Introduction

- **CHARGE AIR SYSTEM**

The diesel engine produces mechanical energy by converting heat energy derived from burning of fuel inside the cylinders. For efficient burning of fuel availability of sufficient air in proper ratio is a pre-requisite.

Types of engine

- naturally aspirated engines
- supercharged or pressure charged engines

- In a naturally aspirated engine, during the suction stroke, air is being sucked into the cylinder from atmosphere due to displacement of the pistons. The volume of air thus drawn into the cylinder through restricted inlet valve passage within a limited time, would also be limited and at a pressure slightly less than the outside atmosphere. The availability of less quantity of air of low density inside the cylinder, would limit the scope of burning only a matching quantity of fuel. Hence mechanical power produced in the cylinder also is limited.

An improvement on the naturally aspirated engines are the supercharged or pressure charged engines. During the suction stroke pressurised air of higher density is being charged into the cylinder through the open suction valve. Air of higher density containing more oxygen will make it possible to inject more fuel into the same size of cylinder and produce more power by effectively burning it.

Supercharging

- The method of increasing density of inlet air for increasing power output of the engine is called **supercharging**.
- Within the same swept volume greater mass of charge can be introduced by the method of **supercharging.**
- Degree of supercharging is limited by thermal & mechanical load on the engine and strongly depend on the type of supercharger used & design of the engine.

Objects of supercharging

- To reduce of weight of engine per horse power
- To reduce space occupied by the engine
- To reduce the consumption of Fuel oil
- To increase power output of engine

Supercharger

- The apparatus / device used to increase inlet air density by supplying air at greater pressure than atmospheric air pressure by natural aspiration to the engine is called **Supercharger or Turbo Supercharger**.

Advantages of a supercharged engine

- 1.A supercharged engine of given bore and stroke dimensions can produce 50% or more power than a naturally aspirated engine. The power to weight ratio in such case is much more favourable.

- 2.Charging of air during the suction stroke causes better scavenging in the cylinders. This ensures carbon free cylinders and valves and better health for the engine also.

- 3. Higher heat developed in a supercharged engine due to burning of more fuel calls for better cooling of the components. The cool air charged into the cylinder have better cooling of cylinder internally, piston, cylinder head and valves and save them from failure due to thermal stresses.

- 4. Better ignition due to higher temperature developed by higher compression in the cylinder.

- 5. Better fuel efficiency due to complete combustion of fuel by ensuring availability of matching quantity of air or oxygen.

Methods of supercharging

- **Three possible methods which might be utilized to increase the air consumption of an engine are-**

1. **Increasing piston displacement-**but this method increases size & weight of engine & introduced additional cooling problem

Methods of supercharging

2. **Running the engine at higher speed**-but result is increasing fluid, mechanical friction losses & imposes greater inertia
3. **Increasing density of charge-**such that greater mass of charge is introduced into the same volume

- **3rd method is widely used and termed as supercharging.**

- The most efficient and economical method of supercharging is by a centrifugal blower run through the exhaust gas driven turbine.

The exhaust gas turbo supercharging system makes use of the energy left over in the exhaust gas to drive the gas turbine in the turbo-supercharger. The turbine in turn drives the centrifugal blower for sucking air from the atmosphere and charging the same to the cylinders under pressure. Thus a part of the heat energy in the exhaust gas which would have otherwise been lost is utilized to our advantage and loss of power for mechanically driving the blower is also saved.

Moreover this system can maintain a more favorable air and fuel ratio at all speed and load condition of the engine than any other system. The charge air pressure commonly referred to, as “BOOSTER PRESSURE” is variable according to the speed and load of the engine and in ALCO 251B engines the max. being 1.6 kg/cm. sq.

WORKING PRINCIPLES OF TURBO-SUPERCHARGING SYSTEM

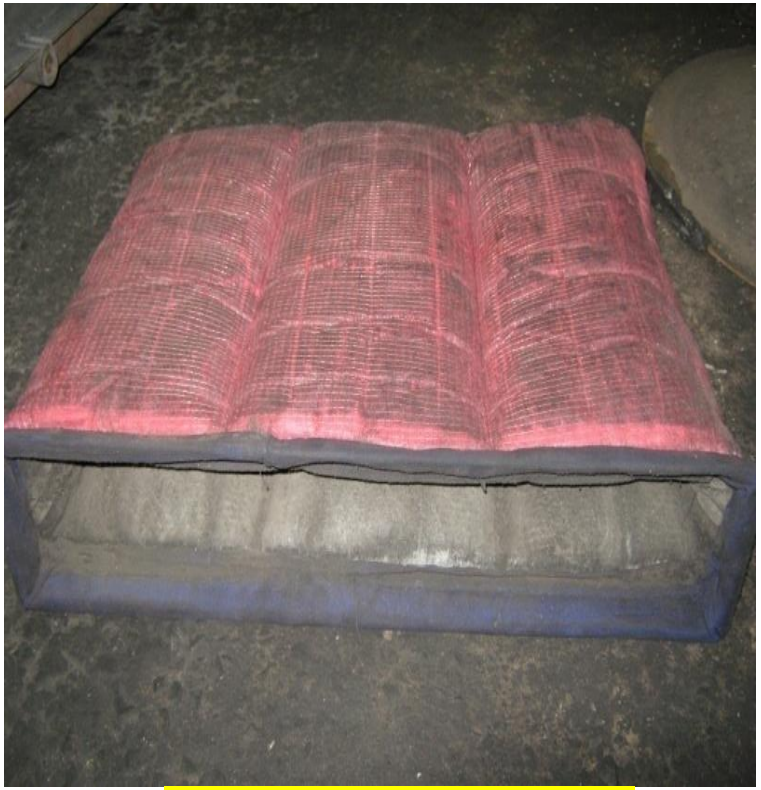
- The exhaust gas discharged from all the cylinders accumulate in the common exhaust manifold at the end of which the turbosupercharger is fitted. The gas under pressure there after enters the turbosupercharger through the connector and the torpedo shaped bell mouth and then passes through the fixed nozzle ring.

