BROOKHAVEN NATIONAL LABORATORY

MEMORANDUM

Date: 11/17/89

To: E. Lessard

From: J. Alessi J.A.

Subject: Review of the Linac security system

Following your memo dated April 20, 1989, the ad hoc committee of P. Montemurro, B. Briscoe, D. Pope, and myself (Chairman) met eight times to review the logic of the design of the security system for High Hazard Radiation Areas in the Linac, HEBT, BLIP, and REF/NBTF. We also compared the design to existing hardware. REF/NBTF was reviewed only at the point where it ties in to the Linac security system, and the Linac system only serves as a reachback in case of a failure of the REF primary or redundant system. Their system is otherwise independent, and had been recently reviewed since it is a new installation. reviewed

Throughout the review, the committee was assisted by A. McGeary, who provided us with all wiring diagrams for the security system (a list is given in Appendix 1), a logic diagram which he had generated from the wiring diagrams (included as Appendix 2), and a preliminary test procedure for the security system. We also received a description of the BLIP security system elements from L. Mausner. The committee started by generating a plan drawing of the Linac/HEBT/BLIP area, which showed the location of all elements in the security system. This drawing is attached as Appendix 3. Working from this drawing, we identified for each gate, crash button, sensor, etc., the appropriate action which should be taken in the security system, assuming the linac is operating. For any one of the actions taken to inhibit beam, there is in addition one level of reachback, which invokes another method of shutting off the beam if the requested action does not occur. These reachbacks were also included in our list. This list was generated independent of what actually existed in the security system wiring. We then went through both the logic and wiring diagrams and checked that the actions actually taken agreed with our list. This was in fact the case, with the exception of one element which should have been included as a reachback action (see #1 in the Findings section). In many cases there were additional actions taken in the hardware which were not essential, but gave additional safety. These were added to our list, so that the final list, included as Appendix 4, shows what actually exists at present. The elements in the system which are part of the High Hazard Radiation security are marked by

asterisks in Appendix 4. The function of each of these elements is shown in Appendix 5. Each of these was checked for redundancy by going and looking at the actual devices and verifying the redundant switches. We then went through the wiring diagrams to verify the redundancy from input to output, and found one point within the relay logic where the redundancy is lost. This is discussed in #2 in "Findings". Finally, all elements that were part of the High Hazard security, as well as all reachbacks, were followed through the wiring diagrams from input to all the resultant actions, and all relays in the string were noted. The test procedure was then reviewed to make sure that the complete string was being tested in every case. A couple of additions or corrections were noted and A. McGeary has made the necessary revisions to the test procedure.

It should be noted that the ability to do "coinjection" (i.e. high intensity H- to BLIP/REF and low intensity polarized H- to the AGS) is no longer in the security system. A new system to allow coinjection is being developed by P. Yamin. HIGH LOW VALUE OF B15 XFMR

Findings

1. The polarized bending magnet (action 6 in Appendix 4) is not included in the reachback circuits for Beam Stop 2 failure (E.7. and E.8.) or LBM1 failure (E.13.).

2. There is a portion of the relay logic for the gates and crash buttons which is not redundant. All inputs are redundant, and two independent actions occur in each case to inhibit the beam. However, the primary and redundant system relays are placed in series to activate relays A21HK7 and A21HK8 on drawing D09-E1776. A single-point failure could occur if a voltage were inadvertently applied at this location.

3. We found no discrepancies between the logic diagram and the wiring diagrams. The logic diagram does not fully show the redundancy of the system, but including the redundancy would complicate the diagram to the point that it would be difficult to follow the functionality. Other than the items above, the system seems to perform as it should. There are a couple of minor changes which could be made in the logic, unrelated to High Hazard Safety but rather regarding some conditions to allow equipment testing when the Linac is off. The committee will present these to A. McGeary for future consideration.

