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PROGRAM DESCRIPTION GUIDE

A. IDENTIFICATION

Program Name - 41-Node Thermoregulatory Model (Steady State Version)

Programmer and Bioengineer Contact - J. I. Leonard, GE/TSS, Houston

Date of Issue - July 15, 1974

B. GENERAL DESCRIPTION

A mathematical model of the human thermoregulatory system, previously developed (References 1-9), has been further modified (Reference 10) to give it greater user flexibility and to provide a more accurate description of evaporative water losses due to respiration, skin diffusion and sweating. This is a steady state version of the more general transient model (Reference 11) and is capable of giving rapid predictions of the behavior of the human thermostat at equilibrium (i.e., a zero heat storage rate) in response to a wide range of environmental conditions, postures and metabolic expenditures.

The version presented here has been modified to operate in conversational mode using a remote terminal. Values for input parameters are entered prior to execution and the user has the capability of choosing among a large number of variables for output. An emphasis has been placed on printing out those variables directly concerned with evaporative loss rate. An additional flexibility has been incorporated to provide for ease of performing parameter estimation studies. These and other modifications which have been made to the previous steady state version have been documented in Reference 10.

C. USAGE AND RESTRICTIONS

Machine, Operating System, and Compiler Required - Univac 1106, EXEC 8, FORTRAN V

Peripheral Equipment Required - Time-Sharing Terminal

D. PARTICULAR DESCRIPTION

The model in its present form is the result of many years of development, modifications, and revisions by several institutions including the John B. Pierce Foundation, Lockheed Electronics Division, General Electric/Houston, and NASA-JSC. The equations used, their derivations and assumptions can be found in the following documents (listed in chronological order):

- Reference 1 and 2: Descriptive papers by Dr. Stolwijk on the basic formulation of the model. Includes comparison of model behavior with some experimental data.
- Reference 3: A complete computer program documentation of the Lockheed version of the Stolwijk model modified for use with space suits and liquid cooled garments. This version contains improved equations for convection, radiation and evaporation.
- References 4-7: Brief documentations of the General Electric modifications to the Lockheed version. This version excludes all logic and data not pertaining to the shirtsleeve mode. Includes improved equations for the convective heat transfer coefficient and evaporative loss coefficient through clothing. A brief description of the steady state algorithm is found in Reference 7.
- Reference 8 and 9: User's instructions for the General Electric version of both the steady state and transient models for use on the Xerox Sigma 3 and Univac 1110. Includes complete program listings and sample runs.
- Reference 10: Detailed descriptions of modifications to the steady state version. A companion report to the present document. Includes validation of the respiratory and diffusion water loss segments.

A software block diagram of the updated steady state version is given in Figure 1. The transient version is similar with the exclusion of Subroutine CONVRG.

#### E. DESCRIPTION OF INPUT

- 1) The program prompts the user to specify the output lists and values for the input parameters. Sample runs are shown in Appendix 2. The program will first prompt the user to designate the output lists desired. The user can choose from one or more of six output lists (see Section F) and designates the choice by typing a "Y" under the numbers 1, 2, 3, 4, 5, or 6. This prompt occurs only on the first run of a series of runs. If the user wishes to modify the output list after this, the run must be aborted either normally (Section G) or with "@@X TIO" and re-executed with "@XQT".
- 2) The second prompt will be a question asking if a listing of input parameters is desired. User responds "Y" or "N". This list will contain the parameter name, the index number (1-13) and the internally stored value. This prompt only occurs during the first run of a series.

- 3) The third prompt will be instruction to change any of the 20 input parameters. Each parameter is designated by an index number and a variable name as shown in Table I. The pre-set internally stored values are given in parenthesis. Parameters can be modified by typing the index number of the parameter followed by the value. After all changes are made, the user types "-1" and this will be followed by a printout of the first 13 parameters. Parameters 14-20 will not be printed unless one of them has been changed from its internally stored value. This prompt will occur after each run. Any changes in input data will be carried over to subsequent runs automatically.

If certain data is needed frequently to initialize any of the twenty input parameters they can be entered rapidly by placing them in file element "SSDATA" according to the format shown in Appendix 1. The user then simply types "@ADD SSDATA" following the prompt for input data.

- 4) If the model does not converge a message "CONVERGENCE NOT OBTAINED" will be printed. This will occur very infrequently. If it does, refer to Reference 10, Section 3 for instructions to obtain a satisfactory solution.

#### F. DESCRIPTION OF OUTPUT

The user can choose from one or more of six output lists. These are given in Table II where the FORTRAN name for each variable is given in place of a numeric value. Samples of actual runs are given in Appendix 2.

#### G. INTERNAL CHECKS AND EXITS

Program echoes back each input parameter value after it is typed. Program checks for invalid input and prompts user to re-enter the value if format is incorrect. On occasion a "READ ERROR" message will be printed even though data was entered correctly. The user should merely repeat the entry. Entry does not have to conform to numerical order of index number.

Program insures that values for VCAB must be greater than 0.0 and that values of POS are either 1.0, 2.0, or 3.0.

A normal exit is obtained after any run by typing "N" following the question "DO YOU WISH TO START NEW RUN?"

## H. INDEPENDENT SUBROUTINES

All subroutines for this program (including source and relocatable elements) are stored in the file "THERM".