The exhaust gas passing through the fixed nozzle ring is directed on to the turbine blades at increased pressure and at the most suitable angle to achieve rotary motion of the turbine at maximum efficiency. After rotating the turbine the exhaust gas goes out to the atmosphere through the exhaust chimney.

The turbine has a centrifugal blower mounted at the other end of the same turbine shaft and rotation of turbine drives the blower at equal speed. The blower connected to the atmosphere through a set of oil bath filters or glass fiber filters suck air from the atmosphere and deliver it at higher velocity. The air then passes through the diffuser inside the turbo, where the velocity is defused to increase the pressure of air before it is delivered from the turbo.

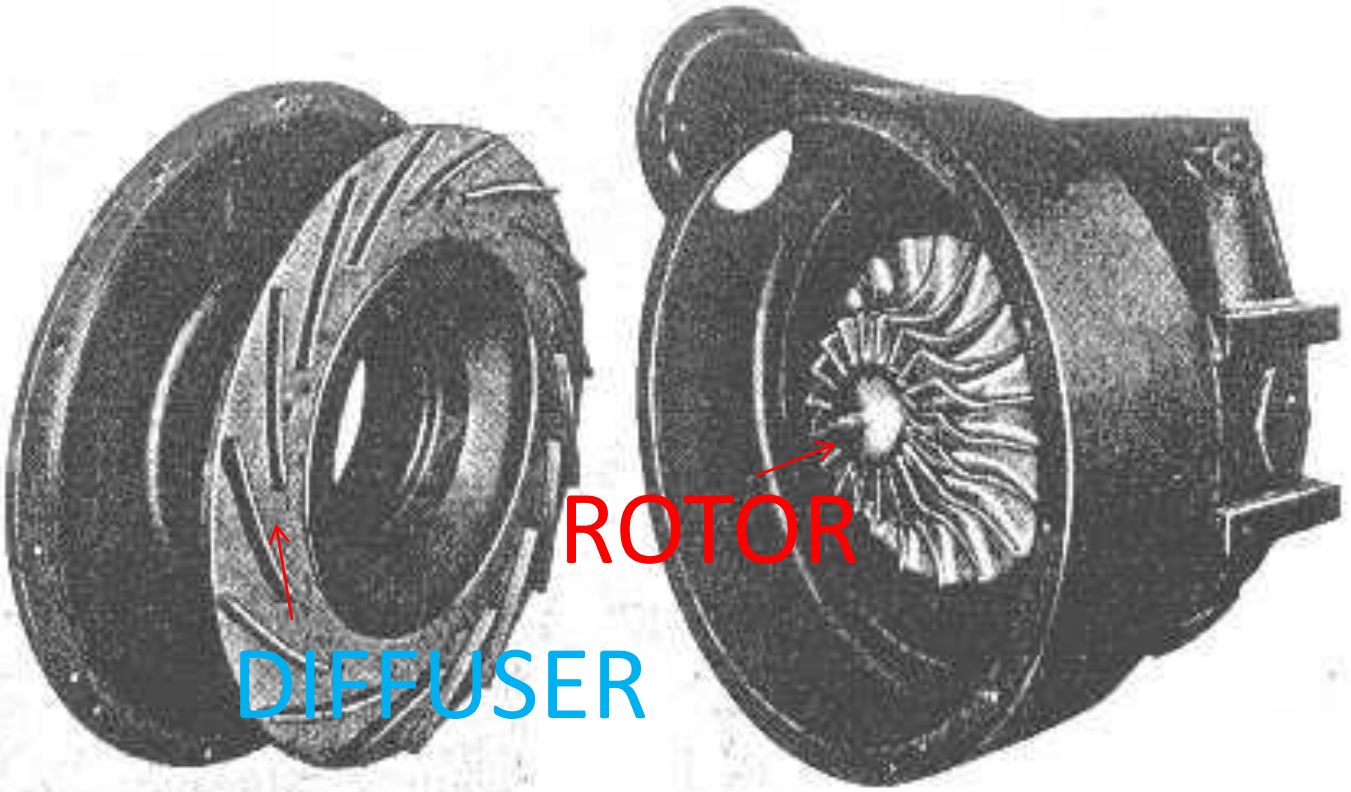
Air filtration System Parts

Air maize oil bath filter



Bag Type filter

BAGGY FILTER(Glass Fibre Filter)


ROTOR
DIFFUSER

- Pressurizing air of-course increases its density which is the ultimate aim to achieve, but at this stage due to compression heat develops in it to cause expansion and reduce the density already achieved. This effects our effort of supplying higher density air to the engine. To take care of the situation, at this stage air is passed through a heat exchanger known as After Cooler.

