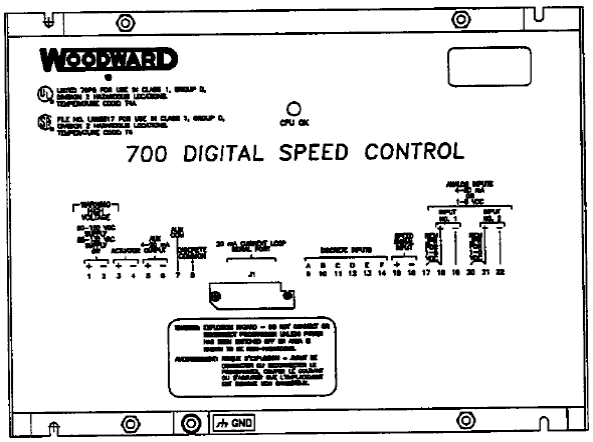
WOODWARD

Product Manual 85185
(Revision D)
Original Instructions



700 Digital Speed Control for Large Gas Reciprocating Engines

9905-110–115, 9905-248, 9905-465
Hardware revision “H” or later
(“CPU OK” LED on control cover)
UL Listed E97763, CSA Listed

Installation and Operation Manual

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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The latest version of most publications is available on the *publications page*. If your publication is not there, please contact your customer service representative to get the latest copy.

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 Out-of-date translations are marked with ⚠.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.

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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.

Regulatory Compliance

The 700 control can be installed in a Class I, Division 2, Group D hazardous location, as long as all wiring is fully enclosed in conduit. All components connected to the control (such as tachometer, actuator, etc.) must be suitable for Class I Group D Division 2 hazardous locations.

The 700 control and operator panel enclosures have knockouts for conduit connections. Figure 1-4 illustrates a typical Class I Group D Division 2 control installation.

⚠WARNING

EXPLOSION HAZARD—Do not disconnect equipment unless power has been switched off or the area is known to be non-hazardous.

Substitution of components may impair suitability for Class I, Division 2.

⚠AVERTISSEMENT

RISQUE D'EXPLOSION—Avant de déconnecter l'équipement, coupler le courant ou s'assurer que l'emplacement est désigné non dangereux.

La substitution de composants peut rendre ce matériel inacceptable pour les emplacements de Classe I, Division 2.

IMPORTANT

Installation wiring must be in accordance with Class I, Division 2 wiring methods in Article 501-4(b) of the NEC, and in accordance with the authority having jurisdiction.

Chapter 1.
General Information

Introduction

This manual describes the Woodward 700 Digital Speed Control models listed in the table on the next page. All have a “CPU OK” LED on the control cover (hardware revision “H” or later). (If your control does NOT have the “CPU OK” LED on the control cover, you should use manual 85124, which describes earlier versions of these controls.)

All models are Underwriters Laboratories (UL) and Canadian Standards Association (CSA) listed for Class I Group D Division 2 hazardous locations.

Application

The 700 Digital Speed Control controls the speed of large gas reciprocating engines in pipeline compressor service. The control includes an input for a 4 to 20 mA remote speed reference setting, an internal speed reference for local control of speed.

The 700 system for a gas compressor engine includes:
- a 700 Digital Speed Control
- an external power source
- a speed-sensing device
- an operator control
- a proportional actuator to position the gas valve
- a terminal for adjusting control parameters

The 700 control (Figure 1-1) consists of a single printed circuit board in a sheet-metal chassis. Connections are via two terminal strips and a 9-pin subminiature D connector.

Control Options

The 700 control provides the following power supply input voltages, with 8 W as the nominal power consumption at rated voltage:
- 18–40 Vdc (24 or 32 Vdc nominal)
- 88–132 Vac 50/60 Hz (120 Vac nominal)
- 90–150 Vdc (125 Vdc nominal)

Actuator output current ranges are:
- 4–20 mA for most pneumatic actuators
- 0–200 mA for Woodward pneumatic or electric-hydraulic actuators

Discrete input voltages provide on/off command signals to the electronic control, such as Raise Speed, Lower Speed, etc. Each discrete input requires 10 mA at its nominal voltage rating:

- 24 Vdc where 24 volts is used for switching logic;
- 5 Vdc for "word" interface with computers (this allows the same hardware used to drive operator panel lamps to be used for operating the control);
- Internal auxiliary voltage provided on the control for use on high-voltage versions of the 700 control in systems where 5 or 24 Vdc switching logic voltage is unavailable (dry contact switches or relays must be used).

Other available options are:

- Proximity switch input for speed signal frequencies below 100 Hz
- Other voltage or current ratings on the analog inputs

These models of the 700 Digital Speed Control are available with the following option combinations. The part number is stamped on the identification tag on the front of the control. The control speed operating range is 8 to 2100 rpm.

Part Number	Speed Input	Power Supply Voltage	Actuator Current	Discrete Input Voltage
9905-110	Mag. Pickup	Low	4–20 mA	24 Vdc
9905-111	Mag. Pickup	Low	0–200 mA	24 Vdc
9905-112	Mag. Pickup	High	4–20 mA	5 Vdc
9905-113	Mag. Pickup	High	0–200 mA	5 Vdc
9905-114	Mag. Pickup	High	4–20 mA	AUX
9905-115	Mag. Pickup	High	0–200 mA	AUX
9905-248	Prox. Switch	High	4–20 mA	AUX
9905-465*	Mag. Pickup	High	0–200 mA	AUX

***—**9905-465 has a rack limiter

700 Digital Speed Control Accessories

Set Point Programmer (Figure 1-2), part number 8280-107, is used for adjusting the 700 control. It plugs into the serial port of the control.

700 Operator Control Panel (Figure 1-3), part number 8280-106, is an operator control designed specifically for use with the 700 Digital Speed Control. Switch contacts are enclosed in hermetically sealed chambers and are Underwriters Laboratories (UL) and Canadian Standards Association (CSA) listed for service in Class I Group D Division 2 installations. The switches are contained in a NEMA Type 13 (oil-tight) enclosure.

