

AFRL-SR-BL-TR-98-
6509

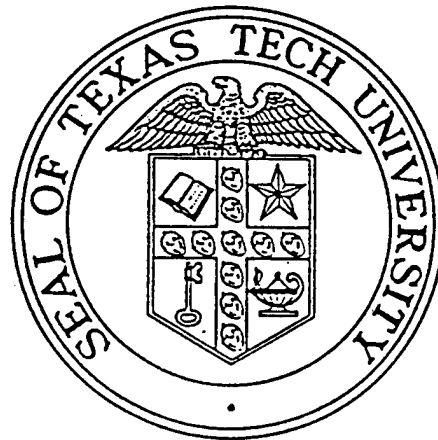
Final Technical Report
On
Ultraclean Experiments for Directed Energy Plasma Science

DURIP - 97

May 31, 1998

Air force Office of Scientific Research

Grant No. F 49620-97-1-0106



19980630 045

M. Kristiansen, Principal Investigator
Pulsed Power Laboratory
Department of Electrical Engineering
Texas Tech University
Lubbock, Texas 79409-3102

Attn: Robert Barker
AFOSR/NE

Bolling AFB, DC 20332-0001

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 074-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503

1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE May 31, 1998	3. REPORT TYPE AND DATES COVERED Final 1 March 97 - 28 Feb 98	
4. TITLE AND SUBTITLE ULTRACLEAN EXPERIMENTS FOR DIRECTED ENERGY PLASMA SCIENCE DURIP-97			5. FUNDING NUMBERS F49620-97-1-0106 PO# FO8671-9700814	
6. AUTHOR(S) Dr. Magne Kristiansen and Dr. Lynn L. Hatfield				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Pulsed Power Laboratory Texas Tech University Lubbock, TX 79409-3102			8. PERFORMING ORGANIZATION REPORT NUMBER AFOSR-98-DURIP	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) Dr. Robert J. Barker AFOSR/NE 110 duncan Avenue Rm B115 Bolling AFB DC 20332-8050			10. SPONSORING / MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION / AVAILABILITY STATEMENT Unlimited			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 Words) Equipment required for the performance of research funded by DoD agencies was purchased and installed in the grantee's laboratories. This included a wide variety of high vacuum ultra clean systems and instruments. The equipment consisted of dry turbopump systems, stainless steel chambers and fittings, bakable high vacuum valves, ion pumps, vacuum gauges, a leak detector, a residual gas analyzer, a cryopump, and associated electronics. The proposed equipment list and the actual equipment purchased list with prices is presented. This equipment has been used on the projects "Tri-University, Multidisciplinary, High Energy, Microwave Device Consortium" (AFOSR/DoD MURI), "Fundamental Limits to Compact, Expendable Pulsed Power and Microwave Sources" (AFOSR New World Vistas), High Power Microwaves (AASERT), and Advanced Power System Technology for Ground Based Radar (WL/POOC-WPAFB).				
14. SUBJECT TERMS Ultra clean vacuum equipment			15. NUMBER OF PAGES	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT	

USE OF THE EQUIPMENT

The equipment purchased with the funds provided by the DURIP grant (\$188,741) and the matching funds provided by Texas Tech University (\$55,000) has been used on the following projects:

1. Tri-University, Multidisciplinary, High Energy Microwave Device Consortium, a MURI '94 grant, administered by AFOSR (Grant No. F49620-95-1-033) which includes:
 - i) Subnanosecond breakdown of insulators such as gas, liquid, solid, and surface for Ultrawide band source development.
 - ii) Relativistic Klystron Oscillator (10 GHz) diagnostic to determine the cell to cell coupling, the input and output coupling factor, parasitic mode coupling, and cavity field distribution, and the design, fabrication and testing of a 94 GHz klystron.
 - iii) Cavity and microwave window breakdown diagnostic, including field distribution and amplitude time history, microwave power, and visible and x-ray emission caused by the breakdown.
 - iv) High Power Microwave Generator (AFOSR Grant No. 49620-93-1-0203) which was changed from the original goals to the investigation of a novel cylindrical vircator microwave source.
2. High Power Microwaves, (AFOSR Grant No. F49620-91-1-0299) which is a supplementary grant (AASERT) to support a Ph.D. candidate in charge of the research.
3. Advanced Power System Technology for Ground Based Radar, supported by Wright Laboratories (Contract No. F33615-97-C2755) at WPAFB. This has two components, the study of insulator flashover at cryogenic temperatures (100K) and a compact, efficient, 1 MW Universal Power Converter.
4. The equipment shown in Table 1, System C was specified by personnel at the Air Force Research Laboratory, Phillips Research Site (AFRL-PRS) for use on their high power microwave project. The title for this equipment resides with Texas Tech University but would be on loan to PRS.
5. Fundamental Limits to Compact, Expendable Pulsed Power and Microwave Sources (AFOSR New World Vistas).

