LPCVD Furnace – CVD Systems

ID: CVD - 5  Location: FabLab CVD Tunnel

The single-tube CVD furnace is used for growing gate oxide, poly silicon, spin on glass dopant drive-in and contact anneals. Different tubes are used for different processes.

This furnace is for the use of FabLab staff only.
# Operating Instructions

CVD Equipment Corporation  
Process Control Software System  
(C) 1997

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I) Introduction to CVD Process Control

CVD's Process Control System is based on electronic monitoring and control, which is provided by a DOS-based computer and a custom control software package. Use of this system allows real-time monitoring, control and datalogging/printout of process variables and system status during the run. The interactive operator interface allows the system operator to "run", "stall" or "abort" the system, initiate data logging, and will also allow on or off-line recipe editing.

SEGMENTS

In CVD's system, the smallest element of process control is called a "segment". A segment consists of:
1) A segment run time in tenths of a second (less than ten hours maximum).
2) A digital output configuration which sets valves and switches "on" or "off" for the duration of the segment.
3) An analog configuration, which sets:
   - initial and final setpoints for individual process parameters. These points, divided by the segment time, may be used to define a linear "ramp" for a process variable.
   - high, low, and deviation alarm levels for each process parameter.
4) Response paths for each analog alarm and digital input, including:
   - "stalls", which will "stop the clock". A stall condition will hold the segment in place until the alarm or input disappears or changes state.
   - "aborts", which will shut down the system in a manner pre-defined by other segments or sequences.
   - re-setting or ending the process.

( Please note: Segment "0" is used as the warm-up and initialization segment. )

SEQUENCES

Individual segments are organized into sequences, which are:
- the order the segments will be executed in, and
- the number of repetitions for each segment.
Control progresses from one segment to the next as each segment's allotted time is completed. Progression may also be initiated or stalled by operator intervention, or by an event such as reaching a temperature or pressure, etc.
In addition to regular process control sequences, the program can also contain abort sequences. These are initiated as a pre-programmed response to an alarm condition, and will bring the system to a pre-determined state in a pre-determined way. Abort sequences can be programmed with respect to each step of a process, so that the impact of an unforeseen condition can be minimized. Segments of an abort sequence are no different from other segments; they control the same way and are numbered in a like manner. Use of a sequence as an abort path can be seen by the letter "A" in front of the sequence number on the control display or in the print-out.
THE RECIPE

Sequences are further organized into recipes. A recipe is a group of sequences which will be executed in order, and constitutes a complete process from start-up to shut-down. Recipes may contain up to 50 different individual segments, each of which can be used as a control or abort, depending on which sequence calls it up. Recipes may also contain up to 50 different sequences, which use the segments in any desired order.

DIAGNOSTICS AND HARD-WIRED RESPONSES

Self-diagnostics are also continually going on, and in the event the system recognizes a failure that it can't recover from, it will prompt the operator to shut it down. Most failures will recover, but their occurrence is still logged so that correlations can be made as to the time, duration, and frequency of the failure.

CVD's equipment is designed and built so that any recognized hazardous condition produces a "hard-wired" response, i.e., certain actions will take place, subsystems will be deactivated, etc, without requiring any control on the computer's part. The wiring that produces such action will also produce input to the computer, and in the event of such an occurrence, the computer will display that input and tell the operator what is going on. "ABORT" sequences specified in the recipe will auto-execute at such times, enabling the response of the system to a given condition to be optimized. When the condition that caused the response goes away or is rectified, control will revert back to the recipe.

LIMITATIONS OF CVD'S PROCESS CONTROL

The process is driven by the system timer interrupt which trips approximately 18.2 times a second. This gives the frequency and resolution of ramping, segment switching, and response to various conditions.

The screen display is executed by a high level program in whatever CPU time remains. If a string of short segments are executed, they may not all display.

The data logging to disk and to printer is buffered by the interrupt program and logged by
the display program (but not dependent on segment displayed.) This provides regular, high speed datalogging without slowing down responses to the process.

Responses to Analog high level, low level, or setpoint deviation alarms are verified three times to screen spurious data.

In the event that there is a recognized failure of the I/O hardware, the software will attempt to reestablish control. Should the failure persist, it will be assumed that the computer no longer has control over the process, and it will try to shut everything down to the safe state.

CVD's Process Control - How It Works

CVD's process control works from a recipe which is generated with the CVDEdit software. The recipe is composed of segments which sequence by a combination of time and event tripping. The segment time is the duration before sequencing to the next step. This specified time can be overridden by event or operator triggered stalls/skips to assure that a process is in a given state before continuing/branching on.

Stalls can be linked to analog low level or high level limits, allowing for heat ups or cool downs to continue until desired levels are achieved. Stalls can also be tied to deviations from setpoint allowing for the system to progress as fast as possible while maintaining control within a given deviation band.

Different thresholds and deviation bands are provided for each segment of the recipe to give flexibility in controlling the most important variables each step along the way. Where a wide range of control is necessary, a system often has more than one controlling variable, or controller offering different methods of control at different points along the range. Examples of this would be low pressure systems with one pressure range between 0 and 1000 torr, and another between 0 and 10 torr to allow for increased resolution at critical operating conditions. Also, a furnace with dual thermocouple control, where furnace spike thermocouples control during low temperatures when a fast response to conditions in the heater is required, with the process profile thermocouples controlling at high temperatures.
when process conditions are critical, and the heat transfer is improved.

Abort responses are also selectable by segment to allow the greatest chance of salvaging some product in the event of an abort, and allowing the system to be placed in as safe a state as possible depending on the conditions of the abort. Abort sequences are also prioritized so that the most critical conditions will be corrected for first.

In the event a problem occurs, or unusual product is produced, the system state throughout the run can be reconstructed from the data logged to disk. This allows for identification of critical process variables as well as the ability to isolate the conditions which lead to either desirable or undesirable states.

Each segment may contain an unique segment message serving as a reminder to the operator, or a description of the purpose of the segment. It is recommended that these messages be used for proper documentation of what each step in a recipe is trying to do.

After defining a set of segments to cover the different states you want the machine in, a sequence is set up to define when and how often a segment is to be run. This sequence is the recipe order. When the process is being run, the segment number, the step number, and the total number of steps in the sequence are all displayed.

NOTE that when segments are inserted or deleted in a recipe with a defined order, the order is not automatically renumbered to reflect the inserted segment, or the change in the numbers of the following segments. Similarly, the abort sequences need to be renumbered to reflect any changes.
Each recipe is verified by the process program before it is run to ensure that a minimum segment time for digital switching is adhered to, and that all segments asked for in the recipe order and abort sequence orders have been defined, and that all abort sequences asked for have been defined. If any crucial information is missing, the process program will reject the recipe indicating what corrections need to be made.

The only step not included in the order is the warmup period defined by segment 0. This also defines the reset state of the machine. Upon completion of the warmup or reset segment, the process suspends, awaiting confirmation from the operator. This only occurs when running segment 0 as a reset or in the warmup mode. Segment 0 can be run in any step of the recipe order or an abort sequence order and will execute just like any other step.

The only other step that suspends upon completion is the last step in the recipe sequence or an abort sequence. The process idles at this point until the system is reset, asked to run one of the abort sequences, or asked to exit back to DOS. Upon exiting to DOS, the system is left as is. As long as the PC/XT/AT is left on, the digital and analog outputs controlling the valves and switches and controllers remain in their given state. Powering down the PC removes the 5 VDC outputs, and the output configuration.

II) Recipe Editor
CVD'S PROCESS RECIPE EDITOR

The Editor program is used for off-line generation and and modification of recipes. This program has online help screens (accessible from the menu bar) which explain the different variables and how to edit each one.

The editor is entered from the MS-DOS SHELL by using "TAB" to highlight the C:/*.* list on the right side of the screen, then using the down arrow key to highlight CVDEDIT. When the "ENTER" key is pressed, the editor will display.

To move around in the editor, use the arrow keys on the keypad. As these keys are pressed, different areas of the screen will be underscored or highlighted. The cursor is a blinking underscore when it is located on a single character or digit, and becomes a highlight.
(reverse video) block when it encompasses a word or phrase. To select a highlighted function, the Enter or Return key is used.

