LANDING GEAR SYSTEMS FOR HELICOPTER

CHAPTER I

1. INTRODUCTION

The landing gear of modem Aircraft - tyres, wheels, brakes, shock struts and associated retraction equipment - represents a substantial unit of an aircraft. It accounts for some 3 5 to 5 % of the gross aircraft weight. In bigger aircrafts like Boeing 747, the landing gear weight alone is as high as 15 tonnes. But Wheel brakes of landing gear for helicopter is relatively lighter due to less or no forward velocity of the helicopter while landing and also due to the lower weight of the helicopter compared to the fixed wing aircrafts. In helicopters, use of wheels is not essential for flight as in the case of fixed wing aircrafts, but useful in case of taxing and towing. Hence in helicopters, landing gear is meant for absorbing energy while landing with specified descent velocity and for taxing and towing.

Landing gear for Helicopters is mainly of two types. They are Skid type & Wheel type. Skid type landing gear is, simple, lighter from weight point of view, involving lesser maintenance and cheaper, but is difficult for ground handling since separate ground handling system is needed and difficult to cater for higher crashworthiness. Wheel type landing gear is, Complex and heavier from weight point of view. This requires more maintenance & costlier but it can be used for ground handling. It is relatively easier to cater for higher crashworthiness with wheel type landing gear.

Type of landing gear (skid or wheel type) is chosen as per customer requirement.

2. SKID TYPE LANDING GEAR

Skid type Ian ding gear consists of forward cross tube, rear cross tube and skid tubes (ref.: fig 1). Size of the cross tube and skid tube is arrived at based on the landing velocities stipulated in standards like FAR 29, AR 56, DEFSTAN 00970 etc. Energy is absorbed by deflection of both cros-3 tubes, which are hinged to the structural brackets. Energy absorbing capability is evaluated by static and drop tests of cross tubes. Wear plates are fitted at the bottom of the skid tubes to avoid damage to skids. A typical skid landing gear details are given in fig. 1. This skid landing gear is fitted on ALH.

3. WHEEL TYPE LANDING GEAR

Wheels type landing gear depending upon the number of landing gears per helicopter and location of installation can be classified as follows.

i) Tricycle nose wheel type is one which has one nose landing gear installed in the front and two main landing gears installed at the rear of the c.g

ii) Tail wheel type is one which has two main landing gears installed in the front and one landing gear installed at the rear of the c.g

iii) Quadricycle type is one, which has two landing gears installed in the front and two landing gears installed in the rear of the c.g of the aircraft.

3.1 CLASSIFICATION OF LANDING GEAR

Depending on the geometry of the landing gear, landing gears can be broadly divided in to three classes (ref: table 1)

i) Non-articulated or telescopic type.

ii) Articulated or levered suspension type

iii) Semi articulated or semi levered suspension type

In a telescopic landing gear the ratio of wheel axle travel to shock strut stroke is unity. If there is an introduction of mechanical advantage to the shock strut, the landing gear can be termed as an articulated landing gear. In articulated landing gear the shock strut is hinged at both the ends and results only axial loads. In the semi articulated landing gears, the shock strut is fixed and a link rod is introduced to complete the four bar mechanism. In this case lateral load on shock shut is not absent but can be reduced to a greater extent In telescopic landing gears, the lateral load on shock strut is appreciable since the gear does not have four bar mechanism. The articulated gear geometry can be further subdivided into two types based on the orientation of the plan of the four bar mechanism.

(i) Variable base type, which changes wheel base of aircraft while telescoping

(ii) Variable track type, which changes wheel track of aircraft while telescoping

Semi articulated gear also can be further subdivided into two types based on position of link rod in four bar mechanism

i) Link at shock strut end

ii) Link at trailing arm end

These classifications of landing gear depending on its geometry is illustrated in table 1 and their relative properties are given in table 2.

3.2 LANDING GEAR RETRACTION SYSTEM

Even though most fixed wing aircrafts are provided with retractable type landing gears owing to its high forward speed, in rotary wing aircraft, landing gear can be either made retractable or non-retractable depending on its forward speed and performance requirements. Retraction system calls for a hydraulically operated actuator. Up lock and Down lock to lock landing gear in both position, a hydraulic selector valve, UPIDOWN micro switches, UP/DOWN switch and indicators in the cockpit and facility for emergency extension etc.

3.3 LANDING GEAR STEERING SYSTEM:

Any wheel type landing gear needs steering, either an active steering by providing steering jacks in nose LG or a passive steering with a freely swiveling nose wheel with mechanical trail which attains yawing, by applying tail rotor thrust. Active steering calls for steering jack on nose landing gear, steering manifold, which controls hydraulic supply to jacks, cockpit controls and indicators.

3.4 WHAT A LANDFNG GEAR CONSISTS OF WHAT?

A typical landing gear consists of a barrel with structural attachment fork, Oleo pneumatic shock absorber, Piston, Axle, Wheel, Brake, Tyre, Toggle links, Drag stay, Retraction extension actuator and UP/DOWN locks. Apart from the above it may consists of nose wheel steering jack, jacking point, mooring point, towing point, earthling cable, micro switches including weight on wheel switch, electrical & hydraulic routings.

Landing gear system would include hydraulic units like retraction/extension selector valve, steering selector valve, accumulator and cockpit controls & indication, circuit for sequencing, needed hydraulic and electrical routings etc.

Refer fig.2 where a typical main landing gear is shown. The barrel (1) basically houses the oleo-pneumatic shock strut and attaches the landing gear on the structure. The barrel is generally made out of Aluminum forging. Oleo-pneumatic shock absorber (2) telescopes and absorbs the energy by compressing the air and allowing the fluid to pass through narrow orifice (details given in para 3.5). Piston (3) is connected to the wheel axle. Axle (4) holds brake, wheel & tyre. Piston and axle are generally are of high strength steel (NCM steel or Maraging steel). Axle is made out of a forging. Wheels (5) are usually made from forged Aluminum alloy and accommodate fire apart from being large enough to house the brake (6). Wheels are often made into two halves and joined by tie bolts Wheel also houses bearing of taper roller type and air inflation valve is installed in the outboard side of the wheel. Tyres (7) are now a days of tubeless type and charged with dry Nitrogen. Present day tyres are of conductive type to discharge state electricity. Toggle links (8), which connects the axle hub and barrel of landing gear, either does the function of holding the wheel in fore & aft position or transfer the steering torque to the wheel. Drag stay (9) is a structural strut that connects landing gear and structure to transfer the drag load. If the landing gear is retractable, in many cases retraction jar-k (10) itself will do the function of drag stay also.

3.5 OLEO PNEUMATIC (GASIOIL) SHOCK ABSORBER:

Most of to-days aircrafts use oleo-pneumatic shock absorber, a typical design of which is shown in fig.3. They have the highest efficiency of all shock absorber types and also have the best energy dissipation. Unlike a coil spring that stores energy and then suddenly releases it since the oil is returned to its uncompressed state at a controlled rate through an orifice as shown in fig-4 during when the energy is converted in to heat. Oleo pneumatic shock absorbers are either single stage or double stage. Shock absorber shown in fig. 3 is double stage in which gas is compressed in two stages (high pressure chamber & low pressure chamber). When aircraft lands, due to load the piston moves up. This forces the oil in the top to move to the piston side through the closure orifice in a controlled manner and compresses the Ist stage pneumatic spring. After this, as load increases, 2nd stage chamber also gets compressed. Due to controlled oil flow, maximum efficiency is obtained by a fairly constant strut load, during dynamic loading.

A 100% efficient ideal strut would have a rectangular shaped drop test curve (load Vs deflection), but in practice the obtained efficiency is usually between 80 and 90 percent.

After piston fully compresses and reaches the required stroke, piston recoils (bounces back). During this process the high pressure chamber expands first and then the low pressure chamber forcing the fluid back to the top of the cylinder through recoil orifice. Recoil orifice enables the entire expansion in a controlled way giving rise to higher energy dissipation and desired recoil acceleration.

4. ALH SKID LANDING GEAR SYSTEM

ALH skid landing gear (fig. 1) consists of a forward cross tube (1), a rear cross tube (2) and two skid tubes (3). Cross tubes are made cut of aluminum alloy and designed to absorb energy during landing up to 2.0 meters per second limit sinking velocity, 2.45 meters per second reserve sinking velocity and up to 4.0 meters per second crash sinking velocity.

Leading particulars of skid landing gear.

Weight	75 Kgs
Track	2800 mm
Radius of forward cross tube	1550 mm
Radius of rear cross tube	1675 mm

5. ALH WHEEL LANDING GEAR SYSTEM

5.1 GENERAL ARRANGEMENTS

The landing gear system consists of retractable, tricycle type, wheeled undercarriage with twin wheels on the nose undercarriage and single wheel on the main undercarriage legs. Both main and nose undercarriage are telescopic type. The nose gear (fig.5) retracts aft into the fuselage, and the main gears (fig.6) retract forward into the stubwings, retraction being achieved by hydraulic actuators. The retraction actuators also act as drag stays for the undercarriage, and incorporate segment type internal locks at both ends to achieve down locking and up locking of the gears. The retraction actuator on the nose gear is placed on the aft side, and for retraction of the landing gear the actuator retracts. For main gear, the retraction actuator (is on the forward side, and ft extends to retract the landing gear. Hydraulic pressure for normal extension / retraction is taken from the utility hydraulic system. Emergency lowering of the U/C is possible using hydraulic pressure from an accumulator. Jacking (for single wheel change), towing and mooring facilities are provided on all the legs. The leading particulars of the system are

Wheel base	:	4333.6 mm
Main wheel track	:	2800 mm
Nose wheel track	:	265 mm
Limit sink velocity	:	3.05 m/sec
Reserve sink velocity	:	3.66 m/sec
Weight	:	180 Kgs

5.2 MAIN LANDING GEAR

The main landing gear is supported on a lateral pivot axis and rotates forward through 80.7 deg. during retraction. Its wheel is offset by 155 mm to the outboard side. The shock absorber is two stage oleo-pneumatic type with separated nitrogen chambers. The low pressure chamber is operational during helicopter static condition and taxiing. Both low pressure and high pressure chambers come into operation at the time of landing. The main wheel is fitted with a disc brake operated hydraulically through a power brake system. A weight-on-wheel switch is mounted on the toggle link to provide electrical signal.

The leading particulars of the main landing gear are

Vertical axle travel	255 mm
Charging pressure I stage	7.5 ± 0.5 bar
Charging pressure if stage	43.5 ± 1.5 bar

5.3 NOSE LANDING GEAR

The nose landing gear retracts aft about a lateral pivot axis with rotation through 80 deg. It has twin wheels spaced at 265 mm, with a mechanical trail of 75 mm. The shock absorber is similar in construction to that of main gear. The nose wheel is of free castor type and capable of self centering to fore and aft position by internal cams, as soon as the aircraft takes off. Steering is achieved by tail rotor thrust or by differential braking. The leading particulars of the nose gear are:

Vertical axle travel 265 mm

Charging pressure I stage 10 ± 0.5 bar

Charging pressure If stage 50 ± 1.5 bar 5.4

5.4 RETRACTION ACTUATORS

The landing gears are retracted and extended using double acting hydraulic actuators. The actuators of nose and main gears are similar in construction. It consists of an inner piston and inner cylinder making the jack for retraction/extension function. In addition an outer piston and outer cylinder form the drag stay. The segment type of internal locks are provided at the end of the outer piston to keep the drag stay in mechanically locked condition in both extended and retracted positions. The locks are hydraulically released using a look cylinder positioned outside the inner cylinder. When the jack reaches retraction or extension stop, the six segments are radially pushed out by a spring loaded locking sleeve to mechanically up/down lock the retraction actuator. The locking sleeve operates microswitch to indicate locked status in the cockpit.

Retraction/extension for normal operations are performed by supplying hydraulic fluid to the normal ports of a shuttle valve mounted on the actuator. For emergency extension, the hydraulic fluid is fed to the retraction actuators through the emergency port of the shuttle valve. To control the extension/retraction rates of the landing gear two-way restrictors are provided within the actuator. Two microswitches are mounted on the outer cylinder to provide status of up/down positions locking.

Extended length of actuators 807.1 mm

Stroke of actuator 259.4 mm

5.5 RETRACTION / EXTENSION SYSTEM

The retraction / normal extension of the landing gears is controlled through an electro-selector valve operated from an u/c lever switch in the cockpit. Upon selection, one of the solenoids of the electro-selector valve gets energized and hydraulic- fluid from utility hydraulic system is fed to the retraction actuators through the shuttle valve to perform the retraction / normal extension of the landing gears.

For emergency extension, the emergency extension lever mounted aft of collective stick on pilot's side has to be pulled. This operates the lever on the emergency manual selector. Pressure for this emergency operation is available from an accumulator and is supplied to the jacks through shuffle valves. The accumulator, charged with dry nitrogen at 67 bars at room temperature, is filled by utility hydraulic system at 206 bars through the isolation valve opened by weight-on-wheel microswitch when the helicopter is on ground. In airborne condition the isolation valve closes and makes emergency extension accumulator isolated from utility system and protects utility system from failure, in the event of a failure of emergency extension hydraulic lines.

The landing gear extension time is approximately 5 seconds and the retraction time is 7 seconds. The operations of retraction / extension system are coordinated by a logic circuit.

5.6 LANDING GEAR HYDRALIUC SYSTEM

The landing gear hydraulic system is powered by the utility hydraulic system. The leading particulars of the utility hydraulic system are:

System Pressure	206 bar
Nominal return line pressure	3.5 bar
Operating fluid	MIL-H-5606G
System cleanliness	Class 8 of NAS 1638 or better

The hydraulic system supplies power for operations of normal extension/retraction. The landing gear hydraulic system consists of one manifold and three valves namely,

i) Electro--selector valve

ii) ii) Manual selector valve

iii) Accumulator manifold

iv) Isolation valve

The electro-selector valve, a four way three position valve, consists of two solenoid valves and a distributor valve. It gets hydraulic supply from utility system and supplies fluid to the three landing gear actuators for retraction and extension of landing gear. The valve has a neutral position also.