EQUIPMENT LISTS

The equipment originally proposed is listed in Table 1. All of the original list was to be purchased from Varian Vacuum Products, Lexington, MA except for item 26, System B and items 1 and 2 under Peripheral Equipment. Those were listed with part numbers from Kurt Lesker, Inc Clairton, PA. The equipment actually purchased is listed in Table 2. The changes are explained by item number following Table 2.

Table I
Equipment Originally Proposed

SYSTEM A

Item	Part Number	Description	Qty.	Unit Price	Amount
1	MSP9050	PUMPING SYS, TURBO, 120V/60 CART STN., V550, 8" CFF	2	14,525.00	29,050.00
2	MSP0202	PUMP, DRY SCROLL, KIT FOR TURBO CART STNS.	1	7,000.00	7,000.00
3	MSP0245	AIR COOLING KIT, FOR V550, V700 HT, CART	2	295.00	590.00
4	MSP0241	VALVE, VENTING, 4 SEC DELAY FOR TURBO CARTS	2	605.00	1,210.00
5	MSP0259	INLET SPOOL, CFF, TURBO 8" CFF, V300HT, V 550, CART	2	750.00	1,500.00
6	MSP0273	VLV, SWING GATE, 4", A/O, ON CFF, SPECIFY SOL.	2	1,775.00	3,550.00
7	FA08000600	ADAPTER, CF, 8.00-A6.00", 2.5" Long, 304 ESR	2	260.00	520.00
8	FLO4002400	COUPLING, FLEXIBLE, 3.8" ID, W/6" CFF, 24" LENGTH	1	500.00	500.00
9	MSP0233	CNTRL, MULTI-G, BASIC UNIT, 110/115/230V 50/60 HZ, CART	1	770.00	770.00
10	MSP0237	PC BOARD, TRANSDUCER, FOR BAYARD-ALPERT GAUGE, CART	2	690.00	1,380.00
11	MSP0234	PC BOARD, TRANSDUCER, FOR TC GAUGES, CARTS	1	470.00	470.00
12	MSP0238	PC BOARD, PROCESS CONTROL, SET POINTS, CARTS	1	195.00	195.00
13	MSP25003	GAUGE TUBE, ION, ON 2-3/4" CONFLAT FLANGE	2	225.00	450.00
14	MSP5312	GAUGE TUBE, THERMCOUPLE, NW-16 FLANGE, CARTS, MINI	4	87.00	348.00
15	MSP0206	PUMP, MECH., SD-300, KIT FOR TURBO CART STNS.	1	1,900.00	1900.00
16	FLO4002400	COUPLING, FLEXIBLE, 3.8" ID, W/6"CFF, 24" LENGTH	1	500.00	500.00
17	L9260325	VLV, SS, RT-AGLE, 1", A/O METAL-BONN, 2.12" CFF, 110V	2	415.00	830.00
18	K0118303	TRAP, ROUGHING BAKEABLE, 2.75" CFF, INLET/OUT	1	780.00	780.00
19	949-9411	MD 60 PUMP	1	2,695.00	2,695.00
20	951-5106	LEAK VALVE	1	1,075.00	1,075.00
21	962-0014	VALVE KIT	1	507.00	507.00
22		ESTIMATED COST OF CUSTOM CART	1	4,000.00	4,000.00
TOTAL					59,820.00

Table I (continued)

