ASD
APOLLO SYSTEMS DEPARTMENT
GENERAL ELECTRIC
HOUSTON, TEXAS

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TECHNICAL INFORMATION RELEASE

TIR 741-MED-3041

FROM	TO
R. C. Croston, Ph.D.	J. A. Rummel, Ph.D./DB6

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SUBJECT

User's Instructions for the High Speed Version of the Cardiovascular Exercise Model

(NASA-CR-160211) USER'S INSTRUCTIONS FOR THE HIGH SPEED VERSION OF THE CARDIOVASCULAR EXERCISE MODEL (General Electric Co.) 27 p
HC A03/MF A01 CSCL 06B

N79-25724

Unclas
G3/52 22200

The purpose of the model is to provide a method to analyze cardiovascular control hypotheses which cannot be easily tested in an animal or human or in a spaceflight environment. The circulatory system model is combined with models of the controlling systems to simulate transient responses to exercise. Other characteristics of the combined model include gravity effects, muscle pumping, venous tone, venous valves, respiratory frequency, and intrathoracid pressure effects.

R. C. Croston

R. C. Croston, Ph.D.

Attachment
/db

CONCURRENCES

Counterpart:

Medical Projects Unit Manager: CWFulcher

Engrg. & Advanced Programs Subsection Mgr. WJBeittel 8/16/73

DISTRIBUTION GE/AGS: Central Product File
D. G. Fitzjerrell
R. F. Hassell
V. J. Marks
Dr.R.White/Dr. R.Gallagher

NASA/JSC: C. F. Sawin, Ph.D.
Technical Library/JM6
(1979 distr)

ASD 4028

PROGRAM DESCRIPTION

A. IDENTIFICATION

Program Name	- Croston Exercise Model (Univac 1110 Version)
Programmer's Name	- R. C. Croston, GE/JSC, Houston
Date of Issue	- August 16, 1973

B. GENERAL DESCRIPTION

A mathematical model and digital computer simulation of the human cardiovascular system and its controls were developed to simulate transient responses to bicycle ergometer exercise. The purpose of the model is to provide a method to analyze cardiovascular control hypotheses which cannot be easily tested in an animal or human or in a spaceflight environment.

C. USAGE AND RESTRICTIONS

Machine and Compiler Required	- Univac 1110 TSS and Fortran V
Peripheral Equipment Required	- Magnetic Tape - Time Sharing Terminal

D. PARTICULAR DESCRIPTION

Equations Used and Derivations	- See TIR No. 741-MED-2010
Definition of Terms Used	- See Table 1.

Detailed Description - Equations describing pulsatile blood flows, pressures, and volumes for 28 model sections of the uncontrolled cardiovascular circulatory system are solved. The circulatory system model, Figure 1, is combined with models of the controlling systems to simulate transient responses to exercise. Other characteristics of the combined model include gravity effects, muscle pumping, venous tone, venous valves, respiratory frequency, and intrathoracic pressure effects.

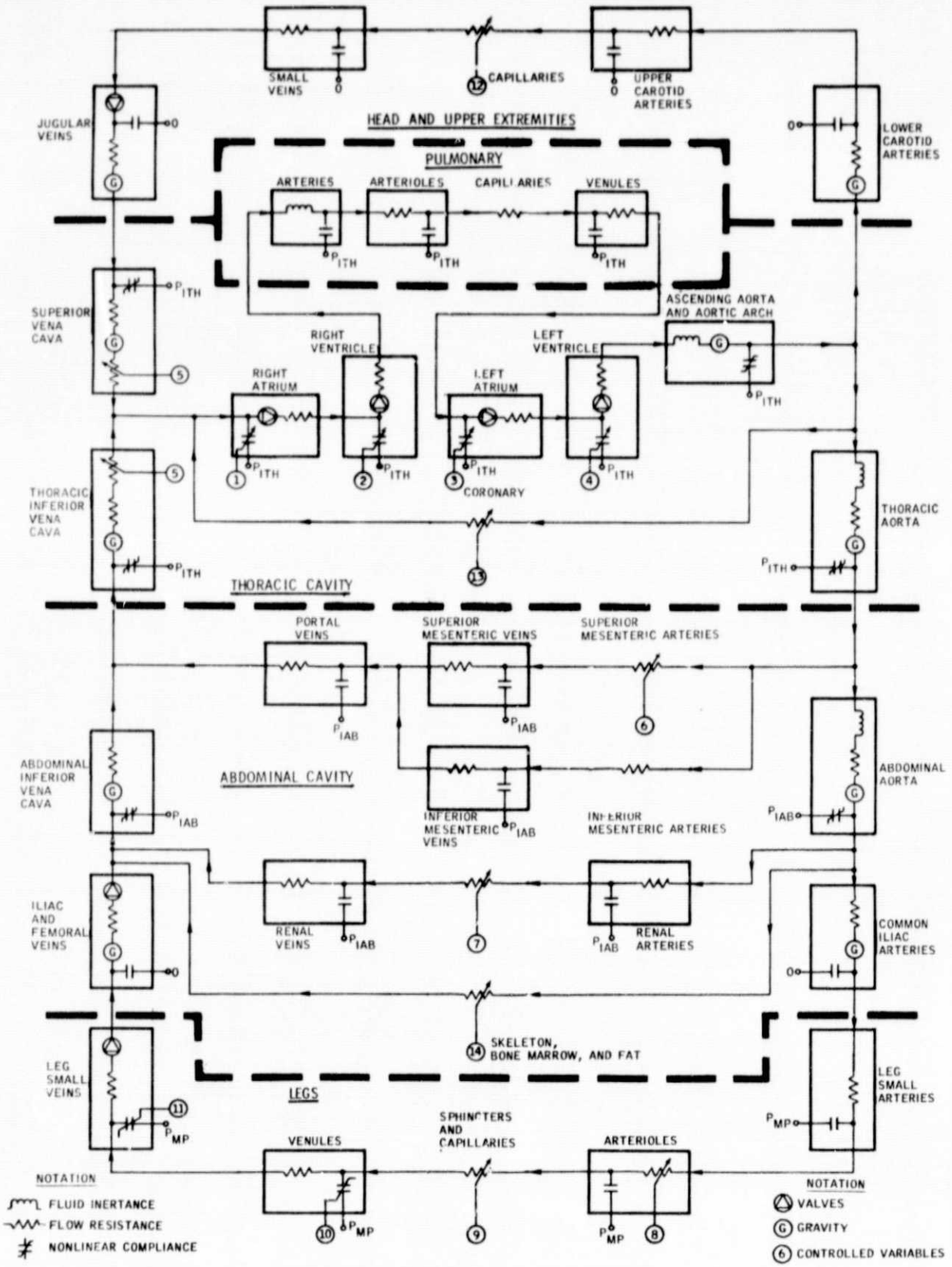

FIGURE 1.

CIRCULATORY MODEL

E. DESCRIPTION OF INPUT

(1) Contact V. J. Marks, GE/JSC, Houston to obtain Univac 1110 sign on procedures and authorization codes.

(2) Interactive operation of the model will ask the user if he wishes to change the standard set of initialization data shown in Table 1. If so, the user enters the appropriate index code and new value for each variable as directed by the conversational output of the program.

F. DESCRIPTION OF OUTPUT

(1) Conversational output of the program will ask the user if he wishes to change the standard terminal output list of variables. If so, the user enters the appropriate index code and new value for each variable as directed by the conversational output of the program.

(2) The standard set of output variables consists of time and 8 dependent variables which are output at the end of each heart beat. The selected standard variables are as follows:

1 Simulation Time (sec)

2 Heart Rate (beats/min)

3 Cardiac Output (liters/min)

4 Stroke Volume (liters)

5 Mean Blood Pressure (mm Hg)

6 Systolic Blood Pressure (mm Hg)

7 Diastolic Blood Pressure (mm Hg)

8 Respiration Rate (Breaths/min)

9 Intrathoracic Pressure (mm Hg)

G. INTERNAL CHECKS AND EXITS

Exit - A normal stop exit occurs when the finish time specified is exceeded.