The manual selector valve is a five way two position valve. In the normal position, the utility system pressure to the electro-selector valve passes through the manual selector. In the emergency position, the normal supply to the electro-selector valve is cut off and the emergency accumulator pressure is given to the three landing gear actuators through the shuttle valve. The manual selector valve has to be reset by the ground crew to normal position after landing with emergency extension system selection.

The accumulator manifold consists of an accumulator with a capacity of 1.2 liters, a non-return valve, a thermal relief valve, a manually operated pressure relief valve, an inflation valve and a pneumatic pressure gauge. The accumulator manifold supplies hydraulic fluid for the emergency extension of the landing gear in the case of failure of normal system. The manual pressure relief valve is provided to release the accumulator pressure to check and maintain accumulator charging pressure at 67 bar (dry nitrogen) at room temperature.

The isolation valve is provided to supply fluid to the emergency accumulator when the helicopter is on the ground and isolates the emergency system during flight.

5.7 LANDING GEAR COCKPIT CONTROL AND INDICATION

The cockpit control panel consists of solenoid protected (using weight-on-wheel switch signal) up/down selector switch,. The indicators include three green fights for down position, one amber light for transition indication and one light for parking brake-on indication. TELEFLEX cable operated mechanical levers are provided for emergency extension of landing gear and parking brake operations.

5.8 WHEELS & BRAKES

The main u/c is fined with single wheel at an off-set of 155 mm outboard of the shock absorber axis and fitted with a tyre of l6x5.5 size inflated to 195-200 psi pressure. It also incorporates the wheel brakes operated by the wheel brake system. The nose u/c has twin wheels spaced at 265 mm with a trail of 75mm and fined with lyres of 13.5x4.25-6 size inflated to 105-110 psi pressure.

The wheel brake system is power operated by the utility hydraulic system of 206 bar and brake system pressure is 68 bar, which is obtained through a pressure reducing valve. The wheel brakes are operated hydraulically and are controlled by the operation of master cylinders actuated by brake pedals. Main pressure line is taken through a pressure reducing valve and brake accumulator, which is initially charged with nitrogen to a pressure of 50 bars. This accumulator also acts as an emergency source of power for operation of wheel brakes sufficient for at least 10 brakings. The brake unit is supplied with fluid from brake control valve in proportion to the force applied on the master cylinders through brake pedals. The pressure in the brake system and pressure in each wheel brake are indicated in the triple pressure indicator located in the cockpit.

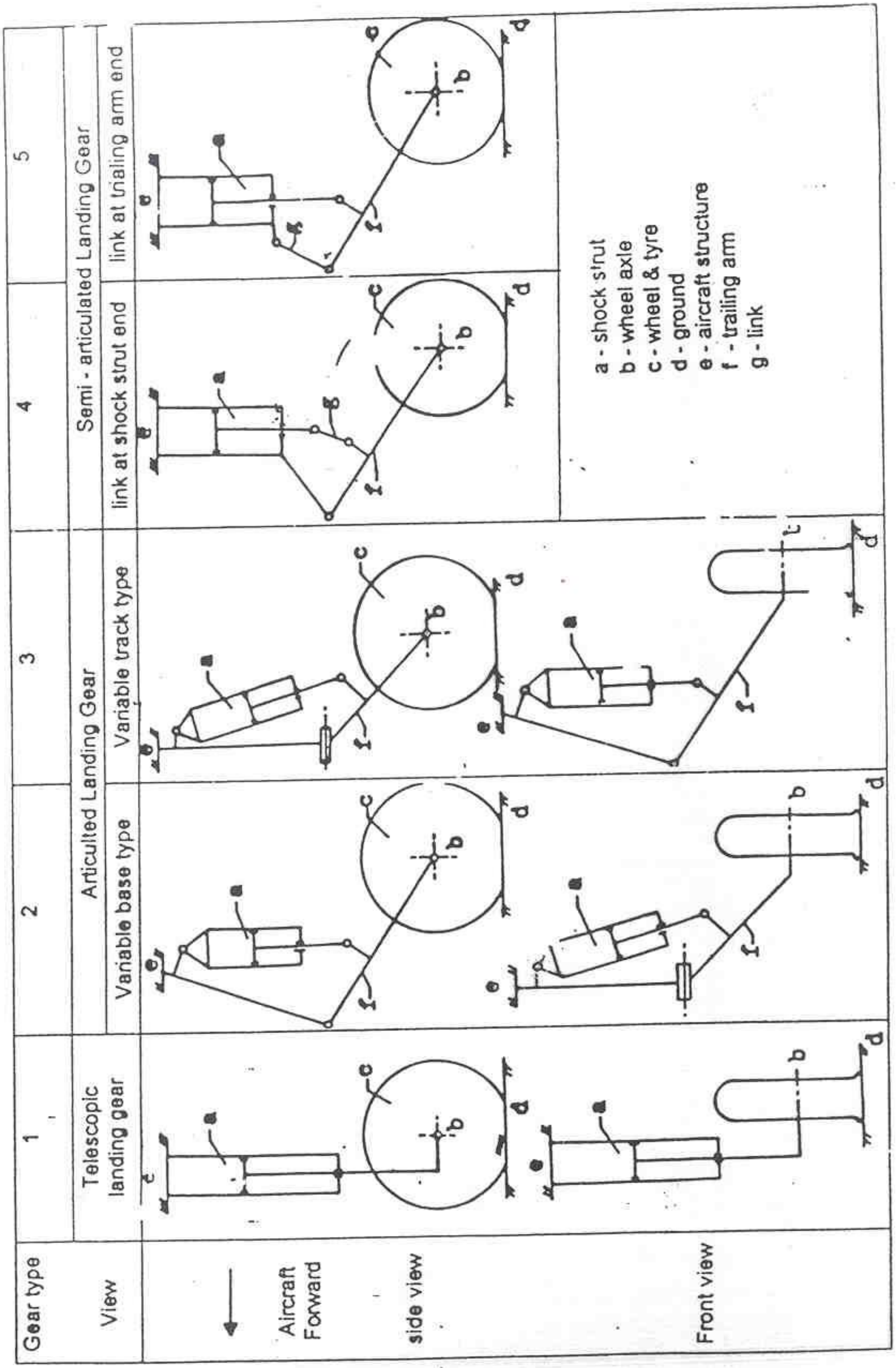
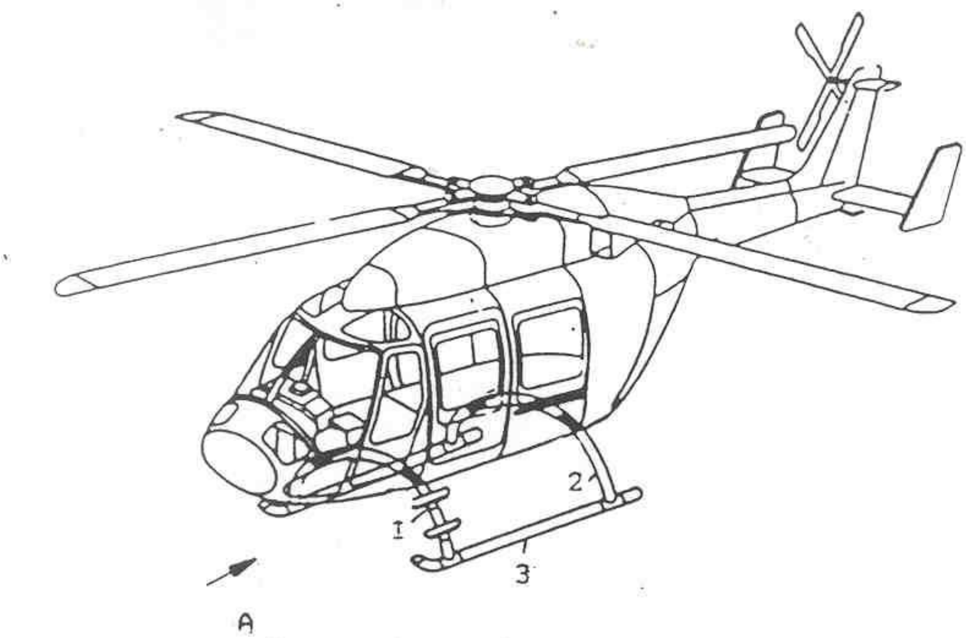
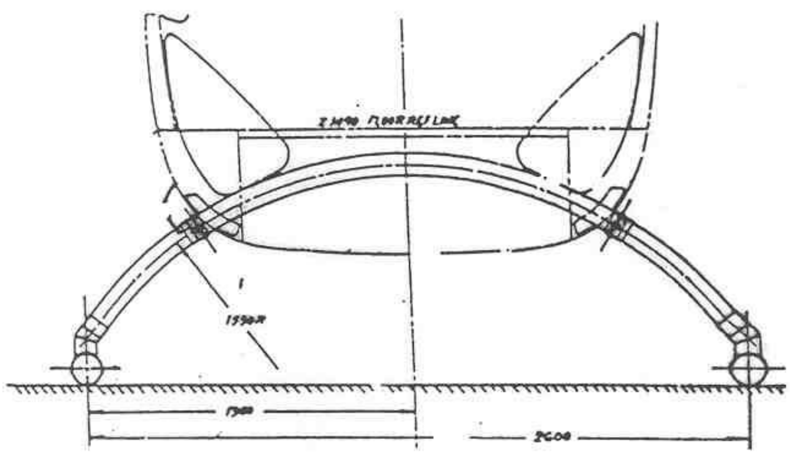


TABLE : 1 **TYPES OF LANDING GEAR GEOMETRIES**

Sl.No.	Property	Telescopic landing gear	Articulated landing gear	Semi-articulated landing gear
1	Shock strut axis is fixed	yes	no	yes
2	Trailing arm is present	no	yes	yes
3	Link rod is present	no	no	yes
4	Four-bar mechanism is present	no	yes	yes
5	Normal load on shock strut	more	zero	less
6	Axial load on shock strut	less	more	more
7	Weight of gear	less	more	more
8	Mechanical advantage is present	no	yes	yes
9	Velocity ratio is present	no	yes	yes
10	Drag load telescope shock strut	no	yes	yes
11	Riding capabality	poor	good	good
12	Higher wheel axle travels can be provided	no	yes	yes
13	Capabality of providing increase in track	not good	good	moderate
14	Easy to design crashworthy gear	no	yes	yes
15	Shock strut is compact	no	yes	yes
16	Overall length is less for the same stroke	no	yes	yes
17	Stowage problem	more	less	less
18	Reduction in max.vertical axle travel in tail down attitude	less	more	more
19	Efficiency both at tail-down & tail up landings	better	good	good
20	Spin-up completes at a lower vertical reaction reducing the magnitude of drag reaction	no	yes	yes
21	Requires longer stroke for the same vertical reaction	no	yes	yes

