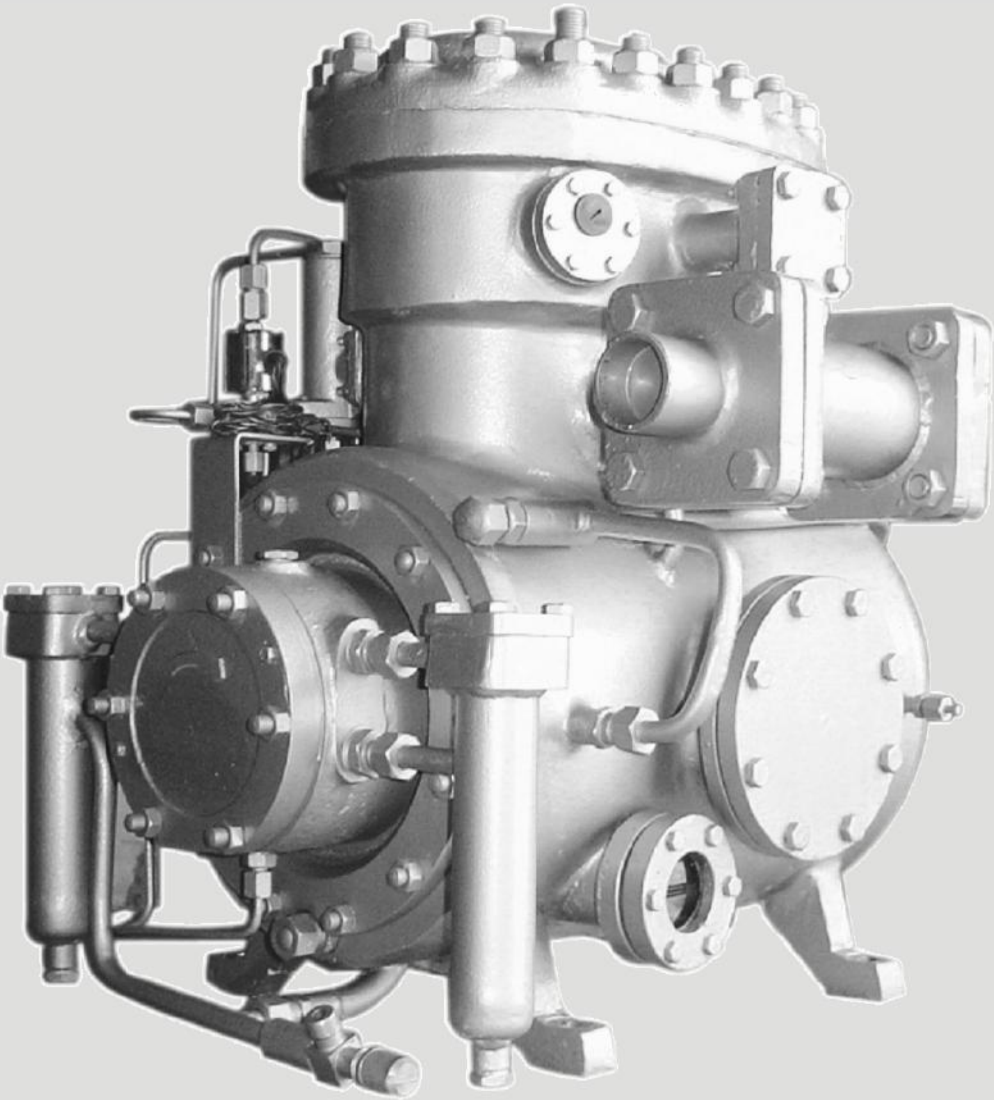
INSTRUCTION & MAINTENANCE MANUAL



REFRIGERATION COMPRESSOR MPX2

metalex™

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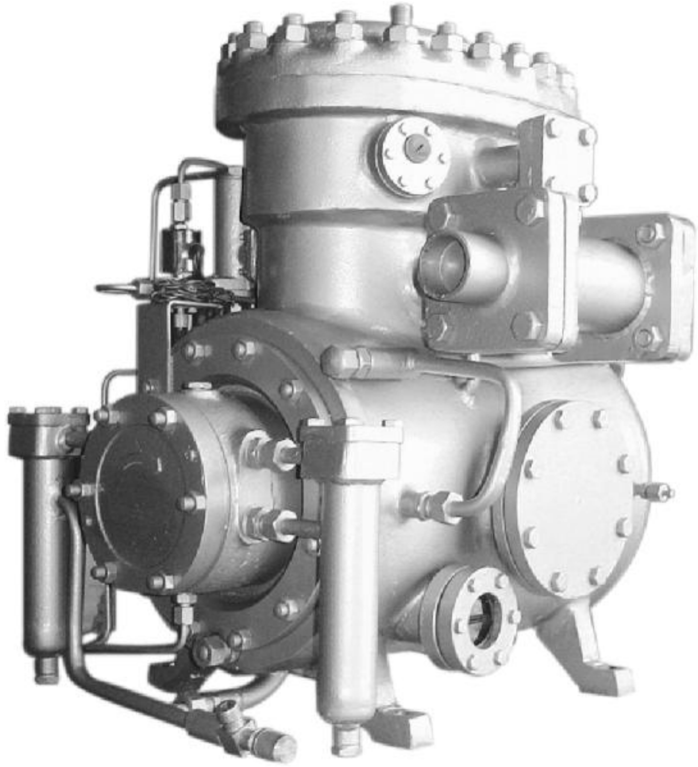
ILLUSTRATIONS



ITEM	MPX2
Length	745 mm
Width	562 mm
Height	685 mm
Cylinders	2 nos
Bore	110 mm
Stroke	85 mm
Speed max.	1450 rpm
Speed min.	600 rpm
Delivery Pressure max.	21.0 kg/cm^{2}G
Displacement at 1450 rpm.	140.7m^3/h
Weight w/o accessories	250 kg

This manual, intended as a guide for the attendant of the Metalex Refrigeration Compressor type MPX2, contains a description of the compressor as well as service and maintenance instructions. It is necessary to read through the text carefully before starting the compressor. Reading the instructions periodically will result in better knowledge, thereby assisting in preventing possible breakdowns. If abnormal operating conditions occur, the fault-finding chart will be of great use in tracing and remedying the trouble.

Repairs should be carried out by qualified personnel as soon as possible. Otherwise irrepairable damage may occur. All the description and illustrations are without engagement. The manufacturers constantly aim at improving their products and working methods. We reserve the right to alter the MPX series described and illustrated here, thereby maintaining the main characteristics but without being obliged to immediately alter this manual accordingly.

1. Description

1.1.1 .A refrigeration compressor forms a part of a cooling plant. It is necessary that the attendants of the plant be familiar with the function of the compressor in the cooling system.

1.1.2. Generally, vapour compression system consists of four main parts, viz., The refrigeration compressor the condenser, the expansion valve and the evaporator (see fig. 1)

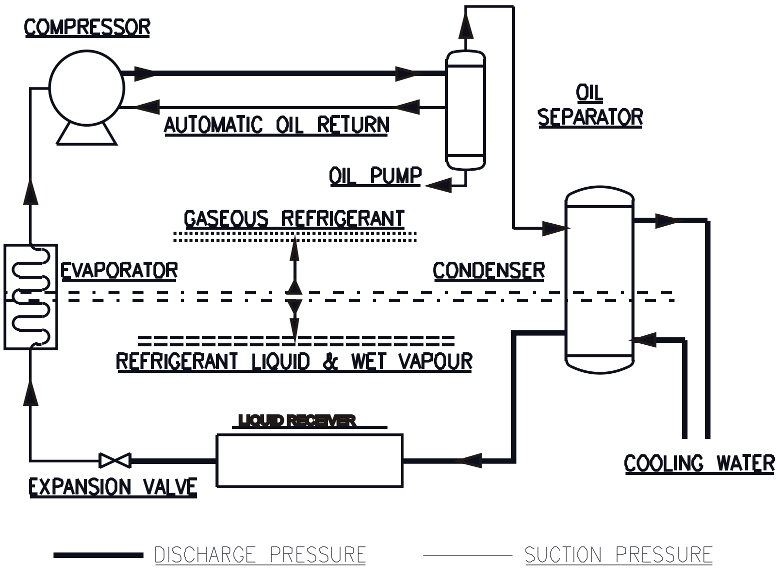


Fig. 1 : Diagrammatic layout of a refrigerating plant.

1.1.3. All these parts are interconnected by means of pipe lines. The entire plant is filled with refrigerant in either gaseous or liquid form, as well as a mixture of the two. One of the halocarbons or ammonia is generally used as the refrigerant.

1.1.4. The compressor sucks the gaseous refrigerant at low pressure and temperature from the evaporator and compresses it. The refrigerant is then discharged at a higher pressure and temperature into the condenser.

1.1.5. The condenser may be air or water cooled. The cooling medium absorbs the heat of rejection which comprises of the heat of evaporation and the heat of compression. The gaseous refrigerant cools down, condenses and accumulates in the receiver. From receiver the liquid is conveyed to the evaporator via the expansion valve.

1.1.6. The expansion valve is a device which controls the rate of flow of refrigerant to the evaporator, while throttling the liquid from high pressure to low pressure. This valve has either a fixed capacity allowing a continuous steady flow; or it is of the automatic type governed by the temperature of the evaporator.

1.1.7. The evaporator receives the refrigerant mostly in liquid form. Here the refrigerant evaporates due to the heat absorbed from the space in which the evaporator is located. The vapours so formed are sucked by the compressor and the cycle continues.

2. REFRIGERATION SYSTEM

2.1 GENERAL

2.1.1. The compressor MPX2 comprises of 2 cylinders and is manufactured only as a single-stage machine. This compressor is normally used for Ammonia. R-12 and R-22 refrigerants; but can also be used for compressing other gases. It is fitted with cylinders having a bore of 110 mm. The standard compressor has a hydraulically operated valve lifting device on each cylinder. The direction of rotation is anti-clockwise (looking from the flywheel end). The maximum safe delivery pressure for continuous operation is 20 kg/cm^2 G.

2.2. CRANKCASE AND CYLINDER JACKETS

2.2.1.The crankcase and cylinder jackets comprise of a fabricated, all-welded, gastight steel structure ensuring absolute stiffness and mechanical strength with a relatively low weight and a high impact strength. After welding, the complete unit is stress -relieved and chemically cleaned.

2.2.2. The suction inlet of the cylinders open into an ample suction manifold in which, a removable strainer is fitted, thus ensuring that the suction gas is filtered before entering the compressor. In this space, any cil entrained in the gas, is partially separated and is automatically returned to the crankcase via a not-return valve.

2.2.3. The cylinder heads are provided, at the top, with cooling water jackets, fitted with water inlets and outlets. Cooling is used only if the compression temperature is higher than 120^{O} C (248^{O} F) and the cooling water should be non-coroosive. When cooling is applied, provision should be made for starting and shutting off both the water supply and water drain simultaneously.

2.2.4. The gas manifold are provided with connection lines to a common panel on the oil delivery strainer. On this panel are fitted all connections for the valve lifting, capacity control, pressure gauges and pressure cutouts, if provided.

2.3. CYLINDER LINERS

2.3.1 The renewable cylinder liners, madeof fine grain cast iron, are pressed into the cylinder jackets and can be easily replaced. An extremely smooth surface finish is obtained by precision boring and honing. The collar at the top of the cylinder liner is provided with holes and serves as a valve seat for the suction valve ring and as centering for the stroke limitor for the suction valve.

2.4 VALVES

2.4.1. The suction and delivery valves (see fig.2) are of the ring type and of special cast iron. Their design ensures ample gas passage with a minimum lift. The suction valve ring is held on the valve seat by a series of light springs. The suction stroke limitor is centered in the cylinder jacket and is provided at the top with a centering edge for the stroke limitor of the delivery valve. The delivery valve consists of a stroke limitor, a valve seat, two wavy springs and one valve ring. The whole being assembled by the centre bolt with nut. Both the stroke limitors are fixed together by means of two socket head cap screws.

2.4.2. The valve seat and the suction stroke limitor together form the seat of the delivery valve ring. The valve ring as well as the two wavy springs are centered in the delivery stroke limitor. The unit is held against the cylinder cover by a heavy buffer spring. This construction enables the delivery valve as well as the suction stroke limitor to lift in case of liquid stroke.In this way undue material stresses are avoided. See also para 4.6

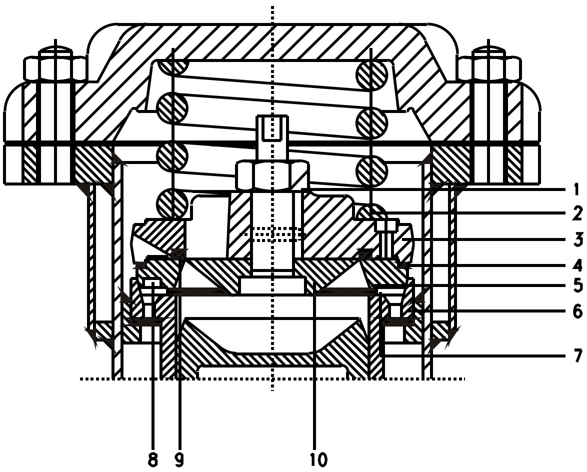


Fig. 2 : Valve Mechanism

1 Lock washer
2 Buffer spring
3 Delivery stroke limitor
4 Wavy spring
5 Suction stroke limitor
6 Cylinder liner
7 Valve spring
8 Pressure spring
9 Delivery valve ring
10 Valve seat

2.5 PISTONS

2.5.1. For the light alloy pistons, a special form has been chosen to obtain a highly favourable efficiency of the compressor. In conjunction with the valves specially constructed for the purpose, the clearance is reduced to a minimum. Three piston rings ensure a good piston seal, so that there is hardly any piston leakage. The oil scraper ring together with the third piston ring admits only a minimum oil consumption thereby providing generous lubrication.

