Section 8

Constant Speed Drive Unit

INTRODUCTION

Modern aircraft electrical systems demand considerable electrical power. Research has shown that constant frequency alternator systems are well suited for aircraft basic power supplies. When alternators are operated in parallel better reliability and flexibility are obtained. A distribution system in which there are a number of power sources, with one or more power lines to important load points, and a means of isolating a section of the system under fault conditions, contributes to its reliability. Alternating power offers distinct advantages, among these being:-

(a) Voltages can be stepped up and down by transformers

(b) Sparking and arcing problems are reduced.

(c) A.C. motors are simpler, reliable, more compact and lighter.

(d) Dry plate rectifiers may be used for D.C. supply.

(e) Brush gear problems are greatly eased.

(f) Inverters can be made redundant.

GENERAL INFORMATION

The introduction of this the Constant Speed Drive Unit, has been followed by the production of a system consisting of one or more alternators driven irrespective of engine speed, at a constant speed by an automatically controlled, continuously variable, hydro-mechanical, transmission unit.

Basically the C.S.D.U. is a hydraulic transmission unit comprising a variable displacement pump, driven by the aircraft engine, and an hydraulic pump, driven by the aircraft engine, and an hydraulic motor which is coupled to the alternator. Pump and motor are combined in the same housing, and are arranged to operate as a differential.

OPERATION

The diagram shows in schematic form the arrangement of the drive and its oil system. The drive comprises a variable displacement, axial-piston type pump and a fixed displacement axial-piston type motor housed in a common cylinder block assembly and bolted together, with the port plate positioned in between to direct the oil flow between pump and motor.

The cylinder block assembly is rotated by the engine through the input shaft.

Initial rotation of the input shaft causes the cylinder block assembly to rotate as well as the CHARGE and SCAVENGE oil pumps. The gear type charge oil pump is used to deliver oil to the pump and motor assembly and the governor system. This charge oil supplies the inlet of the pump and motor so that the pistons and push-rods will be held in contact with their swash-plates at all times.

The variable displacement pump consists of the cylinder block assembly, the pump swash-plate assembly and the manifold assembly. As the charge pressure holds the pistons against the swash-plate assembly, piston stroking is accomplished when the cylinder block is rotated. The displacement of the pump is regulated by the angle of the swash-plate which is determined by the governor system through a hydraulic signal. The manifold assembly serves to deliver charge oil to the pump and working pressure oil to the Charge Relief Valve.

Cont/ The fixed-displacement....

The fixed-displacement motor consists of a cylinder block assembly and the motor drive shaft. The motor cylinder block assembly receives working pressure oil which forces the pistons to move out against the fixed angle swash-plate, thus converting axial-piston movement into rotary motion. The swash-plate is free to rotate independantly of the cylinder block and hence can operate at speeds in excess of, or below that of, the rotating cylinder block assembly. The off set of the motor valve plate is always in the same position with respect to the angle of the swash-plate, this position being such that the motor pistons are exerting a clockwise torque upon the swash-plate.

The speed signal for the governor system is taken from the output shaft. The alternator is driven through a clutch located in the output shaft of the transmission. This ensures that the drive and alternator will not transmit "Reverse power".

DIFFERENTIAL SPEED

From the diagrams the following points should be noted:-

(a) The Pump

(i) The fixed valve plate and eccentric pin.

(ii) The direction of rotation.

(iii) The variable angle of the swash-plate.

(iv) That charge oil pressure is constantly supplied to the centre of the valve plate through the manifold.

(v) That any cylinder at B.D.C. or T.D.C. will be blanked off.

(b) The Motor

(i) The eccentric pin and motor valve plate are part of the swash-plate shaft and rotate with it.

(ii) The fixed angle of the swash-plate.

(iii) The eccentric pin and valve plate rotate in phase with the motor swash-plate shaft.

(c) Oil Flow

It will be seen that some of the pistons are in communication with the centre of the valve plate and others with the working pressure annulus outside the valve plate rim. Charge pressure oil is supplied to the cylinder blocks by the manifold keeping the pistons in contact with their respective swash-plates. On being reciprocated the working pressure oil from the pump causes the motor pistons to exert a thrust on the motor swash-plate. This thrust is transmitted to the motor swash-plate drive shaft. The speed of the motor shaft relative to thecylinder block speed is governed by the quantity of oil flowing through the motor per revolution of the cylinder blocks. This is the DIFFERENTIAL SPEED. With oil flowing from pump to motor the differential speed will be positive as the action of the pistons in the motor are rotating the motor shaft in the same sense as the cylinder blocks. However, as the pump swash-plate changes its angle so that oil now flows from the motor to the pump, the motor shaft will be rotating in the opposite sense to the cylinder blocks and the differential speed will be negative. The resultant speed of the motor shaft will therefore be the sum of the differential speed and the speed of the cylinder blocks. In conclusion therefore the pump swash-plate angle determines the speed and direction of rotation of the motor shaft with respect to the cylinder blocks.