H. INDEPENDENT SUBROUTINES

SWIN	Switch Input
FCNSW	Function Switch
DELAY	Delay
ALGO	Integration Algorithm
CVS	Pulsatile Circulatory Model
CONTRL	Cardiovascular Controlling Systems
XIO	Conversational Input/Output
BLKDAT	Initialization Data

I. COMPUTER PROGRAM LISTING

(Attached)

TABLE 1

DEFINITIONS

ELEMENT NO.	MNEMONIC	DEFINITION	CONSTANT OR INITIAL VALUE	UNITS
1	X(1)	Stressed Vol., RT. Atrium	71.88	ml
2	X(2)	" " , RT. Ventricle	158.2	"
3	X(3)	" " , Left Atrium	29.62	"
4	X(4)	" " , Left Ventricle	147.6	"
5	X(5)	" " , Pulmonary Arteries	12.08	"
6	X(6)	" " , " Capillaries	16.51	"
7	X(7)	" " , " Venules	24.97	"
8	X(8)	Total Vol. , Aortic Arch	165.7	"
9	X(9)	Inertance Integral	0.0	-
10	X(10)	Integral of Aortic Arch Pressure/Beat	0.0	mmHg-sec
11	X(11)	Inertance Integral	0.0	-
12	X(12)	Total Vol., Thoracic Aorta	202.6	ml
13	X(13)	Integral of Carotid Pressure/Beat	0.0	mmHg-sec
14	X(14)	Total Vol., Abdominal Aorta	112.5	ml
15	X(15)	Stressed Vol., Common Iliac Arteries	100.3	"
16	X(16)	" " , Legs Small Arteries	101.2	"
17	X(17)	" " , Legs Arterioles	109.3	"
18	X(18)	" " , Legs Venules	81.79	"
19	X(19)	" " , Legs Small Veins	61.72	"
20	X(20)	" " , Femoral Veins	4.982	"
21	X(21)	Total Vol., Abdominal Vena Cava	597.7	"
22	X(22)	Total Vol., Thoracic Vena Cava	348.6	"
23	X(23)	Total Vol., Superior Vena Cava	2.587	"
24	X(24)	Stressed Vol., Lower Carotid Arteries	25.37	"
25	X(25)	" " , Upper Carotid Arteries	25.35	"
26	X(26)	" " , Head Small Veins	0.0	"
27	X(27)	" " , Jugular Veins	0.0	"
28	X(28)	" " , Superior Mesenteric Veins	264.4	"
29	X(29)	" " , Inferior Mesenteric Veins	32.62	"
30	X(30)	" " , Portal Veins	127.3	"
31	X(31)	" " , Renal Arteries	24.31	"
32	X(32)	" " , Renal Veins	82.68	"
33	X(33)	Integral of Left Vent. Flow/Beat	0.0	"
34	X(34)	Inertance Integral	0.0	-
35	X(35)	" "	0.0	-
36	X(36)	" "	0.0	-
37	X(37)	Integral of Pulmonary Arterial Pressure	0.0	mmHg-sec.
38	X(38)	" " " Arterioles "	0.0	"
39	X(39)	Not Used	-	
40	X(40)	"	-	

ELEMENT NO.	MNEMONIC	DEFINITION	CONSTANT OR INITIAL VALUE	UNITS
41	X(41)	(ACCMET) Metabolites	0.0	-
42	X(42)	Not Used	-	-
43	X(43)	(XN4) Neural Signal	0.0	-
44	X(44)	(DA) Alactic Debt	0.0	Liters O_2
45	X(45)	(DL) Lactic Debt	0.0	Liters O_2
46	X(46)	(AVDA) AVD Lag	0.0	-
47	X(47)	Not Used	-	-
48	X(48)	(DO_2) O_2 Deficit	0.0	Liters O_2
49	X(49)	(XN3) Neural	0.0	-
50	X(50)	Not Used	-	-
51 - 100		Time Derivatives of the above state variables		
101	QRA	Flow from RT. Atrium	Computed	ml/sec
102	QRV	" " RT. Ventricle	Variable	"
103	QLA	" " Left Atrium	"	"
104	QLV	" " " Ventricle	"	"
105	QPA	" " Pulmonary Arteries	"	"
106	QPC	" " Pulmonary Arterioles	"	"
107	QPV	" " " Venules	"	"
108	QAA	" " Aortic Arch	"	"
109		Not Used		
110		" "		
111		Not Used	Computed	ml/sec
112	QLTA	Flow from Thoracic Aorta	Variable	"
113		Not Used		
114	QLABA	Flow from Abdominal Aorta	"	"
115	QCILL	Flow from Common Iliac Arteries	"	"
116	QLGSA	" " Leg Small Arteries	"	"
117		Not Used		
118	QLGCAP	Flow from Leg Arterioles	"	"
119	QLGVE	" " Leg Venules	"	"
120	QLGSV	" " Leg Small Veins	"	"
121	QFEV	" " Femoral Veins	"	"
122	QABVC	" " Abdominal Vena Cava	"	"
123	QTHVC	" " Thoracic " "	"	"
124	QSPVC	" " Superior Vena Cava	"	"
125	QLOC	Flow to Lower Carotid Arteries	"	"
126	QUPC	" " Upper " "	"	"
127	QHCAP	" from Upper Carotid Arteries	"	"
128	QHSV	" from Head Small Veins	"	"
129	QJV	" from Jugular Veins	"	"
130	QCØR	Coronary Blood Flow	"	"

ELEMENT NO.	MNEMONIC	DEFINITION	CONSTANT OR INITIAL VALUE	UNITS
131	QCSMA	Flow to Superior Mesenteric Veins	Computed	ml/sec
132	QIMA	" " Inferior Mesenteric Veins	Variable	"
133	QCSMV	Flow from Superior Mesenteric Veins	"	"
134	QPØV	" " Portal Veins	"	"
135	QIMV	" " Inferior Mesenteric Veins	"	"
136	QRENA	Flow to Renal Arteries	"	"
137	QRALE	Flow from Renal Arteries	"	"
138	QRENV	" " Renal Vein	"	"
139	QRET	Flow to RT. Atrium	"	"
140	QD(1)	Not Used		
141		Not Used		
142		Not Used		
143		Not Used		
144		Not Used		
145		Not Used		
146		Not Used		
147		Not Used		
148		Not Used		
149	QD(10)	Not Used		
150	QSKB	Flow Through Skeleton, Bone Marrow, and Fat	Computed Variable	ml/sec "
151	CRA	Compliance, Right Atrium	"	ml/mmHg
152	CRV	" , Right Ventricle	"	"
153	CLA	" , Left Atrium	"	"
154	CLV	" , Left Ventricle	"	"
155	CPA	Compliance, Pulmonary Arteries	1.2	ml/mmHg
156	CPC	" " Arterioles	1.7	"
157	CPV	" " Venules	5.3	"
158		Temporary Storage		
159		" "		
160		" "		
161		" "		
162		" "		
163		" "		
164		" "		
165	CCILL	Compliance, Common Iliac Arteries	0.8	"
166	CLGSA	" , Leg Small Arteries	0.8	"
167	CLGAR	" , Leg Arterioles	0.3	"
168	CLGVE	" , Leg Venules	Computed Variable	"
169	CLGSV	" , Leg Small Veins	"	"
170	CFEV	" , Leg Femoral Veins	0.2	"
171		Temporary Storage		
172		" "		
173		" "		
174	CLØC	Compliance, Lower Carotid Arteries	0.3996	"
175	CUPC	" , Upper " "	0.3996	"
176	CHSV	" , Head Small Veins	5.328	"
177	CJV	" , Jugular Veins	0.9058	"
178	CCSMV	" , Superior Mesenteric Veins	9.59	"
179	CIMV	" , Inferior Mesenteric Veins	1.505	"
180	CPØV	" , Portal Veins	6.047	"

