COOLING TOWERS

CONTENTS PAGE

1. GENERAL

1.01 This section describes the operation and maintenance of mechanical draft cooling towers used for air conditioning systems.

2. DESCRIPTION

2.01 A cooling tower cools the water which has been used in the condenser of the refrigeration equipment for extracting heat from the refrigerant. It cools the water sufficiently for reuse and thereby minimizes the amount of water consumed for this purpose. Its place in an air conditioning system is illustrated in Fig. 1.

2.02 Cooling is accomplished by exposing the condenser heated water to outside air so that the water loses heat partly by transfer of sensible heat to the cooler air, but mainly by evaporation of a portion of the water.

2.03 The tower consists of an enclosure of wood, metal or asbestos cement board. Water is admitted to the top of the enclosure and is sprayed or dripped down over a series of slatted decks to be accumulated in a water basin at the bottom of the tower. Means are provided for forcing air through the sprays of falling water. The cooled water is accumulated in the basin of the tower and is returned to the condenser for recirculation.

2.04 Cooling towers are divided into two general types, natural draft and mechanical draft. The natural draft tower relies on prevailing winds, or on chimney effect for air flow through the tower. The mechanical draft tower is equipped with one or more fans to supply the required quantity of air. Disadvantages inherent in the natural draft tower, e.g., large size, spray nuisance, dependence on natural conditions, etc, generally preclude the use of this type for telephone buildings. This practice is accordingly concerned only with the mechanical draft cooling tower.

2.05 The mechanical draft towers are also divided into two general types, forced draft, illustrated in Fig. 1, and induced draft, illustrated by Figs. 2 and 3. In the forced draft tower the fan is located in the air inlet to the tower. In the induced draft the fan is located in the air outlet from the tower.

2.06 The path of air flow through the tower serves to further classify the mechanical draft tower. In the crossflow tower, air flows horizontally across the path of the falling water. In the counterflow tower, illustrated by Fig. 2, air flows vertically upward counter to the path of falling water. The doubleflow tower, illustrated by Fig. 3, has air flowing in horizontally from both ends of the tower, then upward through the fan discharge.

2.07 Various means are used to break up the water into fine particles in order to expose greater water surface to the cooling action of the tower. Spray headers illustrated in Figs. 1 and 2 break the water in fine drops. In another arrangement, illustrated in Fig. 3, the warm water is fed to a distribution basin located at the top of the tower. The floor of this basin is equipped with a number of uniformly spaced ceramic distribution nozzles. Another method, not illustrated, simply utilizes overflowing troughs to distribute the water.

2.08 The water is distributed over a series of staggered slatted decks, called the fill, which retards the rate at which it returns to the catch basin and serves further to break up the water into fine drops. The fill may be of metal, wood or asbestos cement boards.

2.09 Air flowing through the tower will entrain small water particles. Water lost due to this effect is called drift loss. Baffles, called drift eliminators, in the air stream leaving the tower impede the air flow so the small water particles impinge on the eliminator plates and drop back into the tower, thus minimizing drift loss.

2.10 The water basin of the cooling tower is equipped with a float valve to prevent the water from falling below a certain level, and an overflow pipe to prevent the water from rising above a certain level. There is also a drainpipe for emptying the basin, and a screened sump for the pump inlet to screen out debris. Each of the items is illustrated in Figs. 1, 2 and 3.

3. OPERATION

3.01 As noted, the water in a tower is cooled mainly by evaporation of a portion of the water as it passes through the tower. The latent heat required to evaporate a pound of water is approximately 1000 Btu. This heat is taken from the water which does not evaporate and results in a loss of sensible heat. As the water surrenders sensible heat, its temperature will drop one degree per pound for each Btu surrendered. Applying the above figures, the heat absorbed by the evaporation of one pound of water will cool 100 pounds of cooling tower water 10°.

3.02 The cooling tower theoretically can continue to cool the tower water until the water temperature reaches the wet bulb temperature of the air passing through the tower. When this limiting temperature is reached, evaporation ceases. However, a cooling tower designed to cool water to the wet bulb temperature would be of infinite size, so in actual practice, towers are designed to "approach" the wet bulb temperature. The closer the final water temperature approaches the wet bulb temperature, the larger the tower must be for a given capacity. The actual temperature difference between the final temperature of the water cooled by the tower and the wet bulb temperature is called the Approach of the tower. For air conditioning applications, towers are sized to provide an approach of 5° to 10°, usually 7.5°.

3.03 The warm water is fed to the tower and cooled to a certain approach to the wet bulb temperature, the temperature difference between the inlet water and the outlet water is called the Cooling Range of a tower. Cooling towers used for air conditioning applications are sized to provide a cooling range of 5° to 15°, usually 10°.

3.04 As an illustration, a tower which received water at 95° and cooled it to 85° at an ambient (surrounding) wet bulb air temperature of 78° would have a 10° range (95° -85°) and a 7° approach (85° -78°). Manufacturers will supply range and approach figures for their towers under various wet bulb temperatures and cooling loads.

3.05 The water cooling tower is generally used with the larger capacity refrigerating systems. Its alternate water saving device, the evaporative condenser is usually made in sizes up to 100 tons. Good design requires that the evaporative condenser be installed near the refrigeration equipment. A cooling tower, on the other hand, may be remotely located from the refrigeration equipment. Thus the tower is well suited for installations in which package units are mounted on various floors of a multistory building, or where the refrigeration equipment is in the basement and the tower is on the roof. It is also used with centrifugal compressors, in which the refrigerant circuit must be kept short.