OVERDRIVE

With the swash-plate in the maximum overdrive position the output shaft is over-speeding the input shaft. This overspeed is the ratio of maximum pump displacement to the fixed displacement of the motor. The swash-plate remains in this position until output speed reaches 6,000.

With further increase in input speed, the normal tendency is to increase the output speed still further. At this point however, the governor regulates the control piston and swash-plate assembly to decrease pump piston stroke. Less oil then flows from the pump to the motor and therefore the differential speed between the motor shaft and the cylinder block assembly is reduced to retain constant output speed.

UNDERDRIVE

When the input speed exceeds the output speed the cylinder assembly will be turning faster than the motor shaft. Relative motion between the cylinder block and the motor shaft will now be in a reverse direction since it is now necessary to subtract from input speed to maintain governed output speed. Due to the cylinder block overspeeding the motor shaft, the pump swash-plate is held in an underdrive position (negative angle) which permits an oil flow from motor to pump. In effect the pump is now metering the oil flow from the motor block.

STRAIGHT DRIVE

The pump swash-plate is no longer at an angle and therefore does not cause any pumping action between the pump and motor. The motor shaft will therefore rotate at the same speed as the cylinder block assembly.

GOVERNOR SYSTEM

The Governor system performs two essential functions:-

(a) Control of output speed for constant frequency.

(b) Load equalisation for parallel operation.

(c) In addition it is desirable that during starting the drag of the C.S.D.U. and the Alternator on the engine is a minimum. This is achieved when the C.S.D.U. is in the maximum underdrive condition.

(a) The control function is handled by two separate governors, both being driven at the same speed from the output gear trains viz:- the BASIC GOVERNOR and the LIMITING GOVERNOR.

During normal running the drive is controlled by the basic governor which is of the centrifugal type. This governor controls an hydraulic servo system which includes the underdrive and overdrive control pistons and cylinders, a trip valve and a pressure switch. The limiting governor gives both under and overspeed protection.