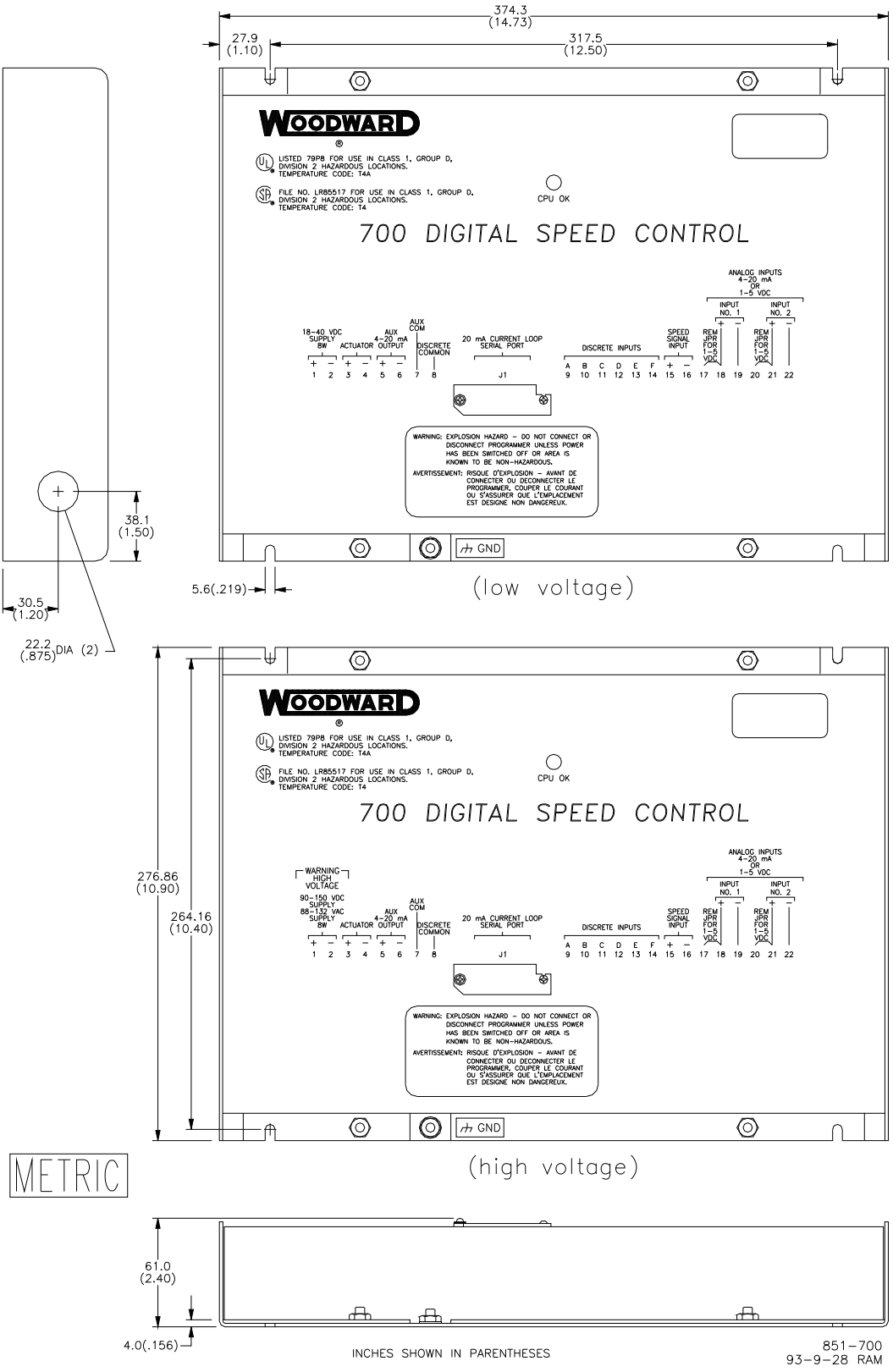


Figure 1-1. 700 Digital Speed Control

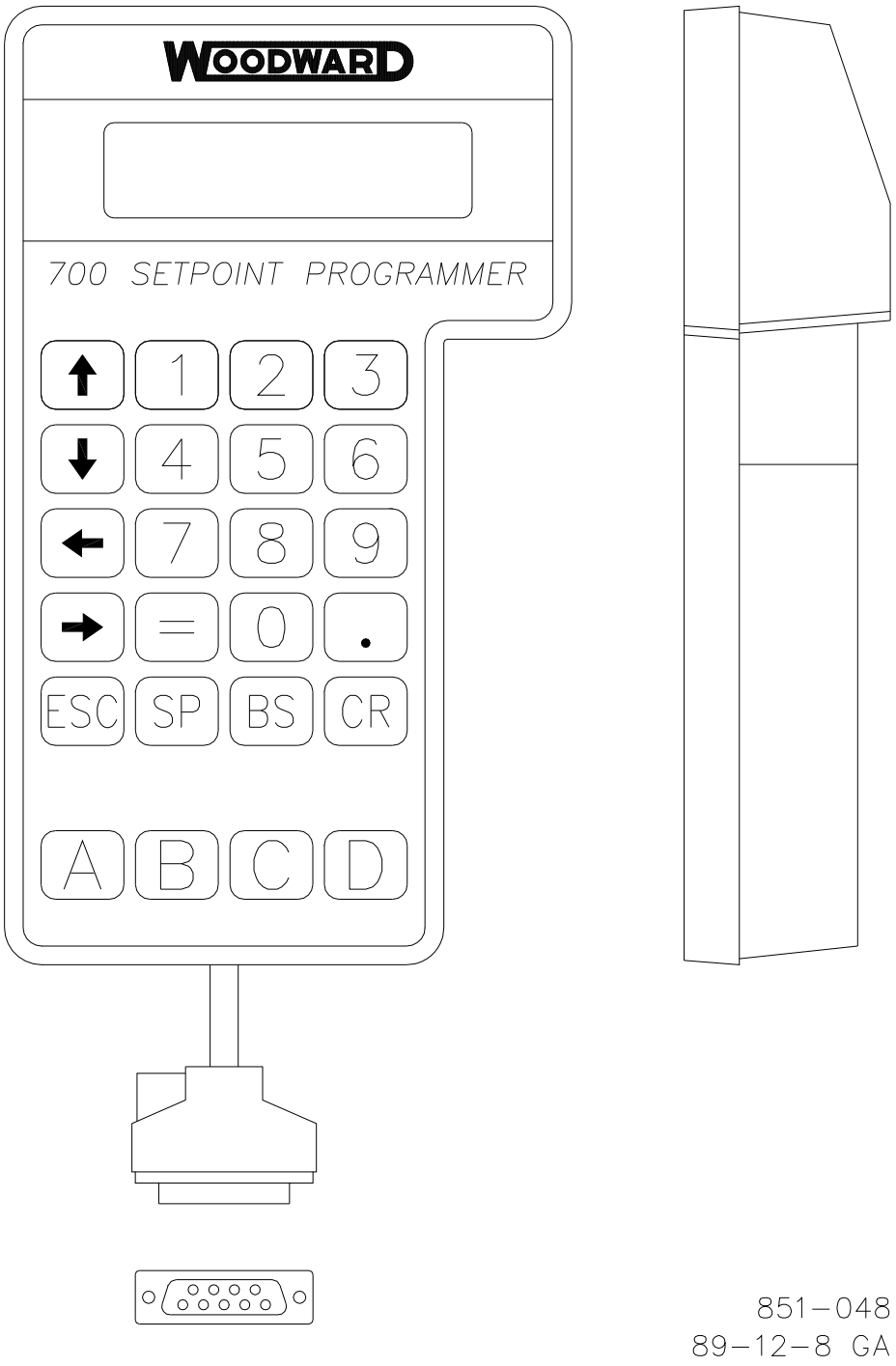


Figure 1-2. Set Point Programmer

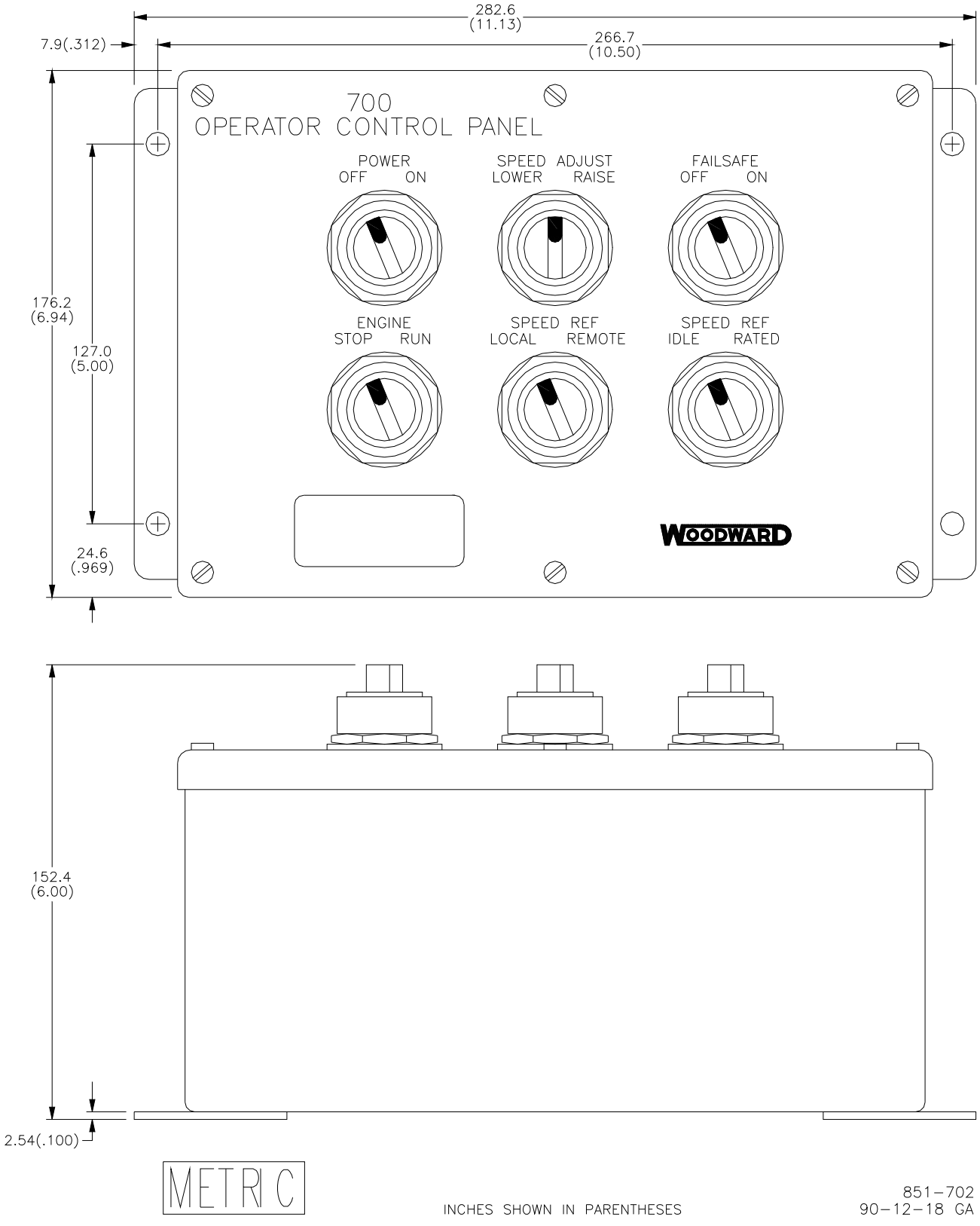


Figure 1-3. 700 Operator Control Panel

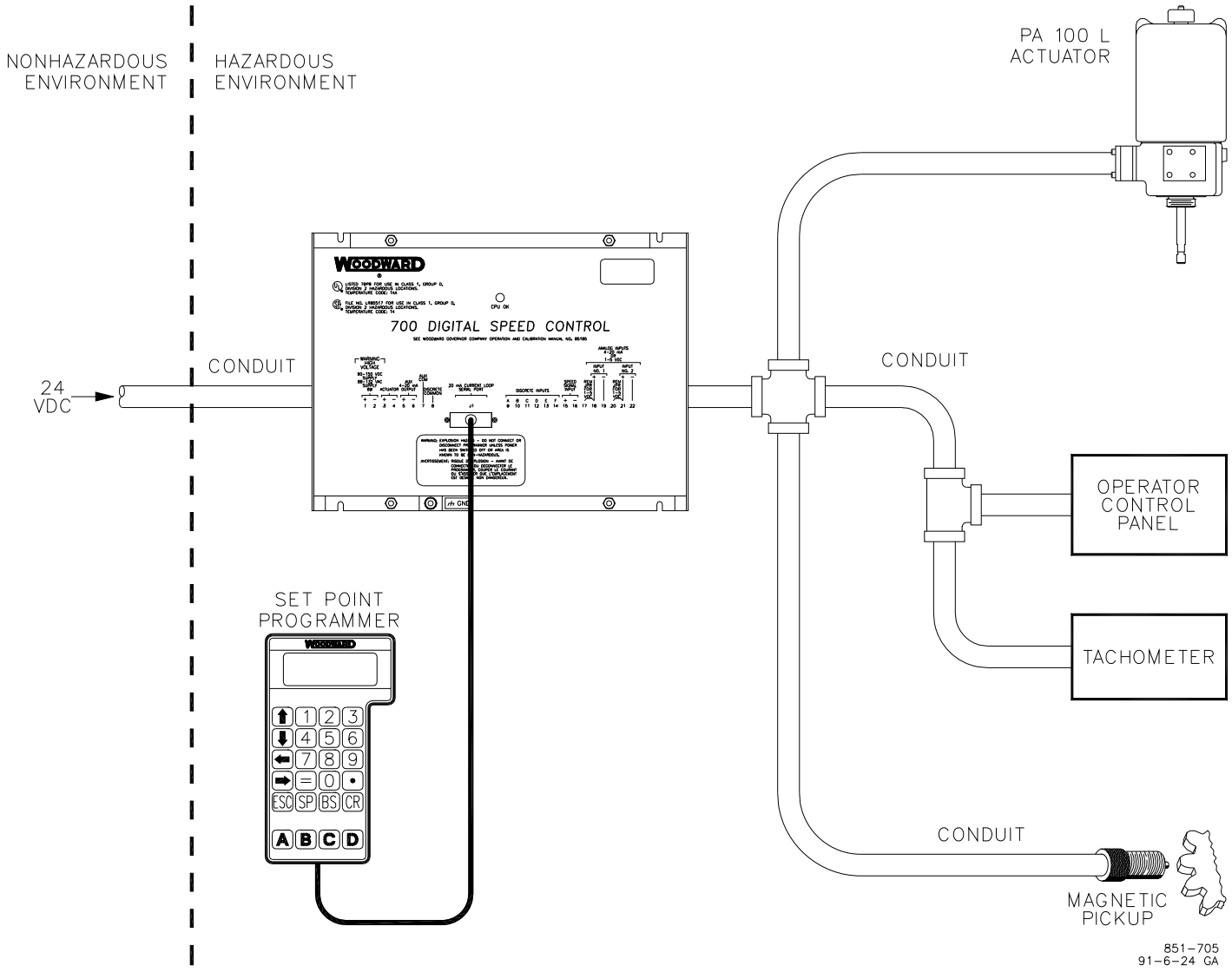
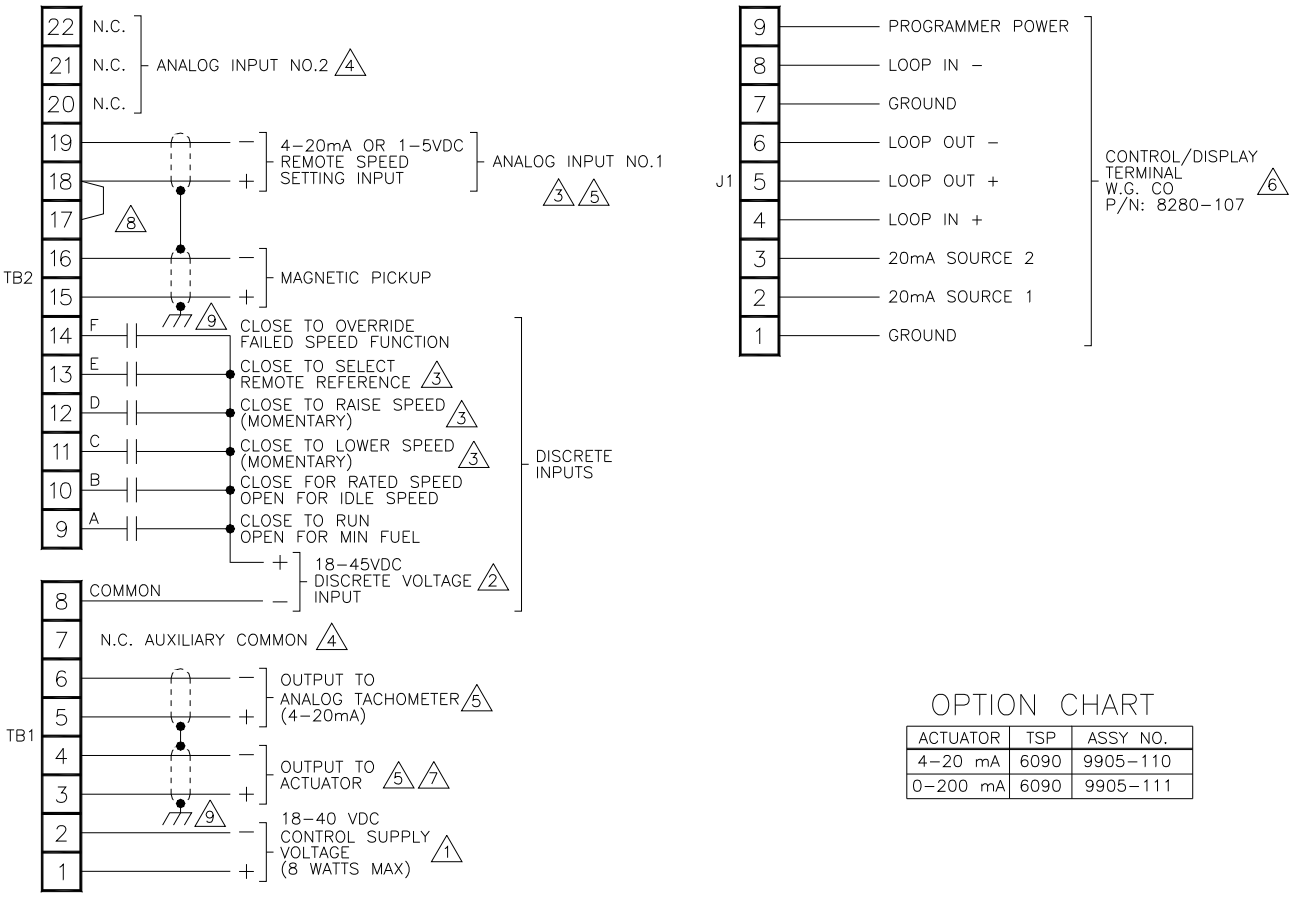


Figure 1-4. Typical Class I, Division 2, Group D Installation



OPTION CHART

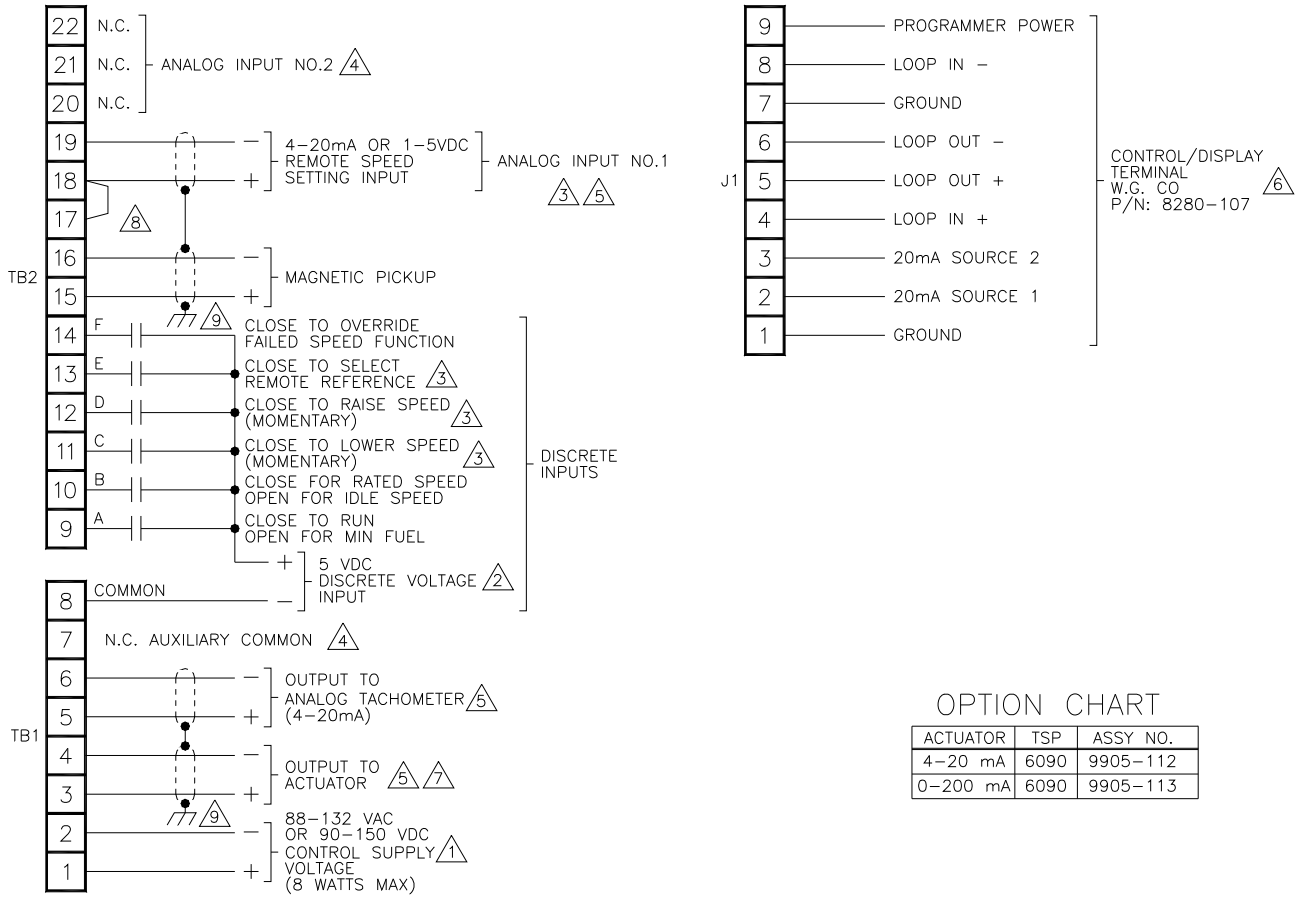
ACTUATOR	TSP	ASSY NO.
4–20 mA	6090	9905–110
0–200 mA	6090	9905–111

NOTES:

1. INTERNAL POWER SUPPLY PROVIDES DC ISOLATION BETWEEN THE POWER SOURCE AND ALL OTHER INPUTS AND OUTPUTS.
2. DISCRETE INPUTS ARE OPTICALLY ISOLATED FROM OTHER CIRCUITS. INPUT CURRENT IS NOMINALLY 10 MILLIAMPS PER INPUT INTO 2100 OHMS.
3. WHEN REMOTE REFERENCE IS SELECTED (DISCRETE INPUT "E" HAS VOLTAGE APPLIED), THE RAISE AND LOWER SPEED INPUTS ARE DISABLED. THE SPEED REFERENCE SETTING IS BASED ON THE VALUE OF CURRENT IN THE REMOTE SPEED REFERENCE INPUT. WHEN REMOTE REFERENCE IS NOT SELECTED (DISCRETE INPUT "E" IS OPEN), THE RAISE AND LOWER SPEED INPUTS ARE ENABLED.
4. DO NOT MAKE CONNECTIONS TO TERMINALS MARKED N.C.
5. WHILE THE CONTROL CIRCUITS ARE ISOLATED FROM THE POWER SOURCE, ANALOG INPUTS AND OUTPUTS ARE NOT ISOLATED FROM EACH OTHER. IF THE 4–20 mA REMOTE SPEED SETTING INPUT IS BEING USED, THE ACTUATOR OUTPUT AND TACHOMETER OUTPUT MUST NOT BE INPUT TO CIRCUITS WITH A COMMON GROUND TO THE 4–20 mA REMOTE SPEED SIGNAL. 20 mA CURRENT LOOP ISOLATORS ARE AVAILABLE FROM A NUMBER OF MANUFACTURERS. CONTACT WOODWARD GOVERNOR COMPANY FOR FURTHER INFORMATION.
6. THE 20mA CURRENT LOOP SERIAL PORT IS SET UP TO INTERFACE WITH THE WOODWARD GOVERNOR CO. P/N 8280–107 CONTROL/ DISPLAY TERMINAL. THIS PORT IS COMPATIBLE WITH OTHER TERMINALS SUPPORTING 20MA CURRENT LOOP. INFORMATION ON UTILIZING OTHER DEVICES ON THE SERIAL PORT IS CONTAINED IN THE USERS MANUAL.
7. SEE OPTION CHART.
8. REMOVE JUMPER FOR 1–5 VDC INPUT.
9. SHIELDED WIRES TO BE TWISTED PAIRS WITH SHIELD GROUNDED AT ONE END ONLY. WHEN MOUNTING CONTROL TO BULKHEAD, USE EXTERNAL TOOTH LOCK WASHER UNDER ONE SCREWHEAD TO ENSURE PROPER GROUNDING. A GROUND STUD IS PROVIDED ON THE CHASSIS.

851–725
93–9–30 RAM

Figure 1-5a. Plant Wiring Diagram (9905-110, -111)



OPTION CHART

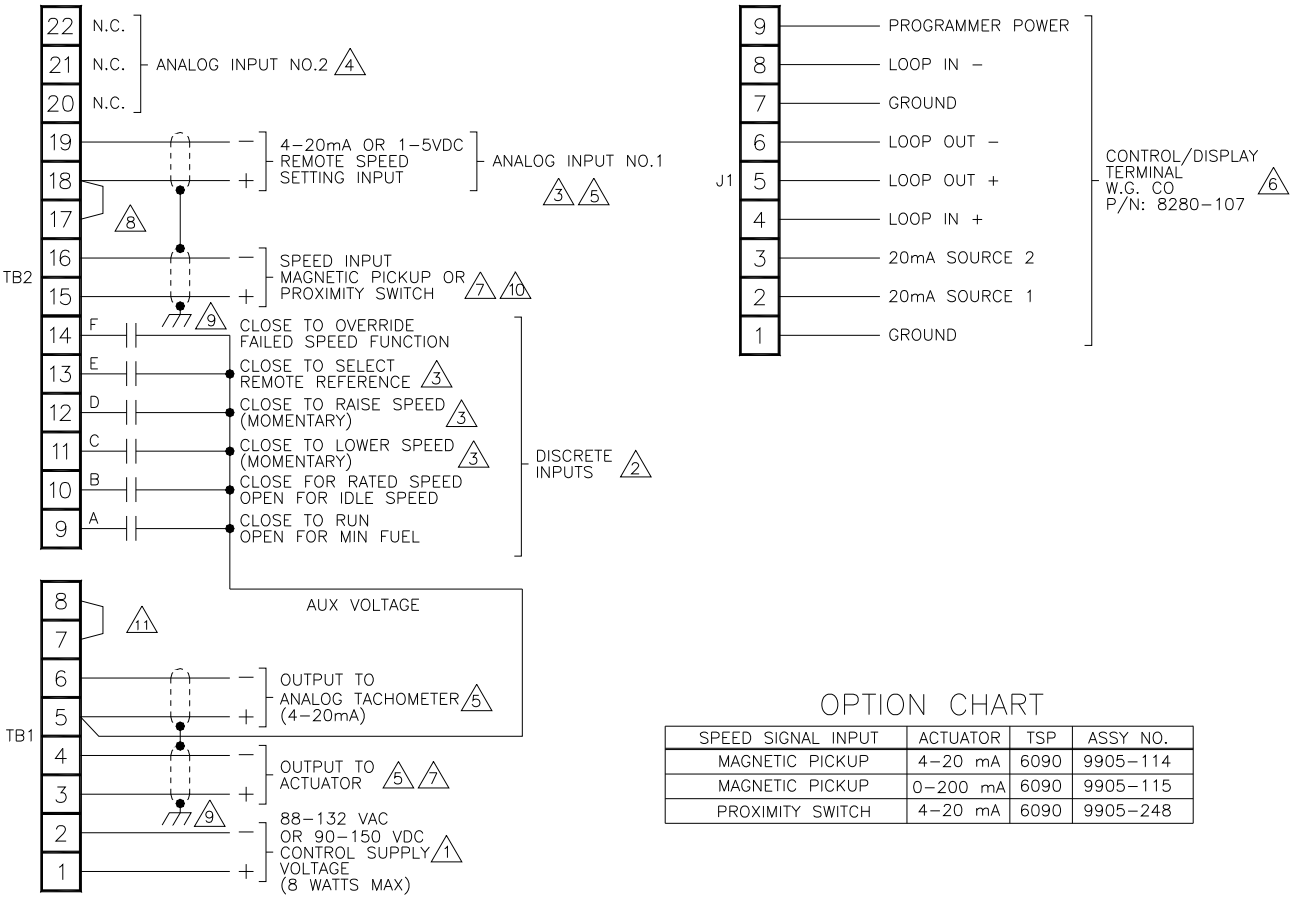
ACTUATOR	TSP	ASSY NO.
4–20 mA	6090	9905–112
0–200 mA	6090	9905–113

NOTES:

1. INTERNAL POWER SUPPLY PROVIDES DC ISOLATION BETWEEN THE POWER SOURCE AND ALL OTHER INPUTS AND OUTPUTS.
2. DISCRETE INPUTS ARE OPTICALLY ISOLATED FROM OTHER CIRCUITS. INPUT CURRENT IS NOMINALLY 10 MILLIAMPS PER INPUT INTO 2100 OHMS.
3. WHEN REMOTE REFERENCE IS SELECTED (DISCRETE INPUT "E" HAS VOLTAGE APPLIED), THE RAISE AND LOWER SPEED INPUTS ARE DISABLED. THE SPEED REFERENCE SETTING IS BASED ON THE VALUE OF CURRENT IN THE REMOTE SPEED REFERENCE INPUT. WHEN REMOTE REFERENCE IS NOT SELECTED (DISCRETE INPUT "E" IS OPEN), THE RAISE AND LOWER SPEED INPUTS ARE ENABLED.
4. DO NOT MAKE CONNECTIONS TO TERMINALS MARKED N.C.
5. WHILE THE CONTROL CIRCUITS ARE ISOLATED FROM THE POWER SOURCE, ANALOG INPUTS AND OUTPUTS ARE NOT ISOLATED FROM EACH OTHER. IF THE 4–20 mA REMOTE SPEED SETTING INPUT IS BEING USED, THE ACTUATOR OUTPUT AND TACHOMETER OUTPUT MUST NOT BE INPUT TO CIRCUITS WITH A COMMON GROUND TO THE 4–20 mA REMOTE SPEED SIGNAL. 20 mA CURRENT LOOP ISOLATORS ARE AVAILABLE FROM A NUMBER OF MANUFACTURERS. CONTACT WOODWARD GOVERNOR COMPANY FOR FURTHER INFORMATION.
6. THE 20mA CURRENT LOOP SERIAL PORT IS SET UP TO INTERFACE WITH THE WOODWARD GOVERNOR CO. P/N 8280–107 CONTROL/ DISPLAY TERMINAL. THIS PORT IS COMPATIBLE WITH OTHER TERMINALS SUPPORTING 20MA CURRENT LOOP. INFORMATION ON UTILIZING OTHER DEVICES ON THE SERIAL PORT IS CONTAINED IN THE USERS MANUAL.
7. SEE OPTION CHART.
8. REMOVE JUMPER FOR 1–5 VDC INPUT.
9. SHIELDED WIRES TO BE TWISTED PAIRS WITH SHIELD GROUNDED AT ONE END ONLY. WHEN MOUNTING CONTROL TO BULKHEAD, USE EXTERNAL TOOTH LOCK WASHER UNDER ONE SCREWHEAD TO ENSURE PROPER GROUNDING. A GROUND STUD IS PROVIDED ON THE CHASSIS.

