



Ciclo de Palestras Sobre Controle Térmico de Satélites

Circuitos Com Bombeamento Mecânico (MPL)

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INPE-2003

Circuitos com bombeamento mecânico

$$Q_{g,l} = C_p \dot{m} \Delta T \quad Q_{2f} = \lambda \dot{m} \quad \Delta P_g \sim \frac{\dot{m}^{7/4}}{\rho^{3/4}} \quad \Delta P_{l,2f} \sim \dot{m}$$

$$N \sim \frac{\dot{m} \Delta P}{\rho}$$

Circuitos de gás:

$$N_g \sim \frac{1}{\rho} \left(\frac{Q}{C_p \Delta T} \right)^{11/4}$$

$$\rho_g \sim 1$$

Circuitos de líquido:

$$\rho_l \sim 10^3$$

$$N_l \sim \frac{1}{\rho} \left(\frac{Q}{C_p \Delta T} \right)^2$$

$$C_p \sim 10^3$$

Circuitos bifásicos:

$$\lambda \sim 10^6$$

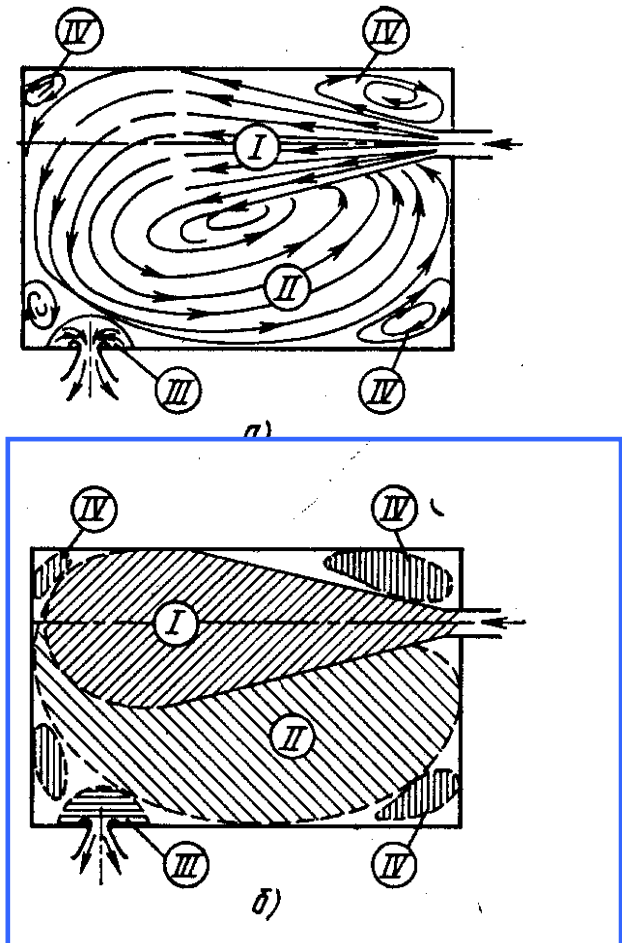
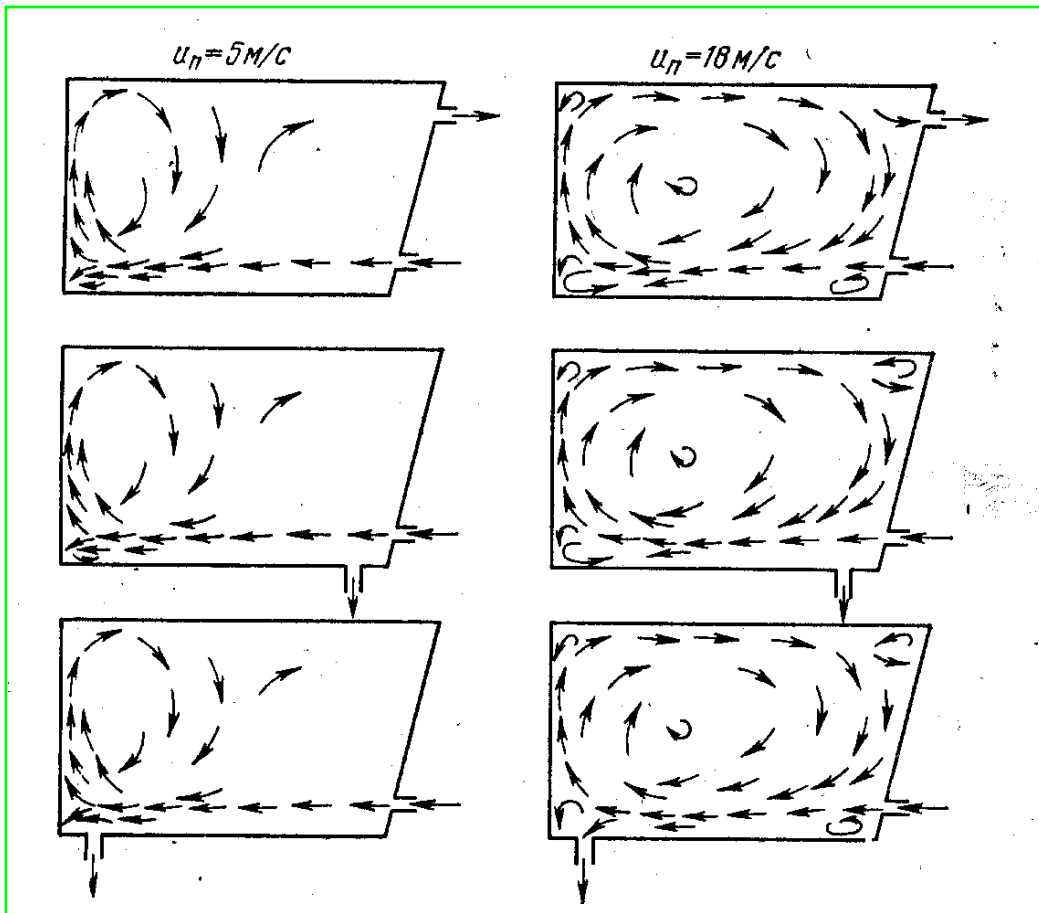
$$N_{2f} \sim \frac{1}{\rho} \left(\frac{Q}{\lambda} \right)^2$$

$$\Delta T \sim 10$$

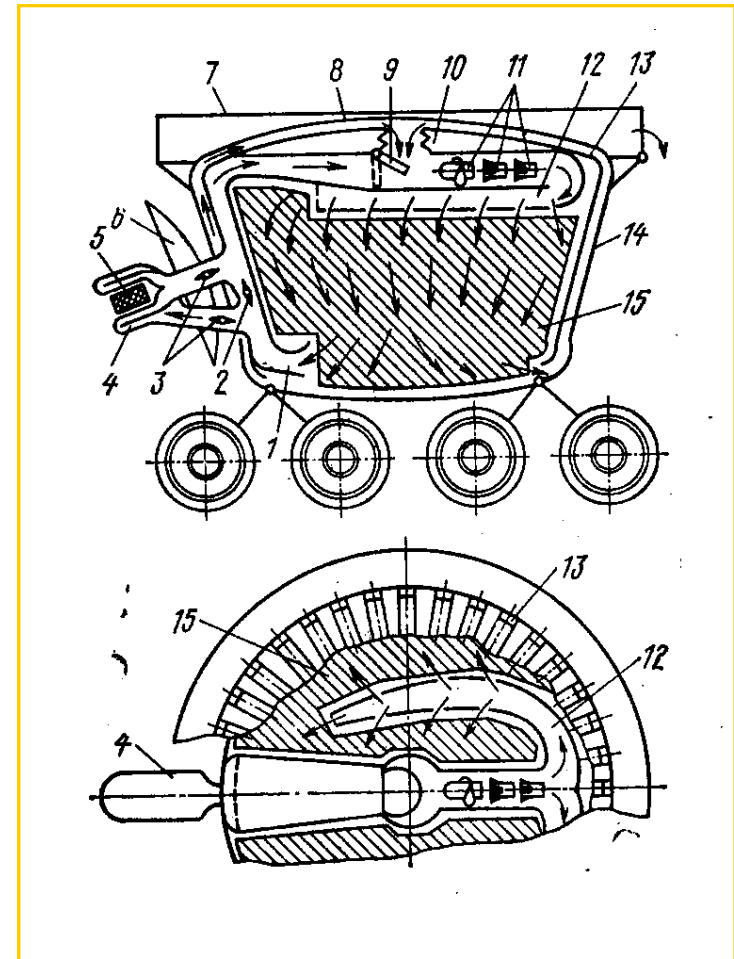
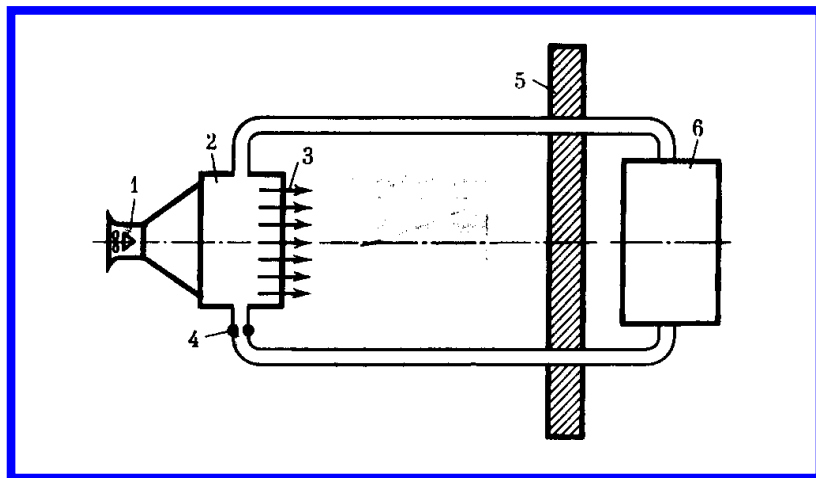
$$N_g / N_l \sim 1000$$

$$N_l / N_{2f} \sim 100$$

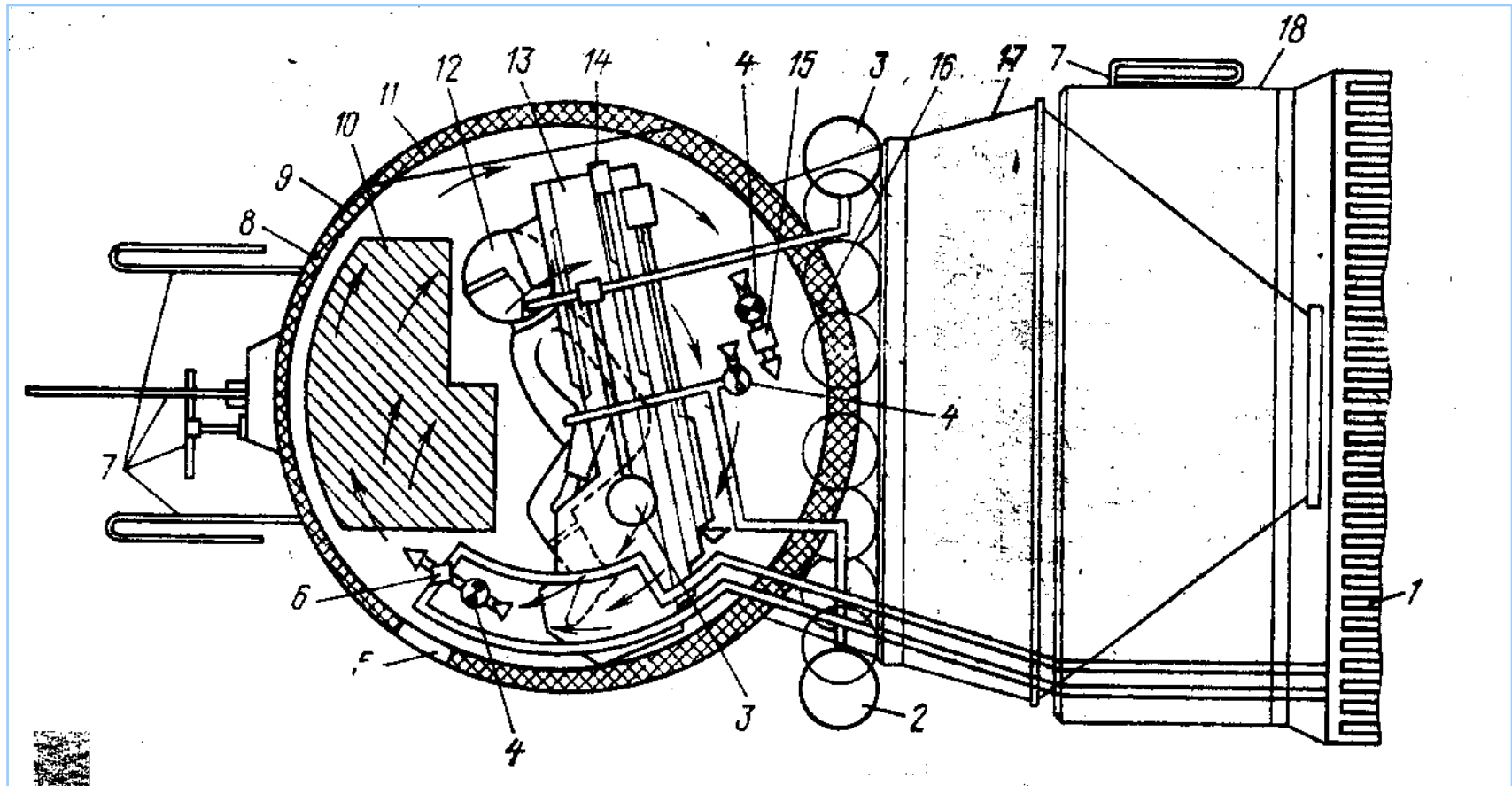
Circuitos de gás: compartimentos de equipamento



