SLAC
TN-64-74
W. Pierce
September, 1964

INSTRUMENTATION FOR VACUUM SYSTEM

1.0 SCOPE

The electronic functions associated with the instrumentation of the vacuum system will be reviewed in this report. The system has evolved from meetings between members of the Vacuum, Light Electronics, and I and C Groups.

1.1 Normal Sector Requirements

1.1. 1 Gauges

A total of nine vacuum gauges will be required per sector. Eight of the gauges will be used primarily for klystron and klystron window protection, and hence will be mounted in their vicinity. These gauges will hereafter be referred to as "Klystron gauges." The remaining gauge will be identified as the manifold gauge and will be mounted on the eight-inch vacuum manifold at approximate mid-sector.

1.1.2 Ion Pumps

The continuous pumping will be performed by four 500 liter per second getter ion type pumps. These pumps will be spaced to provide a minimum pressure differential over the sector length. They also could provide vacuum analog information through the proportionality of pressure and ion current. At present there are no plans to use these pumps for any function other than pumping.

1.1.3 Thin Valves

There will be two thin valves per sector drift tube. The downstream valve will be automatically closed when the vacuum manifold pressure at the manifold gauge exceeds 10^{-5} torr (the trip point will be adjustable locally). The upstream valve will be manually operated from the klystron gallery. The system functions are discussed later in par. 3.4.

2.0 PROPOSED SYSTEM COMPONENTS

2.1 Gauges

A decision was made to use cold cathode ionization type gauges for vacuum measurements throughout the M vacuum system. This decision was based primarily on an anticipated increased useful lifetime, and has been substantiated by the gauge tests currently in progress. The cold cathode gauge is an order of magnitude more sensitive than the alternative hot cathode gauge. The latter would require more elaborate electronic equipment with a resultant decrease in reliability.

The cold cathode gauge is basically a discharge tube with an external magnet to increase the electron path length, and hence the number of ions produced by the electrons colliding with the gas molecules present in the system. The ion current is proportional to the density of gas molecules present in the system and hence an indication of vacuum can be obtained by measuring ion current. The sensitivity of these gauges is nominally 2 amperes per torr, and it is thought that the vacuum may be as high as 10^{-8} torr. This will require a measurement of 2×10^{-8} amperes. A current amplifier will be required to raise the current level to a reasonable value. A high voltage power supply (between 1 to 4 kV) is required to initiate and maintain the discharge.

The following are minimal requirements for the cold cathode gauge electronics:

a. High voltage power supply

b. Magnet

c. Gauge tube

d. Current amplifier

Representative gauges from four manufacturers have been undergoing tests for the past six months. One gauge has demonstrated a distinct superiority. This gauge is the one manufactured by the Geophysics Corporation of America (VACTEK). There were no failures associated with this gauge and the readings were more consistent.

2.2 Gauge Control Unit

One specification has been written for the control units. (P.S. - 840-371-R2). The specification is so written as to allow operation of either a manifold or a klystron gauge from this unit. The flexibility of interchangeable units and the decreased maintenance costs make this compatibility feature particularly attractive.

The current amplifier will be a compressed scale type which will allow presentation of the vacuum range from 10^{-9} torr to 10^{-4} torr on the meter face with no switching of scales. Two reasons for choosing a compressed scale amplifier (e.g. log type) over a conventional linear amplifier follow:

(1) The analog output of this amplifier will be 0 to 5 volts corresponding to 10^{-9} to 10^{-4} torr respectively. This will be compatible with either

the hard-wire or multiplex data transmission systems. The alternative - a linear amplifier - would require two information channels and one control channel per sector to transmit the equivalent information.

(2) Each control unit will require two current sensitive discriminators for fail-safe operation. The compressing amplifier will be more adaptable to these discriminators. In the case of a range switching amplifier the discriminator level setting would be a function of the range switch setting, and would thus be more susceptible to human error than the compressed amplifier. Consequently, this would result in more accidental closings of the sector thin valve. We have been informed that the life of the thin valve will be for only a limited number of closings.

There will be three current discriminators per control unit. Discriminator No. 1 will be used to determine if the control unit is operating. Discriminator No. 2 will be used to detect vacuum levels above a locally adjustable level. Discriminator No. 3 will be used to protect the gauge from damage due to operation above a safe level. A memo from the author to R. Conviser dated 9/5/63 has calculations on the discriminator No. 2 response time. These calculations indicate the response time of a complete thin valve closure, including discriminator No. 2 tripping. This must be less than a hundred milliseconds! This restricts the type of discriminator that can be used for discriminator No. 2 to either electronic or electro-magnetic type.

