

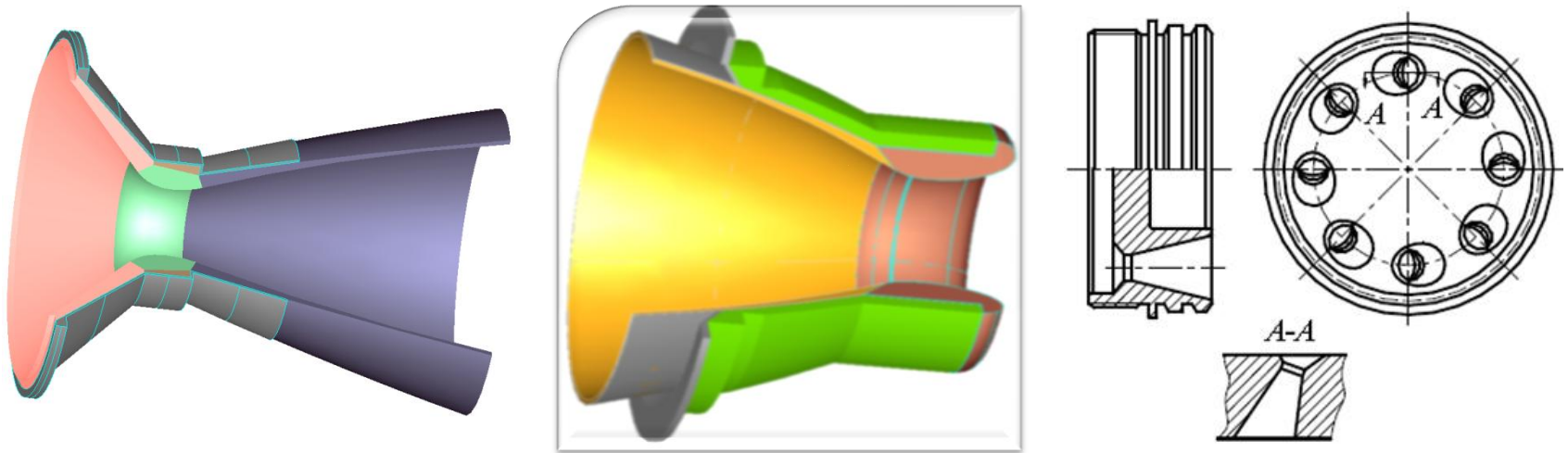
Solid Rocket Motor

Part 7 Design of nozzle and thrust control device

Design of nozzle and thrust control device

■ The basic concept of the nozzle

- Generally located in the tail of the combustion chamber , usually for the Laval nozzle ; It consists of three parts: the convergence section (entrance section), the throat and the expansion section (exit cone)



The design of nozzle should be based on the engine development task book, the nozzle design task book, the relationship diagram between the nozzle and the engine, and the design of the nozzle contour.

Design of nozzle and thrust control device

■ The role of the nozzle

- According to the mass flow rate of the engine, the combustion chamber pressure can be controlled by controlling the throat area;

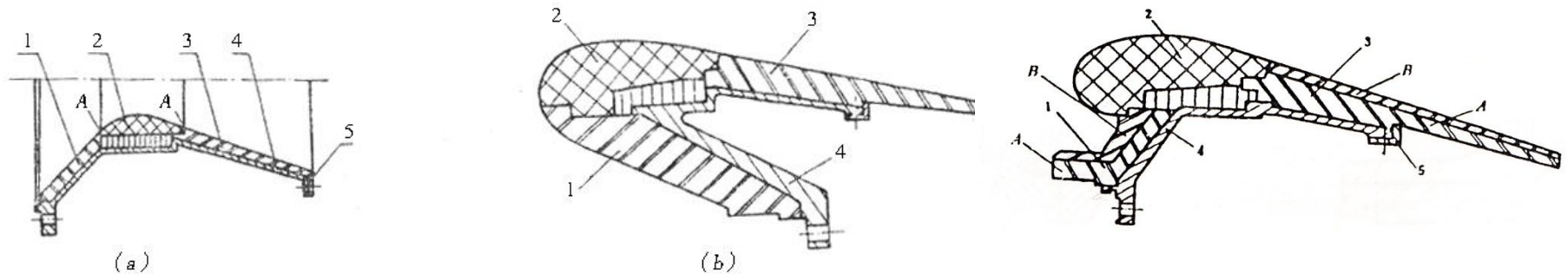
$$A_t = \frac{\dot{m} \cdot C^*}{P_c} = \frac{F}{C_F P_c}$$

- The heat energy from the combustion of the fuel column into gas is converted into kinetic energy;
- Change the thrust direction, control the missile flight attitude;

Design of nozzle and thrust control device

■ Nozzle characteristics

- Passive thermal protection is used in solid rocket motor nozzle;
- According to the nozzle convergent section in the combustion chamber or outside, it can be divided into two types of diving and non diving;


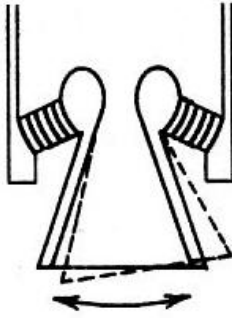
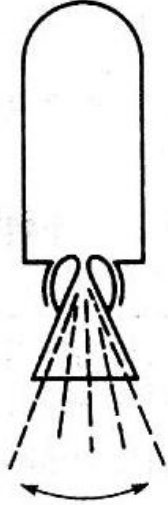
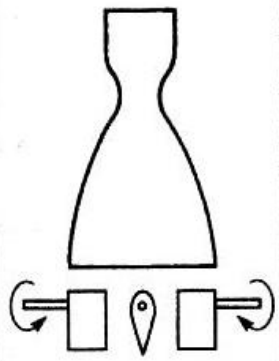


- According to the thrust vector control method is divided into fixed and movable two types of nozzles.