2.6. CONNECTING RODS

2.6.1. The connecting rods are made of light alloy. The big end consists of two parts and is fitted with a split white-metal lined steel backed precision bearing having two holes for lubrication of the gudgeon pin. A bronze bush adequetely grooved for lubrication of the gudgeon pin is pressed into the small end. The connecting rod is provided with internal oil ways through which the forcefeed lubrication to the bearings is effected.

2.7. CRANKSHAFT

2.7.1. The crankshaft made of forged steel, has excellent running characteristics and is extremely resistant to wear. The bearing surfaces and crank pins are precision ground to close tolerances. The crankshaft runs in interchangeable white-metal lined steel backed precision bearing bushes mounted in the bearing covers. The side covers close the front and back side of frame. The bearing cover at the flywheel end incorporates the shaft seal. The crankshaft is dynamically balanced and fitted with cast iron counter-weights so as to ensure smooth operation of the machine. The crankshaft has an internal oil way. Near the bearings and crank pins this oil way is split into smaller oil ways, radially directed to the centre line of the crankshaft and feeding oil to the crankshaft bearings.

2.8 OIL PUMP

2.8.1. The MPX2 compressor is equipped with a two pressure gear pump. I.e., This pump does the same work as two separate gear pumps (see fir. 3) Consequently this oil pump has two delivery sides, viz., One for the lubrication of the compressor and the other for controlling the valve lifting mechanism. The delivery pressure required for the lubrication is controlled by the oil pressure regulator (see para 2.9) and for the valve lifting mechanism (see para2.13) By a bypass safety valve incorporated in the oil pump.

2.8.2.The bypass safety valve communicates both with the delivery side for the valve lifting and with the oil way in the crankshaft. Consequently the oil not used for the valve lifting is utilized for the lubrication of the compressor.

2.8.3.A hydraulic time delay provided in the oil pump enables the compressor to start under “no load” conditions. During the period of thirty seconds up to one minute, this time delay shuts off the oil fed to the valve lifting mechanism of the compressor ; so that all suction valves remain lifted. During this time, the compressor easily attains its normal running speed.

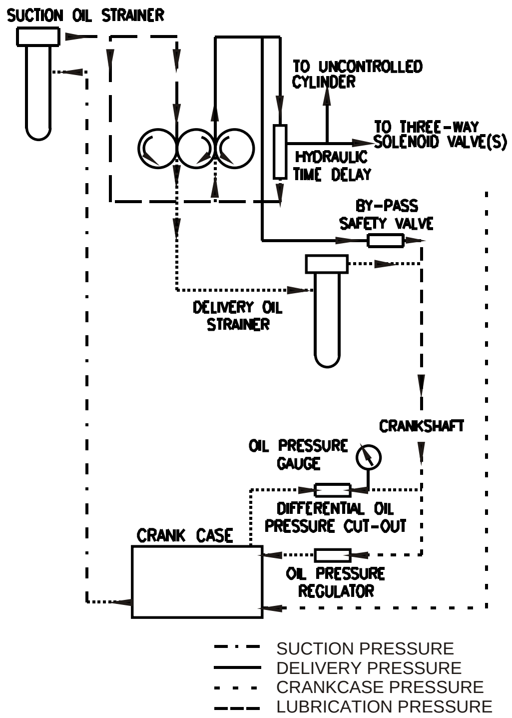


Fig. 3 Diagrammatic layout of oil circuit.

2.8.4.The pump is driven directly from the crankshaft and is mounted on the bearing cover on the side, opposite the shaft seal end of the compressor. The oil leaves the crankcase via a suction oil strainer and enters a joint suction space whence the two combined gear pumps suck the oil and deliver it to their respective delivery spaces. The oil for the lubrication enters the crankshaft via a delivery oil strainer, the oil for the valve lifting being delivered to the valve lifters via the hydraulic time delay. If the pressure for the valve lifting rises to such an extent that the difference between this pressure and the lubrication pressure exceeds 3.5 atm, the excess oil will be fed to the crank-shaft as described above.

2.9. OIL PRESSURE REGULATOR

2.9.1The compressor is fitted with an adjustable oil pressure regulator (see fi. 4) inserted in the oil return line. It is mounted above the oil level glass, external to the crankcase. The regulator consists of a valve housing in which, a ball valve is held against the oil inlet by a spring. The tension of this spring is adjusted by turning a set pin and controls oil pressure in the system. The valve housing is sealed by a nipple and washer. A cap, which has to be removed before the oil pressure can be adjusted, covers the nipple.

2.9.2. After the cap has been removed, the set pin can be turned with the aid of a screw driver. The pressure of the incoming oil, now has to overcome the spring pressure so as to deliver the oil along the ball valve. The more the spring is stressed, the more the oil pressure in the lubrication system. To achieve a higher pressure, the set pin should be turned clockwise and for reducing pressure, this direction should be anticlockwise.

2.9.3. When the oil has passed the ball valve, it leaves the pressure regulator and is fed behind the oil level glass. The oil return jet makes it possible to check the lubrication of the compressor through the oil level glass.

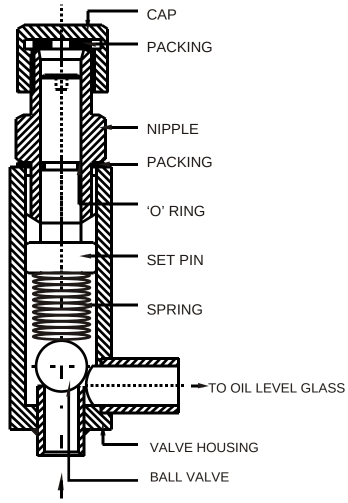


Fig. : 4 oil Pressure regulator

2.10. LUBRICATION SYSTEM

2.10.1. The lubrication of the compressor is of the forced feed type and effected by means of a gear type oil pump, driven directly from the crankshaft. The lubricating oil circuit is shown in fig. 3.

2.10.2. The cil enters the pump via the suction oil strainer and is discharged, through a delivery oil strainer, into the oil way drilled in the crankshaft (see also fig. 3 and para 2.8). Internal oil ways carry the oil from the main oil way in the crankshaft to the bearings and crank pins.

The supply to the small end bearings is provided by means of the oil way drilled through the web of each connecting rod. The cylinder liners are well lubricated, the oil leaving the small end, and big end bearings being liberally deposited on all internal surfaces by the motion of the rotating and reciprocating parts. The arrows indicate the direction in which the oil flows. The driving end of the crankshaft is fitted with a shaft seal preventing the leakage of any oil or refrigerant along the crankshaft to atmosphere. From the shaft seal cap, an external oil return line leads to the oil pump side of the compressor where it is connected to the oil pressure regulator. (Fig. 4.)

2.10.3. This device controls the flow of oil back to the crankcase through the openended return piping which discharges directly behind the oil level glass. The lubrication circuit is thus completed. The oil return line is provided between the oil pressure regulator and the shaft seal, with a line to the common panel on the delivery oil strainer (see para 2.2). A pressure gauge and /or a differenttial oil pressure cut-out may be connected to this panel.

On the delivery oil strainer (see para 2.2). A pressure gauge and / or a differential oil pressure cut-out may be connected to this panel.

2.10.4. The oil pressure should be adjusted by means of the oil pressure regulator and should be at least 1 atm. (14.7 psi) to 1.5 atm. (22 psi) higher than the suction pressure. The oil level in the crankcase and the cil return jet are visible through the oil level glass. The oil level should always be visible in the oil level glass, whilst it is not advisable to let it rise above its centre line. When abnormal working conditions make it desirable or necessary to use a heavier or lighter grade of oil, it is advisable to contact an oil expert.

2.10.5. **Caution:** When supplied the compressor is not filled with oil. If, after some time, it is considered desirable to change the brand of oil, the lubricant must be removed first completely with flushing oil.The strainers, oil separator(s) and all the oil drains of the plant should also be throughly cleaned. **Mixing of two brands of oil should be strictly avoided.**

2.10.6. **LUBRICATION CHART**

SR.NO.	BRAND	QUALITY
(1)	Indian Oil	Servofriz F57
(2)	Hindustan Petroleum	Seetul N 68
(3)	Bharat Petroleum	Freezol-46

Note: For temperature lower than -45^{o} C, it is necessary to consult an oil expert.

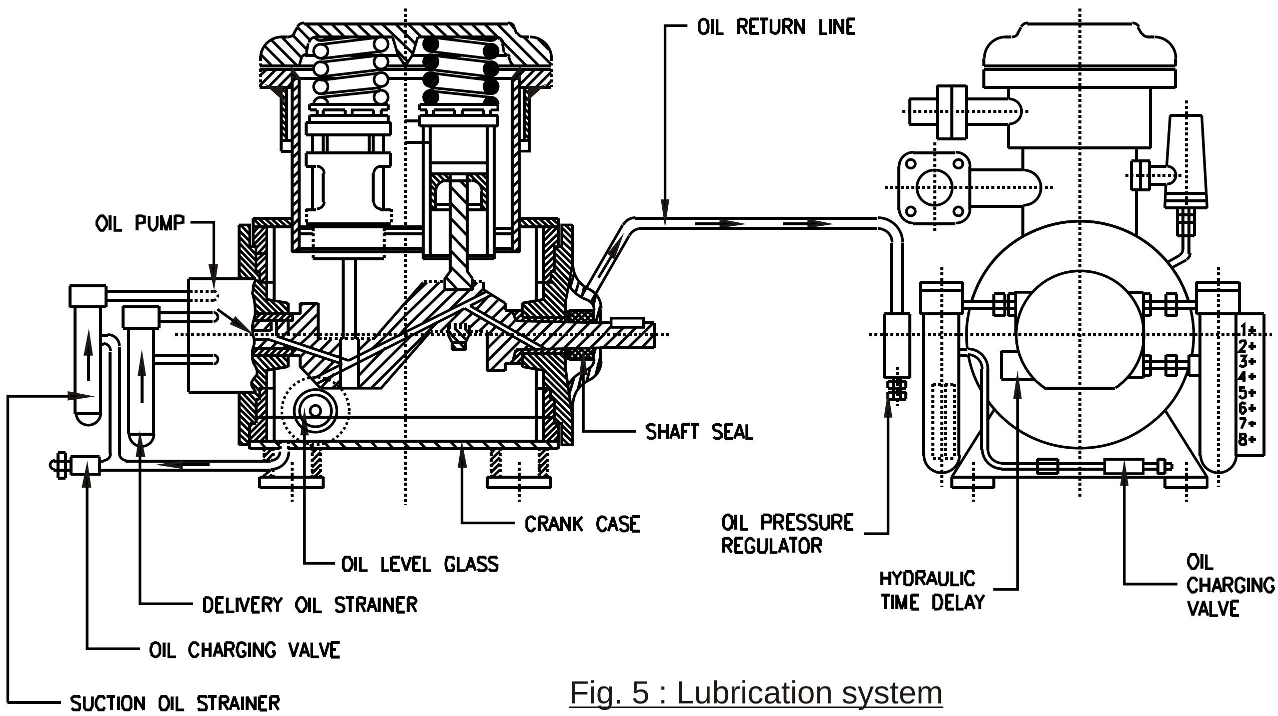


Fig. 5 : Lubrication system

2.11. **PRESSURE EQUALIZING LINE**

2.11.1. A pressure equalizing line is fitted between the suction strainer housing and the crankcase. This line provides an open connection between the crankcase and the suction line which is necessary to evacuate the crankcase of gas before topping up the oil and to equalize piston leakage, if any.

2.12. **HIGH PRESSURE SAFETY VALVE**

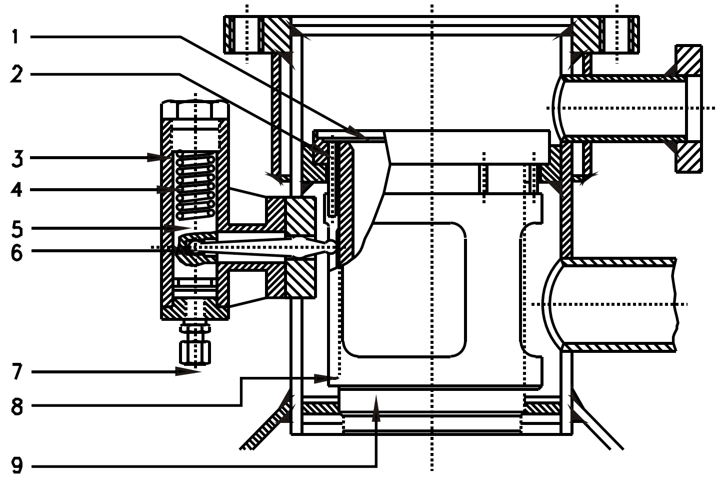
2.12.1. The compressor is fitted with built in H.P. Safety valve. The safety valve is a spring loaded relief valve fitted between the delivery and suction compartments of the cylinder block. At the time of excessive pressure in the delivery compartment, it by-passes gas back into the suction compartment. The device can be easily removed for inspection or renewal. The safety valve is set at a differential pressure of 21.0 kg/cm^{2}G.

2.12.2. **CAUTION :**
The compressor must on no account, be kept running with an open or leaking safety valve as the machine would then become too hot and the cylinder liner and /or the pistons might seize or even get damaged. When the cylinder block becomes too hot, without the delivery pressures being too high, it may be assumed that the safety valve is leaking. In this case the safety valve must be repaired or renewed.

2.13. **VALVE LIFTING MECHANISM**

2.13.1The cylinders of the compressor are all equipped with a hydraulic valve lifting mechanism (see fig. 6). Its purpose is t start the compressor under "no load" conditions and in case a capacity control device has been provided, to switch on and off certain cylinders.

