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Operating Valve For Guide Vane Lock

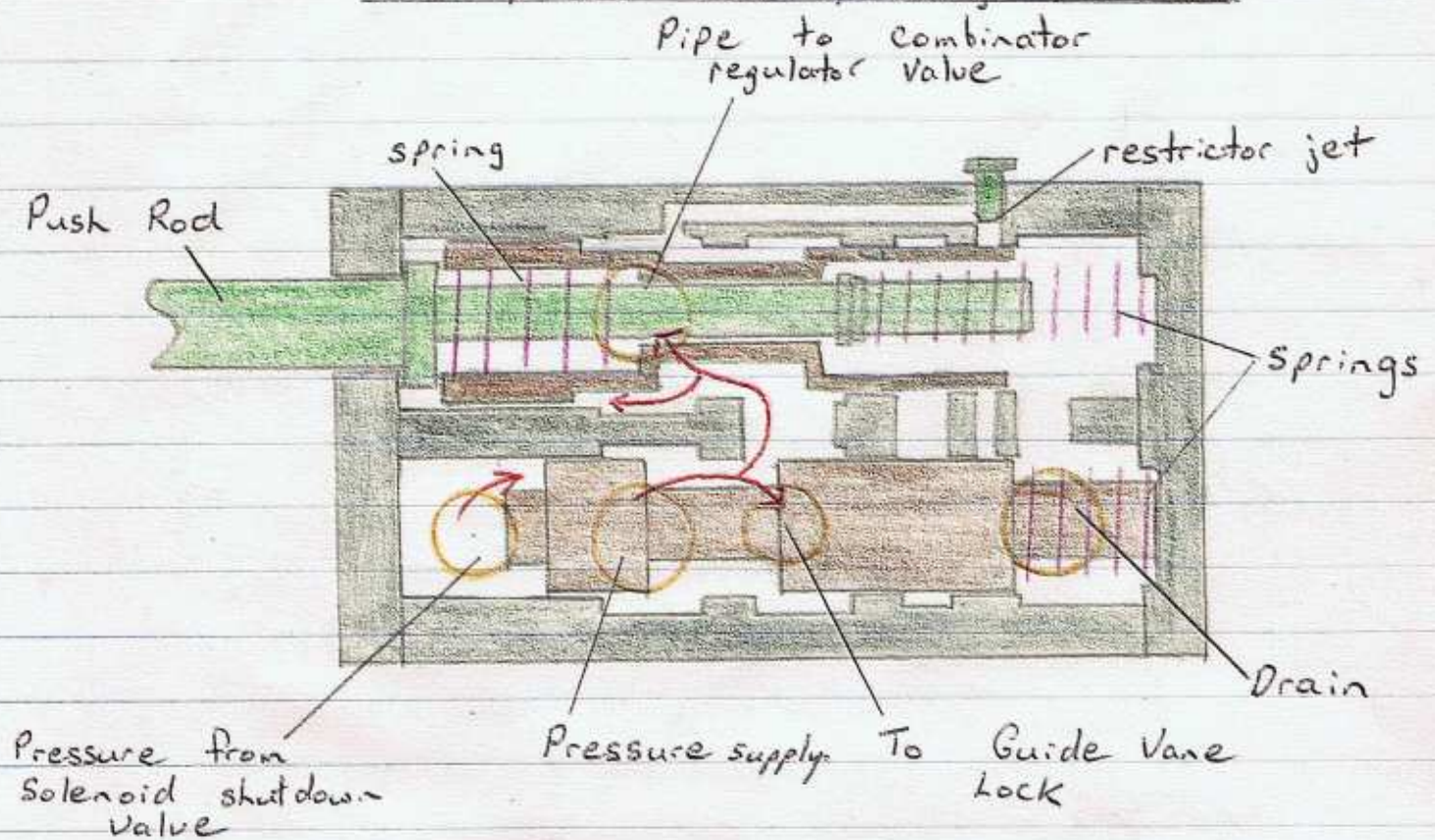
This valve is also referred to as the starting device in some literature explaining governor operation. It is manufactured by Bouing + Co and is shown on drawing No 13012 T in folder GA To GB.

The purpose of this valve is to cause the operation of the guide vane locking pin through the initial operation of the solenoid operated shut down valve, and to cause the removal of the oil pressure that operates the combinator piston, either through the initial action of the solenoid operated shut down valve or by the guide vanes being fully closed.

The valve is located alongside the servomotor to swing ring connecting rod, the push rod of the top piston is pressed in. when the guide vanes are fully shut, by a bracket that is mounted on the servomotor piston.

Drawing shows valve for guide vane lock

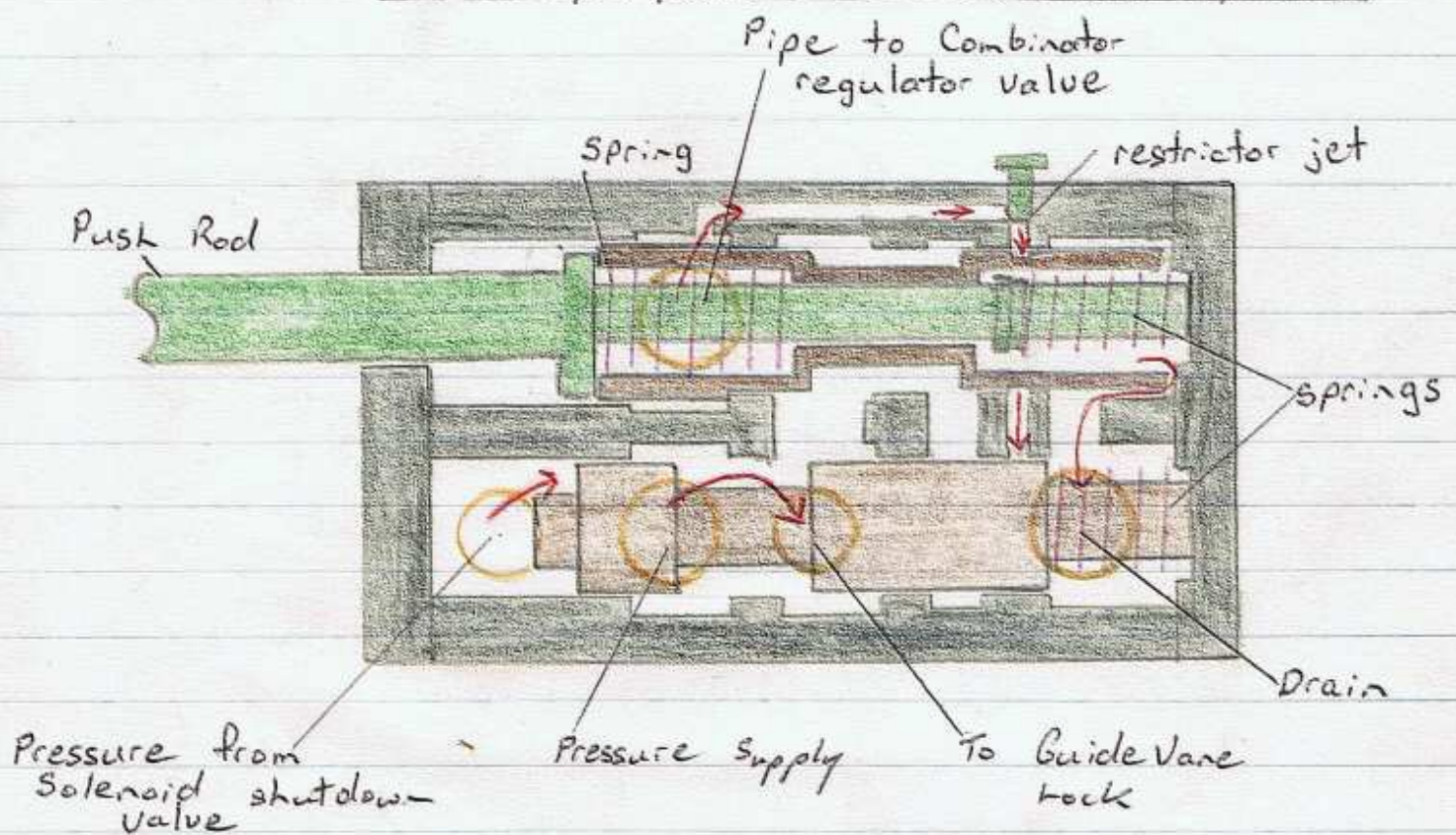
With pistons in operating positions.



When the machine is operating, oil is supplied from the governor pressure line via the solenoid shutdown valve. This pressure overcomes the spring pressure of the bottom piston and pushes it to the operating position (ie. to the right of drawing). When the bottom piston is in the operating position oil pressure via the pressure supply pipe is supplied to the guide vane lock to cause the guide vane lock to disengage. Pressure is also supplied to the top piston and because the left end of the top piston is a larger diameter than the right end the oil pressure causes the piston to move to the left so uncovering the pipe to the combinator regulator valve and allowing the oil pressure to flow to the combinator regulator valve.

Note Red lines show oil flow →

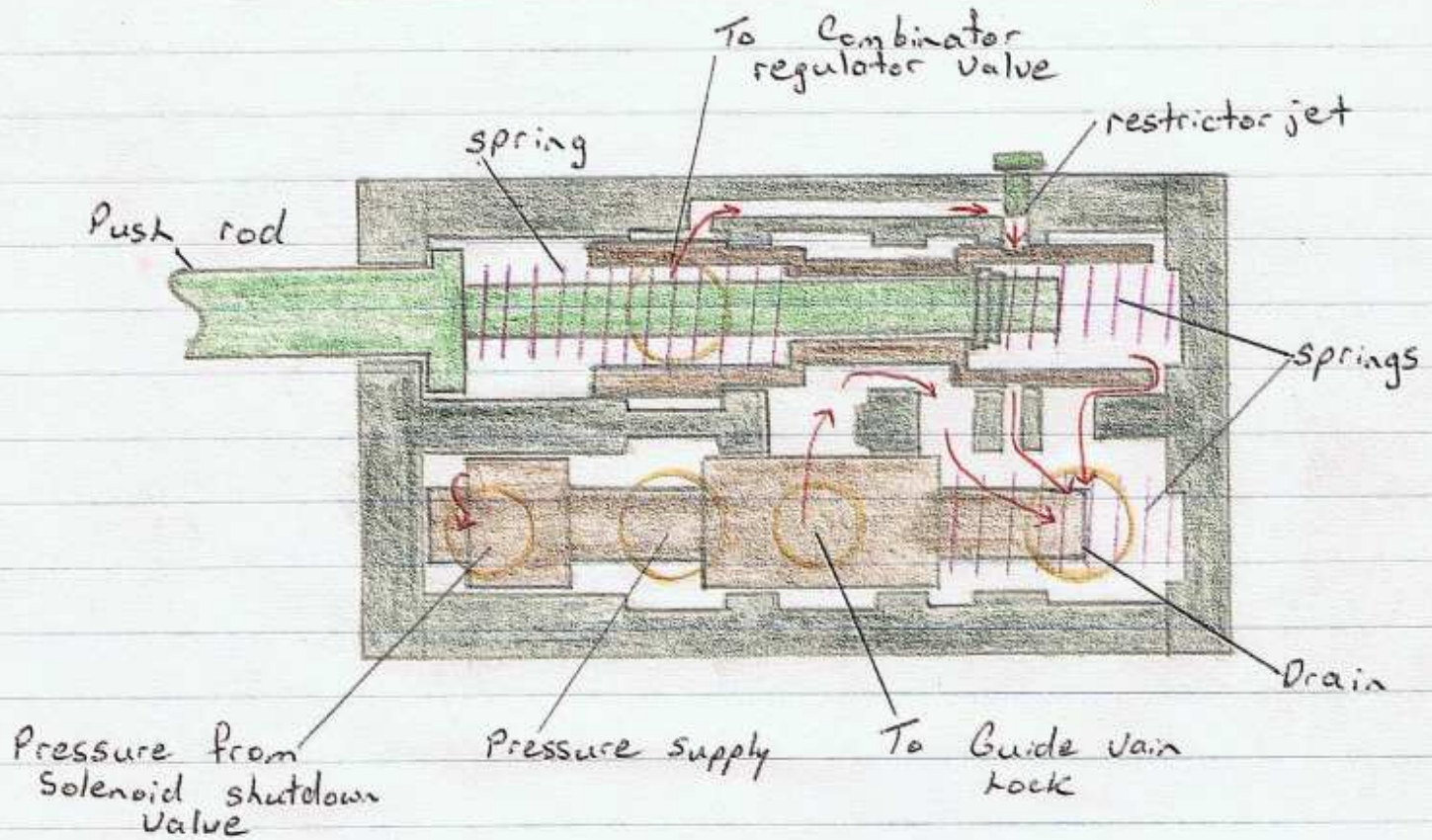
Drawing shows valve for guide vane lock
with top piston in shutdown position



When the machine is stopped i.e. guide vanes shut, (but locking pin not yet engaged) a bracket on the guide vane servomotor piston presses the pushrod which presses the top piston to the shutdown position. The top piston now closes off the pipe to the combinator regulator valve stopping the oil flow which operates the combinator and a groove around the right end of the top piston aligns with the discharge ports of the restrictor jet in readiness to allow the oil to drain away, but as the stop button on the machine has not yet been pressed, the shut down solenoid is still in the operating position supplying pressure to hold the bottom piston in the operating position. With the bottom piston in the operating position, the right hand end of the piston closes off the discharge from the restrictor valve (preventing the combinator shaft dropping) and also supplies pressure to the guide vane lock to keep it disengaged.