Design of nozzle and thrust control device

■ Thrust vector control method

- According to the thrust vector control method it's divided into fixed and movable two types of nozzles.

gimbal	Flexible support	Trapped ball	Jet vane
			
L	S	S	L/S

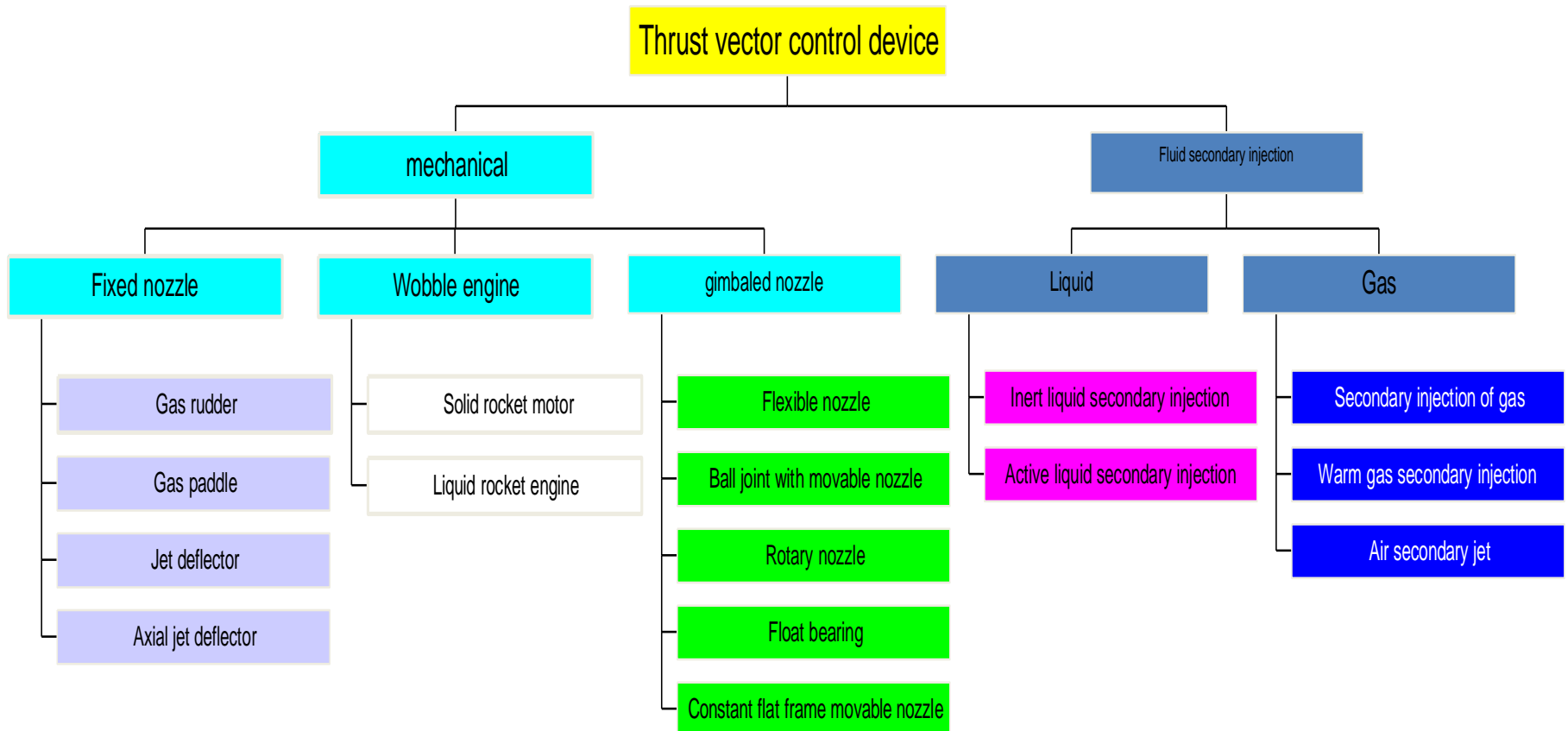
Design of nozzle and thrust control device

