

**ASHRAE Boston Chapter Meeting**  
**Designing AC Refrigeration Systems**  
**Lessons Learned**  
**October 17, 2023**



- Explanation of the refrigeration cycle.
- Compressors. Benefits and operating characteristics.
  - Reciprocating
  - Screw
  - Scroll
- Condenser types and benefits
  - Air cooled
  - Evaporative
- Expansion Valves
  - Thermostatic
  - Non- Balanced port
  - Balanced port
  - Electronic
- Evaporator Design
  - Fins per inch
  - Moisture carryover
  - Distributors



- Standard RTU Concerns
  - Capacity control at part loads
- Split Systems Concerns
  - Piping concerns
  - Receiver
  - Pump down solenoid valve
  - Oil Separator
- 100% Outdoor Air DX Unit Concerns
  - Interlaced evaporators vs. parallel or series
  - Precise capacity control
    - Compressor staging
    - Compressor unloading
      - Scroll- 66% or down to 20% (variable speed)
      - Hot gas bypass to evaporator
      - Tight head pressure control
      - Fan speed control vs. flooded condenser

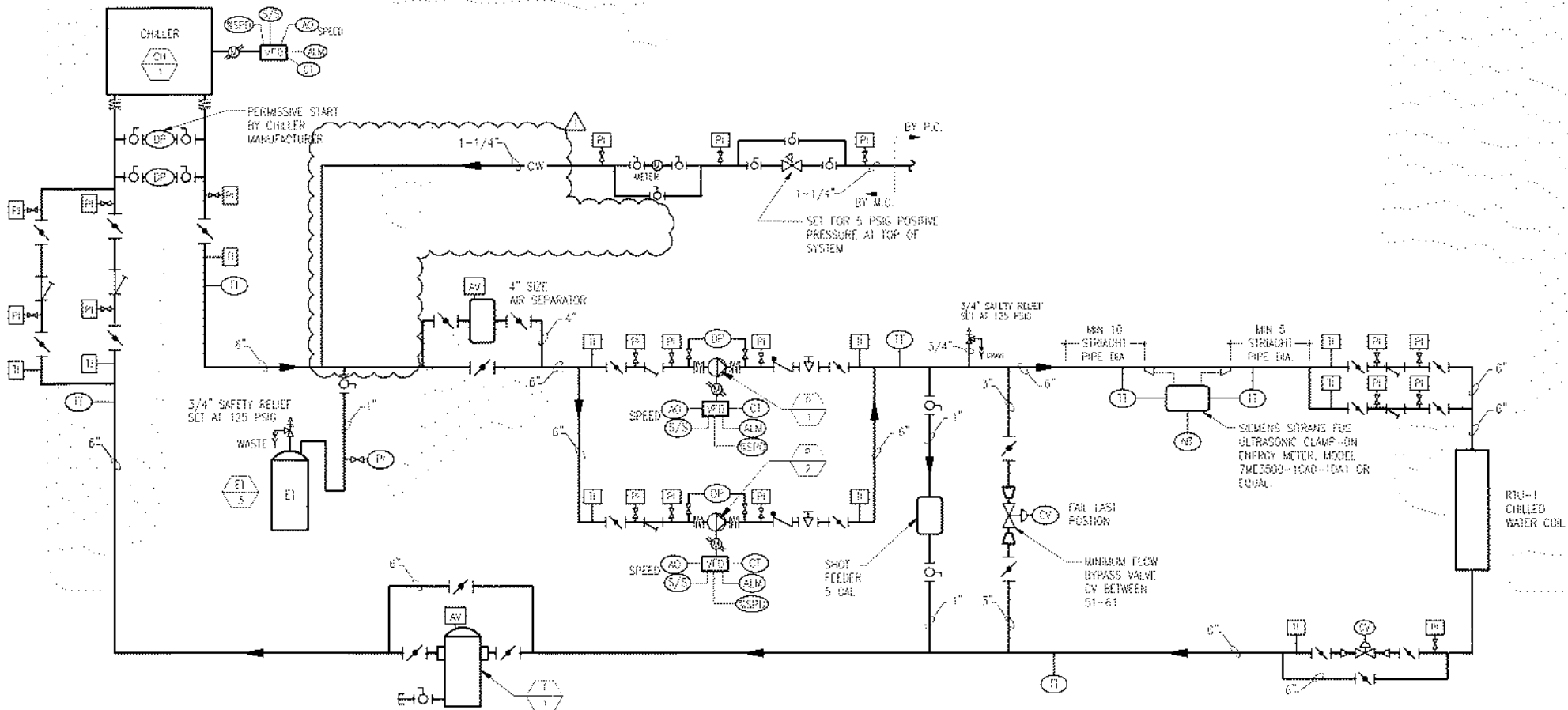
# Heat Pump Comparison

Total Heating Cost					
System	\$/Yr	Savings/Yr vs Propane	Savings/Yr vs Brand X	Savings/Yr vs Electric	Energy Cost \$/Therm
Electric	\$ 11,567				8.9
Propane	\$ 8,596	\$ -		\$ 2,971	6.6
Brand X	\$ 4,309	\$ 4,287		\$ 7,258	3.3
Brand Z	\$ 3,048	\$ 5,548	\$ 1,261	\$ 8,519	2.4
Nat Gas 95%	\$ 3,133	\$ 8,434	\$ 1,176	\$ (85)	2.3
Nat Gas 85%	\$ 3,502	\$ 5,094	\$ (454)	\$ (369)	2.3

