# GOVERNOR CONVERSIONS

2301A and DRU replacement of EGA and MOP

## Purpose of Discussion

The purpose of this discussion is to cover the conversions of governing systems used on Nuclear Power Plant Emergency Diesel Generators (EDG's) from the currently installed Woodward EGA Governor System to the Woodward 2301A Governing System.

The primary reason for the change is the obsolescence of the EGA system.

Secondarily, the 2301A system provides better control, including allowing for slow starting of the unit with capability to respond to 'emergency signal' whenever received.

# Learning Objectives

As a result of this discussion, you will be able to:

- describe the function of the engine control governor
- explain how the governor works
- explain droop and isochronous relationships
- understand the why and how of converting governor system
- learn which plants have already converted systems

## Purpose of Governor

The governor's purpose is to control the fuel to the engine cylinders so as to control the speed of the unit, holding the speed constant for all conditions of load imposed on the generator being driven by the engine. In order to maintain the frequency of the generator output, the engine speed must be held constant. The relationship between the generator output frequency and the engine speed is expressed by the formula:

$$F = N * P / 120$$

Where F is the frequency, N the engine speed in RPM, and P is the number of poles on the generator.

A 900 rpm engine requires an 8 pole generator to produce 60 hz power.

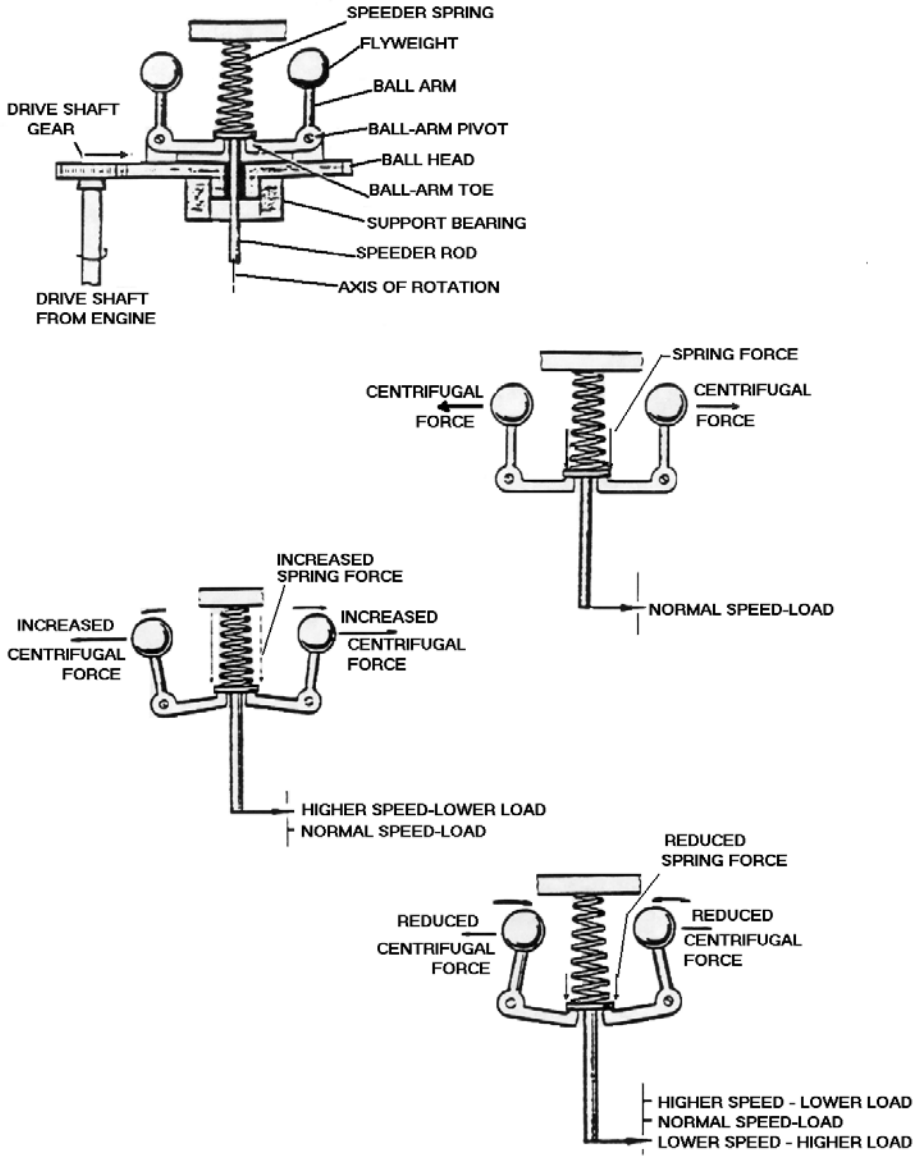



FIGURE 1 - BASIC MECHANICAL GOVERNOR

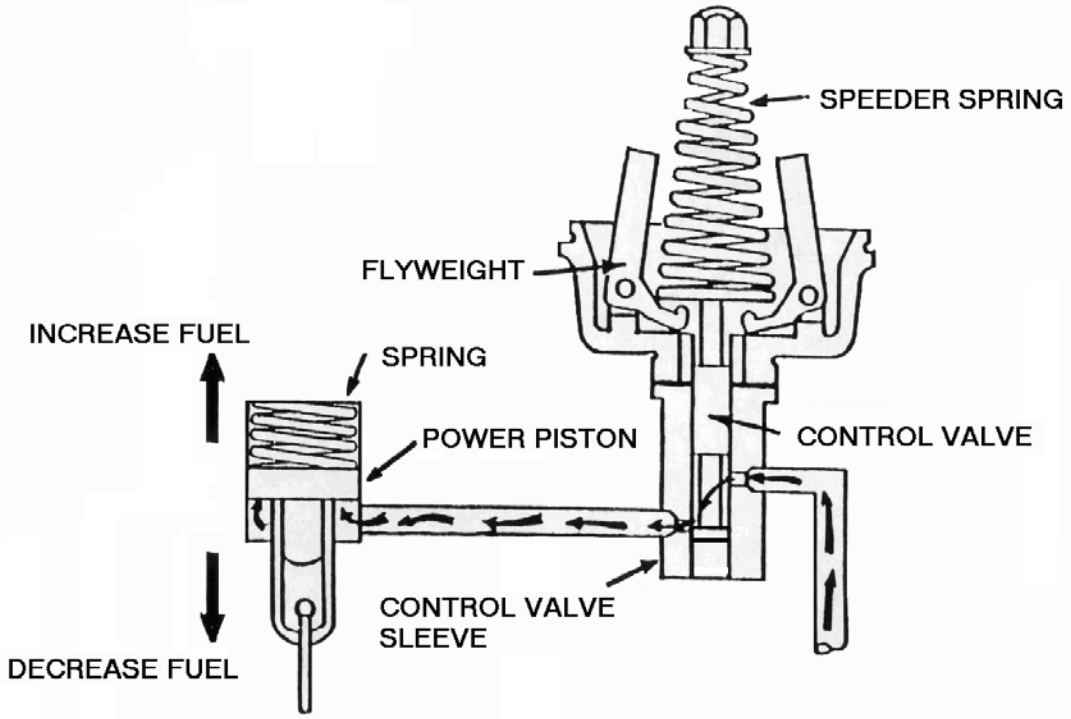



FIGURE 2 - BASIC GOVERNOR W/ HYDRAULIC POWER PISTON

## Basic Governor Elements

Every engine governing system must contain certain basic elements, whether the simple mechanical type or an electrical/electronic type. Those basic elements include:

