BRODSKI POMOĆNI SUSTAVI

Cjevovodi opće službe

Ostale primjene na brodu

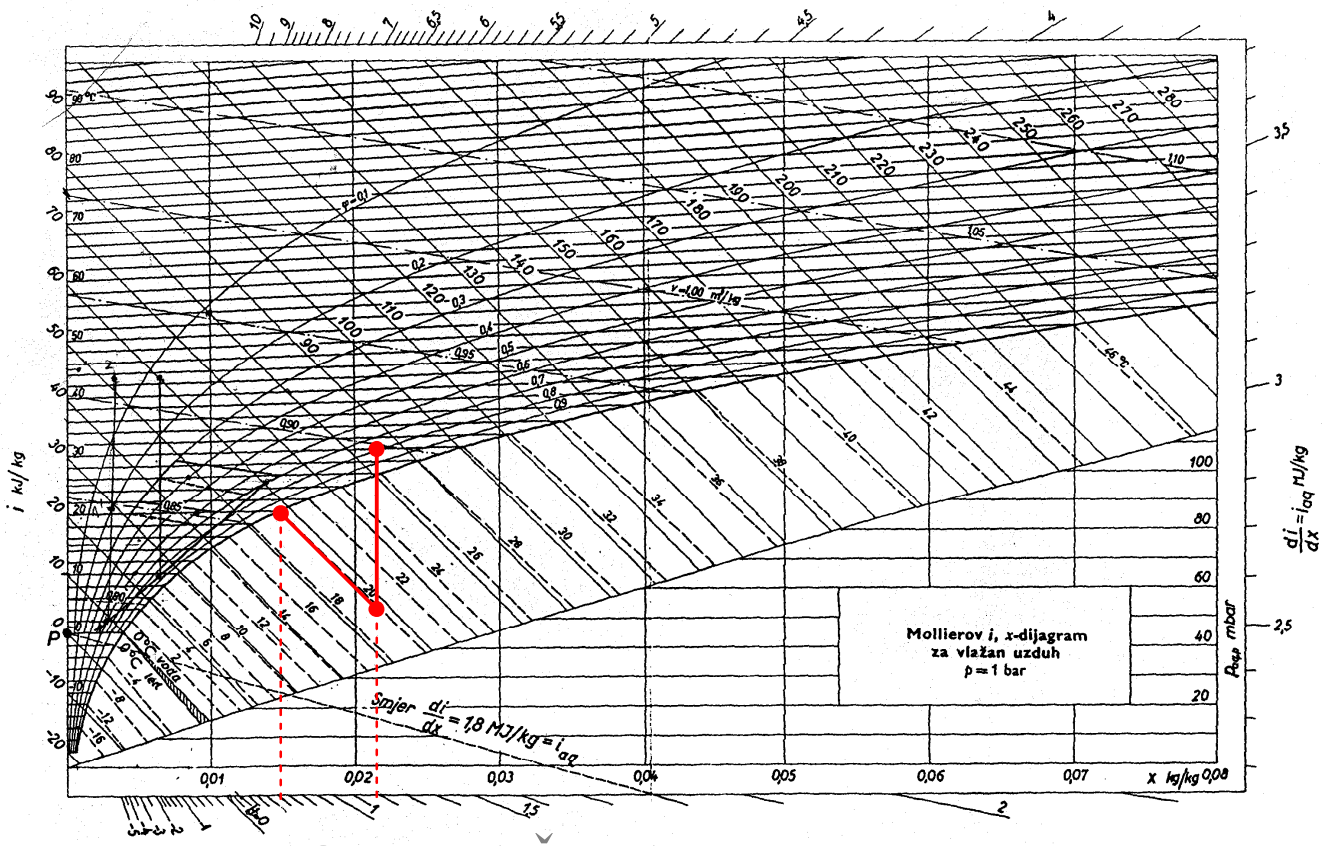
Ostale primjene

- sustav klimatizacije
- sustav hlađenja na brodovima za prijevoz ukapljenog plina (LPG, LNG)
- sustav hlađenja skladišta
- rashladni sustav kontejnera
- rashladni sustav za pothlađivanje i zamrzavanje ribe
- rashladni sustav niskotlačnog CO_2

Klimatizacija

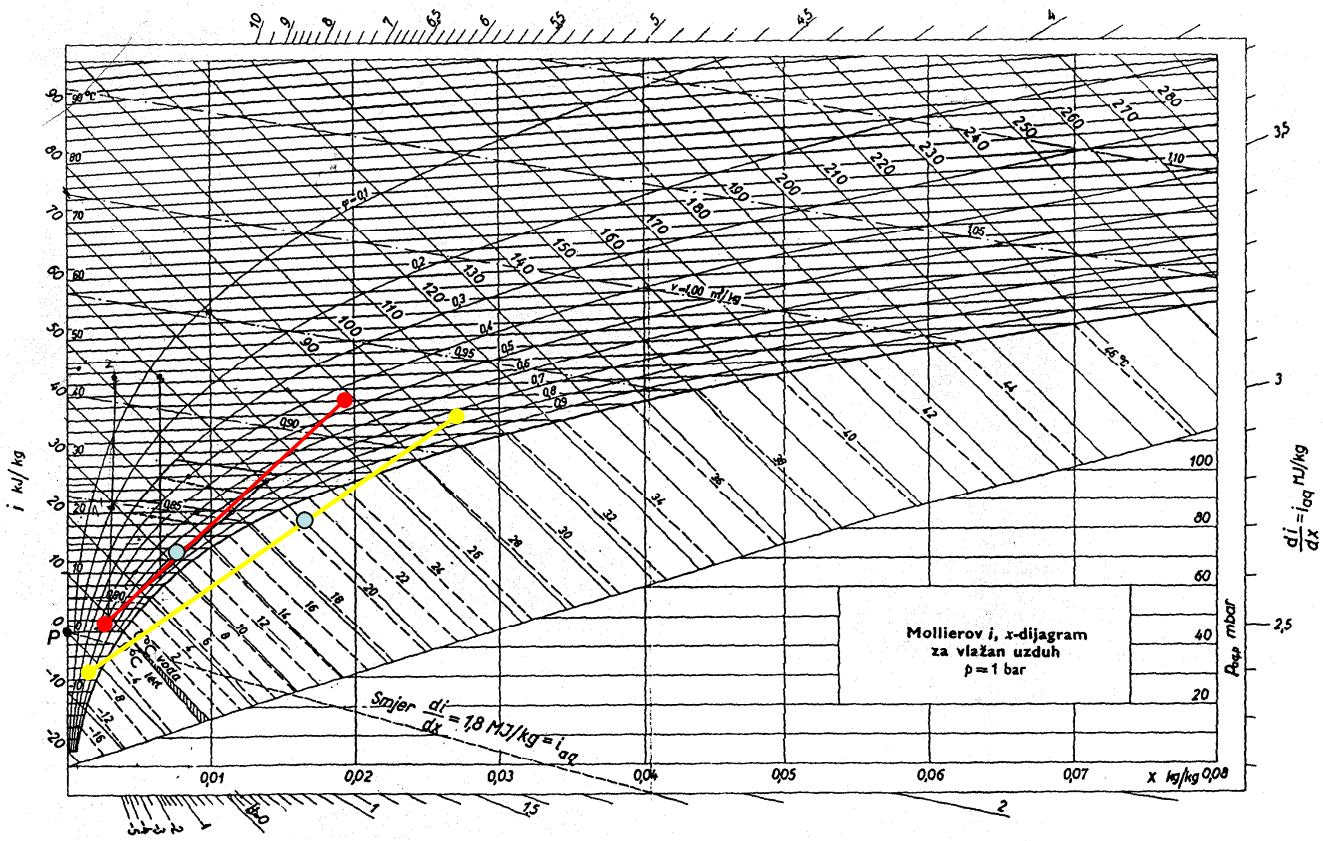
- nadgrađa
- kontrolne prostorije strojarnice
- drugih prostora

Vlažni zrak - hlađenje

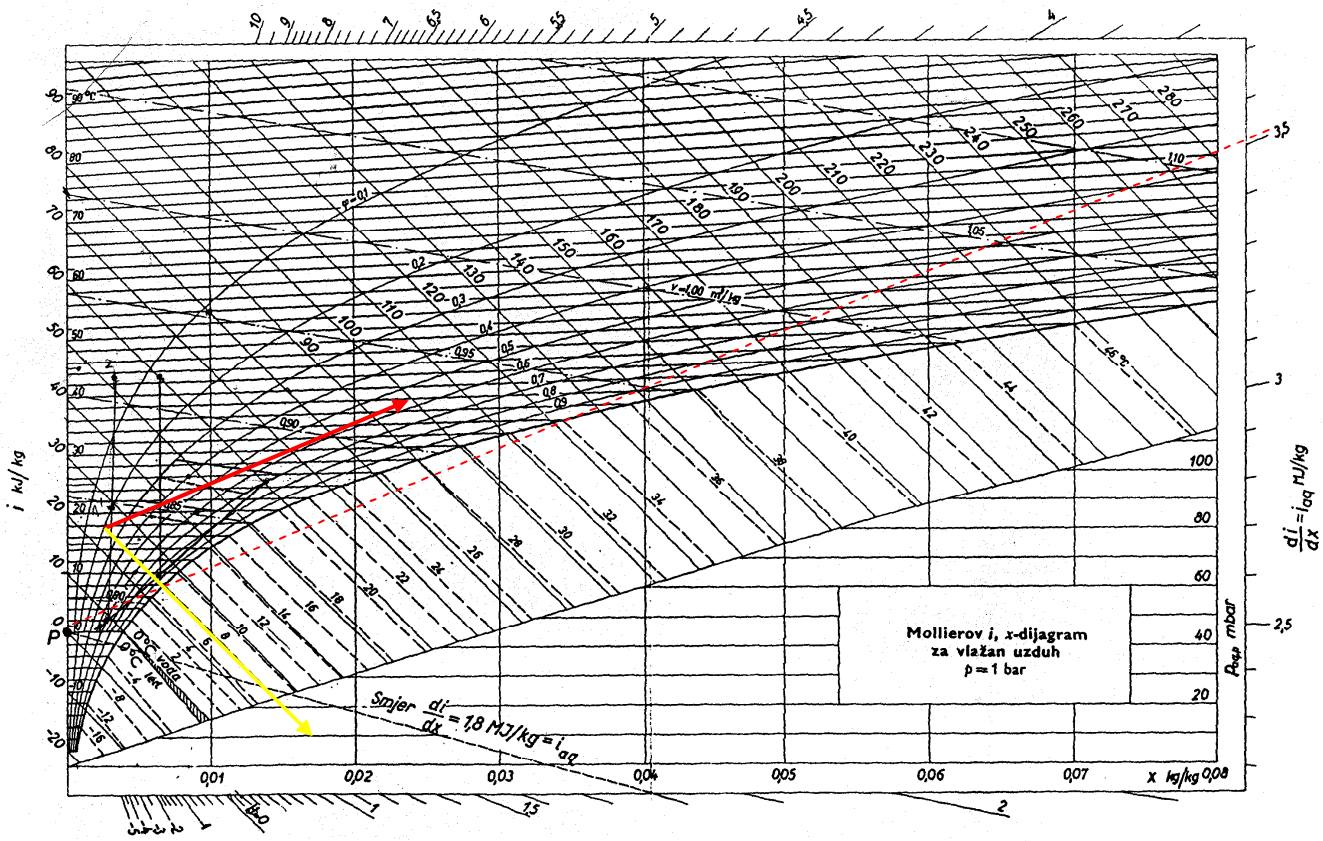


ODVLAŽIVANJE

Vlažni zrak - miješanje

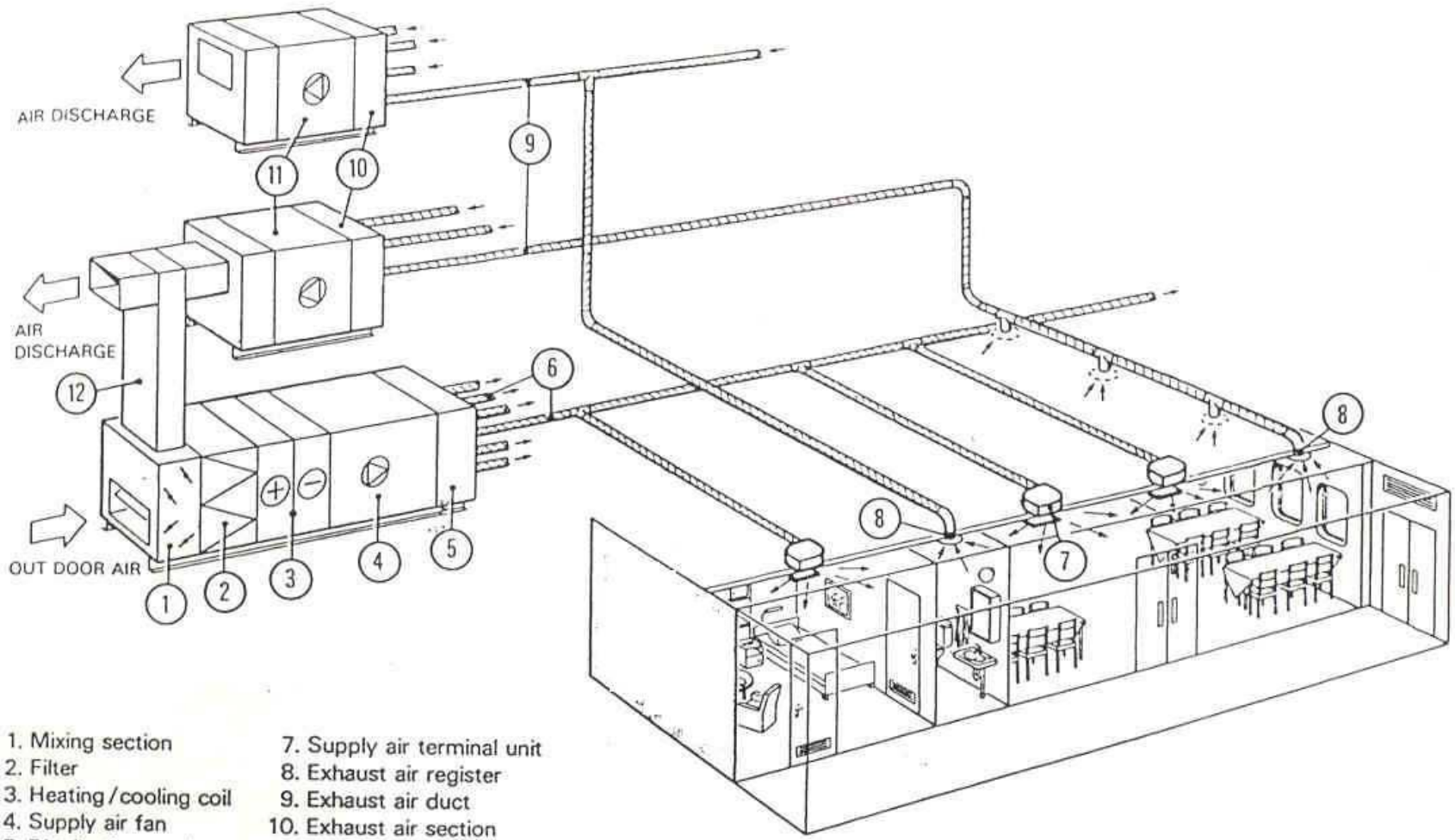


Vlažni zrak–vodena para, voda

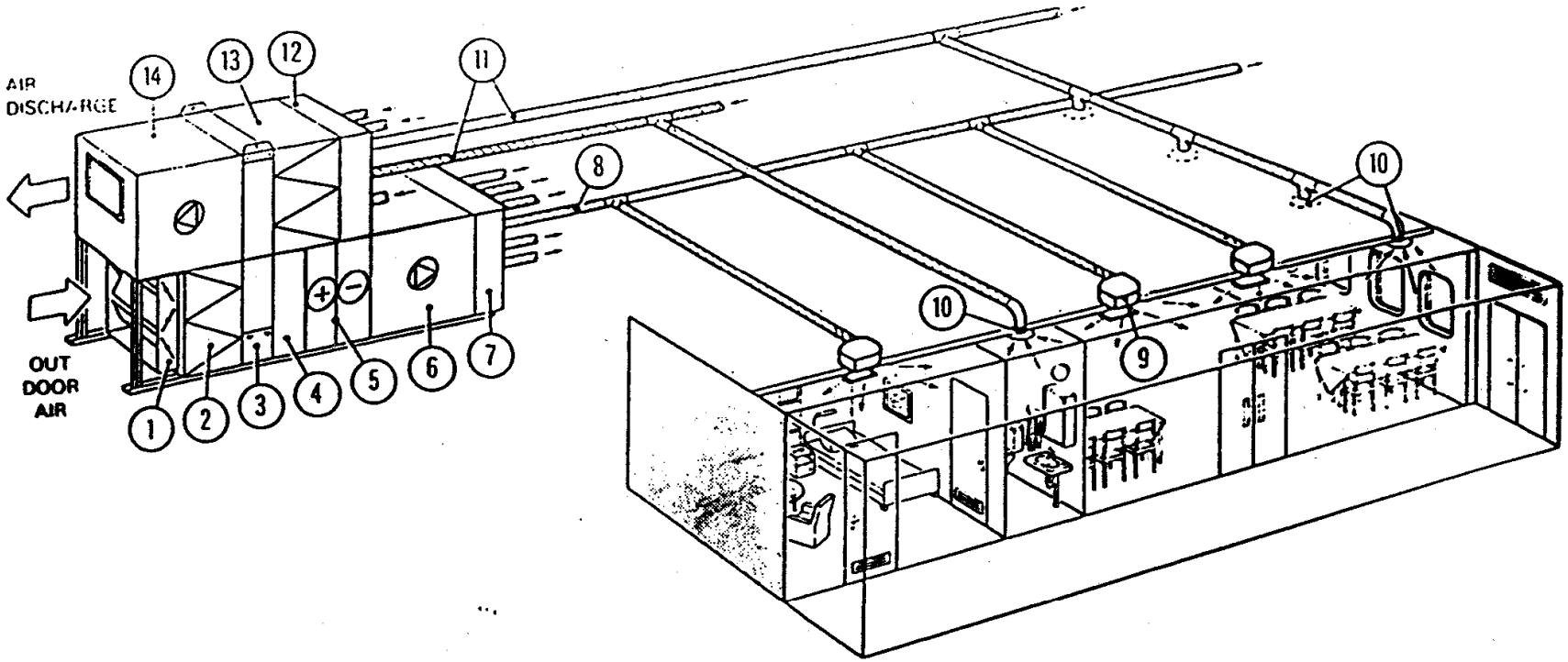


Centralna klima jedinica - sustavi

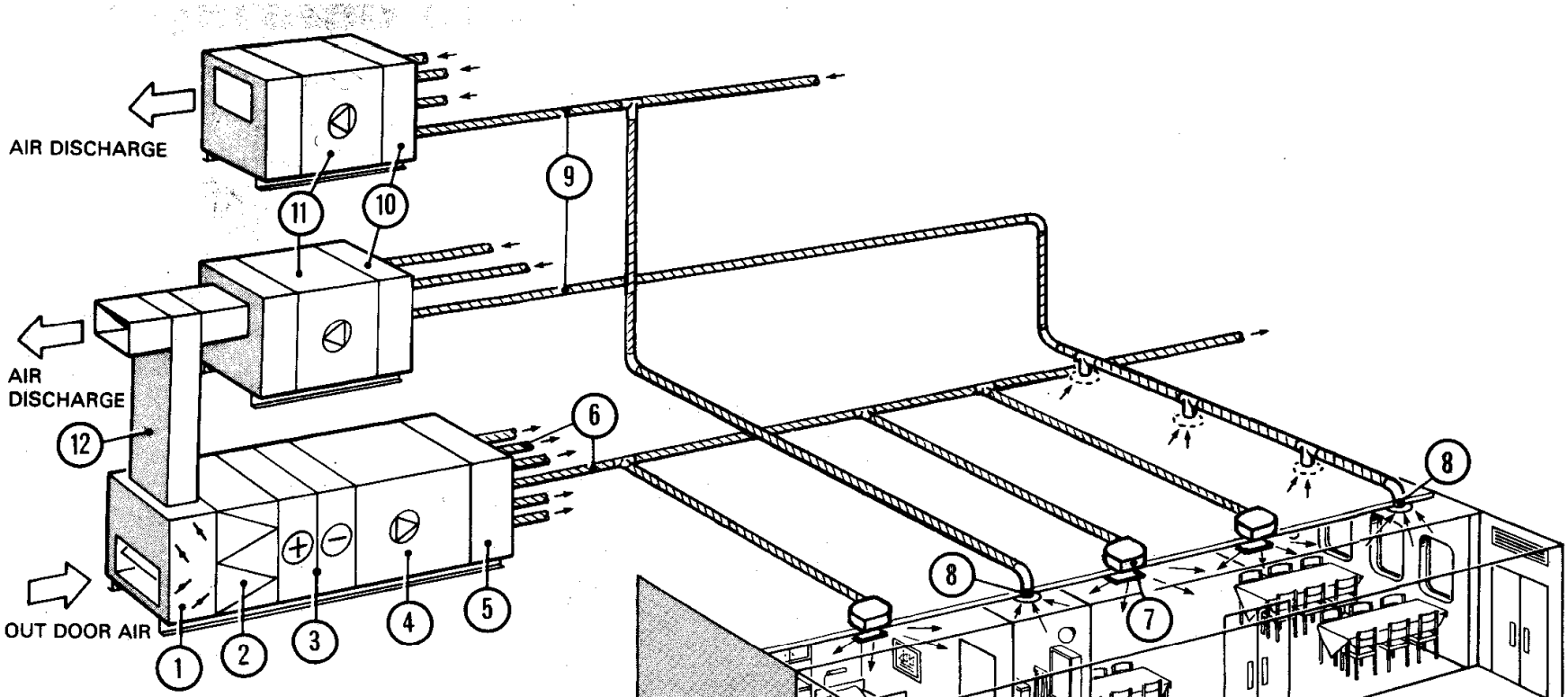
- Jednocijevni sustav
  - jedno-, dvo- ili višezonski
  - recirkulacija ili regeneracija
  - s elektr. dogrijavanjem
- Dvocijevni
  - recirkulacija ili regeneracija
- Skladišta, kuhinje, ECR