2.13.2. The valve lifting mechanism can be divided into hydraulic and mechanical components. The hydraulic assembly represents the control mechanism fitted against the cylinder block. It consists of a housing, a piston, a compression spring and a connecting flange for the oil supply. The mechanical element is the valve lifter proper and comprises a valve lifting sleeve, which is free to move up and down along the cylinder.



1 Suction Valve Ring 3. Housing 5. Control Piston 7 Lifting Bush
2. Lifting Pin 4. Spring 6. Lever 8 Control oil Pressure Connection
9. Cylinder Line

2.13.3. The valve lifting sleeve is provided at the top with six valve lifting pins, lifting the suction valve ring from the valve seat, when the valve lifting sleeve is in its uppermost position. The hydraulic piston and the mechanical lifting sleeve are interconnected through a lever arrangement in such a manner that a downward movement of the piston imparts an upward movement to the lifting sleeve.

2.13.4. Owing to the compression spring causing the piston to descend, the lifting sleeve is in its uppermost position and the suction valve ring is lifted from its seats. This is the case when the compressor is at standstill, consequently when there is no oil pressure. When oil pressure is fed to the control mechanism, it will cause the piston to rise against the force of the compression spring, so that the lifting sleeve is drawn down along the cylinder. This allows the suction valve ring to descend onto its seat, thus putting the cylinder into operation The oil feed during starting to the operation mechanism is controlled by the hydraulic time delay in the oil pump, and in case of capacity control (if applied) by the three-way solenoid valve.

3. OPERATING INSTRUCTIONS

3.1. OPERATION OF COMPRESSOR

3.1.1. When the compressor is at rest, the suction valves are held off their seats by a valve lifting mechanism (see para 2.13)

3.1.2. As rotation commences the oil pump comes into operation, supplying low pressure lubricant to the moving parts, also making available, under the control of a time delay, a high pressure supply which actuates the valve lifting mechanism. The time delay ensures that normal running speed is first attained before allowing the compressor cylinders to be progressively brought on load.

3.1.3. In machines not fitted with capacity control, all cylinders are operated simultaneously. But, where capacity control is fitted, one cylinder only is controlled directly by the time delay, the remainder being on load, by the three-way solenoid valve. While starting, if the suction valve is held clear off its seat as the piston descends on its suction stroke, gas is drawn into the cylinder in the normal manner. But as the piston rises on the compression stroke, the gas is merely recirculated back into the suction manifold, through the open suction valve. Thus, the only energy required to drive the compressor is that necessary to overcome its inertia and the friction and pumping losses.

3.1.4. This condition of starting is referred to as' no load' or 'off-load' starting and is effective in reducing peak starting electrical requirements and heavy wear of the starter, motor and drive gear.

3.1.5. In normal operation, the piston travelling down the cylinder, reduces the pressure therein. Gas in the suction manifold, at a higher pressure lifts the suction valve from its seat against the pressure of the valve springs and flows into the cylinder.

3.1.6. As soon as the gas pressures in the cylinder and the suction manifold are equal the suction valve springs force the valve ring back into its seat. As the piston rises on its compression stroke, the gas pressure is raised until the delivery valve is lifted from its seat and the gas is allowed to flow through the delivery manifold.

3.2. LIQUID STROKE

3.2.1. The term liquid stroke refers to the state where an amount of wet saturated or liquid refrigerant is taken into the cylinder and forced out by the piston, the valve mechanism lifting from its seat audibly. This constitutes an overload on the mechanism, as liquid is not compressible.

3.2.2. Generally, modern compressors without a liquid stroke protection will suffer damage when liquid carry-over and compression occur. They are designed for 'superheated' operation i.e. The suction gas is intended to have a certain amount of superheat (6-8 ^{o}C) (10.8 -14.4^{o}F) When designing a system, it is important to ensure that the suction gas is perfectly dry and that not even the slightest amount of wet vapour is drawn into the cylinder. It happens, however, that MPX2 compressors are installed in systems in which taking in liquid or wet saturated vapour is not excluded. In these cases no responsibility can be assumed for any damage arising due to liquid stroke. In order to safeguard against such a situation, a liquid stroke protection device is fitted to all MPX2 compressors (see para 2.4).

3.2.3. This arrangement, however, only allows the passage of comparatively small quantities of wet refrigerant through the compressor without causing consequential damage. When large quantities of liquid are crawn into the cylinders the delivery valve assembly and the suction valve stroke limitor (see fig. 2) are lifted to such an extent, that they cannot return to their normal position thus permanently retaining the valves off their seats and minimizing the damage suffered by the compressor.

3.2.4. Other factors also play an important part in cases of liquid stroke, for even when only a small amount of wet gas is drawn in, it may still have harmful results, even though liquid stroke proper does not occur, viz:

(a) The operating temperature of the gas at the delivery valves will drop abruptly, thus imposing an additional thermal load on the valve assemblies, over and above the existing mechanical load.If this happens, frequently, it will lead to early failure of the valve assemblies.

B) A quantity of the fluid refrigerant enters the crankcase and becomes mixed with the lubricating oil. The oil characteristics will be consequently impaired which may precipitate damage to bearings, crankshaft and cylinder liners or even total seizure of the compressor itself.

The compressor must be inspected for damage if liquid stroke has occured.

3.3. AMMONIA CHARACTERISTICS

3.3.1. Ammonia (NH_3) causes watering eyes, coughing and very painful skin inflammation, especially the mucous membranes and the eyelids. Inhaling may cause inflammation of the respiratory organs, choking, cramp and even death in severe cases.

3.4. AMMONIA STORAGE

3.4.1. The liquid ammonia stock should be stowed in a properly designed store, outside the compressor room, where no other gas cylinders should be stored. Full and empty ammonia cylinders should be kept, in a horizontal position, in order to avoid their falling over. It is permissible however, to stow the cylinders in a vertical position, provided that each cylinder can be separately fastened in such a way, that the possibility of its falling over, is absolutely precluded.

3.4.2. Ammonia cylinders should not be exposed to direct sunlight or to temperatures exceeding $50^{o}C$ ($122^{o}F$) or lower than about $-10^{o}C$ ($14^{o}F$).
They should be carefully handled.

3.4.3. Before use, the contents should be tested to be sure that it is ammonia and not some other liquid or gas. Even when the cylinder carries a label indicating its contents, this check should not be omitted. The ammonia should be obtained from reliable firms to ensure that the refrigerant does not contain water and /or alcohol.

3.5. AMMONIA LEAKAGE

3.5.1. As it is possible that a leak might suddenly develop, at least one gas mask must be placed in a conspicuous and easily accessible spot. This mask must completely cover the eyes, nose and mouth. It should be occasionally checked for correct functioning and the filter should be renewed periodically; for its effective life is only limited. The mask should be a good fit. A gas mask and a pair of leather or rubber gloves are essential because while working on the plant, the Possibility of ammonia leaks exists. The gloves and the mask should be kept at the same place.

3.5.2. Small leaks can be traced with aid of litmus paper, which will turn violet on coming into contact with ammonia.

3.6. COMPRESSOR ROOM

3.6.1. The compressor room, where the compressor and other machinery of the plant are installed, should have two exits (if possible, situated opposite each other) leading to open air. Doors, shutters and hatch covers should be tight when shut and open outwards. The compressors and other machinery should be easily accessible to the attendants who should also be able to reach into the open without difficulty, if necessary. The walls and ceiling of the compressor room should be fireproof. Ventilation for the space should be provided at floor level (ammonia and halocarbon gases are heavier than air) and be so arranged that any leaking gas cannot penetrate into adjacent compartment. The local labour safety regulations must also be observed, as well as, the additional requirements of the insurance company concerned. Naked lights and fires are dangerous in spaces where ammonia is used and are therefore forbidden.

3.7. HALOCARBON CHARACTERISTICS

3.7.1. Halocarbons are colourless, odourless and non-poisonous. When they come into contact with a hot surface, harmful chemical reactions take place. For this reason, leaks should never be traced whilst the operator is smoking, as they may be inhaled over the burning tobacco, causing inhalation of poisonous gases.

3.8. STORAGE OF HALOCARBONS

3.8.1. The instructions given for the storage of ammonia, are also applicable to the storage of halocarbons (see par. 3.4 and replace the word “ammonia” by “halocarbon”).

3.9. LEAKAGE OF HALOCARBONS

3.9.1. Halocarbons are heavier than air and escape through even the smallest aperture. As the gases are odourless, there is no immediate indication of possible leaks, which may result in a serious loss of these very expansive refrigerants. It is therefore desirable to check the plant regularly, for signs of any leakage by means of a leak detection lamp or an electronic leak detector. While trying to detect possible leaks, the engine room should be thoroughly ventilated.

3.10. PREPARATION FOR COMPRESSOR OPERATION

3.10.1. When a new compressor has been installed, the necessary arrangements for its initial run must be made, i.e., It must be filled with oil. Use the right brand of oil (2.10.6). For renewing and topping up oil during operation refer to the lubrication instruction.

3.11. OIL CHARGING

3.11.1. Remove cover from oil suction strainer.
3.11.2. Pour oil into strainer until level slightly exceeds, oil level glass centre line.
3.11.3. Fit cover back on strainer.
3.11.4. Check whether gas delivery and suction stop valves are open.
3.11.5. Disconnect differential oil pressure cut-out, if fitted.
3.11.6. Start compressor (see para 5.2) and wait until oil return jet becomes visible behind oil glass. About a minute later, the valve lifting mechanism must come into operation.
3.11.7. After charging refrigerant, reset pressure cut-out, referred to step 3.11.5 at the correct value.

3.11.8. Adjust oil pressure, if necessary (see 2.9).

3.12. OIL PRESSURE ADJUSTMENT

3.12.1. The oil pressure regulator is adjusted in our works at a minimum of 1 atm. (14.7 psi) above the gas suction pressure. It is possible, however, that this setting needs to be corrected, after charging with refrigerant. This should be done as follows:
3.12.2. Check whether suction and delivery stop valves as well as the refrigerating circuit are open.
2.12.3. Start compressor (see para 5.2) and wait until its temperature is steady.
2.12.4. Compare, at relevant pressure gauges, oil pressure with gas suction pressure and ascertain what difference exists.
3.12.5. Remove cap from oil pressure retulator. (See also para 2.9.).
3.12.6. With the aid of a screw driver turn slotted set pin anti-clockwise or clockwise, respectively, to obtain a lower or higher oil pressures as required.
3.12.7 .Adjust oil pressure regulator so that oil pressure gauge indicates at least 1 atm. (14.7 psi) above gas suction pressure.
3.12.8. Screw cap back on oil pressure regulator.

3.13. PREPARATION FOR REFRIGERATING PLANT OPERATION

3.13.1. After completion of erection of a new cooling plant, the following procedure must be carried out, before it can be put into full operation.

3.14. LEAK TEST

3.14.1. This test is not only meant to trace leaks, but at the same time to ensure the soundness of all, welded and other connections made during the erection of the plant. To carry out this test, the entire system should be filled with gas under pressure at 10-12 atm. (147-176.5 psia). Usually this gas will be air (as dry as possible) but for halocarbon refrigerants, it is preferable to use nitrogen. To fill the plant the use of an air compressor or cylinders containing compressed air or nitrogen is recommended. On no account oxygen should be used.

3.14.2. The compressed gas is introduced into the plant via the charging valve for the refrigerant. In the case of cylinders, a reducing valve must be used.

3.14.3. In principle, the refrigeration compressor is not suited, to be used as an air compressor. If, however, nothing else suitable is available for this test, it is permissible to use the refrigeration compressor as an air compressor, provided it is operated in the following manner:-

3.14.4. Shut suction stop valve and disconnected it from refrigerant suction strainer housing.

3.14.5. Close all system drains and open all remaining stop valves, so that the whole plant from compressor to suction stop valve is open.

3.14.6. Adjust high pressure cut-out (if fitted) at 17 atm. (250 psi).

3.14.7. Start compressor (see para 5.2)

3.14.8. Check temperature of cylinder covers with a suitable thermometer. As soon as temperature exceeds approx. 120^{o}C (about 248^{o}F) stop compressor.

3.14.9. Restart compressor when temperature has fallen sufficiently.

3.14.10. Repeat step 3.14.8. And 3.14.9. As often as necessary to obtain gas delivery pressure of 10-12 atm.(147-176.5 psia).

3.14.11. Moisten all spots where a leak is believed to exist with a solution of four parts of water and one part of soapsuds. Soap bubbles appearing indicate that a leak exists. Mark these points

3.14.12. Release pressure via all drains fitted in the system.

3.14.13. Repair leaks and repeat leak test, until all leaks have been traced and repaired.

3.14.14. Shut the delivery stop valve and maintain a pressure of 10-12 atm. (147-176.5 psia) in the system for about twelve hours. If at the end of this period, no drop in pressure has occured, the circuit is gas-tight.

3.14.15. Readjust high ipressure cut-out to about the correct setting. When the plant is finally put into operation, this pressure cutout must be reset to the exact setting.

3.14.16. Reconnect suction stop valve to the refrigerant suction strainer.

3.15. EVACUATION OF SYSTEM

3.15.1 Before charging the system with refrigerant, air and water must be cleared from the compressor and plant. This can be done in two different ways, viz. With refrigeration compressor and vacuum pump (for halocarbon plants) or with refrigeration compressor alone (for NH_3 plants)

3.16. WITH COMPRESSOR AND VACUUM PUMP (FOR HALOCARBON) PLANTS)

3.16.1. The halocarbon plant mus be thoroughly dried before charging it with gas; otherwise a mixture of water and refarigerant will produce certain acids which will deleteriously affect the system, causing corrosion, scale to collect internally and impairing the performance and reliability of the plant. In addition, water may cause bolckade through freezing particularly in low temperature plants. Water at a temperature of 20^{o}C (68^{o}F) boils at a vacuum of 743 mm (29.25”) mercury equal to an absolute pressure of 17 mm (0.6875”) mercury or 0.022 ata (0.3124 psia). The water vapour contained in the system decreases, in proportion to the degree of vacuum. As the compressor cannot create a high vacuum on its own, a high vacuum pump should be used to evacuate the plant. This is particularly important for low temperature plants. It is recommended, that the evaporators, condensers etc. Should be warmed during evacuation. The time required for this cannot be laid down strictly as it depends on the capacity of the vacuum pump and the volume of the plant.

