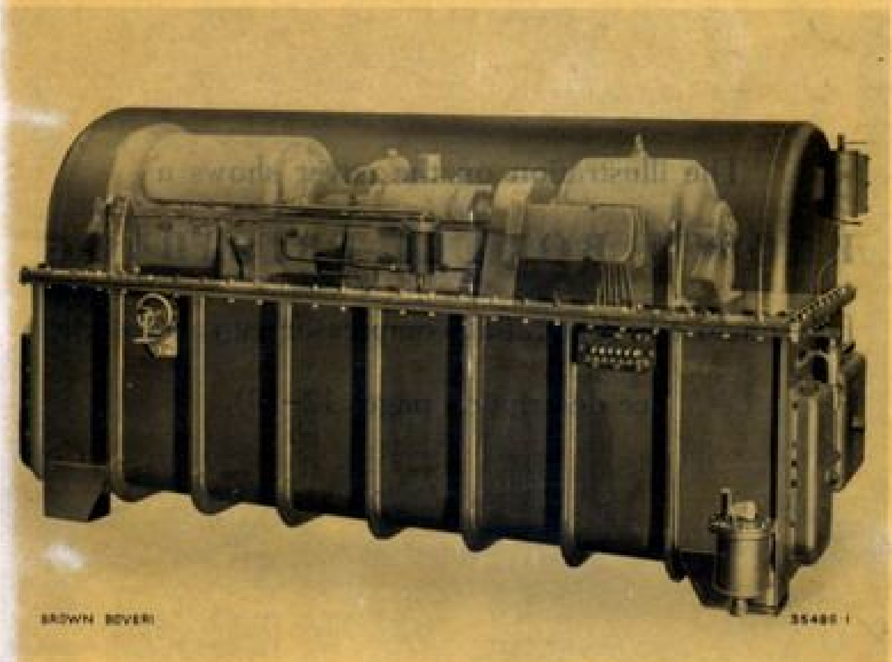
Brown Boveri
Refrigerating Turbo-Compressors



BROWN, BOVERI & COMPANY

LIMITED

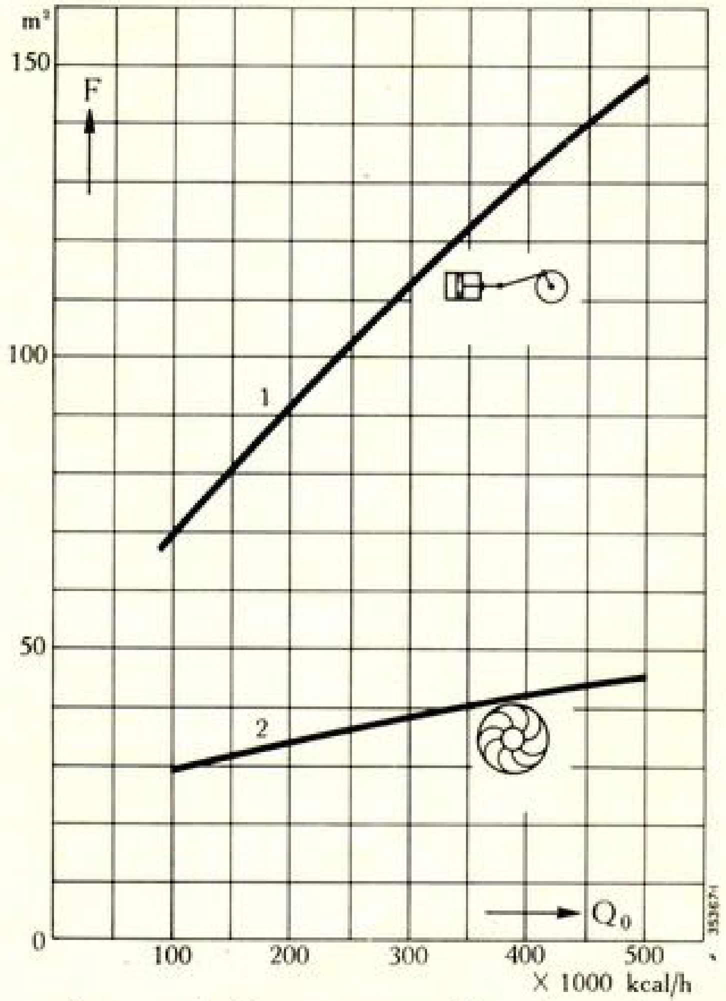
BADEN (SWITZERLAND)

1327 E - IX 1 April, 1932

Brown Boveri refrigerating turbo-compressors

Advantages:-

The compressor runs at high speed, it is therefore of small dimensions.



Space required by compressors of the reciprocating and the turbo type.

Q_0. Refrigerating effect in kcal/h.
F. Floor area of machine room with a normal lay-out.
1. For a reciprocating compressor.
2. For a **Brown Boveri Frigibloc** turbo-compressor (see pages 12–19).

Hence:-

A refrigerating plant with turbo-compressors only requires about **1/3** of the space taken by a plant with reciprocating compressors of the same output.

Brown Boveri refrigerating turbo-compressors

Advantages:-

Having no reciprocating parts, the turbo-compressor does not set up vibrations.

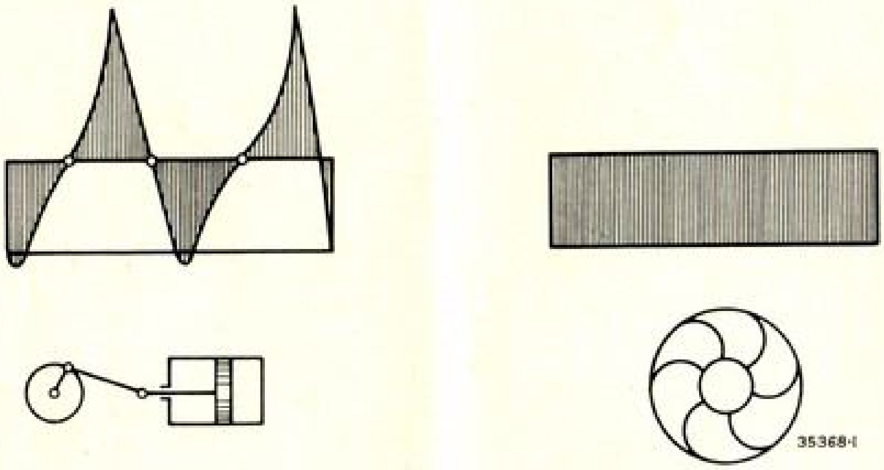


Diagram of tangential forces due to masses in movement of reciprocating compressor (left) and turbo-compressor (right).

