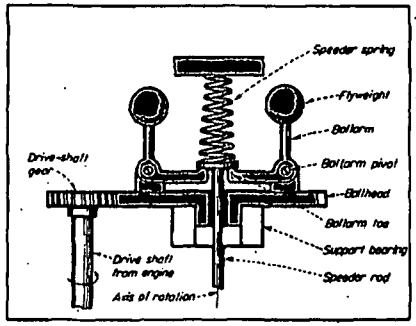
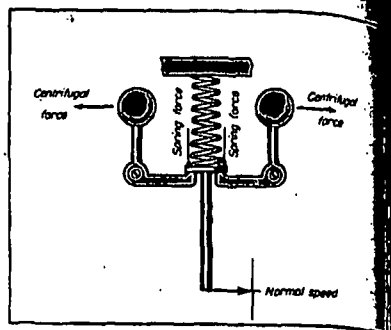
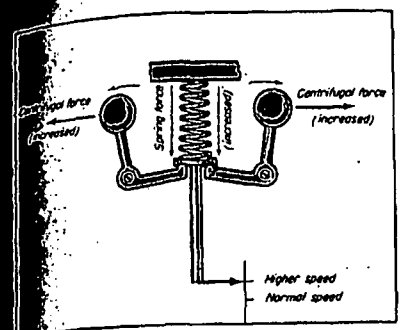


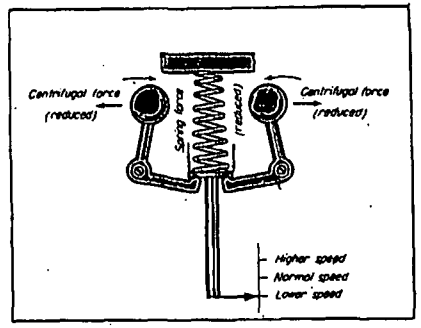
1 Centrifugal ballhead speed-measuring mechanism is simple, has few moving parts and accurately measures engine speed



2 Balanced position of ballheads when engine is running at normal speed. Spring force equals the centrifugal force



3 When engine speeds up, centrifugal force increases and the flyweights move out. Toes rise until forces balance



4 When engine slows down, the flyweights move in, lowering the ball-arm toes. Spring force falls until balance exists

Governor's Heart Is the Centrifugal Ballhead That Accurately Measures

► DIESEL-ENGINE GOVERNORS are speed-sensitive devices that automatically control or limit engine speed by regulating the amount of fuel fed to the engine. Usual governor adjusts fuel-supply rate to keep engine running at steady speed regardless of load. This type is called a *speed governor*.

Governor Principles. Any change in *an engine's load immediately causes* an increase or decrease of engine speed. Up to an engine's capacity, power developed depends on amount of fuel burned in the cylinders. In other words, the more fuel oil or gas we inject per stroke, the more power the engine develops.

If power developed by our engine exceeds the load, this excess accelerates engine parts, causing speed to increase. When load becomes greater than power developed, the engine slows down.

An engine running with a fixed throttle (constant fuel-supply rate) speeds up when load falls off, slows down when load increases. Under some conditions the engine may "run away" if too much load is taken off, or stall if heavily overloaded.

Fuel Supply. To keep engine speed constant, just enough fuel must be supplied cylinders so power developed equals the load at desired speed. We could try to do this manually by stationing an operator at the throttle to change its setting whenever he heard engine speed change or saw the tachometer needle move. With manual control you must open throttle wider to supply more fuel to the cylinders when speed falls. Throttle is closed to reduce fuel flow when engine speed increases.

But even the most skillful operator cannot change throttle setting quickly enough to maintain a reasonably uniform speed unless load is fairly constant or changes very slowly. Function *of a speed governor is to do this job* rapidly, accurately and automatically. It first notes change in engine speed, then adjusts fuel admission rate to suit. We'll learn more about this later.

Flywheels. Amount an engine accelerates when power output exceeds load depends on inertia of the flywheel and other rotating parts because surplus energy is converted to kinetic energy of these parts. When load exceeds engine output the rotating parts give up kinetic energy. In both cases the flywheel reduces the amount of speed change.

Kinetic energy of a rotating part is proportional to its inertia and to the square of its rotating speed. The heavier a flywheel and the larger its diameter, the greater will be its inertia. Therefore large flywheels absorb, in kinetic energy, a given amount of surplus power with less speed increase than small flywheels. Also, there is less speed decrease when load exceeds power output. Thus larger flywheel helps engine run at a steadier speed.

