CONTROL SYSTEM

The main control units of the engine are grouped on the phasing gear case free end casing and comprise, a servo-assisted governor, a starting accumulator and an hydraulic control unit.

Control of the engine is by means of a single lever connected by cables through the governor to the hydraulic control unit. For emergency control of the engine, a lever is provided on the governor. The engine is stopped by a second lever connected by a cable and lever to the governor shut-down mechanism.

ENGINE CONTROLS

Speed Control

Speed changes are impressed on the governor by a cable wheel mounted on a camshaft. The cam actuates a follower mounted on a lever which pivots on the governor speed control shaft. The adjusting lever is splined to the speed control shaft to which the governor speed-control cam is attached.

Movement of the engine control lever is transferred by the cable to the camshaft which actuates the lever to bear against the screw and move the adjusting lever, speed control shaft, and speed control cam to impress a speed setting on the governor.

Output from the governor through the lever is transmitted by an adjustable link rod to a bell-crank lever secured to the drive end of 'B' camshaft casing fuel injection pumps control shaft. A second, double-ended lever secured the same position, transmits movement to 'A' and 'C' bank fuel injection pumps control shafts through control rods of set length and intermediate levers.

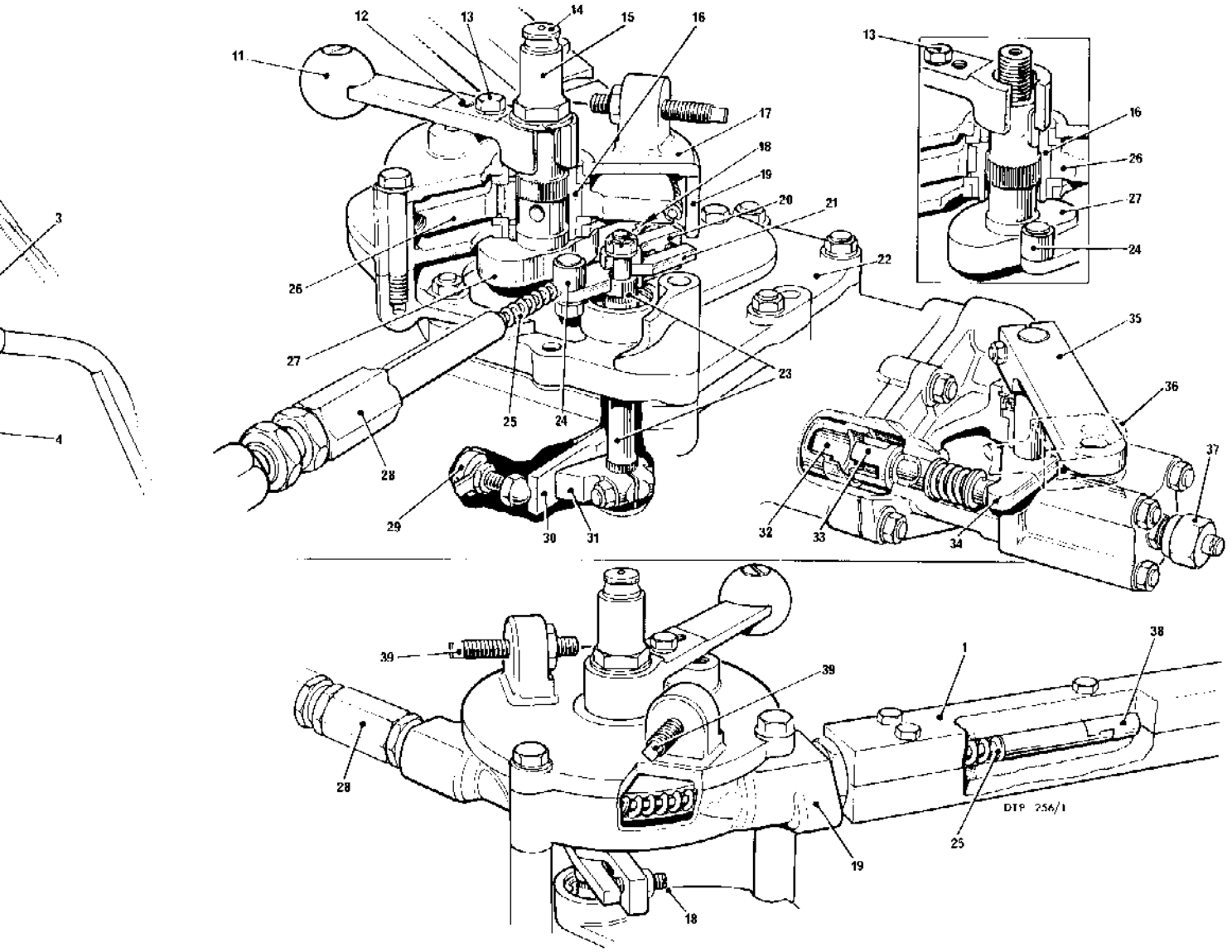
Clutch Selection

Initial movements of the engine control lever and the cables cause no alteration to the position of the cam follower due to the form of the cam but, the movement of the cable is transmitted to the hydraulic control unit cable wheel and the required clutch is engaged by the action of the control unit.

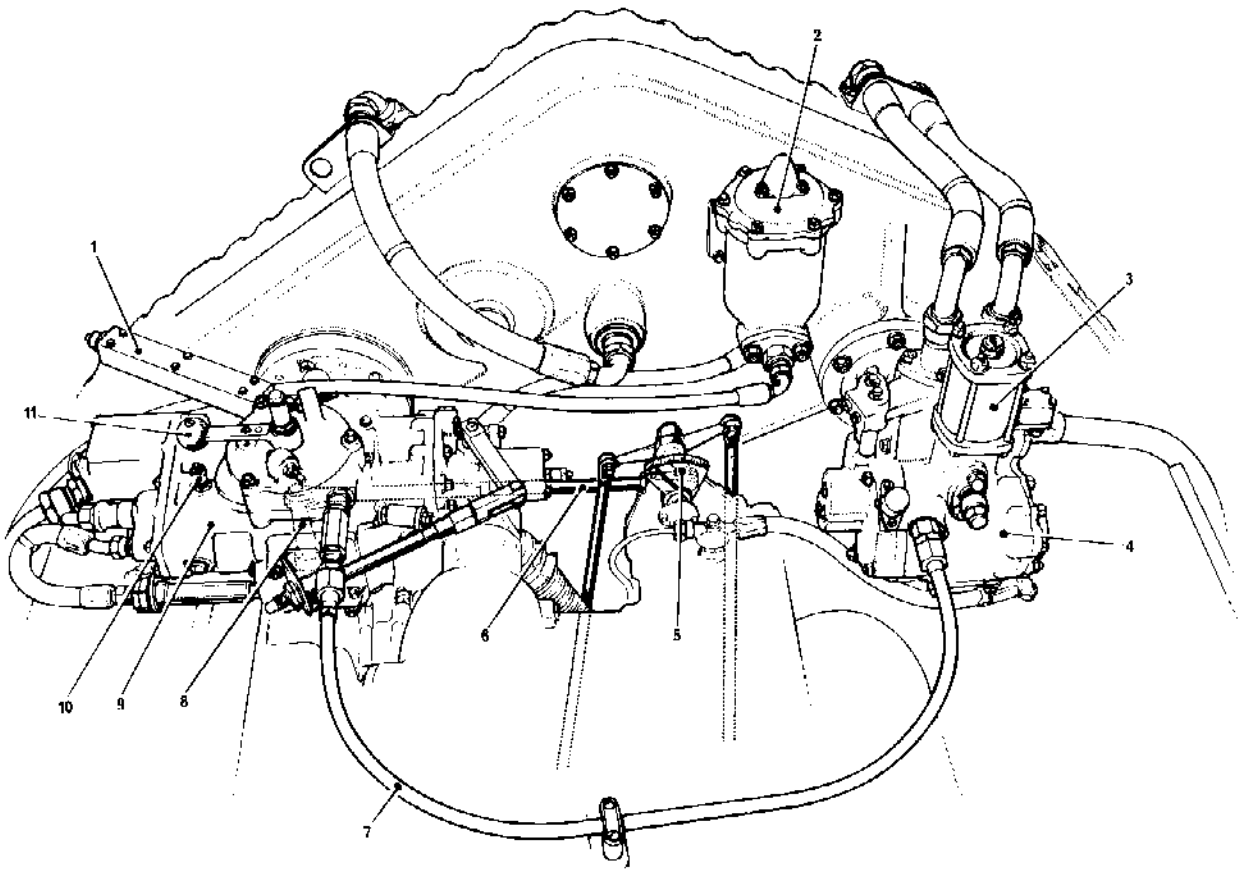
Movement of the engine control lever is limited in initial movements by a hydraulic gate this arrangement prevents speed increase being impressed before the selected clutch has been engaged.

