

OPERATING MANUAL  
OF  
REMOTE DATA-CONTROL STATION  
FOR  
INTERMEDIATE STATIONS

CONTROL DEPARTMENT  
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CHICAGO, ILLINOIS  
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1.0 COMPUTER DATA-CONTROL SYSTEM

The Computer Data-Control System consists of a hierarchy of computers communicating with one another with the purpose of controlling the pipeline network with maximum reliability and flexibility while at the same time minimizing costs. The components of the D/C System are the remote D/C stations, the master station and the decision-making computer.

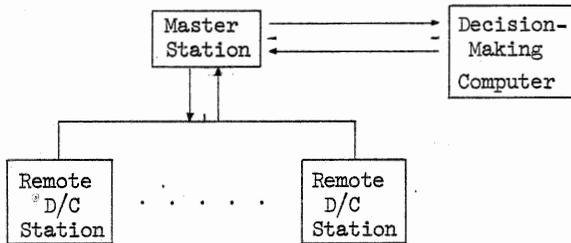


Figure 1

## 1.1 MASTER STATION

The master station, located in the Chicago office, is to provide to Gas Control the data and control necessary to operate the pipeline network. It performs the following functions:

### Data Acquisition

A log, consisting of volumes, pressures and engine speeds, is issued hourly by the master station. Whenever Gas Control desires additional information about a remote station, the appropriate station number and data function can be dialed into the master station data-control panel. The remote D/C station will receive this request and transmit to the master station the desired data. This data will then be displayed on the data-control panel.

### Surveillance

The master station continuously scans all remote D/C stations requesting all present alarm conditions. When an alarm condition occurs at the remote station, the master station is informed of its nature and in turn the master station informs Gas Control.

### Control

The master station provides for remote control of the remote stations by Gas Control. This control consists of starting and stopping of engines and the giving of pressure and volume set-points. To control a remote station, Gas Control gives to the

master station the appropriate control function and station number. If the remote D/C station is in remote control mode and station conditions permit, this control function will be executed.

## 1.2 REMOTE DATA-CONTROL STATION

The remote D/C station, located at the remote station, performs the following functions:

### Data Acquisition

The remote D/C station continuously collects data and displays it locally and transmits it to the master station upon request.

### Surveillance

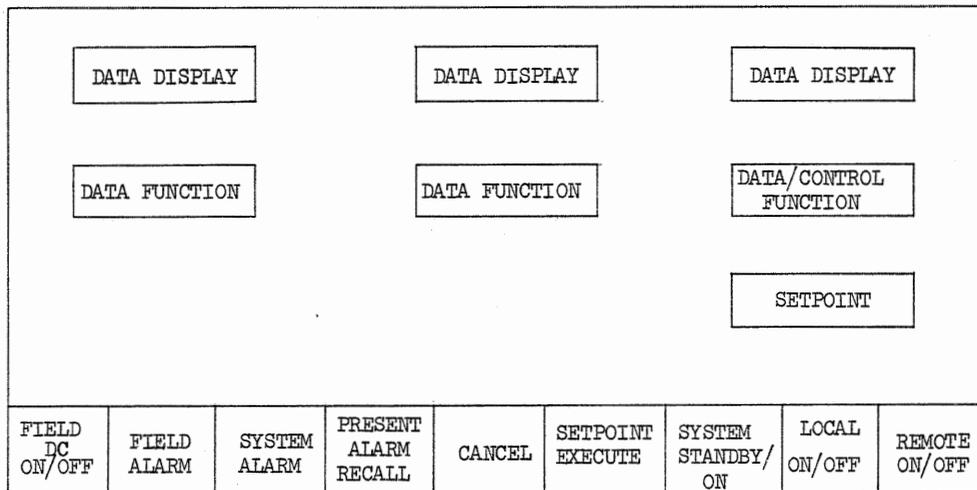
The remote D/C station will inform the station operator and master station of the nature of any present alarm condition and take the appropriate remedial action if the D/C station is in control.

### Control

The remote D/C station will control the station under the direction of either the station operator or Gas Control when it is in a control mode.

The remote D/C station consists of a computer data-control cabinet, computer, interface and typewriter. The computer data-control cabinet contains a D/C console panel, output status panel and calendar clock.

D/C Console Panel



D/C CONSOLE PANEL  
Figure 2

The D/C console panel provides for the station operator control over the remote station and data acquisition through the remote D/C station.

Output Status Panel

The output status panel indicates by lamps the control outputs issued by the remote D/C station. The indicator lamp will remain lit, even though the D/C station may no longer be issuing that output, until the D/C station cancels that output.

Typewriter

The remote D/C station uses the typewriter to inform the station operator of alarms, changes in operating procedures and data. The typewriter should always be kept on-line.

## 2.0 OPERATING MODES OF REMOTE D/C STATION

Note: Refer to figure 2 for the following instructions.

### 2.1 STANDBY MODE

When the D/C station is in standby mode, the D/C system will perform only its functions of alarm surveillance and data acquisition. In this mode the field D.C. power will be off so that the D/C system will not be able to output to the compressor station.

To put the remote D/C station into standby mode:

1. Press SYSTEM STANDBY switch on the D/C console panel.
2. Press SETPOINT EXECUTE switch on the D/C console panel.

### 2.2 LOCAL CONTROL MODE

When the D/C station is in local control mode, the D/C system will collect data, monitor alarms and control the compressor station under the direction of the station operator. Gas Control will not be able to control the compressor station while the D/C station is in this mode.

To put the remote D/C station into local control mode:

1. Press LOCAL ON/OFF switch on D/C console panel.
2. If SYSTEM STANDBY/ON switch does not read SYSTEM ON, press this switch.
3. Press SETPOINT EXECUTE switch.

### 2.3 REMOTE CONTROL MODE

When the remote D/C station is in remote control mode, the D/C system will collect data, monitor alarms and control the compressor station under the direction of Gas Control. The station operator will not be able to control the compressor station while the D/C station is in this mode.

To put the remote D/C station into remote control mode:

1. Press REMOTE ON/OFF switch.
2. If SYSTEM STANDBY ON/OFF switch does not read SYSTEM ON, press this switch.
3. Press SETPOINT EXECUTE switch.

### 2.4 PUTTING COMPRESSOR STATION UNDER CONTROL BY D/C SYSTEM

In both the local control and remote control mode the Field D.C. output power should be on. This is indicated by the FIELD DC switch on the D/C console panel. It should be red and read FIELD DC ON. If not, press this switch.

The compressor station may be put under control by the D/C system only when there are no station sequences in process.