An over pressure relay, sometimes called discriminator No. 3, will be included in each unit. When the maximum allowable gauge current is exceeded, the over pressure relay will trip, removing the high voltage from the gauge.

2.3 Ion Pumps

The ion pumps will be basically the standard commercial products available from such companies as Varian, Ultek, General Electric and Hughes.

2.4 Thin Valve

The thin valves are being developed on the project here. The present developmental model is an air actuated compressed spring with latching action. To close the valve a solenoid is energized, freeing the compressed spring, which then closes the valve. The design objective for total closing time is 9 milliseconds. A device for closing the valve has to be developed. The device will be triggered by a signal from discriminator No. 2 of the manifold gauge control unit.

3.0 PROPOSED SYSTEM FUNCTIONS

3.1 Manifold Gauge

3.1.1 The functions of the manifold gauge are as follows:

(1) Derive a representative sector analog vacuum measurement for presentation at Central Control.

(2) Sense accidents to the vacuum system and actuate devices to protect the systems.

(a) Inhibit the beam at the injector via the Beam Inhibit System.

(b) Status information to Central Control via the Status Monitoring System.

(c) Close the adjacent sector's thin valves.

3.1.2 The block diagram of this system is shown in Figure No. 1. The operation of the systems is as follows: The ion gauge is attached to the eight-inch vacuum manifold and will experience a rapid increase in pressure when a catastrophic accident occurs to the system. The current discriminator No. 2 will be adjusted so that when the ion current (hence pressure) exceeds a certain level (approximately 2×10^{-5} amps) or (10^{-5} torr) discriminator No. 2 will trip and produce an output signal. This signal will perform two functions. It will first cause the beam to be inhibited at the injector; it will then be directed to the two adjacent sector thin valve control units. This control unit will then close the sector thin valve. The signal will be a low power level signal (0 to -9 volts into 3 K ohms). When the pressure is caused to go below the pre-set level again, discriminator No. 2 will reset and allow the thin valve to be manually opened.

The signal labeled as recorder output will be available to Central Control via the analog data transmission system. The signal level is 0 to 5 volts, corresponding to 10^{-9} to 10^{-4} torr respectively. This analog vacuum measurement is also available for local observation. There will be a meter on the front panel of the control unit. The meter scale will be marked in torr; 10^{-9} to 10^{-4} corresponding to 0 to 5 volts output respectively.

Discriminator No. 1 can be used to indicate to Central Control via the Status Monitoring System that the control unit is operating. This discriminator is not used to close the thin valves when the control unit fails. As stated before, the life of the thin valve will be for a limited number of closings. It is, therefore, not desirable to close these valves when the control unit fails. Fail-safe operation is achieved from the fact that each discriminator No. 2 closes the two adjacent valves. A catasprophic vacuum failure will be transmitted to the adjacent sectors via the drift tubes and will cause the discriminators in the two adjacent sector manifold gauge control units to be tripped. These trippings would then close a total of four successive thin valves and isolate three sectors.

There is a relay bypass output from discriminator No. 2. The purpose of this is to produce a faster response time to a catastrophic accident to the system. Maximum response time from gauge sensing to discriminator No. 2 tripping is 2 milliseconds.

3.2 Klystron Gauge See Figure No. 2

3.2.1 The primary function of the klystron gauge is to protect the klystron and the klystron window against operation at an insufficient vacuum level. The gauge will be mounted near the klystron window pump out.

3.2.2 The discriminators No. 1 and No. 2 of this gauge control unit will be used to either remove or hold off the trigger to the modulator with which the particular gauge is associated. It is thought that the reflected power monitor will sense an increase in pressure faster than the vacuum gauge and will hence inhibit the trigger first. There is an automatic recycling procedure built into the modulator circuitry which will allow the trigger to be reapplied again in something like 2.5 seconds. Since the reflected power monitor would require another pulse to produce another fault indication, the vacuum gauge is necessary to hold off the trigger if the vacuum is not sufficiently high. It is important that this trigger removal feature of the No. 2 discriminator be non-latching; otherwise any gas burst that drives the gauge current above the preset level would lock the modulators off and someone would have to be dispatched to reset the device. This would defeat the automatic recycling procedure.