GOVERNOR

Having no flywheel, Deltic engines have a low moment of inertia and, consequently, an inherent tendancy to accelerate rapidly if the load is decreased. Engine of this type require extremely lively governors to prevent hunting and to protect the engine from overspeeding.

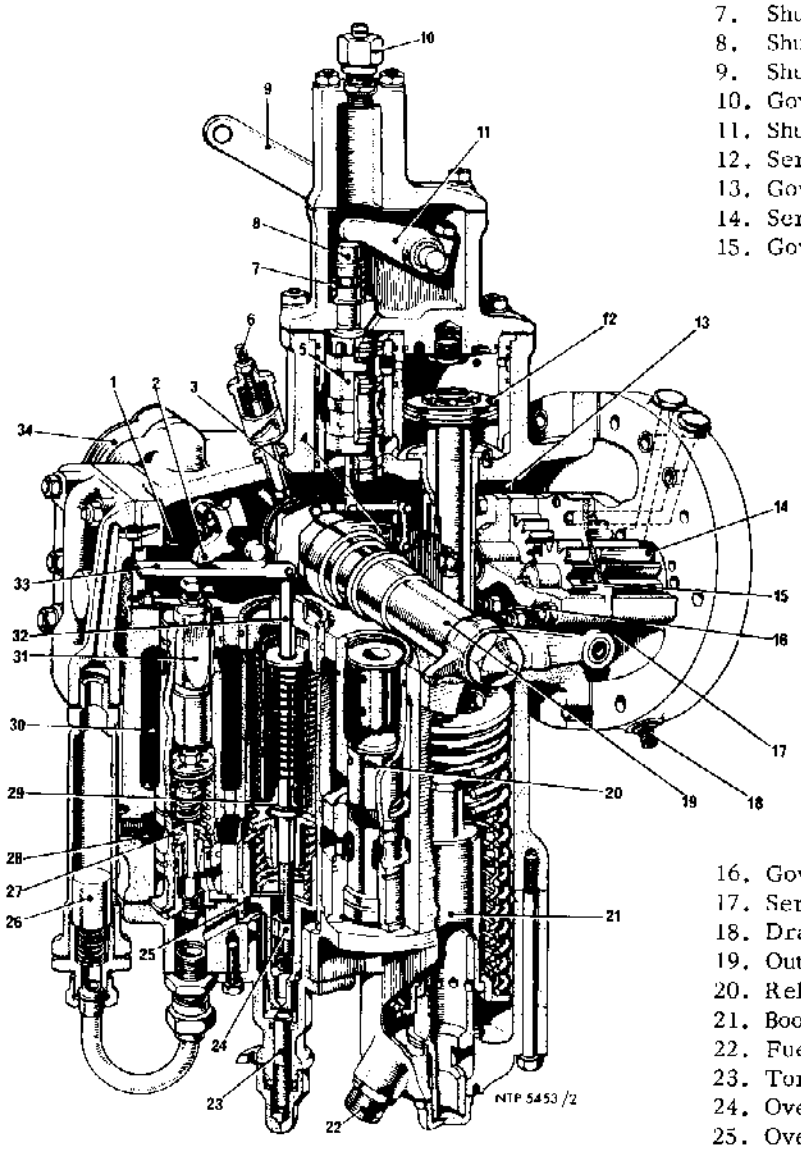


21. Speed control lever
22. Governor side cover
23. Speed- control shaft
24. Cam follower
25. Control cable, governor to hydraulic control unit
26. Cable wheel
27. Speed selection cam
28. Cable conduit adjuster
29. Speed-control valve
30. Feed-back (balance) link
31. Speed-control cam
32. Servo valve
33. Shut down probe
34. Shut-down probe lever
35. Governor shut-down lever
36. Shut-down cable fork end (in broken line)
37. Venting blank
38. Control cable from Master Control
39. Limit screws



