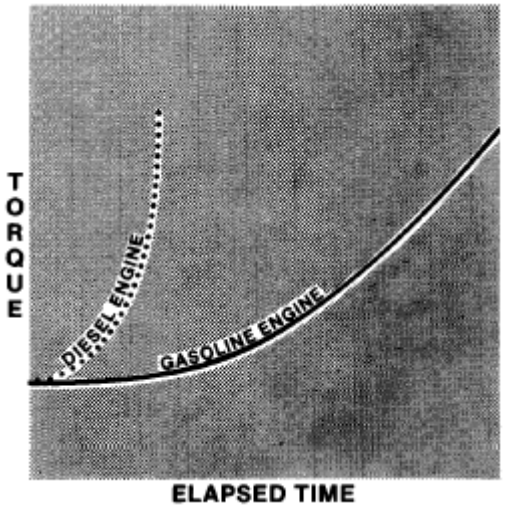
WOODWARD

Application Note 25014
(Revision C, 1/2004)

Original Instructions



Gas Engine Governing

General Precautions

Read this entire manual and all other publications pertaining to the work to be performed before installing, operating, or servicing this equipment.

Practice all plant and safety instructions and precautions.

Failure to follow instructions can cause personal injury and/or property damage.

Revisions

This publication may have been revised or updated since this copy was produced. To verify that you have the latest revision, check manual *26311* , *Revision Status & Distribution Restrictions of Woodward Technical Publications*, on the *publications page* of the Woodward website:

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Proper Use

Any unauthorized modifications to or use of this equipment outside its specified mechanical, electrical, or other operating limits may cause personal injury and/or property damage, including damage to the equipment. Any such unauthorized modifications: (i) constitute "misuse" and/or "negligence" within the meaning of the product warranty thereby excluding warranty coverage for any resulting damage, and (ii) invalidate product certifications or listings.

Translated Publications

If the cover of this publication states "Translation of the Original Instructions" please note:

The original source of this publication may have been updated since this translation was made. Be sure to check manual *26311* , *Revision Status & Distribution Restrictions of Woodward Technical Publications*, to verify whether this translation is up to date. Out-of-date translations are marked with ⚠. Always compare with the original for technical specifications and for proper and safe installation and operation procedures.

Warnings and Notices

Important Definitions

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

- **DANGER**—Indicates a hazardous situation which, if not avoided, will result in death or serious injury.
- **WARNING**—Indicates a hazardous situation which, if not avoided, could result in death or serious injury.
- **CAUTION**—Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.
- **NOTICE**—Indicates a hazard that could result in property damage only (including damage to the control).
- **IMPORTANT**—Designates an operating tip or maintenance suggestion.

⚠WARNING

Overspeed / Overtemperature / Overpressure

The engine, turbine, or other type of prime mover should be equipped with an overspeed shutdown device to protect against runaway or damage to the prime mover with possible personal injury, loss of life, or property damage.

The overspeed shutdown device must be totally independent of the prime mover control system. An overtemperature or overpressure shutdown device may also be needed for safety, as appropriate.

⚠WARNING

Personal Protective Equipment

The products described in this publication may present risks that could lead to personal injury, loss of life, or property damage. Always wear the appropriate personal protective equipment (PPE) for the job at hand. Equipment that should be considered includes but is not limited to:

- **Eye Protection**
- **Hearing Protection**
- **Hard Hat**
- **Gloves**
- **Safety Boots**
- **Respirator**

Always read the proper Material Safety Data Sheet (MSDS) for any working fluid(s) and comply with recommended safety equipment.

⚠WARNING

Start-up

Be prepared to make an emergency shutdown when starting the engine, turbine, or other type of prime mover, to protect against runaway or overspeed with possible personal injury, loss of life, or property damage.

⚠WARNING

Automotive Applications

On- and off-highway Mobile Applications: Unless Woodward's control functions as the supervisory control, customer should install a system totally independent of the prime mover control system that monitors for supervisory control of engine (and takes appropriate action if supervisory control is lost) to protect against loss of engine control with possible personal injury, loss of life, or property damage.

NOTICE

Battery Charging Device

To prevent damage to a control system that uses an alternator or battery-charging device, make sure the charging device is turned off before disconnecting the battery from the system.

Electrostatic Discharge Awareness

NOTICE

Electrostatic Precautions

Electronic controls contain static-sensitive parts. Observe the following precautions to prevent damage to these parts:

- **Discharge body static before handling the control (with power to the control turned off, contact a grounded surface and maintain contact while handling the control).**
- **Avoid all plastic, vinyl, and Styrofoam (except antistatic versions) around printed circuit boards.**
- **Do not touch the components or conductors on a printed circuit board with your hands or with conductive devices.**

To prevent damage to electronic components caused by improper handling, read and observe the precautions in Woodward manual *82715*, *Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules*.