3.16.2. The reading of most vacuum gauges is not sufficiently accurate to determine whether the plant has been evacuated adequately. As this is very important for halocarbon plants, the pump outlet should be provided with a tube or hose discharging into a vessel filled with oil. The evacuation should be stopped only when there are no air bubbles visible in the oil. Evacuating the plant after first filling it with nitrogen, will ensure that it is thoroughly dried. Any moisture still present in the system is absorbed by nitrogen and exhausted with it. This operation should be carried out as follows:-

3.16.3. Shut suction and delivery stop valve and disconnect delivery pressure gauge line from delivery manifold. Shut all drain valves and also oil return valve on the oil separator.

3.16.4. Open all remaining system stop valves, thus ensuring that the system is open from delivery stop valve to suction stop valve. In case, a low pressure cut-out has been fitted, disconnect it.

3.16.5. Start compressor and open suction stop valve slowly, as far as is necessary. Air as discharged from the plant, via the open delivery pressure gauge connection. Be careful that the delivery pressure does not rise too much.

3.16.6. Stop compressor, as soon as, oil return jet behind oil level glass disappears or the cylinder heads become too hot.

3.16.7. Shut suction stop valve.

3.16.8. Connect high vacuum pump to the system (some plants have a special connection for this pupose)

3.16.9. Start vacuum pump and open stop valve between vacuum pump and system.

3.16.10. When most of the air has been evacuated form the system, attach hose, discharging into an oil filled vessel, to outlet of the vacuum pump.

3.16.11. Shut stop valve between vacuum pump and system when gas bubbles are no longer seen to rise in the oil and then stop pump.

3.16.12. Fill system with nitrogen.

3.16.13. Release nitrogen, via a hose leading into the open air until atmospheric pressure of 1 at a prevails in the system.

3.16.14. Shut stop valve between release line and system.

3.16.15. Start compressor and open suction stop valve slowly.

3.16.16. Repeat steps 3.16.6, 3.16.7, 3.16.9, and 3.16.13.

3.16.17. Shut delivery and suction stop valves and hold the vacuum in the system for 24 hours.

3.16.18. Reconnect delivery pressure gauge line to delivery manifold. The plant is now ready to be charged with the refrigerant.

3.17. WITH COMPRESSOR ALONE (for NH_3 plants)

3.17.1. NH_3 Plants are generally evacuated with the refrigeration compressor only.

3.17.2. Shut all stop valves connecting to the atmosphere and at the same time, the suction and delivery stop valves. Also shut the stop valve in the oil return line of the oil separator.

3.17.3. Open all other stop valves.

3.17.4. Disconnect low pressure cut-out (if fitted).

3.17.5. Disconnect delivery pressure gauge line from delivery manifold.

3.17.6. Start compressor with suction valve shut. After starting up the compressor, open suction stop valve slowly, but only as far as needed, to prevent delivery pressure from rising too much and compressor from running hot.

3.17.7. Pay full attention to lubrication of the compressor during evacuation. Stop compressor immediately, when oil return jet behind oil level glass disappears.

3.17.8. Reconnect delivery pressure gauge line to compressor. The plant is now ready to be charged with ammonia.

3.18. REFRIGERANT CHARGING

3.18.1. Only after the system leak test, evacuation and drying out, in the case of halocarbon plants have been carried out, the system should be charged with refrigerant. It is recommended to ventilate the compressor room well while charging the system with refrigerant (see also safety rules). The following procedure should be adopted:-

3.18.2. Make sure that a vacuum exists in the system and that all stop valves in the circuit are open.

3.18.3. Weigh refrigerant cylinder and check that it contains the proper refrigerant, even when indicated on the cylinder label.

3.18.4. Connect a charging line to the cylinder.

3.18.5. Connect charging line to refrigerant charging valve in the system, but do not tighten the union nut.

3.18.6. Open cylinder stop valve slowly and tighten the union nut as soon as refrigerant gas escapes past it. The charging line is now purged. Open cylinder stop valve completely.

3.18.7. Open refrigerant charging valve slowly. In the case of small plants, it will now be necessary to proceed directly with step 3.18.10 as the cylinder cannot be completely emptied.

3.18.8. Shut cylinder stop valve and then refrigerant charging valve. Once the cylinder is empty (frosted charging line thaws), disconnect charging line from cylinder and weigh empty cylinder.

3.18.9. Weigh new cylinder, check the contents and connect it to charging line. Open cylinder stop valve slowly.

3.18.10. Start cooling water pump and open cooling water stop valves on condenser.

3.18.11. Shut liquid stop valve of condenser as well as compressor suction stop valve.

3.18.12. Start compressor (see 5.2.).

3.18.13. Open refrigerant charging valve slowly and then compressor suction stop valve.

3.18.13. Open refrigerant charging valve slowly and then compressor suction stop valve.

3.18.14. Repeat steps 3.18.8, 9, 12 and 13 until the required quantity of refrigerant has been taken in. It is recommended to stop the compressor, as soon as the bottle is empty.

3.18.15. Shut suction stop valve and refrigerant charging valve, disconnect bottle and remove charging line.

3.18.16. Reset L.P. Cutout (if fitted) at the correct setting. When the refrigerant requires topping up, step 3.18.3. Up to 3.18.6. Inclusive and 3.18.10. Up to 3.18.15 inclusive, should be carried out.

3.19. PURGING THE SYSTEM

3.19.1. As the presence of air causes a lot of trouble, the cooling plant must be purged from time to time. Purging is carried out while the compressor is at a standstill and the cooling water left open to the condenser, that is where air mainly collects. The air vent valves, which may be fitted on the gas delivery line or on the condenser, and/or on the liquid receiver, should be fitted with a hose capable of discharging into water. During purging, the vent valves should be opened a 1/4 -1/2 turn only.

3.19.2. On NH_3 plants the hose is kept under water subsequent to opening the air vent valve. Once any bubbles stop rising, only pure ammonia gas escapes which immediately dissolves in the water. The plant is then purged, and the air vent valve should be shut and the hose removed. On R-12 and R-22 plants, the air vent valve should be cracked open and held thus until the system pressure corresponds to the gas saturation pressure at the ambient temperature. The connecting hose must lead to the open air, so that the gas discharged can escape without dangerous effects.

NOTE:- Normally it will be necessary to repeat the purging operation. Every time between each purge, the compressor should be operated for some time, so that any residual air may be returned to and trapped in the condenser.

For correct compressor operation several settings are necessary. Viz:-

3.20. OIL PRESSURE REGULATOR

3.20.1. The oil pressure must be adjusted at 1-1.5 atm (14.7.-22 psi) above suction pressure (see para 2.9).

3.21. PRESSURE CUT-OUTS

3.21.1. These devices serve as a protection against conditions which may be harmful to plant and/or compressor (see para 2.13). The setting of these devices depends on the plant and compressor type.

3.22. OPERATING PROCEDURE

3.22.1. Starting and stopping the compressor should be carried out carefully to prevent mistakes and accidents. Each plant has its own sequence of operations for starting and stopping. As only the compressor is discussed here, the operating manual for the relative plant should be consulted.

3.23. STARTING

3.23.1. When starting the machine for the very first time, or after complete dismantling, it may happen that the gears of the oil pump are dry and the pump has difficulty in picking up the oil. In this case the union nut on the upper line between oul suction strainer and oil pump should be loosened and the oil pump casing filled with oil. The union nut should then be retightened. The shaft seal can also become dry. Therefore, prior to starting the compressor after a long standstill. The oil return line has to be disconnected from the shaft seal cap. This cap is to be filled entirely with clean compressor lubrication oil. Afterwards the oil return line can be re-connected. While starting the following procedure should be adopted.: -

3.23.2. Make sure that suction stop valve of compressor and liquid stop valve of liquid, receiver are shut. Check position of manually operated expansion valve (iffitted) and the oil level.

3.23.3. Open delivery stop valve of compressor and all other stop valves in refrigerant circuit, except those mentioned in step 3.23.2. (See also operating manual of relative cooling plant for cooling water, etc.).

3.23.4. Start compressor. After about one minute it will become operative (see para 2.14).

3.23.5. Open compressor suction stop valve slowly. Make sure that no liquid stroke occurs. The lower parts of the suction lines may under certain conditions still contain liquid refrigerant.

3.23.6. Open liquid stop valve completely.

3.23.7. Adjust pressure gauge stop valves in such a way that pointers do not vibrate.

3.23.8. Consult the operating instructions for the plant for any further action required. In compressors fitted with automatic capacity control, nothing further requires to be done. In compressors fitted with automatic capacity control, nothing further requires to be done. In compressors with manually operated capacity control, however, the second cylinder should be switched on.

3.23.9. During the first quarter of an hour after putting the compressor into operation, its functioning should checked carefully and during that time the attendant should not leave the compressor room.

3.24. SUPERVISION DURING OPERATION

3.24.1. While the compressor is operating the following should be checked regularly:-

3.24.2. Lubrication (oil pressure, oil level and oil return jet behind oil level glass).

3.24.3. H. P. Safety valve leakage (see para 2.12).

3.24.4. Pressure gauges, correct pressures, (see also operating instructions for cooling plant), gauge pointers stationary.

3.24.5. Cylinders head cooling, if fitted (adequate cooling water flow and correct temperature of cooling water outlet).

3.25. STOPPING

3.25.1. Shut liquid stop valve on condenser and then compressor suction stop valve.

3.25.2. Stop compressor.

3.25.3. Consult operating instructions for the related cooling plant for any further action required.

MAINTENANCE

4.1. GENERAL

The compressor, like any other machine, requires regular maintenance. If it is maintained well the cost of this work is recovered, for the most part, in improved performance and increased life of the compressor. It is, therefore recommended to ensure adherence to the following instructions. There is, however, no objection to carry out the following, at times other than those indicated, provided the periods in between them do not exceed the stated number of hours. It is at any rate necessary to inspect the compressor completely every year. Irrespective of the number of hours it has run.

CAUTION: It is strongly recommended to wear a gas mask, when the compressor must be opened. In spite of the evacuation of the compressor there still remains some refrigerant gas in it, which will freely escape into the open air and thus be inhaled with all resultant consequences.

4.2 RENEWING OIL

4.2.1.100 hours running after the initial start of the compressor. Then after a further 500 hours running and again after every 1,500 hours running.

4.3. LUBRICATION INSTRUCTIONS

4.3.1. It is very important to pay full attention to the lubrication of the compressor. The lubrication record chart will be of great assistance, provided that the records are accurately filled in regularly. With the aid of this record, times of all renewal, as well as consumption can be checked.

4.3.2. Never mix different brands of oil.

4.3.3. Topping up may be carried out with the compressor operating, consequently without any interruption in the operation of the plant, provided an additional separate oil pump is available. This pump may be connected to the oil charging valve.

4.3.4. Topping up by means of crankcase evacuation by the compressor itself, causes only a short interruption in plant operation, provided a drum with the oil to be charged is connected to the oil charging valve, before the suction stop valve is being closed. After shutting the suction stop valve the crankcase pressure will fall. When this pressure has fallen below atmospheric, the oil charging valve can be opened. When the oil level reaches the center of the oil level glass, the oil charging valve must be closed. The suction stop valve should then be opened very slowly.

4.3.5. Renewal of the oil should be carried out with the compressor stopped (at working temperature). Before opening the crankcase, it should be evacuated to remove the refrigerant gas.

4.3.6. While the compressor is operating, regularly check the oil pressure indicated on the oil pressure gauge the oil level and the oil return jet behind the oil level glass. The oil pressure must be 1-1.5 atm (14.7-22 psi) above suction pressure. Behind the oil level glass a steady and regular oil return jet should be visible. At all times the level should be visible in the oil level glass.

4.3.7. Half an hour after the initial start, the oil strainers should be cleaned. Then, for some days, after every 4 hours running. When the strainers remain virtually clean, after every 500 hours running. For brands of oil see lubrication chart (Ref. 2.10.6)

4.4. PERIODIC INSPECTION

4.4.1. Periodic inspection should be made during the normal shut-down periods as much as possible, so that the compressor is always available for operation when required. If, at that time, the total number of running hours differs somewhat from the figures stated, the inspection should nevertheless be carried out. In this way it will not be necessary to have to the stop compressor at an inconvenient time.

4.4.2. The number of running hours between these inspections have been established so that the inspection of several items coincides and may be carried cut simultaneously. This procedure will keep the maintenance cost as low as possible.

NOTE :- When it is necessary to work on the compressor, the machine must always be evacuated beforehand.

4.5. OIL STRAINER

4.5.1. The oil strainers can best be cleaned as follows:-

4.5.2. Evacuate the compressor

4.5.3. Remove the strainer cap with the filter element and then the drain plug at the bottom of the strainer housing. Collect the out-flowing oil in a tray.

4.5.4. Screw the filter element off the cap and thoroughly move the element through a tray containing either rinsing oil or carbon tetrachloride.

4.5.5. Throughly shake out the element and try it intensely, which can most easily be done with compressed air.

4.5.6. Rinse the strainer housing with rinsing oil (not with tetrachloride) and blow through it afterwards with compressed air or dry it up with a non-fibrous cloth.

4.5.7. Refit the plug with packing into the strainer housing and fill the housing up to the lower line with the same brand of oil as contained the crankcase.

4.5.8. Screw the strainer element into the strainer cap and refit the whole in the strainer housing. Tightly secure the cap screws.