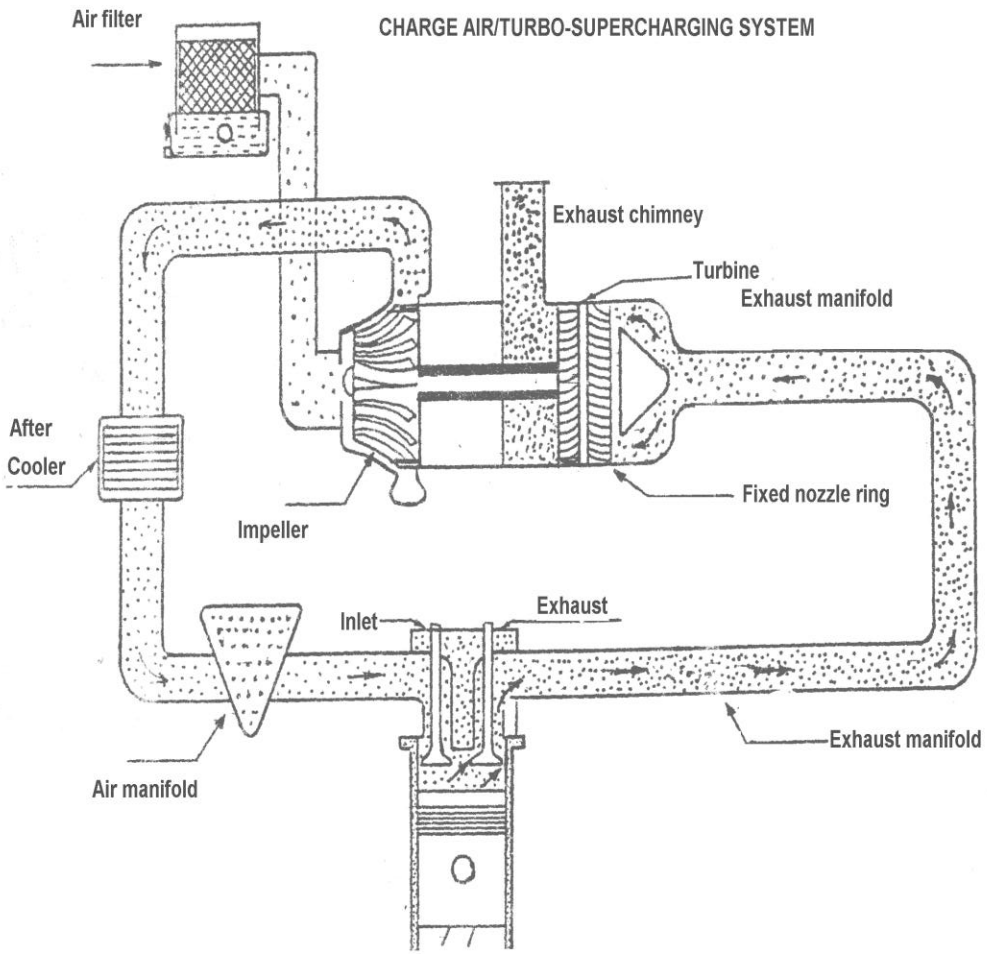
. The after cooler is a radiator where cooling water of lower temperature is circulated through the tubes and around the tubes air passes. Circulation of water through the after cooler is a part of the water cooling system for the engine. The heat in the air is thus transferred to the cooling water and air being cooled regains its lost density.


TSC
TSC outlet to
After cooler
After cooler housing
Water pump outlet
for left bank
Water pump outlet
for left bank
Primary Filter
Lube Oil
Pump
Water Pump

From the after cooler air goes to a common inlet manifold connected to each cylinder head. In the suction stroke as soon as the inlet valve opens the booster air of higher pressure and density rushes into the cylinder completing the process of supercharging.

- The engine initially starts as a naturally aspirated engine and acceleration of engine speed by increased quantity of fuel injection increases the exhaust gas pressure on the turbine. Thus the self adjusting system maintains proper air and fuel ratio under all speed and load conditions of the engine on its own.

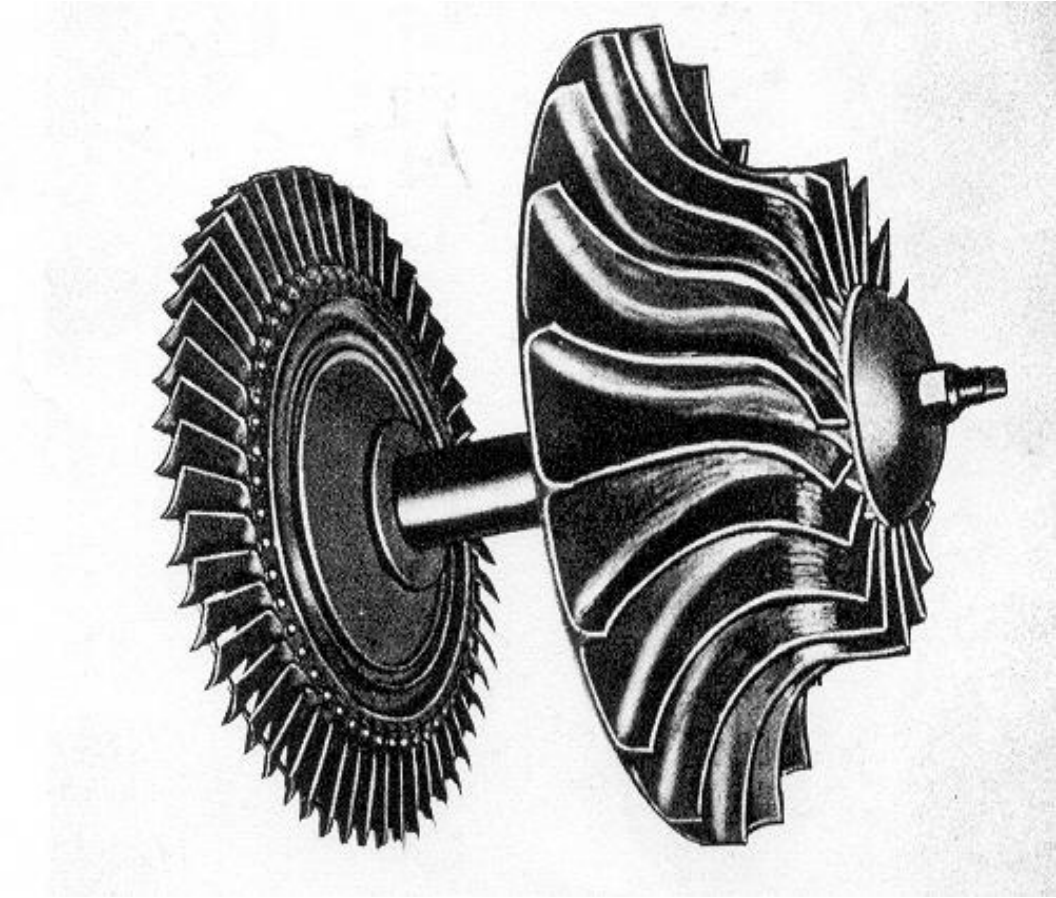
The maximum rotational speed of the turbine is 18,000 rpm for the 720A model Turbo supercharger of ALCO 251B engine. Low booster pressure causes black smoke due to incomplete combustion of fuel with consequential losses of power output and fuel efficiency. High exhaust gas temperature due to after burning of fuel may result in considerable damage to the turbo supercharger and other components in the engine.


