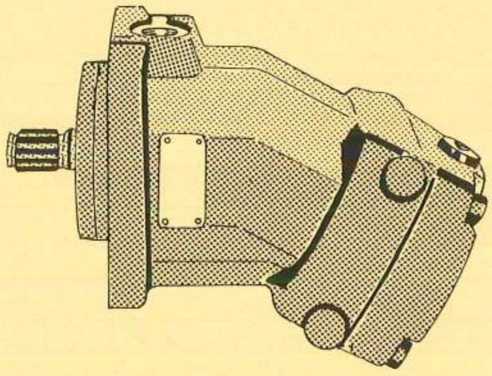

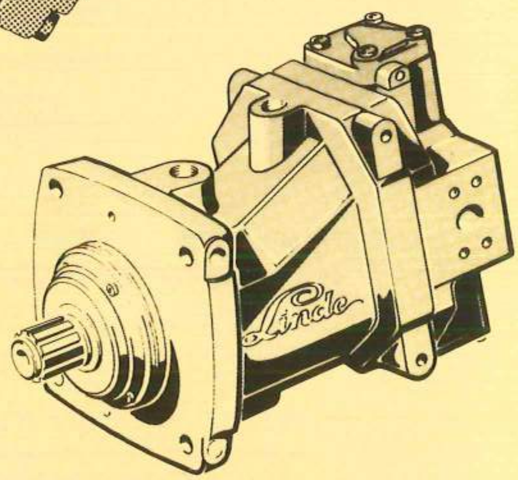

Linde

TECHN. DESCRIPTION

BMF 35
BMF/BMV 50
BMF/BMV/BMR 75
BMF/BMV/BMR 105
BMF/BMV/BMR 140
BMF/BMV/BMR 186
BMR 260

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DESCRIPTION OF DESIGN AND FUNCTION

Fixed displacement motor

BMF

Variable displacement motor

BMV from Linde

1. COMPARISON OF BENT-AXIS AND SWASH PLATE DESIGN

1.1. Piston forces and torque generation

Bent-axis rotating unit (see fig.1)

The pressure force $F_k = A_k \Delta p$ acting on the front area A_k of the piston is transmitted to the drive flange by the connecting rod. Of the two resulting components the axial force F_{ax} is conducted into the housing via roller bearings. The radial force F_r using the drive flange radius as a moment arm creates the effective torque.
It is an advantage of the bent-axis design that the torque is created directly on the drive flange, i.e. on the shaft. Only axial loads are applied to the piston and connecting rod. Bending loads on the connecting rod result from the cylinder barrel drag (inertia forces).

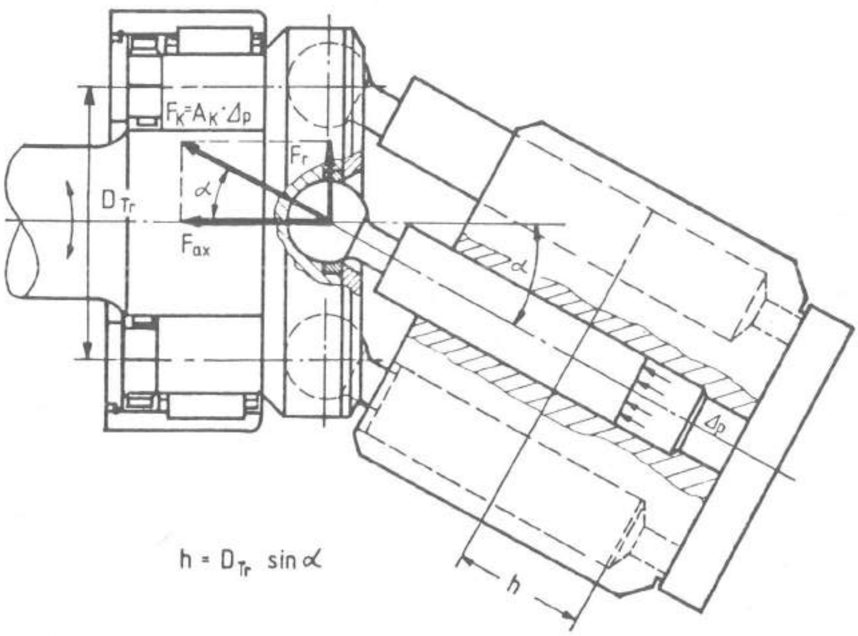

Fig.1 - Bent-axis rotating unit

HNr. 42/7.83e

Swash-plate rotating unit (see fig.2)

The pressure force F_K works via the piston upon the slipper pad which acts upon the swash plate via an hydrostatic bearing. The force F_N (right angles to the swash-plate) is conducted into the housing; the radial component F_r using the cylinder pitch circle as a moment arm creates the torque, not directly on the shaft, but through reaction forces on the cylinder block (which is mechanically less advantageous). Due to this the rotating unit is limited to relatively small swash angles ($\alpha = 18^{\circ}$).