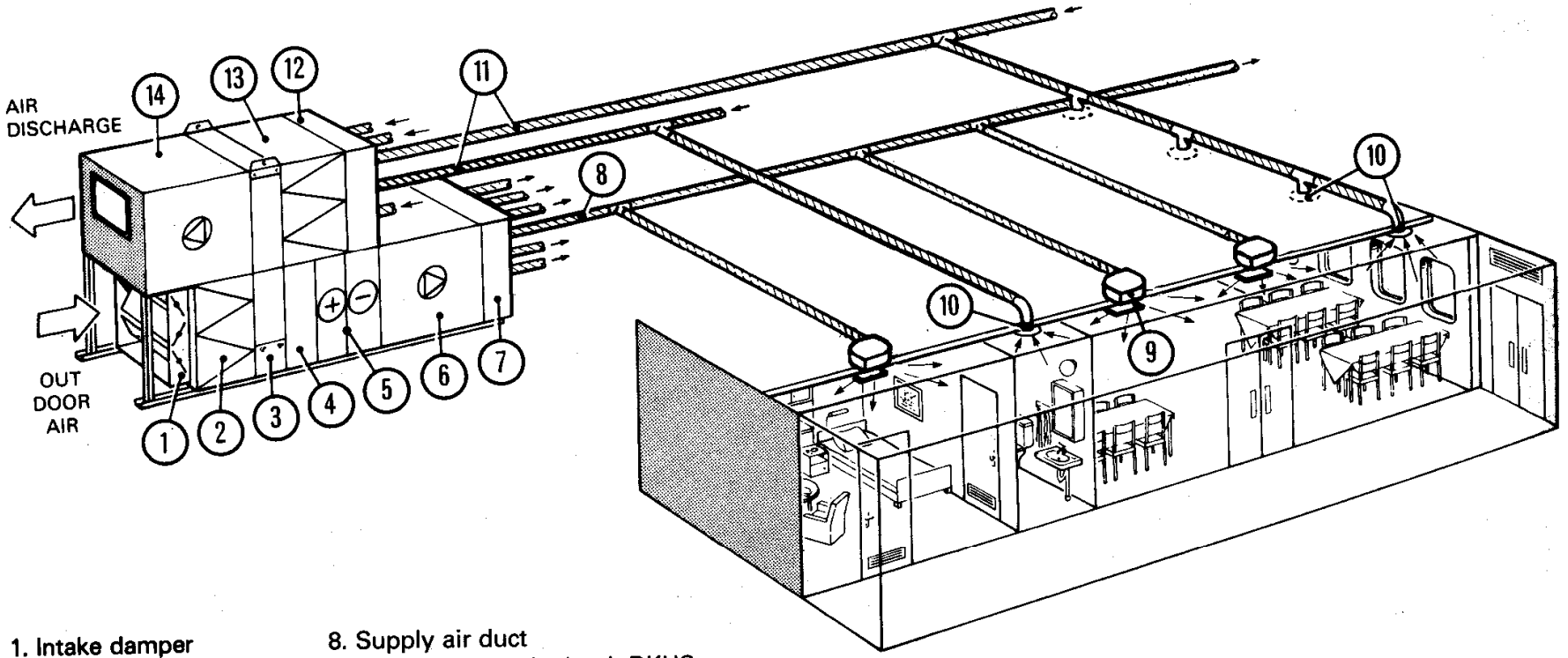
1. Mixing section
2. Filter
3. Heating/cooling coil
4. Supply air fan
5. Distribution section
6. Supply air duct
7. Supply air terminal unit
8. Exhaust air register
9. Exhaust air duct
10. Exhaust air section
11. Exhaust air fan
12. Recirculated air duct



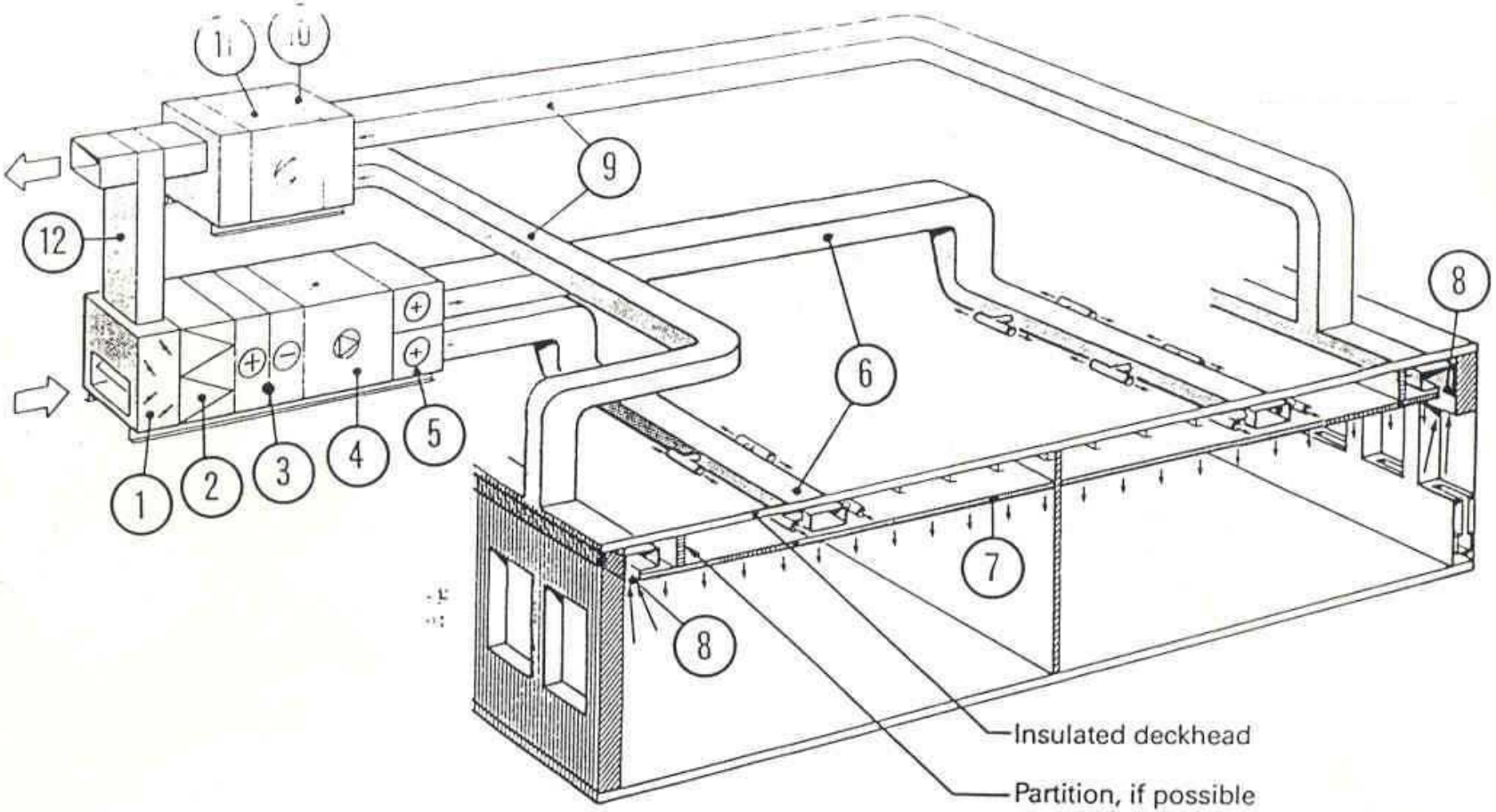
1. Intake damper
2. Filter
3. Recovery unit
4. Empty section
5. Heating/cooling coil
6. Supply air fan
7. Distribution section
8. Supply air duct
9. Supply air terminal unit
10. Exhaust air register
11. Exhaust air duct
12. Exhaust air section
13. Filter
14. Exhaust air fan



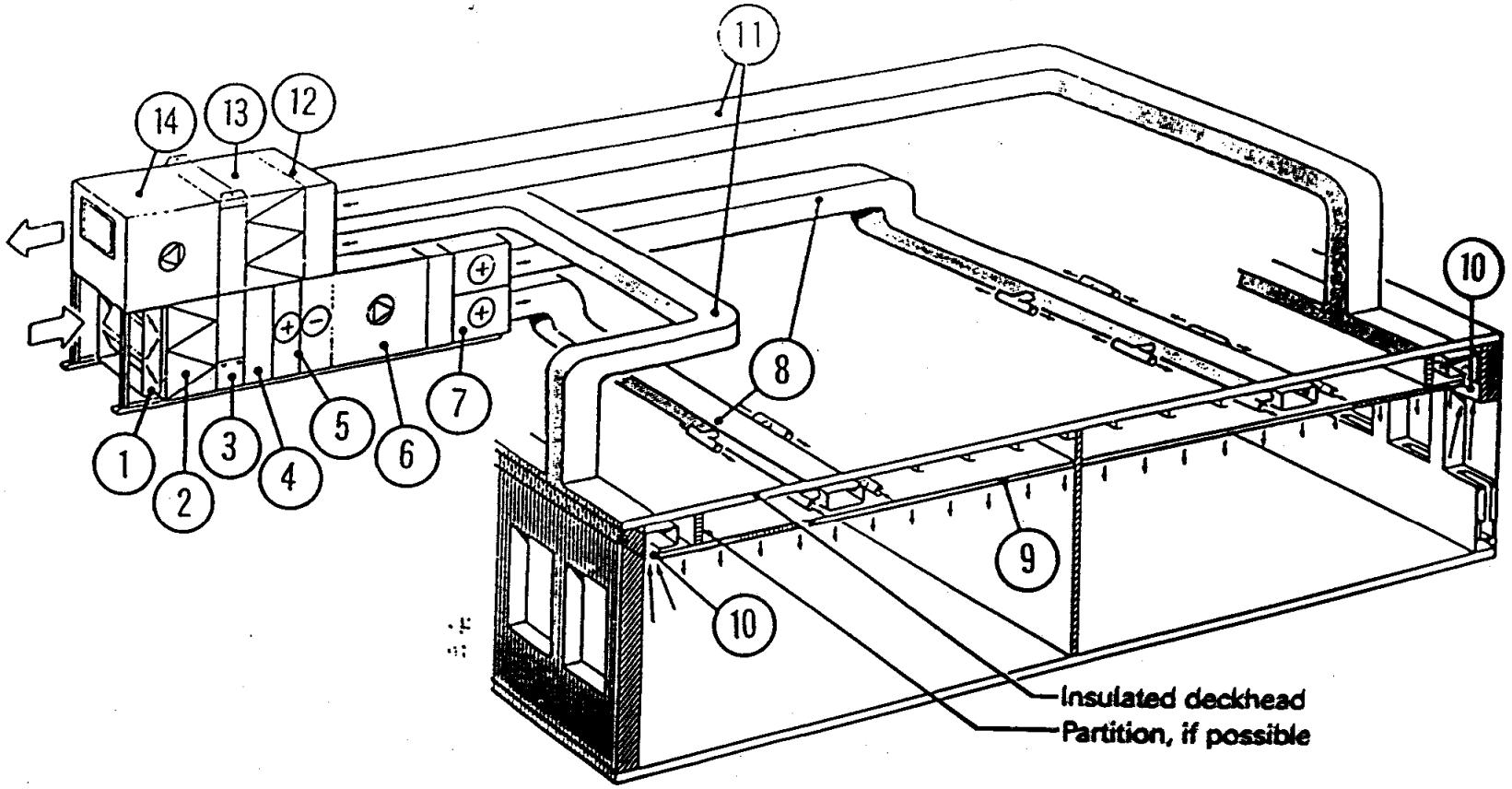
1. Mixing section
2. Filter
3. Heating/cooling coil
4. Supply air fan
5. Distribution section
6. Supply air duct
7. Supply air terminal unit DKHS
8. Exhaust air register
9. Exhaust air duct
10. Exhaust air section
11. Exhaust air fan
12. Recirculated air duct



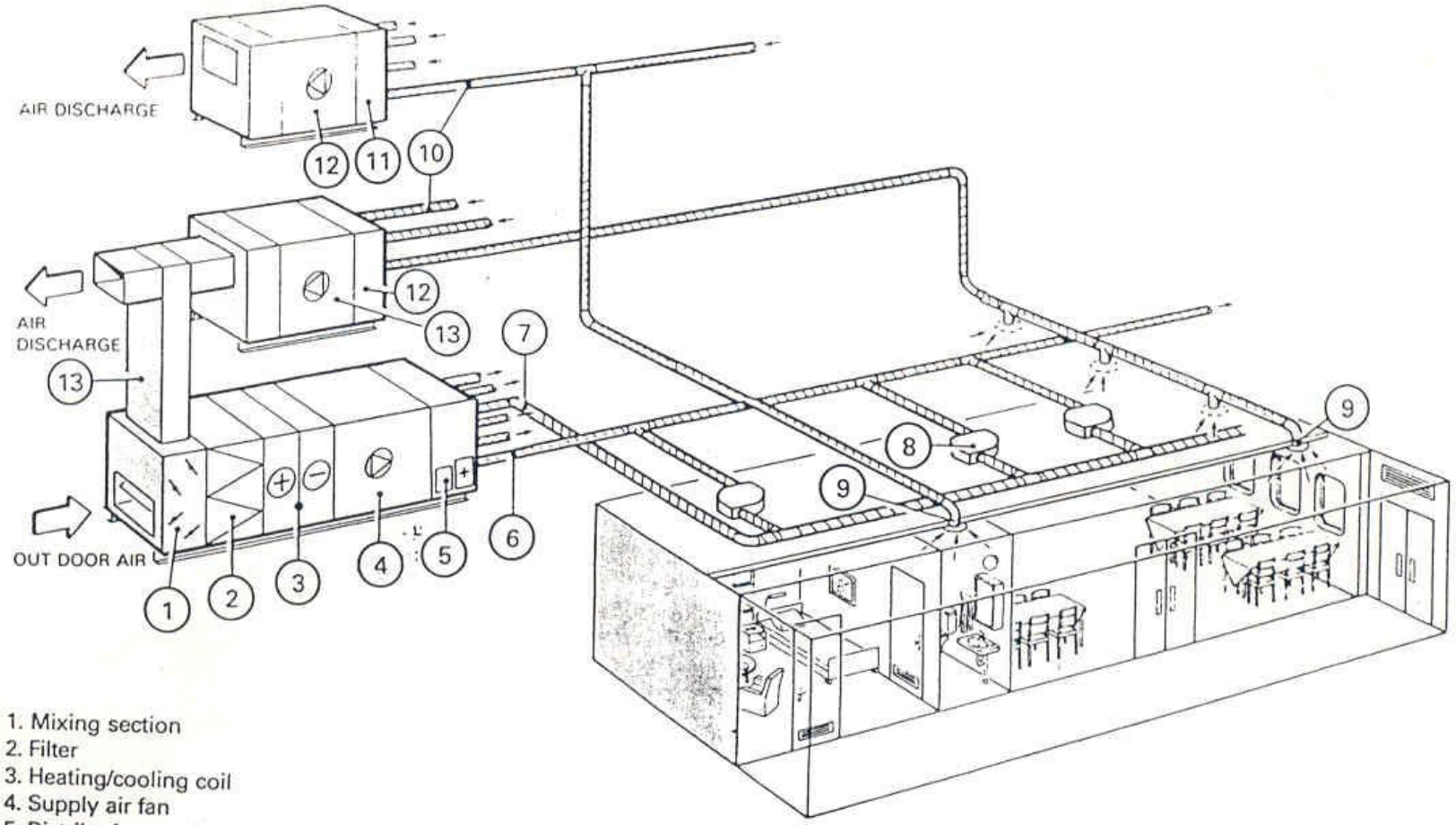
1. Intake damper
2. Filter
3. Recovery unit
4. Empty section
5. Heating / cooling coil
6. Supply air fan
7. Distribution section
8. Supply air duct
9. Supply air terminal unit DKHS
10. Exhaust air register
11. Exhaust air duct
12. Exhaust air section
13. Filter
14. Exhaust air fan



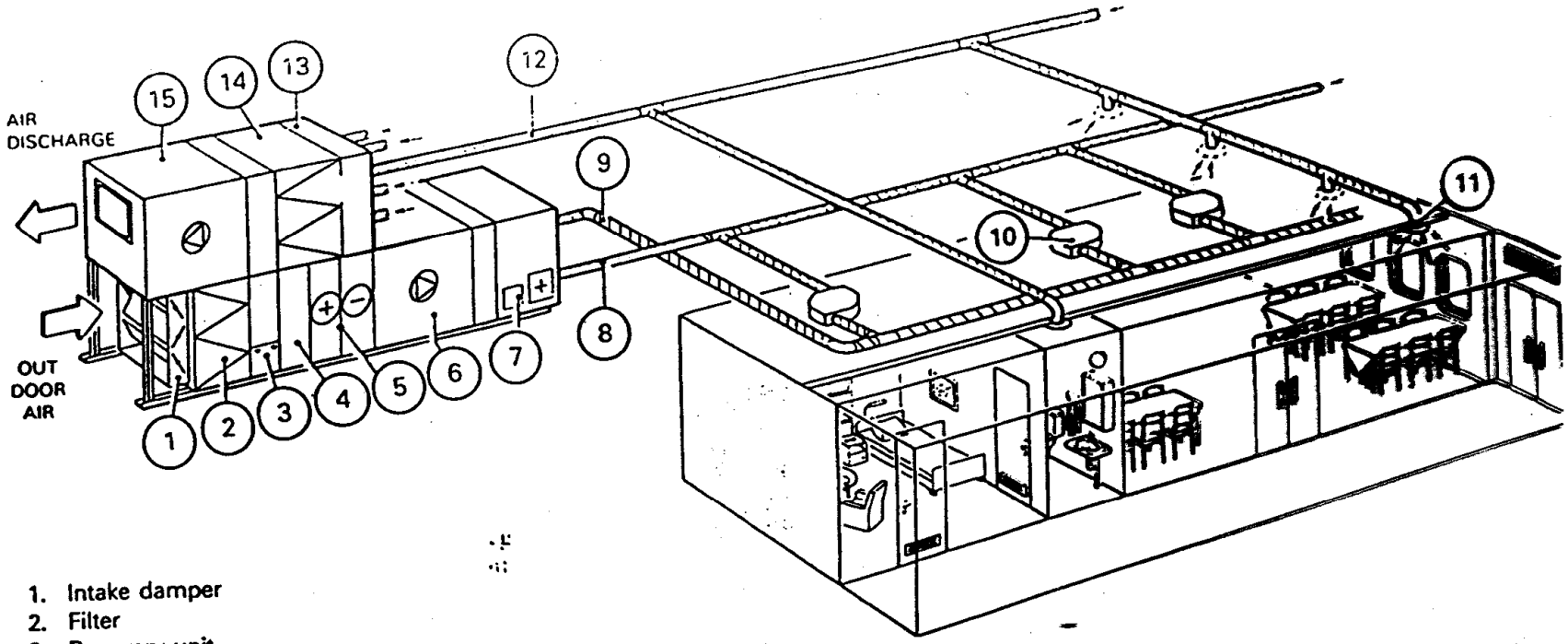
1. Mixing section
2. Filter
3. Heating/cooling coil
4. Supply air fan
5. Distribution section with heater
6. Supply air duct
7. Perforated ceiling
8. Exhaust air grille
9. Exhaust air duct
10. Exhaust air section
11. Exhaust air fan
12. Recirculated air duct



