PRODUCT BULLETIN SB 3010

PITCH CONTROLLER

PNEUMATIC / HYDRAULIC

Type PCA-2L

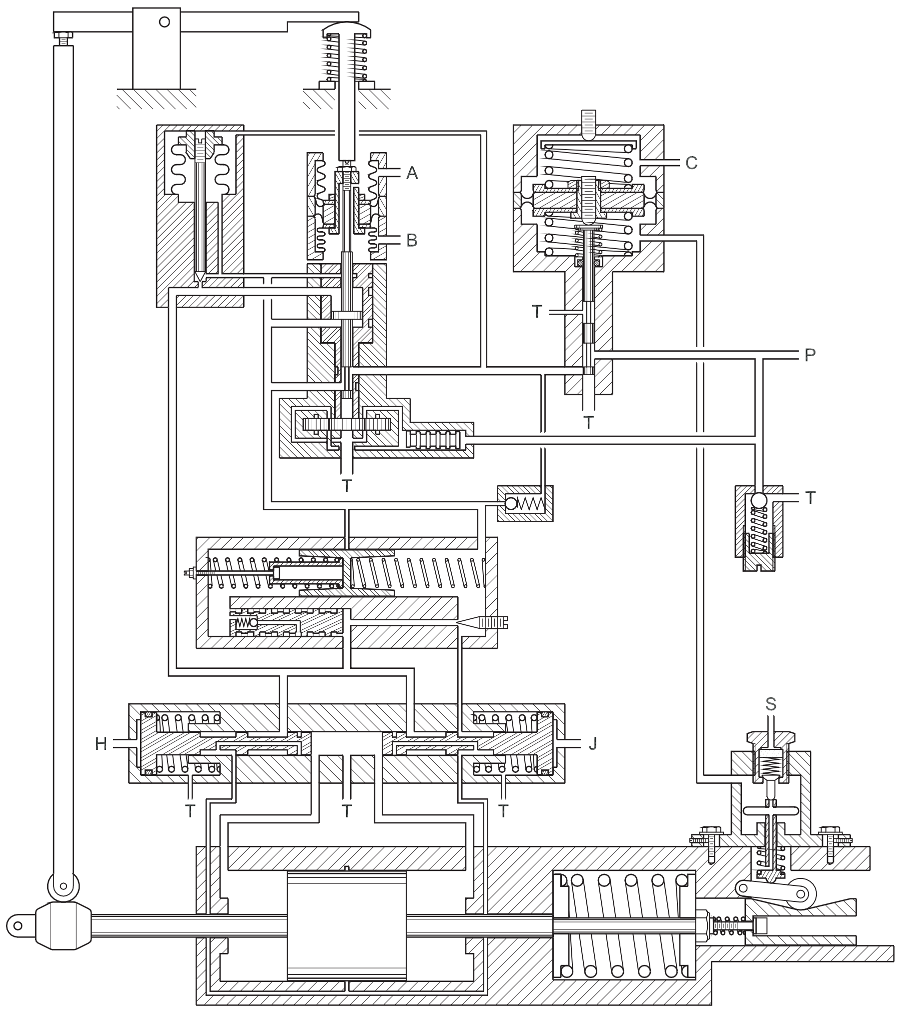
Schematic with Description of Operation

APPLICATIONS

- The PMC Pitch Controller is the nucleus of the PMC control system for C.P. propellers

FEATURES

- Rugged construction with corrosion resistant materials
- Exceptional repeatability and accuracy
- Very low hysteresis
- Proven reliability and performance
- Fast yet stable automatic



PRIME MOVER CONTROLS INC.

1. Introduction

The pitch controller is one of the most important single components in a CPP propulsion control system. It affects reliability, performance and efficiency of the main propulsion system. This bulletin describes the operation of the PMC type PCA-2L pitch controller, which is one of the pitch controllers offered by Prime Mover Controls Inc. The operation of the pitch controller is described, but not the entire control system.

2. General Description

The PMC type PCA-2L pneumatic/hydraulic pitch controller is the nucleus of the PMC control system for CP propellers. It is used on a variety of CP propellers with proportional mechanical pitch setting levers. The PCA-2L pitch controller consists of a pneumatic input section, a hydraulic control section and a hydraulic cylinder, which provides a linear mechanical output to the pitch setting lever.