Follow these precautions when working with or near the control.

1. Avoid the build-up of static electricity on your body by not wearing clothing made of synthetic materials. Wear cotton or cotton-blend materials as much as possible because these do not store static electric charges as much as synthetics.
2. Do not remove the printed circuit board (PCB) from the control cabinet unless absolutely necessary. If you must remove the PCB from the control cabinet, follow these precautions:
   - Do not touch any part of the PCB except the edges.
   - Do not touch the electrical conductors, the connectors, or the components with conductive devices or with your hands.
   - When replacing a PCB, keep the new PCB in the plastic antistatic protective bag it comes in until you are ready to install it. Immediately after removing the old PCB from the control cabinet, place it in the antistatic protective bag.

Gas Engine Governing

Governor control of gasoline and gas fueled engines presents problems which are not there when controlling similar diesel engines.

Diesel engines being fueled with natural gas and a diesel pilot fuel present similar control problems.

The use of a butterfly valve-manifold combination to supply fuel to the combustion cylinders of spark ignition engines means there is a lag between a new fuel setting and change in torque. The control solution to this problem is a slow, or gradual, response to speed changes with a resulting inability to provide the same degree of speed stability available from diesel engines. However, most gasoline engine applications do not require the same degree of speed stability as diesel applications.

Butterfly valves also cause control problems. In the usual diesel injector system, there is an approximate linear relationship between torque and fuel rack positions. In a gas or gasoline manifold engine, the initial butterfly valve opening effects a large change in fuel flow. A correspondingly greater movement of the butterfly valve is needed in the area of full throttle, requiring different control movement. Non-linear linkage as shown in Figure 1 can be designed to largely overcome the control problems inherent in the butterfly valve fuel control system.

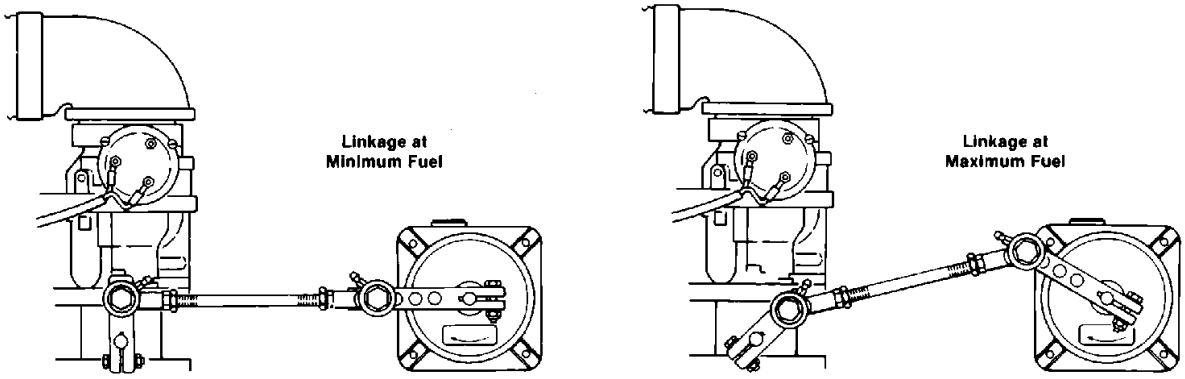

Figure 1. Butterfly Valve Non-linear Linkage Arrangement

Gasoline injection engines avoid both the manifold and butterfly valve problems and will often give the same accuracy of control that is achieved on diesel engines. Two-cycle gas engines with fuel injection require no special control treatment. Gas burning engines with individual carburetors for each cylinder also avoid many of the problems associated with more traditional designs.

Manifold Delay

In the naturally aspirated, four-cycle, gasoline engine, fuel mixture enters the manifold and is drawn into the individual cylinders on the downstroke of the piston after the exhaust cycle (Figure 2). New fuel mixtures must wait for the full cycle of the engine and for the engine to use previously charged fuel from the manifold area before they can affect the engine speed or torque. This means governor response to speed change must be heavily compensated to prevent extensive overshoot and undershoot as new fuel settings are required by load changes.

