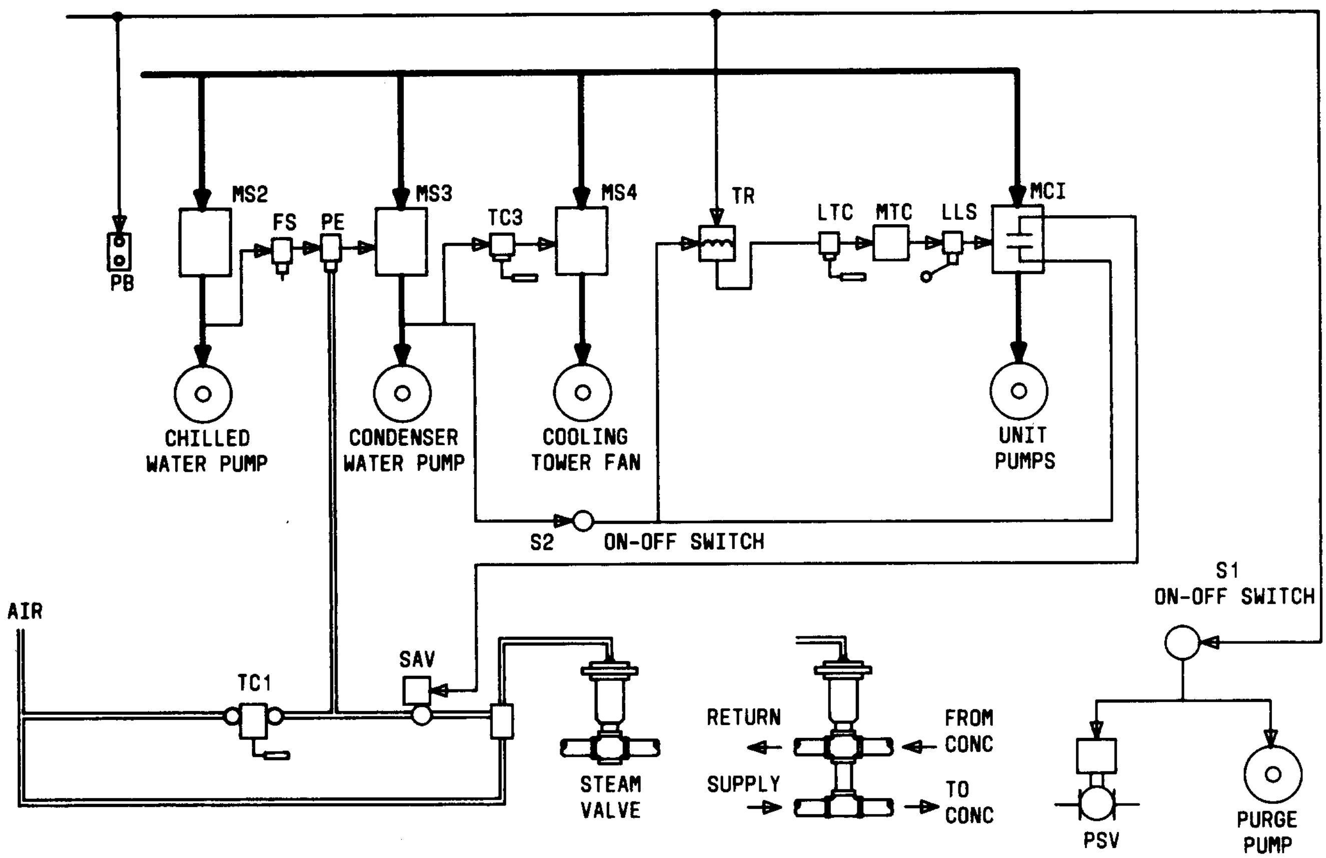

Fig. 10—Block Diagram of Control System

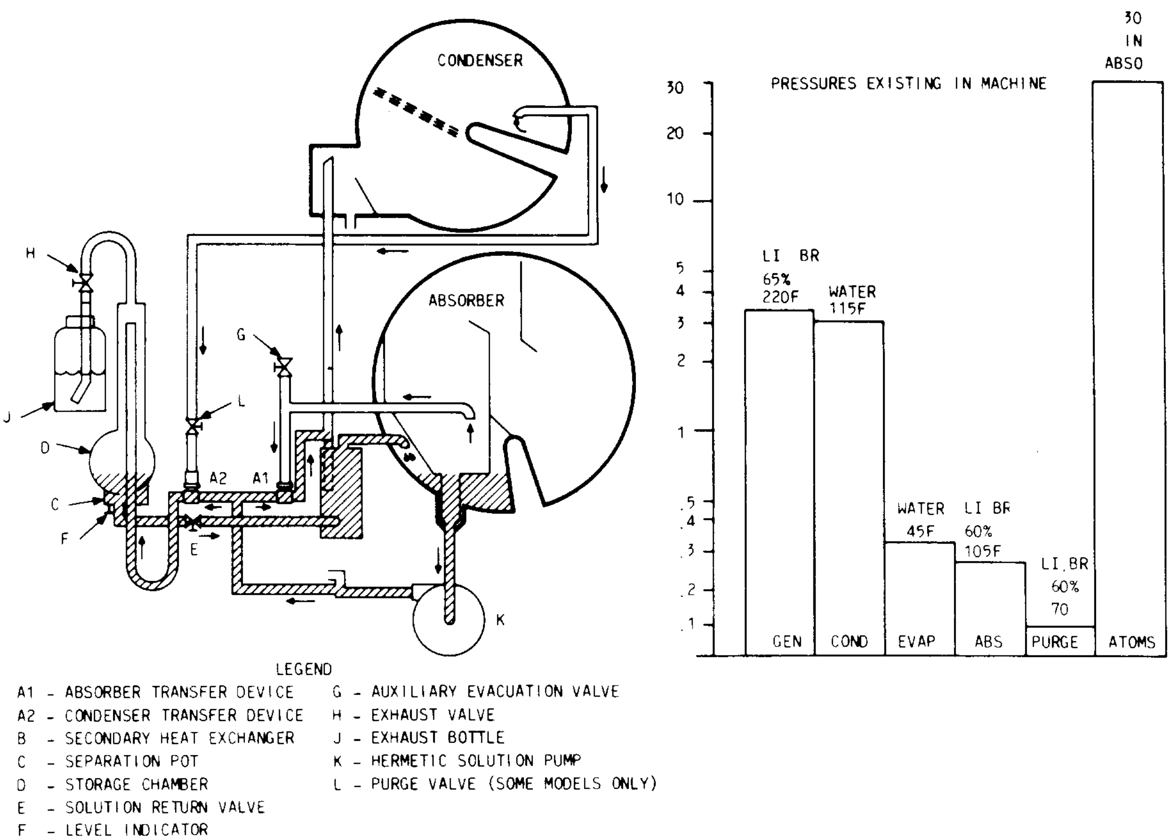

Fig. 11—Noncondensable Path and Machine Pressures

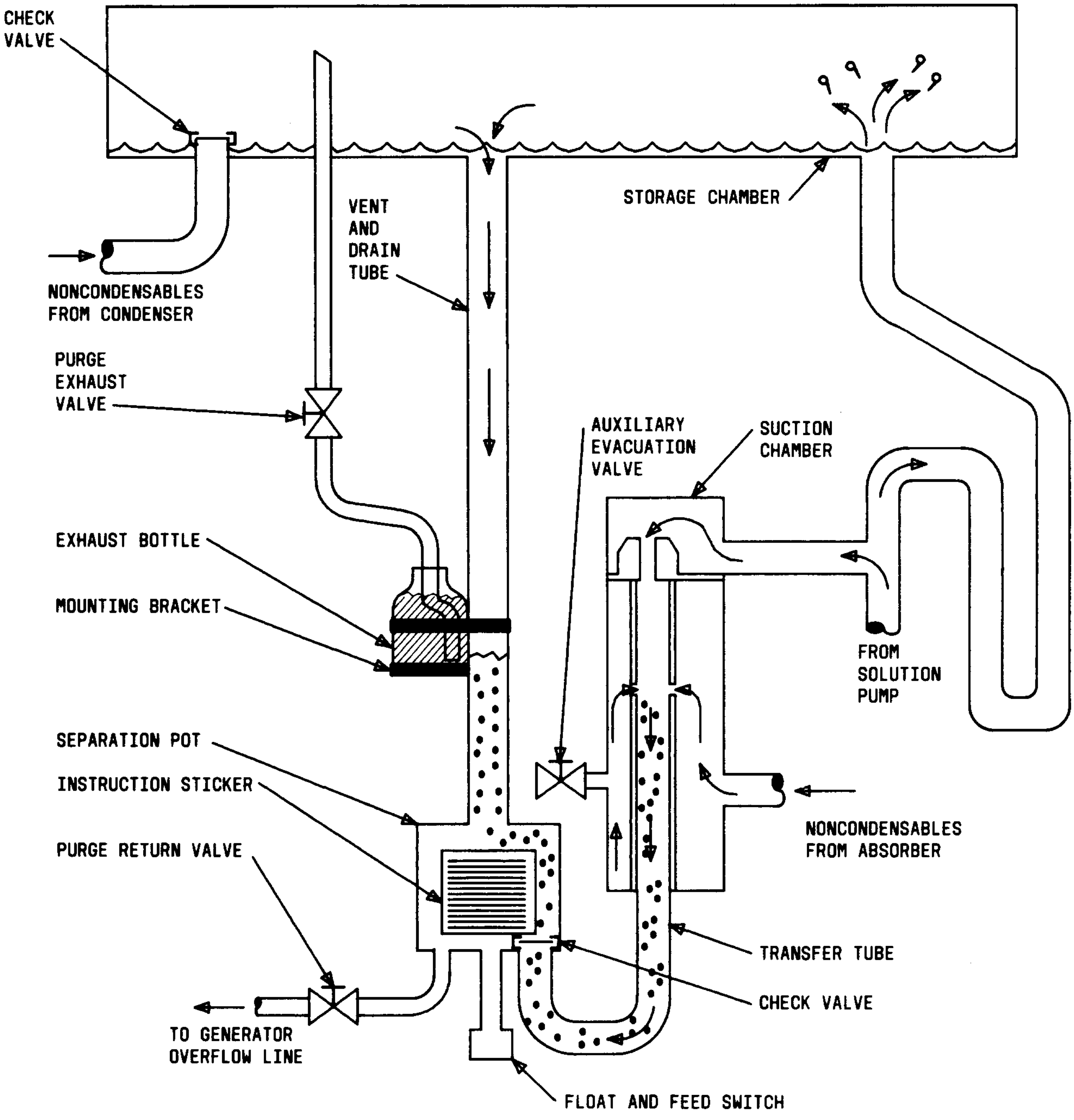

