

AD-A194 231

UNSTEADY WATER CHANNEL(U) UNIVERSITY OF SOUTHERN  
CALIFORNIA LOS ANGELES DEPT OF AEROSPACE ENGINEERING  
C HO 29 MAR 88 AFOSR-TR-88-0466 AFOSR-85-0064

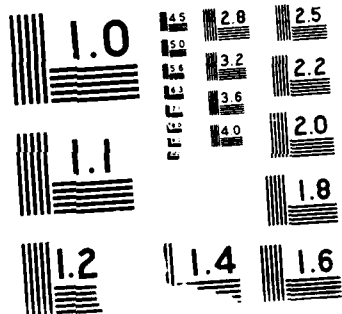
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REPORT DOCUMENTATION PAGE

1 REPORT SECURITY CLASSIFICATION UNCLASSIFIED	10 RESTRICTIVE MARKINGS
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AD-A194 231

3 DISTRIBUTION AVAILABILITY OF REPORT APPROVED FOR PUBLIC RELEASE DISTRIBUTION IS UNLIMITED
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5 MONITORING ORGANIZATION REPORT NUMBER(S) <b>AFOSR-TR- 88-0466</b>
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4a NAME OF PERFORMING ORGANIZATION UNIV OF SOUTHERN CA
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6b OFFICE SYMBOL (if applicable)
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7a NAME OF MONITORING ORGANIZATION AFOSR/NA
--

6c ADDRESS (City, State, and ZIP Code) DEPT OF AEROSPACE ENGIN L.A CA 90089
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7b ADDRESS (City, State, and ZIP Code) BUILDING 410 BOLLING AFB, DC 20332-6448
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8a NAME OF FUNDING SPONSORING ORGANIZATION AFOSR
---

8b OFFICE SYMBOL (if applicable) NA
---

9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER <b>AFOSR-85-0064</b>
--

8c ADDRESS (City, State, and ZIP Code) BUILDING 410 BOLLING AFB, DC 20332-6448
--

10 SOURCE OF FUNDING NUMBERS			
PROGRAM ELEMENT NO. <b>6100P</b>	PROJECT NO. <b>2217</b>	TASK NO. <b>A1</b>	WORK UNIT ACCESSION NO.

11 TITLE (Include Security Classification) (U) UNSTEADY WATER CHANNEL
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12 PERSONAL AUTHOR(S) C-M HO
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13a TYPE OF REPORT FINAL
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13b TIME COVERED FROM 12/84 TO 12/87
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14 DATE OF REPORT (Year, Month, Day) 3/88
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15 PAGE COUNT 14
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16 SUPPLEMENTARY NOTATION
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17 COSATI CODES		
FIELD	GROUP	SUB-GROUP

18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number) WATER CHANNEL, UNSTEADY WATER CHANNEL
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19 ABSTRACT (Continue on reverse if necessary and identify by block number) An unsteady water channel has been constructed. The test section measures 18" by 18" and has a maximum flow rate of 3 ft/sec. In addition, a rotating gate provides programable unsteady flow velocities.
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MAY 03 1988  
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20 DISTRIBUTION AVAILABILITY OF ABSTRACT <input type="checkbox"/> UNCLASSIFIED UNLIMITED <input checked="" type="checkbox"/> SAME AS RPT <input type="checkbox"/> DTIC USERS
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21 ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED
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22a NAME OF RESPONSIBLE INDIVIDUAL HENRY E HELIN, CAPTAIN, USAF
--

22b TELEPHONE (Include Area Code) 202-767-3471
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22c OFFICE SYMBOL AFOSR/NA
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AFOSR-TR- 88 - 0466

UNSTEADY WATER CHANNEL  
AFOSR-85-0064

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Los Angeles, California 90089-1191

29 March 1988

FINAL REPORT for period (12/31/84 - 12/30/87)

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Building 410  
Bolling Air Force Base  
Washington, D.C. 20332-6448  
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88 5 - 02 176