851–726
93–9–30 RAM

Figure 1-5b. Plant Wiring Diagram (9905-112, -113)



OPTION CHART

SPEED SIGNAL INPUT	ACTUATOR	TSP	ASSY NO.
MAGNETIC PICKUP	4–20 mA	6090	9905–114
MAGNETIC PICKUP	0–200 mA	6090	9905–115
PROXIMITY SWITCH	4–20 mA	6090	9905–248

NOTES:

1. INTERNAL POWER SUPPLY PROVIDES DC ISOLATION BETWEEN THE POWER SOURCE AND ALL OTHER INPUTS AND OUTPUTS.
2. DISCRETE INPUTS ARE OPTICALLY ISOLATED FROM OTHER CIRCUITS. INPUT CURRENT IS NOMINALLY 10 MILLIAMPS PER INPUT INTO 2100 OHMS.
3. WHEN REMOTE REFERENCE IS SELECTED (DISCRETE INPUT "E" HAS VOLTAGE APPLIED), THE RAISE AND LOWER SPEED INPUTS ARE DISABLED. THE SPEED REFERENCE SETTING IS BASED ON THE VALUE OF CURRENT IN THE REMOTE SPEED REFERENCE INPUT. WHEN REMOTE REFERENCE IS NOT SELECTED (DISCRETE INPUT "E" IS OPEN), THE RAISE AND LOWER SPEED INPUTS ARE ENABLED.
4. DO NOT MAKE CONNECTIONS TO TERMINALS MARKED N.C.
5. WHILE THE CONTROL CIRCUITS ARE ISOLATED FROM THE POWER SOURCE, ANALOG INPUTS AND OUTPUTS ARE NOT ISOLATED FROM EACH OTHER. IF THE 4–20 mA REMOTE SPEED SETTING INPUT IS BEING USED, THE ACTUATOR OUTPUT AND TACHOMETER OUTPUT MUST NOT BE INPUT TO CIRCUITS WITH A COMMON GROUND TO THE 4–20 mA REMOTE SPEED SIGNAL. 20 mA CURRENT LOOP ISOLATORS ARE AVAILABLE FROM A NUMBER OF MANUFACTURERS. CONTACT WOODWARD GOVERNOR COMPANY FOR FURTHER INFORMATION.
6. THE 20mA CURRENT LOOP SERIAL PORT IS SET UP TO INTERFACE WITH THE WOODWARD GOVERNOR CO. P/N 8280–107 CONTROL/ DISPLAY TERMINAL. THIS PORT IS COMPATIBLE WITH OTHER TERMINALS SUPPORTING 20MA CURRENT LOOP. INFORMATION ON UTILIZING OTHER DEVICES ON THE SERIAL PORT IS CONTAINED IN THE USERS MANUAL.
7. SEE OPTION CHART.
8. REMOVE JUMPER FOR 1–5 VDC INPUT.
9. SHIELDED WIRES TO BE TWISTED PAIRS WITH SHIELD GROUNDED AT ONE END ONLY. WHEN MOUNTING CONTROL TO BULKHEAD, USE EXTERNAL TOOTH LOCK WASHER UNDER ONE SCREWHEAD TO ENSURE PROPER GROUNDING. A GROUND STUD IS PROVIDED ON THE CHASSIS.
10. POWER FOR A PROXIMITY SWITCH MAY BE OBTAINED FROM TERMINALS 5(+) AND 7(–). THE SWITCH MUST BE SUITABLE FOR +21V POWER. THE PROXIMITY SWITCH MUST NOT DRAW MORE THAN 190 mA.
11. JUMPER TERMINALS 7 AND 8 TO TIE AUX COMMON TO DISCRETE COMMON.

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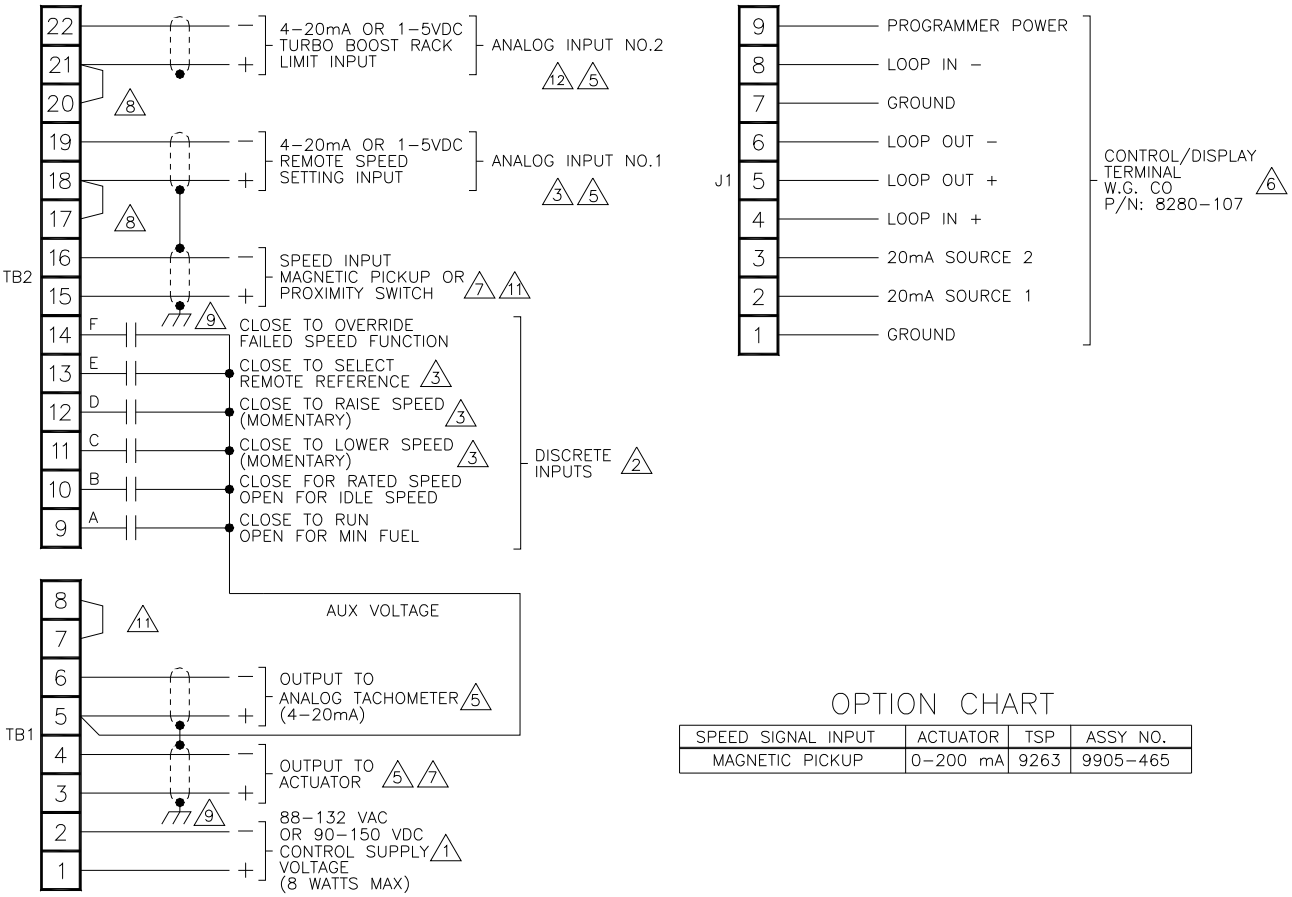
93–9–30 RAM

Figure 1-5c. Plant Wiring Diagram (9905-114, -115, -248)



OPTION CHART

SPEED SIGNAL INPUT	ACTUATOR	TSP	ASSY NO.
MAGNETIC PICKUP	0–200 mA	9263	9905–465

NOTES:

1. INTERNAL POWER SUPPLY PROVIDES DC ISOLATION BETWEEN THE POWER SOURCE AND ALL OTHER INPUTS AND OUTPUTS.
2. DISCRETE INPUTS ARE OPTICALLY ISOLATED FROM OTHER CIRCUITS. INPUT CURRENT IS NOMINALLY 10 MILLIAMPS PER INPUT INTO 2100 OHMS.
3. WHEN REMOTE REFERENCE IS SELECTED (DISCRETE INPUT "E" HAS VOLTAGE APPLIED), THE RAISE AND LOWER SPEED INPUTS ARE DISABLED. THE SPEED REFERENCE SETTING IS BASED ON THE VALUE OF CURRENT IN THE REMOTE SPEED REFERENCE INPUT. WHEN REMOTE REFERENCE IS NOT SELECTED (DISCRETE INPUT "E" IS OPEN), THE RAISE AND LOWER SPEED INPUTS ARE ENABLED.
4. DO NOT MAKE CONNECTIONS TO TERMINALS MARKED N.C.
5. WHILE THE CONTROL CIRCUITS ARE ISOLATED FROM THE POWER SOURCE, ANALOG INPUTS AND OUTPUTS ARE NOT ISOLATED FROM EACH OTHER. IF THE 4–20 mA REMOTE SPEED SETTING OR RACK LIMIT INPUTS ARE BEING USED, THE ACTUATOR OUTPUT AND TACHOMETER OUTPUT MUST NOT BE INPUT TO CIRCUITS WITH A COMMON GROUND TO THE 4–20 mA REMOTE SPEED SIGNAL OR RACK LIMIT SIGNALS. 20 mA CURRENT LOOP ISOLATORS ARE AVAILABLE FROM A NUMBER OF MANUFACTURERS. CONTACT WOODWARD GOVERNOR COMPANY FOR FURTHER INFORMATION.
6. THE 20mA CURRENT LOOP SERIAL PORT IS SET UP TO INTERFACE WITH THE WOODWARD GOVERNOR CO. P/N 8280–107 CONTROL/ DISPLAY TERMINAL. THIS PORT IS COMPATIBLE WITH OTHER TERMINALS SUPPORTING 20mA CURRENT LOOP. INFORMATION ON UTILIZING OTHER DEVICES ON THE SERIAL PORT IS CONTAINED IN THE USERS MANUAL.
7. SEE OPTION CHART.
8. REMOVE JUMPER FOR 1–5 VDC INPUT.
9. SHIELDED WIRES TO BE TWISTED PAIRS WITH SHIELD GROUNDED AT ONE END ONLY. WHEN MOUNTING CONTROL TO BULKHEAD, USE EXTERNAL TOOTH LOCK WASHER UNDER ONE SCREWHEAD TO ENSURE PROPER GROUNDING. A GROUND STUD IS PROVIDED ON THE CHASSIS.
10. POWER FOR A PROXIMITY SWITCH MAY BE OBTAINED FROM TERMINALS 5(+) AND 7(–). THE SWITCH MUST BE SUITABLE FOR +21V POWER. THE PROXIMITY SWITCH MUST NOT DRAW MORE THAN 190 mA.
11. JUMPER TERMINALS 7 AND 8 TO TIE AUX COMMON TO DISCRETE COMMON.
12. INPUT NO. 2 ONLY ACTIVE ON 9905–465 CONTROL.

851–723
93–9–30 RAM

Figure 1-5d. Plant Wiring Diagram (9905-465)