■ Nozzle design content

- Aerodynamic design
- Thermal protection design
- Structural design

Design of nozzle and thrust control device

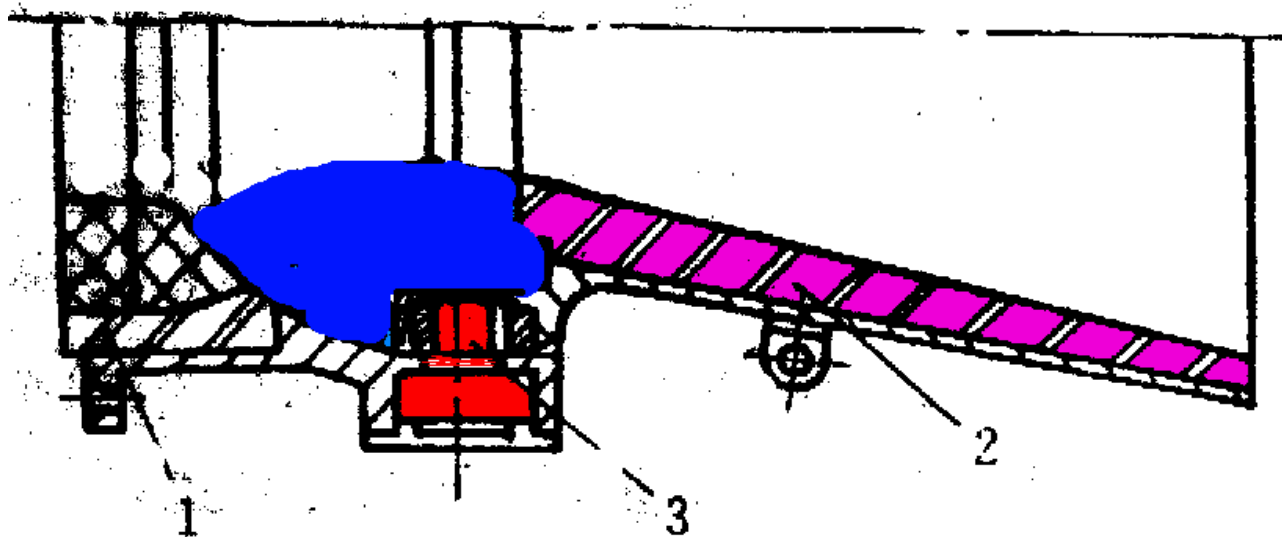
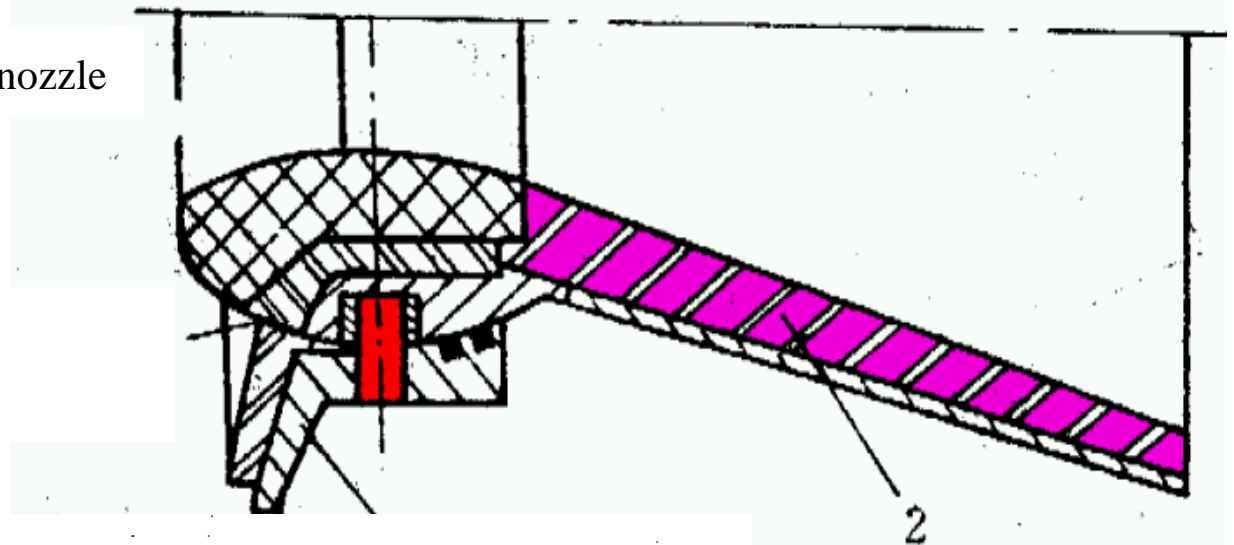
■ Thrust Vector Control of Solid Rocket Motor



Design of nozzle and thrust control device

■ Thrust Vector Control of Solid Rocket Motor

➤ (1) Single axis swing nozzle



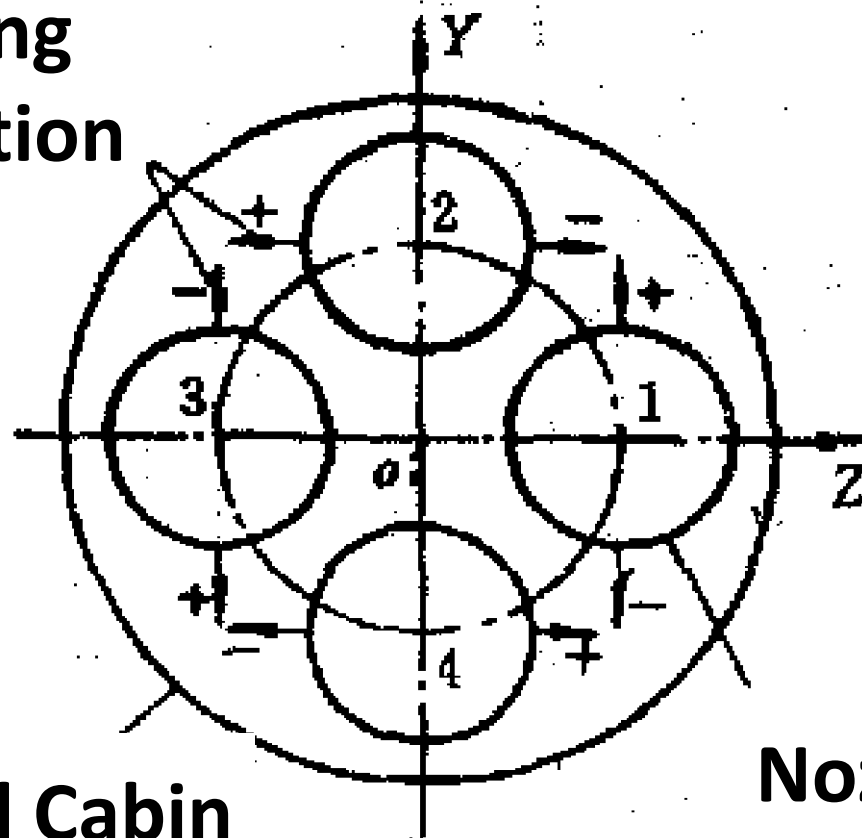
- 1- Fixed body
- 2- Active body
- 3- Hinge joint