To put the compressor station under control by the D/C system:

1. Put NGPL station panel in automatic computer mode.
2. Put engine panels of all engines running in computer mode.
3. Put remote D/C station in local or remote control mode.

## 2.5 REMOVING COMPRESSOR STATION FROM CONTROL BY D/C SYSTEM

The compressor station may be removed from control by the D/C system at any time.

To remove the compressor station from computer control:

1. Put NGPL station panel in manual Foxboro mode.
2. Remove engine panels from computer mode.
3. Put remote D/C station in standby mode.

In emergency, to remove the compressor station from computer control press the FIELD DC switch on the D/C console panel so that it reads FIELD DC OFF. This will immediately remove all output power from the remote D/C station.

## 2.6 CANCEL SWITCH

After pressing the SYSTEM, LOCAL or REMOTE switch on the D/C console panel and before pressing SETPOINT EXECUTE, it is desired to cancel the set, press the CANCEL switch. This will reset the console switches to their last state.

3.0 DATA ACQUISITION

<u>DESCRIPTION</u>	<u>ANALOG CHANNEL</u>	<u>RANGE</u>		<u>FNC. NO.</u>
		<u>MIN.</u>	<u>MAX.</u>	
No. of units on line		0	2	26
Mainline suction pressure	24	400	800	0
Mainline discharge pressure	23	400	800	7
RFM - Unit 1 (Stage 1)	16	0	6000	10
RFM - Unit 2 (Stage 2)	26	0	6000	11
Fuel diff. press. - Unit 1(Stage 1)	6	-20	200	21
Fuel diff. press-unit 2(Stage2)	2	-20	200	22
Station discharge pressure	25	400	800	8
Mainline discharge tempera.	11	0	150	56
Atmospheric temperature	7	-20	200	63
Mainline suction temperature	12	0	150	50
Suction press-unit 1(Stage 1)	4	400	800	43
Suction temp-unit 1 (Stage 1)	3	-20	200	64
Exhaust temp.-unit 1 (Stage 1)	14	700	1100	67
Suction press-unit 2 (Stage 2)	21	400	800	44
Suction temp.-unit 2 (Stage 2)	17	-20	200	65
Exhaust temp.-unit 2 (Stage 2)	13	700	1100	68
Fuel gas pressure	1	200	400	41
Fuel gas temperature	5	-20	200	42
Fuel flow based on DP and static - Unit 1 (Stage 1)		0	15.0 KCF/HR	59
Fuel Diff. Press. - Unit 1 (Stage 1)		0	200	21
Fuel Diff. Press. - Unit 2 (Stage 2)		0	200	22
Eng. & Compr. Combine Efficiency - Unit 1 (Stage 1)		0	100%	32

<u>DESCRIPTION</u>	<u>RANGE</u>		<u>FNC. NO.</u>
	<u>MIN.</u>	<u>MAX.</u>	
Rated HP at Actual Speed - Unit 1(Stage 1)	0	15.0 KHP	01
Rated HP at Actual Speed - Unit 2(Stage 2)	0	15.0 KHP	02
Rated HP at Rated Speed - Unit 1 (Stage 1)	0	15.0 KHP	03
Rated HP at Rated Speed - Unit 2 (Stage 2)	0	15.0 KHP	04
Eng. Operate Hrs. - Unit 1 - in 1/4 Hr. Unit, Start from 0 o'clock A.M.	0	96	30
Eng. Operate Hrs. - Unit 2 - in 1/4 Hr. Unit, Start from 0 o'clock A.M.	0	96	31
Eng. Operate Hrs. - Unit 1 - in 1/4 Hr. Unit, (Previous Day Total)	0	96	38
Eng. Operate Hrs. - Unit 2 - in 1/4 Hr. Unit, (Previous Day Total)	0	96	39
RPM - Unit 1 (Previous Day Average)	0	6000	09
RPM - Unit 2 (Previous Day Average)	0	6000	12
Atmospheric Temperature (Previous Day Aver.)	-20	200	13
Fuel Flow - Unit 1 (Previous Day Average)	0	200	14
Fuel Flow - Unit 2 (Previous Day Average)	0	200	15
Compr. HP - Unit 1 (Previous Day Average)	0	15.0 KHP	16
Compr. HP - Unit 2 (Previous Day Average)	0	15.0 KHP	17
Eng. & Compr. Combine Efficiency - Unit 1 (Previous Day Average)	0	100%	18
Eng. & Compr. Combine Efficiency - Unit 2 (Previous Day Average)	0	100%	19
Rated HP at Actual Speed - Unit 1 (Stage 1) (Previous Day Average)	0	15.0 KHP	20
Rated HP at Actual Speed - Unit 2 (Stage 2) (Previous Day Average)	0	15.0 KHP	23
Rated HP at Rated Speed - Unit 1 (Stage 1) (Previous Day Average)	0	15.0 KHP	24
Rated HP at Rated Speed - Unit 2 (Stage 2) (Previous Day Average)	0	15.0 KHP	25

<u>DESCRIPTION</u>	<u>RANGE</u>		<u>FNC. NO.</u>
	<u>MIN.</u>	<u>MAX.</u>	
Compressor horsepower - Unit 1 (Stage 1)	0	15.0 KHP	36
Compressor horsepower - Unit 2 (Stage 2)	0	15.0 KHP	37
Flow of compressor in MMSCFD - Unit 1	0	2200	46
Flow of compressor in MMSCFD - Unit 2	0	2200	47
Efficiency of compressor - Unit 1	0	100%	28
Efficiency of compressor - Unit 2	0	100%	29
Engine brake horsepower - Unit 1	0	15.0 KHP	34
Engine brake horsepower - Unit 2	0	15.0 KHP	35

To display data, the station operator is to dial into any one of the three DATA FUNCTION thumbwheels the appropriate function number. The data will be displayed above this function number.

The RPM's will have displayed the three most significant digits. The unit exhaust temperatures will have displayed the three least significant digits.

#### 4.0 ALARMS AND DIAGNOSTIC MESSAGES

All alarms will be indicated by a typewritten message. When the D/C station is in a control mode, all alarms will be accompanied by a flashing red light and siren. To silence the siren, press SYSTEM ALARM switch on the D/C console panel. To stop the flashing, press FIELD ALARM switch. The red light will remain until all alarms are cleared. A field alarm indicates an alarm condition with the compressor station. A system alarm indicates an alarm condition with the D/C station.

After receiving a discharge pressure setpoint or a start unit command, the D/C system will clear all field alarms. If they are still present, the D/C system will again issue this field alarm.