# UNSTEADY WATER CHANNEL

## FINAL REPORT

AFOSR-85-0064

PRINCIPAL INVESTIGATOR: HO, CHIH-MING

Department of Aerospace Engineering  
University of Southern California  
Los Angeles, California 90089-1191

### INTRODUCTION

When an airplane undergoes maneuvering, the motion includes many modes: pitching, plunging, translation, acceleration and deceleration. The aerodynamics of the first three types of motion are well-documented. The effects of acceleration and deceleration on the aerodynamic forces of a wing have not been explored in depth because a specially designed unsteady testing facility is necessary. The present water channel is able to provide a wide variety of free stream conditions. 7-147

### DESIGN PRINCIPLE

Careful planning is necessary, as there are many factors to consider in designing an unsteady facility. The most important operational parameter, perhaps, is the frequency of the free stream velocity because the ratio of this frequency to the characteristic frequency of the flow determines the "steadiness". In an air facility, the characteristic frequency of the flow is usually very high. It is difficult to match the free

stream frequency to the characteristic frequency. Therefore, we have chosen to build an unsteady water channel.

In unsteady aerodynamic studies, suction can be very high and it is possible that cavitation can occur on the airfoil. In order to reduce this possibility, the channel is built with a vertical configuration. The water head helps to prevent cavitation. In almost all water channel operations, air bubbles are a troublesome problem. This problem is alleviated by allowing the bubbles to travel upward to the water surface. The other advantage of having a channel with a vertical configuration is that the pump is operated in the designed high efficiency range.

Since the free stream condition is versatile, we are able to easily control the velocity as a function of time. This requirement is achieved by operating the channel in the constant head mode. In this case, the free stream velocity is a function of the flow resistance. The nonlinear characteristics of the pump do not interfere with the control. We use a three-element gate [Fig. 1] to provide a variable flow-resistance. The top two pieces have the same opening patterns and are allowed to rotate over each other to determine the mean flow. The third element is a rotating gear also with the same pattern. When the gear is driven by a stepping motor, the opening area of the gate varies with time and so does the flow resistance. Hence, the free stream speed can be controlled by using a specific angular speed of the gear.



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## CONFIGURATION

The channel is 12' tall [Fig.2] with the test section measuring 18" x 18". The stagnation chamber has a dimension of 42" on each side and connects to the test section through a fifth order polynomial contraction [Fig. 3]. The maximum velocity is 3 ft/sec. Two velocity traces in the prototype channel are shown in Figs. 4 & 5. When the rotating gate has a constant angular speed, the freestream speed has an irregular form [Fig. 4]. However, when the gate is controlled by a micro-processor, a precise triangular waveform is achieved [Fig. 5].