<u>ELEMENT NAME</u>	<u>SUBROUTINE NAME</u>	<u>DESCRIPTION</u>
THERMAL		Main program containing I/O commands
SHIRTS	SHIRT	Calculation of insensible heat losses
MANS	MAN	Thermoregulatory control section, calculation of evaporative water loss, blood flows, heat flows and temperatures
VPPSS	VPPS	Algorithm to compute water vapor pressure from saturation temperature
CONVRG	CONVRG	Convergence algorithm consisting of successive substitution and half-interval methods
SSDATA		Initialization data

## I. COMPUTER PROGRAM LISTING AND EXAMPLE OUTPUT

Appendix 1 - Listing of main program, subroutines and data files

Appendix 2 - Sample runs

FIGURE 1  
SOFTWARE BLOCK DIAGRAM

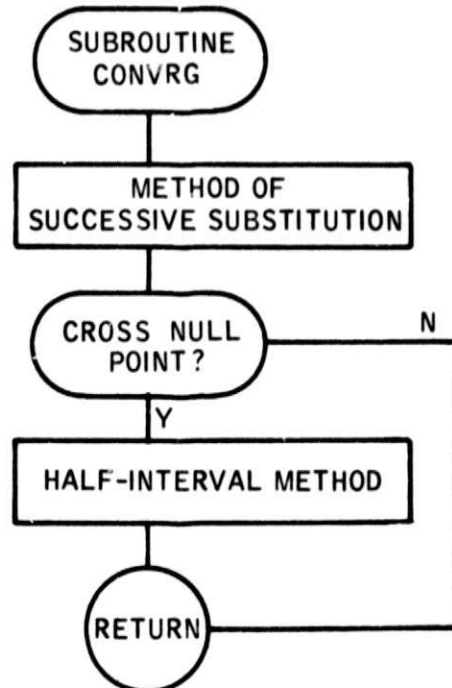
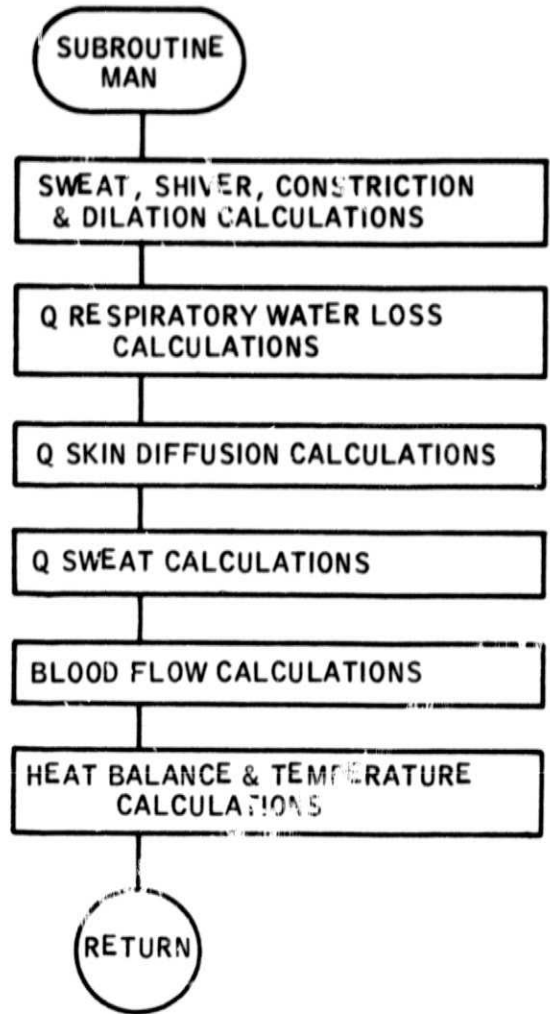
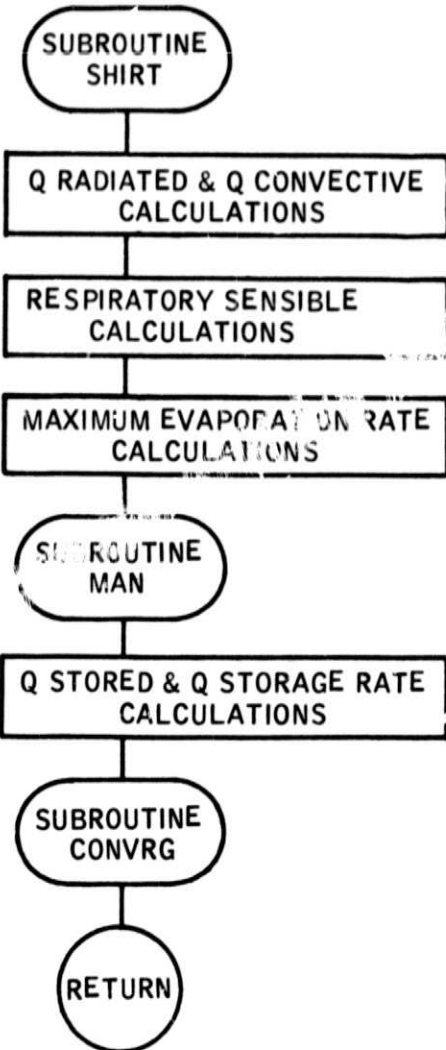
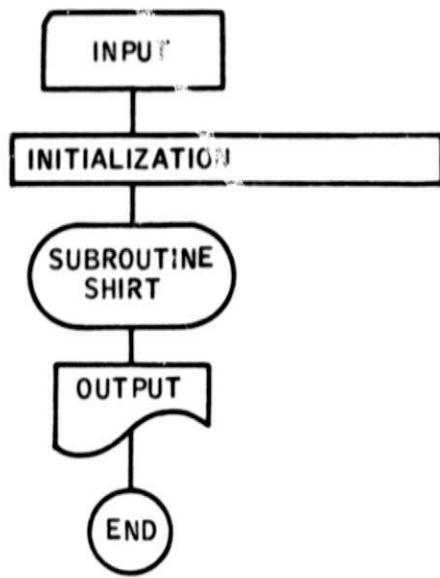