4.5.9. Purge the compressor. (See para 5.4).

4.6. VALVES

4.6.1. Dismantle the vales completely for inspection purposes, after the first 500 hours running. Subsequently, after every 1000-1,500 hours running. Even the slightest damage to the valve rings makes it necessary to renew them. Damaged valve seats must also be repaired or renewed. If the seat face lips are only slightly damaged, they can be repaired on a completely smooth glass plate by grinding them with a very fine abrasive compound. Badly damaged seat face lips can no more be repaired. In that case it will be necessary to fit a new valve.

NOTE:- The valves are only available as a complete assembly except the valve rings and valve springs. (See also parts list).

4.6.2. Before reassembling the valve, all the parts should be cleaned and dried carefully. Then they should be lightly oiled with the same oil as used in compressor. After reassembling, check that the valve ring can be pushed up, flat against the stroke limitor. Only in this way, the correct assembly of the valve ring and valve springs is ensured.

Warning: It is emphatically pointed out that assembly of the valves should be carried out most carefully. Incorrectly assembled valves will immediately give rise to trouble.

4.6.3. It is recommended to have as many complete valve assemblies in stock as there are cylinders. This will considerably reduce the shut-down period of the compressor during routine inspection of the valves, since complete new valve assemblies can be fitted directly to the compressor in plate of the original valves. Those removed can be inspected at leisure and repaired as necessary, once the compressor has been put back into operation with the new valves. Spare parts should also be available, in order to completely renovate damaged valves. All valve rings and springs even when apparently in good condition must be renewed after about 6,000 hours running.

NOTE:- When valve components are replaced, it is important to make a note of the date in the compressor record book; so that a ready check is available to indicate when valve rings and springs require renewal.

4.7. PISTON RINGS

4.7.1. The piston and scraper rings should be inspected after every 6,000 hours running. In the stretched and cold condition they should have a gap clearance of 0.6-0.7 mm. (0.024”-0.028”). These rings must never be removed from the pistons if not strictly necessary. Only when it is essential, they should be removed and then only with the correct ring removal tool. When fitting a complete new set of piston rings, the chromium-plated one must always be fitted in the top -most groove of the piston. Measuring the ring gap clearances can be carried out by pulling up the piston so that the ring to be checked is visible in the top of the cylinder, but still remains in its. The gap clearance can, then be measured with a feeler gauge.

4.7.2. When for some urgent reason or other it is necessary to remove the gudgeon pin, then first remove the circlips. Next it is necessary to heat the piston up to about 80^{o}C, (prefer- ably on an electric element) after which the gudgeon pin can be simply pressed out of the piston.

CAUTION: (1) On no account must the pin be hammered. While fitting the gudgeon pin, the piston must first be heated up to about 80^{o}C after which the pin can be softly forced into the piston. Here, too, it is forbidden to hammer the pin into the piston.
(2) For heating-piston, Direct flame must never be used.

4.8. SAFETY VALVES

4.8.1. The safety valves should be inspected only if they are leaking. They should be then disconnected, dismantled and cleaned. Upon reassembly, they should be lightly oiled with the same oil as used in the compressor.
Warning : The compressor must on no account be kept running with an open or leaking safety valve, as the machine would then become too hot and the possibility of damage to, or even seizure of the pistons and cylinders, could arise. When the cylinder block is getting too hot without the delivery pressure being too high, the safety valve must be leaking and requires replacement or renewal.

4.9. SHAFT SEAL

4.9.1. The shaft seal should be inspected after about 4,500 hours running. In most cases only the rubber O-rings will have to be renewed to ensure that a reliable seal is maintained.

4.10.BEARINGS

4.10.1. All the bearings should be inspected after 6,000 hours running. When a main bearing bush, located in either of the bearing covers, requires renewal, particular attention should be paid to ensure that it is inserted absolutely true to the centre line of the housing bore. If it is introduced even slightly out of the true, it will become distorted and will remain so, even if forced fully home into the housing. It is therefore essential that the bush should be pressed into the bearing cover. While both of them are held true between the parallel faces of a press.

4.10.2. A locating pin is fitted in the end face of both bearing covers. This fits into one of the recesses in the end collar of the bush, thus preventing it from rotating. The main bearing bushes are provided with an oil distribution well and the covers must be fitted to the compressor in such a way that the well lies in a position 45 degree from top dead centre, measured in the direction opposite to the rotation of the shaft. While assembling the connecting rods to the crankshaft full attention should be paid to tightening of the connecting rod bolts. These bolts should be so tightened that both connecting rod halves touch. (Tightening torque 3.5-4.5 kgm.)

4.11. OIL PUMP

4.11.1. The oil pump should be completely dismantled after every 9000 hours running. Various parts of the pump will have become dirty by that period, may impair its efficient operation and cause unnecessary wear, if not rectified. Make sure that the oil pump is reassembled correctly. Incorrect operation of the oil pump will cause faulty lubrication and / or mal-functioning of the compressor control, if fitted. This may result in additional wear, or even damage to the compressor.

NOTE:- On dismantling, the gears should be so marked that, on reassembling, it is possible to refit them in exactly the same way. This is necessary as the gears are meshed to each other. Be careful that no material heaps up on the marked sport.

4.12. REFRIGERANT SUCTION STRAINER

1.12.1. After the initial start of the compressor, this strainer should be cleaned during the first week, after every 8 hours running. Then after every 25 hours running. When practically no dirt and scale is trapped every 500 hours running. For cleaning the suction strainer proceed as follows:

4.12.2. Shut the suction stop valve and start the compressor.

4.12.3. Shut the stop valve of the automatic oil return valve on the oil separator.
4.12.4. Shut the delivery pressure gauge stop valve and disconnect the high pressure cut-out (if fitted).

4.12.5. Connect to this pressure gauge stop valve a hose leading to the open air.

4.12.6. Wait until the suction pressure gauge indicates a vacuum of at least 70 cm . (Mercury).

WARNING:- Pay due attention to the compressor lubrication. The oil jet behind the oil level glass should always remain visible.

4.12.7. Slowly close the delivery stop valve and open the stop valve of the delivery pressure gauge at the moment that the delivery stop valve is entirely being closed.

4.12.8. Pay attention to the compressor lubrication. Stop the compressor as soon as the lubrication ceases (The oil jet behind the oil level glass disappears).

The compressor is now evacuated.

4.12.9. Remove the nuts and bolts of the suction strainer end flange and remove this flange (if necessary, by using a screw driver)

4.12.10. Take the strainer element out of the strainer housing and clean it thoroughly with tetrachloride.

4.12.11. The strainer element should be dried thoroughly (preferably with compressed air)

4.12.12. Insert the strainer element again in the strainer housing and fit the end flange. Make sure that the gasket is still suitable.

4.12.13. Purge the compressor according to para 5.4.

NOTE : Do not forget to remove the hose leading to the open air.

5. MAINTENANCE SCHEDULE

5.1. DAILY INSPECTION:- Oil level.
Oil pressure.
Tension of V-belts (if applied).
Shaft seal leakage.
Delivery pressure within normal limits.
Cylinder head temperature not too high.
Sufficient cylinder head cooling (if applied).

ATTENTION: Before carrying out the work mentioned below, the compressor should be evacuated.. When the work has been completed, the compressor should be purged.

5.2. RUNNING IN OPERATION

5.2.1. ½ hour running after the initial start:- Clean oil strainers thoroughly.

5.2.2. After every 4 hours running:- Clean oil strainers (until they remain clean).

5.2.3. After every 8 hours running :- (for a period of 1 week) Clean oil strainers (until they remain clean). Clean refrigerant suction strainer.

5.2.4. After every 25 hours running :- Clean refrigerant suction strainer. (Until strainer remains practically clean).

5.3. NORMAL OPERATION

5.3.1. 100 hours running after the initial Start:- Clean refrigerant suction strainer. Clean oil strainers. Clean oil strainers. Renew oil (see lubrication instructions).

5.3.2. 500 hours running after the initial Clean refrigerant suction strainer. Clean oil strainers. Clean oil strainers. Renew oil (see lubrication instructions). Completely dismantle and inspect all valves.

5.3.3. After every 500 hours running:- Clean oil strainers. Clean refrigerant suction strainer.

5.3.4. After every 1.500 hours running:- Clean oil strainers . Clean refrigerant suction strainers. Renew oil. Dismantle and inspect all valves.

5.3.5. After every 4500 hours running:- Clean oil strainers. Clean refrigerant suction strainer. Renew oil. Inspect shaft seal.

5.3.6. After every 6000 hours running:- Clean oil strainers. Clean refrigeration suction strainer. Renew oil. Inspect piston and scraper rings. Inspected all bearings. Renew valves.

5.3.7. After every 9000 hours running:- Clean oil strainers. Clean refrigerant suction strainer. Renew oil. Inspect shaft seal. Clean oil pump.

5.4. PURGING OF COMPRESSOR

5.4.1. Whenever maintenance is carried out on the compressor , it should be purged as follows:-

5.4.2. Close suction and delivery stop valves, if not yet closed.

5.4.3. Disconnect delivery pressure gauge line form delivery manifold.

5.4.4. Start compressor.

5.4.5. Wait until suction pressure gauge indicates a vacuum of 73-74 cm. (28.75”-29.12”) mercury.

5.4.6. Reconnect delivery pressure gauge to compressor. Mind the pressure gauge. If the delivery pressure increases, disconnect the delivery pressure gauge momentarily. When the pressure no longer rises appreciably, reconnect delivery pressure gauge permanently.

5.4.7. Stop compressor.

5.4.8. Slowly open delivery stop valve and then suction stop valve.

5.4.9. Restart compressor for about 5 minutes.

5.4.10. Purge the cooling plant in accordance with para 3.19.

6. ACCESSORIES

6.1. PRESSURE CUT-OUT

6.1.1. In the gas delivery and suction lines and the lubrication system, pressure cutouts may be fitted to protect both compressor and cooling plant. These pressure cut-outs are built into the electrical control circuit of the compressor driving motor and interrupt this circuit when abnormal working conditions occur.

6.2. HIGH PRESSURE CUT-OUT

6.2.1. This pressure cut-out serves as a protection against excessive pressure and is connected to the gas delivery line, via the common panel on the delivery oil strainer. The compressor is automatically switched off when the delivery pressure exceeds the present maximum valve. The pressure cut-out can also be arranged to operate via an auxiliary contact, an alarm lamp or a klaxon.

6.2.2. A locking device provides protection against automatic reclosing of the broken contact when the pressure falls below the preset maximum value. Moreover, to restart the compressor, the lock device has to be first reset manually.

NOTE:- Before restarting the compressor the reason for the stoppage should be traced and any troubles should be remedied.

6.3. LOW PRESSURE CUT-OUT

6.3.1. This pressure cut-out serves as a protection against too low an oil pressure and is connected both to the oil pressure and the suction pressure. Both connections run via the common panel on the delivery oil strainer. Thus the device is acted on by the above pressures. The minimum safe oil pressure is preset on the pressure cut-out. When oil pressure drops below the preset value, the electric motor is cut-out by interruption of the electrical control circuit. This circuit is automatically remedied when the pressure exceeds the preset value.

6.4.2. A short-circuiting device like an electric time relay or push button should be connected parallel to this pressure cut-out (if not already incorporated in the cut out itself) to enable the compressor to start initially before any oil pressure has been built-up.

6.5. CAPACITY CONTROL

6.5.1. Capacity control is used to balance the compressor capacity with the load. This is achieved by cutting in or one of the two cylinders. In standard capacity control system, there are two steps, viz, 50% and 100% capacity.

6.5.2. Capacity can be controlled either manually or automatically with electrically operated solenoid valve. In Manual control it is operated with electrical switch while in case of automatic control it is operated by either pressostat or thermostat.

NOTE: Capacity control is installed on special order. Only.

6.6. PRESSURE GAUGES

6.6.1. Three pressure gauges may be fitted viz. Suction, delivery and oil pressure gauge. These are assembled on a pressure gauge panel which can be secured to the wall by means of a bracket or can be mounted on a stand. In this way it is possible to observe all pressure gauges at glance.

6.7. DRIVE

6.7.1. The compressor is driven either by a flywheel, or by a direct flexible coupling. The flywheel is arranged for V-belt drive. The number and profile of the belts depend on the compressor horse power and speed.

NOTE: The flywheel belts and motor pulley must be protected by a belt guard.

6.8. OIL SEPARATOR

6.8.1. A plant is fitted with an oil separator to prevent the capacity of the system from being reduced by oil which has been carried over with the refrigerant. Particularly at very low temperatures this might also lead to blockade of the system owing to freezing of the oil in the evaporator. The separator is fitted between the compressor and the condenser. The oil separator (see fig 7). Consists of a closed cylinder fitted with a refrigerant inlet and outlet, an oil drain stop valve, an automatic oil return valve with float and a deflector plate. The compressed gas enters the separator and impinges on the deflector plate causing the heavier oil droplets to be deposited on it. The gas diffuses outwards in a radial direction, but is prevented from rising upwards by a baffle plate. The remainder of the oil still present in the gas is deposited upon the separator wall by the centrifugal effect of the gas flow.

6.8.2. The separated oil is collected at the bottom of the separator where a float controlled return valve is fitted. When the oil level exceeds a preset level, the valve opens and the oil is returned under pressure to the crankcase. (Pressure in separator exceeds crankcase pressure). The valve automatically shuts off when the oil level has fallen sufficiently.

6.8.3. The hand operated oil drain is fitted in order to be able to drain the surplus oil during the running-in period of a new compressor. During the running- in period the oil is heavily polluted and therefore must not be returned to the crankcase.