- A speed sensing element
- A speed setting (reference) element
- An error sensing/correcting element
- A Power Element sufficient to manage the engine fuel controls
- A compensation/resetting/stabilizing element
- A means of determining the method of operation (droop or isochronous mode)(operating in parallel or alone)

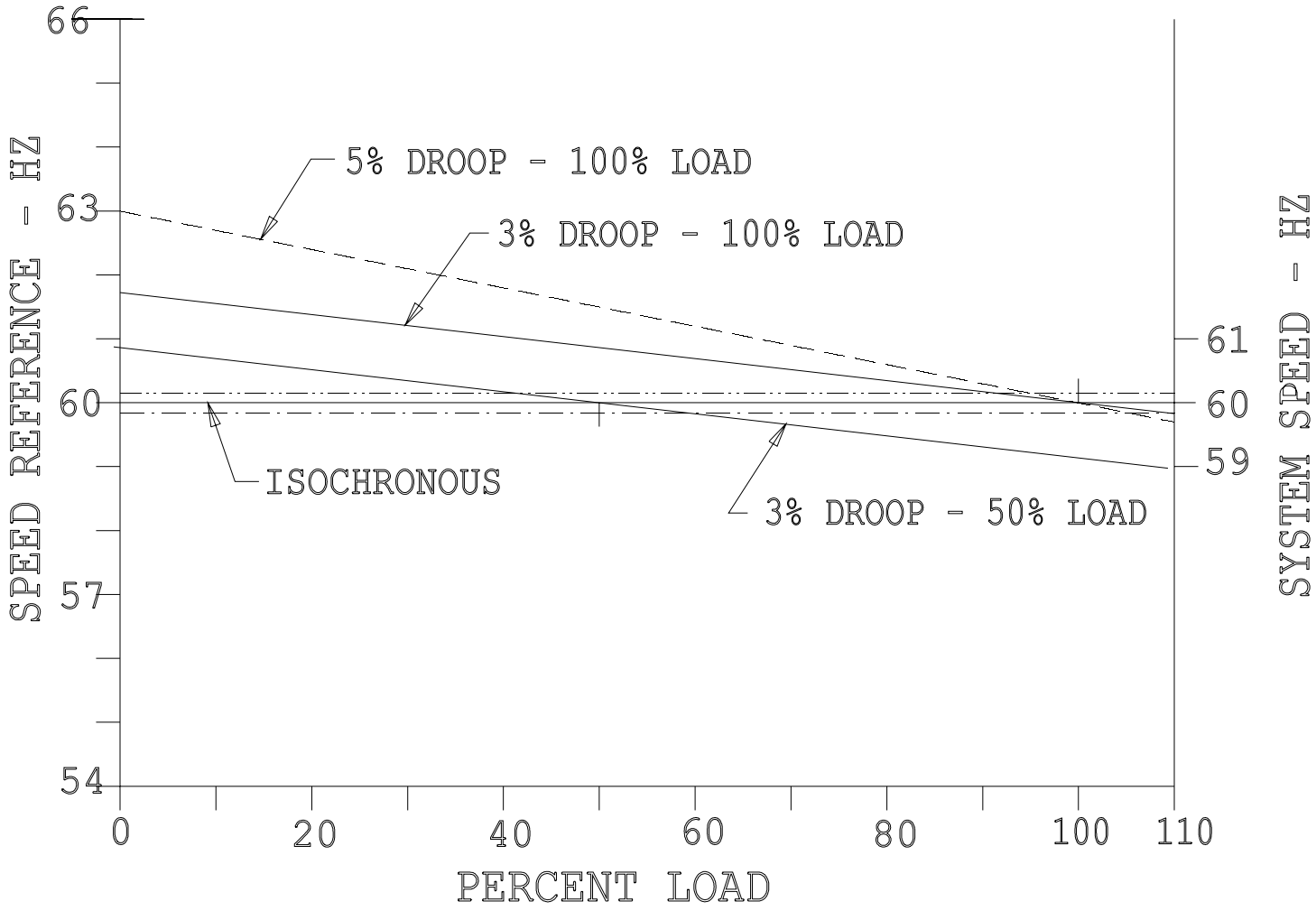
## Droop - Isochronous Relationship

Droop is defined as the percent change in speed as a unit goes from no-load to rated load condition. It can be expressed as:

Droop (%) = Speed Change * 100 / Rated Speed
Speed change = no-load speed - full-load speed

Isochronous means iso (same) chronous (time). Each revolution of the engine takes the same time - speed is constant.

Unit must be in Droop mode when paralleled to the offsite power system. Unit is most desirably in Isochronous when carrying loads on emergency bus during the emergency situation.


66
63
60
57
54
SPEED REFERENCE - HZ
5% DROOP - 100% LOAD
3% DROOP - 100% LOAD
ISOCHRONOUS
3% DROOP - 50% LOAD
61
60
59
SYSTEM SPEED - HZ
0
20
40
60
80
100
110
PERCENT LOAD

# Why CHANGE?

- EGA unit is obsolete
  - Electronic packages have changed
  - PCB would require redesign for new electronics
  - Few are still in service today.
- 2301A unit is newer design with improvements
  - Has better response and is a proportional design
  - Has features not available in older designs
  - Many are in service (little chance of being obsoleted).

# Governor Actuators

EGA Control System uses the EGB-10C or EGB-50C Actuator

- Integrating type system - zero input with no speed error
- Hydraulic Compensation circuit in actuator

2301A Control System uses the EGB-13P or EGB-50P

- Proportional type system - signal varies with speed error and fuel requirement
- Electronic Compensation in control box

Both are ‘reverse acting’ actuators (zero signal=maximum output).

Both have mechanical backup governor sections.

They physically appear very similar - see next figure.