TABLE I  
INPUT PARAMETERS

<u>INDEX NO.</u>	<u>PARAMETER NAME</u>	<u>DESCRIPTION</u>
1	RM	Metabolic rate, BTU/hr
2	QBASAL	Basal metabolic rate, BTU/hr
3	UEFF	Useful work efficiency, percent
4	POS*	*Position of subject (Standing = 1.0, Sitting = 2.0, Prone = 3.0)
5	TCAB	Cabin temperature, °F
6	TW	Temperature of walls, °F
7	TDEWC	Cabin dewpoint temperature, °F
8	VCAB	Cabin Free-stream velocity, ft/min
9	PCAB	Cabin pressure, psi
10	G	Gravity (Earth = 1.0, Moon = .167, Space = 0.0)
11	CLOV	Clothing resistance (clo units)
12	EUG	Emissivity of undergarment
13	CPG	Specific heat of gas, BTU/lb-°F
14	EPSI	**Error criteria for convergence, BTU/hr (0.25)
15	NMAX	**Maximum number of iterations allowed (500)
16	DEBUG	**Switch for debugging routine (Off = 0.0, On = 1.0) (Normally off)
17	R1	**Sweat reabsorption parameter, BTU/hr (0.0)
18	R2	**Multiplier of sweat control parameters (1.0)
19	P1	**Multiplier of convection coefficients (1.0)
20	P2	**Multiplier of radiation coefficient (1.0)

\* The body surface areas for convection and radiation are internally set to the following values according to the input value of POS:

<u>POS</u>	<u>CONVECTIVE AREA(ft<sup>2</sup>)</u>	<u>RADIATIVE AREA(ft<sup>2</sup>)</u>
1.0	19.5	15.5
2.0	15.5	11.5
3.0	12.5	9.5

\*\* Normal values for these parameters are given in parenthesis. Printout of these parameters occurs only when their values are changed from normal

## OUTPUT LISTS

EVAPORATIVE LOSS RATE AT STEADY STATE  
(GMS/HR)

LIST #1	}	RESPIRATION:	WRESP.					
		SKIN DIFFUSION:	WDIFF	DIFF MAX:	DMAX			
		SWEAT:	WSWEAT					
		TOTAL INSENSIBLE LOSS:	WINSEN					
		TOTAL SKIN LOSS:	WSKIN	SKIN EVAP. MAX:	EMAXTL			
		TOTAL EVAP. LOSS:	WEVAP					
		WETTED AREA(%) FOR						
		SKIN DIFF:	DIFWET					
		SWEAT:	SWIWET					
		SWEAT + DIFF:	WET					
		DRIP:	DRIP					
LIST #2	}	TEMPERATURES - DEG F			BLOOD FLOW - L/MIN			
		HEAD CORE:	T(1)	SKIN:	TSBF			
		TRUNK CORE:	T(5)	MUSCLE:	TMBF			
		CENTRAL BLOOD:	T(41)	TOTAL:	CO			
		AVG MUSCLE:	T(43)					
		AVG SKIN:	T(42)					
LIST #3	}	HEAT BALANCE (BTU/HR)				QSTOR(BTU):	QSTOR	
		QBASAL:	QBASAL	QSENS:	SQUG			
		QWORK:	WORK	QEVAP:	QEVAP			
		QSHIV:	QSHIV	STORAT:	STORAT			
LIST #4	}	CONTROLLER SIGNALS						
		SWEAT:	SWEAT	WARM(1):	WARM(1)			
		QSHIV:	QSHIV	COLD(1):	COLD(1)			
		DILAT:	DILAT	WARMS:	WARMS			
		STRIC:	STRIC	COLDS:	COLDS			
LIST #5	}	BODY SURFACE TEMPERATURES - DEG F						
		SKIN:	HEAD	TRUNK	ARMS	LEGS	HANDS	FEET
			T(4)	T(8)	T(16)	T(20)	T(32)	T(40)
		CLOTHING:	TUG(1)	TUG(2)	TUG(4)	TUG(6)	TUG(8)	TUG(10)
LIST #6	}	HEAT TRANSFER COEFFICIENTS						
		CONDUCTION:						
		TOTAL BODY(BTU/HR):					SQUGW	
		FORCED CONVECTION COEF., HC:					HC	
		NATURAL CONVECTION COEF., HCL:					HCL	
		RADIATION:						
		TOTAL BODY(BTU/HR):					SQUGA	
		RADIATION COEF., HR:					HR	
		MAXIMUM EVAPORATION:						
		TOTAL BODY(BTU/HR):					QMAXTL	
		FORCED CONVECTION COEF., HE:					HE	
		NATURAL CONVECTION COEF., HE1:					HE1	
CLOTHING COEF., HECL:					HECL			
COMBINED COEF., HEVAP:					HEVAP			



TABLE III  
GLOSSARY OF NEW TERMS

The following is a list of definitions of output terms that have been added to the original program. All definitions refer to total body effects rather than individual elements or segments.