# HVAC Engineers Understanding of a Refrigeration System



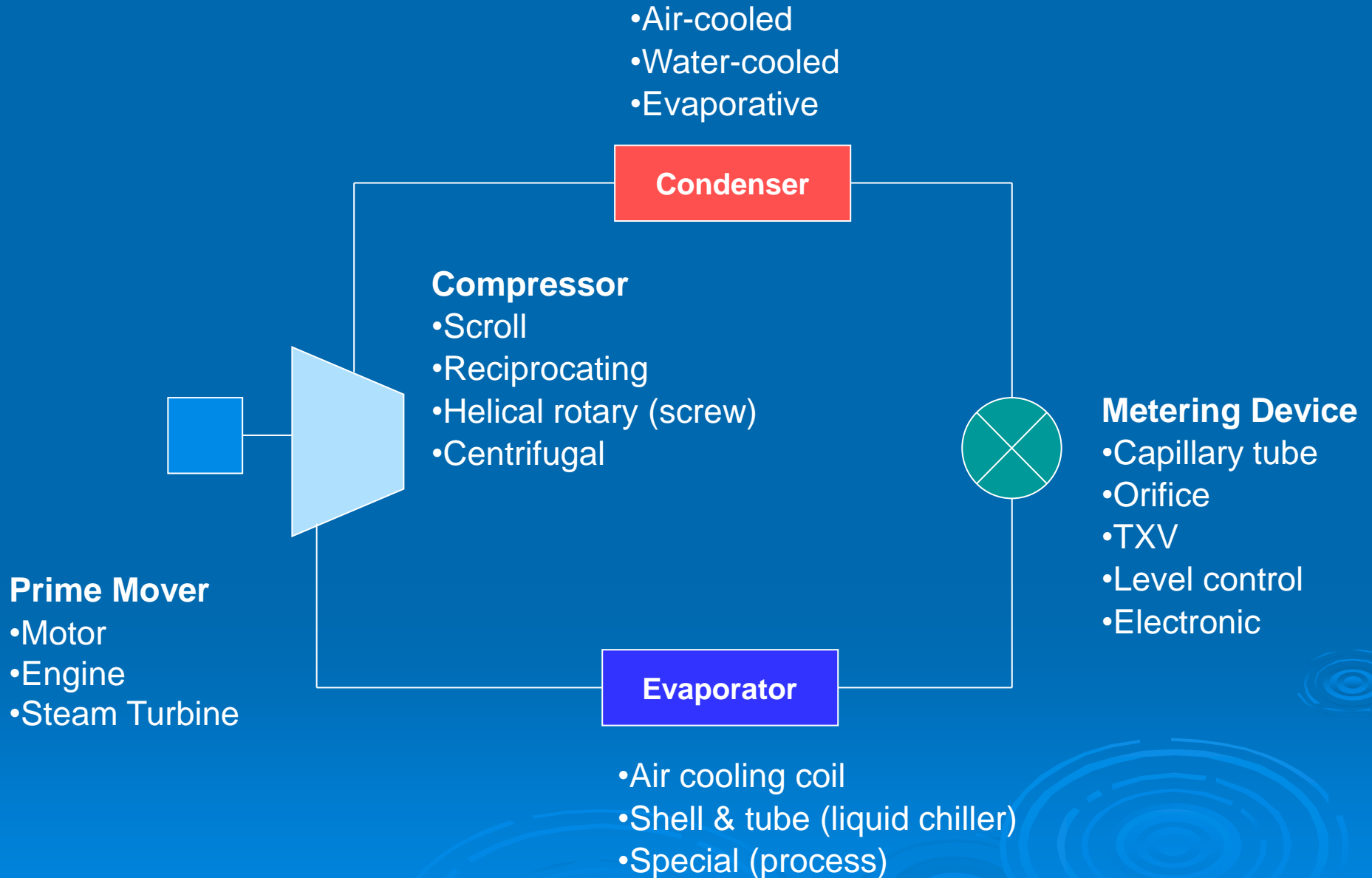
# 1RTU with Chiller



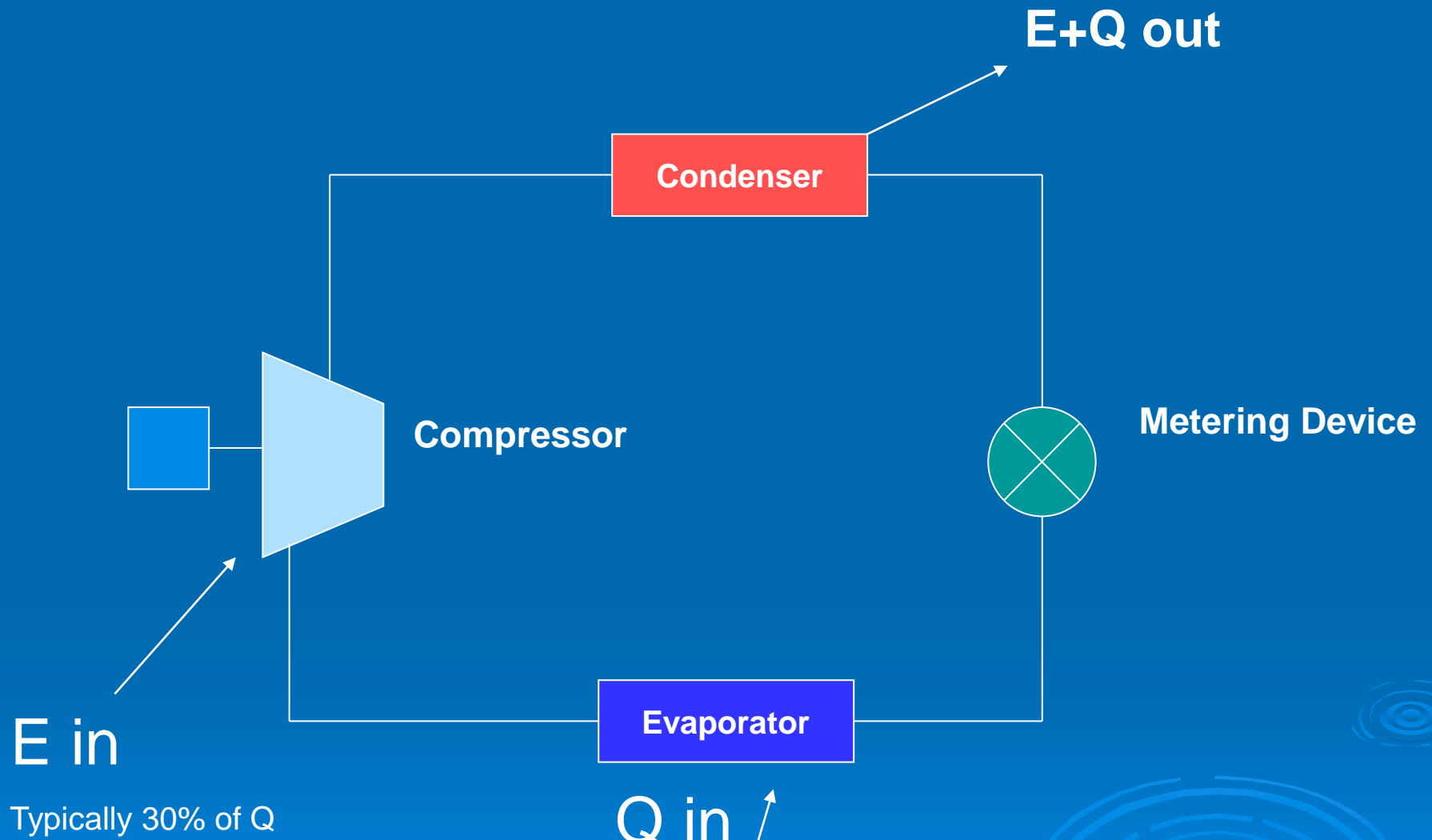
# Frozen Coil



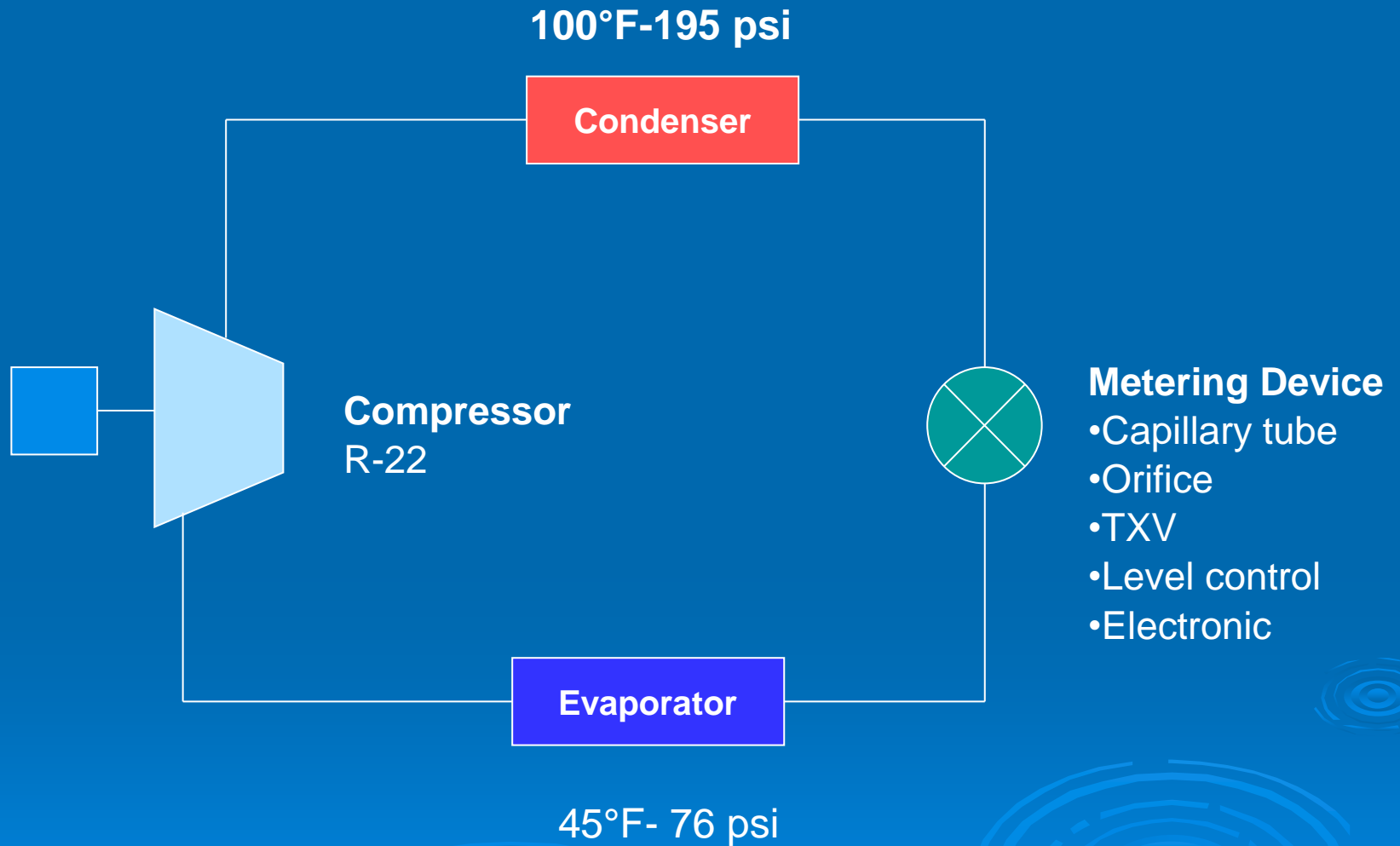
# Basic Refrigeration System



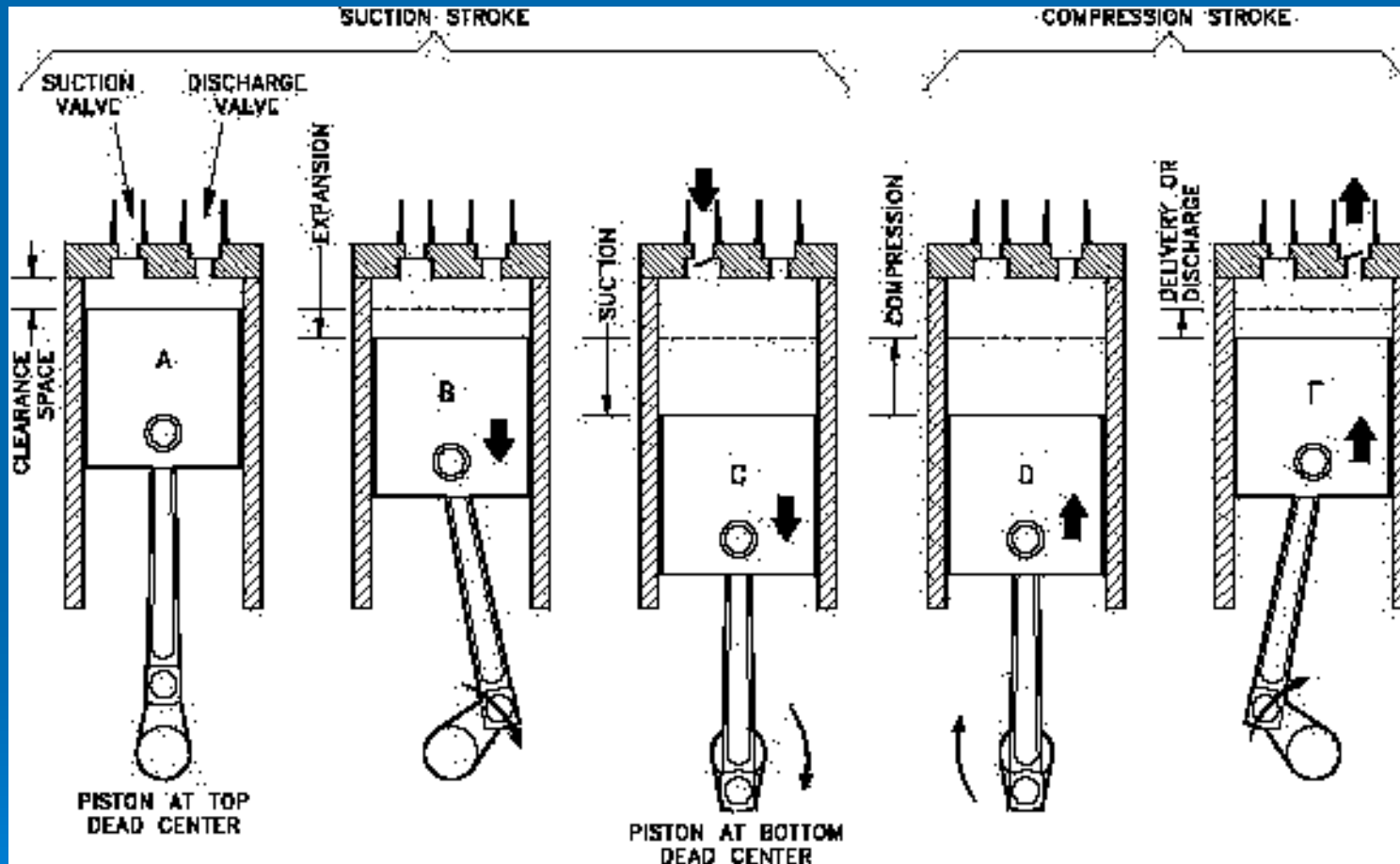
# Basic Refrigeration System



# Basic Refrigeration System

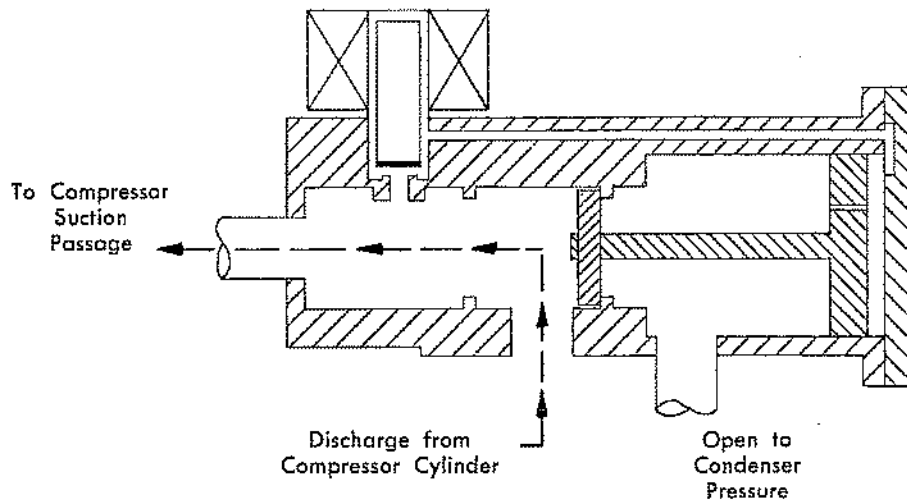


# Reciprocating Compressor



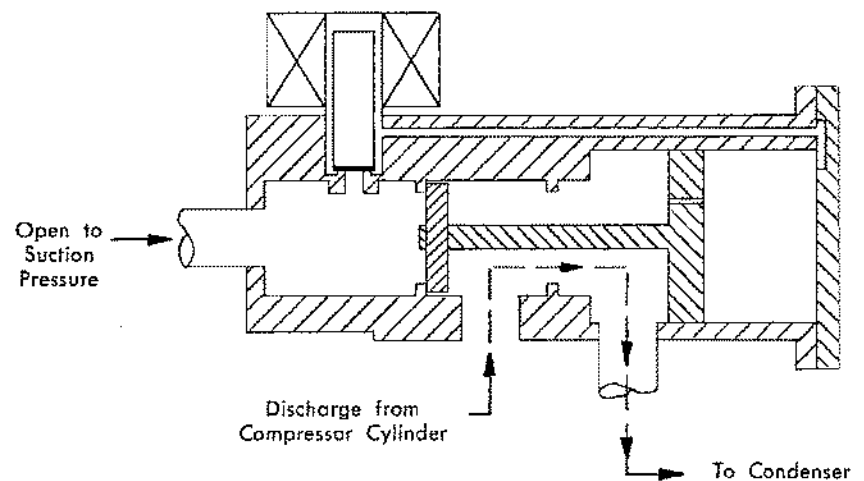