RECIPE CREATION RULES

- A newly created recipe displays segment 0 with default values, and no defined sequences.
- Recipe execution begins with sequence 99 and continues until no more steps are defined.
- Aborts are prioritized by lower numbers having the higher priority. For example, an abort A58 will be executed if called for when running A60, but if A57 has taken control, calling for A58 will have no effect.
- Segments must be defined in order to be edited. Segments can only be defined (inserted) one at a time and next to existing segments. Once a segment has been defined, it can be edited or elected as a target and copied into.

- In order to run successfully the segment must have a minimum segment time of .1 seconds for valve sequencing.
- To guarantee a response to an analog alarm, the minimum time should be 1 second.

- Initial and final setpoints, as well as high and low thresholds, must have values between 0 and the full scale value of the analog device. The editor will round the entered setting to the nearest resolvable value of the A/D. For the analog I/O cards, this is 12-bit or one part in 4,096.

Other considerations to take into account are the response times of each device to different physical phenomena. Up to this point, we have been talking about the response times of the computer control. It is often the system that is the sluggish one. It may be necessary to lengthen times or incorporate stalls to handle the response of a slow process.
USING THE EDITOR

2.1 Purpose

The Recipe Editor was designed to create and edit recipes. Each recipe essentially contains instructions for the process control program to execute. These instructions allow the engineer to completely control the hardware symbolically. Each Recipe consists of one or more segments and sequences. Each Segment is assigned a duration, Setpoints & Values, Alarm Levels, Alarm Responses, and Valve & Switch States. Each Sequence consists of a finite number of segments or other sequences which may be nested one or more times. Any segment or sequence may be used as an abort response.

2.2 Creating/Editing Recipes

To create a recipe, select the "CREATE" option from the main menu. To edit a predefined recipe, select "EDIT" from the main menu. After "CREATE" or "EDIT" has been selected, you can edit the header page of the recipe or proceed to edit the contents of the recipe. If you choose to edit the contents of the recipe, please note that you cannot go back to edit the header page without reloading the recipe. Upon editing the contents, the screen will display the first page of I/O for segment Zero. To change the value of any field, simply move the cursor off the menubar by using the up or down arrow keys to the field of interest and type in the value or response followed by the "ENTER" key. To view or edit the other page of I/O, select "OTHER PAGE" from the menubar.

By default every new segments' setpoints, as well as low alarms, are set to the minimum value. The default high alarm values is set to the maximum. Valves and switches are set to their normal de-energized state. Responses are (by default), None. The default values for segment duration and message are also None.

2.2.0 The Data Sheet

When creating a new recipe or editing an old one, a page containing information about the entire recipe will be displayed for configuration. This is called the Data Sheet. The Data sheet is displayed with the following fields RECIPE, OPERATOR NAME, EDITOR NAME, RUN DATE, EDIT DATE, DESCRIPTION, MESSAGE, (EDIT YOUR PASSWORD, EDIT ALL PASSWORDS,) EDIT SEGMENTS, ABORT. The function of each field is listed below.
RECIPE - This field allows you to change the name that the recipe will be saved as.
OPERATOR NAME - This field consists of 10 characters and is used to describe the name of the operator who will run the recipe.
EDITOR NAME - This field consist of 10 characters and is used to describe the name of the person who configured the recipe.
RUN DATE - Date that recipe was last run. This field is automatically modified by the process control software.
EDIT DATE - Date that recipe was last edited. This field is entered by person making modifications to the recipe.
DESCRIPTION - This field is used to describe the functionality of the recipe.
MESSAGE - This field is used to leave a message or instructions to an operator.
EDIT YOUR PASSWORD - {with password option} Allows a user to change their password for the recipe.
EDIT ALL PASSWORDS - {with password option} Allows Supervisor Access to all passwords for the recipe.
EDIT SEGMENTS - Exits the Data Sheet. Once the data sheet has been exited it can no longer be edited without reloading the recipe.
ABORT - Instructs the editor to disregard a request to create or edit a recipe.

2.2.1 Insertion/ Deletion of Segments

To Insert a new segment into your recipe, select "INSERT" from the menubar. You will then be prompted to enter the number of the new segment. The new segment must be adjacent to or on a predefined segment. All defined segments at or after the insertion point will be moved to the next segment.

To delete a segment from your recipe, select "DELETE" from the menubar. You will then be prompted to enter the number of the predefined segment to be deleted. All defined segments after the deletion point will be moved to the previous segment.

2.2.2 Copying Operations

CVD's Editor includes two types of copy operations designed to reduce repetitive data entry. These are Copy Marked Fields and Copy Columns; either will copy marked information from a source to a target. These routines are especially useful where minor or few changes are
occurring from segment to segment; copying the data eliminates the need to re-enter all of it, step by step.

The target of these copy operations can be either the same recipe or a different recipe. If the target recipe is different than the source recipe then "TARGET RECIPE" must be selected before any copy operation is to begin. The scope of these copy operations can be global or single segment.

2.2.2.1 Copy Marked Fields

Copying marked fields is a two step process. The first step involves selecting the fields to be marked. The next step is determining the scope of the target.

Select your field by moving the cursor to the field of interest and hit the "ENTER" key. The field will now be displayed in reverse video and considered marked. This marked status can be toggled by hitting the "ENTER" key again. Continue in this fashion until all fields of interest have been marked.

After field selection has been completed, select "FIELDS MARKED" from the menu bar. The menu bar will be replaced with a new one. To choose a single segment as your scope, select "SELECT SEGMENT." To perform a global copy operation, select "GLOBAL CHANGE."

2.2.2.2 Copy All (Mark All Fields)

Once "COPY ALL" has been selected, the only thing required to complete the operation is to select the scope of the target. To choose a single segment as your scope, select "SELECT SEGMENT." To choose a global copy operation, select "GLOBAL COPY."

2.2.2.3 Copy Columns

Copying columns is a three step process. The first step is to determine the source column. The next step is to determine the scope of the copy operation. The last step is to determine the target column. The source column and target column must be like data types.

Choose the source column by selecting corresponding description on the menu bar. After the selection has been made, you will be prompted to choose the scope of the copy operation. To choose a single segment as your scope, select "SELECT SEGMENT." To choose a
global copy operation, select "GLOBAL COPY." Choose the target column operation in the same manner as you chose the source column.

2.2.3 (Re)Defining Recipe and Abort Sequences

To view/edit sequence definitions, select "ORDER" from the menubar. You will then be prompted to enter the sequence number you wish to (re)define. To edit the definition of an abort sequence, move the cursor to the particular terms you wish to modify and type over them.

Each term of the sequence expression must be separated from other terms by a comma. Each term may be a sequence number, a segment number, or loop enclosing a term. A loop is denoted by a left square bracket followed by a one or more terms followed by a right square bracket. The maximum number of iterations per loop is 50. The maximum number of characters permitted in an expression is 65.

Examples of proper expressions:

1,2,3
1,2(3),4
1,2,11(5(71)),7,8

Example of invalid expressions

1,,2,3
10(1,2,3(4,5,6),7,8
1,55(2),3

2.2.4 Saving Your Recipe

Now that you've entered all the information for your recipe, you'll probably want to save it. To save your recipe without leaving it, select "SAVE" from the menubar. To save your recipe and exit recipe definition, select "EXIT" from the menubar followed by "SAVE AND EXIT."

2.3 Utilities

There are several utilities available from the main menu of the editor. They are Print Recipe, List Recipes, and Delete Recipe.

To print the entire contents of a recipe, select the "PRINT RCP" option from the menubar. The Printer must be online and communicating properly with the computer before this option is selected. The content of all fields for each segment will printed as well as the defined sequences.

To list the recipes accessible to the editor, select the "LIST RCPS" option from the menubar. The names of the recipe files will be displayed as well as the remaining free hard disk storage available.
To delete recipes accessible to the editor, select the "DELETE RCP" option from the menubar. You will then be prompted to enter the name of the recipe file.