ELEMENT NO.	MNEMONIC	DEFINITION	CONSTANT OR INITIAL VALUE	UNITS
181	CRENA	Compliance, Renal Arteries	0.2224	"
182	CRENV	" , Renal Veins	2.517	"
183	CD(1)	Not Used		
184		"		
185		"		
186		"		
187		"		
188		"		
189		"		
190		"		
191		"		
192		"		
193		"		
194		"		
195		"		
196		"		
197		"		
198		"		
199		"		
200	CD(18)	"		

CALCULATED VARIABLES FOR EACH VOLUME COMPARTMENT

ELEMENT NO.	PRESSURE (mm Hg)			PRESSURE DUE TO GRAVITY		EXTERNAL PRESSURE		VOLUME COMPARTMENT
201	PRA	321	V(1)	421	PG(1)	455	PEXT(1)	RT. Atrium
202	PRV	322	V(2)	422	PG(2)	456	PEXT(2)	RT. Ventricle
203	PLA	323	V(3)	423	PG(3)	457	PEXT(3)	Left Atrium
204	PLV	324	V(4)	424	PG(4)	458	PEXT(4)	Left Ventricle
205	PPA	325	V(5)	425	PG(5)	459	PEXT(5)	Pulmonary Arteries
206	PPC	326	V(6)	426	PG(6)	460	PEXT(6)	Pulmonary Arterioles
207	PPV	327	V(7)	427	PG(7)	461	PEXT(7)	Pulmonary Veins
208	PAA	328	V(8)	428	PG(8)	462	PEXT(8)	Aortic Arch
209	Temporary Storage			429	PG(9)	463	PEXT(9)	
210	"	"		430	PG(10)	464	PEXT(10)	
211	"	"		431	PG(11)	465	PEXT(11)	
212	PLTA	332	V(12)	432	PG(12)	466	PEXT(12)	Thoracic Aorta
213	Temporary Storage			433	PG(13)	467	PEXT(13)	
214	PLABA	334	V(14)	434	PG(14)	468	PEXT(14)	Abdominal Aorta
215	PCILL	335	V(15)	435	PG(15)	469	PEXT(15)	Common Iliac Artery
216	PLGSA	336	V(16)	436	PG(16)	470	PEXT(16)	Leg Small Arteries
217	PLGAR	337	V(17)	437	PG(17)	471	PEXT(17)	Leg Arterioles
218	PLGVE	338	V(18)	438	PG(18)	472	PEXT(18)	Leg Veins
219	PLGSV	339	V(19)	439	PG(19)	473	PEXT(19)	Leg Small Veins
220	PFEV	340	V(20)	440	PG(20)	474	PEXT(20)	Femoral Veins
221	PABVC	341	V(21)	441	PG(21)	475	PEXT(21)	Abdominal Vena Cava
222	PTHVC	342	V(22)	442	PG(22)	476	PEXT(22)	Thoracic Vena Cava
223	PSPVC	343	V(23)	443	PG(23)	477	PEXT(23)	Superior Vena Cava
224	PLØC	344	V(24)	444	PG(24)	478	PEXT(24)	Lower Carotid Arteries
225	PUPC	345	V(25)	445	PG(25)	479	PEXT(25)	Upper Carotid Arteries
226	PHSV	346	V(26)	446	PG(26)	480	PEXT(26)	Head Small Veins
227	PJV	347	V(27)	447	PG(27)	481	PEXT(27)	Jugular Veins
228	PCSMV	348	V(28)	448	PG(28)	482	PEXT(28)	Superior Mesenteric Veins
229	PIMV	349	V(29)	449	PG(29)	483	PEXT(29)	Inferior Mesenteric Veins
230	PPØV	350	V(30)	450	PG(30)	484	PEXT(30)	Portal Veins

CALCULATED VARIABLES FOR EACH VOLUME COMPARTMENT

ELEMENT NO.	PRESSURE (mm Hg)	TOTAL VOLUME (ml)	PRESSURE DUE TO GRAVITY	EXTERNAL PRESSURE	VOLUME COMPARTMENT
231	PRENA 351	V(31) 451	PG(31) 485	PEXT(31)	Renal Arteries
232	PRENV 352	V(32) 452	PG(32) 486	PEXT(32)	Renal Veins
233	PD(1) Mean Pulmonary Arteries				
234	PD(2) Wedge Pressure	453 - 454 Not Used			
235	Not Used	353 - 368 Not Used			
236	" "	369 - V(49) Blood Volume Command = 5325.0 ml			
237	" "	370 - V(50) Total Blood Volume = 5325.0 ml			
238	" "				
239	" "				
240	" "				
241	" "				
242	" "				
243	" "				
244	" "				
245	" "				
246	" "				
247	" "				
248	" "				
249	PM Mean Arterial Pressure			90.0	mmHg
250	PMC Mean Carotid Arterial Pressure			90.0	mmHg

ELEMENT NO.	MNEMONIC	DEFINITION	CONSTANT OR INITIAL VALUE	UNITS
251	RRA	RT. Atrium Valve Resistance	0.007508	mmHg/ml/sec
252	RRV	RT. Ventricle Valve Resistance	0.007508	"
253	RMV	Left Atrium Valve	0.007508	"
254	RAV	Left Ventricle Valve	0.008634	"
255	RPA	Pulmonary Arterioles	0.01502	"
256	RPC	Pulmonary Capillaries	0.05255	"
257	RPV	Pulmonary Venules	0.01502	"
258		Not Used		
259		Not Used		
260		Not Used		
261	RLTA	Thoracic Aorta	0.02400	"
262		Not Used	0.0	
263	RLABA	Abdominal Aorta	0.02400	"
264	RCILL	Common Iliac Arteries	0.02400	"
265	RLGSA	Leg Small Arteries	0.03003	"
266	RLGAR	Leg Arterioles	4.505	"
267	RLGCAP	Leg Capillaries	0.4505	"
268	RLGVE	Leg Venules	0.07508	"
269	RLGSV	Leg Small Veins	0.07508	"
270	RFEV	Femoral Veins	0.02102	"

ELEMENT NO.	MNEMONIC	DEFINITION	CONSTANT OR INITIAL VALUE	UNITS
271	RABVC	Abdominal Vena Cava	0.007380	mmHg/ml/sec
272	RTHVC	Thoracic Vena Cava	0.007508	"
273	RSPVC	Superior Vena Cava	0.01502	"
274	RLØC	Lower Carotid Arteries	0.02252	"
275	RUPC	Upper Carotid Arteries	0.03378	"
276	RHCAP	Head Capillaries	3.431	"
277	RHSV	Head Small Veins	0.3754	"
278	RJV	Jugular Veins	0.004302	"
279	RCØR	Coronary	15.390	"
280	RCSMA	Superior Mesenteric Arteries	2.350	"
281	RIMA	Inferior Mesenteric Arteries	34.5345	"
282	RCSMV	Superior Mesenteric Veins	0.2252	"
283	RPOV	Portal Veins	0.5255	"
284	RIMV	Inferior Mesenteric Veins	0.3003	"
285	RRENA	Renal Arteries	0.01502	"
286	RRALE	Renal Arterioles	0.45045	"
287	RREFF	Efferent Arterioles	2.744	"
288	RRENV	Renal Veins	0.6494	"
289	RD(1)	Not Used		
290		" "		
291		Not Used		
292		" "		
293		" "		
294		" "		
295		" "		
296		" "		
297		" "		
298		" "		
299	RD(11)	" "		
300	RSKB	Skeleton and Fat	5.150	"
301	FLPA	Inertance, Pulmonary Arteries	0.0007508	mmHg/ml/sec^2
302	FLAA	" , Aortic Arch	0.002881	"
303		Not Used		
304		" "		
305		" "		
306	FLLTA	Inertance, Thoracic Aorta	0.008538	"
307		Not Used		
308	FLLABA	Inertance, Abdominal Aorta	0.008977	"
309	FLCILL	" , Iliac Arteries	0.00626	"
310 - 320		Not Used		