# Reciprocating Compressor Unloader

**ENERGIZED**



**COMPRESSOR UNLOADING VALVE**

**DE-ENERGIZED**



# Screw Compressor



# Screw Compressor



# Screw Compressor

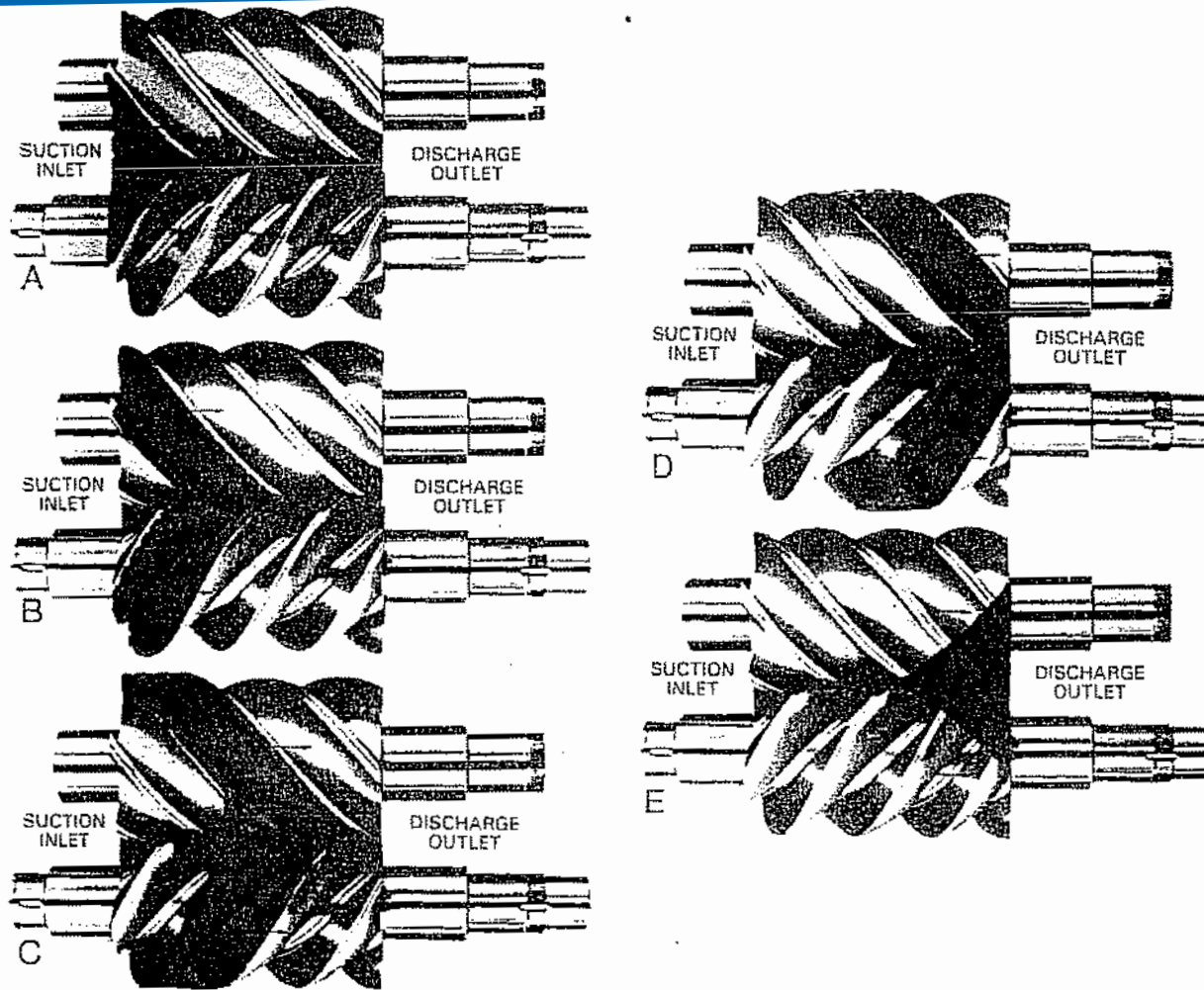
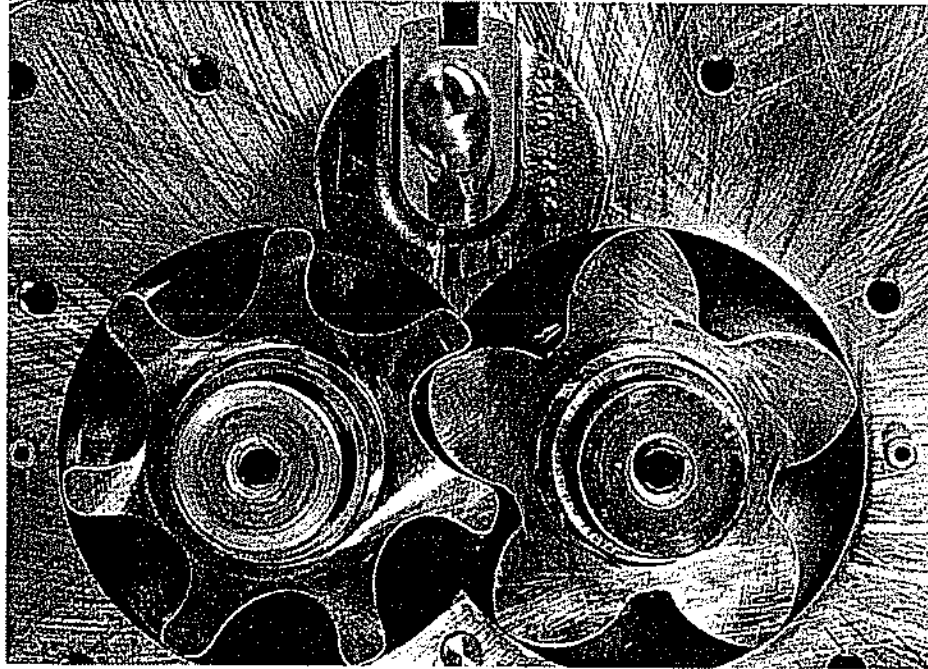


Fig. 4-60. Basic operation of screw-type compressor. Revolving rotor compresses vapor. A—Compressor interlobe spaces being filled. B—Beginning of compression. C—Full compression of trapped vapor. D—Beginning of discharge of compressed vapor. E—Compressed vapor fully discharged from interlobe spaces. (Dunham-Bush, inc.)

