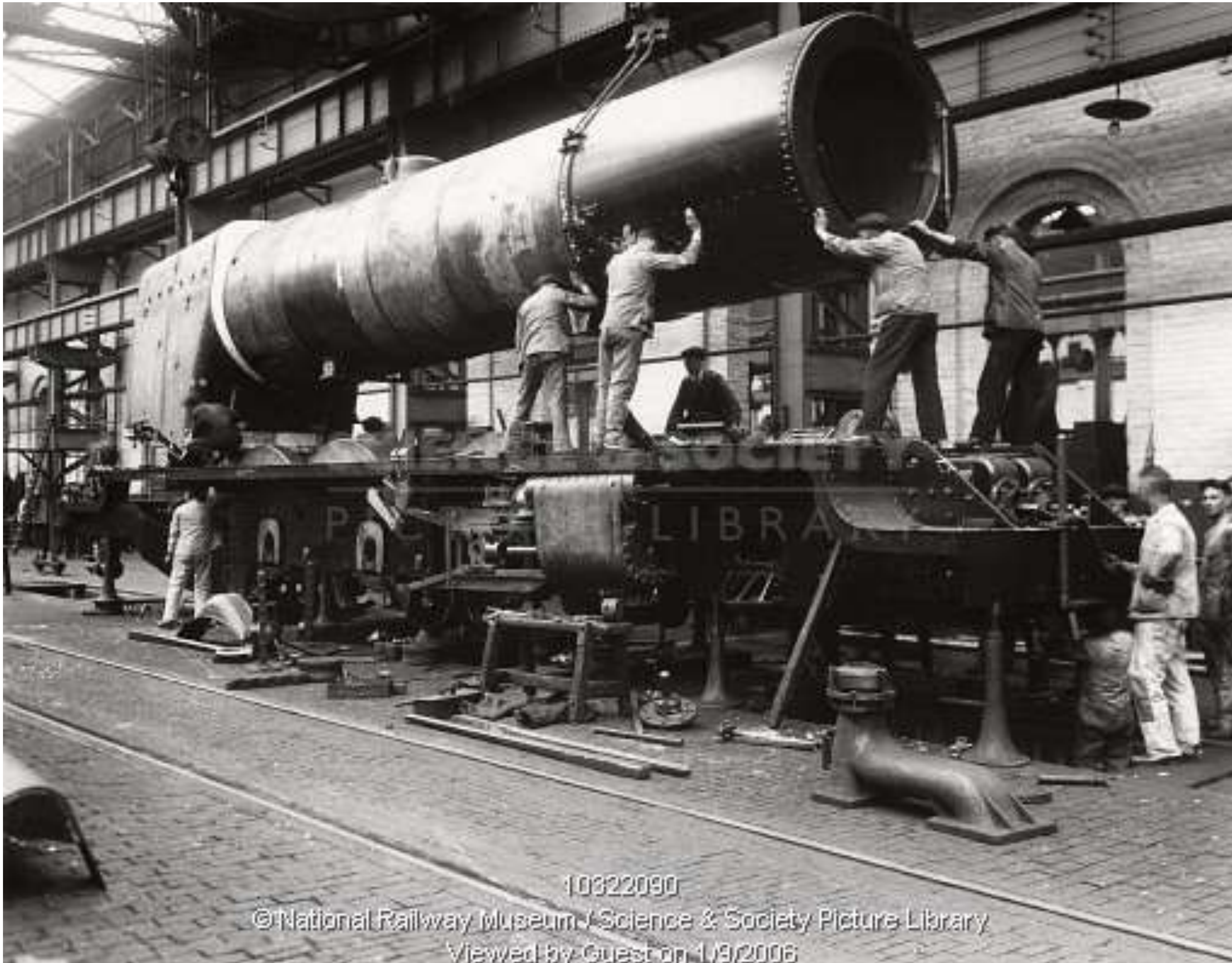
STEAM PLANT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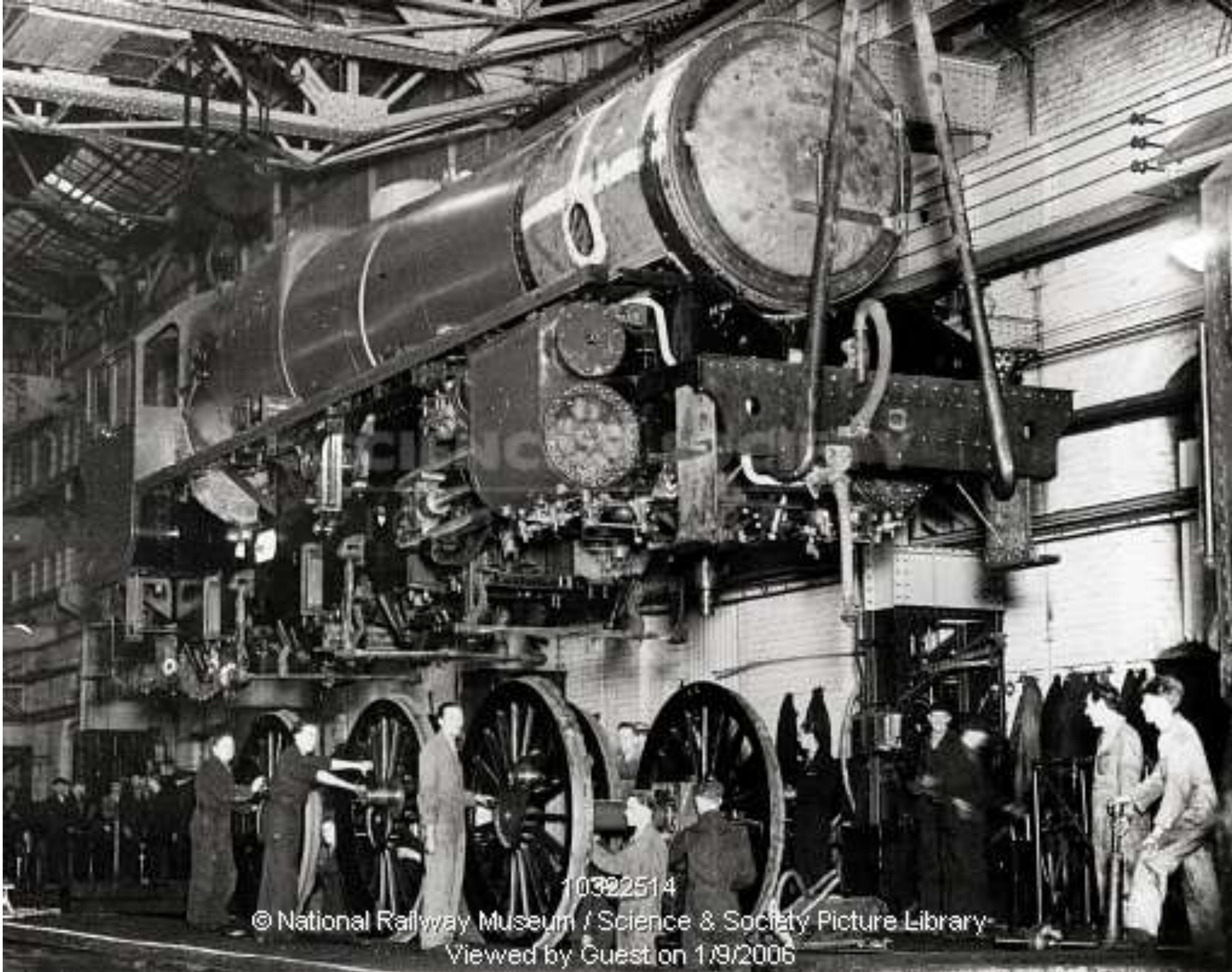


Steam Utilization

Steam is generated for the following plant uses:

1. Turbine drive for electric generating equipment, blowers and pumps
2. Process for direct contact with products, direct contact sterilization and noncontact for processing temperatures
3. Heating and air conditioning for comfort and equipment

The efficiency achievable with steam generation relies heavily on the system's ability to return condensed steam to the operating cycle. Many of the systems described above return a significant portion of the condensed steam to the generation cycle.

Two principal types of boilers are used for industrial applications:

1. **Fire tube boilers-** Products of combustion pass through the tubes, which are surrounded by water.

2. **Water tube boilers-** Products of combustion pass around the tubes containing water. The tubes are interconnected to common channels or headers and eventually to a steam outlet for distribution to the plant system.

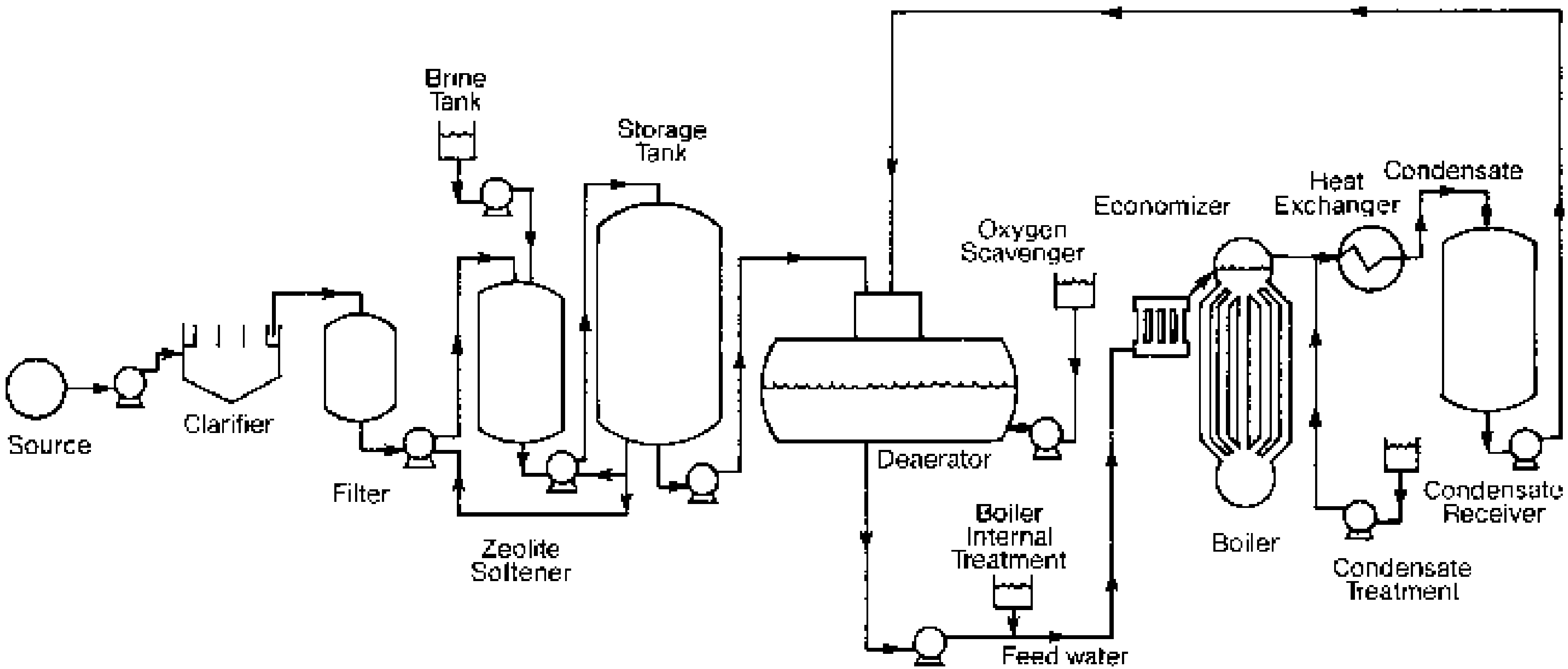
Role of Boilers in Plant Operation (Steam Generation)