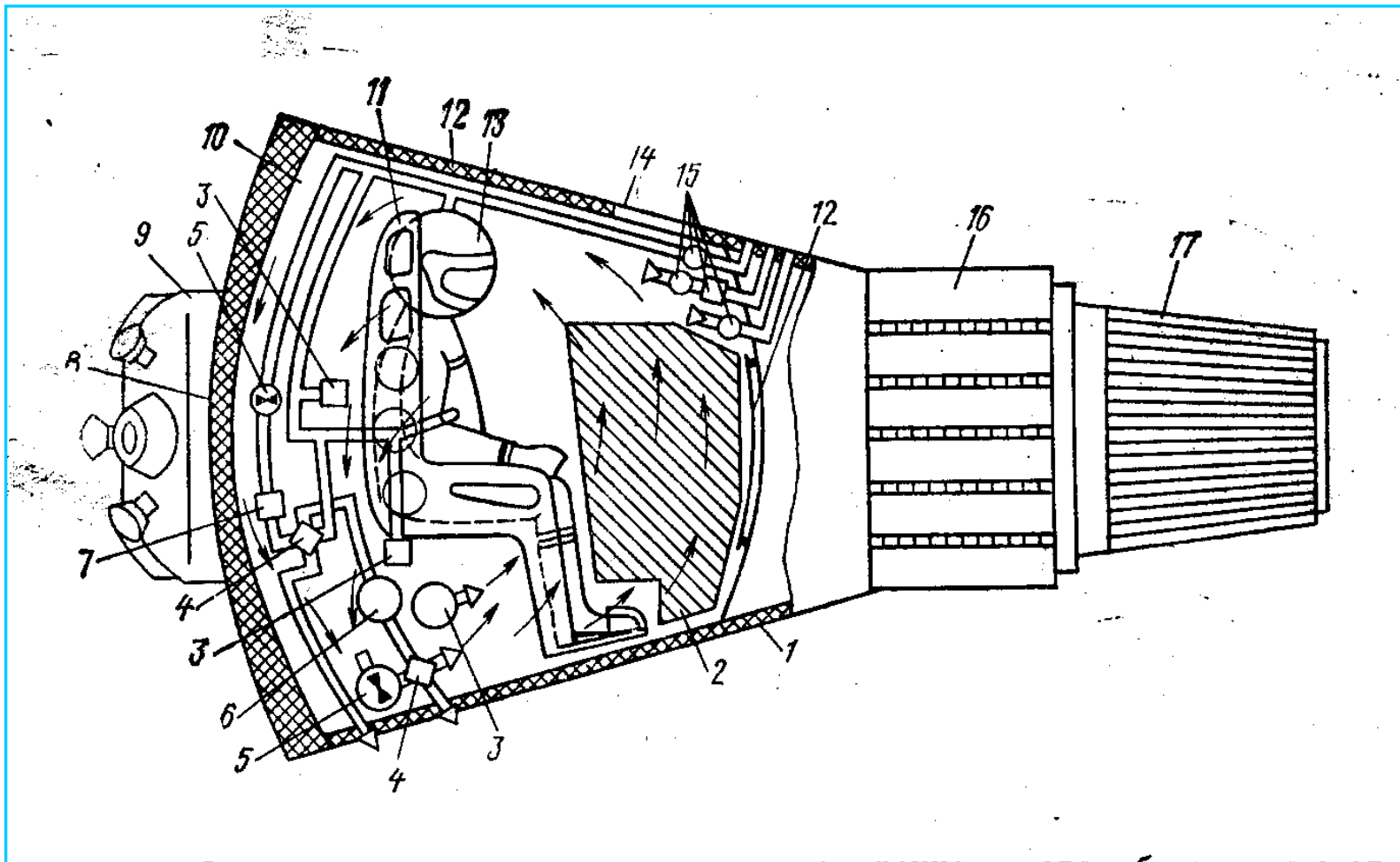
Circuitos de gás: compartimentos de equipamento