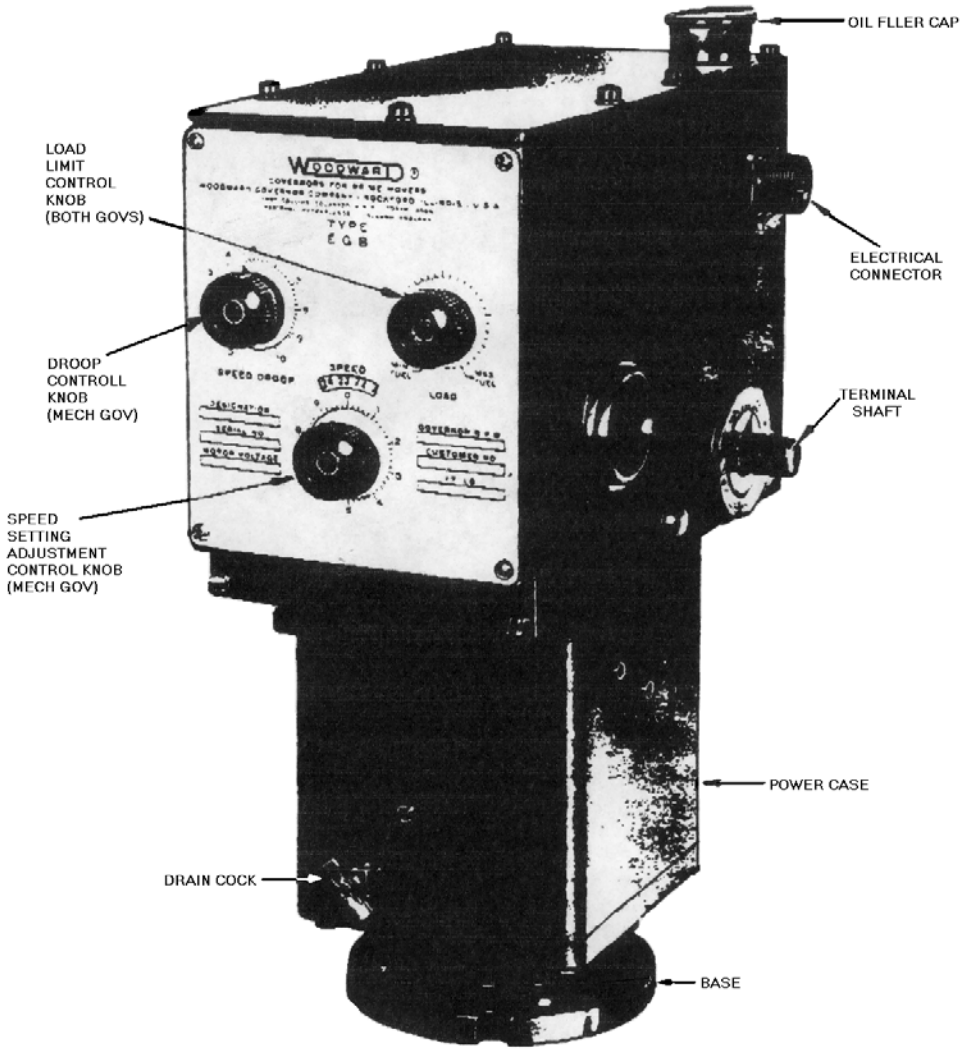



FIGURE 4 - HYDRAULIC ACTUATOR

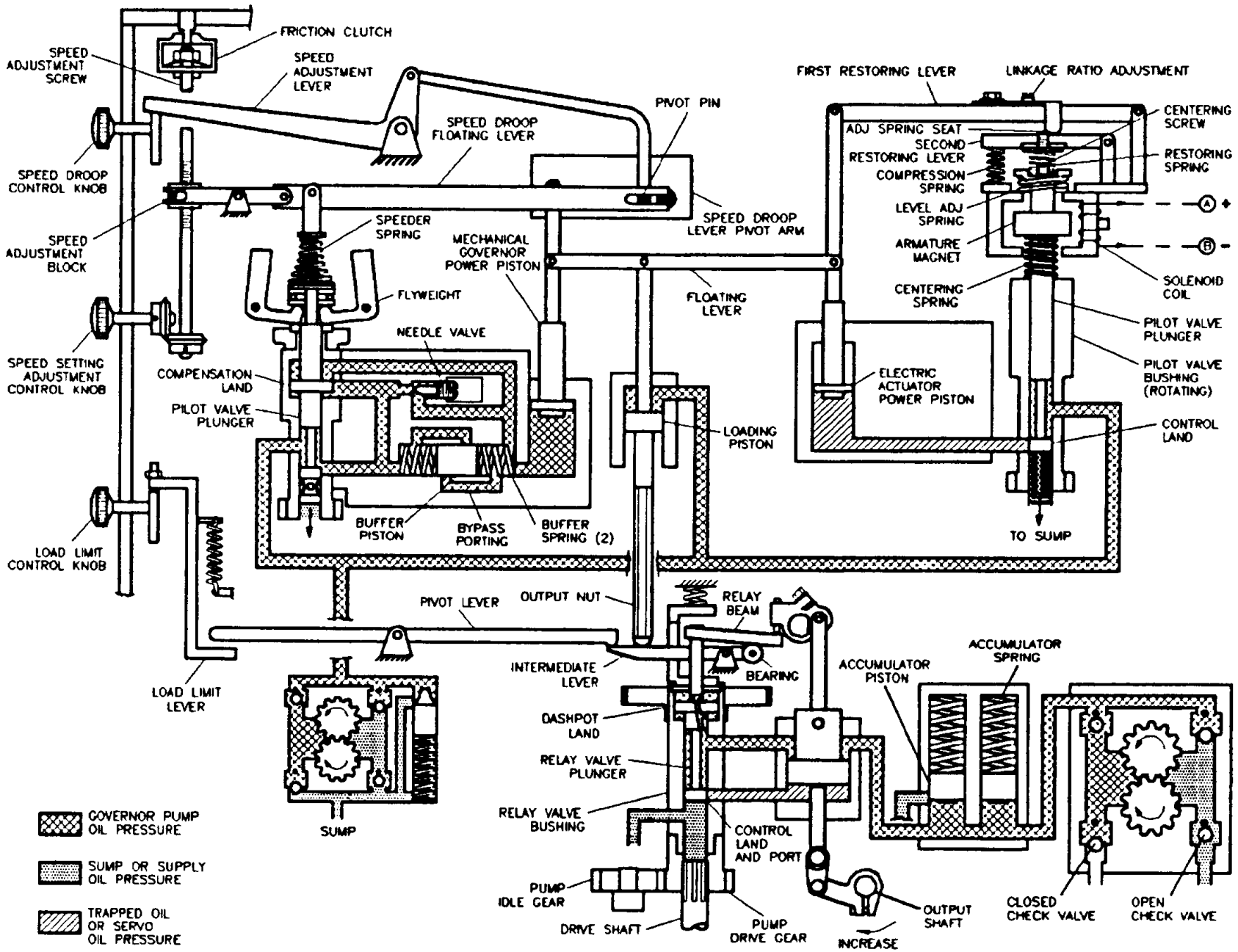



FIGURE 5A EGB-13P ACTUATOR SCHEMATIC

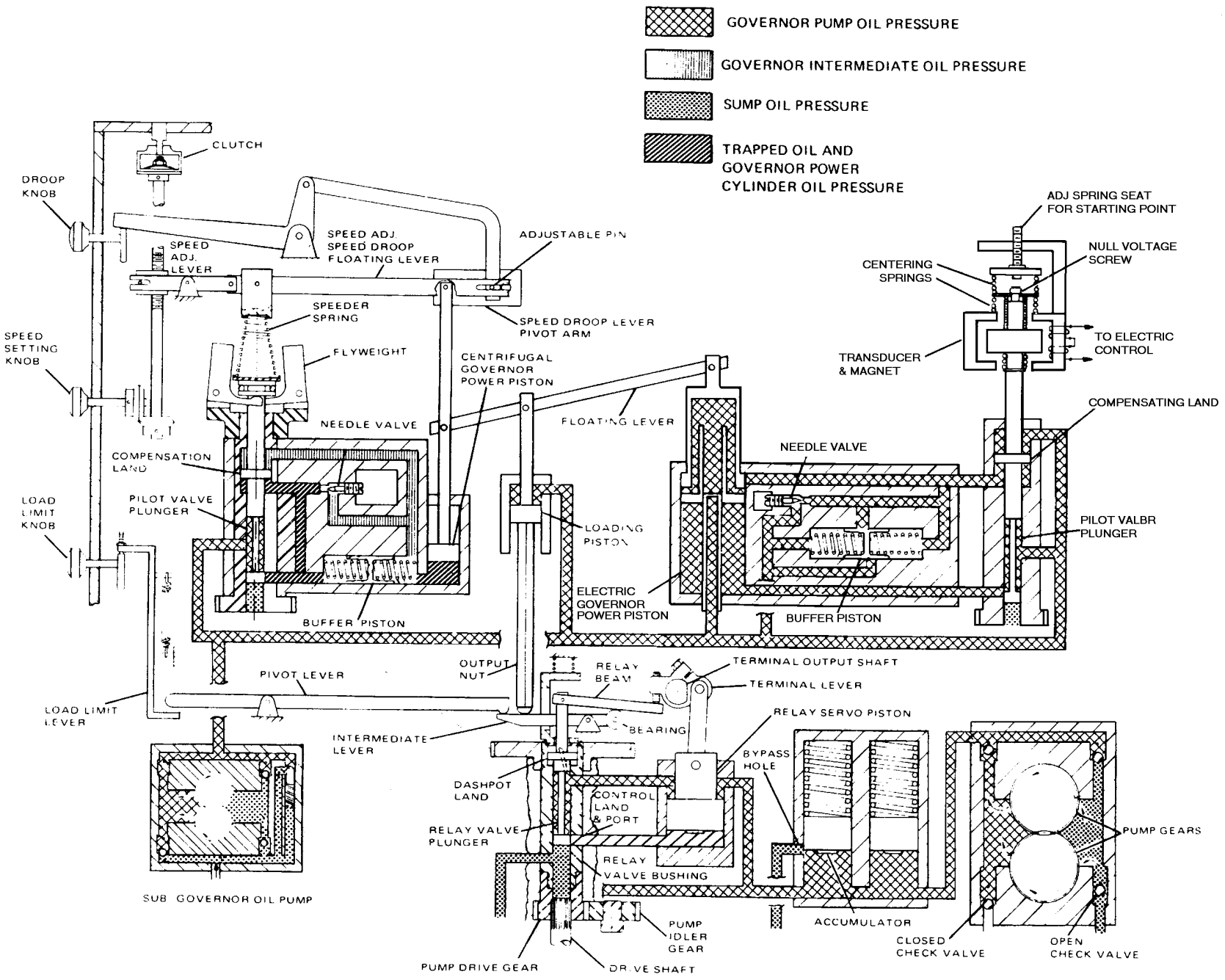



FIGURE 5B - EGB-10C ACTUATOR SCHEMATIC

## Control Packages

Controls are mounted in the control panels and/or switchgear and connected into the electrical system.