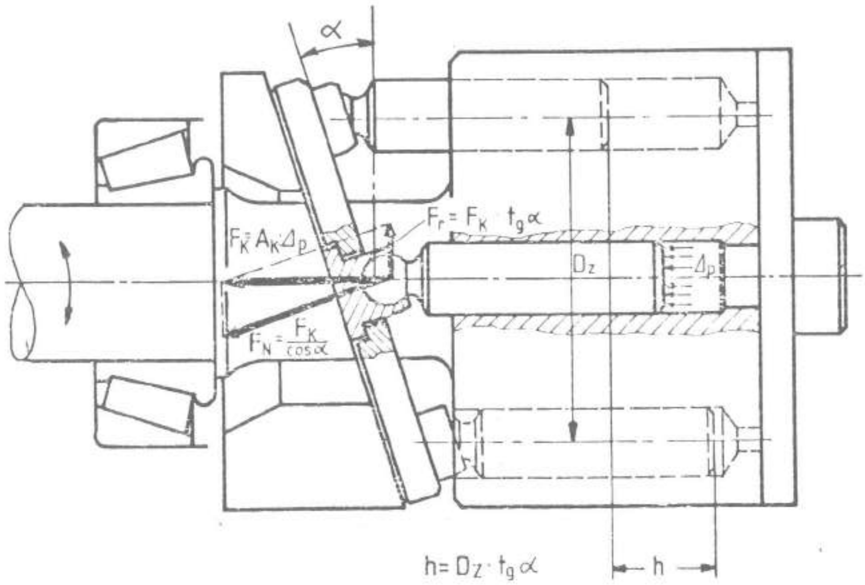

Fig. 2 - Swash-plate rotating unit

1.2. Optimum closed loop drive

The above design principles of axial piston drives - bent-axis and swash-plate - give each their unique characteristics which determine limitations and advantages of their applications.

Hydraulic motor operation (secondary unit)

Swash-plate: The hydraulic motor requires peak pressure and maximum swash angle simultaneously when the highest possible torque is demanded. This is true both for fixed and variable displacement. Under this condition the highest possible tilting forces will occur on the piston thus producing a considerable amount of friction between piston and cylinder bore. This effect is aggravated by a relatively high friction between swash-plate surface and slipper pads especially during the starting phase.

Bent-axis: Its geometry provides substantial advantages since the torque is generated on the drive flange.

Conclusion

The bent-axis drive is better suited for operation as a motor. Its start-up performance, for example, is up to 10% greater than that of the swash-plate motor. Mounting space and production cost of fixed displacement motors are the same for both designs. As for variable displacement motors the bent-axis construction has a distinct advantage.

Variable pump operation (primary unit)

Swash-plate: In the pumping operation peak pressure is more often required when displacement is small (see performance diagrams). The otherwise disadvantageous tilting forces between the piston and cylinder barrel therefore remain within acceptable limits in the pumping mode! The modest starting performance of the swash plate drive also remains relatively unimportant as a pump because it nearly always starts under no load condition and in the zero delivery condition (neutral). As swash plate pumps are fairly insensitive to cyclic speed fluctuations due to their reduced inertia they are particularly suited to be driven by internal combustion engines.

Bent-axis: From its space requirement and due to the higher manufacturing cost the bent-axis pump is less advantageous than the swash-plate pump.

Concul sion

It is mainly for cost reasons that variable pumps in closed loop circuits should preferably be of the swash-plate construction. The disadvantages of the rotating unit do not have the same decisive effect as in motors.

Summary:

Optimum exploitation of the advantages of both drive design principles is achieved when combining a swash-plate pump with a bent-axis motor.

The result is a stepless drive of highest power density at least possible cost.

By the way,

Owing to the different number of pistons in the rotating unit (bent-axis: 7, swash-plate: 9) there are less pulsational resonances in such hydrostatic transmissions.

Figures 3 and 4 show Linde transmissions for closed loop operation as they are currently applied for instance in construction, agricultural and material handling vehicles and many other applications.