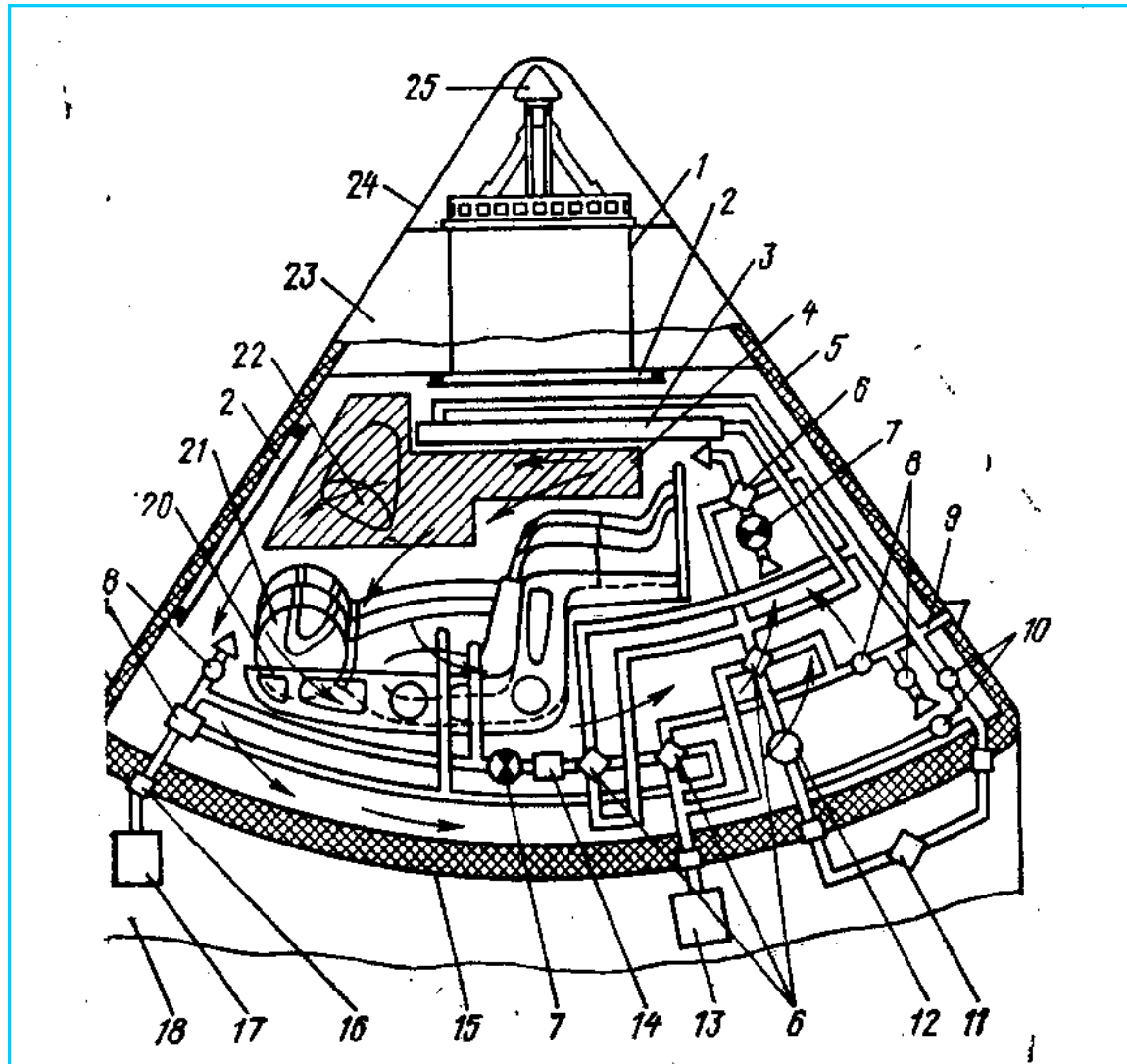
Compartimentos tripulados: Vostok



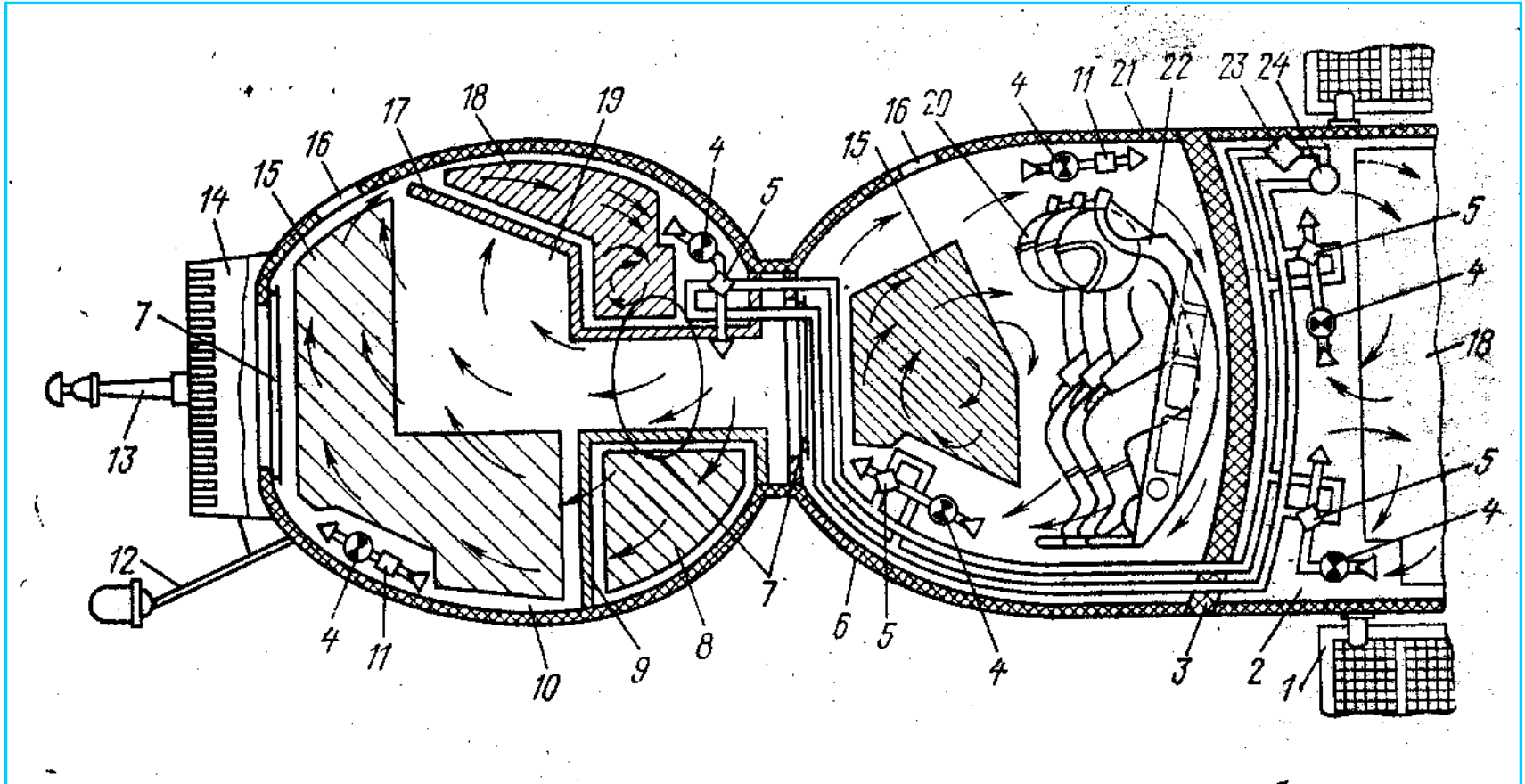
Compartimentos tripulados: Mercury



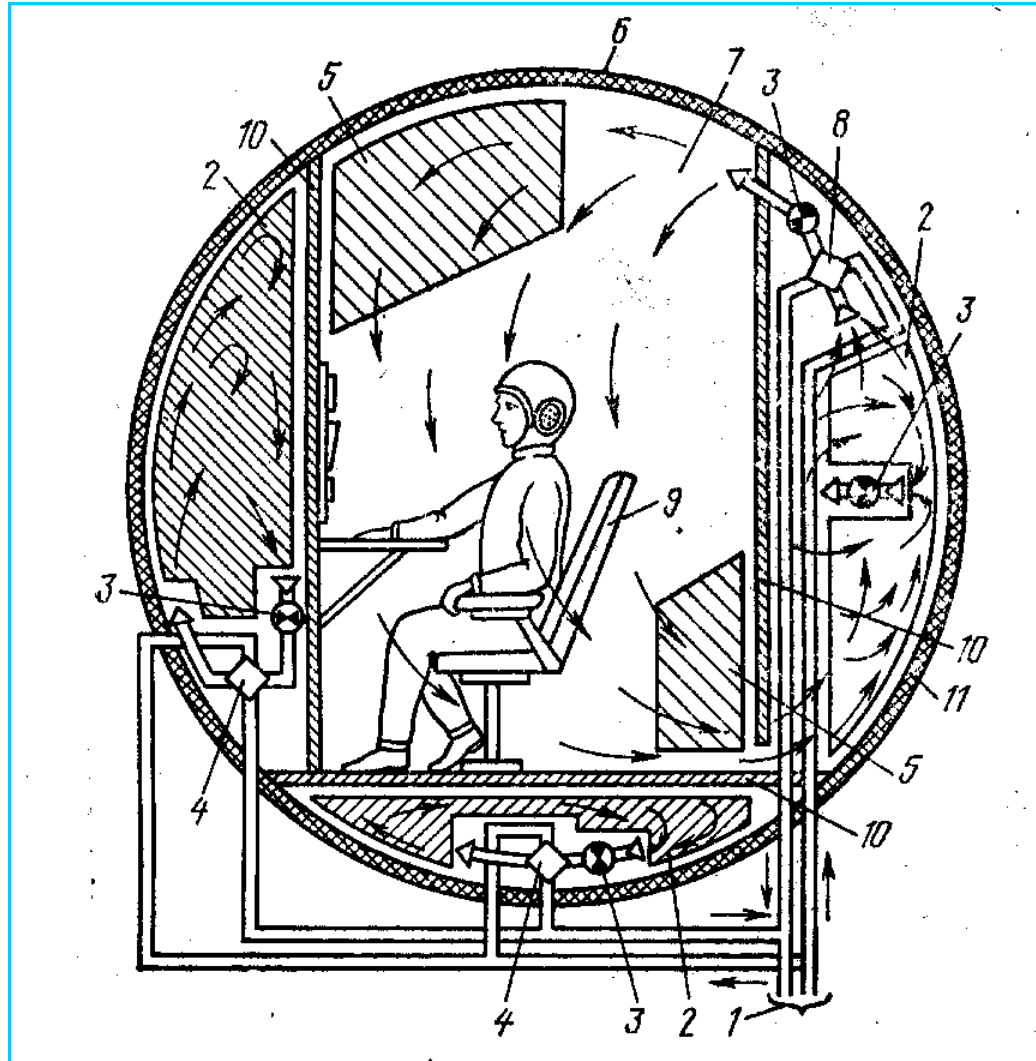
Compartimentos tripulados: Appolo



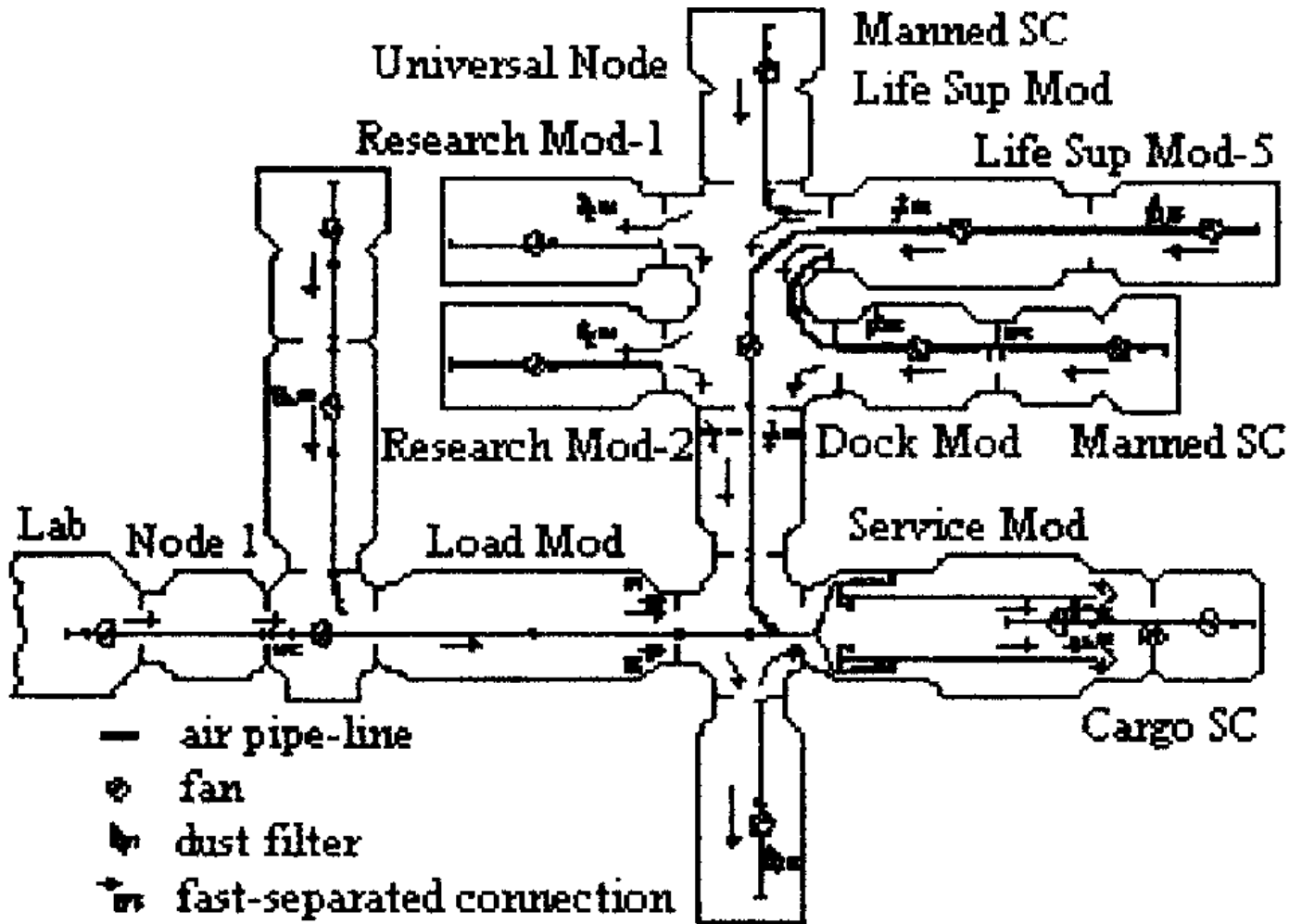
Compartimentos tripulados: Soyuz



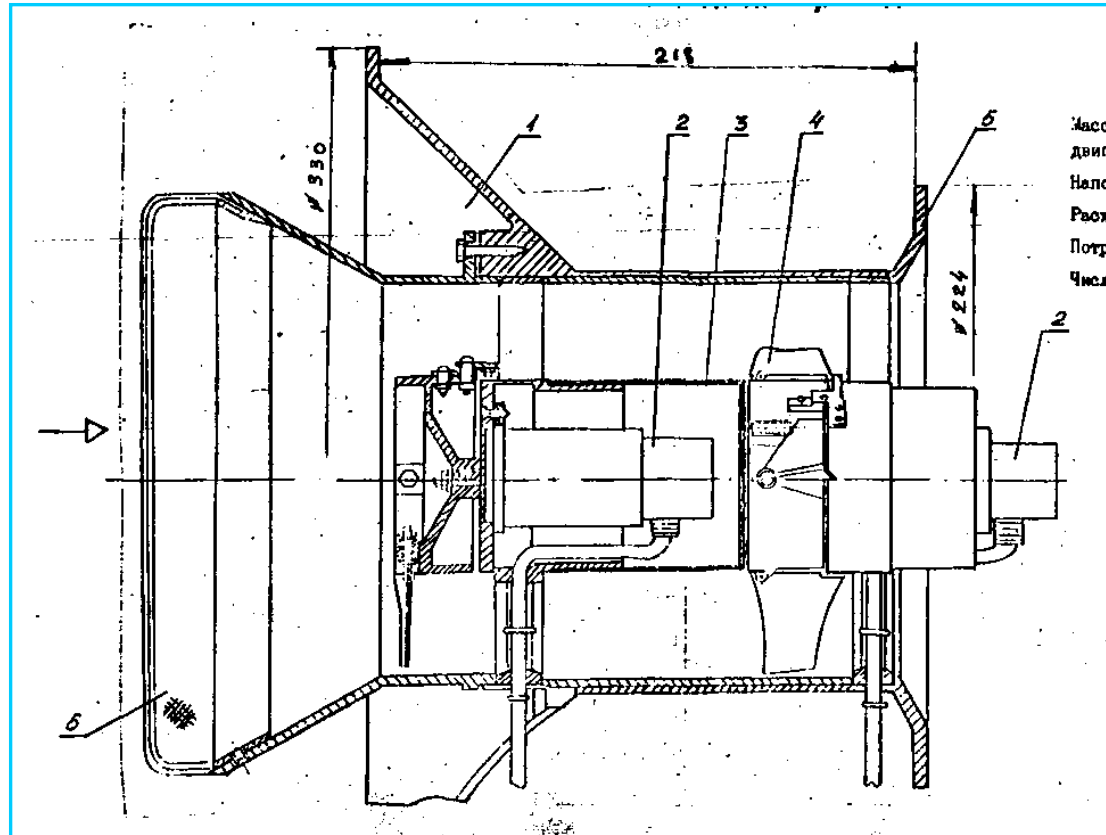
Compartimentos tripulados: Salyut



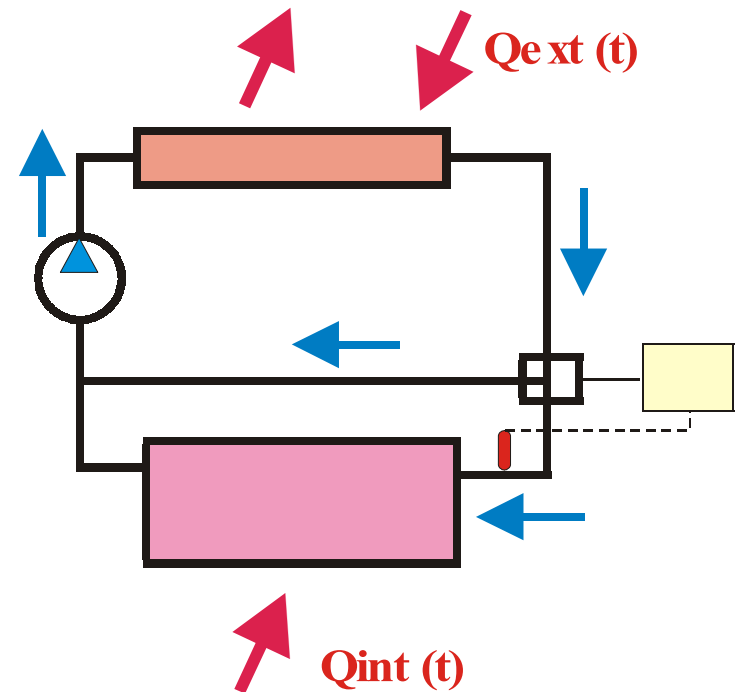
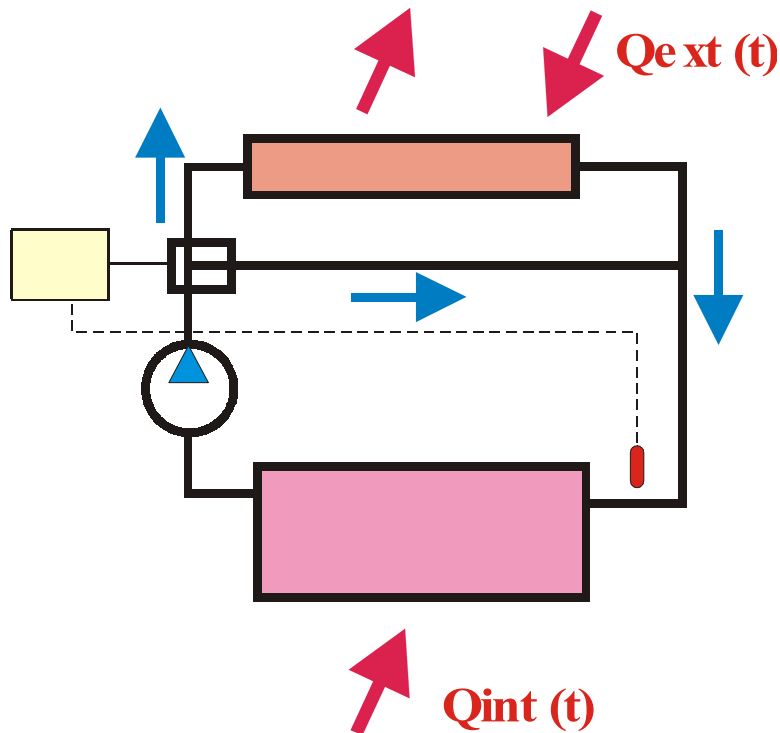
Ventilação dos compartimentos múltiplos: ISS, segmento russo