Note red lines show oil flow →

Drawing shows valve for guide vane lock
with both pistons in shutdown position



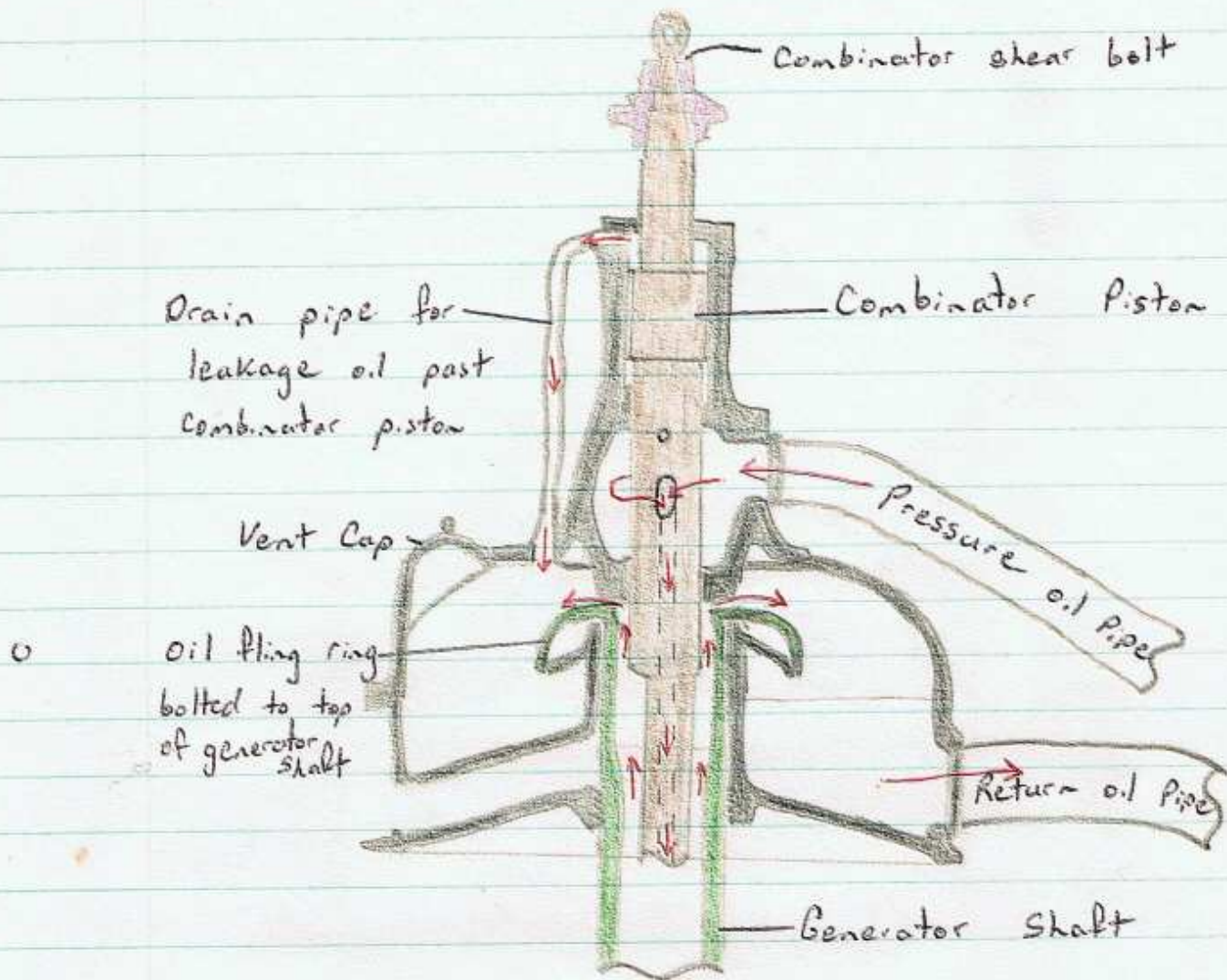
The top piston is moved to the shutdown position in 1 of 2 ways (i) when the machine is stopped i.e. guide vanes shut, a bracket on the guide vane servomotor piston presses the pushrod which presses the top piston to the shutdown position. The top piston now closes off the pipe to the combinator regulator valve, stopping the oil flow which operates the combinator and a groove around the right end of the top piston aligns with the discharge ports of the restrictor ^{jet} ~~valve~~ in readiness to allow the oil to drain away from the combinator. When the stop button on the machine is pressed, the solenoid shutdown valve operates and removes the pressure from the left end of the bottom piston, the bottom piston now moves to the shutdown position. With the bottom piston in the shutdown position the pressure supply is closed off from the guide vane lock and from the top piston, and the discharges from the restrictor jet and the top piston.

Note red lines show oil flow →

a are opened to the drain which flows back to the governor oil reservoir. This allows the oil to flow out of the guide vane lock and allows it to engage and also allows the combinator piston to fall (at a rate depending on the restrictor jet setting)

(2) When the solenoid valve is operated (to the shutdown position) while the guide vanes are still open (this may be the case, as when the guide vanes are locked open during turbine inspections, or during a solenoid instigated shutdown) ~~that~~ the oil pressure is removed from the left end of the bottom piston, allowing the bottom piston to move to the shutdown position. With the bottom piston in the shutdown position the oil pressure supply is closed off from the guide vane lock (if this was not already closed off by the locking pin isolating valve during overhaul) and from the top piston, and the discharges from the restrictor jet and the top piston are opened to the drain which flows back to the governor oil reservoir. This allows the top piston to move to the shutdown position and allows the oil to flow out of the guide vane lock and allows the combinator piston to fall (at a rate depending on the restrictor jet setting).

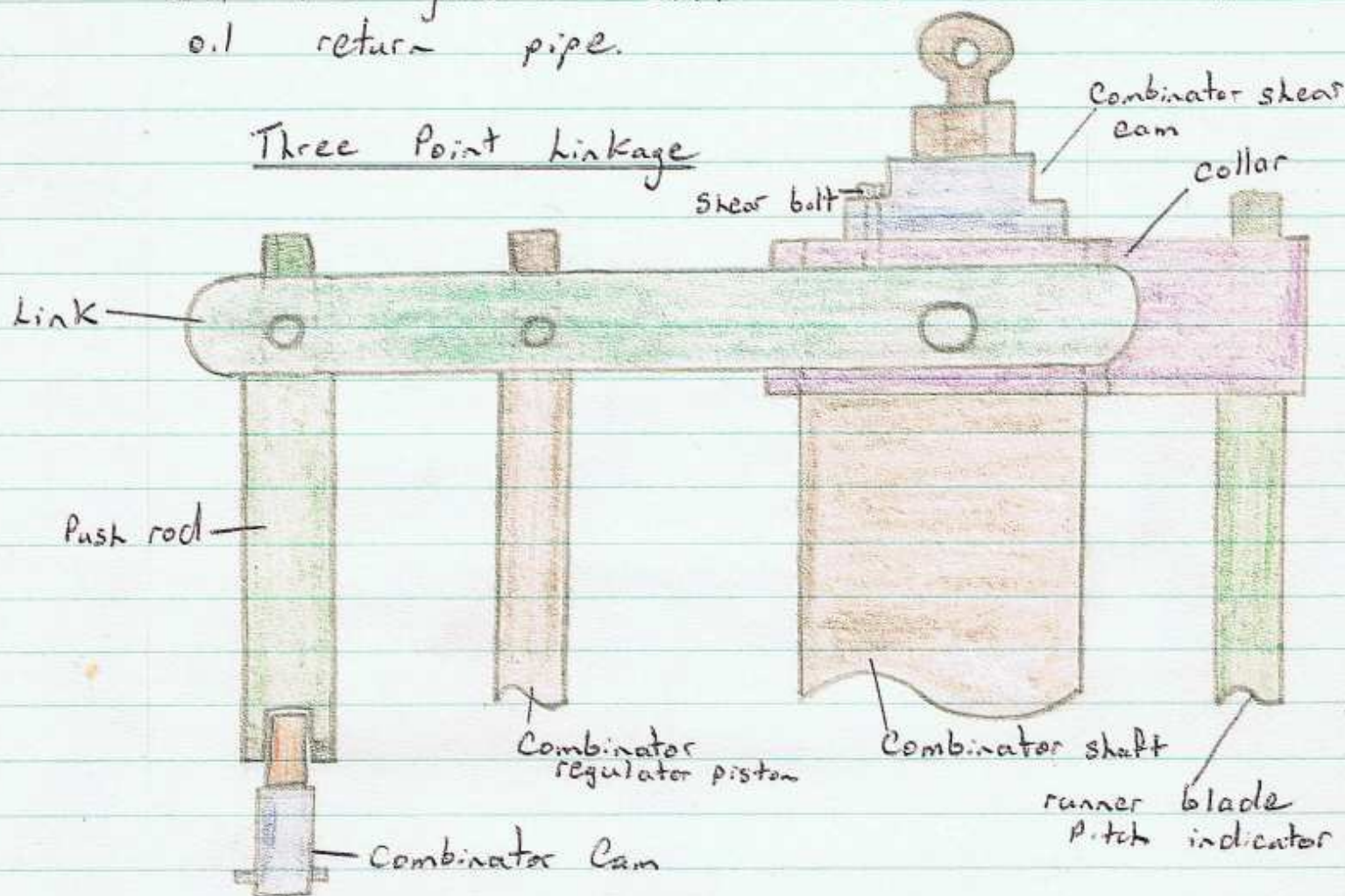
The Combinator head.



It is manufactured by Boeing & Co and is shown on drawing No 11446T in folder 6C

The combinator head contains the combinator regulator piston (not shown in drawing), the combinator piston itself, and the pressure and return o.i. ways for the o.i. that operates the runner servomotor. The combinator shaft itself does not operate the runner blades, but pressure oil (from pressure oil pipe) is carried down the centre of the combinator shaft to operate the runner servomotor piston that is located in the runner itself. The combinator shaft acts only as a regulator piston for the runner servomotor.

Oil returning from the runner servomotor is carried up between the combinator shaft and the generator shaft and out to the oil return pipe.



The combinator shaft has a cam (combinator shear cam) keyed to the top of the shaft and a bolt holding it to the collar to which the three point linkage is attached. If the combinator shaft should bind up inside the generator shaft, the combinator shaft will turn in the collar to which the three point linkage is attached, the shear bolt through the combinator shear cam will shear off and the shear cam will operate a switch that causes the machine to trip of load and shut down.

The purpose of the three point linkage is to cause the combinator regulator piston to be returned to its neutral position by the movement of the combinator shaft after the combinator cam has raised or lowered the push rod in response of a command from the actuator for an alteration of blade pitch.

Example To increase blade pitch, the actuator moves the combinator cam so that the push rod is raised, this also causes the combinator regulator piston to be raised. The result of raising the regulator piston is that the combinator shafts lowers and in doing so also lowers the regulator piston (via the three point linkage) to its neutral position at which point the combinator shaft ceases to lower.

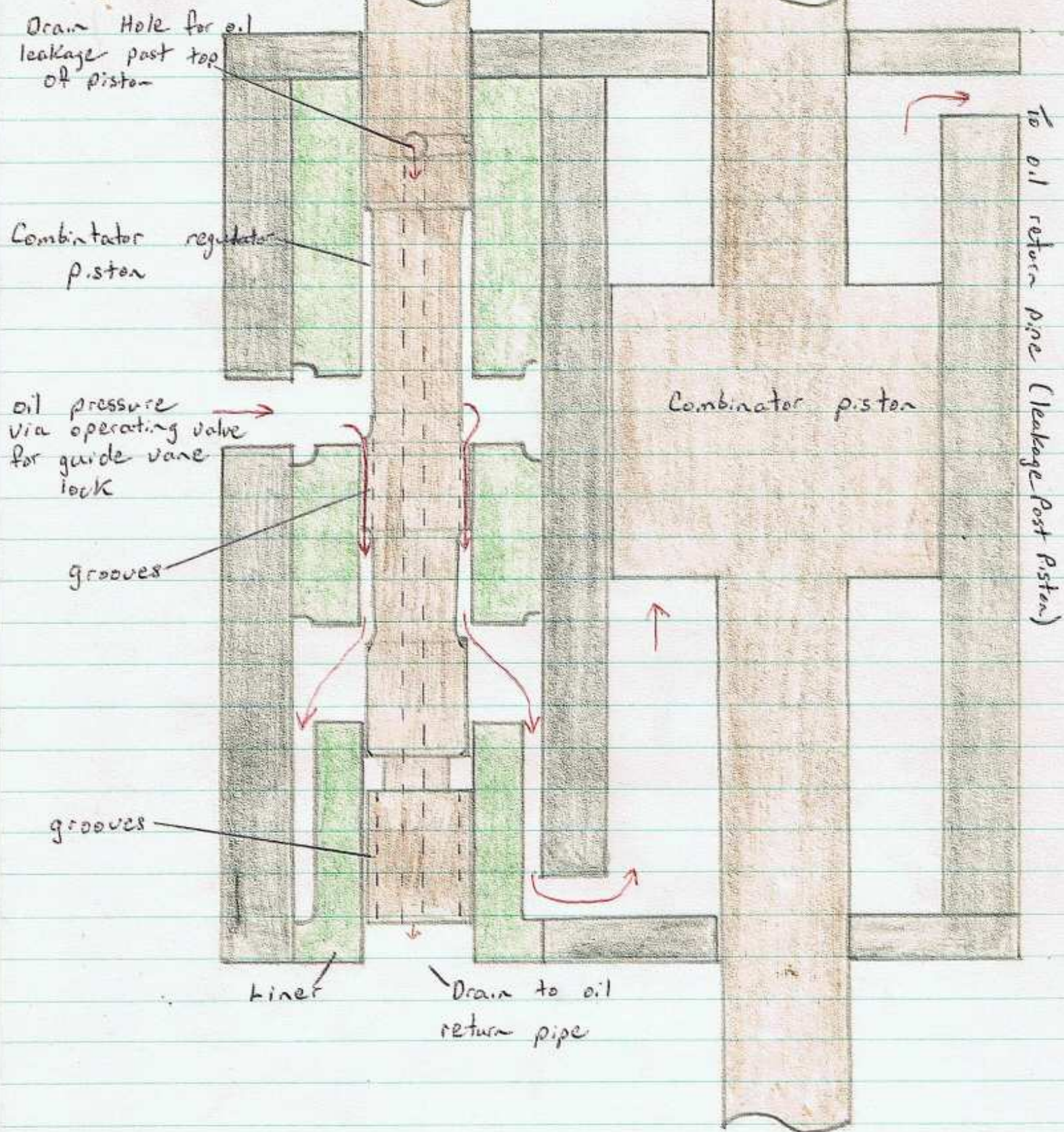
The reverse happens when blade pitch is decreased.
The combinator regulator and piston

The combinator piston is operated by oil pressure to the lower side of the piston only.

Pressure is applied to raise the piston and the pressure is released to lower the piston. The piston itself does not cause the turbine blades to alter pitch but raises and lowers a ported shaft (combinator shaft) that controls oil pressure to a servomotor piston in the runner itself. There is an oil drain pipe from the top of the combinator piston bore to drain off oil that leaks past the piston.

The oil pressure to operate the combinator piston is supplied by the combinator regulator valve via the valve for guide vane lock.

Drawing showing Combinator Rising.