Flywheel Function. Flywheels serve two purposes: They (1) supplement governor action by preventing too much speed change during time governor is changing fuel-flow rate and cylinder start to develop needed power output (2) smooth out momentary speed changes that occur as the pistons go through their cycles of compression, expansion and exhaust. Cyclic speed variations occur because piston tends to *speed up engine during firing stroke* slow it down during compression. Second function is unrelated to governor action.

Other Governors. *Constant-speed* governor described above is intended to maintain engine at a single speed from no load to full load. Other kinds of governors do different jobs, among which are:

Variable-speed governor maintains any selected engine speed from idle to top speed. *Speed-limiting* governors control the engine at its maximum or minimum speed. One that holds an engine at its maximum safe speed is also called an *overspeed* governor. Note that a speed-limiting governor does not control speed when it is within the designed limit or limits.

An overspeed trip shuts down engine if it overspeeds. It is a safety device only.

Load-limiting governors limit the load applied to an engine at any given speed. Their purpose is to prevent overloading the engine at whatever speed it is running. *Load-control* governors control amount of load applied to the engine. Their purpose is to adjust the load to the safe power capacity of the engine at the speed it is running.

Pressure-regulating governors used on engines driving pumps maintain a constant inlet or outlet pressure on the pump. *Torque-converter* governor controls speed of output shaft of a torque converter attached to an engine when *engine runs* at less than its set speed.

Speed Governors. In governing engine speed the first step is to measure it. All governors, from simplest to the most elaborate, include an accurate speed-measuring device.

Second step in governing an engine is to transfer the indication of the speed-measuring device (when a speed change occurs) into a movement of the governor's terminal or output shaft. This shaft connects to the control rod of the fuel-injection system, regulating amount of fuel injected into the engine cylinders.

Speed Measuring. In almost all diesel- and gas-engine governors, speed is measured by a centrifugal ballhead, Fig. 1. Flyweights mounted on opposite sides of a shaft are whirled by the engine through gears. These whirling weights produce a centrifugal force opposed and balanced by the speeder ring.

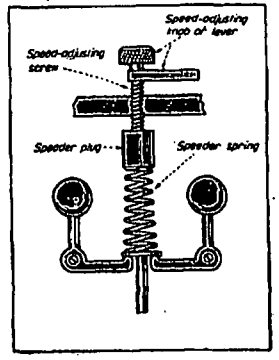
Balanced position of ballheads at normal speed is shown in Fig. 2. Note that ballarms are vertical. If engine speed increases, centrifugal force of the flyweights also increases, and they move out from their axis of rotation.

Outward movement of weights lifts the ballarm toes, increasing the opposing spring force. Since the spring is stiff compared to the centrifugal force, a balance is reached at a point where spring force equals the centrifugal force at some new position of the flyweights a little further out, Fig. 3.

Reverse action occurs if the speed falls. Flyweight centrifugal force decreases and speeder spring pushes flyweights inward until a new balance point is reached, Fig. 4. Thus, for any given speed, the flyweights assume a definite position at a certain distance from the axis of rotation.

Throttle Operation. Second step of governor action is to move engine's fuel-control mechanism. With a jerk-pump fuel-injection system, fuel-control mechanism changes pump delivery. In a common-rail type, control mechanism changes the fuel flow to the injectors. So to save words, let's use the word throttle to mean the engine's full-control mechanism, whatever its type.

Throttle Actuation. If force that moves engine throttle comes directly from the speed-measuring device, we have a *mechanical* governor. If force comes from a hydraulic pressure system controlled by the speed-measuring device, the governor is a *hydraulic or relay* type. *In* mechanical governors movement of the speeder rod itself actuates throttle linkage. In hydraulic governors, speeder rod actuates a small valve controlling a fluid under pressure; this fluid pushes on a piston or servomotor to actuate the throttle.



5 Adjustment for speeder-spring force is made with a knob or a small motor

Speed Adjustment. In most governors engine operator can adjust spring force that resists the centrifugal force of the flyweights. Fig. 5 shows a typical speed adjuster.

Upper end of speeder spring fits into a speeder plug that may be adjusted up or down by a knob or lever on governor's outside. Governors on engines in plants generating electric power often have the speed-adjusting screw operated *by a small reversible motor* controlled from the plant switchboard.

Change in speeder-spring force changes the engine's control speed by destroying the balance between ball-

(*Continued on page 218*)