SYSTEM B

Item	Part Number	Description	Qty.	Unit Price	Amount
1	9190106	PUMP, VACION + 500 STARCEL	1	7,250.00	7,250.00
2	9294011	PWR UNIT, MULTIVAC, 120 V, W/RS-232/422 INTERFACE	1	1,280.00	1,280.00
3	9294040	PC BOARD, MULTIVAC, HV, FOR LARGE PUMPS, NEG PRESET	1	1,790.00	1,790.00
4	9294110	PC BOARD, SETPOINT/REMOTE, FOR MULTIVAC POWER UNIT	1	390.00	390.00
5	9290770	CABLE, HV, BAKEABLE, FISCHER CONN, FOR 919-SERIES PUMPS	1	290.00	290.00
6	L8350301	CNTRL, MULTI-G, BASIC UNIT, 110/115/230v 50/60 HZ	1	750.00	750.00
7	L8321301	PC BOARD, TRANSDUCER, FOR UHV GAUGE	2	645.00	1,290.00
8	L8327301	PC BOARD, PROCESS CONTROL, SET POINTS	1	195.00	195.00
9	L6439301	RS-232 COMPUTER INTERFACE OPTION FOR MULTI-GAUGE	1	150.00	150.00
10	9715008	GAUGE TUBE, ION, UHV-24, W/ TUNGSTEN FIL, ON CFF	2	375.00	750.00
11	9545165	FEEDTHRU, 10-WIRE, NICKEL, ON 2-3/4" FLG, NO CONNECTOR	2	290.00	580.00
12	9545030	FEEDTHRU, 4-PIN, POWER, W/MS CONN ON 2-3/4" CF FLANGE	1	658.00	658.00
13	FT0600	TEE, 6.0", W/8.0 CFF	1	575.00	575.00
14	VGM150FE	6" METAL GATE VALVE	1	14,380.00	14,380.00
15	951-5027	VLV, SS, RT-AGLE, 1", A/O METAL-BONN, 2.12" CFF, 110V	2	655.00	1,310.00
16	941-6501	SORPTION PUMP	1	665.00	665.00
17	944-0011	S.S. DEWAR	1	770.00	770.00
18	944-0045	HEATING BAND	1	290.00	290.00
19	FT-0800	TEE 8" CFF	1	1,000.00	1,000.00
20	FC-0800	CRONS 8" CFF	1	1,600.00	1,600.00
21	FA-0800-0275	REDUCERS	2	155.00	310.00
22	FE-0150	2-3/4" ELLS	2	55.00	110.00
23		ESTIMATED PRICE UHV CHAMBER (Varian)	1	2,500.00	2,500.00
24	EFC 1C12156A	HIGH VOLTAGE FEEDTHROUGH	2	2,205.00	4,410.00
25	EFT 2533093	Feedthrough	2	480.00	960.00
26	RPK-900	8" CRYOPUMP (LESKER)	1	16,930.00	16,930.00
27		ESTIMATED COST OF CUSTOM CART	1	3,000.00	3,000.00
				TOTAL	<u>64,183.00</u>

Table I (continued)

FOR USE AT PHILLIPS LABORATORY
SYSTEM C

Item	Part Number	Description	Qty.	Unit Price	Amount
1	9190106	ION PUMP 500 STARCELL	1	7,250.00	7,250.00
2	929-4040	HV UNIT	2	895.00	1,790.00
3	929-4110	SET POINT BOARD	1	390.00	390.00
4	929-0770	CABLE, HV	1	290.00	290.00
5	929-4011	MULTIVAC CONTROLLER	1	1,280.00	1,280.00
6	941-6501	SORPTION PUMP	1	665.00	665.00
7	944-0011	S.S. DEWAR	1	770.00	770.00
8		HEATING BAND	1	290.00	290.00
9	VAM150FE	1" PNEU VALVE	1	12,495.00	12,495.00
10	FC-0800	8" CROSS	1	1,600.00	1,600.00
11	FT-0800	8" TEE	1	1,000.00	1,000.00
12	VGMC200FE-115-P	8 " ALL METAL GATE VALVE BAKABLE TO 350°C	1	18,560.00	18,560.00
13	" "	INDICATOR	1	375.00	375.00
14	MSP 0233	MULTIGAUGE CONTROLLER	1	770.00	770.00
15	MSP 0237	BA GAUGE BOARD	2	695.00	1,390.00
16	MSP 0234	TC GAUGE BOARD	1	470.00	470.00
17	MSP 0238	SET POINT BOARD	1	195.00	195.00
18		ION GAUGE TUBE	2	225.00	450.00
19		TC GAUGE TUBE	4	87.00	348.00
20	926-0235	1" VALVE	1	415.00	415.00
				TOTAL	<u>50,793.00</u>

Peripheral Equipment

Item	Part Number	Description	Qty.	Unit Price	Amount
------	-------------	-------------	------	------------	--------

KURT LESKER, INC.