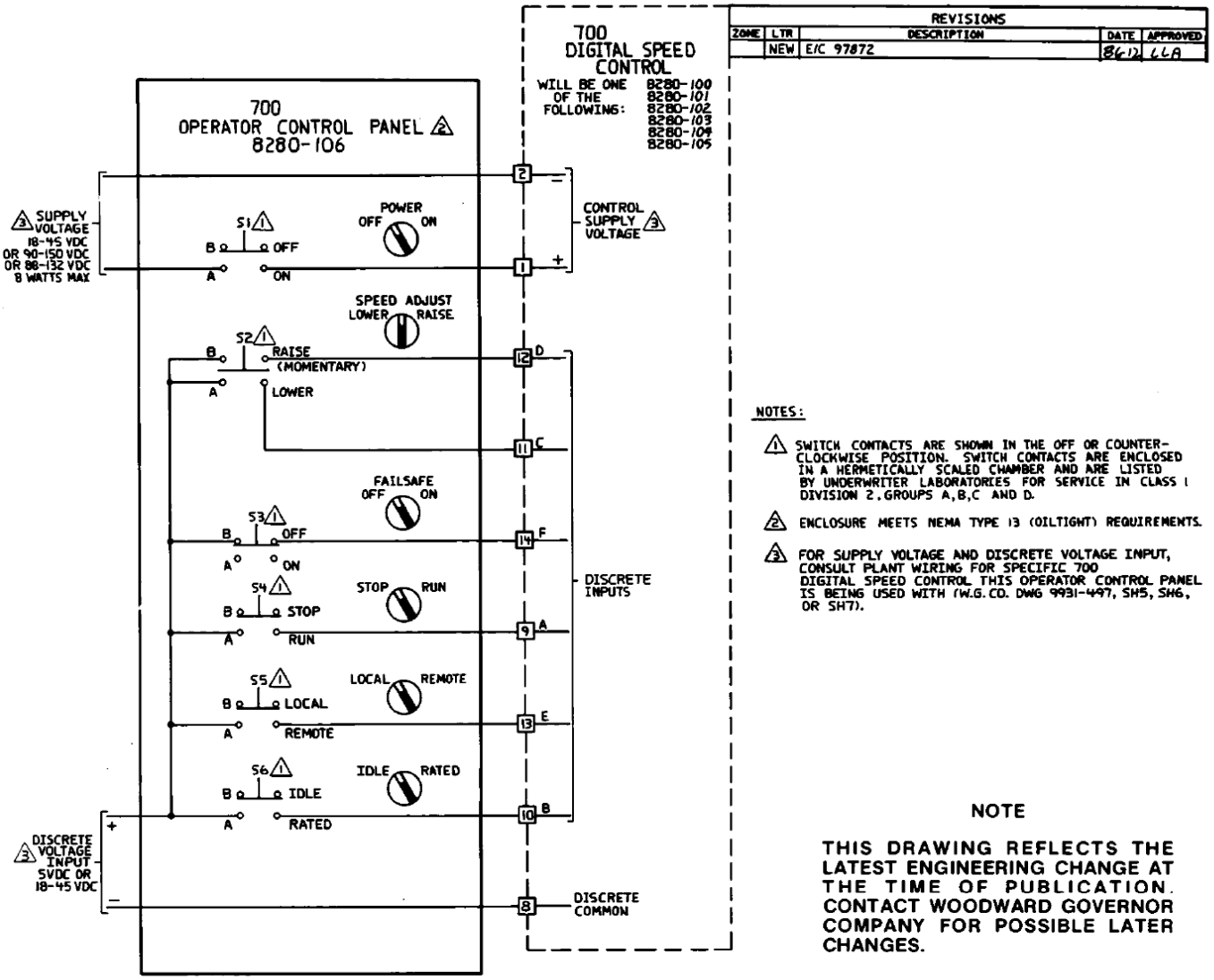


Figure 1-6. Operator Control Panel Plant Wiring Diagram

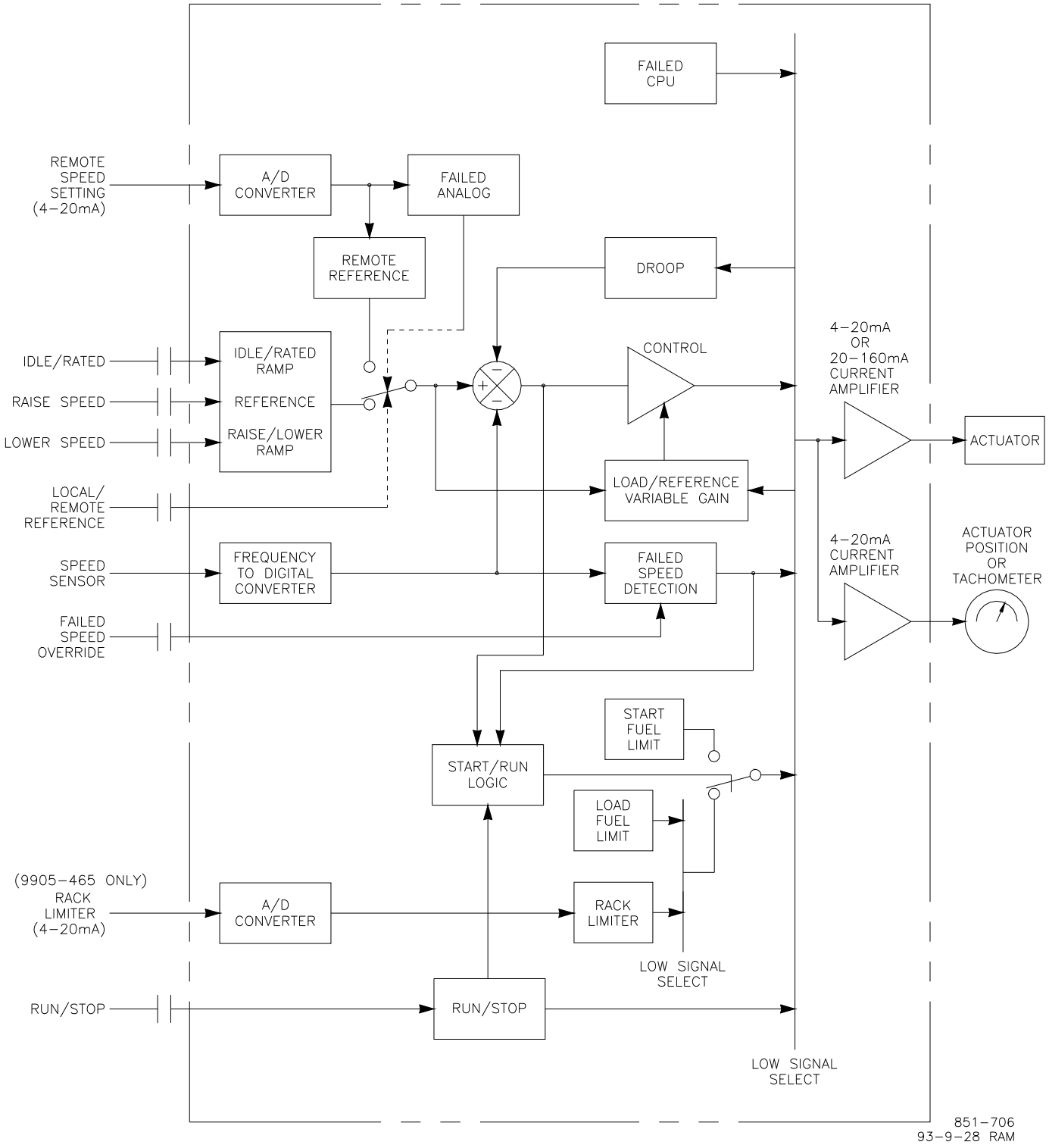


Figure 1-7. Block Diagram

Chapter 2. Installation

Scope

This chapter contains general installation instructions for the 700 control. Power requirements, environmental precautions, and location considerations are included to help you determine the best location for the control. Additional information includes unpacking instructions, electrical connections, and installation checkout procedures.

Unpacking

Before handling the control, read page iv, Electrostatic Discharge Awareness. Be careful when unpacking the electronic control. Check the control for signs of damage such as bent panels, scratches, and loose or broken parts. If any damage is found, immediately notify the shipper.

Power Requirements

The high-voltage versions of the 700 Digital Speed Control require a voltage source of 88 to 132 Vac 45 to 65 Hz or 90 to 150 Vdc. The low-voltage versions require a voltage source of 20 to 40 Vdc.

NOTICE **To prevent damage to the control, do not exceed the input voltage range.**

IMPORTANT **If a battery is used for operating power, an alternator or other battery-charging device is necessary to maintain a stable supply voltage.**

NOTICE **To prevent damage to the control, make sure that the alternator or other battery-charging device is turned off or disconnected before disconnecting the battery from the control.**

Location Considerations

Consider these requirements when selecting the mounting location:

- Adequate ventilation for cooling
- Space for servicing and repair
- Protection from direct exposure to water or to a condensation-prone environment
- Protection from high-voltage or high-current devices, or devices which produce electromagnetic interference
- Avoidance of vibration
- Selection of a location that will provide an operating temperature range of –40 to +70 °C (–40 to +158 °F)

The control must NOT be mounted on the engine.

Electrical Connections

External wiring connections and shielding requirements for a typical control installation are shown in the plant wiring diagrams (Figure 1-5). Use the appropriate plant wiring diagram for your control part number. The plant wiring connections are explained in the rest of this chapter.

Shielded Wiring

All shielded cable must be twisted conductor pairs. Do not attempt to tin the braided shield. All signal lines should be shielded to prevent picking up stray signals from adjacent equipment. Connect the shields to the nearest chassis ground. Wire exposed beyond the shield should be as short as possible, not exceeding 50 mm (2 inches). The other end of the shields must be left open and insulated from any other conductor. DO NOT run shielded signal wires along with other wires carrying large currents. See Woodward application note 50532, *EMI Control for Electronic Governing Systems* for more information.

Where shielded cable is required, cut the cable to the desired length and prepare the cable as instructed below.

1. Strip outer insulation from BOTH ENDS, exposing the braided or spiral wrapped shield. DO NOT CUT THE SHIELD.
2. Using a sharp, pointed tool, carefully spread the strands of the shield.
3. Pull inner conductor(s) out of the shield. If the shield is the braided type, twist it to prevent fraying.
4. Remove 6 mm (1/4 inch) of insulation from the inner conductors.

Installations with severe electromagnetic interference (EMI) may require additional shielding precautions. Contact Woodward for more information.

Power Supply

Power supply output must be low impedance (for example, directly from batteries). DO NOT power low-voltage versions of the control from high-voltage sources with resistors and zener diodes in series with the control power input. The 700 control contains a switching power supply which requires a current surge to start properly.

NOTICE **To prevent damage to the control, do not power low-voltage versions of the control from high-voltage sources.**

Run the power leads directly from the power source to the control. DO NOT POWER OTHER DEVICES WITH LEADS COMMON TO THE CONTROL. Avoid long wire lengths. Connect the positive (line) to terminal 1 and negative (common) to terminal 2. If the power source is a battery, be sure the system includes an alternator or other battery-charging device. This wiring must be fully enclosed in conduit to meet Class I, Division, Group D requirements.
If possible, do NOT turn off control power as part of a normal shutdown procedure. Use the Minimum Fuel discrete input (terminal 9) for normal shutdown. Leave the control powered except for service of the system and extended periods of disuse.

NOTICE

Do NOT apply power to the control at this time. Applying power may damage the control.

NOTICE

To prevent damage to the engine, apply power to the 700 control at least ten seconds prior to starting the engine. The control must have time to do its power up diagnostics and become operational. Do not start the engine if the diagnostic tests fail, because test failure turns off the output of the control.

Actuator Output

The actuator wires connect to terminals 3(+) and 4(–). Use shielded wires with the shield connected to chassis at the control. This wiring must be fully enclosed in conduit to meet Class I, Division 2, Group D requirements.

IMPORTANT

For installation on an engine currently in service with a mechanical actuator, the following will make setting the Start Fuel Limit easier (the procedure is covered in Chapter 4, Initial Adjustments). Start the engine. Measure and record the fuel valve position at no load. The objective will be to position the valve at this position with the new pneumatic actuator and 700 control prior to initial start-up with the newly installed system.

Aux Output

The tachometer or actuator position readout wires connect to terminals 5(+) and 6(–). Use shielded twisted-pair wires. For an electrically isolated input device such as a 4 to 20 mA input analog meter, the shield should be grounded at the control end of the cable. For input to other devices, use the recommendation of the device manufacturer. This wiring must be fully enclosed in conduit to meet Class I Group D Division 2 requirements.

NOTICE

To prevent possible damage to the control or poor control performance resulting from ground loop problems, follow these instructions. The control common is electrically isolated from the power supply input; however, the actuator and tachometer outputs are current sources and have a common mode voltage on them with respect to the control's internal common (terminal 7—Aux Common). The analog inputs to the control use this same common. Connecting the actuator or tachometer outputs to external circuits that are not isolated from the remote speed setting 4 to 20 mA current source will create ground loop problems. We recommend using current-loop isolators if the 700 control's analog inputs and outputs must both be used with non-isolated devices. A number of manufacturers offer 20 mA loop isolators. Consult Woodward for further information.

Discrete Inputs

Discrete inputs are the switch input commands to the 700 control. Figure 1-6 shows the plant wiring diagram for the 8280-106 Operator Control Panel and is typical of the way the control should be wired.

There are several ways these inputs may be powered depending on the version of the control. Low-voltage versions use the same voltage as the power supply. High-voltage versions may use 5 Vdc, 24 Vdc, or the aux voltage generated by the control. Verify that you are using the appropriate wiring diagram and that the voltage rating of the discrete inputs corresponds with the voltage of your switchgear.

If you are using a control-supplied aux voltage, jumper terminal 7 to terminal 8. This connects the control's common to the discrete input common. Terminal 5 then supplies power (approximately +21 Vdc) to the discrete inputs. Since the aux voltage is not isolated from other control circuits, use only isolated contacts (dry or signal voltage rated) for the discrete circuits. DO NOT POWER ANY OTHER DEVICES WITH THE AUX VOLTAGE SOURCE.

If you are supplying the discrete input voltage (5 Vdc or 24 Vdc), connect the voltage source negative (–) to terminal 8. Then run the voltage source positive (+) to the appropriate switch or relay contact and then to the corresponding discrete input.

Minimum Fuel Contact

The minimum-fuel contact is the preferred means for a normal shutdown of the engine. It connects to terminal 9, Discrete Input A, of the control. The control will not operate without voltage applied to terminal 9. When the contact is closed, the voltage applied to terminal 9 allows the control to move the actuator to any position required for operating conditions.

⚠WARNING

The minimum-fuel contact is not intended for use in any emergency stop sequence. To prevent possible serious injury from an overspeeding engine, do NOT use the minimum-fuel contact as part of any emergency stop sequence.

Idle/Rated Ramp Contact

The Idle/Rated contact (open for Idle, closed for Rated) connects to terminal 10, Discrete Input B. This contact also determines which fuel limiter is in effect. In Idle, the control uses the Start Fuel Limit set point. In Rated, the control uses the Max Fuel Limit set point. When the Idle/Rated contact is closed, the control immediately switches the fuel limit to the max limit and ramps engine speed to the Rated (or Remote) speed set point. When the Idle/Rated contact is opened, the control immediately switches on the Start Fuel Limit and ramps engine speed to the Idle speed setting.

The Idle set point cannot be set above the Rated set point. Raise, Lower, and Remote inputs are disabled when in Idle. The fuel limiters remain effective regardless of the Local/Remote input.

Lower Speed Contact

The Lower Speed contact connects to terminal 11, Discrete Input C. When the Lower Speed contact is closed, the control lowers speed at a rate determined by the Raise/Lower Rate set point. When the contact is open, speed remains at its current value. Actuating the Lower Speed contact will cancel the ramps started by the Idle/Rated contact.
The Lower Speed contact input is disabled when the Remote contact is closed and when Idle is selected.

Raise Speed Contact

The Raise Speed contact connects to terminal 12, Discrete Input D. When the Raise Speed contact is closed, the control raises speed at a rate determined by the Raise/Lower Rate set point. When the contact is open, speed remains at its current value. Actuating the Raise Speed contact will cancel the ramps started by the Idle/Rated contact.

The Raise Speed contact input is disabled when the Remote contact or the Lower Speed contact is closed and when Idle is selected.

Local/Remote Speed Reference Contact

The Local/Remote contact connects to terminal 13, Discrete Input E. The Local reference is the speed set by the Idle/Rated and Raise/Lower contacts. Local is selected when the contact is open. Remote speed reference is the 4 to 20 mA signal applied to Analog Input 1. Remote is selected when the contact is closed.

The Raise and Lower inputs are disabled when Remote is selected. When Remote is selected, the Idle/Rated ramps will use the current speed reference as indicated by the 4–20 mA Remote input. Ramp times will be proportional to the Idle and Rated speed set points. The fuel limiters remain effective regardless of the Local/Remote input.

Failed Speed Signal Override

The Failed Speed Signal Override is connected to terminal 14, Discrete Input F. When the contact is open, the control operates normally, turning the control output off in the event of a loss of speed signal.

Closing the contact overrides the failed speed signal function, which may be required for start-up. Prior to engine start-up, the speed signal is nonexistent. On engines requiring fuel during cranking, the Failed Speed Signal Override allows the actuator to open and provide fuel for starting.

Speed Signal Input

Connect a speed-sensing device, such as a magnetic pickup, to terminals 15 and 16 using shielded wire. Connect the shield to the chassis. Make sure the shield has continuity the entire distance to the speed sensor, and make sure the shield is insulated from all other conducting surfaces. This wiring must be fully enclosed in conduit to meet Class I, Division 2, Group D requirements.

⚠WARNING

The number of gear teeth is used by the control to convert pulses from the speed sensing device to engine rpm. To prevent possible serious injury from an overspeeding engine, make sure the control is properly programmed to convert the gear-tooth count into engine rpm. Improper conversion could cause engine overspeed.

Remote Speed Setting Input

Connect the 4 to 20 mA current transmitter to terminals 18(+) and 19(–). Use a shielded, twisted-pair cable. You must install a jumper between terminals 17 and 18 to connect the 243 Ω burden resistor in the loop. This input is not isolated from the other control inputs and outputs (except the power supply input and the speed signal). If any other analog input or output is used in a common ground system, a loop isolator must be installed. A number of manufacturers offer 20 mA loop isolators. Consult Woodward for further information. This wiring must be fully enclosed in conduit to meet Class I, Division 2, Group D requirements.

Installation Checkout Procedure

With the installation complete as described in this chapter, do the following checkout procedure before beginning set point entry (Chapter 3) or initial start-up adjustments (Chapter 3).

1. Visual inspection
   A. Check the linkage between the actuator and fuel metering device for looseness or binding. Refer to the appropriate actuator manual, and Manual 25070, *Electric Governor Installation Guide*, for additional information on linkage.

⚠WARNING

To prevent possible serious injury from an overspeeding engine, the actuator lever or stroke should be near but not at the minimum position when the fuel valve or fuel rack is at the minimum fuel delivery position.

   B. Check for correct wiring in accordance with the appropriate plant wiring diagram (Figure 1-5).

   C. Check for broken terminals and loose terminal screws.

   D. Check the speed sensor for visible damage. If the sensor is a magnetic pickup, check the clearance between the gear and the sensor, and adjust if necessary. Clearance should be between 0.25 and 1.25 mm (0.010 and 0.050 inch) at the closest point. Make sure the gear runout does not exceed the pickup gap.

2. Check for grounds

   Check for grounds by measuring the resistance from all control terminals to chassis. All terminals except terminals 2 and 8 should measure infinite resistance (the resistance of terminals 2 and 8 depends on whether a floating or grounded power source is used). If a resistance less than infinite is obtained, remove the connections from each terminal one at a time until the resistance is infinite. Check the line that was removed last to locate the fault.

Chapter 3.
Entering Control Set Points

Introduction

Because of the variety of installations, plus system and component tolerances, the control must be tuned to each system for optimum performance.

This chapter contains information on how to enter control set points through the control's menu system using the Set Point Programmer. See the next chapter for prestart-up start-up settings and adjustments.

⚠WARNING

An improperly calibrated control could cause an engine overspeed or other damage to the engine. To prevent possible serious injury from an overspeeding engine, read this entire procedure before starting the engine.

Set Point Programmer and Menus

The Set Point Programmer is a hand-held computer terminal that gets its power from the 700 control. The terminal connects to the 20 mA Loop Serial Port on the control. To connect the terminal, slightly loosen the right hand screw in the cover over J1 and rotate the cover clockwise. Insert the terminal connector through the control cover and seat it firmly into J1 inside the control.

The programmer does a power-up self-test whenever it is plugged into the control. When the self-test is complete, the screen will be blank. Press the SP (Space) key to display the part number and revision level of the software in the control. (The SP key also turns on the display backlighting.) Refer to this number and revision level in any correspondence with Woodward Governor Company (write this information in Appendix A).

The set points or adjustments of the control are arranged in five menus. You access these menus with the A, B, C, D, and 1 keys. Pressing the appropriate key selects the first item on each menu.

The programmer keys do the following functions (see Figure 3-1):

(up arrow)	Increases the displayed set point value. Updates Menu D display.
(down arrow)	Decreases the displayed set point value. Updates Menu D display.
(left arrow)	Moves backward through each menu, one step at a time.
(right arrow)	Advances through each menu, one step at a time.
ESC	Not used.
= (equals)	Saves entered values.
SPACE	Displays the 701 control part number and software revision level. Turns on display backlighting.
BS	Not used.
CR	Not used.
1	Selects Menu 1.
2–9,0	Not used.
(decimal)	Not used.
A	Selects Menu A.
B	Selects Menu B.
C	Selects Menu C.
D	Selects Menu D.