1. Controls break unit
2. Starting accumulator
3. Clutch delay solenoid
4. Hydraulic control unit
5. Bell crank lever (in broken line)
6. Adjustable link rod
7. Control cable conduit, governor to hydraulic control unit
8. Governor output lever (in broken line)
9. Napier-Bryce governor
10. Governor venting blank
11. Emergency hand control lever
12. Setting hole
13. Setting pin (in stowage position)
14. Grease nipple
15. Pillar nut
16. Cable wheel hub
17. Cover
18. Minimum stop screw
19. Cable wheel housing
20. Adjusting lever
21. Speed control lever
22. Governor side cover
23. Speed- control shaft
24. Cam follower
25. Control cable, governor t control unit
26. Cable wheel
27. Speed selection cam
28. Cable conduit adjuster
29. Speed-control valve

ENGINE CONTROLS



1. Reservoir
2. Speed-control cam
3. Follow-up link
4. Forked lever
5. Servo valve
6. Retractable maximum stop
7. Shut-down probe spring
8. Shut-down probe
9. Shut-down cable lever
10. Governor vent
11. Shut-down probe lever
12. Servo piston
13. Governor fuel outlet
14. Servo pump
15. Governor pump
16. Governor pump inlet
17. Servo pump inlet
18. Drain
19. Output shaft
20. Release valve
21. Boost plunger
22. Fuel inlet
23. Torque limitation minimum stop
24. Overfuelling stop nut
25. Overfuelling plunger
26. Starting piston
27. Speed-sensitive pressure valve
28. Working pressure gallery
29. Balance piston
30. Control-pressure gallery
31. Speed-control valve
32. Balance-piston rod
33. Feed-back (balance) link
34. Control cable wheel housing

HYDRAULIC GOVERNOR

The Napier-Bryce governor unit comprises a variable-orifice hydraulic governor and a follow-up servo system which amplifies the governor output power.

The governor and the servo mechanism are contained in a casting mounted on and driven from a gear in the phasing gear casing. All fuel supplied to the engine flows through the governor reservoir and thus serves as a coolant. From the reservoir the governor draws fuel which is used as a hydraulic medium.

The governor consists of an engine-driven pump having an output proportional to engine speed, a speed-control valve which converts variations of flow from the pump into variations of pressure; a balance piston responsive to variations of pressure and thereby adjusting the fuel controls through linkages - a release valve which provides a constant datum pressure on one side of the balance piston, and a feed-back link through which the area of the speed-control orifice is changed with movements of the balance piston so that the balance of forces on the piston is restored.

An overfuelling plunger, under certain circumstances, restricts the movement of the balance piston and prevents overfuelling under heavy overloads; the position of the plunger is determined by fuel pressure and a spring. During normal running the limit set by the overfuelling plunger is outside the range of travel of the balance piston, but if the engine should become overloaded the plunger prevents the balance piston moving the fuel controls to the higher settings.

Governor and Servo Pumps

The gear-type governor and servo pumps, seperated by a divider plate, are housed in one assembly bolted to the inside face of the mounting plate. The main features are similar though the governor pump is smaller than the servo pump. Seperate figure-of-eight housings contain each set of pump gears which are supported on common shafts. The pumps are driven by a short quill-shaft which passes through the mounting face and engages internal splines in the driving gears shaft; escape of fuel and ingress of lubricating oil are prevented by two opposed seals in the governor mounting face.

Fuel from the reservoir is admitted to the pumps through a hole, in the end-plate and is pumped through further drillings in the pump housings, mounting plate and governor casting. The output from the governor pump is shown by the green circuit and from the servo pump by the red circuit.

GOVERNOR FUNCTIONING

Fuel is drawn by the pump from the reservoir and pumped through the speed-sensitive pressure valve into the working-pressure gallery, then passes through the release valve into the control- pressure gallery, and from this through the speed-control valve to the reservoir. The pressure in the working-pressure gallery, controlled by the release valve, bears on the balance piston and on the end of the speed-control valve which is held in contact with the feed-back link. The control pressure, controlled by the orifice area of the speed-control valve, bears on the upper side of the balance piston and, augmented by the return spring against that of the working pressure, holds the balance piston in equilibrium.

Governing

If the engine load decreases, the diminished fuel requirements for running at the original governed speed are met by movement of the balance piston to a new position. Movement of the piston operates the injection pumps control shafts through the feed-back link, follow-up link and follow-up servo mechanism and the external control linkage.