1	VQ105351258	RESIDUAL GAS ANALYZER	1	15,795.00	15,795.00
2	VQIM60BCD	RG INLET SYSTEM	1	15,455.00	15,455.00

VARIAN VACUUM

3	D956-0055-UT-120	LEAK DETECTOR	1	28,475.00	28,475.00
4	919-0235	VAC ION PUMP	2	1,460.00	2,920.00
5	929-4011	MULTIVAC CONTROLLER	2	1,280.00	2,560.00
6	929-4035	HV MODULE	2	1,190.00	2,380.00
7	929-0770	HV CABLE	2	290.00	580.00
8	929-4110	SET POINT CARD	2	390.00	780.00

TOTAL 68,945.00

Table II
Equipment Actually Ordered

Item	Part Number and Product Description	Qty.	Unit Price	Amount
1	MSPA701 V550 TURBO DRY PUMPING SYSTEM WITH V550 TURBO & CONTROLLER, 8" CONFLAT INLET, 300DS DRY SCROLL PUMP, INLET SCREEN, VACUUM MANIFOLDING, CABLING FOR SINGLE-SWITCH OPERATION, FULLY ASSEMBLED & TESTED ON A ROLL-AROUND CART	2	16,650.00	33,300.00
2	MSP0245 AIR COOLING KIT, FOR V550, V700HT, CART	2	295.00	590.00
3	MSP0241 VALVE, VENTING, 4 SEC DELAY FOR TURBO CARTS	2	605.00	1,210.00
4	MSP0259 INLET SPOOL, CFF, TURBO 8" CFF, V300HT, V550, CART	2	750.00	1,500.00
5	MAPA7505 Stainless Steel Swing Gate Valve, Metal-Bonnet-Seal, 6" Port, Viton main seal, Copper bonnet seal, gold-plated copper bellows seal, 8" Conflat Flanges, 110/120 V, 50/60 Hz, 100,000 cycles, air pressure 75 to 120 psig	2	2,800.00	5,600.00
6	MSPL91203 TURBO SYSTEM SENTORR GA 1 BA/2 CONVECTR	2	1,385.00	2,770.00
7	MSPL9132 CARD, SET POINT, SENTORR FACTORY INS. ONLY	2	120.00	240.00
8	MSPL6450 INTERFACE, RS232 SENTORR OPTION	2	150.00	300.00
9	MSP25003 GAUGE TUBE, ION, ON 2-3/4" CONFLAT FLANGE	2	225.00	450.00
10	L9090306 CONVECTORR GAUGE TUBE W/NW-25 KF FITTING	4	95.20	380.80
11	FA08000600 ADAPTER, CF, 8.00 - 6.00", 2.5" LONG, 304 ESR	1	221.00	221.00
12	MSPA7573 FLEXIBLE STAINLESS STEEL COUPLING WITH 6" CONFLAT FLANGES, FACE TO FACE LENGTH 3.75"	2	475.00	950.00
13	600DS1UNIV PUMP, SCROLL, 600DS, 1PHASE UNIV MOTOR	1	7,425.00	7,425.00
14	300DS1UNIV 300 liter/min. Dry Scroll Pump	1	4,671.00	4,671.00
15	9515106 VLV, VARIABLE LEAK, W/MINI FLANGE ON INLET	1	913.75	913.75
16	9620014 REPAIR KIT FOR VAR LEAK VALVE	1	430.95	430.95
17	9190106 PUMP, VACION + 500 STARCEL	1	6,162.50	6,162.50

Table II (continued)