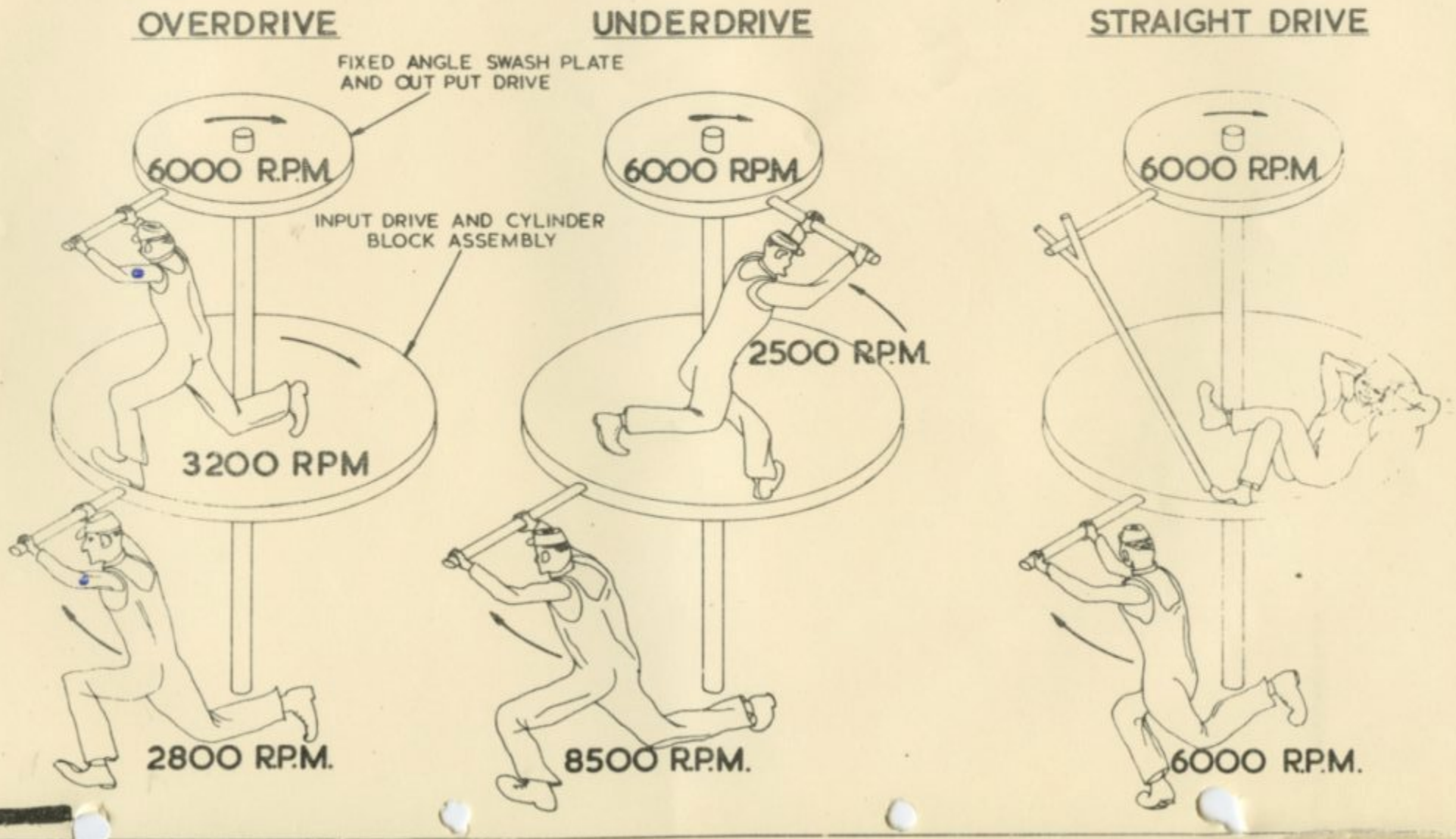
(b) Load equalisation and precise frequency adjustment is accomplished electrically onto the bi-asing spring of the basic governor.

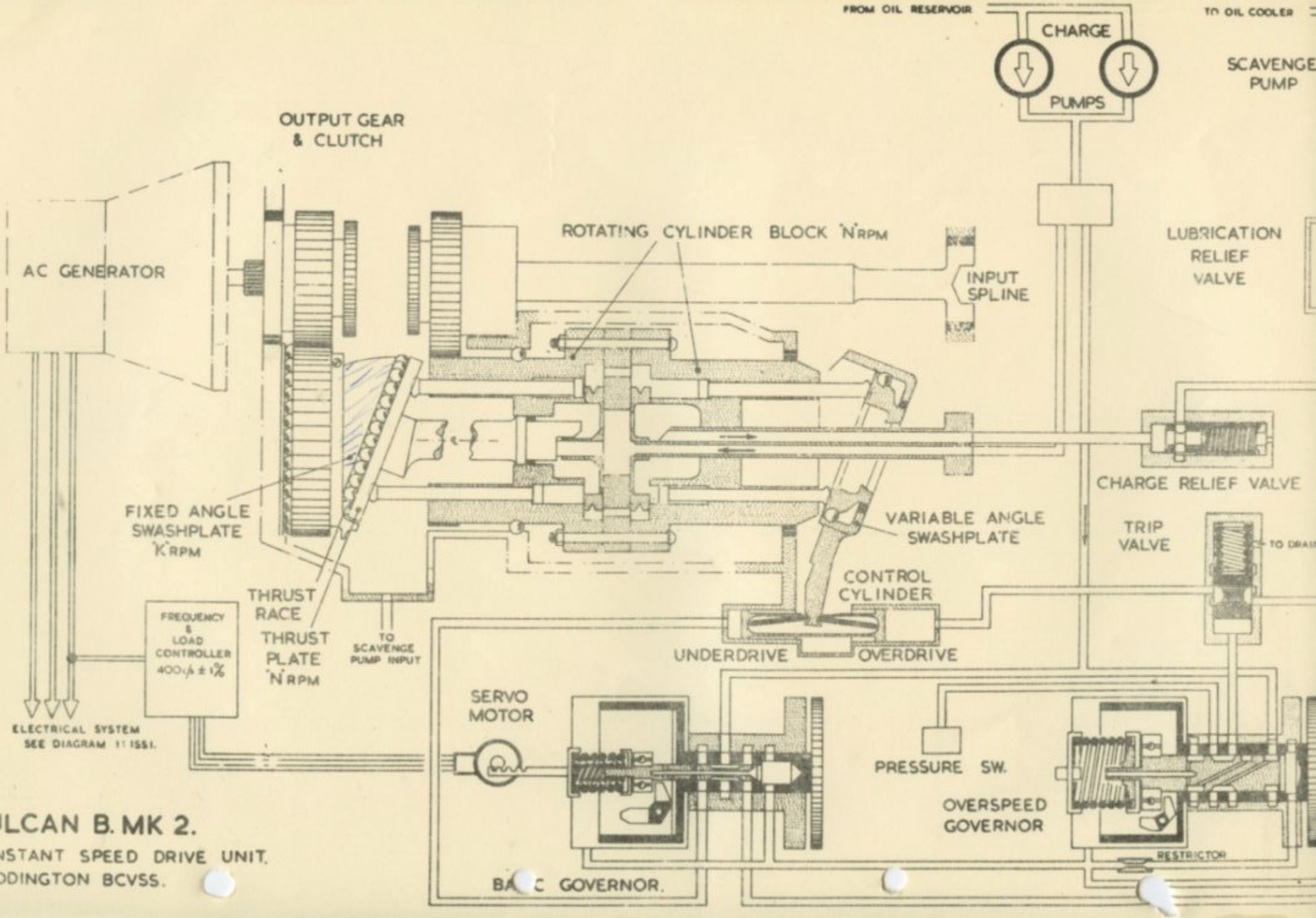
(c) The underspeed protection is simply that the governor will not allow any load to be taken by the alternator until its frequency is above 365 c.p.s. This frequency is transmitted to the limiting governor as an indication by R.P.M. Below 365 c.p.s. the flyweight in the limiting governor cannot compress the overspeed spring and this keeps the valve at the bottom of its stroke. The valve keeps the trip valve and pressure switch free from charge oil and therefore oil directed by the basic governor to the overdrive cylinder cannot pass the trip valve.