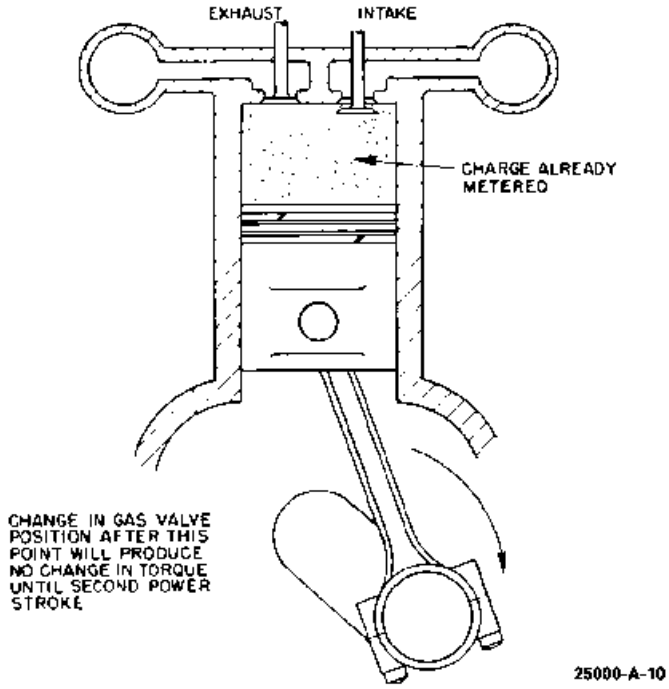

Figure 2. Power Stroke Delay

Massive Compensation

Gasoline engines may, for various reasons, tend to misfire, especially at low speeds and loads. Governors must be designed to “overlook” this occasional miss and not respond with an immediate fuel setting change.

In the usual case, a governor for a gas engine will be slower to respond to a speed change than its diesel counterpart. This does not mean the governor is made insensitive to speed changes. Rather, it requires the rate of movement in response to a speed error be made slow in comparison with a similar situation on a diesel engine.

It is important that a “dead band” not exist in the governor or in the linkage. A “dead band” will further increase the amount of damping required for stability and will, therefore, increase transients more than necessary.

Drive Characteristics

Accurate and close control of gas fired engines is further complicated by the tendency of units to provide erratic or rough drive characteristics to mechanical connections. Gas combustion tends to exert more sudden shocks to the crank shaft and to connected drive linkages than does the slower combustion of diesel fuels. These error readings are translated into “jiggle” of the governor control with corresponding wear and inaccuracy in speed setting.

“Jiggle” conditions are largely overcome in Woodward mechanical controls by the use of spring loaded ballhead drives, oil damped ballheads, and/or preloaded buffers which can accept momentary speed changes without response.

Although a certain amount of drive fluctuation is inherent in the design of gasoline and gas fueled engines, the problems can be cured, or greatly reduced, with care in the design and building of the drive to the governor.

Mechanical Controls

Woodward mechanical governors meet the problems presented by gasoline-manifold type engines in various ways. In the case of the UG-8 governor, a “chopper” type pilot-valve plunger is used in which a slot in a widened pilot-valve-plunger land connects the oil supply with the port connecting to the servo-motor only once per revolution on an indication of under speed. The overspeed land is not altered and provides usual response in this direction. The system is particularly effective in “overlooking” engine misses at low speeds (Figure 3). The system also reduces the rate of butterfly opening with resulting reductions in pre-ignition problems.

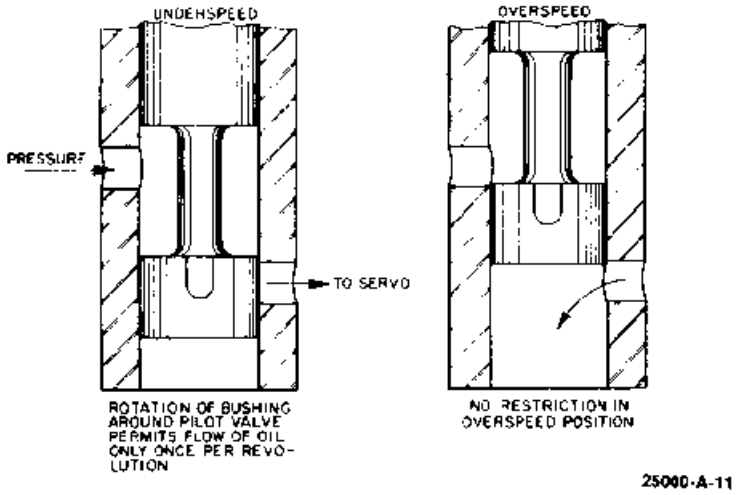

Figure 3. Chopper Pilot Valve Plunger Buffer Compensation

Buffer Compensation

The PG governor line has adjustable preloaded buffer spring seats, allowing for field adjustment to match the characteristics of the controlled engine. This buffer system can be adjusted to ignore a misfire (Figure 4).