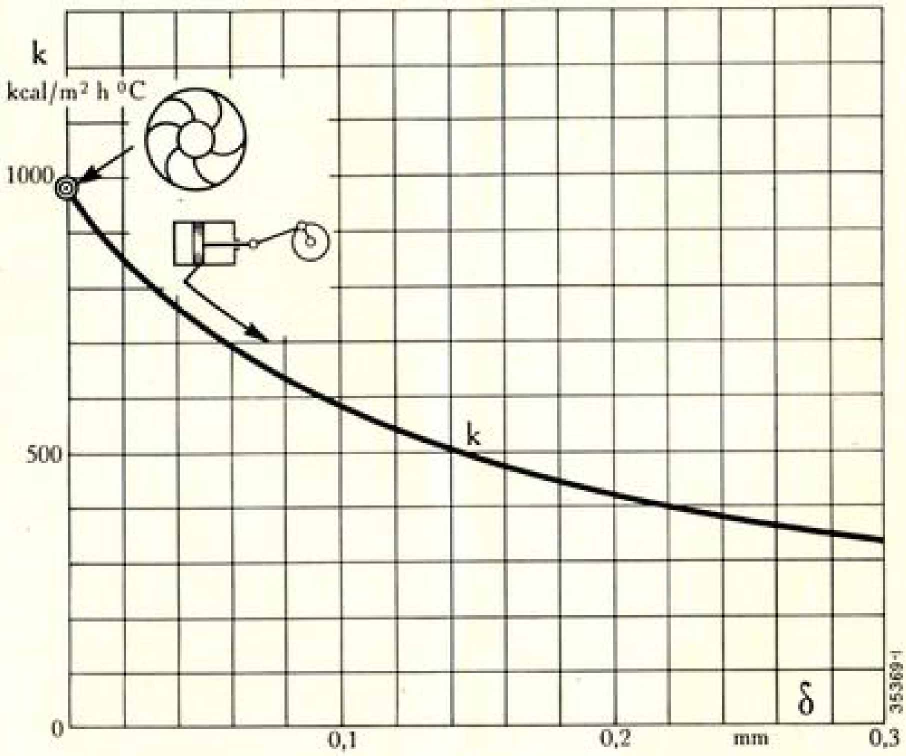
Hence:-

Simple light foundations suffice for turbo-compressors.

Brown Boveri refrigerating turbo-compressors

Advantages:-

The turbo-compressor requires no lubrication of the working surfaces coming into contact with the vapour.



Diminution of the coefficient of heat transference of the apparatus due to presence of oil film.

k = coefficient of heat transference in kcal/m² h °C; δ = thickness of oil film in mm.

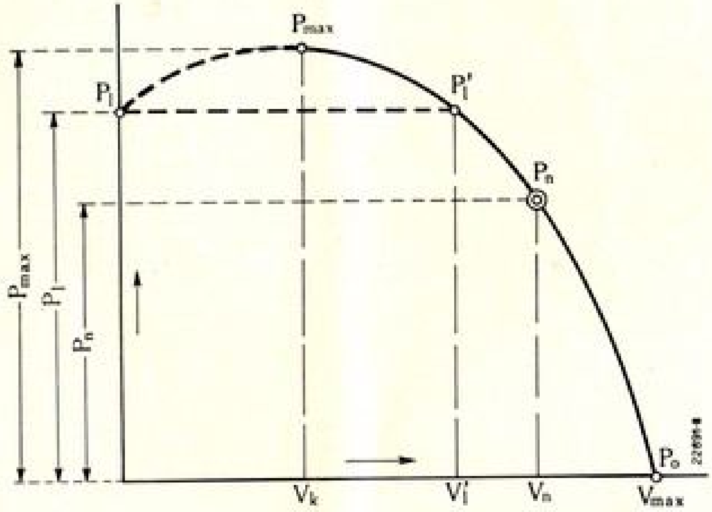
Hence:-

Heat exchange in condenser and evaporator not adversely affected by oil deposits.

Brown Boveri refrigerating turbo-compressors

Advantages:-

The turbo-compressor cannot produce a dangerously high pressure, even when the stop valve is closed.



Characteristic of a turbo-compressor at constant speed.

P_n, V_n.	normal pressure and volume.
P_{max}, V_k.	pressure and volume at the "pumping" limit.
P_l.	no-load pressure (volume = 0).
P_o, V_{max}.	max. volume (difference of pressure = 0).
P'_l, V'_l.	operating point at partial load.

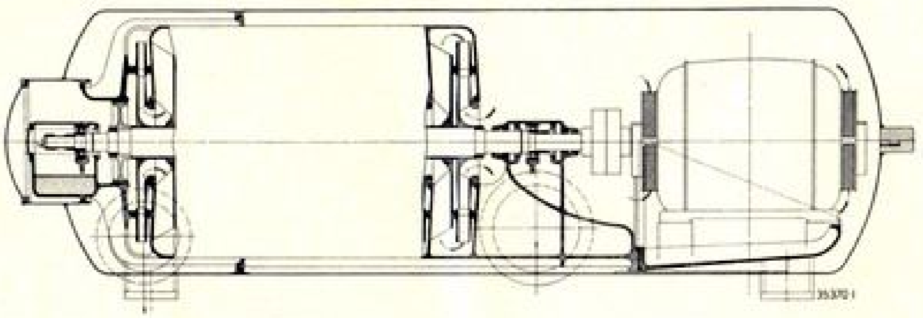
Hence:-

No risk of explosion. Safety valves unnecessary.

Brown Boveri refrigerating turbo-compressors

Advantages:-

The turbo-compressor needs no attendance for lubrication or valve setting. It can be constructed without packing glands.



Refrigerating turbo-compressor with motor, in enclosed gas-tight casing.

