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VACUUM STATUS-DISPLAY AND SECTOR-CONDITIONING PROGRAMS*

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Two programs have been developed for observation and control of the AGS vacuum system, which include these notable features: (1) they incorporate a graphical user interface, and (2) they are driven by a relational database which describes the vacuum system. The vacuum system comprises some 440 devices organized into 28 vacuum sectors. The Status Display Program invites menu selection of a sector, interrogates the relational database for relevant vacuum devices, acquires live readbacks, and posts a graphical display of their status. The Sector Conditioning Program likewise invites sector selection, produces the same status display, and also implements process control logic on the sector devices to pump the sector down from atmospheric pressure to high vacuum over a period extending for several hours. As additional devices are installed in the vacuum system, the devices are likewise added to the relational database; these programs then automatically include the new devices.

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1. INTRODUCTION

We describe here two programs which provide an intuitive graphic view of the AGS vacuum system, encompassing all devices in one selected sector: ion pumps, roughing station, gauges, and sector valves. This graphic view offers a global perspective of the vacuum sector and suggests the geographic relationship among the components. The programs are driven by menu input and require a minimum of training for their users in the technician community. Both the menu and graphic components of the displays for these programs are driven by information retrieved from a relational database which describes the vacuum system. Thus modifications to the vacuum system are reflected in these programs as soon as the changes are entered into the database. Moreover, an entirely new vacuum system can be handled by the same program with the same ease; thus, the vacuum system for the Booster will be entered into the same database and will immediately be available to the software.

The "vacuum_status_display" program is designed for passive observation of the vacuum system; the second program, the vacuum_startup program, is designed to automate the sector conditioning process for a sector. This program incorporates process control logic to bring a sector from an initial state with only rough vacuum through several stages of pumpdown to a final state of high vacuum acceptable for AGS operations. Both programs incorporate the same status display for operator feedback, and both rely on the relational database for the list of devices relevant to the sector

selected by the operator.

2. AGS VACUUM SYSTEM

The AGS vacuum system is partitioned into 28 vacuum sectors, of which 24 are in the AGS ring, and 4 are in the high energy proton injection line. Adjacent sectors are separated by a sector valve, and each sector contains: (1) a roughing station; (2) low and high vacuum gauging; (3) low and high vacuum gauging in the roughing line; (4) multiple ion pumps with readback, with from 4 to 14 pumps in each sector. There is a total of 29 sector valves, 56 low vacuum (Pirani) gauges and 56 high vacuum (Penning ionization) gauges, 28 roughing stations, and ~260 ion pumps. The vacuum system is in the midst of an active upgrade project, with significant reconfiguration occurring each summer, with consequent impact on vacuum related software.

3. COMPUTER ENVIRONMENT

The new AGS control system comprises a net of ~40 Apollo workstations, which communicate via Apollo's proprietary token-ring network. Two workstations are available at each Main Control Room console for Operator programs; additional workstations are available throughout the AGS complex, and a workstation is located in the Vacuum Group work area. The Apollo workstations run the Aegis Operating System which provides for a multi-window multi-task user environment with excellent graphic facilities.

All vacuum devices are connected (by a coaxial cable bus) to "device controllers" which report to "stations" on the Relway control network [1]. The vacuum system is supported by 7 device controllers reporting to 3 stations which are dispersed at 3 sites around the AGS complex. The stations maintain a distributed database describing the state of their dependent devices; this database is updated every 2-3 seconds. Programs operating in the Apollo workstations obtain their reports on device status from the station-resident database.

4. VACUUM_STATUS_DISPLAY PROGRAM

On startup, this program retrieves from the database a list of the vacuum sectors present in the accelerator, constructs and posts a menu of these sectors, and awaits operator selection of a sector. Upon sector selection, the list of devices in the selected sector is compiled from the database, and reports are requested from the network for these devices. The layout of these devices in the sector is also retrieved from the database, and a layout display posted which shows the geographic relationship of the devices. When the device reports are received, the display is updated showing the status and readbacks of the devices; both graphic and textual indications are posted (fig 1) for each device. Should a device fail to report, it remains indicated by its layout symbol in the display. Gauge and pump readbacks are displayed as a logarithmic bar chart, with a chart range appropriate to the operating range of the device. Since the juxtaposition of display elements maps the location of devices in the

vacuum system, the performance of the vacuum system is easily evaluated. Vacuum phenomena, eg a pressure bump, are immediately apparent. The status display is updated once per minute, until the operator requests a new sector or terminates the program.