Air filter
CHARGE AIR/TURBO-SUPERCHARGING SYSTEM
Exhaust chimney
Turbine
Exhaust manifold
After
Cooler
Fixed nozzle ring
Impeller
Inlet
Exhaust
Exhaust manifold
Air manifold

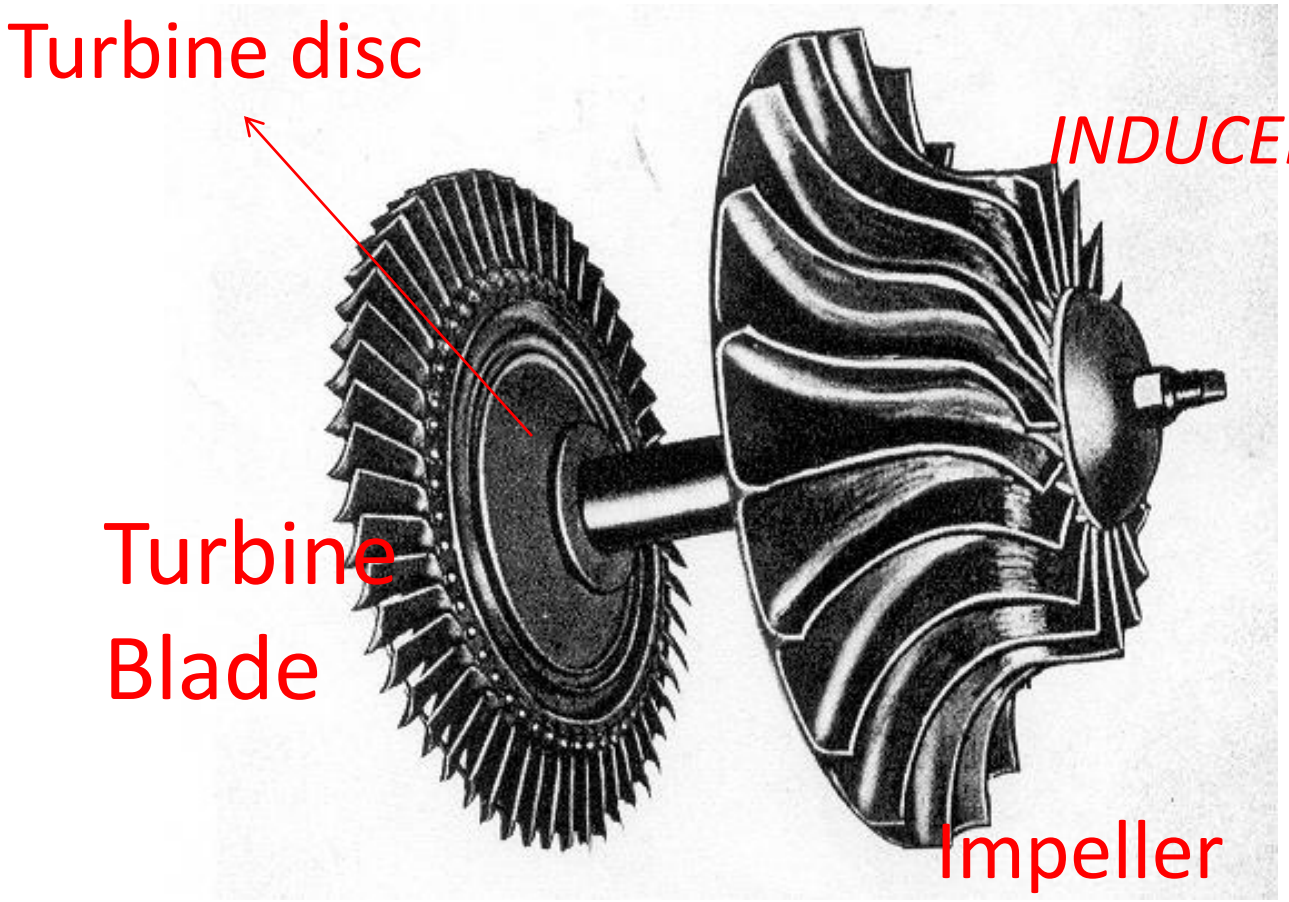
TURBO-SUPERCHARGER

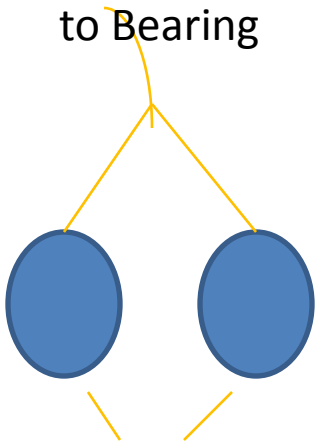
- The turbo-supercharger, the most important assembly in the system consists of the following main components -
- 1. Gas inlet casing
- 2. Turbine casing
- 3. Intermediate casing
- 4. Blower casing with diffuser