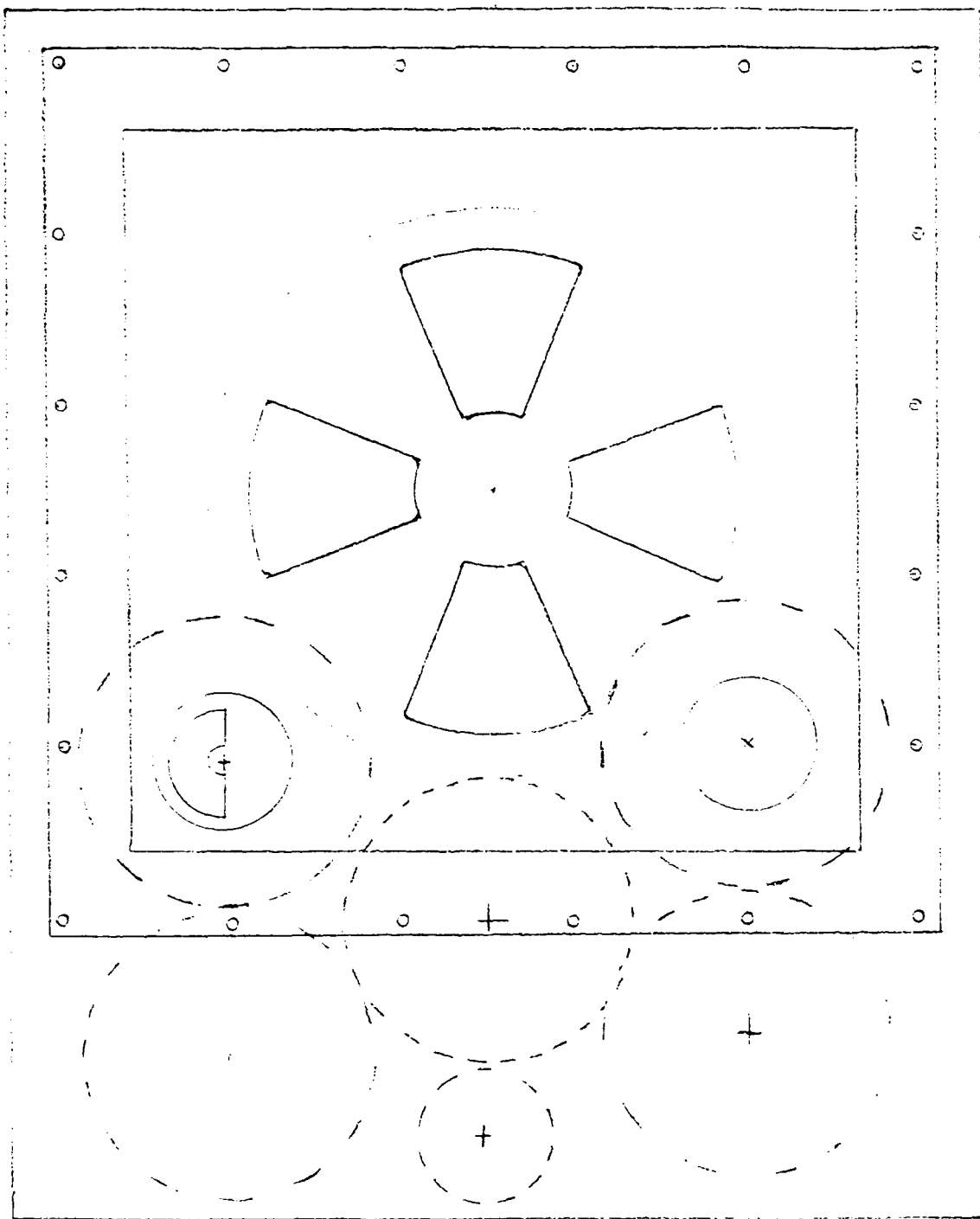


Fig. 1. The three-element gate.