Menus in CVD's Editor

Utility Level Menu

CREATE RCP - create a new recipe  
EDIT RCP - edit an existing recipe  
PRINT RCP - print out a recipe  
LIST RCPS - display a directory of recipes on disk  
DELETE RCP - delete a recipe from the disk  
HELP - go to the help menu  
EXIT - exit the recipe editor

Main Editing Menu

INSERT SEG - insert a segment within the recipe or after the last segment  
DELETE SEG - delete a segment from the recipe  
SWITCH SEG - switch the segment being edited  
COPY DATA - go to the copy menu  
ORDER - edit the recipe sequence and the abort sequences  
EXIT - exit editing the recipe and return to the utility level  
SAVE - save current recipe to disk and resume editing  
<-,-> - change editing page  
A-Z - edit relative markers  
LOOKUP - enter times into the lookup table  
HELP - go to the help menu

To edit any item on the page, just move the cursor to that item and change it. To use a relative marker in a setpoint, high alarm, or low alarm, just enter the marker letter, a + or - and the offset from the marker value (0.0 if none). To toggle a digital output from high to low, highlight the output and hit the enter key.

Insert Segment Menu

ENTER SEGMENT NUMBER - continue with inserting a segment  
ABORT INSERT - return to the main editing menu  
HELP - go to the help menu

Delete Segment Menu

ENTER SEGMENT NUMBER - continue with deleting a segment

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Confirming Segment Deletion

CONFIRM DELETE - confirm the segment deletion
ABORT - abort the segment deletion

Switch Segment Menu

ENTER SEGMENT NUMBER - continue with selecting segment to switch to
ABORT SWITCH - return to the main editing menu
HELP - go to the help menu

Copy Data Menu

EXIT - return to the main editing menu
MARK FIELDS - mark fields to copy to another segment
COPY ALL - copy the entire segment
COPY COLUMN - copy an analog column to a similar type column
TARGET RECIPE - copy to a segment in another recipe on disk
HELP - go to the help menu

Order Menu/ prompts:

SEQUENCE NUMBER TO MODIFY: - enter sequence number to modify
EDIT SEQUENCE - displays the sequence locating the cursor for editing
SEG SWITCH MODE: RESET - normal sequence
MERGE - merged sequence - all analog ramps
VAR TIME - each segment called up uses the next time from the lookup table, the layer number is incremented.
UNDEFINED 1 - 6 - not defined - do not use

Order Exit Menu

EXIT - return to the main editing menu
HELP - go to the help menu

Exit Recipe Menu

SAVE AND EXIT - save current recipe and return to the utility menu
CONFIRM ABORT - return to the utility menu without saving to disk
RETURN TO RECIPE - return to the main editing menu

Help Menu

ANALOGS - get help on analog fields
DIG OUT - get help on digital outputs (valves, switches, etc.)
DIG IN - get help on digital inputs (signals from various state sensors)
INS/DEL - get help on segment inserting and deleting
COPY - get help on copying data
RESP - get help on responses to digital inputs and analog alarms
ORDER - get help on recipe and abort sequences
GENERAL - get a general overview of the process control
EXIT - return to menu that called help

Copy Data Menu Levels

If Target Recipe Has Been Selected

MARK FIELDS - select to mark fields for copying
COPY ALL - select to copy entire segment
COPY COLUMN - select to copy an analog column
HELP - go to help menu

Marking Fields If Mark Fields Was Selected

MARK FIELDS - begin marking fields
FIELDS MARKED - all fields to copy are marked
ERASE - erase current field markers
ABORT - return to main copy menu

Select Source Column To Copy If Copy Column Was Selected

ABORT SOURCE - return to the main copy menu
FSET - copy from final setpoints
HIRESP - copy from high alarm responses
LORESP - copy from low alarm responses
DRESP - copy from deviation alarm responses
HELP - go to the help menu

Select Target Column To Copy To If Copy Column Was Selected

ABORT TARGET - return to main copy menu
ISET - copy into the initial setpoints
FSET - copy into the final setpoints
HLARM - copy into the high alarm settings
HIRESP - copy into the high alarm responses
LLARM - copy into the low alarm settings
LORESP - copy into the low alarm responses
DLARM - copy into the deviation alarm settings
DRESP - copy into the deviation alarm responses
HELP - go to the help menu
Select Target Segment If Fields Are Marked Or Copying All

SELECT SEGMENT - select a target segment to copy into
GLOBAL CHANGE - copy into all segments

A-Z Screen
Displays the current assignments of each marker

EDIT MARKER - begin prompts for editing a marker
EXIT - exit to main menu

Prompts for editing a marker

Enter Marker Letter To Edit: - enter a letter A - Z
Enter Segment of Relative Value: - enter the number of a segment
Enter Loop # of Relative Value: - enter the number of the analog channel
Enter Marker Type (V/S): - enter whether to read the value or setpoint

Relative Markers are realtime variables that are updated at the time the segment is loaded up. The conditions are those at the time of the segment change allowing setpoints to be carried over in a bumpless fashion. Only 10 relative markers can be used in any given segment. An individual marker can be referenced in any number of segments.

Initial and Final Setpoints as well as High and Low alarms may be entered as M+- offset where M is a letter between A-Z, and the offset is in engineering units.

Segment numbers in a marker definition are not updated during a Segment Insert or Delete command. Care should be made when using real time variables that they are defined after segment numbers are finalized or updated when Segment Insert or Delete is performed.

Loop numbers are not checked on the definition against where the marker is used in the recipe. It is possible to have the Iset and Fset of one loop be relevant to another loop. The values are transferred as percentage of scale, not in engineering units.

(A 20 liter MFC with a flow of 5 liters would set a real time variable equal to 25%, when used as a variable with a 10 liter MFC the value is interpreted as 2.5 liters)
LOOKUP

Displays the Contents of the Lookup table

EDIT ELEMENT - prompt for editing an indivial element
NEXT PAGE - display the next page of the table (1-80, 81-160, 161-240)
EXIT - exit to main menu

Enter Element Number To Edit: - enter the number to modify (1-240)
Enter Corresponding Duration: - enter the number of seconds
(real allowed)

The Lookup Table is accessed by segments called up by sequences of
the VAR TIME
sequence type. The segment time is replaced by the duration in
the next available
element in the table. The layer number is a counter for the
number of elements
read in.

Help Screen - Insert/Delete Segments

Insertion is the only way to create a new segment and deletion is
the only way to eliminate an unwanted segment. Deletion of a segment
followed by insertion at that segment location will restore all entered
data to the default values, defined below.

Only defined segments may be deleted. Insertions are permitted
only between, before or after defined segments. Segment numbers of all
following segments are incremented accordingly.

Analog values default to the lowest legal value, typically zero,
except high alarm and deviation alarm thresholds which default to the
highest values. The time default is also zero. Valves are
deenergized, and will be open or closed according to their hardware
default states. Both analog and discrete alarm responses have null
defaults. The default segment message is blank.

The newly inserted segment is automatically shown on the screen
with all default values.

Help Screen - Copy Function

Copying is done only from the displayed segment to a same recipe,
all segments in the same recipe, or a single or all segments in another
recipe currently on disk.

There are three copying modes: marked fields, column, or
everything. All can be used either within the same recipe or between
recipes.

Data fields are marked by moving the cursor to the field and
hitting the enter key; if a field has been previously marked this will
unmark it. When selection is finished, FIELDS MARKED is struck on the menu bar and the target selection sequence is entered.

Column copying is allowed only in the analog fields. This is the only copy mode permitted within a segment - isets may be copied to fsets in the same segment, for example. It is also allowed between segments and between recipes, singly and globally. Source and target columns must be of like type: isets, fsets, hlarms and llarms may be interchanged, as may hresp, lresp and dresp. The dlarm column, with percentages as its units, cannot be copied to another field type. Selection of source and target columns is done through the menubar. Target selection is done similarly. Note that copying between recipes must be indicated at the very start, prior to source selection. Copying may be aborted at any time prior to final target selection.