TABLE : 2 <u>RELATIVE PROPERTIES OF LANDING GEAR GEOMETRIES</u>





VIEW – A

FIG – 1 : L H SKID LANDING GEAR

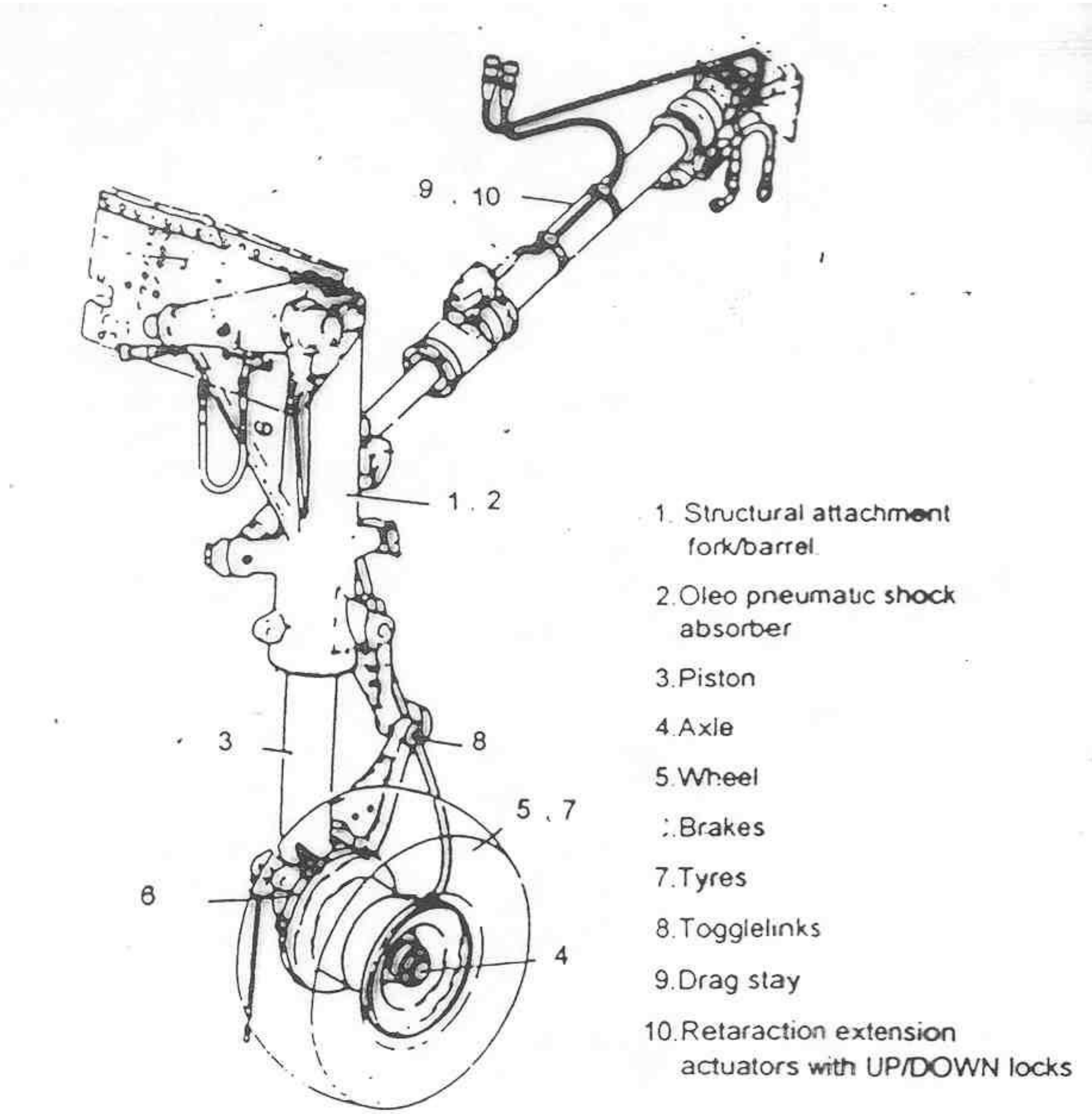


FIG - 2 : A TYPICAL MAIN LANDING GEAR

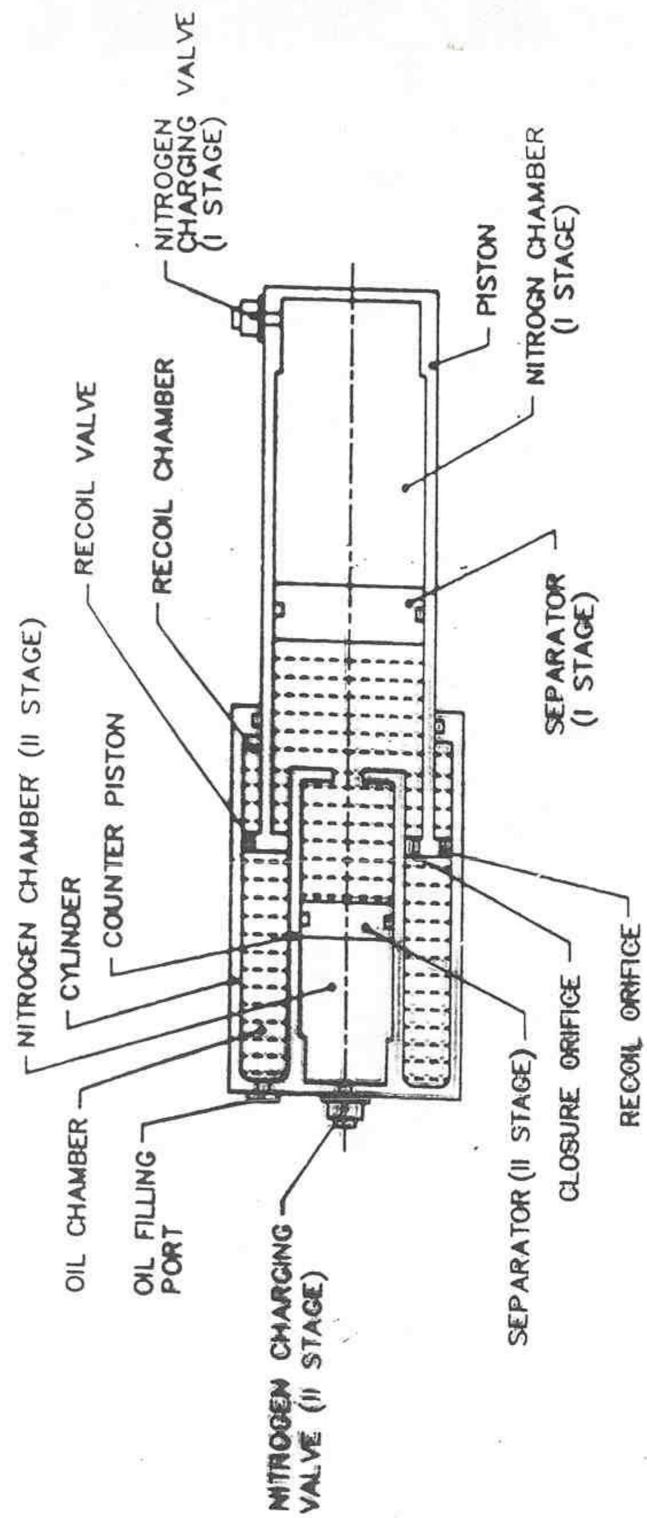


FIG - 3 : TWO STAGE SHOCK ABSORBER FUNCTIONAL DIAGRAM

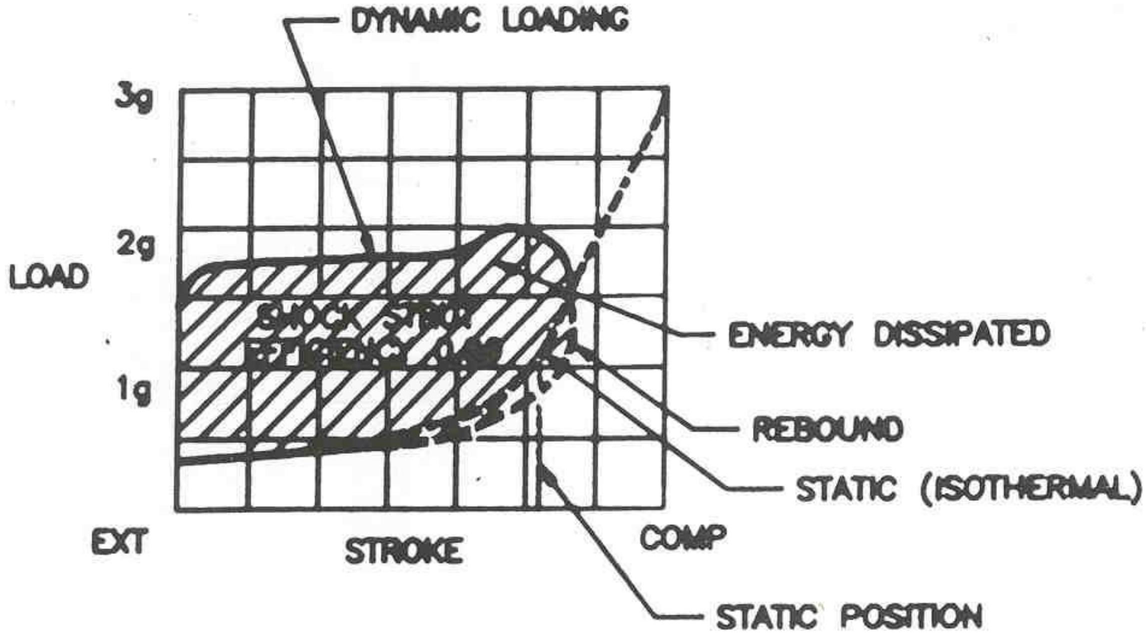


FIG 4 : LOAD Vs DEFLECTION - SHOCK STRUT

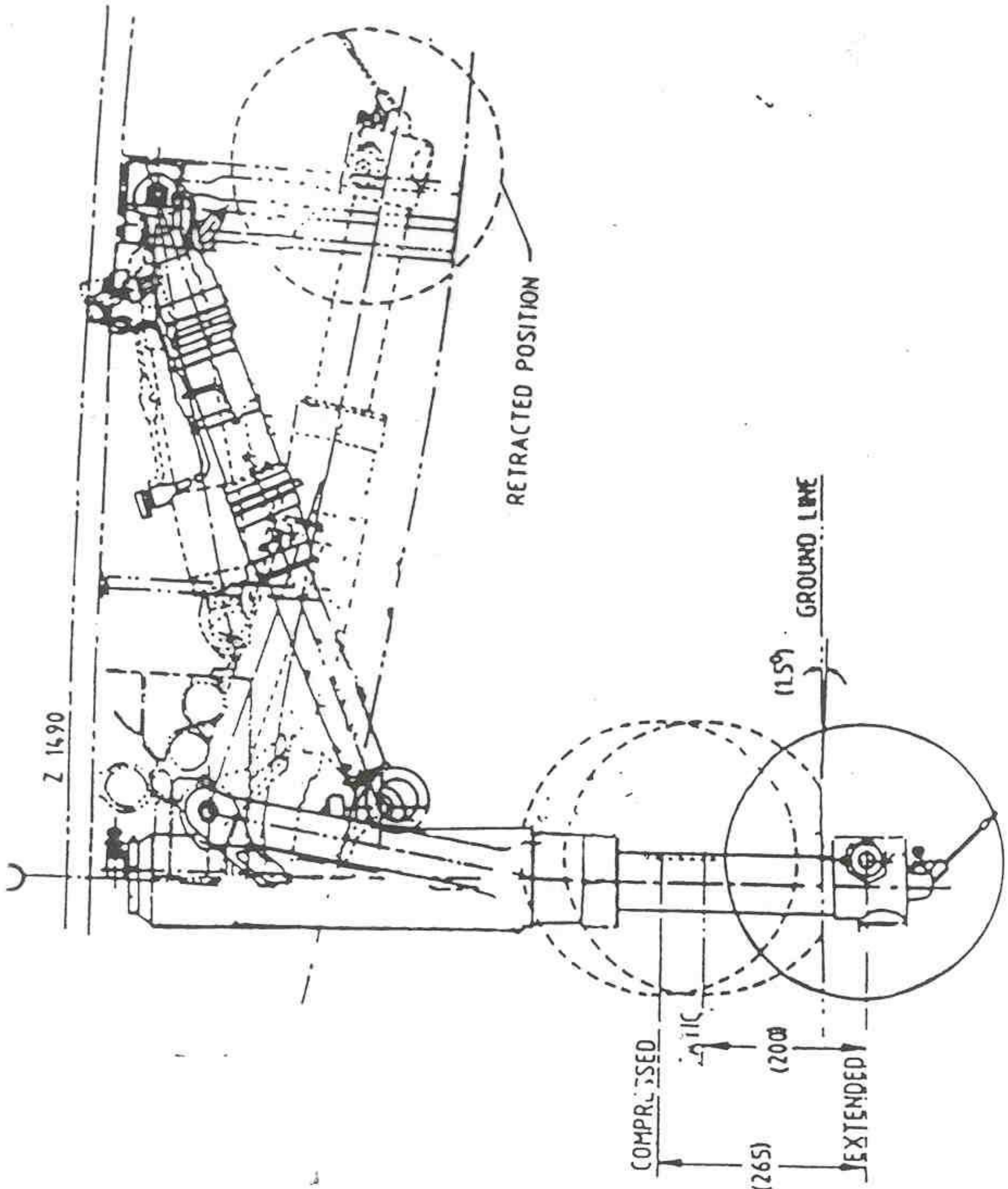


FIG - 3 : A L H NOSE LANDING GEAR

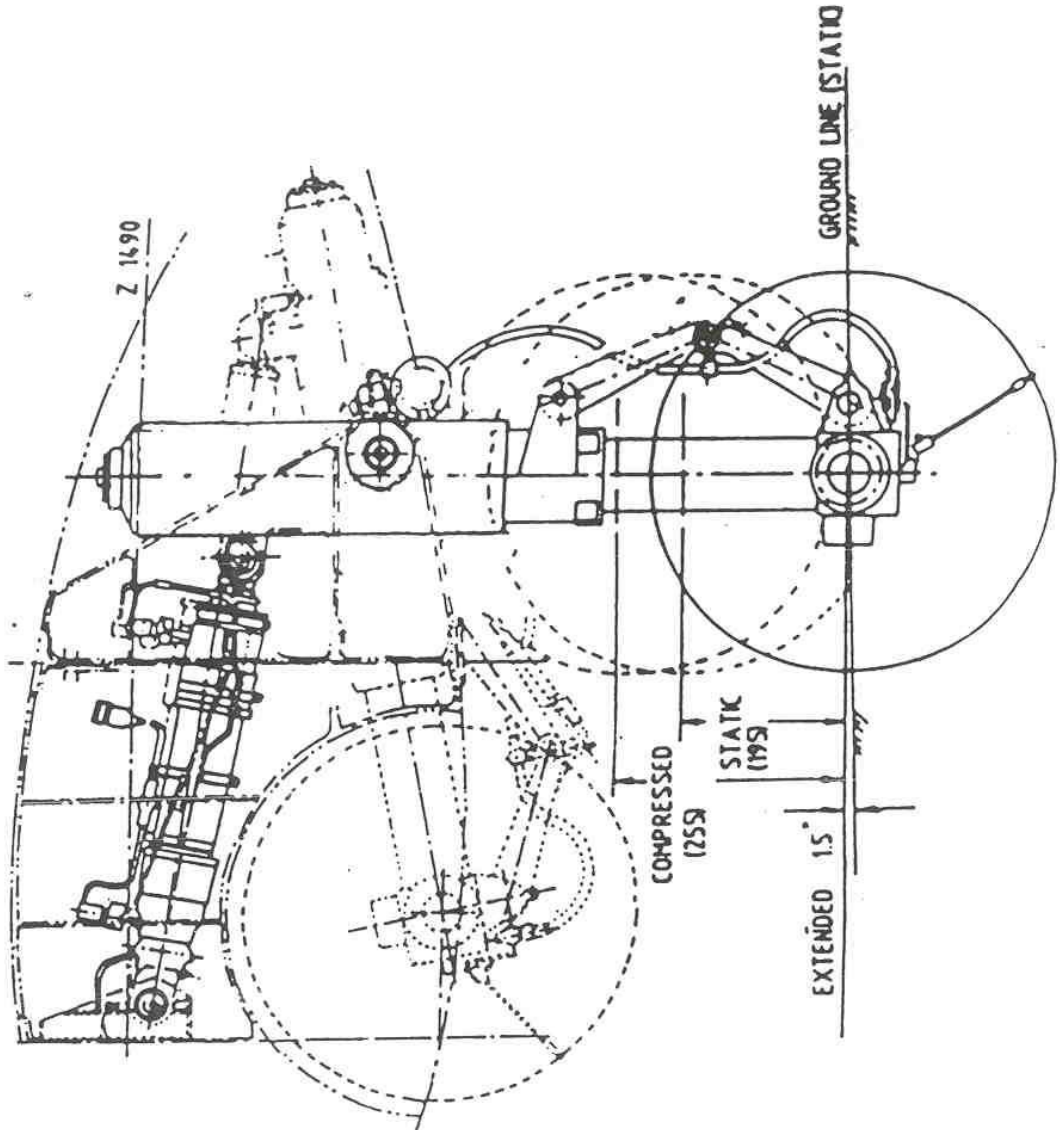


FIG - 6 : A L H MAIN LANDING GEAR

CHAPTER 2

1. LANDING GEAR SYSTEM

1.1 Landing gears

1.1.1 General arrangement

The landing gear system consists of retractable, tricycle type, wheeled undercarriage with twin wheels on the nose undercarriage and single wheel on the main undercarriage legs. Both main and nose undercarriage are telescopic type. The nose gear retracts aft into the fuselage, and the main gears retract forward into the stub wings, retraction being achieved by hydraulic actuators. The retraction actuators also act as drag stays for the undercarriage, and incorporate segment type internal locks at both ends to achieve downlocking and uplocking of the gears. The retraction actuator on the nose gear is placed on the aft side, and for retraction of the landing gear the actuator retracts. For main gear, the retraction actuator is on the forward side, and it extends to retract the landing gear. Hydraulic pressure for normal extension/retraction is taken from the utility hydraulic system. Emergency lowering of the u/c is possible using hydraulic pressure from an accumulator.