#### 4.1 FIELD ALARM MESSAGES

##### 1. NEG STA DIFF PRESS

The suction pressure higher than discharge pressure by 15 psi. If the D/C station is in control mode, the computer will open recycle valve. When discharge pressure becomes equal or greater than suction pressure, the computer will close recycle valve and clear alarm.

##### 2. NO PRESS SETPOINT

The D/C station is in a control mode without a pressure setpoint.

##### 3. STA OPER NOT ALLOW

There is not sufficient number of station sidegates open for station operation by D/C system.

4. XDUCER OUT OF CALIBR

The difference between the station and mainline discharge pressures exceeds 10 psi.

5. STA DID NOT LOAD

Difference between station discharge and suction pressures remains 30 psi after computer commanded main block valves to close.

6. BOILER ALARM

7. MINIMUM LOAD WARNING

This message indicates both units are at minimum speed and discharge pressure is greater than setpoint. If this condition remains for 5 minutes, then the D/C system will shut down one unit. <sup>unit 1</sup>

8. HI DISCH PRESS

Maximum of station and mainline discharge pressure is 720 psi. If D/C station is in a control mode, the computer will stop unit 2 if it is running. If unit 2 is not running, the computer will stop unit 1.

9. FIELD VALVES NOT OK

A field valve was found moving without command by computer or a field valve fails to open or close upon command by the computer. The valve and the condition will also be indicated on the typewriter.

10. PARTIAL STA OPER ALLOW

There is not sufficient number of station sidegates open to operate more than one engine.

11. UNAUTHORIZED ENTRY

12. FIRE-MAIN BLDG

Computer will issue an emergency station blowdown if D/C station is in a control mode.

13. FIRE-AUX BLDG

14. GAS DETECTED

15. EMER STA BLOWDOWN

If D/C station is in a control mode, it will stop all engines, put station off-line and issue a station blowdown. The computer will then put the D/C station in standby mode.

16. STA PANL NO COMP MODE

NGPL station panel is not in automatic computer mode.

17. SUCTION SIDEGATE CLOSED

18. DISCHARGE SIDEGATE CLOSED

19. MAIN BLOCK NOT CLOSED

20. UNIT (1, 2) DID NOT LOAD

Unit failed to load after a computer start.

21. UNIT (1, 2) NO PERM START

Unit does not have a permissive start

22. UNIT (1, 2) FUEL VALVE NOT ON

Unit fuel valve did not open when commanded to do so by computer before start of engine.

23. UNIT (1, 2) IN STRT SEQ FAILD

Unit start sequence failed.

24. UNIT (1, 2) INCMPLT SEQ SIGNAL

25. UNIT (1, 2) FAIL TO START

26. UNIT (1, 2) HIGH PRESS SHUTDOWN

Computer stopped unit because of high discharge pressure.

27. UNIT (1, 2) MALFUNC SHUTDOWN

28. UNIT (1, 2) DID NOT SLOW TO IDLE  
Computer failed to reduce engine speed to idle in order to stop the unit.
29. UNIT (1, 2) FLOW DET, UF CLOSED  
After computer stopped the unit, a fuel flow was detected although fuel valve was closed.
30. UNIT (1, 2) FLOW DET  
After computer stopped a unit, a fuel flow to the unit was detected.
31. UNIT (1, 2) MANIFOLD NOT SAFE  
Unit manifold valves are not in safe shutdown position after computer stopped the unit.
32. UNIT (1, 2) NO FLOW, UF OPEN  
After computer stopped a unit, the fuel valve failed to close although no fuel flow was detected.
33. UNIT (1, 2) MALFUNC WARNING
34. UNIT (1, 2) PANL NO COMP MODE  
Engine panel is not in D/C station mode.
35. UNIT (1, 2) LOW SPEED
36. UNIT (1, 2) HIGH SPEED
37. UNIT (1, 2) FAIL TO REACH MIN SPEED  
Unit failed to reach a minimum speed after a computer start.
38. UNIT (1, 2) MIN FWR SHUTDOWN  
Discharge pressure was higher than pressure setpoint and on line units have been running at min. speed for 5 mins. The computer will shutdown a unit.

4.2 SYSTEM ALARM MESSAGES

1. CLOCK FAILURE

Computer digital clock failed. Computer program will put D/C station into standby mode.

2. RM TEMP SHUTDWN

Control room temperature exceeds 85°. D/C station will go to standby mode. Program should be reloaded into computer.

3. RM TEMP WARN

Control room temperature exceeds 75°.

4. A/D FAILURE

Analog to digital converter is malfunctioning. Data will be incorrect. D/C station will go to standby mode.

5. FIELD DC OFF

Field D.C. input power to the D/C station is off. D/C station will go to standby mode.

4.3 DIAGNOSTIC MESSAGES

1. SURGE VALVE OPEN

2. LOC/STDBY CONTROL

The D/C station is not in remote control mode.

3. UNIT (1, 2) UNNEC POWER SHTDWN

Computer program shut down unit because two units were running at minimum speed and pressure was greater than or equal to setpoint.

4. AC FAILED

AC power to the D/C station failed.

5. CHANGE IN STA OPER

During AC power failure there was a change in the position of a field valve or a unit was started or stopped. The computer program will put the D/C station in standby mode.

4.4 WATCHDOG RELAY

Every 10 seconds the computer program will strobe the watchdog relay. If the computer program is malfunctioning in the computer, it will fail to strobe the watchdog relay. If the watchdog relay times out 50 seconds without being strobed, it will turn off the field DC output power from the D/C station and remove the NGPL station panel from automatic computer mode. The Foxboro setpoint controller will take over discharge pressure setpoint control.

4.5 PRESENT ALARM RECALL

The station operator can request a typewritten list of all present field and system alarms by pressing the PRESENT ALARM RECALL switch on the D/C console panel.

5.0 CONTROL SETPOINTS

<u>DESCRIPTION</u>	<u>FNC.NO.</u>	<u>SETPOINT NO.</u>
Discharge pressure setpoint	70	0000-0712
Unit 1 (stage 1) start	91	0001
Unit 2 (stage 2) start	91	0002
Unit 1 (stage 1) stop	92	0001
Unit 2 (stage 2) stop	92	0002

For station operator to input a control setpoint:

1. Put D/C station into local control mode.
2. Dial appropriate function number into CONTROL FUNCTION thumbwheel on the D/C console panel.
3. Dial the appropriate setpoint number into the SETPOINT thumbwheel.
4. Press SETPOINT EXECUTE switch.

Immediately after the D/C station is removed from standby mode, a discharge pressure setpoint is to be given to the D/C system.