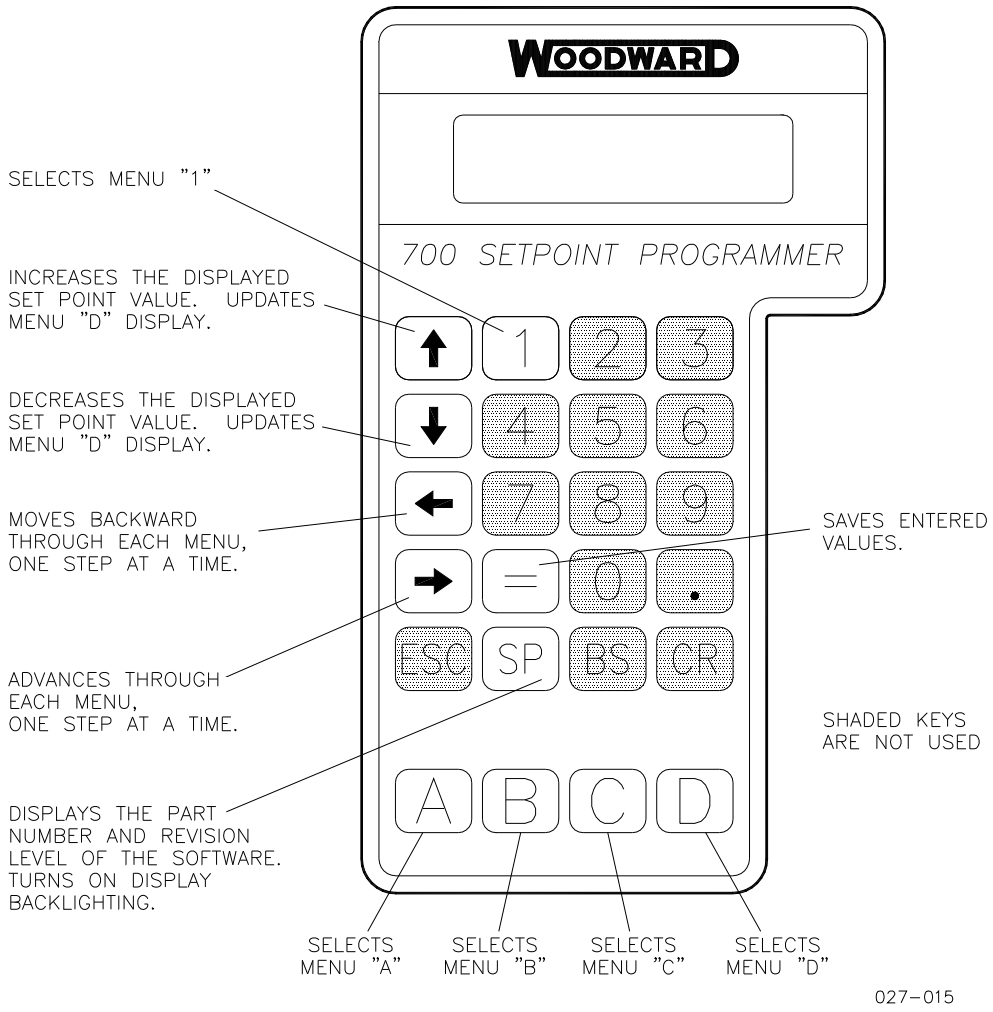


Figure 3-1. Set Point Programmer Functions

	Name	Initial Prestart Setting
Menu A—Dynamics Menu		
1.	Gain	0.010
2.	Reset	1.00
3.	Compensation	0.25
4.	Gain Ratio	1.0
5.	Window Width	3% of rated engine rpm
6.	Gain Slope	0.0
7.	Gain Breakpoint	100%

	Name	Initial Prestart Setting
Menu B—Speed Setting Menu		
1.	Raise Limit	Set to maximum engine operating speed.
2.	Lower Limit	Set to minimum engine operating speed.
3.	Rated Speed Reference	Set to the normal operating speed of the engine.
4.	Idle Speed Reference	Set to the desired start-up speed.
5.	Accel Time	Set to the time desired to ramp from idle to rated speed.
6.	Decel Time	Set to the time desired to ramp from rated speed to idle sped.
7.	Raise Rate	Set to the rpm-per-minute rate desired to raise speed with the Raise command or with the 4 to 20 mA Remote Speed Reference.
8.	Lower Rate	Set to the rpm-per-minute rate desired to lower speed with the Lower command or with the 4 to 20 mA Remote Speed Reference.
9.	20 mA Remote Reference	Set to operating speed with 20 mA input. Skip if remote input is not used.
10.	4 mA Remote Reference	Set to operating speed with 4 mA input. Skip if remote input is not used.
11.	20 mA Tachometer RPM	Set to full scale rpm of your meter.
12.	4 mA Tachometer RPM	Set to minimum scale rpm of your meter.
13.	Droop	Set to 0% for isochronous operation or to desired droop. Note that droop is dependent on the actuator stroke actually used. If actuator stroke is 50% from no load to full load, set droop at twice the desired value.
Menu C—Fuel Limiter Menu		
1.	Start Speed	Set to engine rpm at which ignition normally first occurs.
2.	Start Fuel Limit	50%
3.	Idle Fuel Limit	50%
4.	Maximum Fuel Limit	100%
5.	Minimum Actuator	Set to 20% for 4 to 20 mA pneumatic actuators that require a minimum of 4 mA (20% of 20 mA = 4 mA). Set to 0% for all other actuators.
6.	Min Rack Limit	4 mA (9905-465 only)
7.	Rack Limit @ Min	100% (9905-465 only)
8.	BP Rack Limit	12 mA (9905-465 only)
9.	Rack Limit @ BP	100% (9905-465 only)
10.	Max Rack Limit	20 mA (9905-465 only)
11.	Rack Limit @ Max	100% (9905-465 only)
12.	20mA Aux Output	(will be set after start-up)
13.	4mA Aux Output	(will be set after start-up)

	Name	Initial Prestart Setting
Menu D—Display Menu		
1.	Engine RPM	[actual value]
2.	Speed Reference	[actual value]
3.	Actuator Output	[actual value]
4.	Auxiliary Output	[actual value]
5.	Remote Input	[actual value]
6.	Rack Limit Input	[actual value] (9905-465 only)
7.	Run/Stop Switch	open/closed
8.	Idle/Rated Switch	open/closed
9.	Lower Switch	open/closed
10.	Raise Switch	open/closed
11.	Remote Switch	open/closed
12.	Failsafe On/Off Switch	open/closed
13.	Watchdog Status	OK
14.	Self Test Result	49
15.	ROM Check Sum	[variable with application]
Menu 1—Calibration/Configuration Menu		
1.	Calibration Key	49
2.	Number of Gear Teeth	Set to number of teeth or holes in the gear where the speed sensor is mounted. If this gear is not turning at the same speed as the engine, enter the number of teeth seen by the sensor in one engine revolution.
3.	Aux Output Configuration	Tachometer for 4+20 mA tachometer output; Actuator Percent for 4+20 mA actuator position output
4.	Aux Output Calibration	Do not adjust (see calibration procedure in Chapter 6)
5.	Remote Input Calibration	Do not adjust (see calibration procedure in Chapter 6)
6.	Rack Limit Input Calibration	Do not adjust (see calibration procedure in Chapter 6) (9905-465 only)

Pressing the appropriate key (A, B, C, D, 1) selects the desired menu. To step through the menu, use the left and right arrow keys. The right arrow advances through the menu and the left arrow moves backward through the menu. The menus are continuous; that is, pressing the right arrow at the last menu item takes the menu to the first item, or pressing the left arrow at the beginning of the menu takes the menu to the last item.

To adjust a set point, use the up arrow to increase the value, or the down arrow to decrease the value. Holding the up or down arrow longer than a few moments will cause the rate of change to increase. This is useful during initial setup where a value may need to be changed significantly.

Finally, use the "=" key to save entered values. After you are satisfied with all entries and adjustments, press the "=" key to transfer all new set point values into EEPROM memory. The EEPROM retains all set points when power is removed from the control and restores them when power is reapplied.

NOTICE

To prevent possible damage to the engine resulting from improper control settings, make sure you save the set points before removing power from the control. Failure to save the set points before removing power from the control causes them to revert to the previously saved settings.

The control ignores all other keys on the Set Point Programmer.

Menu (Set Point) Descriptions

Menu A—Dynamics Menu

Dynamic adjustments are settings that affect the stability and transient performance of the engine. Descriptions of each menu item follow. Also see Figures 3-2, 3-3, and 3-4.

1. Gain determines how fast the control responds to an error in engine speed from the speed-reference setting. The gain is set to provide stable control of the engine at light or unloaded conditions.

2. Reset compensates for the lag time of the engine. It adjusts the time required for the control to return the speed to zero error after a disturbance. Reset is adjusted to prevent slow hunting and to minimize speed overshoot after a load disturbance.

3. Compensation compensates for the lag time of the fuel system, actuator time constant, and manifold lag.

4. Gain Ratio is the ratio of the Gain setting at steady state to the Gain setting during transient conditions. The Gain Ratio operates in conjunction with the Window Width and Gain adjustments by multiplying the Gain set point by the Gain Ratio when the speed error is greater than the Window Width. This makes the control dynamics fast enough to minimize engine-speed overshoot on start-up and to reduce the magnitude of speed error when loads are changing. This allows a lower gain at steady state which will not be affected by the rough running typical of spark-ignited engines.

5. Window Width is the magnitude (in rpm) of a speed error at which the control automatically switches to fast response.

6. Gain Slope increases Gain as a function of actuator output. Since actuator output is proportional to engine load, this makes gain a function of engine load. Gain Slope operates in conjunction with the Gain Break Point adjustment to increase gain when percent actuator output is greater than the break point. This compensates for nonlinear fuel systems, those having high gain at low manifold pressure levels. This allows the Gain setting to be lower at light or no load for engine stability, yet provide good control performance under loaded conditions.

7. Gain Breakpoint sets the percent output above which the Gain Slope becomes effective. It should usually be set just above the min load output.

Menu B—Speed Setting Menu

Speed adjustments are the settings that affect the speed reference. Descriptions of each menu item follow.

1. Raise Limit is the maximum speed reference setting. It is used to limit the Raise Speed command to a maximum. It normally is set at the maximum rated engine speed.

2. Lower Limit is the minimum speed reference setting. It is used to limit the Lower Speed command. It normally is set at the minimum operating speed of the engine.

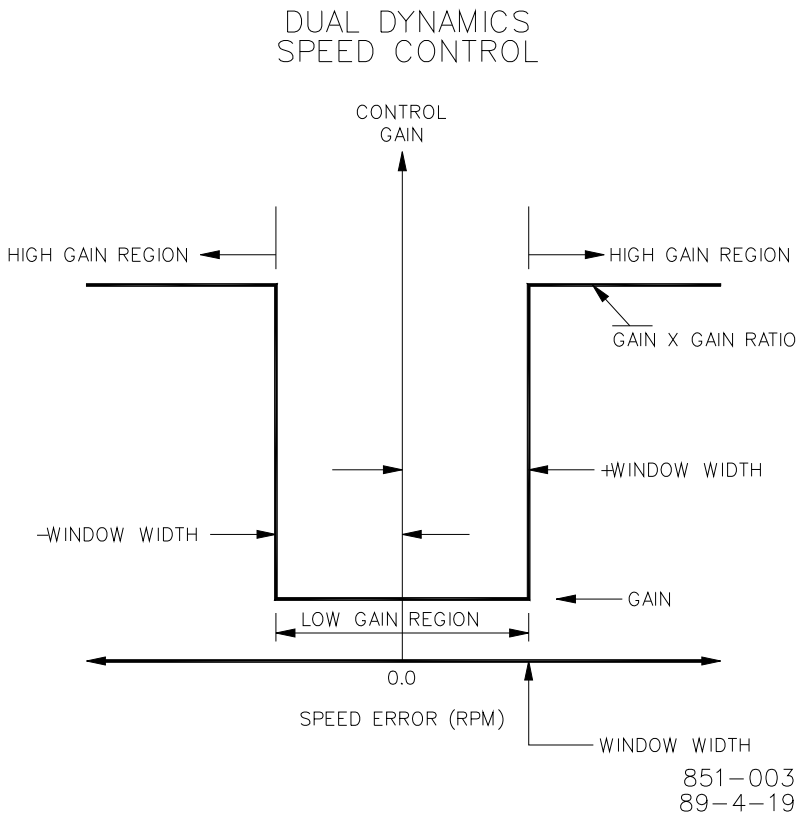


Figure 3-2. Control Gain as a Function of Speed Error

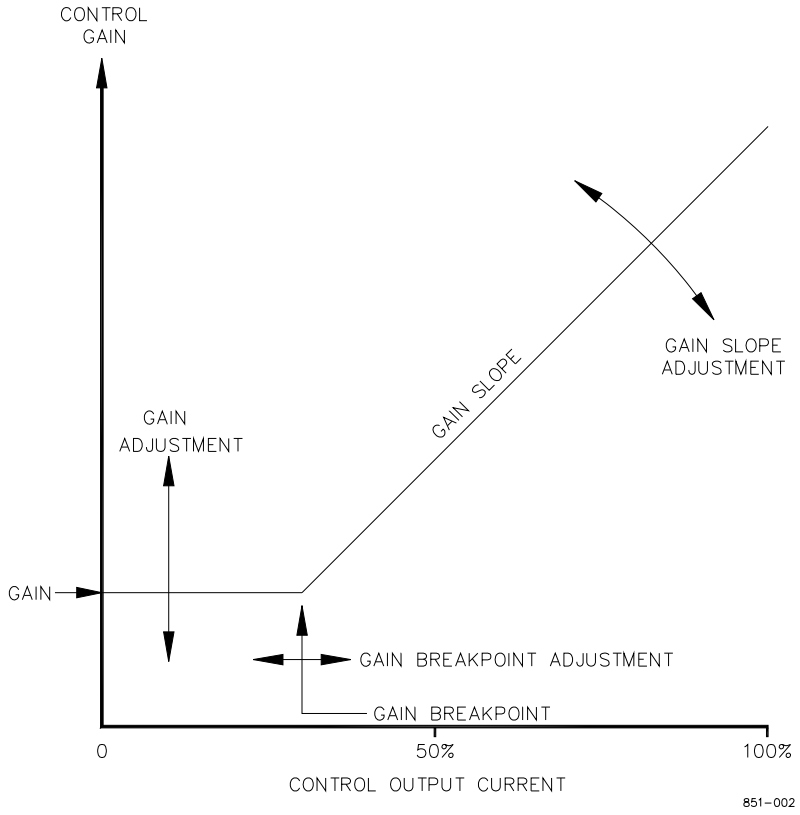


Figure 3-3. Control Gain as a Function of Control Output

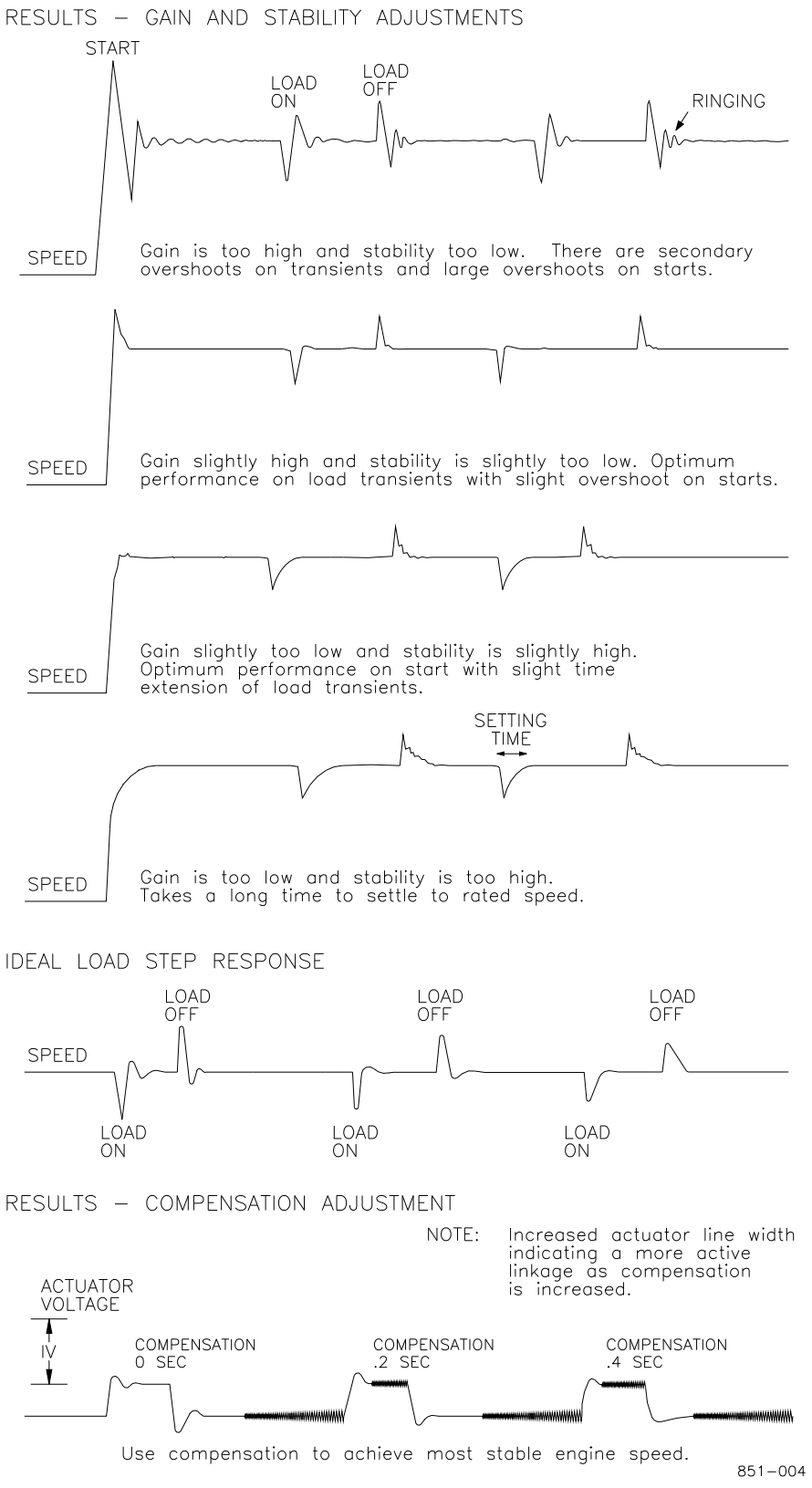


Figure 3-4. Typical Transient Response Curves

3. Rated Speed Reference sets the normal operating speed of the engine. It should be set at the speed at which the engine is operated at full load.

4. Idle Speed Reference sets the speed at which the engine is operated after start-up. It sometimes is used during cool down.

5. Accel Time is the time required for the control to ramp the engine speed from Idle speed to Rated speed. The ramp is started whenever the Idle/Rated switch is closed (Rated speed selected).