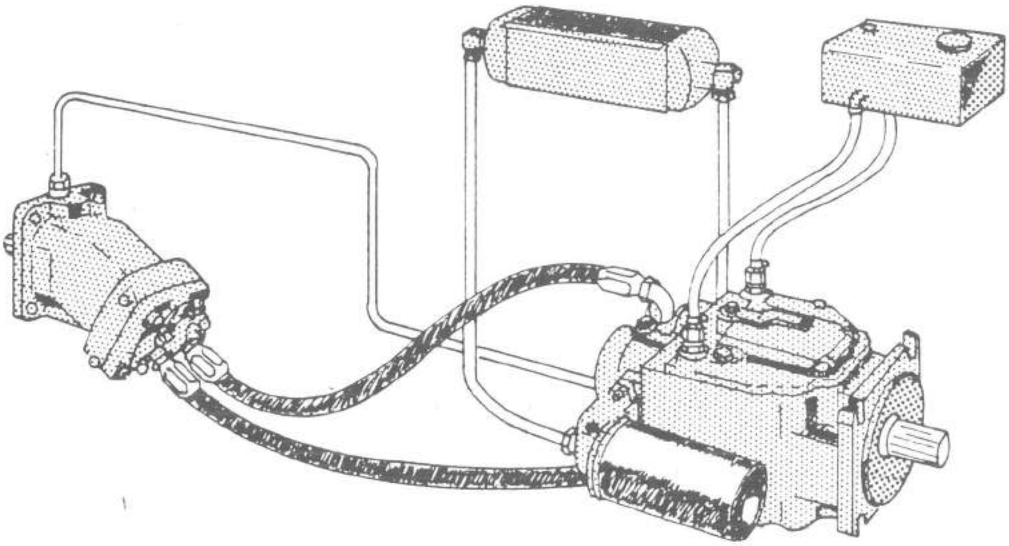

Fig. 3 - Stepless transmission
VARIABLE PUMP + FIXED DISPLACEMENT MOTOR

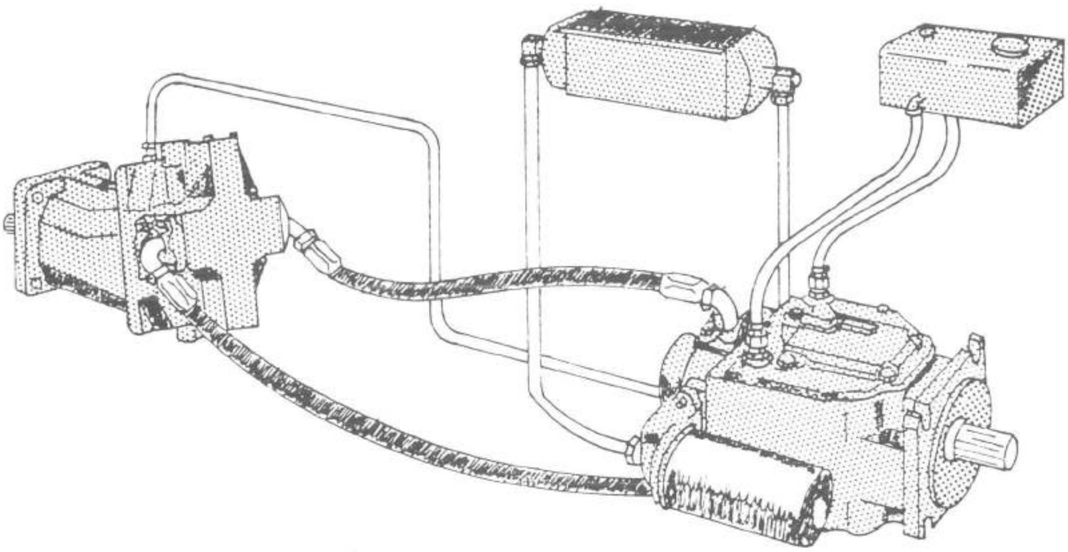

Fig. 4 - Stepless transmission
VARIABLE PUMP + VARIALBE DISPLACEMENT MOTOR

2. Linde hydrostatic motors BMV...TF... (basic design see fig. 5)

General Details:

- Axial piston motors in bent-axis design for use in open and closed loop circuits.
- 7 pistons (1) in all sizes.
- No-play and permanent connection between piston and connecting rod.
- Piston forces are transmitted via connecting rod (2) to the drive shaft flange (3)
- Side-load tolerant drive shaft (5) with extremely robust drive shaft bearings.