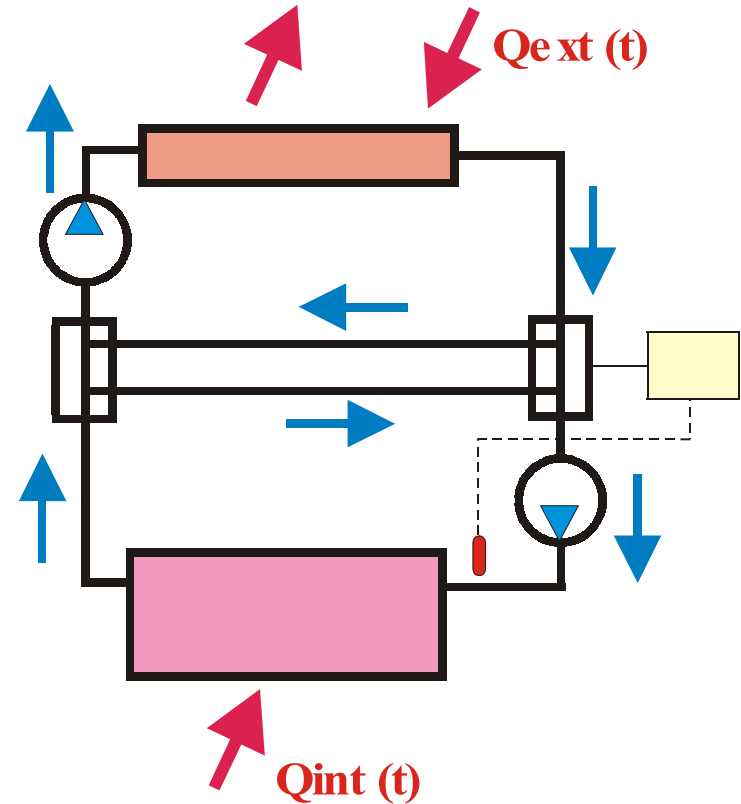
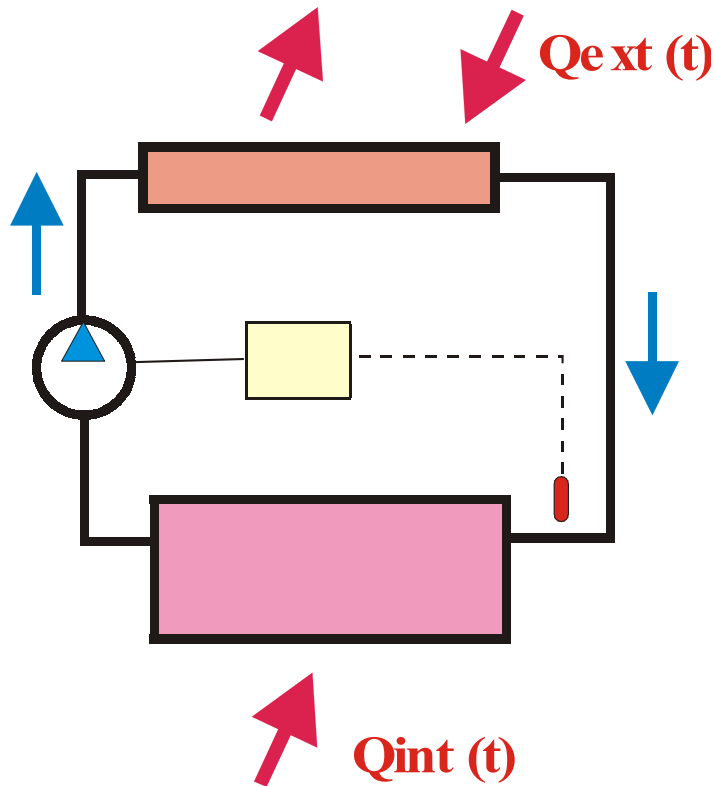
Ventilador de cabine



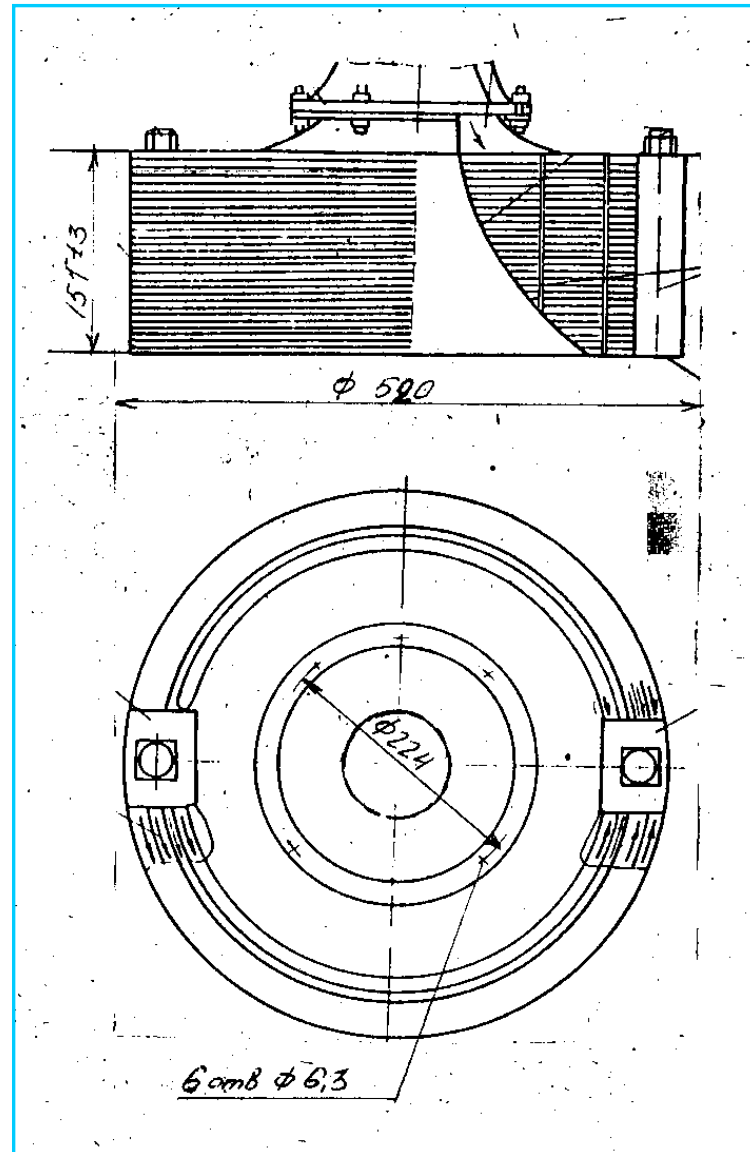
Circuitos de bombeamento mecânico de líquido: concepções de controle



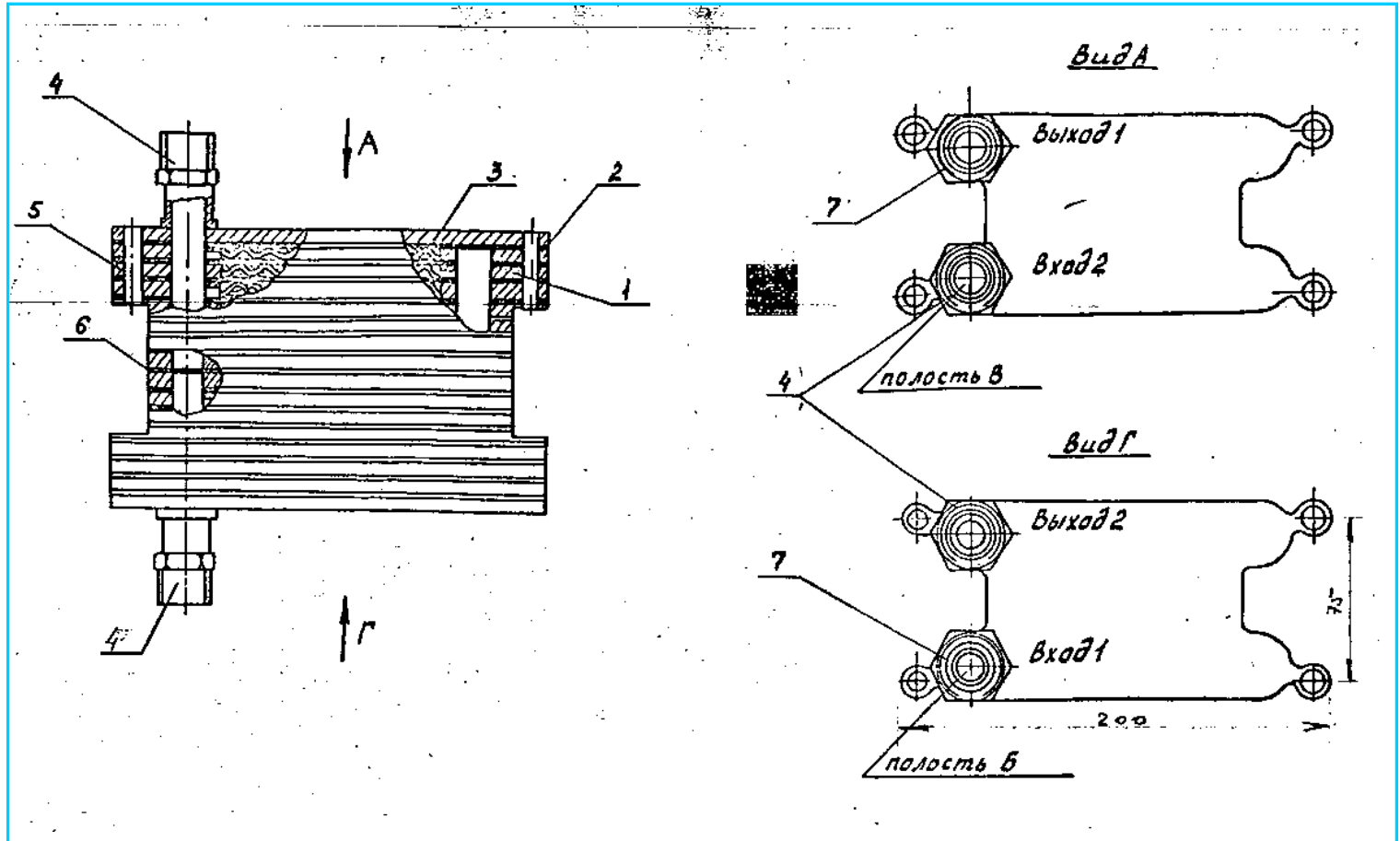
Circuitos de bombeamento mecânico de líquido: concepções de controle