UNSTRESSED VOLUMES

ELEMENT NO.	MNEMONIC	DEFINITION	CONSTANT OR INITIAL VALUE	UNITS
371	VU(1)	Rt. Atrium	30.0	ml
372	VU(2)	Rt. Ventricle	0.0	"
373	VU(3)	Left Atrium	30.0	"
374	VU(4)	Left Ventricle	0.0	"
375	VU(5)	Pulmonary Arteries	85.0	"
376	VU(6)	Pulmonary Arterioles	15.0	"
377	VU(7)	Pulmonary Veins	400.0	"
378	VU(8)	Not Used		
379	VU(9)	" "		
380	VU(10)	" "		
381	VU(11)	" "		
382	VU(12)	" "		
383	VU(13)	" "		
384	VU(14)	" "		
385	VU(15)	Common Iliac Arteries	5.194	"
386	VU(16)	Leg Small Arteries	30.0	"
387	VU(17)	Leg Arterioles	30.0	"
388	VU(18)	Leg Veins	100.0	"
389	VU(19)	Leg Small Veins	68.0	"
390	VU(20)	Femoral Veins	40.0	"
391	VU(21)	Not Used		
392	VU(22)	" "		
393	VU(23)	" "		
394	VU(24)	Lower Carotid Arteries	50.0	"
395	VU(25)	Upper Carotid Arteries	50.0	"
396	VU(26)	Head Small Veins	500.0	"
397	VU(27)	Jugular Veins	28.0	"
398	VU(28)	Superior Mesenteric Veins	451.0	"
399	VU(29)	Inferior Mesenteric Veins	80.0	"
400	VU(30)	Portal Veins	375.0	"
401	VU(31)	Renal Arteries	5..0	"
402	VU(32)	Renal Veins	150.0	"
403 - 420		Not Used		
487	E(1)	Right Atrial Elastance	Computed Variable	mmHg/ml
488	E(2)	Right Ventricle Elastance	" "	"
489	E(3)	Left Atrial Elastance	" "	"
490	E(4)	Left Ventricle Elastance	" "	"
491 - 500		Temporary Storage		

UNSTRESSED VOLUMES

ELEMENT NO.	MNEMONIC	DEFINITION	CONSTANT OR INITIAL VALUE	UNITS
501	Z(1)	Length of Vascular Segment	0.0	cm
502	Z(2)	"	0.0	"
503	Z(3)	"	0.0	"
504	Z(4)	"	0.0	"
505	Z(5)	"	0.0	"
506	Z(6)	"	0.0	"
507	Z(7)	"	0.0	"
508	Z(8)	"	-3.0	"
509	Z(9)	"	0.0	"
510	Z(10)	"	0.0	"
511	Z(11)	"	0.0	"
512	Z(12)	"	20.0	"
513	Z(13)	"	0.0	"
514	Z(14)	"	16.0	"
515	Z(15)	"	0.0	"
516	Z(16)	"	0.0	"
517	Z(17)	"	0.0	"
518	Z(18)	"	0.0	"
519	Z(19)	"	0.0	"
520	Z(20)	"	6.0	"
521	Z(21)	"	16.0	"
522	Z(22)	"	10.0	"
523	Z(23)	"	-3.0	"
524	Z(24)	"	-14.0	"
525	Z(25)	"	0.0	"
526	Z(26)	"	0.0	"
527	Z(27)	"	-14.0	"
528	Z(28)	"	0.0	"
529	Z(29)	"	0.0	"
530	Z(30)	"	0.0	"
531	Z(31)	"	0.0	"
532	Z(32)	"	0.0	"
533	Z(33)	"	0.0	"
534	Z(34)	"	0.0	"
535	Z(35)	"	0.0	"
536	Z(36)	"	0.0	"
537	Z(37)	"	0.0	"
538	Z(38)	"	0.0	"
539	Z(39)	"	0.0	"
540	Z(40)	"	0.0	"
541	WK(1)	Time(Sec), Work(KPM/Min) Steps	0.0	Sec.
542	WK(2)	" "	0.0	KPM/Min
543	WK(3)	" "	8.0	Sec.
544	WK(4)	" "	500.0	KPM/Min.
545	WK(5)	" "	320.0	Sec.
546	WK(6)	" "	0.0	KPM/Min.
547	WK(7)	" "	0.0	Sec.
548	WK(8)	" "	0.0	KPM/Min.
549	WK(9)	" "	0.0	Sec.
550	WK(10)	" "	0.0	KPM/Min.