Recommendations

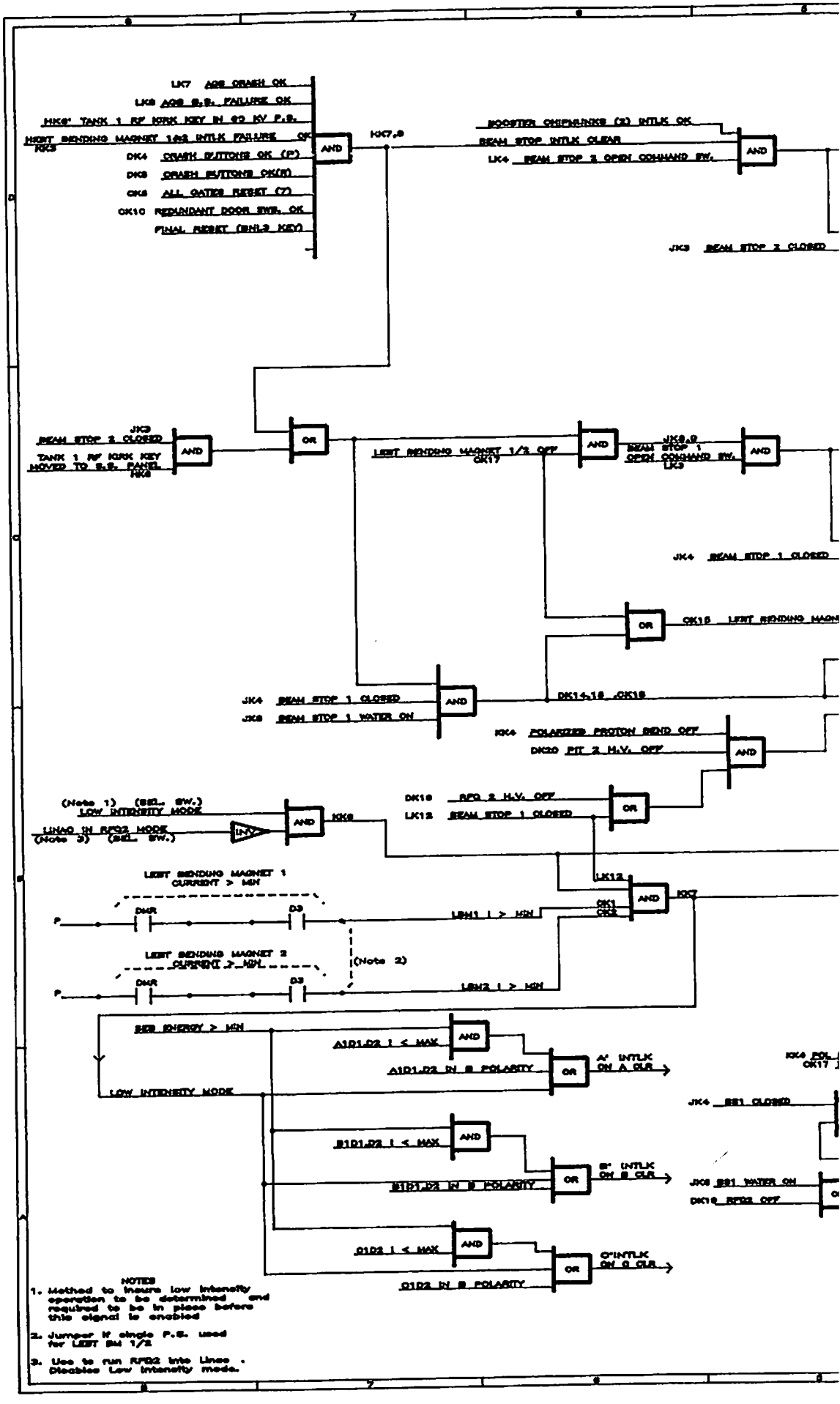
1. We recommend that the polarized bending magnet be added to the reachbacks for Beam Stop 2 and LBM1. This should be corrected before polarized H- is run again (not scheduled for FY90). FAILURE IS TO TRIP RFQ

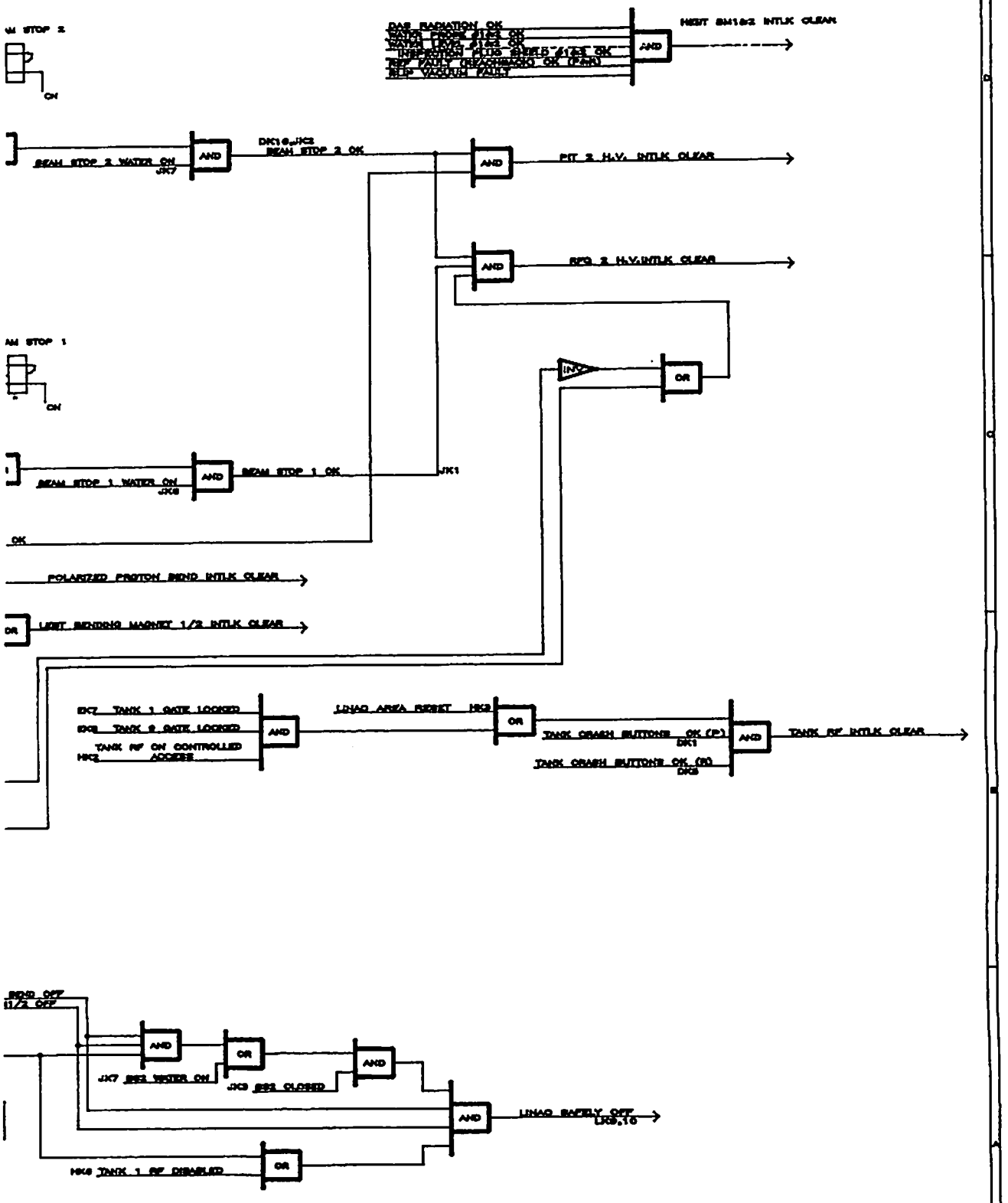
2. We recommend that the non-redundant portion of the relay logic, described in Finding 2, be changed so that the primary and redundant systems are kept separate throughout the relay logic. However, since this is an extremely unlikely failure mode (the point is inside a locked security cabinet), we recommend that the change not be made before the AGS is turned back on, but rather that it be made at a future time (a maintenance day, for example). This change is occuring at a critical location in the security logic, and its implementation should not be rushed, but rather the proper solution should be addressed carefully, and then fully tested.