Discriminator No. 1 is a fail-safe feature. If the high voltage to the supply should fail or if the cable connectors between gauge and control unit should open, the control unit would receive no current and would interpret this as an extremely good vacuum. The triggering point of discriminator No. 1 will be set to a level below which we are sure the pressure will not drop. It must be set above the maximum zero drift and noise pick-up level. If set in between these two levels it will function as a control unit failure indication. It will also remove the trigger from the modulator.

Both outputs from discriminators No. 1 and No. 2 will be form C relay closures. These outputs will be available to the Status Monitoring System for transmission of status information to Central Control.

3.3 Getter Ion Pumps

The getter ion pump control unit will be located in the fiat racks and operate from 208 volts 60 cycle power. The meter on the face of the control unit will have multiple scales to permit direct reading of the following parameters by switching a selector switch:

(1) Ion pump current on a linear switched scale over the pump's operational range.

(2) High voltage applied to the pump

(3) Logarithm of the pressure over the range of 10^{-4} to 10^{-9} torr on one compressed scale.

3.4 Thin Valve Closure See Figure No. 3

The valve is being developed by Marvin Heinz of the Mechanical Design and Fabrication group. Their design objective is for a total closing time of 9 milli-seconds.

A thin valve control unit will be designed in-house to perform the following functions:

3.4.1 Opening of the valve will require an 80 psi compressed air line from the thin valve control unit, which is situated in the klystron gallery above the drift tube, to the thin valve, which is located in the drift tube. Opening of the thin valve will be achieved by depressing a spring loaded push button type air valve. Releasing the push button will remove the air pressure and the normal leakage in the piston chamber of the thin valve will leak off the 80 psi pressure within a one minute period. During this time the response time of the valve will be some function of the pressure in the piston chamber.

3.4.2 Automatic closing will be powered from the -24 volt battery supply. As described earlier, solenoid action will close the valve. The power to operate the solenoid will come from the thin valve control unit. The signal to close the thin valve will come from the discriminator No. 2 relay bypass output. This signal level (9 volts into 3 K) will be of insufficient power level to energize the solenoid. A high peak, low average power device will be required.

3.4.3 Manual closing of the valve can be accomplished by a push button switch located on the control panel of the thin valve control unit. The closing of the thin valve is powered from the 24 volt battery supply. This will permit manual closing of the thin valve during a sector ac power failure.

3.4.4 Status information of the position of the thin valve will be derived from switch contacts mounted directly to the valve structure. Two distinct bits of information are required: valve is open; valve is closed.

4.0 SIGNAL SUMMARY

4.1 The following is a summary of the information that will be available for transmission to Central Control via the Analog Data Transmission System or the Status Monitoring System.