# Screw Compressor



**End view showing male and female rotors and slide valve on an 85-ton intermediate compressor.**

# Scroll Compressor



**(a) Vapour refrigerant enters an outer pocket**



**(b) The pocket is sealed off and compression starts**

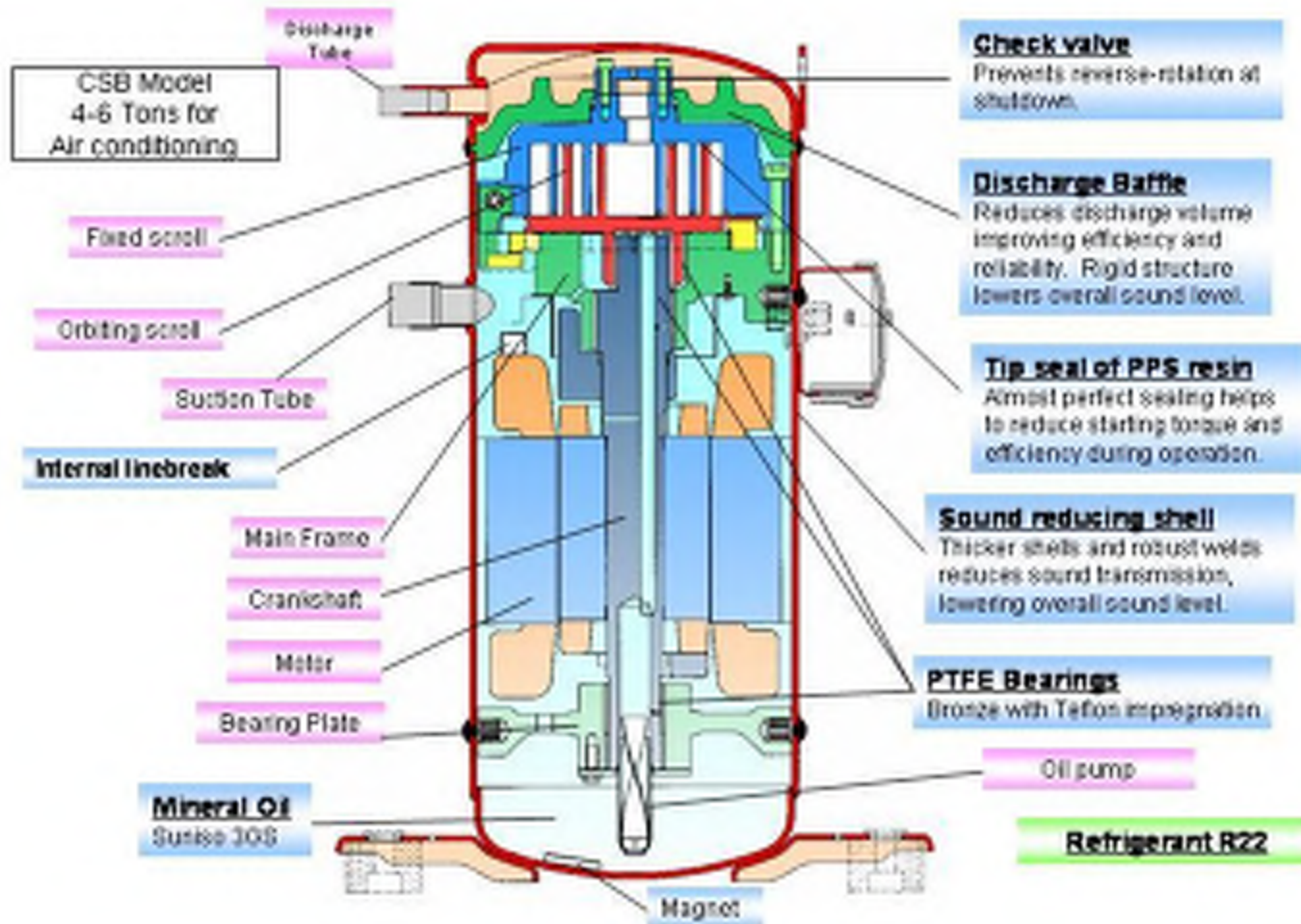


**(c) The pocket is reduced in size**

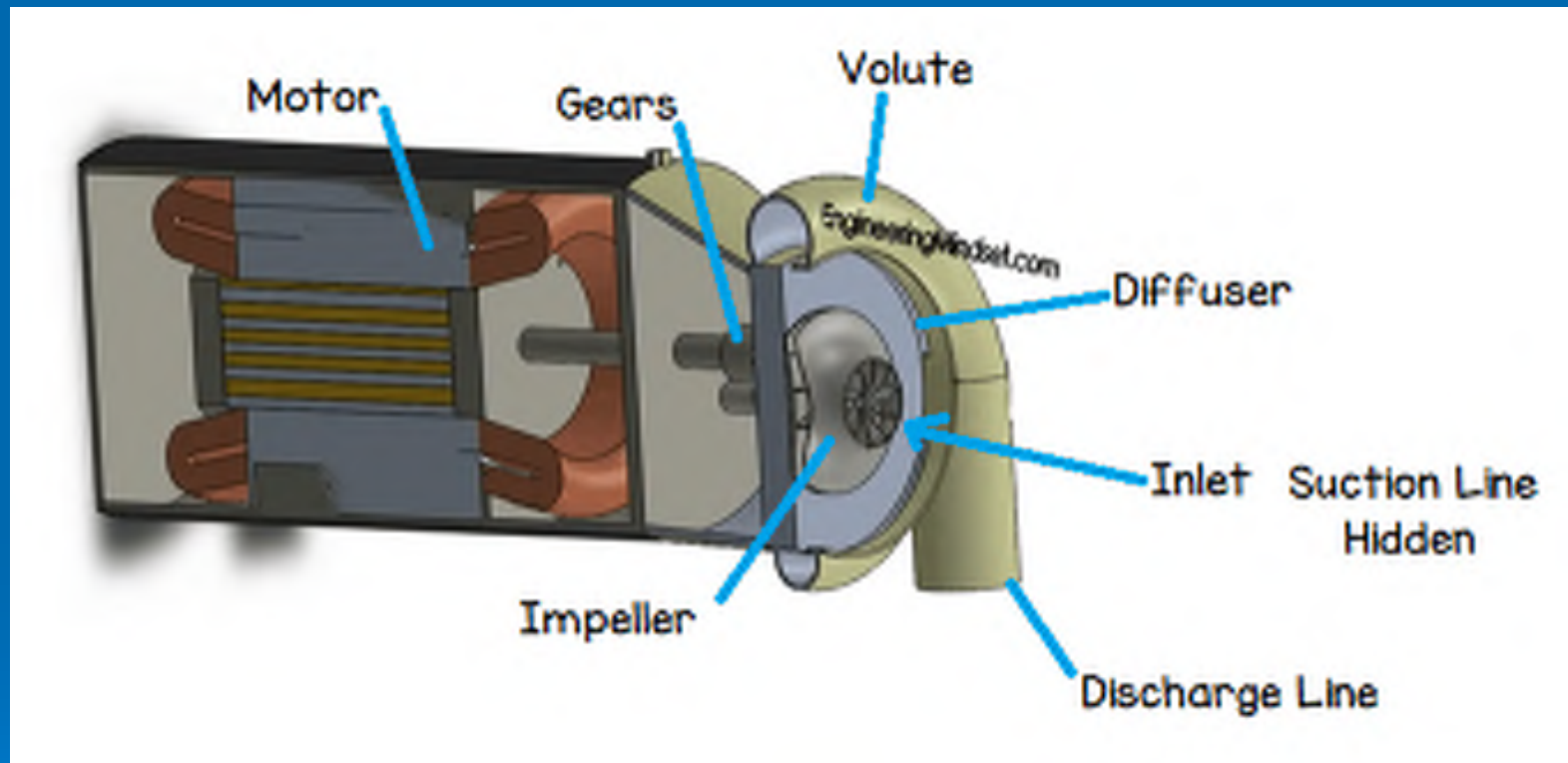


**(d) As the pocket reaches the centre, the discharge port is uncovered and discharges the compressed vapour refrigerant**

# Scroll Compressor



# Centrifugal Compressor



# Compressor Efficiencies

Capacity %	Reciprocating	Helical Rotary	Scroll
	KW/Ton	KW/Ton	KW/Ton
100	0.87	0.70	0.80
50	50%	42%	72% (VFD)
25	35%	26%	65% (VFD)

Part Load Performance (% Power)

Performance at 85°F Cond

# Air Cooled Condenser



# Evaporative Condenser

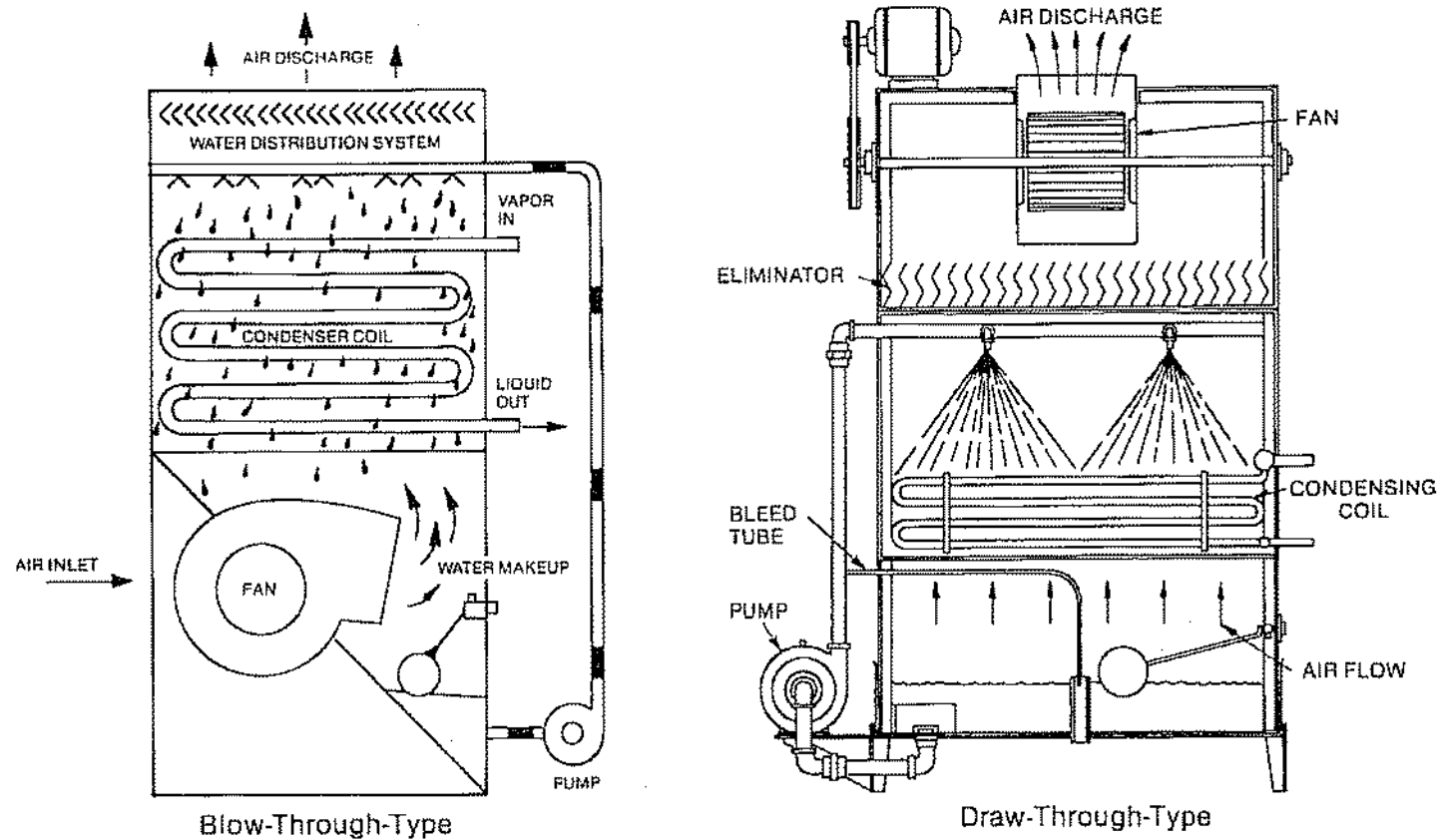
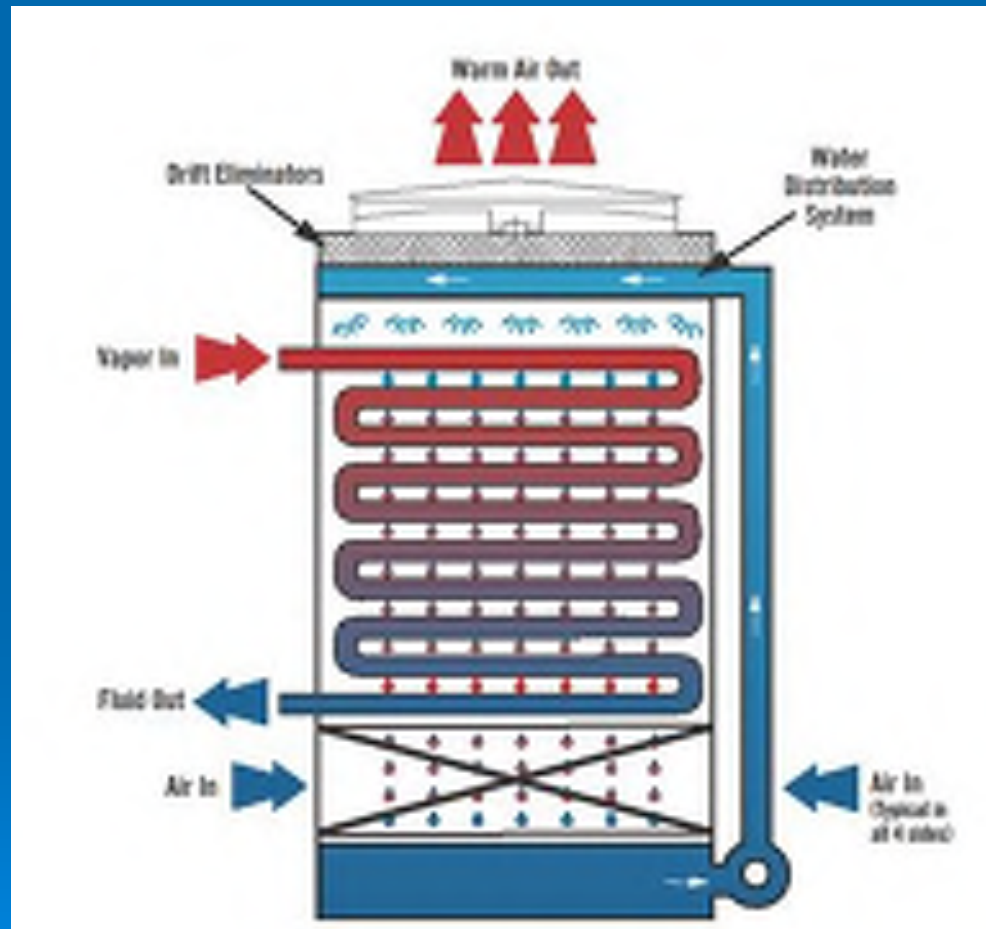