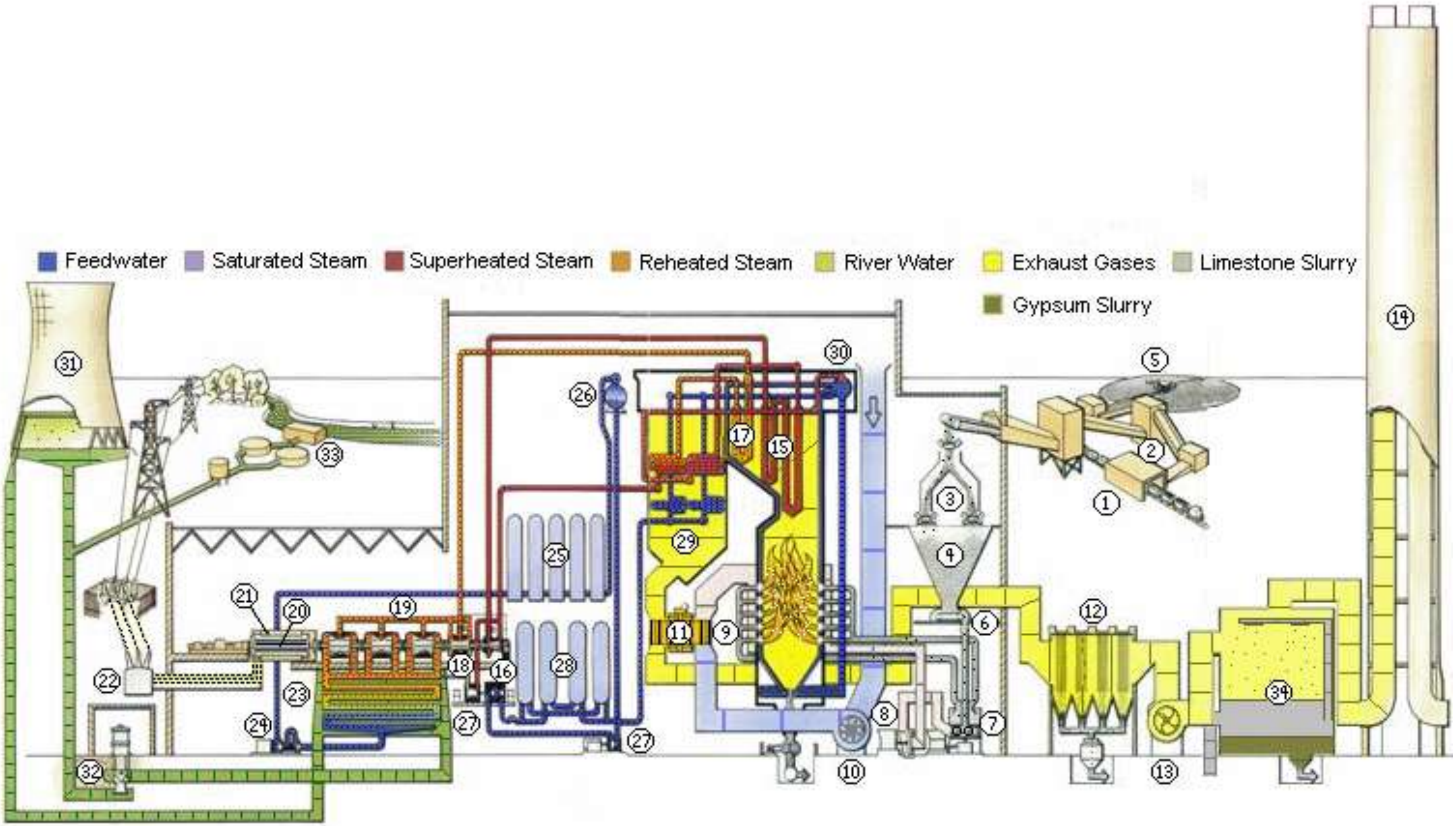
A boiler is a closed vessel in which water under pressure is transformed into steam by the application of heat. In the boiler furnace, the chemical energy in the fuel is converted into heat, and it is the function of the boiler to transfer this heat to the contained water in the most efficient manner. The boiler should also be designed to generate high quality steam for plant use.

A flow diagram for a typical boiler plant is presented in figure below.

A boiler must be designed to absorb the maximum amount of heat released in the process of combustion. This heat is transferred to the boiler water through radiation, conduction and convection. The relative percentage of each is dependent ulpon the type of boiler, the designed heat transfer surface and the fuels.

Boiler Plant Flow Diagram




Feedwater
Saturated Steam
Superheated Steam
Reheated Steam
River Water
Exhaust Gases
Limestone Slurry
Gypsum Slurry
1
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6
7
8
9
10
11
12
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Coal Feeder

A ‘drag link’Coal Feeder feeds coal from the bunkers to the mill via a 450mm diameter pipe. A Coal Feeder can move 40 tonnes of coal in an hour.

Pulverising Mill

Each of the six units at Drax has ten Pulverising Fuel Mills, each capable of pulverising 36 tonnes of coal per hour. The Mills crush the coal into a fine powder with ten large metal balls.
Each mill ball is 1.4 tonnes and 76cm (30 ¼ inches) in diameter.
A Mill rotates at 37 revolutions per minute.

The Role of Water Treatment in Steam Generation

External treatment, as the term is applied to water prepared for use as boiler feed water, usually refers to the chemical and mechanical treatment of the water source. The goal is to improve the quality of this source prior to its use as boiler feed water, external to the operating boiler itself. Such external treatment normally includes:

1. Clarification
2. Filtration
3. Softening
4. Dealkalization
5. Demineralization
6. Deaeration
7. Heating

There are five major problems directly associated with water quality that will effect boiler performance. These are:

Scale formation

Corrosion

Fouling

Foaming

Embrillement

Impurity Source Effect

Algae organic growth fouling
Calcium mineral deposits scale
Carbon dioxide dissolved gases corrosion
Chloride mineral deposits corrosion
Free acids Indus. Wastes corrosion
Hardness mineral deposits scale
Magnesium mineral deposits scale
Oxygen dissolved gases corrosion
Silica mineral deposits scale
Suspended solids undissolved matter fouling/scale

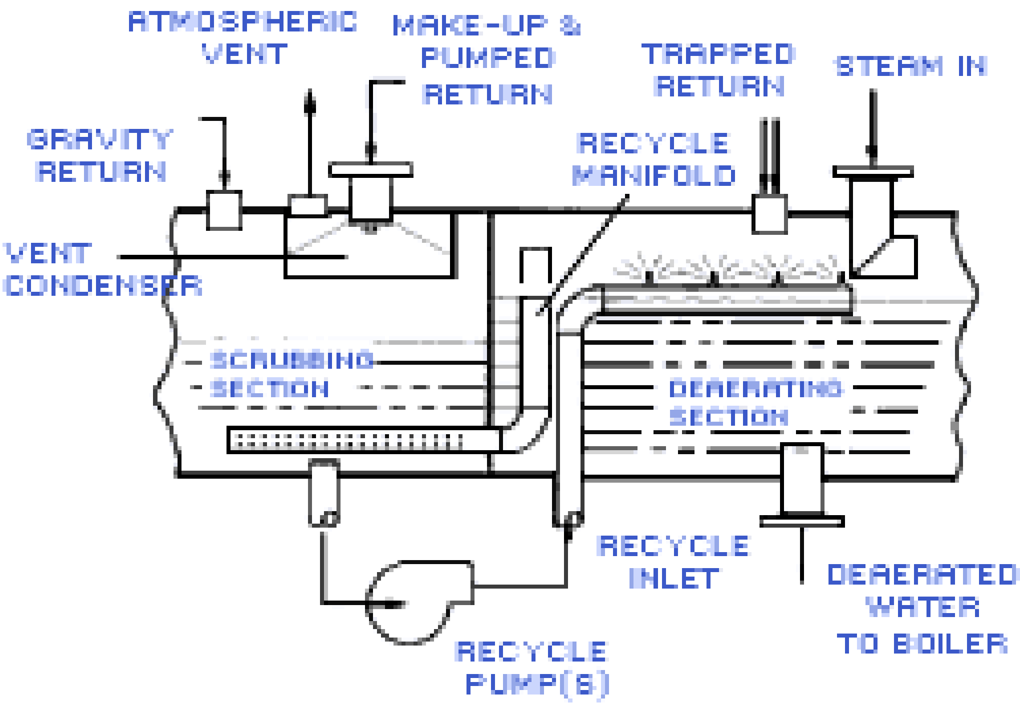
The oxygen in this raw feedwater is released within the boiler as a result of heat and rises in the form of bubbles.

These bubbles attach themselves to the boiler tubes, water legs and the sides of the boiler drum shell at the water line.

The oxygen along with the carbon dioxide attacks the iron and set up chemical musical chairs in which the steel in your system will always lose.

This destructive game will continue until either all the oxygen is entirely removed from the water or the steel or iron is dissolved.

A deaerator is a piece of equipment which removes corrosive gases from boiler feedwater and preheats the water prior to entrance into the boiler.



Hydraulics

Hydraulics are used for providing high torques and high forces with a high level of control of the motion. Hydrualic fluid is virtually incompressible so controlling the flow of fluid provides accurate control of the motion of the relevant actuator..

Typical uses of Hydraulic drives include..

Vehicle drives in agricultural and civil applications
High power low weight motors (high speed and low speed)
Elevators
Aircraft motion control- wings - undercarriage etc
Hydraulic Hoists
Automation actuators
Machine tool drives
Flight Simulators- For training pilots
Motion Simulators- For vibration seismic testing

The primary advantage of hydraulic systems compared to pneumatic and electric systems is that high forces and torques can be developed with comparatively compact motors without the need for gearboxes.

Very accurate motion controls are possible using sophisticated servo valves.

The disadvantages of hydraulic systems include the relatively high cost of components and the need to condition and contain the hydraulic fluid.

Hydraulic system Components

Hydraulic systems are generally confined to local areas e.g. a vehicle, a machine tool. They are not designed as distributed systems as are pneumatic systems.

However large distributed systems have been employed.
In times past, in cities, very extensive systems have been engineered to serve diverse hydraulic units elevators - bridges etc.

Hydraulic systems ...

Operating Conditions.

Hydraulic power systems systems use hydraulic fluids at pressures between 35 barg and 350 barg.

The hydraulic fluid must be maintained within safe temperature regime by use of coolers.

The hydraulic components have close clearances so the fluid must be filtered.

Power Pack

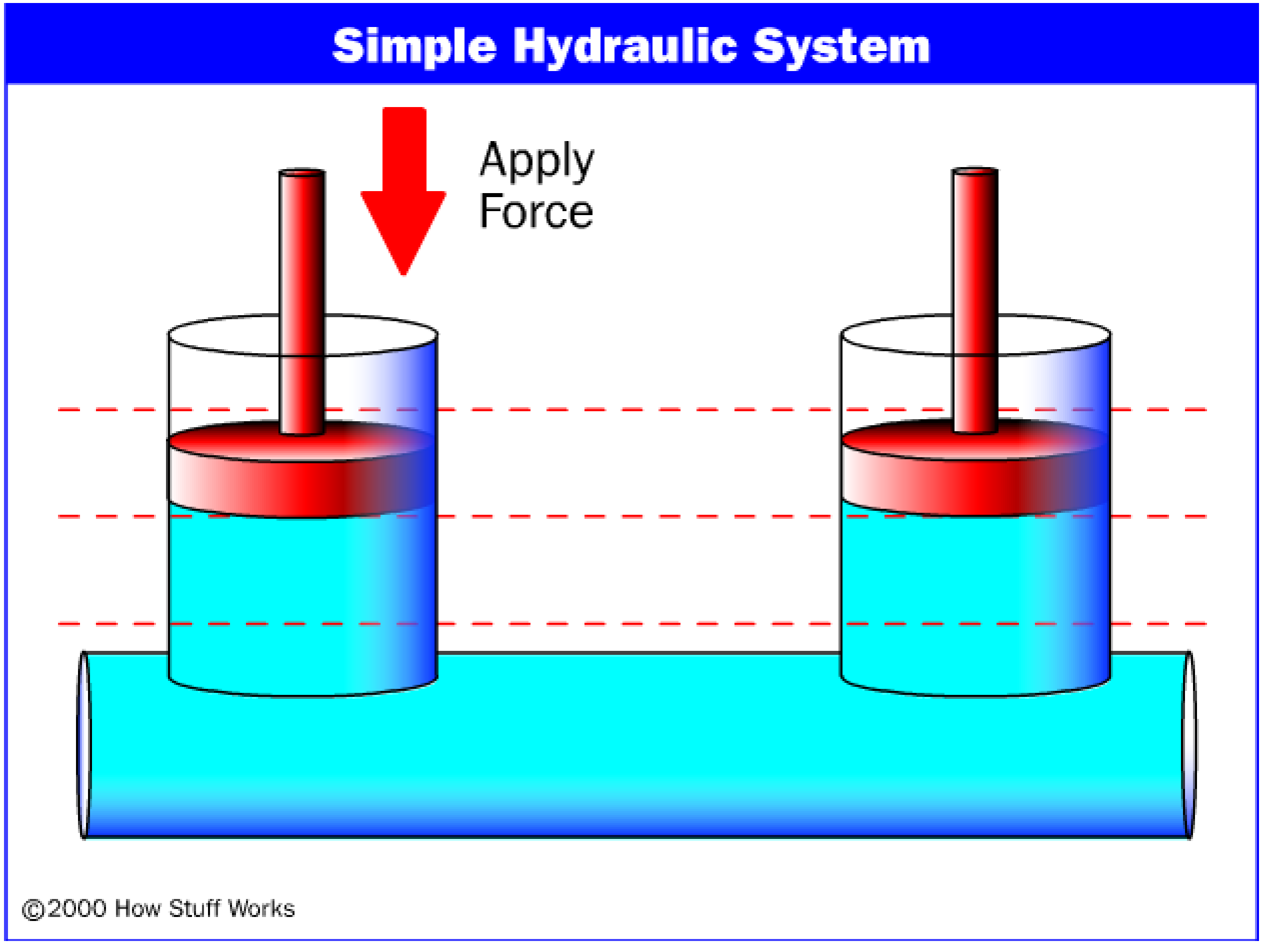
The hydraulic power pack impart the essential potential energy to the hydraulic fluid using appropriate pumps e.g. Gear, Vane, Piston pumps are used. The power pack normally includes the following features