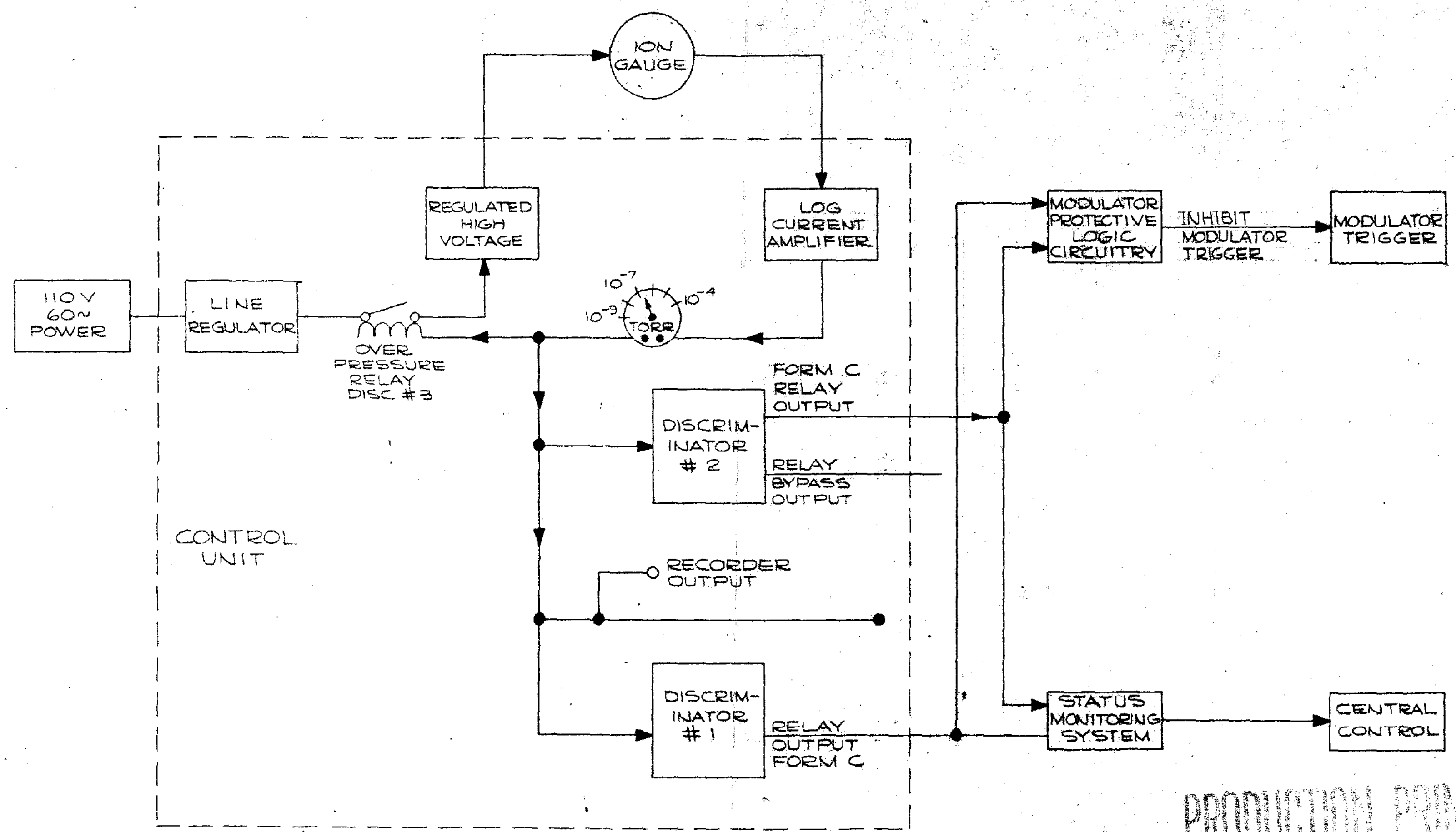
	SIGNAL	SIGNAL SOURCE	TYPE	NO. PER SECTOR
(1)	Representative analog Vacuum measurements	Manifold Vacuum Gauge	Analog (0 to 5 volts)	1
(2)	Trigger to Klystron Modulator Protective Logic	Klystron Vacuum Gauge	Status (Form C relay)	8
(3)	Thin Valve Position	Thin Valve	Status (SPDT switch)	2
(4)	Manifold Gauge Control Unit is Operating	Manifold Vacuum Gauge	Status (Form C relay)	1

4.2 System Interaction

4.2.1 The manifold gauge system will make available to the Analog Data Transmission Signal a 0 to 5 volt signal for presentation at Central Control of the sector analog vacuum indication.

This control unit will also sense catastrophic system failures and deliver a 0 to -9 volt voltage step to that sector and the previous sectors thin valve control unit. The thin valves are located in the drift tubes which are situated at the downstream end of the sector. Closing the indicated thin valves will isolate the gauge and the fault. Before the thin valves are closed it is necessary to inhibit the beam. The 0 to -3 volt step will be transmitted to the Beam Inhibit System which will inhibit the beam by removing the trigger from the injector. The response time of the Beam Inhibit System must be less than the energizing time of the thin valve solenoid; otherwise the beam may be present when the valve is in the process of closing.

4.2.2 The klystron gauge will interact with the modulator protective logic circuitry as described in 3.2.0 of this report. The response time of the complete klystron gauge system must be faster than the recycling period of the klystron protective logic circuitry (2.5 seconds).