Design of nozzle and thrust control device

■ Thrust Vector Control of Solid Rocket Motor

- (1) Single axis swing nozzle

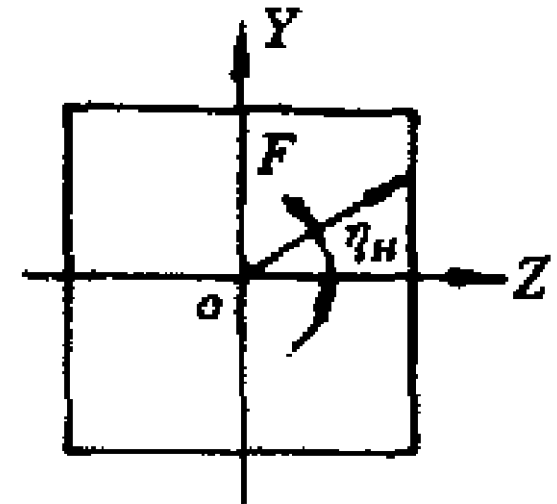
**Swing
direction**



Tail Cabin

Nozzle

(a)



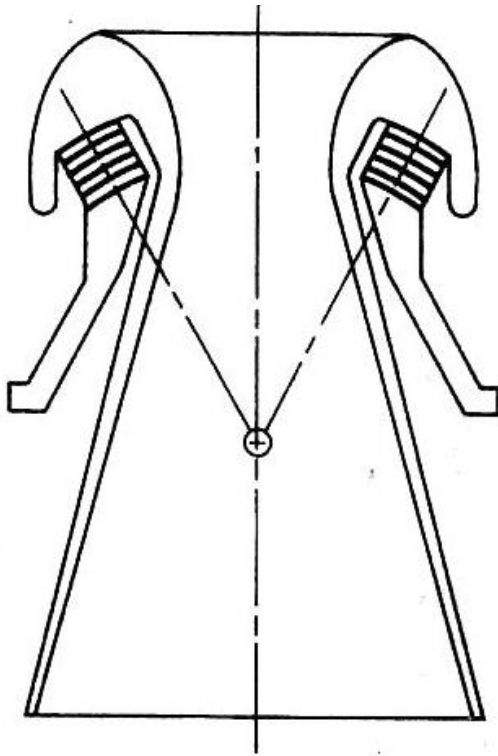
(b)

Design of nozzle and thrust control device

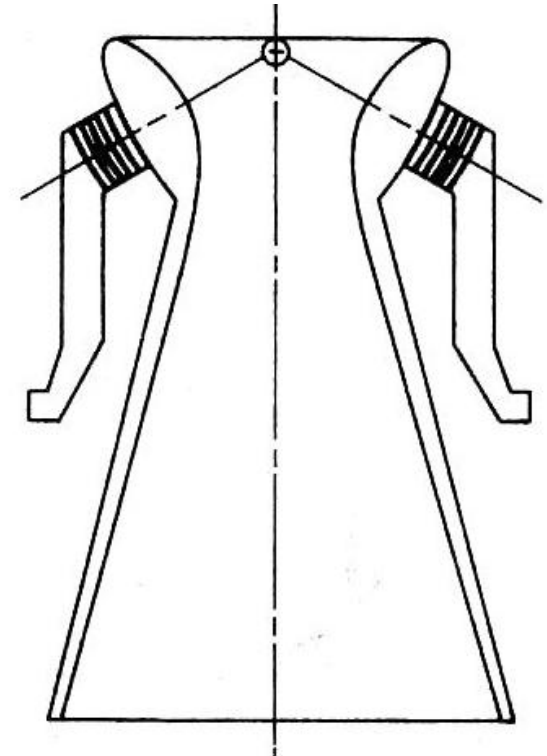
■ Thrust Vector Control of Solid Rocket Motor

