TURBOCHARGER

TYPE HS 400

DESCRIPTION AND OPERATING

INSTRUCTION MANUAL

MANUFACTURED BY HISPANO-SUIZA
DIVISION OF SNECMA

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1. GENERAL

1.1. The HISPANO-SUIZA division of SNECMA taking advantage of its experience in the field of turbine engines has designed and developed a range of turbochargers intended to supercharge Diesel engines.

The field of utilization of the HS.400 family turbochargers is as follows :

- Four-stroke cycle Diesel engine	600 to 1600 kW (815 to 2200 ch)
- Two-stroke cycle Diesel engines	450 to 1200 kW (610 to 1630 ch)

The various versions of this family of turbochargers are all based on the use of a common gas outlet casing and they only differ in the supercharging ratio obtainable and also in the internal arrangement necessary to match the supercharger and turbine to the requirements of the engines with which they are to be used.

The variety of existing compressor and gas intake casing permits combinations making the installation on the engine easier. Furthermore, the mounting arrangement of the turbine and impeller in overhang fashion makes possible the manufacture of casings specially adapted to the geometry of the engine.

1.2. The technical publications relating to HS.400 turbochargers include three manuals namely :

a) the Instruction Manual

b) the Maintenance Manual

c) the Illustrated Parts Catalog.

1.3. Cross-reference list of French and foreign terms and symbols used in some illustrations :

French	ø (diamètre)	Pas	R (rayon)
English	DIA. (diameter)	Pitch	RAD (radius)
German	d (durchmesser)	Gewindesteigung	r (radius)
Spanish	ø (diametro	Paso	RAD (radio)

2. IDENTIFICATION OF TURBOCHARGERS

2.1. Identification principle

Each turbocharger of the HS.400 family is designated by an identification code (i.e.a number of digits and letters) which represents the main particulars of the unit.

This identification code is engraved on the turbocharger nameplate.

Example :	HS.419 Bx2P 17.5 p7 M 86
Digit 4	: indicates the family
Digit 1	: indicates the supercharger series
Digit 9	: indicates the turbine series
Letter B	: indicates the compressor type within the series
Letter x	: associated with the letter representing the supercharger type, indicates rotating guide vanes with special aerofoil section
Digit 2	: number of compressor casing outlets
Letter P	: indicates a special gas outlet casing
Number 17.5	: width of diffuser annulus, in mm.
Letter p	: indicates the diffuser type of attachment
Digit 7	: indicates the diffuser vane stagger angle
Letter M	: indicates the turbine type
Number 86	: turbine nozzle throat area, in square cm.

2.2. Explanation of symbols

Component represented	Symbol	Definition
Common basic component	4	
Compressor impeller	0	impeller diameter : 250 mm
	1	impeller diameter : 266 mm
Turbine	0	37 blades for type M turbine with 40.5 mm high annulus
	6	41 " " " M " " 34 mm high annulus
	8	41 " " " M " " 40 mm high annulus
	9	41 " " " M " " 45 mm high annulus
	9	37 " " " A " " 45 mm high annulus
Compressor air intake geometry	A	with impeller 0_1 diameter at throat : 145 mm
	B	" " 0_1 " " : 126 mm
	B	" " 0_1 " " : 157.2 mm
	E	" " 0_1 " " : 138.4 mm
Rotating guide vanes (inducer)	F, X	rotating guide vanes with special form
Compressor casing	1	1 outlet
	2	2 outlets
Gas outlet casing	P	This symbol indicates a special gas outlet casing
Diffuser annulus	11, 12, 12.5, 13, 17.5	width of annulus in mm.
Diffuser attachment	p	This symbol indicates that the diffuser is attached to the compressor casing cover
Diffuser	2	Diffuser vane angular setting : − 3°
	3	" " " " : − 2°
	4	" " " " : − 1°
	5	" " " " : 0° nominal angular setting
	6	" " " " : + 1°
	6.5	" " " " : + 1°30'
	7	" " " " : + 2°
	7.5	" " " " : + 2°30'
	8	" " " " : + 3°
	9	" " " " : + 4°
	10	" " " " : + 5°
	11	" " " " : + 6°
	12	" " " " : + 7°
	13	" " " " : + 8°
Turbine	A	Turbine with detachable blades
	M	Turbine with integral blades
Turbine nozzle	x	Nozzle throat area in sq.cm.

3. CHARACTERISTICS

3.1. General

Compressor	: centrifugal	
Turbine	: axial flow	
Max. R.P.M.	: 33,000	} continuous operation
Max. temperature at turbine entry	: 650°C	
	: 34,000	} one-hour operation
	: 700°C	
Dry weight	: 145 to 170 kg approx. depending on version	

3.2. Overall dimensions : See figures 8 to 11 as applicable

3.3. Performance data : See figure 3

3.4. Cooling : water cooled (max. allowable pressure 3 bars)

Water flow : See figure 6

3.5. Lubrication

Type	: pressure lubrication
Oil filter	
P2/P1 $\leq$ 2.3	: 30 to 40 microns
P2/P1 $>$ 2.3	: 15 to 20 microns
Oil pressure at turbocharger oil inlet	
at max. speed	: 5 to 6 bars
at idling	: 1.5 bar
Max. oil inlet temperature	: 75°C
Oil flow	: See figure 4

3.6. Intake pressure drop : 200 mm water with clean filter

3.7. Exhaust pressure drop : 300 mm water

4. DESCRIPTION (figure 1)

4.1. General

The turbocharger is basically composed of :

- a main casing assembly (1)
- a balanced turbine assembly (51)
- a turbine nozzle assembly (60)
- a diffuser cover assembly (83)
- a balanced impeller assembly (90)
- a compressor casing assembly (101)

Depending on the version it can be fitted with such additional parts as :

- adaptation parts
- attachment parts

4.2. Detail (figure 1, detail A)

4.2.1. Main casing assembly (1)

The main casing assembly which forms the basic structure of the turbocharger comprises the gas outlet casing (2) in which are mounted the shaft and rear bearing assemblies.

A. Gas outlet casing

The gas outlet casing (2) has oil inlet and outlet holes and water inlet and outlet holes (see figure 8).

Internal passages are provided for lubricating oil, cooling water and rear bearing pressurizing air.

Rain water that may enter the gas outlet casing is drained out through a hole provided at the bottom part of the casing and blanked off with a plug (40).

B. Shaft

The shaft (9) rotates in front and rear bearings (17) (32). It is axially positioned by a thrust bearing assembly located on the rear face of the front bearing. Both journal bearings and the thrust bearing are pressure lubricated with oil.

The thrust bearing assembly includes two thrust washers (10)(11) placed on either side of the shaft collar and retained in position by two plates (13). A spacer (12) provides for the required axial clearance. Both plates (13) as well as the spacer (12) are positioned by Mecanindus spring pins (14) and secured to the front bearing with bolts (21) and tabwashers (20).

The thrust washers (10) (11) and bearing sleeves (17) (32) consist of a steel web or shell lined with copper-lead alloy the working surfaces of which are lead plated.

Sealing between the gas outlet casing and the front bearing (16) is achieved by interposition of a gasket (23) and O'ring seal (22). A labyrinth seal (25) located in the front bearing (16) is secured to the gas outlet casing (2) with bolts (27) and tabwashers (26). A gasket (24) is interposed between the labyrinth seal (25) and the front bearing (16).

C. Rear bearing

An O'ring seal (28) and a gasket (29) are provided between the rear bearing (31) and the gas outlet casing. A deflector ring (34) and the turbine labyrinth seal (36) prevent oil leakage to the turbine side. The turbine labyrinth seal (36) and rear bearing (31) are secured to the gas outlet casing (2) with bolts (39) and lockplates (37) (38). A gasket (35) is interposed between the labyrinth seal and the rear bearing.

D. Storage parts

The gas outlet casing is blanked off by a cover plate secured to the gas outlet flange. The oil inlet hole is blanked off with a plug.

For storage or shipment of the main casing assembly alone the water inlet and outlet holes, the oil outlet hole and the vent hole are blanked off with plugs. The shaft ends are protected by plastic caps.

NOTE : The two versions of main casing assembly currently delivered differ only by an additional drilling in the gas outlet casing (see figure 8)

4.2.2. Balanced turbine assembly (51)

Two interchangeable types of turbine wheels can be installed :

- turbine wheel with integral blades (code M)
- turbine wheel with detachable blades (code A)

A. Turbine wheel with integral blades (detail C)

It is a cast turbine wheel (53) with a thrust ring (54) inserted in its bore. It may be fitted with a vibration damping wire (57)

B. Turbine wheel with detachable blades (detail A)

It consists of a turbine disc with a ring (54) inserted in its bore. The blades (56) are anchored to the disc by fir-tree roots and locked in position by tabs (55) the ends of which are bent down. This turbine wheel is fitted with a vibration damping wire (57).

C. Turbine wheel to shaft attachment

The balanced turbine wheel assembly (51) is splined to the shaft (9) and radially located on it by locating diameters provided at both ends of the splined portion.

The axial position of the turbine is set by interposition of adjusting washers (50). The turbine is secured to the shaft (9) by a nut (59) and tabwasher (58).

4.2.3. Turbine nozzle assembly (60)

The turbine nozzle assembly consists of a gas intake casing (62) to which are fitted the nozzle guide vanes and rings.

A. Gas intake casing

The various types of gas intake casings together with their dimensions are shown in figure 10.

Some gas intake casings are heat insulated with braided asbestos.

B. Nozzle guide vane assembly

This assembly is composed of inner and outer rings (74) (73) and nozzle guide vanes (75).

The vanes are inserted in slots provided in both rings. The vane setting angle is determined by the angle at which the slots are positioned relatively to axial direction.

The outer and inner rings (73) (74) are secured to the gas intake casing (62) with bolts (77) and tabwashers (76).

C. Turbine nozzle assembly attachment

A gasket (79) is interposed between the nozzle assembly and the gas outlet casing to ensure a gas tight joint.

The turbine nozzle assembly is angularly positioned relatively to the gas outlet casing by three locating pins (80) which engage slots in the gas intake casing flange. The turbine nozzle assembly (60) is secured to the gas outlet casing (2) with bolts (82) and tabwashers (81).

D. Turbine nozzle assembly with support frame (detail C)

In one version, a nozzle support frame (65) is interposed between the gas intake and outlet casings (62 and 2). In this case the turbine nozzle assembly is secured to this support frame. To ensure a gas tight joint, a gasket (64) is interposed between the gas intake casing (62) and the support frame (65) which are secured with bolts (69), tabwashers (70) and nuts (71).

NOTE : The gas inlet openings of intake casings are blanked off by plugs for storage.

4.2.4. Compressor diffuser cover assembly (83)

This assembly consists of a cover (84) to which is secured the diffuser (85).

In this cover (84) circular grooves are machined to form labyrinth seal lips.

The diffuser (85) is secured to the cover with bolts (86), washers (87) and nuts (88).

The diffuser and cover assembly is located in the gas outlet casing and secured with three screws (89).

In some versions the diffuser is secured to the compressor casing with three screws (109). In these versions the diffuser cover assembly is reduced to the cover (84) alone (detail D).

4.2.5. Balanced impeller assembly (90)

This assembly is composed of an impeller sub-assembly and a rotating guide vanes (inducer) sub-assembly.

A. Impeller sub-assembly

It includes the impeller proper which is a light alloy forging, in which are machined circular grooves forming labyrinth seal lips; a bushing (93) fitted in the bore and four dowel pins (94).

B. Rotating guide vanes (inducer) sub-assembly

It includes the cast steel rotating guide vanes (inducer) (96) in which a ring (97) is inserted.

The rotating guide vanes sub-assembly is located on the impeller by the impeller bushing (93) and the dowel pins (94).

C. Impeller to shaft attachment

The balanced impeller is coupled to the shaft (9) through the rotating guide vanes (inducer) splines and radially located on it by locating diameters provided at both ends of the splines.

The impeller is axially positioned on the shaft (9) by adjusting washers (98) and is secured by a cap nut (100) and a lockwasher (99).

4.2.6. Compressor casing assembly (101)

The volute-shaped compressor casing (103) has a central air intake and two tangential air outlets.

The figure 9 shows the dimensions and shape of the various types of compressor casings.

It locates on the diffuser cover (84) and is secured to the gas outlet casing (2) by nuts (112) and lockwashers (111).

Sealing between the compressor casing and diffuser (85) is achieved by an O'ring seal (110).

NOTE : I. In some versions, the diffuser (85) is secured to the compressor casing (103) by three screws (109). The clearance between the diffuser vanes and the cover (84) is adjusted by means of washers (108) -detail D).

II. In case where the turbocharger is delivered or stored without any adaptation part, the compressor casing central air intake and tangential air outlets are blanked off.

4.2.7. Adaptation parts (figure 11)

A. Air intake duct

On some versions an air intake duct is fitted to the compressor casing central air intake. It is secured with bolts, spring and plain washers.