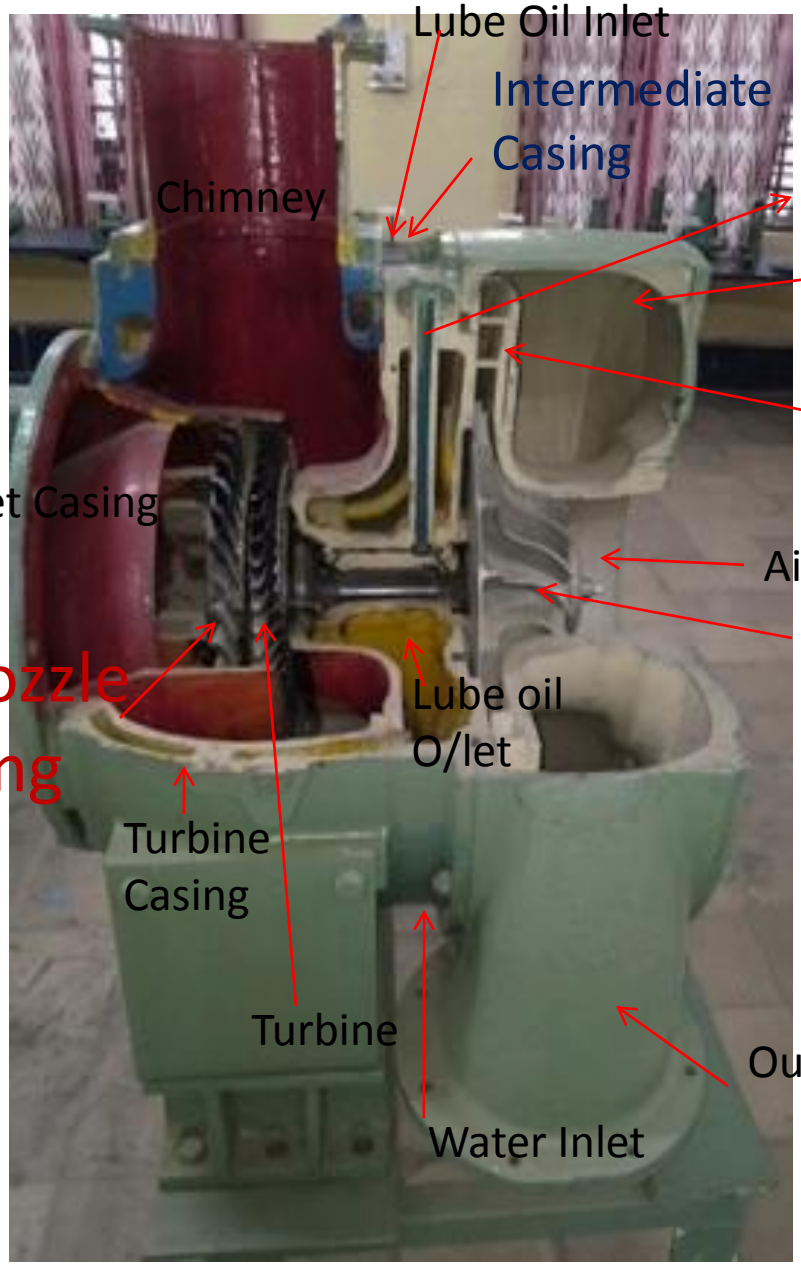
5. Rotor assembly with turbine and blower on the same shaft



ROTOR ASSEMBLY




Lube Oil Inlet
to Bearing
Lube Oil
Outlet to
Sump


Lube Oil Inlet
Intermediate
Casing
Chimney
Water Out let I/ Casing
Blower Casing
Diffuser
Gas Inlet Casing
Air Inlet
Blower
Nozzle
Ring
Lube oil
O/let
Turbine
Casing
Turbine
Out Let
Water Inlet

GAS INLET CASING

- The inlet casing of the latest type of turbo are of CH 20 stainless steel which is highly heat resistant. Function of this casing as already explained is to take the hot gas from exhaust manifold and pass it through nozzle ring which is bolted to the casing face. This assembly is fitted on to the turbine casing with cap screws.
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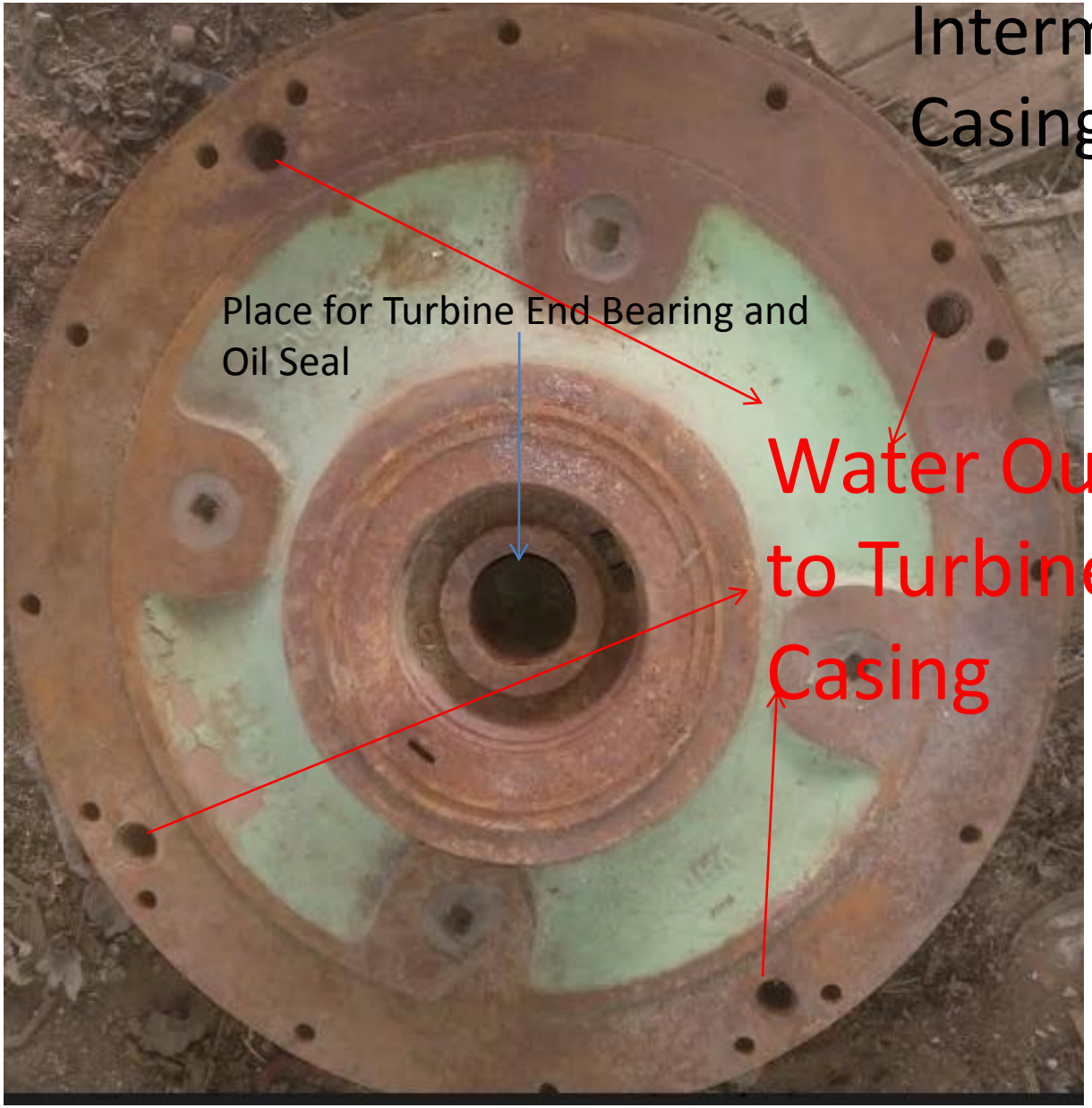
Vent pipe connection
Steam Accumulator
Chimney
Water return to suction pipe
Gas Inlet Casing
Blower Casing
Vent pipe connection
Intermediate Casing
Turbine Casing