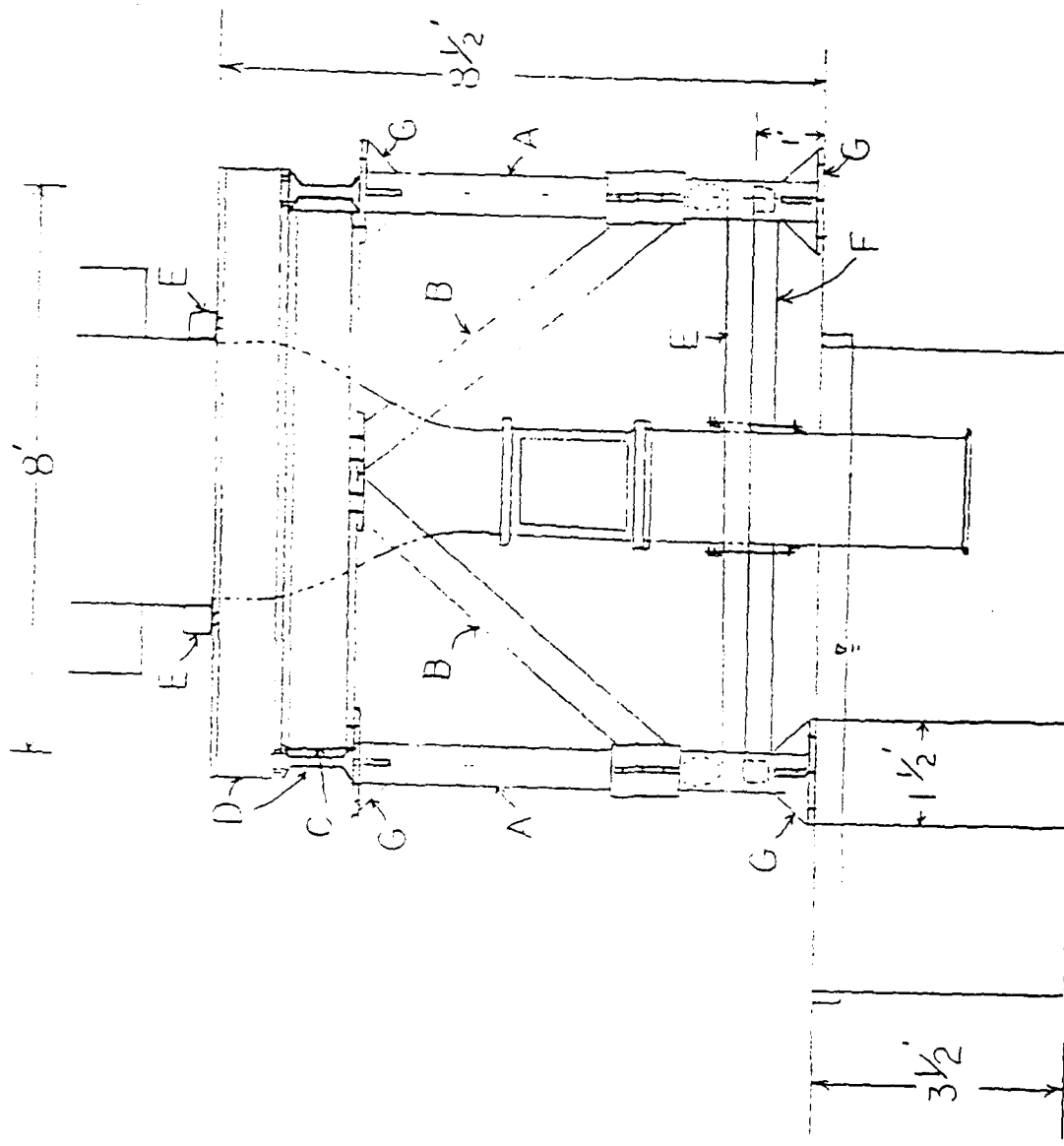


Fig. 2. The configuration of the unsteady water channel.