Help Screen - Order/Sequences

With two exceptions, the numbers designating segments and sequences are arbitrary - segments or sequences may be run in any order. The setup segment to reach initial conditions is always #0; the master recipe sequence, run automatically when the recipe is loaded, is sequence #99. Both must be defined for the recipe to be executable. Sequences or segments used as alarm responses must be defined, as must all segments referenced in used sequences. The CVD Control program will reject the recipe if these conditions aren't satisfied.

Sequences are series of segments and/or other sequences executed in the order in which they are listed in the sequence. There are 50 definable sequences, designated 51 through 99. All sequences can be either (or both) components of the recipe sequence or sequences to be executed upon alarm conditions.

Numbers less than 51 refer to segments; if they are given as alarm responses then that single segment will be executed. Sequence/segment numbers are separated by commas.

Numbers of sequences not yet defined are permitted; a sequence referencing itself would never terminate and so this is not permitted.

Looping of a sequence subsection is done by enclosing the section in parentheses and preceding the opening parenthesis by the number of times the section is to be repeated before advancing execution to what follows the closing parenthesis. The maximum number of loop repetitions is 50. Loops may be nested in loops an unlimited number of times.

The maximum sequence length is 65 characters.

Help Screen - General CVD Control Strategy

The CVD Recipe Editor is designed to give the user maximum meaningful control over the System hardware. Valve states and setpoints can be changed at rates that surpass the machine response.
time, and the full setpoint resolution of all devices is always available.

A recipe contains a maximum of 50 segments. A segment is defined by initial and final setpoints for all analog values, a fixed valve configuration, high, low and deviation alarm thresholds, separately defined alarm responses to each analog and discrete alarm, and a duration. Segment #0 is always for setup – warming up the machine to the desired state for beginning the recipe. When this segment has completed the machine idles until the operator directs the process to begin.

Alarm responses (also available as keyboard interrupts) include RESET to initial conditions, STALL the process until the alarm condition ends, ABORT the process by entering any defined sequence or segment numerically lower than the sequence underway, PRINT data obtained when the alarm condition begins and ends, skip to NEXT segment, END – Ends recipe ceasing datalogging to disk.

Up to 49 sequences comprised of defined segments or other sequences may be defined for use as alarm responses or components of the recipe itself. These sequences may contain subsections which repeat up to 50 times. In these sequences segments may be run in any order.

Help Screen - Responses

The alarm responses for both discrete and analog conditions are: RESET to initial conditions, END the recipe at current state, ABORT to any of 49 definable sequences or 50 single segments, STALL timer and maintain current setpoints until alarm condition disappears, or simply PRINT occurrence and ending of alarm along with pertinent data.

If several responses are indicated only the most severe is retained in the recipe. The order of severity is END/RESET/ABORT/STALL. These are mutually exclusive responses; the PRINT response may be used in conjunction with all the others or by itself.

Discrete alarms can be switched to trigger responses when inactive by inserting an I in the alarm response field.

Responses can be entered in any order. If an ABORT is indicated there must be a sequence number; a number entered without ABORT being indicated is disregarded.

N - Skip
A - Abort
R - Reset
E - End
P - Print
S - Stall
I - Invert (discrete alarms only)
Error Messages In CVD's Editor

IMPROPER EXPONENT FIELD - exponent not assigned number

NOT A NUMERIC VALUE - a numeric value was expected in this field

BLANK EMBEDDED IN NUMBER - number must take up entire field - e.g. 23.000 not 23.0 or 23 000

EXTRA DECIMAL POINT - only one decimal point is allowed in a number - e.g. 23.000 not 23.0

ILLEGALLY LOW NUMBER - for non-zero based ranges e.g. 200.0 entered for a 400.0 to 1200. range

ILLEGALLY HIGH NUMBER - a number greater than the maximum allowed was entered.

ILLEGALLY HIGH HOURS: MUST BE 10 OR BELOW

MISSING NON-EXPONENT FIELD - significant number not assigned to exponential number.

BAD TARGET SEG RESELECT OR INSERT NEW SEG - target segment selected has not been defined

BLANK FIELD NOT ACCEPTED -

SOURCE AND TARGET COLUMNS DIFFERENT TYPES - tried to copy between two differing field types

CURRENT RECIPE SELECTED - target in copy to target recipe is the same as the source

NAMED RECIPE NOT ON DISK OR ZERO LENGTH - recipe specified does not exist on the current disk and directory

RECIPE NAME ALREADY IN USE - tried to create a recipe with the same name as an existing recipe

SELECTED RECIPE DEFECTIVE - recipe selected has been damaged or was not created in the editor

INSERT ONLY IN OR AT END OF RECIPE - tried to insert beyond the end of the defined recipe

ERROR IN ACCESSING DISK: NO DELETION - a problem occurred when trying to delete a recipe

MAXIMUM SEQUENCE IS 99

III) Process Control
CVD's PROCESS Program

Purpose:

CVD's Process Control Software allows the user to run a completely automated process using a predefined "recipe", or to operate components of the machine through manual control.

STARTING UP THE PROCESS

When turned on, the computer system will execute the "DOS-SHELL" automatically. Upon seeing this, the operator may use the "TAB" key to bring the blue color bar over to the "C:\*.*" field on the right side of the display. Pressing the "down" arrow key several times will bring the color bar onto "PROCESS.BAT". Pressing the "ENTER" key will start the process control system.

When entering the process for each run, a screen will appear prompting the operator for information on what recipe to run, how often to print a hard copy process "snapshot", and how often to record a "snapshot" on disk. The operator may use the default values, or may enter different ones or none at all. The program will then read in and verify the named recipe, and begin the warmup segment (segment 0) which also defines the reset state.

At the completion of the warmup segment, process control will idle, waiting for the operator to manually enter a go-ahead signal. When this is given, the process will begin, executing sequences and segments in the order the recipe calls for.

OPTIONS FOR OPERATOR INTERVENTION WHILE RUNNING THE PROCESS

At any time, this software allows the operator to:

1) Abort the process to any preprogrammed sequence or segment at any time.
2) Stall the process clock, suspending analog ramping and segment sequencing
3) Reset the process, running the warmup segment and idling upon completion
4) End the process, causing it to idle in manual mode.
5) Request a snapshot of the system to be saved to disk or dumped to the printer.

These options are presented at the bottom of the process screen, and may be accessed by using the arrow key to highlight the desired function and then pressing "ENTER". These commands to disrupt the recipe all require confirmation to avoid accidental aborts.
Running the Process Control Software:

Upon executing the process control program, you will encounter the copyright notice. Please read it to understand full rights, privileges, and restrictions of the product.

After the copyright notice is displayed, you are asked which mode you wish to run process in - Manual or Automatic. Anything entered other than 'M' is interpreted as Automatic. Manual mode is used primarily for system testing, whereas Automatic mode is used to run a process recipe.

3.1 Manual Operation

If manual mode was selected, you will see a menubar on the bottom of the current page describing the current options available from that level of the mode. They are EXIT TO DOS, NEW RCP, PRINT, HELP, SETPT, DIG, <-, ->, GRAPH.

3.1.1 Controlling Setpoints/Reading Values

To change the setpoint value of any loop, use the arrow keys to highlight the "SETPT" option from the menubar. When this option is selected, a new screen will appear which bears the descriptions of all available analog loops. This screen is the "Analog I/O Page". To select a particular loop to modify, move the cursor bar to the corresponding description within the page and hit the enter key. Then enter the new setpoint value.

The new value will be displayed in the setpoint column of the corresponding loop on the analog I/O page.

3.1.2 Controlling Switch & Valves/Reading Digital Alarms

Switch position, valve states, and other "on-off" devices are referred to as "Digital." To toggle the state of any digital device, select the "DIGITAL" option from the menubar. When this option is selected a screen bearing the descriptions of all valves and switches is displayed. To toggle the state of a particular valve or switch, move the cursor to the corresponding description and hit the enter key.

To read the state of digital alarms produced by the system, simply read the abbreviation next to each alarm description on the digital input page.