The figure 11 shows the shapes and dimensions of different air intake ducts.

The turbochargers equipped with an air intake duct are delivered or stored with a blanking plate fitted on the intake duct.

B. Flanges

Some versions are fitted with flanges or pipes for oil outlet and water inlet and outlet connections.

Refer to figure 11 and para. 6.4 and 6.5.

4.2.8. Turbocharger mounting supports

Some turbocharger versions are delivered with two mounting supports (see para. 6.1.1 and figure 8).

5. OPERATION (Figure 2)

5.1. Rotation (detail A)

The single stage axial flow turbine is rotated by the exhaust gases of the Diesel engine. These gases collected in the gas intake casing are guided between the nozzle inner and outer rings and directed to the turbine blades by nozzle guide vanes. Expanded gases are then exhausted through the gas outlet casing.

The turbine drives the impeller through the common shaft to which both are splined.

The turbocharger rotational speed for the engine operating speed and power is governed by the type of compressor, diffuser area and angular setting of vanes on the one hand, by the turbine type, the nozzle area and vane setting angle on the other hand. By proper selection of the above elements a desired supercharging pressure ratio is obtained ensuring operation in the region of maximum efficiency while allowing a sufficient margin for surge.

The adaptation of turbochargers to Diesel engines is carried out by our Technical Departments.

5.2. Lubrication (Figure 2 B)

Oil under pressure (5 to 6 bars at maximum speed) for lubrication of the turbocharger is tapped from the engine main oil system at the filter outlet (see para. 6.4). Oil is fed to the journal and thrust bearings through internal passages machined in the casing. Oil returns to the engine crankcase sump under gravity.

5.3. Cooling (Figure 2 C)

The general cooling of the unit is achieved by a cooling system which is an extension of the engine cooling system.

Circulation of the cooling water is in an upward direction, the coolant inlet being at the bottom of the casing and the outlet at the top. A pressure cooling system may be used if desired as the gas outlet casing is pressure tested at a maximum pressure of 6 bars.

Cooling of the turbine disc is achieved by pressurized air.

5.4. Internal sealing (Figure 2 D)

Sealed points :

- air : between impeller and diffuser cover
- oil : at front and rear bearings
- gas : between turbine and gas outlet casing.

5.4.1. Air leakage between impeller and diffuser cover

Concentric grooves are machined on the impeller rear face to form labyrinth seal lips that reduce air leakage between the impeller and diffuser cover.

Leakage air is collected in a chamber formed between the diffuser cover and the gas outlet casing and used as a pressurizing chamber.

5.4.2. Oil leakage from front and rear bearings

Oil leakage from the end faces of the front and rear bearings is prevented by the combined use of labyrinth seals and pressurizing air. The latter is fed to the rear bearing through internal passages provided in the gas outlet casing.

The sealing air pressure can be controlled by the use of a restrictor plug (117) fitted in place of the normal blanking plug (118) (Figure 1 E).

One of the three holes provided at the bottom of the gas outlet casing is used to drain any leakage oil from the front bearing. The two remaining holes are blanked off by a plug (116). What holes are to be plugged depends on the position of the turbocharger on the engine.

5.4.3. Gas leakage between turbine and gas outlet casing

Exhaust gas is prevented from entering the annular space between the turbine disc and rear bearing by the combined use of labyrinth seals and pressurizing air. This air is used to cool the turbine disc and leakage air past the seals is discharged into the gas outlet duct.

6. INSTALLATION

6.1. Mounting (Figure 8)

The turbocharger can be mounted on the engine using either :

6.1.1. Two mounting supports

- one (147) secured to the gas outlet casing with bolts (150) and washers (149)
- the other (148) secured to the gas outlet casing through the compressor casing studs and nuts (112).

6.1.2. Or one mounting support fitting on the gas outlet casing circular flange and secured with six bolts, (size 10 x 150) screwed into 13 mm deep tapped holes.

The figure 8 shows the location of these holes.

6.2. Angular position

6.2.1. Angular position of main casing assembly

The turbocharger may be so mounted that in the axial direction its shaft lies at an angle to the horizontal plane. The maximum permissible angle is 15° above or below that plane.

In a crosswise direction the maximum angle at which the main casing assembly may be set to the vertical plane is 30° on either side of that plane.

6.2.2. Angular position of the compressor casing

This casing can be set relatively to the gas outlet casing at any 15° position through 360°.

6.2.3. Angular position of the gas intake casing

The gas intake casing can be set relatively to the gas outlet casing at any 30° position through 360° by changing the location of locating pins (80) in the gas outlet casing.

6.3. Connections

6.3.1. Oil inlet

Connection to the oil system is made by means of a flanged fitting or an elbow fitting screwed into the gas outlet casing. These fittings, which are not supplied, must not have an inside diameter smaller than 12 mm.

Oil inlet port thread size : 3/8" BSF, nominal diameter 16.66 mm, 19 threads per inch.

6.3.2. Oil outlet - Water inlet and outlet

We supply flanged connections secured with three 8 mm dia. bolts or studs and nuts (see figure 11).

However elbow fittings screwed into the gas outlet casing may be used in place of the above flanged connections.

Tapped holes thread size : 1" BSP, nominal diameter 33.25 mm, 11 threads per inch.

NOTE : Oil and water pipes shall preferably be flexible pipes. In case where rigid pipes are used expansion sleeves shall be interposed to prevent excessive load on the casings.

6.3.3. Exhaust gas ducting

A. Gas intake casing connection

The connection of the gas intake casing to the engine exhaust manifold must be made using expansion boxes or preferably expansion bellows so as to eliminate any abnormal stresses on the gas intake casing or the turbocharger.

B. Connection to the silencer

The connection between the exhaust box and the silencer is to be made using flexible ducting. The weight of the connecting duct shall not exceed 75 kgs.

In no case the exhaust back pressure shall exceed 300 mm of water so as to prevent contamination of labyrinth seals with sooty deposits which might result in a locking of the blower or deterioration of the performance characteristics of the unit.

6.3.4. Air intake and outlet ducts (figure 12)

The air intake and outlet ducts shall meet some requirements with regard to installation to prevent the corresponding flanges on the turbocharger from being stressed at a higher level than that for which the compressor casing has been designed.

A. Air intake ducting

The flexional and torsional stresses set up in the compressor casing flange by the air intake ducting shall not be such as to exceed the following values.

Tensile - compressive - flexional stress : 4 h.bars
Shear stress : 2 h.bars

To meet the above requirements the flange must not have to take the weight of heavy intake ducts and provision must be made for devices allowing expansion of the ducts without abnormal stresses being set up.

As regards noise, our soundproofed intake ducts reduce the noise level. However noise reduction by the intake duct alone may be insufficient considering noise regulations in force. In such a case it is recommended as far as possible to extend the soundproofed intake duct by a length of 1.50 m. Soundproofing will be achieved by a double wall forming an annular space 30 mm wide, the inner wall being made of perforated sheet metal and the space being filled up with expanded polyurethane.

B. Air outlet ducting

The same installation requirements are applicable to the air outlet ducting. In particular the installation shall be such as to allow free expansion of the outlet elbow in the various directions where it takes place. Interposing expansion boxes is a solution to the problem only if they work perfectly and allow sufficient freedom of movement in all directions. If this requirement cannot be met it is recommended to install a connecting sleeve made of wired glass cloth and silicone between the compressor air outlet elbow and the remaining part of the air outlet ducting.

6.4. Connection to oil system

The turbocharger main oil supply pipe is connected to the Diesel engine main oil system at the oil filter outlet.

Refer to "Characteristics" para. 3.5 for oil pressure and required filtration power.

If the engine oil filter does not meet these specifications another filter should be installed at the turbocharger oil inlet. The size of this filter will be determined by consulting our Technical Departments.

Oil flow vs. r.p.m. see figure 4.

As oil return is under gravity the oil return pipe shall be directly connected to the engine crankcase. Pressure losses shall be reduced to a minimum. It is recommended to use a pipe with a minimum diameter of 30 mm and a maximum length of 1 metre.

NOTE : In case of prolonged operation of the engine at adling, a special device shall be installed in the oil return system to avoid choking up of the bearings.

CAUTION : On rapid speeding or loading power generator units it is essential to provide for an oil pressure supply to the turbocharger as soon as the power generator unit is started. The purpose of this is to feed the turbocharger oil system during the time taken by the engine oil pump to build up pressure.

Likewise, if engine shutdowns are frequent it is recommended to have an auxiliary lubricating device to ensure lubrication of the turbocharger during idle rotation of the rotor due to inertia and then for at least ten minutes after the rotor has stopped to ensure cooling of the shaft.

6.5. Connection of water cooling system

Cooling of the turbocharger is achieved using water by-passed from the engine main cooling system.

Circulation of the cooling water is in an upward direction the inlet pipe being connected to a connection at the bottom of the casing and the outlet pipe to one or preferably both bosses at the top of the casing.

NOTE : If the turbocharger is set an angle to the vertical plane the coolant outlet pipe should be connected to the boss in highest position.

- Refer to figure 6 for diagram of pressure drop vs. water flow.
- Refer to figure 5 for diagram of water dissipated heat vs. gas flow.

7. OPERATING INSTRUCTIONS

7.1. Checks before initial operation

7.1.1. Preparation inspection and checks before starting

A. Preparation for checking the rotational speed (Fig.7)

The turbocharger rotational speed is measured by a frequencymeter (220 V a.c. or 72 V d.c.) connected through a SOURIAU connector to a speed pick-up installed in the air intake of the compressor casing (103) in line with the impeller retaining nut.

This pick-up counts pulses generated by a slot machined at the end of the impeller nut (100).

NOTE : The speed pick-up P/N 53487 will be used on compressor casings P/N 53175, 53576 and 53577. (Dimension B = 47 mm. See figure 1)
The speed pick-up P/N 53620 will be used on compressor casings P/N 53354, 53467 and 53469. (Dimension B = 87 mm. See figure 1)

B. Installation and setting of a speed pick-up

- Measure the axial play of the rotor
- Push the shaft (9) fully backward to take-up axial play in direction of turbine
- Slacken the locknut of the speed pick-up adjusting screw and screw out this one
- Install the speed pick-up support frame on the compressor casing air intake flange
- Screw in the pick-up adjusting screw until it contacts the impeller nut (100)
- Back out the screw to obtain a clearance of (0.5 + axial play) $^{+\ 0.1}_{-\ 0}$ mm between the pick-up and the impeller nut.
- Tighten the adjusting screw locknut.

The pick-up is now ready for a speed check.

C. Checks

- Check that the engine cooling system is filled up with coolant
- Check that oil circulates in the turbocharger by means of the hand pump of the engine (with the pipe disconnected, there must be a flow of oil from the turbocharger oil outlet).

  This operation primes the whole lubricating system with oil and will prevent the journal and thrust bearings from working in "dry" condition until the oil pressure in the engine system is built-up.

CAUTION : It is strongly recommended not to check the rotor for free rotation by spinning it with a compressed air jet as no provision is made for self-lubrication of the turbocharger.

7.1.2. Checks and measurements after start-up

A. Measurements

Note the oil pressure and temperature :

- mean oil pressure : 5 to 6 bars
- minimum oil pressure at idling : 1.5 bar.

For a given engine speed note the following :

- turbocharger speed as measured by the speed pick-up
- air discharge pressure at compressor outlet
- check that observed pressure and speed values agree with the values specified by the manufacturer.

NOTE : If pressure values do not agree :

- check the air intake system for leaks and the compressor air intake filter for cleanliness.

If speed values disagree :

- check the exhaust gas inlet system for leaks.

B. Checks

Check that :

- the coolant circulates and there are no leaks from pipe connections and taper plugs
- the oil system is free from leaks
- there are no leaks from the various joint faces of the gas intake casing and the compressor casing.

NOTE : Any leakage reduces the engine efficiency.

7.2. Special servicing operations

7.2.1. Protection of cooling system during cold weather

When an anti-freeze agent is poured into the engine coolant system, the coolant should be circulated for a time long enough to obtain a homogeneous mixture and proper distribution of the anti-freeze agent up to the turbocharger.

7.2.2. Draining of gas outlet casing (rain water)

After prolonged shutdown of the engine under bad weather conditions, the gas outlet casing should be drained by removing the plug provided for that purpose at the bottom of casing. This will allow any rain water that may have entered the casing to be evacuated.

7.3. Turbocharger troubles that may be experienced in service

7.3.1. Abnormal vibrations

Abnormal vibrations may result from :

- unsecure attachment of the turbocharger on its mounting support
- unbalance due to impeller or turbine damage. In this case the engine should be stopped and possibly re-started and operated at a reduced speed after evaluation of the damage.