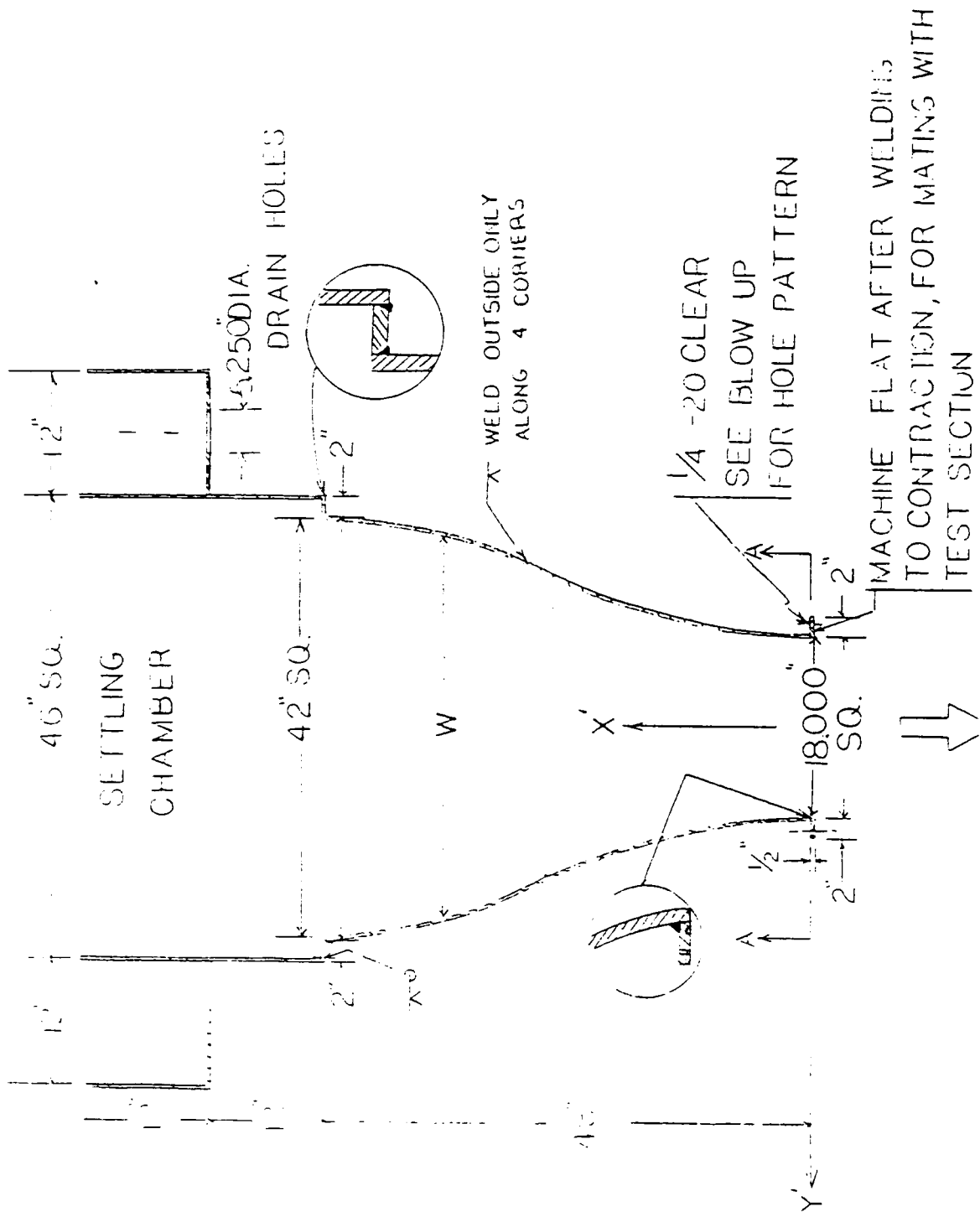


Fig. 3. The contraction section.

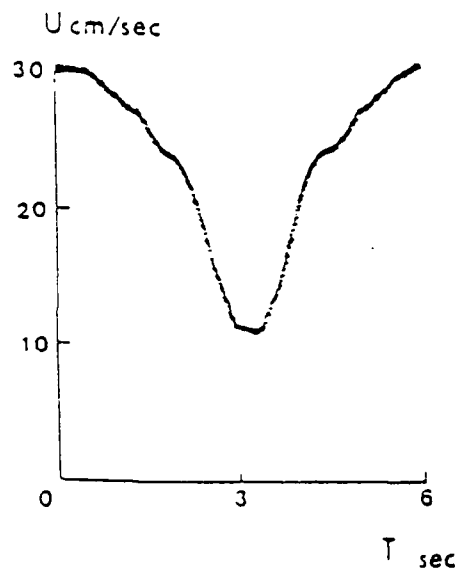


Fig. 4. Free stream velocity with rotating gate at constant angular speed.