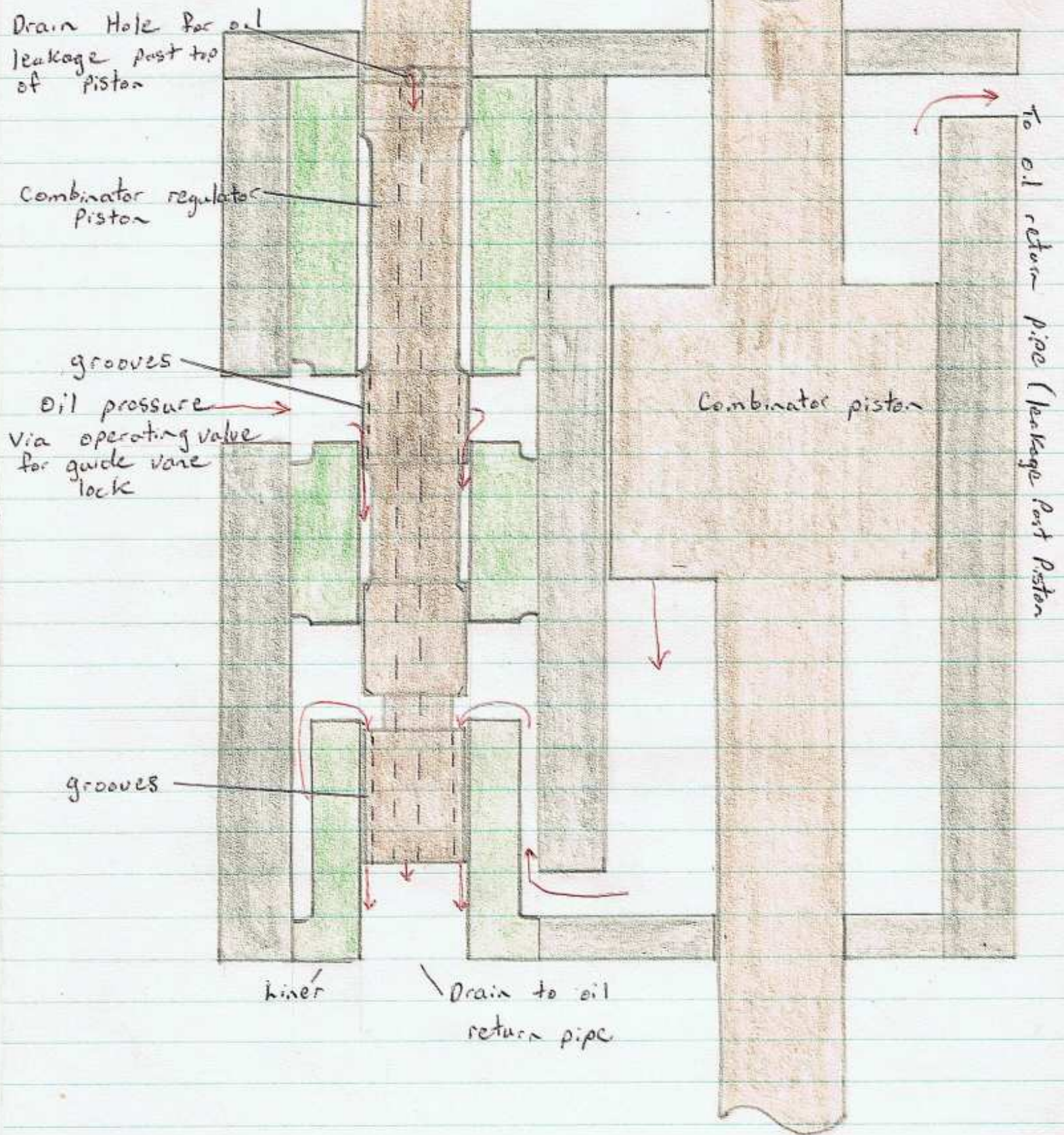


When less power is required out of the turbine the governor actuator reduces the guide vane opening and also reduces the pitch of the runner blades. To reduce the pitch of the runner blades the actuator causes the coupling rods to move the combinator cam.

Note Red lines show oil flow →

which lowers the Combinator regulator piston from its neutral position. This allows the pressure oil (which comes via the operating valve for guide vane lock) to flow down the four lateral grooves in the combinator regulator piston, through the ports in the liner and to the lower side of the combinator piston, causing the combinator piston and shaft to rise. As the combinator shaft rises the three point linkage on top also causes the combinator regulator piston to rise ^{again} and so return to its neutral position so cutting off the flow of oil to the combinator piston. The combinator piston then stays at that level (apart from a small down and up motion caused by oil leakage past the combinator piston) until the governor actuator commands another change. The oil which leaks past the combinator piston is piped back to the return oil pipe via the port in the top of the combinator piston bore.

Drawing Showing Combinator Lowering



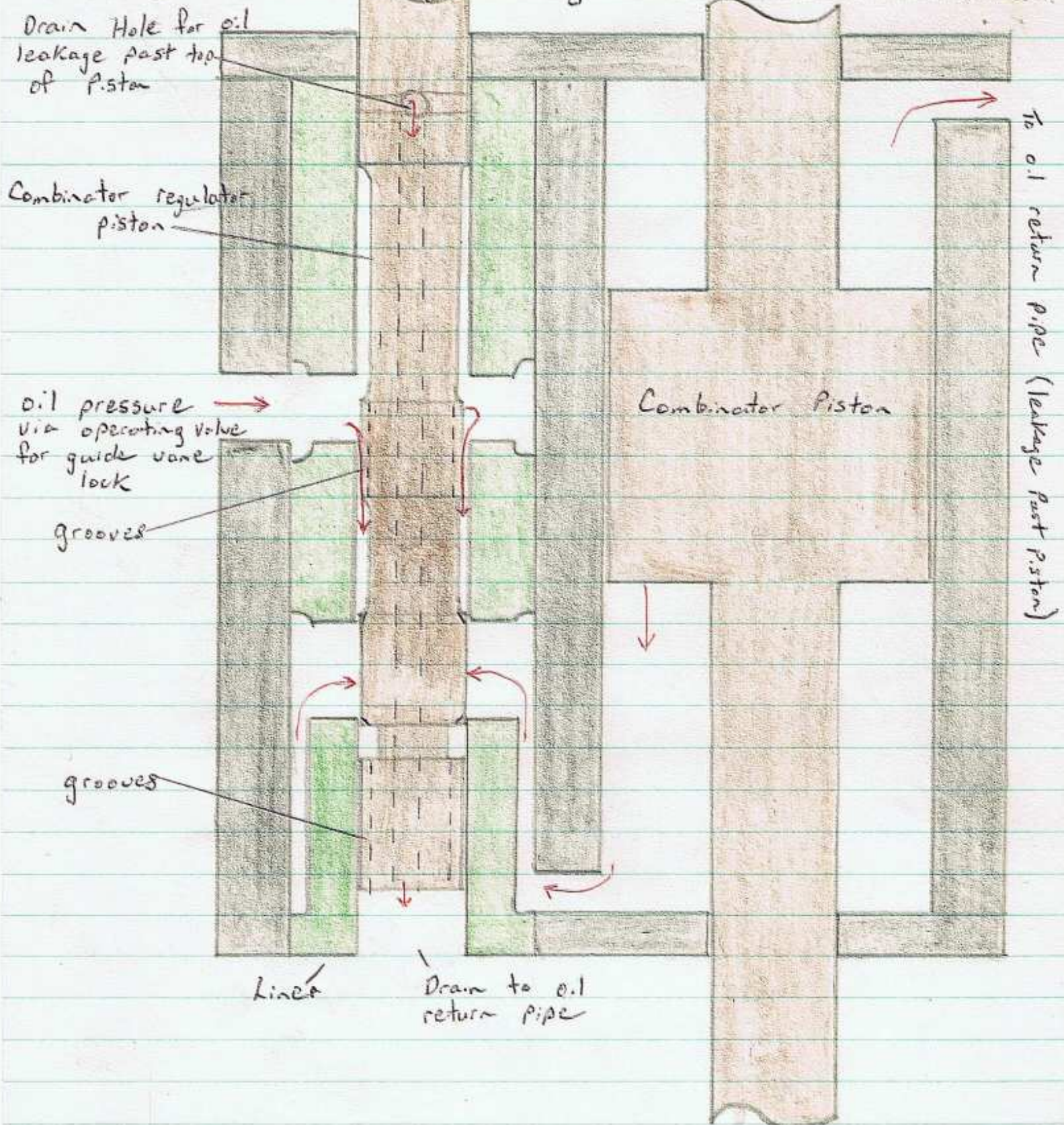
When more power is required out of the turbine the governor actuator increases the guide vane opening and also increases the pitch of the runner blades. To increase the pitch of the runner blades the actuator causes the coupling rods to move the combinator

Note Red lines show oil flow →

Cam which raises the combinator regulator piston from its neutral position. This allows the oil supporting the combinator piston (under pressure from the weight of the combinator piston and shaft) to flow down the four lateral grooves in the bottom part of the combinator regulator piston and out to the oil return pipe. As the combinator shaft lowers the three point linkage on top also causes the combinator regulator piston to lower again and so return to its neutral position so cutting off the flow of oil from the combinator piston. The combinator piston then stays at that level (apart from a small up and down motion caused by oil leakage past the combinator piston) until the governor actuator commands another change.

The oil which leaks past the combinator piston is piped back to the return oil pipe via the port in the top of the combinator piston bore.

Drawing Showing Combinator in Neutral Position



When there is o.i. pressure being supplied (via operating valve for guide vane lock) the combinator cam can move the combinator regulator piston and cause the combinator piston to move to any position within the length of its stroke and through the action of the three point linkage cause the combinator

Note Red lines show o.i. flow →

regulator piston to return to the neutral position.

In the neutral position the lower ports in the regulator piston liner are closed off by the regulator piston so that oil cannot be supplied to or drained from the lower side of the combinator piston. (apart from small amounts of leakage past the pistons).

Actions When stopping and starting.

Stopping

When the machine is idling (off load) prior to shut down, the combinator cam causes the regulator piston to be lowered which causes the combinator piston to rise and so reducing the runner blade pitch to a minimum. When the machine is stopped (guide vanes shut) the top piston in the operating valve for guide vane lock is pushed by the bracket on the servomotor piston and so the oil pressure supply to the combinator regulator valve is closed off. Leakage past the combinator piston allows the piston to creep down slowly causing the combinator regulator piston (via three point linkage) to move to the combinator raise position, but the combinator does not raise because the oil supply has been closed off. When the stop button on the machine is pressed the oil from the combinator piston is allowed to exhaust via the restrictor jet (in the operating valve for guide vane lock) to the drain and the combinator piston falls at a faster rate to the bottom of its stroke and in so

doing applies maximum pitch to the runner blades.

Starting

When the machine is shut down the combinator piston is at the bottom of its stroke and so the runner blades have maximum pitch, the combinator regulator piston is in the raise position but oil pressure is not supplied (via operating valve for guide vane lock) until the guide vanes have been opened, so the machine is started with maximum pitch on the blades, and at the time the guide vanes open, oil is supplied to the combinator regulator piston to bring the combinator piston to the normal running position.

The Kaplan Runner Hub.

The runner is manufactured by Boeing & Co, it is shown in drawings 10783T (Sectional Assembly), 10784T (Sectional Plan), and 11128T (Assembly and Descriptive Notes).

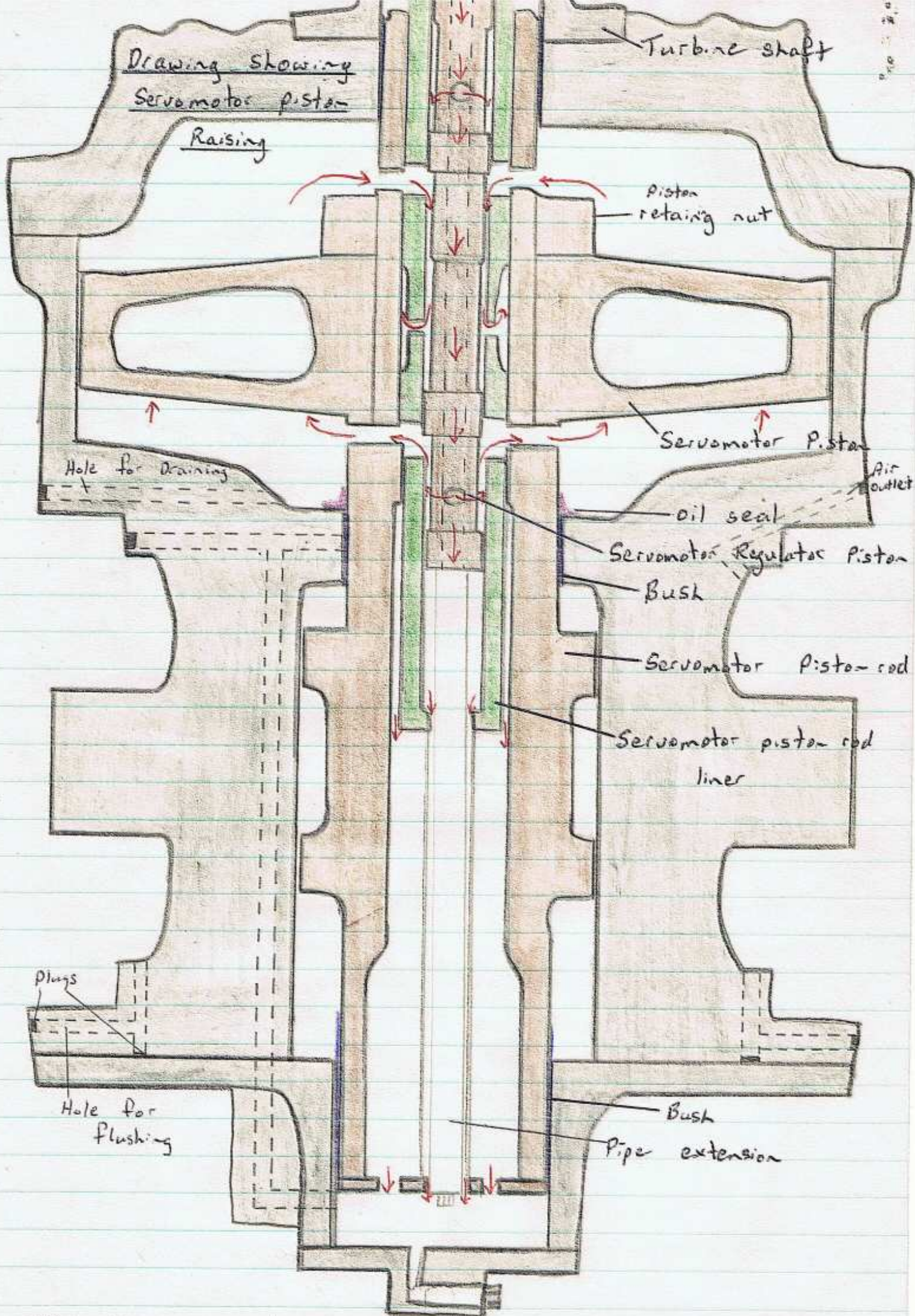
The runner hub contains a servomotor piston, a regulator piston to control the servomotor piston position and supports five runner blades, the angle of which are controlled by the servomotor piston via the five arms on the servomotor piston rod.

The piston is not part of the piston rod but is placed on the piston rod and retained by a large nut.

The body of the runner consists of the main body which supports the blades and houses the servomotor piston, a top and bottom cover which are both removable and also a nose cone to streamline water flow.