Fig. 11 Functional View of Evaporative Condenser

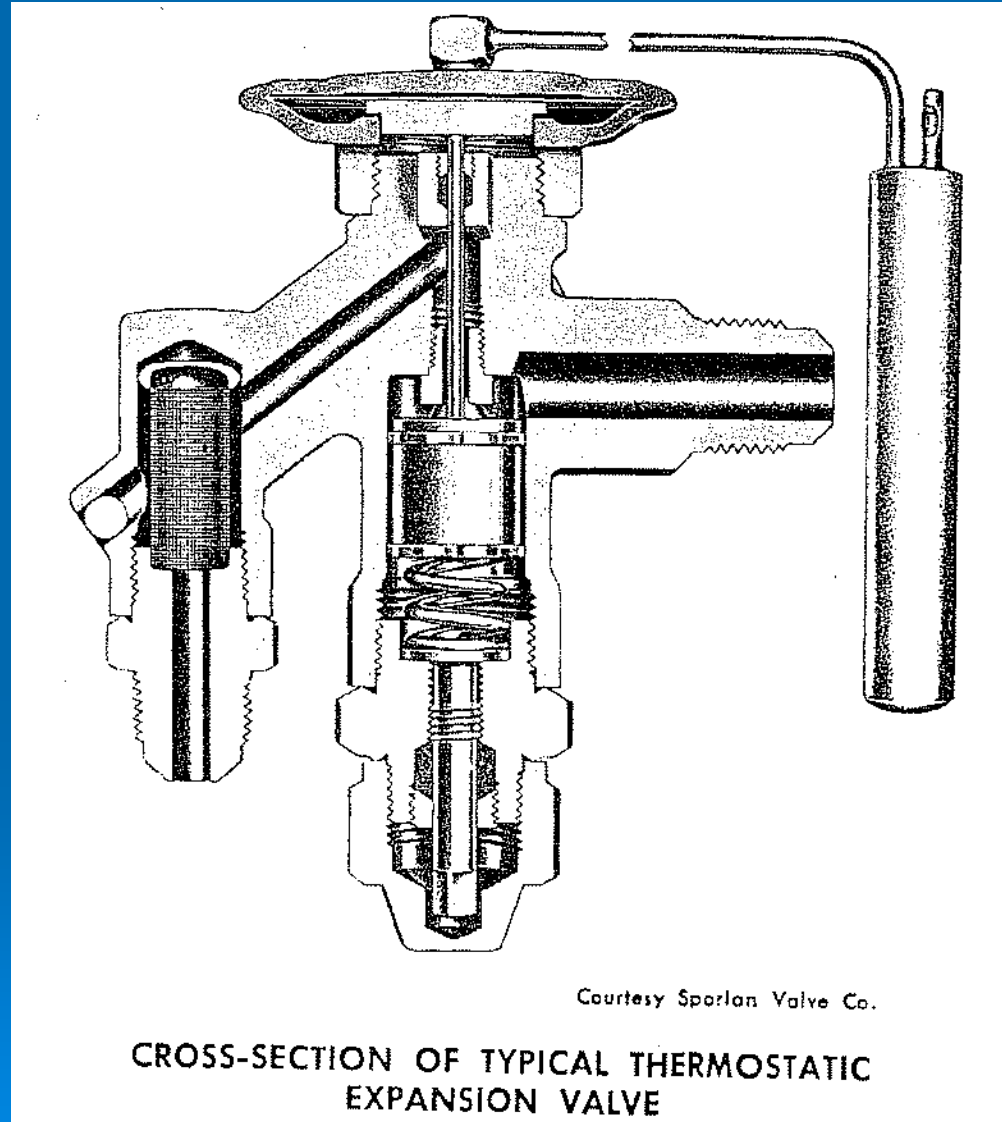
# Evaporative Condenser



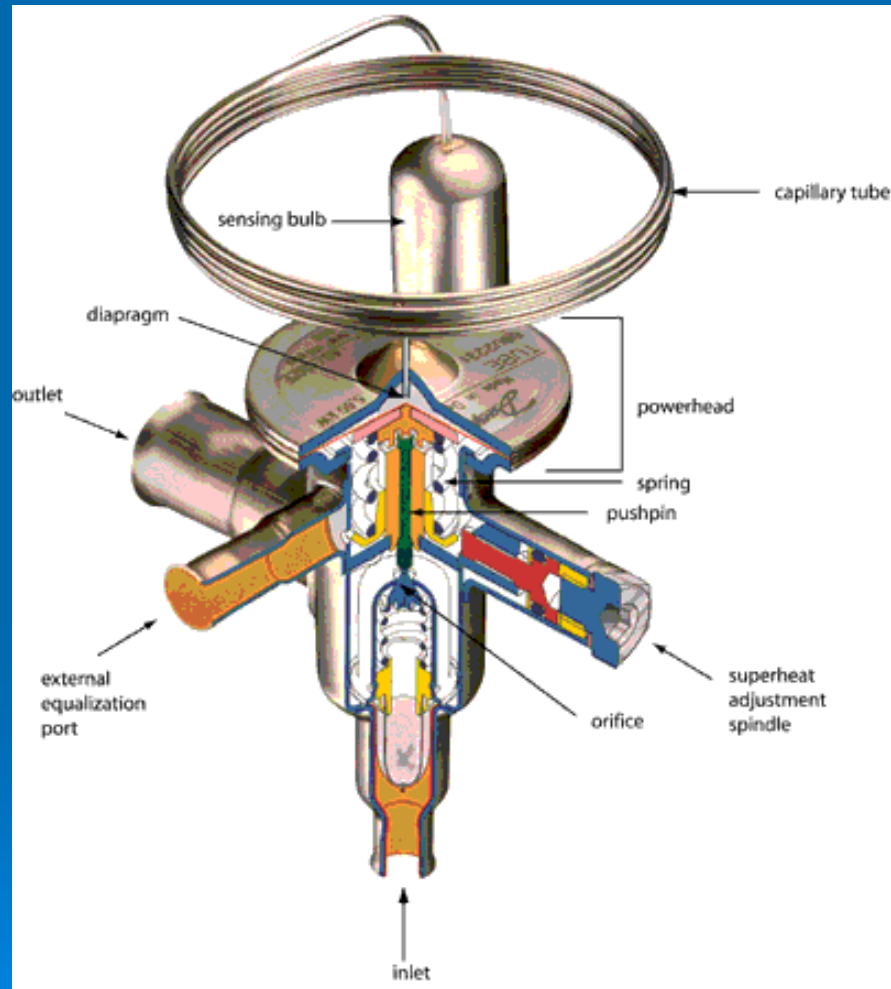
# Condensers Efficiencies

<b>R-22</b>	<b>Ambient temp</b>	<b>Sat. liquid temp</b>	<b>Ambient minus liquid</b>	<b>Head pressure</b>
<b>Air-cooled</b>	95°F db	115°F db	20°F db	243 psi
<b>Water-cooled</b>	78°F wb	90°F db	12°F db	168 psi
<b>Evap-cond</b>	78°F wb	85°F db	7°F db	156 psi