TURBINE CASING

- The turbine casing houses the turbine inside it and is cored to have circulation of water through them for the purpose of cooling. This has an oval shaped gas outlet passage at the top. It is made of alloy cast iron and is fitted in between the inlet casing and the intermediate casing.

INTERMEDIATE CASING

- This casing is also water cooled and have cored passage for water circulation and is made of alloy cast iron like the turbine casing. Remaining in between the turbine casing and the blower casing it separates the exhaust and the air sides and also supports the turbine rotor on two trimetal bearings which are interference fit in the intermediate casing.


Intermediate Casing
Place for Turbine End Bearing and Oil Seal
Water Out let to Turbine Casing

BLOWER HOUSING ASSEMBLY

- This houses the blower and is in two parts, namely the blower inlet and the blower housing. Air enters through the blower inlet axially and discharged radially from the blower through vane diffuser. The vane diffuser is a precision aluminium casting and screwed on to the blower casing.
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ROTOR ASSEMBLY

- The rotor assembly consists of the rotor shaft, rotor blades, thrust collar, impeller, inducer, centre studs, nose piece, lock nut etc. assembled together. The rotor blades are fitted into “ fir tree slots “ and locked by tab lock washers. This is a dynamically balanced component as this has a very high rotational speed.
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COOLING SYSTEM

- The cooling system in this model of turbo charger is integral with the water cooling system of the engine. Circulation of water takes place through the turbine casing and intermediate casing which are in contact with hot exhaust gas. The cooling water after being circulated through the turbo returns back again to the cooling system of the locomotive.

LUBRICATING SYSTEM

- One branch line from the lubricating system of the engine is connected to the turbo supercharger. Oil from the lube oil system circulates through the turbo supercharger for lubrication of its bearings. After the lubrication is over the oil returns back to the lube oil system through a return pipe.
- Oil seals are provided on both the turbine and blower ends of the bearings to prevent oil leakage from bearing to the blower or the turbine housing.
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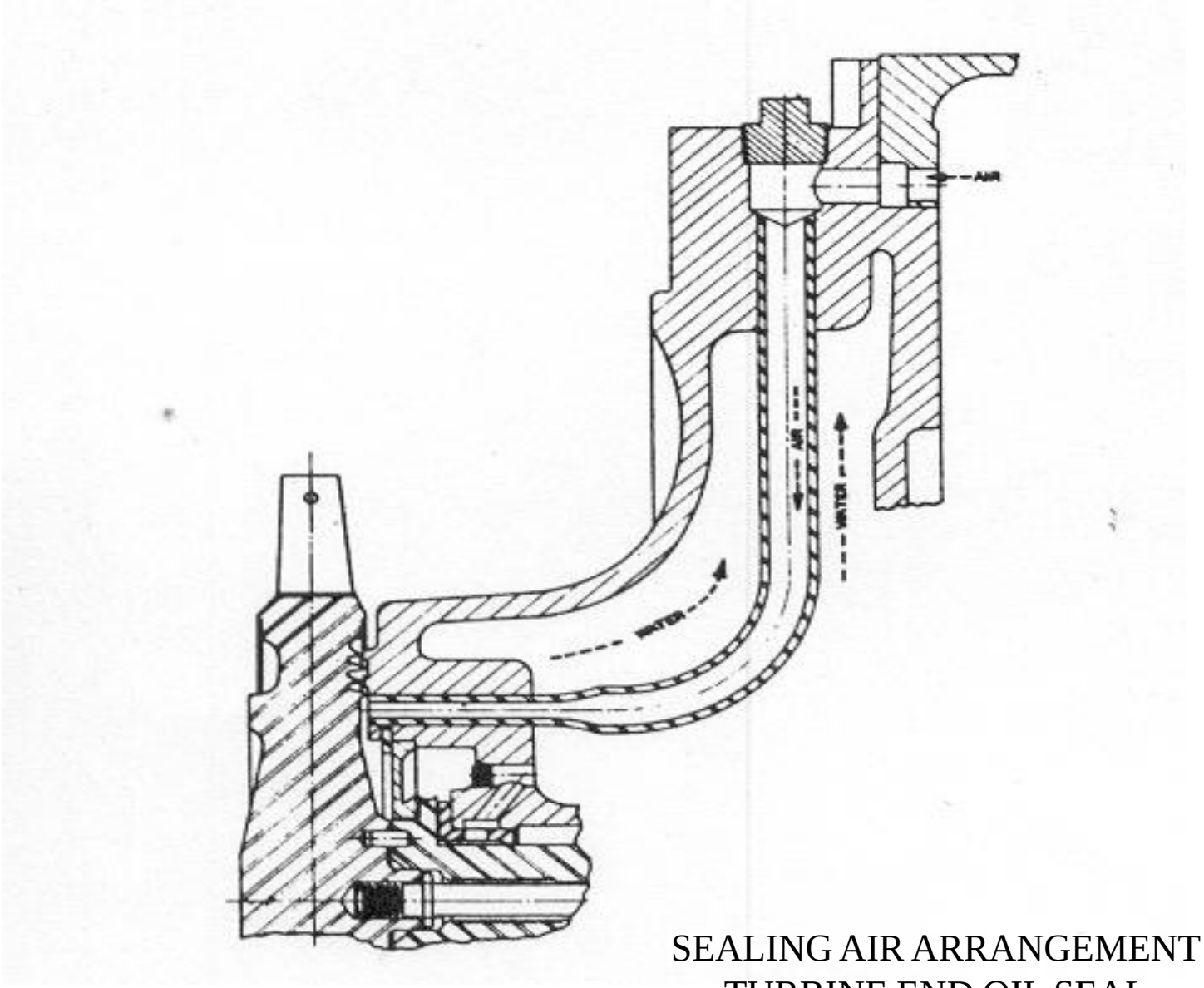