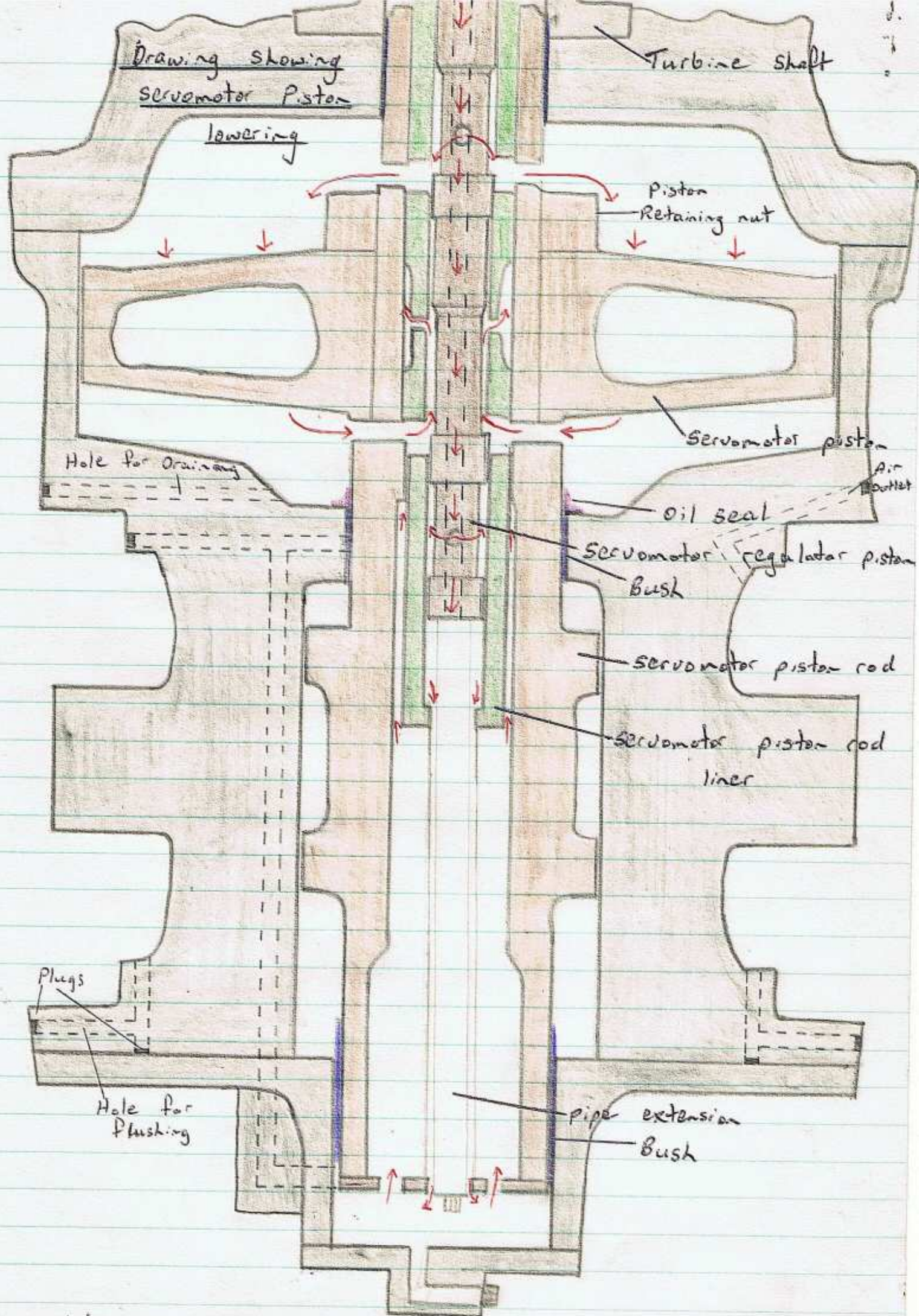
A piston type oil pump is placed beneath each of the five arms on the servomotor piston rod and the top of the pump pistons are bolted to the underside of each arm so that with every alteration of runner blade angle, oil is pumped through a drilling to the "Crank pin ring" journal.

In the following drawings oil holes are shown for draining the under side of the piston cavity and for flushing out the runner blade cavity, and also an air outlet from the blade cavity. These holes are not ~~necessary~~^{all} shown in the position that they actually are on the machine.



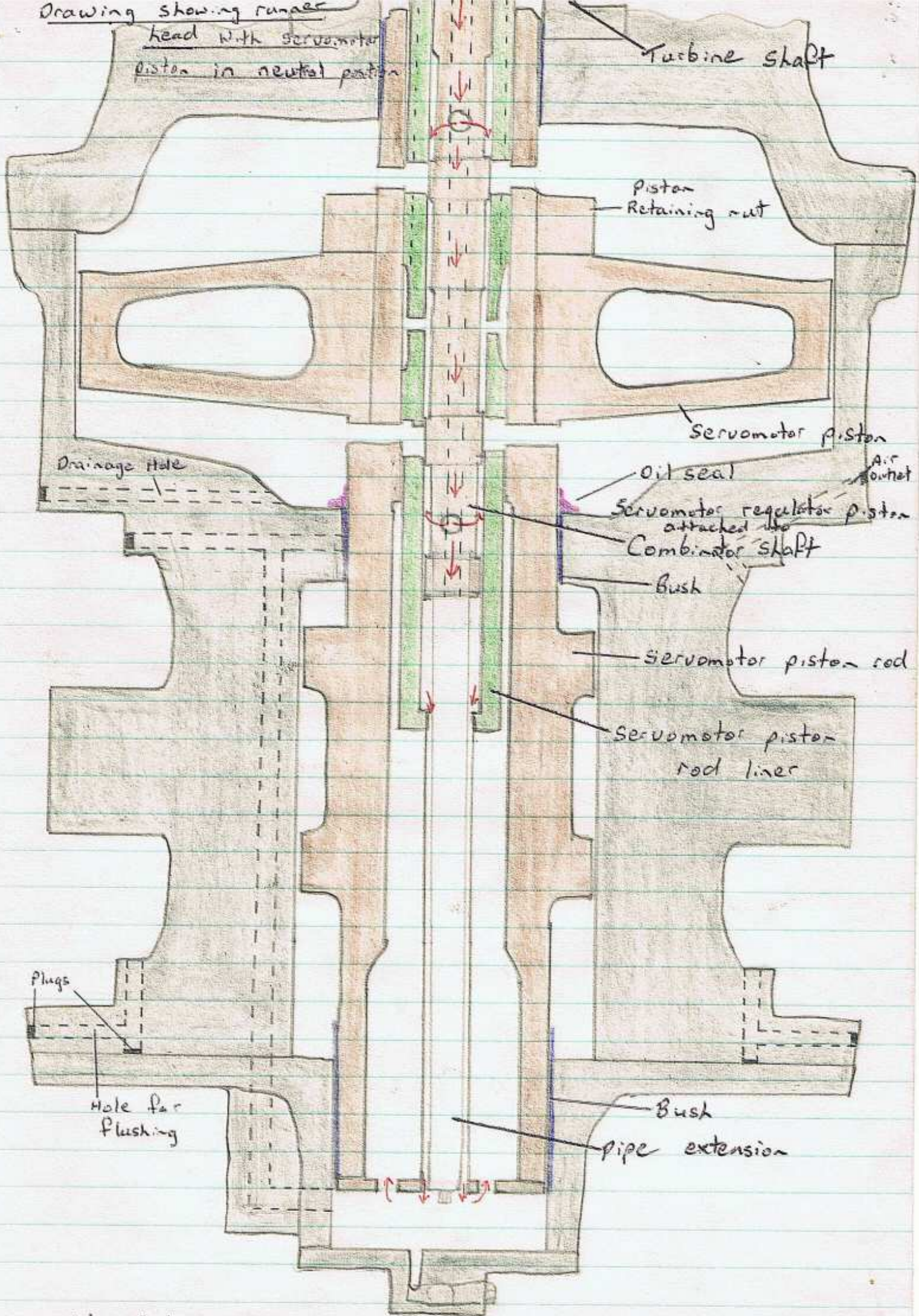
Note Red lines show oil flow →

When the servomotor regulator piston is raised from the neutral position (by instruction from governor actuator for less blade pitch) the ports are opened so that the pressure oil that is flowing down the centre of the combinator shaft and servomotor regulator piston, is allowed to enter the bottom side of the servomotor piston. The ports are also opened so that oil from the top side of the servomotor piston is allowed to exhaust by travelling down between the regulator piston and the servomotor piston rod liner and then pass through the ports in the liner and travel up the four longitudinal grooves in the outer surface of the liner and up between the combinator shaft and the turbine shaft. The servomotor piston will continue to raise until the ports are closed off when the servomotor piston reaches the neutral position in relation to the regulator piston. Oil exhausting from the top side of the servomotor piston is forced down the four longitudinal grooves in the outer surface of the piston rod liner to fill the area beneath the servomotor piston rod as the piston raises, this prevents a vacuum forming that could draw water into the runner head. The pressure is created due to difference in oil level at top of piston rod and in oil in the oil pass through between combinator shaft and turbine shaft i.e. oil is compressed by upward movement of servomotor piston rod.



Note Red lines show oil flow →

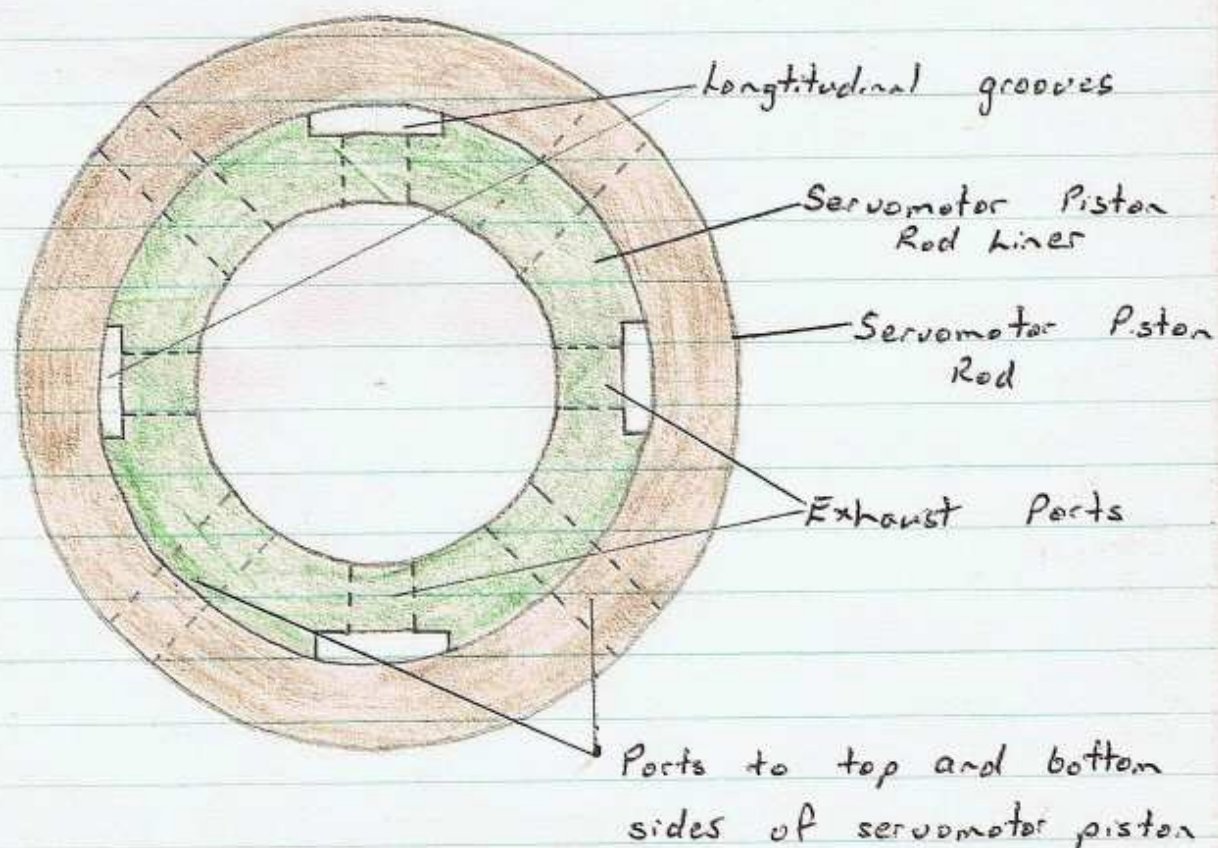
When the servomotor regulator piston is lowered from the neutral position (by instruction from governor actuator for more blade pitch) the ports are opened so that the pressure oil that is flowing down the centre of the combinator shaft and servomotor regulator piston is allowed to enter the top side of the servomotor piston. The ports are also opened so that oil from the lower side of the servomotor piston is allowed to exhaust by travelling up between the regulator piston and the servomotor piston rod liner and then passing through the ports in the liner and travel up the four longitudinal grooves in the outer surface of the liner and up between the combinator shaft and the turbine shaft. The servomotor piston will continue to lower until the ports are closed off when the servomotor piston reaches the neutral position in relation to the regulator piston. Oil in the area beneath the servomotor piston rod flows through the holes in the flange at the end of the piston rod and up the grooves in the outer surface of the piston rod liner.



The stroke of the combinator piston, to which the servomotor regulator piston is attached, is the same length as the stroke length of the servomotor piston and so no matter what part of its stroke the servomotor regulator piston is in, the servomotor piston is able to move to the neutral position in relation.

In the neutral position the ports from the top and the bottom side of the servomotor piston are closed off by the servomotor regulator piston, preventing oil entering or exhausting from ~~both~~^{either} sides of the servomotor piston. The servomotor piston stays in the neutral position until the governor actuator commands a change of blade pitch.

Plan Drawing Showing Porting In Servomotor
Piston Rod and Piston Rod Liner



The Servomotor Piston Rod

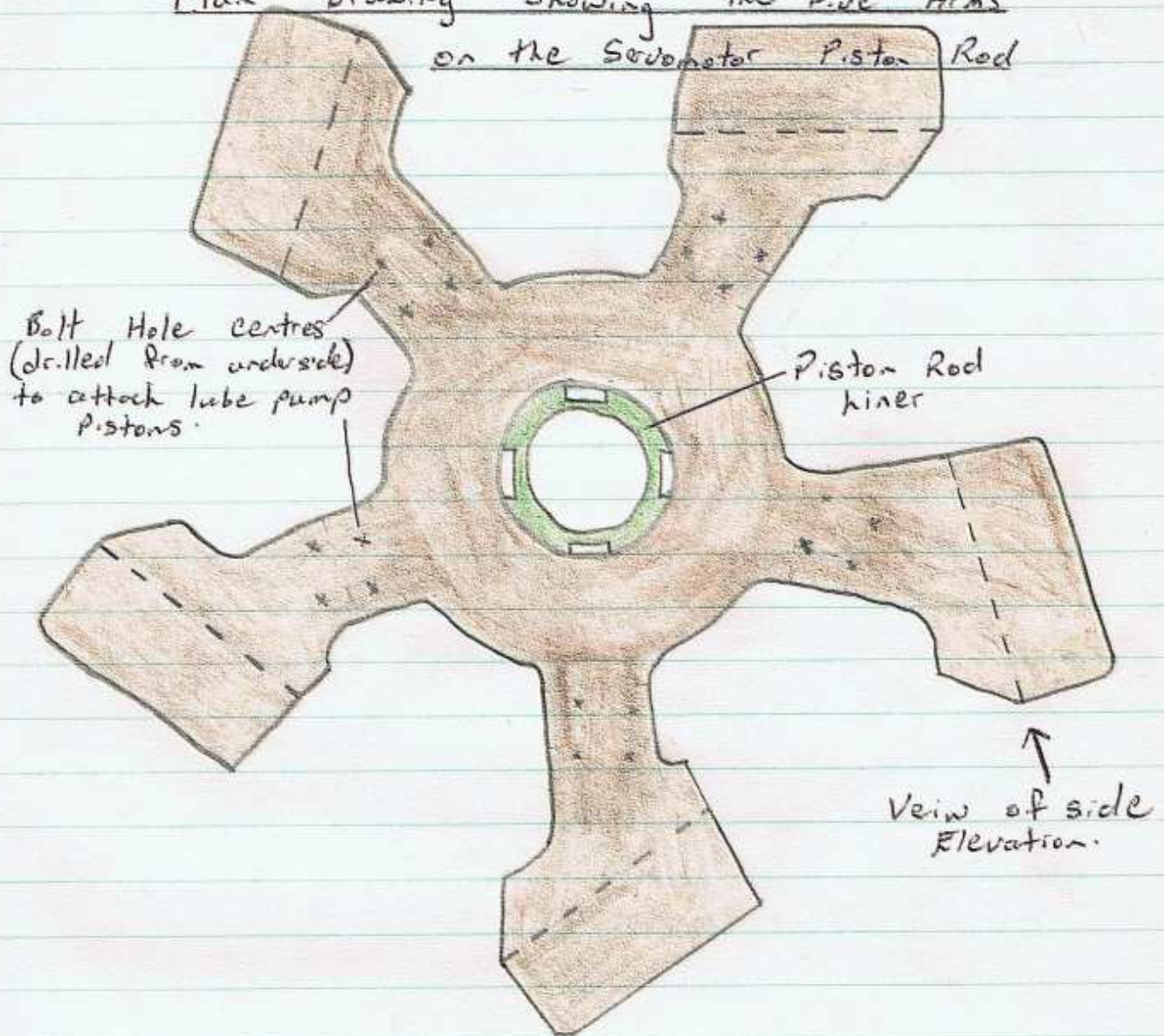
The servomotor piston rod has five arms, one to control the pitch of each runner blade. Each arm has a slot in the end of it, into which fits a block called the crank pin block. The crank pin block has a bushed hole for the crank pin to fit into. As the piston rod is raised and lowered to alter blade pitch, the crank pin blocks slide in the slots so that they can follow the arc of the crank pin ring.