Initially, the increasing engine speed resulting from the reduced load, increases the governor pump delivery; the working pressure in the gallery is unaffected because it is maintained constant by the release valve, but the pressure in the control-pressure gallery rises since the increased flow from the pump must escape through the unchanged orifice of the speed-control valve. The rise in control pressure disturbs the equilibrium of the balance piston which, biased by the pressure rise, moves the balance-piston rod and follow-up link and begins to shut down the fuel controls. Continued movement of the piston opens the speed-control valve due to the movement of the feed-back link, thus the control pressure decreases progressively. Movement of the balance piston is rapidly arrested by the restoration of equilibrium between the forces on either side of the piston.

When the load on the engine increases, the above sequence of events is reversed. Should the fuel supply or the mechanical drive fail, the balance-piston shuts down the engine; thus the governor fails safe.

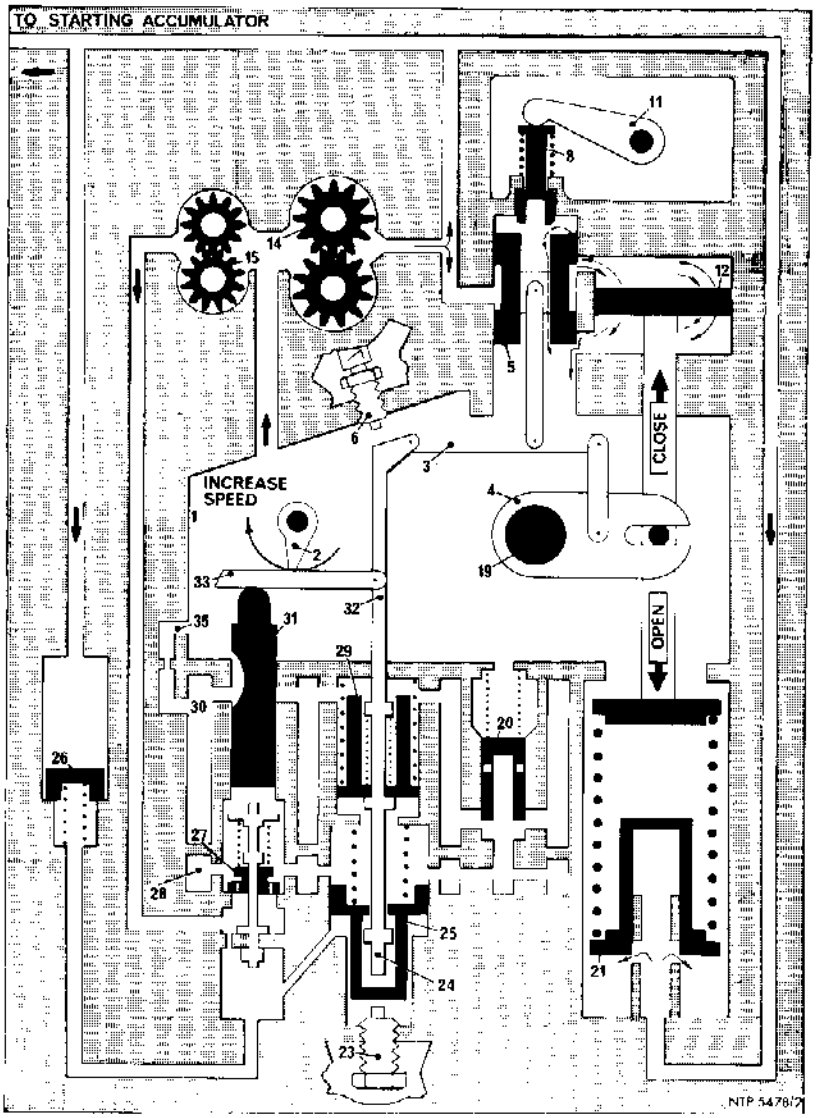
Torque Limitation

The governor has two fixed stops which limit the engine speed; the minimum stop and the maximum stop. In order to prevent the engine from being overloaded at any intermediate condition between these two stops, a torque limitation, or overfuelling, device is incorporated in the governing system.

During normal operation of the engine within the limits of propeller power absorbtion, the position of the overfuelling plunger in no way limits the movement of the balance piston rod but, should the boat be overloaded, be engaged upon emergency towing, be operated on a single engine or other similar circu,stance which would call for an increased power for a given speed selection, the overfuelling stop-nut on the balance piston rod will contact the overfuelling plunger and an increase in engine speed will be prevented.