SEALING AIR ARRANGEMENT
TURBINE END OIL SEAL

AIR CUSHIONING

- Pressurized air from the blower casing is taken through a pipe inserted in the turbo to the space between the rotor disc and the intermediate casing.

- There is an arrangement for air cushioning between the rotor disc and intermediate casing for the following purpose:-

- a. To prevent hot gas coming in contact with the lubricating oil

- b. Prevent leakage of lubricating oil through the oil seal

- c. Cool the hot turbine disc.

- d. Reduce thrust load on the thrust face of the bearing.

MAINTENANCE OF TURBO-SUPERCHARGER

- Careful attention to the turbo-supercharger at regular intervals are required as the equipment is highly thermally loaded and prone to damage if not maintained properly. The healthy turbo-supercharger ensures better health and efficiency of the engine as well and produce much more power with fuel efficiency. It is advised that going strictly by the maintenance instructions laid down by the manufacturer in the maintenance manual is the best way of maintenance of the turbo-superchargers. Maintenance of proper clearance, tolerance and use of recommended tools are very important.
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TURBO RUN-DOWN TEST

- Turbo run-down test is a very common type of test done to check the free running time of turbo rotor. It indicates whether there is any abnormal sound in the turbo, seizure / partial seizure of bearings, physical damage to the turbine, or any other abnormality inside it.

- The engine is started and warmed up to normal working temperature(min. 65 degree c) and kept running at max. notch speed up to 15minute. Then kept engine ideal and shut down through the over speed trip mechanism, manually operated, and after the rotation of the engine crank shaft stops, the free running time of the turbine is watched through the chimney and recorded by a stop watch. The normal time allowed for free running is 90 seconds to 180 seconds. Low or high turbo run time are both considered to be harmful for the engine.
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AFTER COOLER

- The after cooler which is a simple radiator to transfer heat from the booster air to the cooling water to regain its lost density, also has to be properly maintained. Scaling on the tubes internally or externally, or choking of tubes can reduce heat transfer capacity. This can also reduce the flow of air through it and efficiency of the diesel engine is reduced for low density of the booster air. This is indicated by black exhaust smoke emission and fall in booster pressure.

Conventional

Larger

Different Types of TSC

- Make wise-
- Water cooled-
- Alco 720A2
- Alco 350C
- ABB VTC 304
- Napier (NA-295)
- GE 7S1716

Air Cooled

ABB TPR 61

ABB for WDS6

Hispanosuiza (HS 5800)