A unit start command can be given to the D/C system only if a discharge pressure has first been given.

6.0 ENGINE CONTROL

6.1 START ENGINE CONTROL

If the 36", 26" and 24" suction and discharge sidegates are all open, both engines may be started through the D/C system. Both engines may be started at the same time. The D/C system will delay the start of the second engine commanded to be started until after the first engine has reached warm up speed.

If one of the 36", 26" or 24" suction or discharge sidegates is not open, the D/C system will not start an engine if another one is running.

If one of the following conditions holds the D/C system will not start any engine:

1. 36" suction and 26" or 24" suction sidegates are not open.
2. 36" discharge and 26" or 24" discharge sidegates are not open.

Note: For Station 191 see section 9.1 for remainder of start sequence.

After the D/C system has received a start command, it will try to reset the malfunction warning relay and will check for the following conditions:

1. A discharge pressure setpoint has been given to the D/C system.
2. The engine panel is in computer mode.
3. Malfunction shutdown contact is reset.
4. The engine has a permissive start.
5. The engine manifold valves are in safety shutdown position.

If the fuel valve opens, the D/C system will issue a start to the engine and monitor the start sequence. If any of the following takes place, the D/C system will stop the engine and close the fuel valve. If fuel flow is detected or manifold valves are not in safe shutdown, the D/C system will issue an emergency station blow-down.

1. Engine fails to start.
2. Engine has an incomplete start sequence.
3. Compressor speed is less than warm up speed (1000 RPM) after 45 minutes.
4. Compressor speed drops below 500 RPM after reaching warm up speed.
5. Engine fails to load after 32 minutes from start of warm up.
6. Compressor speed remains less than 3150 RPM after 32 minutes from start of warm up.

After the start sequence is completed, the D/C system will try to reset the malfunction warning relay if it is set.

## 6.2 LOAD STATION

After the D/C system has started an engine and the engine has completed the start sequence, the D/C system will load the station in the following sequence:

1. Close the recycle valve.
2. Open all discharge sidegates.

3. Close all main block valves.
4. Increase compressor speed to 3950 RPM.

If any of the following conditions occur, the D/C system will stop the engine starting with step (5) of engine stop sequence (see section 6.3 or 9.2).

1. The recycle valve or one of the main block valves fails to close.
2. Discharge pressure does not exceed suction pressure by 30 psi by 7 minutes after closing of main block valves.
3. Compressor speed fails to reach 3950 RPM by 7 minutes after closing of main block valves.

### 6.3 ENGINE STOP CONTROL

Note: For station 191 see section 9.2 for engine stop sequence.

After receiving a stop command, the D/C system will stop the engine with the following sequence while continuing to exercise pressure setpoint control with the other engine if it is running:

1. Decrease compressor speed to 3600 RPM
2. Delay 10 minutes
3. Decrease compressor speed to <sup>1300</sup>~~1800~~ RPM
4. Delay 5 minutes
5. Issue stop command
6. Close fuel valve
7. Check for engine manifold valves in safe shutdown
8. Open recycle valve when the D/C system detected main block valve open if no other engine is running.

If the combined time spent in decreasing the speed in steps (1) and (3) is 15 minutes without the speed reaching 3600 RPM or 1800 RPM, the D/C system will leave step (1) or (3) and go immediately to step (5).

If during step (1) (step (3)) the surge valve opens, the D/C system will release the decrease speed command. If the surge valve closes within 3.5 minutes, the D/C system will return to step (1) (step (3)) and re-initialize the 15 minute time interval mentioned in the above paragraph. If the surge valve fails to close within 3.5 minutes, the D/C system will decrease the compressor speed to 1500 RPM and continue with step (4). If the compressor speed fails to reach 1500 RPM within 6 minutes, the D/C system will go immediately to step (5).

If in step (6) a fuel flow is detected, the D/C system will immediately issue an emergency station blowdown.

If in step (7) the unit manifold valves are not in safe shutdown, the D/C system will immediately issue an emergency station blowdown.

6.4

HIGH SPEED SHUTDOWN

<u>Engine</u>	<u>Overspeed</u>
Cooper-Bessemer	5500
Ingersoll-Rand	5500
Clark	5700
DeLaval	6500

If a compressor engine overspeeds, the D/C system will issue a decrease speed command to the engine for one minute. If it continues to overspeed, the D/C system will close its fuel valve and continue with the stop engine sequence starting with step (5).

#### 6.5 LOW SPEED SHUTDOWN

If the compressor speed of an engine falls below 3400 RPM (2700 RPM for DeLaval), the D/C system will issue an increase speed command for one minute. If the speed remains less than 3400 RPM, (2700 RPM), the D/C system will stop the engine starting with step (5) of stop engine sequence.

#### 6.6 MALFUNCTION SHUTDOWN

If an engine has a malfunction shutdown, the D/C system will stop the engine starting with step (1) but will omit steps (2) and (4) in stop engine sequence. D/C system will also stop the other unit, if it is running, in the same manner. For station 191, the D/C system will stop both engines, as above, but without omitting any step in the stop engine sequence.

7.0 DISCHARGE PRESSURE SETPOINT CONTROL

After the D/C system is given a discharge pressure setpoint, it will check for the following:

1. NGPL station panel is in computer mode.
2. Unit panel is in computer mode.

7.1 STATION ON LINE

After the D/C system is given a discharge pressure setpoint, and if station is on line operation it will check for the following:

1. Unit panel is in computer mode if the unit is running.
2. 36" suction or both 26" and 24" suction sidegates are open.

If these conditions are not satisfied, the D/C system will not do setpoint control. If they are satisfied, the D/C system will open all discharge sidegates. If the 36" discharge and the 26" or 24" discharge sidegates fail to open, the D/C system will not do pressure setpoint control.

7.2 SETPOINT CONTROL

The discharge pressure used for control is taken as the higher of the station discharge pressure and mainline discharge pressure.

If the difference between discharge pressure and setpoint exceeds 15 psi, the D/C system will increase or decrease the pressure at a rate not exceeding 10 psi/min. If the difference between discharge pressure and setpoint is less than 15 psi, the D/C system will increase or decrease the pressure at a rate not exceeding 2 psi/min.

<u>Engine</u>	<u>Minimum Speed</u>	<u>Maximum Speed</u>
Cooper-Bessemer	3900	5180
Ingersoll-Rand	3900	5250
Clark	3900	5600
DeLaval - Unit 1	3400	5800
DeLaval - Unit 2	3400	6100

If one unit is running, the D/C system will increase or decrease its speed until setpoint is attained or until maximum or minimum speed is attained.