An example of the function of the device can be shown by considering single engine operation. For a given engine speed selection, a higher power will be required than in twin engine operation to drive the boat at a given speed. As speed selection is increased from idling, the balance piston and rod will be progressively moved in an "increase fuel" direction.

As fuel demand increases, the pressure above the balance piston will fall, causing the balance piston and rod to continue its upward movement to 'open' the fuel controls. As engine speed increases, the output from the governor pump will increase and pressure proportional to the pump output will be applied below the overfuelling plunger. The continued increasing demand for fuel will cause the balance piston and rod to rise more rapidly than the overfuelling plunger and, at a predetermined brake horsepower and crankshaft r.p.m. the overfuelling stop-nut will contact the underside of the plunger and prevent further upward movement of the balance piston.



1. Reservoir
2. Speed control cam
3. Follow-up link
4. Forked lever
5. Servo valve
6. Retractable maximum stop
8. Shut-down probe
11. Shut-down probe cover
12. Servo piston
14. Servo pump
15. Governor pump
19. Output shaft
20. Release valve
21. Boost plunger
23. Torque limitation minimum stop
24. Overfuelling stop-nut
25. Overfuelling plunger
26. Starting piston
27. Speed-sensitive pressure valve
28. Working-pressure gallery
29. Balance piston
30. Control-pressure gallery
31. Speed control valve
32. Balance-piston rod
33. Feed-back (balance) link
35. Trimming bleed

To facilitate cross references each component bears the same annotation number as previous illustration "Hydraulic Governor".
The broken numerical sequence in the above key is therefore unavoidable.

GOVERNOR FUNCTIONING

Retractable Maximum Stop

A retractable maximum stop, located on the governor with the contact face above the balance-piston rod, restricts the upward movement of the rod passing through the balance piston, thereby limiting the fuel supply. This stop is retractable and, when difficulty in starting the engine is experienced in extreme low temperature conditions, may be withdrawn to a higher maximum setting to increase the supply of fuel to the engine. The stop must be returned to normal as soon as the engine starts.

The stop is screwed to the bore of a sleeve which is assembled over a body to retain the loading spring. A helical slot in the sleeve engages a peg in the body.

To prevent fuel leakage from the governor, the stop is sealed by a synthetic rubber ring, and the joint between the body and the governor by a metal/rubber bonded washer.

A visual warning is provided by a red-painted groove in the body, which is exposed when the stop is retracted.

Speed Selection

Selection of the desired speed is achieved by rotation of the speed-control cam which, through the feed-back link, sets the speed-control valve at the appropriate datum position, thereby exposing the requisite area of speed-control orifice. The balance piston, in moving to the new point of equilibrium, adjusts the fuel requirements of the engine.

Starting

When the engine is set for starting, the balance piston is back against the upper torque-loading spring plate, the speed-control cam is at the idling position and the release valve is shut. During the initial stage of the starting impulses the working pressure is increased by the injection of fuel from the accumulator and the movement of the starting piston. The balance piston is therefore displaced against its spring, opening the fuel controls until the pressure rises sufficiently to open the release valve, the over-fuelling plunger having been moved clear by the starting piston. With continued acceleration, and the increased speed of the governor pump, the increasing control pressure returns the balance piston from the open position, and this movement progressively opens the speed-control valve until piston equilibrium is attained at idling speed.

The starting piston remains in the lower position under the action of the servo pressure, until the engine is stopped, when the piston spring returns the piston ready for the next start.

FOLLOW UP SERVO MECHANISM

Operation of the servo mechanism conforms to the well-known follow-up principle whereby the governor, by moving a double-acting valve, admits fuel under pressure to one side or the other of a servo piston; the resulting force on the piston is sufficient to move the injection pumps controls to the extent and at the speed required by the governor.

The components of the servo mechanism are housed within the governor casting and comprise a gear-type pump, a boost plunger, a double-acting servo valve, a servo piston, and a follow-up link. The output from the servo mechanism is transmitted to the controls through a forked lever and output shaft.

SERVO FUNCTIONING

Normal Running

During normal steady running, the greater part of the fuel from the servo pump returns to the reservoir through the ports in the boost plunger sleeve, and the boost plunger, after accumulating a small quantity of fuel, maintains a high pressure in the system.