Reservoir for hydraulic fluid - with instrumentation, air filter and strainer over outlet
Protection for pump including filter
Pump located below reservoir to minimise suction feed requirement
Accumulator to maintain steady pressure against flow variations
Cooler for removing waste heat from the system (Air cooler /Water cooler)
Control valves, relief valve, unloading valve, isolation valves
Provision for containing any leaks with suitable instrumentation

The Basic Idea

The basic idea behind any hydraulic system is very simple: **Force that is applied at one point is transmitted to another point using an incompressible fluid.** The fluid is almost always an oil of some sort. The force is almost always multiplied in the process. The picture below shows the simplest possible hydraulic system:

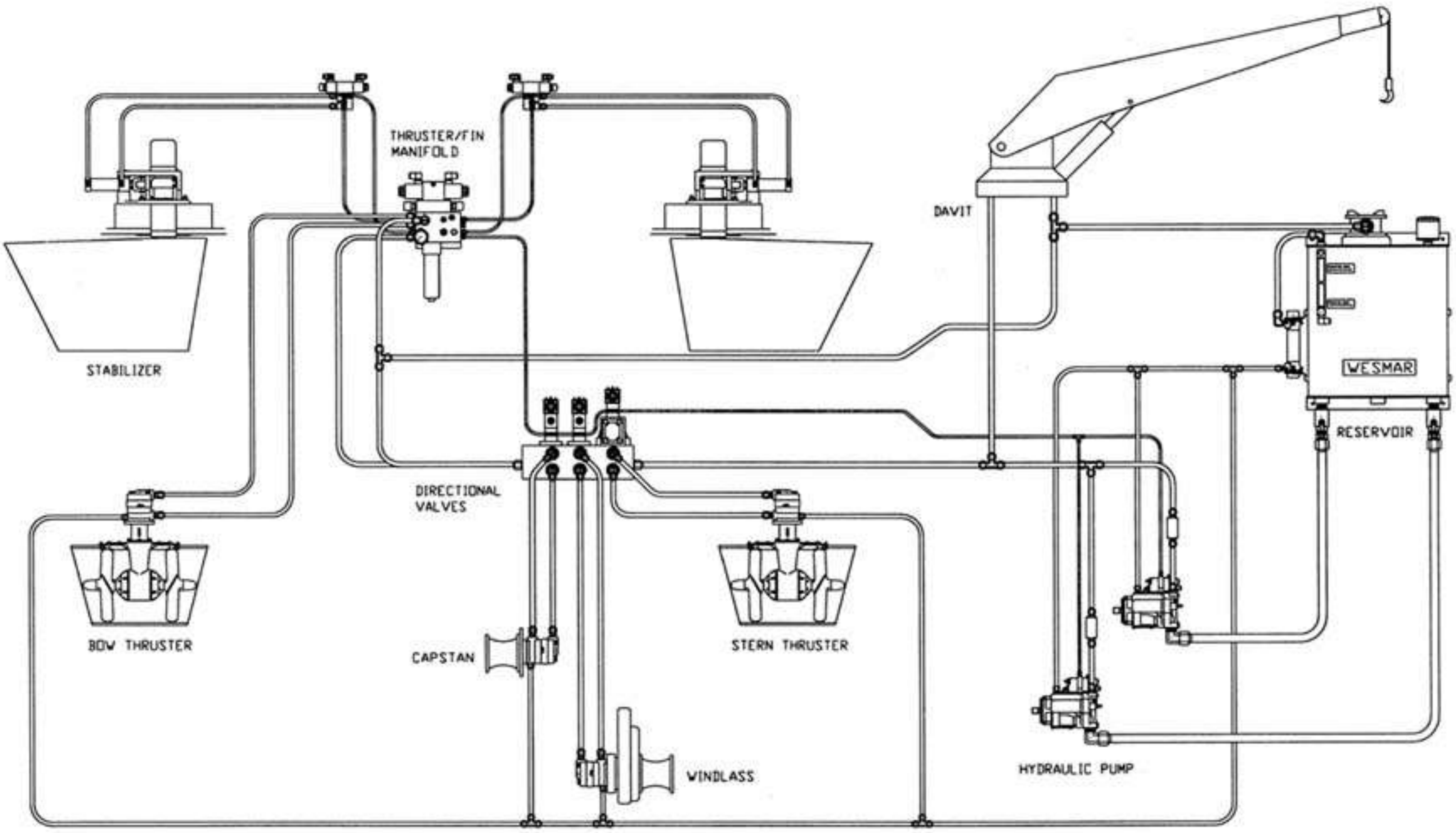
A



Hydraulic multiplication. The piston on the right has a surface area nine times greater than the piston on the left. When force is applied to the left piston, it will move nine units for every one unit that the right piston moves, and the force is multiplied by nine on the right-hand piston.

High-pressure oil from the pump is shown in light blue, and low-pressure oil returning to the tank is shown in yellow.

Hydraulic System



Typical Hydraulic System Reservoir

This aluminum tank is equipped with a 2" suction 100 mesh stainless steel screen, sight glass and breather, and one return line inlet. The reservoir should be mounted to provide flooded suction to the pump.

Gate Valve used so the pump can be isolated out of circuit for repairs.

Load Sensing Pump "senses" the amount of pressure necessary to move the load and adjust output flow to match the valve opening selected on the flow control.

Check Valve used to keep from back pressuring the pump.

Pressure compensated Flow Control maintains accurate constant flow at pressures up to 3000 PSI.

Bow Thruster Directional Control Valve handles flows up to 93 GPM and pressure up to 3000 PSI, including 3 position directional control and manifold.

Cushion Valve designed to minimize or eliminate shock surge and overload conditions on hydraulic equipment
.
Return Filter with a 3 micron filter element.

Gate Valve allows easy filter element replacement.

Small Cooler used to cool oil.

Pressure Gauge 0 to 3000 PSI.

Pneumatics

Compressed air systems are generally used to provide controlled motion using cylinder actuators for linear motion and rotary actuators rotary motion.. Typical uses of compressed air drives include..

Power tools
Valve Operators
Positioning cylinders
Hammer drills.
Paint Spray Guns
Air driven Hoists
Air Motors
Packaging systems
Pick and Place units
Air lift pads
Air Conveyor systems
Fluid agitation systems
Impact wrenches

The main disadvantage of pneumatic actuators compared with electrical and hydraulic actuators is that the motive fluid (air) is compressible and hence accurate speed control and position control is difficult and often requires ancillary systems..

The advantages of pneumatic systems are
The low cost of the components
The ease of design and implimentation
The huge range of available components
The use of air limits the force/torque that can be generated providing a safety feature

Compressed Air system Components

Operating Conditions.

Normal compressed air systems operate at a pressure of approximately 7 barg...
The compressor would need to be rated for some margin above the e.g. 10-12 barg.
The equipment would be rated for use at pressures 4 barg to 6 barg

A compressed air systems generally includes the following components..

Air compressor..
This is either electric driven or driven by an internal combustion engine.. The compressor output has to be balanced with the demand and can be operated on a variable displacement basis or, more normally, it is operated intermittently under pressure control..

Air Receiver..
This is a vessel so sized that the pressure is maintained within set limits as the flow to the users varies.

Air Preparation
On a large system there may be a main air treatment system on the main header and a individual air treatment system for each group of users. An air treatment system will include an Filter, Lubricator, Isolation Valve, and Pressure Regulator (with gauge) as a minimum