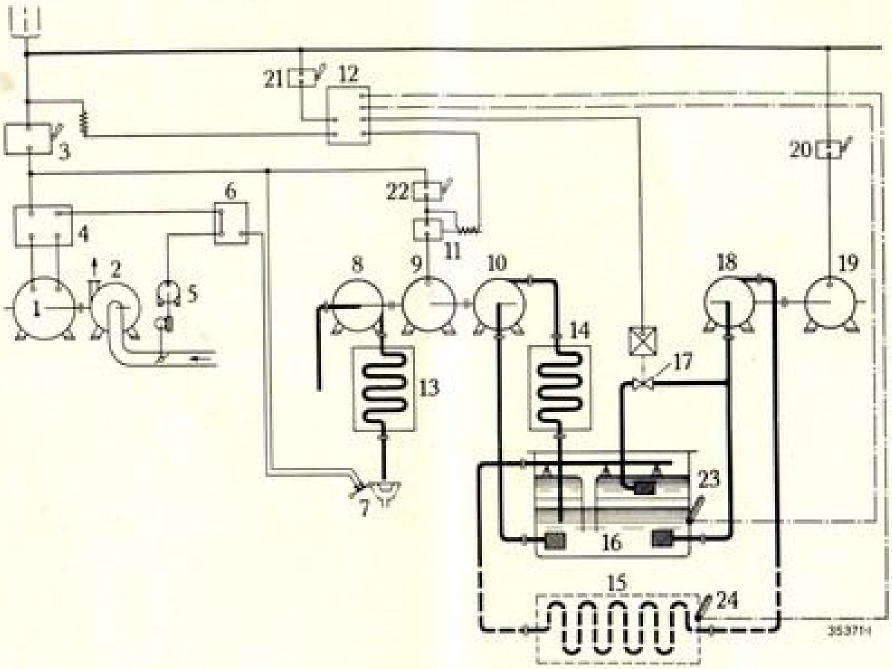
Hence:-

No leakage of vapour and no unpleasant odours in the machine room.

Brown Boveri refrigerating turbo-compressors

Advantages:-

On account of its simplicity of operation, the turbo-compressor is specially suitable for automatic plants.



Connection diagram of an automatic turbo-compressor refrigerating plant.

1. Driving motor of compressor.
2. Compressor.
3. Main switch.
4. Automatic star-delta switch.
5. Throttling valve with motor drive.
6. Relay.
7. Water flow indicator.
8. Circulating pump for cooling water.
9. Driving motor for 8 and 10.
10. Brine pump.
11. Three-pole contactor.
12. Temperature regulator.
13. Condenser.
14. Evaporator.
15. Refrigerating chamber.
16. Brine tank.
17. Automatic brine mixing valve.
18. High-pressure brine pump (circulation between tank and refrigerating chamber).
19. Driving motor.
20. — 22. Switches.
23. Temperature measuring point in brine tank.
24. Temperature measuring point in refrigerating chamber.

At certain temperature limits in the brine tank 16, the temperature regulator 12 switches the pumps 8 and 10, and by means of the rocker switch 7 the main compressor 2, automatically in and out. The same regulator keeps the temperature of the brine constant in the refrigerating chamber 24 by opening or closing the mixing valve 17.

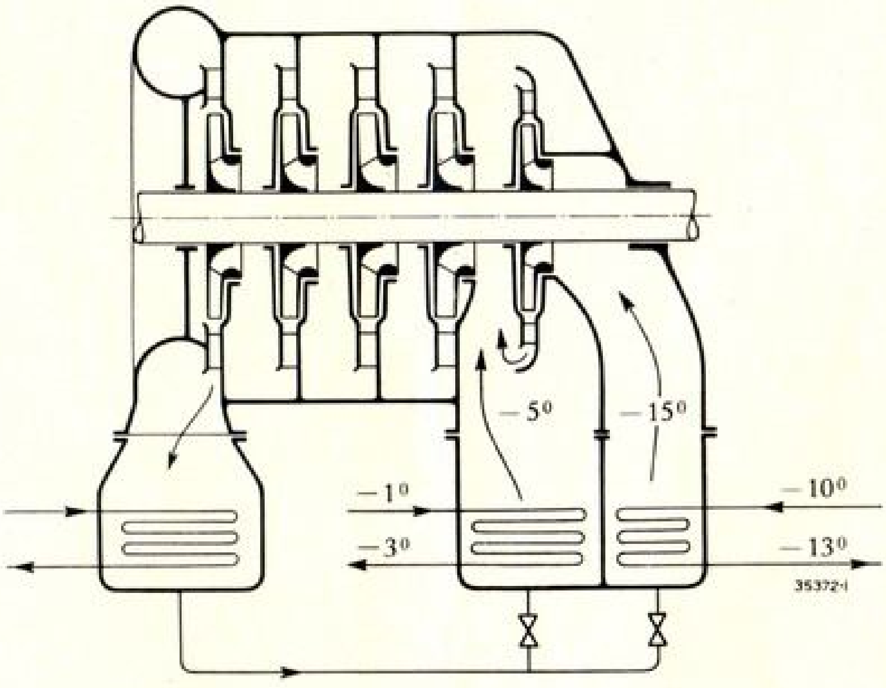
Hence:-

Reliable maintenance of the most favourable working conditions. Avoidance of operating mistakes; saving in staff.

Brown Boveri refrigerating turbo-compressors

Advantages:-

As a result of the division of the pressure in stages from impeller to impeller, two evaporators at different temperatures can also be connected to a single-cylinder compressor.



Refrigerating turbo-compressor with two inlets and two evaporators at different temperatures.