3.3 Automatic Operation:

Automatic Operation can be reached by responding with a letter other than 'M' at the manual prompt during startup or after 'NEW RECIPE' has been selected in manual control mode. When automatic operation has been set, the program will ask whether you wish to list available recipes. After recipes have been listed or if you responded NO, you must then specify the name of the recipe. Names of recipes are the same as the DOS filename with extension (.RCP) entered.
3.3.1 Start Process Run:

After the name of the process recipe has been specified, other pertinent information about the run must be answered before the process can begin. These are:

- Operator Name
- Date of Run
- Data Logging Interval
- Print Logging Interval
- Lot Number (Name of data file)
- Comment About the Run

After the information has been completely entered, you are given the opportunity to terminate the program or select a different recipe if you wish. Otherwise, the recipe will be processed and validated. If the recipe has been determined to be valid, the recipe sequence will run starting with segment zero. Segment zero is known as the "warmup" segment and will require an Enter keystroke when it is done to allow the recipe to proceed.

3.3.2 Termination of Process Run:

A process run can be terminated by selecting 'END' from the menubar at anytime during the run. The system will "Freeze", maintaining the setpoint levels of analog devices and state of all switches and valves at the last moment prior to termination. No alarm responses are processed after termination of run.

3.3.3 Altering Recipe Contents During the Process Run:

CVD’s Process Control Software allows alteration of some parts of the recipe during the process run. Except for sequence order and alarm responses, which cannot be changed outside of the recipe editor, all items can be modified. If the recipe change is specified for a segment currently being executed, the changes will be acted upon immediately. Otherwise, changes will not be effective until next time the segment is executed. Any important recipe changes should be written down in a logbook. This is required because these changes are not permanent; exiting to DOS or loading a new recipe will discard any changes made during the process run.

To change the contents of a recipe in memory, select 'RCP' from the menubar at anytime during the process run. The program will then ask for the segment in the recipe to change. Once the segment has been specified, the menubar will be replaced with a new one listing recipe items that can be changed. They are:

- Analog loop fields
- Digital Outputs
- Time

To change analog loop information, select "Analog loop" in the recipe change submenu. Then select the analog loop you wish to modify.
You must then choose which field you wish to modify. All values entered for the analog loop field must conform to the range allowed by the software for the given device with the exception of deviation alarm levels which are based on percentage. Additional fields for the specified loop can be changed until loop field selection is exited.

Changing digital output states during a recipe run is done by selecting 'DIGITAL' from the recipe change submenu. The states of the outputs from the recipe are displayed as a new menubar. These can be toggled in memory just like real digital output states can be toggled in manual operation.

Changing the time of a segment duration during a recipe run is done by selecting 'TIME' from the recipe change submenu. Unlike in the editor, the colons delimiting hours, minutes, and seconds are not automatically entered for you; you will need to key them in manually. A period is needed after seconds to delimit fractions of a second.

3.3.4 Stalling/Skipping:

Stalling or skipping to the next segment affects the duration of the entire recipe run. It may be operator induced or specified as an alarm response. Alarm responses can only be entered through the recipe editor. An operator can induce a stall by selecting 'STALL' from the menubar and then confirming it. Likewise an operator can cause the recipe to skip to the next segment by selecting 'NXT SG' from the menubar followed by confirmation.
3.3.5 Print Log/Data Log

Both data logging and print logging can be periodically triggered or induced by operator command. Periodic logging is specified before the recipe is run for the first time during a session. Inducing a data log by operator command is done by selecting 'SAVE' from the menubar. A message at the "I/O" field, located at the top portion of the screen below "ELAPSED TIME", will display 'SAVING DATA.' Likewise a print log may be induced by selecting 'PRINT' on the menubar. The I/O field will display 'PRINT SCAN' following the command.

************** Miscellaneous Sections *******************

NEW RECIPE

New Recipe allows you to change mode of operation to Automatic from Manual.

PRINT

Print allows you to print the current state of all I/O in the machine.

HELP

Help allow you to view information on particular topics without disturbing the operation of the machine. The topics currently available are Setpoints, Analog Alarms, Digital Inputs, Digital Outputs, Recovery, General, and Responses.

3.3.6 GRAPH (requires CVDGRAPH.COM and Hercules monochrome video system)

Graph allows you to create a graph or load a predefined one and view incoming or logged data in the format defined. Note: When operating in Manual mode, data is not logged to disk so only real-time graphs are allowed.

3.3.6.1 Graph Definition

When the "GRAPH" option is selected, the current display page is cleared. You will be asked for the name of the graph definition file. The rest of the definition page will be displayed upon name entry. If the file was not found, all graph parameters will be assigned default values. Otherwise, graph parameters will be equal to values saved.

After all graph parameters have been entered, you have the option of saving the graph definition, aborting the definition, or exiting the definition and viewing the graph. If you choose to view the graph, the graph definition page will be cleared and replaced with the graph. The menubar will display options specific to this part of the program.

3.3.6.2 Graph Layout

Rev. 9/24/09/joc
The group of numbers displayed on the bottom of the left side of the graph are the minimum values you specified in the definition. Similarly, the group of numbers displayed on the top of the left side of the graph are the maximum values you specified. The left and right time displayed is the starting and ending time of the graph. These will be updated when the graph is tracking data. The center time label CURSOR TIME displays the time corresponding to the position of the cursor time. The values of the selected analog loops at cursor time are located under the starting time. The cursor time and the corresponding loop values will display N/A when cursor is not available.

3.4 Process Control Menubar Structures

The following pages will list all other menus that the operator may face, as well as all the system messages that may crop up and the condition each is referring to.

Confirmation Menu's

CONFIRM STALL
CONFIRM NEW RECIPE
CONFIRM RESET
CONFIRM END
CONFIRM EXIT TO DOS
EXIT

EXIT - Returns to the main menu without interruption to the process
Menu during a keyboard triggered abort

ABORT RESET NXT SG END STALL RCP GRAPH PRINT SAVE <- --> HELP

ABORT - Aborts recipe and executes abort sequence.
RESET - Ends recipe and restarts it at warmup segment.
NXT SG - Allows recipe to go to next segment without waiting for expiration of current segment.
END - Terminates recipe leaving system in state of last executed segment.
STALL - Halts further execution of recipe until stall is ended.
RCP - Allows the modification of setpoint values, digital output states, and duration of a segment while recipe is being executed.
GRAPH - Plots data to graph.
PRINT - Prints current state of system.
SAVE - Saves current state of system as a record in a data file for future analysis.
<- - Changes current display page.
->
HELP - Accesses Information about software.

Menu during a Reset before the zero segment has timed out

ABORT RESET END NXT SG STALL RCP GRAPH PRINT SAVE <- --> HELP

Menu during a keyboard triggered stall

END STALL ABORT END RESET RCP GRAPH PRINT SAVE <- --> HELP

Menu after a reset, while in the idle state before operator go ahead

GO AHEAD ABORT END RCP PRINT SAVE <- --> HELP

Menu during a process triggered stall

ABORT RESET NXT SG END STALL RCP GRAPH PRINT SAVE <- --> HELP
End of process menu

DOS  RESET  ABORT  NEW  RCP  PRINT  HELP  SETPT  DIGTL  <-  -->  GRAPH

DOS - Retain system state, and exit PROCESS to DOS
RESET - Place system in the Reset state
ABORT - Run a defined abort sequence
NEW RCP - Load up and run a new recipe
PRINT - Print current state of system
HELP - Access information about software.
SETPT - Change setpoint value of analog loop.
DIGTL - Change state of valve or switch.
<- - Change current display page.
->
GRAPH - Plot data in graph.