3.06 During conditions of light load on the refrigerating system, or when outdoor wet bulb temperatures are low, the cooling tower water temperature will drop. When such conditions occur, the capacity of the cooling tower exceeds requirements and is out of balance with the load on the refrigeration system. Abnormally low water temperature in the condenser causes abnormally low compressor discharge pressure. As the discharge pressure drops, the compressor tends to lose its oil to the refrigerant piping system, creating difficulties in compressor lubrication with the possibility of plant shut down.

3.07 To minimize potential trouble of this kind, the fans in the cooling tower may be controlled, either by a pressure controller on the compressor discharge line, or by a temperature controller in the condenser water line from the cooling tower. Such controls will maintain satisfactory compressor discharge pressure.

3.08 Another method of controlling the temperature of the cooled water from the tower is by means of a modulated by-pass valve which by-passes water from the warm water line to the cooled water line without circulating through the cooling tower. The modulated valve is operated by a modulating type temperature controller in the cooled water line from the tower.

3.09 Normally, operation of the refrigeration equipment and the tower is unnecessary in the winter season, and the tower is drained to prevent damage by freeze-ups. However, sometimes on warm winter days the outside air intake ducts are too small to dissipate the heat developed in telephone equipment rooms, and the temperatures in the switch rooms may rise to an uncomfortable degree. If careful study shows increasing the capacity of the outside air ducts to be impractical, it will be necessary to operate the refrigeration equipment and the tower during the winter season. Whenever the outdoor temperature drops below the freezing point, ice will form on the intake louvers and the fill of the tower. Shutting down the tower fan will in most cases melt the ice. One method of preventing ice formation on the tower when operation during freezing weather is necessary is to provide a by-pass arrangement around the spray heads or distribution deck. The warm water coming from the condenser is valved off from the spray heads or distribution deck and piped directly into the collection basin in such a way as to create a swirling motion of the water in the basin. The fill and the air intake louvers remain dry and thus can not form ice. The warm condenser water swirling into the basin prevents the basin from freezing over.

4. CAPACITY RATINGS

4.01 Cooling tower capacity ratings are listed by the manufacturer in table form or in a series of rating curves. The tables or curves specify the amount of refrigeration in tons of capacity that the tower will handle under various conditions of wet bulb temperature, inlet water temperature and gallons per minute of water circulated through the tower. The range and approach of the tower under varying conditions will also be found in the tables or curves.

4.02 Cooling towers are sized to remove 15,000 Btu's per hour per ton of refrigerating capacity. Since a refrigerating system absorbs only 12,000 Btu's per hour per ton, the extra 3000 Btu's capacity of the tower is provided to remove the heat added in compressing the refrigerant, and the heat added by the tower circulating pump.

4.03 It is possible to make a rough test on the performance of the tower to determine if it is functioning properly. The following information is required.

(a) Cooling range of the tower. This is found by subtracting the temperature of the outlet water from the temperature of the inlet water of the tower.

(b) Weight of the water circulated through the tower per hour. This may be measured by several means. If a pitot tube measuring device is available the flow of water through the inlet pipe may be measured. If pump capacity curves are available, the amount of water pumped may be determined by noting the total pumping head on the pump pressure gauges and reading rate of flow corresponding to the head on the pump curve.

(c) Wet bulb temperature of outside air.

(d) Approach. This is found by subtracting the wet bulb temperature from the outlet water.

4.04 The information gathered will give the operating capacity of the cooling tower when substituted in the following formula:

$$\text{Cooling cap. in tons of refrig.} = \frac{\text{Wt. of water circulated per hr x range}}{\text{15,000 Btu/hr/ton}}$$

The result obtained may be checked against the manufacturer's rating tables to see if the tower is performing satisfactorily.

4.05 As an example of the above test, assume a tower serving a 300 ton refrigerating system operating at full capacity. The measured rate of water flow is 900 gallons per minute (gpm). The inlet water temperature is 95° the outlet water temperature is 85° and the wet bulb air temperature is 75°. Substituting in the formula, the solution is:

$$\text{Cooling cap. in tons of refrig.} = \frac{900 \text{ gpm x } 8.33 \text{ lbs/gal x } 60 \text{ min/hr x } 10^\circ \text{ range}}{\text{15,000 Btu/hr/ton}}$$

$$\text{Cooling cap.} = \frac{4{,}498{,}200}{15{,}000}$$

Cooling cap. = 299.9 tons

The manufacturer's table for this tower rates it at 300 tons with a 10° range and 10° approach at a wet bulb temperature of 75°. This corresponds with the test results so the tower is operating properly.

4.06 If the measured cooling range is greater than specified for the tower it is an indication that the rate of water flow is less than design rate. Generally, cooling ranges and water flow rates follow the following table:

Flow Rate	Cooling Range
2 gpm/ton	15°
3 gpm/ton	10°
4 gpm/ton	7.5°

If the measured approach of the tower is greater than specified it is an indication that the tower is not performing properly. A higher than normal approach may be caused by any of the troubles listed in the trouble chart under the symptom of high head pressure.