When the governor is dealing with an increase in engine load, movement of the governor balance-piston rod moves the follow-up link, and displaces the servo valve, which opens two ports in the servo valve sleeve; one admits fuel to the servo piston crown and the other exhausts fuel from the opposite side of the piston to the reservoir. The pressure on the servo piston crown moves the servo mechanism in the increase fuel direction against the action of the boost plunger springs. The motion pivots the follow-up link about its joint on the governor balance-piston rod and thus gradually closes the servo valve ports and decreases the movement of the piston until equilibrium is restored.

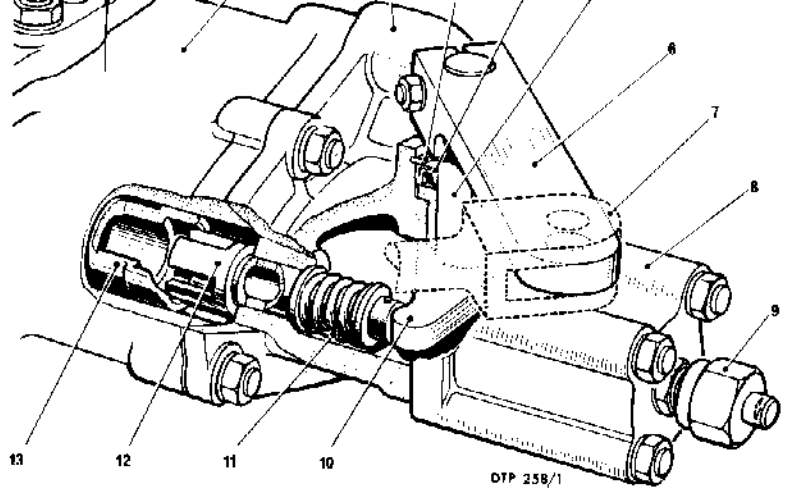
In the reverse process of reducing engine speed the servo piston is accelerated by the action of the boost plunger springs which supplement the hydraulic pressure acting on the piston. In addition, the boost plunger is incorporated to regulate the servo pressure and to augment the output of the pump. The cumulative effort enables the governor to shut down from the full-power setting in less than one-tenth of a second, and this prevents overspeeding of the engine.

Starting

Initial movement of the governor balance piston during starting opens the servo valve and permits fuel to flow to the servo piston crown but the capacity of the servo pump is too small to produce the required response during the first revolutions of the engine. A large pump, however, would be an unnecessary burden during normal running so the initial volume of fuel under pressure is supplied to the servo system by the starting accumulator.

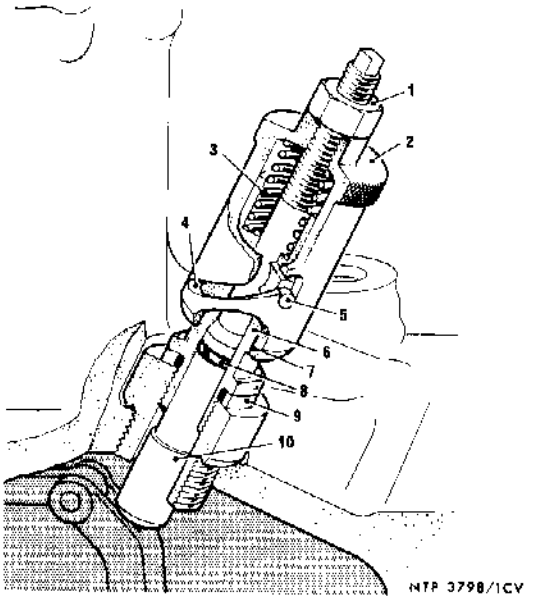
Shut-down Assembly

The engine is stopped by a hand-operated shut-down lever positioned in the engine room control booth. When the lever is moved to STOP, a connecting cable moves the governor shut-down lever and the shut-down probe lever moves the spring loaded probe to depress the servo valve. As the servo valve is held manually depressed, the servo mechanism moves the fuel controls to the 'no fuel' position and the engine stops.