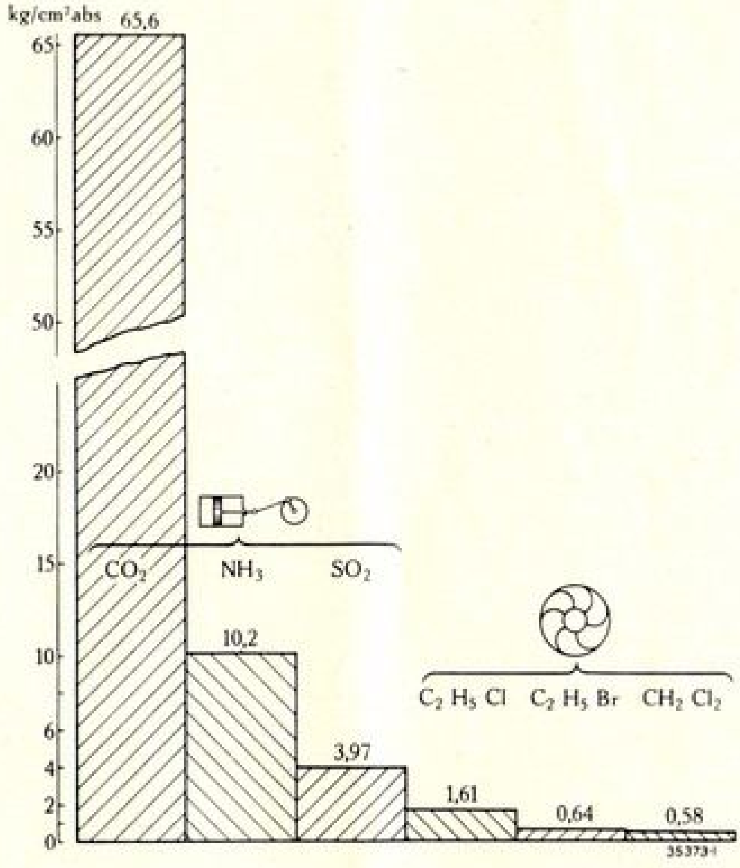
Hence:-

Saving of work of compression because part of the refrigerant evaporates at a higher temperature, and needs not, therefore, be compressed in the first impeller; this also results in a simple lay-out.

Brown Boveri refrigerating turbo-compressors

Advantages:-

For turbo-compressors, refrigerants working at low pressures are chiefly used.



Condenser pressure for various refrigerants at 25° C.

Reciprocating plants:-
- CO_2. Carbon dioxide.
- NH_3. Ammonia.
- SO_2. Sulphur dioxide.

Turbo-compressor plants:-
- C_2H_5Cl. Ethyl chloride.
- C_2H_5Br. Ethyl bromide.
- CH_2Cl_2. Methylene chloride (dichloromethane).

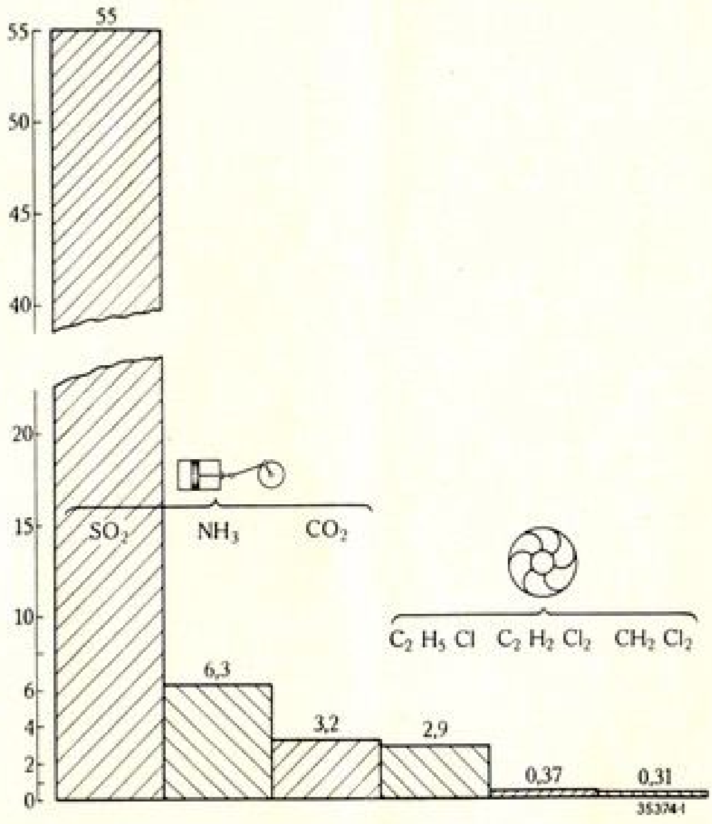
Hence:-

Simple sealing against leakage. The evaporator is always, and the condenser usually, under a vacuum. No transport of refrigerant in costly steel bottles.

Brown Boveri refrigerating turbo-compressors

Advantages:-

The new refrigerants for turbo-compressors are non-poisonous and non-explosive; they do not attack ordinary materials.



Relative poisoning effect of different refrigerants (unit: chloroform = 1·0).

Reciprocating compressor plants: -
CO_2. Carbon dioxide.
NH_3. Ammonia.
SO_2. Sulphur dioxide.

Turbo-compressor plants: -
C_2H_5Cl. Ethyl chloride.
$C_2H_2Cl_2$. Dichloroethylene.
CH_2Cl_2. Methylene chloride (dichloromethane).

Hence:-

No danger to health of attendants. No costly special materials. For the condenser and evaporator, brass tubes with their high heat conductivity can be used.

Brown Boveri refrigerating turbo-compressors

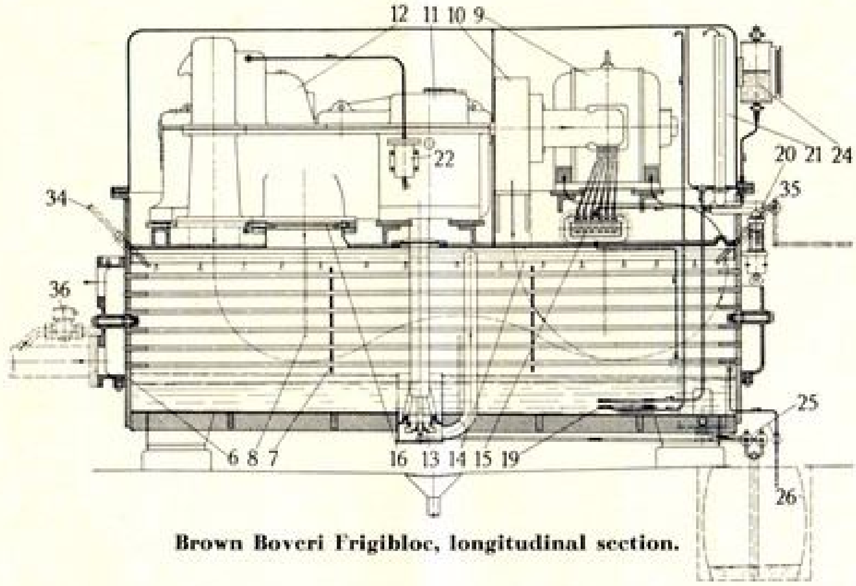
Construction:-

The most suitable form of construction of refrigerating turbo-compressors is the

BROWN BOVERI FRIGIBLOC

for 100,000 - 1,000,000 kcal/h

(33–330 standard tons of refrigeration)