5. AIR REQUIREMENTS

5.01 Mechanical draft cooling towers require from 300 to 400 cfm of air per ton of capacity for efficient functioning. Obstructions near the tower which restrict the free entry of air, or which cause recirculation or short-cycling of discharge air into the air inlet of the tower will adversely affect tower efficiency.

6. WATER LOSSES

6.01 Cooling towers circulate from two to four gallons of water per minute per ton of refrigerating capacity. Approximately 1% of the water circulated is evaporated for every 10° of tower cooling range.

6.02 Since a cooling tower is sized to remove 15,000 Btu's/hour per ton of refrigerating capacity, and since one pound of water absorbs 1000 Btu's in evaporating, the evaporation loss of a tower is 15 pounds or 1.8 gallons per hour per ton of capacity.

6.03 Drift loss through entraining of small water particles by air flowing through the tower is minimized by drift eliminators in the discharge air stream and is negligible in a well designed tower. Drift from a redwood tower may stain surroundings due to the water leaching tannin from the redwood.

6.04 Blow down or bleed loss is an intentional loss to a drain and is adjusted to limit the concentration of solids caused by evaporation of the water. It is further described under water treatment in this practice. Bleeding may be accomplished by means of a small valved line from the warm water inlet pipe of the tower to a drain. It may be necessary to provide a solenoid valve in series with the bleed adjusting valve if the bleed line continues to flow when the pump is off and the tower is inoperative. The electrical connections of the solenoid should be tied into the pump starting control to operate only when the circulating pump operates. Another method of bleed-off utilizes a collecting funnel installed in the overflow pipe of the tower in the path of the water falling through the tower. The rate of bleed is adjusted by means of a sliding lid on the rectangular top rim of the funnel. This type is especially suited for smaller rates of bleed where silt or debris might clog a small bleed line.

7. WATER TREATMENT

7.01 The municipal water used to fill the cooling tower and to make up water losses may be broadly classified as either hard or soft. Generally, reservoirs supplied primarily by the surface run-off water or rainfall have soft water. Sources supplied by underground streams and wells contain dissolved minerals and are hard. The hard water tends to form scale in the tower circulating system and damage the wood in the cooling tower. Soft water tends to be corrosive to the metal in the circulating system due to its dissolved oxygen and carbon dioxide content. Treatment is generally necessary, either to control scale formation or corrosion.

7.02 The municipal water supply with its dissolved solids and gases may not have serious scale forming or strongly corrosive characteristics. However, the water which evaporates from the tower in normal operation is pure water. The mineral impurities remain behind and increase in concentration, thus changing the characteristics of the water. It is possible, through evaporation, for the tower water to contain twenty times as much dissolved solids as the make-up water supply. The number of times the amount of dissolved solids in the tower water is increased over the amount of dissolved solids in the make-up water is called the Cycles of Concentration. The most basic and simplest step in controlling scale or corrosion is to bleed a portion of the concentrated tower water to a drain and dilute the remainder with fresh make-up water. The amount of bleed needed to provide various cycles of concentration is given in the following table:

Cycles of Concentration to be Maintained	Bleed-off Rate, gal. per hr. per ton of refrig. cap.
2	1.80
3	.90
4	.60
5	.45
6	.33
7	.30
8	.26
9	.22
10	.20

Scale Control

7.03 If the municipal water supply is hard, as the concentration builds up, the water becomes harder, and the solids tend to precipitate out as scale on the high temperature surfaces of the circulating system, the water side of the condenser tubes. The scale retards the transfer of heat from the refrigerant gas to the cooling tower water, thus decreasing condenser efficiency and causing high compressor head pressure.

7.04 Several methods of controlling scale formation are possible. With moderately hard water, by bleeding to provide two to three cycles of concentration, a thin protective scale may be built up on the condenser tubes without seriously impairing condenser efficiency. However, with this method, the pH control and the bleed rate adjustments are very critical to prevent the scale from continuing to build up. Generally, scale formation is more easily controlled by adding polyphosphates in concentrations of three to five ppm. To prevent possible corrosion by this method eight to ten ppm of chromate are added with the polyphosphate. The bleed rate should be adjusted to provide from three to five cycles of concentration and the pH value adjusted to 6.5 to 7.5 for wooden towers, or 6.5 to 8.5 for metal towers.

7.05 If the water supply is very hard (over 180 ppm calcium carbonate) it will probably be necessary to neutralize some of the alkalinity in the water with sulphuric acid to adjust the pH value to the recommended range. The three to five ppm polyphosphate and eight to ten ppm chromate should also be added. With this method of treatment, the number of cycles of concentration allowable is generally five to eight.

7.06 As an alternative to the treatment suggested in Paragraph 7.04, the make-up water supply or some portion of it may be fed through a Zeolite exchange softener which reduces the hardness content of the water.

Corrosion Control

7.07 Corrosion or rusting is the loss of metal in the water circulating system, due either to chemical or electrochemical action. It may be in the form of broad, generally corroded areas, or in the form of severe localized pitting. Corrosion is accelerated by dissolved oxygen in the cooling water and by water having pH values below seven. The oxygen content and the acidity of the water tend to build up because of the oxygen and acid forming gases present in the air drawn through the tower.