cc:
D. Beavis
B. Briscoe
D. Lowenstein
A. McGeary
P. Montemurro
D. Pope

Record#	OLDNO	ORCADNO	REVISION	DATE	SIZE	AREA	NAME
191	D09-E1770-5	LINAC70	A	08/16/89	C	LIN	LINAC SS PANEL LAYOUT
192	D09-E1771-3	LINAC71	A	08/16/89	C	LIN	LINAC SS TANK 1 GATE
193	D09-E1772-3	LINAC72	A	08/16/89	C	LIN	LINAC SS PLUG DOOR
194	D09-E1773-3	LINAC73	A	08/16/89	C	LIN	LINAC SS HEBT GATE
195	D09-E1774-3	LINAC74	A	08/16/89	C	LIN	LINAC SS INTERNAL GATES
196	D09-E1775-3	LINAC75	A	08/16/89	C	LIN	LINAC SS CRASH BUTTONS
197	D09-E1776-3	LINAC76	A	08/16/89	C	LIN	LINAC SS PRIME INTLK
198	D09-E1777-3	LINAC77	A	08/16/89	C	LIN	LINAC SS BEAM STOPS
199	D09-E1778-3	LINAC78	A	08/16/89	C	LIN	LINAC SS REDUNDANT SW'S
200	D09-E1779-3	LINAC79	A	08/16/89	C	LIN	LINAC SS REDUNDANT CRASH
201	D09-E1780-3	LINAC80	A	08/16/89	C	LIN	LINAC SS LIGHT PANEL
202	D09-E1781-3	LINAC81	A	08/16/89	C	LIN	LINAC SS EXTERNAL FACILITIES
203	D09-E1782-3	LINAC82	A	08/16/89	C	LIN	LINAC SS MCR INTERFACE
204	D09-E1783-3	LINAC83	A	08/16/89	C	LIN	LINAC SS COCKCROFT WALTON
205	D09-E1784-4	LINAC84	A	08/16/89	D	LIN	LINAC SS PRIME CKT CABLING
206	D09-E1785-3	LINAC85	A	08/16/89	C	LIN	LINAC TANK RF SS
211	D09-E1855-4	LININTLK	A	08/17/89	D	LIN	LINAC BENDING MAGNET 1&2 INTLK CHASSIS
214	D09-E1887-2	LIN60DEG	A	08/17/89	B	LIN	LEBT 60 DEG BENDER AND SEB ENERGY BYPASS
216	D28-LE1357-3	LINTCTRL	A	08/17/89	C	LIN	AGS/LINAC CONTROLS SCHEMATIC
224	D28-LE1357	LICORAM0	A	08/17/89	A	LIN	LINAC COINJECTION & RADIATION MONITORS
233		LEBT24	A	08/22/89	D	LIN	LOW ENERGY BEAM TRANSPORT 24V POWER SUPPLY
238		BMAG4&5		/ /	A	LIN	LINAC BEAM ONLY BENDING MAGNET [illegible]
275		LINLOGIC	G	07/20/89	C	LIN	LINAC SECURITY SYSTEM LOGIC DIAGRAM
		HEBTGATE		8/24/87	E		HEBT GATE - AGS DOOR