UNSTRESSED VOLUMES

ELEMENT NO.	MNEMONIC	DEFINITION	CONSTANT OR INITIAL VALUE	UNITS
551	WK(11)	Time(Sec), Work(KPM/Min) Steps	0.0	Sec.
552	WK(12)	" "	0.0	KPM/min
553	WK(13)	" "	0.0	Sec.
554	WK(14)	" "	0.0	KPM/min.
555	WK(15)	" "	0.0	Sec.
556	WK(16)	" "	0.0	KPM/min.
557	WK(17)	" "	0.0	Sec.
558	WK(18)	" "	0.0	KPM/min.
559	WK(19)	" "	0.0	Sec.
560	WK(20)	Finish Time	320.0	Sec.
561	HR	Heart Rate	72.0	Beats/Min
562	SV	Stroke Volume	0.09	Liters
563	CO	Cardiac Output	6.7	Liters/Min
564	RT	Total Peripheral Resistance	Calculated	mmHg/L/Min
565	PEX	Exercise Boolean (Floating)	0.0	
566	W	Work Rate	0.0	KPM/Min
567	PSYS	Systolic Blood Pressure	0.0	mmHg
568	PDYS	Diastolic Blood Pressure	0.0	"
569	FREQ	Respiratory Frequency	8.3	Beats/Min
570	VO2DOT	Oxygen Uptake	Calculated	Liters O_2/Min
571	AVD	Arterio-Venous O_2 Difference	0.055	$\frac{\text{Liters } O_2}{\text{Liters Blood}}$
572	PIAB	Intra-Abdominal Pressure	Calculated	mmHg
573	PITH	Intra-Thoracic Pressure	"	"
574	PMP	Leg Muscle Pump During Exercise	"	"
575	THETA	Body Angle Relative to Horizontal	90.0	Degrees
576	SF	Constriction Strength Factor	1.0	-
577	TTOT	Heart Period	0.833	Sec.
578	TAS	Period of Systole	0.19	Sec.
579	TVS	Period of Diastole	0.36	Sec.
580	C1	Gain Constant	46.0	-
581	C2	Gain Constant	10.0	-
582	GNEW	Gain Constant	-0.005	-
583	PEXIN	Pressure Set Point	88.0	mmHg
584	TR	Respiratory Period	Calculated	sec.
585-600		Not Used		

```
CJOB  XERCIS MODEL WITH DATA INITIALIZATION  8/2/73
      COMMON/STATE/X(50),XDOT(50)
     2/STATE/QRA,QRV,QLA,QLV,QPA,QPC,QPV,QAA,QARC,QLAA,QUTA,QLTA,QUABA,
     3QLABA,QCILL,QLGSA,QLGAR,QLGCAP,QLGVF,QLGSV,QFEV,QABVC,QTHVC,QSPVC,
     4QLOC,QUPC,QHCAP,QHSV,QJV,QCOR,QCSMA,QIMA,QCSMV,QPOV,QIMV,
     5QRENA,QRALE,QRENV,QRET,QD(10),QSKB
     6/STATE/CRA,CRV,CLA,CLV,CPA,CPC,CPV,CAA,CARC,CLAA,CUTA,CLTA,CUABA,
     7CLABA,CCILL,CLGSA,CLGAR,CLGVE,CLGSV,CFEV,CABVC,CTHVC,CSPVC,
     8CLOC,CUPC,CHSV,CJV,CCSMV,CIMV,CPOV,
     9CRENA,CRENV,CD(18)
     A/STATE/PRA,PRV,PLA,PLV,PPA,PPC,PPV,PAA,PARC,PLAA,PUTA,PLTA,PUABA,
     BPLABA,PCILL,PLGSA,PLGAP,PLGVE,PLGSV,PFEV,PABVC,PTHVC,PSPVC,
     CPLOC,PUPC,PHSV,PJV,PCSMV,PIMV,PPOV,
     DPRENA,PRENV,PD(16),PM,PMC
      COMMON/STATE/
     ERRA,RRV,RMV,RAV,RPA,RPC,RPV,RARC,RLAA,RUTA,RLTA,RUABA,
     FRLABA,RCILL,RLGSA,RLGAR,RLGCAP,RLGVE,RLGSV,RFEV,RABVC,
     GRTHVC,RSPVC,RLOC,RUPC,RHCAP,RHSV,RJV,RCOR,RCSMA,RIMA,RCSMV,
     HRPOV,RIMV,RRENA,RRALE,RREFF,RRENV,RD(11),RSKB
     I/STATE/FLPA,FLAA,FLARC,FLLAA,FLUTA,FLLTA,FLUABA,
     JFLLABA,FLCILL,FLCSMA,FLIMA,FLRENA,FLDM(8)
     K/STATE/V(50),VU(50),PG(34),PEXT(32),E(4),SPACE(10)
     L,Z(40),WK(20),HR,SV,CO,RT,PEX,W,PSYS,PDYS,FREQ
     M,V02DOT,AVD,PIAB,PITH,PMP,THETA,SF
     N,TTOT,TAS,TVS,C1,C2,GNEW,PEXIN,TR,DUMMY(16)
      CALL XIO(T)
      DO 10 I=1,32
   10 PG(I)=SIN(THETA/57.2958)*Z(I)*1.05*980./1332.
      CALL CONTRL(T)
      CALL CVS(T)
C     DO 20 I=1,600
C  20 WRITE (108,30) I,X(I)
C  30 FORMAT(5X,1H(,I3,2H)=,F15.7)
    1 CALL ALGO(T)
      IF (T.LT.WK(20)) GO TO 1
      STOP
      END
```

```
      SUBROUTINE CVS(T)
C                CARDIOVASCULAR EXERCISE MODEL
C                R. C. CROSTON (1973 SIMPLIFIED VERSION)
C                          CONTROLLED SYSTEM
      COMMON/STATE/X(50),XDOT(50)
     2/STATE/QRA,QRV,QLA,QLV,QPA,QPC,QPV,QAA,QARC,QLAA,QUTA,QLTA,QUABA,
     3QLABA,QCILL,QLGSA,QLGAR,QLGCAP,QLGVE,QLGSV,QFEV,QABVC,QTHVC,QSPVC,
     4QLOC,QUPC,QHCAP,QHSV,QJV,QCOR,QCSMA,QIMA,QCSMV,QPOV,QIMV,
     5QRENA,QRALE,QRENV,QRET,QD(10),QSKB
     6/STATE/CRA,CRV,CLA,CLV,CPA,CPC,CPV,CAA,CARC,CLAA,CUTA,CLTA,CUABA,
     7CLABA,CCILL,CLGSA,CLGAR,CLGVE,CLGSV,CFEV,CABVC,CTHVC,CSPVC,
     8CLOC,CUPC,CHSV,CJV,CCSMV,CIMV,CPOV,
     9CRENA,CRENV,CD(18)
     A/STATE/PRA,PRV,PLA,PLV,PPA,PPC,PPV,PAA,PARC,PLAA,PUTA,PLTA,PUABA,
     BPLABA,PCILL,PLGSA,PLGAR,PLGVE,PLGSV,PFEV,PABVC,PTHVC,PSPVC,
     CPLOC,PUPC,PHSV,PJV,PCSMV,PIMV,PPOV,
     DPRENA,PRENV,PD(16),PM,PMC
      COMMON/STATE/
     ERRA,RRV,RMV,RAV,RPA,RPC,RPV,RARC,RLAA,RUTA,RLTA,RUABA,
     FRLABA,RCILL,RLGSA,RLGAR,RLGCAP,RLGVE,RLGSV,RFEV,RABVC,
     GRTHVC,RSPVC,RLOC,RUPC,RHCAP,RHSV,RJV,RCOR,RCSMA,RIMA,RCSMV,
     HRPOV,RIMV,RRENA,RRALE,RREFF,RRENV,RD(11),RSKB
     I/STATE/FLPA,FLAA,FLARC,FLLAA,FLUTA,FLLTA,FLUABA,
     JFLLABA,FLCILL,FLCSMA,FLIMA,FLRENA,FLDM(8)
     K/STATE/V(50),VU(50),PG(34),PEXT(32),E(4),SPACE(10)
     L,Z(40),WK(20),HR,SV,CO,RT,PEX,W,PSYS,PDYS,FREQ
     M,VO2DOT,AVD,PIAB,PITH,PMP,THETA,SF
     N,TTOT,TAS,TVS,C1,C2,GNEW,PEXIN,TR,DUMMY(16)
      DIMENSION PRS(1),CMP(32),R50(50),FINR(12)
      EQUIVALENCE (PRS,PRA),(CMP(1),CRA),(R50(1),RRA),(FINR(1),FLPA)
C                T IS ELAPSED TIME
C                TT IS A CLOCK FOR ONE BEAT
      TT=T-TSVE
      IF (TT-TTOT) 1002,1001,1001
 1001 TSVE=T
      IFST=SPACE(1)
      CO=X(33)/TTOT*.06
      X(33)=0.0
      PM=X(10)/TTOT
      X(10)=0.0
      PMC=X(13)/TTOT
      X(13)=0.0
      PD(1)=X(37)/TTOT
      PD(2)=X(38)/TTOT