The overspeed protection is acheived by the limiting governor valve being lifted and allowing the charge pressure in the trip valve and pressure switch lines to drain away so causing the contacts in the pressure switch to open. The oil in the overdrive cylinder can now drain through the trip valve and allow the C.S.D.U. to move into the maximum underdrive postion. This action is permanent in duration and can only be cancelled by shutting down the drive.

CONSTANT SPEED DRIVE

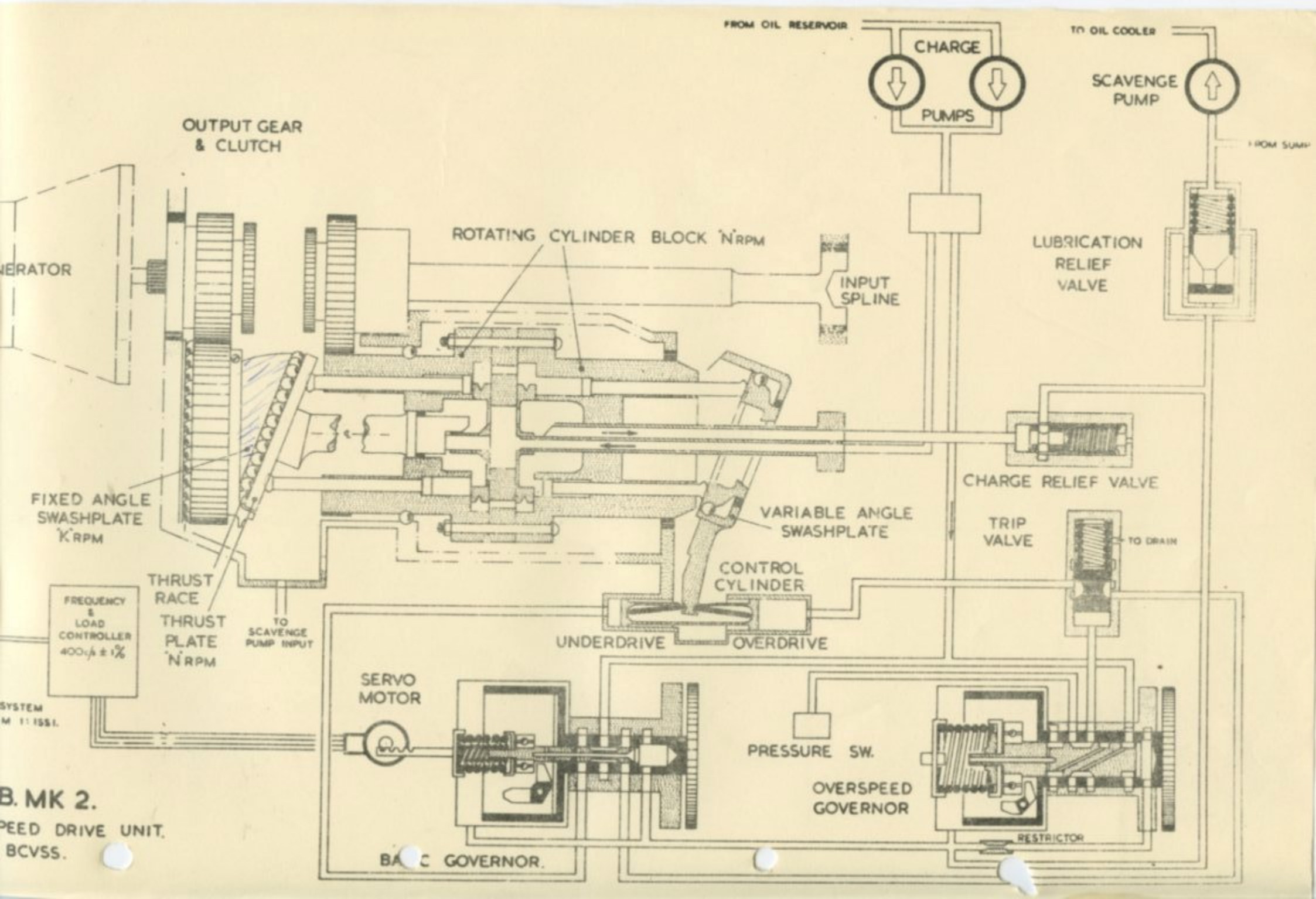
DIFFERENTIAL ACTION





VULCAN B. MK 2.

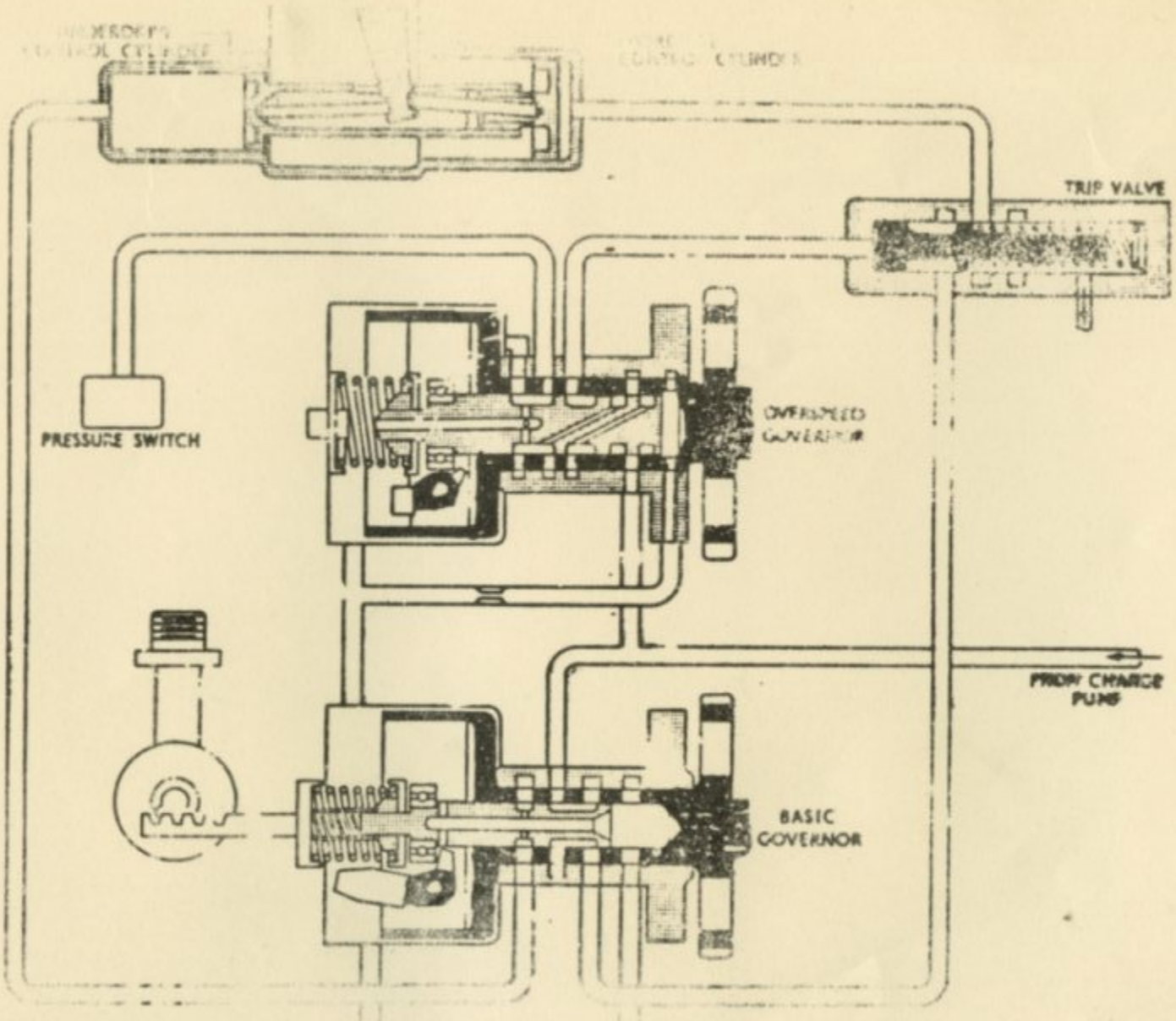
CONSTANT SPEED DRIVE UNIT.
WADDINGTON BCVSS.