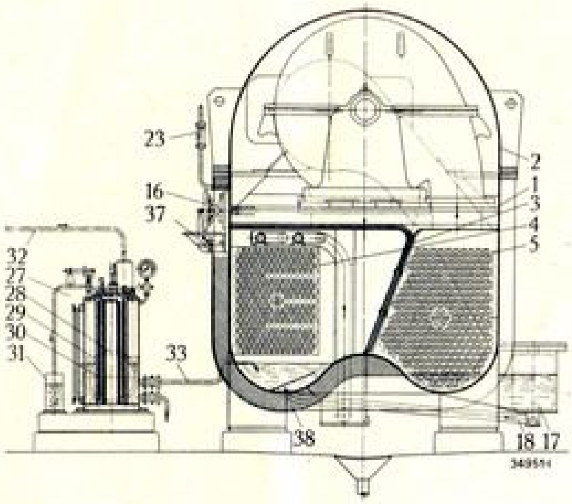
Brown Boveri Frigibloc, longitudinal section.

1. Casing of "bloc".
2. Cover.
3. Partition between evaporator and condenser.
4. Evaporator.
5. Condenser.
6. Tube plate.
7. Supporting plate in evaporator.
8. Supporting plate in condenser.
9. Motor.
10. Fan for cooling the motor and circulating the gas in the condenser.
11. Gear.
12. Compressor.
13. Circulating pump.
14. Sprinkling tubes.
15. Terminal box.
16. Hand-operated or automatic throttle valve in compressor suction pipe for temperature regulation.
17. Automatic throttle valve with float.
18. Refrigerant from the condenser to the evaporator.
19. Cooling coil in inlet pipe of air collector.

Brown Boveri refrigerating turbo-compressors

Construction:-

Compressor with drive and accessories contained in the smallest possible space.



Brown Boveri Frigibloc, cross section.

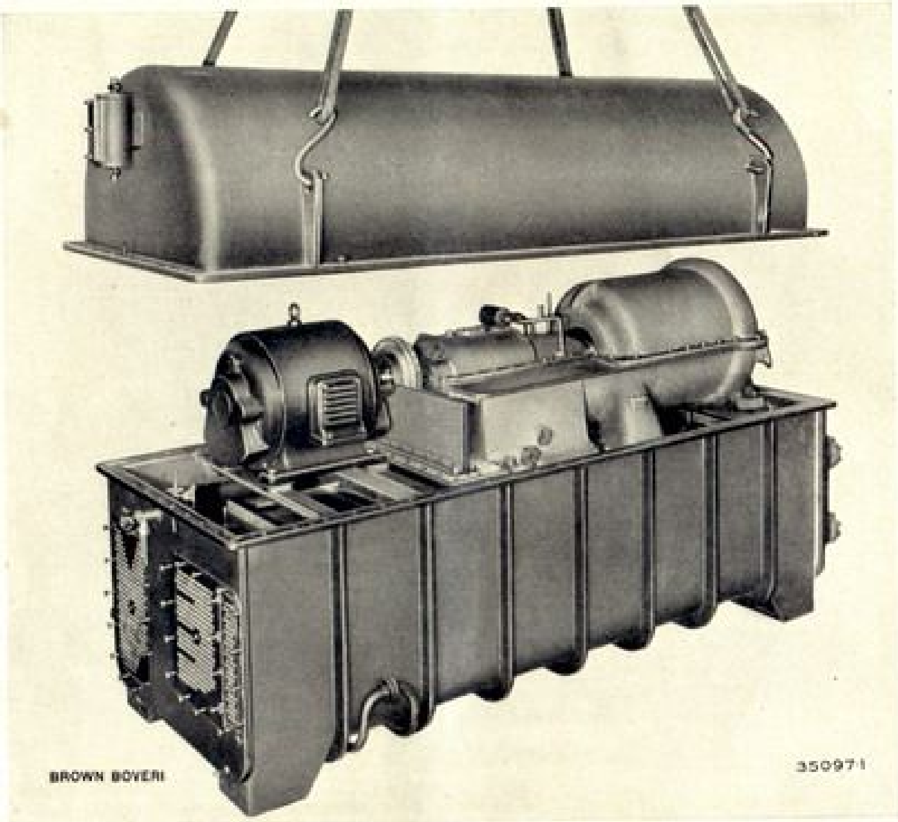
20. Air indicator in inlet pipe.
21. Air collector.
22. Lubricant separator for the sealing vapour.
23. Lubricant indicator.
24. Container for sealing liquid.
25. Filling and drain cock.
26. Container for refrigerant.
27. De-aerating set.
28. Motor.
29. Vacuum pump (used when starting up).
30. Cooler for separation of refrigerant.
31. Air indicator.
32. Air from collector to vacuum pump.
33. Refrigerant from the cooler to the evaporator.

Safety devices:-

34. Thermostat for switching off the motor at too high a compression temperature.
35. Thermostat for switching off the motor at too high a pressure.
36. Water circulation indicator for switching off the motor when the circulating water supply fails.
37. Switch to prevent starting up with the throttle valve in compressor suction pipe open.
38. Lagging.