APPENDIX 1


LK7 ADS CRASH OK
LK8 ADS S.S. FAILURE OK
HK6' TANK 1 RF KICK KEY IN 90 KV P.S.
HIGH BENDING MAGNET 1&2 INTLK FAILURE OK
HK5
DK4 CRASH BUTTONS OK (P)
DK5 CRASH BUTTONS OK(R)
DK6 ALL GATES RESET (Y)
DK10 REDUNDANT DOOR SWS. OK
FINAL RESET (SHL2 KEY)
AND
KK7,8
BOOSTER CHOPS/KK8 (2) INTLK OK
BEAM STOP INTLK CLEAR
LK4 BEAM STOP 2 OPEN COMMAND SW.
AND
JK3 BEAM STOP 2 CLOSED
JK3
BEAM STOP 2 CLOSED
TANK 1 RF KICK KEY MOVED TO S.S. PANEL HK8
AND
OR
LIGHT BENDING MAGNET 1/2 OFF
DK17
AND
JK8,9
BEAM STOP 1 OPEN COMMAND SW. LK9
AND
JK4 BEAM STOP 1 CLOSED
OR
DK18 LIGHT BENDING MAGN
JK4 BEAM STOP 1 CLOSED
JK8 BEAM STOP 1 WATER ON
AND
DK14,18 ,DK18
KK4 POLARIZED PROTON BEND OFF
DK20 PIT 2 H.V. OFF
AND
(Note 1) (SS... SW.)
LOW INTENSITY MODE
LINAC IN RFQ2 MODE
(Note 3) (SS... SW.)
INV
AND
KK8
DK18 RFQ 2 H.V. OFF
LK12 BEAM STOP 1 CLOSED
OR
LK12
LIGHT BENDING MAGNET 1
CURRENT > MIN
DMR
D3
P
LBM1 I > MIN
DK1
DK2
AND
KK7
LIGHT BENDING MAGNET 2
CURRENT > MIN
(Note 2)
DMR
D3
P
LBM2 I > MIN
BEB ENERGY > MIN
A1D1.D2 I < MAX
AND
A1D1.D2 IN B POLARITY
OR
'A' INTLK ON A CLR
LOW INTENSITY MODE
KK4 POL...
DK17
JK4 BB1 CLOSED
B1D1.D2 I < MAX
AND
B1D1.D2 IN B POLARITY
OR
'B' INTLK ON B CLR
JK8 BB1 WATER ON
DK19 RFQ2 OFF
D1D2 I < MAX
AND
D1D2 IN B POLARITY
OR
'D'INTLK ON D CLR
NOTES
1. Method to insure low intensity operation to be determined and required to be in place before this signal is enabled
2. Jumper if single P.S. used for LEBT BM 1/2
3. Use to run RFQ2 into Linac . Disables Low Intensity mode.