B. MK 2.

PEED DRIVE UNIT.

BCVSS.



CHARGE PRESSURE

OVERDRIVE CONTROL PRESSURE

UNDERDRIVE CONTROL PRESSURE

LUBRICATION PRESSURE

SCAVENGE

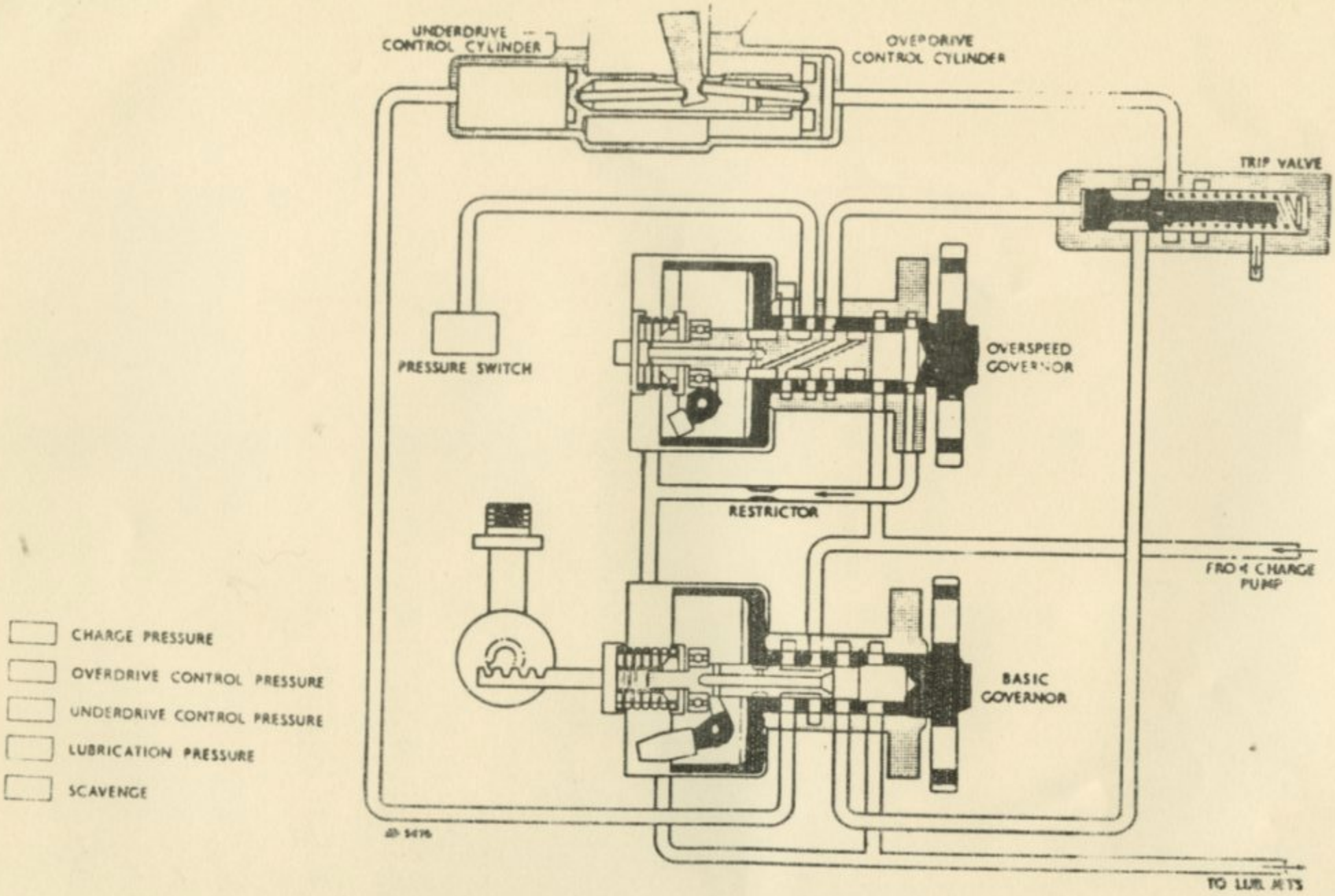
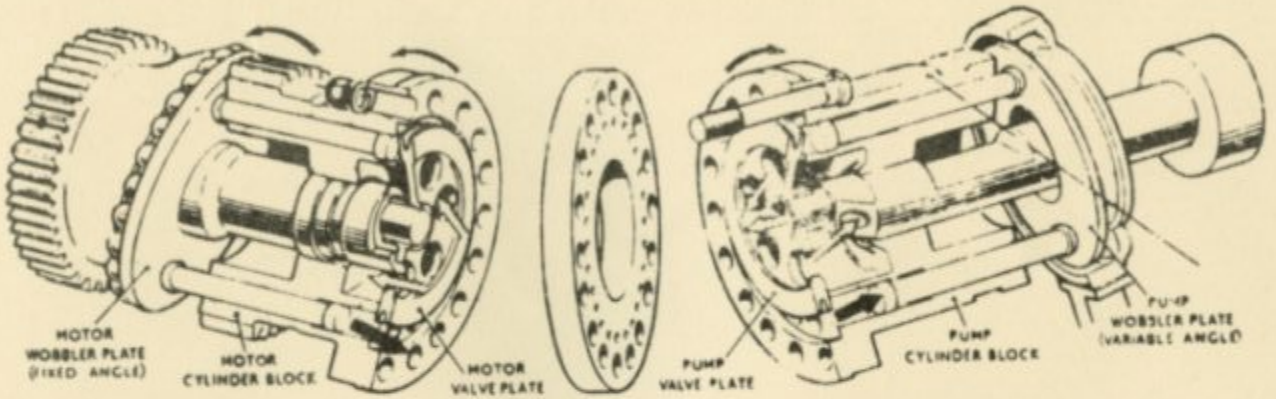
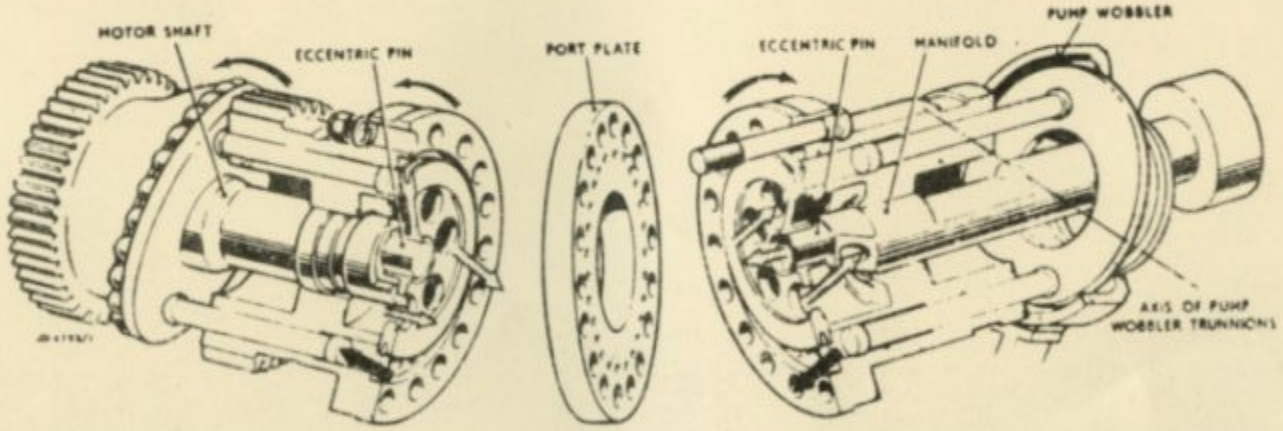