Jacking (for single wheel change), towing and mooring facilities are provided on all the legs.

The leading particulars of the system are:

Wheel base	:	4333.6 mm
Main wheel track	:	2800 mm
Nose wheel track	:	265 mm
Static ground clearance	:	380 mm (at #5)
Nose tyre	:	13.5 x 4.25 - 6, 6 PLY
		105-110 psi, DR 4123T - DUNLOP
Main tyre	:	18 x 5.5 - 8, 10 PLY
		195-200 psi, DR 9837T - DUNLOP
Limit sink velociy	:	3.05 m/sec
Reserve sink velocity	:	3.66 m/sec

Overall lengths:

Nose gear	:	1024 (extended)
Main gear	:	979 (extended)

1.1.2 **Main landing gear**

The main landing gear is supported on a lateral pivot axis and rotates forward through 80.7 deg. during retraction. Its wheel is offset by 155 mm to the outboard side. The shock absorber is one stage oleo-pneumatic type with nitrogen chambers. The main wheel is fitted with a disc brake, operated hydraulically through a power brake system.

A weight-on-wheel switch is mounted on the toggle link to provide electrical signal. Main wheels are fixed in fore and aft direction.

The leading particulars of the main landing gear are:

Vertical axle travel	:	255 mm
Oleo charging pressure	:	13.7±0.5 Kgf/Cm^2 (Dry Nitrogen)

1.1.3 **Nose landing gear**

The nose landing gear retracts aft about a lateral pivot axis with rotation through 80 deg. It has twin wheels spaced at 265 mm, with a mechanical trail of 75 mm. The shock absorber is similar in construction to that of main gear. Nose wheels are free castoring and self centering is achieved by internal cams. Steering is achieved by differential braking / tail rotor thrust.

The leading particulars of the nose gear are:

Vertical axle travel	:	265 mm
Oleo charging pressure	:	15.8±0.5 Kgf/Cm^2 (Dry Nitrogen)

1.1.4 **Retraction actuators**

The landing gears are retracted and extended using double acting hydraulic actuators. The actuators of nose and main gears are similar in construction. It consists of an inner piston and inner cylinder making the jack for retraction/extension function. In addition an outer piston and outer cylinder form the drag stay. The type of internal locks are provided at the end of the outer piston to keep the drag stay in mechanically locked condition in both extended and retracted positions. The locks are hydraulically released using a lock cylinder positioned outside the inner cylinder. When the jack reaches retraction or extension stop, the six segments are radially pushed out by a spring loaded locking sleeve to mechanically up/down lock the retraction actuator. The locking sleeve operates microswitch to indicate locked status in the cockpit. Retraction/extension for normal operations are performed by supplying hydraulic fluid to the normal ports of a shuttle valve manifold mounted on the actuator. For emergency extension, the hydraulic fluid is fed to the retraction actuators through the emergency port of the shuttle valve manifold. To control the extension/retraction rates of the landing gear one-way restrictors are provided within the actuator.

Two microswitches are mounted on the outer cylinder to provide status of up/down positions locking.

Extended length of actuators	:	807.1 mm
Stroke of actuator	:	259.4 mm
Actuator cylinder bore	:	26.75 mm

1.1.5 **Retraction/Extension system**

The retraction/normal extension of the landing gears is controlled through Landing gear control manifold operated from an u/c lever switch in the cockpit.

Upon selection, one of the solenoids of the electro-selector valve gets energised and hydraulic fluid from utility hydraulic system is fed to the retraction actuators through the shuttle valve to perform the retraction / normal extension of the landing gears. For emergency extension, the emergency extension lever mounted aft of collective stick on pilot‘s side has to be pulled. This operates the lever on the Landing gear control valve. Pressure for this emergency operation is available from an accumulator and is supplied to the jacks through shuttle valves. The accumulator, charged with dry nitrogen at 67 bars at room temperature, is filled by utility hydraulic system at 206 bars through the isolation valve opened by weight-on-wheel microswitch when the helicopter is on ground. In airborne condition the isolation valve closes and makes emergency extension accumulator isolated from utility system. In the event of utility hydraulic system failure, fully charged accumulator is sufficient to provide the complete emergency lowering of the undercarriage from the operation of emergency lever. In case of a leakage on emergency system, utility system is protected from failure. The landing gear extension time is approximately 5 seconds and the retraction time is 7 seconds.

1.1.6 **Toe-out system**

The wheel toe-out system is used to bring the wheels in rotated positions to orient the helicopter in required direction (to enable spot turning of the helicopter around a harpoon on ship deck.) to facilitate traversing of helicopter in and out of hanger on ship deck.

Toe in/out operations are done manually with hand operated hydraulic hand pump connected to pressure line and return line of toe out actuators through QDCs. The toe out actuators (LH and RH) are connected to a Quick disconnecting couple (QDC) placed at a convenient point on aft of RH stub wing.

On selection of toe-out position, the nose wheels are rotated through 90 deg. Also, the main wheels are rotated through 36 deg. and manually locked. Toe-out rate is approximately 20 deg. per second.

On selection of fore-and-aft position, all wheels are brought to fore-and-aft position and manually locked. These operations are permissible on a stationary helicopter on a ship deck.

1.1.7 **Hydraulic system**

The landing gear hydraulic system is powered by the utility hydraulic system. The leading particulars of the utility hydraulic system are:

System pressure	:	206 bar Nominal return line pressure
	:	3.5 bar Operating fluid
	:	MIL-H-5606G System cleanliness
	:	Class 8 of NAS 1638

or better. The hydraulic system supplies power for operations of normal extension/retraction, locking, and charging the emergency accumulator. The services for the system are three retraction actuators.

The landing gear hydraulic system consists of,

A. Retraction Manifold
B. Accumulator Manifold
C. Isolation Valve

Retraction Manifold is used for operating the normal and emergency landing gear system of helicopter. It consists of two three-way two position electro selectors, a distributor valve and a manual selector with a plunger operated check valve.

The accumulator manifold consists of an accumulator with a capacity of 1.2 litres, a non-return valve, a thermal relief valve, a manually operated pressure relief valve, an inflation valve and a pneumatic pressure gauge. The manifold supplies hydraulic fluid for the emergency extension of the landing gear and unlocking of the steering jack in the case of failure of normal system. The manual pressure relief valve is provided to release the accumulator pressure to check and maintain accumulator charging pressure at 67 bar (dry nitrogen) at room temperature.

The isolation valve is provided to supply fluid to the emergency accumulator when the helicopter is on the ground and isolates the emergency system during flight.

1.1.8 **Electrical system**

The electrical system consists of various input sensors (microswitches and cockpit pot), a control panel, a controller, a servo valve, solenoid valves and indicators apart from connectors and looms.

The operation of the landing gear and nose wheel steering system is controlled by a landing gear electronic controller unit (LGC-EU). The LGC-EU is microprocessor based software driven microcontroller to monitor and control various landing gear functions like steering, retraction, extension, wheel centering, etc. The landing gear controller takes inputs from the input sensors (totaling upto 15) indicating the status of the landing gears and wheels and also from the control panel representing various commands (totaling upto 7) from the pilot. Electronic logic included in the controller verifies the validity of each command with respect to the switch positions in the control panel and also with respect to the status signals from input sensors and finally drives the servo/solenoid valves (totaling upto 9) to physically achieve the command execution. Depending upon the success of the execution of the command (determined from the status signals from the input sensors) controller gives outputs (totaling upto 8 i.e., 7 indicators and one up-enable solenoid) feeding the panels.

When the electrical power is switched ‘ON‘ on ground, the controller goes through ‘power on built in test’ (PBIT) and the success of PBIT is indicated by glowing of the three green lamps. In case of the PBIT failure, the three green lamps remain OFF even after 1 sec from the power‘ON’ on the ground.

1.1.9 Cockpit control and indication

The cockpit control panel consists of solenoid protected (using weight-on-wheel switch signal) up/down selector switch, steering ON/OFF switch, and steering knob. The indicators include three green lights for down position, one amber light for transition indication, one light for steering-on indication, one light for parking brake-on indication. TELEFLEX cable operated mechanical levers are provided for emergency extension of landing gear and parking brake operations.

1.2. Wheels & brakes

The main u/c is fitted with single wheel at an off-set of 155 mm outboard of the shock absorber axis and fitted with a tyre of 18x5.5 size inflated to 195-200 psi pressure. It also incorporates the wheel brakes operated by the wheel brake system. The nose u/c has twin wheels spaced at 265 mm with a trail of 30 mm and fitted with tyres of 13.5x4.25-6 size inflated to 105-110 psi pressure. The wheel brake system is power operated by the utility hydraulic system of 206 bar and brake system pressure is 68 bar, which is obtained through a pressure reducing valve. The wheel brakes are operated hydraulically and are controlled by the operation of master cylinders actuated by brake pedals. Main pressure line is taken through a pressure reducing valve and brake accumulator which is initially charged with nitrogen to a pressure of 50 bars. This accumulator also acts as an emergency source of power for operation of wheel brakes sufficient for at least 10 brakings. The brake unit is supplied with fluid from brake control valve in proportion to the force applied on the master cylinders through brake pedals. The pressure in the brake system and pressure in each wheel brake are indicated in the triple pressure indicator located on the MIP.

CHAPTER 3

HYDRAULIC WHEEL BRAKE SYSTEM

SYSTEM INTRODUCTION:

The wheel brake system is power operated by the utility hydraulic system. The supply pressure of 206 bars is reduced to the brake system pressure of 68 bars through a Pressure Reducing Valve (PRV). The hydraulic fluid from the PRV is supplied to a Brake Control Valve (BCV). The ports in BCV direct this fluid to the LH and RH wheels according to the operation of master cylinders. The master cylinder is foot operated by the pilot by pressing the rudder pedal at the toe. Both the ports to LH and RH brake units will get opened simultaneously during parking brake and normal braking. An accumulator is provided to supply pressurised fluid (68bars) during emergency conditions and also to dampen out any fluid pulsation when the system units are operated. Three pressure transmitters are provided in the circuit, to show the system pressure (after the pressure-reducing valve), fluid pressure in the LH and RH wheels, in the cockpit.

Fig. 2.1 shows the complete circuit details of ALH Wheel brake system.

UNIT DESCRIPTION

Brake unit with brake cylinder is housed inside the wheel drum. A pair of metallic brake pads, one fixed and other moveable by two sets of brake cylinders, is also fitted on to the brake unit.

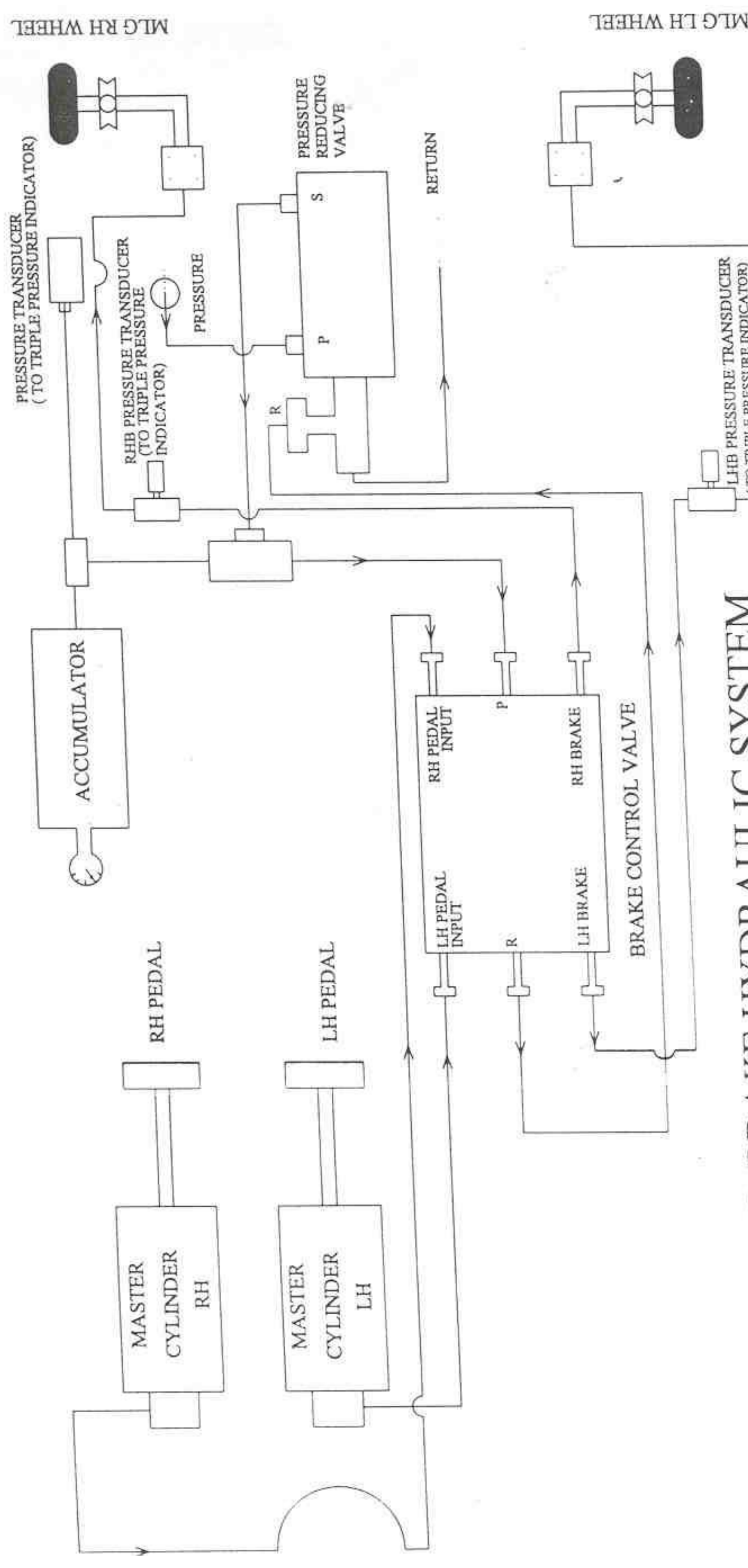


FIG. 2.1 WHEEL BRAKE HYDRAULIC SYSTEM
(BLOCK DIAGRAM)

BRAKE SYSTEM OPERATION:

The wheel brake system can be operated under the following conditions:

a) **Normal Braking** :

1.Straight braking : to stop moving of helicopter

2. Differential braking : for turning of helicopter on the ground.

3. Parking brake : for parking the helicopter

b) **Emergency braking**

To apply brake in case of failure of main pressure system (utility hydraulic system)

a) Normal braking Operations:

1. Straight braking

In this case, Pilot applies both the brakes simultaneously so that equal pressure will be applied to both the brake units and the helicopter will stop moving.