If two units are running and setpoint exceeds the discharge pressure, the D/C system will increase the lower speed until one of the following conditions occurs:

1. Setpoint is attained. In this case, the D/C system will start equalizing the compressor speeds by decreasing the higher speed.
2. Compressor speeds are equal to within 10 RPM. In this case the D/C system will increase both speeds until either
  - a. setpoint is attained or
  - b. one of the compressor speeds reaches maximum speed.

In the latter condition, the D/C system will proceed as in (4) below.

3. 15 minutes elapses. In this case the D/C system will continue increasing the lower speed and also increase the higher speed until either

- a. setpoint is attained or
- b. the higher speed reaches its maximum.

In both cases, the D/C system will continue trying to increase the lower speed until speeds are equal or pressure exceeds setpoint.

- 4. Compressor speed reaches maximum. In this case the D/C system will release the increase speed commands and delay 15 minutes. Then it will increase the speed of the other unit until either
  - a. setpoint is attained or
  - b. the unit's speed reaches its maximum.

If two units are running and setpoint is below discharge pressure, the D/C system will decrease the higher speed until one of the following conditions occurs:

- 1. Setpoint is attained. In this case the D/C system will start equalizing the compressor speeds by decreasing the higher speed.
- 2. Compressor speeds are equalized within 10 RPM.  
In this case the D/C system will decrease both speeds until either
  - a. setpoint is attained or
  - b. a compressor speed reaches minimum speed.

In the latter case the D/C system will continue as in (3) below.

3. Compressor speed reaches minimum speed. In this case the D/C system will release the decrease speed command for this unit and start decreasing the speed of the other unit until either
  - a. setpoint is attained or
  - b. the unit's speed has reached a minimum.

In the latter case the D/C system will give a min. load warning alarm and delay 5 min. If at the end of this time the pressure is equal to or greater than setpoint, the D/C system will stop unit 2 starting with step (1) of stop engine sequence.

### 7.3 HIGH DISCHARGE PRESSURE

If the discharge pressure is greater than or equal to 713 psi, the D/C system will decrease the higher speed. If the discharge pressure reaches 718 psi for 25 seconds, the D/C system will stop unit 2 starting with step (1) of stop engine sequence. If, at the end of step (3), the discharge pressure remains greater than or equal to 718 psi, the D/C system will omit step (4) and go immediately to step (5).

### 7.4 HIGH DISCHARGE TEMPERATURE

If the mainline discharge temperature is greater than or equal to 135° while the D/C system is doing setpoint control, the D/C system will stop increasing speeds of all engines running. If the temperature exceeds 136°, the D/C system will decrease the higher speed until either

1. mainline discharge temperature is less than 136° or
2. compressor speeds are equalized if two units are running.

In the latter case, the D/C system will reduce both speeds until the temperature is less than 136° or the speeds are at a minimum speed.

8.0 EMERGENCY STATION BLOWDOWN

When issuing an emergency station blowdown, the D/C system will open the recycle valve, close fuel valves and issue stop commands to the engines. It will then put the D/C station in standby mode. The station operator will not be able to put the D/C station in a control mode until after the station blowdown relay is reset.

The D/C system will issue an emergency station blowdown only for one of the following reasons:

1. Fire in main building.
2. Fuel flow is detected after the unit is stopped.
3. Manifold valves are not in safety shutdown after the unit is stopped.
4. Emergency blowdown relay is set.

9.0 STATION 191

9.1 START ENGINE CONTROL

After the D/C system has received a start command, it will try to re-set the malfunction warning relay and will check for

1. A discharge pressure setpoint has been given to the D/C system and
2. The engine panel is in computer mode.
3. 36" suction or both 26" and 24" suction sidegates are open and the D/C system will open all discharge sidegates, and will check for 36" discharge or both 26" and 24" discharge sidegates are open.

If these conditions are satisfied, the D/C system will open the fuel valve. If the fuel valve fails to open, the D/C system will close the fuel valve. If fuel flow is detected, the D/C system will issue an emergency station blowdown. If the fuel valve opens, the D/C system will start the generator. If there is a permissive start within 5 minutes, the D/C system will issue a start command to the engine and monitor the start sequence.

If any of the following takes place, the D/C system will stop the engine starting with step (5) of stop engine sequence.

1. Engine does not have a permissive start within 5 minutes.
2. Engine fails to start.
3. Engine has an incomplete start sequence.
4. Compressor speed remains less than 2750 RPM after 20 minutes from start of engine.
5. Engine fails to load after 20 minutes from start of engine.

After the start sequence is completed, the D/C system will try to reset the malfunction warning relay if it is set.

9.2 STOP ENGINE CONTROL

After receiving a stop command, the D/C system will stop the engine with the following sequence while continuing to exercise pressure setpoint control with the other engine if it is running:

1. Decrease compressor speed to <sup>3600</sup>~~3200~~ RPM
2. Open recycle valve
3. Check difference between discharge and suction pressure is less than 45 psi within 5 minutes after recycle valve is open
4. Close recycle valve
5. Issue stop (10 sec.)
6. Close fuel valve
7. Check for engine manifold valves in safe shutdown
8. Open recycle valve if the computer detected main block valve open and no other engine is running.

If in step (1) the compressor speed doesn't decrease to 3200 RPM within 8 minutes, the D/C system will immediately go to step (2).

If in step (3) the difference remains greater than or equal to 45 psi after 5 minutes, the D/C system will immediately go to step (4).

If in step (1) the surge valve opens, the D/C system will release the decrease speed command. If the surge valve closes within 3.5 minutes, the D/C system will return to step (1) and re-initialize the 8 minute time interval. If the surge valve remains open after 3.5 minutes, the D/C system will decrease the compressor speed to 3350 RPM or for 6 minutes, whichever comes first, and continue with step (2) of stop sequence.

10.0 COMMUNICATION WITH GAS CONTROL

The remote D/C system communicates with Gas Control through the Master station located in the Chicago office.

Each hour the Master station will type on the logging typewriter at Gas Control the following data:

1. Number of engines running
2. Mainline suction pressure
3. Mainline discharge pressure

When the remote D/C station in remote control mode, Gas Control can issue the following control functions to the remote D/C station:

1. Start engine
2. Stop engine
3. Discharge pressure setpoint

When an alarm condition occurs at the remote D/C station, the master station will alert Gas Control of this alarm by a typewritten message.