Fig. 16 Governor system at overspeed



UNDERDRIVE CONDITION



CHARGE OIL PRESSURE

OVERDRIVE CONDITION

WORKING OIL PRESSURE

Transmission unit in underdrive and overdrive conditions

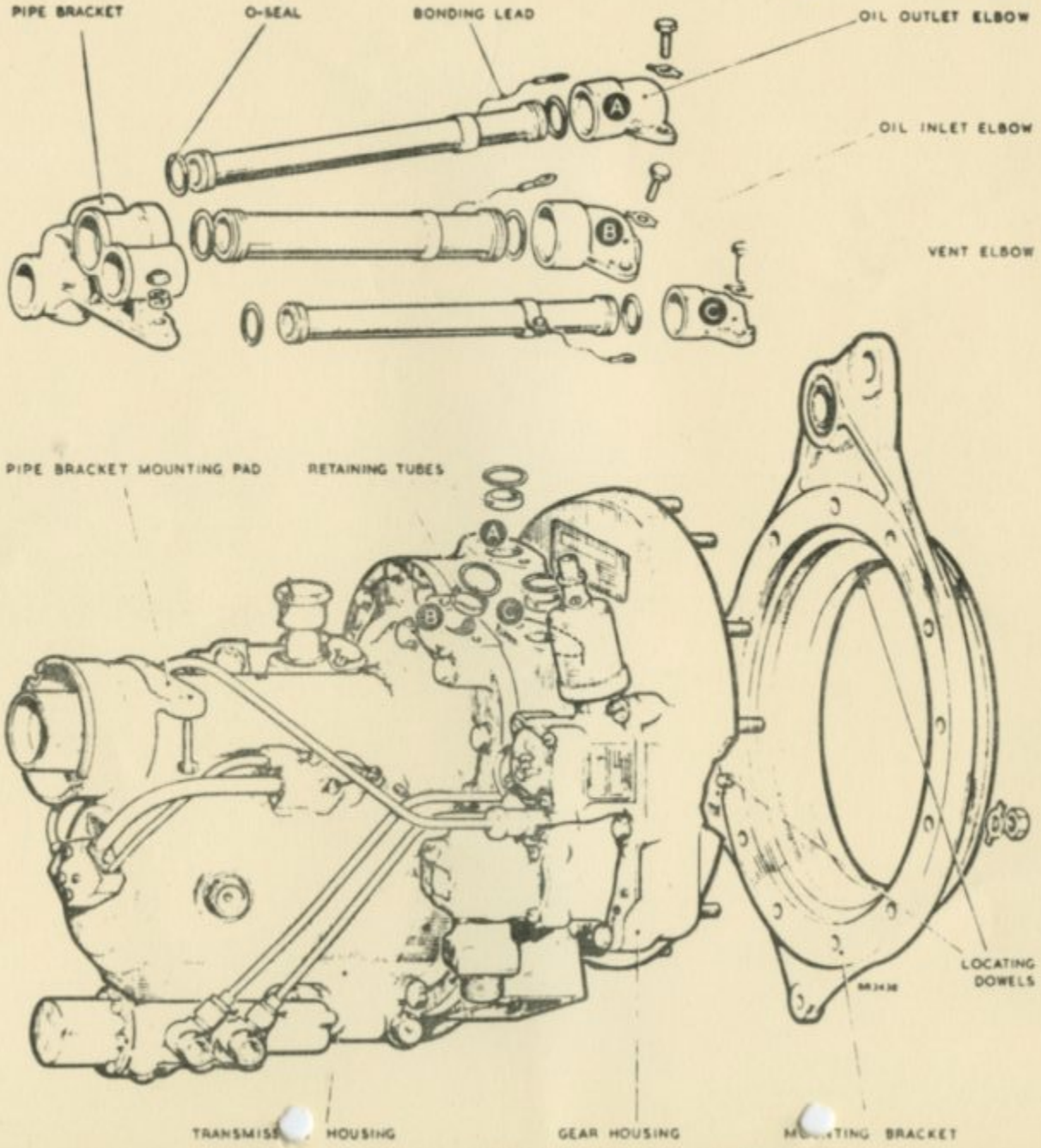


Fig. 2. Constant-speed drive unit—installation fittings