➤ (2) Flexible nozzle

Rotation fulcrum at downstream



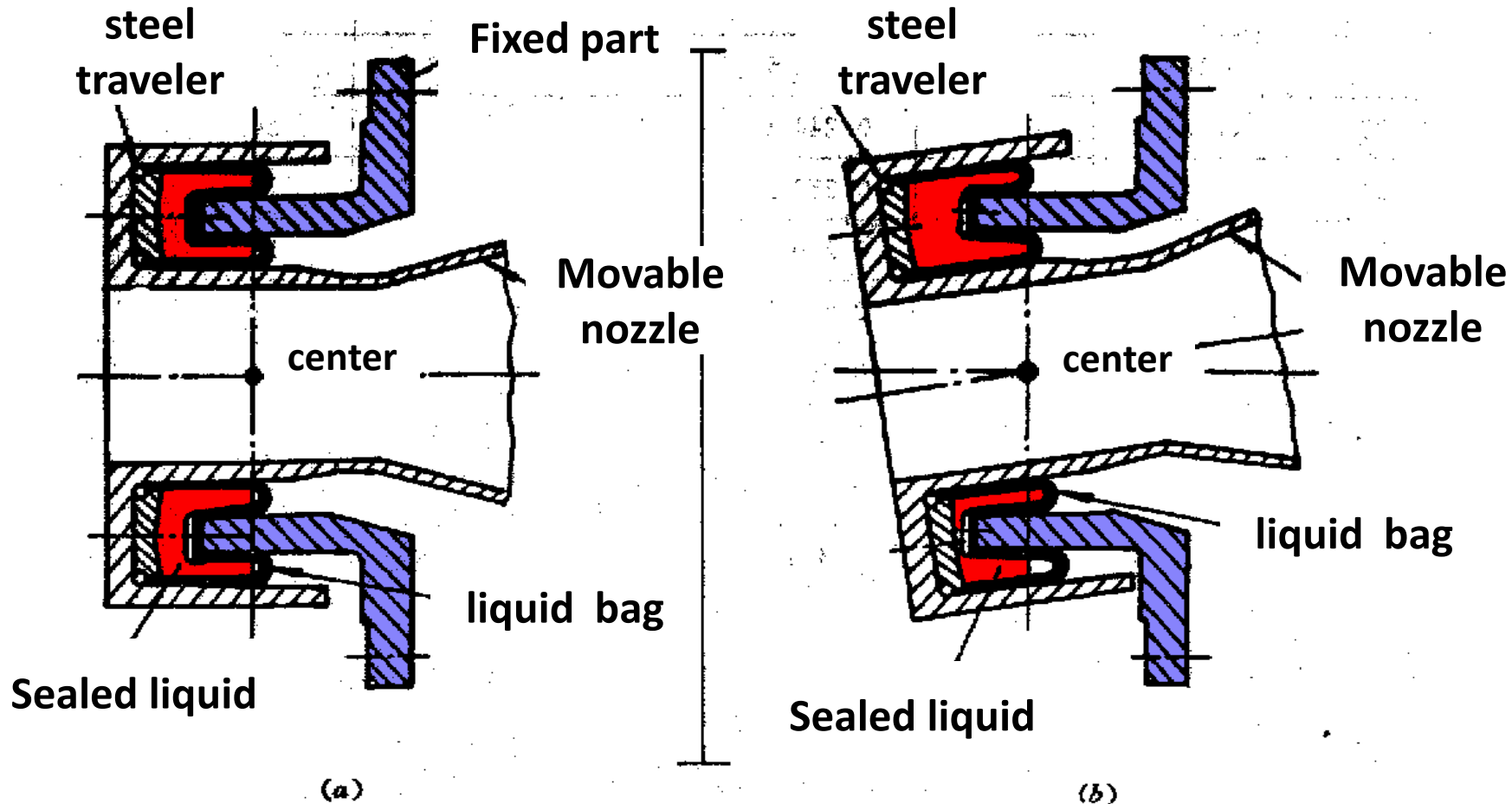
up stream



Design of nozzle and thrust control device

■ Thrust Vector Control of Solid Rocket Motor

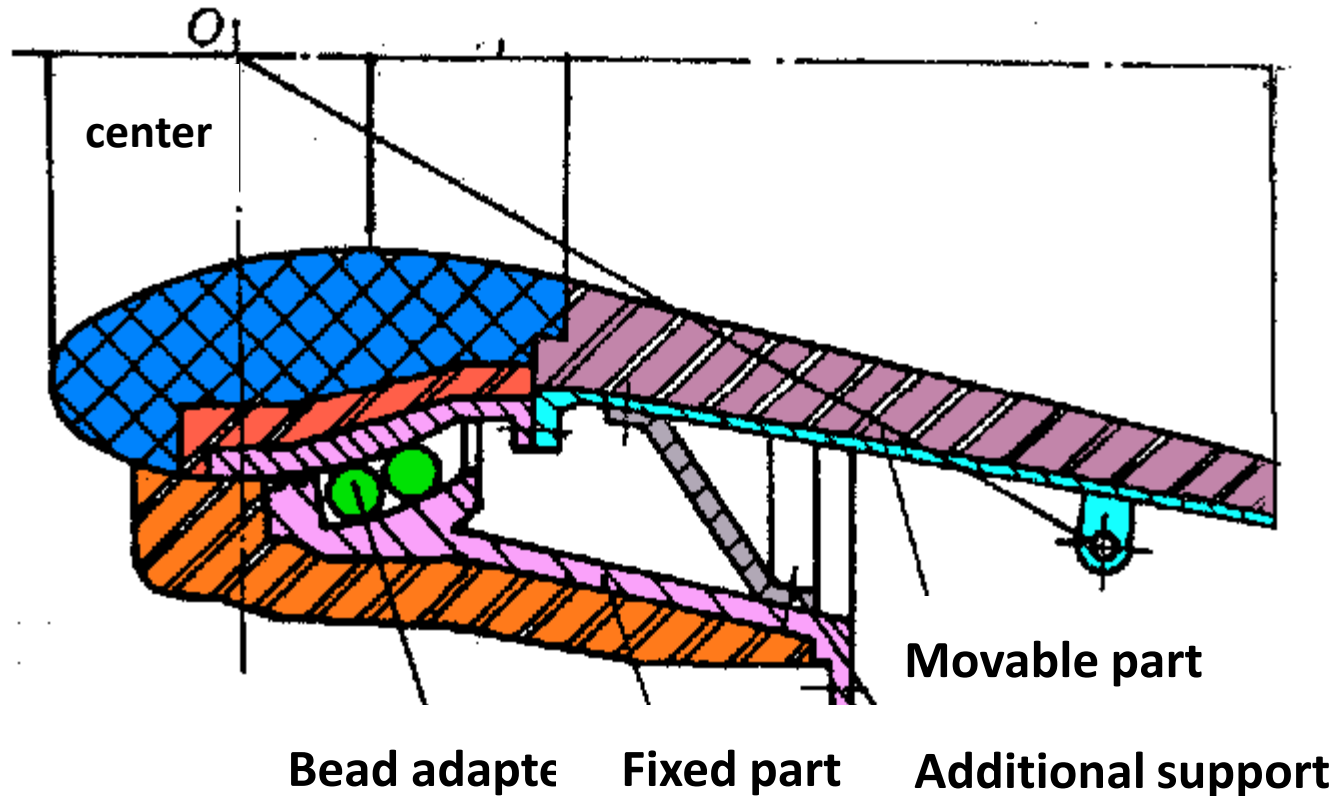
➤ (3) Liquid floating nozzle



Design of nozzle and thrust control device