3.5 Help Screens & Messages

Messages from the startup of a recipe

WARMUP SEGMENT UNDERWAY
PROCESS STATE BEFORE OUTPUTS ACTIVATED
AWAITING OPERATOR GO AHEAD
WAITING FOR END OF PRE-PURGE TIMEOUT

Message indicating that a stall is being invoked

STALLING TO END DISCRETE ALARM
STALLING BY OPERATOR COMMAND
STALLING TO END HIGH ALARM
STALLING TO END LOW ALARM
STALLING TO END EXCESS DEVIATION

Messages indicating an abort has been invoked

PROCESS ABORTED BY DISCRETE ALARM
PROCESS ABORTED BY OPERATOR
PROCESS ABORTED BY ANALOG ALARM

Messages indicating the reset state has been invoked

RESET BY DISCRETE ALARM
RESET BY OPERATOR
RESET BY ANALOG ALARM
Messages indicating the end state has been invoked

PROCESS ENDED BY DISCRETE ALARM
PROCESS ENDED BY OPERATOR COMMAND
PROCESS ENDED BY ANALOG ALARM

Message showing a fault has been detected by internal diagnostics

MISSED LOOP SCAN: OLD ANALOG DATA
RECIPE ABORTED BY SOFTWARE ERROR
RECIPE TERMINATED BY HARDWIRED ABORT
ANALOG AND DIGITAL OUTPUTS ZEROED

System Status

DISCRETE ALARM STALL
KEYBOARD STALL
HIGH ALARM STALL
LOW ALARM STALL
DEVIATION ALARM STALL

DISCRETE ALARM ABORT
ANALOG ALARM ABORT
KEYBOARD ABORT
WARMUP UNDERWAY
INITIAL STATE
AWAITING GO AHEAD
WAITING FOR PRE-PURGE DONE

RESET BY ANALOG ALARM
RESET BY DISCRETE ALARM
RESET BY OPERATOR

END BY ANALOG ALARM
END BY DISCRETE ALARM
KEYBOARD END

DATA TO BE LOGGED
DATA LOGGED
DATA PRINTED
DATA TO BE PRINTED

PERIODIC DATA LOG
LAST SCAN IN SEGMENT
HARDWIRED ABORT
OUTPUTS ZEROED

SOFTWARE ERROR
I/O BOARD FAILURE
CATASTROPHIC BOARD FAILURE

Rev. 9/24/09/joc
Process help screens are available on-line to the operator and are headed by a realtime display of analog and digital alarm states. The Help menu has selections on the hardware interfaces, the hardwired interlocks, the screen layout, the data logging, and the general strategy. The help screens are contained in HELP.VID and are accessed by CVDHELP.COM when it is run.

ANALOG SETPOINTS

All segments are defined with initial and final setpoints for each analog loop. At the segment start each loop is set to the initial value, then the setpoint approaches the final setpoint by an amount proportional to the percentage of segment time elapsed. Sequences with the merge segment switch option have the analog values ramped at the rate set in the first segment of the sequence for the duration of the sequence. The merge alarm response will similarly continue the preceding segment’s ramp. Both process value input and setpoint generation have a precision of 1 in 4095 for the temperature, gas flows and pressure.

See printout of configuration for specific loops

ANALOG ALARMS

Each loop has high, low and deviation alarm thresholds and responses defined separately for every segment. Every time the process values are scanned the inputs are compared with the current thresholds; exceeding a threshold value triggers the appropriate response.

The deviation of the process value from the setpoint is calculated as a percentage of full scale, i.e., the difference between the lowest and highest values that the measuring device can register. It thus translates into a fixed value in measurement units no matter what the value of the current setpoint.

DIGITAL INPUTS

Digital inputs are used to indicate process conditions which are either binary in nature or where the actual analog value would not be useful, as for some critical limit alarms. The presence or absence of a specific digital input can be used to trigger all alarm responses. Loss of power to the digital processing hardware in the reactor will appear to the computer as all digital alarms occurring at once. On the other hand a disconnected ribbon cable, which carries the digital signal from the system to the computer, will appear as the complete absence of alarms. The correct functioning of the digital input/output control hardware within the computer is checked each time the discrete inputs are monitored. If the board fails repeatedly and cannot be reset then the process is shut down to its power fail safe state. Certain conditions provoke a hardwired response from the system; these are designated with an asterisk. The hardwired response is: . The abort state is latched until the triggering condition ends and the system is reset by the operator.
DIGITAL INPUTS
   See printout of configuration

DIGITAL OUTPUTS
   See printout of configuration

RECOVERY FROM HARDWARE/SOFTWARE FAILURES

SOFTWARE

Software failures should occur only as a result of defective storage of the code in the computer memory at runtime, or corruption of the code by degraded memory on the storage disk. Disks deteriorate or become damaged; backup copies should be kept on hand. A software failure will try to put the system in a safestate - all digital outputs will be deenergized and all analog outputs will be set to zero. The computer will monitor and display all digital inputs and analog process values but take no alarm response actions. The operator should note the error code number, the segment number, and the procedure name and call CVD Corp. with this information as soon as possible.

DIGITAL

The board controlling the digital inputs and outputs is monitored for failure. Loss of this board prevents control of the system. If this occurs the system is set to its power fail safe state.

ANALOG

Repeated failures in an analog controller board which will not reset correctly will cause the system to shut down in its power fail state.
DISPLAY INFORMATION

The information displayed on the screen is the process state captured at the last scan. Process scans are initiated after each display; the displayed data is only one or two seconds old when displayed.

The SEQ/SEG field shows the numbers of the current sequence and segment, followed by the position of this segment in the recipe or abort sequence underway. The same segment or sequence may repeat any number of times in a sequence. The SEGMENT DESCRIPTION is provided by the recipe creator to briefly summarize the purpose of the segment. SEG TIME shows the time elapsed since the segment began, relative to segment duration; time spent in stalls does not count towards this total. RECIPE is the recipe name; RECIPE DESCRIPTION serves to summarize the recipe for anyone viewing the display. PROC START is the time the initialization segment began. ELAPSED TIME is the total of completed segment times and the elapsed time in the current segment; stall times and warmup time during the initialization are not included in this figure.

STATE is the most global description of the process. SETUP is shown while initializing; RUNNING while the recipe is underway; ABORT (with sequence number) if an abort is underway; DONE if the recipe has ended or been terminated; RESET if the recipe has been reset to the initialization segment; ZEROED if all digital and analog outputs have been turned off.

MODE is used only to show the process is in a stall; STALLTIME is the length of time that an ongoing stall has lasted. I/O shows whether the displayed scan has been selected for printing or logging to disk.

SYSTEM MESSAGE alerts the operator to any anomalous conditions or prior events no longer displayed which have affected the course of the run. RAMP TIME gives the total time the analogs have been ramped in a shared ramp sequence. The nature of the analog and digital data displayed is discussed in the appropriate help screens.
ALARM RESPONSES

Each analog and digital alarm has an individually defined response which can be varied from segment to segment. These response options are:

- **Print** - print a one-line summary of the alarm when it begins and when it ends, with both real and process-relative times.
- **Stall** - idle the process at its current state, stopping the segment timer, until the condition ends.
- **Abort** - execute one of 49 sequences or 50 single segments with the process terminating when it finishes.
- **End** - terminate the recipe where it is without changing the process inputs.
- **Reset** - restart the recipe from the beginning of the initialization segment.
- **Next** - jump to next segment in recipe.

The setting of an alarm threshold without a response will cause the alarm to be flagged on the display, and process snapshots to be logged to disk at the start and end of the alarm condition. This logging is automatic with all the alarm responses.

Stall, Abort, End and Reset are mutually exclusive possibilities. If two or more are tripped together, they are processed in the reverse of the above order. If different abort sequences are called for then the sequence with the smaller number has precedence. If an abort sequence is underway a response which calls for that sequence or a higher sequence will be ignored. Note that as soon as a redirecting response occurs the alarm response environment for all subsequent scans is changed. When the process ends there is no further alarm checking; a dummy segment with an indefinite stall can be created if this is undesirable.

GENERAL

This program is designed to run recipes created with the editor program also provided with this system.

Computer control permits the automatic execution of a process limited only by the reaction time of downstream hardware, with a reproducibility manual control cannot equal. With this software sequencing of valves and setpoint updates for ramps or step changes can be accomplished with .055 second resolution. The flow of control is structured by sequences of segments, a segment being comprised of a duration, a digital output configuration, initial and final analog loop setpoints, and a set of alarm thresholds and responses for each analog and digital input. The recipe is a sequence of any of 49 defineable sequences and 50 defineable segments; The master sequence has been reserved at 99. The abort responses are any sequence or segment. Alarm monitoring is continuous, with a wide range of definable alarm...
responses which can reset, redirect, terminate or stall the process, or simply log the event to disk or printer.