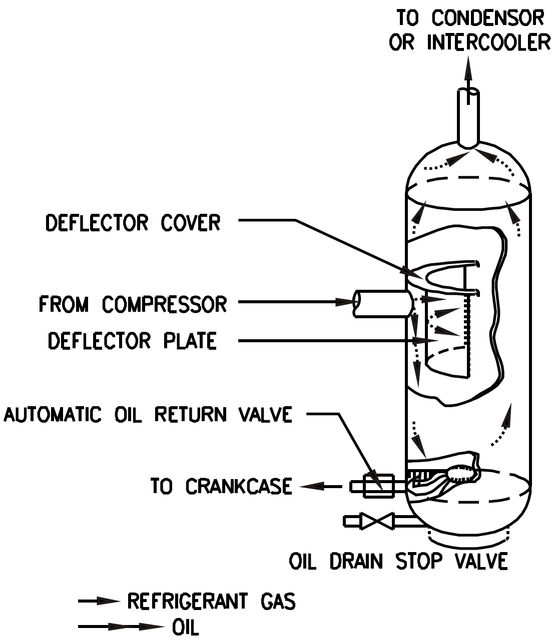


Fig. 7 : Oil Separator

6.9. **SURGE DRUM**

6.9.1. Frequently a new compressor may be installed in an existing plant. This mostly causes an increase in the capacity of the plant, resulting in a higher refrigerant gas velocity through the system. During the period prior to the installation of the new compressor, finely divided deposits may have collected at the lowest points in the system. As a result of the increased gas velocity, these deposits will be carried over to the gas suction strainer, of the new compressor. The compressor may thus be damaged and in order to prevent this, it is recommended that a surge drum should be temporarily fitted in the suction lines close to the compressor. The surge drum acts on the principle of admitting the gas into a large volume, with a consequent fall in its velocity.

6.9.2. In addition, when it is not quite certain that a new plant is internally clean, it is strongly recommended that a surge drum should be temporarily fitted in the suction line.

7. TROUBLE SHOOTING CHART

Sometimes faults may develop which prevent the plant and the compressor from operating satisfactory. Some of the most frequent faults, together with their causes and methods of remedying them, are tabulated below. With the aid of this table faults may be easily traced and remedied, thus limiting period during which the compressor is unavoidably stopped.

FAULT	CAUSE	REMEDY
7.1. Delivery pressure too high probably H.P. Cutout becomes operative) (On water-cooled condenser the temperature indicated by delivery pressure gauge rises more than 6^{o}C (11^{o}F) above that of cooling water outlet. On air cooled condensers the temperature indicated by delivery pressure gauges rises more than 10^{o}C (18^{o}F) above that of air temperature at condenser outlet).	7.1.1. Delivery stop valve not open wide enough	7.1.1. Open fully
	7.1.2. Too little or too warm cooling water	7.1.2. Increase water supply
	7.1.3. Gas suction pressure too high (during starting up period only)	7.1.3. Partially close stop valve.
	7.1.4. Suction pressure higher than normal	7.1.4. See 7.3
	7.1.5. Too much refrigerant in condenser	7.1.5. Open liquid control valve further or release some Liquid in the system.
	7.1.6 Condenser tubes blocked or dirty	7.1.6 Clean condenser
	7.1.7. Air in system	7.1.7 Purge system
	7.1.8. Defective delivery pressure gauge.	7.1.8. Repair or renew
7.2. Delivery pressure too low (as indicated by plant instruction manual)	7.2.1. Leaking H.P. Safety valve	7.2.1. Repair or renew
	7.2.2. Suction stop valve not open wide enough	7.2.2. Open fully
	7.2.3. Suction pressure lower than normal	7.2.3. See 7.2.2
	7.2.4. Faulty delivery pressure gauge	7.2.4. Repair or Renew
	7.2.5. Defective delivery valve	7.2.5. Renew
7.3 Suction pressure too high	7.3.1. Leaking H.P. Safety valve	7.3.1. Repair or renew
	7.3.2. Liquid control valve open too wide	7.3.2. Readjust setting
	7.3.3. Defective pressure gauge	7.3.3. Repair or renew
	7.3.4. Capacity control (if fitted) out of order.	7.3.4. Inspect and repair
	7.3.5. Suction or delivery valves defective.	7.3.5. Renew
	7.3.6. Excessive leakage past piston	7.3.6. Renew piston rings

FAULT	CAUSE	REMEDY
7.4. Suction pressure too low (probably L.P. Cut-out	7.4.1. Suction stop valve not open wide enough 7.2.2. Liquid control valve not open wide enough 7.4.3. Refrigerant suction strainer choked 7.4.4 Too little refrigerant in system	7.4.1 Open fully 7.4.2. Open further 7.4.3. Clean suction strainer 7.4.4. Top up with refrigerant
7.5. Liquid stroke	7.5.1. Liquid control valve wide open 7.5.2. Capacity control (if fitted) out of order 7.5.3. Defective evaporator float (if fitted)	7.5.1. Readjust setting 7.5.2. Inspect and repair 7.5.3. Inspect and repair or renew
7.6. Oil pressure too high during operation (during running-up period oil pressure is always higher than normal until operating temperature has been reached).	7.6.1. Oil pressure regulator defective or maladjusted 7.6.2. Defective pressure gauge	7.6.1. Repair or readjust 7.6.2. Repair or renew
7.7 Oil pressure too low (differential oil pressure cut-out probably operates).	7.7.1. Oil pressure regulator defective or maladjusted 7.7.2. Insufficient oil in crankcase 7.7.3. Gas suction pressure too low 7.7.4. Oil suction and/or delivery strainer blocked. 7.7.5. Oil suction pipe between crank case and oil suction strainer blocked. 7.7.6. Slack bearings 7.7.7. Blocking of oilways in crankshaft	7.7.1. Repair or readjust 7.7.2. Top up with oil 7.7.3. See 7.4 and para 2.11 7.7.4. Clean 7.7.5. Clean out or repair 7.7.6. Refit 7.7.7 Clean out
7.8 Pressure difference between suction and delivery pressure too small	7.8.1. Suction pressure too high 7.8.2. Delivery pressure too low	7.8.1. See 7.3 7.8.2. See 7.2
7.9 Cylinder block too hot (delivery pressure, however not too high.)	7.9 Leaking safety valve	7.9 Repair or renew
7.10Oil consumption too high	7.10.1. Automatic oil return valve of oil separator defective 7.10.2. Worn piston rings 7.10.3. Oil return valve(s) in cylinder jackets defective	7.10.1. Repair or renew 7.10.2. Fit new piston rings 7.10.3. Renew

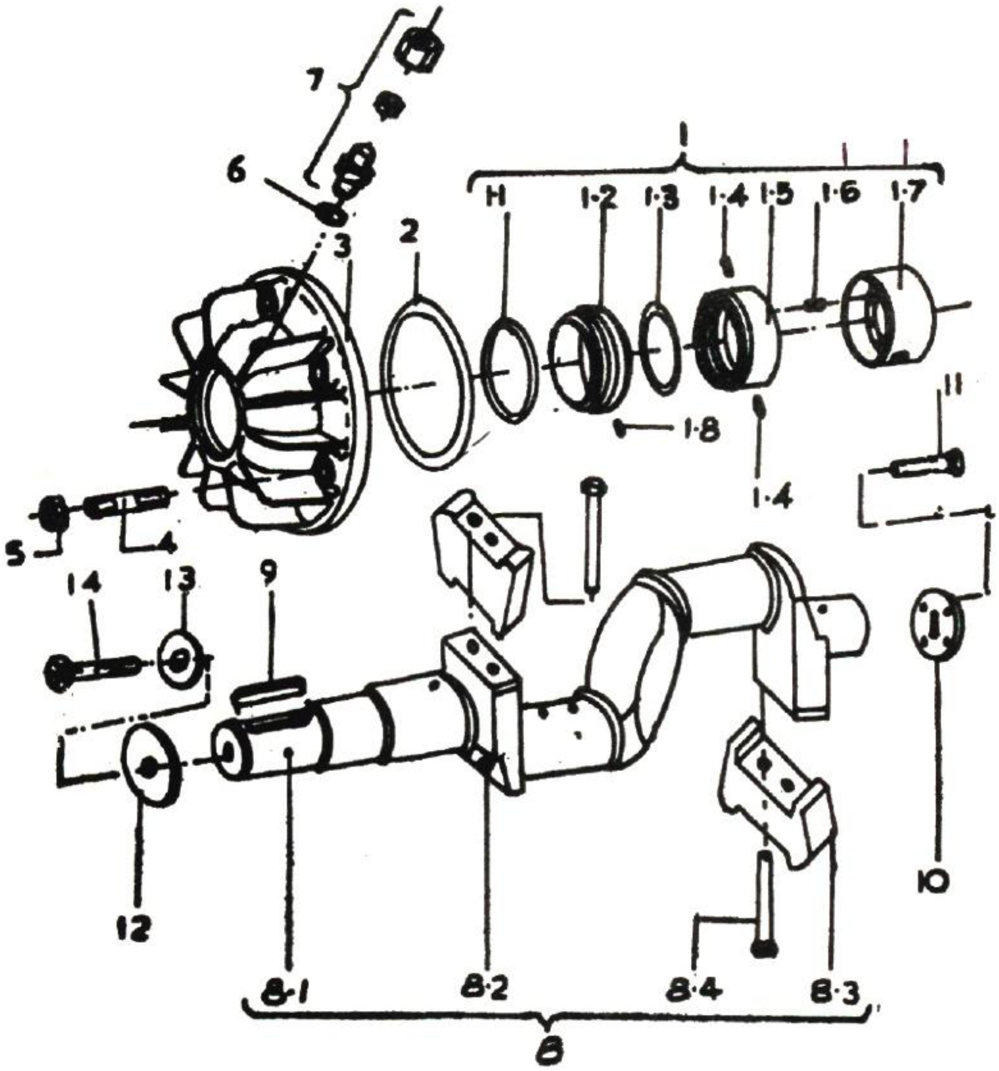


Fig. 8 : Crankshaft with shaft seal.

8. SPARE PARTS

Sr. No	Name of Parts	MX_No	Qty	I/P
8.1	**Crankshaft with Shaft Seal (Fig No.B)**			
1	Shaft Seal Complete	Xh80204050	1	
1.1	O Ring (Shaft Seal outer)	XH80204550	1	
1.2	Stationary Seal ring	XH80204480	1	
1.3	O ring (Shaft Seal inner)	XH80204251	1	
1.4	Set screw M4 x 8		2	
1.5	Rotary Sealing ring	XH80204150	1	
1.6	Spring (for Shaft Seal)	XH80204350	8	
1.7	Ring pressing		1	
1.8	Set Screw		1	
2	O Ring	Xh80205050	1	
3	Shaft Seal Cap	XH80203050	1	
4	Stud (M12 x 40L)	JJ90365350	6	
5	Hex Nut M12	JJ90565050	6	
6	Alu. Packing	JJ91853750		
7	Union socket Screw assly	JJ81626150	1	
8	Crankshaft Shaft complete	Xh80300150	1	
8.1	Cranshaft	HH80201150	1	
8.2	Grub Screw		2	
8.3	Counter weight		2	
8.4	Allen hd scres Grub M 10		4	
9	Key	XH80202050	1	
10	Carrier Plate	XH80207050	1	
11	Screw Hex Hd.	XH80208050	4	
12	Retaining Plate	XH80206050	1	
13	Spring Washer	JJ91127450	1	
14	Screw Hex Hd.	JJ90166450	1	

(a) Items 1.1 to 1.8 are available in a set & Sr. No. 1.1 and 1.3 are also available Separately.

(b) Items 8.1 to 8.4 are covered in a set.

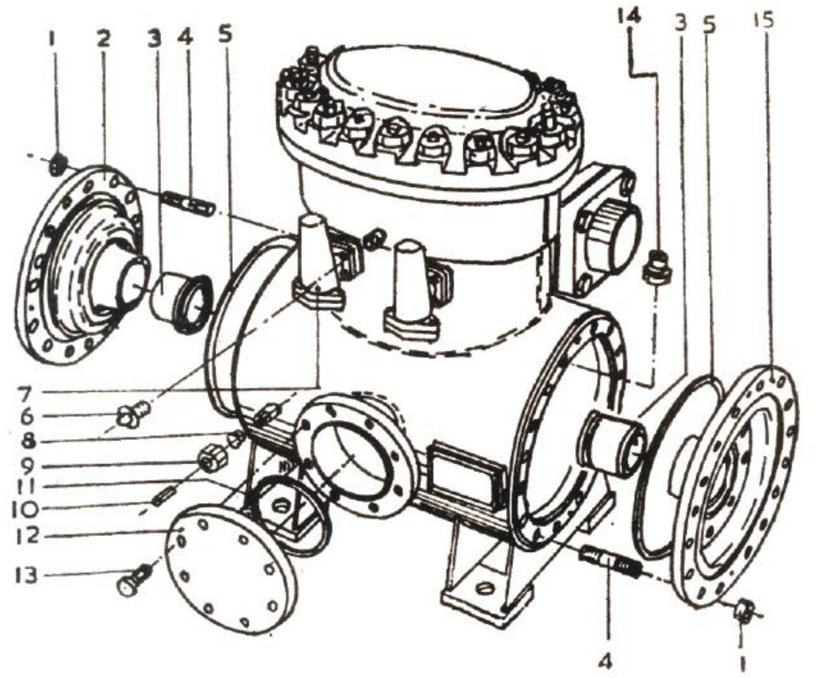


Fig. 9 : Frame MPX 2.