CO	= Cardiac output, liters/min = $TBF * 0.454 / 60.0$
DIFWET	= Wetted skin area due to skin diffusion, percent $WDIFF / EMAXTL * 100.$
DMAX	= Maximum rate of water loss allowed for skin diffusion, gm/hr = $0.06 * EMAXTL$
DRIP	= Rate of water secretion due to sweating + diffusion that is greater than the maximum evaporation rate, gm/hr = $(WET / 100.0 - 1.0) * EMAXTL$
EMAXTL	= Maximum evaporation possible from body surface, gm/hr = $GMAXTL * 454.0 / 1040.0$
QMAXTL	= Maximum evaporation possible from body surface, BTU/hr = 10 = $\sum_{I=1} EMAX(I)$
SWTWET	= Wetted skin area due to sweating, percent $WSWEAT / EMAXTL * 100.0$
WDIFF	= Rate of water loss due to skin diffusion, gm/hr = $QD * 454.0 / 1040.0$
WET	= Wetted skin area due to sweating and skin diffusion, percent = $(WDIFF + WSWEAT) / EMAXTL * 100.0$
WEVAP	= Total evaporative loss due to respiration, diffusion and sweating, gm/hr = $WRESP + WDIFF + WSWEAT$
WINSEN	= Total insensible water loss (respiration + diffusion), gm/hr = $WRESP + WDIFF$
WRESP	= Water loss due to respiration, gm/hr = $QR * 454.0 / 1040.0$
WSKIN	= Evaporative loss rate from skin surface, gm/hr = $WDIFF + WSWEAT$
WSWEAT	= Evaporative loss rate due to sweating, gm/hr = $QSWEAT * 454.0 / 1040.0$

REFERENCES

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APPENDIX 1

FORTRAN PROGRAM LISTING OF MAIN PROGRAM  
AND ALL SUBROUTINES

6-G03432\*TPF5,THERMAL

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1  CJOB  41-NODE THERMOREGULATORY STEADY STATE MODEL
2  COMMON T(43),TUG(10),ACE(10),ARE(10),PCAB,TCAB,RM,VPPCAB,
3  *QSHIV,D,LAT,STRIC,TOTL,QLCG,C(41),TSET(43),ERROR(41),
4  *QEVAP,WORK,QBASAL,TBF,QRSTOL,TSBF,TMBF,QDIF(10),QSWEAT,
5  *QRLEON,VRESP,HUMIN,HUMEXP,DEBUG,EPSI,NMAX,
6  *TW,EUG,CLO,CPG,G,SQUG,QSTOR,TUGAV,U,VCAB,STORAT,
7  *EMAX(10),QRSEN1,QRSEN2,QRSEN3,QRSEN5,QRSEN6,
8  *QSEN(10),QRAD(10),HEVAP,HE,HE1,HECL,HR,HC,HCI,
9  *WARMS,COLDS,SWEAT,QR,QD,QMAXTL,HCSAVE,HESAVE,
10 *QVAP1,QVAP2,QVAP,WARM(41),COLD(41),NCOUNT,TOTAL,TSTFP,FLAG,
11 *TN(40),SQUGA,SQUGW,R1,R2,P1,P2
12 DIMENSION PCA(10)
13 NAMELIST/OPTION/DEBUG,EPSI,NMAX
14 NAMELIST/PARAM/R1,R2,P1,P2
15 DATA R1,R2,P1,P2/0,0,1,0,1,0,1,0
16 DATA DEBUG,EPSI,NMAX/0,0,0,25,500
17 DATA PCA/.07,.3602,.06705,.06705,.1587,.1587,.025,.025,2*.0343/
18 DATA TSET/98.53,95.13,94.66,94.24, 98.40,97.30,94.15,92.52,
19 * 95.95,93.42,92.46,91.85, 95.95,93.42,92.46,91.85,
20 * 96.46,95.54,95.56,93.38, 96.46,95.54,95.56,93.38,
21 * 95.74,95.68,95.54,95.40, 95.74,95.68,95.54,95.40,
22 * 95.25,95.05,95.20,95.07, 95.25,95.05,95.20,95.07,
23 * 98.4,0,0,0,0/
24 DATA C/4.89,0.727,0.485,0.529, 26.59,35.57,9.36,2.67,
25 * 1.56,3.35,0.635,0.474, 1.56,3.35,0.635,0.474,
26 * 4.67,10.10,1.58,1.19, 4.67,10.10,1.58,1.19,
27 * 0.154,0.066,0.099,0.187, 0.154,0.066,0.099,0.187,
28 * 0.254,0.0660,0.143,0.243, 0.254,0.0660,0.143,0.243,
29 * 4.96/
30 C
31 C DEFINITION OF BODY SEGMENT TEMPERATURE SUBSCRIPTS
32 C T(1) = HEAD CORE T(2) = HEAD MUSCLE T(3) = HEAD FAT
33 C T(4) = HEAD SKIN T(5) = TRUNK CORE T(6) = TRUNK MUSC
34 C T(7) = TRUNK FAT T(8) = TRUNK SKIN T(9) = RIGHT ARM
35 C T(10) = RIGHT ARM MUSCLE T(11) = RIGHT ARM FAT T(12) = RIGHT ARM
36 C T(13) = LEFT ARM CORE T(14) = LEFT ARM MUSCLE T(15) = LEFT ARM F
37 C T(16) = LEFT ARM SKIN T(17) = RIGHT LEG CORE T(18) = RIGHT LEG
38 C T(19) = RIGHT LEG FAT T(20) = RIGHT LEG SKIN T(21) = LEFT LEG C
39 C T(22) = LEFT LEG MUSCLE T(23) = LEFT LEG FAT T(24) = LEFT LEG S
40 C T(25) = RIGHT HAND CORE T(26) = RIGHT HAND MUSCLE T(27) = RIGHT HAND
41 C T(28) = RIGHT HAND SKIN T(29) = LEFT HAND CORE T(30) = LEFT HAND
42 C T(31) = LEFT HAND FAT T(32) = LEFT HAND SKIN T(33) = RIGHT FOOT
43 C T(34) = RIGHT FOOT MUSCLE T(35) = RIGHT FOOT FAT T(36) = RIGHT FOOT
44 C T(37) = LEFT FOOT CORE T(38) = LEFT FOOT MUSCLE T(39) = LEFT FOOT
45 C T(40) = LEFT FOOT SKIN T(41) = CENTRAL BLOOD T(42) = AVERAGE SK
46 C T(43) = AVERAGE MUSCLE
47 C
48 C
49 DATA RM,QBASAL,UEFF,POS,TCAB,TW,TDEWC,VCAB,
50 *PCAB,G,CLOV,EUG,CPG/
51 *283.00,283.00,22.0,2.0,75.0,75.0,52.0,30.0,
52 *14.7,1.00,0.30,0.95,0.220/
53 DATA KY,KX/IHN,IHY/
54 DATA K1,K2,K3,K4,K5,K6/IHN,IHN,IHN,IHN,IHN,IHN/
55 WRITE (6,40)
56 40 FORMAT (////' 41-NODE THERMOREGULATORY STEADY STATE MODEL'/