2. Differential Braking: (Fig 2.2)

To turn the helicopter towards right, the pilot applies brake to the right wheel by pressing the RH pedal toe. Now the fluid from the master cylinder opens the RH pedal port in the brake control valve. This will allow the system pressure fluid from the pressure-reducing valve, at 68 bars, to enter into the RH side brake unit. The pressurised fluid will move the brake piston. In turn, the moveable brake pad will push the rotating brake plate against the fixed brake pad and applying the RH wheel brake. Due to the difference in brake pressure applied to LH wheel (0 bar) and RH wheel (68 bar) the helicopter will turn towards right. A schematic diagram is given in Fig. 2.2.

Similarly if the pilot applies the LH wheel brake then the helicopter will turn towards left.

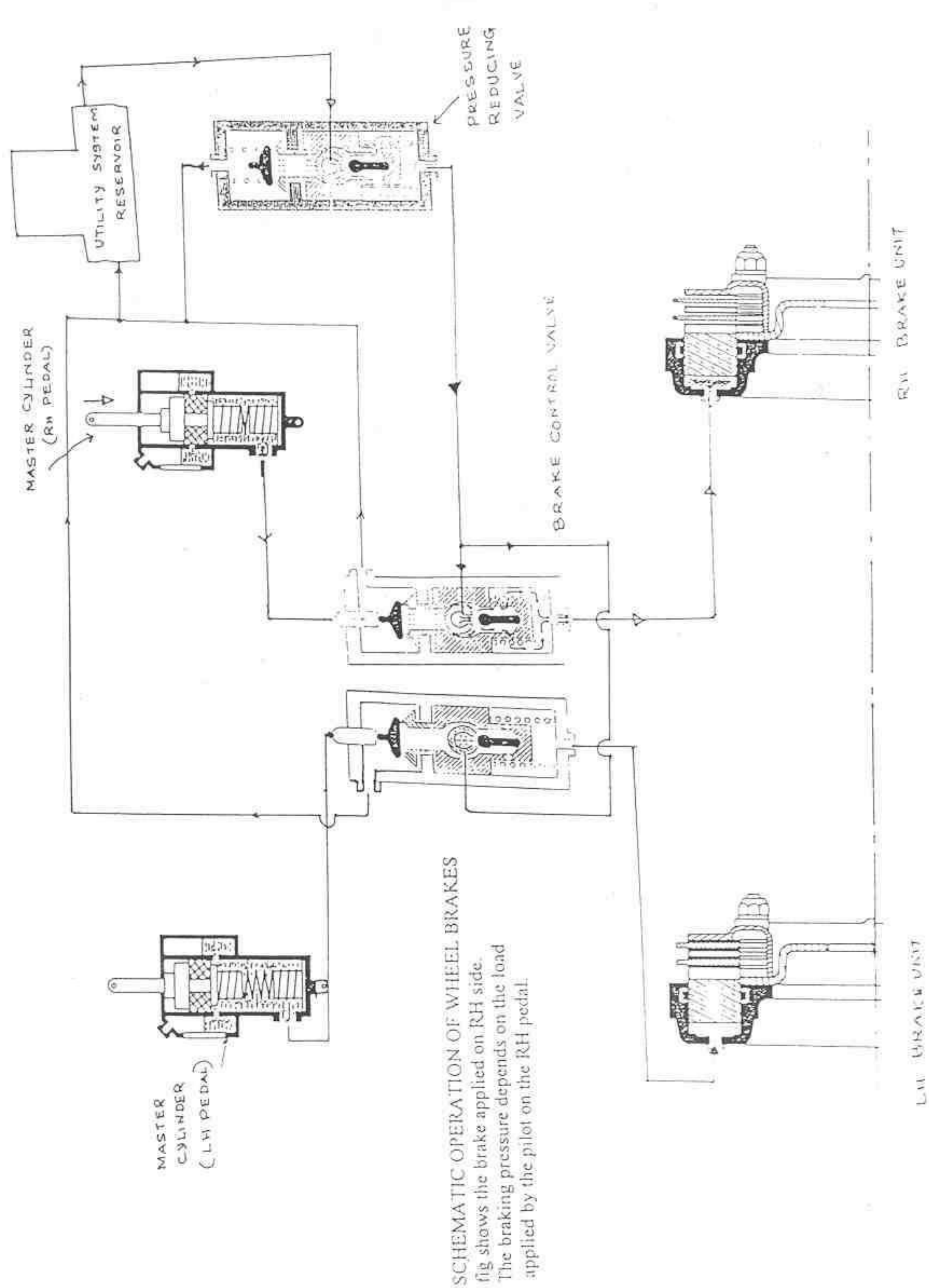


FIG 2.2 SCHEMATIC OPERATION OF WHEEL BRAKES
fig shows the brake applied on RH side.
The braking pressure depends on the load applied by the pilot on the RH pedal

1. Parking brake:

Parking brake is applied for parking the helicopter. Parking brake is applied by pulling the parking brake lever in the central console within the pilot reach. If the parking brake lever is pulled UP the teleflex cable connected to the lever mechanism will open the ports in the BCV; supplying pressurised fluid to LH and RH brake units simultaneously. The pressurised fluid from the accumulator enters into the cylinders in the brake unit and applies the parking brake.

b) Emergency brake operation:

The emergency brake system is operated through an accumulator connected in the system pressure line after the pressure-reducing valve (this accumulator also helps to dampen out any fluid pressure fluctuations under normal operation of wheel brake – details of the accumulator are given later). When the main fluids supply system (utility hydraulic system) fail, the fluid in the accumulator at 68 bars is supplied to the brake unit through the BCV according to the brake operation.

SYSTEM ARRANGEMENT

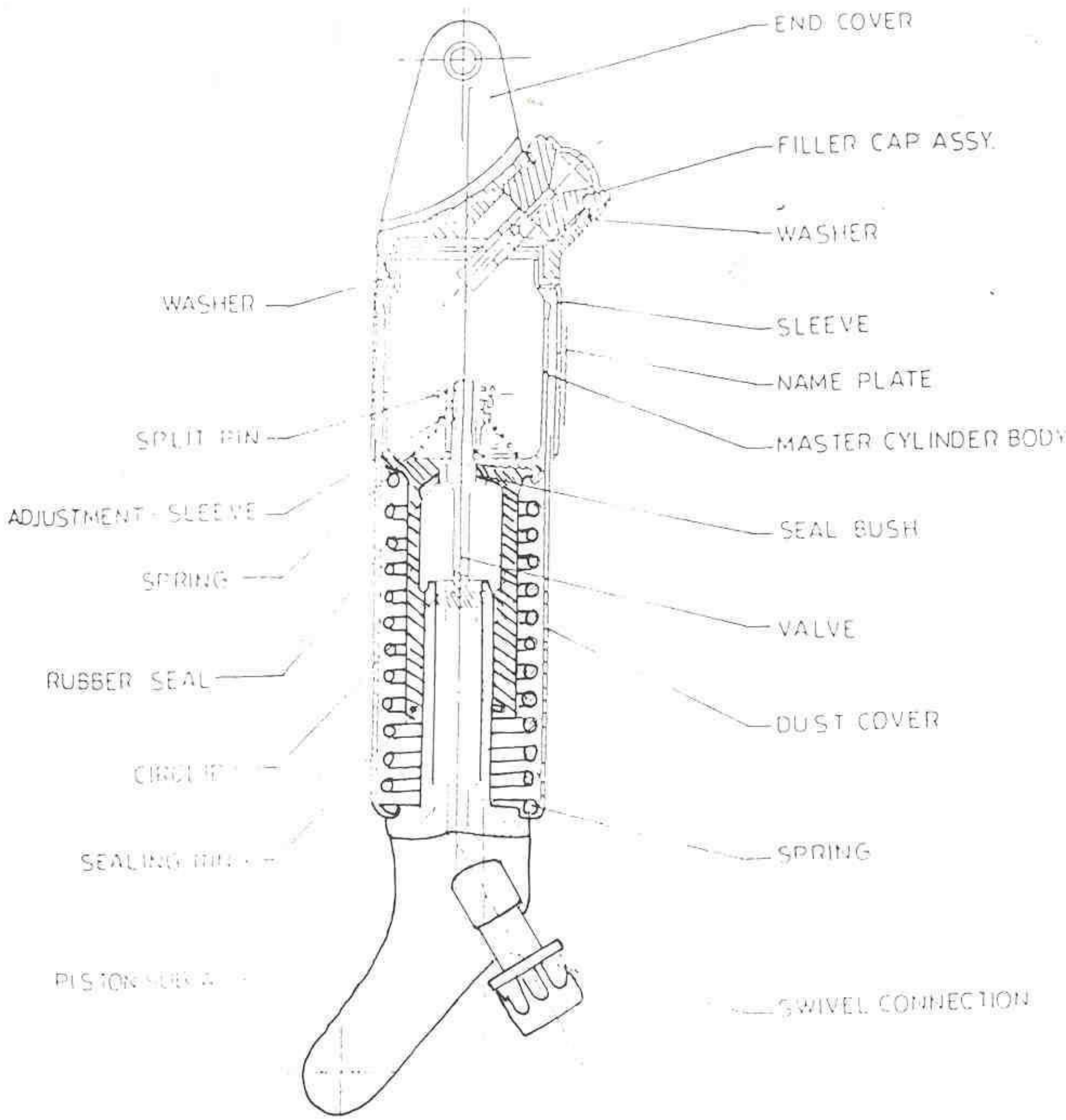
A) Brake Master Cylinder:

Purpose:

This telescopic unit is foot operated, to produce fluid pressure proportional to the load applied, to actuate a brake control valve and allow the main hydraulic system fluid to pass into the brake unit.

Description: (Fig. 2.3)

This unit consists of a piston, which slides inside a spring supported cylinder assembly incorporating a reservoir. A spring loaded valve assembly, arranged with a preset gap, extends through the reservoir base and locates inside the piston.



SECTION OF BRAKE MASTER CYLINDER

FIG. 2.3

B) <u>Pressure Reducing Valve:</u>

<u>Purpose:</u>

This unit maintains a pre set pressure of 68 bars in the delivery circuit of the hydraulic system.

<u>Description:</u> (Fig 2.4)

The inlet valve is carried in a spring-loaded cradle surmounted by an exhaust valve cap via a plunger. The top cover incorporates a spring-loaded non-return valve to prevent the ingress of foreign matter from the system reservoir. Attached to the valve body is a filter housing embodying an inlet connection and a brake manifold embodying a delivery connection.

<u>Operation</u> (Fig. 2.5)

Supply fluid pressure (206 bar) passes through the unit and the reduced pressure fluid (68 bar) is supplied to the delivery connection as shown in Fig 2.5A. As the pressure in the delivery line builds up to the preset value (68 bar), the exhaust valve cap is lifted, reducing the pressure setting spring load and the inlet valve is permitted to reseat under the influence of the cradle spring. The supply is isolated and a balanced condition is produced as shown in Fig 2.5B.

When the delivery line pressure is reduced by the operation of a service, the pressure setting spring forces the exhaust valve and cradle down, unseating the inlet valve and allowing the supply fluid to restore the delivery pressure to the preset value.

Conversely any excess pressure in the delivery line reacts to lift the exhaust valve cap and is relieved into the return line by the non-return valve as shown in Fig. 2.5C in either case, the balanced condition as shown in Fig. 2.5B is restored when the preset delivery pressure is reached.