Setpoint update, data scanning/alarm monitoring and segment switching all occur independently of display, printout or processing of keyboard input. This uncoupling insures the precise timing of control actions and reproducibility from run to run.

The system permits the operator to assert control at any point in a recipe run through the menubar at the bottom of the screen. All the alarm responses are available as operator commands, with run-disrupting commands requiring confirmation. This set of help screens is always available to the operator.

IV) Data Retrieval
CVD's Data Retrieval Software

Purpose:

Data Retrieval is used for in-depth review of a completed process run. It allows the user to examine the state of the machine and it's I/O at various times during the run.

Data may be viewed, printed, or exported via ascii file format into 1Lotus 1-2-3 compatible and spreadsheet programs.

Entering Data Retrieval:

To enter Data Retrieval from Dosshell, hit tab until the Directory Tree window border changes color. Using the arrow keys, move selector to the CVD subdirectory and hit "ENTER". Then hit tab to move to the file window to the right of the Directory Tree. Move selector down to CVDDATA.EXE and hit enter.

To enter Data Retrieval from the DOS command line, follow this sequence.

c: [ENTER]
cd \CVD [ENTER]
CVDDATA [ENTER]

Overview:

A scan is a snapshot of the system's state at a particular instance of time. A scan may have been triggered periodically or induced by operator command. A collection of scans logged to disk forms a data file. The format in which each scan is logged to disk is called a record. Each record has a unique integer number which identifies it. This is called a record number. These record numbers reflect the order in the scans were logged to disk. The name of the data file is the Lot Number assigned during the process run. A unique Lot Number should be assigned during each process run to ensure that the data file will not be overwritten.

Digital devices are displayed only in their energized state. When they are de-energized, they are mapped to the screen as blank
Information about Analog Controllers and Measuring Instruments are displayed in one line per device. These lines will be referred to as loops since most analog devices recognized by the software have setpoints controlled by the software. System messages displayed during the process run are also displayed on their own screen or display page. Information about time and place in recipe sequence is displayed as heading in each display page. Information about time and place in recipe sequence is considered to be "global."

Menus are located at the bottom of the screen. Each menu contains options which may be selected by arrow-keying the selector to the option and hitting the enter key. These options are commonly known as menu items. A menu item which is itself another menu is called a submenu.

View state of all I/O during a scan:

To view the state of all I/O at a particular scan time, select 'DISP SCANS' at the main menu. Note it may be necessary to change display pages to view different I/O types. This is accomplished by selecting the arrow menu items from the scan submenu to page forwards or backwards.

Changing Scans:

There are three ways to change scans while viewing. They are:

- Advance to next scan
- go to prior scan.
- go to scan by record number.

To advance to next scan, select 'NEXT SCAN' from the view scan submenu. To go to the prior scan, select 'LAST SCAN' from the view scan submenu. Attempts to access before the beginning or beyond the end of the data file will merely wrap the pointer to the scan on the other end of the data file. To access by record number, select 'SELECT SCAN' from the view scan submenu. You will then be prompted to enter the record number. Record numbers out of range will generate an error message.

Print Scan(s):

There are two ways to print one or more scans. The first method is to print the scan while you are viewing it. To print a scan while viewing it, select 'PRINT SCAN' from the view scan submenu. The second is to print a series of scans starting at a particular record number. To print a series of scans, select 'PRINT' from the main menu. You will then be prompted to enter the record number that it will start with.
Create Data Table:

A data table may be output to file or printer by selecting 'TABULAR DATA' from the main menu after the data file has been loaded.

The starting and ending time of the data table are the beginning and end of the data file by default. These times may be changed to focus on any smaller time period within those two times. To change starting time, select 'SET START TIME' from the menubar. The prompt will display the last starting time entered or the default value. Enter the time with hours, minutes, and seconds separated by colons and fractions of a second preceded by a decimal point. (i.e. 01:23:45.6). To change end time for the data table, etc.

Once start time and end time have been set, the data table's destination must be determined. (One advantage of sending it to file is that it may then be imported into 1Lotus 1-2-3 or compatible spreadsheet program.) Regardless of which output destination is chosen, a loop must be selected in either case.

To File:

When sending a data table to file, the file will bear the same name as the Lot Number but end with a PRN extension. (i.e. LOT123.PRN.) Select 'SEND TO FILE' from the tabular data submenu. A new screen will appear with n will clear with short abbreviations of the loop names arranged in rows. To select a particular loop, move the selector until the item is blinking and hit enter. The item will now be marked and displayed in reverse video. The item can be deselected by hitting enter again. Output will not begin until the user hits the down key enough times to exit each row of loop selectors.

To Printer:

To select output to a printer, select 'PRINT DATA' from the tabular data submenu. The rest of the procedure is identical to that of outputting to file. The printout will be formatted such that time is displayed in seconds followed by up to three pairs of setpoints/values per line. If more than three loops were selected, a new line bearing the same time would display the next set of loops.

Changing Data Files:

To Change the data file being examined, select 'SELECT FILE', from the main menu.
Glossary of Terms

A/D - Abbreviation for Analog to Digital
Abort response - A controlled disruption of the process due to a prescribed condition.
Abort condition - A tolerance set on a monitored condition which when exceeded will specify an abort.
Accuracy - The exactness of a value.
Alarm - An indication of a monitored variable being out of tolerance.
Alphanumeric - A character set including both letters and numbers.
Analog - Pertaining to a variable condition with continuous states such as voltage, temperature, pressure, and flow rate.
Automatic control - The execution of a process without operator assistance.

Baud - The rate information is sent in bits per second.
Background program - A program of lower priority with regards to time which may be interrupted by other programs.
BAK - the filetype of an older generation {from backup}.
Bit - The smallest unit of data indicating one of two possible states; the abbreviation of binary digit.
Buffer - An intermediate storage area between two devices used for holding information until the receiving device is ready for it so as not to slow up the sending device.
Byte - A group of bits considered as the unit of information for a computer indicating a single character in the character set.

Closed loop control - The output signal is dependant on the input signal.
Counts - The increments an analog scale is broken into when digitizing.
Cycle time - The time taken in one pass through a repetitious routine.

D/A - Abbreviation for Digital to Analog.
Data logging - A recording of information for future reference.
Derivative Control - When the output signal is modified due to the rate of change in the input signal over time.
Deviation alarm - An indication that the process value is higher or lower than the setpoint by a set percentage.
Diagnostic routine - A series of steps taken to verify the working order of a piece of hardware.
Digital - A numeric representation with discrete possible values.
Digital filter - A screening method limiting the effects of erroneous input signals on the output signals.
Digital output - An output that has two possible states.
Discrete - Non-continuous, distinct.
DOS - Disk Operating System - The software interface that coordinates the computer with its keyboard, crt, disk drives, printer, and other peripheral equipment.

End response - A branching of process to the END step and idling upon completion.
Event oriented - Dependent or affected by realtime process readings.
Execute - The implementation of a program.

Fail-safe - Default state of the system in the event of a failure.
Flag - A status bit indicating a state.

Gain - The parameter determining the proportional response.
Global - Affecting an entire entity.

Hard copy - A printout on paper.
Hardware - The machinery, cables, and other equipment.
Hardwired response - An automatic action taken independent of the computer.

I/O - Abbreviation for Input-Output.
Initialize - A routine for insuring a starting state for repeatability.
Input - A signal sent to the computer from the process.
Integral Control - When the output signal is modified as a function of the time integral of the input signal.
Integral sum - The error term that is added to or subtracted from to indicate the magnitude of the integral control response.
Interface - A connection of two dissimilar devices.
Interrupt - The halting of the execution of one program in order to execute another program which has taken priority.
Interrupt Service Routine - A program specifically designed to execute in response to an interrupt.
Inverse - The reverse state or reciprocal state.

Lag - The time difference between a cause and an effect.
Latching - A state that remains in effect when the cause of the state goes away.
Limit checking - Checking a process reading against specified limits.