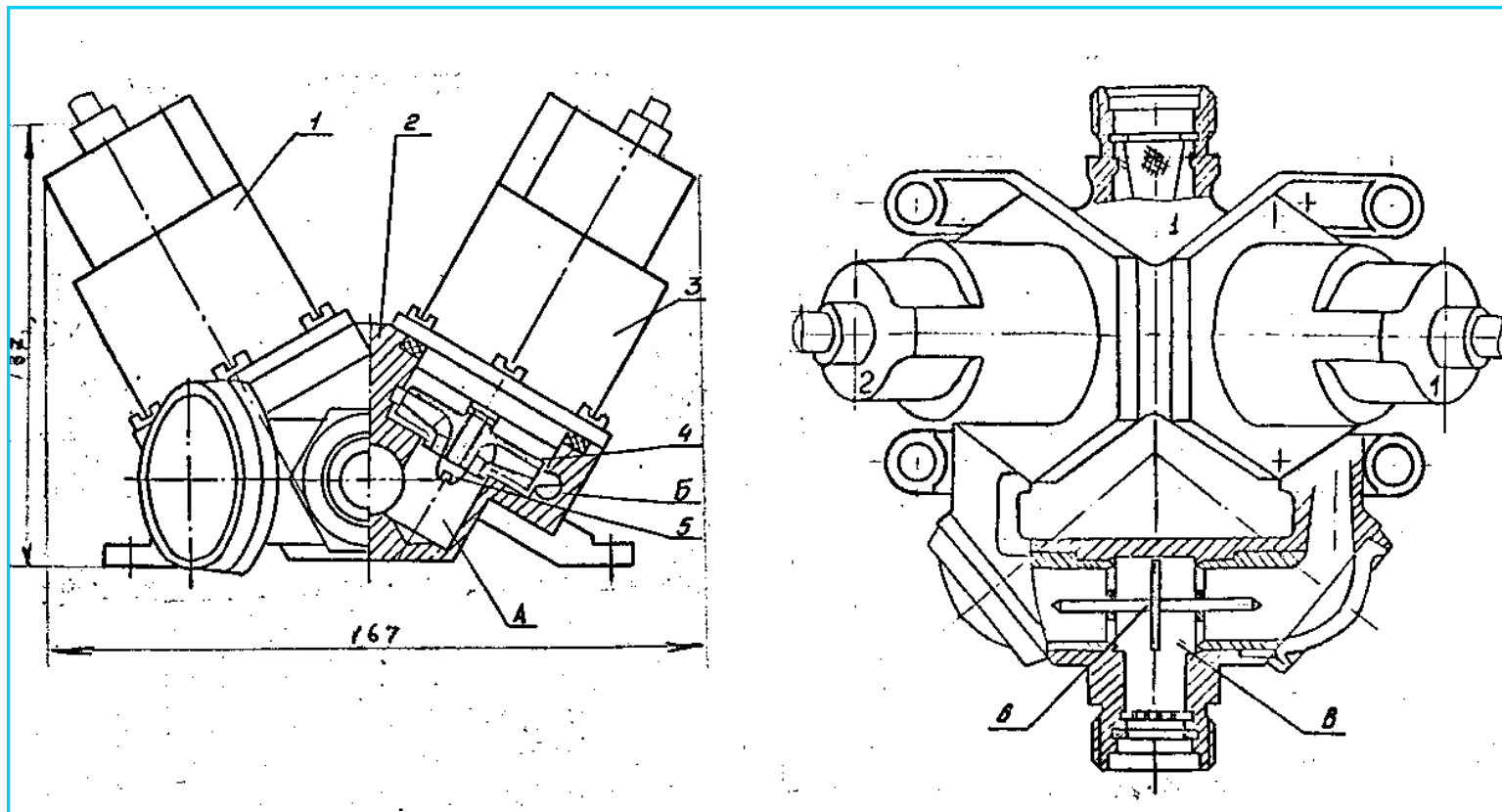
Trocador de calor: gás-líquido



Trocador de calor: líquido-líquido

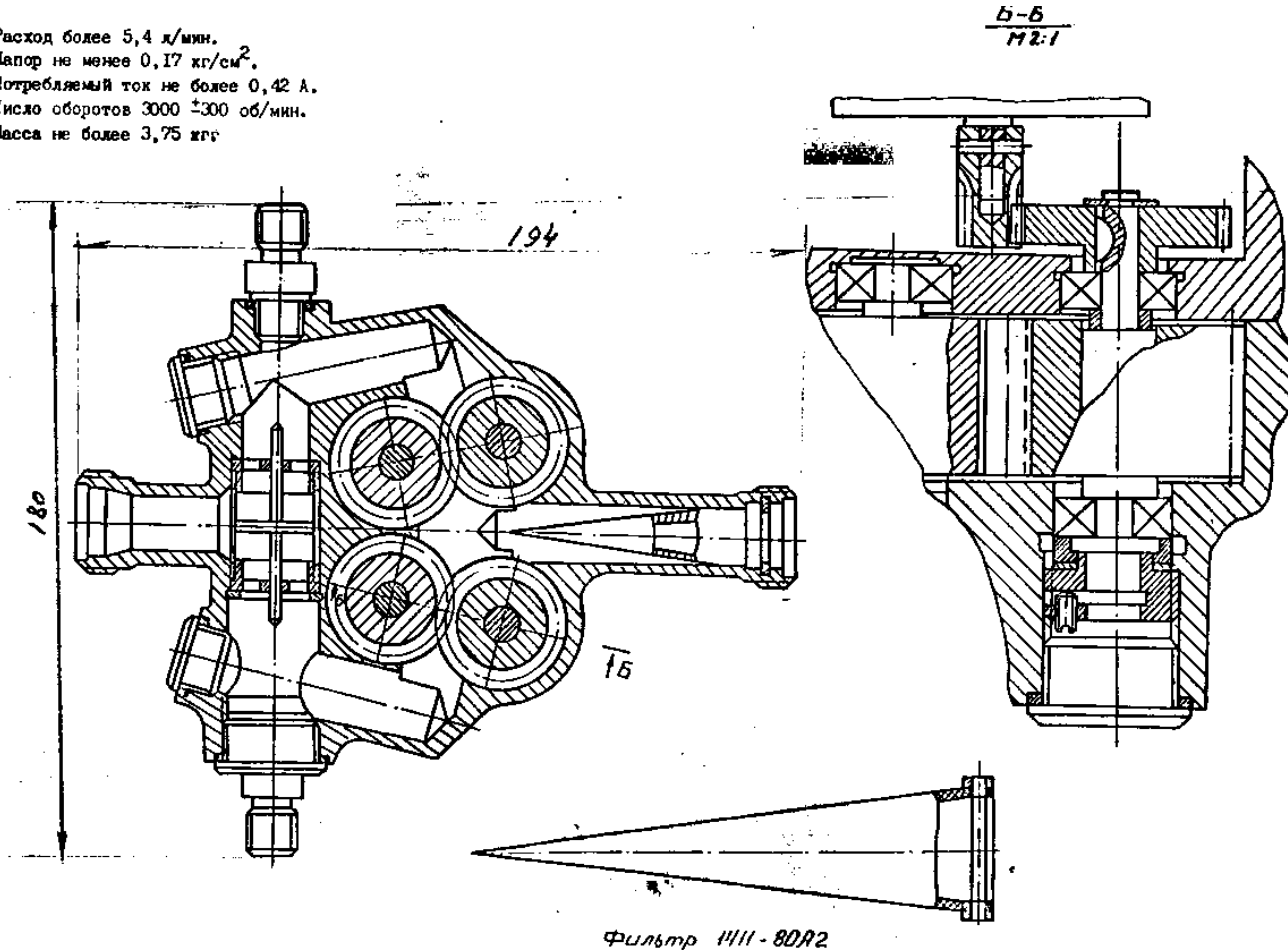


Bomba de líquido axial

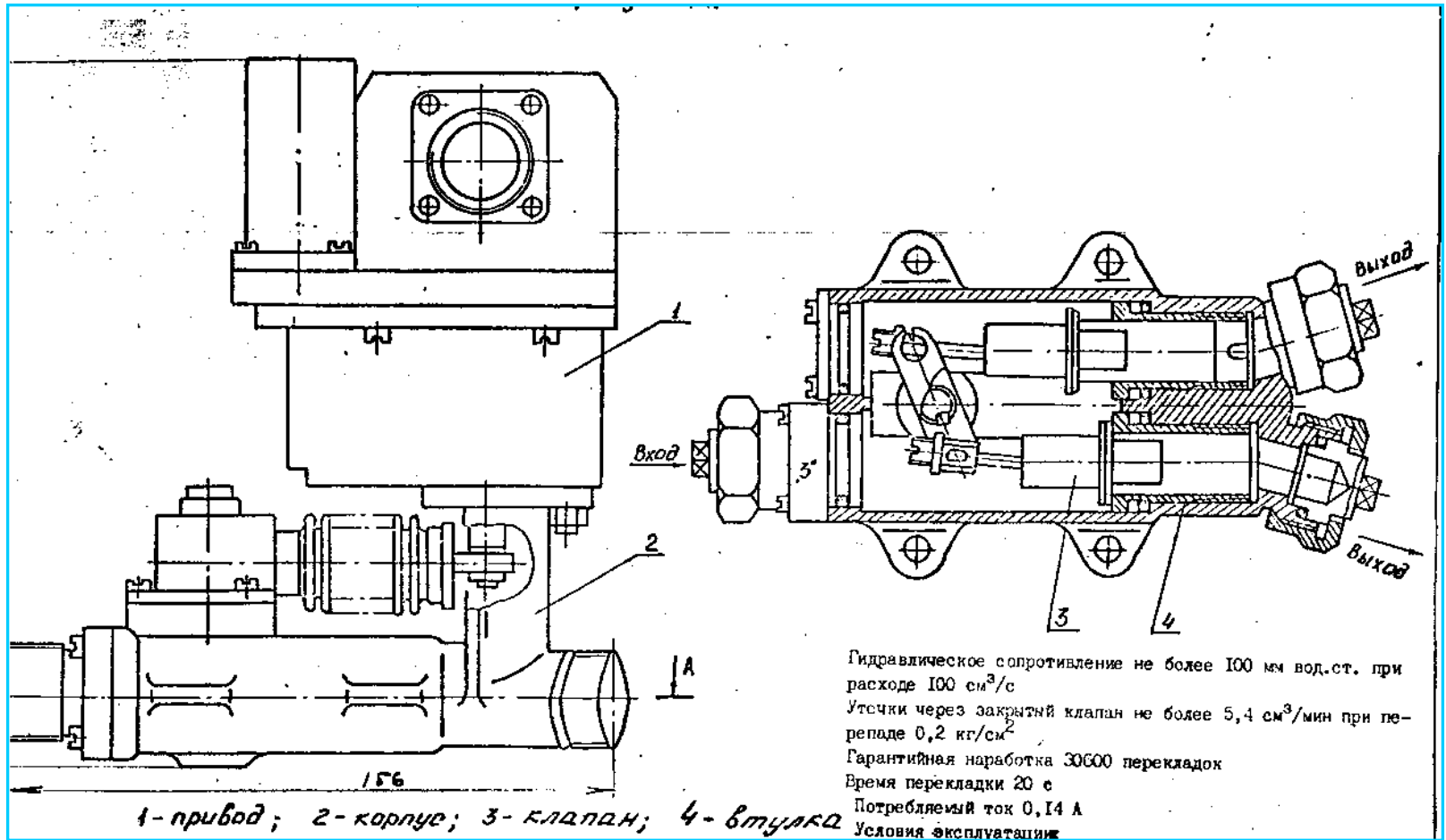


Bomba de líquido tipo “giro”

Расход более 5,4 л/мин.
 Напор не менее 0,17 кг/см².
 Потребляемый ток не более 0,42 А.
 Число оборотов 3000 ±300 об/мин.
 Масса не более 3,75 кгг



Válvula-reguladora



“Cold plate” de circuito líquido para aplicação na ISS

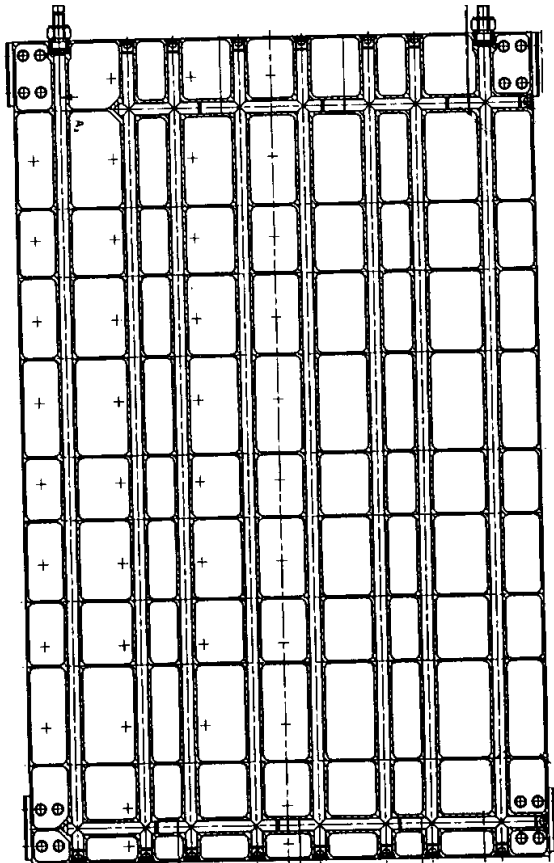
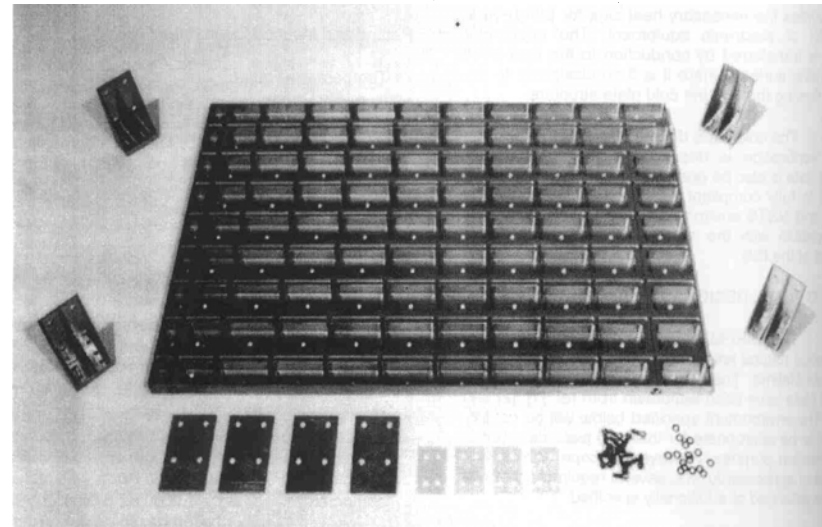
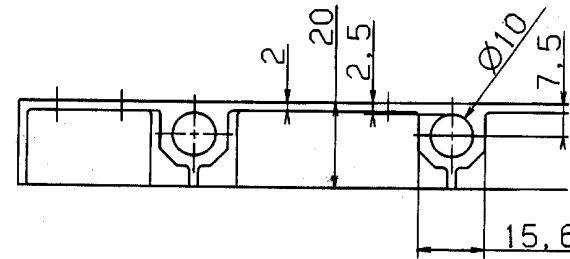