7.08 Chromate concentrations of 300 to 500 ppm afford acceptable corrosion protection within a pH range of 7 to 8.5 for cooling tower circulating systems. The wooden portions of the tower are least susceptible to deterioration at a pH value of 7.2. An effective and less expensive method of protecting both wood and metal in contact with the tower water is to use a mixture of ten ppm polyphosphate, and 160 ppm chromate maintaining a pH value of 6.5 to 7.5. Bleed-off should be adjusted to maintain five to eight cycles of concentrations. The pH value, which normally tends toward the acid side, may be adjusted by addition of caustic soda or soda ash. If the tower is not constructed of wood, the same chemical treatment may be used with a pH range of 6.5 to 8.5.

Algae and Slime

7.09 Algae is a form of plant life, greenish in color, which multiplies rapidly in water exposed to light. Slime is a form of organic life which flourishes in dark portions of the water circuit. Both growths will impede water circulation and insulate heat exchange surfaces if allowed to grow.

7.10 Algae and slime may be removed by scrubbing manually, by hosing down with a high pressure hose, or by poisoning with chemicals. Since the use of chemicals does not require shutting down the system, it is the preferred means of control.

7.11 Sodium pentachlorophenate seems best suited for use as an algaecide. It is highly toxic to algae and slime life and has no corrosive effect on the tower or circulating system in the concentrations recommended. Sodium pentachlorophenate may be used in the slowly soluble block form for continuous treatment, or in powdered form for shock treatment. Experience will determine which treatment is more effective. For continuous treatment, a concentration of 20 to 30 ppm of sodium pentachlorophenate is maintained in the circulating water. If this does not turn the algae from a green to a brown color after a few days, shock treatment in the order of 100 ppm should be used about once a week.

7.12 Other commonly used algaecides are copper sulphate and chlorine. Copper sulphate may cause serious corrosion of steel in the circulating system if improperly used. Chlorine as a hypochlorite is very effective, but losses of the chemical are high when the water is aerated in passing through the tower. This results in high costs and difficulties in maintaining proper proportions.

Wood Preservation

7.13 Deterioration of the wood in cooling towers may be caused by any of three forms of attack: chemical action, biological action and mechanical disintegration.

7.14 One form of chemical attack removes lignin, the binder that holds the wood fibres together. Wood subject to this attack forms long, whitish, loosely bonded fibres on the surface. This form of attack occurs in alkaline waters which have either strong concentrations of sodium carbonate or high chlorine content. It is controlled by keeping the pH of the water below 7.5, proper bleed to limit the sodium carbonate concentration, and by keeping the chlorine content below one ppm.

7.15 A rarer form of chemical attack removes cellulose, a substance similar to lignin from the wood, resulting in a surface condition of long reddish brown fibres. It is caused by the acid in water with a pH value below 5. Maintaining the pH of the water within the limits of 6.5 to 7.5 will prevent this form of attack.

7.16 Biological attack is caused by various microscopic organisms such as bacteria and fungi. Redwood normally contains certain extractives toxic to these organisms and resists biological attack unless these protective extractives are leached out by chemical attack. If the leaching action has occurred, the wood should be protected from biological attack by treating the water with an algaecide.

7.17 Biological attack may reveal itself in three different conditions of the tower wood. Delamination of the wood may occur in which the softer grain of the wood erodes and the hard grain stands out in ridges. Another form of biological attack causes a soft, punky center under a sound exterior. A third form of attack does not change the appearance of the wood, but weakens the fibres so that the wood breaks cleanly across the grain instead of with a normal splintering action.

7.18 Mechanical disintegration sometimes occurs in the section of the tower exposed to alternate wetting and drying action. The wood absorbs water with its dissolved salts when wet, and is ruptured by the crystallization of the salts as the wood dries out. Damage to the wood from this action may be minimized by proper bleed to limit the concentrations of salts, and by periodically scraping or hosing down salts which form on the surface of the alternately wet and dry wood sections.

7.19 More complete information on water treatment will be found in BSP H51.370 "Fundamental Principles of Water Conditioning" and BSP H51.371 "Water Treatment, Air Conditioning Systems." The latter section describes water analysis, types of treatment and procedures for evaluating the effectiveness of the treatment program.

Precautions

7.20 The chromate compounds used for water treatment are poisonous. Hands must be washed well after contact with this chemical.

7.21 Sodium pentachlorophenate also is poisonous and care must be exercised in handling it. Dust from the chemical is irritating to mucous membranes and both the dust and water solution may be irritating to the skin if exposure lasts longer than five minutes.

8. PREVENTIVE MAINTENANCE

8.01 The preventive maintenance procedures outlined in this practice apply generally to all cooling towers. For more specific information, refer to maintenance manuals published by the tower manufacturer or by the supplier of the materials used for maintenance, e.g., packing materials, oils, greases, etc. Characteristics of various lubricants are covered in BSP A710.012, "Materials - Greases, Oils and Cleaning Fluids." Details of fan and bearing maintenance are covered in BSP H51.317, "Inspection and Maintenance of Ventilating Fans."

8.02 A daily visual check may be made to detect abnormal operating conditions or incipient troubles. The daily check would cover:

(a) Unusual noise.

(b) Circulating pump gauge pressures.

(c) Inlet and outlet water temperatures.

(d) Electric motor temperatures. (Hand test)

(e) Proper flow and distribution of water.

(f) Float valve functioning.

(g) V-belt and coupling appearance.