The bushes in the crank pin blocks have eight grooves running lengthwise and one ^{annular} in the bushes, oil for lubrication enters these grooves through oil ways drilled in the crank pin.

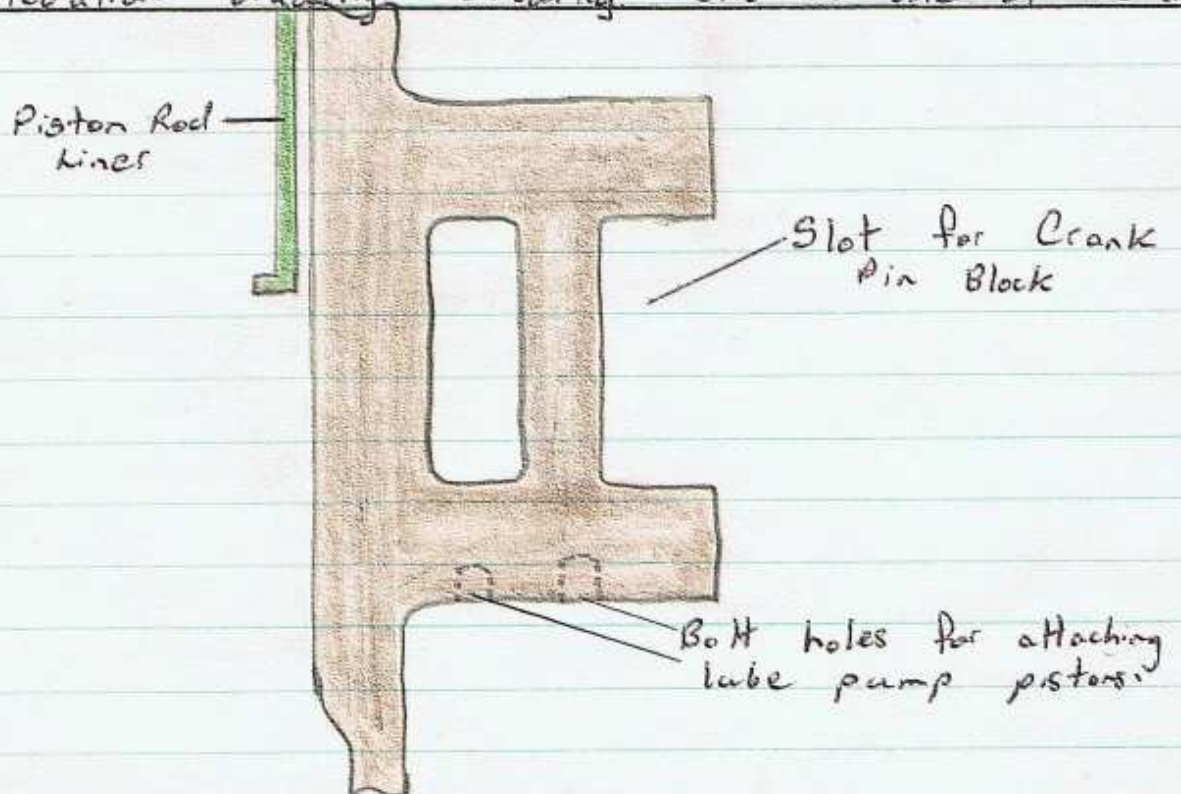
There is an oilway drilled from the bush through to the centre of each of the two sliding faces of the crank pin blocks, and each sliding face has two grooves running diagonally corner to corner (crossing at the oilway) so as to distribute the lubricating oil over the entire sliding face of the crank pin block.

The drawing on the following page is a plan view of the five servomotor piston arms, and shows where the lube pump pistons are bolted on. The elevation drawing shows the shape of one of the arms with the slot in the in.

Plan Drawing Showing The Five Arms
on the Servomotor Piston Rod



Side Elevation Drawing Showing end of one of the arms



Method of Securing Blades

When the runner head is assembled, the servomotor piston rod is fitted first, the crank pin blocks are fitted and then the crank pin ring is placed on the journal. The bearing ring is then fitted and this is secured to the runner body by 23 bolts. The bearing ring is a steel ring with Babbitt metal liners on the inner face that the crank pin ring slides on and the outer face that the runner blade slides on.

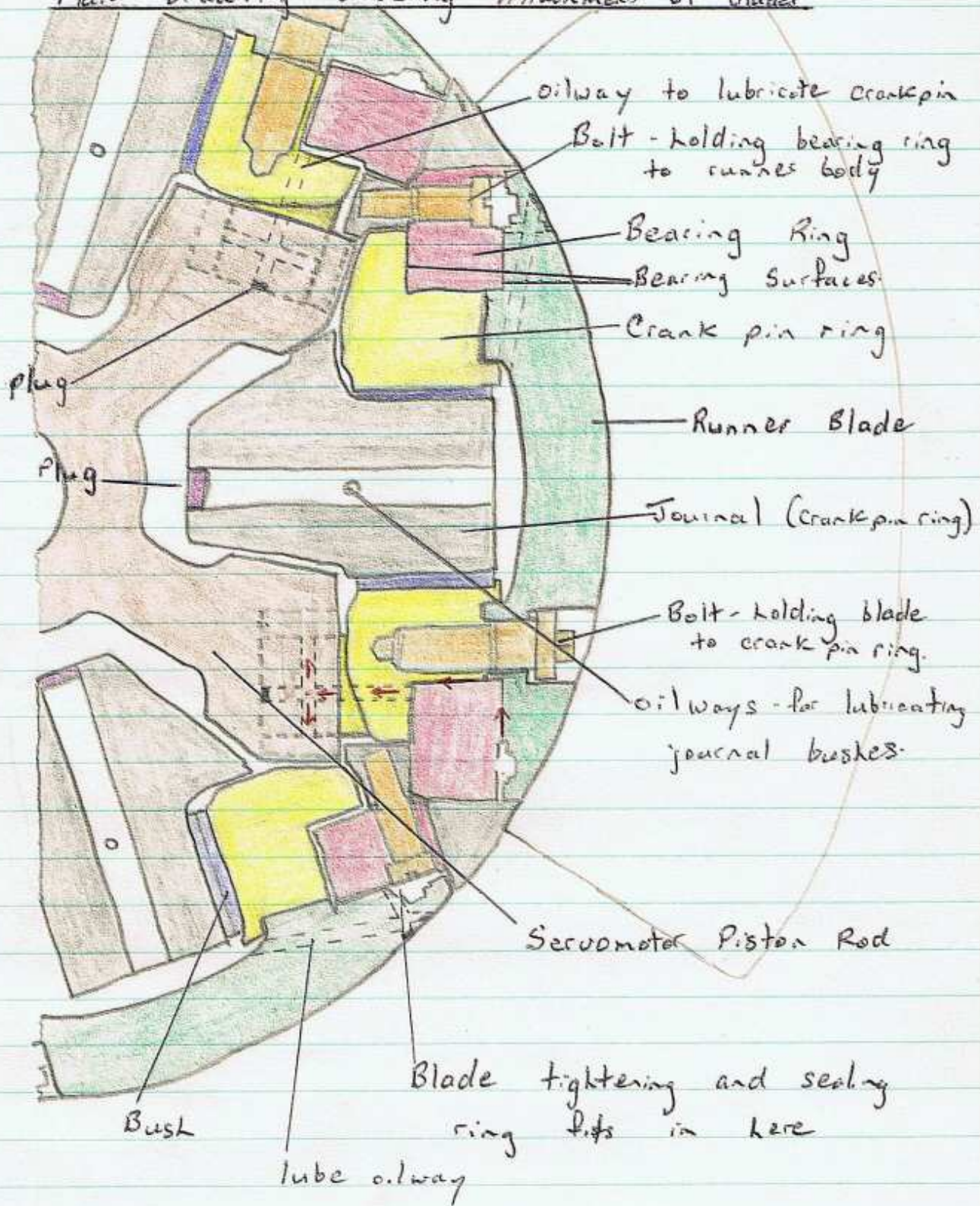
The bearing ring prevents the crank pin ring from coming off the journal.

The blade tightening and sealing ring is fitted next (this will be illustrated and explained later) and is secured to the bearing ring by twenty six bolts.

The runner blade is now fitted and is secured to the crank pin ring by nine bolts. There are six bolts above the blade and three below.

The drawing on the following page is a plan view of the runner head, showing how the runner blades are secured and also showing the oilways for lubricating the crank pin.

Plan Drawing Showing Attachment of Blades



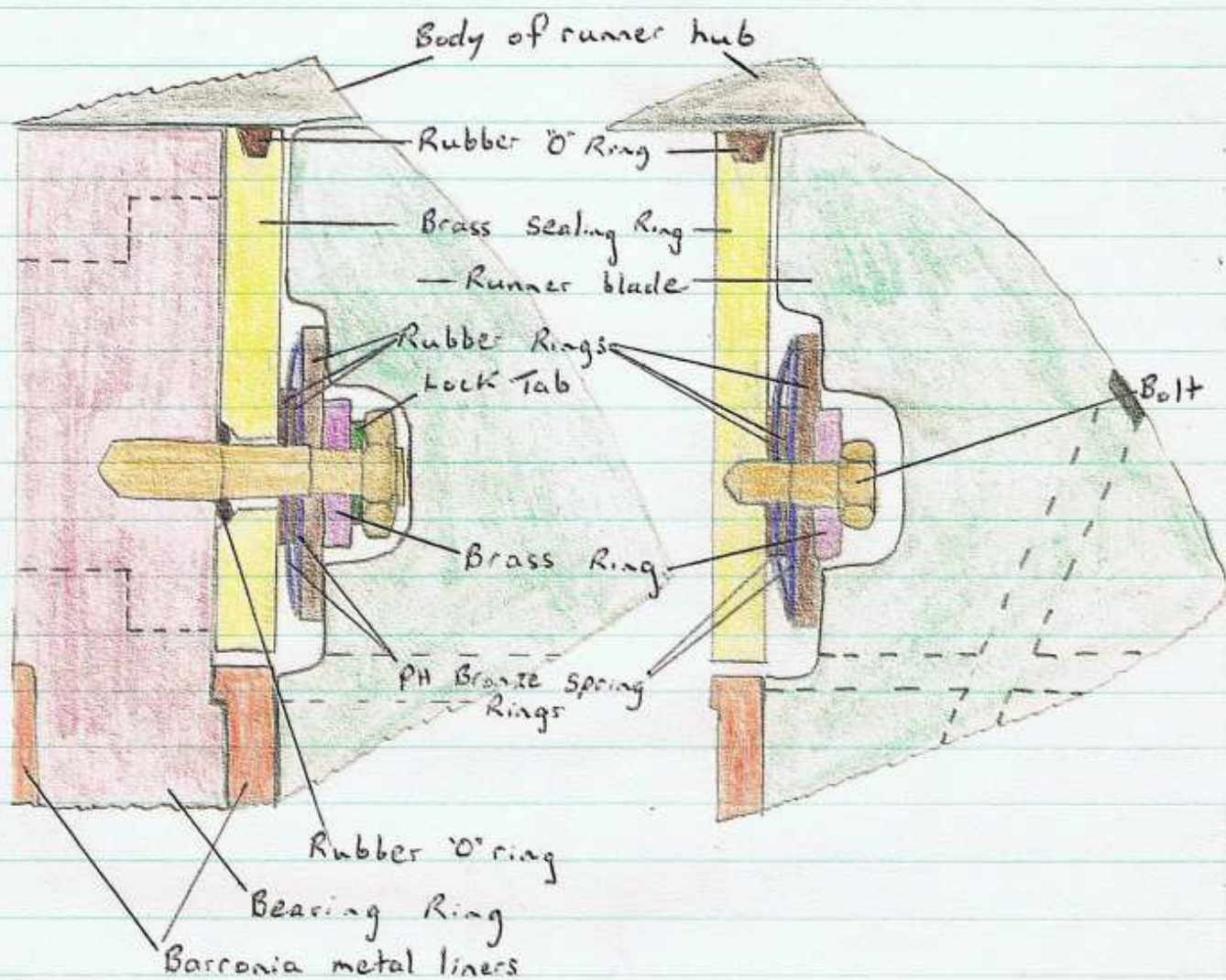
Note: Red lines show oil flow →

Method of Blade Sealing.

The combination blade tightening and sealing ring is fitted between the bearing ring and the runner blade flange. There are forty six half inch studs that secure the brass sealing ring to the bearing ring, these studs are situated in pairs, between the bearing ring securing bolts. To prevent oil or water passing the inner face of the sealing ring, there is a rubber 'o' ring placed over each of the forty six securing studs, these seal each of the stud holes, and the brass sealing ring has a rubber 'o' ring in its outer edge to seal against the body of the runner. A rubber (sheet) ring is fitted on the outside of the brass sealing ring, this seals between the sealing ring and the dished phosphor bronze spring ring that is fitted next. Another rubber (sheet) ring is fitted to seal between the dished spring ring and the flat phosphor bronze spring ring that is next fitted. A larger rubber (sheet) ring is now fitted to seal between the flat spring ring and the flange of the runner blade. A brass ring is the last item fitted, this brass ring holds the larger rubber (sheet) ring tight against the flat spring ring. The nuts on the studs are secured with a lock tabs that ~~are~~^{is} fitted to each pair of studs.

To ensure uniform pressure (and so eliminate distortion of the sealing faces) on the rubber (sheet) rings and spring rings, there are forty six bolts which are fitted in pairs between each pair of studs. These bolts screw into the brass sealing ring only, and so equally spaced around the sealing ring is alternately two bolts, two studs, two bolts etc.

The cavity for the stud and bolt heads (in the runner blade) fills with oil (there must be a small leakage for lubricating the sealing surfaces - approx .1 to 1 litre a week) to a pressure that is lower than the runner body but higher than the draught tube and so it is impossible for water to enter the seals.



Lubrication Of Blade Movement Mechanism

The piston rod and runner blade cavities are full of oil, these cavities are filled manually prior to the machine going into service, they are filled via the drain pipes on the bottom of the runner body, while air is bled from the air outlets near the top of the runner body.