■ Thrust Vector Control of Solid Rocket Motor

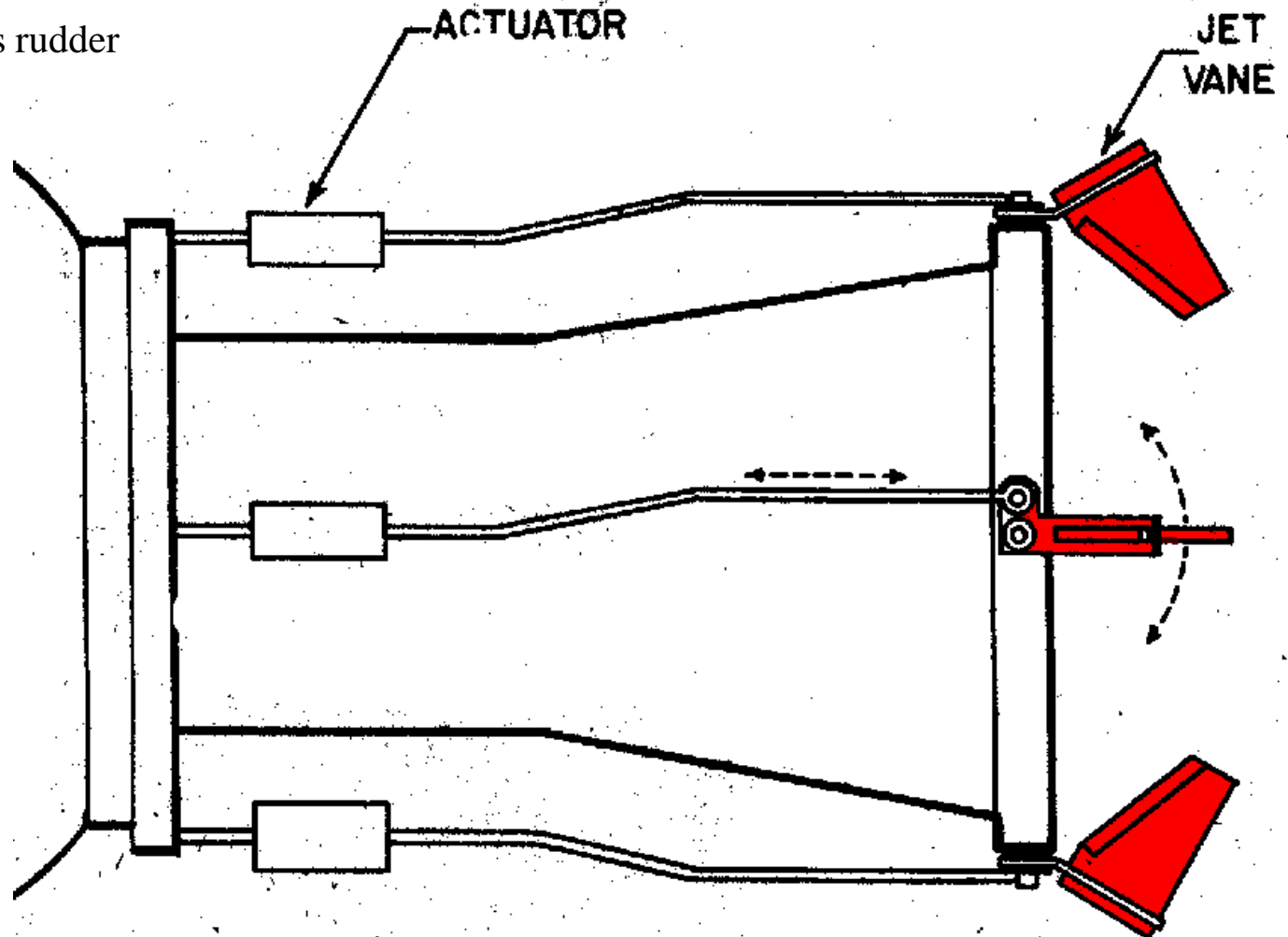
➤ (4) Bead nozzle



Design of nozzle and thrust control device

■ Thrust Vector Control of Solid Rocket Motor

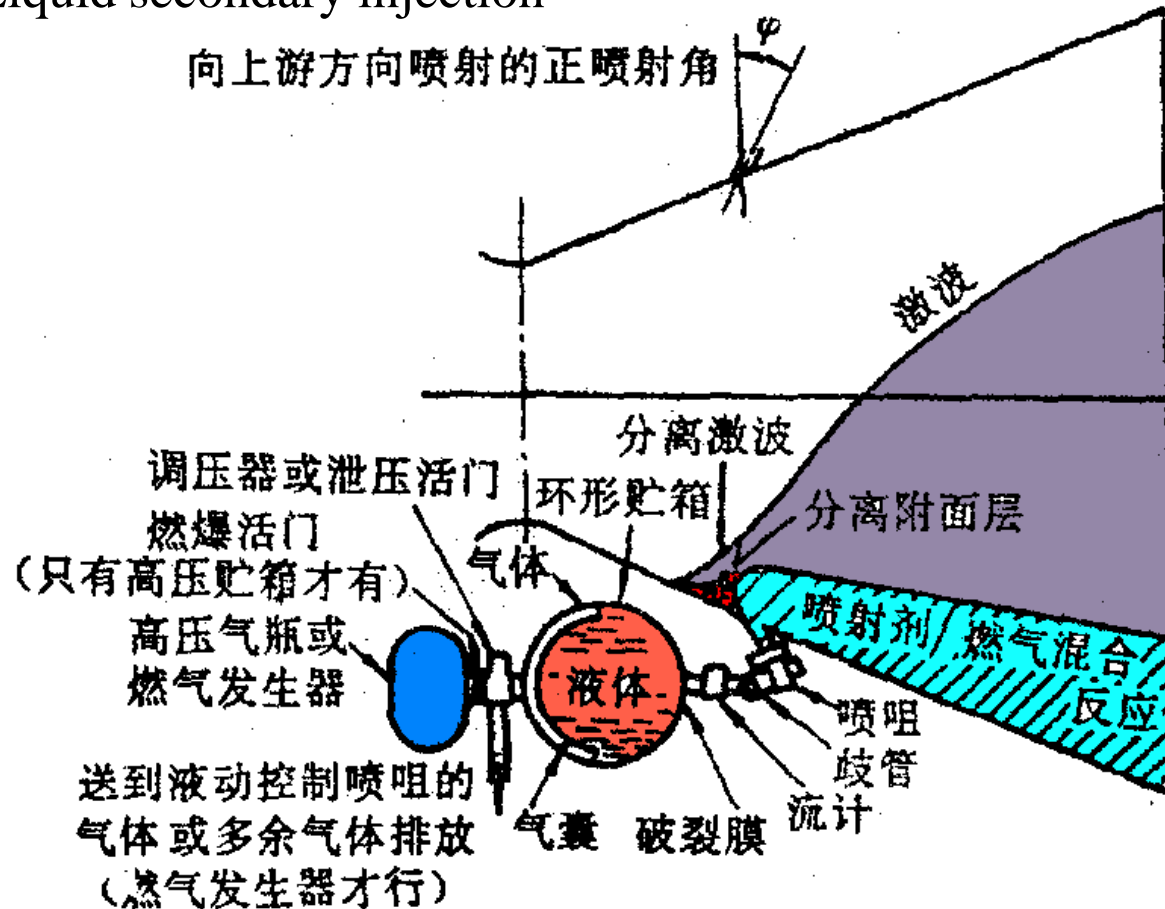
➤ (5) Gas rudder



Design of nozzle and thrust control device