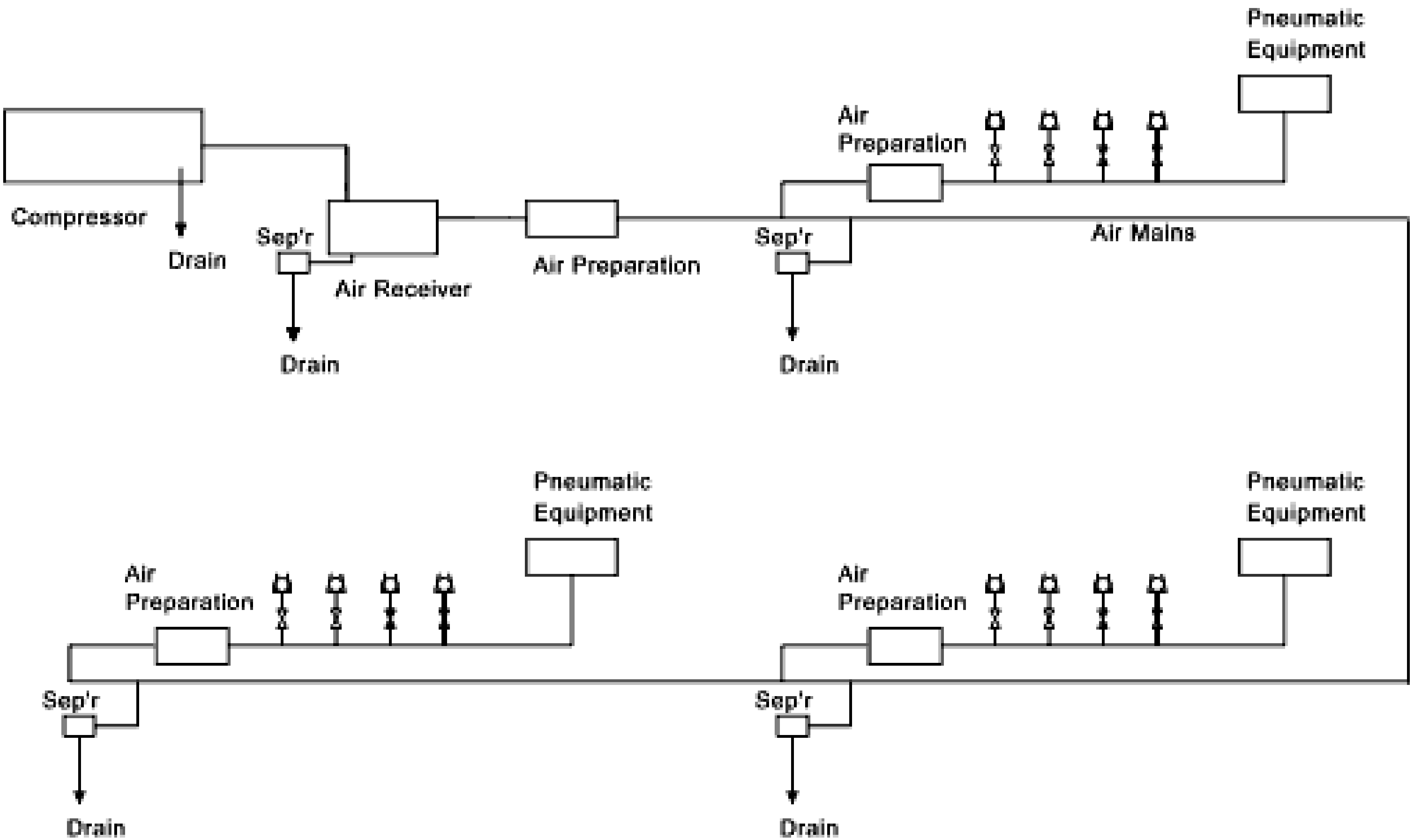
Air piping system

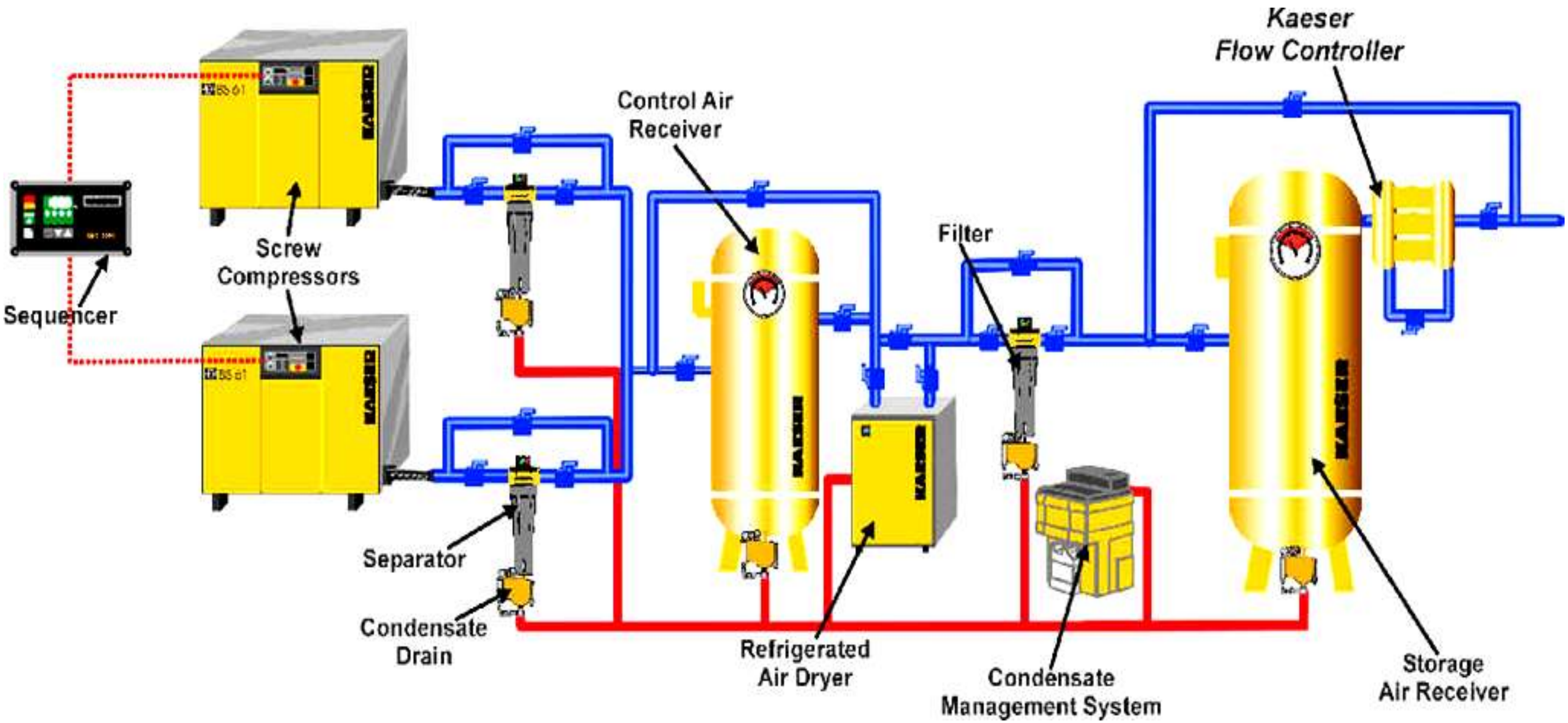
On normal systems the main air pipes will be suitably rated steel /galvanized iron /Wrought iron piping.

The local piping to users will be copper and plastic piping can be used for small bore connections.

The piping should include the necessary slopes down to separators for removing any moisture in the compressed air supply which forms in the piping over time.

The velocity of air within the air supply header should be limited to about 15m/s.


Pneumatic Equipment
Air Preparation
Compressor
Drain
Sep'r
Air Receiver
Air Preparation
Sep'r
Air Mains
Drain
Drain
Pneumatic Equipment
Pneumatic Equipment
Air Preparation
Air Preparation
Sep'r
Sep'r
Drain
Drain


Kaeser
Flow Controller
Control Air
Receiver
Screw
Compressors
Sequencer
Filter
Separator
Condensate
Drain
Refrigerated
Air Dryer
Condensate
Management System
Storage
Air Receiver

Problems caused by water in compressed air:

Washing of required lubrication.

Maintenance and wear increases.

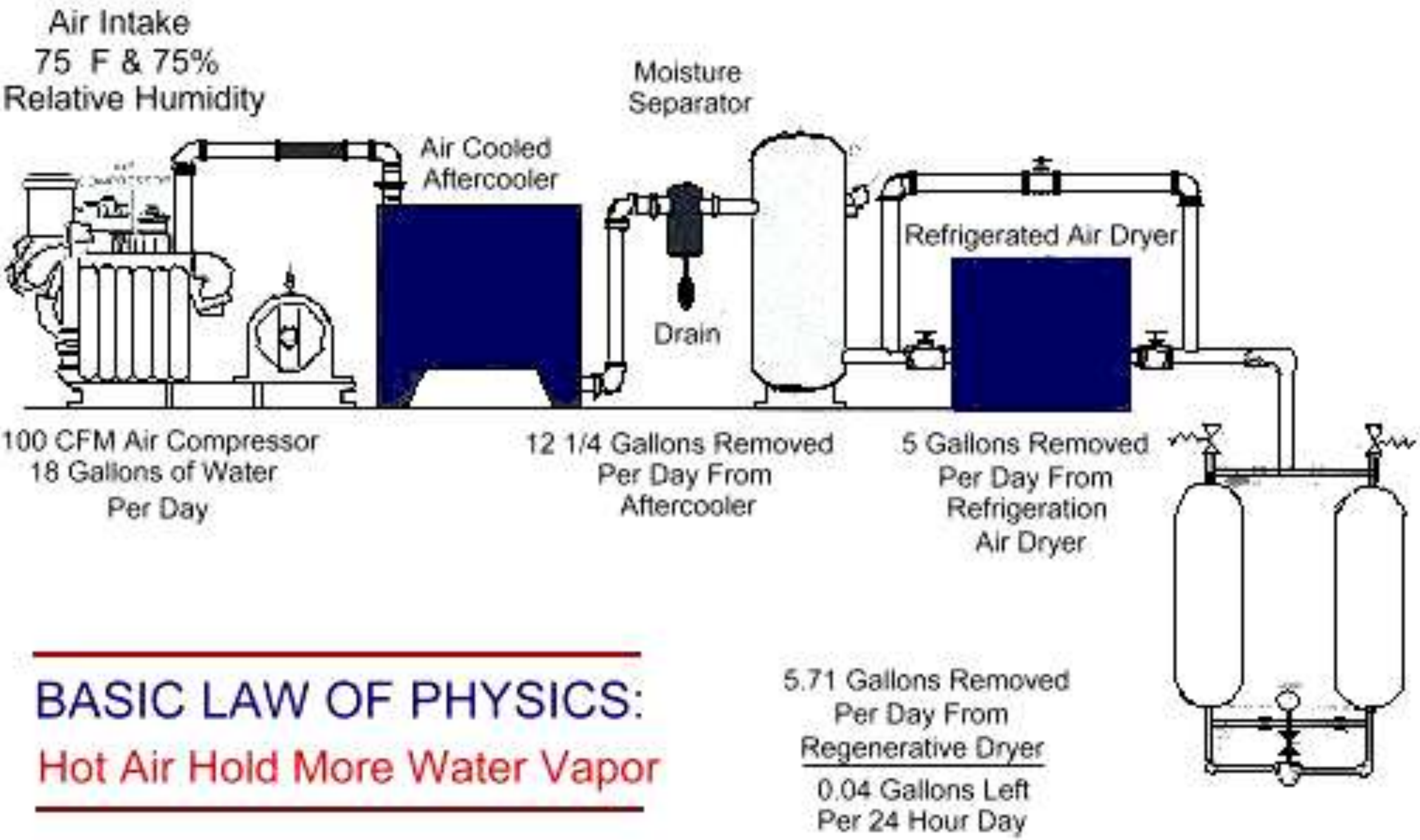
Air equipment sluggish.

Promotes rust.

Promotes paint spotting.

Air line freeze.

Shortens air tool life.

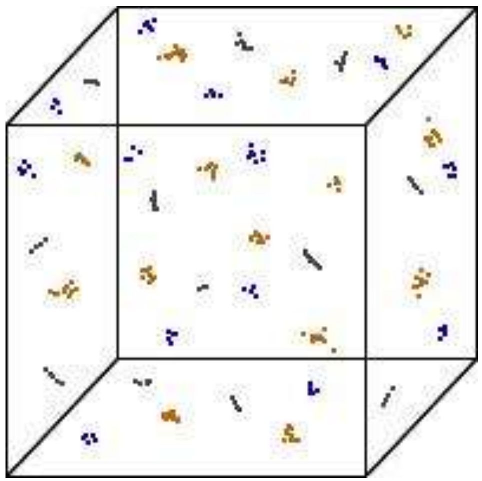


BASIC LAW OF PHYSICS:

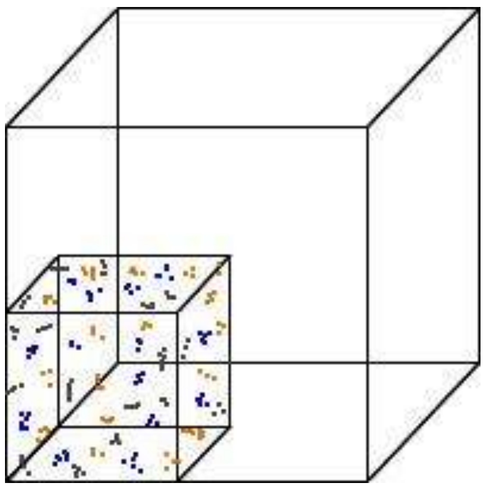
Hot Air Hold More Water Vapor

One Cubic Foot of Air Contains:
Water Vapour
Dust & Dirt
Odours & Vapours

The volume of air has changed, but the amount of water vapour, dust, dirt & odours has not changed. It is more concentrated!



Atmospheric air contains impurities that must be removed.



When compressed to 100 PSIG it becomes 1/8 its previous size.