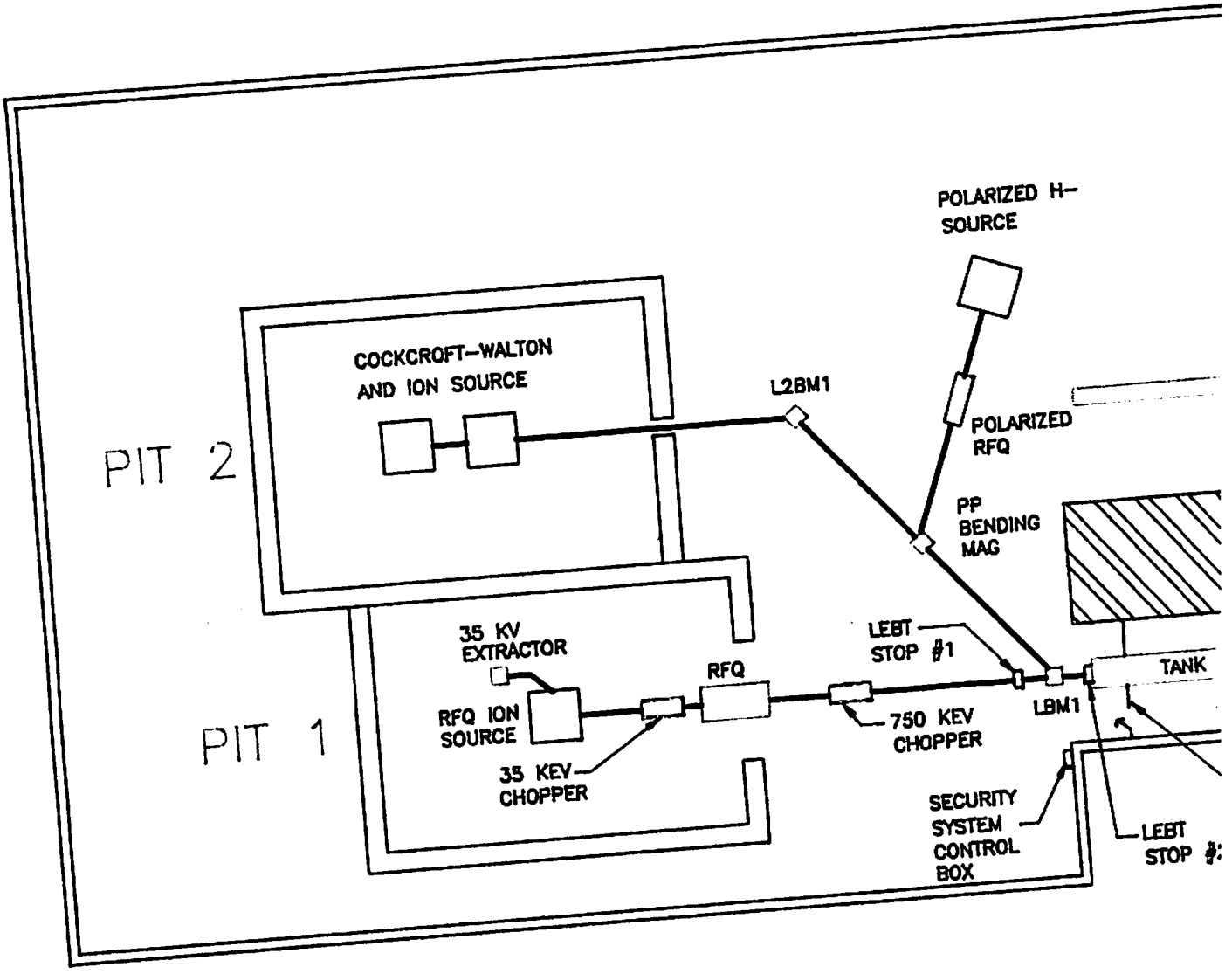
BROOKHAVEN NATIONAL LABORATORY UPTON, N.Y. 11973			
Title APPROVED LINAC SECURITY LOGIC			
Size D	Document Number LINLOGIC	A.J.McGeary	REV 0
Date: July 20, 1989	Sheet	of	1