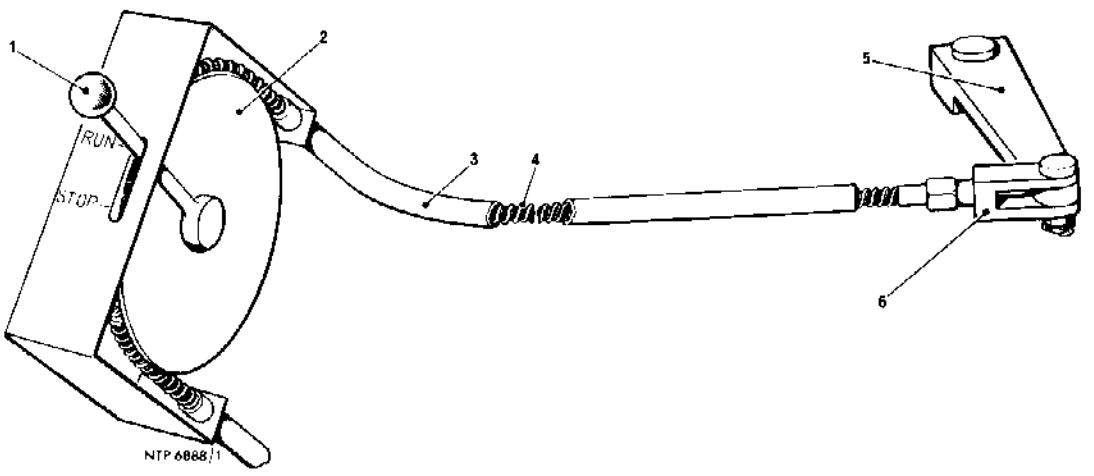
1. Governor casing
2. Shut-down housing
3. Circlip
4. Seal
5. Shaft
6. Shut-down lever
7. Shut-down cable fork-end
8. Cover
9. Venting blank
10. Shut-down probe lever
11. Spring
12. Shut-down probe
13. Governor servo valve

SHUT-DOWN MECHANISM



1. Lock nut
2. Sleeve
3. Loading spring
4. Helical slot
5. Peg
6. Body
7. Groove (red)
8. Sealing ring
9. Bonded washer
10. Stop

RETRACTABLE MAXIMUM STOP



1. Shut-down lever
2. Cable wheel
3. Cable conduit
4. Shut-down cable
5. Governor shut-down lever
6. Shut-down cable fork-end

SCHEMATIC LAYOUT OF SHUT DOWN CONTROL

STARTING ACCUMULATOR

During the initial stages of starting, the fuel controls must be open. As the capacity of the governor servo pump is too small to provide, in the first few revolutions of the engine, the quantity of fuel necessary to move the servo piston, an accumulator is used to store a quantity of fuel and release it under pressure to operate the governor for starting. When the engine is running the servo pump re-charges the accumulator in preparation for the next start.

Accumulator Body

The accumulator is a cast cylindrical body containing a free piston, the skirt of which is sealed with a synthetic rubber ring; the two ends of the body are thereby isolated by the piston. An air release valve fitted into the end cover enables one side of the accumulator to be charged with a gas, while a priming connection, fitted with a non-return valve, at the other end of the unit enables the other side of the accumulator to be filled with fuel, the pressure of the fuel depending on the gas pressure.

Release Valve

The release valve is accommodated in a bore at right angles to the priming valve bore but intersecting it at a point between the accumulator and the priming ball valve so that the accumulator may be charged and discharged through the same port. A spring-loaded ball seals the release valve and prevents the escape of fuel until the ball is depressed. This is achieved at starting by air pressure tapped from the engine starting air supply being applied to the crown of a small plunger which is thereby depressed and in turn moves a push-rod, a small spring-loaded ball seal, and finally the release valve. The small ball is fitted to seal the push-rod guide against leakage when the accumulator is not in use.

Delivery Valve

The delivery union contains a ball valve which is opened by the fluid discharging from the accumulator. A hole in the valve seat permits a small return flow of fuel, thereby enabling the accumulator to be re-charged without making excessive demands on the servo pump.

Functioning

When the air supply to the air starting system is opened, pressure is transmitted from the starting air manifold pipe to the head of the release plunger, thereby depressing the ball valves and releasing the fuel stores under pressure in the accumulator.

HYDRAULIC CONTROL UNIT

When the engine control lever is moved, a cam-operated valve in the hydraulic control unit directs a flow of oil to one side or the other of a