■ Thrust Vector Control of Solid Rocket Motor

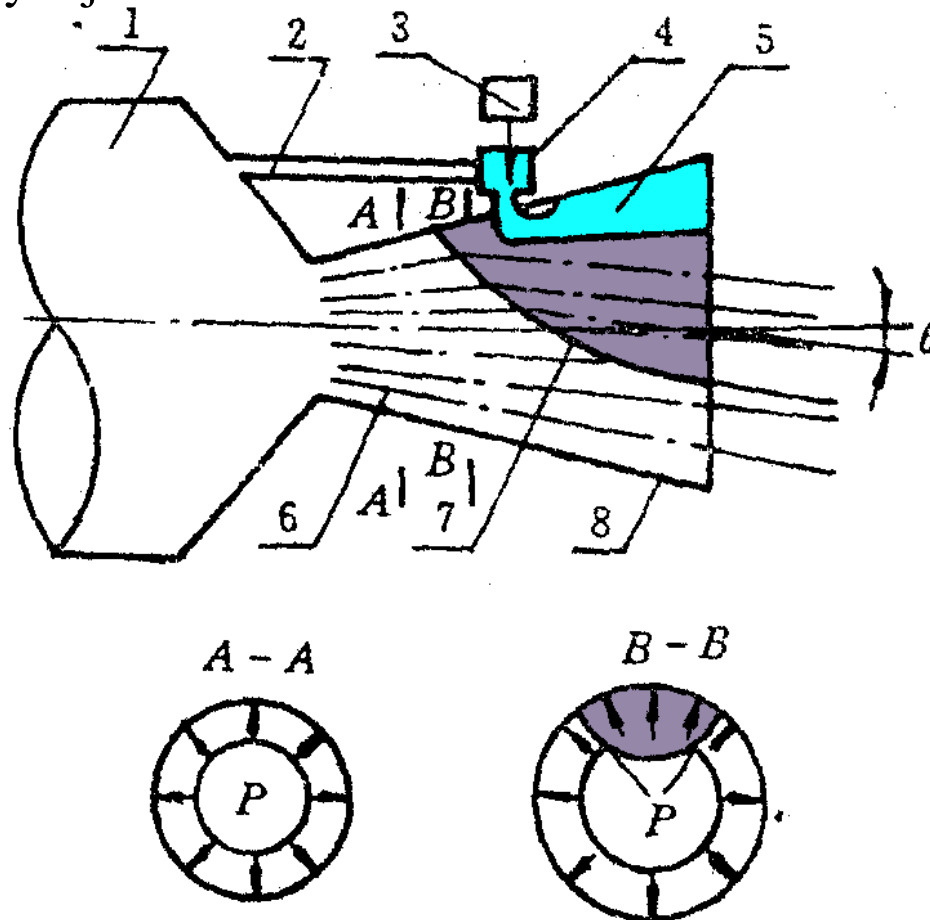
➤ (6) Liquid secondary injection



Design of nozzle and thrust control device

■ Thrust Vector Control of Solid Rocket Motor

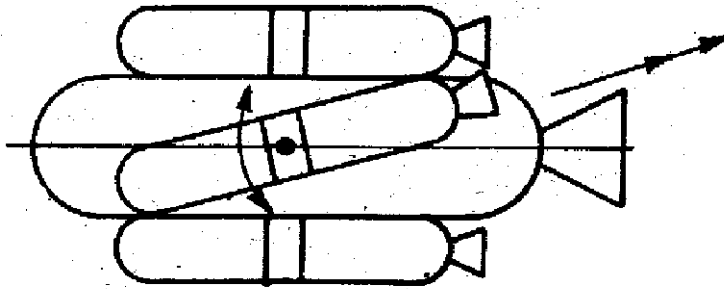
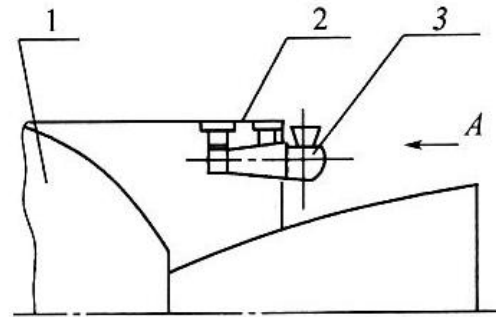
➤ (7) Gas secondary injection