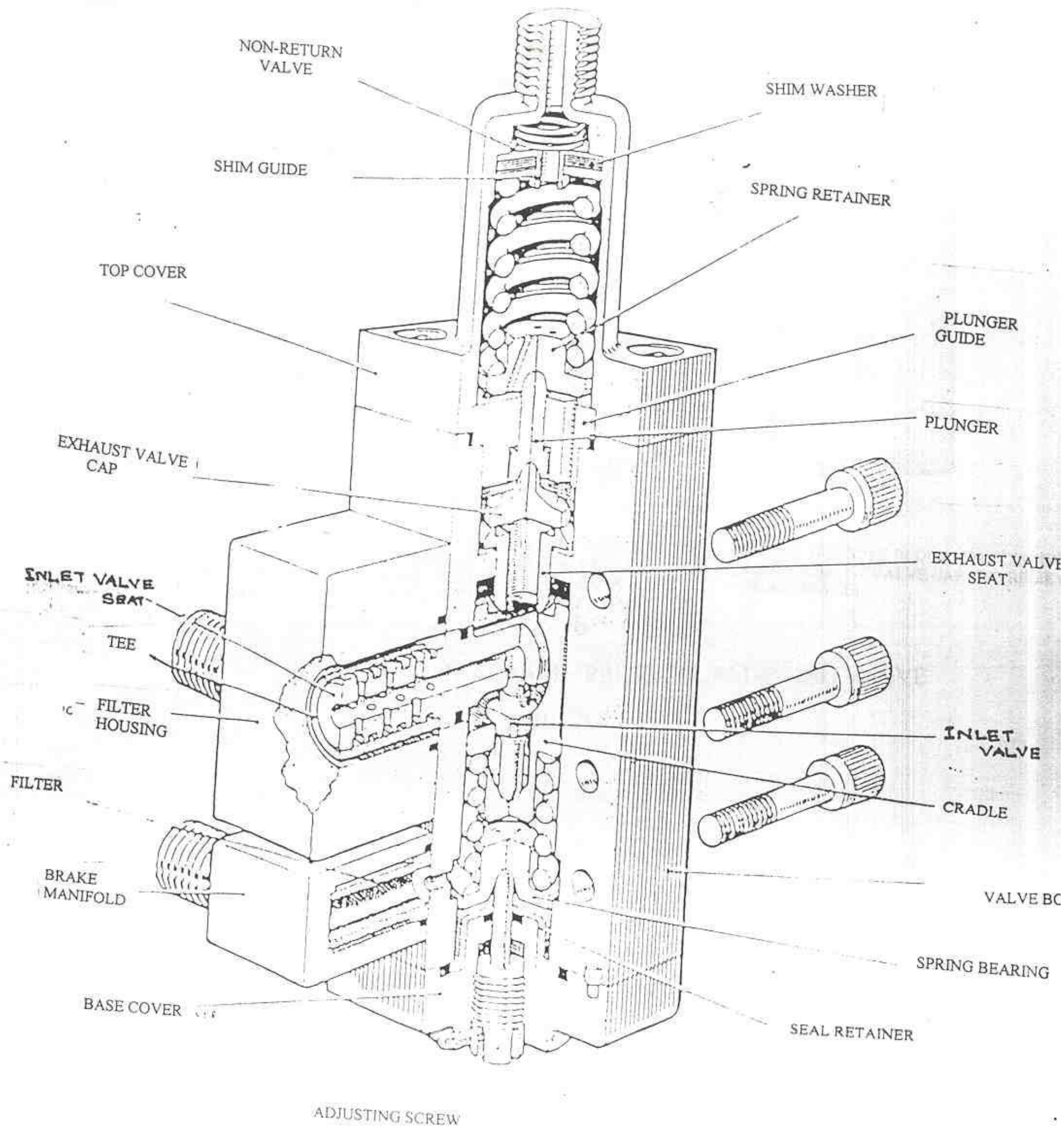
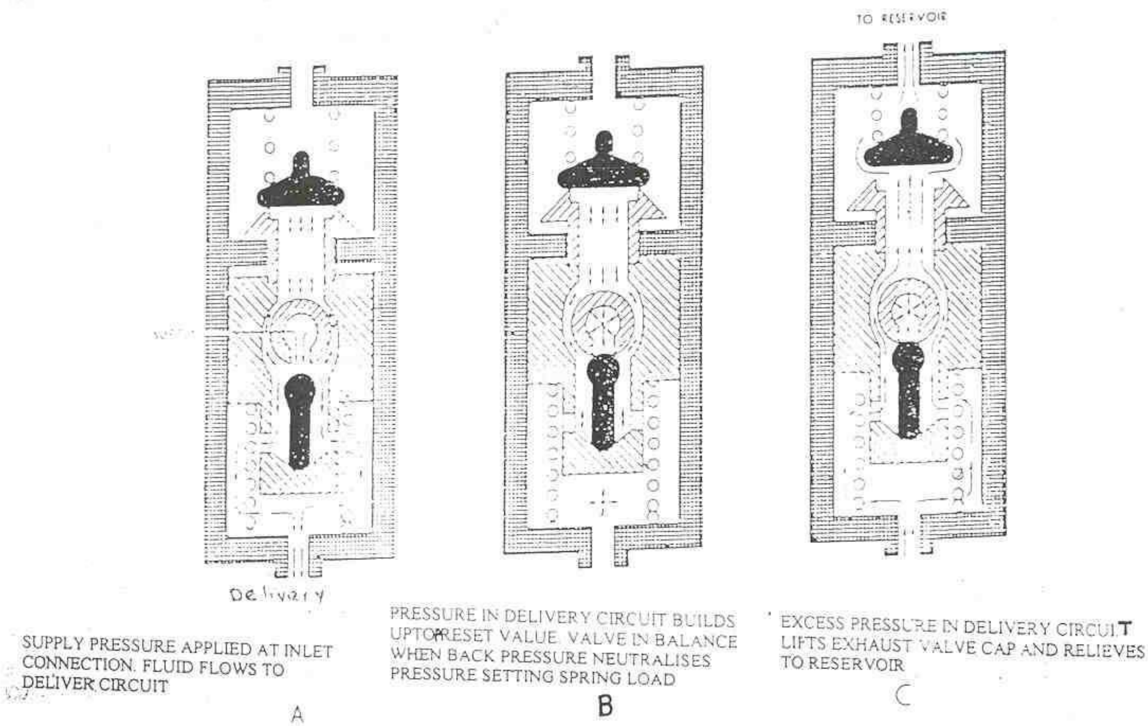


FIG. 2.4

PRESSURE REDUCING VALVE



FUNCTIONAL DIAGRAM - PRESSURE REDUCING VALVE

FIG. 2.5

C) **Brake Control Valve:**

Purpose:

This unit regulates the delivery pressure fluid to the wheel brake units.
Description: (Fig. 2.6)

This unit comprises of two identical variable pressure reducing valve elements, which are operated together for parking and straight braking, or independently for differential braking. A teleflex cable fitted between the unit and the parking control effects parking brake. Each valve element incorporates an inlet and exhaust valve, and both elements are contained within a valve-body enclosed by a top and base cover as illustrated in Fig.2.6

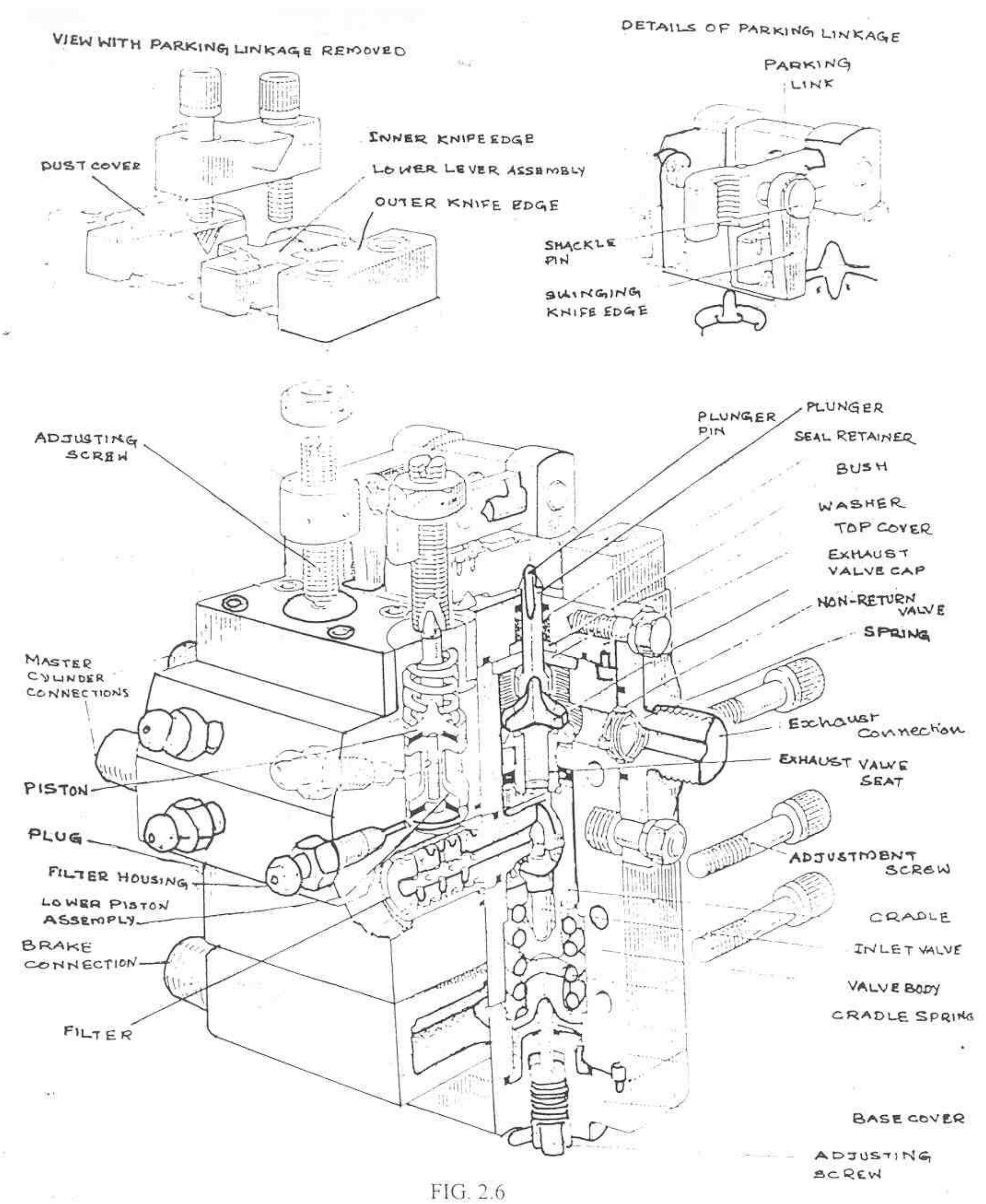


FIG. 2.6

SECTION OF BRAKE CONTROL VALVE

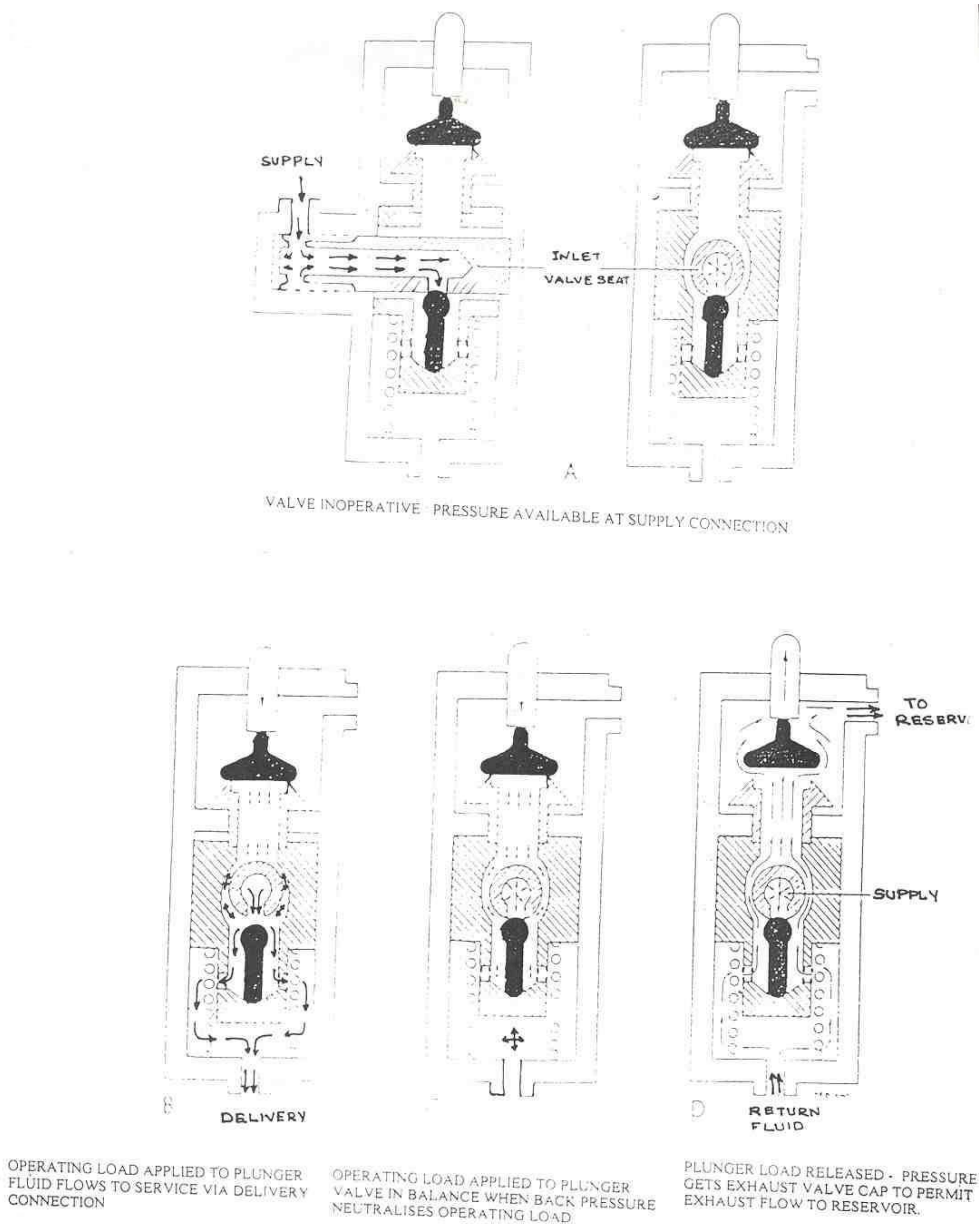


FIG. 2.7 FUNCTIONAL DIAGRAM - BRAKE CONTROL VALVE

Each inlet valve is carried in a spring-loaded cradle surmounted by an exhaust valve seat and cap. A piston operated lever assembly is mounted on the top cover and loads the exhaust valve cap via a plunger. The lever assembly-actuating piston is located in filter housing, attached to a valve body, incorporating a supply connection.