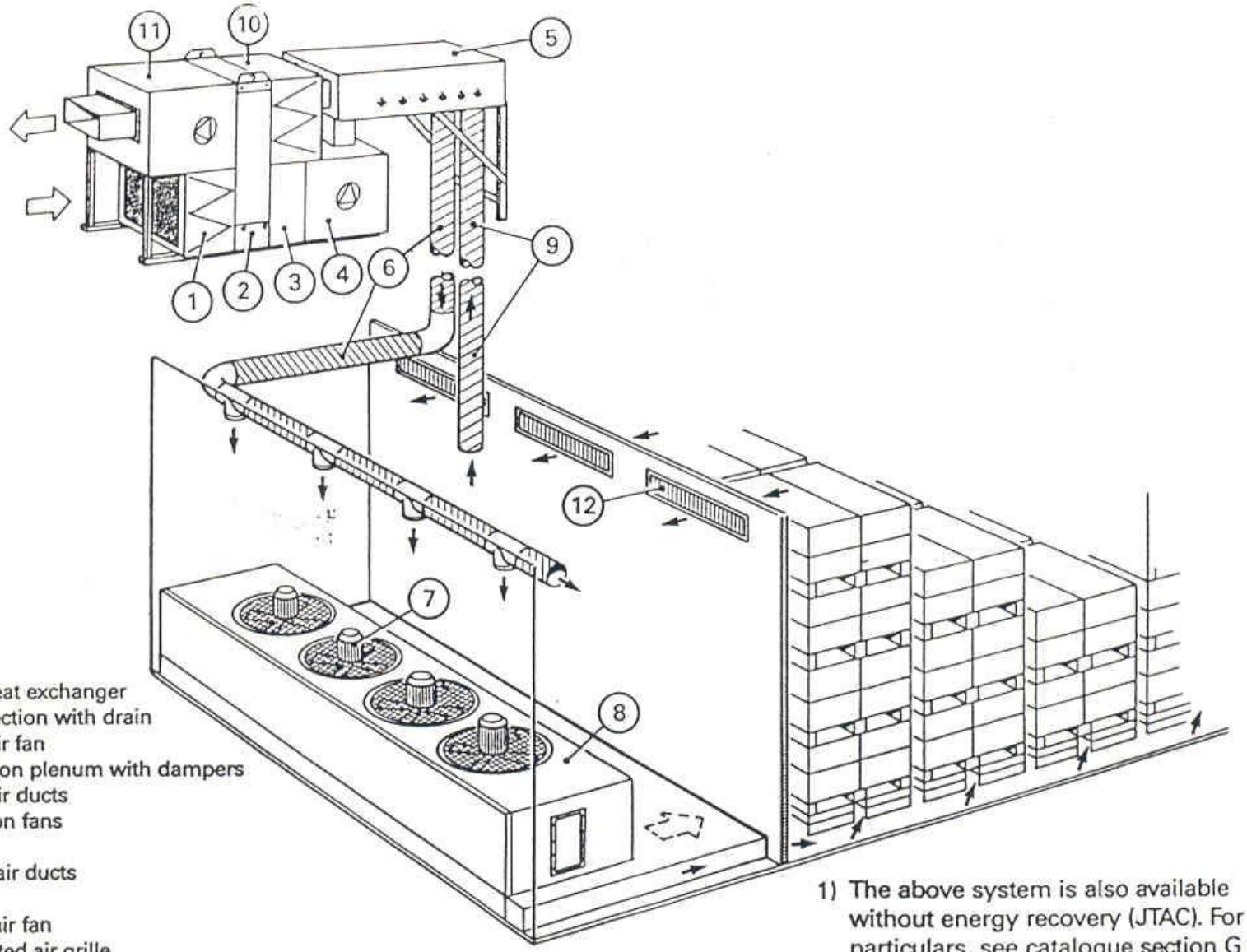
1. Intake damper
2. Filter
3. Recovery unit
4. Empty section
5. Heating/cooling coil
6. Supply air fan
7. Distribution section with heater
8. Supply air duct
9. Perforated ceiling
10. Exhaust air grille
11. Exhaust air duct
12. Exhaust air section
13. Filter
14. Exhaust air fan



1. Mixing section
2. Filter
3. Heating/cooling coil
4. Supply air fan
5. Distribution section with reheating coil
6. Warm supply air
7. Cold supply air duct
8. Supply air terminal unit DKFS
9. Exhaust air register
10. Exhaust air duct
11. Exhaust air section
12. Exhaust air fan
13. Recirculated air duct

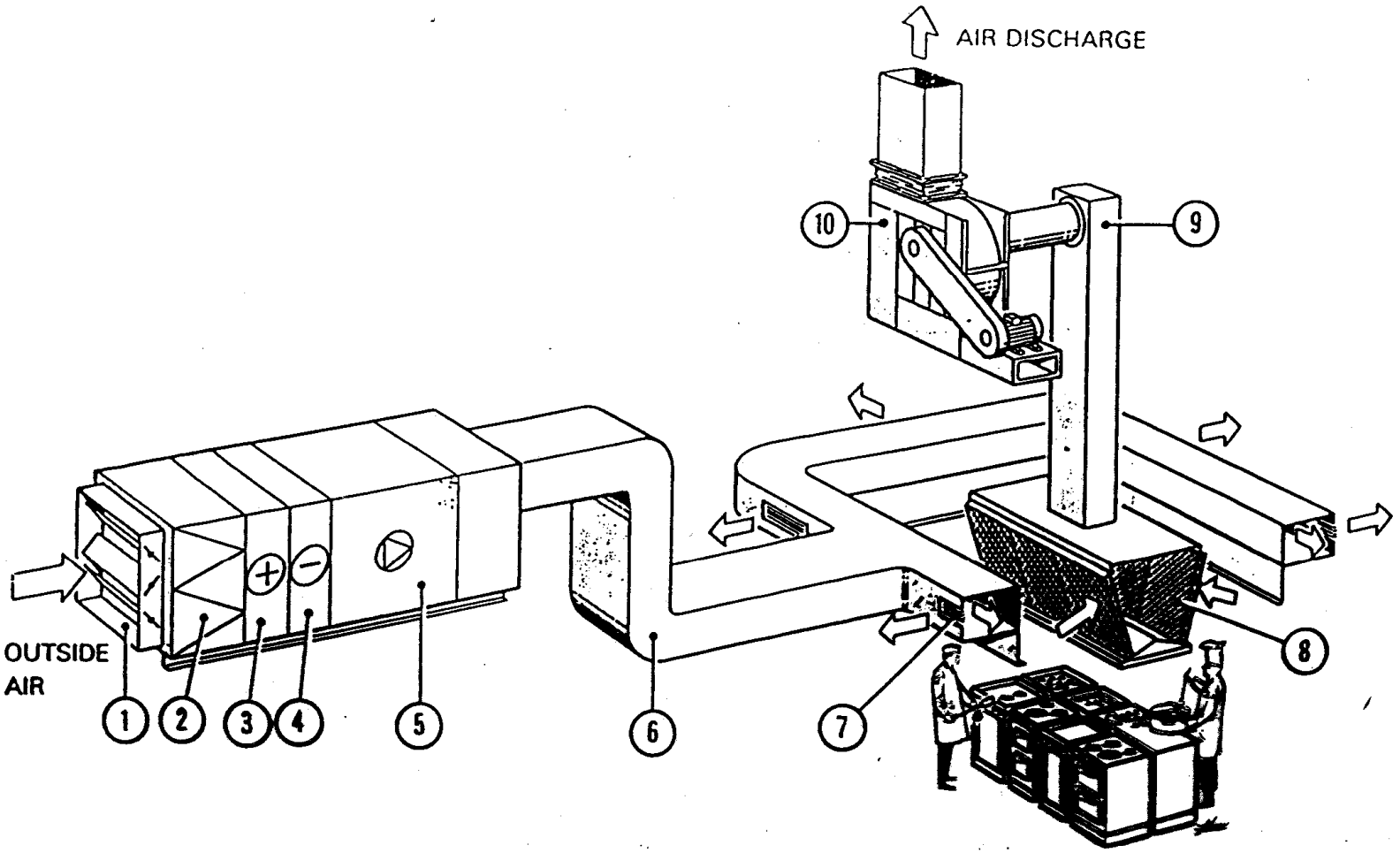


1. Intake damper
2. Filter
3. Recovery unit
4. Empty section
5. Heating/cooling coil
6. Supply air fan
7. Distribution section with reheating coil
8. Warm supply air duct
9. Cold supply air duct
10. Supply air terminal unit DKFS
11. Exhaust air register
12. Exhaust air duct
13. Exhaust air section
14. Filter
15. Exhaust air fan

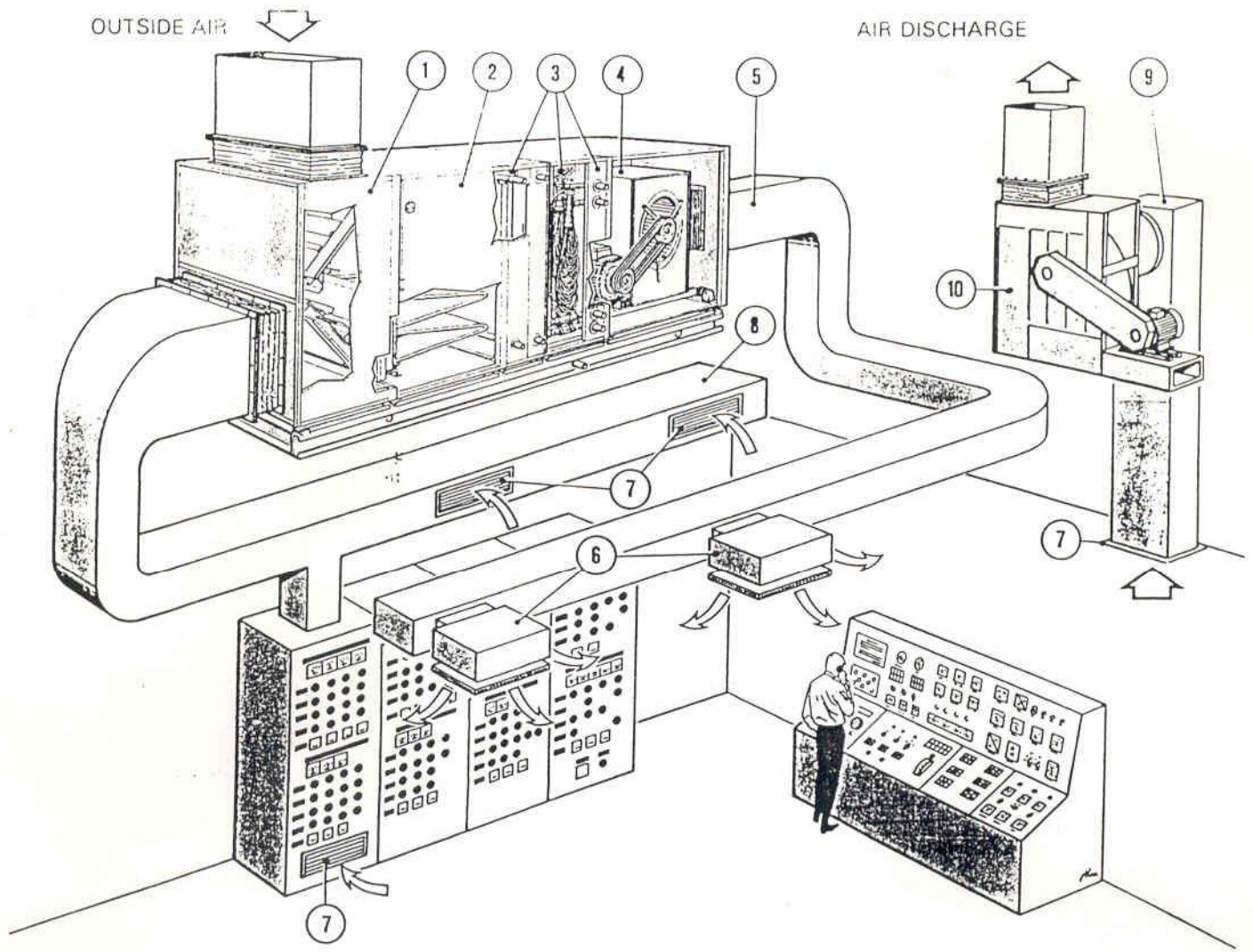


1. Filter
2. Rotary heat exchanger
3. Empty section with drain
4. Supply air fan
5. Distribution plenum with dampers
6. Supply air ducts
7. Circulation fans
8. Cooler
9. Exhaust air ducts
10. Filter
11. Exhaust air fan
12. Recirculated air grille

1) The above system is also available without energy recovery (JTAC). For particulars, see catalogue section G 80.

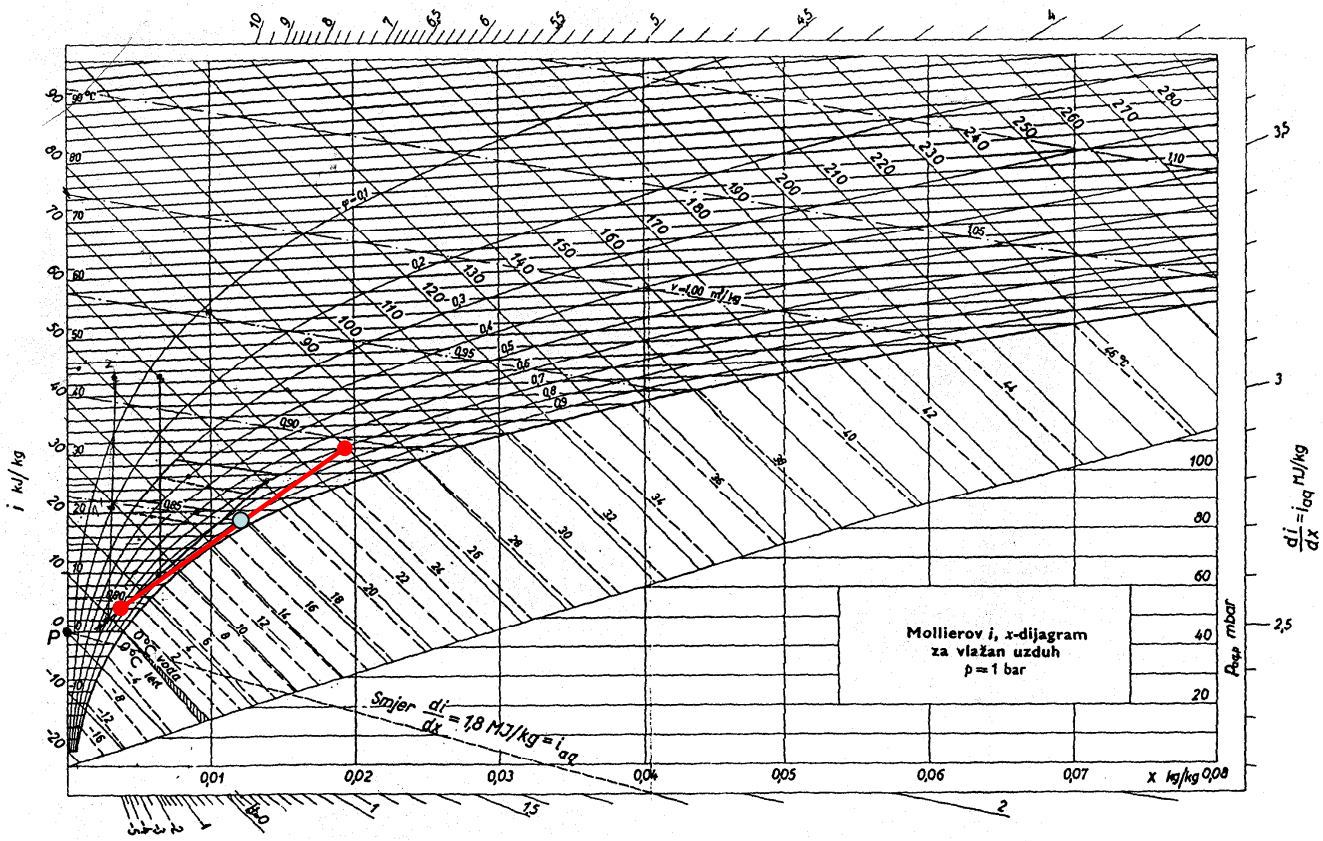


1. Intake damper
2. Filter
3. Heating coil
4. Cooling coil
5. Supply air fan
6. Supply air duct
7. Supply air device
8. Grease filter
9. Exhaust air duct
10. Exhaust air fan

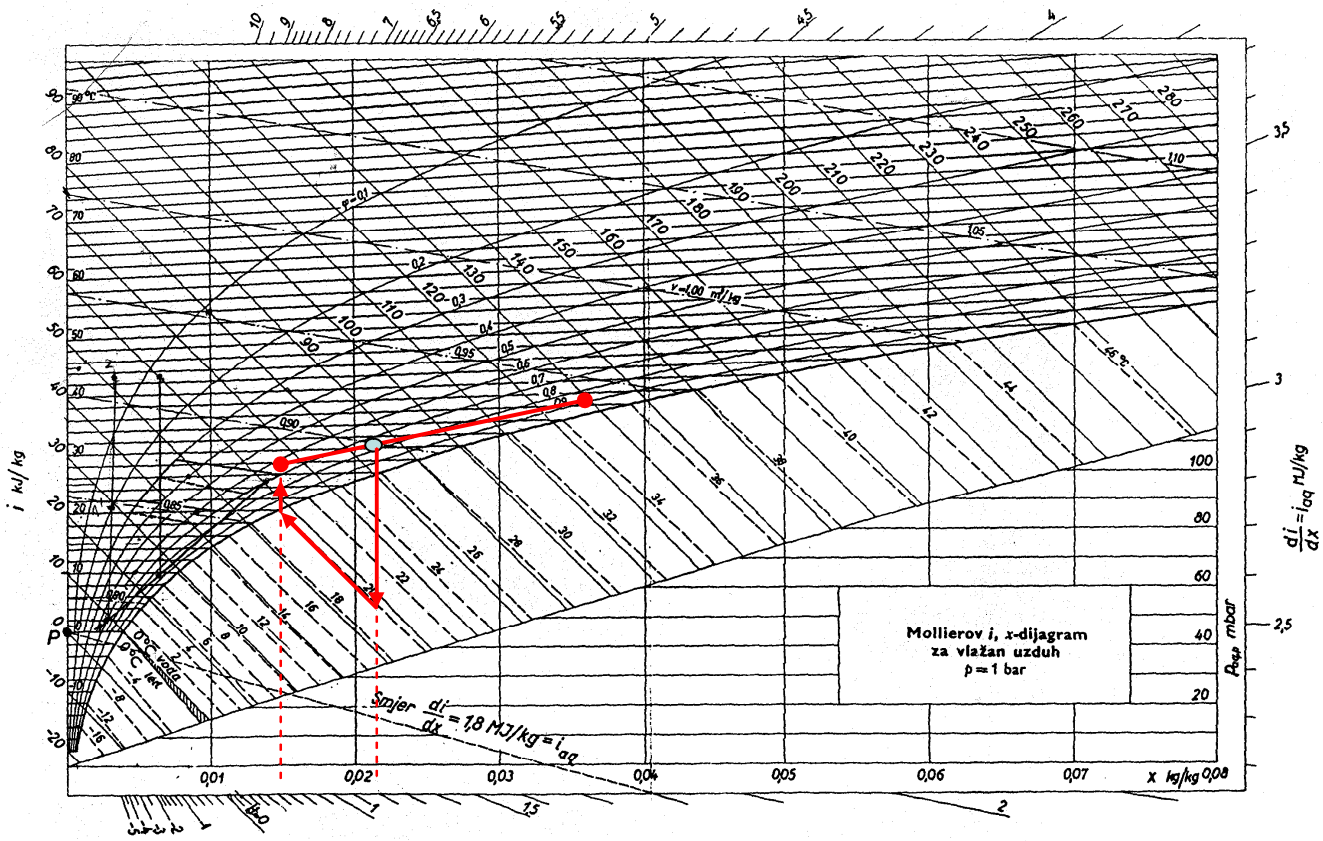


1. Mixing section
2. Filter
3. Cooling / Heating coils
4. Supply fan
5. Supply air duct
6. Supply air device
7. Exhaust air device
8. Recirculated air duct
9. Exhaust air duct
10. Exhaust fan