5. VACUUM_STARTUP PROGRAM

This program, like the vacuum_status_display program, is entirely driven by lists of devices and sectors that are retrieved from the relational database. The startup, or conditioning, procedure for a sector proceeds through four stages:

1. Roughing stage: ion pumps are off until pressure drops to 0.1 milli-torr.
2. Intermittent ion pump operation; cyclic on-off operation is necessary to prevent pumps from overheating, until pressure drops to 0.01 milli-torr.
3. Continuous ion pump operation; this stage continues until pressure drops to 2.0 micro-torr.
4. Foreline close-off; the roughing line is valved off. If this is accomplished without a pressure bump and the pressure drops to 1.0 micro-torr, the procedure is completed.

The process logic which drives the program through these stages includes substantial allowances for failure conditions and loopback through the stages. The typical AGS vacuum sector requires >5 hours to complete the conditioning process. This process is managed by the

program with no manual intervention or monitoring, although intervention is still possible should the technician deem it advisable.

During operation of the vacuum_startup program, the status display is updated every minute. Also, a separate process is automatically initiated which logs the pump and gauge readbacks every minute, for subsequent playback and analysis with a standard offline program.

6. RELATIONAL DATABASE

A commercial relational database is used to maintain relations which describe:

1. The vacuum sectors present in the accelerator.
2. The vacuum elements present in the accelerator.
3. The straight sections present in the accelerator.

The vacuum_elements relation indicates for each element:

1. The type of vacuum element (sector valve, ion pump, etc.)
2. The sector to which the element belongs.
3. The straight section in which the element is located, and where along the straight section it is located.

The sector valves are entered twice in the vacuum_elements relation since they belong to two sectors, once as a downstream sector valve, and once as an upstream sector valve. A qualified retrieval [2] from the database of all vacuum_elements belonging to the selected sector

permits these programs to construct a list of device upon which subsequent operations or readbacks may be based.

7. GRAPHICS

Some notes on the conventions used in the graphic display are included here, with reference to fig 1. Vacuum devices, by convention, incorporate in their name the straight section in which they are located, eg I4PI.P is located in the I4 straight section. Names for pressure readings from ion pumps terminate in "PI.P"; the name of an upstream sector valve terminates in "VS_US"; the name of a Penning ion gauge terminates in "GCC" (cold cathode gauge); the name of a Pirani gauge terminates in "GTC" (thermo-couple gauge); names of roughing line devices terminate in "PR" (pump-rough).