(h) Water treatment facilities.

(i) Condition of suction screen.

8.03 Periodic maintenance routines are listed in the following chart.

8.04 Maintenance Schedule for Cooling Towers

Item	Routine	Minimum Frequency	Materials Used
Ball bearings in fans, pumps and electric motors.	Lubricate as per instructions in BSP H51.317 or manufacturer's instructions.	Every 3 to 6 months	Short fiber medium consistency all purpose soda soap basegrease or manufacturer's recommendations.
	Flush out, check for roughness or excessive play. Relubricate.	Every 3 years	Flush with mineral spirits. Relubricate, filling bearing 1/3 full of grease as above.
Sleeve type bearings in fans, pumps and electric motors.	Check oil cup level. Add oil if necessary. See BSP H51.317 for instruction.	Monthly	SAE 20 oil for ambient air temperatures of 30° to 90°F or manufacturer's recommendations.
	Drain and flush bearings. Check for wear, scoring, excessive play, oil slinger ring operation, seals. Refill with oil.	Every 3 years	Flush with mineral spirits. Refill with oil as above.
Fan drive reducing gear box.	Stop fan, and after several minutes check for proper gear box oil level. Add oil & check for leaks if low. Drain completely and refill if high. (Water contamination raises oil level.)	Weekly	Use oil as specified by manufacturer. The oil type is generally found on the name plate of the gear box, and is a waterproof oil with a specific gravity higher than water.
	Drain sample of gear box oil and check for water droplets or white or yellow streaks indicating moisture contamination. Drain and refill if moisture is found.	Monthly	Manufacturer's recommendation as above.
	Change gear box oil.	Every 3 months of operation	Manufacturer's recommendation as above.
	Check coupling tightness.	Every 3 months	
	Drain and disassemble gear box, checking shaft play, worn areas on gear teeth, corrosion. If found satisfactory reassemble and fill completely with oil to prevent corrosion during idle period. Cover with tarpaulin.	At annual shutdown	Manufacturer's recommended oil.
	Drain gear box oil and refill to proper level.	Annual startup	Manufacturer's recommended oil.
Tower Basin	Check pump intake screen for breaks, clogging.	Weekly	
	Check for silt or debris in basin and clean if necessary.	Monthly	High pressure hose, stiff brush. If a wet pick-up vacuum cleaner is available, tower need not be drained to clean silt and debris.
	Test water treatment concentration, pH value, bleed rate.	Weekly	pH measuring kit, chromate comparator kit. Chloride test kit.

Item	Routine	Minimum Frequency	Materials Used
	Drain, clean thoroughly, check for deterioration or corrosion. Make replacements, or repairs found necessary on inspection. Paint where necessary.	At annual shutdown	High pressure hose, stiff brush for cleaning or vacuum pick-up.
	Close drains, refill to swell wood.	Two weeks before annual start-up.	
	Tighten basin bolts, caulk where necessary to stop leaks.	At annual start-up	Oakum and pitch, or caulking compound.
Tower distribution basins, troughs, nozzles, fill louvers and eliminators.	Check for proper, even break-up and distribution of water flow over fill. Clean if necessary.	Monthly	High pressure hose, stiff brush.
	Clean thoroughly, check for deterioration or corrosion, replace, repair or repaint as necessary.	At annual shutdown	High pressure hose, wire brush, scraper.
Fan	Visually check for fan blade damage. Check weep holes in hollow blades for clogging. Check while in operation for vibration or tower sway indicating unbalance.	Weekly	
	Check mounting bolt tightness, pulley set screws.	Monthly	
	Check belt alignment, tightness, and condition.	Monthly	
	Clean blades, paint if necessary. Check fan balance.	At annual shutdown	
	Remove belts and store in protected location. Paint pulley sheaves to prevent corrosion.	At annual shutdown	Rust preventive paint.
	Replace belts.	At annual start-up	
Pump	Check stuffing box for proper leakage.	Monthly	
	Repack pump. Be sure to remove packing behind metal lantern seal ring. Be sure lantern seal ring is replaced in proper position. Install rings with joints staggered.	At annual shutdown	Square graphited asbestos packing cut in rings with diagonal joints. Pump packing tool.
	Check coupling alignment, coupling tightness, bushing condition.	At annual shutdown	

Item	Routine	Minimum Frequency	Materials Used
	Drain water from pump, leaving drain plug out.	At annual shutdown	
	Replace pump drain plug.	At annual start-up	
	Overhaul pump, inspect shaft, impeller and wearing seal rings.	Every 3 years	New pump gaskets.
Electric motors	Clean windings by removing end bells.	Every 3 years	Vacuum cleaner or blower, soft brush.
Controls for electric motors. Caution: Be sure power is OFF before performing routines.	Check condition of contacts. Replace when silver thickness is reduced to 1/3 of original size. File large projections. Surface conditions similar to rough sandpaper are satisfactory. Do not file smooth.	Monthly	
	Check braided shunts to moving contacts for broken or burnt strands. Replace if damaged.	Monthly	
	Operate moving contacts by hand to check for binding or improper meeting of contact surfaces.	Monthly	
	Check tightness of all electrical connections. Check fuse clips and switch contacts for tightness or discoloration of copper indicating poor contact.	Annually	
	Wipe magnet sealing surfaces in starter box.	Monthly	Lint free cloth, slightly moistened with oil.