# Thermostatic Expansion Valve



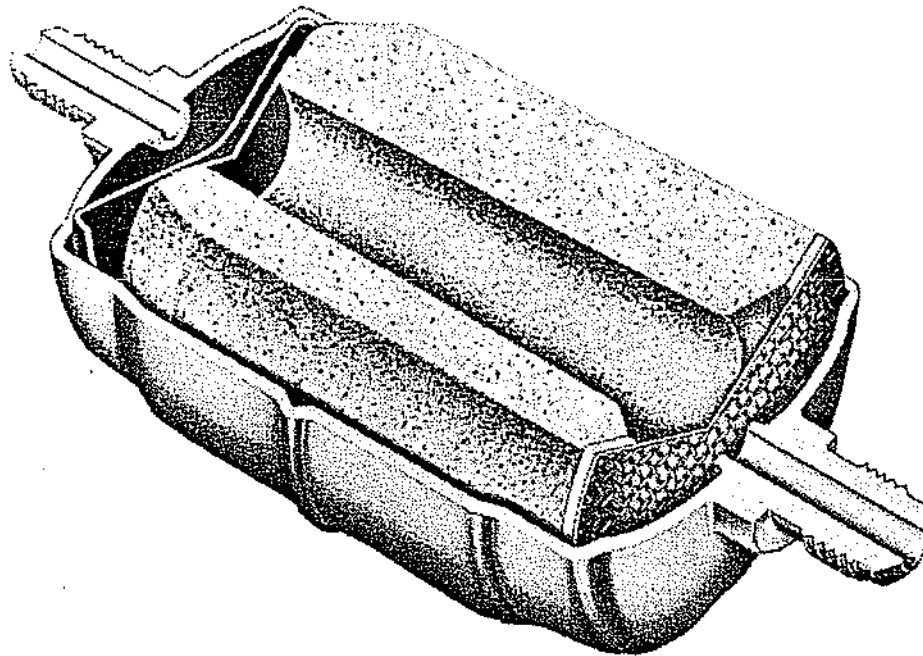
# Thermostatic Expansion Valve



# Oil Separator



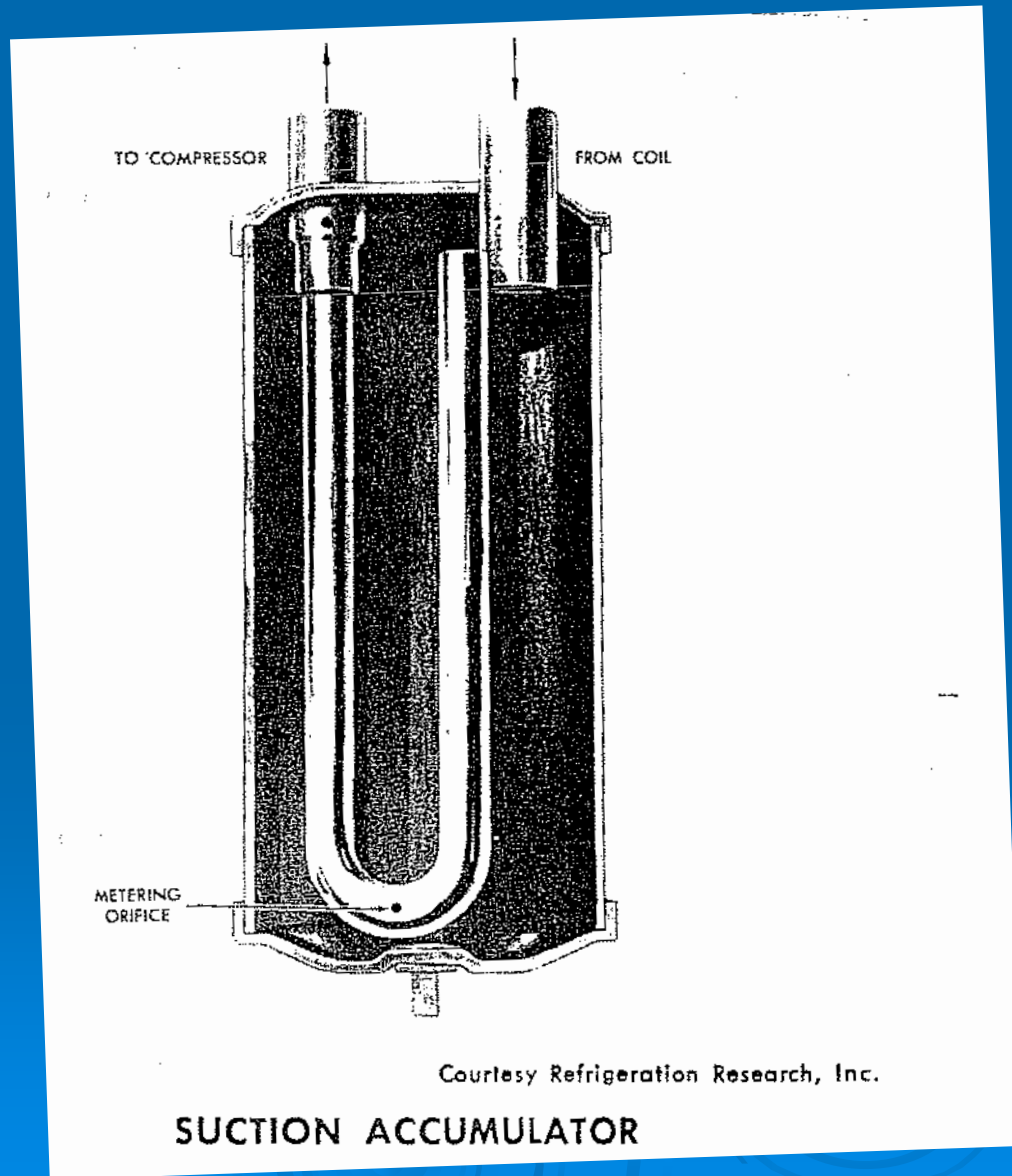
# Filter-Drier



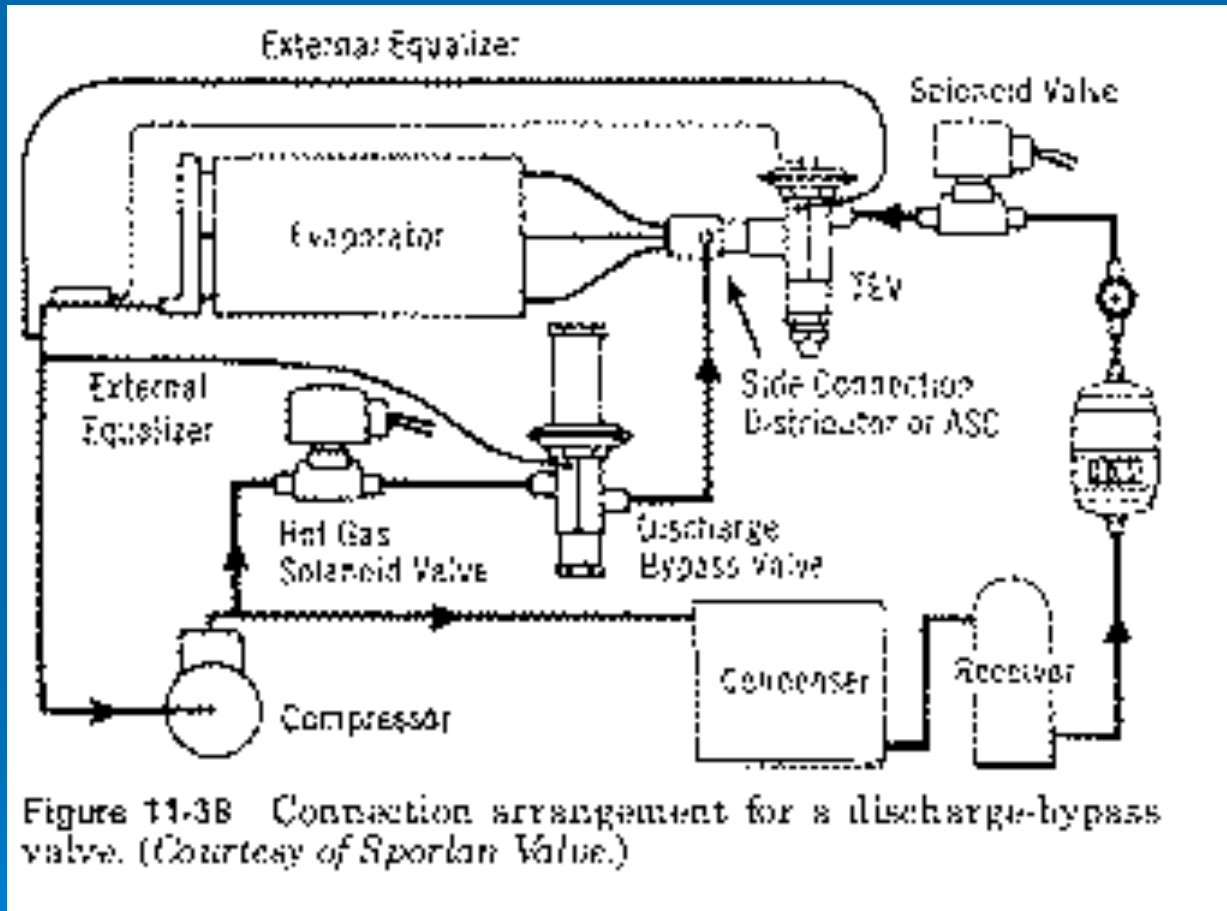
Courtesy Sporlan Valve Co.

**TYPICAL FILTER-DRIER**

# Suction Accumulator



# Hot Gas Bypass



# Refrigerant Distributor

## REFRIGERANT DISTRIBUTOR

### *What is it?*

The refrigerant distributor is a device connected to the outlet of a thermostatic expansion valve (TEV). The outlet of the distributor is machined to accept tubing which connects the distributor to each evaporator coil circuit.

### *What is its function?*

The refrigerant distributor equally distributes refrigerant flow from the thermostatic expansion valve (TEV) into each circuit of a multi-circuit evaporator coil.