Accompanying each alarm will be the following data points:

1. Number of engines running
2. Mainline suction pressure
3. Mainline discharge pressure
4. Compressor speed of unit 1
5. Compressor speed of unit 2

GENERAL AND DIAGNOSTIC ALARMS

REMOTE TO MASTER STATION ALARM MESSAGES	FUNC. NO.	ALARM WORD BIT	ALARM NO.	GROUP OF REMOTE STATION ALARM MESSAGES
NEG STA DIFF PRESS	251	0	1	NEG STA DIFF PRESS
MIN LOAD WARNING	251	1	2	MIN LOAD WARNING
SURGE VALVE OPEN	251	2	3	SURGE VALVE OPEN
HI DISCH PRESS	251	3	4	HI DISCH PRESS
STATION NOT IN REMOTE CONTROL	251	4	5	STN IN LOCAL/STDBY MODE
NO PRESS SETPOINT	251	5	6	NO PRESS SETPOINT
			7	CLOCK FAILURE
			8	HI ROOM TEMP SHUTDN
CONTROL SYSTEM MALFUNCTION	251	6	9	HI ROOM TEMP WARN
			10	A/D FAILURE
			11	FIELD DC OFF
			12	STN OPER NOT ALLOW
			14	SUCTION SIDEGATES CLOSED
			15	RCVL WILL NOT CLOSE
PIPELINE SYSTEM MALFUNCTION	251	7	16	MAIN BLOCK NOT CLOSE
			18	DISCH SIDEGATES CLOSED
			19	

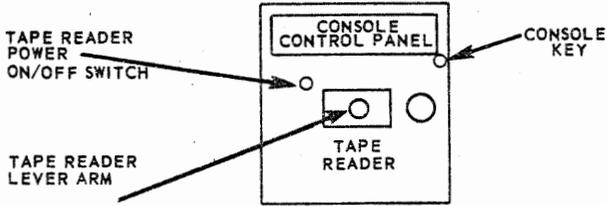
REMOTE TO MASTER STATION ALARM MESSAGES	FUNC. NO.	ALARM WORD BIT	ALARM NO.	GROUP OF REMOTE STATION ALARM MESSAGES
			20	
			21	FIELD VALVES NOT OK
PARTIAL STA OPER ALLOWABLE	251	8	22	PARTIAL STA OPER ALLOW
UNAUTHORIZED ENTRY	251	9	23	UNAUTHORIZED ENTRY
FIRE	251	10	24	FIRE-MAIN BUILDING
			25	FIRE-AUX. BUILDING
GAS DETECTION	251	11	26	GAS DETECTION
EMER STATION BLOWDOWN	251	12	27	EMER STATION BLOWDOWN
STA PANEL NOT IN COMPUTER MODE	251	13	28	STA PANEL NOT IN COMPUTER MODE
EMERG STA SHUTDOWN	251	14		

UNIT ALARMS

REMOTE TO MASTER STATION ALARM MESSAGES	FUNC. NO.	ALARM WORD BIT NO.		ALARM NO.		GROUP OF REMOTE STATION ALARM MESSAGES
		UNIT 1	UNIT 2	UNIT 1	UNIT 2	
				29	48	
				30	49	NO PERMISSIVE START
				31	50	FUEL VALVE NOT ON
				32	51	
FAIL TO START	252	0	7	33	52	FAIL TO REACH MIN SPEED
				34	53	FAIL TO START
				35	54	NOT READY TO LOAD
SHUTDOWN	252	1	8	36	55	HI PRESS SHUTDOWN
				37	56	LOW SPEED
				38	57	HIGH SPEED
				39	58	FLOW DET BUT UF CLOSE
				40	59	FLOW DET
ABNORMAL SHUTDOWN	252	2	9	41	60	MANIFOLD NOT SAFE MALFUNCTION SHUTDOWN
				42	61	NO FLOW BUT UF OPEN
				43	62	IN START SEQ FAILED
						INCOMPLETE SEQ SIGNAL
PANEL NOT IN COMPUTER MODE	252	4	11	45	64	PANEL NOT IN COMPUTER MODE

11.0 LOADING PROGRAM INTO COMPUTER

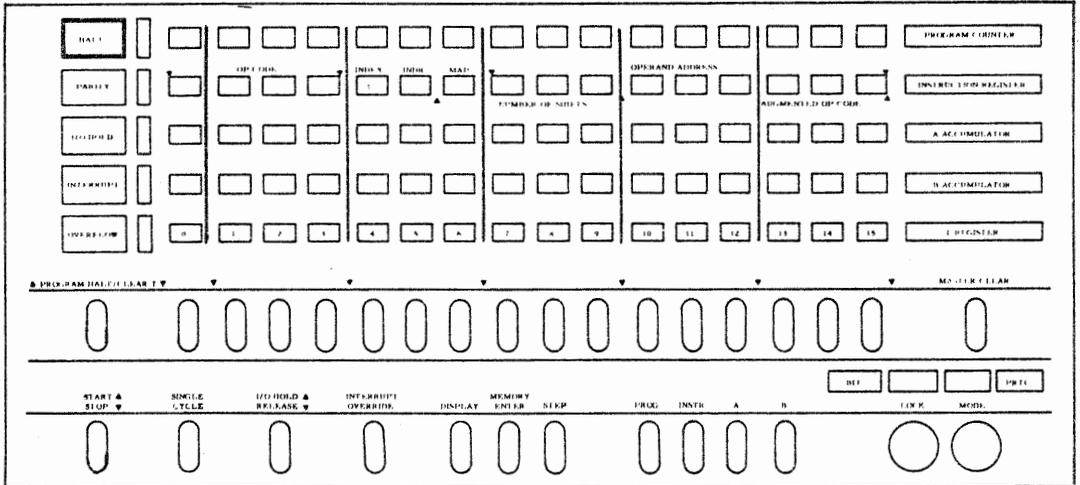
LOADING PROGRAM INTO COMPUTER



COMPUTER  
Figure 4

11.1 COMPUTER CONSOLE CONTROL PANEL

The computer console control panel, located on the computer, enables the station operator to load the Remote D/C Station program into the computer.

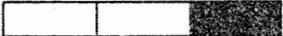
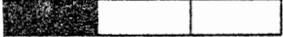


COMPUTER CONSOLE CONTROL PANEL  
FIGURE 5

11.2 OCTAL NUMBER SYSTEM

In loading the remote D/C station program into the computer, use is made of the octal number system. The digits of this number system go from 0 to 7. The 16 indicator lights, numbered 0 to 15, of the T-Register of the computer console control panel are divided into groups of three except for the indicator light 0 which is grouped by itself.