9. TROUBLES

9.01 Since the function of a cooling tower is to cool water used by the condenser in a refrigeration system, any trouble in a tower generally results in warmer water being supplied to the condenser. With warmer water in the condenser, the discharge pressure gauge of the compressor will rise. Thus the discharge pressure gauge of the compressor indicates the relative efficiency of the cooling tower.

9.02 Trouble Chart for Cooling Tower

Symptom	Trouble	Possible Cause	Remedy
High head pressure. Liquid refrigerant in bottom of condenser or receiver very warm. Compressor may cut out on high head pressure.	1. Insufficient air through tower. (Less than 300 to 400 cfm/ton of capacity.)	a. Blown fuses, tripped overload relays, or tripped vibration switch	a. Find cause of failure, repair, and replace fuses or reset overload relay or vibration switch.
		b. Motor and fan running backwards.	b. Reverse motor leads. If not a new installation, check for recent power changes. If a single phase capacitor start motor, check for stuck centrifugal starting switch in the motor.

Symptom	Trouble	Possible Cause	Remedy
		c. Low voltage to fan motor. (Over 10% difference in actual and rated voltage is bad for motor.)	c. Increase wire size. Consult Power Co. Change taps on owned transformers.
		d. Fan drive shaft or fan drive coupling broken.	d. Replace drive shaft or coupling.
		e. Gear box frozen or binding.	e. Repair gear box.
		f. Loose motor pulley or fan pulley.	f. Align pulleys and tighten set screws.
		g. Fan belts slipping or broken.	g. Adjust belt tension or replace belts with matched set.
		h. Pitch setting on fan blades changed due to loose set screws.	h. Reset pitch on blades to proper angle and tighten set screws. Check motor current afterwards to stay within motor current rating.
		i. Obstructions in fill, louvers or eliminators.	i. Clean fill, louvers and eliminators.
	2. Insufficient water circulation.	a. Clogged strainers in circulation piping.	a. Clean strainers.
		b. Clogged pump intake screen.	b. Clean screen. If algae, see Sec. 7.
		c. Clogged spray nozzles.	c. Clean nozzles.
		d. Scale in lines or condensers.	d. Chemically remove scale, treat water to prevent recurrence.
		e. Pump coupling loose or broken.	e. Repair or replace coupling, check alignment.
		f. Eroded pump impeller.	f. Replace impeller.
		g. Pump packing too tight or binding on shaft.	g. Loosen or replace packing. Check for damage to shaft.
		h. Low voltage to pump motor.	h. Increase wire size; consult Power Co.
		i. Blown fuses or tripped overload relay.	i. Find cause and replace fuses or reset relay.
		j. Pump motor running backwards.	j. Change power leads. If not a new installation, check recent power change-over.
		k. Float valve stuck closed.	k. Repair float valve.
	3. Insufficient water breakup.	a. Spray nozzles, distribution nozzles or distribution troughs clogged with algae or debris.	a. Clean, treat water for algae if necessary. See Paragraphs 7.07 through 7.12.
		b. Collapsed, broken, missing or warped fill.	b. Replace or repair fill.

Symptom	Trouble	Possible Cause	Remedy
	1. Tower discharge air recirculating into tower intake.	a. Intake and discharge of tower too close.	a. Install baffle or duct work to separate intake and discharge areas.
		b. Discharge air leaves at too low velocity.	b. Increase fan speed or fan blade pitch; do not overload fan motor in making change.
Noisy opereration.	1. Complaint of building occupants or neighbors.	a. Gear box or fan drive shaft worn or out of alignment.	a. Repair or realign.
		b. Pump, fan or drive motor bearings worn.	b. Replace bearings.
		c. Fan unbalanced.	c. Balance fan.
		d. Pump or fan coupling worn or broken.	d. Repair coupling.
		e. Fan belts loose.	e. Adjust belt tension.
		f. Three phase motor operating on single phase due to faulty wiring or blown fuse.	f. Repair wiring or replace fuse.