FINNED COIL



PLATE EVAPORATOR

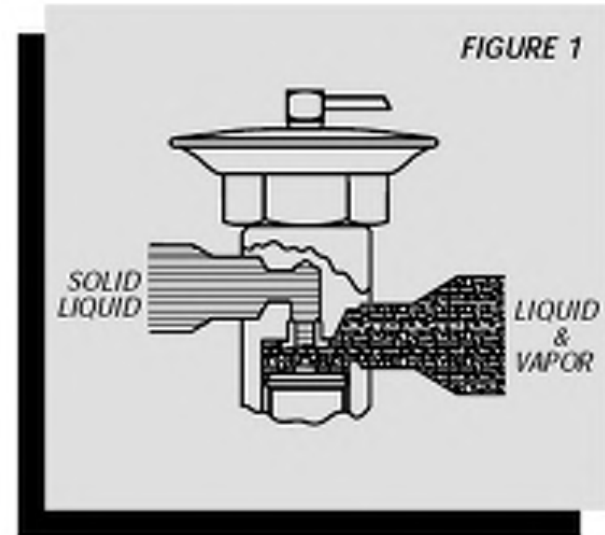
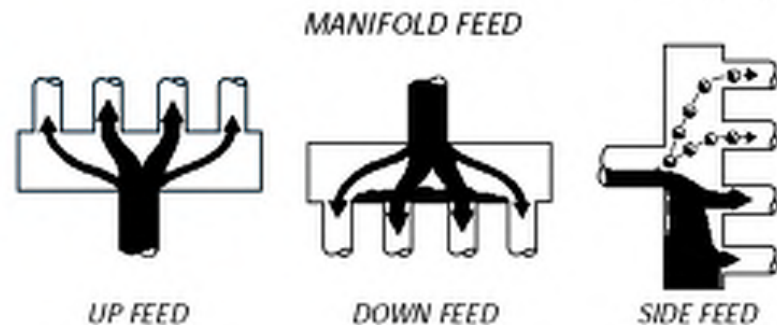


FIGURE 2



UP FEED

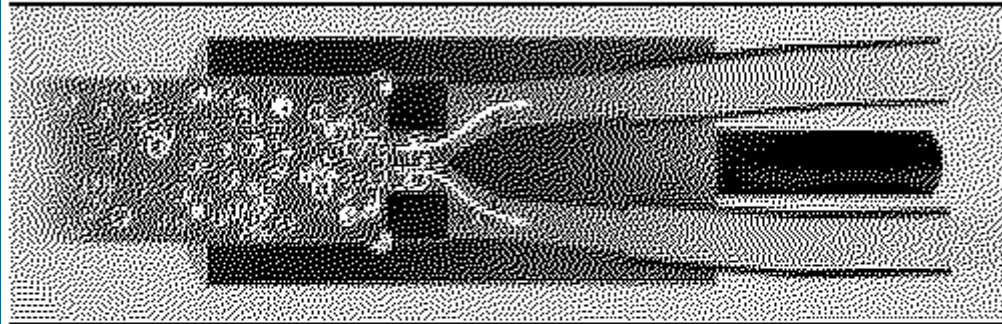
DOWN FEED

SIDE FEED

FLOW WILL BE GREATEST TO PATH OF LEAST RESISTANCE

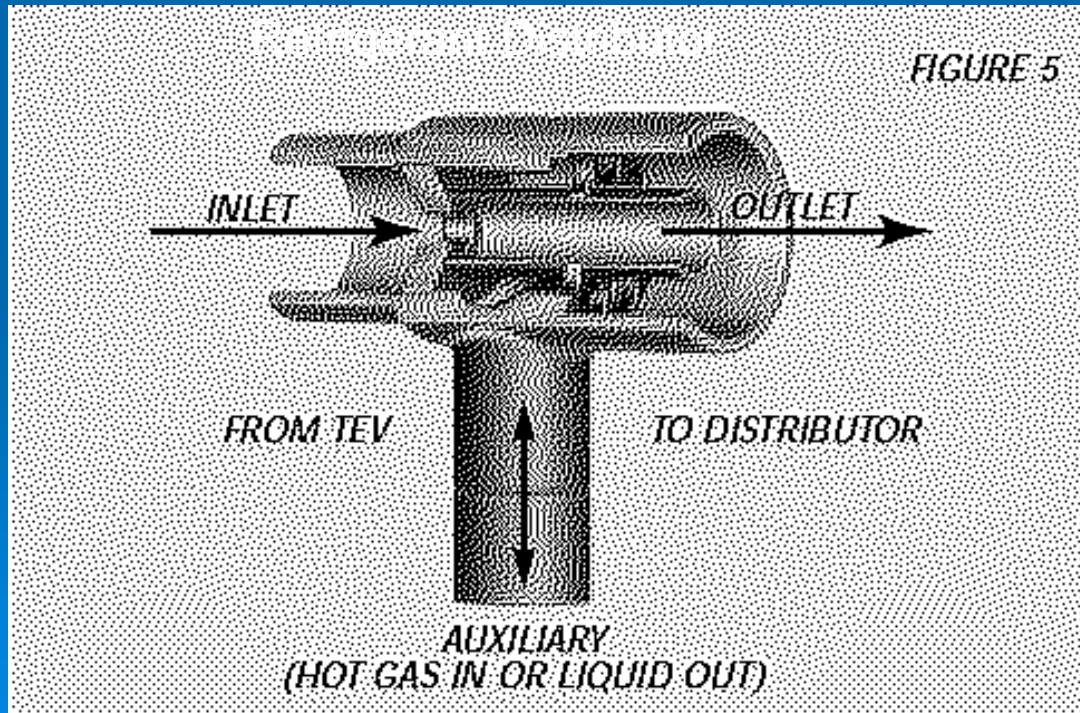
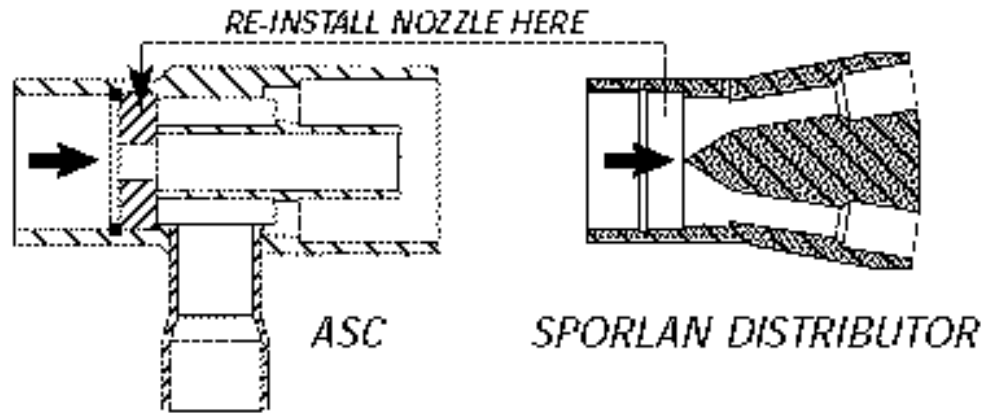
# Refrigerant Distributor

## OPERATION OF SPORLAN PRESSURE DROP TYPE DISTRIBUTORS

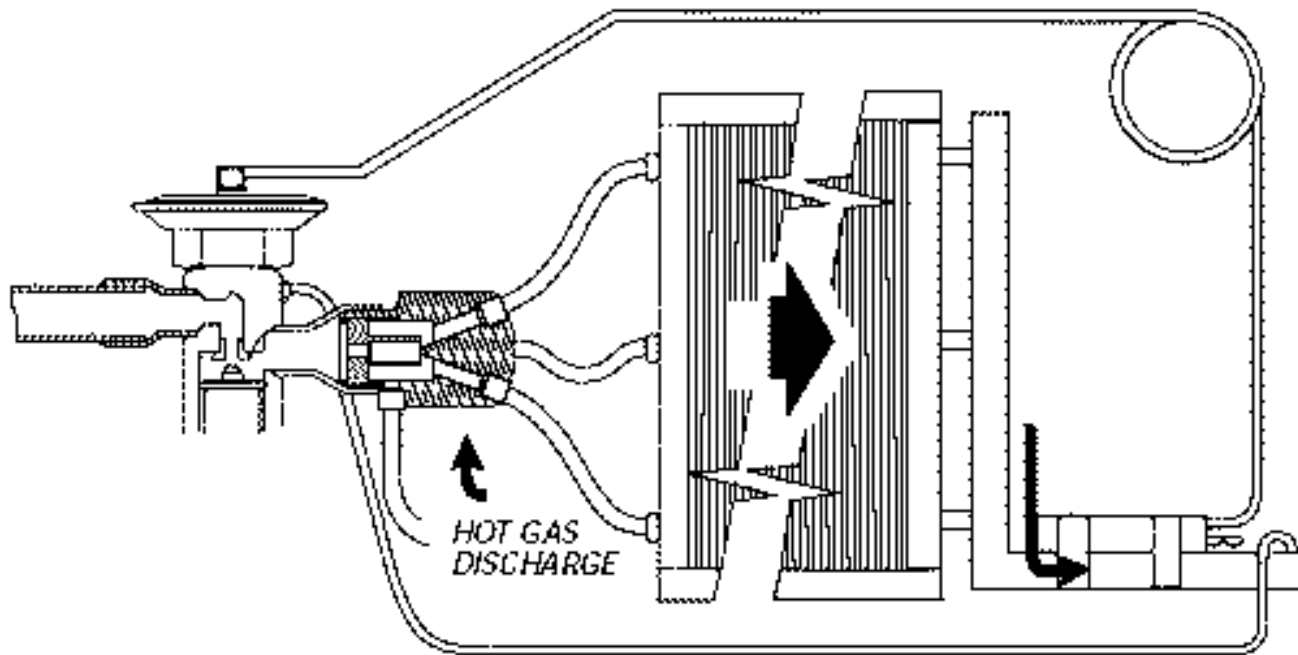


- 1 - Velocity of refrigerant LIQUID-VAPOR MIXTURE increased by flow through nozzle orifice*
- 2 - Orifice provides homogeneous MIXING through turbulence created by pressure drop*
- 3 - Refrigerant MIXTURE divided by conical button while still at high velocity*
- 4 - MIXTURE fed equally to circuits*