The PCA-2L is designed for control systems with single lever remote control for pitch and RPM or for independent control of pitch and RPM. It has separate pneumatic input ports for pitch command, load command and load feedback signals. This arrangement facilitates exceptional versatility, including engine manifold pressure dependent load limiting to reduce exhaust smoke during acceleration.

The pitch controller operates in two different modes: Inching, and Automatic Load Control. As long as the load feedback signal is less than or equal to the load command signal, the pitch controller remains in Inching mode, in which the output is proportional to the pitch command input signal. If the load feedback signal exceeds the load command signal the pitch controller will go into automatic load control and output to the pitch setting mechanism will be reduced until the load feedback signal is equal to the load command signal.

3. Description of Operation

This description of operation is in a sequence or step by step format for ease of understanding. During actual operation these "steps" happen simultaneously, in a way that gives smooth and stable control.

3.1. Inching Control

(Proportional Positioning)

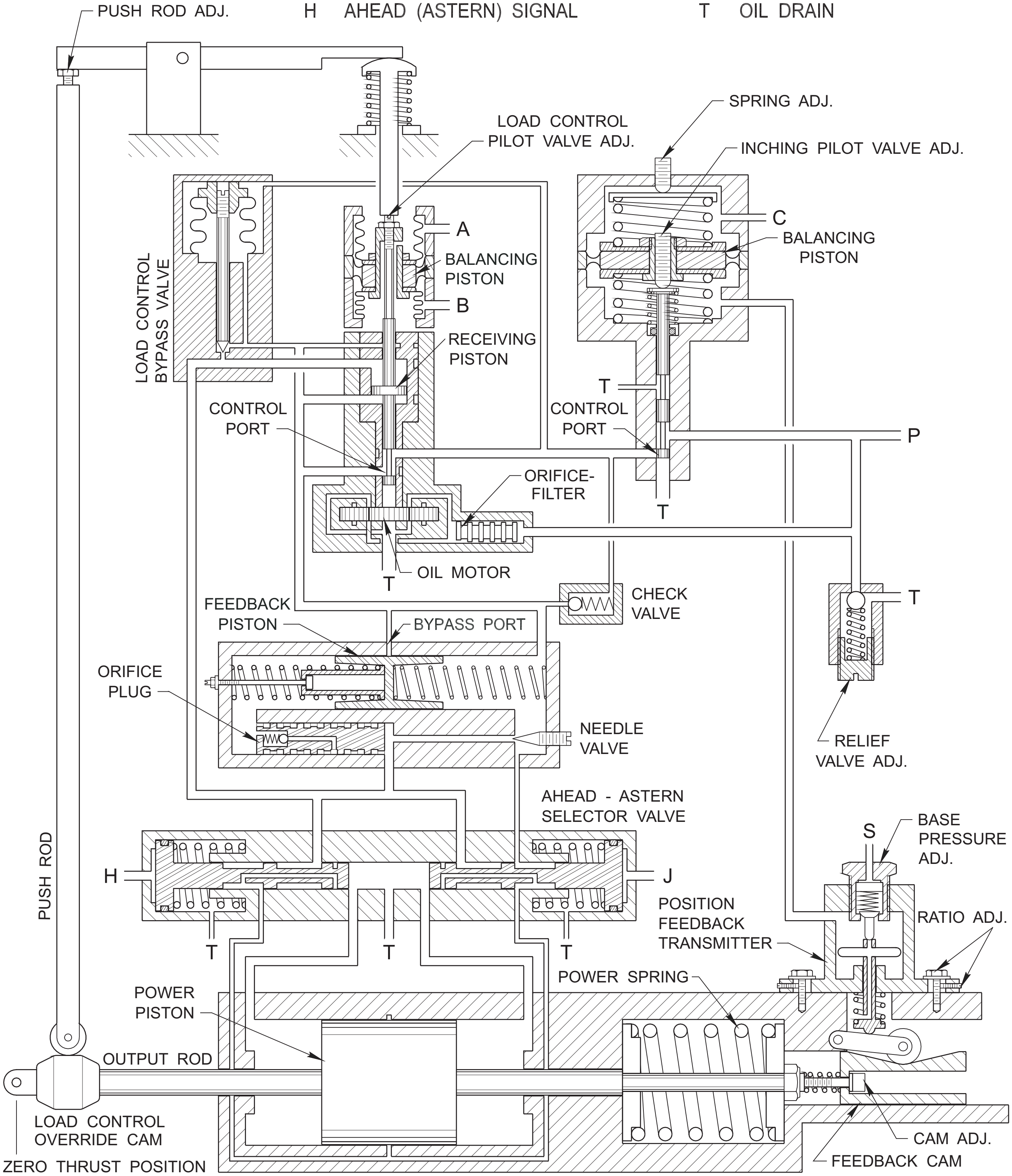
Pitch setting command is increased when inching signal air pressure from remote control is increased at port C. In response to the increased air pressure the spring centered inching balancing piston moves down, this also moves the inching pilot valve plunger down and the pilot valve control land uncovers the control port. Oil under pressure from port P now flows through the inching pilot valve to the supply port of the load control pilot valve. When in inching control, the load control pilot valve plunger is down and the load control bypass valve plunger is up. This allows oil to flow freely through the load control pilot valve and the load control bypass valve to the activated ahead or astern selector valve and into one side of the power cylinder, moving the power piston. The opposite end of the power piston is open to drain. As the power piston moves, the caged power spring is compressed, which produces a force that opposes the force of the oil pressure. The output end of the piston rod is connected to the C.P. Propeller pitch setting mechanism.