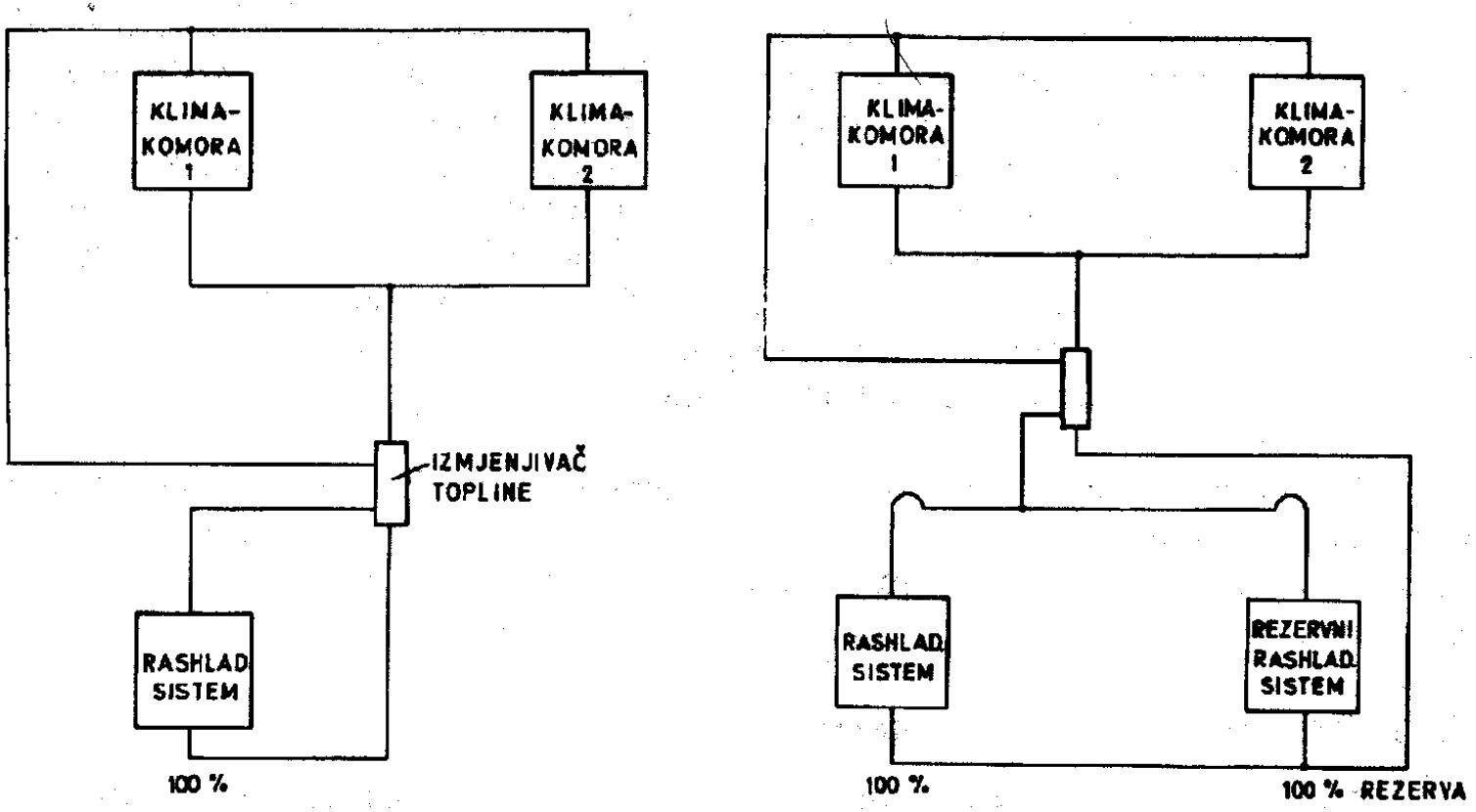
Primjer: zima, recirkulacija



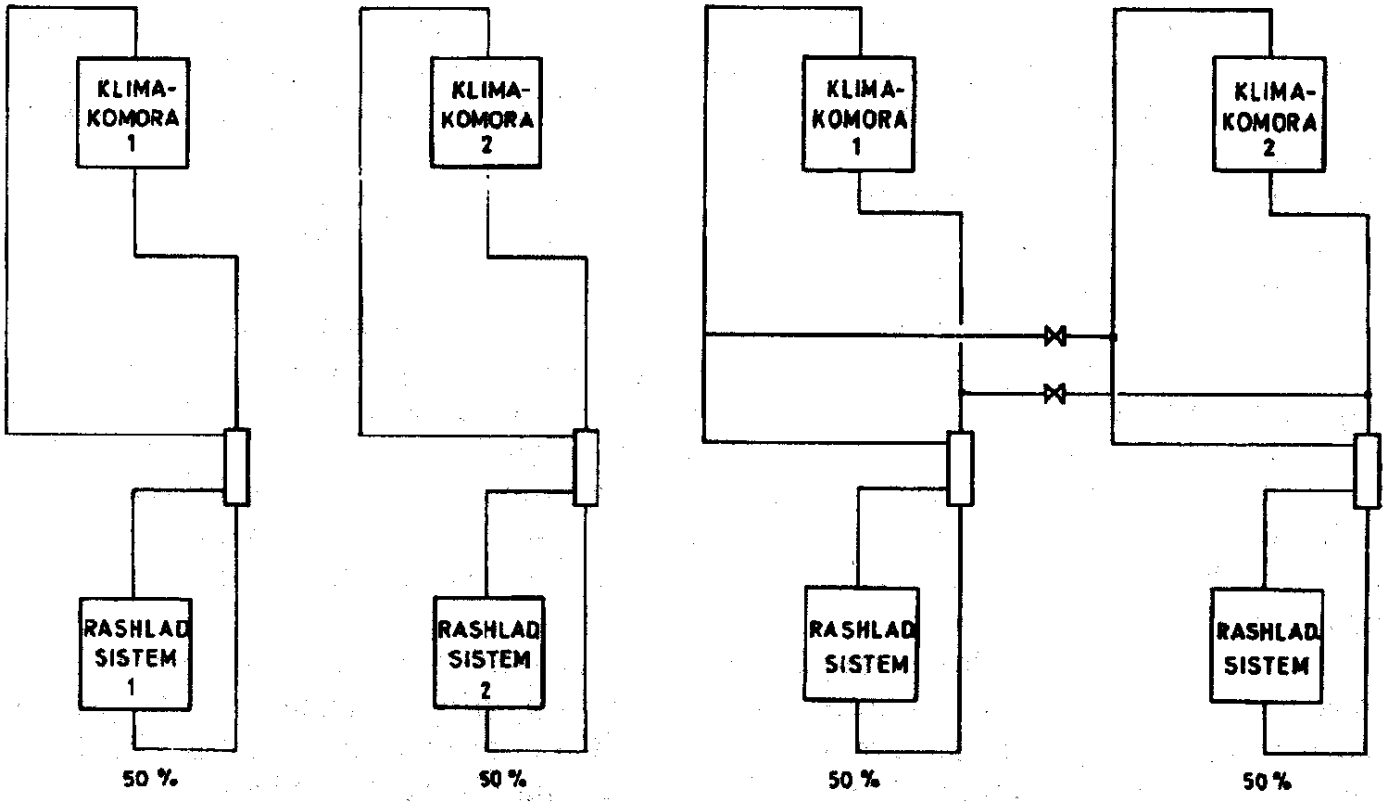
Primjer: ljeto, recirkulacija



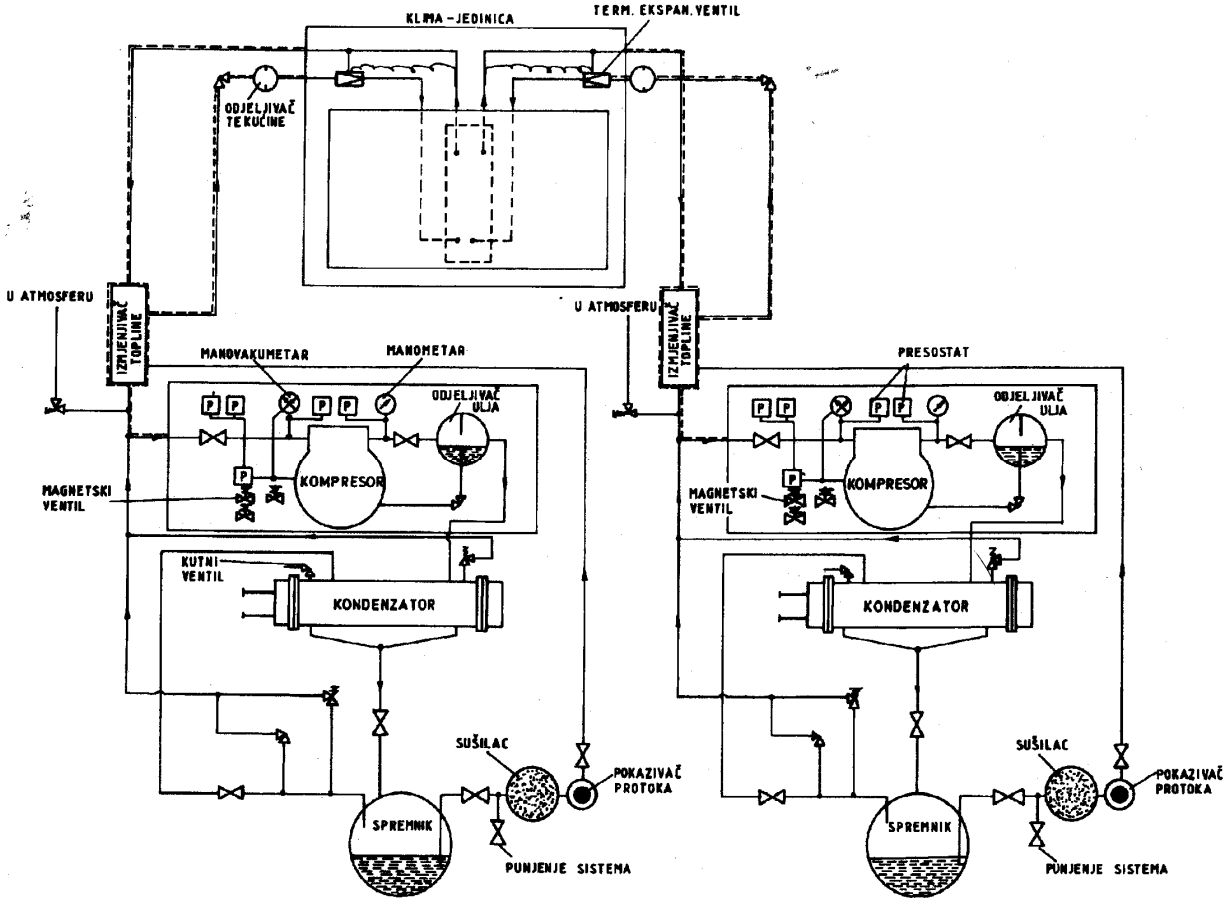
Izvedbe


KLIMA-
KOMORA
1
KLIMA-
KOMORA
2
IZMJENJIVAČ
TOPLINE
RASHLAD.
SISTEM
100 %
KLIMA-
KOMORA
1
KLIMA-
KOMORA
2
RASHLAD.
SISTEM
REZERVNI
RASHLAD.
SISTEM
100 %
100 % REZERVA

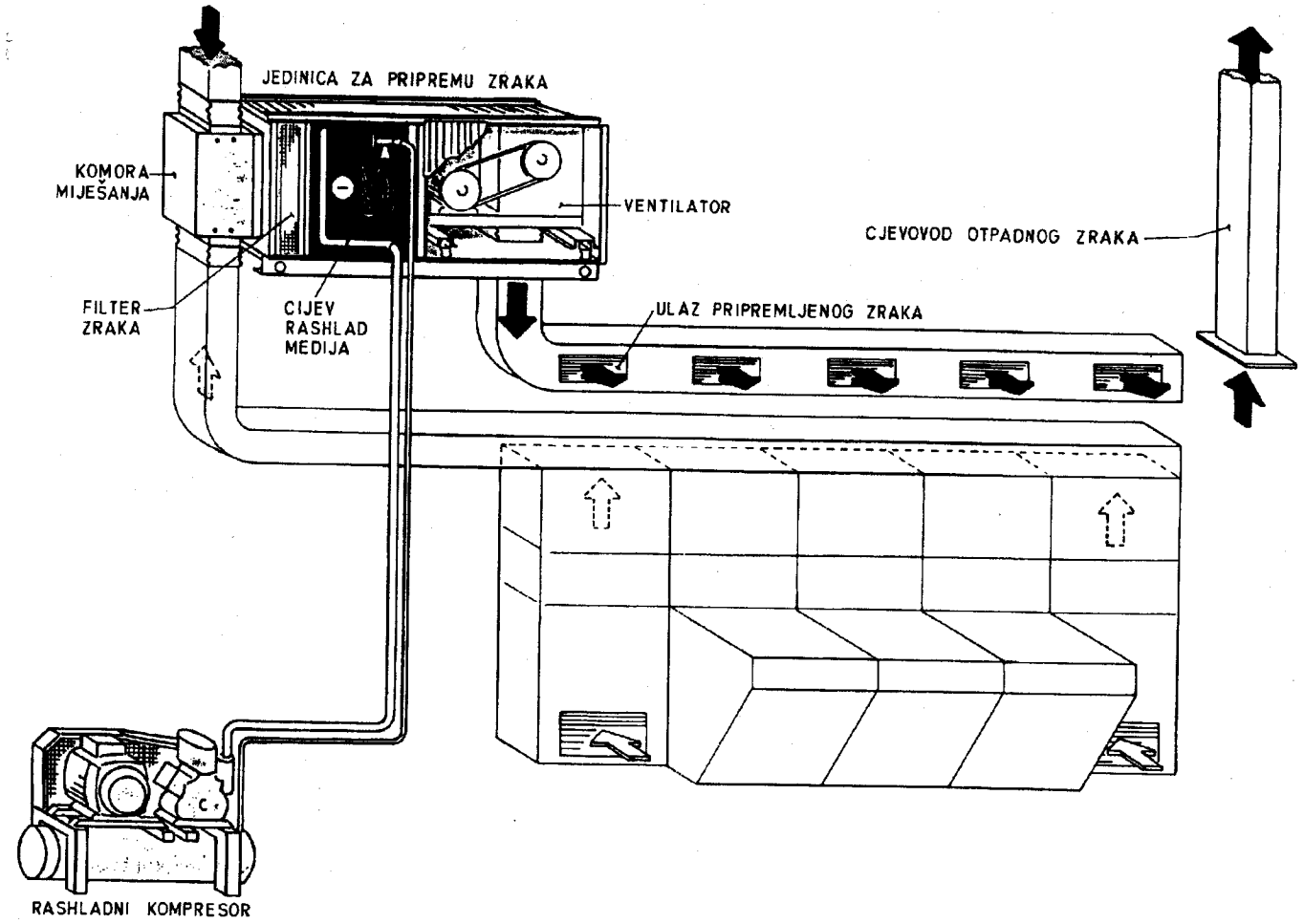
Izvedbe


KLIMA-
KOMORA
1
RASHLAD
SISTEM
1
50 %
KLIMA-
KOMORA
2
RASHLAD
SISTEM
2
50 %
KLIMA-
KOMORA
1
RASHLAD
SISTEM
50 %
KLIMA-
KOMORA
2
RASHLAD
SISTEM
50 %

Izvedbe


KLIMA-JEDINICA
TERM. EKSPAN. VENTIL
ODJELJIVAČ TEKUĆINE
U ATMOSFERU
IZMJENJIVAČ TOPLINE
MANOVAKUMETAR
MANOMETAR
ODJELJIVAČ ULJA
KOMPRESOR
MAGNETSKI VENTIL
KUTNI VENTIL
KONDENZATOR
SUŠILAC
POKAZIVAČ PROTOKA
SPREMNIK
PUNJENJE SISTEMA
U ATMOSFERU
IZMJENJIVAČ TOPLINE
PRESOSTAT
ODJELJIVAČ ULJA
KOMPRESOR
MAGNETSKI VENTIL
KONDENZATOR
SUŠILAC
POKAZIVAČ PROTOKA
SPREMNIK
PUNJENJE SISTEMA

Izvedbe


JEDINICA ZA PRIPREMU ZRAKA
KOMORA MIJEŠANJA
VENTILATOR
CJEVOVOD OTPADNOG ZRAKA
FILTER ZRAKA
CIJEV RASHLAD MEDIJA
ULAZ PRIPREMLJENOG ZRAKA
RASHLADNI KOMPRESOR