In service, oil to replace that which is lost from leakage at the blade seals, enters the cavity by seepage past the piston rod guide bushes. The bottom piston rod guide bush (in bottom cover) has seven annular grooves to aid lubrication of the bush and to aid seepage past the bush.

Oil travels to the piston rod guide bush in the runner body (just above piston rod arms) via the oilway that runs from the underside of the piston rod (in bottom cover), this bush has five annular grooves. The oil enters the centre groove which is wider than the other four, and this groove distributes the oil around the bush, the oil then seeps past the bush to replace that which is lost from the blade cavities by leakage at the blade seals.

By supplying oil to the piston rod cavity via the upper piston rod ^{guide} bush, it also ensures adequate lubrication of this bush. Because oil is prevented from reaching this bush from the piston cavity (by an oil seal in the bottom of piston cavity) adequate lubrication might otherwise not occur.

The annular grooves in the piston rod ^{guide} bushes

have radiused edges to aid the movement of oil past these bushes, these grooves are not intended as seals, as would be the case if the edges were square.

The pressure of the oil in the piston rod and blade cavity is at least equal to the pressure exerted by the head of oil in the turbine and generator shafts - approx 30-35 PSI.

The drawing on page shows one of the lubricating oil pumps, there is one pump under each of the five piston rod arms, to supply oil to the bearing surfaces of its respective runner gear. During the upward movement of the ^{lube pump} piston, the pressure of the coil spring in the pump cylinder is overcome, so that the collar of the piston lifts clear of the top of the lube pump cylinder, oil then enters through the pump cylinder to the cavity below.

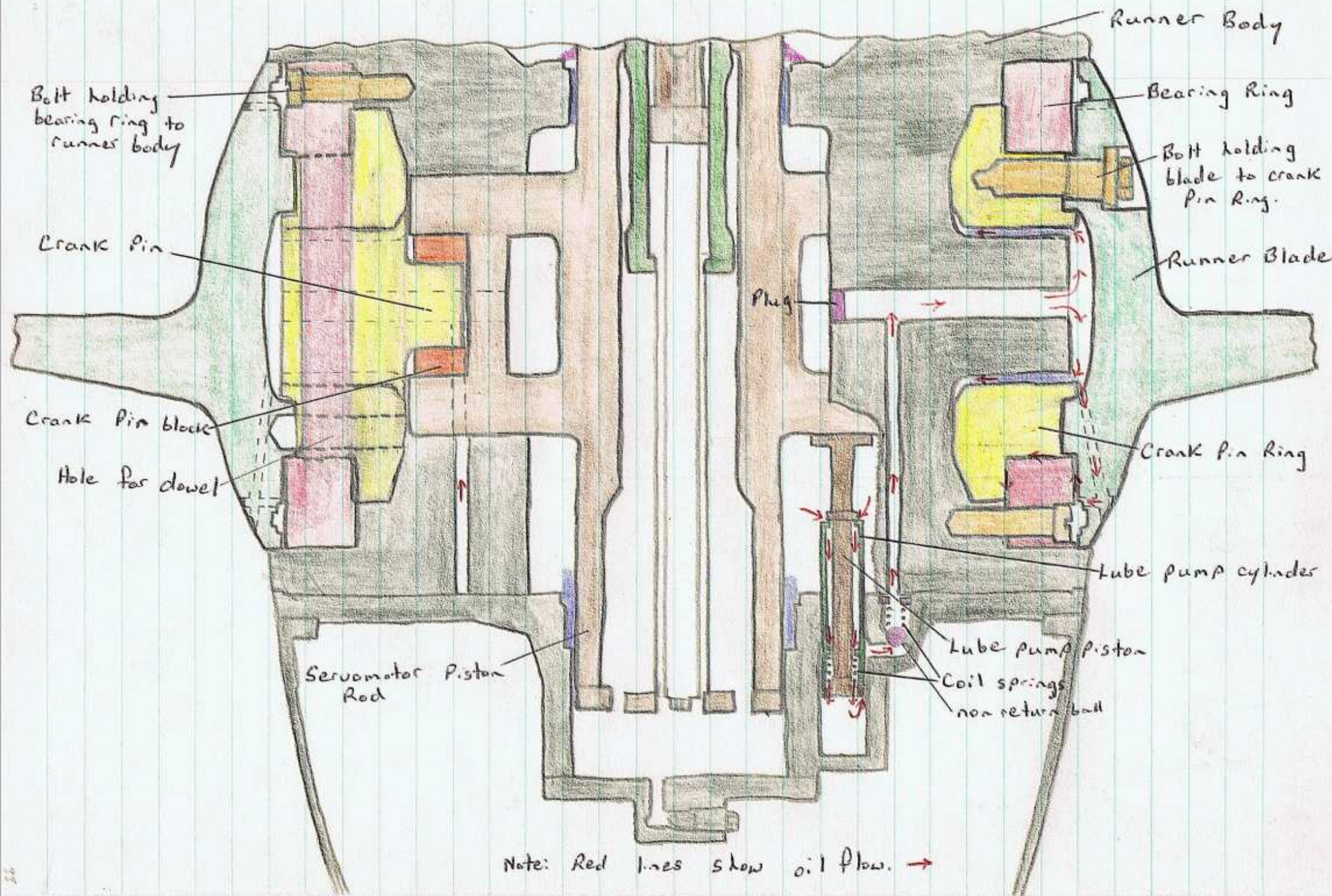
When the lube pump piston moves down, the piston collar is hard against the top of the pump cylinder, so that the only place for the oil to go is out via the non return ball and through the oilway to the crank pin ring journal. The bush in the crank pin ring has ten grooves, running lengthwise in the bush, some of the oil is forced through these grooves lubricating the bush, before it returns to the piston rod cavity.

The balance of lube oil supplied via the crank pin ring journal, travels through three oilways in the flange of each runner blade to lubricate the sliding surfaces of the runner blade - Bearing ring, and the runner blade seals.

The borronia metal face of the bearing ring has thirty two radial grooves through which the oil is forced and distributed over the entire bearing surface. The oil then travels round the inside edge of the bearing ring, where some is forced through an oilway in the crank pin, to lubricate the crank pin and crank pin block before returning to the piston rod cavity.

The remainder of the lube oil lubricates the crank pin ring - Bearing ring surfaces by being forced through thirty two radial grooves in the borronia metal face of the bearing ring, it is then returned to the piston rod cavity.

See pages and for discription and drawing of crank pin lubrication.



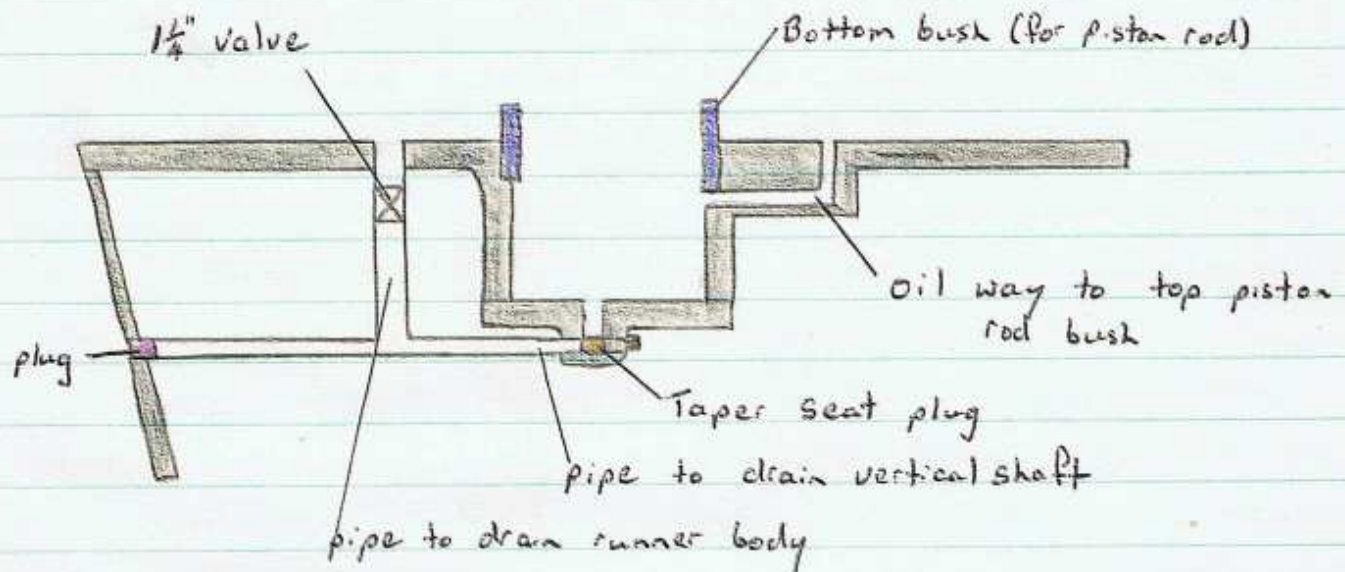
The Runner Bottom Cover

The bottom cover is secured to the runner body with 30 bolts. The cover contains the bottom piston rod bush, the bases for the five lube pump cylinders, part of the oilway leading to the top piston rod bush and drainage holes for draining the vertical shaft and the blade cavities.

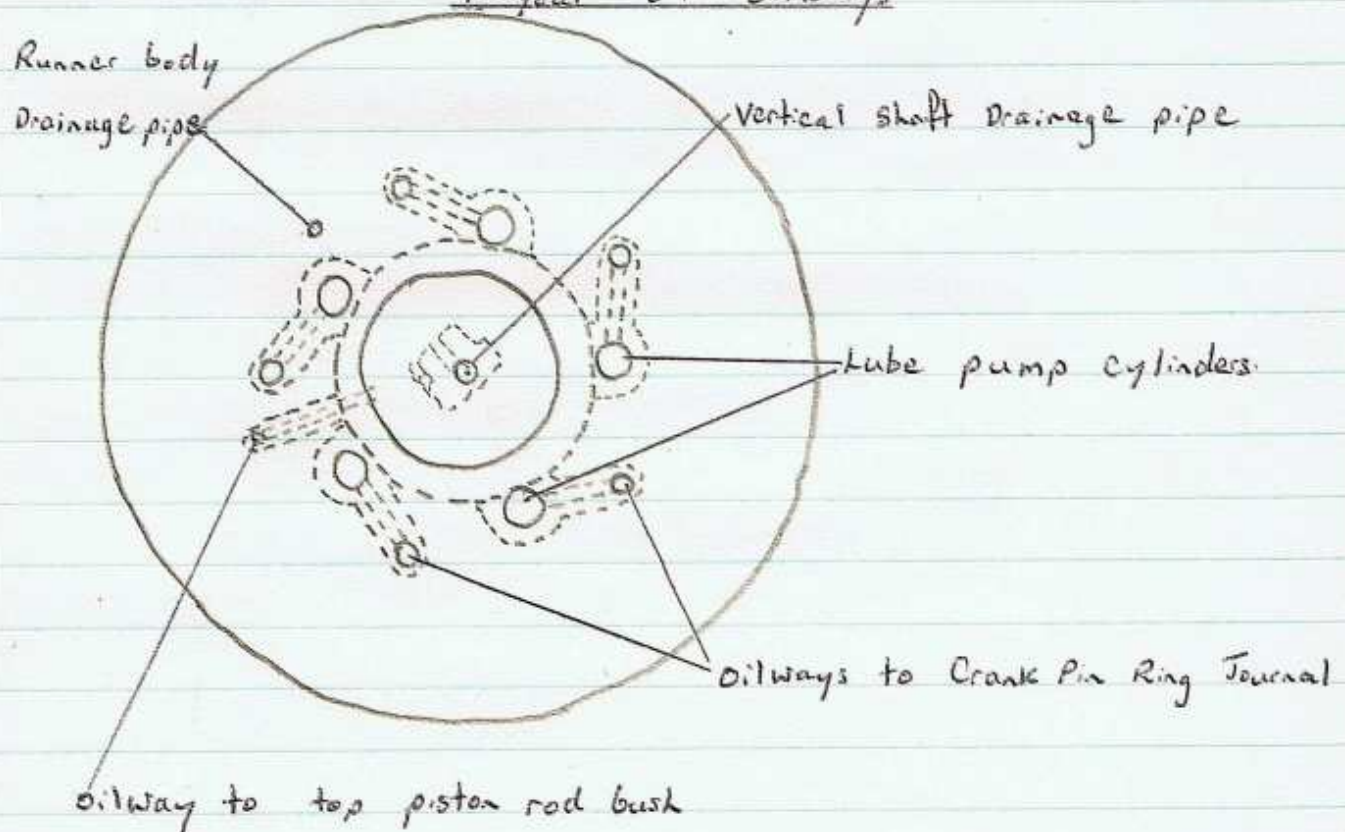
A plan and elevation drawing of the bottom cover can be seen on the following page. For the purposes of illustration, the oilways on the elevation drawing are not radially positioned as they are on the actual machine, the plan drawing does show the actual ^{radial} position of these oilways.

As can be seen from the elevation drawing the drains for the blade cavity and vertical shaft are connected by a $1\frac{1}{4}$ " drain pipe that has a cap (plug) fitted over the outer end. The vertical pipe from the blade cavity has a $1\frac{1}{4}$ " valve fitted in it and the outlet from the vertical shaft has a taper seat plug, when the machine is in service both of these are closed.

Elevation Drawing of Bottom Cover For Runner
Showing Drainage Oil Pipes.



Plan Drawing of Bottom Cover Showing
Layout of Oilways



The Solenoid Shutdown Valve

The solenoid shutdown valve is mounted on top of the regulator - all being part of the guide vane servomotor assembly. The valve itself is manufactured by Bouing + Co and is shown on drawings 13276T (Body) and 13277T (Piston). There are variations in design of this valve, depending on the country to which it is supplied, the version supplied to Scotland employed a piston of different dimensions to give a slightly different function. For the application it is employed in on these machines the valve has porting chambers that are not entirely necessary. The solenoid is manufactured by A.S.E.A Electric (NZ) LTD Wellington.