Manual Control - Control dependent on an operator for change.
Mark - Specifying an item to perform an operation on.
Mask - A filter designating items to ignore or alter.
Monitor - 1) A CRT display. 2) Reading a process value without the ability to directly modify it by changing an output.
Multitasking - The execution of several functions in a parallel fashion using a timesharing or priority interrupt scheme.

Noise - A variation in a signal caused by an external force.

Open-loop - Where the output signal is independent of the input signal.

Operator - The human element.

Optimize - The strive for perfection.

Order - The sequence of segment numbers to be run in a recipe.

Output - A signal being sent from a device.

Override - Disregarding a control signal.

Overshoot - The amount the process exceeds the setpoint after a step change.

Parameter - A settable constant which enters into a given function.

PID control - Where the output is modified according to proportional integral, and derivative evaluations of the input signal.

\[ m(t) = K_c \left[ e + \frac{1}{T_i} \int e \, dt + T_d \frac{de}{dt} \right] \]

where: \( m(t) \) = output signal from controller

\( K_c \) = Proportional gain

\( T_i \) = Integral Reset

\( T_d \) = Derivative Rate

\( e(t) \) = error between setpoint and process value

Precision - The digits used in representing a value.

Priority - The relative importance of items competing for a resource.

Proportional Band - The amount of change in the input necessary cause a full scale change in the output. Inversely related to the gain.

Proportional Control - Where the output is modified proportionally to the error between the setpoint and the process input.

Queue - A group of items waiting to be serviced.

Ramp - A series of small steps in the analog setpoint over a period of time (presently only linear ramping is supported).

Range - A span which data may be measured in.

Rank - The priority of an item.

Rate - The constant specifying the weight given the derivative control in the control algorithm.

Real-time - Occurring during a process while the process can still be affected.

Redundancy - Protecting against isolated failure by duplicate action.

Remote - Distanced from the process.
Reset - The constant specifying the weight of the integral control.
Reset State - The state the process is originally initialized to.
Resolution - The number of increments a scale is divided into.
Response time - The amount of time required after an action takes place before the appropriate reaction occurs.
Sampling - Acquiring data
Scale - The range a device is measuring in or sending signals in.
Scan - A complete pass through the data being read in from the process.
Segment - A time, digital output states, analog initial and final states, alarm limits and responses, and an operator message.
Sensitivity - The amount a signal must change before any change is indicated.
Sequence - An order in which to run the segments defined in the recipe.
Setpoint - A designated level an analog value should achieve.
Snapshot - A complete set of information depicting the state of the process at a given time.
Source - Where information is coming from.
Stall - A suspension of the process clock and analog ramps.
Step - A position in a sequence indicating a segment to run.
Step change - An instantaneous change in the control setpoint.
Supervisory - A level of control at least once removed from the process which allows monitoring and some manipulation.
Synchronize - An initialization procedure in communications.
Target - Where information is going to.
Toggle - When repeating the same action causes a reversal in state.
A flip-flop.
TSR - Terminate Stay Resident - A program that is loaded only once upon bootup, and stays active until the system is rebooted.
Tuning - The procedure for determining the proper settings of various process parameters.
Zeroing outputs - setting outputs to their power-fail state.
Zone - A region that control is acting upon.
VI) File Nomenclature / Special File information

FILES FOR CVD'S PROCESS CONTROL SOFTWARE SYSTEM:

IOCFG.EXE          Configuration Editor
CVD2344.CFG        Configuration File
CVDEdit.EXE        Editor - {creates .RCP files, .ASC files}
       EDHELP.VID   Editor Help Screens
COPY.EDR           Editor Copyright Notice
BOXTOPS.EDR        Editor Screen Mapping
FIELD.P.EDR        Editor Screen Mapping
PAGES.EDR          Editor Screen Mapping
PPOINTS.EDR        Editor Screen Mapping
CVDPRC.EXE         Process Control Executable - Operator Interface

       - {reads .RCP files, creates .DAT files}
CVDGO.COM          Interrupt Service Routine - Hardware Interface
CVDGRAPH.COM       Graphics Driver (optional - requires Hercules Monochrome Display)
HELP.VID           Help Screens used by

CVDHELP
       CVDHELP.COM        Help Screen Driver
       CVDPRINT.COM      Printer Driver
       CVDDATA.EXE       Data Retrieval
       HELPMMAKE.EXE     Help Screen .VID Generator
       HELP2344.TXT      Ascii for HELP.VID
       EDHELP.TXT        Ascii for EDHELP.VID
       MRGTIM.EXE        Recipe Generator for System
       - {reads STANDARD.RCP and TIMTABL.PRN}
       - {creates a new .RCP from user prompts}
       MRGTIM.C          Source Code for
       MRGTIM.EXE
       MRGTIM.H
MRGTIM.EXE

MRGTIM.EXE and MRGTIMF.EXE were created to fill the time table in a recipe (STANDARD.RCP for MRGTIM.EXE) from a .PRN file (TIMTABL.PRN for MRGTIM.EXE) and allow the operator to enter the number of desired layers, the starting layer, and the new recipe name. The new recipe will contain the numbers from the .PRN file in the Time Data Table, and Sequence 90 will be modified to run sequence 91 for layer 1, and sequence 92 for layer 2. Note that the default number of layers equals the number of entries in the data table, and the default starting layer is layer 1.

TIMTABL.PRN is a list of numbers in ascii format easily produced from a spreadsheet program such as LOTUS 1-2-3 by printing to a file.

STANDARD.RCP is a recipe which uses sequence 91 to grow Layer 1, and sequence 92 to grow Layer 2. Each layer will run only one segment of variable time.

IOCFG.EXE

IOCFG.EXE reads in CVD2344.CFG allowing the operator to configure the analog loops, digital alarms, and the digital outputs, as well as print out the configuration to a printer.

Configuring analog loops allows the user to enter the Description of the Device, an abbreviated description, Scale type, Maximum value, Minimum Value, number of decimal places, and whether both inputs and outputs are used. Note that certain items are hard coded and cannot be altered on all loops for all programs. Changing Scale type, or I/O type may not produce the desired results. Serial Communications loops are hard coded on all items except descriptions.

Digital Alarms and Digital Outputs both allow a description for a HIGH state and a LOW state. The I/O type determines whether the LOW state description is displayed when not checking an inverted response for digital alarms, or not in a menu for digital outputs.
Note that the length of the description allowed may not fit on all the screens that description is used. This may cause characters to be overwritten during a screen update.

HELPMAKE.EXE

Helpmake is a utility to produce .VID files for help screens from ascii text files that can be edited in DOS EDIT.EXE. The text file must follow certain guidelines. Each screen must be no larger than 20 line of less than 80 characters. Each screen is delimited by a .PA appearing at the beginning of a line. There are 14 screens (whether they are used or not).

Helpmake will prompt for the input file name. No default extension is expected so the entire file name must be entered.

Helpmake will prompt for the output file name. Only the 8 character DOS name is given. A .VID extension will automatically be added to the given name. Note that CVDHELP.COM will always look for HELP.VID, and CVDEEDIT.EXE will always look for EDHELP.VID.

VII) System hardware requirements

PC/AT compatible with an 80X87 math coprocessor, 640 Kb of memory, a fixed disk, a parallel printer port, a color or VGA monochrome monitor, a serial port, keyboard and a printer. (80386 or 80486 dx recommended)

DOS 3.1 or greater
NOTE: This Software Is Not Designed To Run With Windows!

A CGA Video system or greater.

Data Translation DT2817 digital I/O card with CVD's distribution card, 5-24 VDC digital output modules, 24-5 VDC digital input modules and interconnecting cables.
First Address - 228 hex

Robotrol ADA88 analog cards to handle 12 bit analog D/A and A/D operations (or similar cards)
First Address - 320 hex

A Send enabled RS232-RS485 2 wire converter and Temperature Controllers using EI-Bisync Communications Protocol similar to the Eutotherm 2416 temperature controllers addressed at Front Zone 0.1
Center Zone 0.2
Rear Zone 0.3

Generator for System

- (reads STANDARD.RCP and TIMTABL.PRN)
- (creates a