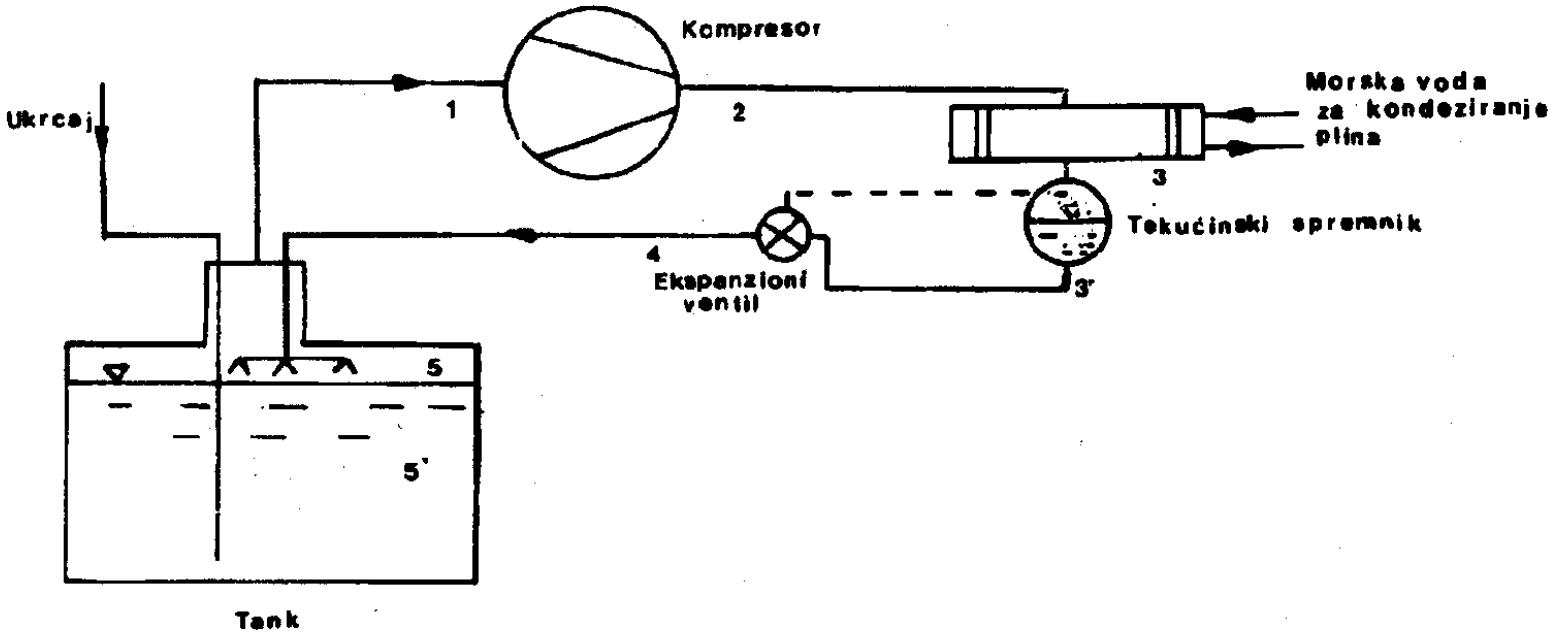
Ukapljeni plin

- LNG
- LPG
- smanjuje se volumen cca 600 puta

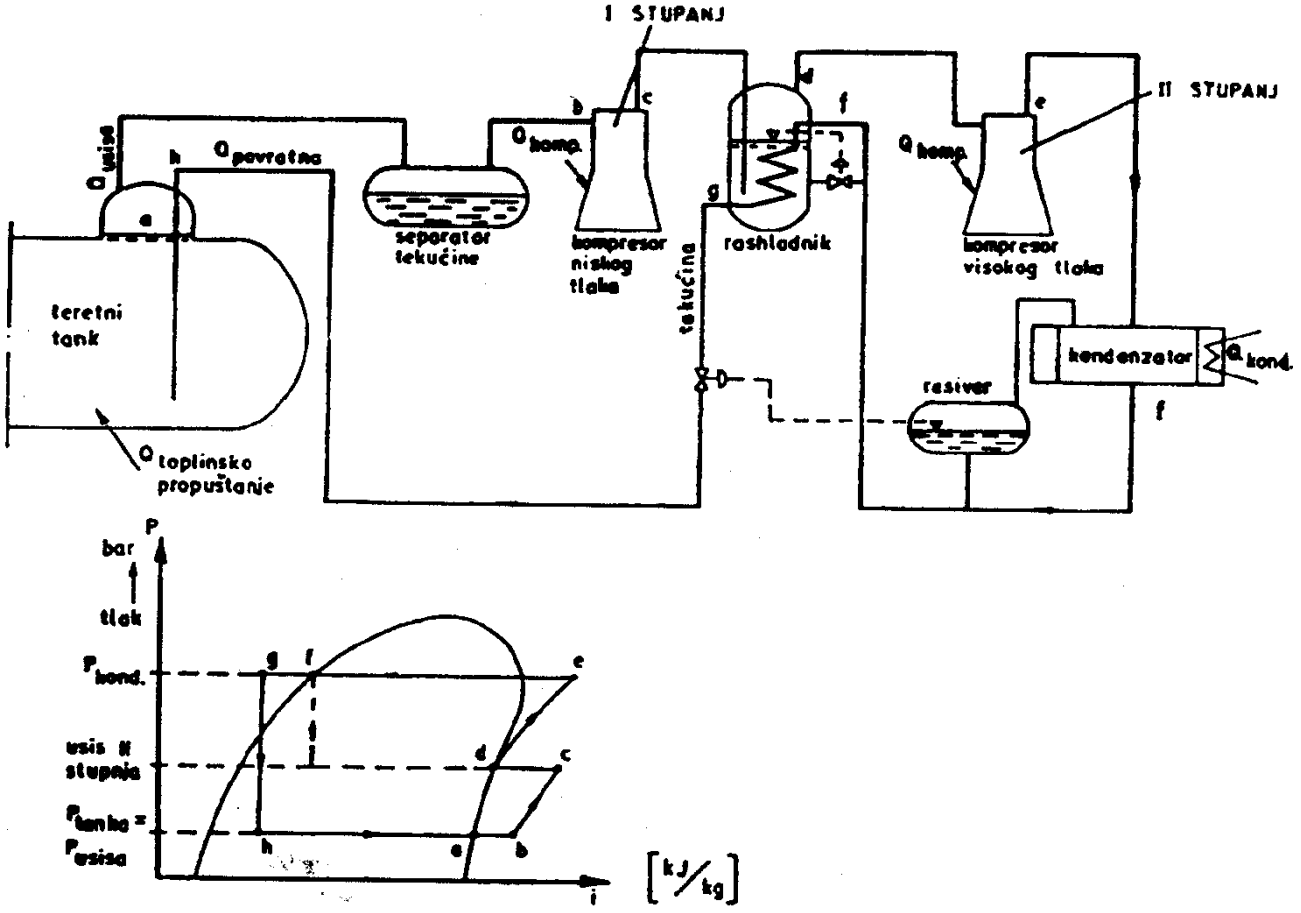
Ukapljeni plin

- $p=p_o$, $T<<T_o$
- $p>>p_o$, $T=T_o$
- $p>p_o$, $T<T_o$

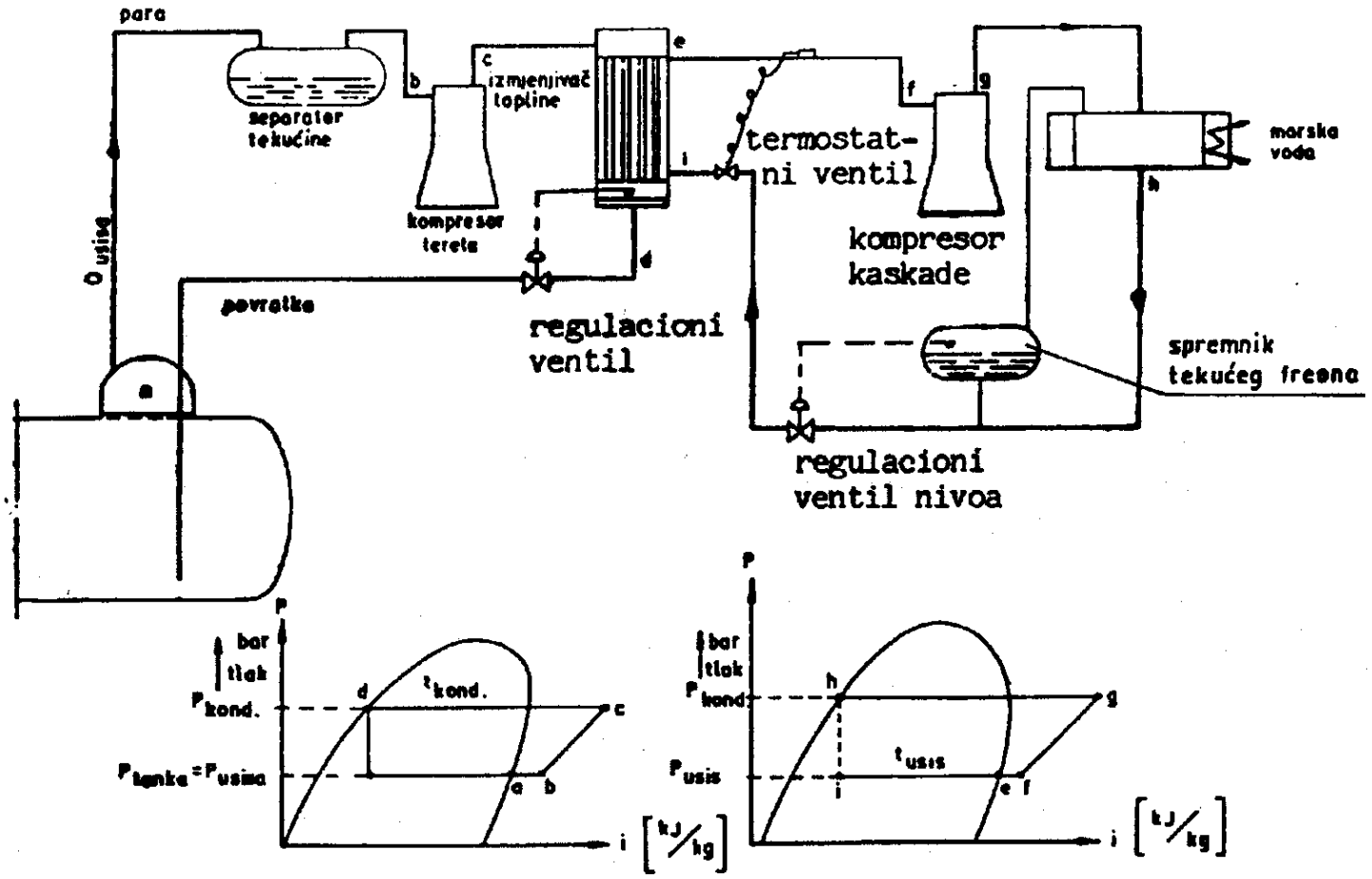
Jednostepena kompresija



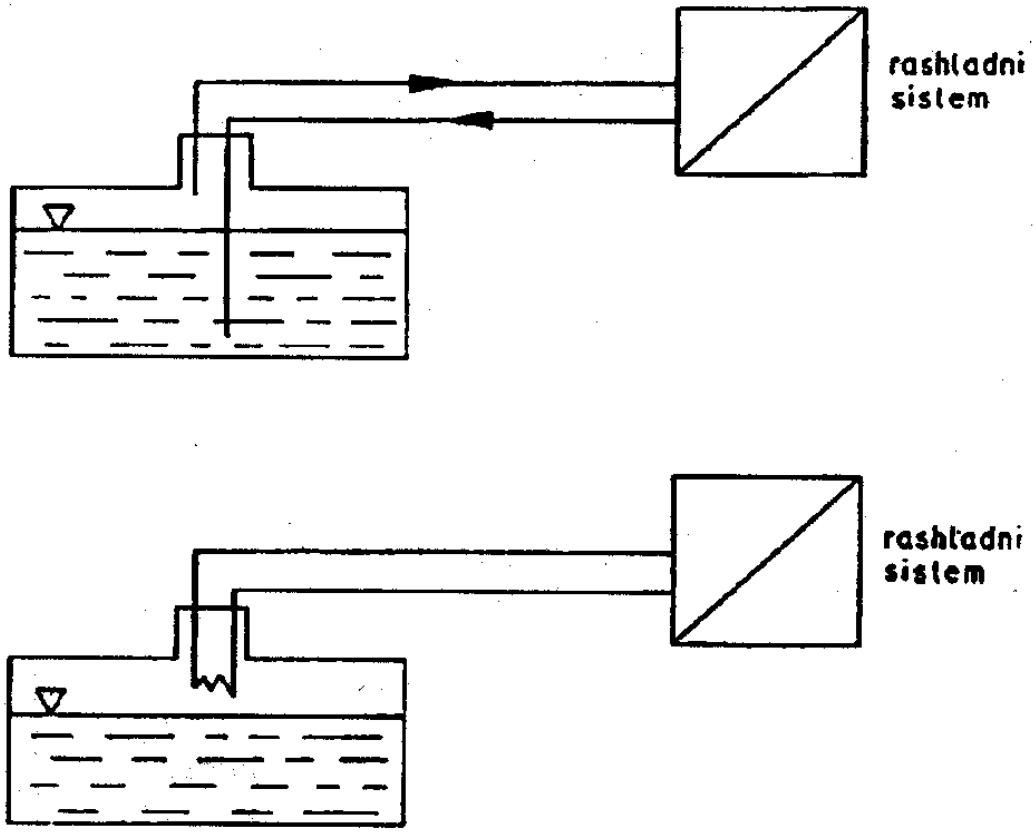
Dvostepena kompresija



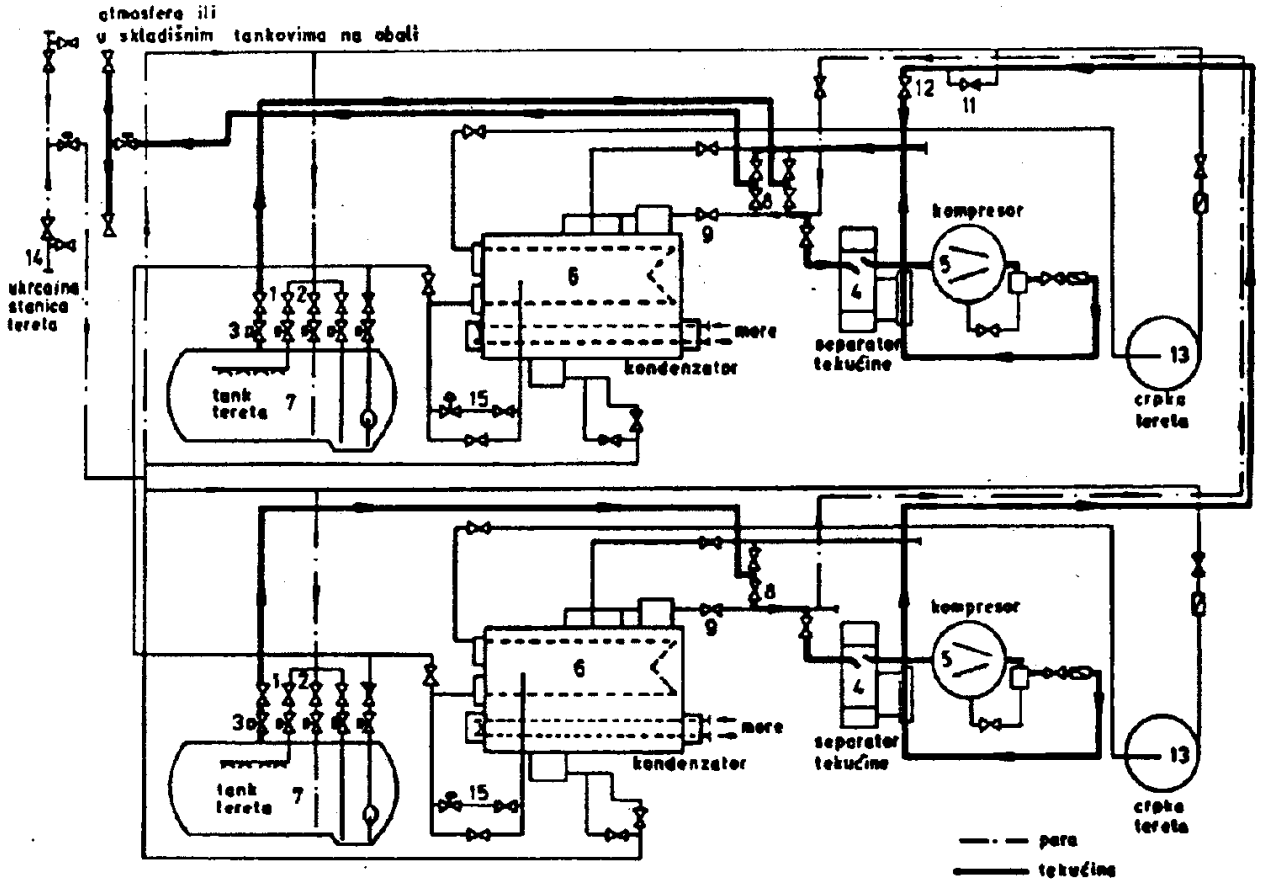
Kaskadni


para
separater tekućine
izmjenjivač topline
kompresor tereta
termostat-ni ventil
kompresor kaskade
morska voda
usisna
povratka
regulacioni ventil
spremnik tekućeg freona
regulacioni ventil nivoa
bar
tlak
t kond.
P kond.
P tanka = P usisa
P usis
t usis
i [kJ/kg]

Direktno i indirektno

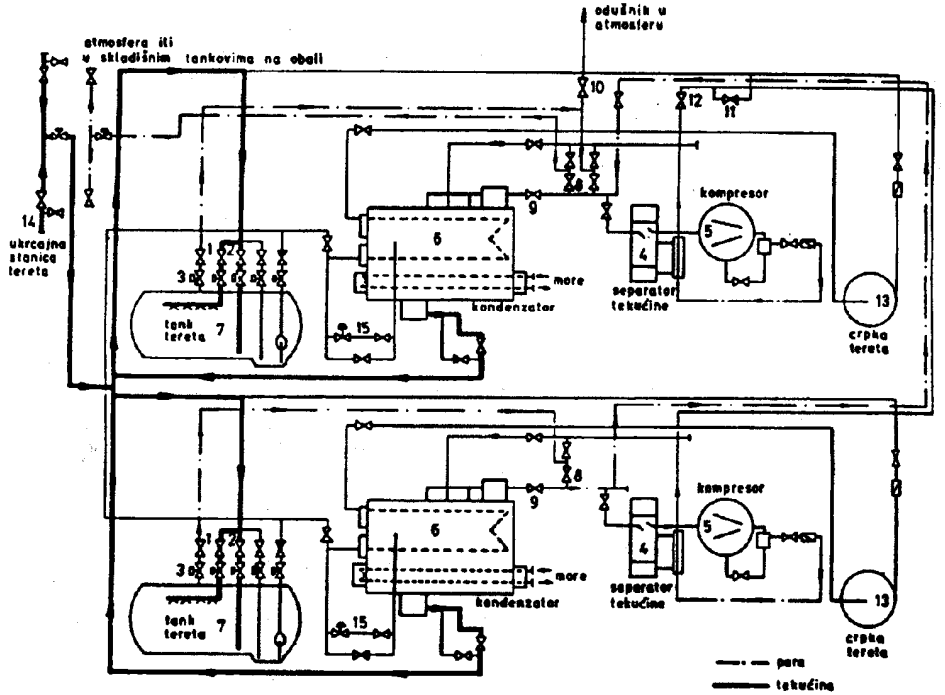


LPG-vakuumiranje



Vakuumiranje tankova i tereta

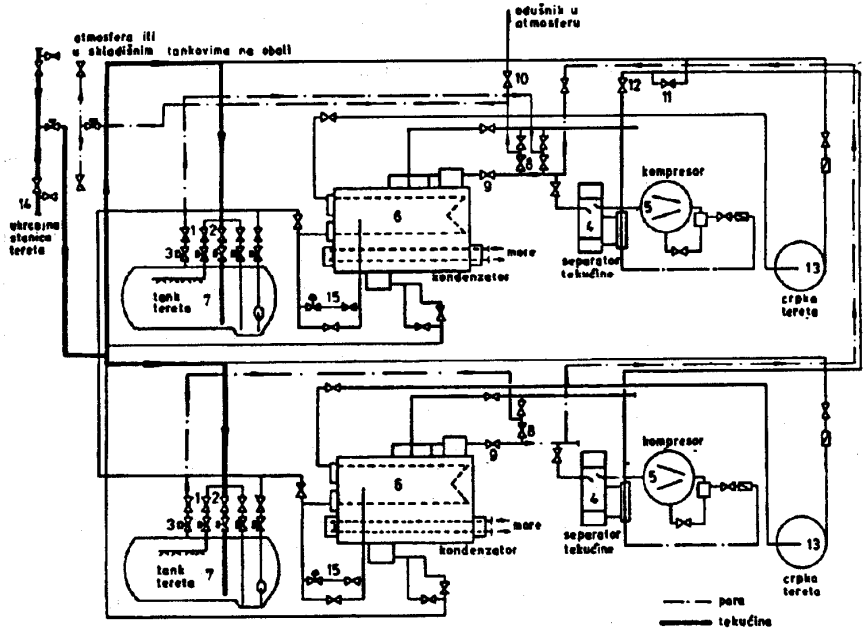
LPG-ukrcaj



1 – ventil za pothlađivanje,
2 – ukrcajni ventil,
3 – prekotlačni ventil tekućinskih para,
4 – odvajač tekućine,
5 – kompresor,
6 – kondenzator,
7 – tank tereta,
8 – zaobilazni ventil,
9 – zaporni ventil,
10 – ventil odušnika,
11 – nepovratni ventil,
12 – zaporni ventil,
13 – crpka tereta,
14 – ukrcajno-iskrcajni ventil,
15 – regulacijski ventil.

Ukrcaj ukapljenog plina s pothlađivanjem

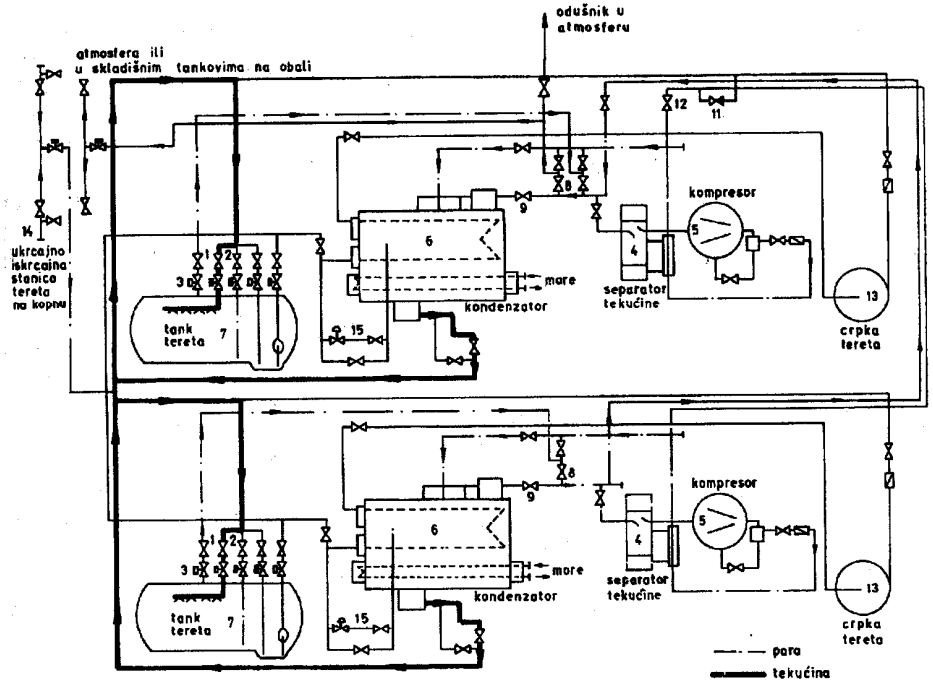
LPG-ukrcaj



1 – ventil za pothlađivanje,
2 – ukrcajni ventil,
3 – prekotlačni ventil tekućinskih para,
4 – odvajač tekućine,
5 – kompresor,
6 – kondenzator,
7 – tank tereta,
8 – zaobilazni ventil,
9 – zaporni ventil,
10 – ventil odušnika,
11 – nepovratni ventil,
12 – zaporni ventil,
13 – crpka tereta,
14 – ukrcajno-iskrcajni ventil,
15 – regulacijski ventil.