Brief Comparison
Reciprocating Compressor

Advantages
- Simple Design
- Lower initial cost
- Easy to install
- Two stage models offer the highest efficiency
- No oil carryover
- Large range of horsepowers
- Special machines can reach extremely high pressures

Disadvantages
- Higher maintenance cost
- Many moving parts
- Potential for vibration problems
- Foundation may be required depending on size
- Many are not designed to run at full capacity 100% of the time

Rotary Screw Compressor

Advantages
- Simple Design
- Low to Medium initial cost
- Low to Medium maintenance cost
- Two-stage designs provide good efficiency
- Easy to install
- Few moving parts
- Most popular compressor design in plants

Disadvantages
- Limited airend life
- Airends are not field serviceable
- High rotational speeds
- Shorter life expectancy than other designs
- Oil injected designs have oil carryover
- Single-stage designs have lower efficiency
- Two-stage, oil-free designs have higher initial cost
- Difficulty with dirty environments

Rotary Vane Compressor

Advantages

- Simple Design
- Easy to install
- Low to Medium cost
- Low maintenance cost
- Field serviceable airend
- Long life airend
- Low rotational speeds
- Very few moving parts
- Forgiving to dirty environments

Disadvantages

- Oil injected designs have oil carryover
- Single-stage designs have lower efficiency
- Difficulty with high pressures (over 200 psi)
- Oil-free designs are unavailable

Centrifugal Compressor

Advantages

- High efficiencies approaching two-stage reciprocating compressors
- Can reach pressures up to 1200 psi
- Completely packaged for plant or instrument air up through 500 hp
- Relative first cost improves as size increases
- Designed to give lubricant free air
- Does not require special foundations

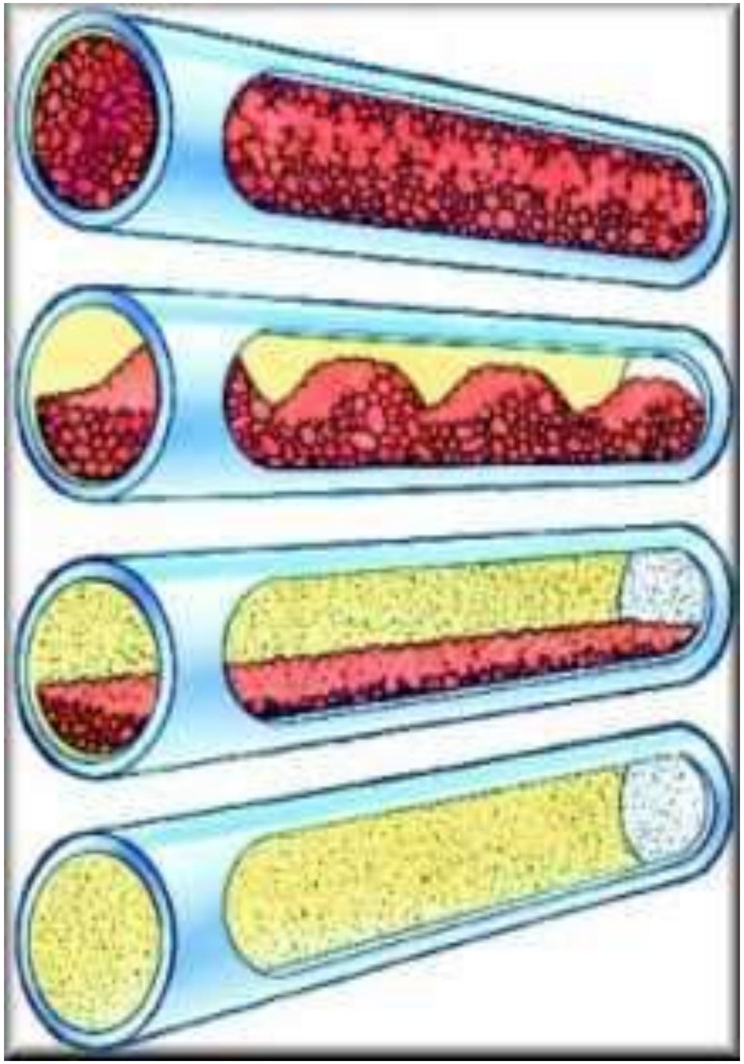
Disadvantages

- High initial cost
- Complicated monitoring and control systems
- Limited capacity control modulation, requiring unloading for reduced capacities
- High rotational speeds require special bearings and sophisticated vibration and clearance monitoring
- Specialized maintenance considerations

With enough air you can move anything. Although this comment is true, we should qualify it by saying there is a cost related to air consumption. Some materials are just not good candidates for pneumatic conveying. If the material meets some of the following criteria, then you should consider pneumatic conveying as a preferred method:

- Very fine, dry & free flowing.
- Dust containment is required.
- Potentially hazardous.
- More suitably controlled for an injection or metering process.
- Blending

Pneumatic Conveying offers many advantages. Generally, the installed cost is less expensive than with other conveying methods, and the equipment often requires less maintenance per ton of material conveyed. Also, it becomes very attractive wherever the conveyor system is routed through limited space in a plant, and/or if housekeeping is an important issue.

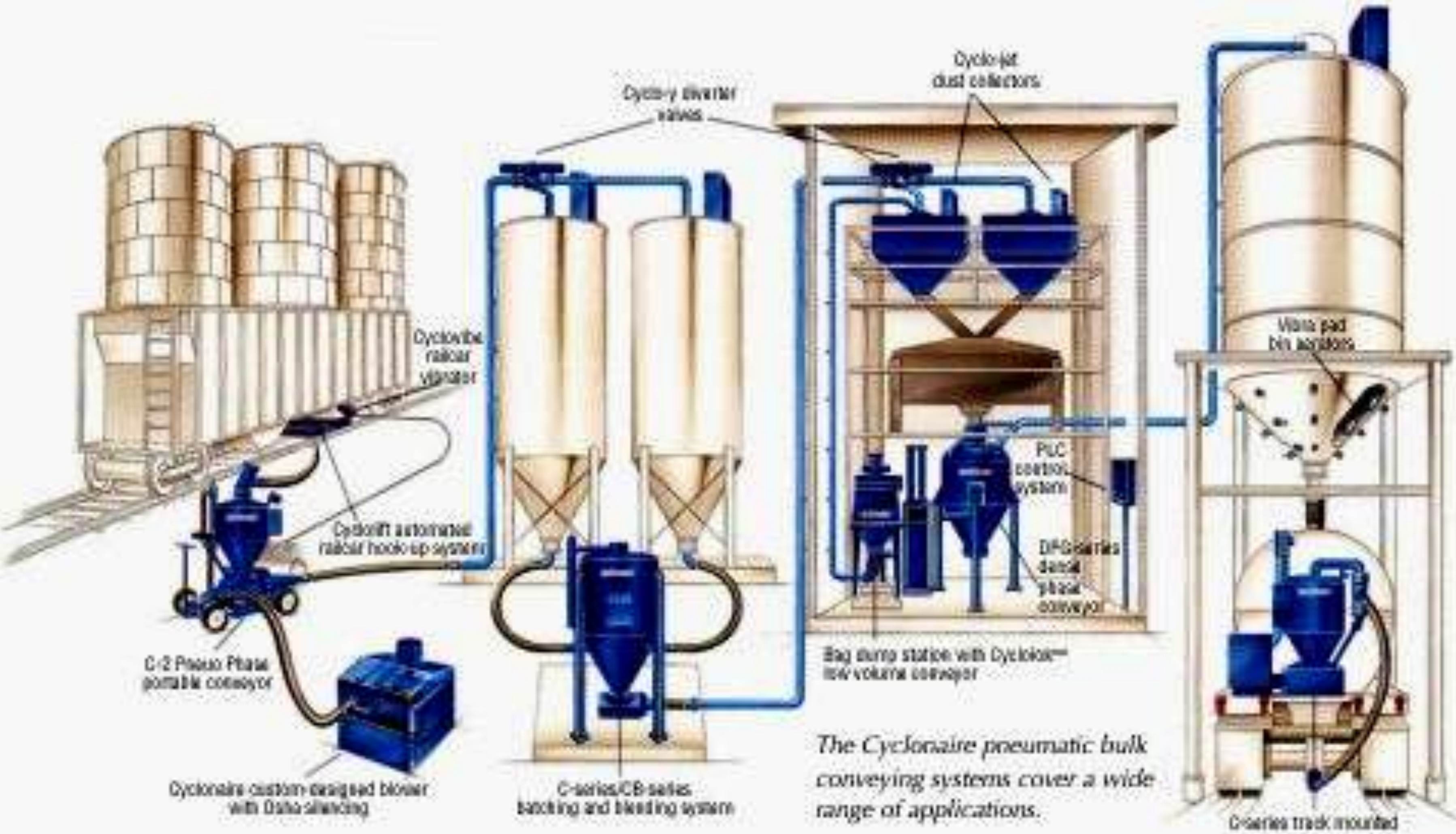


1. **Solid Dense Phase** - Very low material velocity, pipeline full of material - an excellent regime for fragile materials.

2. **Discontinuous Dense Phase** - Low material velocity - with high line loading ... material moves in plug flow fashion - best regime for most applications in which power economy, pipe erosion, and material degradation issues are important.

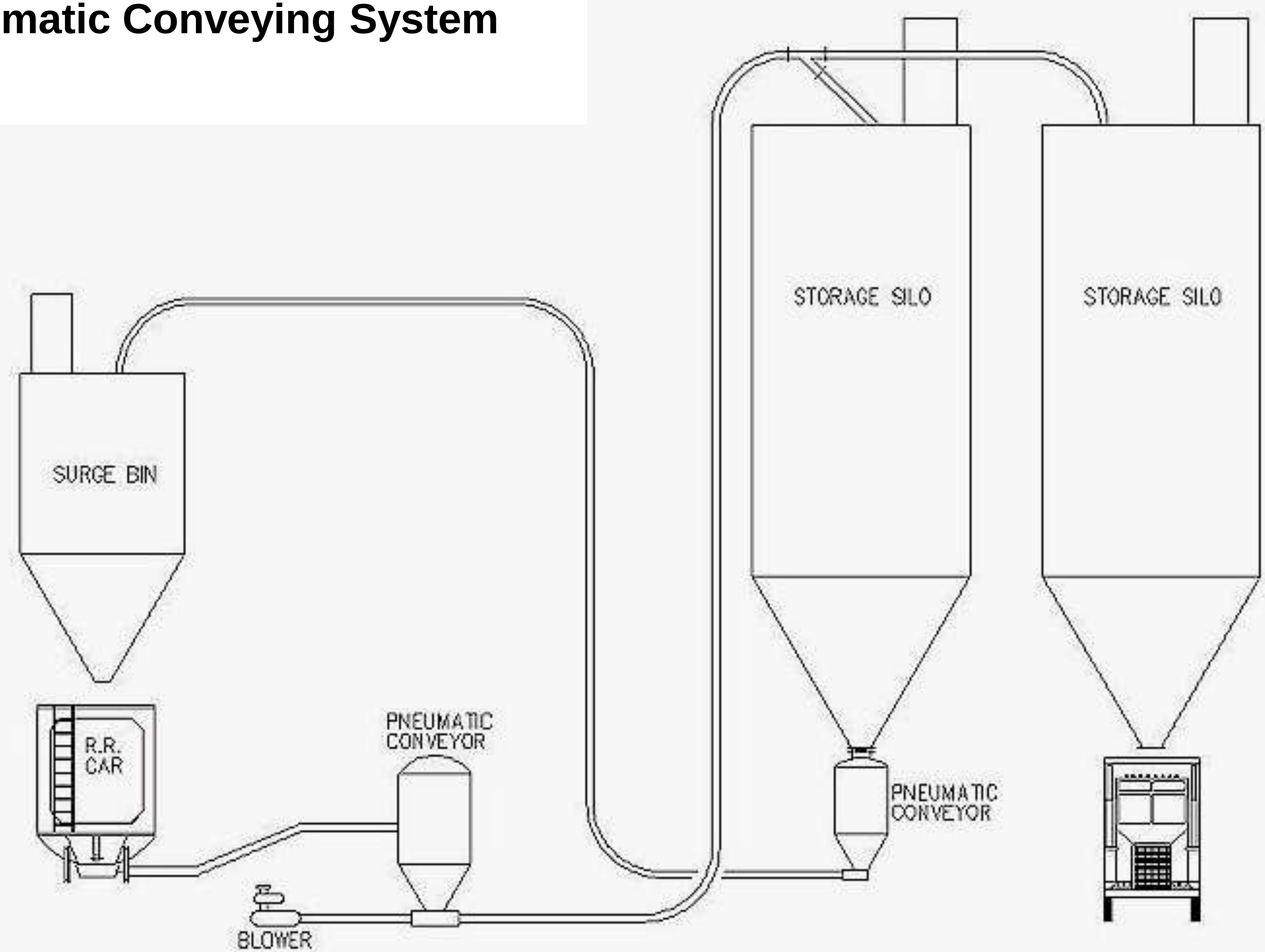
3. **Continuous Dense Phase** (Moving Bed) - Higher velocity than discontinuous dense phase, but much lower than dilute phase. Used for handling powders that can be fluidized.