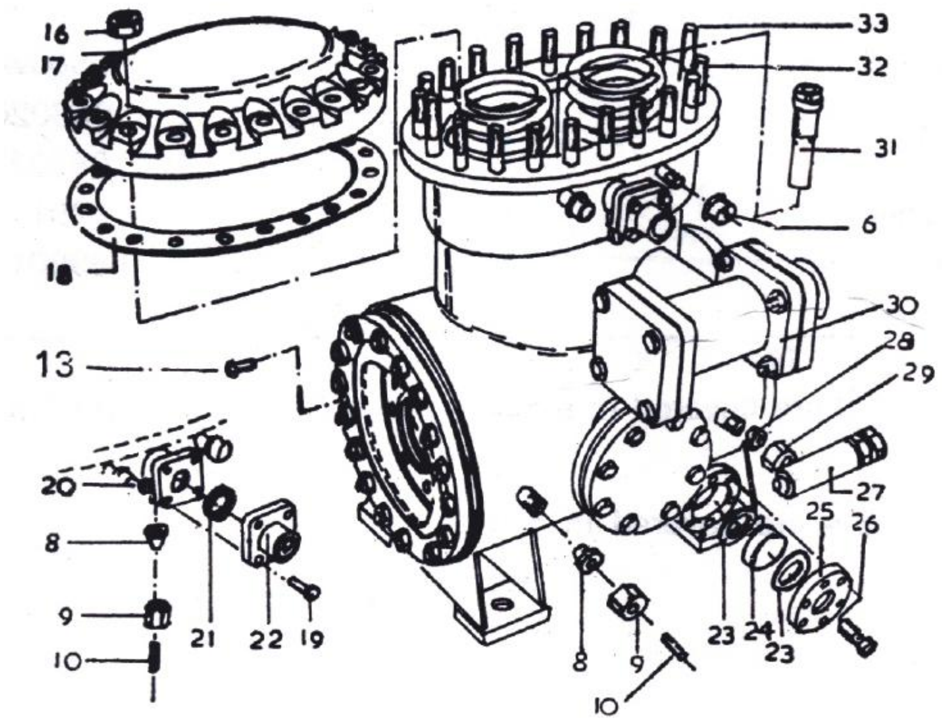


Fig. 10 : Frame MPX 2.

Sr. No	Name of Parts	MX_No	Qty	I/P
8.2	**Frme (See Fig 9 and Fig. 10)**			
1	Nut	JJ9068750	32	
2	Bearing Cover O/P Eng	XH80107050	1	
3	Main Bearing Bush	CE10800350	2	
4	Stud M 12 x CE	JJ90370250	32	
5	Gasket 0.5 mm thk. Bearing Cover	XH80108050	2	
5	Gasket 1.0 mm thk. Bearing Cover	XH80108250	2	
5	Gasket 1.5 mm thk. Bearing Cover	XH80108150	2	
6	Plastic Cap	XH20750050	3	
7	Valve Lifting Mechanism	Xh80700050	2	
8	Ferrule M6	JJ91600350	3	
9	Union Nut M6	JJ91606350	3	
10	Cylindrical Pin 6 dia	JJ90965050	3	
11	Gasket (Side cover to frame)	XH22863050/51	2	
12	Side Cover	XH21203151	2	
13	Hex hd Bolt	JJ90166850	16	
14	Oil Return Valve	XH20600050	1	
15	Bearing Cove F/ W End	XH80107050	1	
16	Nut Hex. Hd.	JJ90674250	20	
17	Cylinder Cover	XH80105050	1	
18	Gasket Cylinder Cover	Xh80106150	1	
19	Hex. Hd. Bolt	JJ90164350	4	
20	Hex. Nut	JJ90663250	4	
21	Gasket	XH50401850	1	
22	Flange	XH50402150	1	
23	Gasket (oil Level glass_pressing ring)	XH50501850	2	
24	Oil Level Glass	XH22817050	1	
25	Cover Sight Glass	XH22818050	1	
26	Hex hd. Screw M 8 x 30	JJ90162450	6	
27	Oil Pressure Regulator	XH21100050	1	
28	Ferrule	JJ91602150	1	
29	Union Nut	JJ91608150	1	
30	Suction Strainer Assly		1	
31	By_pass Safety Valve Assly	CE10102050	1	
32	Stud M 20 x M 16 x 65	JJ90375650	18	
33	Stud M 20 x M 16 x 70`	JJ90375750	2	
34	Cylinder Cover	XH80101550	1	
35	Frame	XH80101550		
36	Crankcase Base			
37	Compressor tool			
38	Compressor block P x 8			
39	M 8 x 30 L			

* As per Assembly required

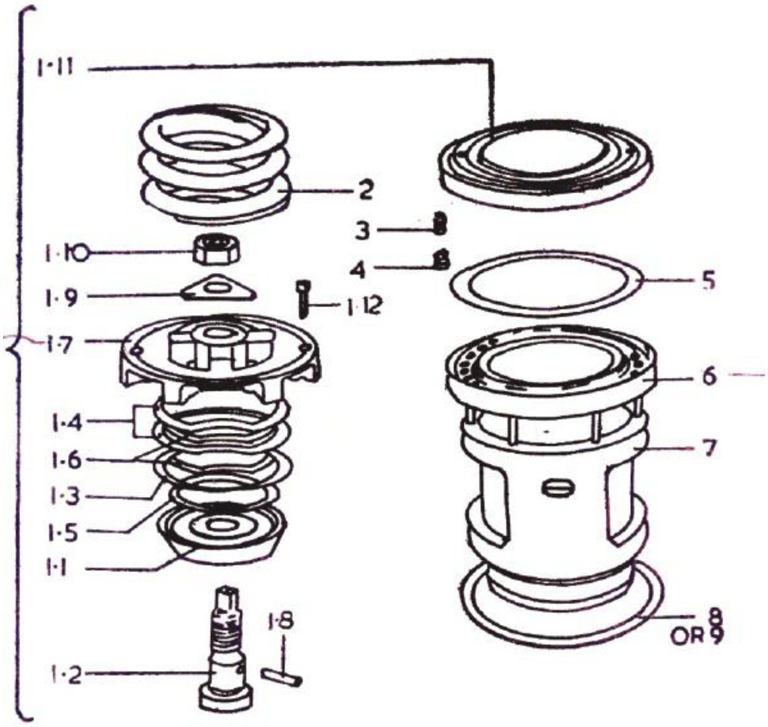


Fig. 11 : Cylinder and valve.

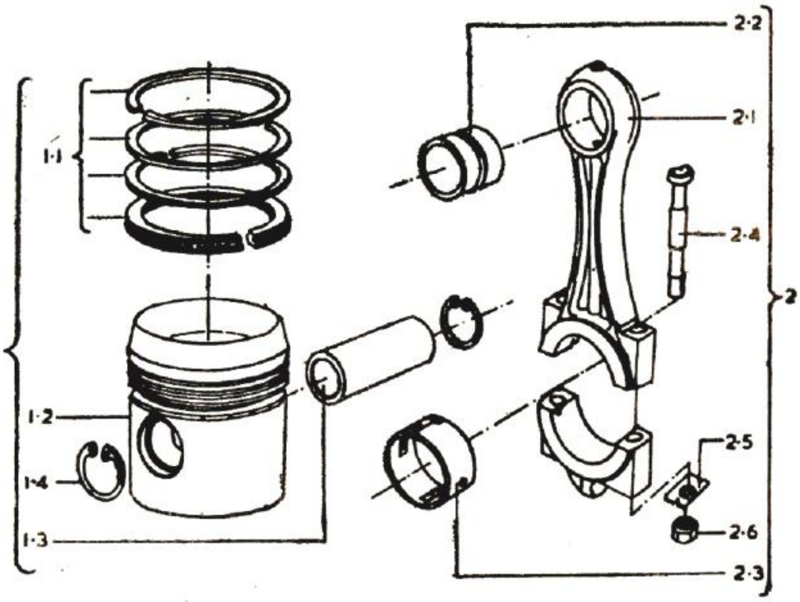


Fig. 12 : Piston and connecting rod assembly.

Sr. No	Name of Parts	MX_No	Qty	I/P
8.3	**Cylinder and Valve (Fig. No 11)**			
1	Delviery valve Assly	XH80600050	1	
1.1	Valve Seat	XH80614050	1	
1.2	Centre Bolt	XH80606050	1	
1.3	Delivery Valve Ring	XH80604050	1	
1.4	Spring wavy	XH80615050	2	
1.5	Delivery Valve Ring	XH21103050	1	
1.6	Spring wavy	XH21111050	2	
1.7	Delivery Stroke Limitor	XH80613050	1	
1.8	Locking Pin	JJ90965550	1	
1.9	Tab Washer	XH80609050	1	
1.11	Suction Stroke Limitor	XH80602050	1	
1.12	Allen hd. Screw	JJ90260750	1	
2	Buffer Spring	XH80612050	2	
3	Spring	XH22814050	12	
4	Cheese Hd. Screw	XH21110050	12	
5	Suction Valve Ring	XH80601050	1	
6	Cylinder Liner	XH80121050	1	
7	Valve lifting sleeve (with pins)	XH80700150	1	
8	Gasket (1 mm thk) (Cylinder liner & frame)	XH80122050	1	
9	Gasket (1.5 mm thk)	XH80122150	1	

Quantity given above is meant for one cylinder

Sr. No	Name of Parts	MX_No	Qty	I/P
8.4	**Piston & Connecting Rod Assembly (Fig No. 12)**			
	Piston Connecting Rod Assly			
1	Piston Assembly	XH80400050	1	
1.1	Piston Ring Set	XH80410050	1	
1.2	Piston	XH80401050	1	
1.3	Piston Pin	JJ91372450	1	
1.4	Circlip	JJ91372450	2	
2	Connecting rod Assly	XH80500050	1	
2.1	Connecting Rod with bolt	XH80505050	1	
2.2	Small End Bush	XH80502050	1	
2.3	Big End Bearing	XH80503050	1	
2.4	Connecting rod bolt	XH80504050	2	
2.5	Tab Washer (Safety Plate)	XH70609050	2	
2.6	Nut Hex. M 12 x 1.75 p	XH80510050	2	
	Connecting rod	XH80501050		

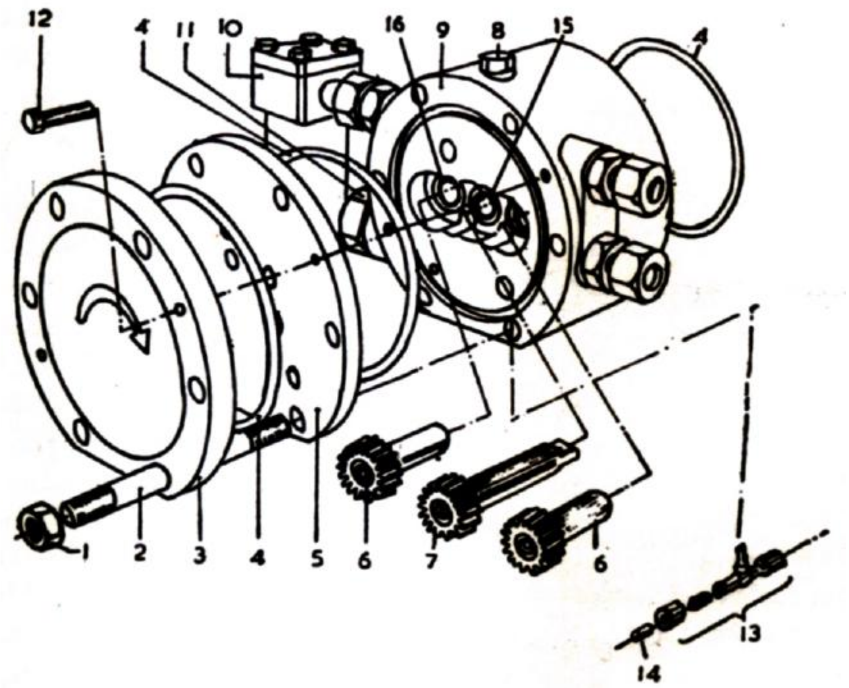


Fig. 13 : Oil pump assembly.

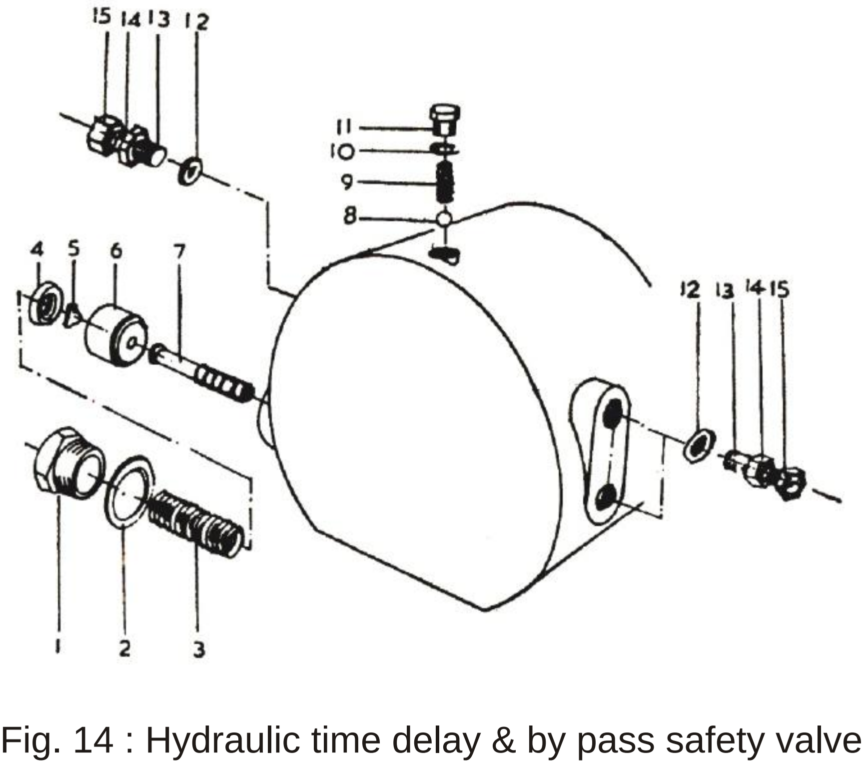


Fig. 14 : Hydraulic time delay & by pass safety valve

Sr. No	Name of Parts	MX_No	Qty	I/P
8.5	**Oil Pump Assembly (Fig No. 13)**			
	Oil Pump Assembly	XH80300050		
1	Nut M 12	JJ90665050	6	
2	Stud M 12 x 140 L	JJ90368950	6	
3	Oil Pump Cover	XH80306050	1	
4	O Ring	XH80205050	3	
5	Distance Plate	XH80305050	1	
6	Driven Gear Complete	XH80303050	2	
7	Driving Gear Complete	XH80302050	1	
8	By Pass Safety valve See Fig. 14		1	
9	Oil Pump body with Bushes	XH80301050	1	
10	Oil Strainer (Suction) see fig 18		1	
11	Hydraulic time delay See fig. 14		1	
12	Hex Hd Bolt	JJ901611050	2	
13	Union male stud tee tupe assly	JJ81660350	1	
14	Cylinderical pin	JJ90964250	1	
15	Bush	XH207CC050	1	
16	Bush	XH80301150	2	
17	Spindle _ Driven Gear	XH8030315	1	
18	Gear Wheel (2 x 17)	XH80302250	2	
19	Spindle Driving Gear	XH80302150	1	
8.6	**Hydraulic time delay & By Pass Safety Valve (See Fig. No 14)**			
1	Plug 1/2 BSP	XH20713050	1	
2	Aluminium Packing	JJ91856150	1	
3	Spring	XH20712050	1	
4	Oil Pump Stroke Limitor	XH20711050	1	
5	Valve Plate	XH20602050	1	
6	Piston Time Delay	XH20709050	1	
7	Hydraulic time Delay Plunger	Xh20708050	1	
8	Ball	JJ93078250	1	
9	Spring	XH70308050	1	
10	Aluminium Packing	JJ91852550	1	
11	Plug	XH80323050	1	
12	Aluminium Packing	JJ91853750	3	
13	Union Socket Screw	JJ91629150	3	
14	Ferrule	JJ91602150	3	
15	Union Nut	JJ91608150	3	