PRODUCTION PRINT

SEP 1964

FIG. 2

STANFORD LINEAR ACCELERATOR—M
U. S. ATOMIC ENERGY COMMISSION

TITLE INSTRUMENTATION KLYSTRON GAUGE

ENGR. W. PIERCE CHK'D

DFTS. C. SCHMIERER APPV'D

DATE 12-20-63

SCALE ——

BD-132-014-RO

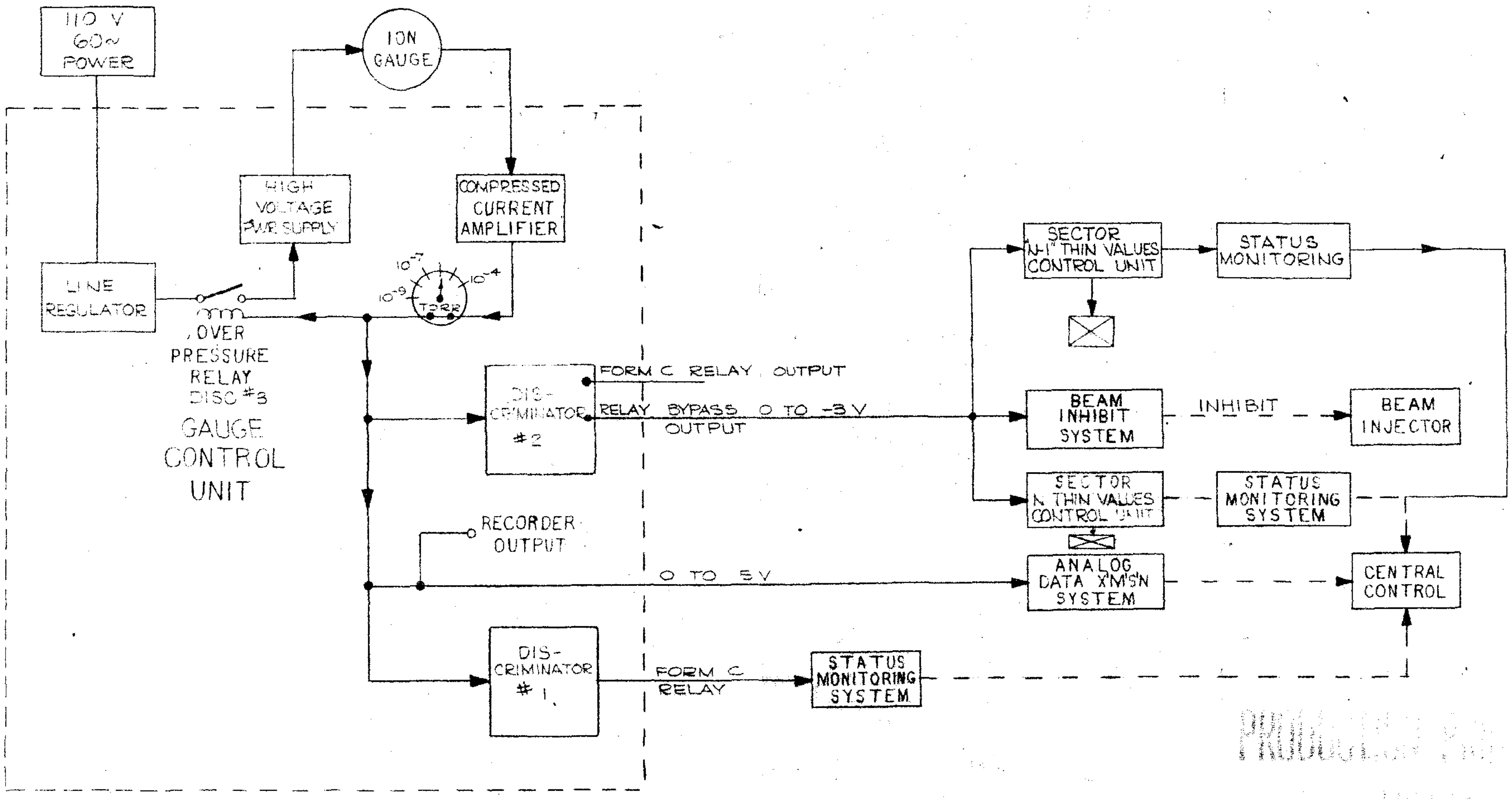


FIG. 1

STANFORD LINEAR ACCELERATOR—M U.S. ATOMIC ENERGY COMMISSION	TITLE INSTRUMENTATION — VACUUM MANIFOLD GAUGE
ENGR. W. PIERCE CHK'D. Pierce DFTS. S.F. SMITH 7/30/63 APPV'D. Pierce 7/30/63	DATE 7-30-63 SCALE NONE
	BD 132-006 R0