      X(37)=0.0
      X(38)=0.0
      SV=TTOT/60.*CO
      RT=PM/CO
      DIFF=-V(50)+V(49)
      X(18)=X(18)+DIFF*0.6
      X(19)=X(19)+DIFF*0.4
      PSYS=SYS
      PDYS=DYS
      CALL XIO(T)
  110 CALL CONTRL(T)
      TEMP=TEMP+0.2
```

```
      IF (TEMP-T) 110,111,111
  111 CONTINUE
      SYS=0.0
      DYS=1000.
      TTOT=60./HR
      TAS=0.10+0.09*TTOT
      TVS=0.16+0.20*TTOT
 1002 CONTINUE
      IF(TT-TAS)1,2,2
    1 SAS=SIN(3.1416*TT/TAS)
      E(1)=0.05+0.05*SAS*SF
      E(3)=0.12+0.14*SAS*SF
      RSPVC=(20.+SAS*40.)/1332.
      RTHVC=(10.+SAS*20.)/1332.
      GO TO 3
    2 E(1)=0.05
      E(3)=0.12
      RSPVC=.015015
      RTHVC=.0075075
    3 TV=TT-0.1
      IF(TV.LT.0.0)TV=0.0
      IF(TV-TVS)4,5,5
    4 SVS=SIN(3.1416*TV/TVS)
      E(2)=0.0175+.39*SF*SVS
      E(4)=0.0200+1.50*SF*SVS
      GO TO 6
    5 E(2)=0.0175
      E(4)=0.02
    6 CONTINUE
      DO 11 I=1,4
   11 CMP(I)=1./E(I)
      IF(X(4).LT.0.0)X(4)=0.0
C                COMPUTE VOLUMES
      V(50)=0.0
      DO 55 I=1,32
      V(I)=VU(I)+X(I)
   55 V(50)=V(50)+V(I)
      V(50)=V(50)-V(9)-V(11)-V(13)-V(10)
C                RESPIRATORY PUMPS
      TRSP=TRSP+T-TPS
      IF(TRSP.GT.TR)TRSP=0.0
      TI=TRSP/TR
      PITH=-2.67-19.704*TI+56.409*TI*TI
     ,-53.479*TI*TI*TI+16.602*TI*TI*TI*TI
      IF(THETA.GT.60.)PITH=PITH-1.
      IF(IFST.EQ.1)PITH=-5.
      PIAB=-PITH/2.
      DO 71 I=1,12
   71 PEXT(I)=PITH
      PEXT(22)=PITH
      PEXT(23)=PITH
      DO 72 I=28,32
   72 PEXT(I)=PIAB
      PEXT(14)=PIAB
      PEXT(21)=PIAB
C                MUSCLE PUMP
```

```
      TMP=TMP+T-TPS
      TPS=T
      IF(TMP.GE.1.)TMP=0.
      SMP=SIN(2.*3.1416*TMP)
      PMP=40.*SMP
      IF(SMP.LT.0.0)PMP=0.0
      IF(PEX.LT.1.)PMP=0.0
      IF(IFST.EQ.1)PMP=0.0
      DO 44 I=16,19
   44 PEXT(I)=PMP
C                COMPUTE PRESSURES
      DO 12 I=1,7
   12 PRS(I)=X(I)/CMP(I)+PEXT(I)
      DO 13 I=15,20
   13 PRS(I)=X(I)/CMP(I)+PEXT(I)
      DO 14 I=24,32
   14 PRS(I)=X(I)/CMP(I)+PEXT(I)
      PAA=3.7666-0.10573*V(8)+0.0031933*V(8)*V(8)
      IF(PAA.GT.SYS)SYS=PAA
      IF(PAA.LT.DYS)DYS=PAA
      PLTA=-48.028+0.62018*V(12)+0.00021565*V(12)*V(12)
      PLABA=-11.826+0.002265*V(14)+0.0097734*V(14)*V(14)
      PTHVC=-5.5006+0.1154*V(22)-0.00065873*V(22)*V(22)
     ,+0.000001236*V(22)*V(22)*V(22)
      PABVC=-5.4996+0.082408*V(21)-0.00033598*V(21)*V(21)
     ,+0.0000045026*V(21)*V(21)*V(21)
      PSPVC=-5.4999+0.92409*V(23)-0.042246*V(23)*V(23)
     ,+0.00063485*V(23)*V(23)*V(23)
      QRA=(PRA-PRV)/RRA
C                HEART MODEL
      IF(PRA.LT.PRV)QRA=0.0
      QRV=X(09)/FLPA
      IF(QRV.LT.0.0)QRV=0.0
      XDOT(09)=PRV-PPA-RRV*QRV
      IF(XDOT(09).LT.0.0.AND.QRV.EQ.0.0)XDOT(09)=0.0
      QLA=(PLA-PLV)/RMV
      IF(PLA.LT.PLV)QLA=0.0
      QLV=X(11)/FLAA
      IF(QLV.LT.0.0)QLV=0.0
      XDOT(11)=PLV-PAA+PG(8)-RAV*QLV
      IF(XDOT(11).LT.0.0.AND.QLV.EQ.0.0)XDOT(11)=0.0
C                PULMONARY CIRCULATION
      QPA=(PPA-PPC)/RPA
      QPC=(PPC-PPV)/RPC
      QPV=(PPV-PLA)/RPV
C                ARTERIAL MODEL
      QAA=X(34)/FLLTA
      XDOT(34)=PAA-PLTA+PG(12)-RLTA*QAA
      QLTA=X(35)/FLLABA
      XDOT(35)=PLTA-PLABA+PG(14)-RLABA*QLTA
      QLABA=X(36)/FLCILL
      XDOT(36)=PLABA-PCILL+PG(15)-RCILL*QLABA
C                LEGS
      QCILL=(PCILL-PLGSA)/RLGSA
      QLGSA=(PLGSA-PLGAR)/RLGAR
      QLGCAP=(PLGAR-PLGVE)/RLGCAP
      RLGVE=.075075
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```
      IF(QLGVE.LT.0.0)RLGVE=67.567567
      QLGVE=(PLGVE-PLGSV)/RLGVE
      IF(QLGVE.GT.0.0.AND.PEX.GT.0.0.AND.IFST.EQ.1)QLGVE=1.15*QLGVE
      RLGSV=.075075
      IF(QLGSV.LT.0.0)RLGSV=67.567567
      QLGSV=(PLGSV-PFEV)/RLGSV
      IF(QLGSV.GT.0.0.AND.PEX.GT.0.0.AND.IFST.EQ.1)QLGSV=1.15*QLGSV
C               VENOUS MODEL
      RFEV=.021021
      IF(QFEV.LT.0.0)RFEV=67.567567
      QFEV=(PFEV-PG(20)-PABVC)/RFEV
      QABVC=(PABVC-PG(21)-PTHVC)/RABVC
      QTHVC=(PTHVC-PG(22)-PRA)/RTHVC
      QSPVC=(PSPVC-PG(23)-PRA)/RSPVC
C               HEAD+ARMS
      QLOC=(PAA+PG(24)-PLOC)/RLOC
      QUPC=(PLOC-PUPC)/RUPC
      QHCAP=(PUPC-PHSV)/RHCAP
      QHSV=(PHSV-PJV)/RHSV
      RJV=.004301
      IF(QJV.LT.0.0)RJV=67.567567
      QJV=(PJV-PG(27)-PSPVC)/RJV
C               CORONARY CIRCULATION
      QCOR=(PAA-PRA)/RCOR
C               CONTINUITY FOR VENOUS RETURN
      QRET=QSPVC+QTHVC+QCOR
C               HEPATIC-SPLANCHNIC CIRCULATION
      QCSMA=(PLTA-PCSMV)/RCSMA
      QIMA=(PLTA-PIMV)/RIMA
      QCSMV=(PCSMV-PPOV)/RCSMV
      QPOV=(PPOV-PTHVC)/RPOV
      QIMV=(PIMV-PPOV)/RIMV
C               RENAL CIRCULATION
      QRENA=(PLABA-PRENA)/RRENA
      QRALE=(PRENA-PRENV)/(RRALE+RREFF)
      QRENV=(PRENV-PABVC)/RRENV
C               SKELTON,BONE MARROW,AND OTHER
      QSKB=(PLABA-PABVC)/RSKB
C               STATE VARIABLE DERIVATIVES
      XDOT(1)=QRET-QRA
      XDOT(2)=QRA-QRV
      XDOT(3)=QPV-QLA
      XDOT(4)=QLA-QLV
      XDOT(5)=QRV-QPA
      XDOT(6)=QPA-QPC