Fig. 12—Typical Nonmechanical Purge Unit

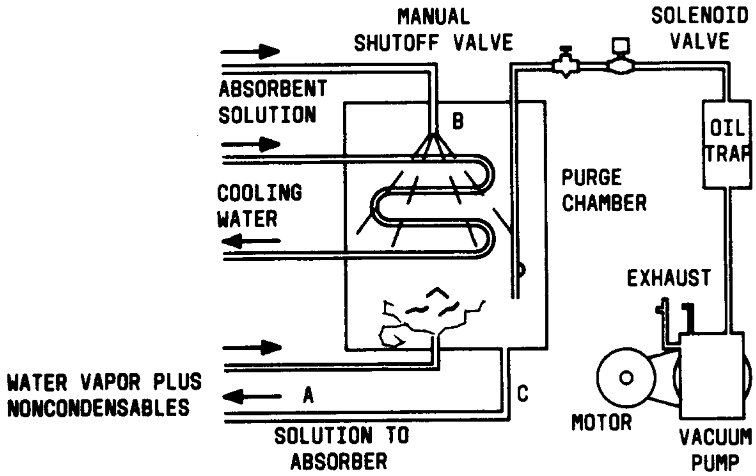

Fig. 13—Schematic of Purge System

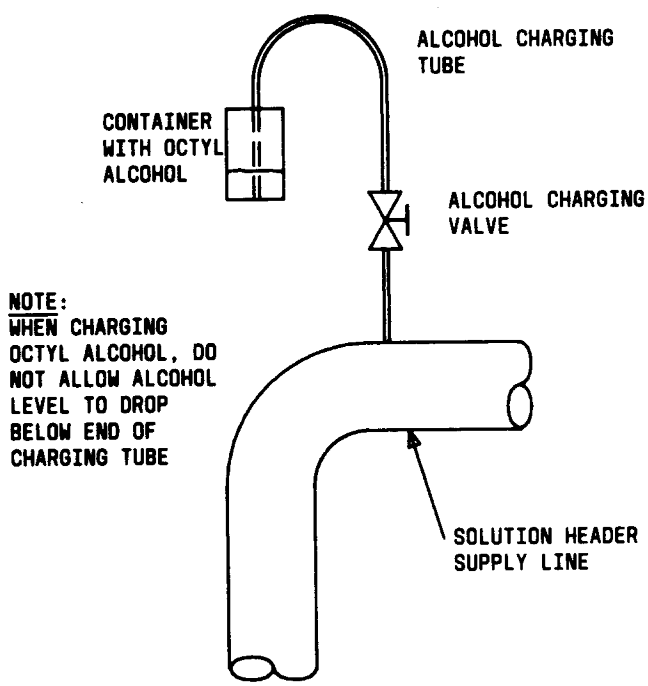

Fig. 14—Alcohol Charging Connection

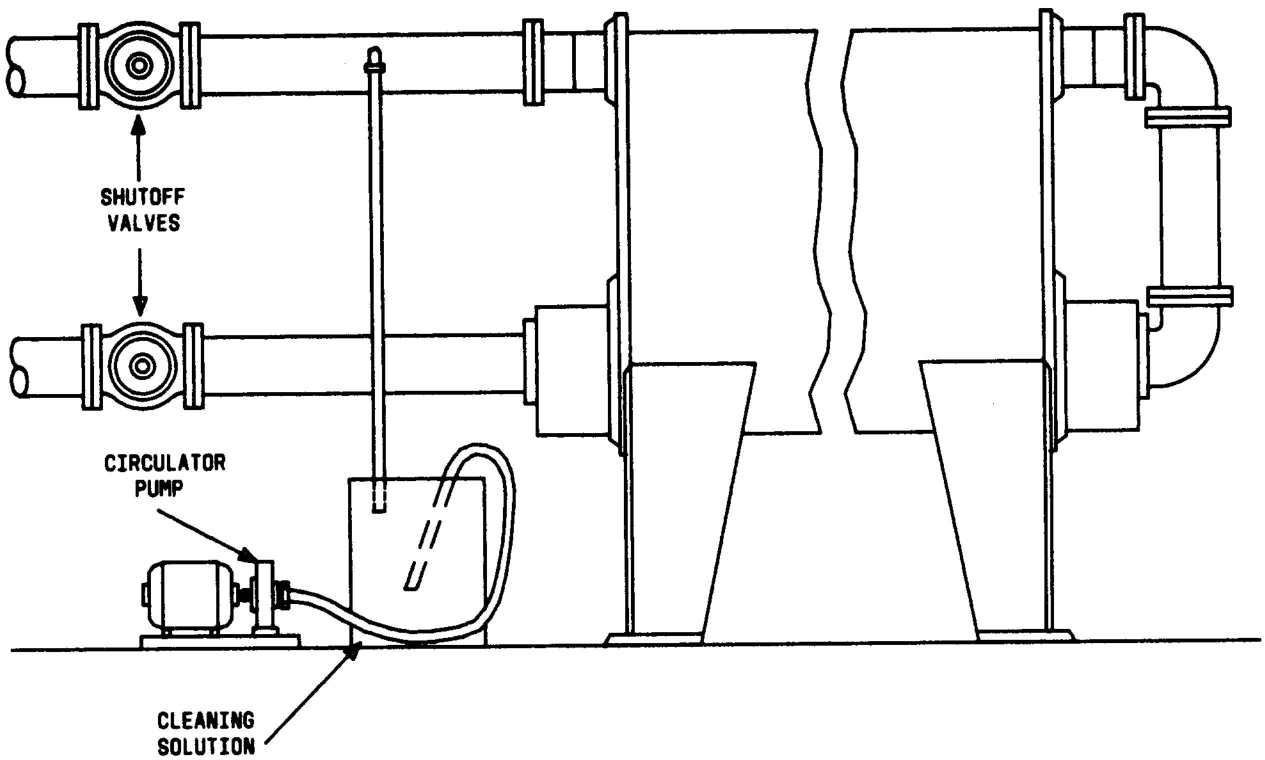