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57      * ' REFER TO GE-AGS USER GUIDE TIR 741-MED-4015'//)
58      C.....
59      C
60      C READ INPUT DATA
61      C
62      C.....
63      WRITE(6,45)
64      45 FORMAT(//,'OTO OBTAIN OUTPUT LISTS 1 - 6 WRITE "Y" ',
65      * ' UNDER APPROPRIATE NUMBER, THEN CR'/' 1 2 3 4 5 6 ')
66      GO TO 49
67      48 WRITE(6,92)
68      49 READ(5,50,ERR=48) K1,K2,K3,K4,K5,K6
69      50 FORMAT(6A2)
70      WRITE(6,56)
71      56 FORMAT(//,'ODO YOU WISH A LISTING OF INPUT PARAMETERS?
72      * (Y/N) CR')
73      READ(5,57) KK
74      57 FORMAT(1A3)
75      IF (KK .EQ. KY) GO TO 85
76      WRITE(6,70) RM,QBASAL,UEFF,POS,TCAB,TW,TDEWC+VCAB,
77      * PCAB,G,CLOV,EUG,CPG
78      70 FORMAT(//,'OINPUT PARAMETERS SET TO FOLLOWING VALUES:',//,
79      * '//,'OINDEX', 4X, 'NAME', 5X, 'VALUE'/
80      * ' 1',7X,'RM =',F10.3/' 2',7X,'QBASAL=',F10.3/
81      * ' 3',7X,'UEFF =',F10.3/' 4',7X,'POS =',F10.3,5X,
82      * '/' 5',7X,'TCAB =',F10.3/
83      * ' 6',7X,'TW =',F10.3/' 7',7X,'TDEWC =',F10.3/
84      * ' 8',7X,'VCAB =',F10.3/
85      * ' 9',7X,'PCAB =',F10.3/' 10',6X,'G =',F10.3/
86      * ' 11',6X,'CLOV =',F10.3/' 12',6X,'EUG =',F10.3/
87      * ' 13',6X,'CPG =',F10.3/)
88      85 WRITE(6,90)
89      90 FORMAT('OTO CHANGE INPUT, ENTER INDEX NO.(1-15), VALUE ',
90      * '(12,E15.5)'/,
91      * '.....WHEN LIST IS COMPLETED TYPE "-1", THEN CR.....')
92      GO TO 93
93      89 CONTINUE
94      WRITE(6,95) I,VALNEW
95      95 FORMAT(4X,3H... ,14,F10.4)
96      GO TO 93
97      91 WRITE(6,92)
98      92 FORMAT('...READ ERROR...PLEASE TRY AGAIN...')
99      93 READ(5,94,ERR=91) I,VALNEW
100     94 FORMAT(12,E15.5)
101     IF(I .LT. 0) GO TO 96
102     IF(I .LT. 1 .OR. I .GT. 20) GO TO 91
103     GO TO (1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20), I
104     1 RM = VALNEW
105     GO TO 89
106     2 QBASAL = VALNEW
107     GO TO 89
108     3 UEFF = VALNEW
109     GO TO 89
110     4 POS = VALNEW
111     IF(POS .GT. 3.0 .OR. POS .LT. 1.0) GO TO 91
112     GO TO 89
113     5 TCAB = VALNEW