As the power piston moves, the feedback cam moves with it, activating the pneumatic position feedback transmitter. The feedback air pressure is proportional to power piston position and is directed to the under side of the inching balancing piston. When the feedback pressure equals the inching command air pressure at port C the spring centered inching balancing piston will move upward until the inching pilot valve control land covers the control port. The oil flow stops and the power piston stops at this position.

When the inching signal air pressure at command port C is decreased, the spring centered inching balancing piston moves up and the pilot valve control land opens the control port. This allows the trapped oil in the power cylinder to flow to sump through port T. The caged power spring will move the power piston in decreased pitch direction until the feedback air pressure has decreased to equal the command air pressure at port C. The spring centered inching balancing piston will now move downward until the inching pilot valve control land covers the control port. This stops the oil flow and the power piston stops.

Figure 1: Type PCA-10-2L Pitch Controller (typical schematic)

A LOAD COMMAND SIGNAL
B LOAD FEEDBACK SIGNAL
C PITCH INCHING COMMAND SIGNAL
H AHEAD (ASTERN) SIGNAL
J ASTERN (AHEAD) SIGNAL
P OIL SUPPLY
S AIR SUPPLY
T OIL DRAIN



It can be seen that inching is proportional positioning with the output end of the piston rod taking a definite position relative to inching air pressure command signal at port C. Maximum pitch trim is easily accomplished from the remote control by limiting the maximum pitch command air pressure to port C.

3.2.Automatic Load Control

(Proportional & Integral Positioning)

Automatic load control maintains constant surveillance of engine load under all conditions and is capable of immediate override of the inching control at any time. In a single lever combinator control system, (one lever controlling both pitch and RPM) maximum pitch is achieved as the remote control lever is moved beyond the inching range. Under normal power response, engine speed increases until the engine fuel consumption reaches the predetermined speed/power relationship. The control system is now in the form of a closed loop and should the load change for any reason the pitch controller will automatically change the pitch position to maintain optimum loading on the prime mover. With separate pitch and RPM remote control levers or with constant RPM applications the automatic load control is the same.

The load command signal air pressure at port A is determined either by engine governor speed setting or actual speed. Air pressure from a pneumatic fuel rack position transmitter is directed to load feedback port B. An increase in fuel rack position increases the air pressure.

Manifold air pressure on turbo charged engines can also be used as a factor in independently limiting the maximum pitch and maximum load. This helps to reduce smoke in the engine exhaust during acceleration.

During low engine power operation (below the predetermined load control speed/power relationship) the air pressure at port A is higher than at port B and the spring centered load control balancing piston is in the down position. The load control pilot valve plunger is also down with the control land uncovering the control port, which allows free oil flow as required for inching control.

With an increase in engine load the RPM decreases and the engine governor moves the fuel rack position in the increase direction to maintain commanded RPM. This increases the air pressure from the fuel rack position transmitter to load feedback port B. If this air pressure is high enough to move the balancing piston above its centered position the pitch controller will automatically shift into the automatic load control mode of operation.