Fig. 15—Typical Tube Cleaning Hookup

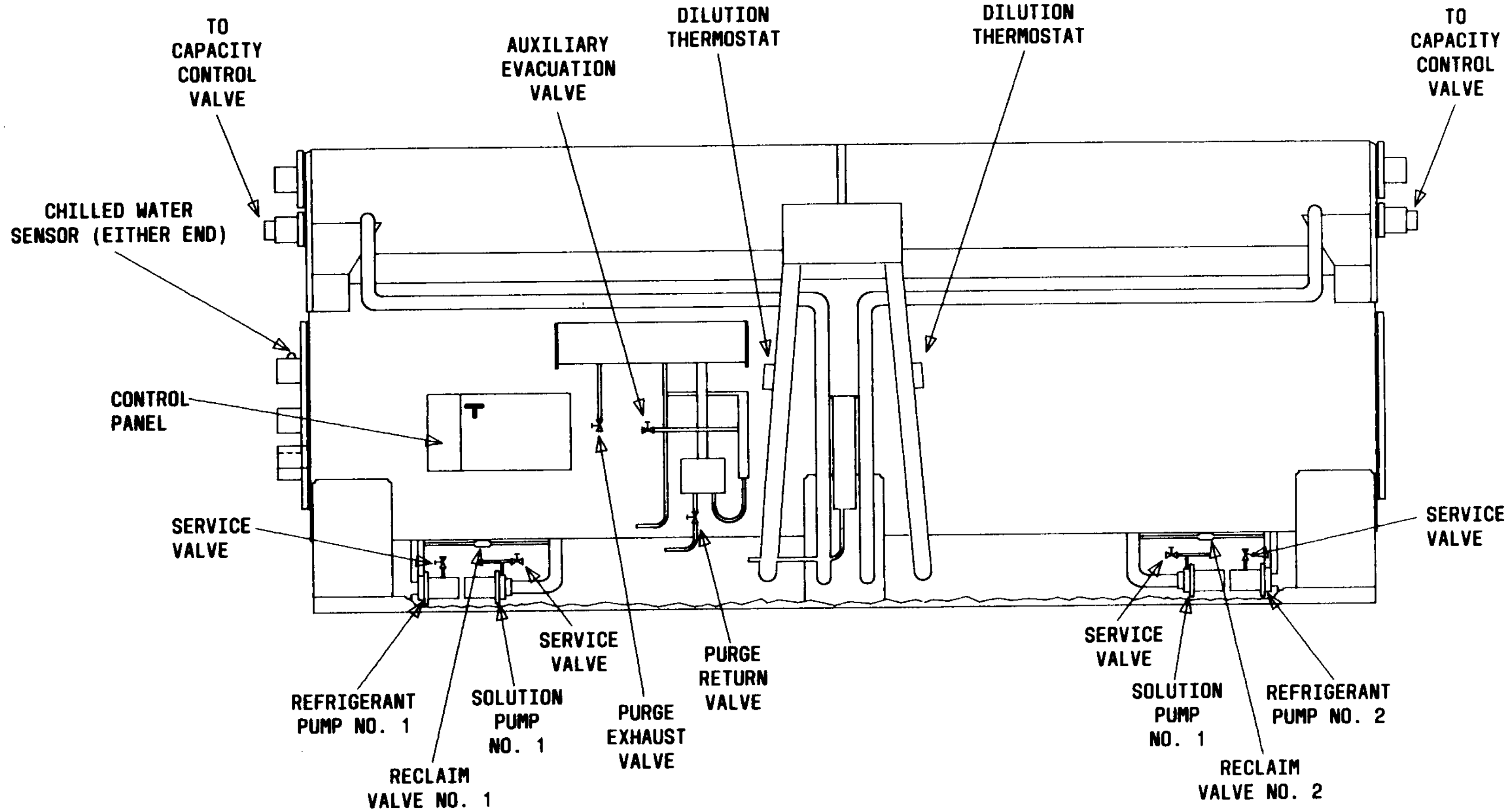

Fig. 16—Solution or Refrigerant Sampling

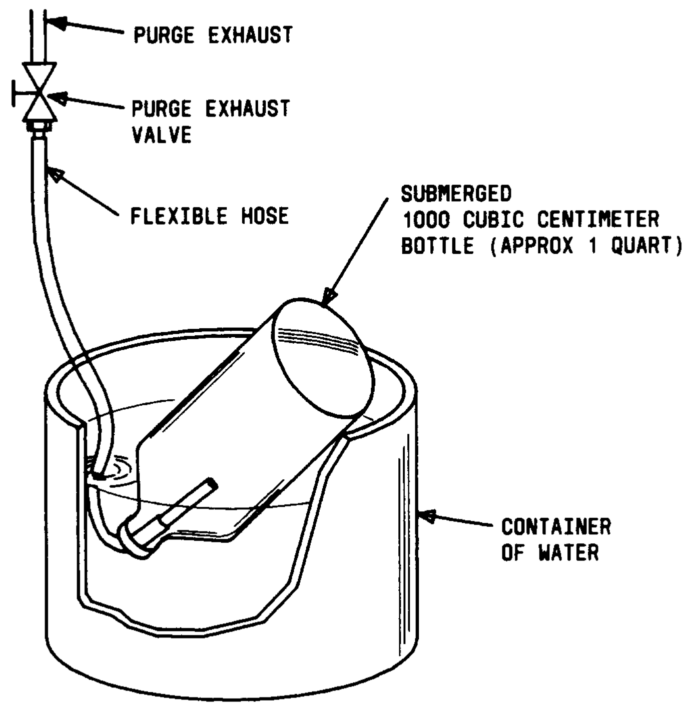

Fig. 17—Purge Exhaust Sampling

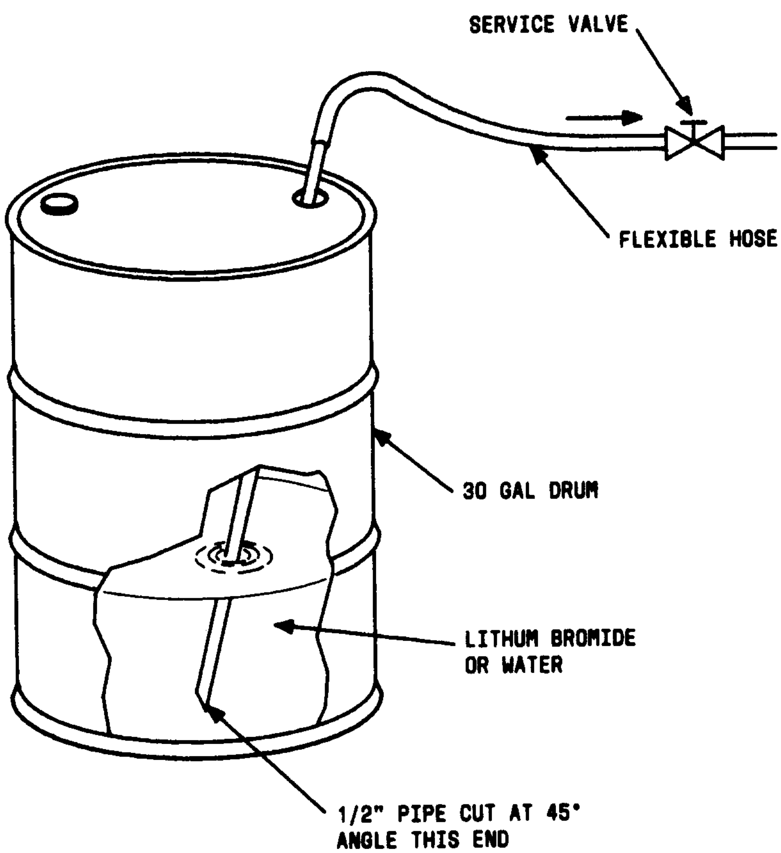