Ukrcaj ukapljenog plina bez pothlađivanja

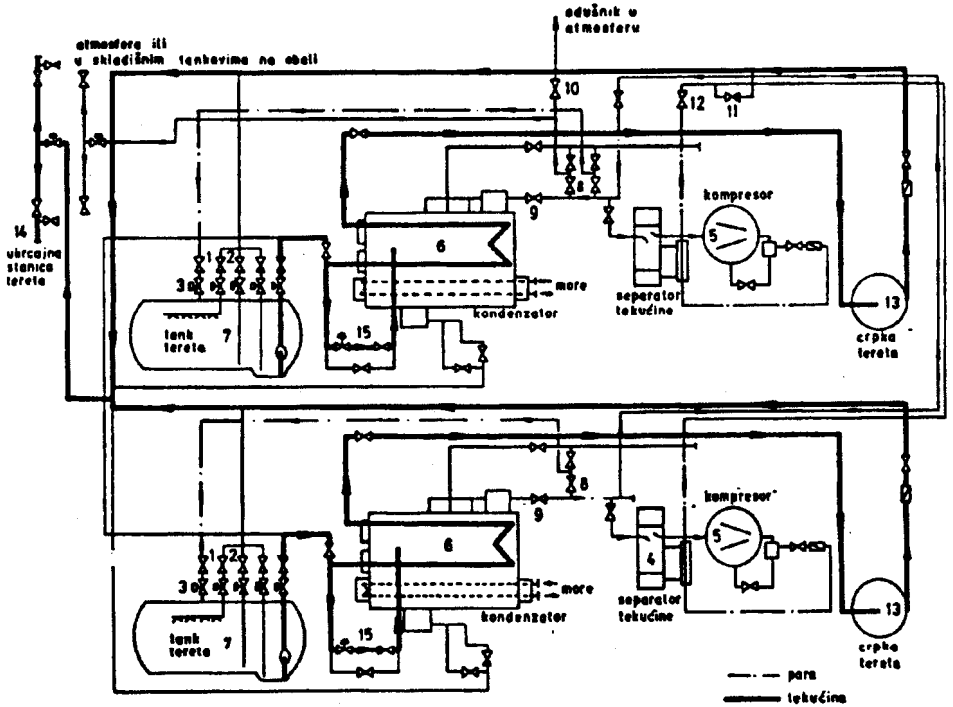
LPG-plovidba



1 – ventil za pothlađivanje,
2 – ukrcajni ventil,
3 – prekotlačni ventil tekućinskih para,
4 – odvajač tekućine,
5 – kompresor,
6 – kondenzator,
7 – tank tereta,
8 – zaobilazni ventil,
9 – zaporni ventil,
10 – ventil odušnika,
11 – nepovratni ventil,
12 – zaporni ventil,
13 – crpka tereta,
14 – ukrcajno-iskrcajni ventil,
15 – regulacijski ventil.

Pothlađivanje tijekom plovidbe

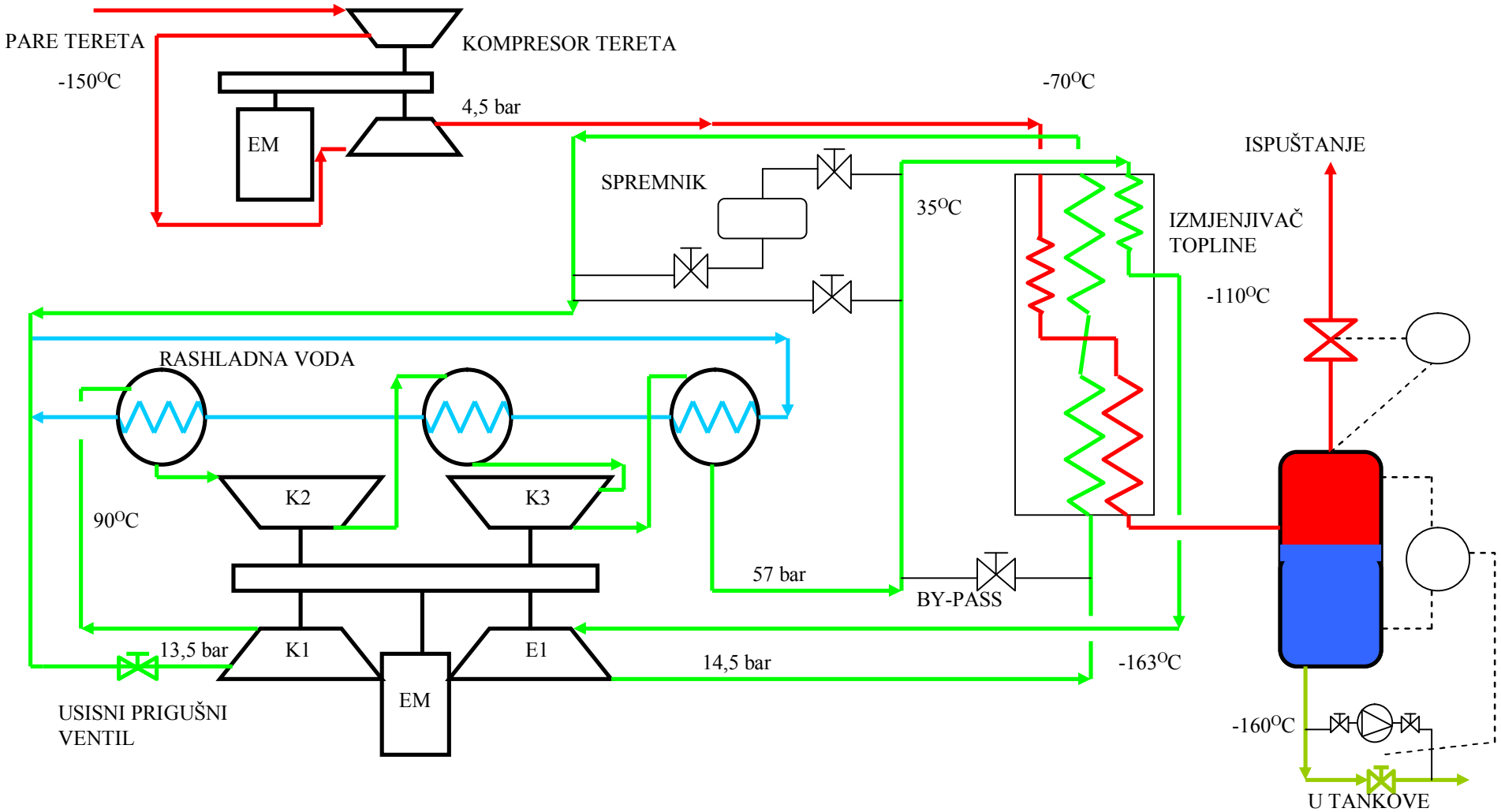
LPG-iskrcaj



1 – ventil za pothlađivanje,
2 – ukrcajni ventil,
3 – prekotlačni ventil tekućinskih para,
4 – odvajač tekućine,
5 – kompresor,
6 – kondenzator,
7 – tank tereta,
8 – zaobilazni ventil,
9 – zaporni ventil,
10 – ventil odušnika,
11 – nepovratni ventil,
12 – zaporni ventil,
13 – crpka tereta,
14 – ukrcajno-iskrcajni ventil,
15 – regulacijski ventil.

Iskrcaj ukapljenog plina pomoću para na brodu

Rashladni sustav za LNG



Hlađenje skladišta

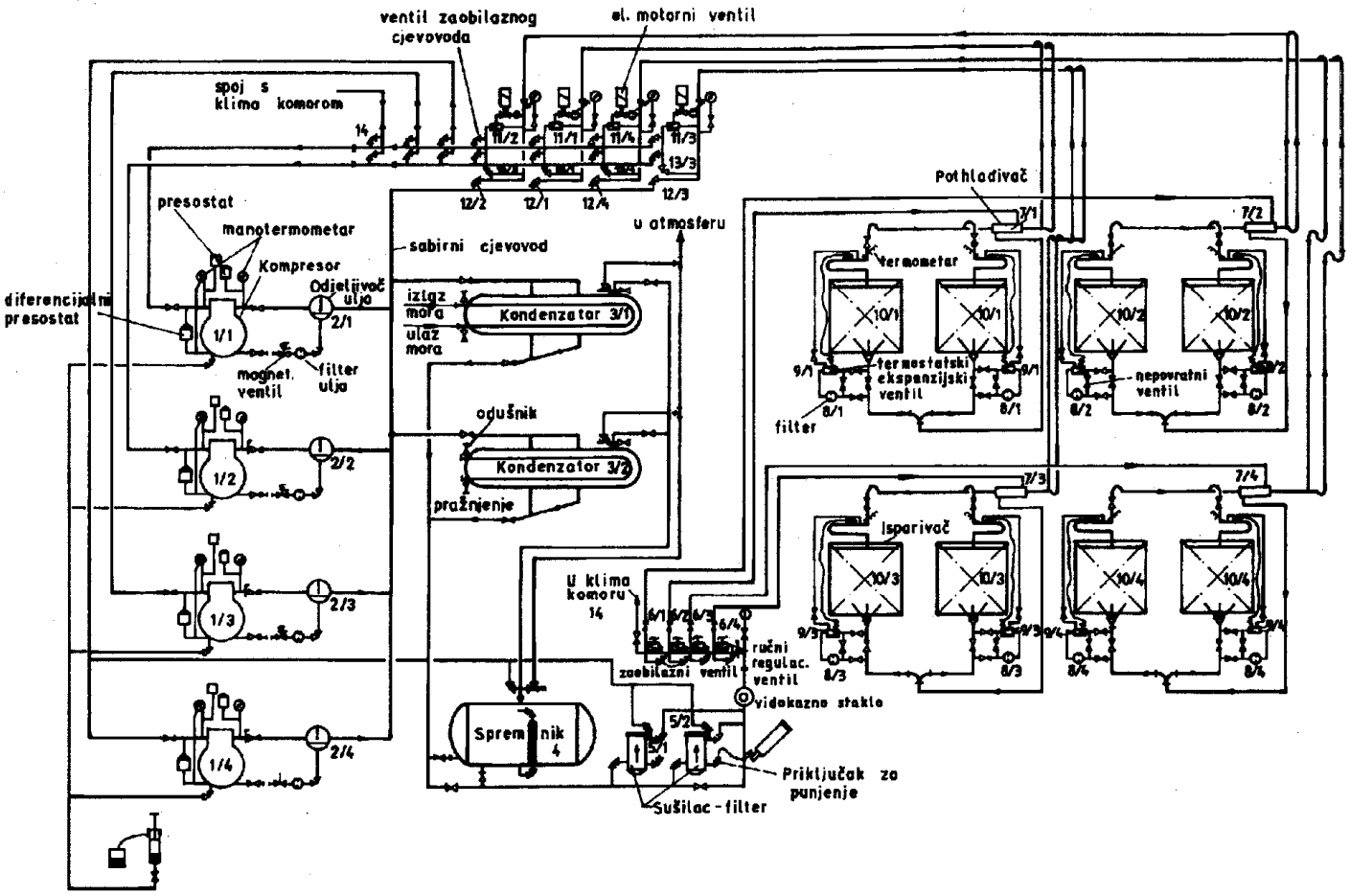
- usporava kvarenje i razvoj mikroorganizama
- toplinsko opterećenje

- mirno i burno [redacted]
- sastav zraka?
- direktno i indirektno hlađenje

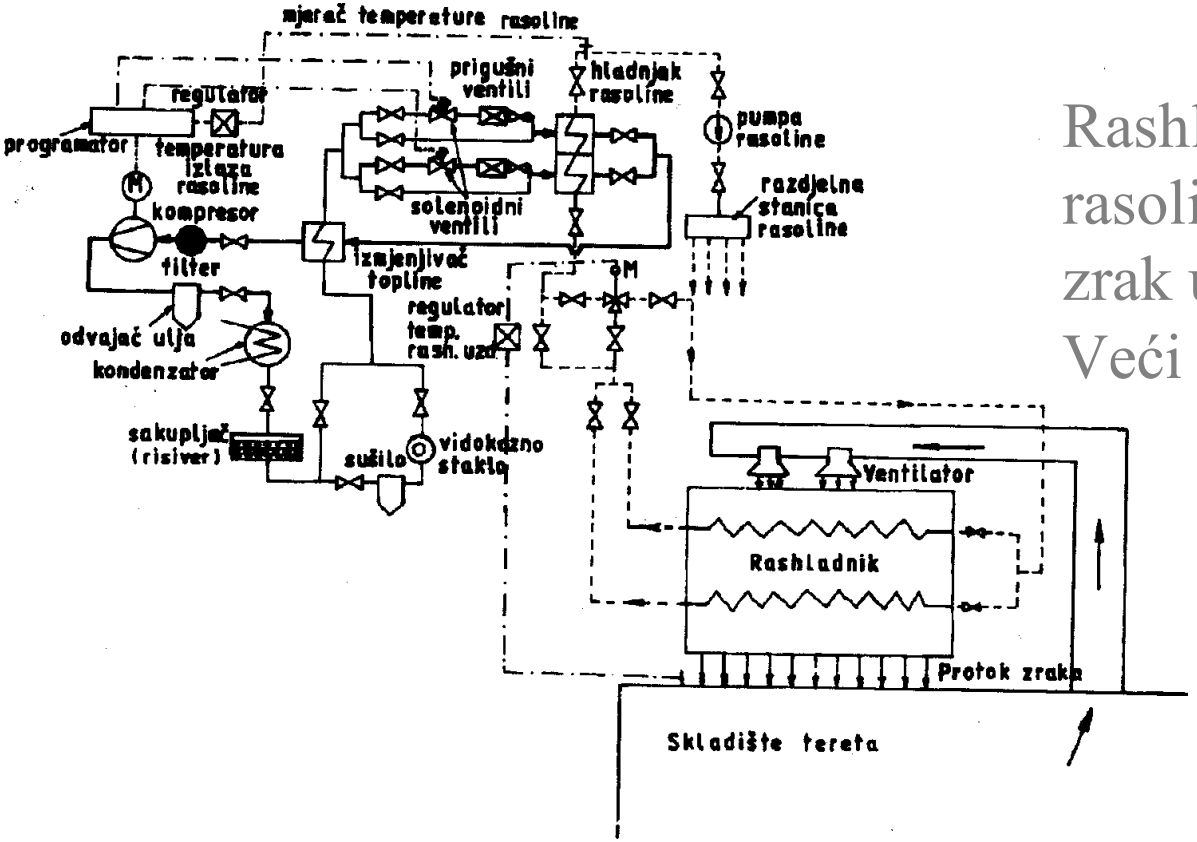
Teret

- konvencionalni prijevoz
- kontejneriziran
- hlađenje cijelog skladišta – debljina izolacije?

Direktno


ventil zaobilaznog cjevovoda
el. motorni ventil
spoj s klima komorom
presostat
manotermometar
Kompresor
Odjeljivač ulja
diferencijalni presostat
magnet. ventil
filter ulja
sabirni cjevovod
u atmosferu
izlaz mora
ulaz mora
Kondenzator 3/1
odušnik
Kondenzator 3/2
pražnjenje
Pothladivač
termometar
termostatski ekspanzijski ventil
nepovratni ventil
filter
Isparivač
U klima komoru 14
ručni regulac. ventil
zaobilazni ventil
vidokazno staklo
Spremnik 4
Priključak za punjenje
Sušilac - filter

Indirektno



Shema indirektnog rashladnog sustava

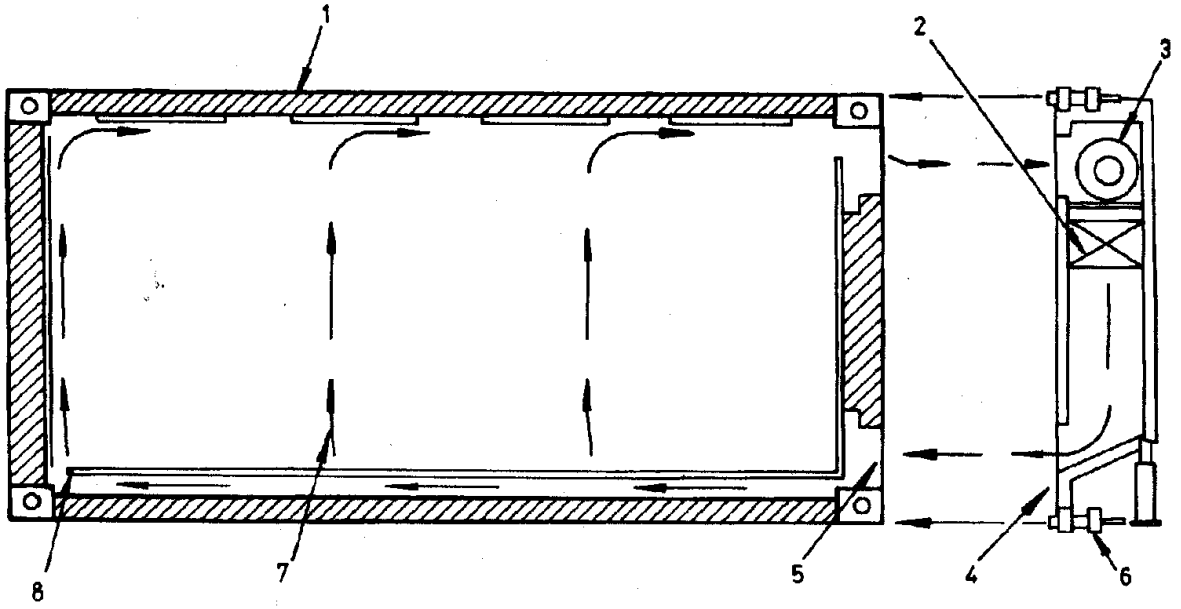
Rashladni medij hladi rasolinu, a ova zrak u skladištu. Veći Δt!!!