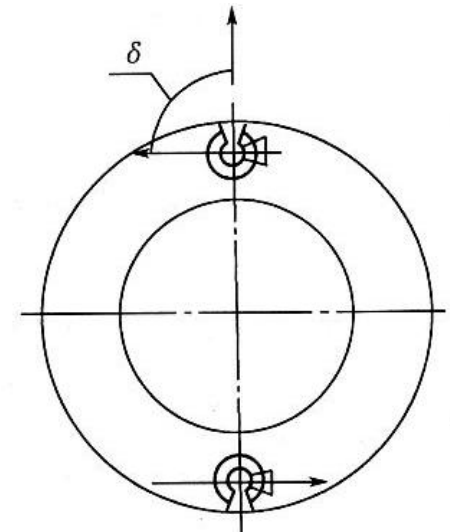
Design of nozzle and thrust control device

■ Thrust Vector Control of Solid Rocket Motor

➤ (8) Auxiliary engine



A - view



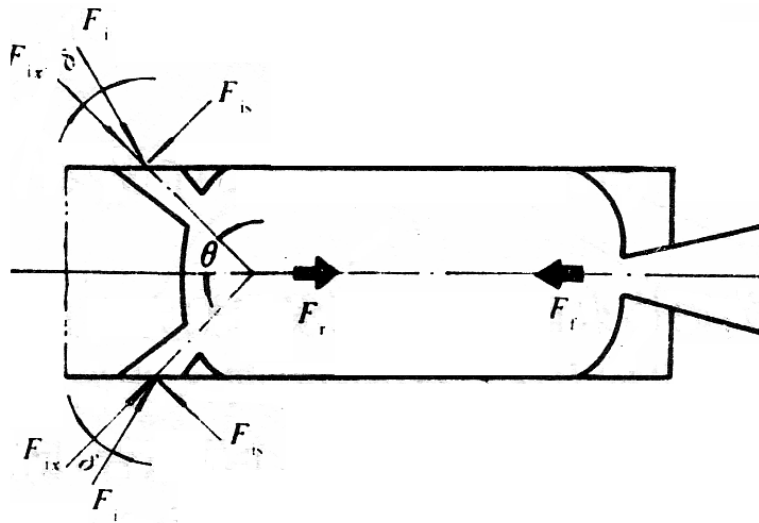
Design of nozzle and thrust control device

■ Thrust Vector Control of Solid Rocket Motor

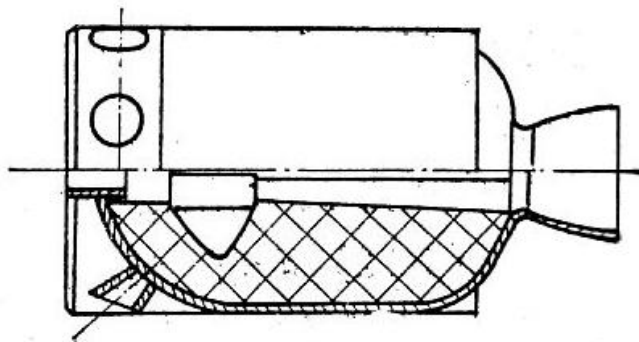
Device	Performance	Maximum thrust deflection angle (°)	Maximum frequency response (Hz)	Servomechanism Power and size
Single hinge swing nozzle		15	2~5	Larger
Flexible nozzle		15	2~5	large
Liquid floating nozzle		15	10	medium
Rotating nozzle		10	2	Larger
Bead nozzle		20	2	Larger
Gas rudder		10	10~15	small
Gas paddle		13		small
Jet deflecting ring		18		medium
Liquid secondary injection		6	12	small
Gas secondary injection		10	15	small

Design of nozzle and thrust control device

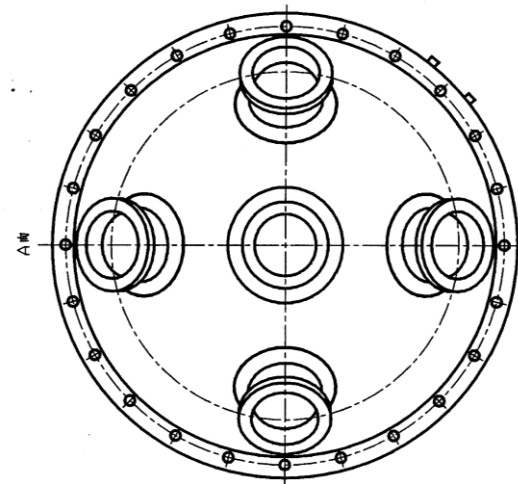
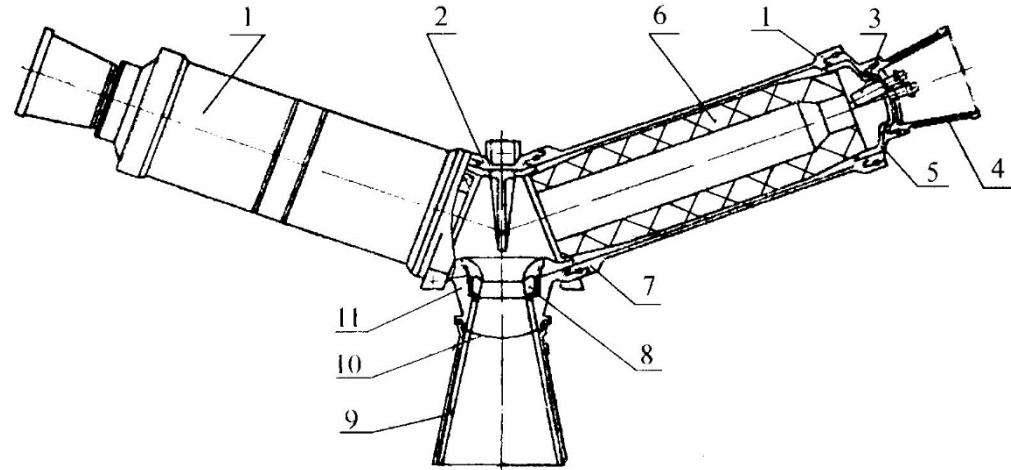
■ Thrust termination



反喷管



(a)



THE END