Fig. 18—Charging Solution and Refrigerant

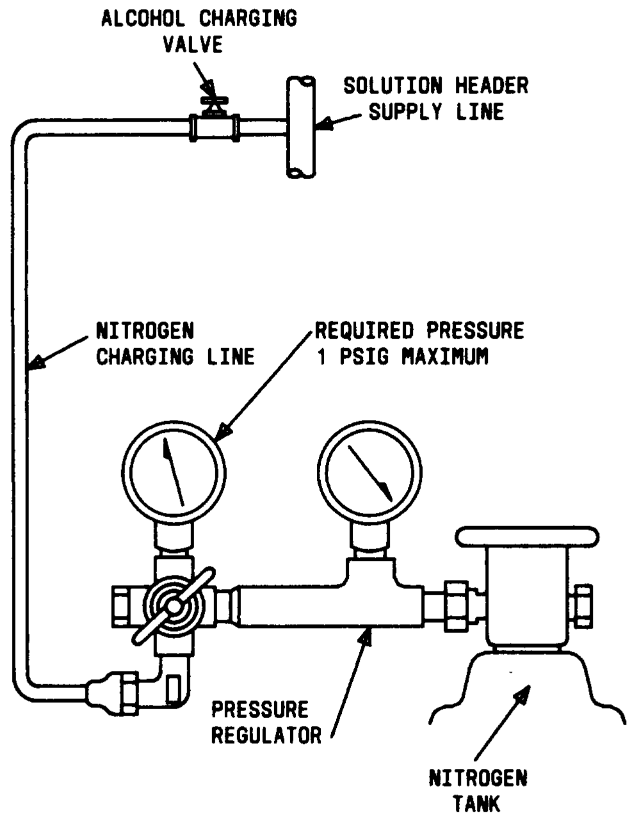

Fig. 19—Nitrogen Manifold

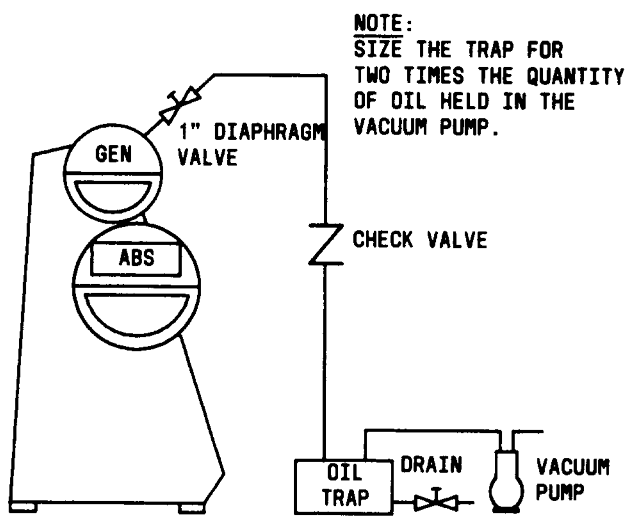

Fig. 20—Auxiliary Evacuation

ABSORPTION REFRIGERATION LOG

DESCRIPTION ____________

IDENTIFICATION NO ____________

LOCATION ____________

PERIOD: FROM ______ TO ______

BUILDING ____________

CITY & STATE ____________

		FREQ *	DATE OR TIME	
1	STEAM PRESSURE TO ABSORBER			1
2	CAPACITY CONTROL VALVE POSITION			2
3	SOLUTION LEVEL IN ABSORBER			3
4	SOLUTION TEMPERATURE ABSORBER SUMP			4
5	SOLUTION TEMPERATURE CONCENTRATOR			5
6				6
7				7
8				8
9				9
10				10
11	CHILLER WATER TEMPERATURE IN			11
12	CHILLER WATER TEMPERATURE OUT			12
13				13
14				14
15				15
16	CONDENSER WATER TEMPERATURE IN			16
17	CONDENSER WATER TEMPERATURE OUT			17
18				18
19				19
20				20
21				21
22				22
23				23
24				24
25				25

* H = HOURS W = WEEKS M = MONTHS

Fig. 21—Absorption Refrigeration Log