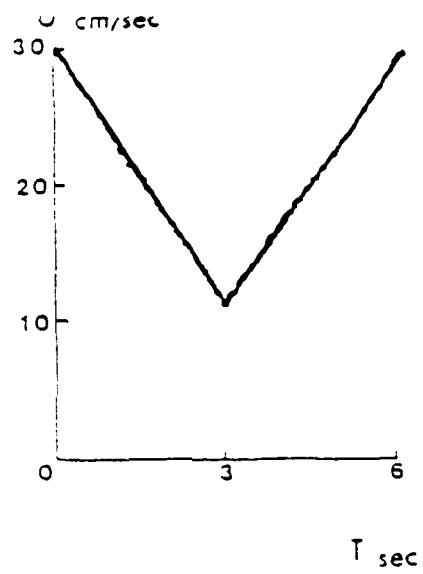


Fig. 5. Free stream velocity with computer-controlled rotating gate.

LIST OF EQUIPMENT ITEMS ACQUIRED DURING THE DURATION OF THE GRANT:

QTY.	DESCRIPTION	MANUFACTURER	UNIT PRICE	TOTAL (Includes shipping, handling, and tax)
1	Netcom, 4x8 back plane #HV1123	Chrislin Ind.	1,195.00	1,249.00
5	Tank adapter 4" dia. PVC Cat#7000-040	Ryan Herco	67.00	356.78
1	Lot fabricate 18" x 18" unsteady water channel facility - constructed of 304 grade stainless steel; labor and materials	L&F Industries	12,533.33	12,533.33
1	Lot 10Mhz oscilloscope w/ counter timer/multimer Cat#2236	E&I Co-op Tektronix	2,332.00	2,483.58
1	Beckman function generator #FG2	EIL	175.96	196.64
1	12 bit A/D plug in #15-16	RC Electronics	2,495.00	3,503.85
1	Mass storage upgrade #1SDL-00.4		795.00	
1	Basil rewirements for control #RC-2021	RC Electronics	895.00	2,438.85
1	16 bit arbitrary waveform generator #2161		1,395.00	
1	D/A Converter module #55L93	Dantec Elec.	565.25	633.68
1	Lot 12" ship channel-3"	Earl M. Jorgensen	444.00	1,459.35
1	Lot cutting		51.00	
1	Lot 12" standard I beam		572.40	
2	MO93-FC11 DC stepping	Minarik Elec.	215.00	

4	BM133832-009 dropping resistor	15.50		761.48
1	M200T Carver audio power	319.50	Gross Nat'n Prod.	319.50
2	AYA-15 Boston Gear	6.52	Garrett Ind.	
2	AYA-160 Boston Gear	89.28	Supply	204.05
1	1/4-5052-.002x28"x96" Hexaconal	215.60	Hexcell	229.61
1	12" Pitch dia. Spur gear (16 D.P.)	150.00	Industrial Sprocket	
1	3" Pitch dia. Spur gear (16 D.P.)	150.00		319.50
1	New water channel development labor and materials	1,991.00	USC Engr. Shop	1,991.00
1	Fabricate 2 laser drives support	310.00	USC Engr. Shop	310.00
1	BCC-52 Controller board	254.54	The Micromint, Inc.	254.54
1	58 hrs./materials for stepping motor support structure	949.00	USC Engr. Shop	949.00
1	CCK3 Vector card cage	62.50	Empire	
1	3662 Vector circuit card	11.95	Electronics	
1	4112-4 Vector circuit	18.65		
1	Lot R644 Vector receptacles	4.97		104.44
2	L&H 5x6x9 la carver end suction centigal pump, w/ option - all 316	3,685.00	L.A. Liquid Handling System	7,849.00
1	M112-FJ327 steppin motor PSD-048 B Power Supplies	438.00	Minarik Electric Co.	855.20
		365.00		