Brown Boveri Frigibloc

Casing and accessories



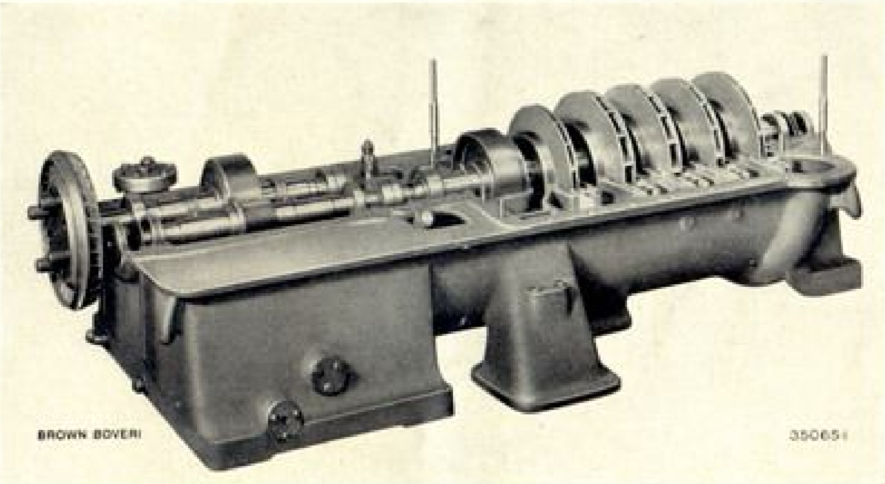
**Frigibloc for 300,000 kcal/h (100 tons) during erection.
End covers removed.**

The illustration shows the machines and apparatus. The horizontal joint of the casing is kept tight by means of a sealing groove filled with liquid refrigerant.

In the lower part are placed the evaporator and the condenser. In both of these brine or cooling water flows **through** the tubes (normally of brass or copper); the refrigerant evaporates and condenses in the space surrounding the tubes; this arrangement is in accordance with the ratios of the volumes. The tubes can be cleaned out with brushes after removing the side covers, without vapour escaping or air entering.

Brown Boveri Frigibloc

Turbo-compressor and gear



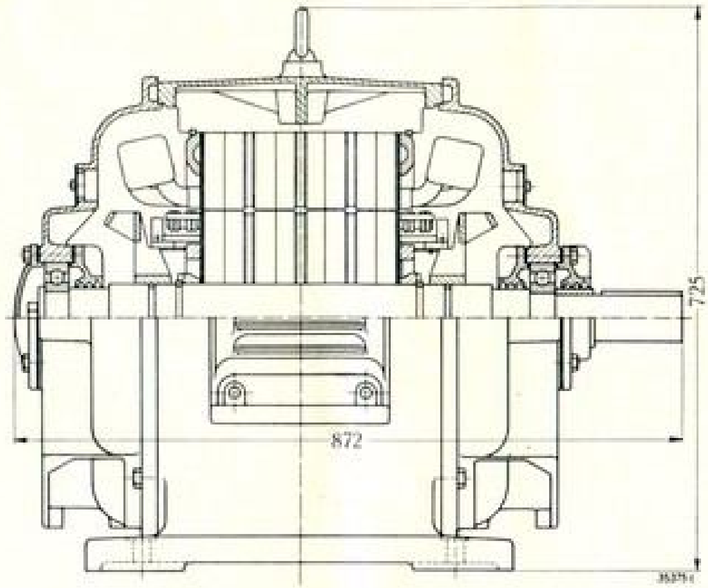
Refrigerating turbo-compressor for 300,000 kcal/h (100 tons) with gear drive incorporated. n = 2900/8300 r. p. m.

The turbo-compressor consists of several stages, the number of which depends on the pressure conditions. Special attention is paid to the quality of the material of the impellers and to careful fixing of the blades.

The compressor is driven through a gear. The reliability of this gear is amply vouched for by the fact that over 1000 such drives have been supplied for powers up to 12,000 kW.

Brown Boveri Frigibloc

Motor



Squirrel cage motor, 82 kW, 2900 r. p. m. with ball bearings.

The simplest form of drive is constituted by a squirrel-cage motor for low tension a. c. (max. 650 V). Inadmissible current rushes are avoided by special windings and star-delta starting. The refrigerant has no harmful effects on the windings; this has been proved by one year's continuous test.

In the case of slip-ring motors, the brushes are operated through non-rotating packing glands sealed by membranes.

Synchronous or d.-c. motors are fitted with packing glands on account of supervision of the commutator. By using high-grade steel for the shaft, the diameter of the glands is kept as small as possible.

Brown Boveri Frigibloc

Circulation of refrigerant

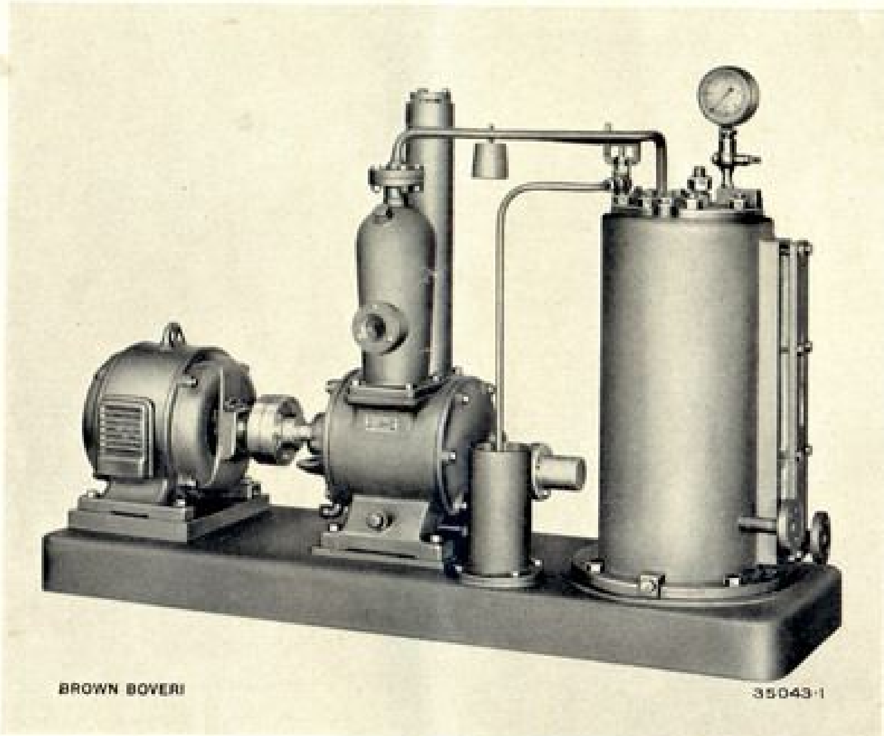
Circulating pump for the liquid refrigerant, driven by worm gearing from the main gear wheel shaft.