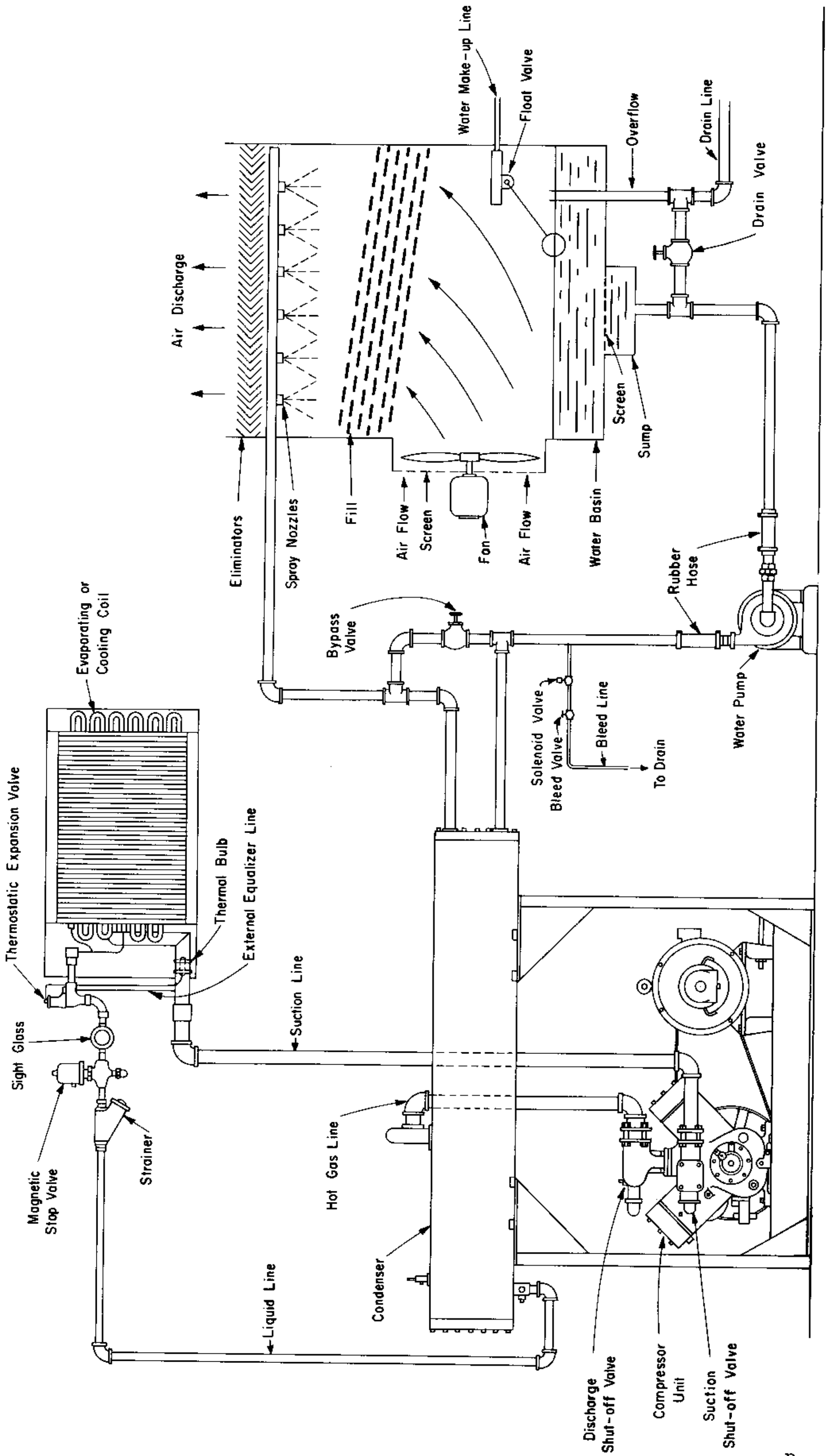

Fig. 1 - Forces Draft Cooling Tower Serving Refrigeration System

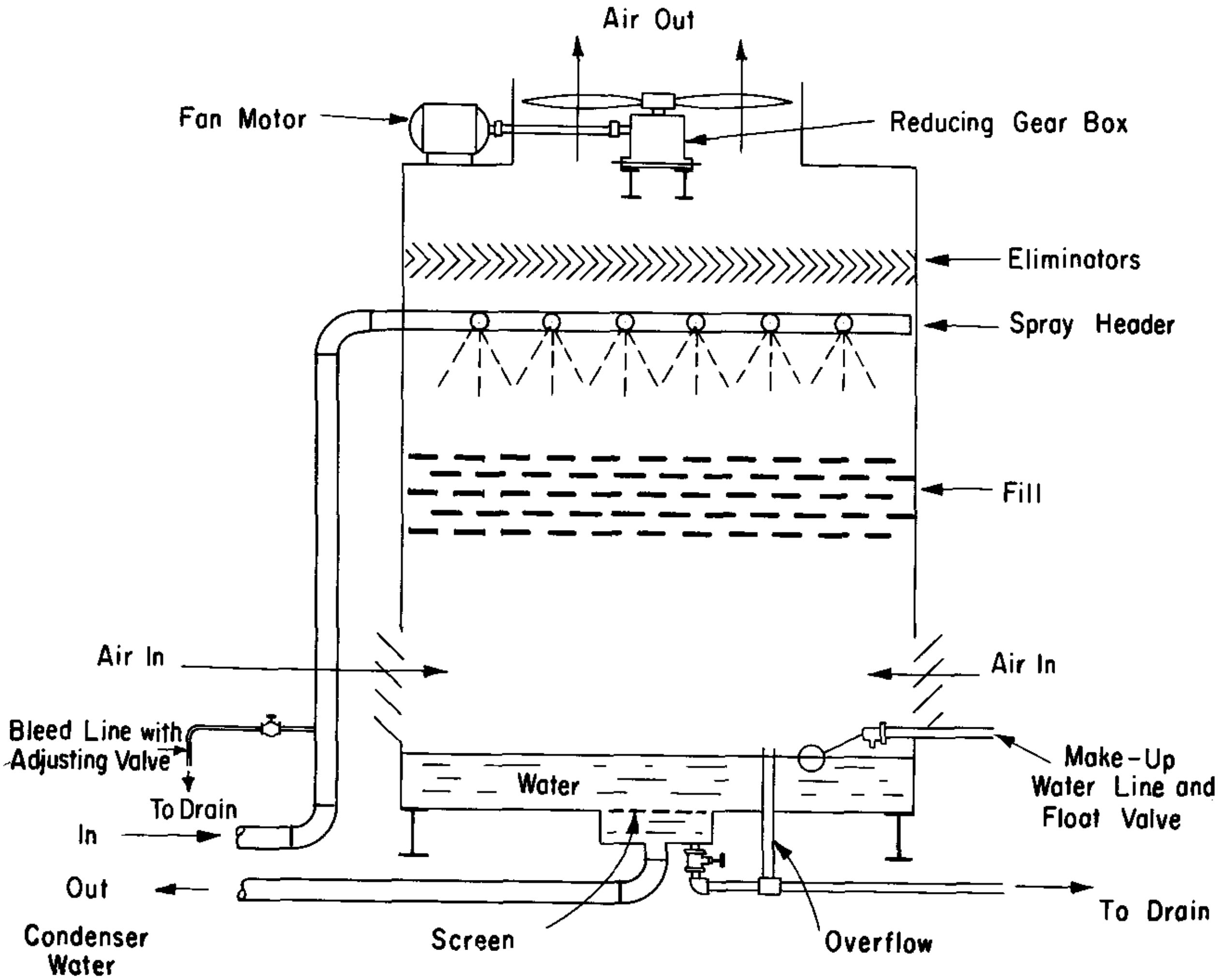