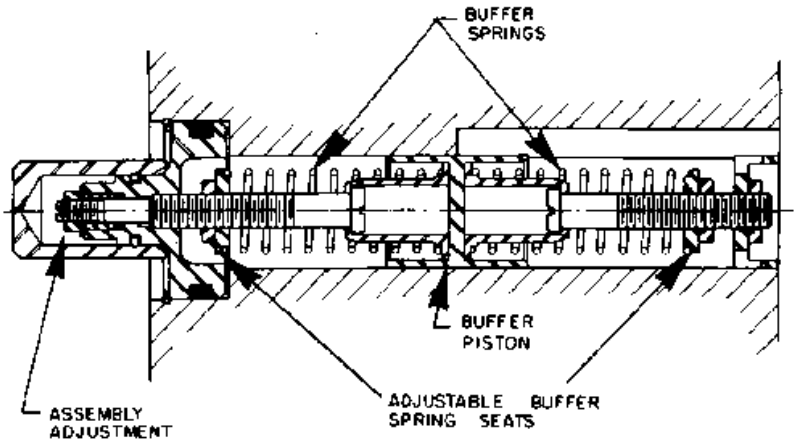

Figure 4. Adjustable Buffer Springs

The 3161 governor is also used to control gasoline and gas fueled engines. In this governor, preloaded buffer springs are matched to the engine to provide steady control and to overcome the misfire problem associated with gas or gasoline engines.

Spring Driven Ballheads

In general, all mechanical governors used on gasoline or gas fueled engines should be fitted with spring-driven ballheads. The spring connection between the drive shaft and the ballhead will provide “filtration” of undesirable torsional vibrations to the governor drive.

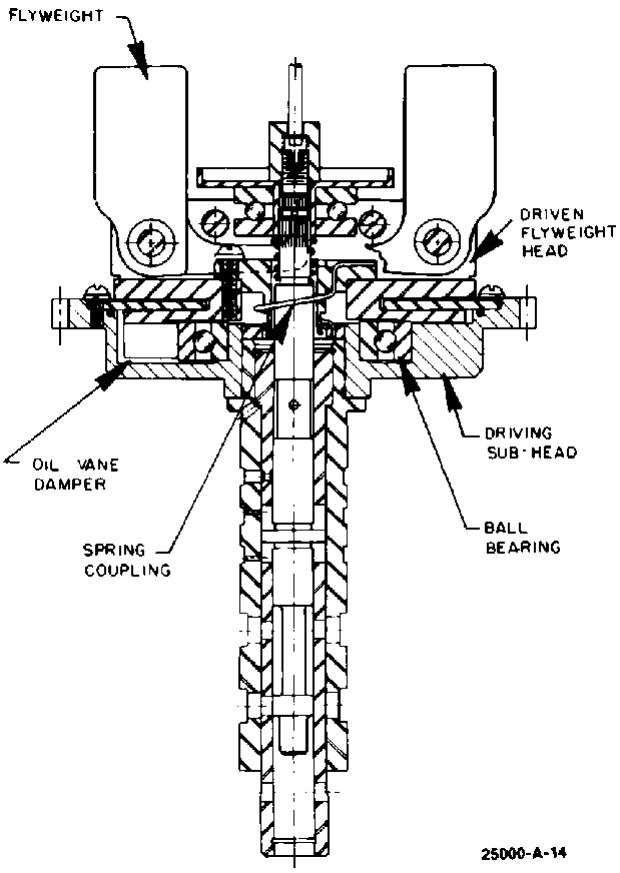

Figure 5. Spring Driven Ballhead

Electrical Governors

Woodward 2301 and 2500 electrical governors can also be applied to gasoline and gas fueled engines. Since the magnetic pickup system used by these governors is normally fitted to either the flywheel or the driven machine, many of the problems associated with missing and rough drive conditions are overcome before the governor has an indication of speed change. The governor electric circuits may be adjusted for proper compensation to overcome the lag in speed change presented by manifold fuel systems.

Woodward actuators are matched with the engine and the electronic control unit to make a governing system. Actuators with buffer systems similar to those used in mechanical governors are available for special control problems.

Control Linkage

Butterfly valve non-linearity can be largely overcome with properly designed linkage between the valve and the governor. Angular linkage from the governor will provide minimal valve movement for load or speed changes at low loads or low speeds and relatively large valve movements at high speeds or under heavy loads (see Figure 1). Another solution to the problem is to use a valve with ports contoured to give the proper area change for a given movement of the governor throughout the stroke.

Dual Fuel Control

Diesel engines burning natural gas as the primary fuel with a diesel pilot fuel can be held closer to desired speed than can most gasoline or spark controlled engines. Dual fuel engines will often require a greater mix of pilot fuel under light load conditions in order to provide the most constant and even engine speed.

We appreciate your comments about the content of our publications.

Send comments to: icinfo@woodward.com

Please reference publication 25014C.

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