Rasoline

- NaCl, $CaCl_2$, $MgCl_2$
- NaCl do –16^{o}C
- $CaCl_2$ do -45^{o}C (min. -55^{o}C pri 30%)
- kapacitet dobavne pumpe

$$V = \frac{Q_o}{c\left(t_{1r} - t_{2r}\right)\rho}$$

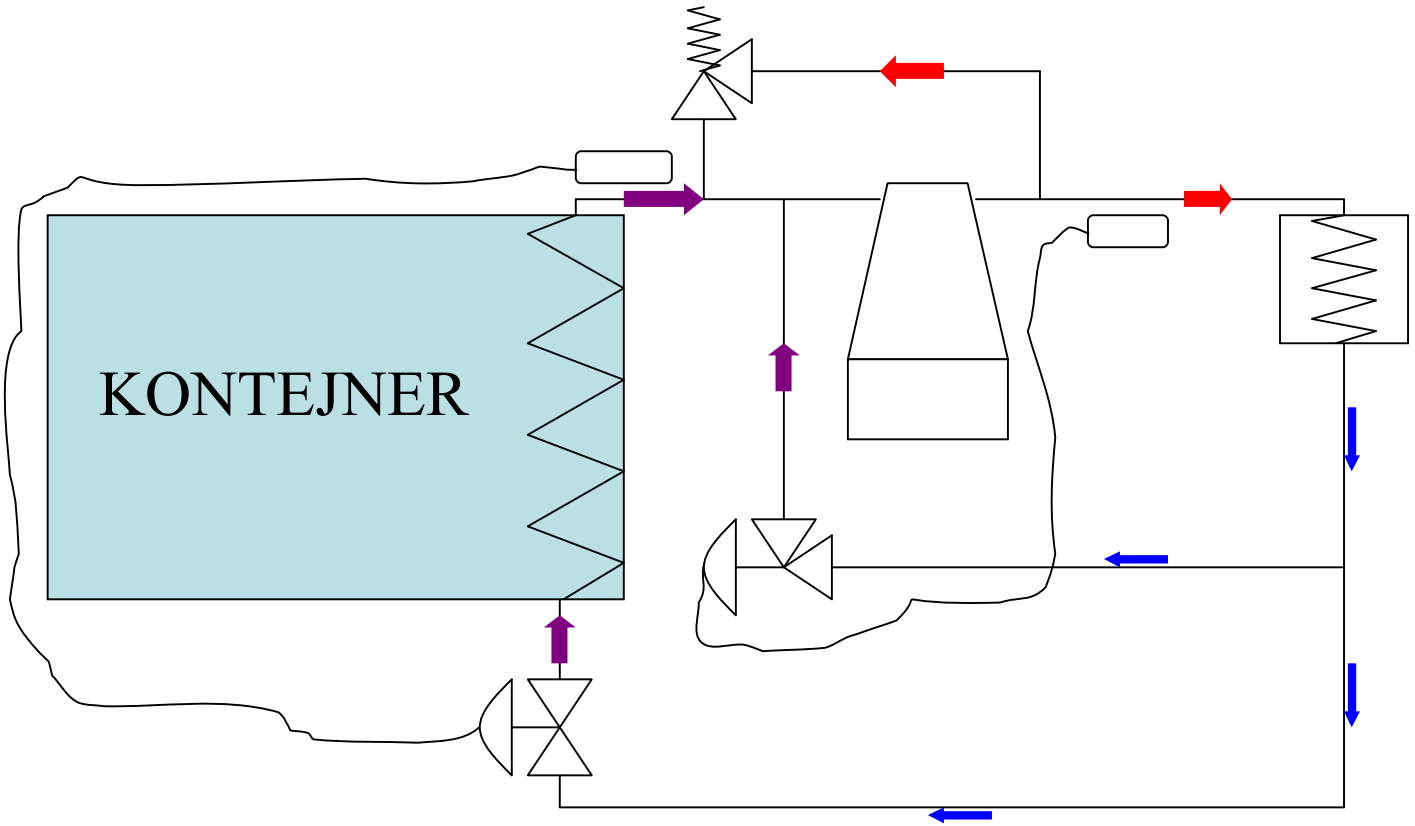
Kontejneri



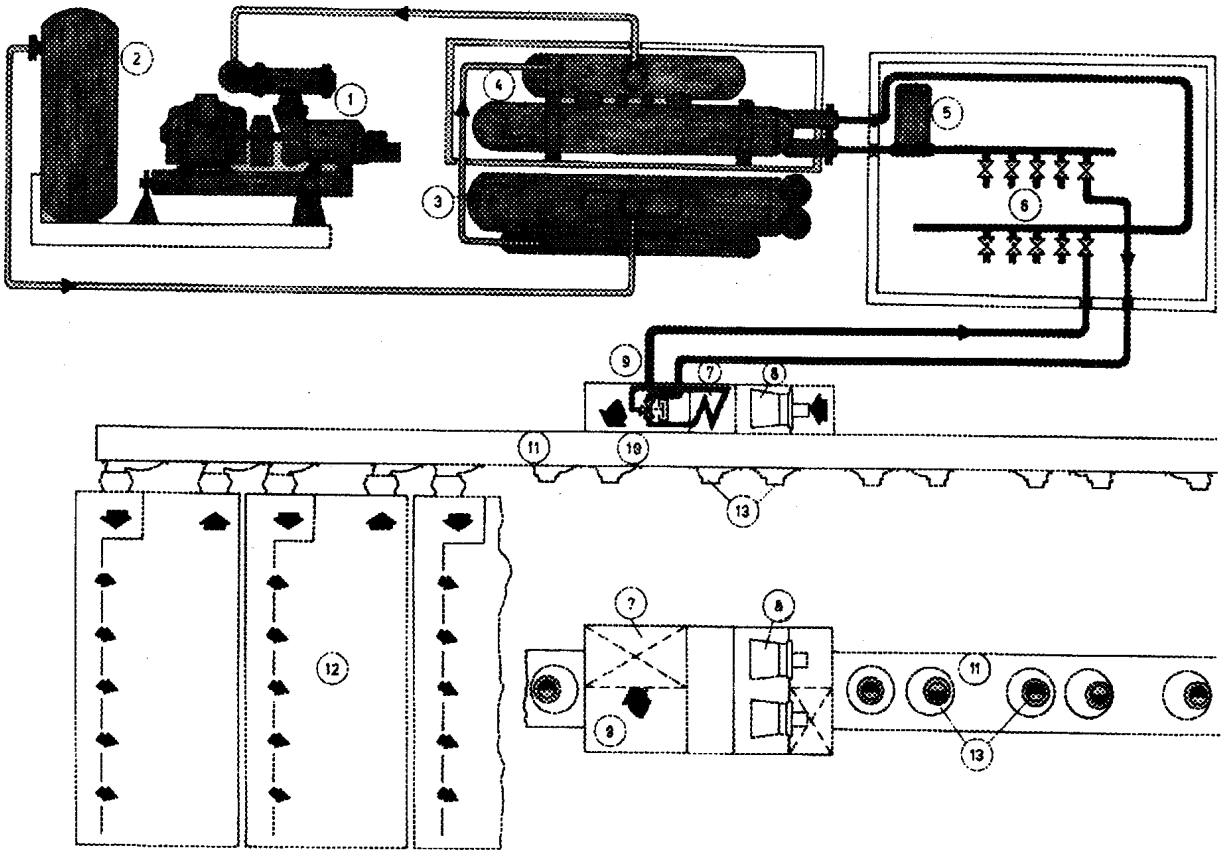
1 – izolacija,
2 – rashladno tijelo,
3 – ventilator,
4 – brtvila,
5 – dva zračna otvora,
6 – zatega na rashladnom uređaju,
7 – protok zraka,
8 – otvori za zrak.

Rashladni kontejner sa skidljivim rashladnim agregatom

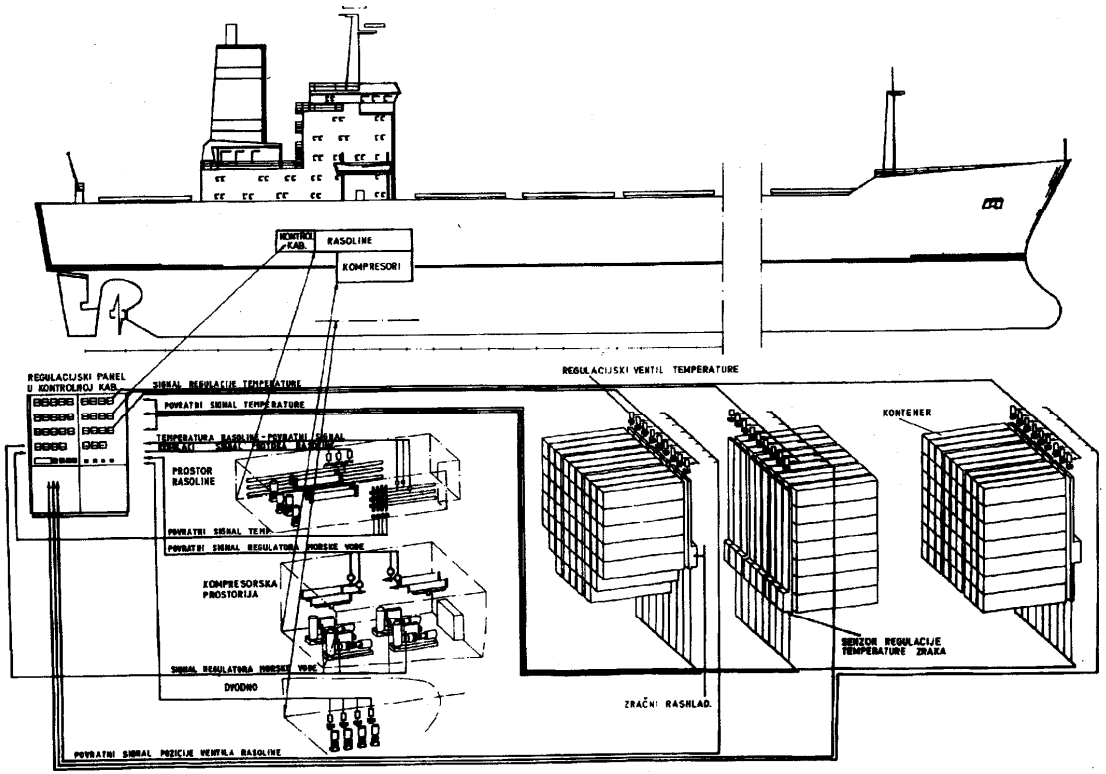
Shema uređaja



Kontejneriziran teret

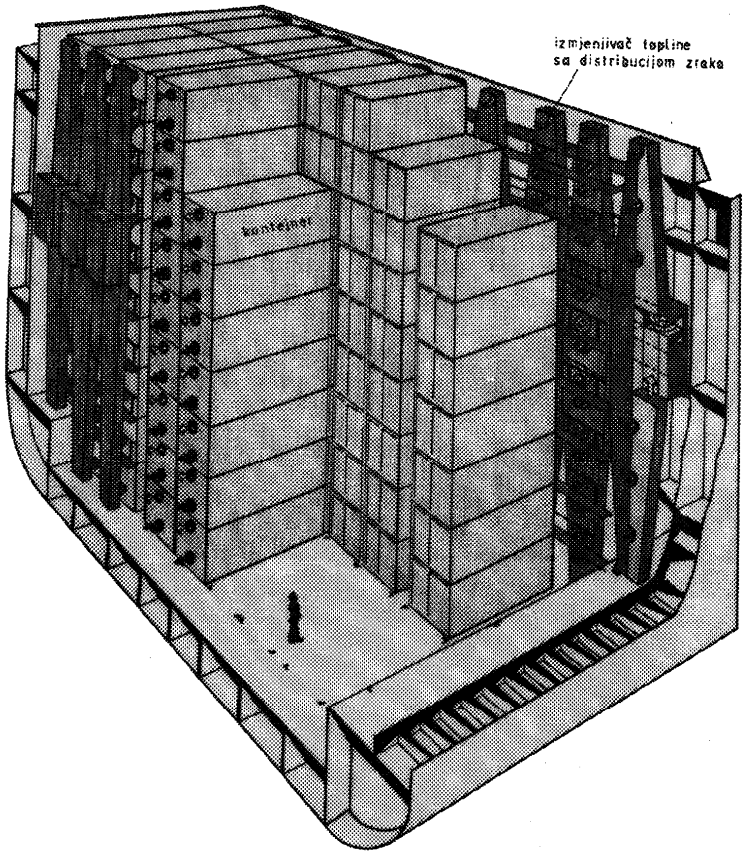


Kontejneri



Brod za prijevoz rashladnih kontejnera (Izvor: 41)

Kontejneri



Smještaj rashladnih kontejnera u skladištu broda (Izvor: 41)

Riba

- mlaz hladnog zraka (- 20-25°C)
- rasolina (- 12°C)
- isparivačke ploče
- pothlađivanje s morem (0°C)
- ekspanzija tekućeg dušika

Ostali tipovi

- apsorpcijski
- ejektorski (s mlaznim duhaljkama)

- indirektni – rasoline
- azeotropske smjese

APSORPCIJSKI

- smjese: dva ili više sudionika
- dvojne (binarne) smjese
- homogene i heterogene

Homogene i heterogene

- Homogene smjese imaju u svim po volji izvučenim volumenskim dijelovima isti tlak, temperaturu, gustoću i sastav i ne mogu se rastaviti na sastavne dijelove bez utroška rada
- Heterogene smjese mogu se teoretski bez utroška rada, samo mehaničkim sredstvima, rastaviti na tvari iz kojih su sastavljene

Binarne

- Komponenta (1) – *h', s', v', G'*;
- Komponenta (2) - *h'', s'', v'', G''*
- *ξ - udio tvari (2) u 1 kg smjese*
- *za čistu je tvar (1) ξ=0, a za čistu tvar (2) ξ=1*

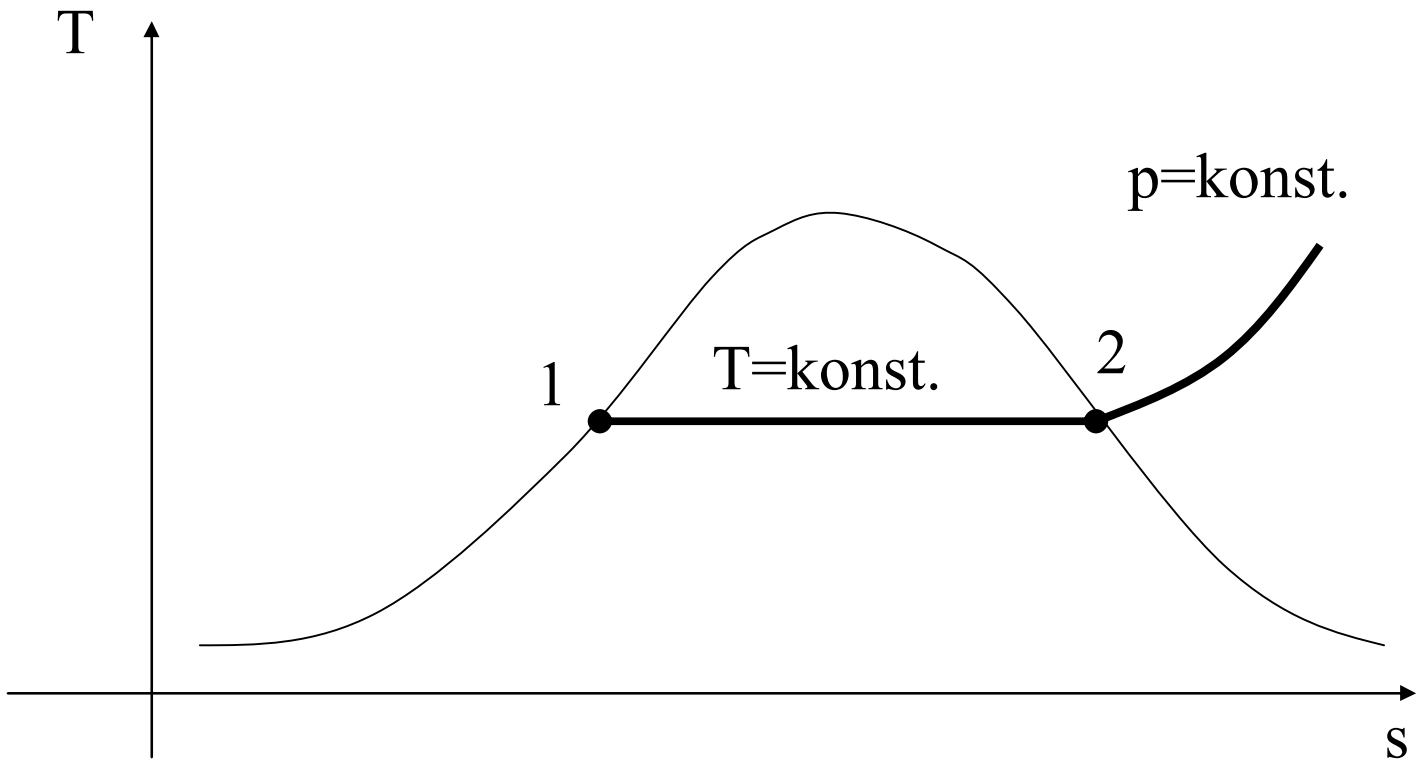
Toplinske pojave kod miješanja

- idealni (realni) plinovi: $t = t' = t''$
- smjese $\rightarrow q \Rightarrow t \neq$ konst.
- izotermna toplina miješanja q_t je toplina koju odvodimo ili dovodimo kako bi temperatura ostala ista

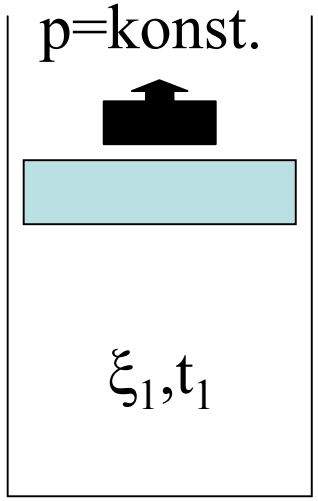
Toplina miješanja

- ovisi o vrsti smjese, sastavu, a nekad i o temperaturi
- primjeri H_2O+NH_3 i H_2O+etilni alkohol

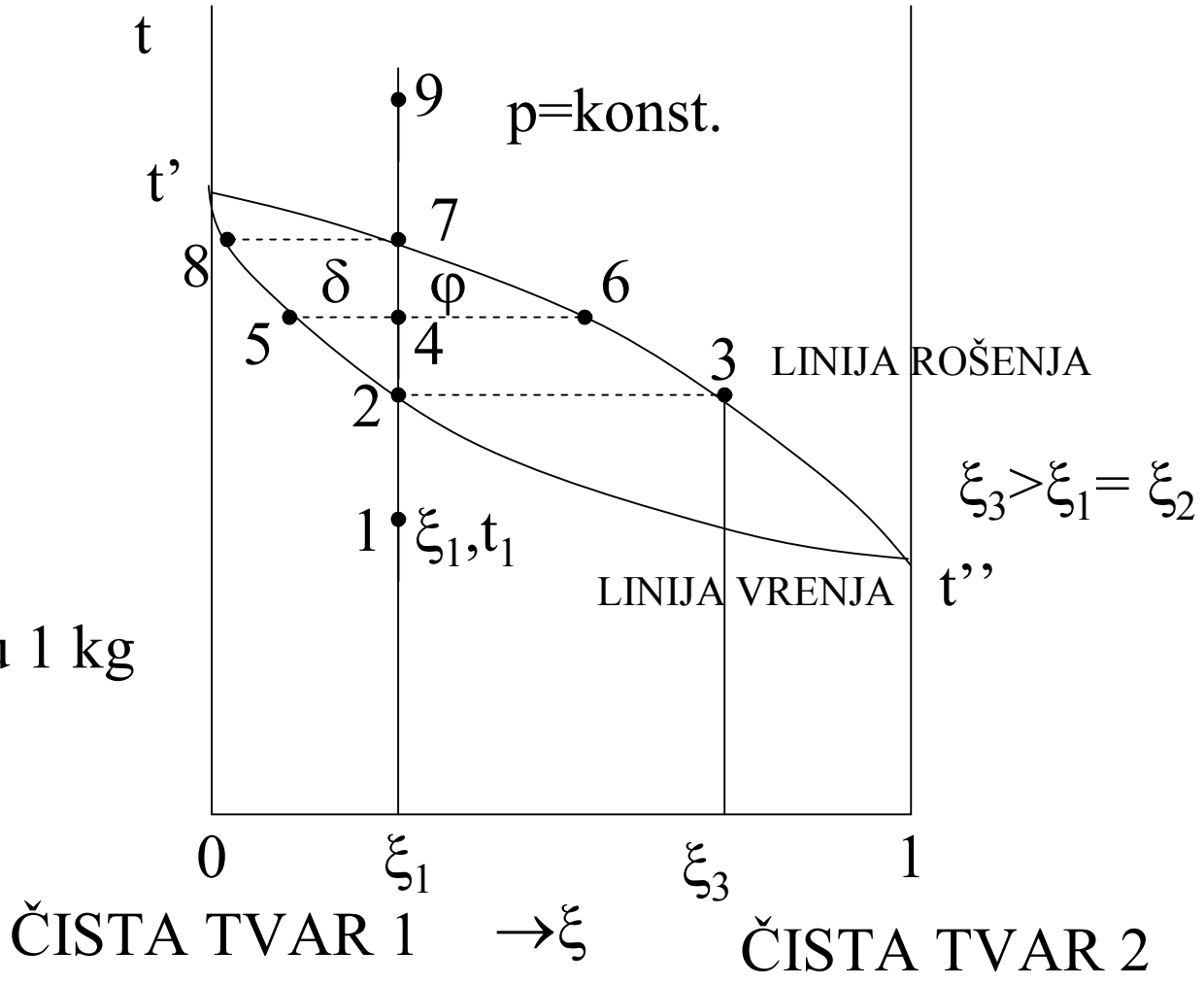
Jednostavna tvar



Binarna smjesa - isparivanje



ξ je udio tvari 2 u 1 kg smjese.