Counting from the right in a group of three indicator lights, the first light represents a 1, the second a 2 and the third a 4. All other digits are formed from these digits by addition. Thus

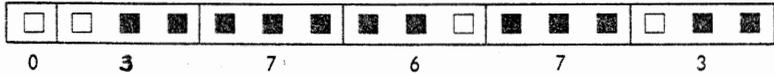
<u>DIGIT</u>	<u>COMPUTER REPRESENTATION</u>
0	
1	
2	
3	
4	
5	
6	
7	

where  indicates light off and  
 indicates light on

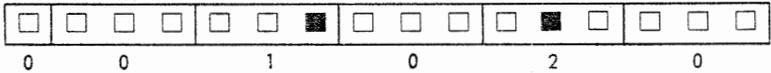


Examples:

1. The octal number 037673 is represented in the T-Register as



2. The octal number 001020 is represented in the T-Register as



### 11.3 BINARY BOOTSTRAP LOADER

The binary bootstrap loader is a computer program consisting of the following numbers:

<u>PROGRAM LOCATION</u>	<u>OCTAL NUMBER</u>
0	130101
1	004000
2	170301
3	000022
4	111006
5	111002
6	170301
7	001016
10	174301
11	033016
12	000022
13	000026
14	<del>003000</del>
15	111006
16	137671
17	037673

### 11.4 STEPS FOR LOADING REMOTE D/C STATION PROGRAM

In order to load the Remote D/C Station program in the computer, it is necessary that the Loader program be already in the computer. Usually this is the case. When it is present in the computer, it

is sufficient to load the Remote D/C Station program (see below). When it is necessary to load the Loader program into the computer, it is first necessary to load manually the Binary Bootstrap Loader into the computer.

#### Binary Bootstrap Loader

To load the Binary Bootstrap Loader into the computer:

1. Depress the MASTER CLEAR toggle switch.
2. Enter first octal number (130101) of Binary Bootstrap Loader into T-Register by depressing toggle switches 0, 2, 3, 9, 15.
3. Depress MEMORY ENTER switch.
4. Depress MEMORY STEP switch.
5. Depress PROGRAM HALT/CLEAR T switch.
6. Enter second octal number (004000) of bootstrap loader into T-Register.
7. Depress MEMORY ENTER switch.
8. Depress MEMORY STEP switch. Then depress PROGRAM HALT/CLEAR T switch.
9. Repeat steps (6)-(8) for remaining octal numbers of bootstrap loader.
10. After binary bootstrap loader is loaded into computer, depress MASTER CLEAR toggle switch.

#### Loader Program

After the Binary Bootstrap Loader is present in the computer, the Loader program can be loaded into the computer. To load the Loader program turn typewriter on and:

1. Place the tape of the LOADER program in the tape reader of the computer.
2. Turn tape reader power ON and lower tape reader lever arm. Make sure lever arm is in outermost position.
3. Depress START/STOP toggle switch on computer console control panel.
4. The tape reader arrives at a normal stop at end of the tape.
5. Depress MASTER CLEAR switch.
6. Raise lever arm on tape reader and remove loader program tape from tape reader.

Remote D/C Station Program

To load the Remote D/C Station program into the computer:

1. Mount remote D/C station tape onto tape reader and lower lever arm. Turn tape reader and typewriter on.
2. Depress MASTER CLEAR toggle switch.
3. Enter octal number <sup>027673</sup> 017673 into T-Register.
4. Depress PROG toggle switch.
5. Depress PROGRAM HALT/CLEAR T toggle switch.
6. Raise toggle switch 1 under indicator light 1.
7. Depress START/STOP toggle switch twice.
8. Tape reader will read tape and come to a normal halt at end of tape.
9. Remove tape from tape reader and turn power OFF to tape reader.
10. Center toggle switch 1.

11. Depress MASTER CLEAR switch.
12. Enter octal number 001020 into T-Register.
13. Depress PROG toggle switch.
14. Depress PROGRAM HALT/CLEAR T toggle switch.
15. Depress START/STOP switch twice.

The program should now be running in the computer. Turn console key so as to deactivate switches.

#### 11.5 FAILURE OF PROGRAM TO LOAD

If the Loader program fails to load completely, reload the Binary Bootstrap Loader. If the typewriter types K or CK after loading a tape, this indicates an incorrect loading. Check for dirt or tears on the tape and reload the tape. Sometimes it is sufficient to depress the START/STOP toggle only once instead of twice as stated above. If so, depress a third time.

12.0 DATA-CONTROL FUNCTIONS

Data Functions

<u>Number</u>	<u>Item</u>
00	Mainline suction pressure
07	Mainline discharge pressure
08	Station discharge pressure
10	RPM-turbine 1 (stage 1)
11	RPM-turbine 2 (stage 2)
26	No. of turbines in operation
43	Suction pressure-turbine 1 (stage 1)
44	Suction pressure-turbine 2 (stage 2)
50	Mainline suction temperature
56	Mainline discharge temperature
63	Atmospheric temperature
64	Suction temp.-turbine 1 (stage 1)
65	Suction temp.-turbine 2 (stage 2)
67	Exhaust temp.-turbine 1 (stage 1)
68	Exhaust temp.-turbine 2 (stage 2)
41	Fuel gas pressure
42	Fuel gas temperature
59	Fuel flow based on DP and static - Unit 1

12.0 DATA-CONTROL FUNCTIONS

Data Functions

<u>Number</u>	<u>Item</u>
21	Fuel Diff. Press. - Unit 1
22	Fuel Diff. Press. - Unit 2
32	Eng. & Compr. Combine Efficiency - Unit 1
33	Eng. & Compr. Combine Efficiency - Unit 2
01	Rated Horsepower at Actual Speed - Unit 1
02	Rated Horsepower at Actual Speed - Unit 2
03	Rated Horsepower at Rated Speed - Unit 1
04	Rated Horsepower at Rated Speed - Unit 2
30	Eng. Operate Hrs. - Unit 1 - in 1/4 Hr. Unit, Start from 0 o'clock A.M.
31	Eng. Operate Hrs. - Unit 2 - in 1/4 Hr. Unit, Start from 0 o'clock A.M.
38	Eng. Operate Hrs. - Unit 1 - in 1/4 hr. Unit, (Previous Day Total)
39	Eng. Operate Hrs. - Unit 2 - in 1/4 Hr. Unit, (Previous Day Total)
09	RPM - Unit 1 - (Previous Day Average)
12	RPM - Unit 2 - (Previous Day Average)
13	Atmospheric Temperature - (Previous Day Average)
14	Fuel Flow - Unit 1 (Previous Day Average)
15	Fuel Flow - Unit 2 (Previous Day Average)
16	Compr. HP - Unit 1 (Previous Day Average)
17	Compr. HP - Unit 2 (Previous Day Average)
18	Eng. & Compr. Combine Efficiency - Unit 1 (Previous Day Average)