7.3.2. Substantial drop in compressor discharge pressure

If discharge pressures obtained for a given engine speed are low as compared with those obtained during tests at the manufacturer's plant this may be due to :

- clogging of the air filter
- fouling of the compressor (impeller and diffuser) see para.7-4-3.
- sudden fall in turbocharger speed that may be caused by :
  - fouling of turbine labyrinth seals by sooty deposits : engine with high oil consumption or operating conditions which promote a tendency to fouling of the exhaust system
  - a damaged rotor (impeller or turbine).

NOTE : The latter trouble may be avoided by periodic inspections.

7.3.3. Compressor surge

This phenomenon results from a disturbed aerodynamic flow of air between the diffuser vanes . It may be due to :

- air intake filter clogging; maximum allowable pressure drop : 200 mm water with clean filter 300 mm water with clogged filter.

  NOTE : For pressure drops greater than 300 mm water the air intake filter should be cleaned.

- external clogging of cooler matrix (reduction of air flow through matrix)
- internal scaling of cooler matrix with resultant rise in intake air temperature. Surge is eliminated by cleaning the above components.

7.4. Safety devices

Depending on engine applications, Turbocharger operating troubles may result in serious consequence for the engine which in extreme cases may be as serious as piston seizure.

Engine manufacturers are therefore recommended to provide the engine with devices enabling to check the following parameters :

- min. oil pressure at turbocharger inlet
- compressor discharge pressure drop with engine torque
- compressor discharge air temperature rise

7.5. Overhaul and inspection periods

The overhaul and inspection periods recommended for turbochargers type HS.400 are as follows.

7.5.1. Inspection

Every 6000 operating hours (approximately) the gas intake casing should be removed and the turbine wheel and nozzle visually inspected.

If found excessively fouled clean the turbine nozzle. If the inner wall of the gas intake casing is covered with a heavy sooty deposit (1 mm thick and over) remove the turbine and inspect labyrinth seals for clogging and the rear bearing for security.

On the occasion of this onspection check the shaft axial play for possible increase. An increase of the original axial play by 0,08 mm or more is an indication of premature wear of the compressor side thrust bearing (the original axial play is given in the log book for a new unit and in the last overhaul sheet for an overhauled unit).

In such a case the thrust bearing should be replaced in accordance with instructions given in the Maintenance Manual.

7.5.2. Overhaul

- Every 12000 hours or 24 months of operation (approximately)
- Every 24000 hours or 48 months of operation (approximately)

The recommended overhaul periods are to be adapted by operators to suit the overhaul periods of the engine on which the turbocharger is installed.

NOTE : Instructions for accomplishing Overhaul operations i.e. disassembly, cleaning, inspection, repair, assembly, are given in the Maintenance Manual.

7.5.3. Special maintenance instructions

A substantial drop of the compressor discharge pressure due to the presence of a thick hard deposit on the impeller vanes can be remedied by spraying water into the compressor with the engine running at full load. This water spraying, by impingement of water droplets on the impeller rotating at high speed produces a mechanical descaling effect.

This method of cleaning by spraying water in the compressor air intake prevents too quick a fouling of the impeller vanes but should in no case be considered as one dispensing the operator from carrying out overhaul operations during which the turbocharger must be disassembled and cleaned.

8. COMPREHENSIVE TABLE OF TURBOCHARGER VERSIONS

Symbol letters shown in columns 4, 5, 6 and 7 are explained in plates 8, 9, 10 and 11 respectively.

For cross-reference table of gas intake casing types and part numbers refer to para.9

Turbocharger designation	Serial No	Adaptation No	Main casing assembly type	Compressor casing type	Gas intake casing type	Adaptation parts
1	2	3	4	5	6	7
HS 400A2 17,5-5M71	0001	5525	A	E	K	FD
HS 406B1 11-5M52	1001	6146	A	C	K	FB+FC+FE
HS 410E1 12p5M77	2001	6195	A	D	H	FA+FG
HS 410E1 11p5M71	3001	6800	A	D	H	FA+FG
HS 416E1 12p6M52	4001	6602	A	D	T	FH
		6613	A	D	T	FH
		6729	A	D	T	
		6730	A	D	T	
HS 416E1 12p6M52	5001	6944	A	D	U	FC
		6945	A	D	U	FC
HS 416BF1 17,5p9M75	6001	6836	A	D	S	FA
HS 416B2 17,5p10M61	7001	6929	A	E	W	
HS 419B1 17,5p9M87	8001	6901	A	D	H	FA+FG
HS 418B2 17,5p6M71	10001	6918	A	E	P	
HS 419BX1 17,5p5M98	12001	53014	A	D	H	FA+FG
HS 418B1 17,5p7M74	13001	6985	A	D	T	
HS 418B2 17,5p6M71	14001	53382	A	E	J	
HS 419BX1 17,5p5M128,5	15001	53283	A	D	N	
		6993	A	D	N	
HS 419BX1 17,5p7M89	16001	53047	A	D	P	
HS 416B1 17,5p12M52	17001	53034	A	D	Y	
HS 418B1 17,5p6M74	18001	53071	A	D	L	FA+FG
HS 419BX2P 17,5p7M83	19001	53054	B	E	X	FG+FK
HS 416B2 17,5p11M58	20001	53129	A	E	W	
HS 418BX2 17,5p6M77	21001	53130	A	E	P	
HS 416B1 17,5p12M52	22001	53136	A	D	P	
HS 419BX2 17,5p9AB1	23001	53152	A	E	X	
		53260	A	E	X	

1		2	3	4	5	6	7
HS 418B1	17,5p10M78	24001	53160	A	D	H	FA+FG
HS 419BX1	17,5p7M79	25001	53166	A	D	H	FA+FG
HS 419BX1	17,5p2M102	26001	53184	A	D	W	
HS 419BX2	17,5p7,5A86	27001	53200	A	E	X	
			53373	A	E	X	
HS 419BX1	17,5p2M115	28001	53204	A	D	V	
HS 416E1	12,5p9M55	29001	53214	A	D	H	FA+FG
HS 419BX1	17,5p6,5M86	31001	53297	A	D	R	
HS 418B1	17,5p6M83	33001	53323	A	D	L	FA+FG
HS 419BX1	17,5p4M97	34001	53338	A	D	H	FA+FG
HS 419BX2	17,5p3M98	35001	53352	A	G	H	FA+FG
HS 418B2	17,5p6,5M68	36001	53409	A	E	P	
HS 416B1	17,5p13M63	37001	53402	A	D	H	FA
HS 418BX2	17,5p7M80	38001	53406	A	E	H	FA
HS 418B2	17,5p4M99	39001	53449	A	E	Q	FA+FM
HS 419BX2P	17,5p7M86	40001	53455	B	E	X	FG+FK
HS 419BX1	17,5p4M94	41001	53459	A	D	R	
			53482	A	D	R	
HS 418BX2	17,5p6M77	42001	53473	A	E	K	
HS 419BX1	17,5p6M83	43001	53484	A	D	R	
			53485	A	D	R	
HS 418BX2	17,5p6M77	44001	53504	A	E	P	
HS 418B1	17,5p7M68	45001	53506	A	D	T	
HS 419BX1	17,5p2M115	46001	53509	A	D	M	
HS 419BX2	17,5p6M86	47001	53513	A	G	H	FA+FG
HS 419BX2	17,5p6,5A83	48001	53525	A	E	R	
HS 418B1	17,5p9M74	49001	53548	A	D	L	FA+FG
HS 416BF1	17,5p13M53	50001	53569	A	D	Z	
HS 419B1	17,5p7A83	52001	53579	A	D	P	
HS 416E1	13p10,5M48	53001	53593	A	D	Y	
HS 419B1	17,5p9M90	54001	53605	A	D	H	FA+FG
HS 418B1	17,5p6M80	55001	53627	A	D	P	
HS 416B1	17,5p12,5M52	56001	53656	A	D	Y	

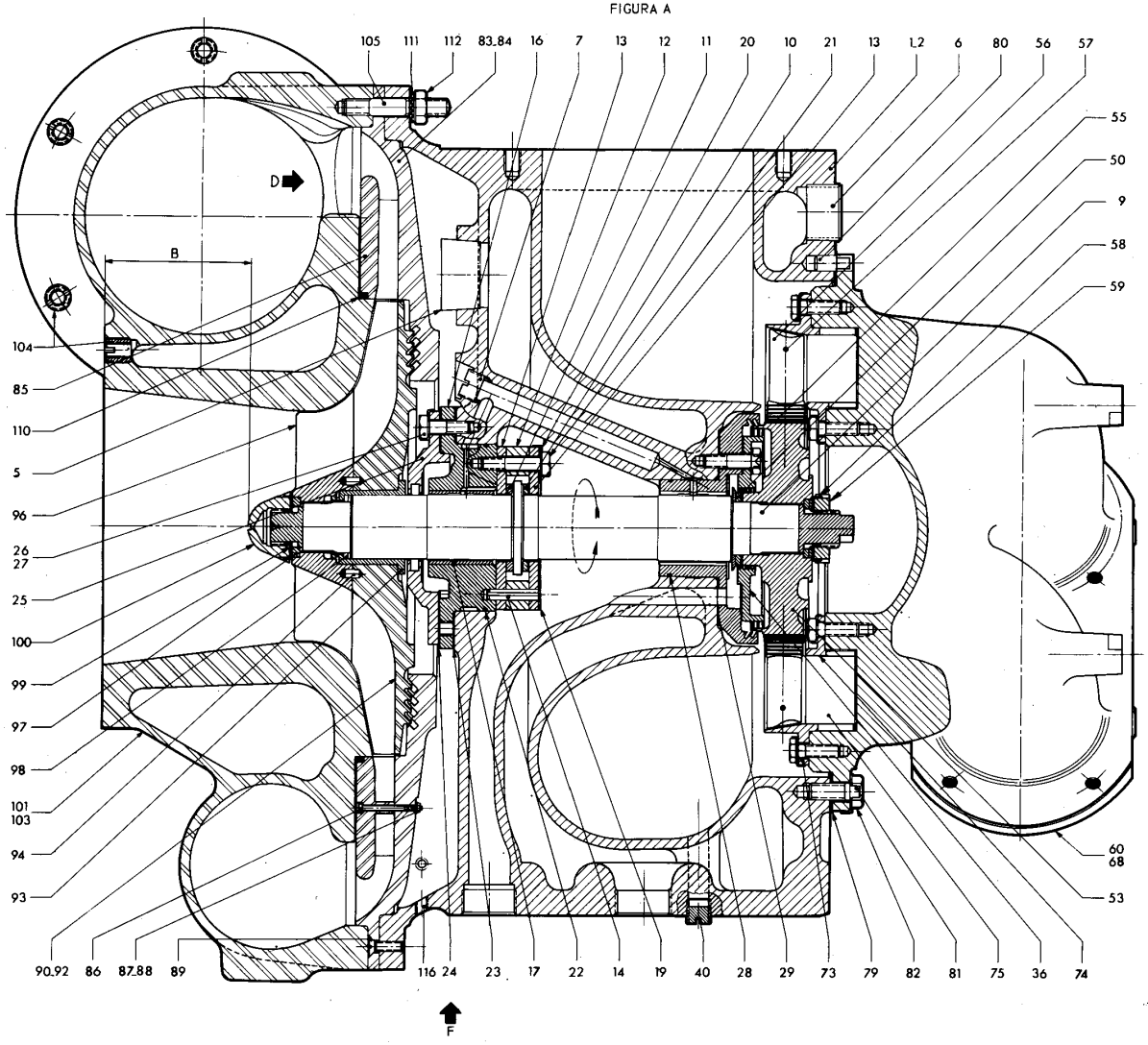
1	2	3	4	5	6	7
HS 416B1 17,5p13M52	57001	53658	A	D	Y	
HS 419B1 17,5p9M79	58001	53663	A	D	H	FA
HS 418B1 17,5p9M93	59001	53696	A	D	P	
HS 418B1 17,5p9M81	60001	53699	A	D	T	
HS 419BX2 17,5p6,5A86	61001	53711 53712	A A	E E	X X	
HS 416B1 17,5p11M61	62001	53722	A	D	T	
HS 418B1 17,5p8M81	63001	53730	A	D	L	FA+FG
HS 416B1 17,5p12,5M52	64001	53747	A	D	S	

9 - CROSS-REFERENCE TABLE OF GAS INTAKE CASING PART NUMBERS AND TYPES
(See figures 10-1 to 10-3)

Type	Part No	Type	Part No	Type	Part. No	Type	Part. No
H	6740 6782 53182	N	53333	T	53199 6991	Y	53138
J	53379	P	53134 53452 53045	U	6941	Z	53566
K	6743 53475	Q	53532	V	75264		
L	53066	R	53290	W	6925 53154		
M	53573	S	6891	X	53435		