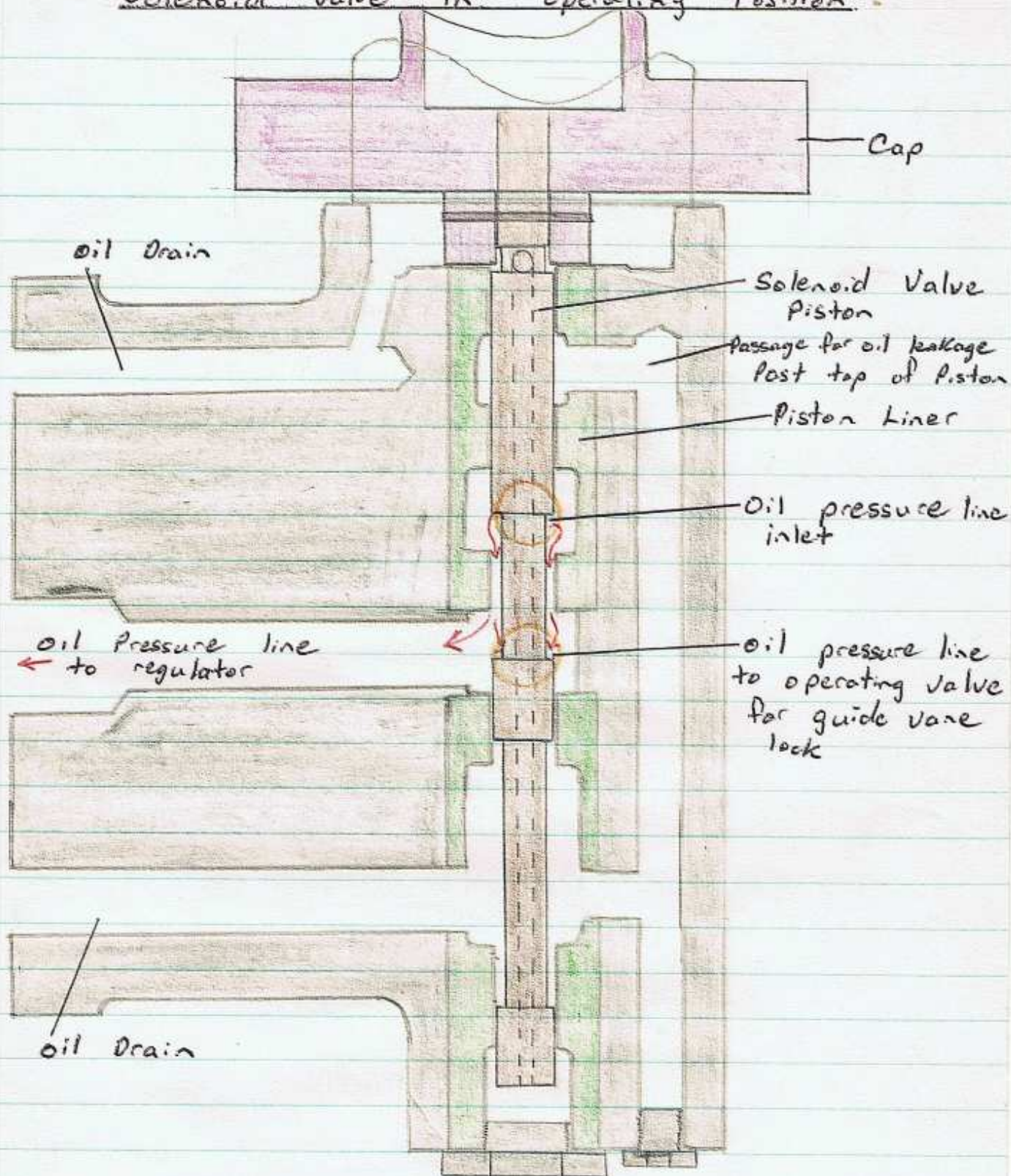
specifications: Brake lifting magnet B.V.R. LA 170
110V
Stroke 30 mm
Weight of core .6 Kg
Total pull 7.0 Kg
Intermittent service factor .30

Although the stroke of the solenoid is 30 mm the dimensions of washers on the solenoid shaft and the cap on the valve piston restrict the stroke to 9 mm.

The prime purpose of this valve is to cause immediate shutdown of the machine through the operation of an electrical relay or electrical push button, as with - out the pressure this valve it supplies to the regulator, instantaneous closing of the guide vanes will occur and also instantaneous operation of the guide vane locking pin.

When the solenoid valve is operated to the shutdown position, the solenoid is energised ^{so as} to raise the piston, cap and core assembly. When the solenoid reaches the top of its stroke it is latched up by a mechanical latch, so that the solenoid does not have to be continually energised to maintain the shutdown position. This mechanical latch is released (by electric solenoid) when the machine start button is operated.

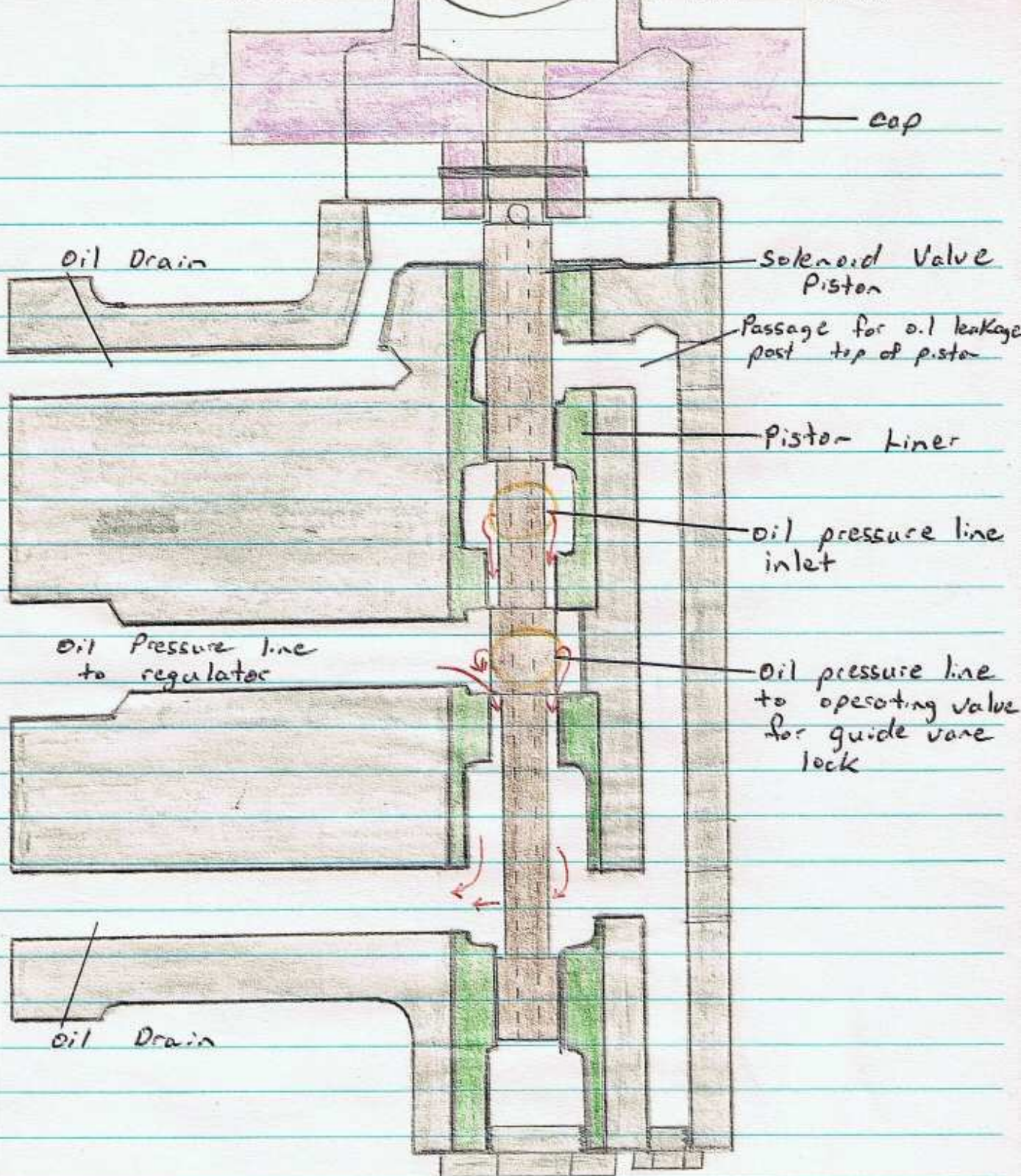
Solenoid Valve in Operating Position



In the operating position the valve piston is at the bottom of its stroke and is maintained in that position by the weight of the cap. In the operating position, oil flows in through the oil pressure line inlet and is able to flow out the pressure lines to the regulator and to the operating valve for guide vane lock.

Note red lines show oil flow →

Solenoid Valve in Shut down Position

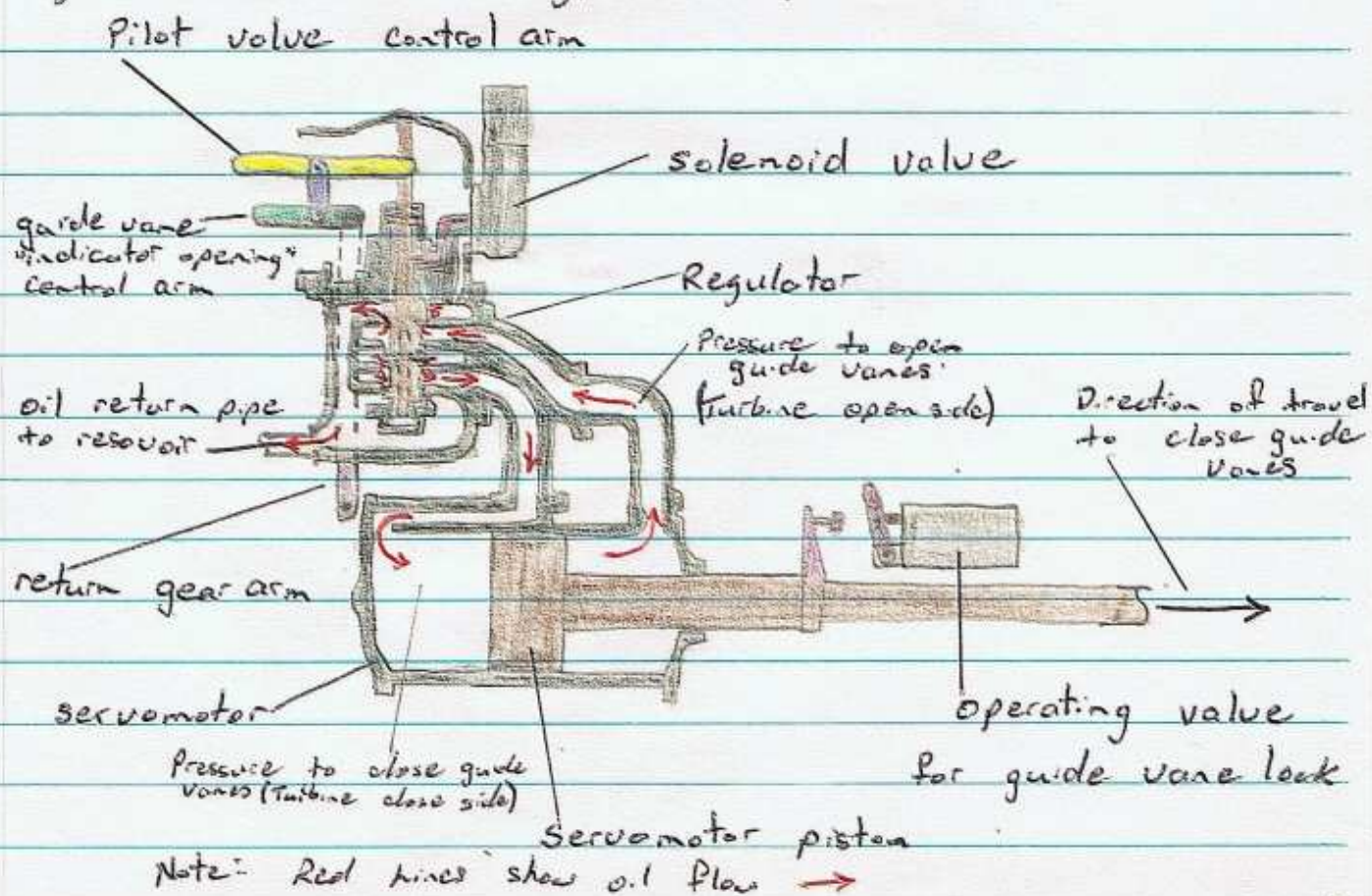


In the shutdown position the valve piston is at the top of its stroke and is maintained in that position by a mechanical latch in the solenoid. In the shutdown position the oil from the pressure line inlet is prevented from flowing to the regulator or to the operating valve for guide vane lock, and the oil in the pressure lines to the regulator and operating valve for guide vane lock is allowed to exhaust to the drain.

There is no seal fitted to the top of the solenoid valve piston and so small amounts of oil are able to seep between the piston and piston liner, also the piston has an oil way up the centre, exhausting at the bottom of the collar on the piston cap, this is to allow small amounts of oil to coat the top of the piston, (which is exposed to the atmosphere), and so prevent a rust coat forming, that would hinder the operation of the valve. An oil drain is provided from the top of the valve body to carry this oil away.

Arrangement of Regulator + Servomotor Assembly

The guide vane servomotor is a large cylinder with one piston in it, movement of the piston is achieved by supplying oil pressure to one side of the piston and allowing the oil to exhaust from the other side of the piston. The main valve in the regulator controls the flow of oil to and from the servomotor piston. In the drawing the oil flow direction shown is for the servomotor piston to travel to the closed position. For the servomotor piston to travel to the open position the oil flow to and from the piston would be reversed. When the servomotor piston nears the end of its travel in the close direction, the skirt of the piston begins to close off the port that the oil is exhausting through, so causing a dampening effect to prevent the guide vanes slamming, on rapid shut down.



The R.C. 2-7-1-6 Regulator

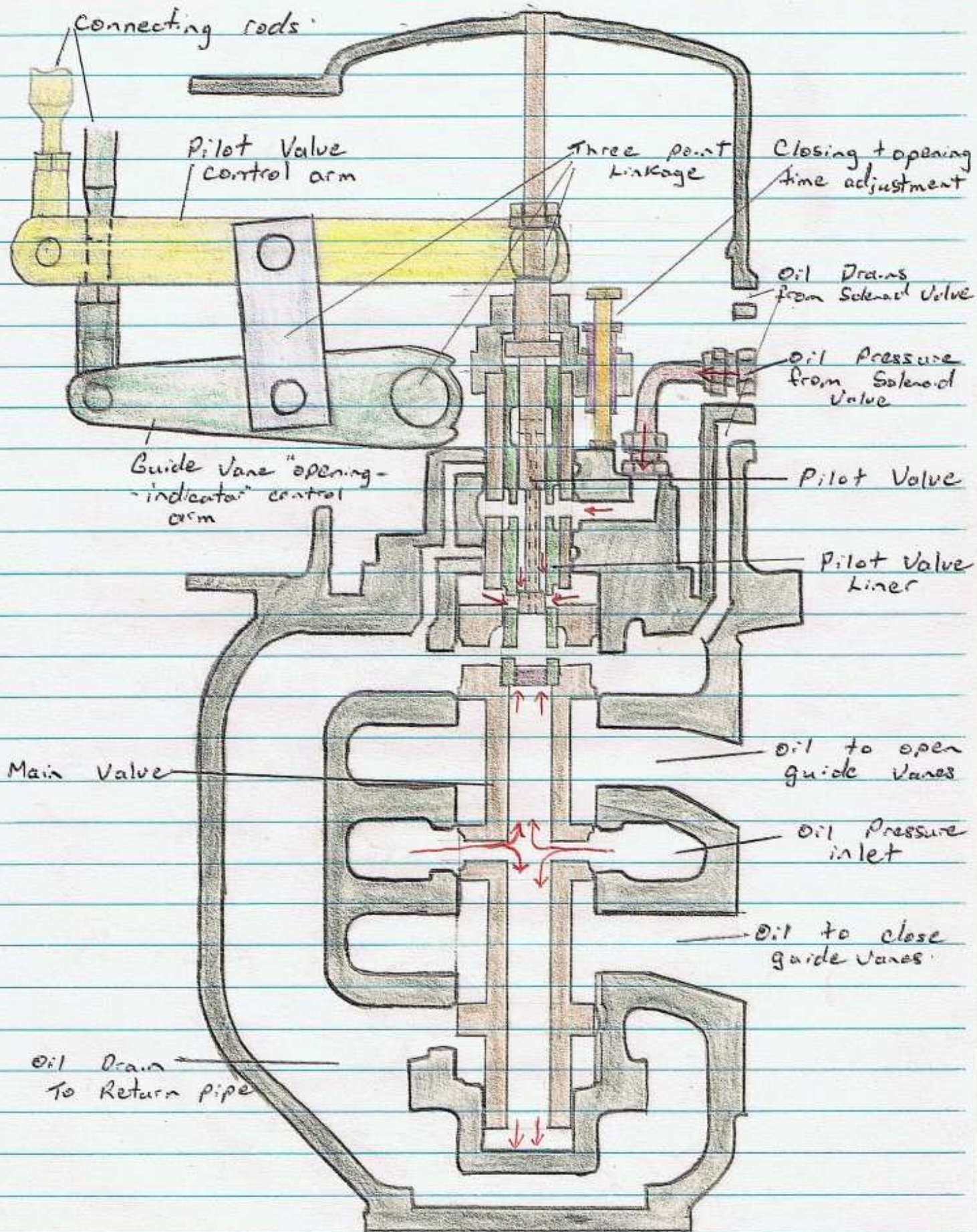
The RC 2-7-1-6 regulator is part of the guide vane servomotor assembly, it is manufactured by Boeing + Co, and is shown in drawing 15977T (folder 6C), the body only is shown in drawing 11938T and the pilot valve and liner is shown in drawing 11944T.