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114          GO TO 89
115      6 TW = VALNEW
116          GO TO 89
117      7 TDEWC = VALNEW
118          GO TO 89
119      8 VCAB = VALNEW
120          IF(VCAB .EQ. 0.0) GO TO 31
121          GO TO 89
122      31 VCAB = 1.0
123          WRITE(6,32)
124      32 FORMAT('0*****VCAB NOT PERMITTED TO BE ZERO*****')
125          GO TO 89
126      9 PCAB = VALNEW
127          GO TO 89
128     10 G = VALNEW
129          GO TO 89
130     11 CLOV = VALNEW
131          GO TO 89
132     12 EUG = VALNEW
133          GO TO 89
134     13 CPG = VALNEW
135          GO TO 89
136     14 EPSI = VALNEW
137          GO TO 89
138     15 NMAX = VALNEW
139          GO TO 89
140     16 DEBUG = VALNEW
141          GO TO 89
142     17 R1 = VALNEW
143          GO TO 89
144     18 R2 = VALNEW
145          GO TO 89
146     19 P1 = VALNEW
147          GO TO 89
148     20 P2 = VALNEW
149          GO TO 89
150     96 WRITE(6,70)  RM,QBASAL,UFFF,pOS,TCAB,TW,TDEWC,VCAB,
151          *PCAB,G,CLOV,EUG,CPG
152          IF(DEBUG.NE.0.0.OR,EPsi.NE.0.25.OR,NMAX.NE.500)
153          * WRITE(6,OPTION)
154          IF(R1.NE.0.0 .OR. R2.NE.1.0 .OR. P1.NE.1.0 .OR. P2.NE.1.0)
155          * WRITE(6,PARAM)
156          CONTINUE
157      C.....
158      C
159      C  INITIALIZATION
160      C
161      C.....
162          DO 100 I=1,43
163      100 T(I)=TSET(I)
164          DO 110 I=1,10
165          J=4*I
166      110 TUG(I)=T(J)
167          IF(pOS .EQ. 1.0) GO TO 120
168          GO TO 125
169      120 AC = 19.5
170          AR = 15.5

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171          GO TO 150
172 125 IF(POS .EQ. 2.0) GO TO 130
173          GO TO 135
174 130 AC = 15.5
175          AR = 11.5
176          GO TO 150
177 135 IF(POS .EQ. 3.0) GO TO 140
178          WRITE(6,80)
179          80 FORMAT('POSITION PARAMETER ENTERED INCORRECTLY - ABORT RUN')
180          CALL EXIT
181 140 AC = 12.5
182          AR = 9.5
183 150 CONTINUE
184          DO 160 I=1,10
185             J=4*I
186             ACE(I)=PCA(I)*AC
187             ARE(I)=PCA(I)*AR
188 160 CONTINUE
189             U=UEFF/100.*(RM-QBASAL)
190             WORK=RM-QBASAL-U
191             VPPCAB=VPP(TDEWC)
192             CLO = 0.88 * CLOV
193 C.....
194 C
195 C     MAIN LOOP FOR SHIRTSLEEVE CASE
196 C
197 C     CALL SHIRT
198 C
199 C.....
200 C
201 C     COMPUTE EVAPORATIVE LOSSES IN GM/HR AND PREPARE
202 C           FOR OUTPUT
203 C
204 C.....
205 WRESP = QR*454./1040.
206 WDIFF = QD*454./1040.
207 WSWEAT = QSWEAT*454./1040.
208 WINSEN = WRESP + WDIFF
209 WSKIN = WDIFF + WSWEAT
210 WEVAP = WRESP + WDIFF + WSWEAT
211 EMAXTL = QMAXTL*454./1040.
212 DMAX = 0.06*EMAXTL
213 DIFWET = WDIFF/EMAXTL*100.
214 SWTWET = WSWEAT/EMAXTL*100.
215 WET = ((WDIFF + WSWEAT)/EMAXTL)*100.
216 DRIP = (WET/100. - 1.0)*EMAXTL
217 IF(DRIP .LT. 0.0) DRIP = 0.0
218 IF(SWEAT .NE. 0.0) PHI = SWTWET/SWEAT
219 IF(SWEAT .EQ. 0.00) PHI = 1.0E+05
220 CO = TBF*0.454/60.
221 TSBF = TSBF*0.454/60.
222 IMBF = IMBF*0.454/60.
223 IF(K1 .NE. KX) GO TO 325
224 WRITE(6,310)
225 310 FORMAT('///.17X,'EVAPORATIVE LOSS RATE AT STEADY STATE',/
226          '03X,'(GMS/HR)')
227 WRITE(6,320) WRESP,WDIFF,DMAX,WSWEAT,WINSEN,WSKIN,