Item	Part Number and Product Description	Qty.	Unit Price	Amount
18	9296002 MULTIVAC,120V,1 HV CARD,NEG PRES,RS232	1	2,949.50	2,949.50
19	9294110 PC BOARD,SETPOINT/REMOTE, FOR MULTIVAC POWER UNIT	1	331.50	331.50
20	9290770 CABLE,HV,BAKEABLE,FISCHER CONN, 4M (13') LONG FOR 919 PU	1	301.75	301.75
21	L8350301 CNTRL,MULTI-G,BASIC UNIT, 110/115/230V 50/60HZ	1	701.25	701.25
22	L8321301 PC BOARD,TRANSDUCER,FOR UHV GAUGE	1	548.25	548.25
23	L8327301 PC BOARD,PROCESS CONTROL, SET POINTS	1	165.75	165.75
24	L6439301 RS-232 COMPUTER INTERFACE OPTION FOR MULTI-GAUGE	1	127.50	127.50
25	9715008 GAUGE TUBE,ION,UHV-24,W/ TUNGSTEN FIL,ON CFF	2	318.75	637.50
26	L64553025 25 ft. BA Cable	1	161.50	161.50
27	9545165 FEEDTHRU,10-WIRE,NICKEL, ON 2-3/4 FLG,NO CONNECTOR	2	246.50	493.00
28	9545030 FEEDTHRU,4-PIN,POWER,W/MS CONN ON 2-3/4" CF FLANGE	1	559.30	559.30
29	FT0600 TEE,6.0",W/8.0" CFF	1	488.75	488.75
30	Q1524308 VLV,METL BONNET SL,A/O,6" W/KALREZ SEAL	1	3,085.50	3,085.50
31	9515027 VLV,ALL-METAL,1-1/2",RT-ANGLE	2	556.75	1,113.50
32	FC0800 CROSS,8.0",W/10.0" CFF	1	1,360.00	1,360.00
33	FR100002754 FLNG,CF,REDUCING,10"-2.75",304 SST	2	195.50	391.00
34	FE0150 ELBOW,1.5",W/2.75" CFF	2	46.75	93.50
35	MSPA7507A 10" CONFLAT ADAPTER WITH TWO 2.75" CONFLAT FLANGE PORTS	1	430.00	430.00
36	MSPA7507B 10" CONFLAT ADAPTER WITH THREE 2.75" CONFLAT FLANGE PORTS	1	510.00	510.00
37	9190106 PUMP,VACION + 500 STARCEL	1	6,162.50	6,162.50
38	9296002 MULTIVAC,120V,1 HV CARD,NEG PRES,RS232	1	2,949.50	2,949.50

Table II (continued)

Item	Part Number and Product Description	Qty.	Unit Price	Amount
39	9294040 MULTIVAC HV CARD/NEG	1	1,521.50	1,521.50
40	9294110 PC BOARD,SETPOINT/REMOTE, FOR MULTIVAC POWER UNIT	1	331.50	331.50
41	9290770 CABLE,HV,BAKEABLE,FISCHER CONN, 4M (13") LONG FOR 919 PU	1	301.75	301.75
42	9416501 PUMP,VACSORB,SINGLE, W/LN2 SPLASH SHIELD	1	624.75	624.75
43	9440011 DEWAR,METAL,FOR 941-6501 VACSORB	1	722.50	722.50
44	9440044 HEATER,VACSORB,115V 350W	1	272.00	272.00
45	L6591320 VLV,SS,RT-AGLE,1-1/2",A/O M/BON,2-3/4,CFF,110V	1	369.75	369.75
46	FC0800 CROSS,8.0",W/10.0" CFF	1	1,360.00	1,360.00
47	MSPA7509 8" CROSS WITH 10" CONFLAT FLANGES AND ONE 2.75" CONFLAT FLANGE FOR ION GAUGE PORT	1	1,190.00	1,190.00
48	VGMC200FE155P ALL METAL GATE VALVE WITH 8" X 10" CONFLAT FLANGES, BAKEABLE TO 300 C, BODY STAINLESS, SEALING MATERIAL-GATE (DISC) SILVER-PLATED STAINLESS STEEL, REPEATABLE SEAL 10,000 CYCLES, COMPACT ELECTROPNEUMATIC ACTUATOR, 110/115V,	1	17,817.60	17,817.60
49	L8350301 CNTRL,MULTI-G,BASIC UNIT, 110/115/230V 50/60HZ	1	701.25	701.25
50	L8321301 PC BOARD,TRANSDUCER,FOR UHV GAUGE	2	548.25	1,096.50
51	L9887301 PC BOARD,TRANSDUCER FOR CONVECTORRS	1	165.75	165.75
52	L8327301 PC BOARD,PROCESS CONTROL, SET POINTS	1	165.75	165.75
53	L6439301 RS-232 COMPUTER INTERFACE OPTION FOR MULTI-GAUGE	1	127.50	127.50
54	9715008 GAUGE TUBE,ION,UHV-24,W/ TUNGSTEN FIL,ON CFF	2	318.75	637.50
55	L9090302 MINI-CFF CONVECTORR TUBE	4	103.70	414.80
56	L64403025 CABLE ASSY, 25 FT, BAKEABLE FOR USE W/ 0580 & UHV TUBE	1	276.25	276.25
57	L91223025 25' Convector cable	2	68.00	136.00
58	L9260325 VLV,SS,RT-AGLE,1",A/O METAL-	1	352.75	352.75