Fig. 2 - Induced Draft Counter-Flow Cooling Tower

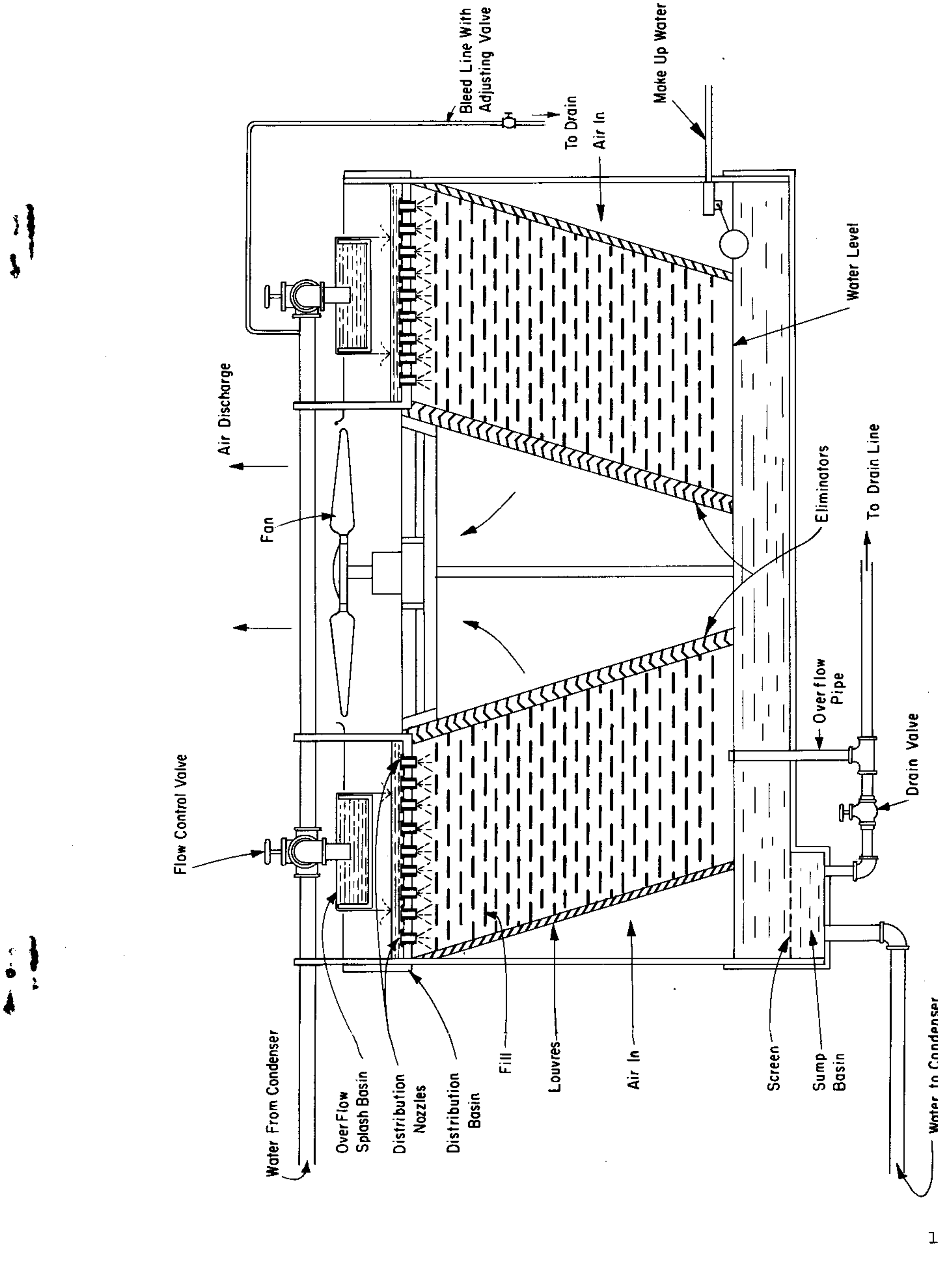

Fig. 3 - Induced Draft Double Flow Cooling Tower