4. **Dilute Phase** - Material velocity above the saltation velocity - no upper limit to the velocity - least attractive regime for operating economy - unsuitable for fragile or abrasive materials or materials with wide particle size distribution.

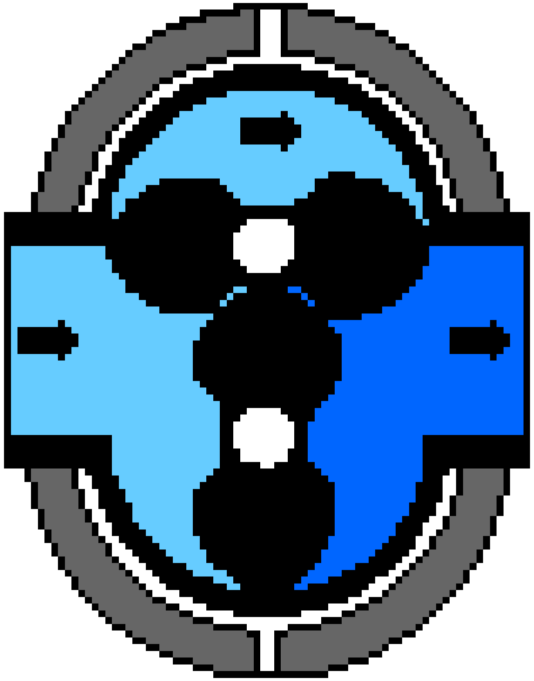


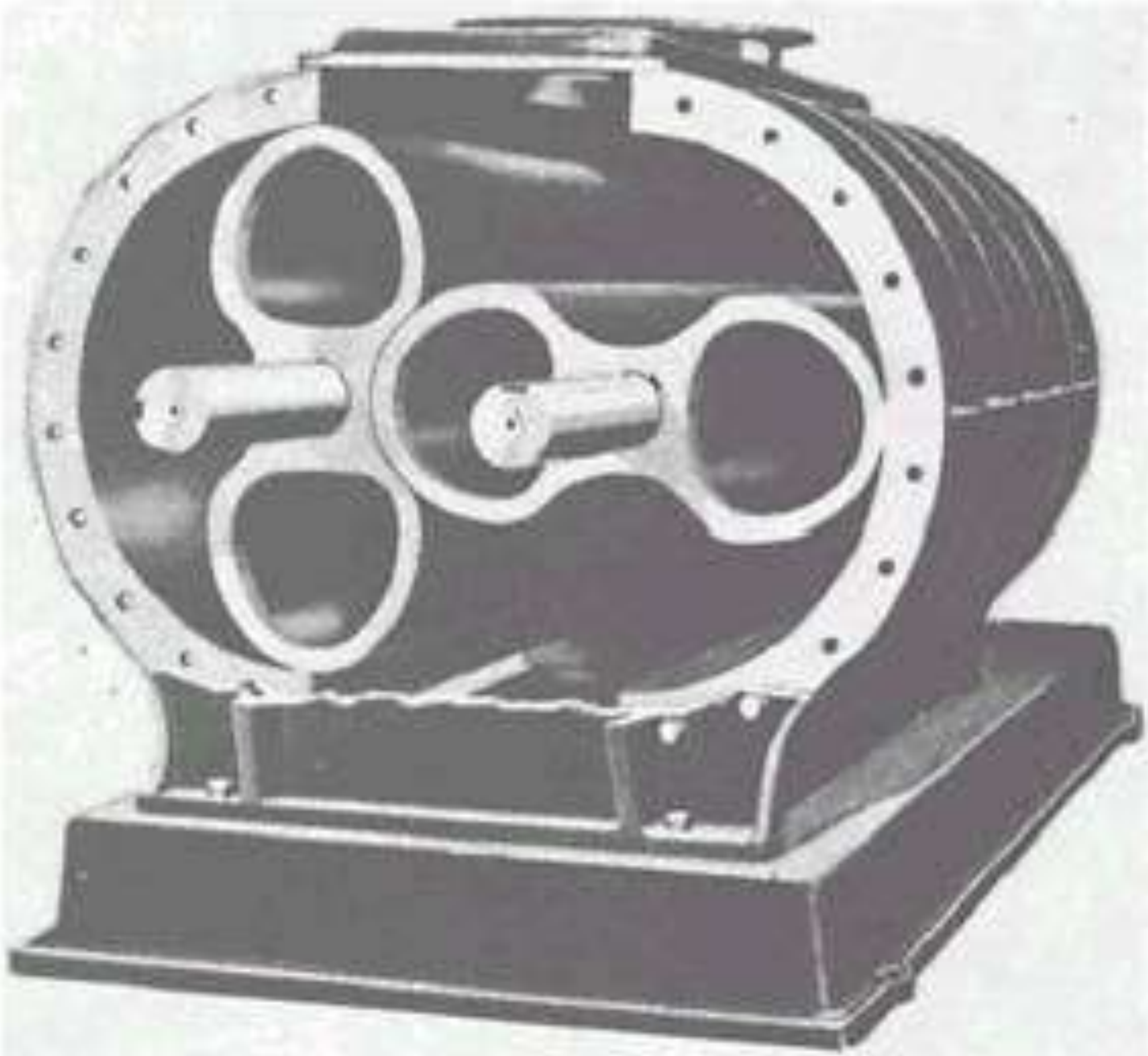
The Cyclonaire pneumatic bulk conveying systems cover a wide range of applications.

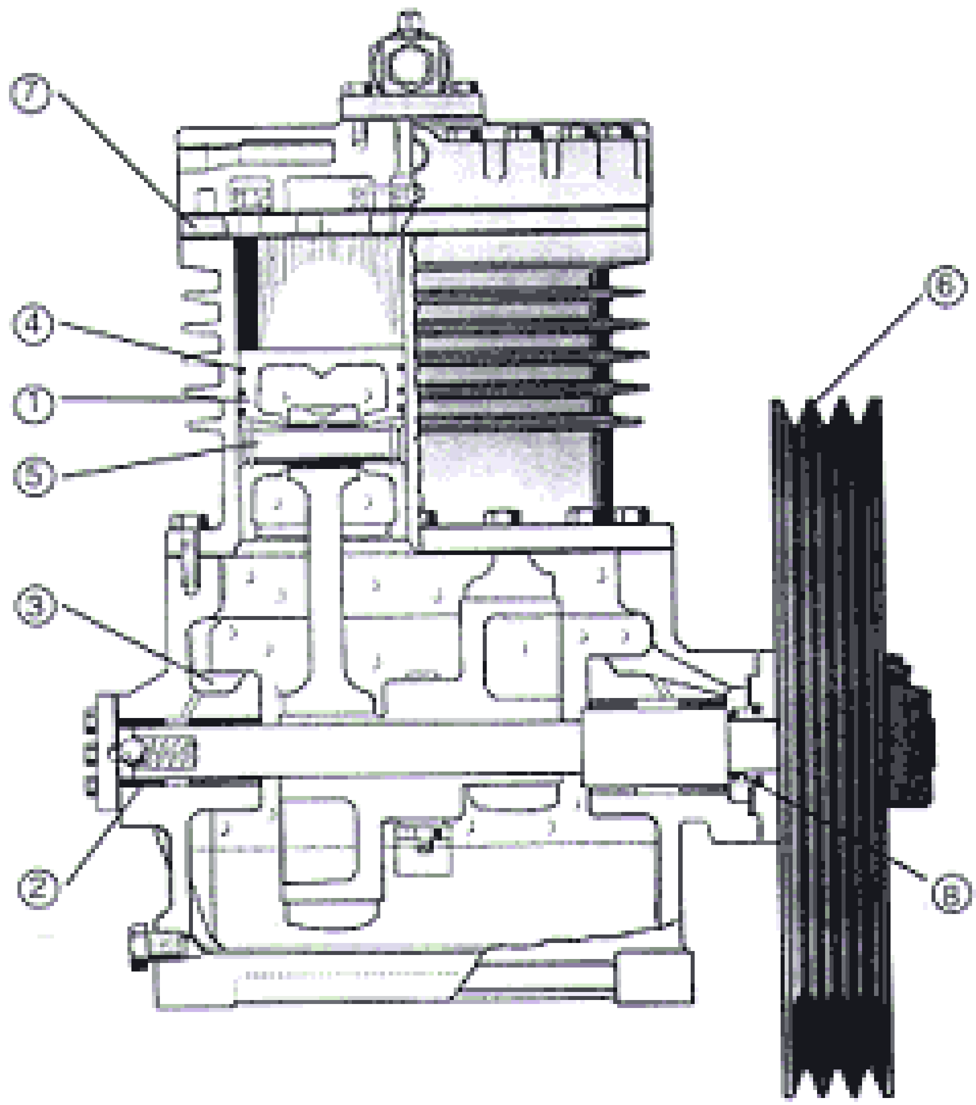
Pneumatic Conveying System



As the dual, figure-8 shaped impellers rotate, a fixed quantity of gas (or air) at the inlet is trapped between the impeller and the casing parts. With each revolution, four of these "pockets" of gas are trapped, then forced out the discharge against whatever pressure exists in the system.