COUPE DE L'ENSEMBLE
CROSS SECTION OF ASSEMBLY
LÄNGSSCHNITT
SECCION TRANSVERSAL

FIGURE A
BILD A
FIGURA A



VUE SUIVANT F
VIEW IN DIRECTION OF F
ANSICHT NACH F
VISTA EN DIRECCION DE F

FIGURE E
BILD E
FIGURA E

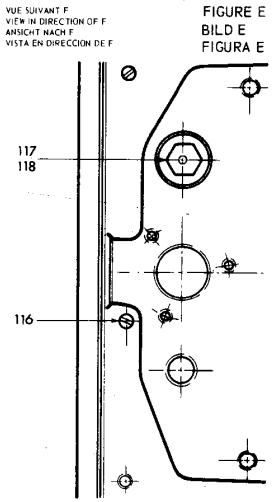


FIGURE D
BILD D
FIGURA D

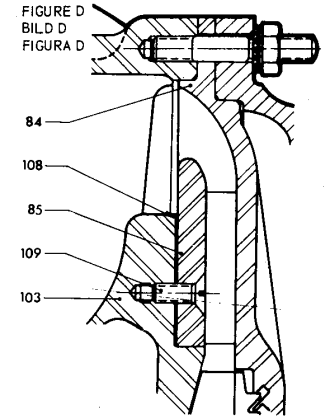
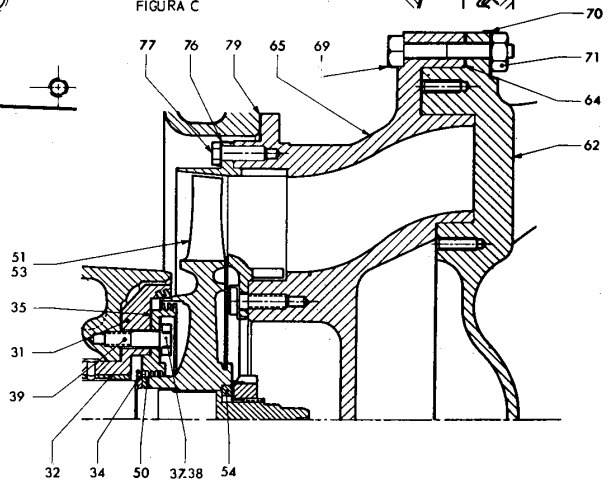


FIGURE C
BILD C
FIGURA C



FONCTIONNEMENT
OPERATION
ARBEITSWEISE
FUNCIONAMIENTO

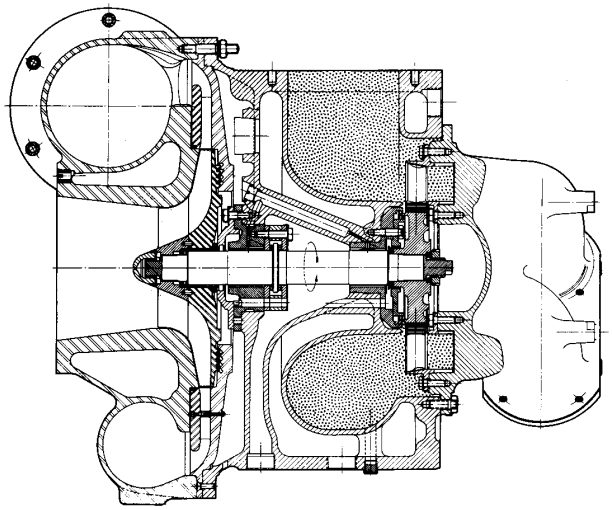


FIGURE A GAZ ECHAPPEMENT
FIGURE A EXHAUST GAS
BILD A AUSPUFFGAS
FIGURA A GAS DE ESCAPE

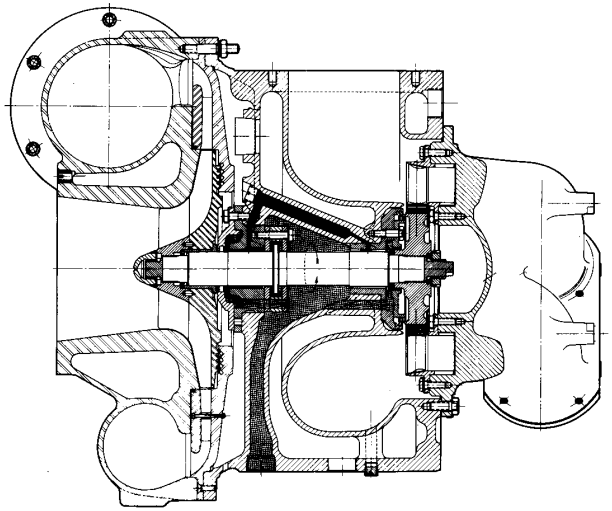
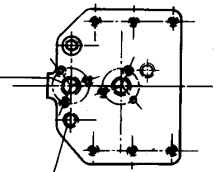