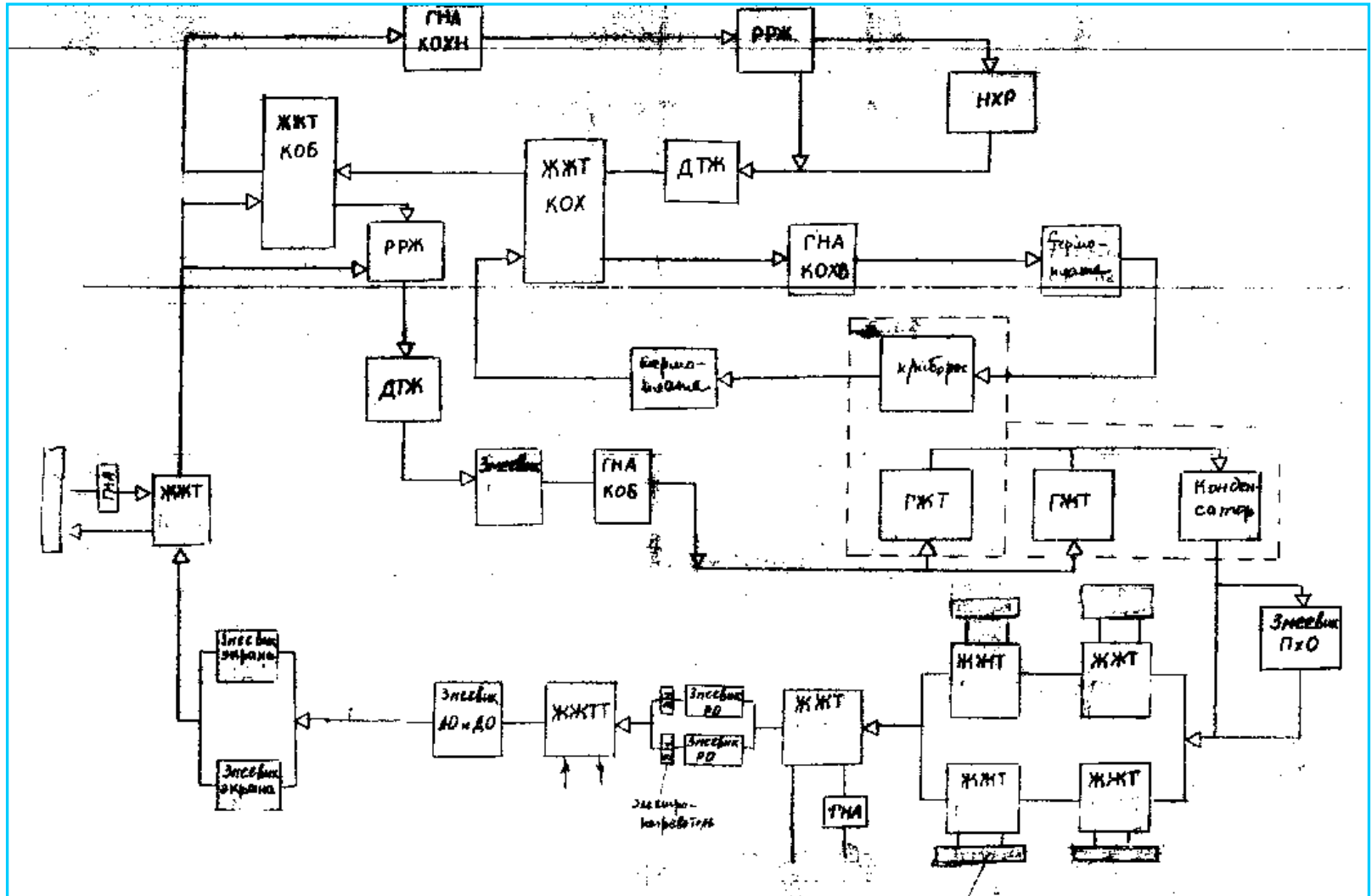
Figure 3: Cold Plate Cross Section



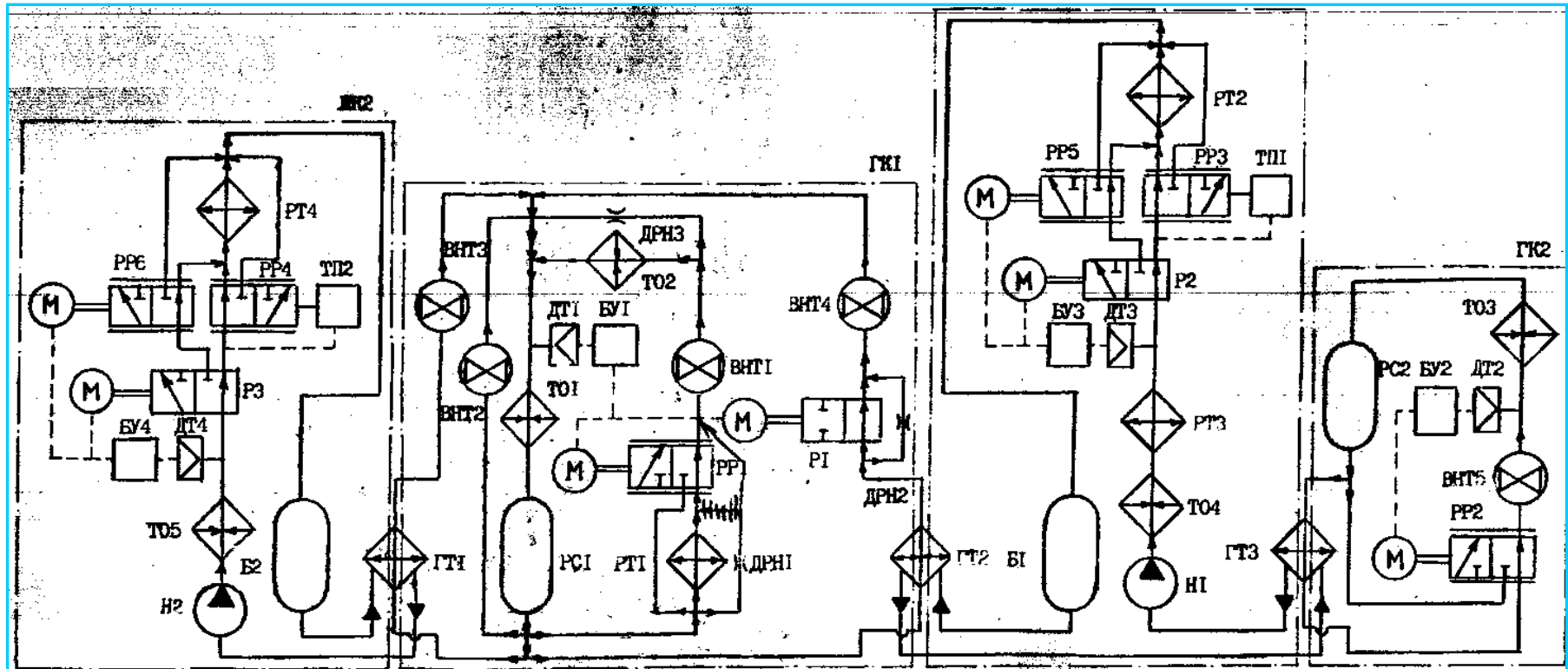
Líquido: água
Material: aço inox (Cr/Ni)
Massa: ~40 kg
Calor removido: 300 W
Temperaturas: 17 C (in), <50 C (out)

Miezda B., 1997, 6th European Symposium on Space Environment Control Systems

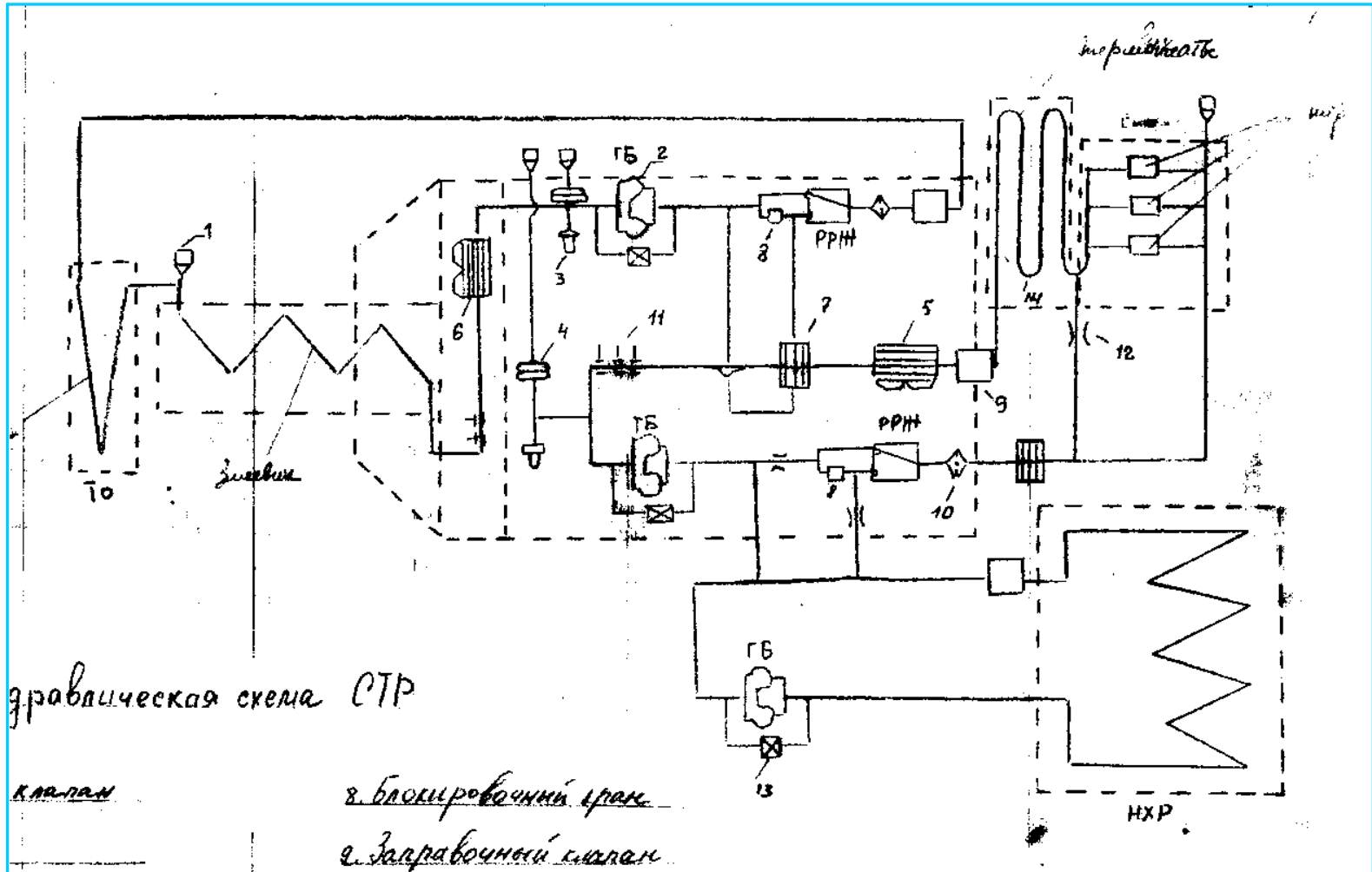
Sistema de controle térmico da “Soyuz”



Sistema de controle térmico da estação "Salyut"

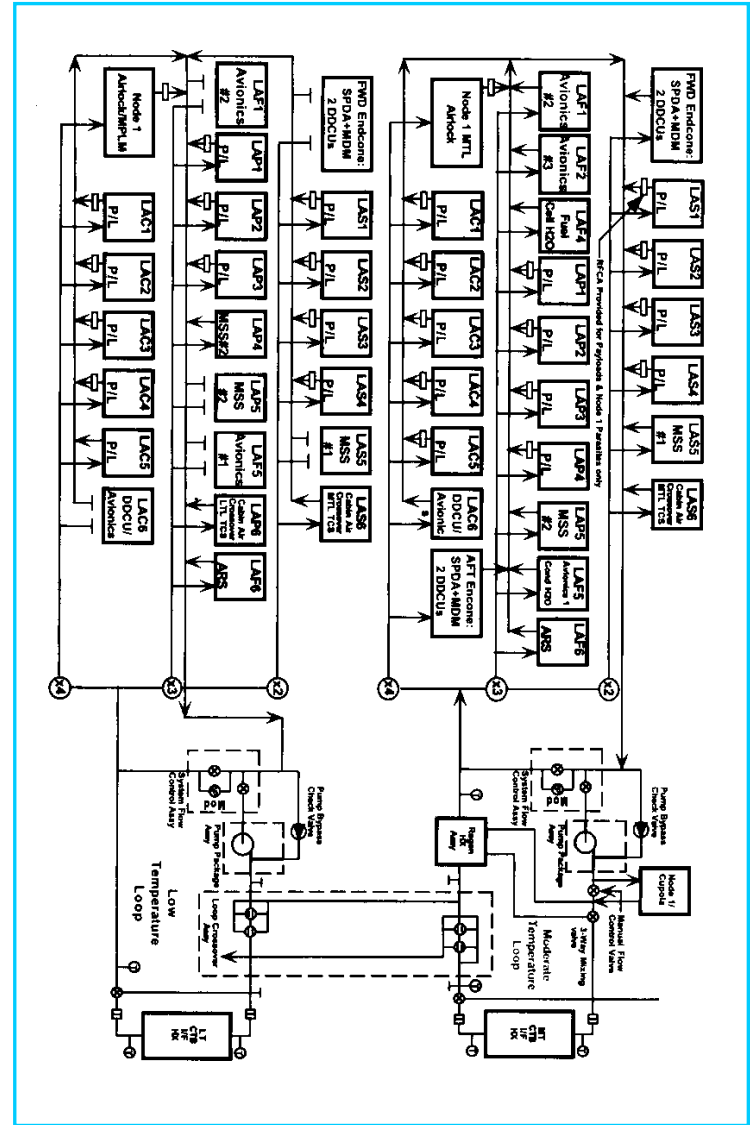
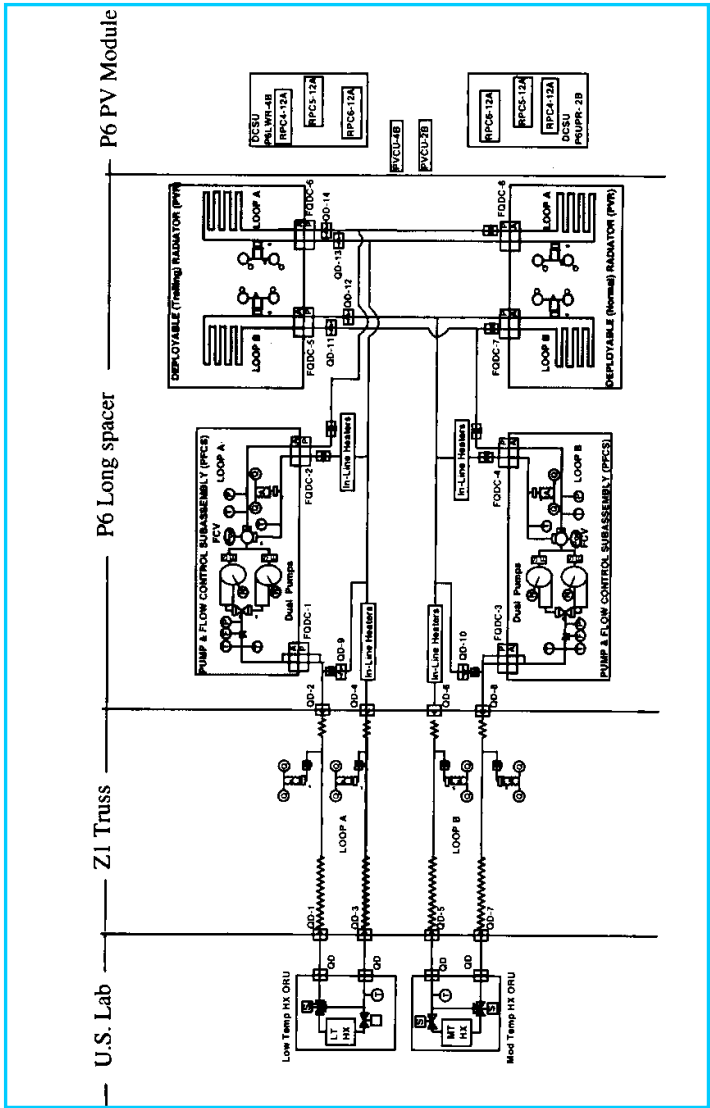