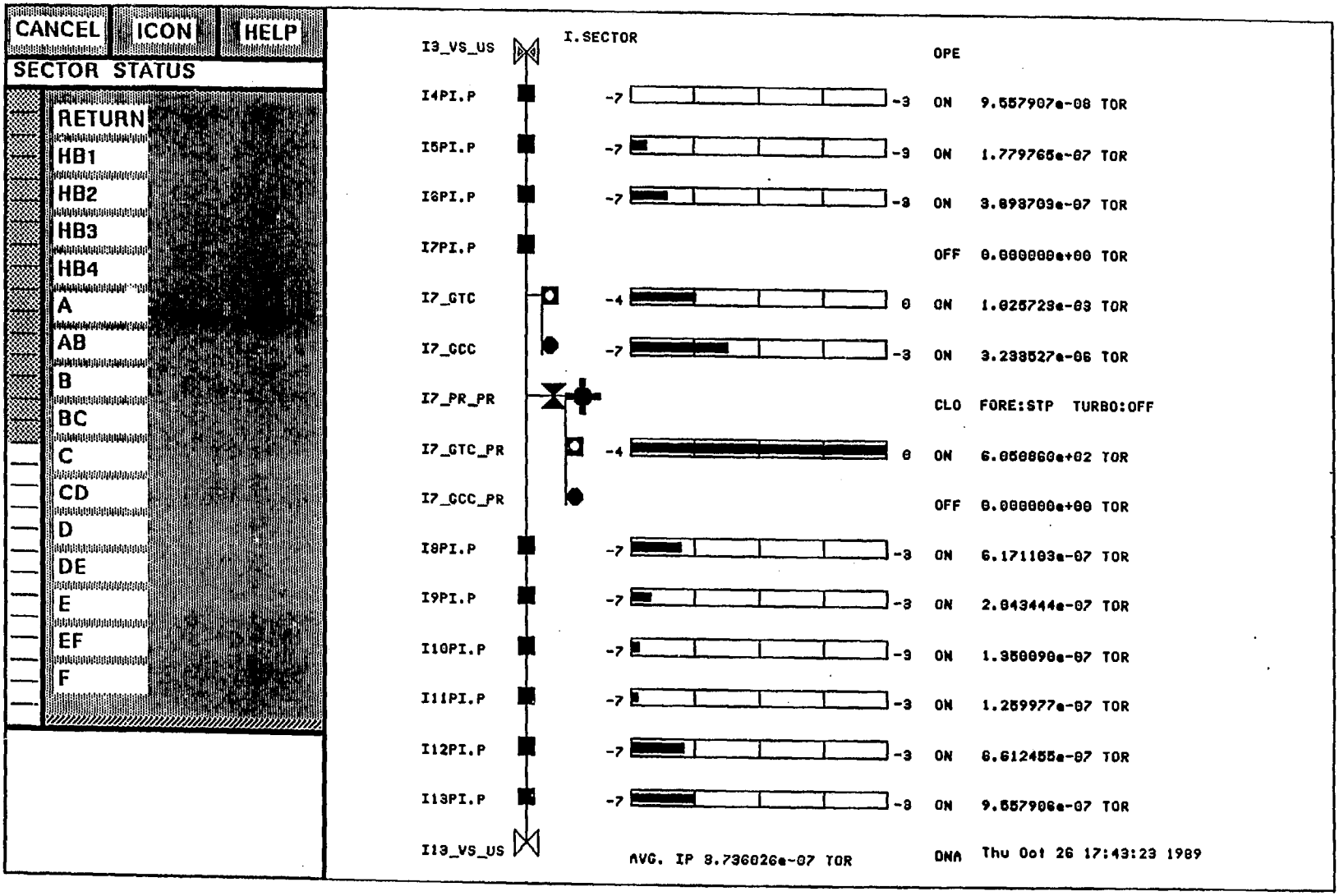
The graphic icon for an ion pump is a filled square; that for a Penning ion gauge is a filled circle; that for a Pirani gauge is a filled square enclosing an open circle. A roughing station is marked by a 4-bladed fan. Valves are marked by bow-ties: a bow-tie outline marks a non-reporting valve, filled bow-ties mark a closed valve, and an open valve is marked by a bow-tie enclosing triangles.

8. References

[1] A. Stévens, T. Clifford, R. Frankel, "Distribution of Computer Functionality at the Brookhaven AGS", IEEE Trans. Nucl. Sci., NS-32, 2023 (1985).
[2] T. Clifford, R. Katz, C. Griffiths, "A C Programmer's View of a Relational Database", this conference.

9. Figure Captions

fig 1 - Menu and graphic display for the vacuum_status_display program.


CANCEL
ICON
HELP
SECTOR STATUS
RETURN
HB1
HB2
HB3
HB4
A
AB
B
BC
C
CD
D
DE
E
EF
F
I.SECTOR
OPE
I3_VS_US
I4PI.P -7 -3 ON 9.557907e-08 TOR
I5PI.P -7 -3 ON 1.779765e-07 TOR
I6PI.P -7 -3 ON 3.898709e-07 TOR
I7PI.P OFF 0.000000e+00 TOR
I7_GTC -4 0 ON 1.025723e-03 TOR
I7_GCC -7 -3 ON 3.238527e-06 TOR
I7_PR_PR CLO FORE:STP TURBO:OFF
I7_GTC_PR -4 0 ON 6.050860e+02 TOR
I7_GCC_PR OFF 0.000000e+00 TOR
I8PI.P -7 -3 ON 6.171103e-07 TOR
I9PI.P -7 -3 ON 2.043444e-07 TOR
I10PI.P -7 -3 ON 1.350090e-07 TOR
I11PI.P -7 -3 ON 1.259977e-07 TOR
I12PI.P -7 -3 ON 8.612455e-07 TOR
I13PI.P -7 -3 ON 9.557906e-07 TOR
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AVG. IP 8.736026e-07 TOR
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