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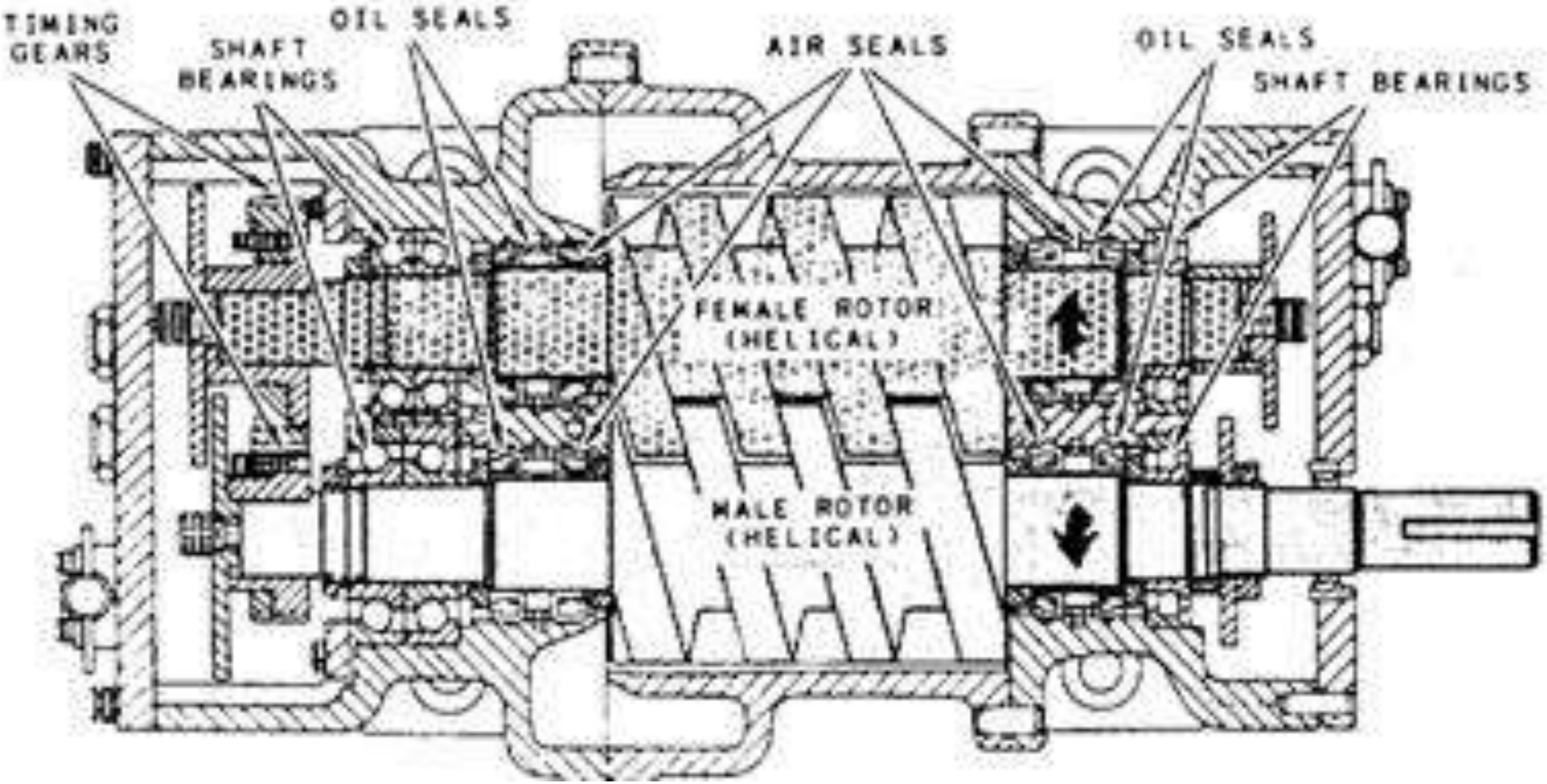
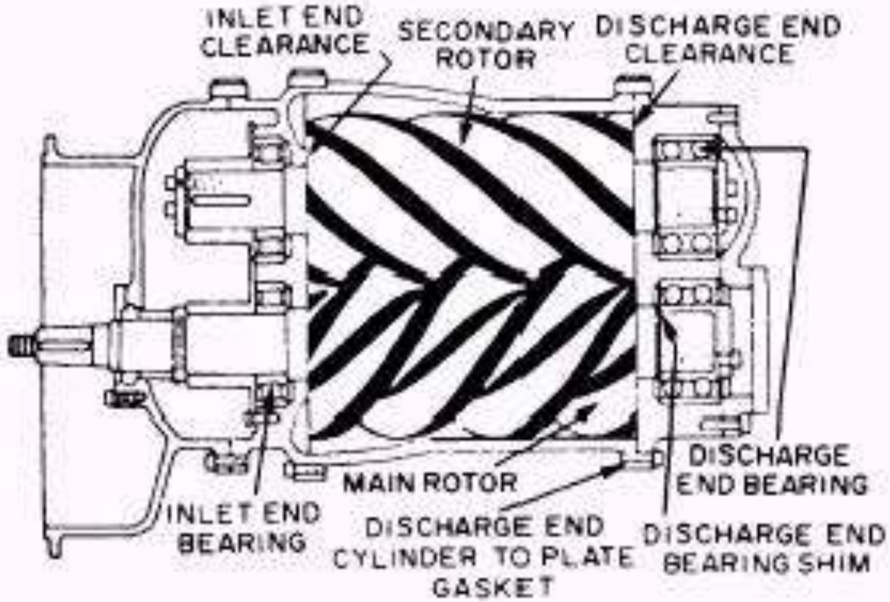
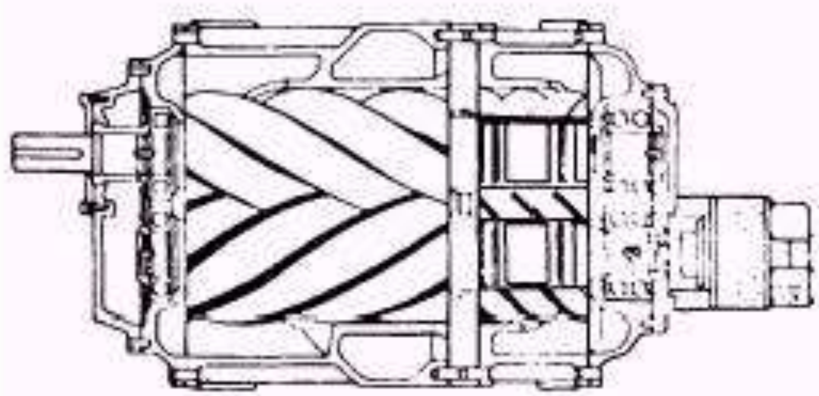

TIMING GEARS
SHAFT BEARINGS
OIL SEALS
AIR SEALS
OIL SEALS
SHAFT BEARINGS
FEMALE ROTOR (HELICAL)
MALE ROTOR (HELICAL)

HELICAL SCREW COMPRESSORS



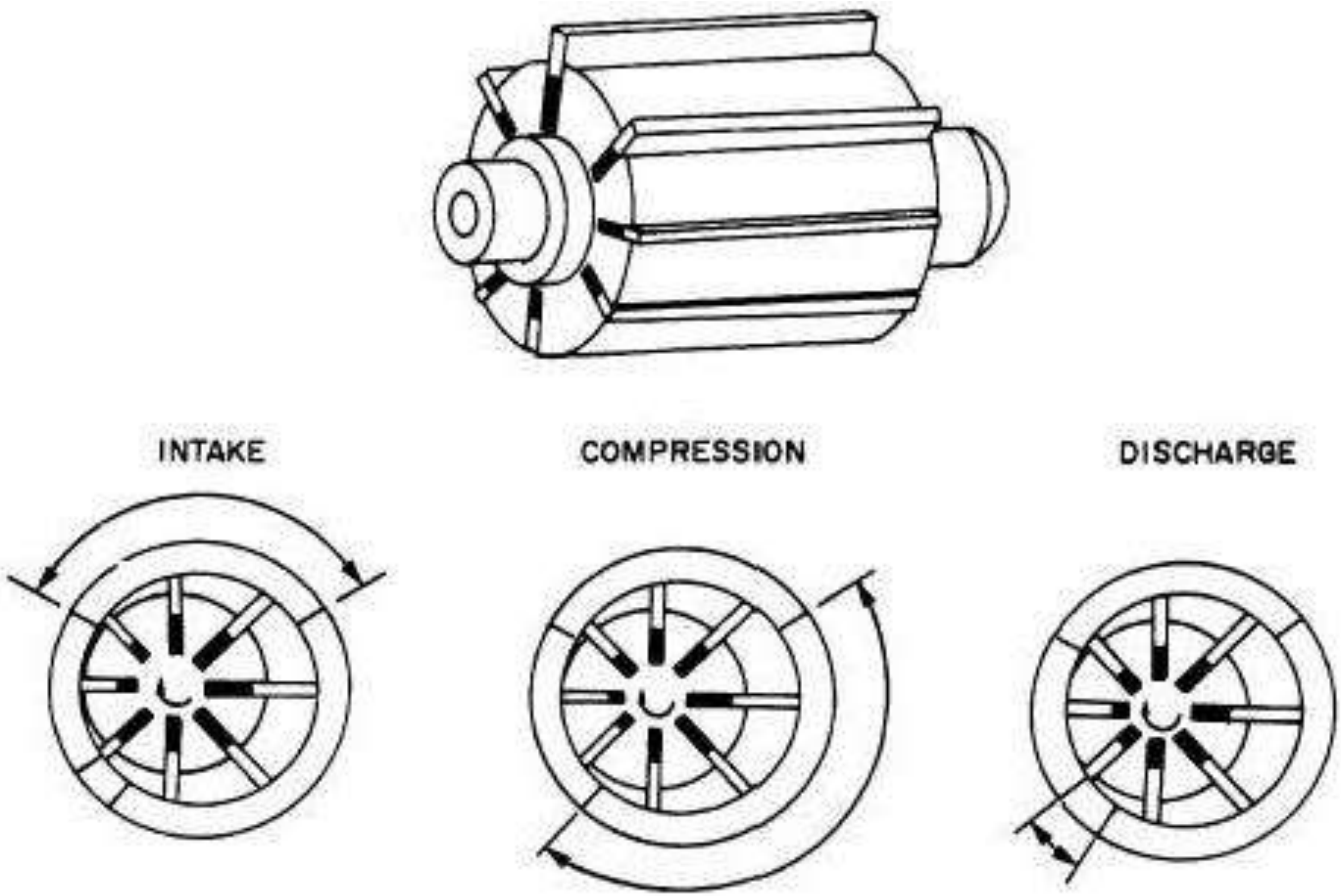
TYPICAL SINGLE-STAGE DESIGN

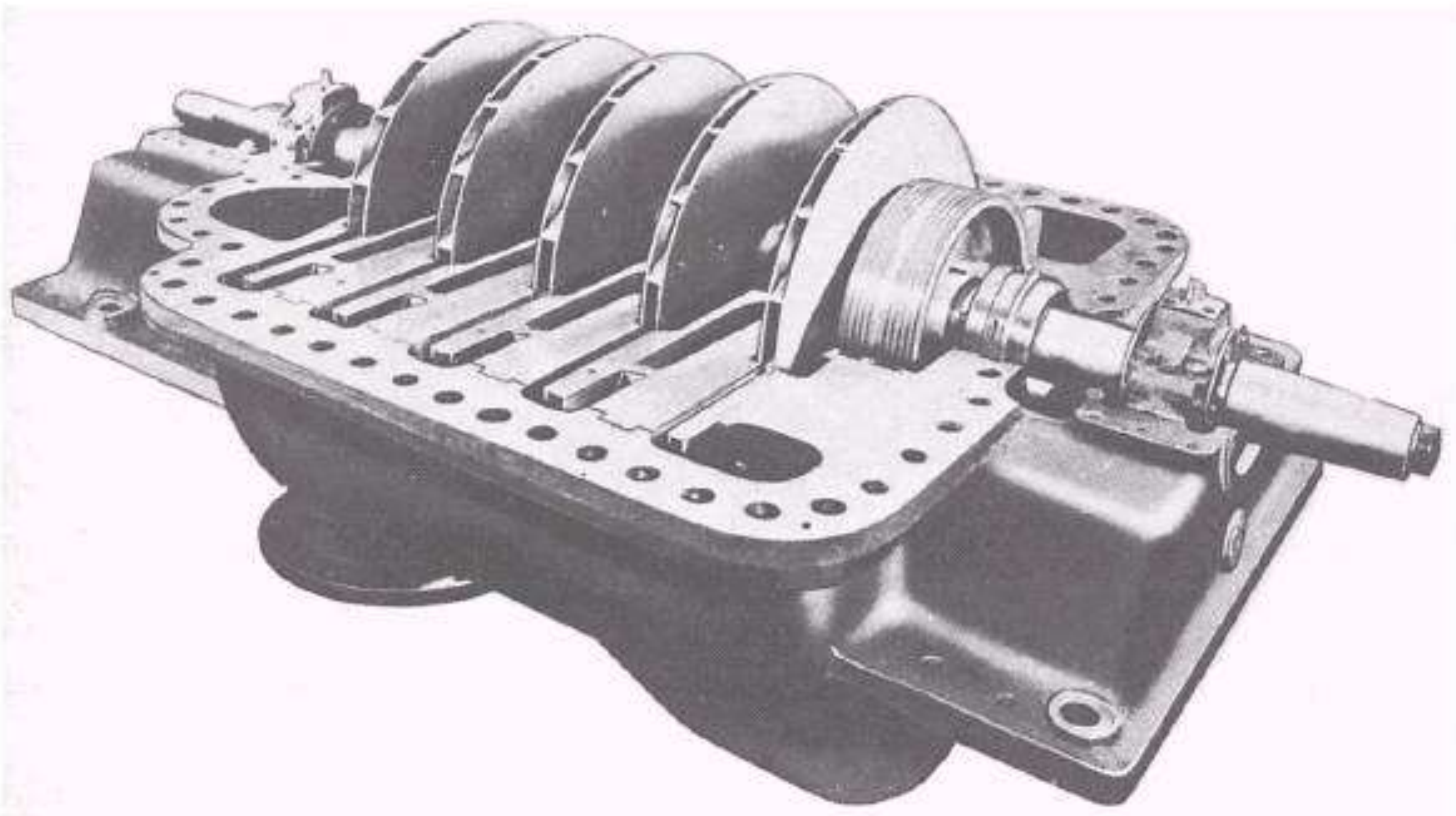


TYPICAL TWO-STAGE DESIGN


CHAMPION

Compression cycle of rotary compressor.





Internal view of a multistage centrifugal compressor.