6. Decel Time is the time required for the control to ramp the engine speed from Rated speed to Idle speed. The ramp is started whenever the Idle/Rated switch is opened (Idle speed selected).

7. Raise Rate is the rate at which the speed reference is ramped when using Raise as well as when the Remote Speed Setting input is increased. A step change increase on the remote input does not cause an immediate change in the reference, but is ramped to the new setting at the Raise rate.

8. Lower Rate is the rate at which the speed reference is ramped when using Lower as well as when the Remote Speed Setting input is decreased. A step change decrease on the remote input does not cause an immediate change in the reference, but is ramped to the new setting at the Lower rate.

9. 20 mA Remote Reference is the engine speed desired when 20 mA is applied to the Remote Speed Reference input.

10. 4 mA Remote Reference is the engine speed desired when 4 mA is applied to the Remote Speed Reference input.

11. 20 mA Tachometer RPM is the engine speed when the tachometer output is 20 mA.

12. 4 mA Tachometer RPM is the engine speed when the tachometer output is 4 mA.

13. Droop is based on the control output, which is proportional to engine load. The droop obtained is dependent on linkage adjustment and stroke. For example, 5% droop gives a real droop of 2.5% if the control output changes 50% from no load to full load.

Menu C—Fuel Limiter Menu

Fuel Limiters limit the actuator output current from the control. Descriptions of each menu item follow.

1. Start Speed is the engine speed at which ignition usually occurs during engine start-up. When engine speed is below the Start Speed setting, the maximum percent actuator output current is determined by the Start Fuel Limit. When the engine accelerates between Start Speed and Idle Speed, the maximum current is ramped to the Idle Fuel Limit in proportion to speed.

2. Start Fuel Limit sets the maximum percent actuator output current when at the Start Speed specified above. The limit is usually set to provide the fuel manifold pressure required for reliable ignition during start-up. The Start Fuel Limit is independent of the rack limiter, so it may be set higher or lower than that limit.

3. Idle Fuel Limit sets the maximum percent actuator output current when the engine is operated at idle. During engine start-up, the maximum fuel is increased (or decreased if Idle Fuel Limit is less than the Start Fuel Limit) from the Start Fuel Limit to the Idle Fuel Limit in proportion to the engine speed.

4. Maximum Fuel Limit sets the maximum percent actuator output current when Rated Speed is selected. Maximum (100%) is based on either 20 mA or 200 mA, depending on which control you have. The limit is usually set just above the output at full load. The percent output is displayed on Menu D.

5. Minimum Actuator sets the minimum percent actuator output current when the engine is running. This is overridden by the speed-failed function and the Stop switch, both of which drive the output current full off. This is normally used only for the 4 to 20 mA output versions driving a pneumatic actuator.

6. Min Rack Limit (9905-465 only) determines the maximum percent actuator output current when the boost pressure input is 4 mA (1 Vdc). The control responds to inputs from 2 to 20 mA (0.5 to 5 Vdc). Inputs between 2 and 4 mA (0.5 and 1 Vdc) are treated as 4 mA (1 Vdc). The control interpolates the rack limit between the Min Rack Limit and the BP Rack Limit set points. An input below 2 mA (0.5 Vdc) is considered failed and the control defaults to the maximum setting at 20 mA (5 Vdc) for continued operation.

7. Rack Limit @ Min (9905-465 only) is the percent actuator output current at the Min Rack Limit set above.

8. BP (breakpoint) Rack Limit (9905-465 only) is the input milliamps from the turbo boost pressure sensor at which the slope of the two-slope rack limiter changes.

9. Rack Limit @ BP (breakpoint) (9905-465 only) is the percent actuator output current at the BP Rack Limit set above.

10. Max Rack Limit (9905-465 only) determines the percent actuator output current when the torque boost pressure input is 20 mA. Straight line interpolation is made between the breakpoint and max settings.

11. Rack Limit @ Max (9905-465 only) is the percent actuator output current when the rack limiter input is at the Max Rack Limit set point. The limiter interpolates between the BP Rack Limit and Max Rack Limit.

    Figure 3-5 illustrates the breakpoint and these adjustments.

12. 20mA Aux Output sets actuator percentage when Aux Output is 20 mA.

13. 4mA Aux Output sets actuator percentage when Aux Output is 4 mA.

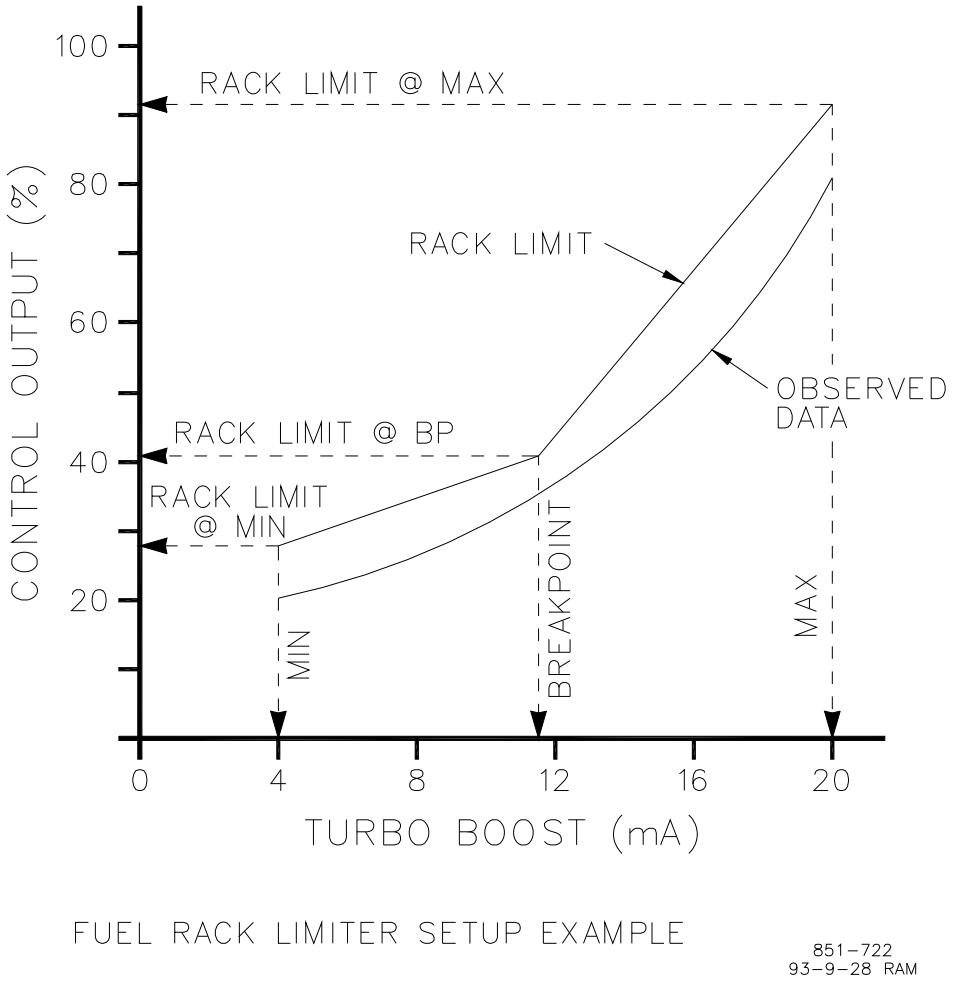


Figure 3-5. Rack Limiter Setup Example

Menu D—Display Menu

Input and output values are displayed once when each item is selected. To get a continuous update, hold down the up or down arrow. Descriptions of each menu item follow.

1. Engine RPM displays the current engine speed.

2. Speed Reference displays the current speed reference.

3. Actuator Output displays the current percent of output. Maximum (100%) is 20 mA or 200 mA, depending on which control you have. This is useful for setup of the control fuel limiters and gain break point settings.

4. Auxiliary Output displays the current from the auxiliary output. This value is useful during setup and testing of the control.

5. Remote Input displays the input current on the Remote Speed Setting Input. This value is useful during setup and testing of the control.

6. Rack Limit Input (9905-465 only) displays the milliamps currently on the turbo boost pressure rack limit input. This is useful for testing and system calibration.

7. Run/Stop Switch status displays whether the Run/Stop discrete input switch is open or closed. This menu item and those below are used during testing of the control.

8. Idle/Rated Switch displays the status of the Idle/Rated discrete input switch. Open indicates Idle Speed is selected, closed indicates Rated (or Remote) Speed is selected.

9. Lower Switch displays the status of the Lower discrete input switch. Closed indicates the control is being requested to lower the speed setting.

10. Raise Switch displays the status of the Raise discrete input switch. Closed indicates the control is being requested to raise the speed setting.

11. Remote Switch displays the status of the Local/Remote input switch. Open indicates the local speed reference is being used. Closed indicates the 4–20 mA Remote Speed Setting input is being used to generate the speed reference.

12. Failsafe On/Off Switch displays the status of the Failed Speed Function Override switch input. Open indicates the control should reduce output current to 0 mA when no speed signal is obtained. Closed indicates the control is to output maximum current as determined by the selected fuel limit when no speed signal is obtained.

13. Watchdog Status displays the status of the control CPU. The normal status displayed is CPU OK. If a CPU fault occurs, the CPU OK indicator on the front of the control will turn off, the Actuator Output and Aux Output will decrease to minimum output, and the Watchdog Status will display TIME OUT. To reset the watchdog, turn off power to the control for a minimum of 10 seconds.

14. Self Test Result displays the result of power up diagnostics performed on the microprocessor, data, and program memory. A successful test gives a result of 49. Report any other result to Woodward when returning the control for repair.

15. ROM Check Sum is used by Woodward during factory tests. An incorrect result will give a Self Test Result error also.

Menu 1—Calibration/Configuration Menu

1. Calibration Key is a code which you must enter before you can change any of the set points on the calibration menu. This helps prevent accidental modification of the set points. The code is factory set to “49”. Use the up and down arrow keys to select the code. Whenever the Run/Stop input is changed, the code will be reset to “0”.

2. Number of Gear Teeth is the number of teeth or holes in the gear or flywheel the speed sensing device is on. If the gear is running at camshaft speed (one-half engine speed) then you must enter one-half the number of teeth on the gear. The control requires the number of teeth seen by the control per full engine revolution.

IMPORTANT

Best control performance will be obtained when sensing speed from a gear rotating at full engine speed. Slower-speed gears (such as the camshaft) provide a lower sampling rate which reduces control response time.

⚠WARNING

The number of gear teeth is used by the control to convert pulses from the speed-sensing device to engine rpm. To prevent possible serious injury from an overspeeding engine, make sure the control is properly programmed to convert the gear-tooth count into engine rpm. Improper conversion could cause engine overspeed.

3. Aux Output Configuration selects either actuator position readout or tachometer readout for Menu C 20mA/4mA Aux Actuator. Use the up and down arrow keys to select the desired display.

4. Aux Output Calibration calibrates the 4–20 mA Tachometer output by adjusting the value of the aux output current as seen by the control software. This calibration is performed by Woodward prior to shipment and should not normally require field adjustment. See the Control Test and Calibration section in Chapter 6 for proper adjustment procedure.

5. Remote Input Calibration is used for calibration of the 4–20 mA Remote Speed Setting input. This set point adjusts the value of the input current as seen by the control software. This calibration is performed by Woodward prior to shipment and should not normally require field adjustment. See the test and calibration section for proper adjustment procedure.

6. Rack Limit Input Calibration calibrates the 4–20 mA Rack Limit input by adjusting the value of the input current as seen by the control software. This calibration is performed by Woodward prior to shipment and should not normally require filed adjustment. See the Control Test and Calibration section in Chapter 6 for proper adjustment procedures.

At this time, save this setup by pressing the “=” key on the Set Point Programmer. The programmer will display the message “Set Points Saved”. Be sure to select a menu prior to continuing.

NOTICE

To prevent possible damage to the engine resulting from improper control settings, make sure you save the set points before removing power from the control. Failure to save the set points before removing power from the control causes them to revert to the previously saved settings.

Chapter 4.
Initial Adjustments

Introduction

This chapter contains information on control calibration. It includes initial prestart-up and start-up settings and adjustments.

WARNING

An improperly calibrated control could cause an engine overspeed or other damage to the engine. To prevent possible serious injury from an overspeeding engine, read this entire procedure before starting the engine.

Start-up Adjustments

1. Complete the installation checkout procedure in Chapter 2 and the prestart menu settings in Chapter 3.

2. Close the Run contact. Close the Failed Speed Override contact. Be sure the Idle/Rated contact is in Idle (Open). Apply power to the control.

3. Set up Start Fuel Limit.

   Observe that the pneumatic actuator is near mid stroke, 50% as set in the Initial Prestart Settings. Select Menu C on the Set Point Programmer. Advance the menu to “Start Fuel Limit”. Observe that the position of the actuator can be moved in the increase fuel direction by incrementing, or in the decrease fuel direction by decrementing the Start Fuel Limit. Verify that the fuel valve reaches minimum prior to 0% (20% on 4 to 20 mA systems).

   If the no-load position of the fuel valve was recorded prior to converting the control system, adjust the Start Fuel Limit to position the valve to this position. This will be used as the initial setting for start-up.

   If the starting position is unknown, it is best to begin by setting the Start Fuel Limit where the fuel valve just begins to open. The required setting will be determined by starting the engine.

4. Check the speed sensor.

   Minimum voltage required from the speed sensor to operate the control is 1.0 Vrms, measured at cranking speed or the lowest controlling speed. For this test, measure the voltage while cranking, with the speed sensor connected to the control. Before cranking, be sure to prevent the engine from starting. At 5% of rated speed, the failed speed sensing circuit function is cleared.

WARNING

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.

5. Start the engine.

   If there is insufficient fuel to start the engine, increase the Start Fuel Limit (Menu C) while observing the intake manifold pressure. If the required starting pressure is known, set the Start Fuel Limit as required to get that pressure. It normally will take a lower fuel pressure for starting than required for idle. (The control will reduce fuel as required when the speed setting is reached. It requires extra fuel to accelerate the engine to idle speed.) It may take a few starts to determine the final setting of the Start Fuel Limit. If the start time is excessive, increase the Start Fuel Limit. If the start time is too fast or flooding is occurring, decrease the Start Fuel Limit. Set the Idle Fuel Limit slightly higher than required for idle operation. We recommend trying both hot and cold starts to determine final settings.

6. Adjust for stable operation.

   If the engine is hunting at a rapid rate, slowly decrease the Gain (Menu A) until performance is stable. If the engine is hunting at a slow rate, increase the Reset time. If increasing the Reset time does not stabilize the engine, it also may be necessary to slowly decrease the Gain OR to slowly decrease the Gain and increase the Compensation.

This completes the Start-up adjustments. We recommend saving the settings at this time by pressing the “=” key on the Set Point Programmer.

Dynamic Adjustments

The objective of the dynamic adjustments is to get the optimum, stable engine speed response at minimum load and at full load operating conditions.

1. No Load Adjustments

   Do this adjustment at the lowest operating speed of the engine without load applied.

   Slowly increase the Gain set point until the engine becomes slightly unstable, then reduce the Gain as necessary to stabilize the engine.

   After acceptable performance at no load, record the Actuator Output as read on Menu D. Set the Gain Break Point (Menu A) to this reading.

2. Minimum Load Adjustment

   Do this adjustment at the minimum speed and load conditions at which the compressor is put on line. Be sure to select Rated Speed to switch to the maximum-fuel limit. Speed may be set either with the Raise and Lower commands in local or with a 4 to 20 mA speed reference in remote.

   Observe the movement of the actuator. If the activity of the actuator is excessive, reduce the Gain set point slightly to get the actuator movement to an acceptable level.

If there is a slow periodic cycling of the engine speed above and below the speed setting, there are two possible causes:

- Gain is too high and Reset is too low. Reduce the gain by 50% (that is, if the gain was 0.02, reduce it to 0.01) and increase Reset slightly. Observe the movement of the actuator. Continue to increase Reset until the movement is acceptable but not excessive. A final value of Reset should be between 1.0 and 2.0 for most engines. If the Reset value exceeds 2.0, but this procedure continues to improve performance, increase the Compensation set point 50% and repeat the procedure.

- Gain is too low. If the preceding procedure does not improve the slow periodic cycling of the engine speed, the control may be limiting cycling through the low gain control region set by the Window Width set point. Increase the Gain set point to minimize the cycling. If actuator movement becomes excessive, reduce the Compensation set point until movement is acceptable. In some cases, Compensation may be reduced to zero and only the Gain and Reset adjustments used. This should be done only if necessary to eliminate excessive actuator response to misfirings or other periodic disturbances. Reduce the Window Width set point until the limit cycle amplitude is acceptable without excessive rapid actuator movement.

3. Full Load Adjustment

   Do these adjustments at the speed and load ratings at which the engine is most often operated.

   If operation in this range is satisfactory, no further dynamic adjustments are necessary. If during changes in speed or load, excessive speed errors occur, increase the Gain Slope adjustment until engine performance is satisfactory. If excessive actuator movement again occurs, do Procedure 4, then repeat Procedure 3. If the settling time after a speed or load change is too long, reduce the Reset set point slightly and increase the gain slightly. If slow-speed hunting occurs after a load or speed change but decreases or stops in time, increase the Reset set point slightly and reduce the Gain set point. See Figure 3-4.

⚠WARNING

The use of negative gain slope should be considered carefully. Low gain at high fuel levels will result in poor load rejection response or possible overspeed. To prevent possible serious injury from an overspeeding engine, the Max Fuel Limit, Menu C, must be set near the full load output current demand to prevent excessive integrator windup and a subsequent low gain condition.

4. When speed and load changes occur, the control should switch automatically to high gain to reduce the amplitude of the offspeeds. Reduce (or increase) the Window Width set point to just greater than the magnitude of acceptable speed error caused by misfiring. The Gain Ratio normally will remain set at 10.0. A value of Gain ratio too high will cause the control to hunt through the low-gain region. This normally will occur only if the Window Width is too low. If necessary to decrease the Window Width to control limit cycling (identified by the engine speed slowly cycling from below to above the speed setting by the amount of Window Width), the Gain Ratio may be reduced for more stable operation.