FIGURE B HUILE
FIGURE B OIL
BILD B ÖL
FIGURA B ACEITE

SORTIE D'HUILE
OIL OUTLET
ÖLAUSLASS
SALIDA DE ACEITE

SOUS-PRESSION
UNDER PRESSURE
UNTER DRUCK
BAJO PRESSION

RETOUR D'HUILE
OIL RETURN
ÖLRUCKLAUF
RETORNO DE ACEITE



ENTREE D'HUILE
OIL INLET
ÖLEINLASS
ENTRADA DE ACEITE

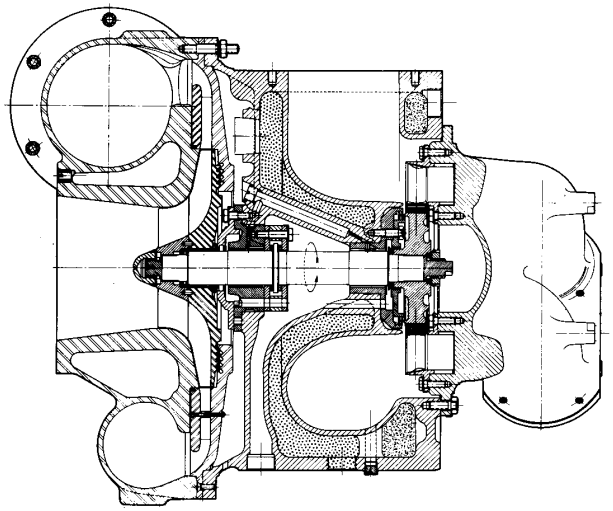


FIGURE C REFROIDISSEMENT
FIGURE C COOLING
BILD C KÜHLUNG
FIGURA C ENFRIAMIENTO

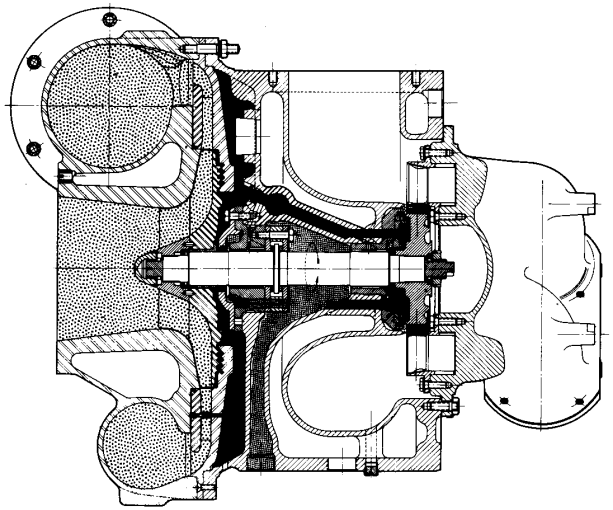


FIGURE D AIR
FIGURE D AIR
BILD D LUFT
FIGURA D AIRE

AIR COMPRESSEUR
SUPERCHARGER INTAKE AIR
VERDICHTERLUFT
AIRE DEL COMPRESOR

AIR PRESSURISATION
SEALING AIR
AUFLADUNGSLUFT
AIRE DE PRESURIZACION

TURBOCOMPRESSEURS HS. 400

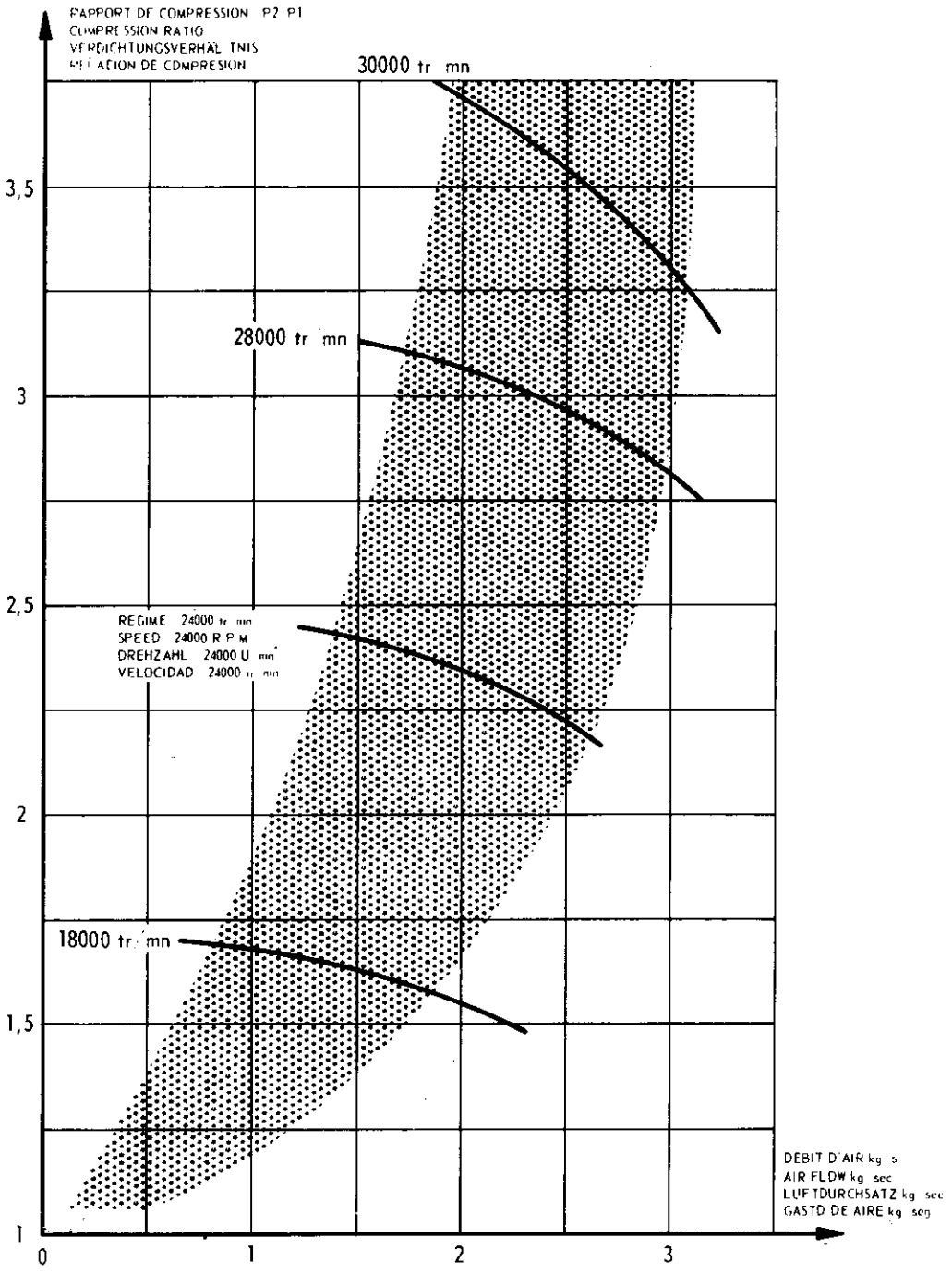
Pl. 3

PERFORMANCES

PERFORMANCE CHARACTERISTICS

LEISTUNGEN

RENDIMIENTO

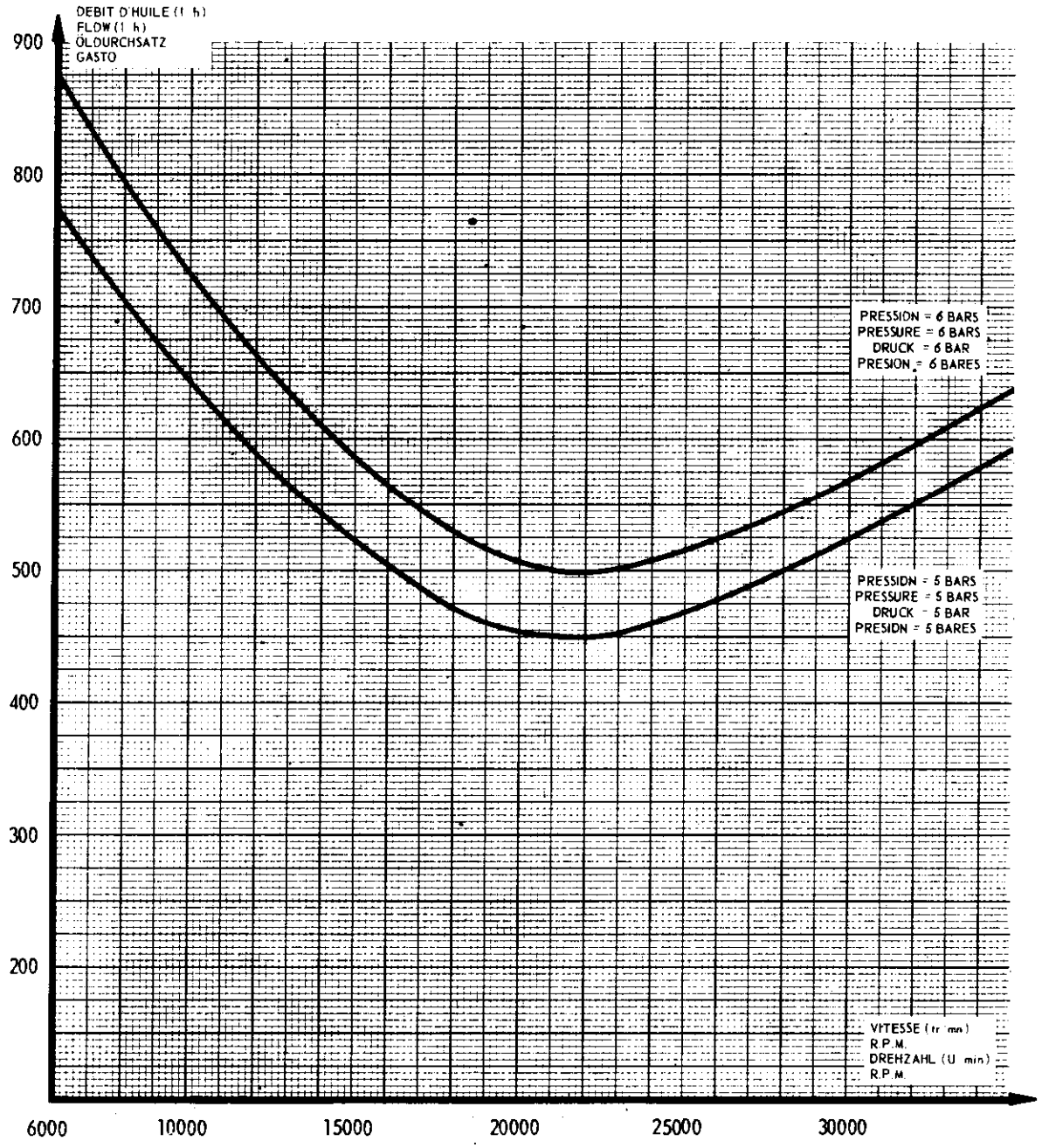


DÉBIT D'HUILE EN FONCTION DU RÉGIME
(Pression d'alimentation : 5 à 6 bars)

OIL FLOW VERSUS RPM
(Oil inlet pressure : 5 to 6 bars)

ABHÄNGIGKEIT DER ÖLDURCHFLUSSMENGE VON DER DREHZAHL (Speisedruck : 5 bis 6 bar)

GASTO DE ACEITE EN FUNCION DEL NUMERO DE R.P.M. (presion de alimentacion : de 5 a 6 bares)