Fitted to the valve body is an exhaust connection incorporating a spring loaded non-return valve to prevent ingress of foreign matter from the system reservoir and a corresponding exhaust port is blanked off. A brake manifold embodying two brake connections is located under the filter housing.

Operation: **(Fig. 2.7)**

In the brakes OFF condition, the exhaust valve caps are unloaded and the inlet valves isolate the supply pressure, as shown in Fig. 2.7A.
When the brakes are applied, fluid from the brake master cylinders lifts the pistons causing the lever assembly to pivot and load exhaust valve caps. The exhaust valves and cradles are forced down, unseating the inlet valves and allowing the supply fluid to be delivered to the brake units as shown in Fig. 2.7B. Delivery continues until fluid pressure under the exhaust valve caps reacts against the load applied by the lever assembly and the inlet valves are permitted to reseat under the influence of the cradle spring. The supply is isolated and the balanced condition is produced as shown in Fig.2.7C . When the brakes are released, pressure in the brake units is dissipated into the return line past the unloaded exhaust valve caps as shown in Fig. 2.7D and the unit returns to the brakes OFF position.

D) Accumulator:

Purpose:

The accumulator, when charged provides a volume of pressurised fluid for the operation of the brake system during emergency conditions and dampens out any fluid pulsations when the system units are operated. The accumulator is charged with N_2 to a pressure of 50 bar.

<u>Description:</u> (Fig. 2.8)

This unit consists of a floating piston contained within a casing formed by a cylindrical body and end cap as illustrated in Fig. 2.8. The piston divides the body into hydraulic and pneumatic chambers, which are indicated on the outside of the body.

<u>Operation:</u>

Application of air pressure to the accumulator through the pneumatic connection pushes the piston towards the end cap. Fluid under pressure introduced via the filter assembly, forces the piston back, compressing the air, until the pressures on both sides of the piston are balanced.

Immediately the brake system is operated, fluid displacement occurs and the piston moves towards the end cap to maintain the balanced condition and exert pressure on the receding fluid. Fluid replenishment by a hydraulic supply forces the piston back to its original position.

The capacity of the accumulator ensures that in the event of the failure of the hydraulic supply or when the supply is inoperative sufficient pressurised fluid is available for a number of brake applications. (In ALH the accumulator acts as an emergency power source for 10 brake operations).

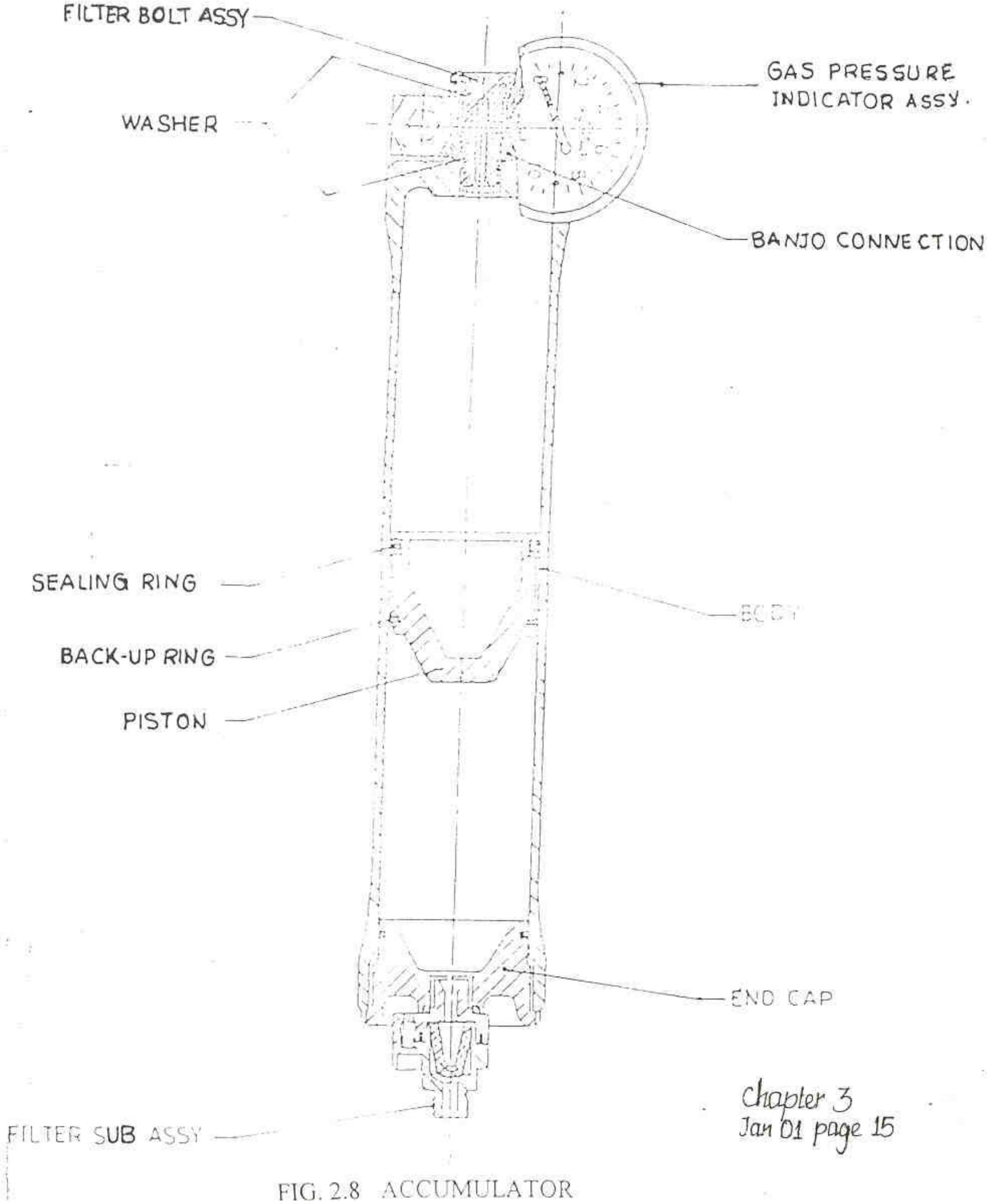


FIG. 2.8 ACCUMULATOR

CHAPTER 4

SKID LANDING GEAR

1. **GENERAL** (FIGURE 1)

The Helicopter is equipped with a skid type landing gear which absorbs the landing impact energy by the deformation of the cross tubes. The skid landing gear basically consists of a forward cross tube (1), a rear cross tube (2) and two skid tubes (3).

Cross tubes are made of Aluminium alloy and are designed to absorb energy during landing up to 2.0 meters per second limit sinking velocity, 2.54 meters per second reserve sinking velocity and up to 4.0 meters per second Crash sinking cross tube. The cross tubes are attached to the structure of the helicopter through hinges.

The skid tubes are made of Carbon Composite, curved at front ends and have caps at the rear ends. Stainless steel wear plates are attached to these tubes to prevent wear.

2. **ATTACHMENTS**

The constructional features of installation of forward and rear cross tubes on the structural lugs are similar. The hinge attachment consists of a bearing ring with installation bolts which are connected to the attachment lugs fitted on to the frames. A rubber bush separates the bearing ring and the cross tube. To prevent any axial movement of the cross tube a clamping ring is provided.

The forward cross tube is installed to the structural lugs at frames 3 and 3A and the rear cross tube at frames 5 and 5A. The drag bracket is provided aft of frame 3A for the forward cross tube attachment lug. Details of structural attachment of forward cross tube is shown in Figure 4 and that of rear cross tube is shown in Figure 5.

2.1 **Key to Figure 4**

- I. Forward Rubber Bush.
- II. Forward Installation Bolt.
- III. Attachment Lug on Frame 3
- IV. Forward Cross tube Assembly.
- V. Forward Clamping Ring.

VI. Forward Bearing Ring.

VII. Attachment Lug on Frame 3A.

VIII. Drag Bracket.

IX. Rear Installation Bolt.

2.2 **Key to Figure 5**

I. Forward Installation Bolt

II. Attachment Lug on Frame 5.

III. Rear Cross Tube Assembly.

IV. Rear Rubber Bush.

V. Rear Clamping Ring.

VI. Rear Bearing Ring.

VII. Attachment Lug on Frame 5A

VIII. Rear Installation Bolt.

2.3 The Cross tube to the skid tube attachment is called as the skid shoe and is typical for forward and rear attachments (Figures 6 and 7).

2.3 The skid shoe consists of a sleeve (2), which receives the end of the cross, tube (1), a curved bracket (3) which sits on the skid (4) and a funnel (5), which connects the sleeve to the curved bracket.

3 **MAIN PARAMETERS**

Type	… Skid Landing Gear
Radius of forward cross tube	… 1550mm
Radius of rear cross tube	… 1675mm
Track	… 2600mm

Ground clearance at Frame 5 … 455mm
(skid gear unloaded)

Lateral stability angle … 29.22 degree
(at operational Empty Weight)

Pitch stability angle … 20.37 degree
(at operational Empty Weight)

Weight … 67 Kg.