- High efficiency turbo supercharger (NAPIER NA-295, ABB VTC-304)-

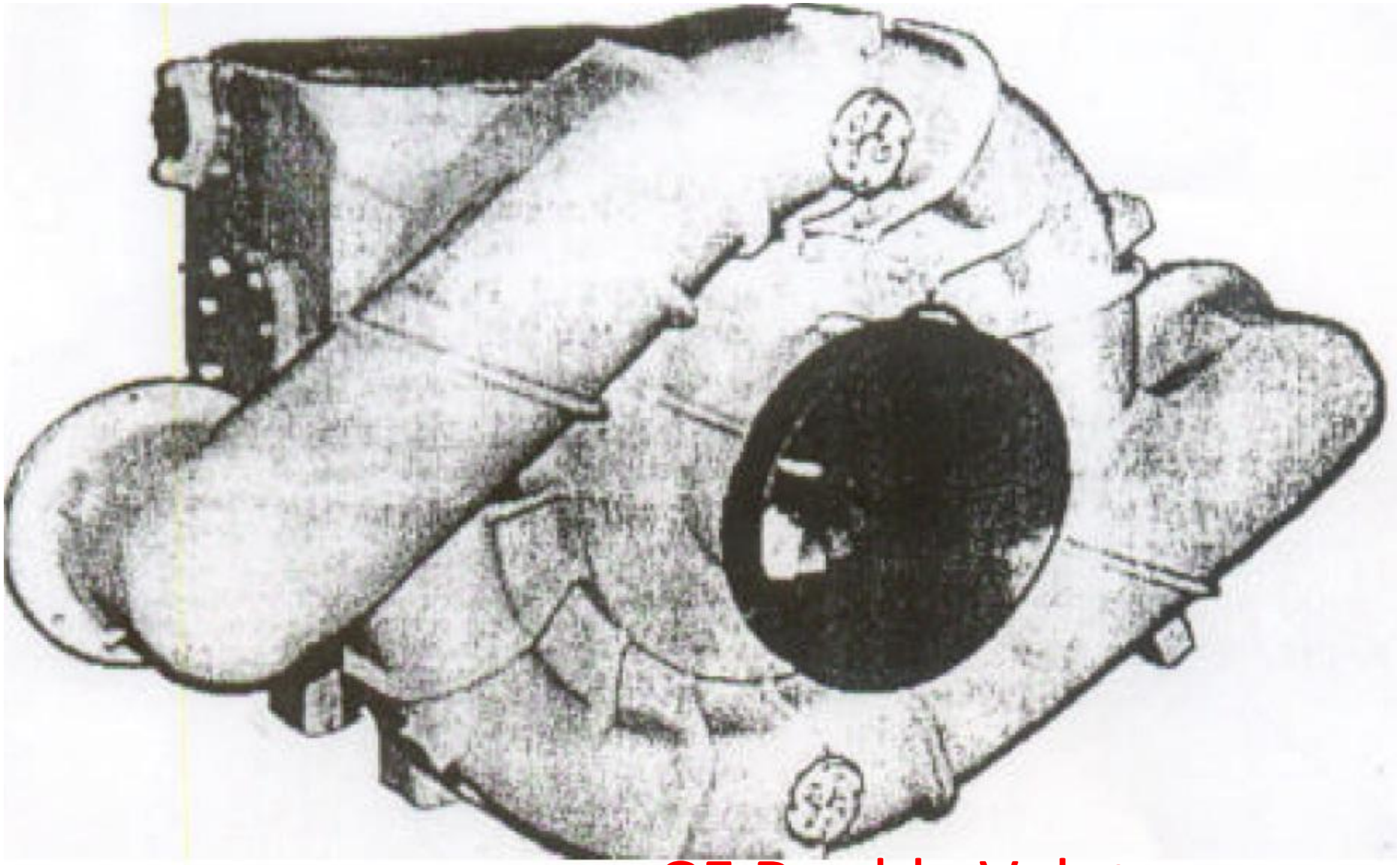
-to improve Engine Performance ,

- Lesser maintenance,

- Improved SFC(166 to 156)

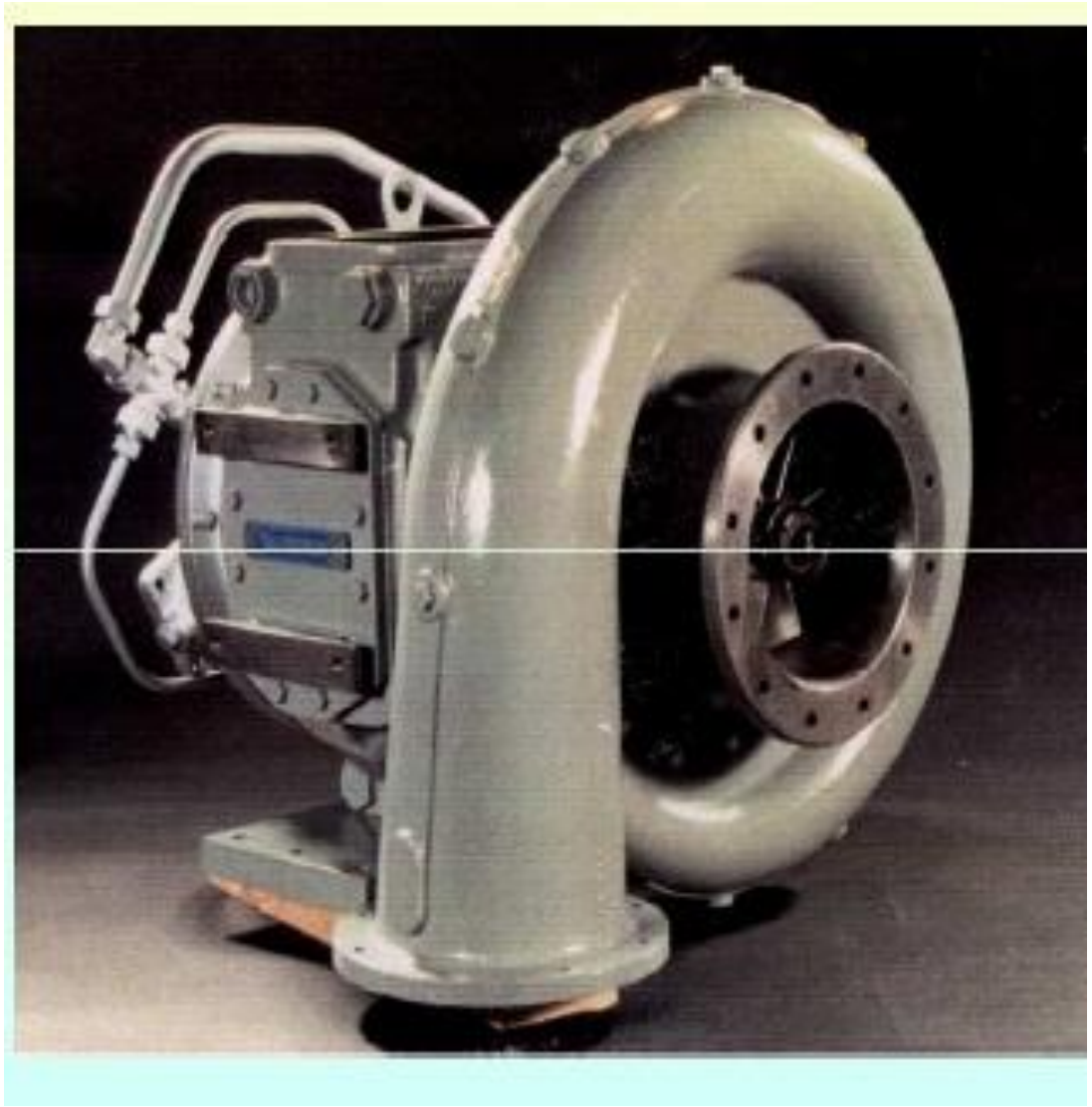
720 TSC

ABB VTC 304



GE Double Volute

GE Single discharge



NAPIER 295

ABB TPR61

HS5800 NGT

BAP

- Alco 720A2= 1.6 kg/Cm2
- Alco 350C= 1.2 Kg/Cm2
- ABB VTC 304= 1.8 to 2.0 kg/Cm2
- Napier (NA-295)= 1.8 to 2.0 Kg/Cm2
- GE 7S1716= 2.2 to 2.5 Kg/Cm2
- ABB TPR 61 =2.2 Kg/Cm2
- Hispanosuiza (HS 5800)=2.0 Kg/Cm2
- ABB for WDS6=1.2 Kg/Cm2


धन्यवाद


Thank
You!