12.0 DATA-CONTROL FUNCTIONS (contd)

Data Functions

<u>Number</u>	<u>Item</u>
60	Fuel flow based on DP and static - Unit 2
36	Compressor horsepower - Unit 1
37	Compressor horsepower - Unit 2
46	Flow of compressor in MMSCFD - Unit 1
47	Flow of compressor in MMSCFD - Unit 2
28	Efficiency of compressor - Unit 1
29	Efficiency of compressor - Unit 2
34	Engine brake horsepower - Unit 1
35	Engine brake horsepower - Unit 2
19	Eng. & Compr. Combine Efficiency-Unit 2 (Previous Day Average)
20	Rated HP at Actual Speed-Unit 1 (Prev. Day Aver)
23	Rated HP at Actual Speed-Unit 2 (Prev. Day Aver)
24	Rated HP at Rated Speed-Unit 1 (Prev. Day Aver)
25	Rated HP at Rated Speed-Unit 2 (Prev. Day Aver)

Control Functions

<u>Number</u>	
70	Discharge Pressure Setpoint
91	Start Turbine
92	Stop Turbine

BIT

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15			
40	Minute Display - Tens 4 2 1				Minute Display - Units 8 4 2 1				Seconds Display - Tens 4 2 1				Seconds Display - Units 8 4 2 1						
41	Day Display - Tens 2 1				Day Display - Units 8 4 2 1				Hour Display - Tens 2 1				Hour Display - Units 8 4 2 1						
42									Month Display - Tens 2 1				Month Display - Units 8 4 2 1						
43	System On	Local On	Remote On					Switch Five - Tens 8 4 2 1				Switch Five - Units 8 4 2 1							
44	Switch Seven - Tens 8 4 2 1				Switch Seven - Units 8 4 2 1				Switch Six - Tens 8 4 2 1				Switch Six - Units 8 4 2 1						
45	Switch Eight - Thousands 8 4 2 1				Switch Eight - Hundreds 8 4 2 1				Switch Eight - Tens 8 4 2 1				Switch Eight - Units 8 4 2 1						
46	36" Suct. Sidegate Open B5	36" Suct. Sidegate Close B6	26" Suct. Sidegate Open B3	26" Suct. Sidegate Close B4	24" Suct. Sidegate Open B1	24" Suct. Sidegate Close B2	4-36" SUCT SIDE GATE OPEN	4-36" SUCT SIDE GATE CLOSE	4-36" DISCH. SIDE GATE OPEN	4-36" DISCH. SIDE GATE CLOSE	36" Disch. Sidegate Open B15	36" Disch. Sidegate Close B16	26" Disch. Sidegate Open B13	26" Disch. Sidegate Close B14	24" Disch. Sidegate Open B11	24" Disch. Sidegate Close B12			
47	Surge Open B17	D/C POWER ON/OFF	Recycle Valve Open B19	Recycle Valve Close B20	Fuel Supply =1 On B21	Fuel Supply =1 Off B22	Boiler Alarm M3	Hi Disch. Gas Press. S.D. M4					LOW STROKE GAS PRESS M.L	LOW CONTROL GAS PRESS M.2	4-36" BLOCK VALVE OPEN	4-36" BLOCK VALVE CLOSE			
50	Unauthorized Entry K1	Fire Main Bldg. K2	Gas Detection K3					Fuel Supply =2 On D3	Fuel Supply =2 Off D4	Malfunction Shutdown =1 L1	Malfunction Warning =1 L2	Unit =1 Loaded L3	Permissive Start =1 L4	In Start Sequence =1 L5	Inc. Start Sequence =1 L6	Valves In Shut-down Position =1 L7	Fire Aux. Bldg. M5	Station Panel Computer Mode M8	Mode Selected =1 K4
51	36" Block Valve Open F5	36" Block Valve Close F6	26" Block Valve Open F3	26" Block Valve Close F4	24" Block Valve Open F1	24" Block Valve Close F2	Malfunction Shutdown =2 L12	Malfunction Warning =2 L13	Unit =2 Loaded L14	Permissive Start =2 L15	In Start Sequence =2 L16	Inc. Start Sequence =2 L17	Valves In Shut-down Position =2 L18	Station Blowdown M6	Block Valve Control Sig. Returned M7	Mode Selected =2 K5			
52																			
53																			
54																			
55																			
56																			
57																			
TEU 40	Set Point Executive	High Room Temp.	Low Room Temp.	ALARM RECALL															

INPUT CHANNEL/BIT ASSIGNMENT

BIT

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15						
40					Left Nixie Display - Hundreds 8 4 2 1				Left Nixie Display - Tens 8 4 2 1				Left Nixie Display - Units 8 4 2 1									
41					Center Nixie Display - Hundreds 8 4 2 1				Center Nixie Display - Tens 8 4 2 1				Center Nixie Display - Units 8 4 2 1									
42					Right Nixie Display - Hundreds 8 4 2 1				Right Nixie Display - Tens 8 4 2 1				Right Nixie Display - Units 8 4 2 1									
43	Set Point Execute Reset	System On	Local On	Remote On	Control Console Reset																	
44	36" Suct. Sidegate Open A5 Close A6		26" Suct. Sidegate Open A3 Close A4		24" Suct. Sidegate Open A1 Close A2		4-36" SUCT SIDEGATE OPEN CLOSE		4-36" DISCH SIDEGATE OPEN CLOSE		36" Disch. Sidegate Open A15 Close A16		26" Disch. Sidegate Open A13 Close A14		24" Disch. Sidegate Open A11 Close A12							
45	Station Blowdown II		Recycle Valve Open A19 Close A20		Fuel Supply #1 On A21 Off A22		MALFUNCTION SHUTDOWN RESET #1		RPM Set Point #1 Increase I3 Decrease I4		Field Alarm I7		System Alarm I8		DC Power On/Off		Watchdog Strobe		Start Unit #1 J3		Stop Unit #1 J4	
46	Block Valves Open E1, E3, E5 Close E2, E4, E6				Fuel Supply #2 On C3 Off C4		MALFUNCTION SHUTDOWN RESET #2		RPM Set Point #2 Increase I5 Decrease I6								Start Unit #2 J5		Stop Unit #2 J6			
47																						
0																						
1																						
2																						
3																						

OUTPUT CHANNEL/BIT ASSIGNMENT