A circulating pump delivers the liquid refrigerant, which has collected underneath, back to the upper part of the evaporator, thus ensuring active circulation with a corresponding high coefficient of heat transference.

The expansion between the condenser and the evaporator is controlled by an automatic throttle valve with float.

Brown Boveri Frigibloc

Removal of air

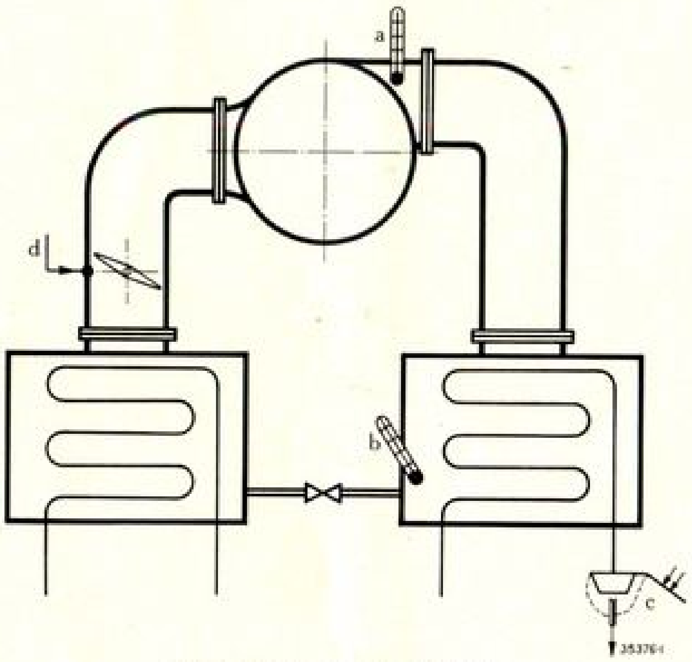


Air pump with jet cooler.

For the removal of the air, a small air pump with motor drive is provided, mounted separately near the machine. It has to run before the first starting up and afterwards only at long intervals.

Brown Boveri Frigibloc

Safety devices



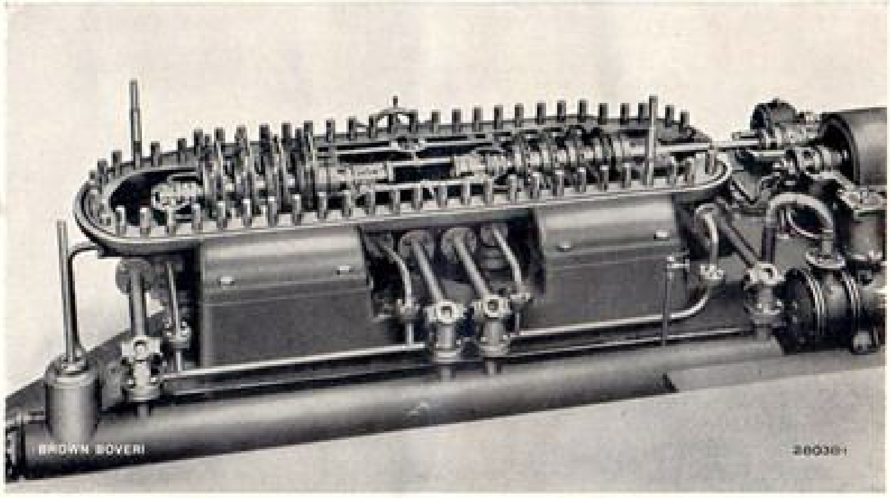
Safety devices on the Frigibloc.

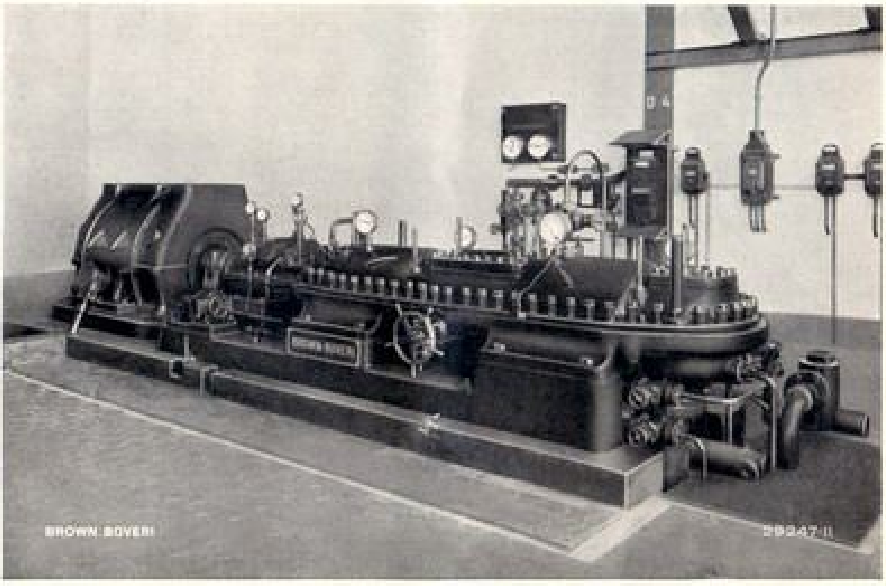
a, b. Contact thermometers causing machine to be shut down in case of too high a temperature at the outlet of the compressor or in the condenser.
c. Rocker switch for shutting down the machine in case of lack of cooling water.
d. Interlocking contact preventing machine being started up with throttle valve open.

The machine being enclosed, suitable devices ensure reliable operation and shutting down in case of disturbance.