There are five basic parts to any refrigerator (or air-conditioning system):

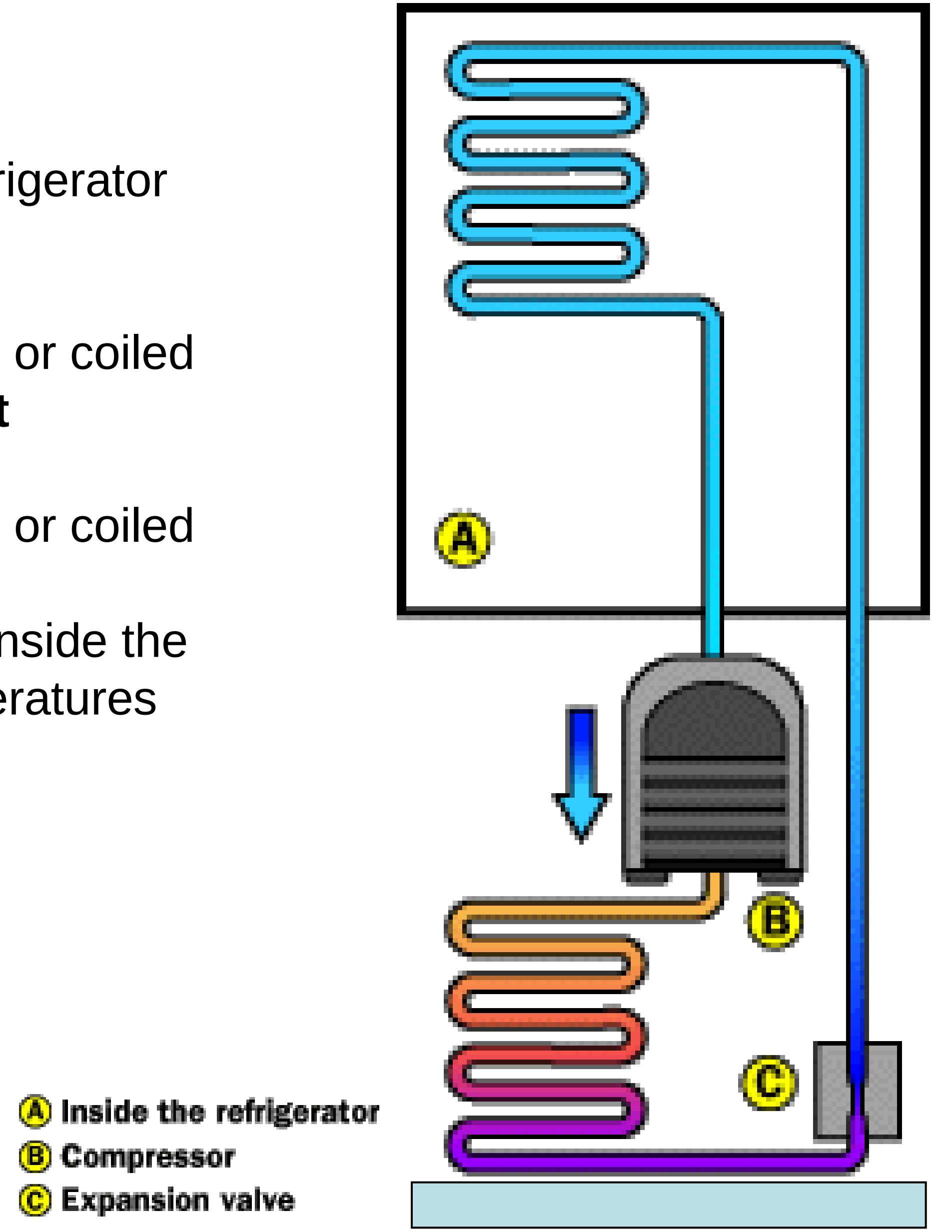
Compressor

Heat-exchanging pipes - serpentine or coiled set of pipes **outside the unit**

Expansion valve

Heat-exchanging pipes - serpentine or coiled set of pipes **inside the unit**

Refrigerant - liquid that evaporates inside the refrigerator to create the cold temperatures

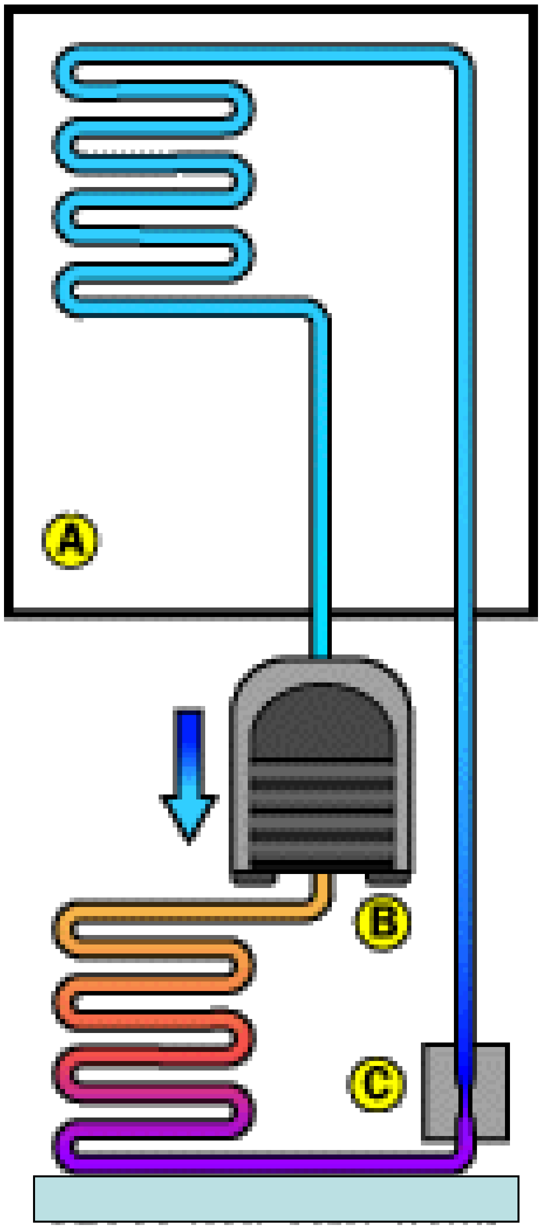


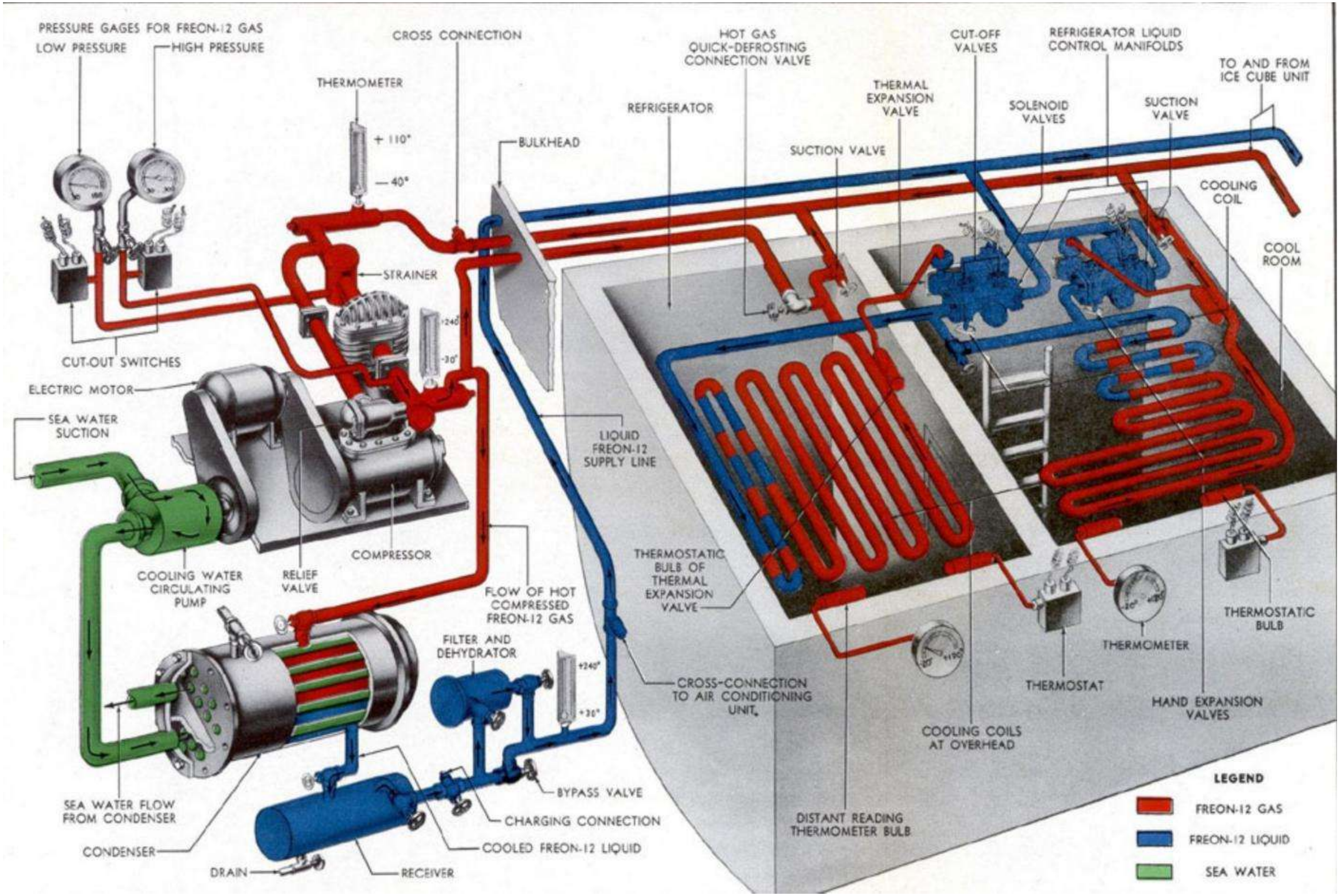
The compressor compresses the refrigerant gas. This raises the refrigerant's pressure and temperature (orange), so the heat-exchanging coils outside the refrigerator allow the refrigerant to dissipate the heat of pressurization.

As it cools, the refrigerant condenses into liquid form (purple) and flows through the expansion valve.

When it flows through the expansion valve, the liquid refrigerant is allowed to move from a high-pressure zone to a low-pressure zone, so it expands and evaporates (light blue). In evaporating, it absorbs heat, making it cold.

The coils inside the refrigerator allow the refrigerant to absorb heat, making the inside of the refrigerator cold. The cycle then repeats.




PRESSURE GAGES FOR FREON-12 GAS
LOW PRESSURE
HIGH PRESSURE
CROSS CONNECTION
THERMOMETER
+ 110°
— 40°
HOT GAS QUICK-DEFROSTING CONNECTION VALVE
CUT-OFF VALVES
REFRIGERATOR LIQUID CONTROL MANIFOLDS
TO AND FROM ICE CUBE UNIT
THERMAL EXPANSION VALVE
SOLENOID VALVES
SUCTION VALVE
REFRIGERATOR
BULKHEAD
SUCTION VALVE
COOLING COIL
COOL ROOM
STRAINER
CUT-OUT SWITCHES
ELECTRIC MOTOR
SEA WATER SUCTION
LIQUID FREON-12 SUPPLY LINE
COMPRESSOR
COOLING WATER CIRCULATING PUMP
RELIEF VALVE
FLOW OF HOT COMPRESSED FREON-12 GAS
THERMOSTATIC BULB OF THERMAL EXPANSION VALVE
THERMOSTATIC BULB
THERMOMETER
FILTER AND DEHYDRATOR
THERMOSTAT
CROSS-CONNECTION TO AIR CONDITIONING UNIT.
HAND EXPANSION VALVES
COOLING COILS AT OVERHEAD
BYPASS VALVE
SEA WATER FLOW FROM CONDENSER
CHARGING CONNECTION
DISTANT READING THERMOMETER BULB
CONDENSER
COOLED FREON-12 LIQUID
DRAIN
RECEIVER
LEGEND
FREON-12 GAS
FREON-12 LIQUID
SEA WATER


WARNING