5. Verify that performance at all speed and load conditions is satisfactory and repeat the above procedures if necessary.

6. While operating at full load, record the Actuator Output on Menu D. Select the Max Fuel Limit set point on Menu C. Set at approximately 10% over the full load output if desired, otherwise leave at 100%.

We recommend you check the operation from both hot and cold starts to get the optimum stability under all conditions.

Speed Adjustments

Adjustment of the Local Speed References (Idle, Rated, Raise Max, and Lower Min) should not require further setting as they are precisely determined. The Remote Speed Input and the Tachometer Output however involve analog circuits and may require adjustment.

1. 4 to 20 mA Remote Speed Setting Input

   Apply 4 mA to the Remote Speed Setting Input. Be sure Remote is selected. Observe the operating speed of the engine as displayed on Menu D. If the engine rpm is lower or higher than desired, increase or decrease the 4 mA Remote Reference set point on Menu B to get the correct speed. There may be a small difference between the set point and actual speed which compensates for the inaccuracies in the analog circuits.

   Now apply 20 mA to the Remote Speed Setting Input. Wait until the ramp stops. Increase or decrease the 20 mA Remote Reference set point to get the tach speed desired.

   Repeat the above steps until the speeds at 4 mA and 20 mA are within your required range.

2. 4 to 20 mA Tachometer Output

   Set engine speed to the speed desired for 4 mA output. If this is not possible, skip this step or use a signal generator into the speed input with the correct frequency corresponding to the desired rpm. Trim the 4 mA Tach rpm set point for 4 mA output.

   Set engine speed to the speed desired for 20 mA output. Trim the 20 mA Tach rpm set point for 20 mA output.

   Repeat the above steps until the speeds at 4 mA and 20 mA are within your required range.

3. 4 to 20 mA Aux Actuator Output

   Select 20mA Aux Actuator on Menu C. Adjust to the desired actuator percentage for 20 mA output.

   Select 4mA Aux Actuator on Menu C. Adjust to the desired actuator percentage for 4 mA output.

For Aux Actuator configuration and calibration, see the calibration procedure in Chapter 6.

IMPORTANT **If 4mA Aux Output and 20mA Aux Output are the same value, the Aux Output will be 0 mA.**

Fuel Rack Limit Adjustment

If a turbo boost pressure rack limiter is not being used, leave the set points at the 100% values set during prestart adjustment.

The values of the Actuator Output (Menu D) and turbo boost pressure sensor outputs obtained above provide the guide to adjustment of the rack limit set points. As a starting point, plot actuator output percent versus turbo boost pressure milliamps as show in Figure 3-5. If necessary, extrapolate the curve to include Min and Max Rack Limit. Plot a best-fit two-slope line 10% of the output range (maximum—minimum output values) above the curve obtained. Set the BP Rack Limit to the turbo boost pressure input current corresponding to the breakpoint in the two lines. Set the Min Rack Limit, BP Rack Limit, and the Max Rack Limit at the output values obtained at their respective points. Test engine performance through the speed and load range for satisfactory performance. Set point values may require readjustment from the starting values to obtain the desired result.

Conclusion of Setup Procedures

This completes the adjustment chapter. Save the set points by pressing the "=" key on the Set Point Programmer. Run through all the set points and record them for future reference. This can be useful if a replacement control is necessary or for start-up of another similar unit. Power down the control for about 10 seconds. Restore power and verify that all set points are as recorded.

NOTICE

To prevent possible damage to the engine resulting from improper control settings, make sure you save the set points before removing power from the control. Failure to save the set points before removing power from the control causes them to revert to the previously saved settings.

Disconnect the Set Point Programmer from the control. Close the cover over J1 and retighten the retaining screw.

Chapter 5.
Description of Operation

General

The 700 Digital Speed Control uses a 16-bit microprocessor for all control functions, such as computing engine speed, performing the control algorithm calculations, speed ramps, etc. All control adjustments are made with a hand-held terminal/display that communicates with the control via a serial port. The terminal/display is disconnected from the control when not in service to provide security against tampering.

Figure 1-7 shows a control block diagram.

The control features a switching power supply with increased spike, ripple, and EMI (electromagnetic interference) rejection. Discrete inputs are optically isolated and capable of rejecting EMI and variable resistance in switch or relay contacts. Analog inputs are differential type with extra filtering for common mode noise rejection. This protects the control from spurious interference and noise which can cause speed and load shifts.

Control Operation

The control ignores the rough firing and compensates for nonlinear fuel systems normally associated with spark-ignited gas-fueled engines. This gives smooth steady-state operation, yet the control retains fast response to speed and load changes.

The control operates automatically with two dynamic settings depending on engine speed error (speed error is the difference between the speed setting and the actual engine speed). During steady-state operation with a constant load, the control uses “slow” dynamics. This prevents the control from responding to minor fluctuations in engine speed caused by rough firing, which eliminates potentially damaging jiggle of the actuator and fuel system. The control automatically switches to “fast” dynamics when a large speed error occurs. Operation with “slow” dynamics is restored once the control senses the return to steady-state speed.

The control compensates for nonlinear fuel systems and changes in engine dynamics with load. The control dynamics are mapped as a function of actuator current (actuator current is proportional to engine load). This provides optimal dynamics and smooth steady-state operation for all conditions from no load to full engine load.

The speed sensor contains a special tracking filter designed for low speed engines, which minimizes the effects of engine torsionals or irregularities in the gear used for sensing speed. This provides exceptionally smooth steady-state control and allows the control dynamics to be matched to the engine rather than detuned to compensate for speed torsionals. The speed signal itself is usually provided by a magnetic pickup or proximity probe supplying from 1 to 60 Vrms to the control.

The 700 Digital Speed Control provides a Start Fuel Limiter to limit overfueling or flooding during start-up. The limiter is set to provide the desired maximum fuel during starts. The control will reduce the fuel when the speed set point is reached as required to control engine speed, but will not exceed the start limit.

The control provides a 4 to 20 mA output for an analog meter or as input to a computer. The output is selectable to provide a tachometer signal or a signal proportional to control output. The offset and span are adjustable for range.

The control also provides a 4 to 20 mA remote speed-setting input for remote setting of engine speed. The control responds to inputs from 2 to 20 mA. Inputs between 2 and 4 mA are treated as 4 mA. An input below 2 mA is considered failed and the control remains at the last reference setting (does not ramp to the 4 mA setting).

Fuel Rack Limiter

The control provides a 4–20 mA/1–5 Vdc input for fuel rack limiting based on turbo boost pressure. When used, the two-slope limiter helps prevent overfueling and subsequent smoke emission.

Power Up Diagnostics

The Power Up Diagnostics feature is provided to verify the proper operation of the microprocessor and memory components. The diagnostics take about four seconds after the control is powered on. A failure of the test will turn off the output of the control. If diagnostic testing is successful, the CPU OK indicator on the control cover will light.

Chapter 6. Troubleshooting

General

The following troubleshooting guide is an aid in isolating trouble to the control box, actuator, plant wiring, or elsewhere. Troubleshooting beyond this level is recommended ONLY when a complete facility for control testing is available.

NOTICE

The control can be damaged with the wrong voltage. When replacing a control, check the power supply, battery, etc., for the correct voltage.

Troubleshooting Procedure

Table 6-1 is a general guide for isolating system problems. This guide assumes that the system wiring, soldering connections, switch and relay contacts, and input and output connections are correct and in good working order. Make the checks in the order indicated. Each system check assumes that the prior checks have been properly done.

Control Test and Calibration

General

Do the following checks on the 700 Control. Then verify the functioning of set points and adjustments.

1. Connect the Set Point Programmer to the control in accordance with the instructions in Chapter 3. Verify that correct voltage and polarity are applied to the control. Verify that the programmer does its power-up tests. Failure to do the power up test indicates either the control or Set Point Programmer has failed. Replace the control or Set Point Programmer.

2. Press the SP key. The message “700 Speed Control P/N 5410-865 xxx” should appear. Failure indicates either the control or Set Point Programmer has failed. Replace the control or Set Point Programmer.

3. Select Menu D. Step through the menu to the Self Test Result step. Verify that the displayed value is 49. If any other value is displayed, replace the control.

4. Select Menu A. Verify that all set points are as recorded during installation. Repeat for Menus B, C, and 1. If any differences are found, change the set point(s) to the correct value. Press the “=” key. The message “Set Points Saved” should be displayed. Remove power from the control for at least 10 seconds. Verify correct values were retained during power down. Failure indicates the control has failed and should be replaced.

Discrete Inputs

Do the following test to verify the function of the Discrete Inputs. Do not do these tests with the engine in operation. When reading the Set Point Programmer, be sure to update the display by pressing the up or down arrow.

1. Open all contacts used with the discrete inputs. Remove any jumpers. Check switch state of all the Discrete Input Switches on Menu D. All Switch states on Menu D should read Switch Open. If any Switch state of the Discrete Input Switches reads Switch Closed, verify that the voltage is zero between terminal 8(–) and terminals 9 through 14. If any non-zero voltage is found, correct and recheck the switch state of all the Discrete Input Switches on Menu D. (Be sure to press the up or down arrow to update the display.) If any Switch state of the Discrete Input Switches reads Switch Closed, the control has failed and should be replaced.

2. Close the Run/Stop contact or apply 24 Vdc (5 Vdc on some high-voltage power supply controls) between terminals 8(–) and 9(+) to select Run. Select the Run/Stop Switch item on Menu D. The Display should read Run/Stop Switch Closed. If Display reads Run/Stop Switch Open, verify the voltage at the control terminals. If correct voltage is verified, the control has failed and should be replaced.

3. Repeat step 2 using the Idle/Rated contact or apply voltage to terminal 10(+). Check the Idle/Rated Switch on Menu D.

4. Repeat step 2 using the Lower contact or apply voltage to terminal 11(+). Check the Lower/Rated Switch on Menu D.

5. Repeat step 2 using the Raise contact or apply voltage to terminal 12(+). Check the Raise Switch on Menu D.

6. Repeat step 2 using the Local/Remote contact or apply voltage to terminal 13(+). Check the Local/Remote Switch on Menu D.

7. Repeat step 2 using the Failsafe contact or apply voltage to terminal 14(+). Check the Failsafe Switch on Menu D.

Remote Input

The following tests calibrate and verify the function of the Remote Input, Analog Input 1. When reading the Set Point Programmer, be sure to update the display by pressing the up or down arrow.

1. Connect a 4 to 20 mA or 1 to 5 Vdc source to terminals 18(+) and 19(–). If a mA source is used, a jumper must be installed across terminals 17 and 18. Connect a dc voltmeter across terminals 18(+) and 19(–) for voltage calibration. A mA meter may be installed in series with the 4 to 20 mA source. Use the same type of source as will be provided in service as there is a small difference between 5 V and 20 mA.

2. Set the source for 5.0 Vdc (20.0 mA) on the meter. Select Menu 1 on the Set Point Programmer.

3. Set the Calibration Key to 49. Select Remote Input Calibration on Menu 1.

4. Set the source for 5.0 Vdc (20.0 mA). The Remote Input value should be 20.0 ± 0.2 mA. Press the up or down arrow until the display reads 20.0 ± 0.1 mA. If the voltmeter indicates proper voltages are present on the Analog Input 1, but readings on the Set Point Programmer are incorrect, the 700 control is defective and should be replaced.

Rack Limit Input

The following tests calibrate and verify the function of the Rack Limit Input, Analog Input 2. When reading the Set Point Programmer, be sure to update the display by pressing the up or down arrow.

1. Connect a 4 to 20 mA or 1 to 5 Vdc source to terminals 21(+) and 22(–). If a mA source is used, a jumper must be installed across terminals 20 and 21. Connect a dc voltmeter across terminals 21(+) and 22(–) for voltage calibration. A mA meter may be installed in series with the 4 to 20 mA source. Use the same type of source as will be provided in service as there is a small difference between 5 V and 20 mA.

2. Set the source for 5.0 Vdc (20.0 mA) on the meter. Select Menu 1 on the Set Point Programmer.

3. Set the Calibration Key to 49. Select Rack Limit Input Calibration on Menu 1.

4. Set the source for 5.0 Vdc (20.0 mA). The Rack Limit Input value should be 20.0 ± 0.2 mA. Press the up or down arrow until the display reads 20.0 ± 0.1 mA. If the voltmeter indicates proper voltages are present on the Analog Input 2, but readings on the Set Point Programmer are incorrect, the 700 control is defective and should be replaced.

Actuator Output

The following tests verify the actuator output of the control.

1. Select Run and Failed Speed Function Off. (If terminals 9 and 14 have the correct voltage applied, the Discrete Inputs value will be 33.) Connect a mA meter across terminals 3(+) and 4(–) if no actuator is connected. Connect the mA meter in series with the actuator if one is connected to the control. (Alternately, a dc voltmeter may be connected across the output, terminals 3(+) and 4(–), when an actuator is connected. The correct output currents must be computed using the voltage measured and the input resistance of the actuator.)

2. Select the Start Fuel Limit set point on Menu C. Set Start Fuel Limit to 20%. The output current should be 42 ± 2 mA (4.2 ± 0.2 mA for the 20 mA output versions of the 700 control).

3. Set the Start Fuel Limit to 100%. The output current should be 210 ± 10 mA (20 ± 1 mA for the 20 mA output versions of the 700 control). If with all connections verified, the output of the control fails to perform as above, replace the control.

Speed Input

The following tests verify the operation of the Speed Input.

1. Connect an audio frequency signal generator to the speed signal input. Set the output level above 1.0 Vrms. Set the Number of Gear Teeth set point on Menu 1 to 60 (this causes the rpm values and Hertz values to be the same for ease of performing the tests).

2. Set the signal generator to 60 Hz. Read engine rpm value of 60 Hz on Menu D. Increase the signal generator frequency to 400 Hz. The value read should follow the signal generator frequency.

NOTICE **To prevent possible damage to the engine, return the Number of Gear Teeth to the correct value.**

Aux Output

The following tests calibrate and verify the operation of the Aux Output.

1. Connect a mA meter across the Aux 4+20 mA Output, terminal 5(+) and terminal 6(–). Select Menu 1 on the Set Point Programmer.

2. Set the Calibration Key to 49. Select Aux Output Configuration on Menu 1, and select Actuator Percent.

3. Select Actuator Output on Menu D and record the value shown.

4. Select 20mA Aux Actuator on Menu C and record the value. Then set to the same value recorded in step 3.

5. Select Aux Output Calibration on Menu 1 and update the value on the meter by pressing the up or down arrow until the meter reads 20.00 ± 0.01 mA.

IMPORTANT **If 4mA Aux Actuator and 20mA Aux Actuator are the same value, the Aux Output will be 0 mA.**

6. Select 20mA Aux Actuator on Menu C and reset to the original value recorded in step 4.

7. Select 4mA Aux Actuator on Menu C and record value. Then set to the same value recorded in step 3. The mA meter should read 4.00 ± 0.05 mA. Failure of this test indicates a faulty control, which should be replaced.

8. Select 4mA Aux Actuator on Menu C and reset to the original value recorded in step 7.

Conclusion of Test and Calibration Procedures

This completes the test and calibration section. Save the set points by pressing the "=" key on the Set Point Programmer. Power down the control for about 10 seconds. Restore power and verify that all set points are as recorded.

NOTICE

To prevent possible damage to the engine resulting from improper control settings, make sure you save the set points before removing power from the control. Failure to save the set points before removing power from the control causes them to revert to the previously saved settings.

Disconnect the Set Point Programmer from the control. Close the cover over J1 and retighten the retaining screw.

⚠WARNING

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.

Table 6-1. System Troubleshooting

Problem	Cause	Remedy
Engine will not start. Actuator not moving to start fuel position. **IMPORTANT** If the actuator moves to start position, a problem with the engine fuel supply is indicated.	Supply voltage polarity reversed, or no supply voltage.	Check for supply voltage from terminals 1(+) to 2(–). Reverse leads if polarity is incorrect.
	Actuator not responding to input signal from control. **IMPORTANT** The pneumatic actuator must have air pressure to operate (respond).	If there is a voltage output at control terminals 3(+) and 4(–), but the actuator does not move, check the wiring to the actuator for opens or shorts. With EG-P actuators, remember that terminals C and D of the mating plug should be jumpered. Make resistance checks at the actuator. Coil resistance is approximately 35 ohms. (Read with leads at T3 and T4 disconnected.)
	Start fuel limit set too low.	Increase start fuel limit until engine starts. Check actuator and linkage for proper installation and operation. Problems may be oil supply, air supply, direction of rotation, insufficient drainage, linkage, worn actuator components, or improper adjustment.
	No actuator voltage at terminals 3 and 4.	Check for shorted or grounded actuator leads by removing wires to terminals 3 and 4. Check for at least 1 Vrms at terminals 15 and 16, and at least 5% of the minimum rated speed frequency range.
	Speed setting too low on initial start.	Speed setting may be lower than cranking speed. Control should be set for rated speed. Increase Rated Speed setting. **NOTICE** **If adjusting Rated Speed does not produce the correct output, return Rated Speed setting to normal start position.**
	Idle Speed setting may be set too low.	Adjust idle speed.