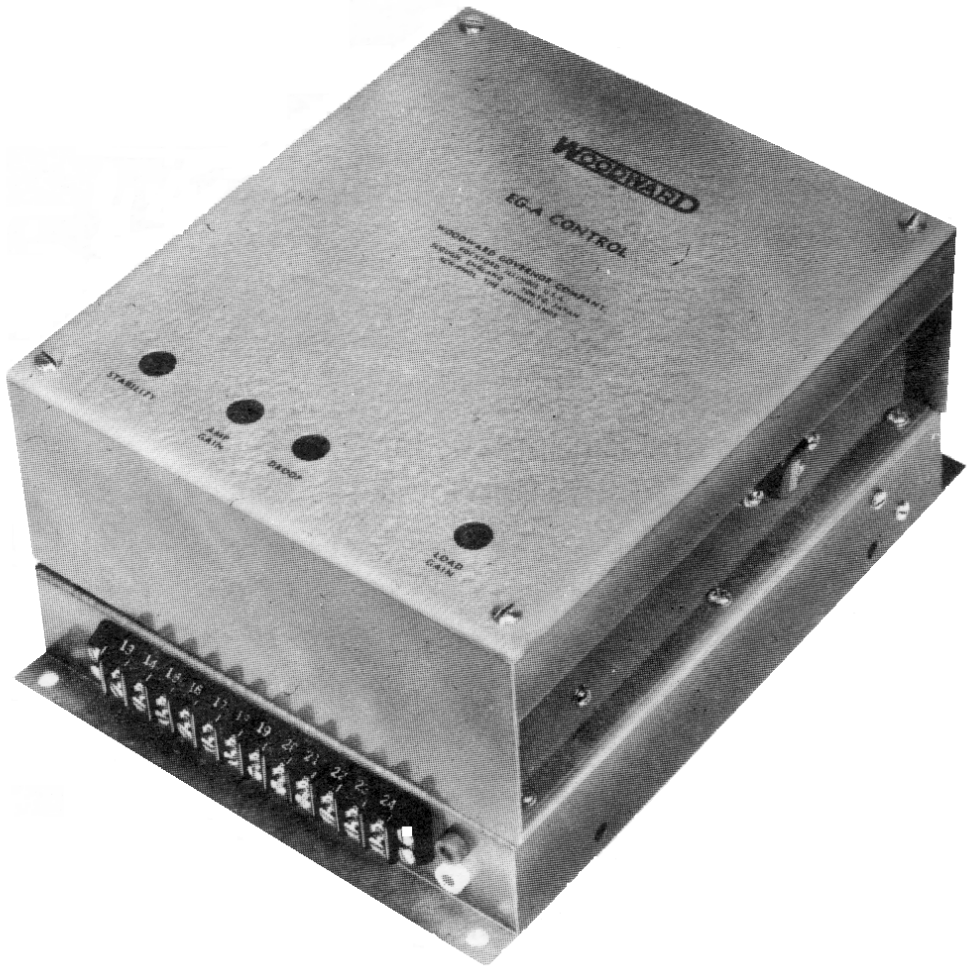



FIGURE 6A — EGA CONTROL BOX

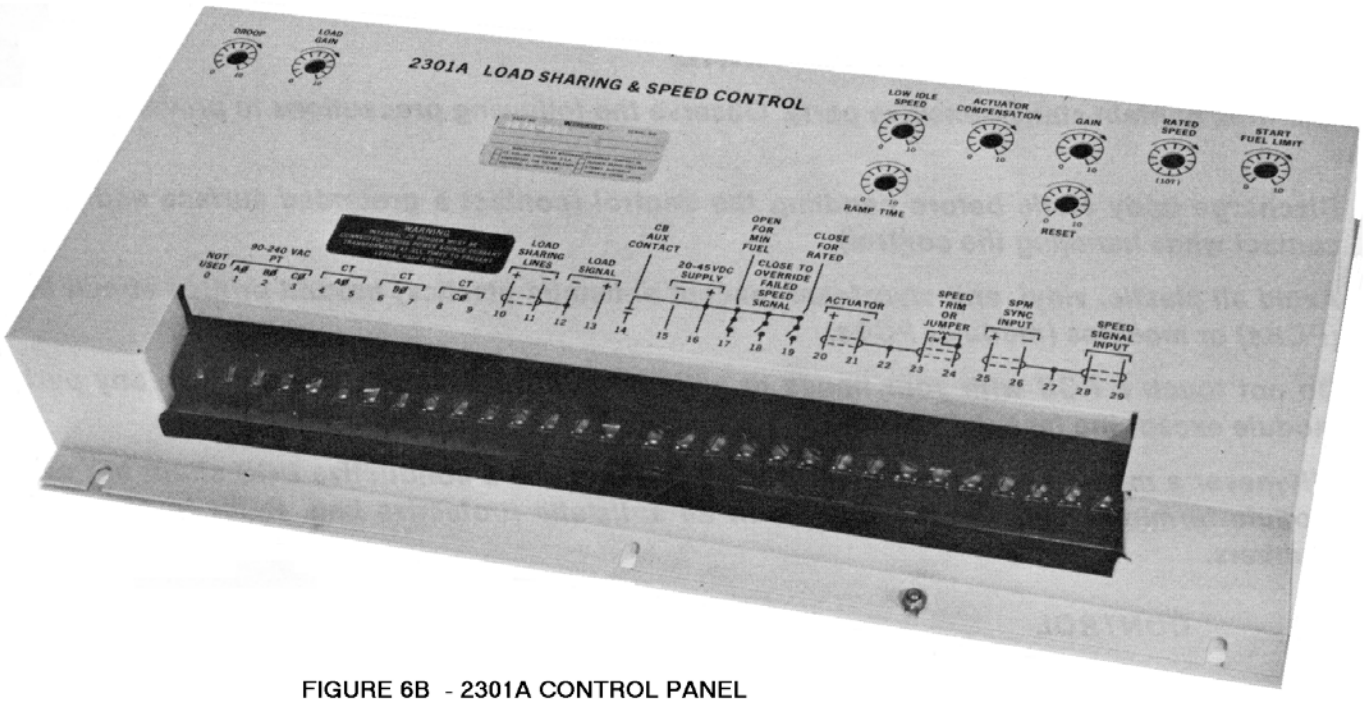



FIGURE 6B - 2301A CONTROL PANEL

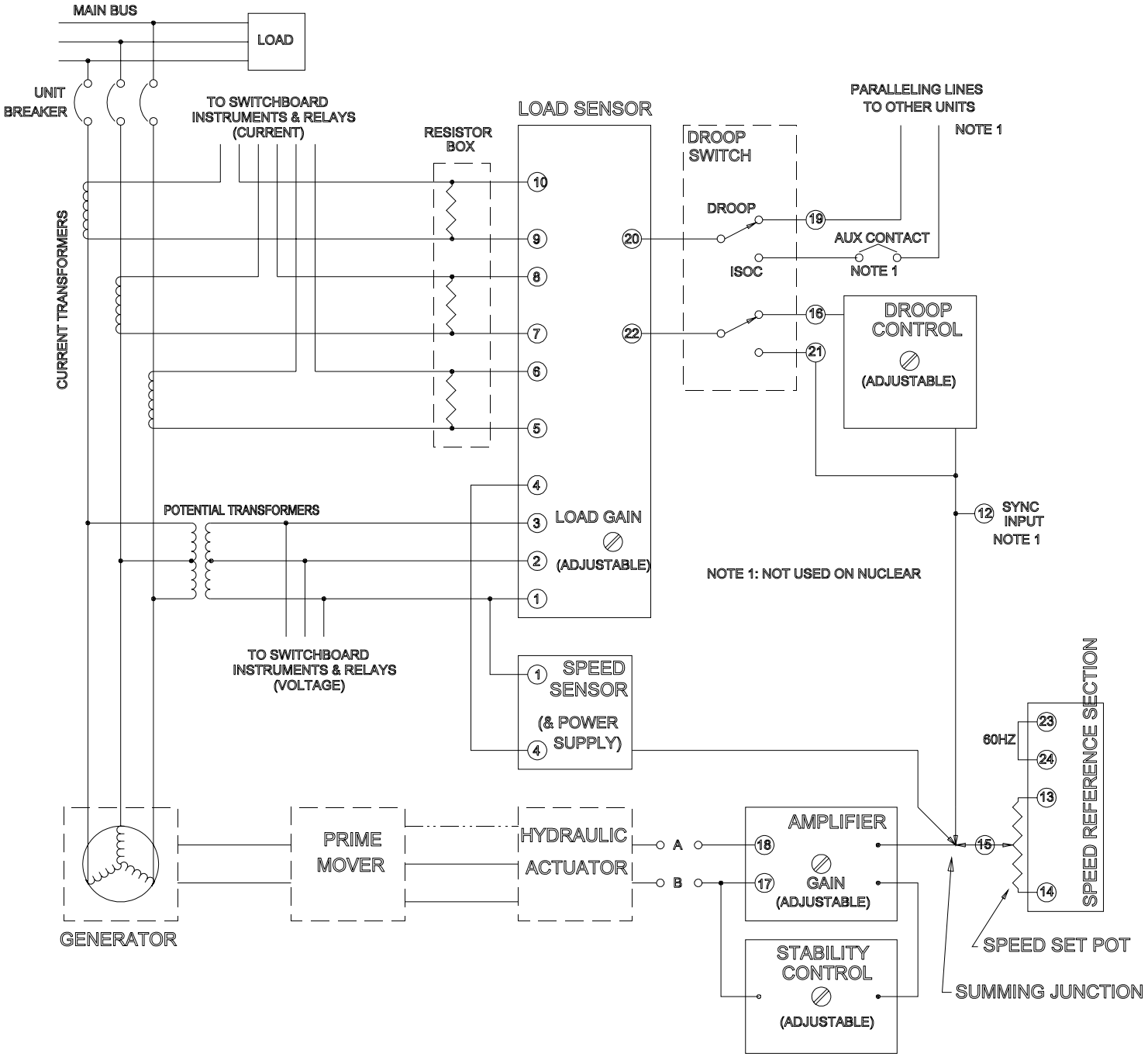



FIGURE 7 - EGA CONTROL BLOCK DIAGRAM

# EGA Summary

## EGA Advantages:

- Powered from Generator Voltages - Self Sufficient

## Disadvantages:

- No governing until Generator is at voltage
  - For power supply and
  - For Speed Sensing
- Will not operate at reduced speed (see above)
- Part of Compensation is hydraulics within actuator, subject to oil temperature and condition.

Most failures result in operation on backup governor in actuator (at higher speed)