Sistema de controle térmico do módulo “Kvant” da estação “MIR”



Sistema de circuitos diferentes da ISS

Líquido:
 Amônia/
 água



Reysa R.P., et al, 1997, "BOING", 6th European Symposium on Space Environment Control Systems



P6

Circuito externo da ISS

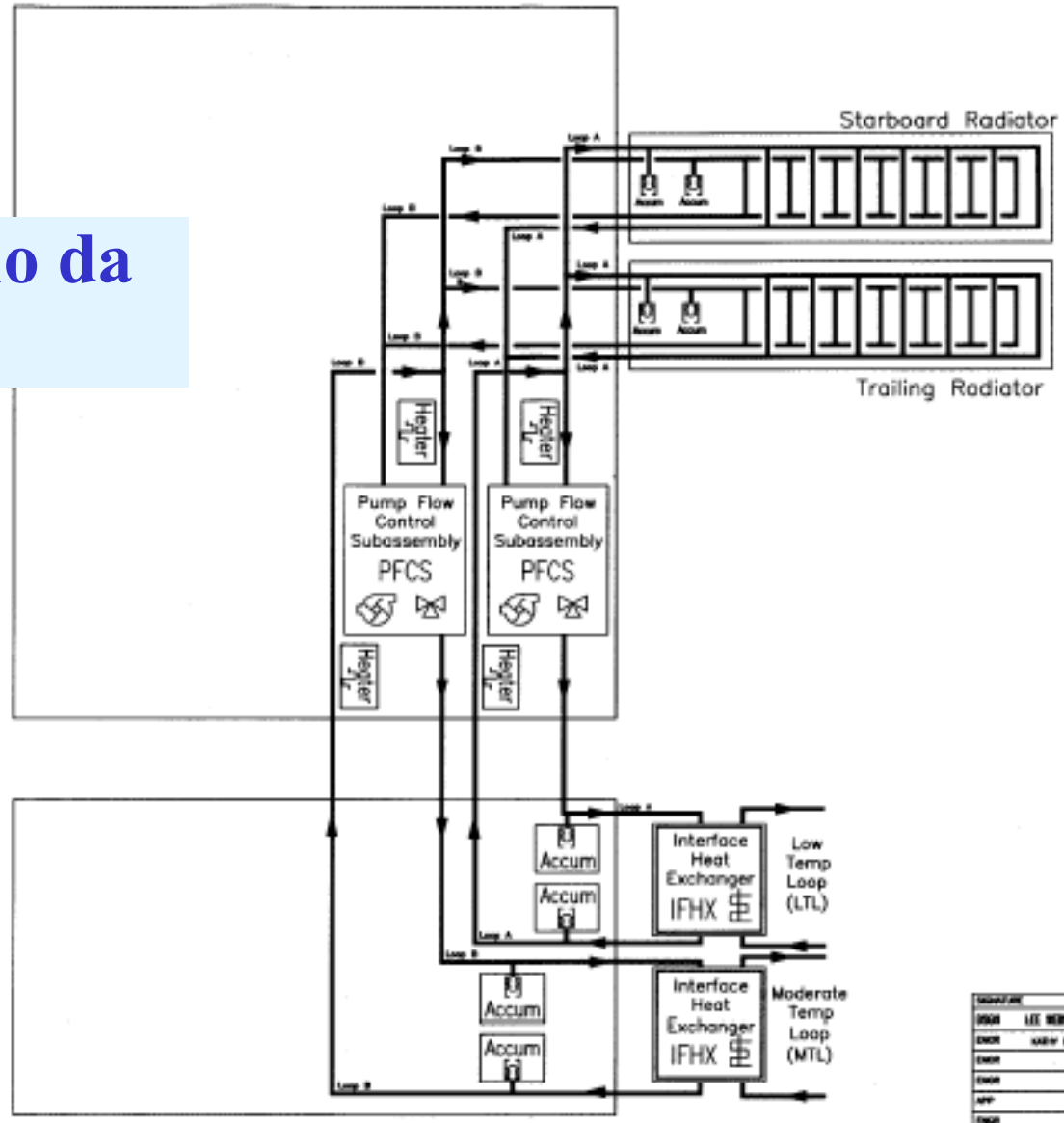
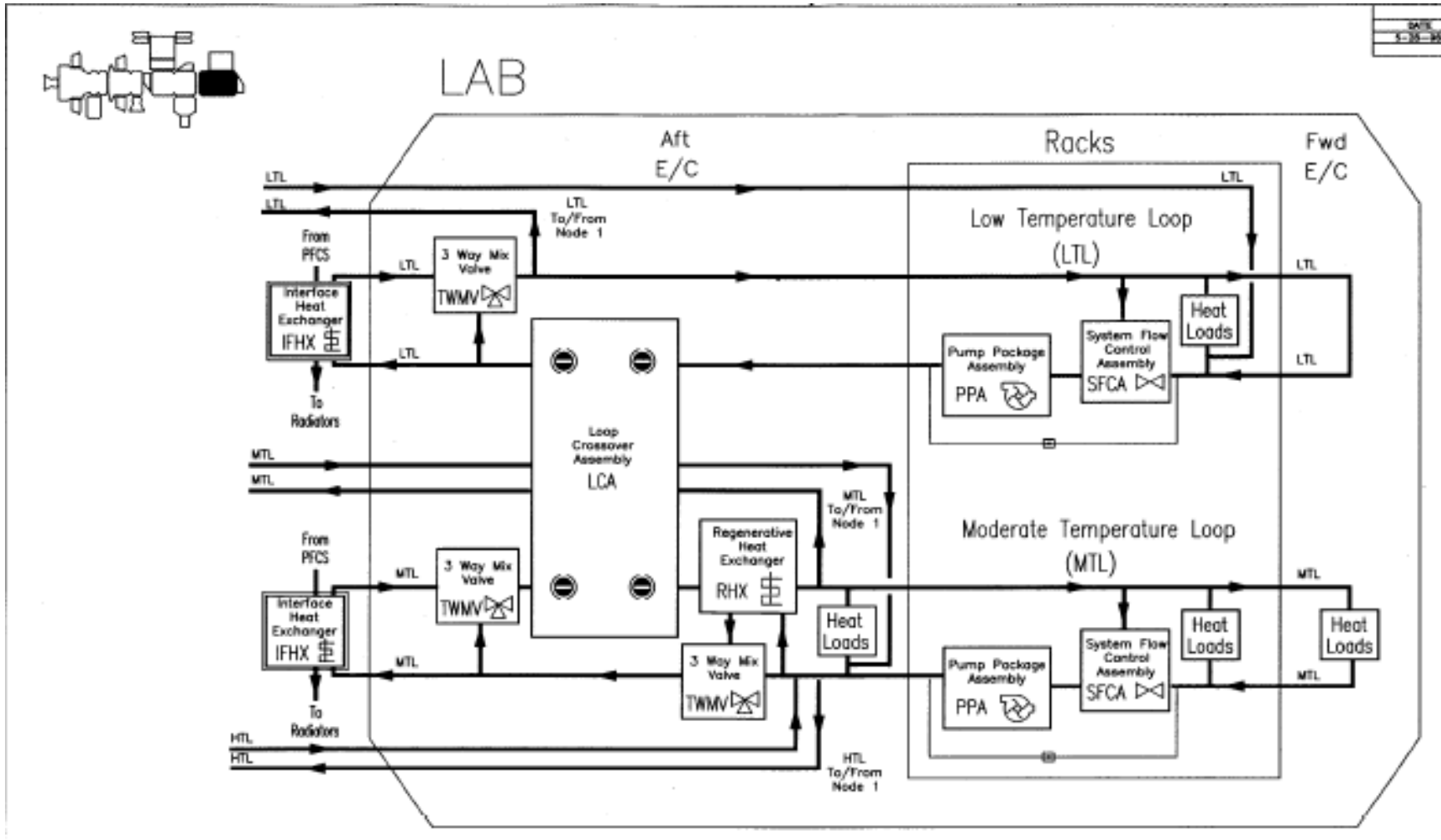


Figure 5-4 Early External Thermal Control System Level 1B Overview

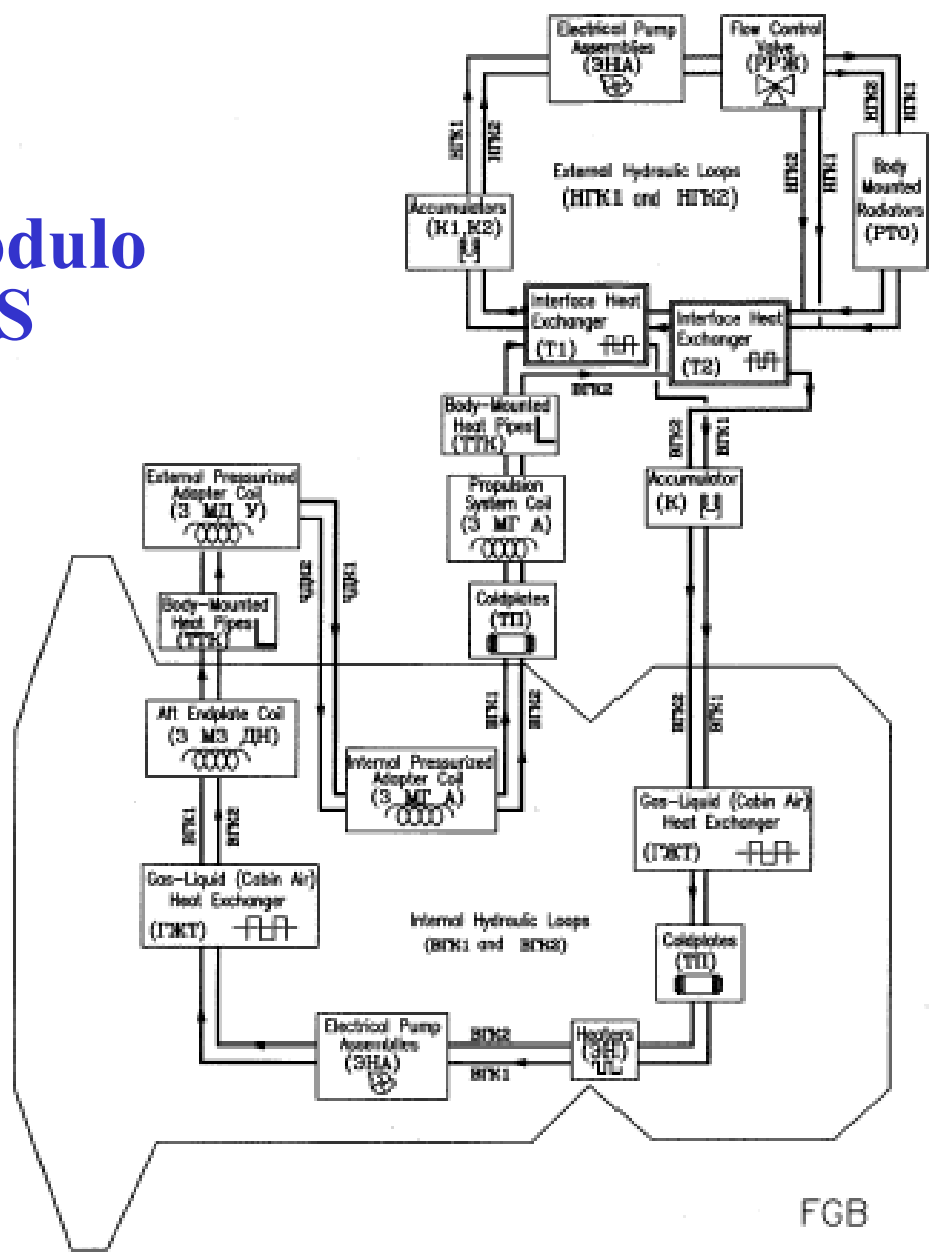
Z1

Symbol	Description
Star	Starboard Radiator
Trail	Trailing Radiator
Accum	Accumulator
IFHX	Interface Heat Exchanger
PFCS	Pump Flow Control Subassembly
Heater	Heater
Valve	Valve