  Size 35 to 75: taper roller bearing (4)
  Size 105 to 186: axial, radial cylinder roller bearing (6).
- Fixing of all connecting rods in the drive flange by means of a retainer plate (7).
- No-play retension of connecting rods in the drive flange due to special production and measurement facilities.
- Pre-loading of cylinder barrel on the valve plate by spring force (8).
- Area balancing assures increase of cylinder barrel loading (9) upon the valve plate with growing working pressure and thus reliably overcoming the lift off forces.
- Additional safety is obtained by introducing the additional mechanical lift off security device (10) with a precisely controlled gap "A".

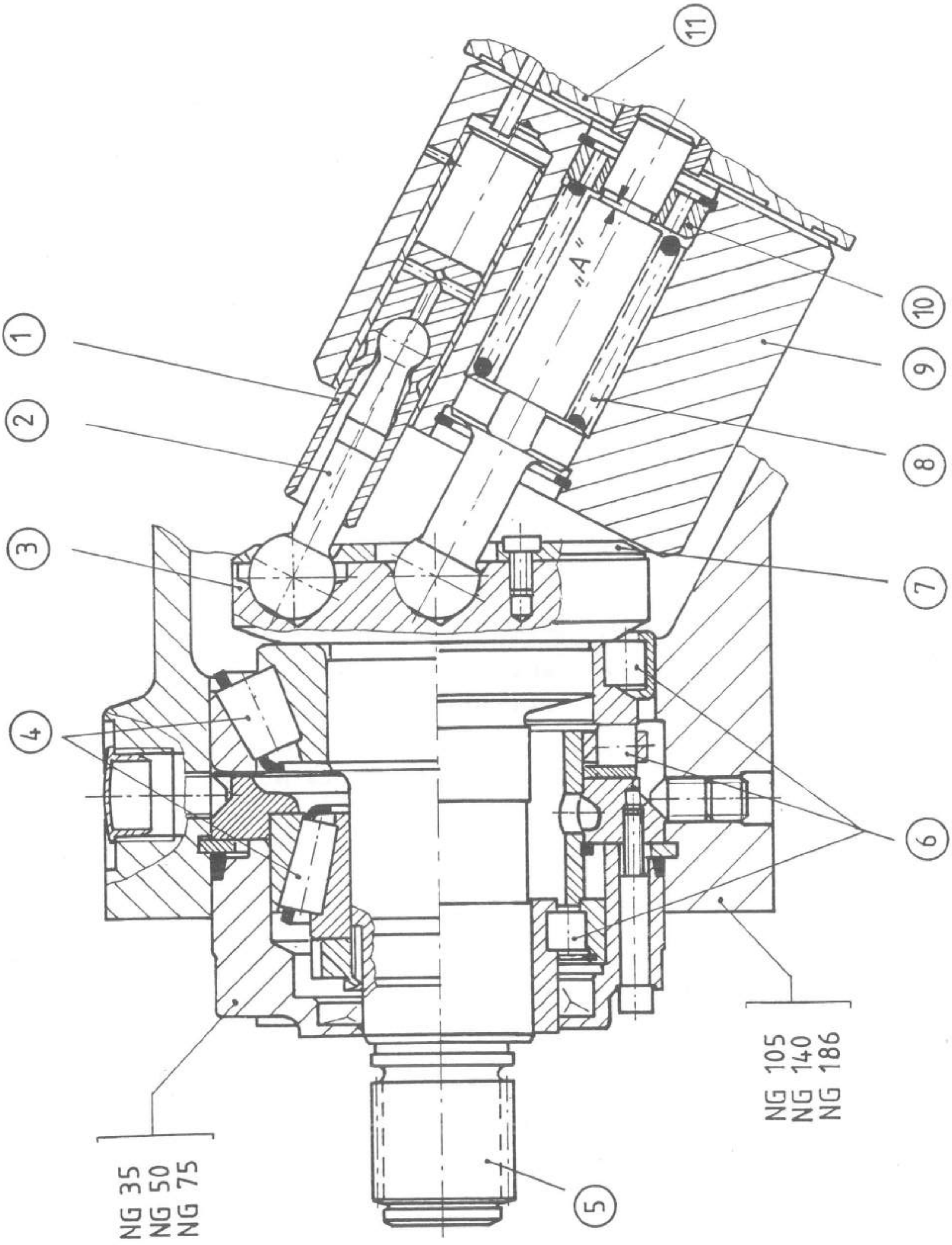

Fig. 5-Design of the

Linde hydrostatic motors BM...TF..

3. Linde purging device

3.1. Function

The Linde purging arrangement - optionally usable in both fixed displacement and variable motors is a combination of two flushing systems:

a) Circuit purging (fig. 6 and fig. 7)

In closed loop systems without purging facility the circulating working fluid is renewed by as much cooled fluid as is lost due to leakage. The excessive boost pump delivery of cooled working fluid is discharged across the base-pressure relief valve.