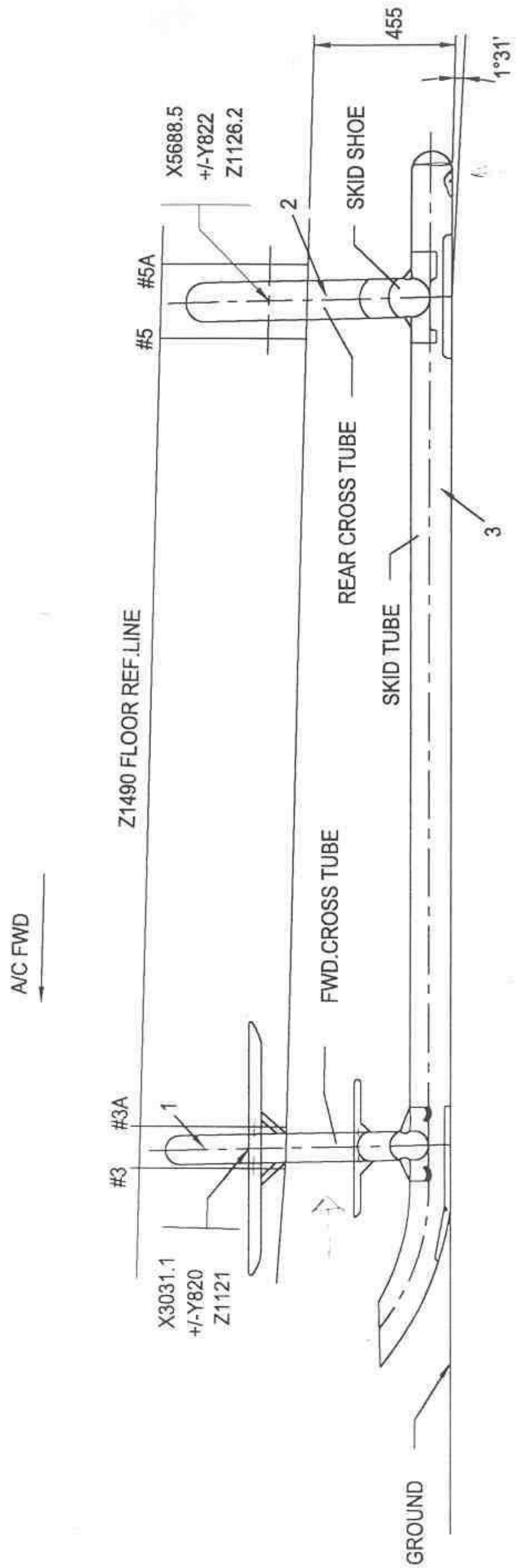


FIGURE 1 SKID LANDING GEAR

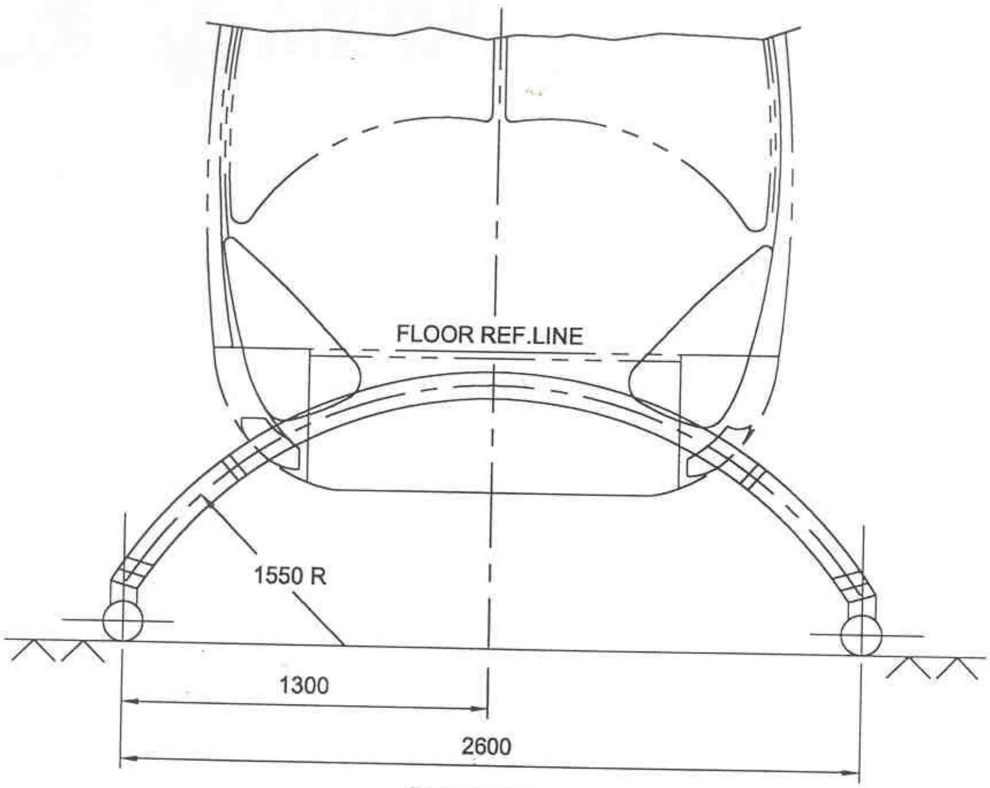


FIGURE 2

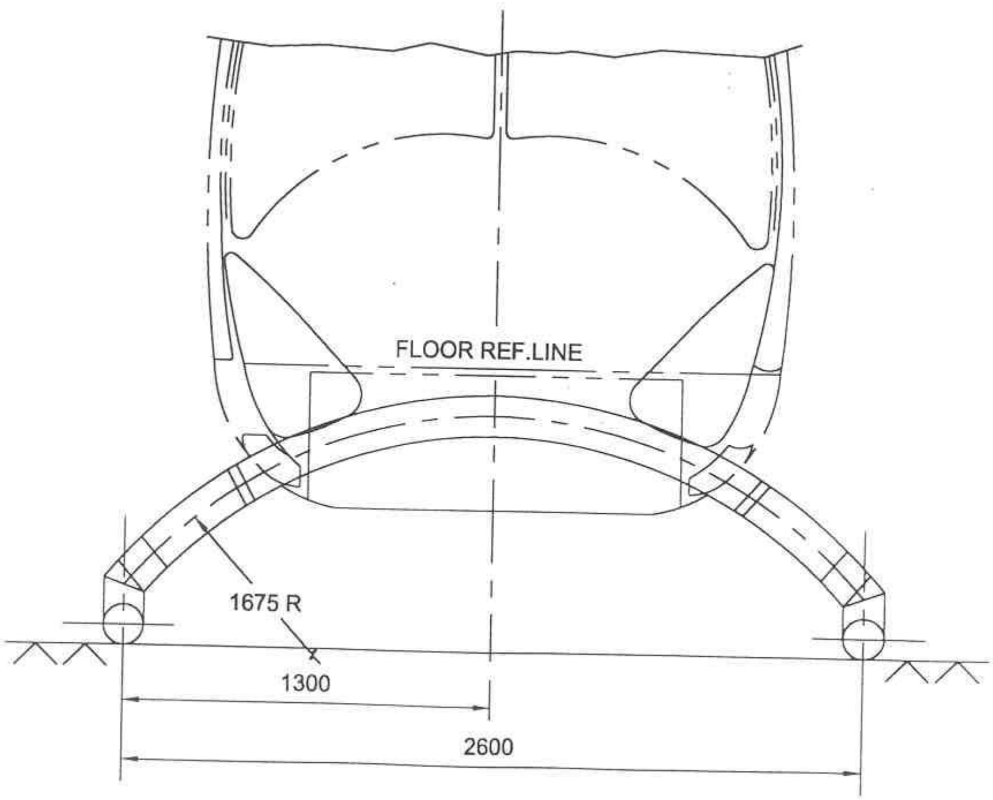


FIGURE 3

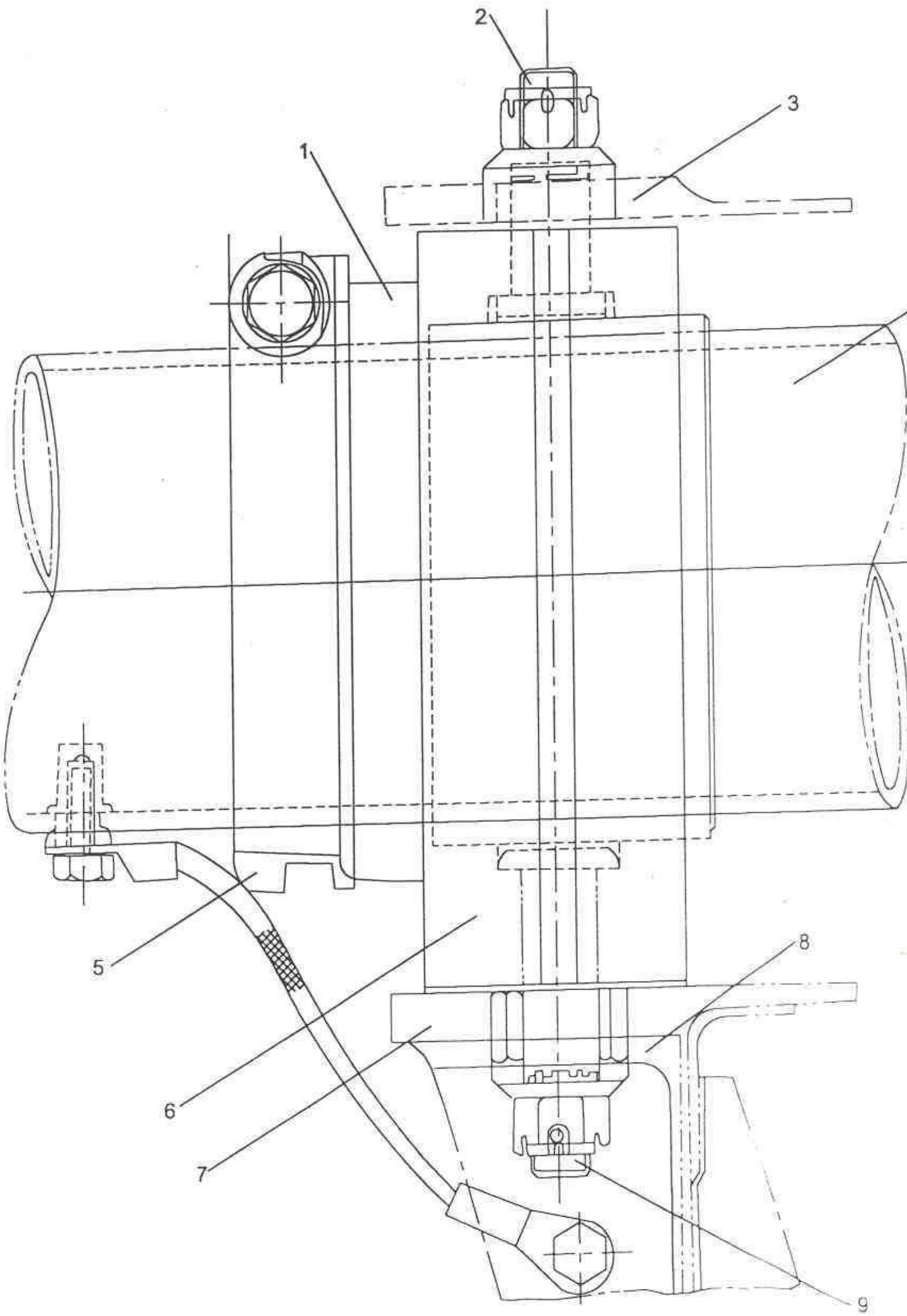


FIGURE 4

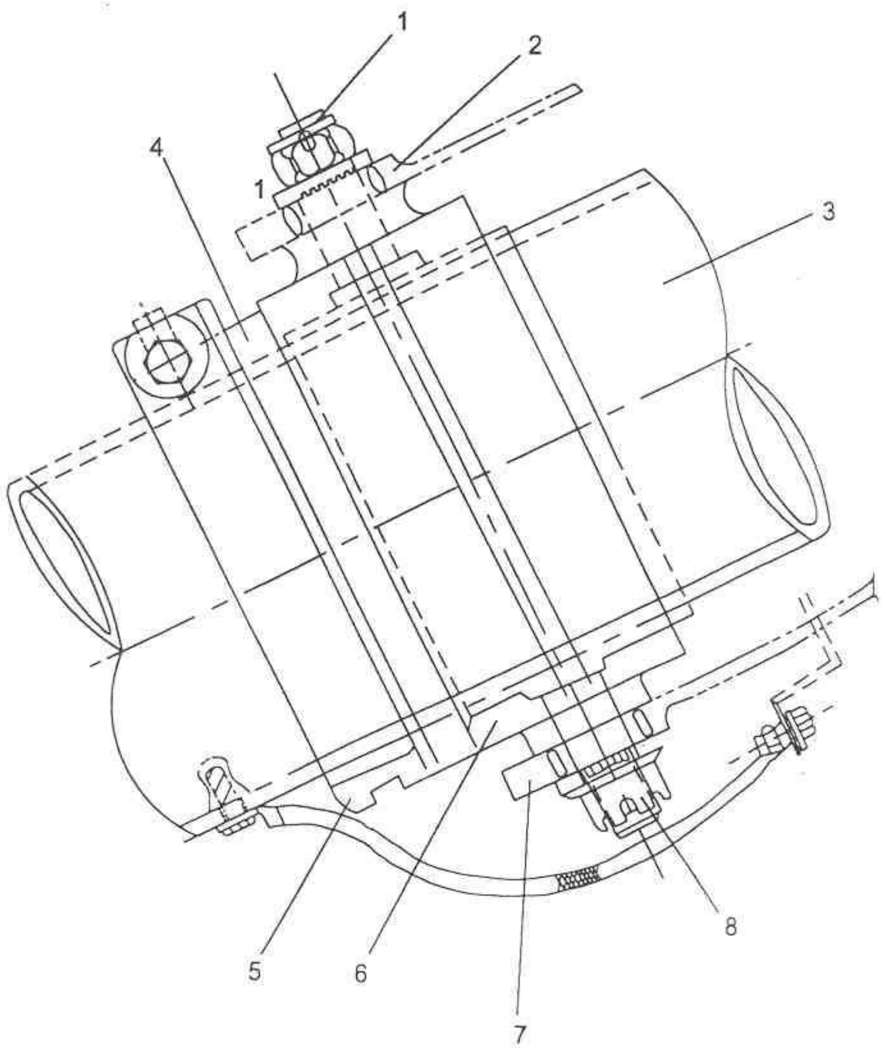


FIGURE 5

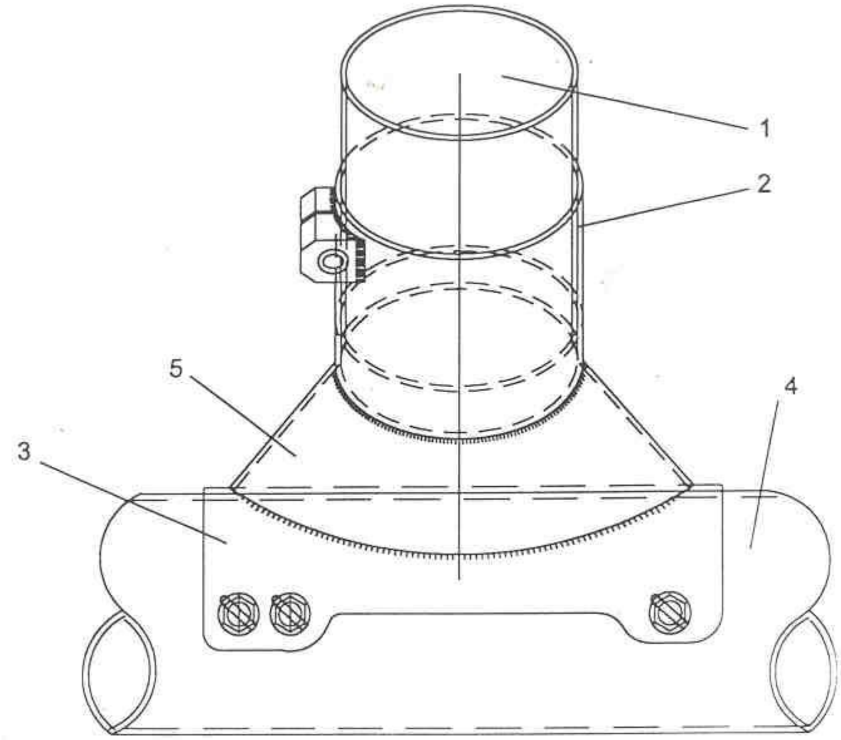


FIGURE 6

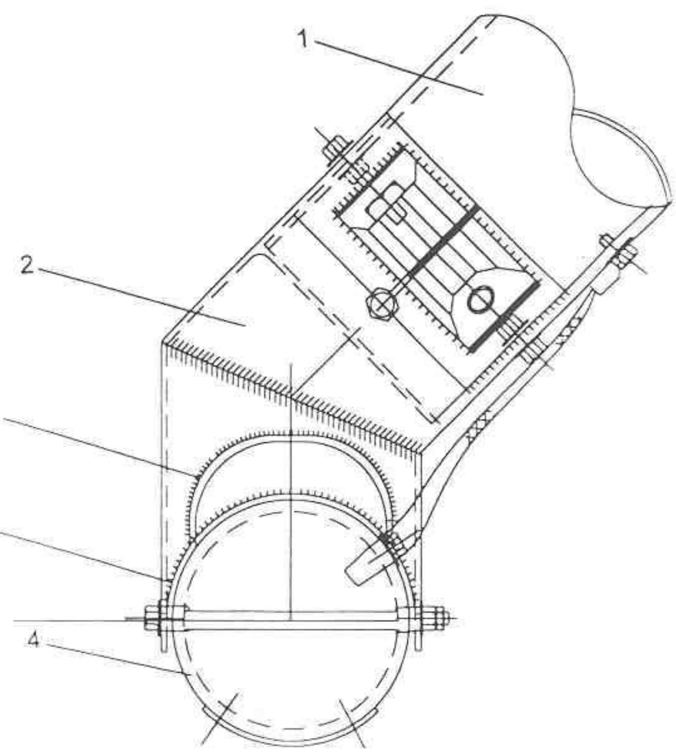


FIGURE 7