TURBOCOMPRESSEURS HS. 400

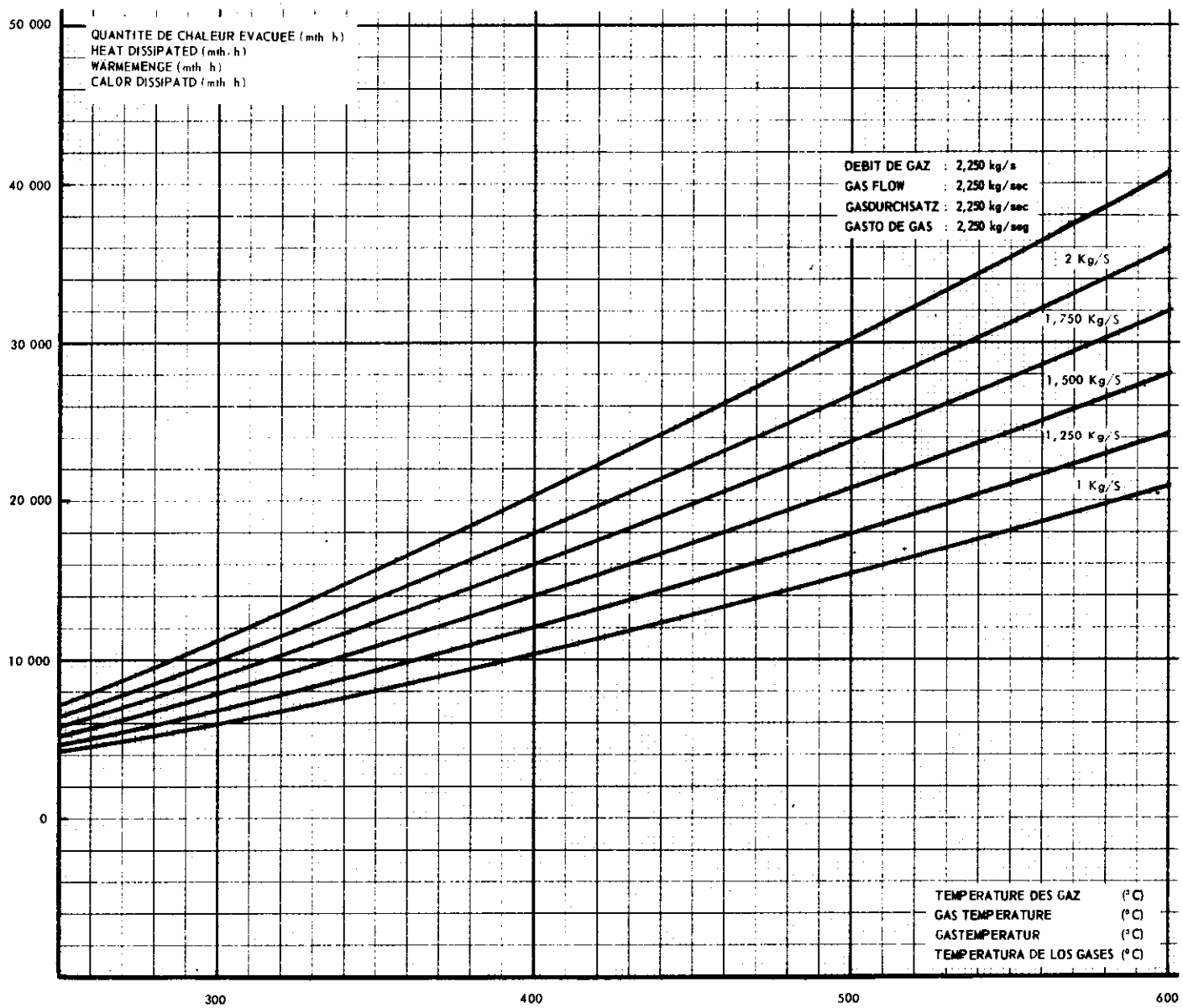
Pl. 5

QUANTITÉ DE CHALEUR ÉVACUÉE PAR L'EAU EN FONCTION DE LA TEMPERATURE ET DU DEBIT DES GAZ

HEAT DISSIPATED BY WATER VERSUS GAS FLOW AND TEMPERATURE

ABHÄNGIGKEIT DER EVAKUIERTEN KALORIEN VON DER GASTEMPERATUR

CALOR DISIPADO POR EL AGUA EN FUNCION DEL GASTO Y DE LA TEMPERATURA DE LOS GASES



TURBOCOMPRESSEURS HS. 400

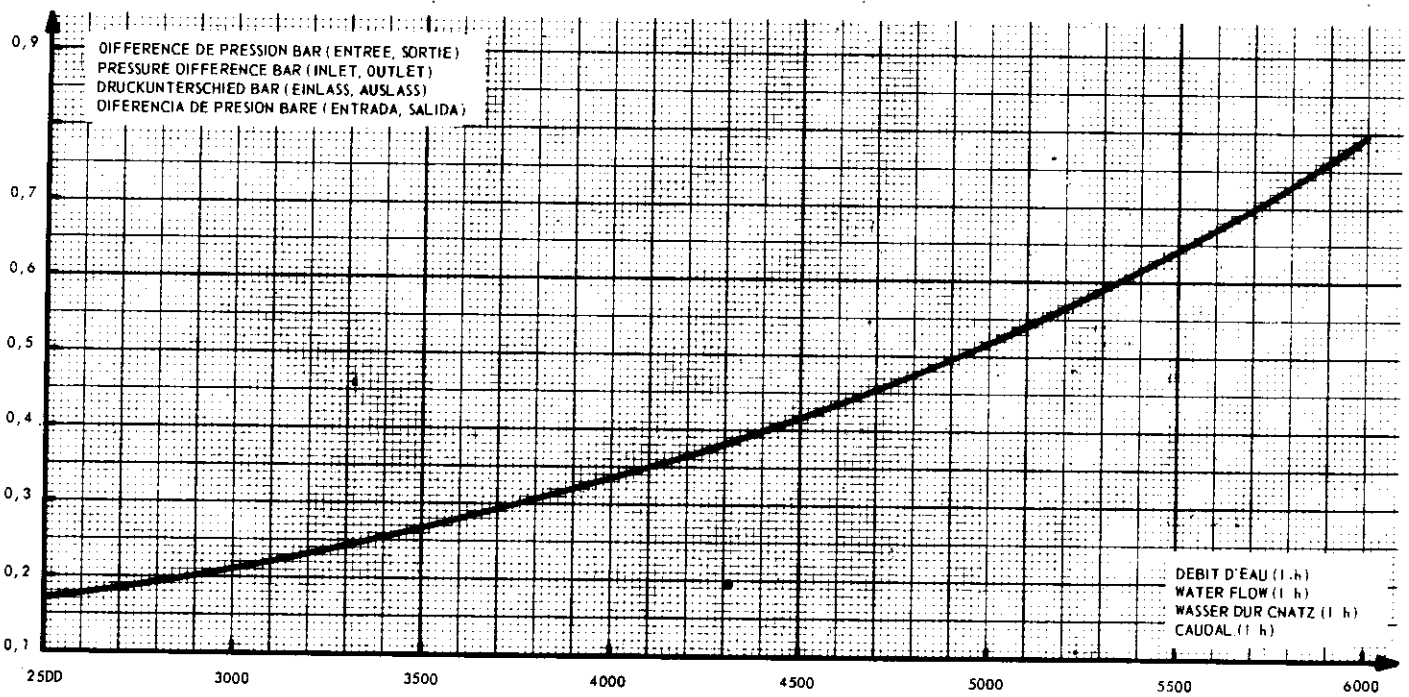
FIG .6

PERTE DE CHARGE EN FONCTION DU DÉBIT D'EAU

PRESSURE DROP VERSUS WATER FLOW

ABHÄNGIGKEIT DES DRUCKABFALLS VON DER WASSERDURCHFLUSSMENGE

CAIDA DE PRESION EN FUNCION DEL GASTO DE AGUA



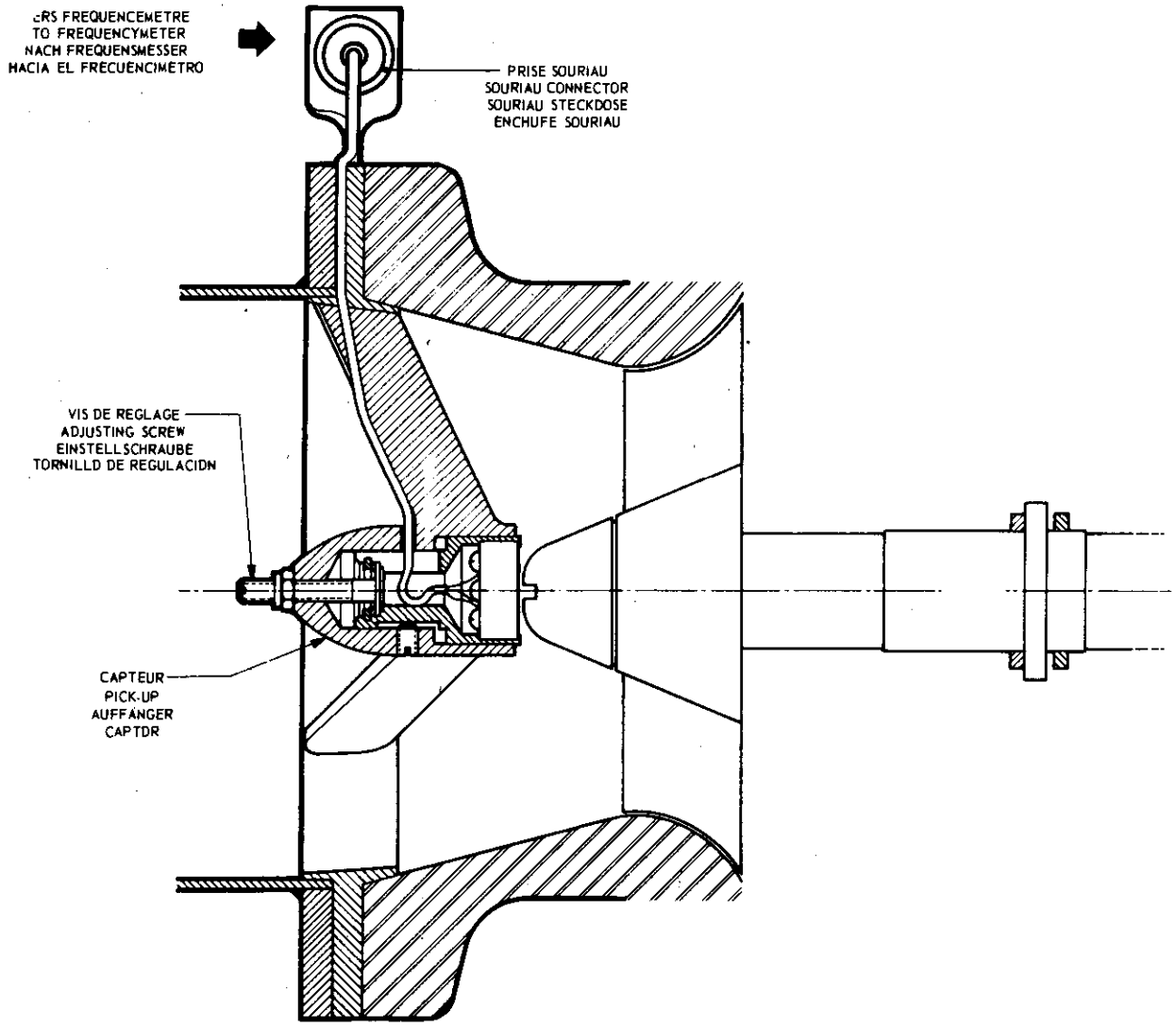
Pl. 7

SCHEMA DE MISE EN PLACE DU CAPTEUR DE VITESSE

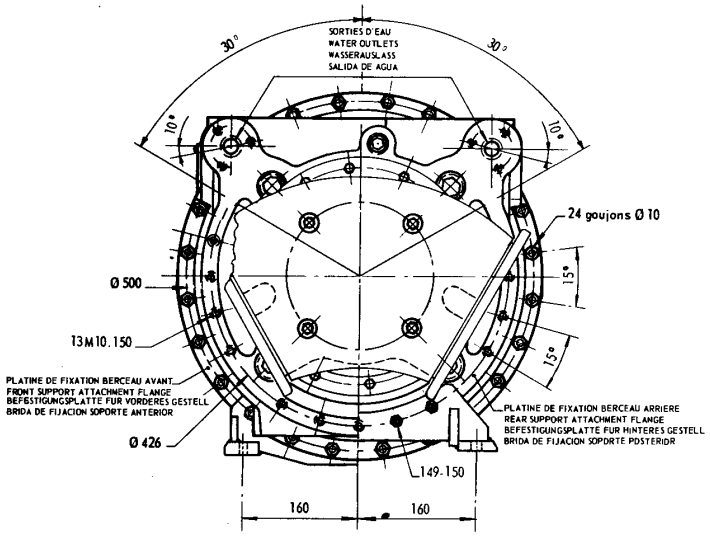
PICK-UP INSTALLATION DIAGRAM

MONTAGESCHEMA DES GESCHWINDIGKEITSAUF-FÄNGERS

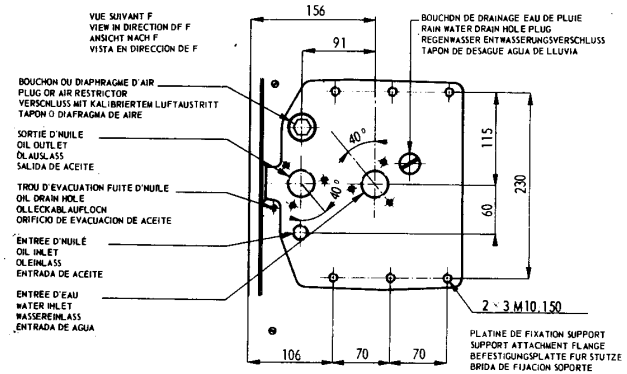
ESQUENA DE INSTALACION DEL CAPTOR DE VELOCIDAD

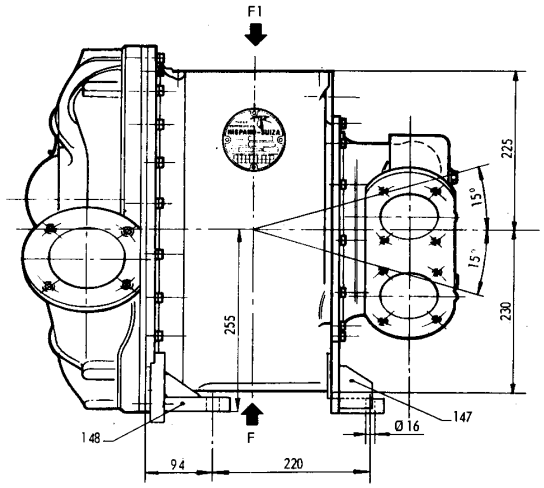


INSTALLATION COMMUNE
STANDARD INSTALLATION
GRUND-UND ZUSÄTZLICHE EINRICHTUNGEN
INSTALACION STANDARD

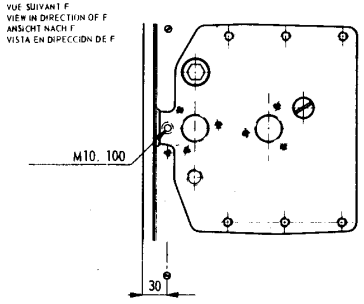


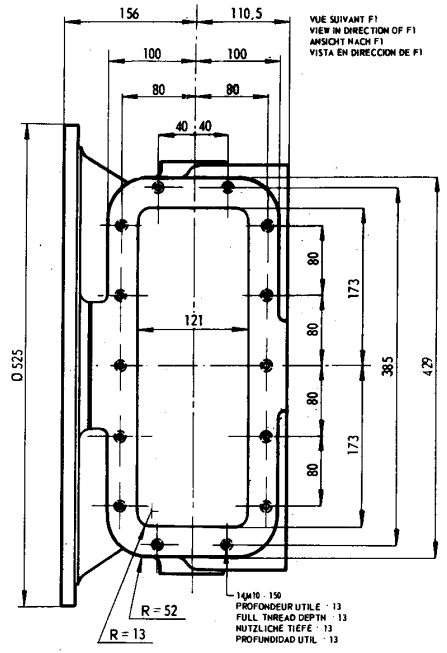
PERCAGE DU CARTER D'ECHAPPEMENT DE LA PIVDTERIE TYPE A
TAPPED HOLES IN TYPE A TURBINE CASING ASSEMBLY
BOHRUNG IM TURBINENGEHÄUSE TYP A
TALADRO DEL CARTER DE ESCAPE DEL CONJUNTO TURBINA TIPO A



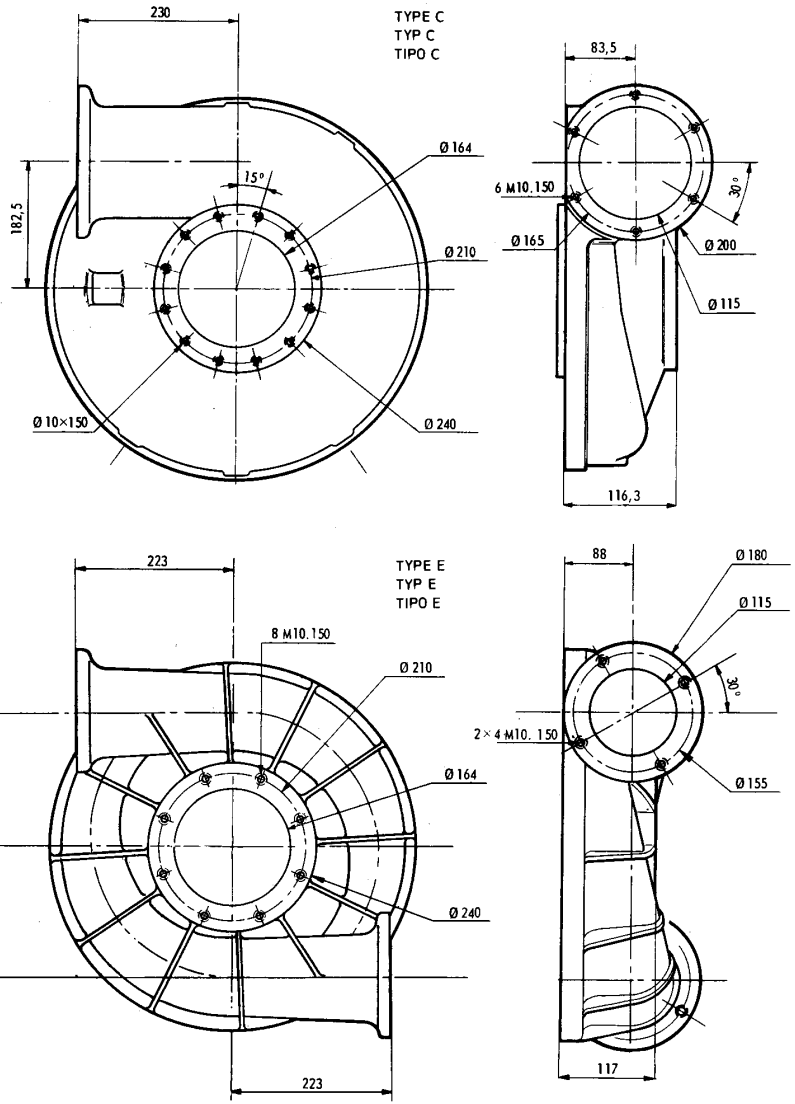


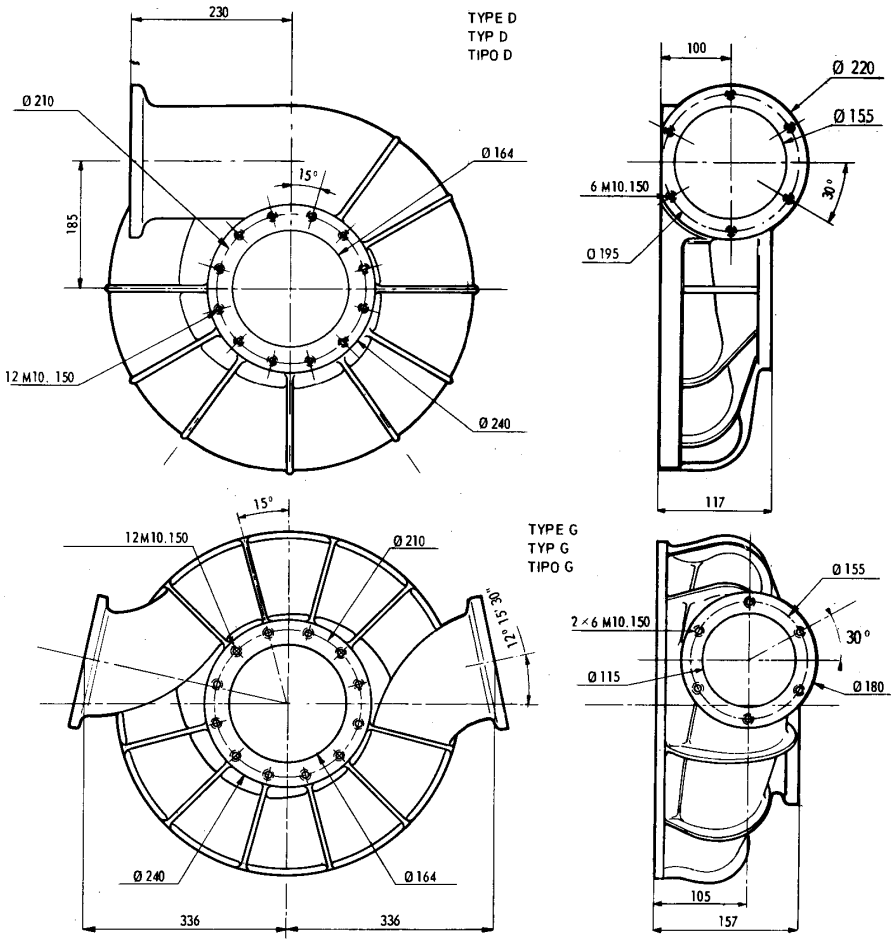
PERCAGE DU CARTER D'ECHAPPEMENT DE LA PIVDTERIE TYPE B
TAPPED HOLES IN TYPE B TURBINE CASING ASSEMBLY
BOHRUNG IM TURBINENGEHÄUSE TYP B
TALADRO DEL CARTER DE ESCAPE DEL CONJUNTD TURBINA TIPD B