Udio pare i kapljevine

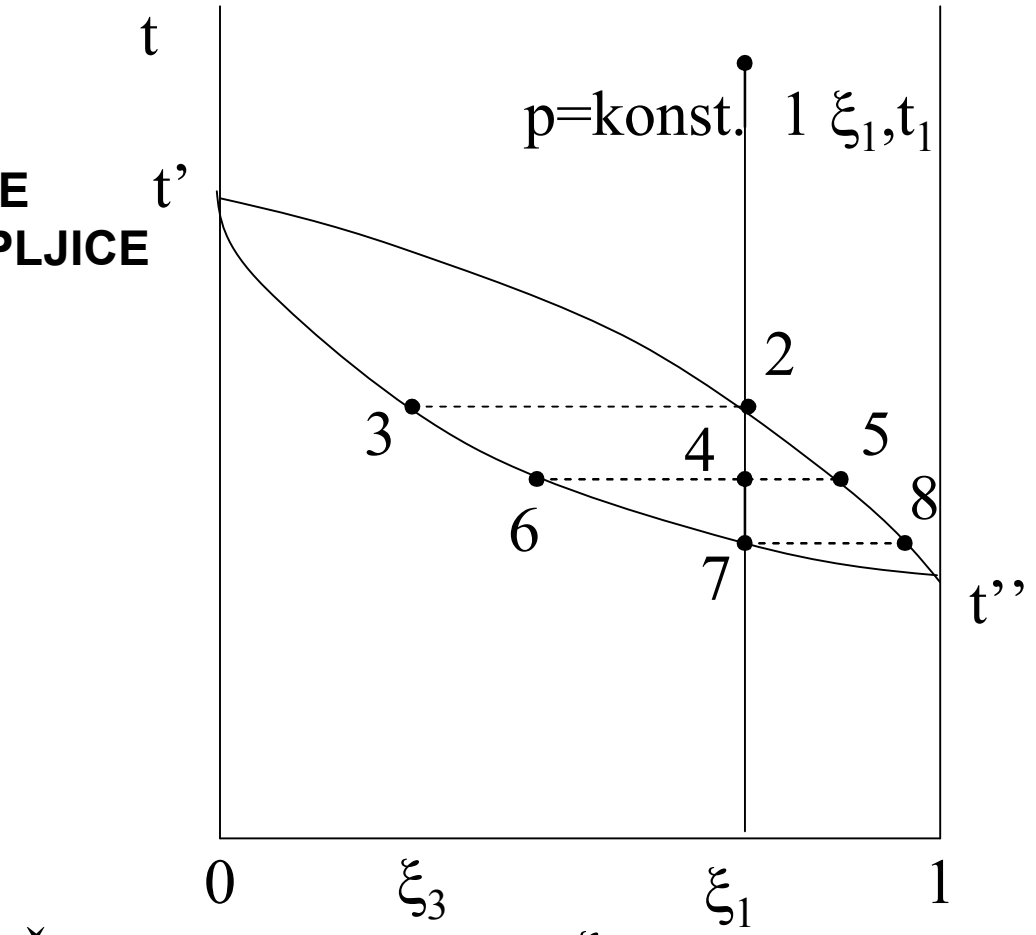
- φ - udio kapljevine
- δ - udio pare
- $\varphi + \delta = 1$

Binarne smjese

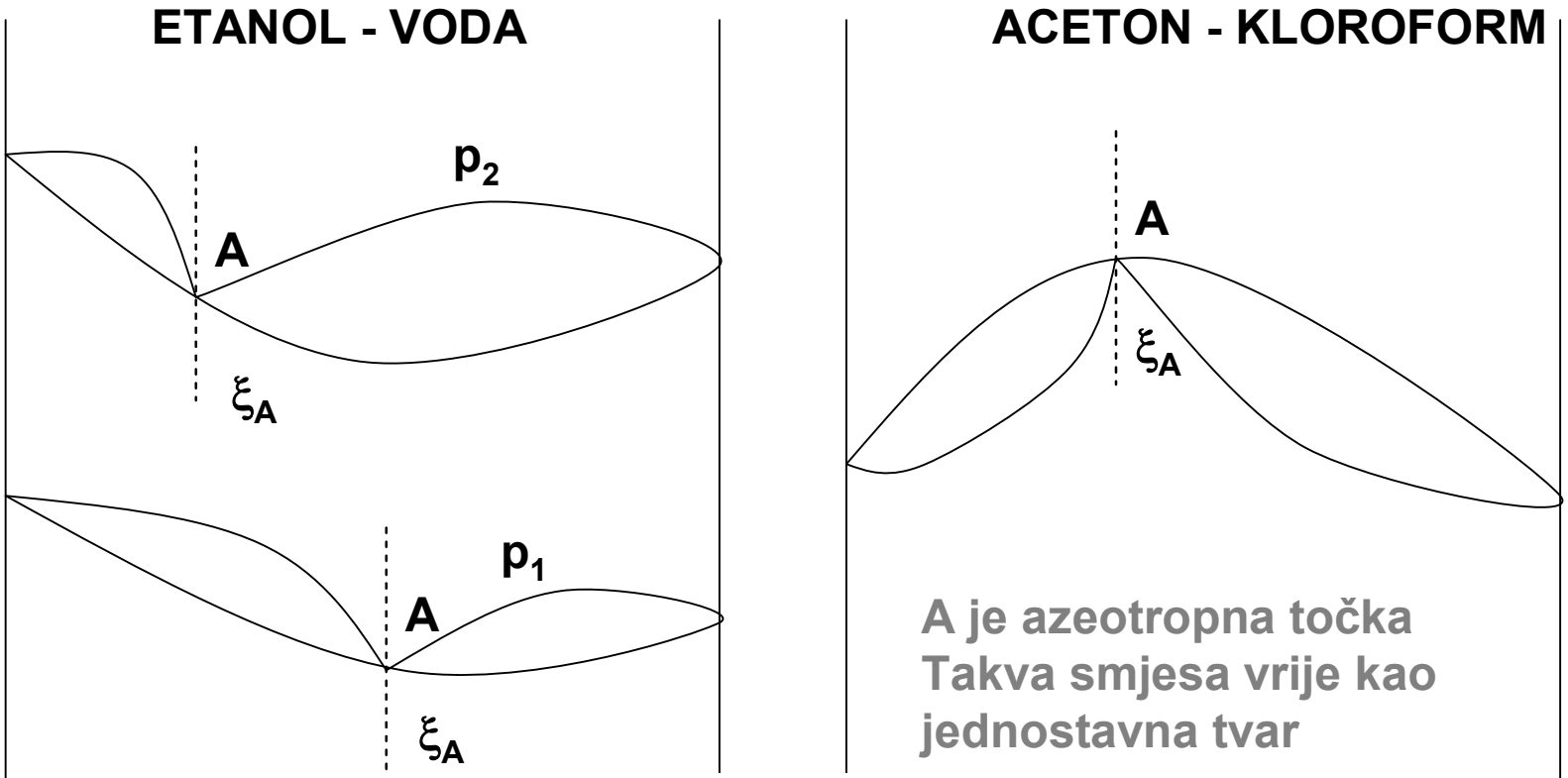
- kod p=konst. binarne smjese nemaju jednaku temp. vrenja već ovisi o sastavu
- za vrijeme isparivanja mijenja se sastav kapljevine i pare (prosječni je isti)
- za vrijeme isparivanja raste temperatura
- ako paru stanja 7 nastavimo grijati ulazi u područje pregrijanja i ponaša se kao plinska smjesa

Kondenzacija

1-2 HLAĐENJE
2 – PRVE KAPLJICE
SASTAVA ξ_3



Azeotropne smjese



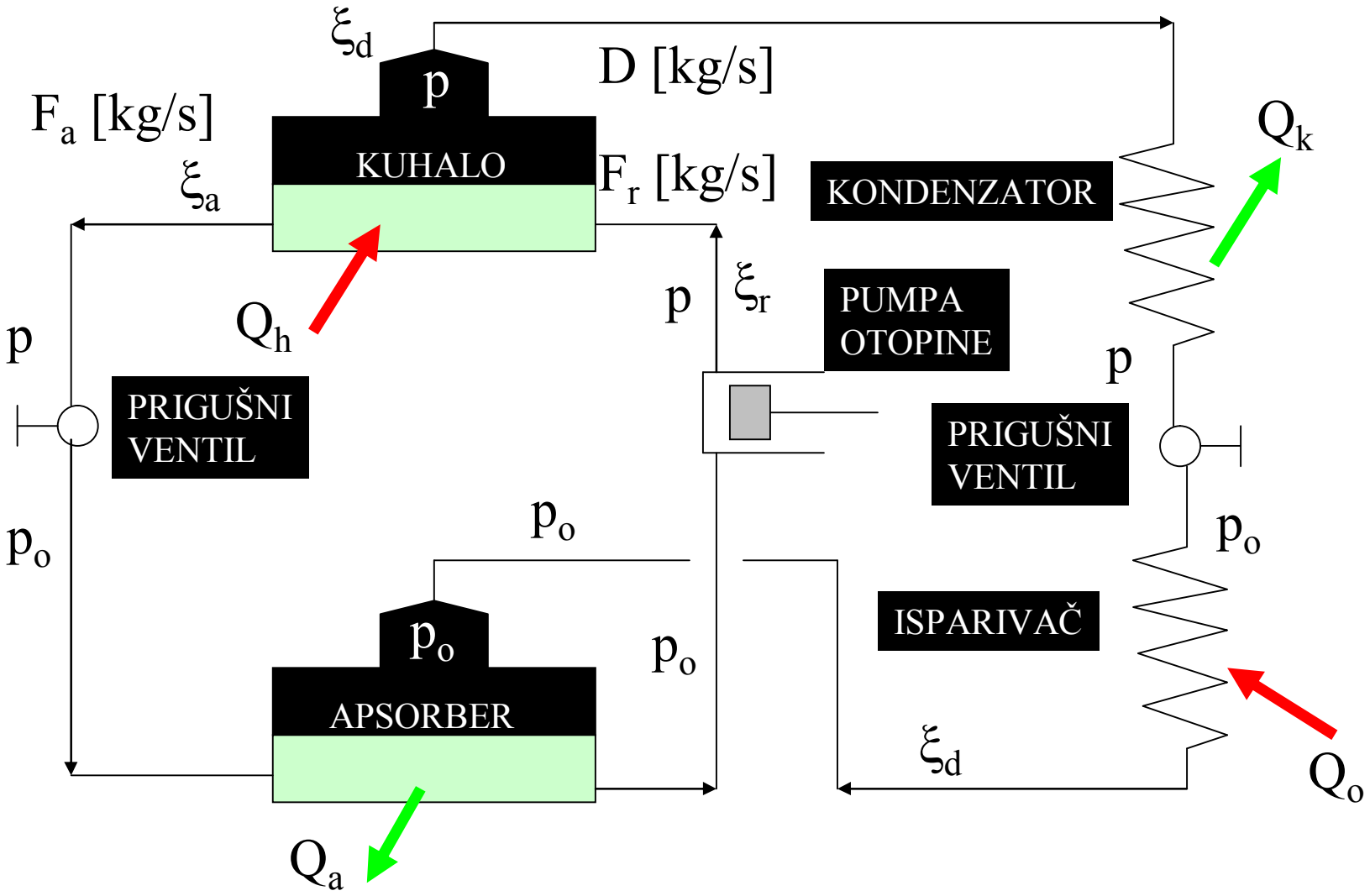
A je azeotropna točka
Takva smjesa vrije kao jednostavna tvar

SMJESE S TEMPERATURNIM MINIMUMOM ILI MAKSIMUMOM U TOČKI A DODIRUJU SE LINIJE ROŠENJA I VRENJA PA PARA I KAPLJEVINA IMAJU ISTI SASTAV – TEMPERATURA SE NE MIJENJA DOK SVE NE ISPARI

Apsorpcijski rashladni uređaji

- termodinamika smjesa
- većinom H_2O-NH_3, H_2O-LiBr, H_2O-H_2SO_4 …

Apsorpcijski uređaj



Bilance

- tvari

$$F_r = D + F_a$$

- tvari sudionika

$$F_r \xi_r = \xi_a (F_r - D) + D \xi_d$$

- topline

$$Q_h + Q_o + L_p = Q_a + Q_k$$

- bilance se m

$$Q + Q_o = Q_a + Q_k$$

Efikasnost

- toplinski omjer hlađenja (rashladni omjer):

$$\xi_{teor} = \frac{Q_o}{Q_h} = \frac{T_o}{T - T_o} \cdot \frac{T_h - T}{T_h}$$

- ne može s $\xi < \xi_{teor}$

Usporedba p-k i aps. ur.

- apsorpcijski rashladni uređaj troši toplinu
- parnokompresijski uređaj troši rad, a za proizvodnju rada treba toplina
- moguća usporedba ξ_{apsorp} i ξ_L

$$\eta_t = \frac{L}{Q_L}$$

$$\xi_L = \frac{Q_o}{Q_L} = \frac{Q_o}{L} \cdot \frac{L}{Q_L} = \varepsilon \cdot \eta_t$$

Poboljšanje

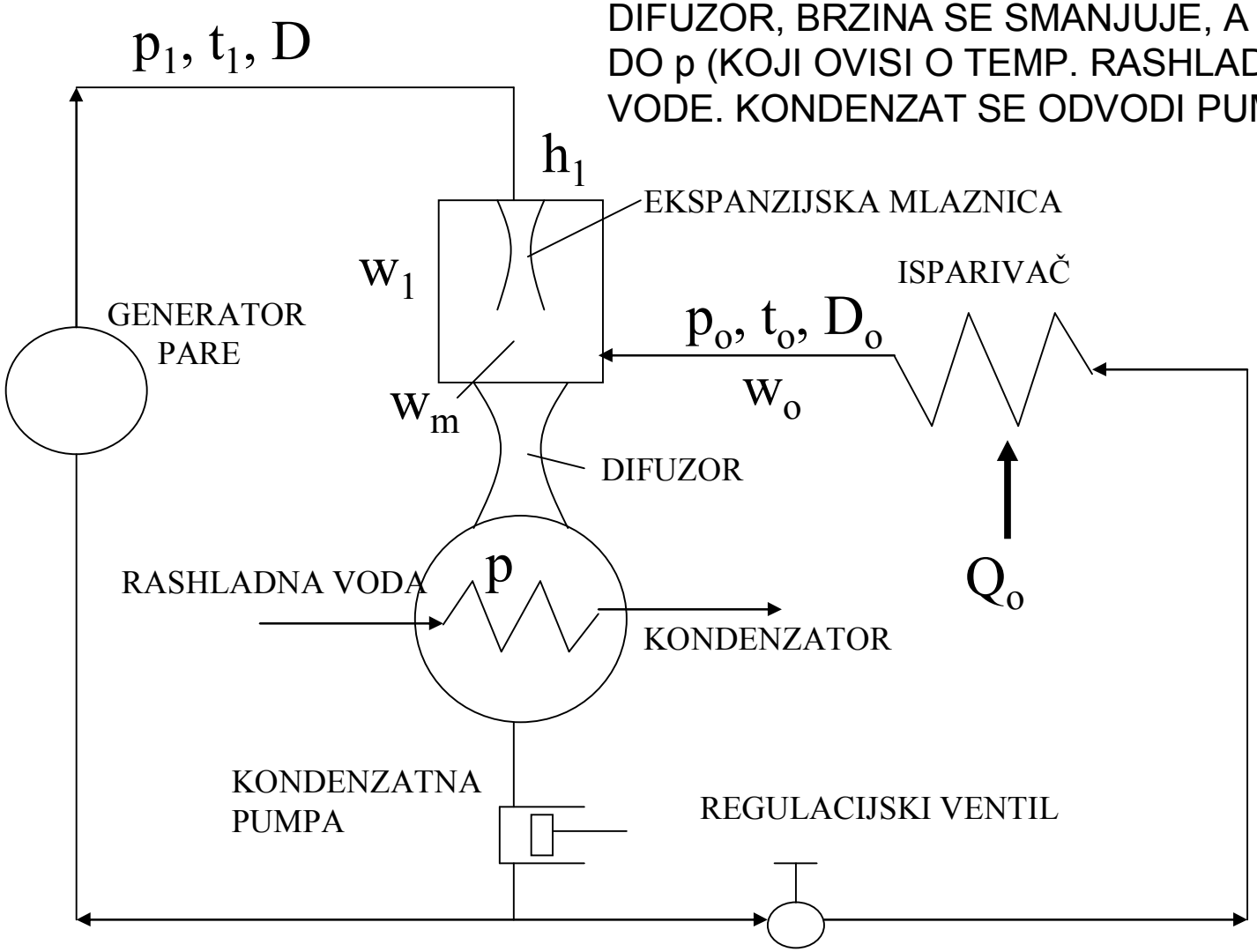
- opremanje kuhala s rektifikacijskom kolonom
- opremanje sa štednjacima (izmjenjivačima) topline
- dvostepeni

Ejektorski

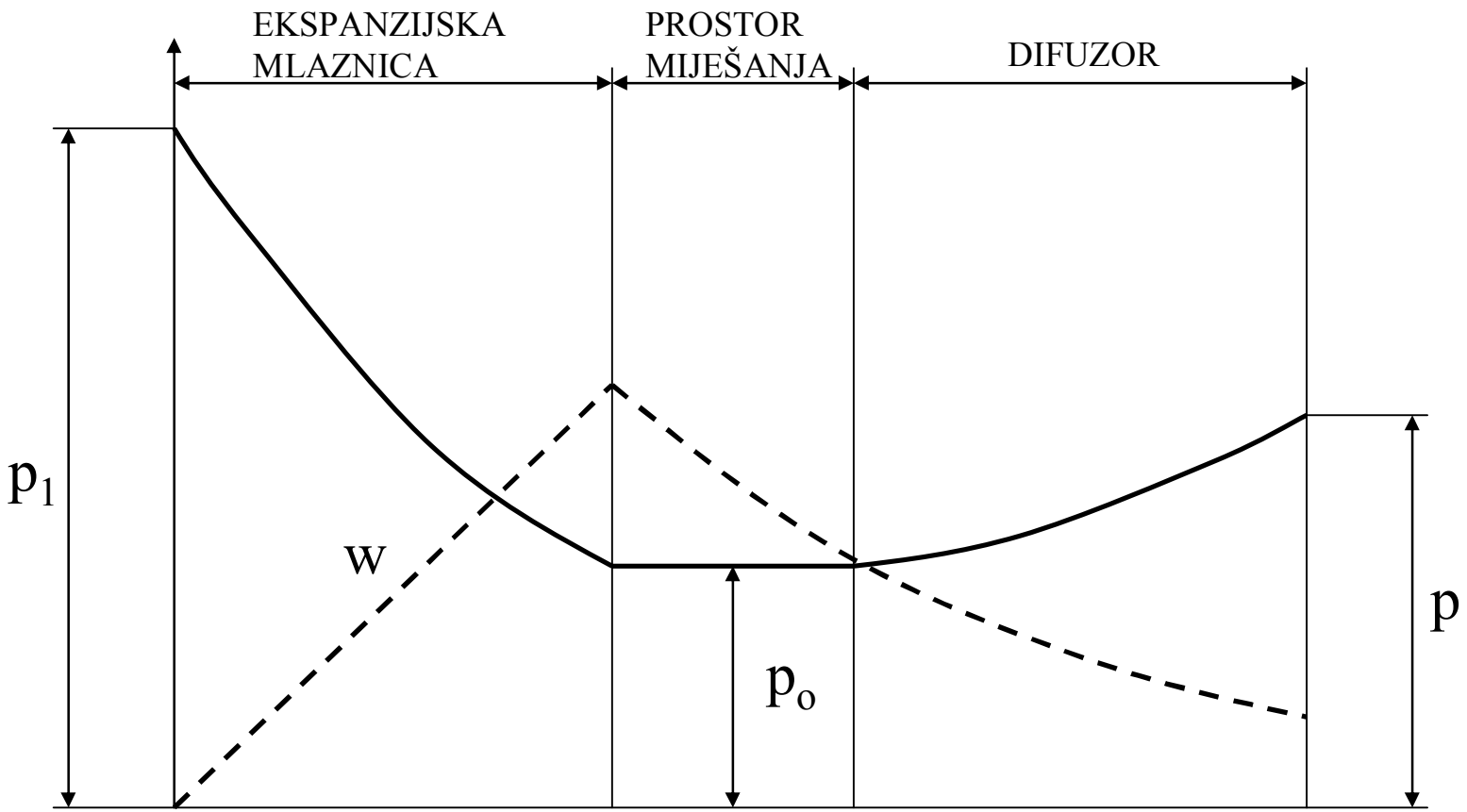
- uređaj s mlaznim duhaljkama
- miješanje dvaju parnih struja
- glomazan, potreban visoki vakuum

Ejektorski

RADNA PARA D EKSPANDIRA U MLAZNICI NA TLAK NEŠTO NIŽI OD p_o PA SE KONTINUIRANO SIŠE PARA D_O. MJEŠAVINA PARA D I D_O ULAZI U DIFUZOR, BRZINA SE SMANJUJE, A TLAK RASTE DO p (KOJI OVISI O TEMP. RASHLADNE MORSKE VODE. KONDENZAT SE ODVODI PUMPOM.



Ejektorski



Karakteristike

- mlazne duhaljke rade s gubicima: najveći su zbog sraza i miješanja
- najracionalniji tlak radne pare 1 MPa, a minimalni 0,2 MPa
- pr. p_1=0,7 MPa, $t_{rashl.vode}$=20°C utrošak radne pare D za rashladni učin Q_o=1000 kJ/h dat je tablicom

t_o	+15	+10	+6	+2
D[kg/h]	0,48	0,72	0,96	1,43

- utrošak rashladne vode je 3-4 puta veći nego kod kompresorskih rashladnih uređaja