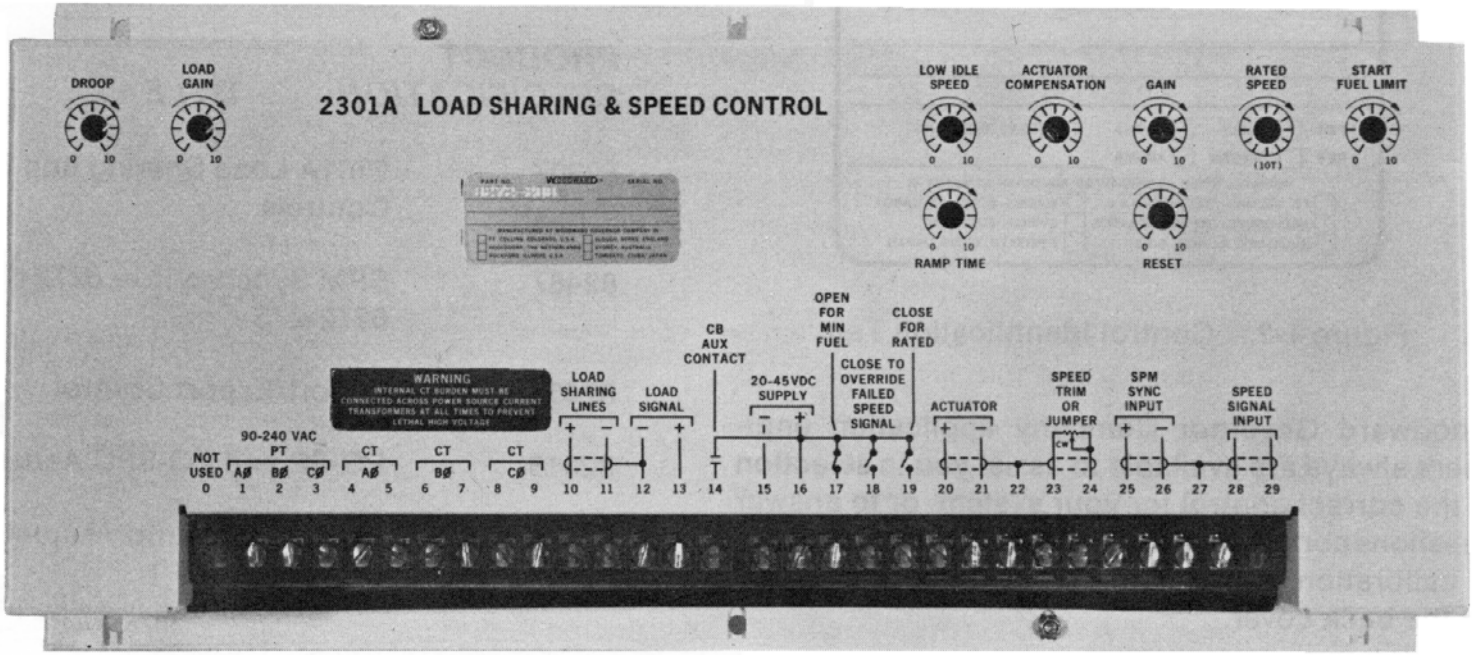



FIGURE 6C - 2301A CONTROL VIEW

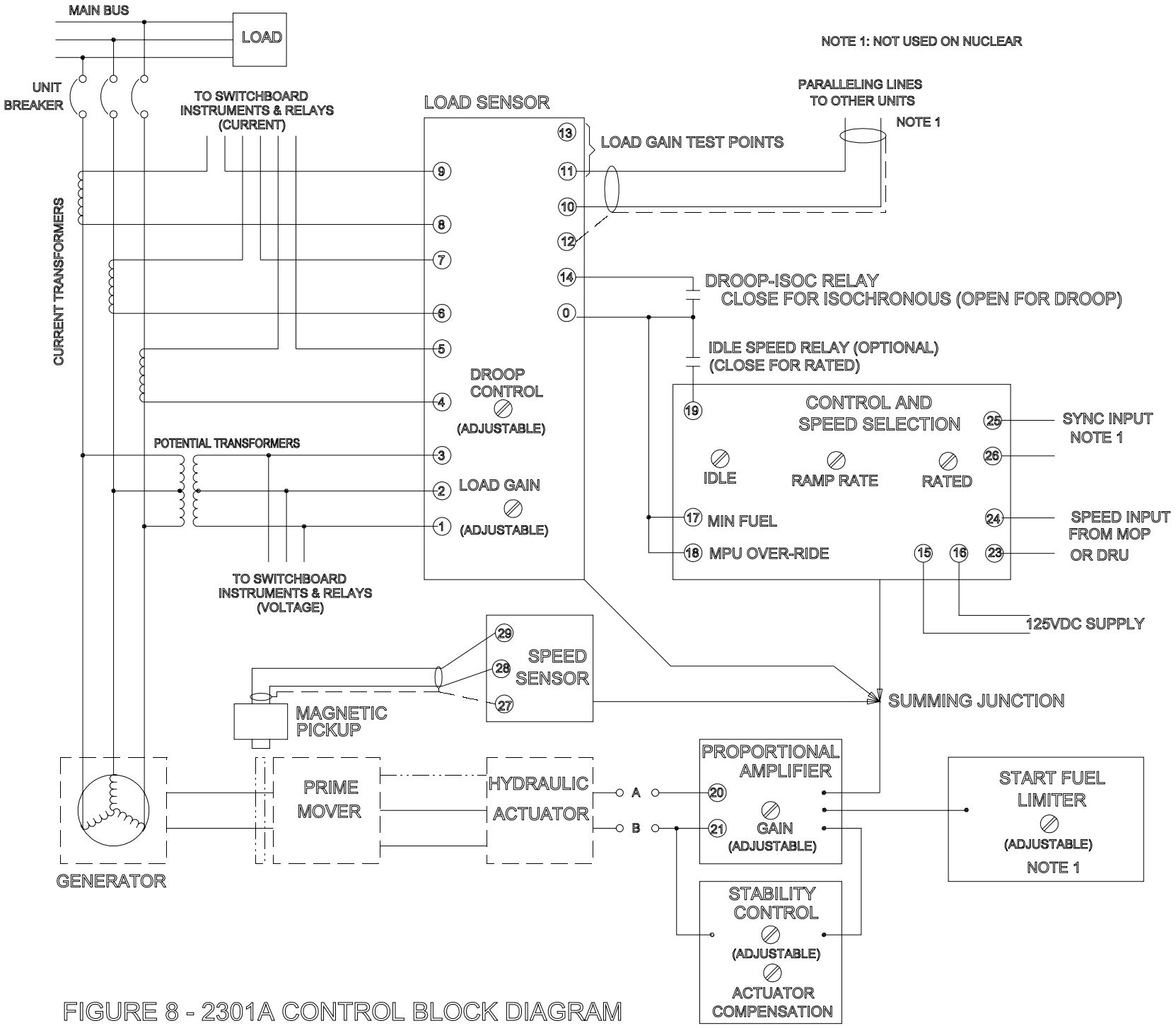



FIGURE 8 - 2301A CONTROL BLOCK DIAGRAM

FIGURE 9 - TYPICAL MAGNETIC PICKUP

## 2301A Summary

### Advantages:

- Control at all conditions (not dependent on Generator Voltages)
- In conjunction with DRU, can respond to Emergency Signal while shutdown or at idle
- All Compensation is electronic - tuned for best performance
- Can control at idle or rated speed equally well

### Disadvantages:

- Requires external power (125 VDC) to operate
- Requires Magnetic Pickup (MPU) for speed input
  - Requires gear wheel on engine/generator
  - (MPU's are very reliable)

Most failures result in operation on backup governor (at higher speed)

## Speed Input Devices

Either of the speed input devices discussed here can be used on either the EGA or the 2301A systems equally well.

The use of the DRU with the 2301A results in much more flexibility in the operational capabilities of the EDG.