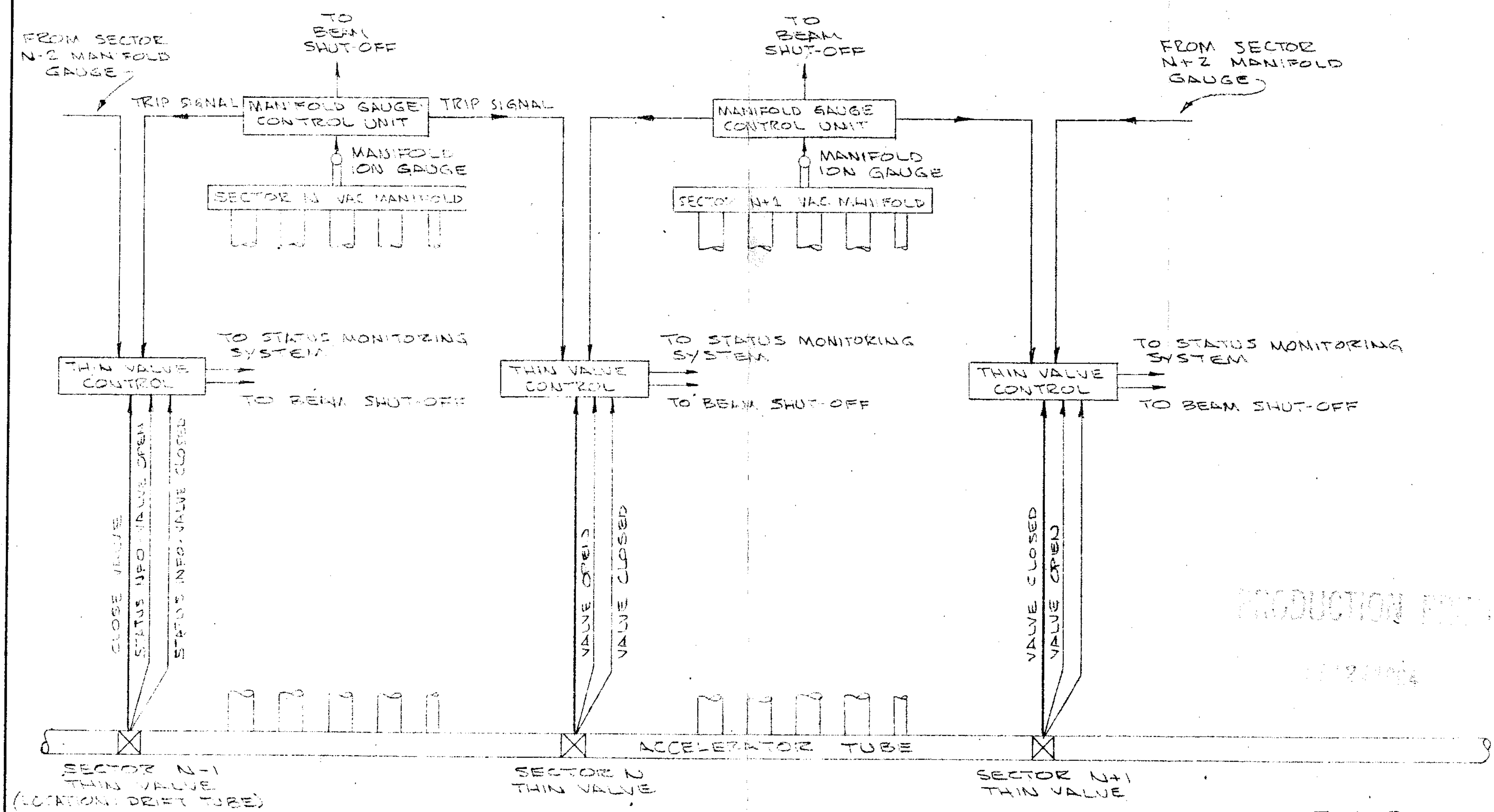


FIG. 3.

STANFORD LINEAR ACCELERATOR U. S. ATOMIC ENERGY COMMISSION	TITLE THIN VALVE CONTROL SYSTEM	
ENGR. PIERCE CHK'D [illegible] DFTS. SUTHERLAND APPV'D [illegible]	DATE 9-23-64 SCALE —	BD-132-035-RO | B