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228      *EMAXTL,WEVAP,DIFWET,SWTWET,WET,DRIP,PHI
229      320 FORMAT(/,12X,'RESPIRATION:',F10.2/9X,
230      *'SKIN DIFFUSION:',F10.2,10X,'DIFF MAX:',F8.2/
231      *18X,'SWEAT:',F10.2//2X,'TOTAL INSENSIBLE LOSS:',F10.2/
232      *8X,'TOTAL SKIN LOSS:',F10.2,4X,'SKIN EVAP. MAX:',
233      *F8.2/7X,'TOTAL EVAP. LOSS:',F10.2//5X,'WETTED AREA(S) FOR',/
234      *14X,'SKIN DIFF:',F10.2/18X,'SWEAT:',F10.2/11X,'SWEAT +',
235      *' DIFF:',F10.2//19X,'DRIP:',F10.2,5X,'WETNESS/DRIVE:',F8.4)
236      325 CONTINUE
237      IF(K2 .NE. KX) GO TO 335
238      WRITE(6,330) T(1),TSBF,T(5),TMBF,T(41),CO,T(43),T(42)
239      330 FORMAT(/,7X,'TEMPERATURES = DEG F',8X,'BLOOD FLOW = L/MIN',
240      *5X,'HEAD CORE:',5X,F7.2,10X,'SKIN:',5X,F6.2//4X,'TRUNK CORE:',
241      *5X,F7.2,8X,'MUSCLE:',5X,F6.2/' CENTRAL BLOOD:',5X,F7.2,9X,
242      *'TOTAL:',5X,F6.2/4X,'AVG MUSCLE:',5X,F7.2/6X,'AVG SKIN:',5X,F7.2)
243      335 CONTINUE
244      IF(K3 .NE. KX) GO TO 345
245      WRITE(6,340) QBASAL,SQUG,QSTOR,WORK,Q VAP,QSHIV,STORAT
246      340 FORMAT(/,22X,'HEAT BALANCE (BTU/HR)'/5X,'QBASAL:',F8.2,
247      *6X,'QSENS:',F8.2,5X,'QSTOR(BTU)':F8.2/6X,'QWORK:',
248      *F8.2,6X,'QEVAP:',F8.2/6X,'QSHIV:',F8.2,5X,'STORAT:',F8.2)
249      345 CONTINUE
250      IF(K4 .NE. KX) GO TO 355
251      WRITE(6,350) SWEAT,WARM(1),QSHIV,COLD(1),DILAT,
252      * WARMS,STRIC,COLDS
253      350 FORMAT(/,23X,'CONTROLLER SIGNALS'/10X,'SWEAT:',F9.2,12X,
254      *'WARM(1)':F9.2/10X,'QSHIV:',F9.2,12X,'COLD(1)':,
255      *F9.2/10X,'DILAT:',F9.2,14X,'WARMS:',F9.2/10X,
256      *'STRIC:',F9.2,14X,'COLDS:',F9.2)
257      355 CONTINUE
258      IF(K5 .NE. KX) GO TO 365
259      WRITE(6,360) T(4),T(8),T(12),T(24),T(32),T(40),
260      *TUG(1),TUG(2),TUG(4),TUG(6),TUG(8),TUG(10)
261      360 FORMAT(/,17X,'BODY SURFACE TEMPERATURES = DEG F',/
262      *12X,'HEAD',5X,'TRUNK',5X,'ARMS',4X,'LEGS',5X,
263      *'HANDS',4X,'FEET'/5X,'SKIN:',F7.2,5F9.2//
264      *' CLOTHING:',F7.2,5F9.2)
265      365 CONTINUE
266      IF(K6 .NE. KX) GO TO 375
267      WRITE(6,370) SQUGA,HCSAVE,HCI,SQUGW,HR,QMAXTL,HESAVE,HEI,
268      *HECL,HEVAP
269      370 FORMAT(/,20X,'HEAT TRANSFER COEFFICIENTS'/10X,'CONDUCTION:'/
270      *13X,'TOTAL BODY(BTU/HR)':,11X,F7.2/13X,'FORCED ',
271      *'CONVECTION COEF.,HC:',13X,F7.2/13X,'NATURAL CONVECTION'
272      *' COEF.,HCL:',1X,F7.2//10X,'RADIATION:'/13X,
273      *'TOTAL BODY(BTU/HR)':,11X,F7.2/13X,'RADIATION COEF.,'
274      *'HR:',11X,F7.2//10X,'MAXIMUM EVAPORATION:'/13X,
275      *'TOTAL BODY(BTU/HR)':,11X,F7.2/13X,'FORCED CONVECTION ',
276      *' COEF,HE:',3X,F7.2/13X,'NATURAL CONVECTION COEF.,HEI:',
277      *1X,F7.2/13X,'CLOTHING COEF.,HECL:',10X,F7.2/
278      *13X,'COMBINED COEF.,HEVAP:',9X,F7.2)
279      375 CONTINUE
280      WRITE(6,300)
281      300 FORMAT(////,'ODO YOU WISH TO START NEW RUN? (Y/N) (CR)')
282      READ(5,57) KKK
283      IF(KKK .NE. KY) GO TO 85
284      CALL EXIT
285      END