Problem	Cause	Remedy
Engine will not start. Actuator not moving to start fuel position. (continued)	Minimum Fuel contact open.	Check T9. Minimum Fuel contact must be closed for normal operation. Check for 20 to 45 Vdc from terminal 9(+) to 8(–).
	Speed sensor signal not clearing failed speed signal circuit.	Check wiring for proper connection. Check shields for proper installation. Speed sensor not spaced properly. Check for at least 1.0 Vac at terminals 15 and 16 during cranking. If less than 1.0 Vac, magnetic pickup may be spaced too far from gear. Make sure there are no metal chips on end of pickup. If no voltage is present, magnetic pickup may be open-circuited or shorted. Make resistance check with the leads disconnected from control. Should be about 100 to 300 Ω. Failed speed-signal circuit may be disabled by connecting 20 to 45 Vdc to terminal 14. **⚠WARNING** **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.**
	Faulty 700 control.	Replace control.
Engine overspeeds only on starts.	Ramp adjustment	Increase Ramp Time. This decreases acceleration rate (from low idle to rated).
	Rated Speed setting too high.	Set Rated Speed as described in Chapter 3.
	Control adjustment.	Control may be adjusted for sluggish operation causing overspeed on start. Slowly adjust GAIN for fastest stable response. RESET may be adjusted too low. Increase RESET setting.
	Determine if engine is malfunctioning.	Verify that fuel rack is not binding and linkage is properly adjusted. It may be necessary to determine if the fuel rack is quickly following the actuator input voltage. Verify proper operation of overspeed protection devices to determine if a shutdown is occurring without an overspeed condition.
	700 control.	If the control does not cut back the actuator voltage (T3 and T4), the 700 control may be faulty. If the voltage is cut back, look for a problem in the linkage or actuator.
Engine overspeeds after operating at rated speed for some time.	Engine.	Check for proper operation of engine fuel system. If actuator moves toward minimum fuel during overspeed, problem is in fuel system.
	Magnetic pickup and 700 control.	Check the magnetic pickup output voltage at speeds above idle , at least 1.0 Vrms. If magnetic pickup should fail and the speed-signal-override-failed circuit is disabled, the 700 control will call for maximum fuel.

Problem	Cause	Remedy
Low speed is not regulated at idle speed.	Actuator and linkage. **IMPORTANT** On carbureted engines, the minimum fuel stop rpm setting will vary with engine temperature. An improper cold setting may give interference with the Idle Speed setting when the engine is hot.	The Idle Speed setting may be below the minimum-fuel position of the actuator or engine fuel stop. In this case, the output voltage to the actuator will be zero. The engine will be maintained at the minimum-fuel position by the actuator or the engine minimum-fuel stop. These conditions indicate that the engine minimum-fuel position should be decreased by linkage adjustment (diesel engine) or low-idle set screw (gas engine), or the Idle Speed setting should be raised. If this action does not correct the problem, the 700 control may be faulty.
Engine does not decelerate when Rated contact is open.	Faulty Rated contact.	Check Rated contact. Remove wire from terminal 10. Engine should decelerate.
	700 control ramp circuitry.	A faulty Rated contact may remain in the accelerate position with the contact open. If the Rated contact is operative, loss of idle control may be due to a faulty circuit. **⚠WARNING** **The speed-setting controls have sufficient range to override the ramp and bring the engine speed up to rated while still in the low-idle mode (either by defect or switching). Therefore, a Rated contact that is intermittent may cause the engine to overspeed if the Rated Speed setting is adjusted for rated speed with T10 open.**
Engine will not stabilize at rated no-load speed. The instability may occur at no load or it may vary with load. Control may be erratic.	700 control.	Adjust GAIN, RESET, and ACTUATOR COMPENSATION as described in Chapter 3.
	Improper linkage adjustment.	Make sure that the actuator moves approximately 2/3 of its travel from no load to full load. Be sure linkage is linear on turbine, diesel, and fuel-injected engines. Be sure linkage is nonlinear on carbureted engines. Refer to actuator manual for proper installation.

Problem	Cause	Remedy
Engine will not stabilize at rated no-load speed. The instability may occur at no load or it may vary with load. Control may be erratic. (continued)	Necessary external wires not properly shielded. (Electrical noise, caused by wiring carrying an ac voltage, stray magnetic fields from transformers, etc., can be picked up by improperly shielded wire. Noise will cause instability if picked up by magnetic pickup lines and actuator lines.)	The following tests will isolate noise and interference. Verify that the switchgear frame, governor chassis, and engine have a common ground connection. Temporarily remove the battery-charger cables from the control battery system. If the prime-mover operation is significantly improved by these modifications, replace the wires one at a time to locate the source of the trouble. External wiring may require additional shielding or rerouting from high-current lines or components. If the problem cannot be solved by these checks, it will be necessary to remove the 700 control from the switchgear. Temporarily mount the control next to the engine and connect only a battery, magnetic pickup, and actuator to the control (use a separate battery placed next to the engine). After starting the engine, if necessary, apply load to check stability. If stability occurs when the control is mounted next to the engine, return the control to the switchgear. Run new magnetic pickup, actuator, and battery power lines. Shield all wires to the control. Route all wires through conduit or an outer shield. Tie the outer shield to system ground at the end opposite to the control.
Engine will not stabilize at rated no-load speed. The instability may occur at no load or it may vary with load. Control may be erratic. (continued)	Engine may not be receiving fuel as called for by the actuator voltage.	Check actuator linkage to fuel-controlling mechanism for any lost motion, binding, or excessive loading. Verify a steady fuel pressure of proper value. Check actuator per appropriate manual.
	Engine not operating properly.	Engine may be causing speed variations. Control engine manually to determine if instability is in engine or governor control. Verify proper adjustment of fuel control linkage.
	Input voltage low.	Check supply voltage. It should be at least 18 Vdc or 88 Vac.
Engine does not maintain constant speed (isochronous).	Actuator.	If actuator has a ballhead backup, verify that its hydraulic governor section, speed setting, and speed droop adjustments are properly set (see the applicable governor manual).
	Engine.	If droop occurs near the full-load point only, it is possible the engine is not producing the power called for by the fuel control, or is being overloaded. Either is indicated if the fuel control is at maximum position.
	700 Control.	Check Max Fuel Limit setting. Increase if required. Check droop setting. Set to 0 if required.

Chapter 7.
Product Support and Service Options

Product Support Options

If you are experiencing problems with the installation, or unsatisfactory performance of a Woodward product, the following options are available:

1. Consult the troubleshooting guide in the manual.
2. Contact the **OE Manufacturer or Packager** of your system.
3. Contact the **Woodward Business Partner** serving your area.
4. Contact Woodward technical assistance via email (**EngineHelpDesk@Woodward.com**) with detailed information on the product, application, and symptoms. Your email will be forwarded to an appropriate expert on the product and application to respond by telephone or return email.
5. If the issue cannot be resolved, you can select a further course of action to pursue based on the available services listed in this chapter.

OEM or Packager Support: Many Woodward controls and control devices are installed into the equipment system and programmed by an Original Equipment Manufacturer (OEM) or Equipment Packager at their factory. In some cases, the programming is password-protected by the OEM or packager, and they are the best source for product service and support. Warranty service for Woodward products shipped with an equipment system should also be handled through the OEM or Packager. Please review your equipment system documentation for details.

Woodward Business Partner Support: Woodward works with and supports a global network of independent business partners whose mission is to serve the users of Woodward controls, as described here:

- A **Full-Service Distributor** has the primary responsibility for sales, service, system integration solutions, technical desk support, and aftermarket marketing of standard Woodward products within a specific geographic area and market segment.
- An **Authorized Independent Service Facility (AISF)** provides authorized service that includes repairs, repair parts, and warranty service on Woodward's behalf. Service (not new unit sales) is an AISF's primary mission.
- A **Recognized Engine Retrofitter (RER)** is an independent company that does retrofits and upgrades on reciprocating gas engines and dual-fuel conversions, and can provide the full line of Woodward systems and components for the retrofits and overhauls, emission compliance upgrades, long term service contracts, emergency repairs, etc.

A current list of Woodward Business Partners is available at **www.woodward.com/directory**.

Product Service Options

Depending on the type of product, the following options for servicing Woodward products may be available through your local Full-Service Distributor or the OEM or Packager of the equipment system.

- Replacement/Exchange (24-hour service)
- Flat Rate Repair
- Flat Rate Remanufacture

Replacement/Exchange: Replacement/Exchange is a premium program designed for the user who is in need of immediate service. It allows you to request and receive a like-new replacement unit in minimum time (usually within 24 hours of the request), providing a suitable unit is available at the time of the request, thereby minimizing costly downtime.

This option allows you to call your Full-Service Distributor in the event of an unexpected outage, or in advance of a scheduled outage, to request a replacement control unit. If the unit is available at the time of the call, it can usually be shipped out within 24 hours. You replace your field control unit with the like-new replacement and return the field unit to the Full-Service Distributor.

Flat Rate Repair: Flat Rate Repair is available for many of the standard mechanical products and some of the electronic products in the field. This program offers you repair service for your products with the advantage of knowing in advance what the cost will be.

Flat Rate Remanufacture: Flat Rate Remanufacture is very similar to the Flat Rate Repair option, with the exception that the unit will be returned to you in "like-new" condition. This option is applicable to mechanical products only.

Returning Equipment for Repair

If a control (or any part of an electronic control) is to be returned for repair, please contact your Full-Service Distributor in advance to obtain Return Authorization and shipping instructions.

When shipping the item(s), attach a tag with the following information:
- return number;
- name and location where the control is installed;
- name and phone number of contact person;
- complete Woodward part number(s) and serial number(s);
- description of the problem;
- instructions describing the desired type of repair.

Packing a Control

Use the following materials when returning a complete control:
- protective caps on any connectors;
- antistatic protective bags on all electronic modules;
- packing materials that will not damage the surface of the unit;
- at least 100 mm (4 inches) of tightly packed, industry-approved packing material;
- a packing carton with double walls;
- a strong tape around the outside of the carton for increased strength.

NOTICE

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*.

Replacement Parts

When ordering replacement parts for controls, include the following information:
- the part number(s) (XXXX-XXXX) that is on the enclosure nameplate;
- the unit serial number, which is also on the nameplate.

Engineering Services

Woodward's Full-Service Distributors offer various Engineering Services for our products. For these services, you can contact the Distributor by telephone or by email.

- Technical Support
- Product Training
- Field Service

Technical Support is available from your equipment system supplier, your local Full-Service Distributor, or from many of Woodward's worldwide locations, depending upon the product and application. This service can assist you with technical questions or problem solving during the normal business hours of the Woodward location you contact.

Product Training is available as standard classes at many Distributor locations. Customized classes are also available, which can be tailored to your needs and held at one of our Distributor locations or at your site. This training, conducted by experienced personnel, will assure that you will be able to maintain system reliability and availability.

Field Service engineering on-site support is available, depending on the product and location, from one of our Full-Service Distributors. The field engineers are experienced both on Woodward products as well as on much of the non-Woodward equipment with which our products interface.

For information on these services, please contact one of the Full-Service Distributors listed at **www.woodward.com/directory**.

Contacting Woodward's Support Organization

For the name of your nearest Woodward Full-Service Distributor or service facility, please consult our worldwide directory published at **www.woodward.com/directory**.

You can also contact the Woodward Customer Service Department at one of the following Woodward facilities to obtain the address and phone number of the nearest facility at which you can obtain information and service.

Products Used In Electrical Power Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany:	
Kempen	+49 (0) 21 52 14 51
Stuttgart	+49 (711) 78954-510
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
Poland	+48 12 295 13 00
United States	+1 (970) 482-5811

Products Used In Engine Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany	+49 (711) 78954-510
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
United States	+1 (970) 482-5811

Products Used In Industrial Turbomachinery Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
Poland	+48 12 295 13 00
United States	+1 (970) 482-5811

For the most current product support and contact information, please visit our website directory at **www.woodward.com/directory**.

Technical Assistance

If you need to contact technical assistance, you will need to provide the following information. Please write it down here before contacting the Engine OEM, the Packager, a Woodward Business Partner, or the Woodward factory:

General

Your Name _____

Site Location _____

Phone Number _____

Fax Number _____

Prime Mover Information

Manufacturer _____

Engine Model Number _____

Number of Cylinders _____

Type of Fuel (gas, gaseous, diesel, dual-fuel, etc.) _____

Power Output Rating _____

Application (power generation, marine, etc.) _____

Control/Governor Information

Control/Governor #1

Woodward Part Number & Rev. Letter _____

Control Description or Governor Type _____

Serial Number _____

Control/Governor #2

Woodward Part Number & Rev. Letter _____

Control Description or Governor Type _____

Serial Number _____

Control/Governor #3

Woodward Part Number & Rev. Letter _____

Control Description or Governor Type _____

Serial Number _____

Symptoms

Description _____

_____

If you have an electronic or programmable control, please have the adjustment setting positions or the menu settings written down and with you at the time of the call.

Appendix.
Programming Checklist

We recommend you write down the final value of each menu item here so you will have a record if you later need to reprogram or replace the control.

_____ Software Part Number and Revision Letter

A—Dynamics Menu

_____ 1. Gain
_____ 2. Reset
_____ 3. Compensation
_____ 4. Gain Ratio
_____ 5. Window Width
_____ 6. Gain Slope
_____ 7. Gain Breakpoint

B—Speed Setting Menu

_____ 1. Raise Limit
_____ 2. Lower Limit
_____ 3. Rated Speed Reference
_____ 4. Idle Speed Reference
_____ 5. Accel Time
_____ 6. Decel Time
_____ 7. Raise Rate
_____ 8. Lower Rate
_____ 9. 20 mA Remote Reference
_____ 10. 4 mA Remote Reference
_____ 11. 20 mA Tachometer RPM
_____ 12. 4 mA Tachometer RPM
_____ 13. Droop

C—Fuel Limiters Menu

_____ 1. Start Speed
_____ 2. Start Fuel Limit
_____ 3. Idle Fuel Limit
_____ 4. Maximum Fuel Limit
_____ 5. Minimum Actuator
_____ 6. Min Rack Limit (9905-465 only)
_____ 7. Rack Limit @ Min (9905-465 only)
_____ 8. BP Rack Limit (9905-465 only)
_____ 9. Rack Limit @ BP (9905-465 only)
_____ 10. Max Rack Limit (9905-465 only)
_____ 11. Rack Limit @ Max (9905-465 only)
_____ 12. 20mA Aux Output
_____ 13. 4mA Aux Output

D—Display Menu

_____ 1. Engine Speed
_____ 2. Speed Reference
_____ 3. Actuator Output
_____ 4. Auxiliary Output
_____ 5. Remote Input
_____ 6. Rack Limit Input (9905-465 only)
_____ 7. Run/Stop Switch
_____ 8. Idle/Rated Switch
_____ 9. Lower Switch
_____ 10. Raise Switch
_____ 11. Remote Switch
_____ 12. Failsafe On/Off Switch
_____ 13. Watchdog Status
_____ 14. Self Test Result
_____ 15. ROM Check Sum

1—Calibration/Configuration Menu

_____ 1. Calibration Key
_____ 2. Number of Gear Teeth
_____ 3. Aux Output Configuration
_____ 4. Aux Output Calibration
_____ 5. Remote Input Calibration
_____ 6. Rack Limit Input Calibration (9905-465 only)

700 Menu Summary

A—Dynamics Menu
1. Gain
2. Reset
3. Compensation
4. Gain Ratio
5. Window Width
6. Gain Slope
7. Gain Breakpoint

B—Speed Setting Menu
1. Raise Limit
2. Lower Limit
3. Rated Speed Reference
4. Idle Speed Reference
5. Accel Time
6. Decel Time
7. Raise Rate
8. Lower Rate
9. 20 mA Remote Reference
10. 4 mA Remote Reference
11. 20 mA Tachometer RPM
12. 4 mA Tachometer RPM
13. Droop

C—Fuel Limiters Menu
1. Start Speed
2. Start Fuel Limit
3. Idle Fuel Limit
4. Maximum Fuel Limit
5. Minimum Actuator
6. Min Rack Limit (9905-465 only)
7. Rack Limit @ Min (9905-465 only)
8. BP Rack Limit (9905-465 only)
9. Rack Limit @ BP (9905-465 only)
10. Max Rack Limit (9905-465 only)
11. Rack Limit @ Max (9905-465 only)
12. 20mA Aux Output
13. 4mA Aux Output

D—Display Menu
1. Engine RPM
2. Speed Reference
3. Actuator Output
4. Auxiliary Output
5. Remote Input
6. Rack Limit Input (9905-465 only)
7. Run/Stop Switch
8. Idle/Rated Switch
9. Lower Switch
10. Raise Switch
11. Remote Switch
12. Watchdog Status
13. Self Test Result
14. ROM Check Sum

1—Calibration/Configuration Menu
1. Calibration Key
2. Number of Gear Teeth
3. Aux Output Configuration
4. Aux Output Calibration
5. Remote Input Calibration
6. Rack Limit Input Calibration (9905-465 only)

700 Digital Speed Control Specifications

Woodward Part Numbers:	
9905-110	700 w/ MPU, 24 Vdc power supply, 4–20 mA output, 24 Vdc discrete input voltage
9905-111	700 w/ MPU, 24 Vdc power supply, 0–200 mA output, 24 Vdc discrete input voltage
9905-112	700 w/ MPU, 115 Vac/dc power supply, 4–20 mA output, 5 Vdc discrete input voltage
9905-113	700 w/ MPU, 115 Vac/dc power supply, 0–200 mA output, 5 Vdc discrete input voltage
9905-114	700 w/ MPU, 115 Vac/dc power supply, 4–20 mA output, AUX discrete input voltage
9905-115	700 w/ MPU, 115 Vac/dc power supply, 0–200 mA output, AUX discrete input voltage
9905-248	700 w/ proximity switch, 115 Vac/dc power supply, 4–20 mA output, AUX discrete input voltage
9905-465	700 w/ MPU, 115 Vac/dc power supply, 0–200 mA output, AUX discrete input voltage, rack limiter
8280-107	Set Point Programmer
8280-106	700 Operator Control Panel
Power Supply Rating	18–40 Vdc (24 or 32 Vdc nominal) 88–132 Vac 50/60 Hz (120 Vac nominal) 90–150 Vdc (125 Vdc nominal)
Power Consumption	8 W nominal
Steady State Speed Band	MPU: 100–15 000 Hz (8–2100 rpm) proximity switch: 0–1000 Hz (8–2100 rpm)
Discrete Inputs (6)	5 Vdc or 24 Vdc (external), or 21 Vdc (internal)
Remote Speed Setting Input	4–20 mA
Rack Limiter Input	4–20 mA
Tachometer Output	4–20 mA
Programmer Serial Port	20 mA current loop, 9-pin D connector, 1200 baud, full duplex
Ambient Operating Temperature	–40 to +70 °C (–40 to +158 °F)
Storage Temperature	–55 to +105 °C (–67 to +221 °F)
EMI/RFI Specification	US MIL-STD 461C (Parts 5 & 9)

We appreciate your comments about the content of our publications.

Send comments to: icinfo@woodward.com

Please reference publication 85185D.

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