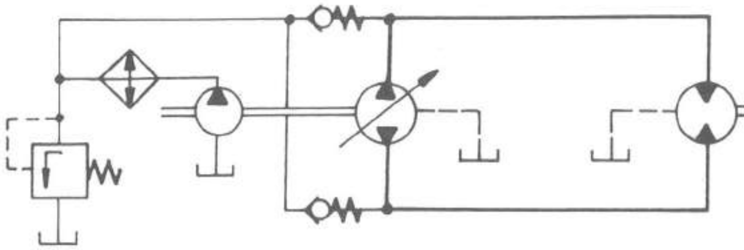

Fig. 6-Closed loop circuit without circuit purging

The circuit purging arrangement shown on fig. 7 connects the low pressure side with the discharge (or purge) relief valve by means of a shuttle valve.

After intensively mixing the cooled oil with the circulating fluid and restitution of the leakage loss a limited flow bleeds through the discharge relief valve. Wherever temperature problems arise (for example at high ambient temperature) the circuit temperature can be lowered considerably by means of "circuit purging".

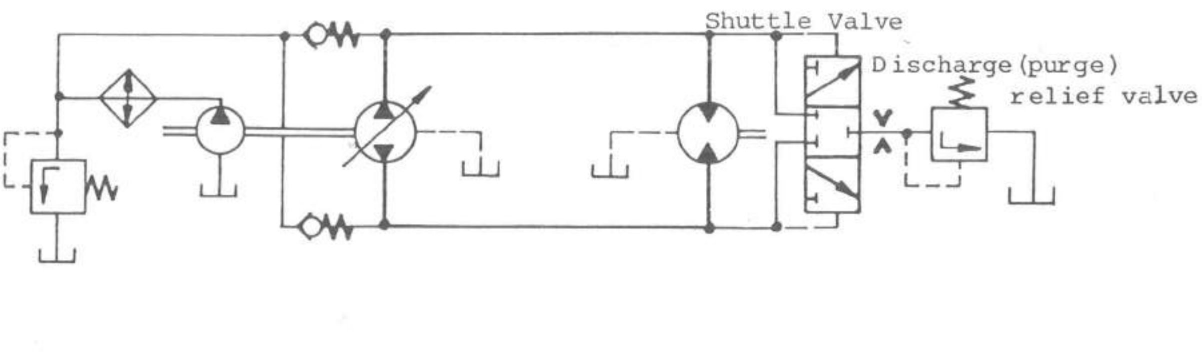

Fig. 7-Closed loop with circuit purging

b) Case flushing

The heat generated in the rotating assembly parts of hydraulic motors like bearings, joints, sliding surfaces, can be dissipated from the housing only by the leakage. Under certain conditions of operation (high speed, low working pressure) the actual leakage is not sufficient to dissipate the actual friction heat.

In these cases an additional flushing flow is introduced into the motor housing through the second drain connection port and carried away through the normal drain port together with the normal leakage. This results in a more intensive heat transfer and, therefore, in more effective cooling of the rotating assembly.

The Linde purging arrangement shown fig.8 unites the advantages described under a) and b).

i.e. the flushing oil from the discharge valve is fed into the inside of the motor housing and then, after having flushed the housing, flows out together with the normal leakage.

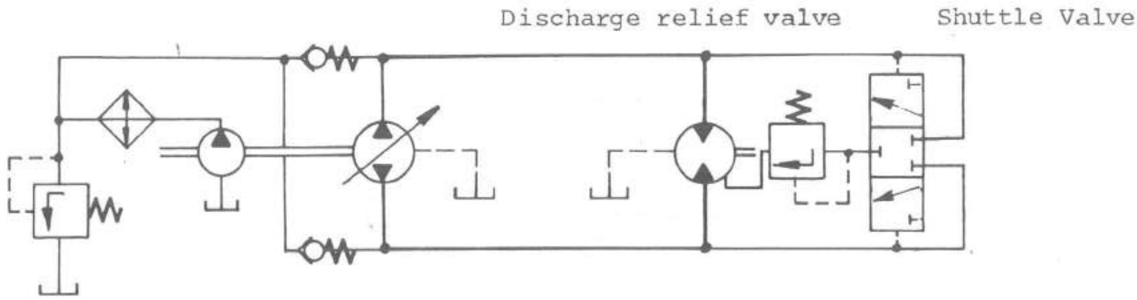

Fig. 8 – Linde purging system with circuit purging and case flushing