Table II (continued)

Item	Part Number and Product Description	Qty.	Unit Price	Amount
59	FR100008004 FLNG,CF,REDUCING,10"-8" 304 SST	2	238.00	476.00
60	MSPA7507A 10" CONFLAT ADAPTER WITH TWO 2.75" CONFLAT FLANGE PORTS	1	430.00	430.00
61	FR100002754 FLNG,CF,REDUCING,10"-2.75",304 SST	1	195.50	195.50
62	9190235 PUMP,VACION + 20 STARCELL W/FERRITE MAGNET	2	1,309.00	2,618.00
63	9295000 MIDIVAC,SINGLE NEGATIVE OUTPUT,120V	2	1,530.00	3,060.00
64	9295020 SETPOINT OPTION, MIDIVAC IP CONTROLLER	2	80.75	161.50
65	9295010 RS-232 COMPUTER INTERFACE FOR MIDIVAC	2	131.75	263.50
66	9290770 CABLE,HV,BAKEABLE,FISCHER CONN, 4M (13') LONG FOR 919 PU	2	301.75	603.50
			Total \$	127,069.45

CHANGES

- Table 1 System A, items 1 through 8 were furnished as a system by Varian (items 1 - 5 in Table 2). Items 9 through 12 were changed from the Multigauge to the Varian Sentorr gauge. Item 15 was changed from an SD-300 vane pump to a Varian 600DS Scroll pump which is a dry pump and therefore ultraclean (Item 13, Table 2).
- Table 1 System A, item 22, a custom cart for item 1, was included by Varian in the price of item 1 at no charge.
- Table 1 System B, item 14, a 6" metal gate valve, was changed to item 30 in Table 2. Item 24, a high voltage vacuum feedthrough, was actually purchased from Insulator Seal Incorporated for \$2685.95. Item 26, a cryopump, was listed as a model RPK-900 from Kurt Lesker, Inc. for \$16,930. The pump was actually purchased from APD for \$14,040.75.
- Table 1 System B, item 27, a custom cart for items 1, 2, and 23 was not purchased but fabricated locally at no cost to the contract.
- Table 1 Peripheral Equipment, items 1 and 2 listed as from Kurt Lesker Inc. for \$31,250 were actually purchased from MKS Instruments for \$20,713. Item 3, a vacuum leak detector from Varian for \$28,475 was actually purchased from Edwards High Vacuum for \$24,489.

Not shown in the original list:

1. \$1594.50 to Varian for the special bolts, nuts, and copper gaskets for the conflat flanges on the vacuum fittings.
2. Two more Turbo dry pumping systems (as per Table 2, item 1) for a total of \$43,007.90. This was made possible by the lower prices on several items as reported above.
3. An assortment of vacuum fittings, valves, a glass bell jar, and quartz windows from Telesis High Vacuum, Duniway Stockroom, Kone Valve, and Varian for a total of \$6129.95.

Not yet delivered

- Item 12 Table 1, System C, an all metal bakable vacuum valve, listed for \$18,560, has not been delivered. This appears in Table 2 as item 48 bid at \$17,817.60. Varian has some difficulty with fabrication of this item. Discussions are under way to decide what substitution will be made.