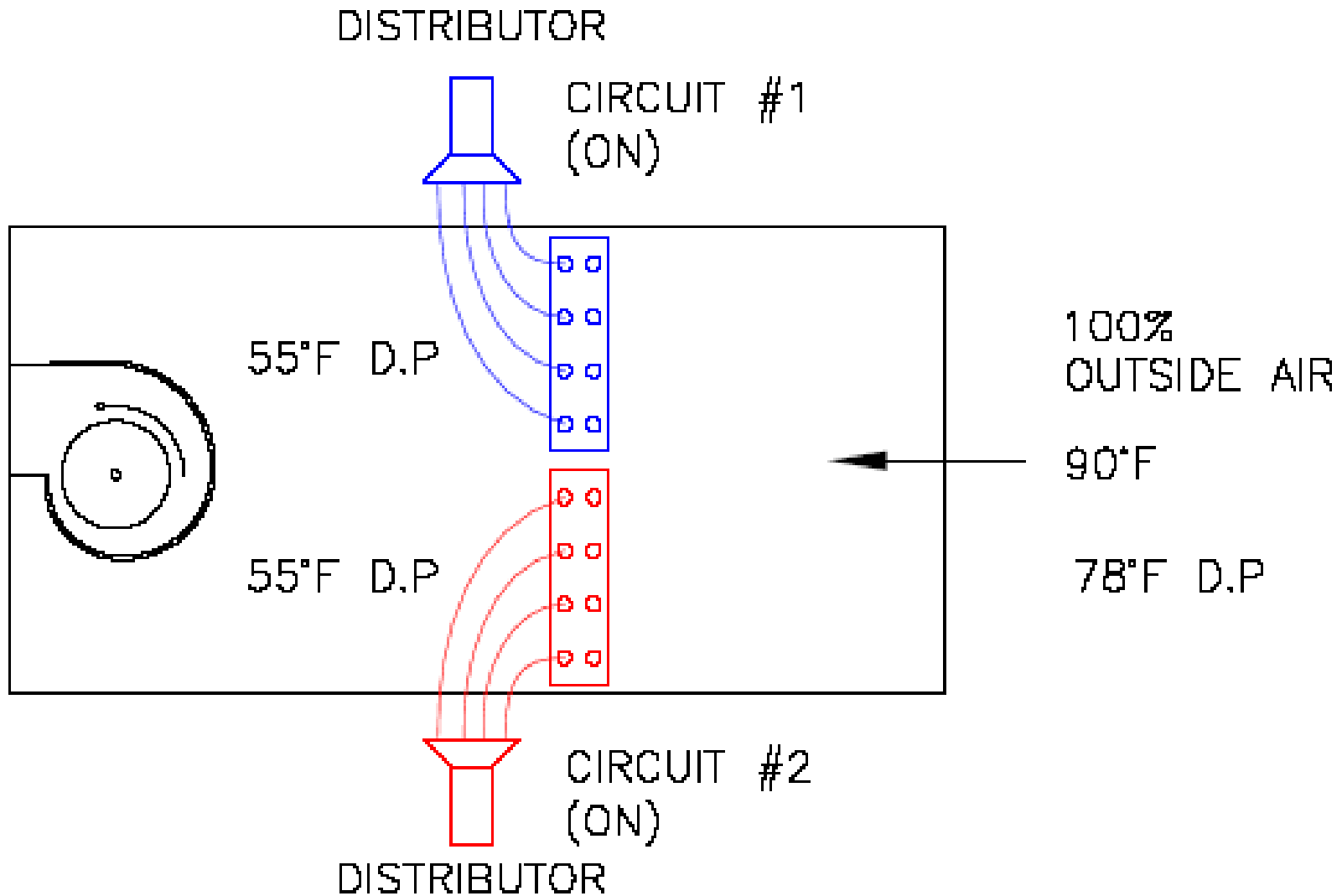
# Refrigerant Distributor



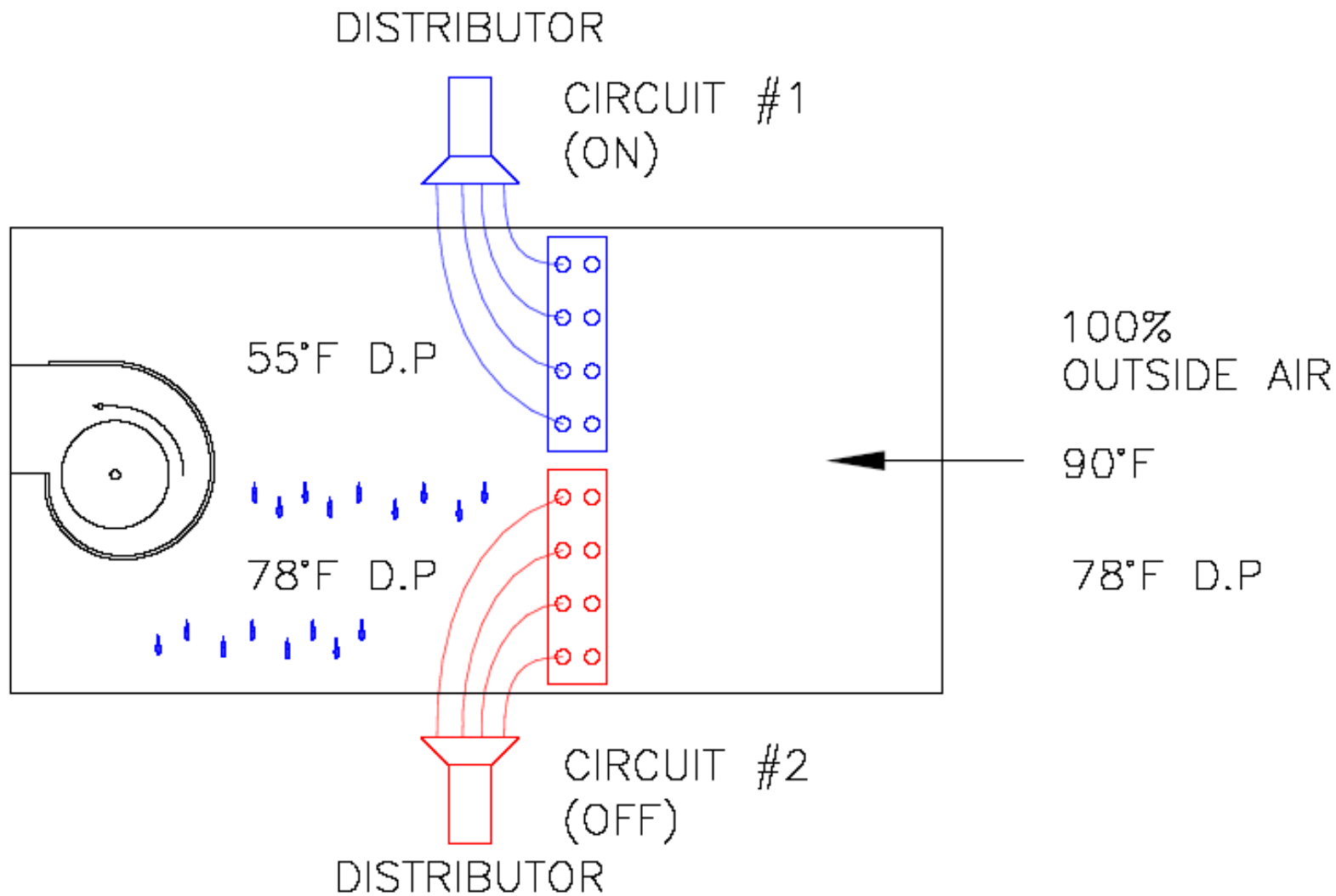
# Refrigerant Distributor



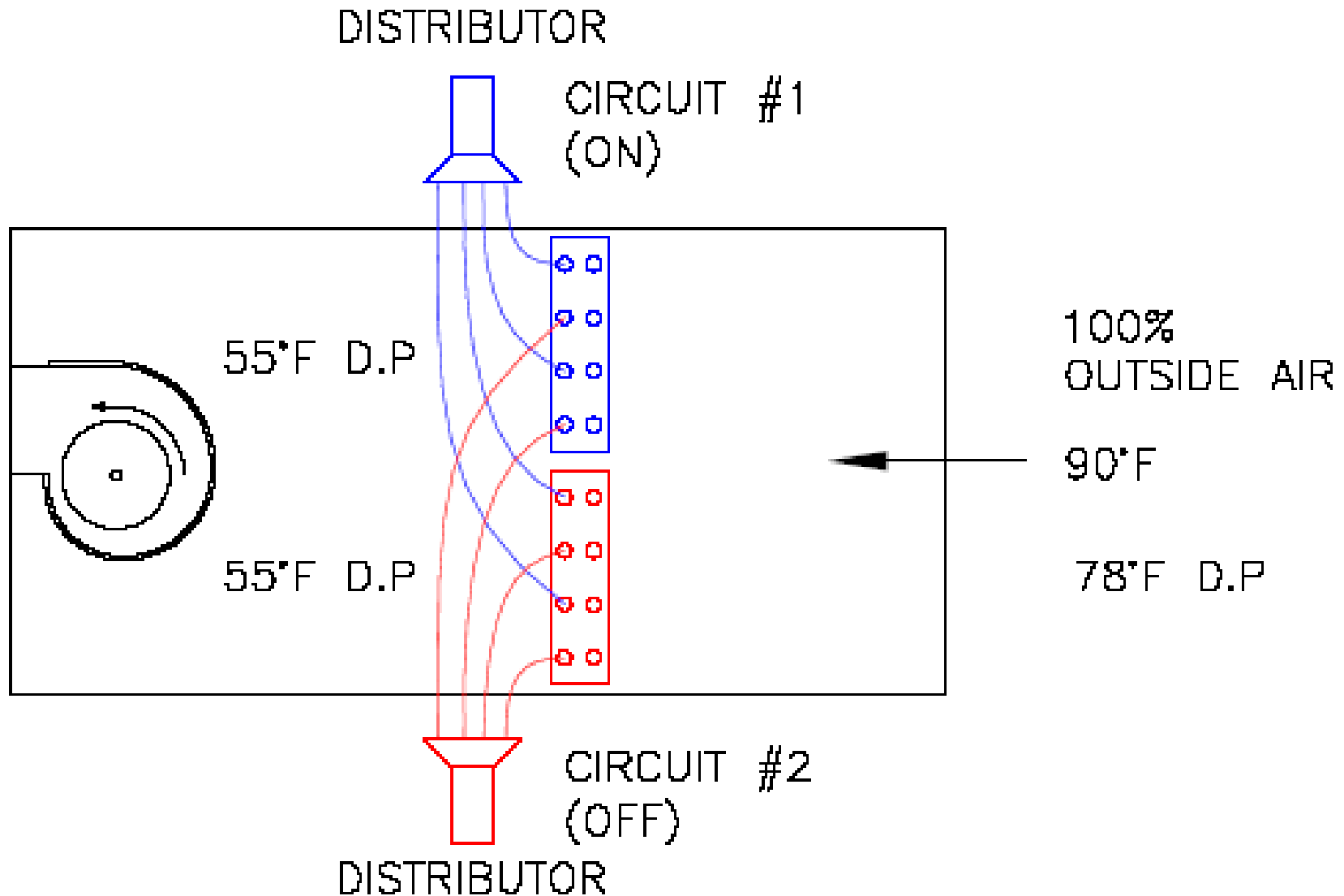
# Split Faced Evaporator Coils



# Split Faced Evaporator Coils



# Interlaced Evaporator Coils



THE END