Item No. 1 to 7 are for Hydraulic time delay and 8 to 15 for by pass safety valve.

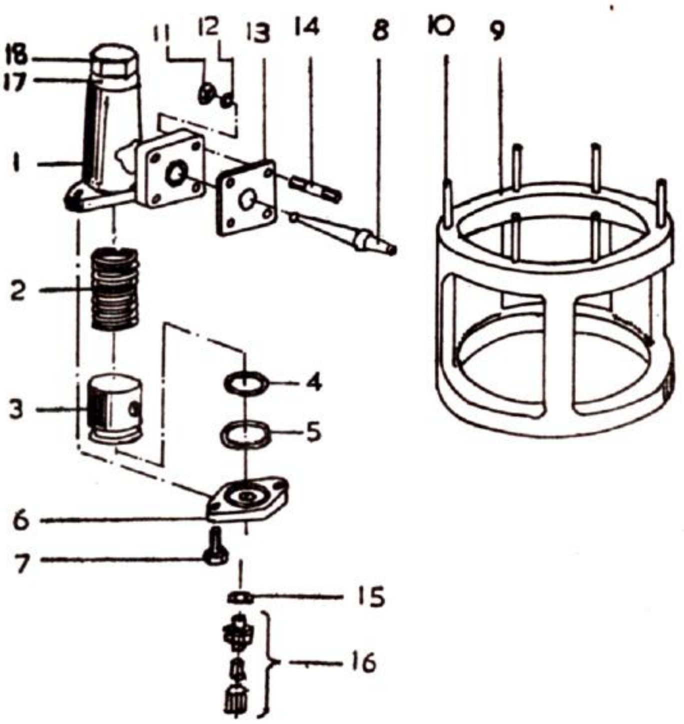


Fig. 15 : Valve lifting mechanism.

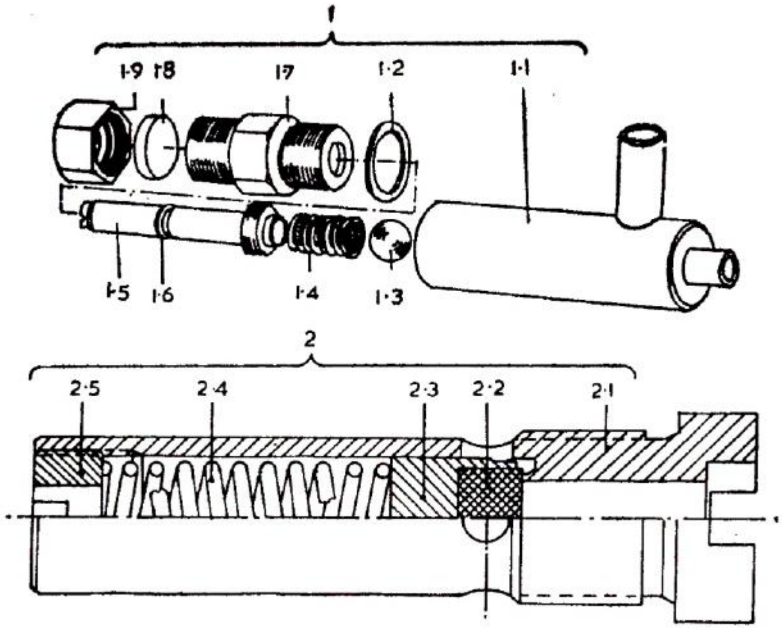


Fig. 16 : Oil pressure reulator and by-pass valve

Sr. No	Name of Parts	MX_No	Qty	I/P
8.7	**Valve Lifting Mechanism (Fig No. 15)**			
1	Housing for VLD	XH70703050	1	
2	Spring	XH80705050	1	
3	Piston	XH70706050	1	
4	O Ring	JJ91221300	1	
5	O ring	XH70710050	1	
6	Flange	XH80770950	1	
7	Screw Hex. Hd.	JJ90163850	2	
8	Lever for Rod	XH70707050	1	
9	Valve Lifting Sleeve	XH80701050	1	
10	Lifting Pin	XH80702050	6	
11	Nut	JJ90662350	4	
12	Washer	JJ91872050	4	
13	Gasket	XH70704050	1	
14	Stud M 8 x 30	JJ90362550	4	
15	Packing Aluminium	JJ91852550	1	
16	Union Socket Screw Assly	JJ91624350	1	
17	Packing	JJ91856150	1	
18	Plug 1" BSP	XH20713050	1	
8.8	**Oil Pressure Regulator Assly. & By_Pass Safety Valve Assly (Fig No. 16)**			
1	Oil Pressure regulator Assly	XH21100050	1	
1.1	Housing Assembly (Body)	XH20901051	1	
1.2	Aluminium Packing	JJ91853750	1	
1.3	Ball	JJ93078550	1	
1.4	Spring	XH20902050	1	
1.5	Set Pin	XH20903050	1	
1.6	O Ring	JJ91262750	1	
1.7	Nipple	XH20904050	1	
1.8	Alu. Packing	JJ91852550	1	
1.9	Blind union nut	XH22850050	1	
2.0	Safety By_pass Valve Assly	CE10102050	1	
2.1	Safety Valve Housing	CE10102150	1	
2.2	Disc Valve	CE10102250	1	
2.3	Piston Valve	CE10102CE0	1	
2.4	Spring	CE10102450	1	
2.5	Set Screw	CE10102550	1	

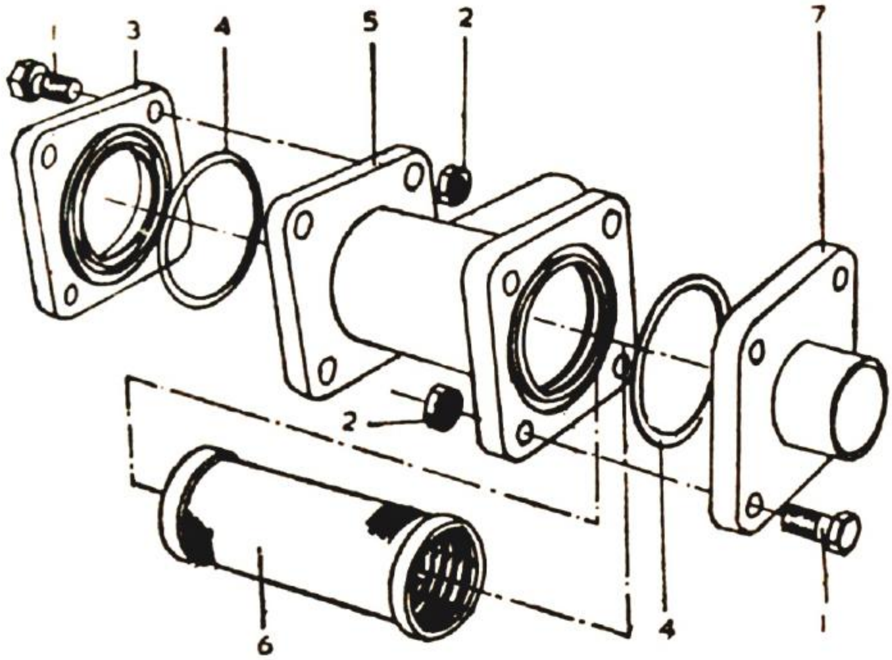


Fig. 17 : Suction strainer assembly.

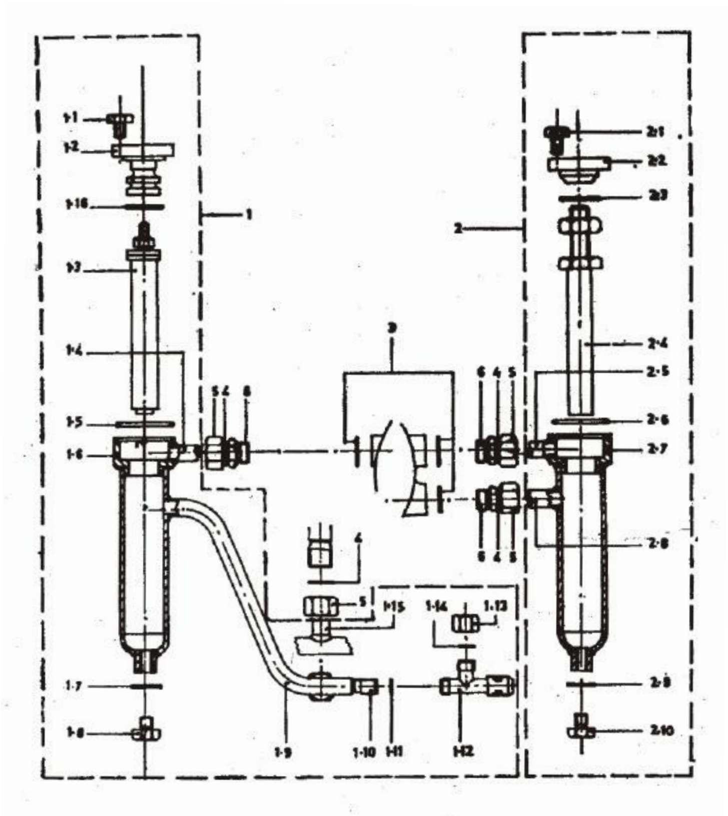


Fig. 18 : Oil strainer assembly.

Sr. No	Name of Parts	MX_No	Qty	I/P
8.9	**Suction Strainer Assembly (Fig No. 17)**			
1	Bolt Hex. Hd	JJ90169550	8	
2	Nut	JJ90668750	8	
3	Blind Flange	XH80803050	2	
4	Gasket (Suction strainer Flanges)	XH50801850	2	
5	Suction Strainer Housing		1	
6	Suction Strainer Element	XH80801050	1	
	* Welded to crnacase frame			
8.10	**Oil Strainers (Fig No.18)**			
1	Oil Strainer (suction) assembly)	XH81000050	1	
1.1	Belt	JJ90163950	4	
1.2	Head oil strainer	XH21401050	1	
1.3	Strainer element	XH21403050	1	
1.4	Pipe		*	
1.5	O Ring	JJ91269650	1	
1.6	Strainer Housing Suction	XH81000250	1	
1.7	Packing Alu.	JJ91852550	1	
1.8	Plug	XH20723050	1	
1.9	Pipe Bend		1	
1.10	Welding Adaptor		1	
1.11	Packing Alu.	JJ91852550	1	
1.12	TAH_8 valve assly	CE10900350	1	
1.13	Cup Nut	XH22850050	1	
1.14	Packing Alu.	JJ91852550	1	
1.15	Pipe Straight		*	
1.16	O ring	JJ91270550	1	
2	Oil Strainer (Discharge) Assly	XH81050050	1	
2.1	Bolt	JJ90163950	4	
2.2	Head oil strainer	XH21409050	1	
2.3	O Ring	JJ91270550	1	
2.4	Megnetic strainer element	XH21410050	1	
2.5	Pipe		⬟	
2.6	O Ring	JJ91269650	1	
2.7	Strainer Housing	XH81000250	1	
2.8	Pipe		⬟	
2.9	Packing Alu.	JJ91852550	1	
2.10	Plug	XH20723050	1	
3	Packign Alu	JJ91854850	3	
4	Ferrule	JJ91602150	4	
5	Union Nut	JJ91608750	4	
6	Socket Union Screw	JJ91626150	3	

* Included in Item 1.6 ⬟ Included in Item 2.7

Sr. No	Name of Parts	MX_No	Qty	I/P
	Flywheel PC2	XH80155050		
	Frame for compressor	XH80017050		
	Retaining Plate for Flywheel	XH80200050		
	Carrier Plate for Flywheel	XH80206050		
	Braker for S. V. Control	XH80010750		
	Welding Socket	CC61000450		
	Sq End oil Strianer Hsg	XH81402050		
	Sperical Cap	CA_0426		
	Set Screw	XH80204750		

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