With the balancing piston moved up, the load control pilot valve plunger control land opens the control port to sump through passage T. This decreases the downstream oil pressure, which is directed to the inside of the load control bypass bellows. The oil supply pressure to the load control pilot valve is directed to the outside of the load control bypass bellows. The pressure differential causes the bellows to close the load control bypass valve.

The reduced downstream oil pressure also allows the power spring to move the power piston in the decrease pitch direction. Oil flows through the activated ahead or astern selector valve and load control orifice plug, moving the spring centered feedback piston to the right (in the direction of oil flow) and compressing the spring on the right. During the oil flow there is a pressure drop across the orifice plug and the further the feedback piston moves to the right the higher the oil pressure differential is across the feedback piston.

This combined pressure differential is directed to the upper and lower side of the receiving piston, which is part of the load control pilot valve plunger. The higher pressure is directed to the upper side of the receiving piston. This causes a downward force, which re-centers the load control pilot valve plunger and closes the control port, stopping movement of the power piston before an over correction occurs.

Stopping the load correction in advance of full fuel correction (by anticipating the new pitch setting required) enhances the quality of the control system, as an engine does not instantly develop the new torque of which it is capable when a fuel setting change is made.

The pressure drop across the orifice plug and its effect on the receiving piston creates a flow control arrangement that very effectively slows down the power piston movement. An optional orifice plug check valve assembly is sometimes used that has less restriction in pitch decrease direction, thus giving faster pitch decrease movements than pitch increase movements.

The needle valve setting determines the rate at which the pressure equalizes and the feedback piston is centered by its springs. As the feedback piston moves towards its center position the differential pressure dissipates at the load control pilot valve receiving piston at a rate that does not jeopardize stability.

A preloaded negative feedback spring arrangement is often used to further dampen unnecessary pitch corrections that may be caused by small and quick temporary load changes. However, it maintains the proper loading within a narrow band, because it responds to small sustained load changes, as well as large changes. Also the springs are normally arranged to have a higher rate in the increase pitch direction than in the decrease pitch direction. This minimizes overloading during transients while maintaining stability.

On a very large overload condition the negative feedback piston moves only far enough to uncover the by-pass port in the top of the cylinder. Oil then flows directly past the piston without further increasing the pressure differential across the piston. Under such conditions the pitch reduction is larger, returning the load to normal faster.

As the automatic load control is activated and the power piston reduces pitch, the air pressure from the position feedback transmitter decreases and the inching pilot valve plunger moves down. This movement uncovers the control port and insures that the oil supply pressure from port P is available at automatic load control pilot valve.

With a decrease in engine load as caused, for example, by a head wind changing to a tail wind, the engine governor decreases fuel to maintain commanded RPM. This decreases the air pressure from the fuel rack position transmitter to load feedback port B.

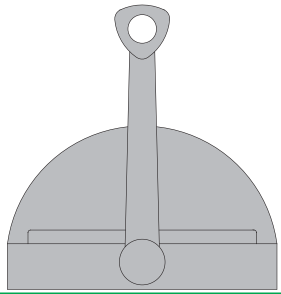
The sequence of events to increase load by increasing the pitch is similar to decreasing load by decreasing pitch except that the oil flow is in the opposite direction. At the end of the pitch correction sequence the fuel rack is back to its previous position and the air pressure signals at port A and B are again balanced. The pitch increase cannot exceed maximum pitch trim setting, if used.

If the pressure at port A stays continually larger than at port B, the pitch controller changes from load control operation to inching operation. This occurs when the pressures on both sides of the load control bypass bellows equalize. The time required to accomplish this change is determined by the magnitude of the pressure differential between port A and port B.

The load control pilot valve is extremely sensitive, with very low hysteresis. This is partly due to the use of an integral oil motor that rotates the pilot valve bushing, virtually eliminating the friction between the pilot valve plunger and the bushing.

Maximum Load Trim is easily accomplished from the remote control by limiting the maximum load command air pressure to port A.

The mechanical feedback linkage on the pitch controller is used to limit the maximum allowable pitch movement in the decrease direction by the load control pilot valve. During a pitch reduction, as the load control override cam contacts the push-rod roller, the push-rod moves up and through the lever and pilot valve push-rod, mechanically depresses the pilot valve plunger. This stops oil flow to the sump, and prevents any further pitch reduction. Even though the oil is trapped at this point, pitch can be reduced through the inching pilot valve with the pmc



CONTROL AND INSTRUMENTATION

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