Brown Boveri refrigerating turbo-compressors

Machines for outputs over 1,000,000 kcal/h (330 tons)



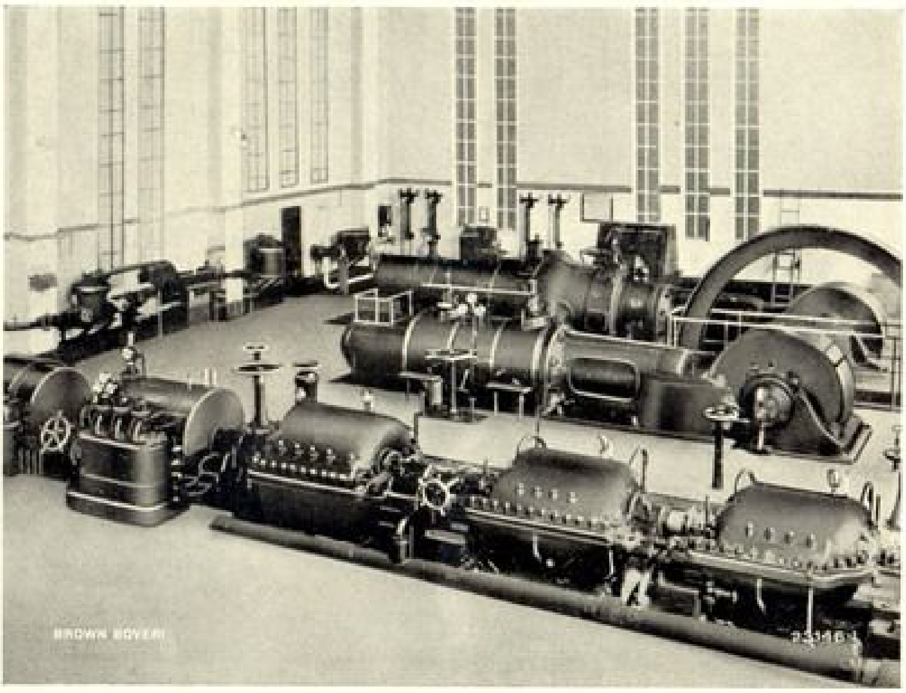


Ammonia turbo-compressor for 1,540,000 kcal/h (506 tons), – 15/ + 27° C (+5/81° F), n = 16,000 r. p. m.

On account of the size of the driving machine, large machines are constructed with outside drive and, as far as possible, with only one packing gland; the bearings are placed in the vapour space.

Brown Boveri refrigerating turbo-compressors

The largest refrigerating turbo-compressor in the world

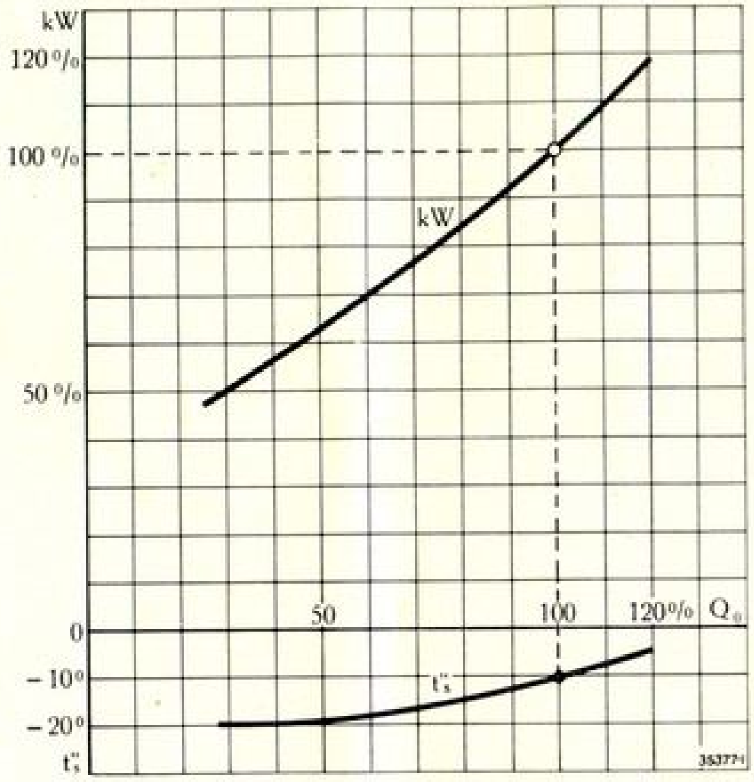


Ammonia turbo-compressor for 6,000,000 to 8,000,000 kcal/h – (2000–2640 tons) - 15/+30° C (5/86° F), n = 6000 r. p. m.

The refrigerating turbo-compressor shown above, which was started up at the beginning of 1927, is the first and also the largest of this kind to be built. Since that time it has given every satisfaction in continuous service.

Brown Boveri refrigerating turbo-compressors

Adaptation to variable operation conditions



Characteristic of a refrigerating plant with turbo-compressor.

Q_o. Refrigerating effect } as % of normal value.
kW. Power input }
t_s''. Brine outlet temperature in °C.

With a decreasing refrigerating effect, the turbo-compressor can produce a larger pressure ratio and consequently, when the temperature of the cooling water remains constant, a correspondingly lower brine temperature. In the case of a reduced temperature drop, e. g. when starting up after a long period of rest, the delivery of the turbo-compressor, and therefore the refrigerating effect, increases, thus shortening the time to attain the normal operating condition.

Brown Boveri refrigerating turbo-compressors

Kindly give the following information with enquiries:-

(A) For complete machines including condenser and evaporator

1. Refrigerating output
2. Temperature of cooling water
3. Available quantity of cooling water
   (or at least state if a plentiful supply of cooling water is available or not)
4. Temperature of the brine at the inlet and outlet of the evaporator

(B) For refrigerating turbo-compressors without accessories

1. Refrigerating output
2. Temperature of liquefaction
3. Temperature of vaporization
4. Refrigerant

(C) For the driving machine

1. With motor drive:-
   Kind of current
   Voltage
   Frequency
   (If necessary, give particulars of special requirements, e. g. power factor improvement)

2. With steam turbine drive:-
   (Generally only pays for powers of about 1,000,000 kcal/h [330 tons] and more)
   Steam pressure and temperature
   Back pressure, or temperature of cooling water