The regulator has two valves, the pilot valve and the main valve. The pilot valve controls the position of the main valve and is operated by the actuator via a series of connecting rods.

The pilot valve control arm is pivoted onto the guide vane "opening-indicator" control arm, to form what is in effect a three point linkage, the reason for this is that, after the pilot valve control arm has been moved by the actuator (to alter the guide vane opening), the movement of the guide vane "opening-indicator" control arm causes the pilot valve control arm to return the pilot valve (and so also the main valve) to the neutral position.

The pilot valve has a hole up the centre, to drain away any oil that leaks between the liner and the top part of the valve. The pivot shaft of the guide vane "opening-indicator" control arm has another arm attached, ^(the return gear arm) which is in turn attached (via a connecting rod) to the servomotor piston. This causes the guide vane "opening-indicator" control arm to move in relation to the servomotor piston.

The RC 2.7-1.6 Regulator With Valves in Neutral Position



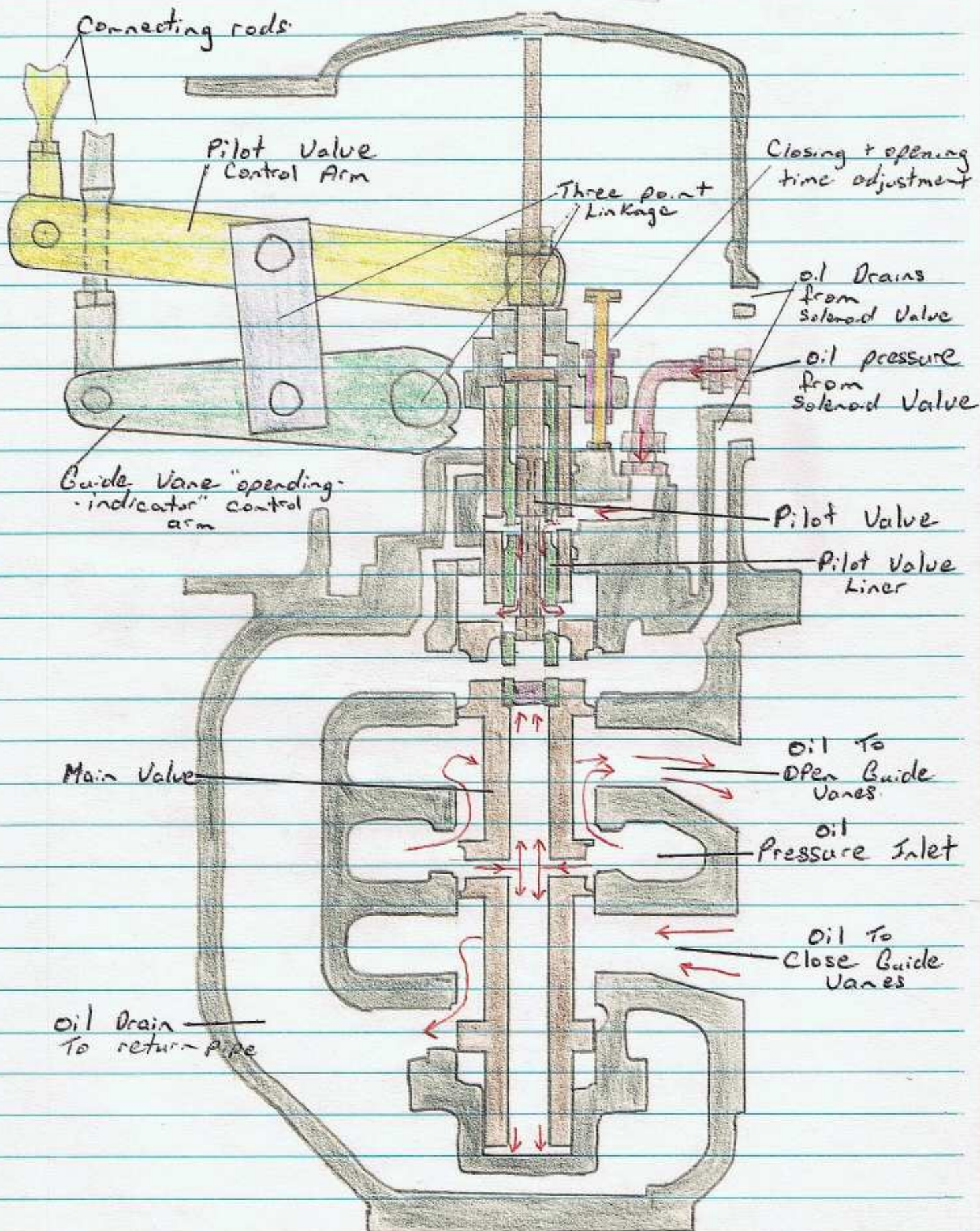
Note: Red lines show oil flow →

After each adjustment of guide vane opening the three point linkage of the control arms, causes the regulator valve to return to the neutral position. In the neutral position, oil entering through the oil pressure inlet, is exerting an upward pressure on the main valve (via the drilling up the centre of the main valve), but the main valve is not able to travel upwards because the oil on the top side of the main valve is not able to exhaust, as it is prevented from doing so by the pilot valve which in the neutral position is closing off the port.

Oil pressure enters via the solenoid shut down valve, and the pilot valve, to replenish oil to the top side of the main valve, that may have escaped due to leakage past the valves. A small up and down motion of the main valve may be present due to leakage past the valve. If the shut down solenoid is operated (to the shutdown position), the absence of oil pressure to replenish oil lost from the top side of the main valve will allow the main valve to travel upward to the guide vane closed position. As the main valve rises oil from its top side will exhaust via the solenoid valve.

The RC 2-7-1-6 Regulator

With valves in Guide Vane open Position



Note: Red lines show oil flow →

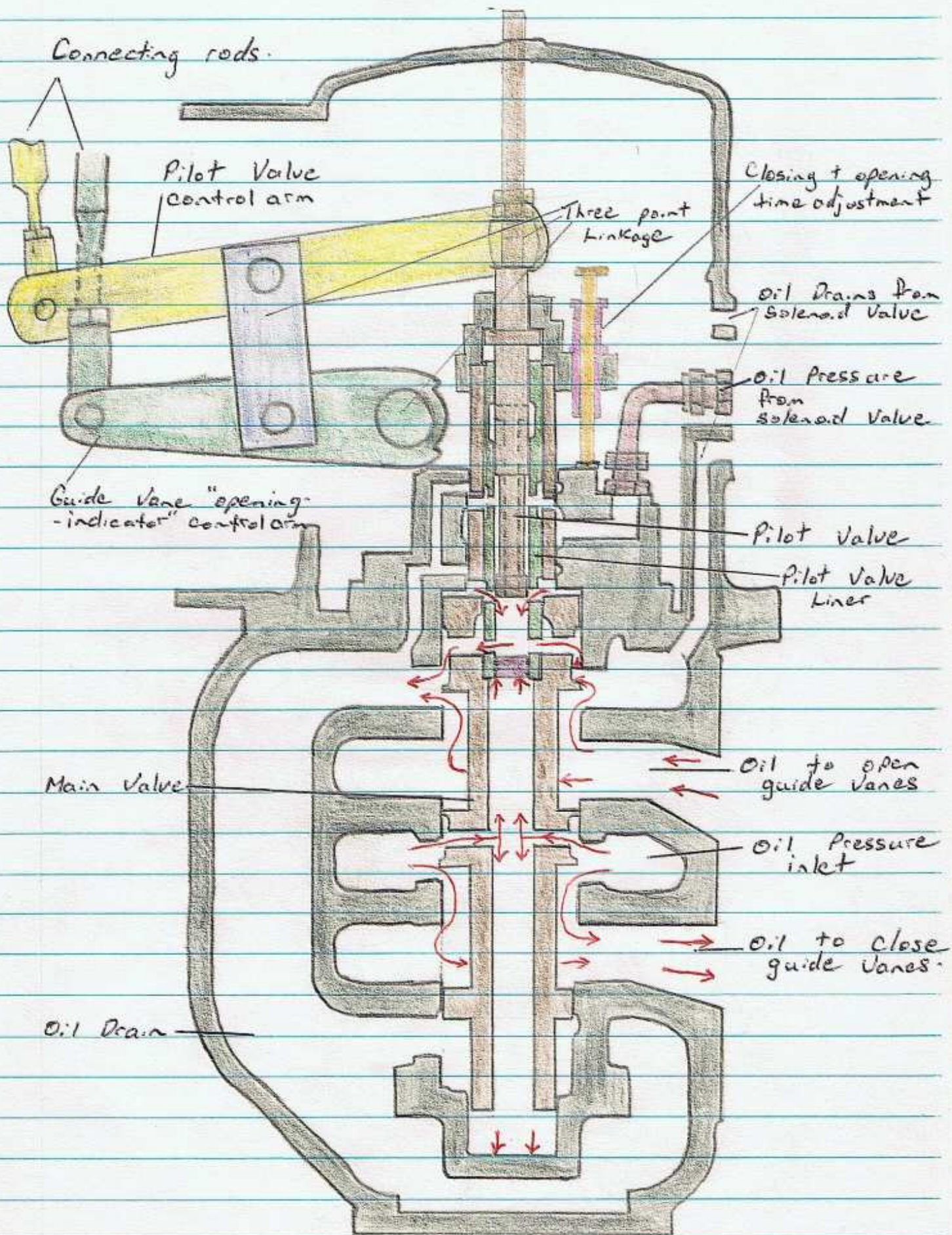
When more power is required out of the turbine, the actuator causes the connecting rod to the pilot valve control arm to be raised, this causes the pilot valve to be lowered, allowing oil pressure via the solenoid valve to enter the top side of the main valve. Because the oil pressure on the top of the main valve is acting on a larger diameter than the oil pressure in the drilling up the centre of the valve, the pressure on the top of the valve causes it to lower. When the main valve lowers from its neutral position, the ports are opened so that oil from the oil pressure inlet is able to flow to the turbine open side of the guide vane servomotor piston.

At the same time the ports are opened so that oil from the turbine close side of the guide vane servomotor piston is able to exhaust via the oil drain to the return pipe to the governor reservoir.

As the guide vanes open, the connecting rod and return gear arm cause the indicating control arm to rise, this causes the pilot valve to move back to the neutral position. In moving back to the neutral position, the pilot valve allows oil from the top side of the main valve to exhaust and so the main valve moves to the neutral position also.

The RC 2-7-1-6 Regulator

With Valves in Guide Vane Oppose Position



Note: Red lines show oil flow. →

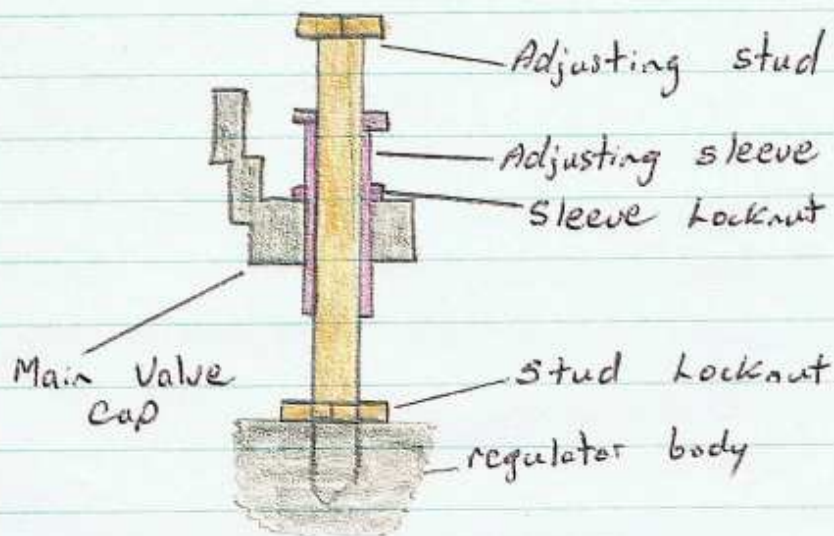
When less power is required out of the turbine, the actuator causes the connecting rod to the pilot valve control arm to be lowered, this causes the pilot valve to be raised, allowing oil from the top side of the main valve to exhaust to the drain. With the oil exhausting from the top side of the main valve, the oil pressure in the drilling up the centre of the main valve is able to cause the main valve to rise. When the main valve rises from its neutral position, the ports are opened so that oil from the oil pressure inlet is able to flow to the turbine close side of the guide vane servomotor piston.

At the same time the ports are opened so that oil from the turbine open side of guide vane servomotor piston, is able to exhaust via the oil drain, to the return pipe to the governor reservoir.

As the guide vanes close, the connecting rod and return gear arm causes the indicator control arm to lower, this causes the pilot valve to move back to the neutral position.

In moving back to the neutral position, the pilot valve closes off the exhaust passage of the oil from the top side of the main valve and allows oil pressure via the solenoid valve to enter (to the top side of the main valve), and so the main valve moves to the neutral position also.

Closing + Opening Time Adjustment



The cap on the main valve of the regulator has a flange on it, through which is threaded an adjustable sleeve. An adjusting bolt is fitted through the sleeve and screwed into the top of the regulator body, this is to enable adjustments on the limit of travel of the main valve and as a consequence this affects the opening and closing time of the guide vanes. Screwing the sleeve down, limits the main valve travel on the downward stroke (opening guide vanes) and screwing the stud down, limits the main valve travel on the upward stroke (closing guide vanes). By this method the length of time taken for the ~~guide vanes~~ ^{guide vanes} to open or close can be limited without having to limit pilot valve travel. The connecting rod from the actuator to the pilot valve control arm is spring loaded.