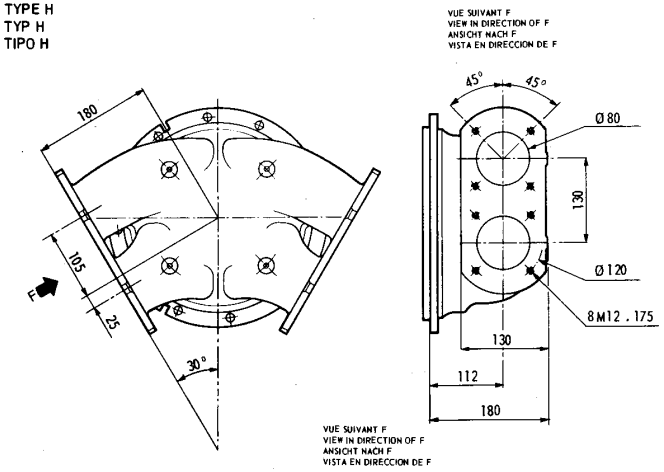
CARTER COMPRESSEUR - IMPELLER CASING
VERDICHTERGEHÄUSE - CARTER COMPRESOR



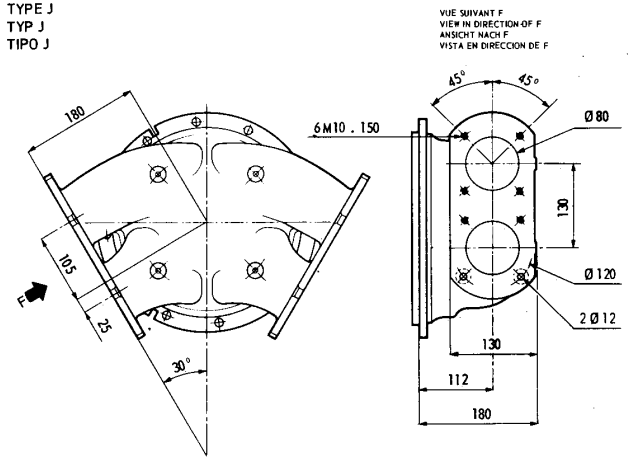


CULOTTE D'ADMISSION
INTAKE CASING
EINTRITTSHOSE
TUBO DE ENTRADA

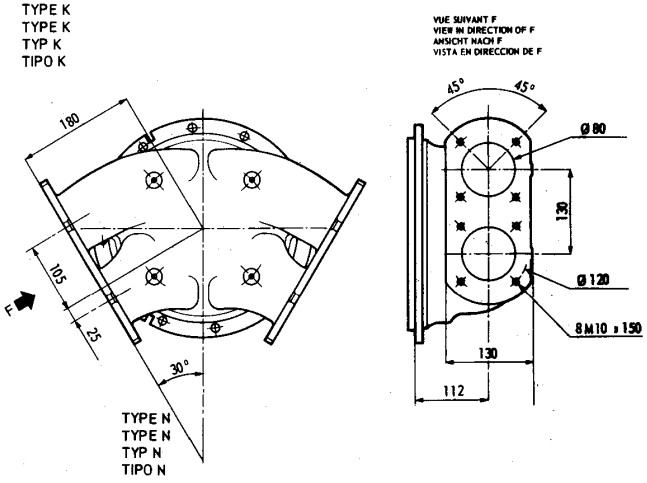
TYPE H
TYPE H
TYP H
TIPO H



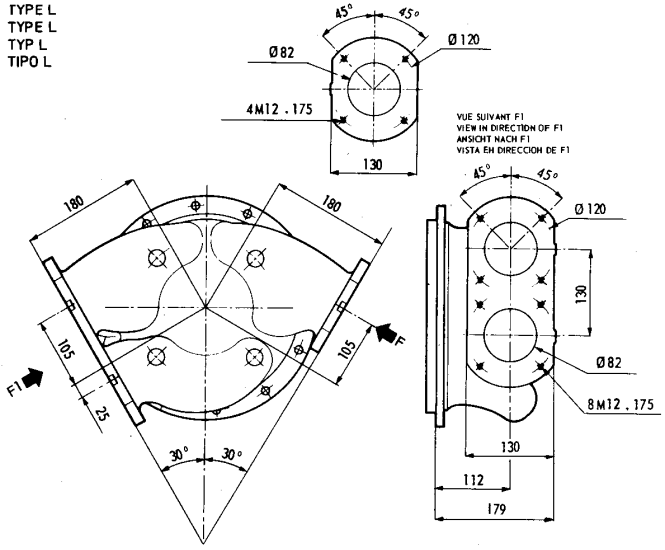
TYPE J
TYPE J
TYP J
TIPO J



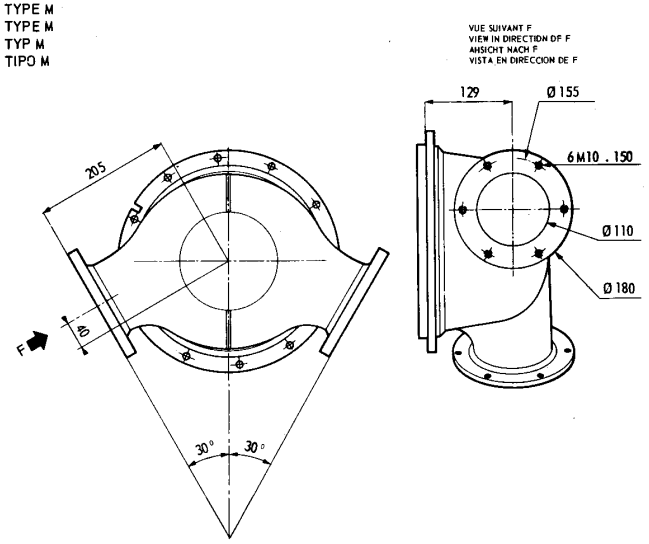
TYPE K
TYPE K
TYP K
TIPO K



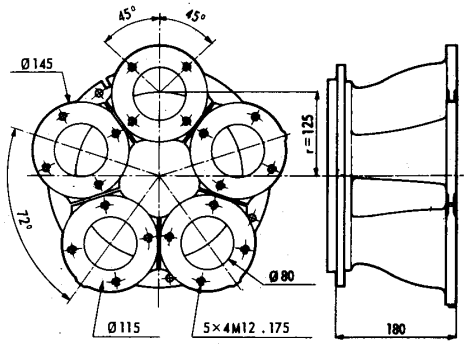
TYPE L
TYPE L
TYP L
TIPO L



TYPE M
TYPE M
TYP M
TIPO M

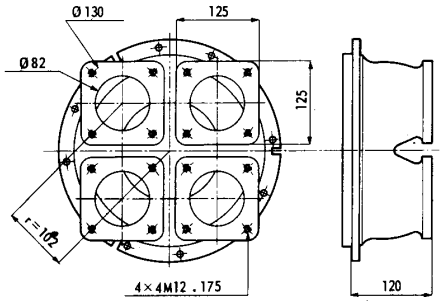


TYPE N
TYPE N
TYP N
TIPO N

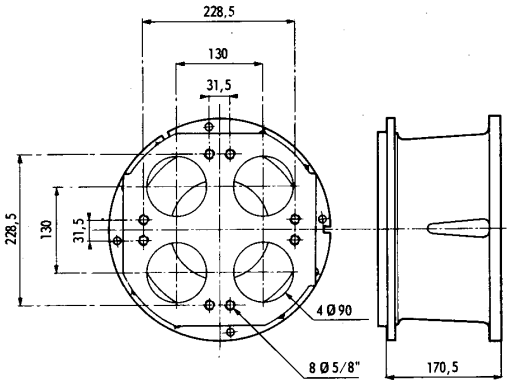


CULOTTE D'ADMISSION
INTAKE CASING
EINTRITTSHOSE
TUBO DE ENTRADA

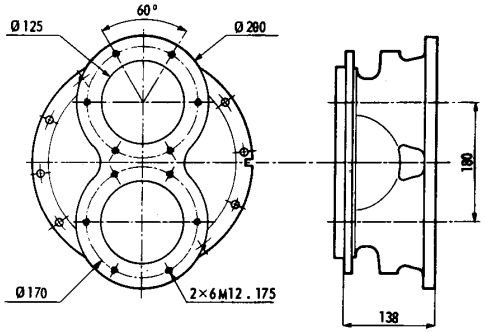
TYPE P
TYPE P
TYP P
TIPO P



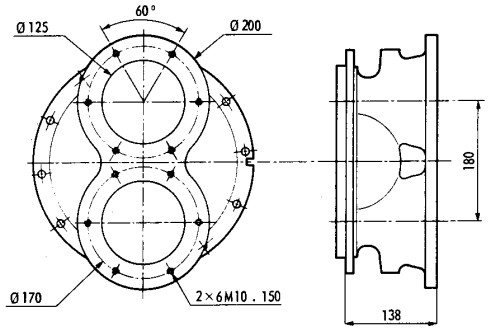
TYPE Q
TYPE Q
TYP Q
TIPO Q



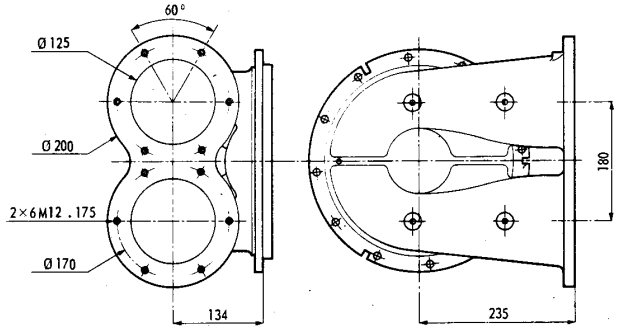
TYPE R
TYPE R
TYP R
TIPO R



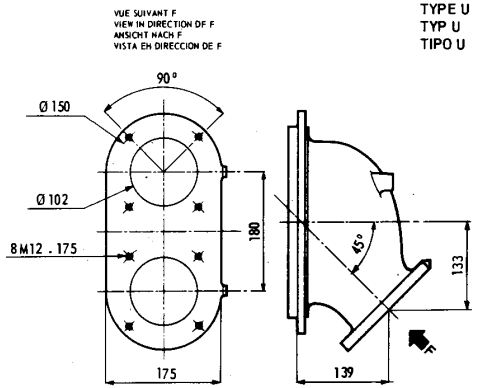
TYPE S
TYPE S
TYP S
TIPO S



TYPE T
TYPE T
TYP T
TIPO T

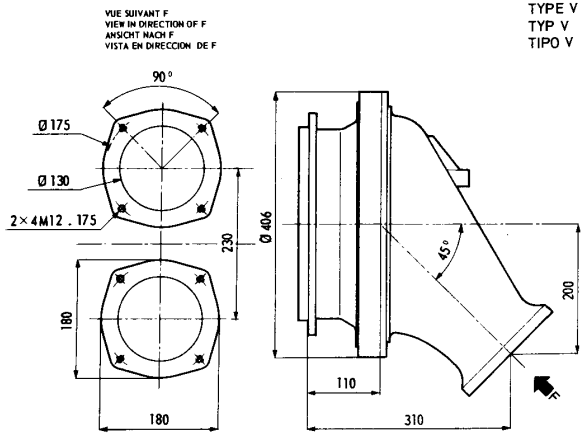


TYPE U
TYPE U
TYP U
TIPO U

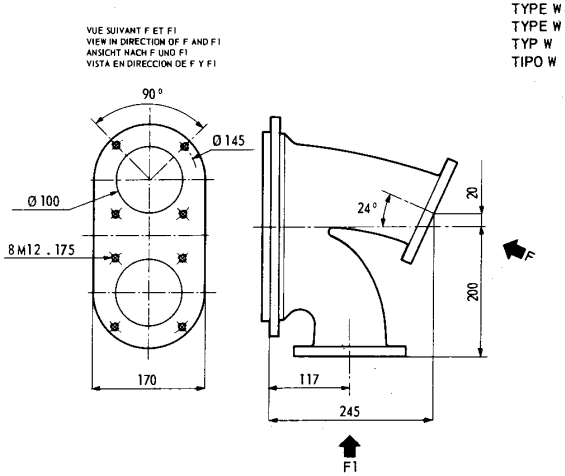


CULOTTE D'ADMISSION
INTAKE CASING
EINTRITTSHOSE
TUBO DE ENTRADA

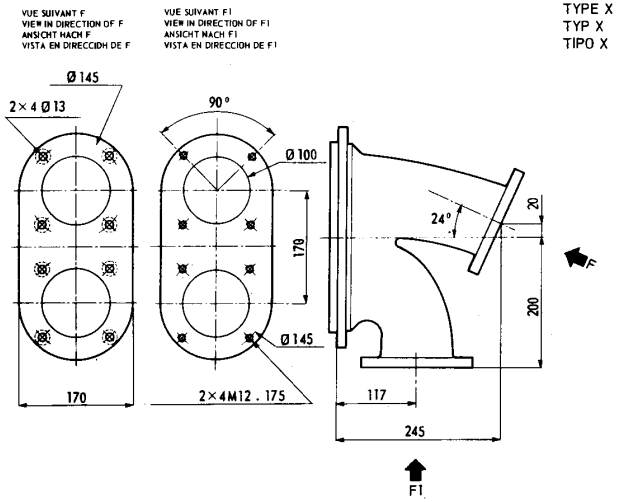
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TYPE V
TYP V
TIPO V