      XDOT(7)=QPC-QPV
      XDOT(8)=QLV-QAA-QCOR-QLOC
      XDOT(10)=PAA
      XDOT(12)=QAA-QLTA-QCSMA-QIMA
      XDOT(14)=QLTA-QLABA-QRENA-QSKB
      XDOT(15)=QLABA-QCILL
      XDOT(16)=QCILL-QLGSA
      XDOT(17)=QLGSA-QLGCAP
      XDOT(18)=QLGCAP-QLGVE
      XDOT(19)=QLGVE-QLGSV
      XDOT(20)=QLGSV-QFEV
      XDOT(21)=QFEV-QABVC+QRENV+QSKB
```

```
XDOT(22)=QABVC+QPOV-QTHVC
XDOT(23)=QJV-QSPVC
XDOT(24)=QLOC-QUPC
XDOT(25)=QUPC-QHCAP
XDOT(26)=QHCAP-QHSV
XDOT(27)=QHSV-QJV
XDOT(28)=QCSMA-QCSMV
XDOT(29)=QIMA-QIMV
XDOT(30)=QIMV+QCSMV-QPOV
XDOT(31)=QRENA-QRALE
XDOT(32)=QRALE-QRENV
XDOT(33)=QLV
XDOT(13)=PLOC
XDOT(37)=PPA
XDOT(38)=PPC
RETURN
END
```

```
      SUBROUTINE CONTRL(T)
      COMMON/STATE/X(50),XDOT(50)
     2/STATE/QRA,QRV,QLA,QLV,QPA,QPC,QPV,QAA,QARC,QLAA,QUTA,QLTA,QUABA,
     3QLABA,QCILL,QLGSA,QLGAR,QLGCAP,QLGVE,QLGSV,QFEV,QABVC,QTHVC,QSPVC,
     4QLOC,QUPC,QHCAP,QHSV,QJV,QCOR,QCSMA,QIMA,QCSMV,QPOV,QIMV,
     5QRENA,QRALE,QRENV,QRET,QD(10),QSKB
     6/STATE/CRA,CRV,CLA,CLV,CPA,CPC,CPV,CAA,CARC,CLAA,CUTA,CLTA,CUABA,
     7CLABA,CCILL,CLGSA,CLGAR,CLGVE,CLGSV,CFEV,CABVC,CTHVC,CSPVC,
     8CLOC,CUPC,CHSV,CJV,CCSMV,CIMV,CPOV,
     9CRENA,CRENV,CD(18)
     A/STATE/PRA,PRV,PLA,PLV,PPA,PPC,PPV,PAA,PARC,PLAA,PUTA,PLTA,PUABA,
     BPLABA,PCILL,PLGSA,PLGAR,PLGVE,PLGSV,PFEV,PABVC,PTHVC,PSPVC,
     CPLOC,PUPC,PHSV,PJV,PCSMV,PIMV,PPOV,
     DPRENA,PRENV,PD(16),PM,PMC
      COMMON/STATE/
     ERRA,RRV,RMV,RAV,RPA,RPC,RPV,RARC,RLAA,RUTA,RLTA,RUABA,
     FRLABA,RCILL,RLGSA,RLGAR,RLGCAP,RLGVE,RLGSV,RFEV,RABVC,
     GRTHVC,RSPVC,RLOC,RUPC,RHCAP,RHSV,RJV,RCOR,RCSMA,RIMA,RCSMV,
     HRPOV,RIMV,RRENA,RRALE,RREFF,RRENV,RD(11),RSKB
     I/STATE/FLPA,FLAA,FLARC,FLLAA,FLUTA,FLLTA,FLUABA,
     JFLLABA,FLCILL,FLCSMA,FLIMA,FLRENA,FLDM(8)
     K/STATE/V(50),VU(50),PG(34),PEXT(32),E(4),SPACE(10)
     L,Z(40),WK(20),HR,SV,CO,RT,PEX,W,PSYS,PDYS,FREQ
     M,VO2DOT,AVD,PIAB,PITH,PMP,THETA,SF
     N,TTOT,TAS,TVS,C1,C2,GNEW,PEXIN,TR,DUMMY(16)
      REAL   NUM9DI,NUM9D
      EQUIVALENCE
     2 (ACCMET,X(41)),(XN4,X(43)),(DA,X(44)),(DL,X(45)),
     3(DO2,X(48)),(XN3,X(49))
      DIMENSION AVDTS(50),VO2TS(50)
      DATA DTS/.001/
C           SAVE OLD XDOT(41-49)
      DO 10 I=41,49
   10 SPACE(I-39)=XDOT(I)
C                                     W= WORK RATE KG-M/MIN
      DO 25 I=1,17,2
      IF(T-WK(I)) 26,25,25
   25 W=WK(I+1)
   26 IF(W) 27,27,28
   27 PEX=0.0
      GO TO 29
   28 PEX=1.0
   29 CONTINUE
C                                     OXYGEN REQUIREMENT FUNCTION VO2WDT
      IF(DO2.LT.0.0)DO2=0.0.
      VO2WDT=.00048508I5*W/.25
      PSW=-1.5+DO2
      DT1=DO2
      DT2=(2.*DO2-1.275)/1.15
      DT3=DA+DL
      DTIN=SWIN(PSW,DT1,DT2)
      DT=FCNSW(PEX,DT3,DT3,DTIN)
C                                     ALACTIC OXYGEN DEBT DA
      DAIH=.15*(DT-1.5)+1.5
```

```
      DAI=SWIN(PSW,DO2,DAIH)
      DAO=FCNSW(PEX,0.0,0.0,DAI)
      T8=FCNSW(PEX,0.0,300.,2.)
      XDOT(44)=(DAO-DA)/T8
C                                        LACTIC OXYGEN DEBT DL
      DLIH=.85*(DT-1.5)
      DLI=SWIN(PSW,0.0,DLIH)
      DLO=FCNSW(PEX,0.0,0.0,DLI)
      T7=FCNSW(PEX,0.0,300.,2.)
      XDOT(45)=(DLO-DL)/T7
C                                        ARTERIAL-VENOUS OXYGEN DIFFERENCE AVD
      NUM9DI=.03A*DO2
      CALL DELAY(0.0,.05,NUM9DI,AVDTS,NUM9D,1)
      AVD=X(46)+0.055
      XDOT(46)=(NUM9D-X(46))/5.
      IF(PEX.EQ.0.0)FLAG=0.0
      IF(FLAG.EQ.1.0)GO TO 60
      IF(PEX)60,60,61
   61 ANF=1.0
      TDN=T+20.
      FLAG=1.0
   60 IF(T.GT.TDN)ANF=0.0
      TAN=FCNSW(ANF,3.,36.,3.)
      XDOT(49)=(11.00*ANF-XN3)/TAN
      XDOT(43)=(5.5*PEX-XN4)/6.
      DMMX=2.0
      DM=DO2*25./23.
      IF(PEX.GT.0.0)DTS=DT
      IF(PEX.GT.0.0)DMS=DM
      IF(PEX.LT.1.)DM=DMS/DTS*DT
      CHEMON=DO2/0.8
      IF(CHEMON.GT.0.5)CHEMON=0.5
      FN=2.*XN4+XN3
      IF(FN.GT.11.)FN=11.
      IF(PEX.GT.0.)FNS=FN
      IF(PEX.LT.1.)FN=FNS/DTS*DT
C               CONTROLLED RESISTANCES
      RRALE=(600.+(11020.-5140.)*DL/0.9)/1332.
      RSKB=(6860.+(21900.-6860.)*DL/0.90)/1332.
      RCSMA=(3130.+(8770.-4130.)*(FN/11./2.+DM/DMMX/2.))/1332.
      RHCAP=(4570.+(7690.-6975.)*DM/DMMX)/1332.
      RCOR=(20500.-(20500.-8770.)*DM/DMMX)/1332.
      RLGCAP=(260.-ACCMET*065.+340.-340.*DM/DMMX)/1332.
      RLGARM=(260.-ACCMET*065.+340.-340.*DM/DMMX)/1332.
      RLGARN=-FN*5400./11./1332.
      RLGAR=5400./1332.+RLGARN+RLGARM
C                                        PRESSURE REFERENCE FUNCTION PR
      PRN=90.+C1*DO2+C2*ACCMET
      E3=E2
      E2=E0
      E0=EN
      EN=PRN-PM/2.-PMC/2.+XN3+3.*XN4+FN/2.
      ER=(E3+E2+E0+EN)/4.
      DDP=0.533+(ER*GNEW)
      IF(DDP.LT.0.0)DDP=0.0
      TOT=0.300+DDP
      HR=60./TOT
```

```
C                CONTROLLED COMPLIANCES
      ERC=PRN-PMC
      IF(ERC.LT.0.0)GO TO 7
      IF(ERC.GT.40.)ERC=40.
      CLGVE=3.956*(1.0-0.0167*ERC)
      CLGSV=3.1435*(1.0-0.0167*ERC)
      VU(18)=100.-ERC
      VU(19)=68.-ERC*.68
    7 CONTINUE