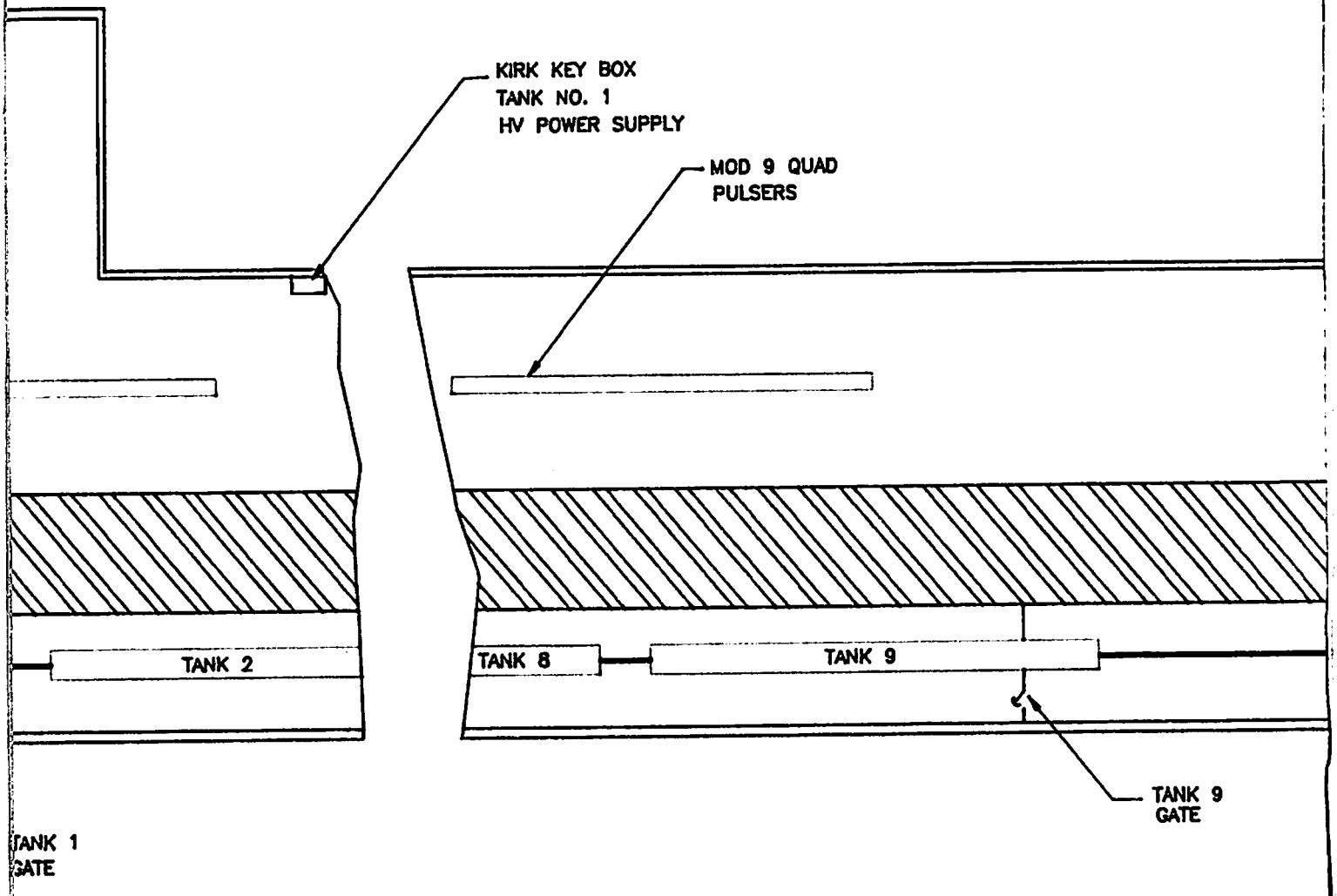
8

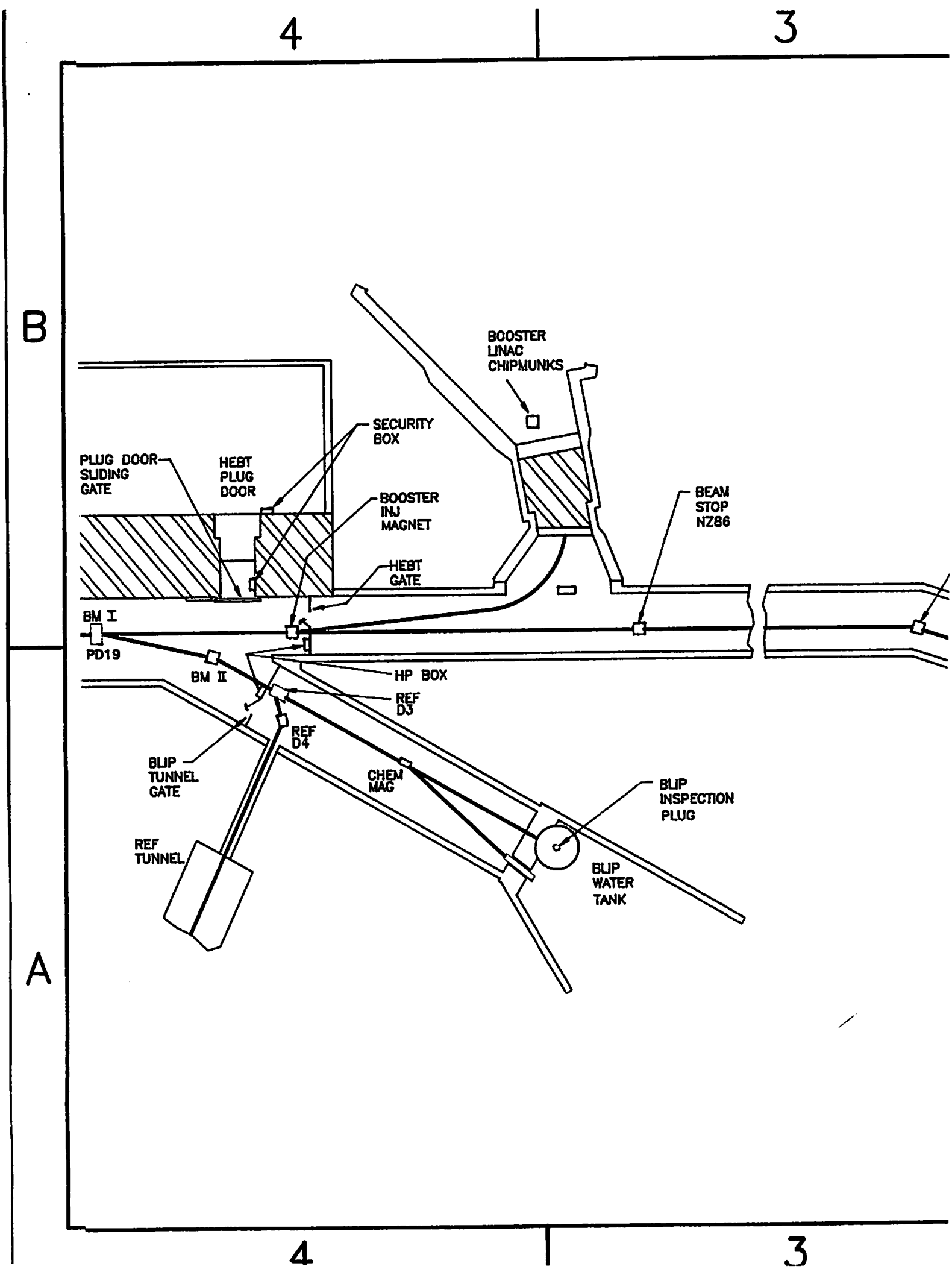
7

B

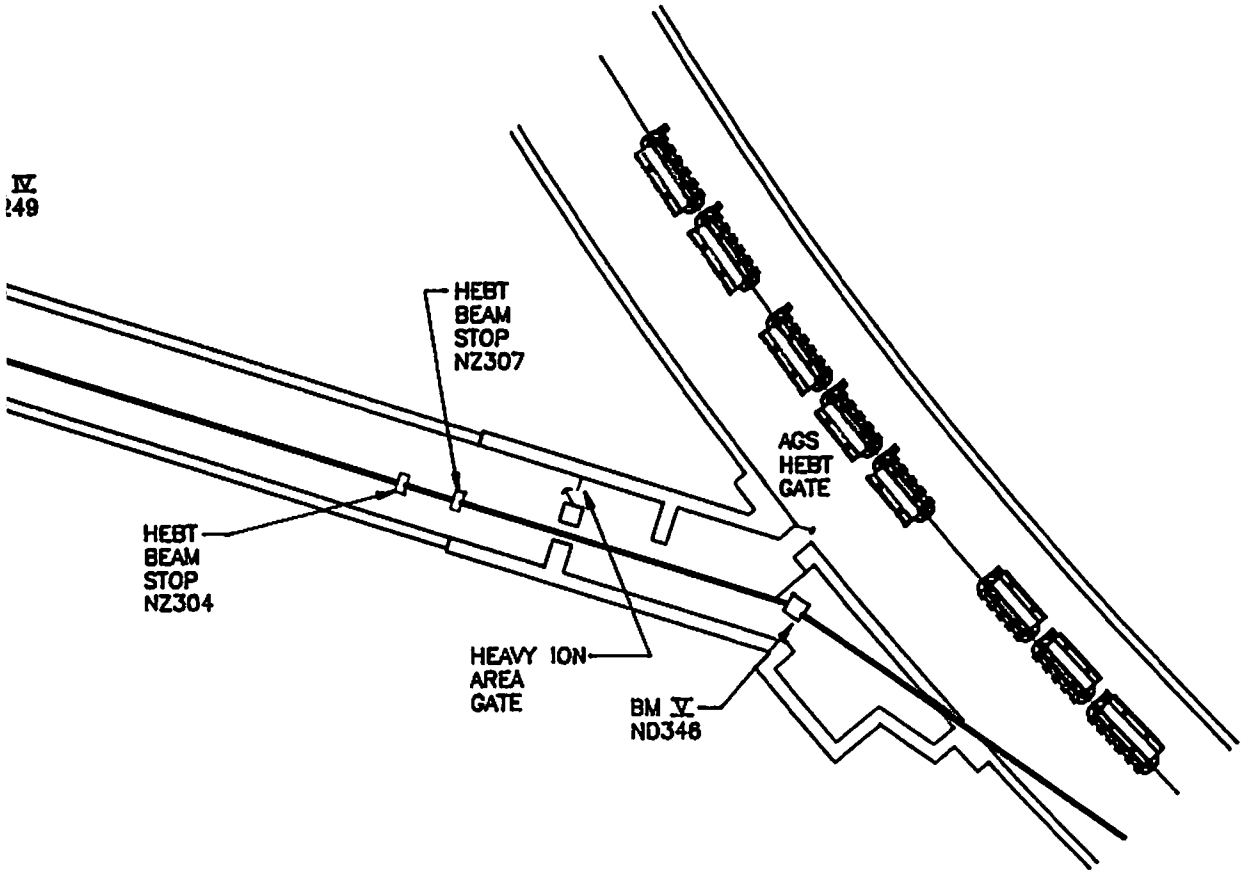
A


POLARIZED H–
SOURCE
COCKCROFT–WALTON
AND ION SOURCE
L2BM1
POLARIZED
RFQ
PP
BENDING
MAG
PIT 2
35 KV
EXTRACTOR
LEBT
STOP #1
TANK
RFQ
RFQ ION
SOURCE
750 KEV
CHOPPER
LBM1
PIT 1
35 KEV
CHOPPER
SECURITY
SYSTEM
CONTROL
BOX
LEBT
STOP #


KIRK KEY BOX
TANK NO. 1
HV POWER SUPPLY
MOD 9 QUAD
PULSERS
TANK 2
TANK 8
TANK 9
TANK 9
GATE
TANK 1
GATE


4
3
B
A
BOOSTER
LINAC
CHIPMUNKS
SECURITY
BOX
PLUG DOOR
SLIDING
GATE
HEBT
PLUG
DOOR
BOOSTER
INJ
MAGNET
BEAM
STOP
NZ86
HEBT
GATE
BM I
PD19
BM II
HP BOX
REF
D3
REF
D4
BLIP
TUNNEL
GATE
CHEM
MAG
BLIP
INSPECTION
PLUG
REF
TUNNEL
BLIP
WATER
TANK
4
3

ITEM NO.	QTY.	DESCRIPTION	MAT'L, DWG. NO. OR BNL NO.



BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.
UPTON, N.Y. 11973

LINAC SECURITY SYSTEM

DRAWN BY	J.SCOTT	FILE NAME:	LSS.DWG	7/21/89

*AUTOCAD

APPENDIX 4

LINAC SECURITY SYSTEM

		ACTION	
A. Gates, Plug Doors			
*1. Tank 1 gate		1,2,3,6,8	2 switches (one magnetic)
2. Tank 9 gate		1,2,3,6,8	1 switch
*3. HEBT plug door		1,2,3,6	2 switches
4. HEBT sliding gate		1,2,3,6	1 switch
5. BLIP tunnel gate (HP)		1,2,3,6	1 switch
*6. BLIP inspection plug		9,10	2 switches
7. HEBT gate (HP)		1,2,3,6	1 switch
8. Heavy ion security gate	locked for HI running		No switches
*9. AGS-HEBT gate		1,2,3,6	2 switches
B. Crash Buttons			
*1. Tanks		1,2,3,6,8	2 contacts, 1 norm. open, 1 norm. closed
*2. HEBT		1,2,3,6	Primary - 110 V relay drops out
*3. BLIP		1,2,3,6	Redundant - 12 V relay energizes
4. AGS (MCR crash of Linac beam)		1,2,3,6 (not redundant; equipment protection)	
C. Radiation Monitors			
1. BLIP high radiation - panel		9,10	EBERLINE Model RMS II
2. BLIP high radiation - hot cell		(3 connected in series)	
3. BLIP high radiation - pump pit			
4. Booster-Linac chipmunks (2)		2 (not high rad. hazard)	
D. Sensors			
1. BLIP vacuum failure		9,10	Ashcroft pressure switch
*2. BLIP low shaft water level		9,10	2 conductivity probes (MEKONTROL MEK 54)
3. shaft water leak		9,10	2 sensors (Cond. probe MEK 54)
E. Reachbacks			
1. REF D3 not off (command off)		9,10	Aux. contact on relay for primary power
2. REF D4 not off (command off)		9,10	Aux. contact on relay for primary power
3. HEBT BM1 not off (command off)		1,2,3,6	Aux. contact on relay for primary power
4. HEBT BM2 not off (command off)		1,2,3,6	Aux. contact on relay for primary power
5. BS-1 cooling water failure		4	Shur-flo
6. BS-1 not closed (command closed)		4	1 switch
7. BS-2 cooling water failure		4,5	Shur-flo
8. BS-2 not closed (command closed)		4,5	1 switch
9. NZ-304 cooling water failure		1,2,3,6	Shur-flo
10. NZ-304 not closed (command closed)		1,2,3,6	2 switches in series
11. NZ-307 cooling water failure		1,2,3,6	Shur-flo
12. NZ-307 not closed (command closed)		1,2,3,6	2 switches in series
13. LBM1 not off (command off)		5	Aux. contact on relay for primary power

Above actions are when linac is operating. Alternative of 2,7 for linac testing

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F. Actions used to inhibit beam	
1. BS-1 closed	
2. BS-2 closed	
3. LBM1 (and L2BM1) ps off	Interrupt primary power
4. RFQ2 HV ps off	Interrupt primary to 30 kV ps
5. Pit 2 H.V. off	Interrupt primary to motor generator
6. Pol. BM off	Interrupt primary power
7. Tank 1 rf off	Kirk key on primary pwr to 60 kV ps
8. All tank rf off	Interrupt rf driver card (not part of high hazard)
9. HEBT BM1 off	Interrupt primary power
10. HEBT BM2 off	Interrupt primary power

APPENDIX 5

Elements in the high hazard radiation security system:

I. Elements to keep personnel out of the Linac/HEBT tunnel:
   1. Tank 1 gate (2 switches)
   2. HEBT plug door (2 switches)
   3. AGS-HEBT gate (2 switches)
   4. Crash buttons (except "AGS Crash") - primary and redundant system

II. Elements to ensure proper shielding at the BLIP target:
   BLIP inspection plug (2 switches)
   BLIP shaft water level (2 sensors)

III. Elements to keep beam out of AGS (AGS review, linac only enters as reachback)
   Beam stops NZ304 and NZ 307

IV. Elements to keep beam out of BLIP
   HEBT dipoles BM1 and BM2

V. Elements to keep beam out of REF (REF review, linac only enters as a reachback)
   REF dipoles D3 and D4

VI. Elements to keep beam out of the linac
   RFQ line : BS-2 and BS-1
   Pit 2 : BS-2 and LBM1
   Polarized H- : BS-2 and LBM1
   Alternative for all 3 lines is BS-2 closed and tank 1 rf locked off

Note:
There is one level of automatic reachback in the event of a failure of any of the devices used to keep beam out of an area.
(except polarized H-; see "Findings")

Elements in the security system which are not part of the high hazard, redundant system:
   Tank 9 gate
   HEBT sliding gate
   BLIP tunnel gate
   HEBT gate
   Heavy ion security gate
   Blip radiation monitors (panel, hot cell, pump pit)
   Booster-Linac chipmunks
   BLIP vacuum failure
   BLIP shaft water leak
   Tank rf (except Tank 1)