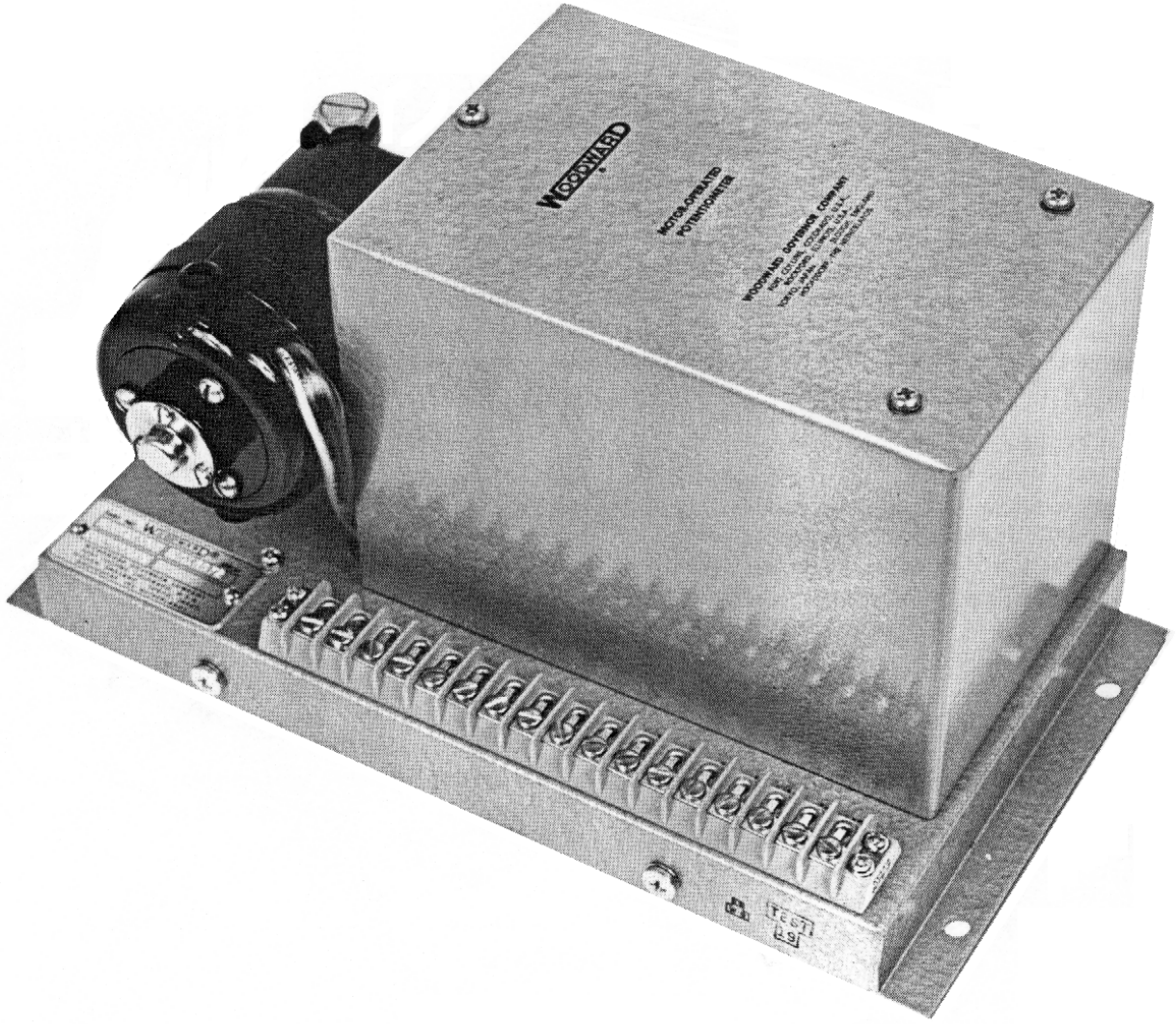



FIGURE 10 - MOP FOR 125VDC MOTOR

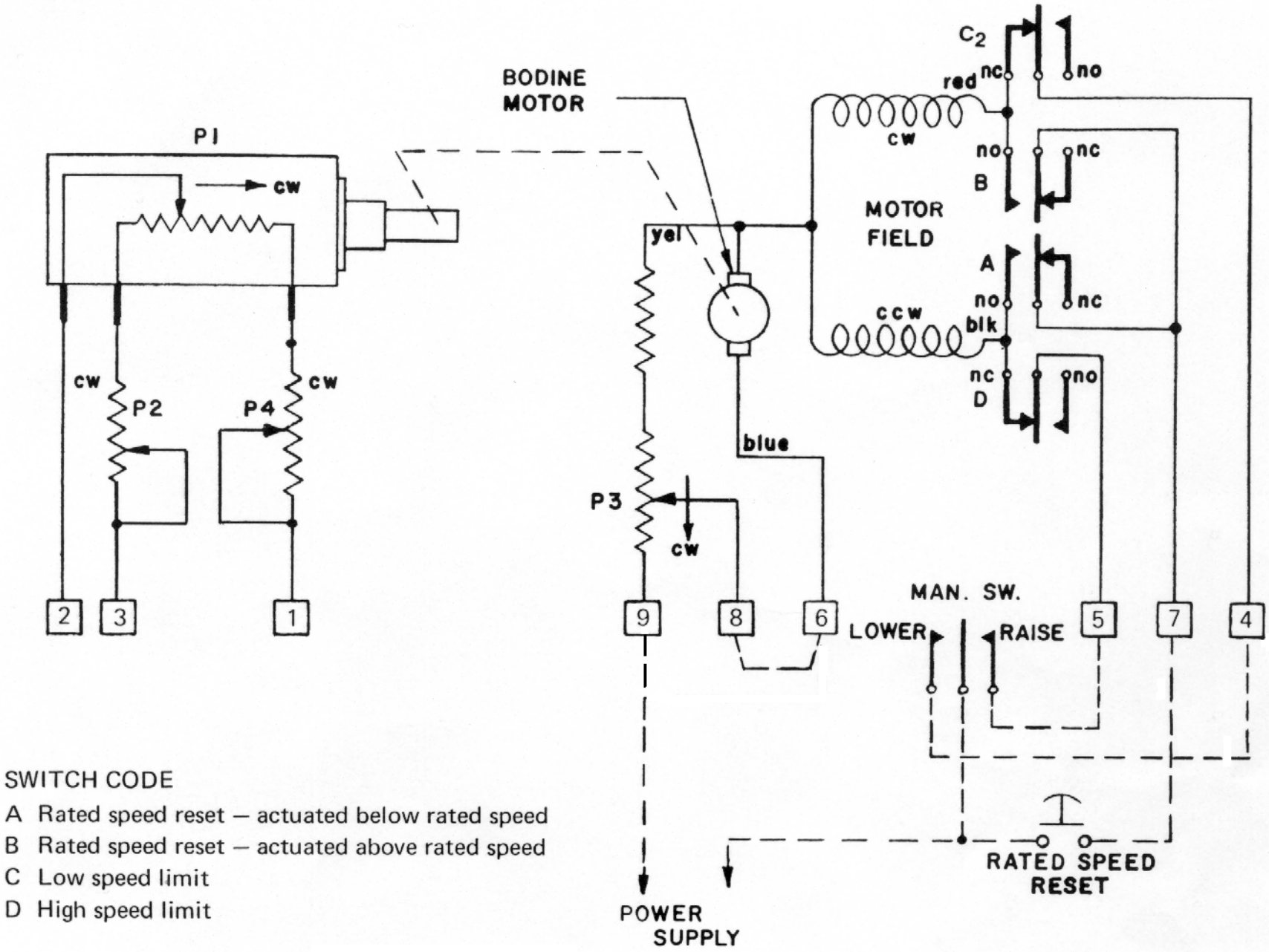



FIGURE 11 - SCHEMATIC OF MOP UNIT

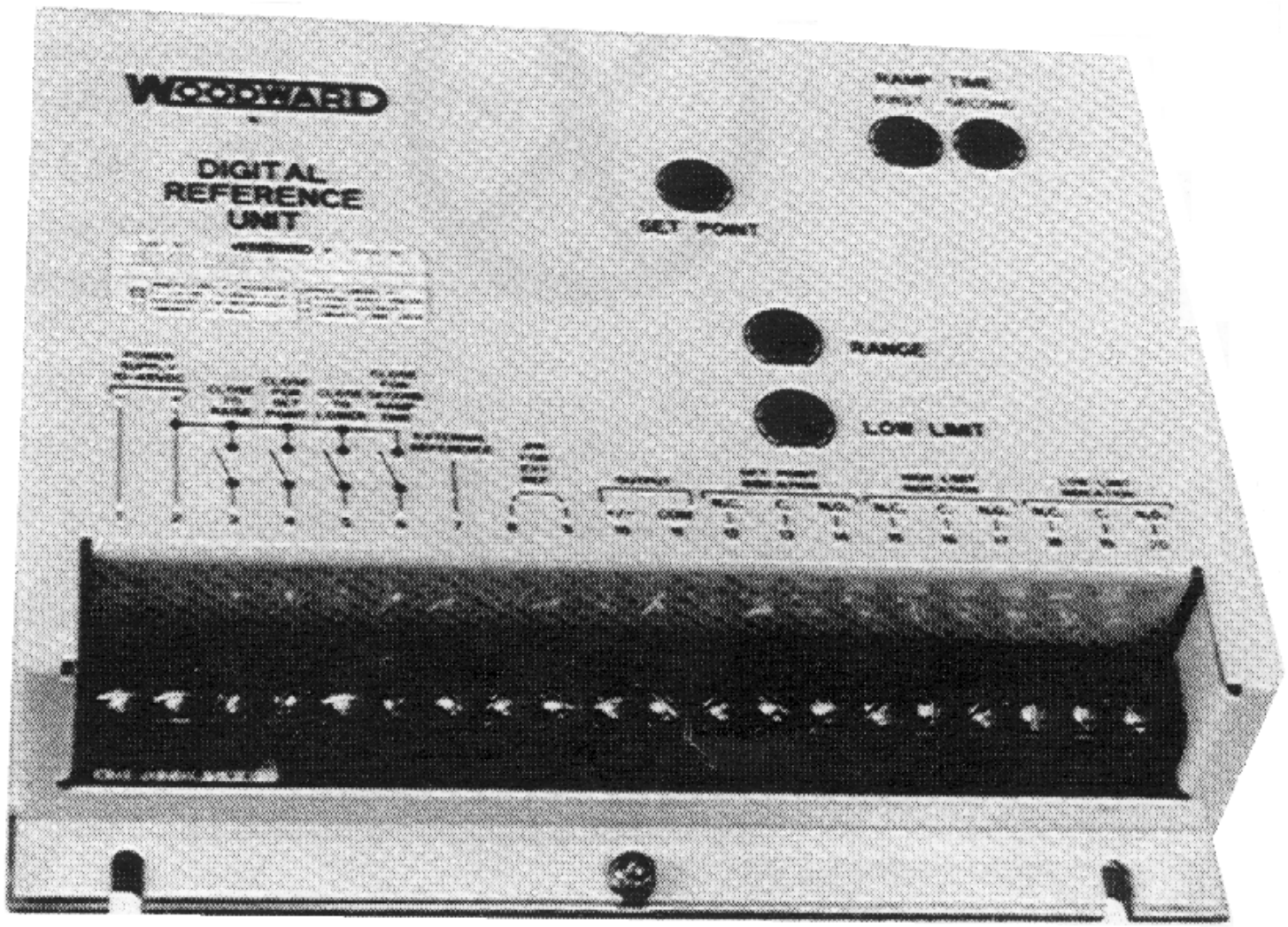



FIGURE 12 - DIGITAL REFERENCE UNIT (DRU)

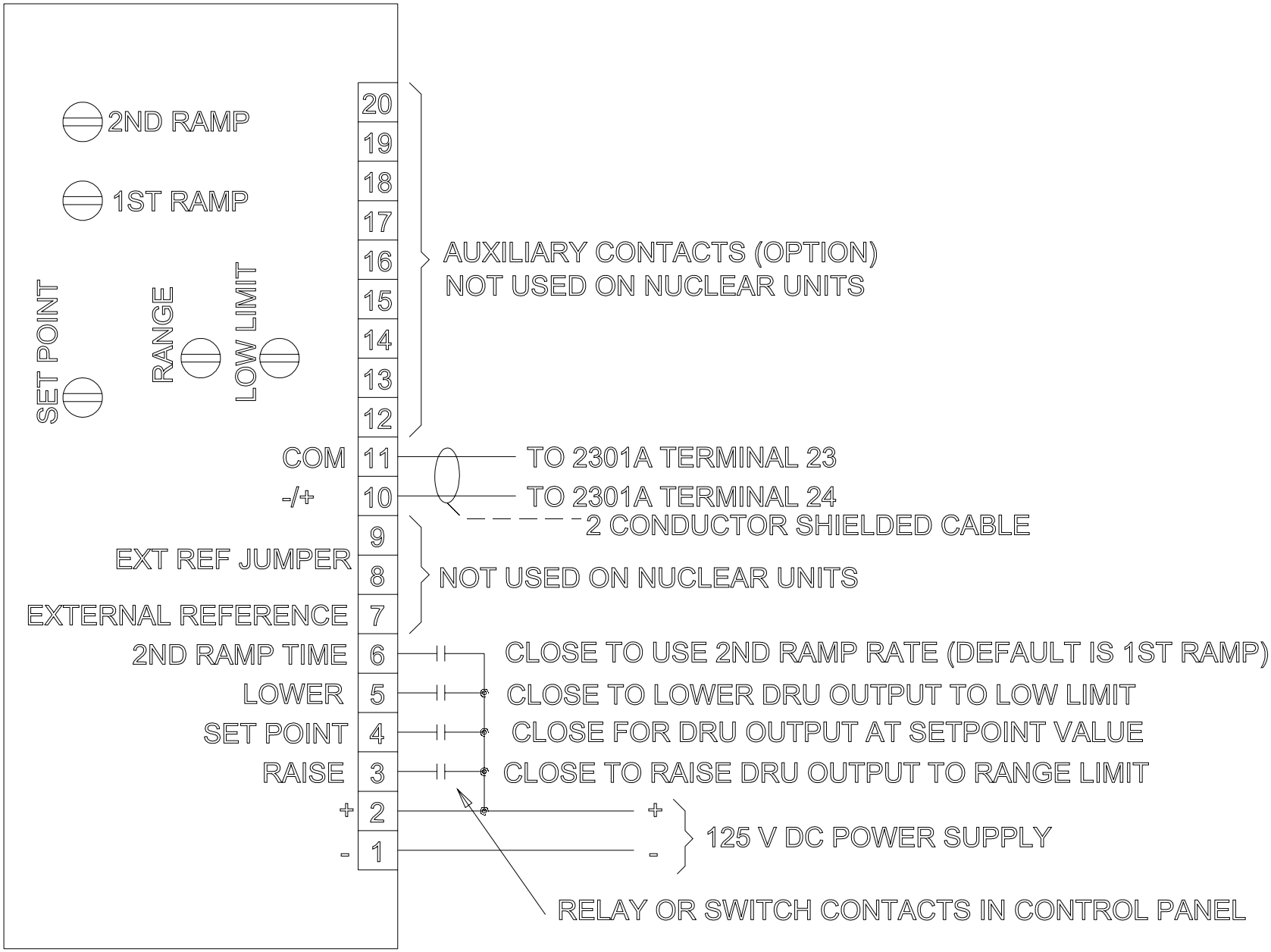



FIGURE 13 - DRU CONNECTIONS

# Fast Start Problem

A ten-second start sequence is equivalent to 35 to 50 hours of engine operation at rated load. Fast starts ultimately reduce the life and reliability of the unit. Fast starts along with fast loading of the generator stress the engine and the generator.

The NRC authorized plants to make slow starts by Generic Letter 84-15. However, units with the EGA governing system can not make a slow start on the electric governor. It is necessary to use the mechanical backup governor (in the actuator). In this state, the unit **can not** respond to an emergency start signal. The unit is effectively 'inoperable' when on the mechanical governor.

The 2301A governor, when applied with the DRU, can be operated at idle speed under electronic governor control and **can** immediately go to rated speed (in about 5 seconds) upon an emergency signal.

## Summary of Converted Units

The following Plants have made a governor conversion:

- Detroit Edison - Enrico Fermi II - 4 OP units
- Beaver Valley-Duquene P&L - 2 Pielstick Units
- SNUPPS - Callaway, MO - 2 Pielstick Units
- SNUPPS - Wolf Creek, KA - 1 of 2 Pielstick Units converted
- PSNH - Seabrook - 1 of 2 Pielstick Units converted
- Calvert Cliffs - 1 OP unit (of 3) partial conversion - replaced MOP with DRU on EGA governor system. This unit and remainder to be converted to 2301A in the future.

Others that have expressed interest in conversion:

- South Carolina-VC Summer - 2 Pielstick Units
- PECO-Peach Bottom and Limerick - OP Units
- Millstone III - 2 Pielstick Units

## In Summary

The EGA Governing System IS obsolete. Woodward has stated they will attempt to repair old units providing they are repairable. No new EGA units will be built and units will only be repaired as long as appropriate components exist.

The 2301A is actually a better governing system. It has better response and is more flexible in applicability. Coupled with a DRU, it can solve a number of problems such as reducing the number of fast starts that units are subjected to. Because of the number of 2301A units in use, it will be maintained into the foreseeable future.

The End!

Time for Questions and Answers