      DELTA=0.9*(DO2-0.49)
      IF(DO2.LT.0.6)DELTA=DO2/6.
      SF=0.67+ACCMET/4.+DELTA
C                RESPIRATION
      VO2DOT=AVD*CO
      FREQ=VO2DOT*8.24+5.28
      IF(FREQ.GT.30.)FREQ=30.
      TR=60./FREQ
      XDOT(41)=(VO2DOT-0.38)/300.
      IF(PEX.EQ.0.0)XDOT(41)=-1./300.
      IF(ACCMET.LE.0.0.AND.PEX.EQ.0.0)XDOT(41)=0.0
C                                        OXYGEN DEFICIT FUNCTION DO2
      CALL DELAY(0.0,5,VO2DOT,VO2TS,VO2DD,1)
      XDOT(48)=(-VO2DD+PEX*VO2*DT+0.33)/60.
      IF(DO2.LE.0.0.AND.PEX.EQ.0.0)XDOT(48)=0.0
      DO 31 I=41,49
   31 X(I)=X(I)+0.1*(XDOT(I)+SPACE(I-39))
      RETURN
      END



      SUBROUTINE DELAY(FIC,N,X,TS,XOUT,K)
C                N=NO. OF SECS. DELAY
      DIMENSION TS(100)
      ST=0.2
      M=IFIX(FLOAT(N)/ST)
      IF(K)10,10,20
   20 XOUT=TS(1)
      DO 1 I=1,M
    1 TS(I)=TS(I+1)
      TS(M)=X
      RETURN
   10 DO 2 I=1,M
    2 TS(I)=FIC
      RETURN
      END
```

```
      SUBROUTINE ALGO(T)
C                INTEGRATION ALGORITHM
      COMMON /STATE/ X(50),XDOT(50)
      DIMENSION XDS(50)
      IF(H)1,1,2
    2 DO 3 I=1,NOSV
    3 XDS(I)=XDOT(I)
      T=T+H
      CALL CVS(T)
      DO 4 I=1,NOSV
    4   X(I)=H/2.*(XDOT(I)+XDS(I))+X(I)
   10 RETURN
    1 CONTINUE
      NOSV=38
      H=.0025
      RETURN
      END



      FUNCTION SWIN(X,A,B)
      IF(X) 1,2,2
    1 SWIN=A
      RETURN
    2 SWIN=B
      RETURN
      END



      FUNCTION FCNSW(X,A,B,C)
      IF(X)1,2,3
    1 FCNSW=A
      RETURN
    2 FCNSW=B
      RETURN
    3 FCNSW=C
      RETURN
      END
```

```
      SUBROUTINE XIO(T)
      COMMON/STATE/X(600)
      DATA KY,INIT/1HY,0/
      DATA N2,N3,N4,N5,N6,N7,N8,N9/561,563,562,249,567,568,569,573/
      IF (INIT.GT.0) GO TO 200
      INIT=1
      WRITE (  6,10)
   10 FORMAT('0DO YOU WISH TO CHANGE INITIALIZED DATA" (Y/N)')
      READ (  5,20) K
   20 FORMAT(1A1)
      IF (K.NE.KY) GO TO 60
      WRITE (  6,30)
   30 FORMAT('0PLEASE ENTER INDEX(1-600), VALUE, CR: (I3,E12.6)')
   40 READ (  5,50) I,VALNEW
   50 FORMAT(I3,E12.6)
      IF (I.LT.1 .OR. I.GT.600) GO TO 60
      X(I) = VALNEW
      GO TO 40
   60 WRITE (  6,70)
   70 FORMAT('0DO YOU WISH TO MODIFY THE OUTPUT LIST" (Y/N)')
      READ (  5,20) K
      IF (K.NE.KY) GO TO 200
      WRITE (  6,80)
   80 FORMAT ('0PLEASE ENTER POSITION(2-9), INDEX(1-600), CR: (I2,I4)')
   90 READ (  5,100) IP,I
  100 FORMAT(I2,I4)
      IF (IP.LT.2 .OR. IP.GT.9) GO TO 200
      IF (I.LT.1 .OR. I.GT.600) GO TO 200
      GO TO (90,102,103,104,105,106,107,108,109),IP
  102 N2=I
      GO TO 90
  103 N3=I
      GO TO 90
  104 N4=I
      GO TO 90
  105 N5=I
      GO TO 90
  106 N6=I
      GO TO 90
  107 N7=I
      GO TO 90
  108 N8=I
      GO TO 90
  109 N9=I
      GO TO 90
  200 CONTINUE
      IF (T.LT.290.) RETURN
      WRITE(  6,210)T,X(N2),X(N3),X(N4),X(N5),X(N6),X(N7),X(N8),X(N9)
  210 FORMAT (F7.2,8F8.3)
      RETURN
      END
```

```
      BLOCK DATA
      COMMON/STATE/A(100)
      COMMON/STATE/B(50)
      COMMON/STATE/C(50)
      COMMON/STATE/D(50)
      COMMON/STATE/E(50)
      COMMON/STATE/F(20)
      COMMON/STATE/G(280)
C** STATE
      DATA A/71.88,158.2,29.62,147.6,12.08,16.51,24.97,165.7,0.,0.,          1- 10
     1 0.,202.6,0.,112.5,100.3,101.2,109.3,81.79,61.72,4.982,                11- 20
     2 597.7,348.6,2.587,25.37,25.35,0.,0.,264.4,32.62,127.3,                21- 30
     3 24.31,82.68,8*0.,10*0.,50*0./                                         31-100
C** FLOW
      DATA B/50*0./                                                          101-150
C** COMP
      DATA C/4*0.,1.2,1.7,5.3,7*0.,.8,.8,.3,0.,0.,.2,                        151-170
     1 3*0.,.3996,.3996,5.328,.9058,9.59,1.505,6.047,.2224,2.517,18*0./      171-200
C** PRES
      DATA D/48*0.,90.,90./
C** RES
      DATA E/3*.007508,.008634,.01502,.05255,.015022,3*0.,                   251-260
     1 .024,0.,.024,.024,.03003,4.505,.4505,.07508,.07508,.02102,            261-270
     2.00738,.022996,.04513,.02252,.03378,3.431,.3754,.004302,15.39,2.35     271-280
     3 ,34.5345,.2252,.5255,.3003,.01502,.45045,2.744,.6494,0.,0.,           281-290
     4 9*0.,5.15/                                                            291-300
C** INRT
      DATA F/.0007508,.002881,3*0.,.008638,0.,.008977,.00626,11*0./          301-320
C** MISC
      DATA G/48*0.,5325.,5325.,30.,0.,30.,0.,85.,15.,400.,3*0.,              321-380
     1 4*0.,5.194,30.,30.,100.,68.,40.,                                      381-390
     2 3*0.,50.,50.,500.,28.,451.,80.,375.,                                  391-400
     3 50.,150.,18*0.,34*0.,32*0.,4*0.,10*0.,                                401-500
     4 7*0.,-3.,3*0.,20.,0.,16.,5*0.,6.,16.,10.,-3.,-14.,2*0.,-14.,13*0.,    501-540
     5,0.,0.,8.,600.,320.,14*0.,320.,72.,.09 6.7,5*0.,8.3,0.,                541-570
     6 4*.0550,90.,1.,.833,.19,.36,46.,10.,-.005,88.,17*0./                  571-600
      END
```