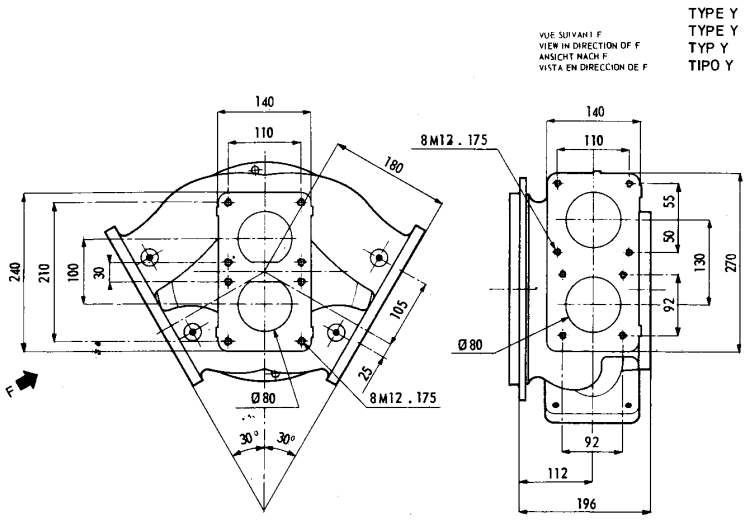
TYPE W
TYPE W
TYP W
TIPO W



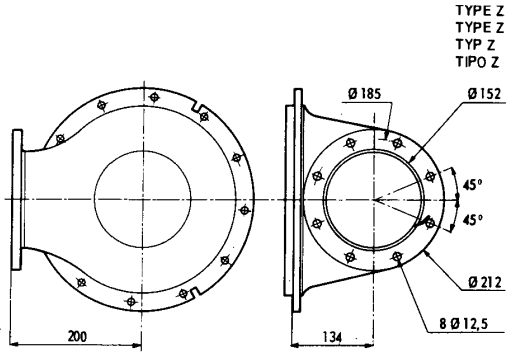
TYPE X
TYPE X
TYP X
TIPO X



TYPE Y
TYPE Y
TYP Y
TIPO Y

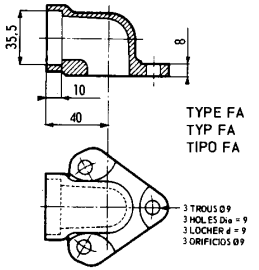


TYPE Z
TYPE Z
TYP Z
TIPO Z

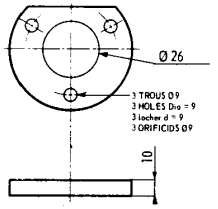


PIECES D'ADAPTATION
ADAPTATION PARTS
ANPASSUNGSTEILE
PIEZAS DE ADAPTACION

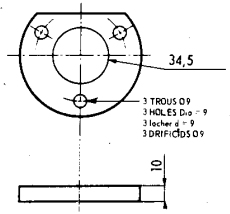
BRIDE SORTIE D'HUILE, ENTREE ET SORTIE D'EAU
OIL OUTLET FLANGE, WATER INLET AND OUTLET FLANGE
FLANSCH FUR OLAUSLASS, WASSEREINLASS UND WASSERAUSLASS
BRIDA DE SALIDA DE ACEITE, ENTRADA Y SALIDA DE AGUA



TYPE FA
TYP FA
TIPO FA

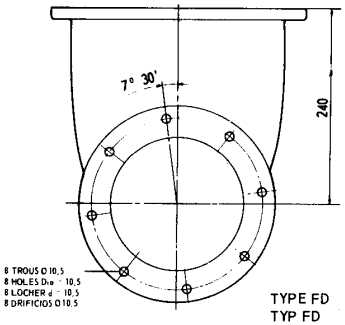


TYPE FB
TYP FB
TIPO FB

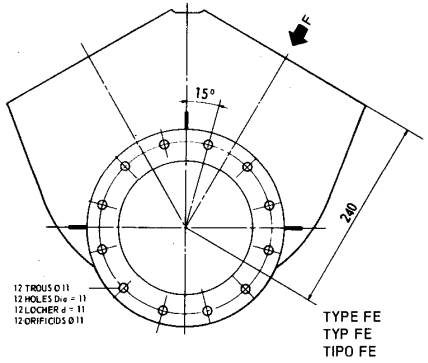


TYPE FC
TYP FC
TIPO FC

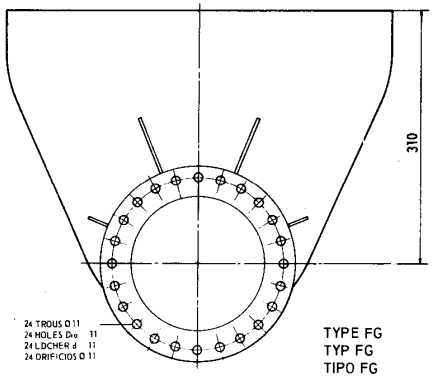
PIPE D'ENTREE D'AIR DU COMPRESSEUR
SUPERCHARGER AIR INTAKE DUCT
VERDICHTER - LUFTEINLASSKRUMMER
TUBERIA DE ENTRADA DE AIRE DEL COMPRESOR



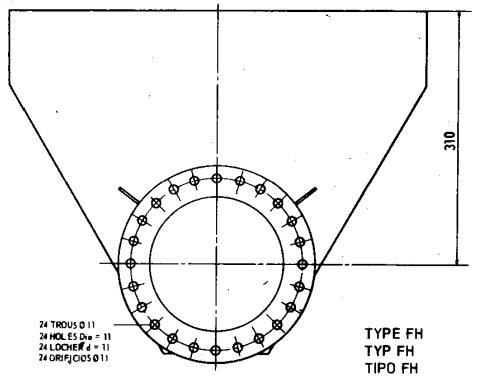
TYPE FD
TYP FD
TIPO FD



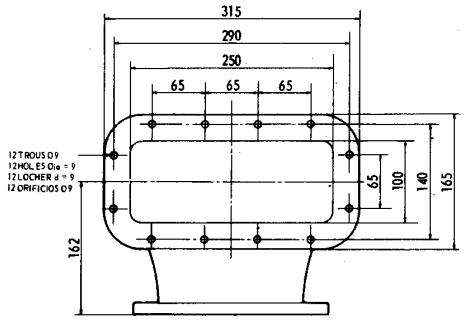
TYPE FE
TYP FE
TIPO FE

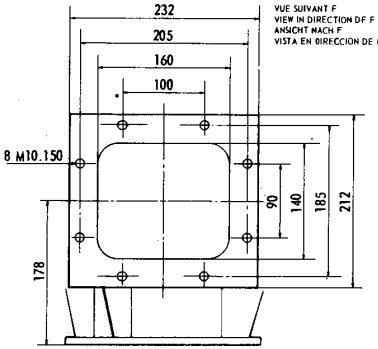


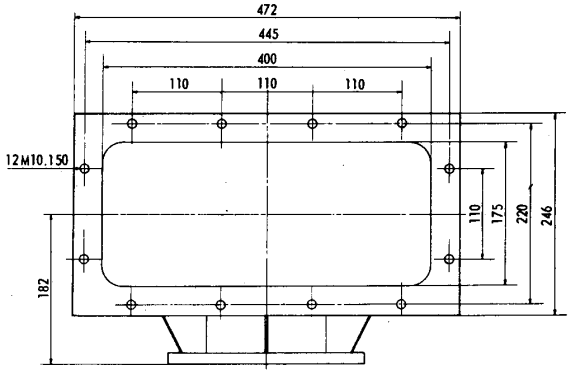
TYPE FG
TYP FG
TIPO FG

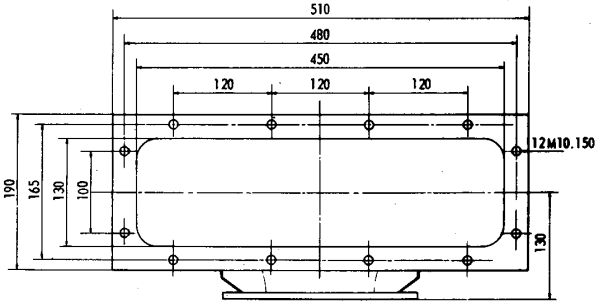


TYPE FH
TYP FH
TIPO FH









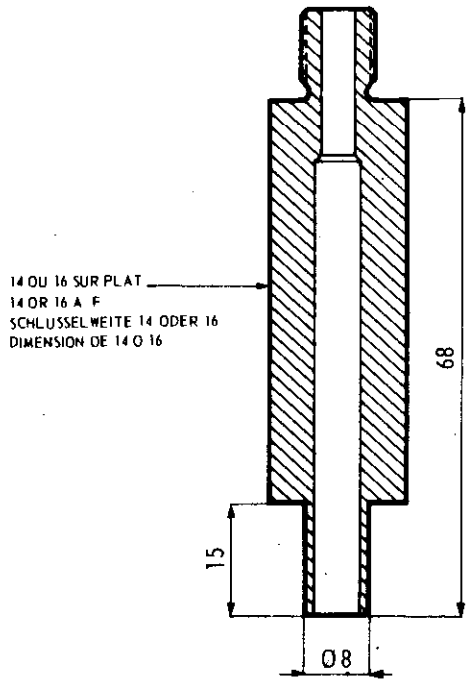
PIECES D'ADAPTATION

ADAPTATION PARTS

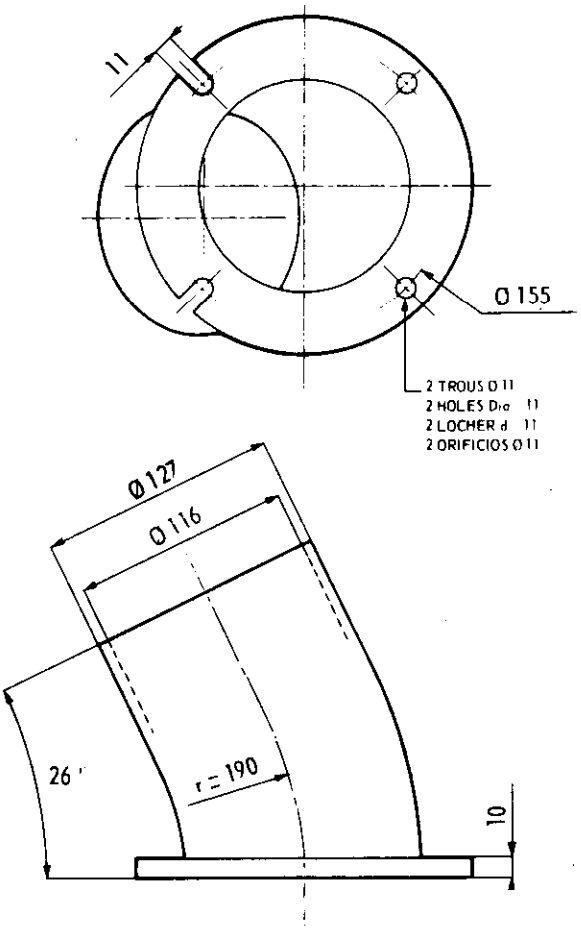
ANPASSUNGSTEILE

PIEZAS DE ADAPTACION

SUPPORT DE TUYAUTERIE TYPE FK
PIPE SUPPORT TYPE FK
ROHRSTUTZE TYP FK
SOPORTE TUBERIA TIPO FK



TUBULURE INTERMEDIAIRE TYPE FM
INTERMEDIATE PIPE TYPE FM
ZWISCHENKRUMMER TYP FM
TUBERIA INTERMEDIARA



Pl. 12

MONTAGE CONDUITS ASPIRATION ET REFOULEMENT

ASSEMBLY OF INTAKE AND OUTLET DUCTS

MONTAGE DER ANSAUG- UND FÖRDERKANÄLE

MONTAJE DE LAS TUBERIAS DE ENTRADA Y DESCARGA