1	12F9575 1K Potentiometer	Newark Electronics	37.24	
2	12F9575 10K Potentiometer		37.24	
2	12F9575 20K Potentiometer		37.24	
2	81F9439 Unregulated power supply		70.95	349.43
1	Lot Cutting	Earl M. Jorgensen	51.00	
1	Lot 4" Sq. Mesh Tubing		230.88	
1	Lot Cutting		21.00	
4	6 ft. 6"x1/16" pipe	Lakewood Pipe Serv.	80.00	
6	35" cut pipe 6" to 6"		95.00	
2	pipe, contoured		90.00	1,139.55
	40" cut pipe 6" to 7-3/8			
1	6" x 18" x 3/8" plate	Behnmaier Steel	5.37	
	8" x 8" x 11" triangle		51.84	
	plate 3/8" thick			
	1-1/2" x 18" x 3/8" bar		13.20	
	18" x 18" x 1/2" plate		163.04	248.62
2	Function generator, #FG2	EK Instruments	199.95	425.89
1	Everex 3MB RAM board-RAM3000	Altech	375.00	518.66
1	Parallel port		28.00	
1	Deskvue Software		60.00	
10	Quad density disks		24.00	
2	Rolls PVC 3/8" x 49" x 180' foam	Packaging Alternatives	419.00	892.47
2	RLO2 disk	Hamilton Avnet	230.00	489.90
6	3/8" PL 10x7	Behnmaier Steel	5.28	
2	3/8" PL 12x7		5.93	46.37
4	18" x 18" x 1/2" Neoprene isolation pads	Cal Dynamics	42.53	181.18
1	PM section No. 9055x0083	Dantec	2,735.00	12,840.81
1	Beamsplitter-color 448nm + 514nm		2,820.00	
1	Pinhole section, 55x31		2,195.00	
1	Color separator		2,150.00	
1	Interference filter, 488nm		520.00	
1	Frequency shifter channel		2,010.00	

3	MTO 3-1/2" P.D. nylon gear 3/4" face	55.00		
5	MTO 7" P.D. nylon gear 3/4" face	88.00	1,123.58	
1	Modulynx, stepping motor driver	3,163.00	4,549.68	Minarik Electric
1	Slo-syn stepping motor, MH172-FD8030	1,109.00		
1	Lot safety valves, elbow valves, etc.	1,514.44	1,514.44	Harrington Plastics
1	Polyeth tank 48" x 24" x 12"	159.75	380.01	Ryan Herco
1	Duo block series, true union ball & materials, etc.			
5	CNI 6004s	15.00	79.88	Inter-American
1	10 mesh standard sq. stainless steel wire	424.32	539.83	Citywire
1	10 mesh standard sq. stainless steel			
100	Ft. 2" x 2" stainless square tubing	7.10	756.15	Ace Stainless
70	70 ft., 0,250" in. dia buna-n seal shore 50 hardness	.71	52.93	Dimension seal
1	Wire FDM cut on 24" x 30" stainless steel gate	765.00	814.73	Microcut
11	VT-800 vibration isolation pad	62.00	66.03	Cal Dynamics
1	Lot materials for flow dist. manifold	116.39	116.39	Harrington Plastics
1	12 ft. rod s.s. 303 5/8" dia.	42.46		McMaster-Carr
1	12 ft. rod, No. 8984K14	27.19		
10	Ft. light weight lock-nut, 91831A035	2.87		
5	Light weight lock-nut, 91831A033	1.11	110.65	
100	Ft. 1-1/2" x 1-1/2" O.D. x .12 D sq. tubing	596.40	596.40	Tube Sales
1	Pick-up 2 x 2 sq. stainless	30.77	30.77	Ernst Air Speed Trucking

1	Installation of duplex receptacles	USC Physical Plant	418.00	
1	Installation of power switches		1,370.00	1,788.00
2	20" long low pressure water filter	Harrington Plastics	36.60	220.35
10	20" long water filter cartridges		6.25	
10	20" long water filter cartridges		7.02	
1	Labor verticle water channel test section	USC Engr. Shop	5,171.00	5,171.00
1	Lot supplies for degassing unit	C&H Sales	259.86	259.86
1	Lot supplies for test section	McMaster Carr	193.08	195.97
1	Base plate of gate for water channel	USC Engr. Shop	1,965.00	1,965.00
1	Fabrication of stepping motor	Physical Plant	40.73	40.73
1	Labor on vertical water channel	Engr. Shop	359.82	359.82
1	APL 100D 208V circuit (DD 5742)	USC Physical Plant	836.54	836.54

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