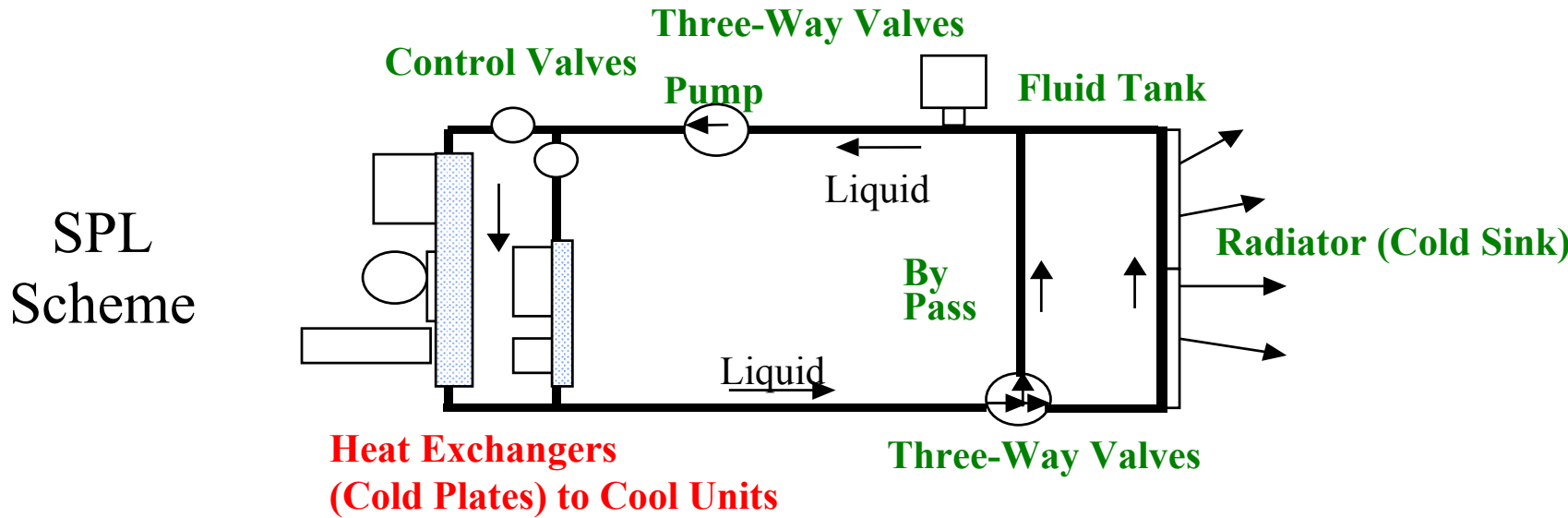
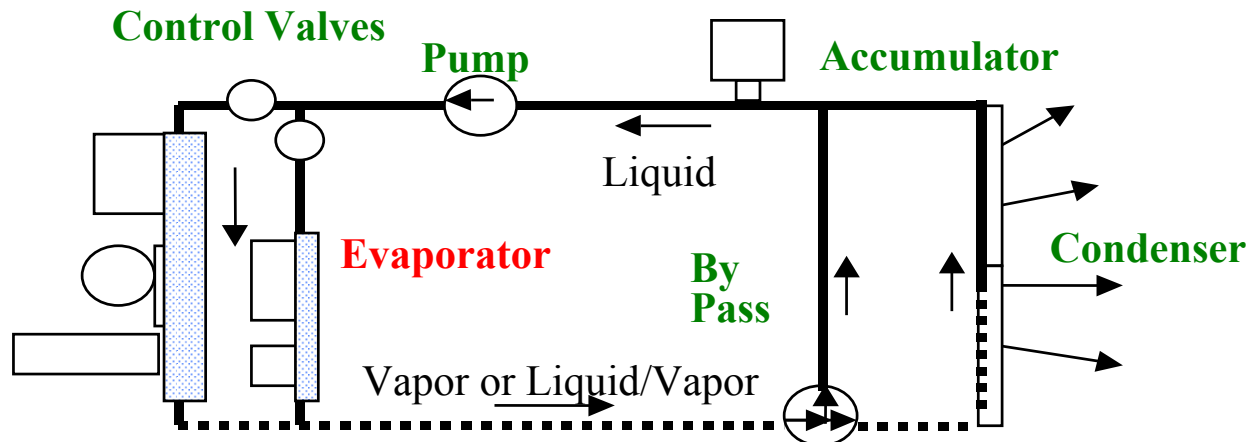
Circuito interno da ISS



Sistema do módulo FGB da ISS

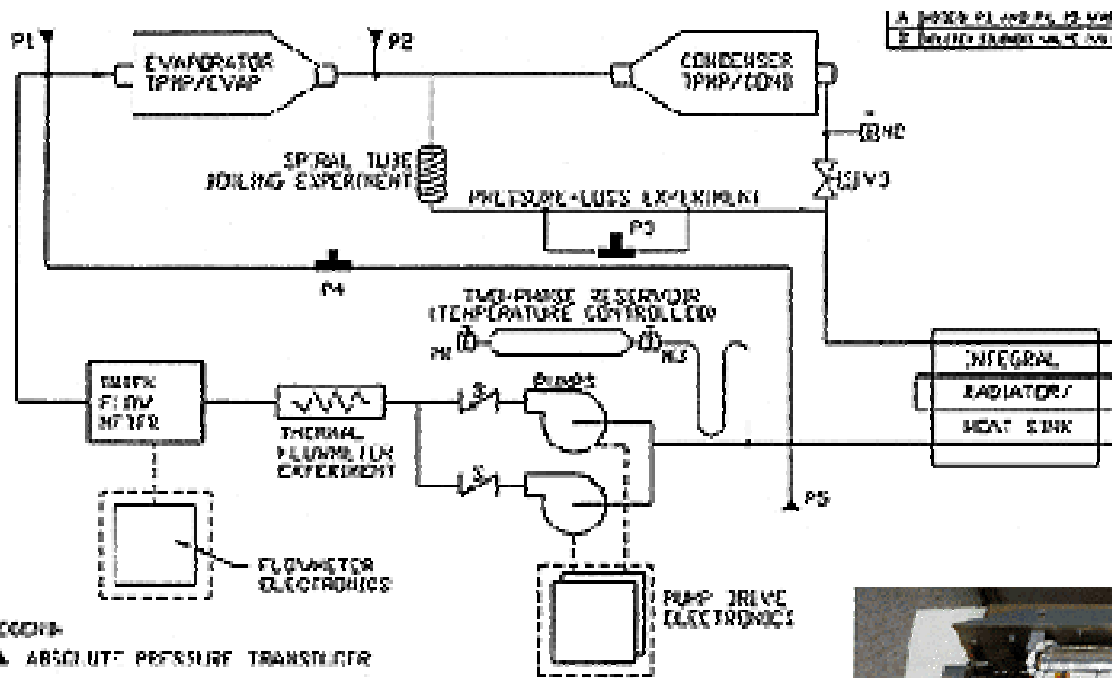


Concepção de 1 fase e de 2 fases

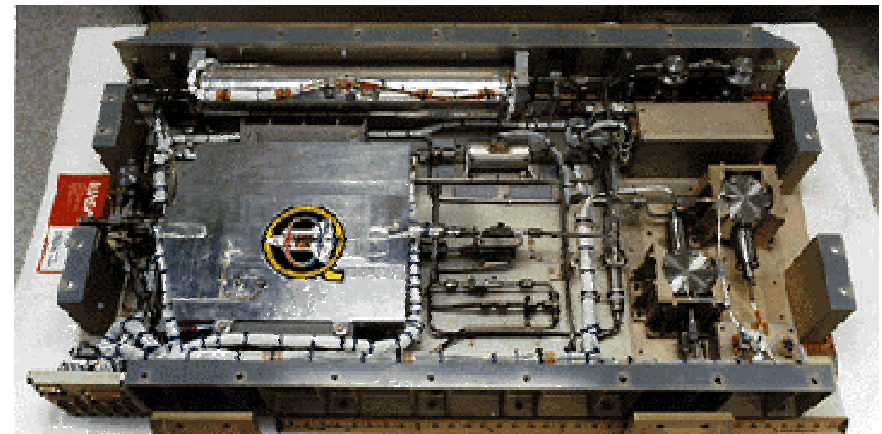


Hugon, Alcatel; Int. Two-Phase Thermal Control Technology Workshop September, 24-26,2002

Experimento TEMP 2A-3 : MPL de 2 fases

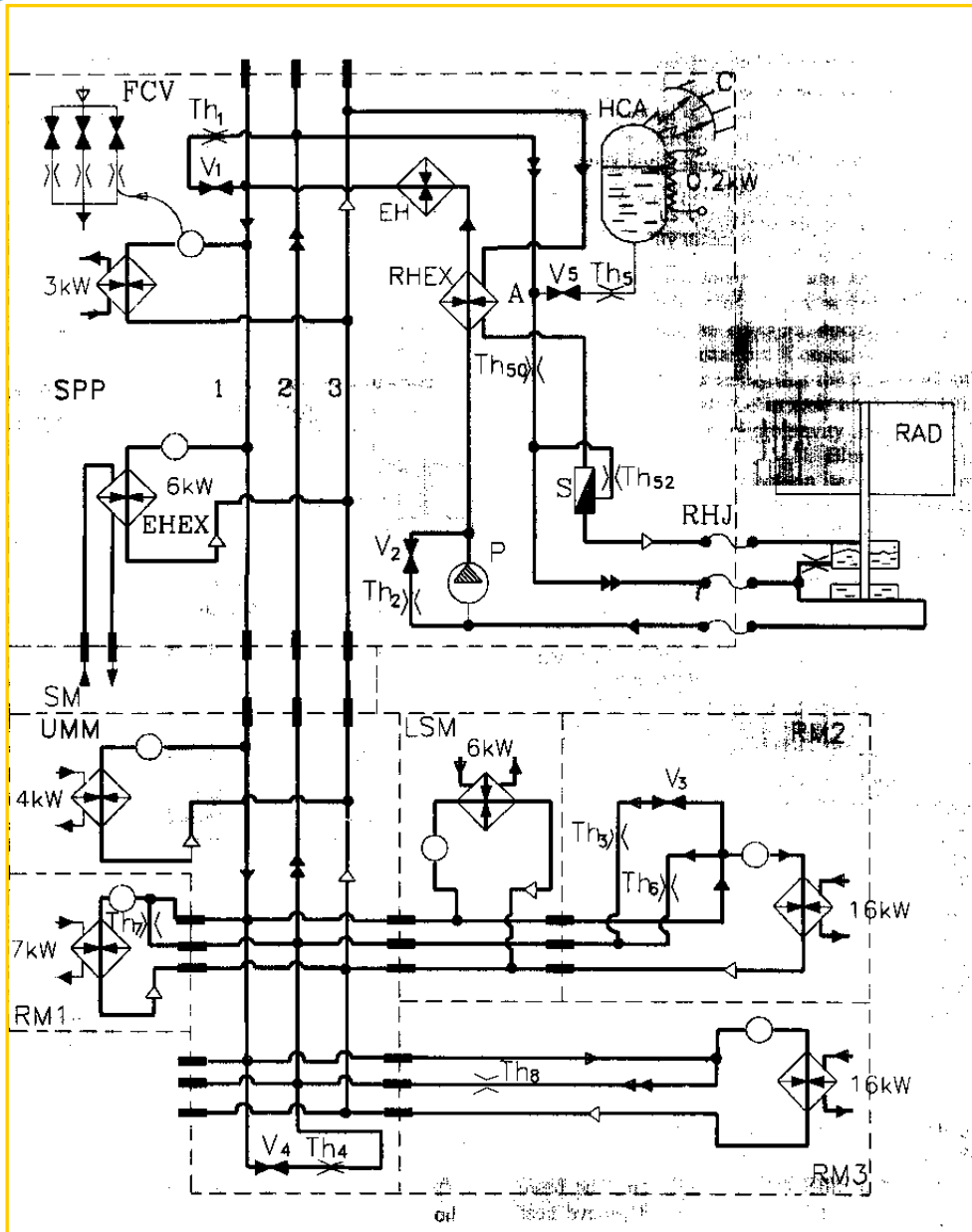


The TEMP 2A-3 experiment was the first flight of a mechanically pumped two-phase ammonia thermal control system. This proof of concept mission was successfully flown on the STS-46 shuttle flight in August 199



<http://mscweb.gsfc.nasa.gov/545web/Groups/P2/545p2.html>

Concepção inicial de 2 fases para a ISS



Fluxo de calor: 0..30 kW
Distancia: ~50 m
Líquido: Amônia
Consumo: 200 W
Temperatura: 10 C
Taxa: 90 g/sec
Dif. de P: 1.5 atm

Prokhorov Y.M., et al, 1997, "Energia", 6th European Symposium on Space Environment Control Systems