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03432\*TPFS,SHIRTS

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1      SUBROUTINE SHIRT
2      COMMON T(43),TUG(10),ACE(10),ARE(10),PCAB,TCAB,RM,VPPCAB,
3      •QSHIV,DILAT,STRIC,TOTL,QLCG,C(41),TSET(43),ERROR(41),
4      •QEVAP,WORK,QBASAL,TBF,QRSTOL,TSBF,TM6F,QDIF(10),QSWEAT,
5      •QRLEON,VRESP,HUMIN,HUMEXP,DEBUG,EPSI,NMAX,
6      •TW,EUG,CLO,CPG,G,SQUG,QSTOR,TUGAV,U,VCAB,STORAT,
7      •EMAX(10),QRSEN1,QRSEN2,QRSEN3,QRSEN5,QRSEN6,
8      •QSEN(10),QRAD(10),HEVAP,HE,HE1,HECL,HR,HC,HCI,
9      •WARMS,COLDS,SWEAT,QR,QD,QMAXTL,HCSAVE,HESAVE,
10     •QVAP1,QVAP2,QVAP,WARM(41),COLD(41),NCOUNT,TOTAL,TSTEP,FLAG,
11     •TN(40),SQUGA,SQUGW,R1,R2,P1,P2
12     DIMENSION H(10)
13     DATA H/.033,.026,2*.036,2*.033,2*.04,2*.036/
14     FLAG = 0.0
15     NCOUNT=0
16     1 NCOUNT=NCOUNT+1
17     TWR=TW+460.
18     SQUGA=0.0
19     SQUGW=0.
20     C.....
21     C
22     C CALCULATION OF Q-RADIATED(QRAD) AND Q-SENSIBLE(QSEN)
23     C
24     C.....
25     DO 60 I=1,10
26     J=4+I
27     TUGR=TUG(I)+460.
28     HC=H(I)*ACE(I)*SQRT(PCAB*VCAB)*PI
29     HCSAVE = HC
30     HCI=(0.06*ACE(I))*(PCAB**2*G*ABS(TUG(I)-TCAB)**.25)*PI
31     IF( HCI .GT. HC) HC=HCI
32     HR=0.1713E-8*ARE(I)*EUG*(TUGR**3+TUGR*TUGR*TWR+TUGR*TWR*TWR+
33     •TWR**3)*P2
34     IF(CLO .LT. 0.01) GO TO 20
35     IF(I .LT. 2 .OR. I .GT. 6) GO TO 20
36     TUG(I)=(HR*TW+HC*TCAB+ACE(I)/CLO*T(J))/(HR+HC+ACE(I)/CLO)
37     GO TO 40
38     20 TUG(I)=T(J)
39     40 QUGW=HR*(TUG(I)-TW)
40     QUGA=HC*(TUG(I)-TCAB)
41     SQUGW=SQUGW+QUGW
42     SQUGA=SQUGA+QUGA
43     QSEN(I)=QUGA
44     QRAD(I)=QUGW
45     60 CONTINUE
46     C.....
47     C
48     C CALCULATION OF RESPIRATORY SENSIBLE
49     C
50     C.....
51     QRSEN1=0.5*0.041R*PCAB*144.0/(48.3*(TCAB+459.69))*RM*CPG*((0.385*
52     •T(1)+0.086*T(2)+0.0287*T(3)+0.238*T(5)+0.2615*T(6))-TCAB)
53     •(1.0 - 0.33*(14.7 - PCAB))
54     QRSEN2 = 0.172 * QRSEN1
55     QRSEN3 = 0.0574 * QRSEN1
56     QRSEN6 = 0.523 * QRSEN1

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57      QRSENS = 0.476 * QRSEN1
58      QRSEN1 = 0.771 * QRSEN1
59      C
60      C
61      SQUG = SQUGA + SQUGW + QRSEN1 + QRSENS + QRSEN2 + QRSEN3 +
62      .QRSEN6
63      C.....
64      C
65      C      CALCULATE MAXIMUM EVAPORATION RATE
66      C
67      C.....
68      DO 80 I=1,10
69      J=4*I
70      VPTUG=VPP(TUG(I))
71      HE=0.126*ACE(I)*(TCAB+460.)*.04*VEFF/100.*SQRT(VCAB/PCAB)
72      HESAVE = HE
73      HE1=1.32*ACE(I)*(TCAB+460.)/PCAB*(PCAB*G*(ABS(.005*PCAB*(TUG(I)-
74      * TCAB))+1.02*(VPTUG-VPPCAB)))*.25
75      IF(HE1 .GT. HE) HE=HE1
76      IF(I .LT. 2 .OR. I .GT. 6) GO TO 70
77      IF(CLO .LT. .01) GO TO 70
78      HECL=22.36*ACE(I)*(T(J)+460.)*.081/(CLO*PCAB)
79      HEVAP = (HE*HECL)/(HE+HECL)
80      EMAX(I)=HEVAP*(VPP(T(J))-VPPCAB)
81      GO TO 75
82      70 EMAX(I)=HE*(VPP(T(J))-VPDEW)
83      75 IF(EMAX(I) .LT. 0.0) EMAX(I)=0.0
84      80 CONTINUE
85      QMAXTL = 0.0
86      DO 90 I = 1,10
87      QMAXTL = QMAXTL + EMAX(I)
88      90 CONTINUE
89      C-----
90      C
91      CALL MAN
92      C
93      C-----
94      QSTOR=0.
95      DO 100 I=1,41
96      QSTOR=QSTOR+C(I)*(T(I)-TSET(I))
97      100 CONTINUE
98      C.....
99      C
100     C      CRITERIA FOR CONVERGENCE
101     C
102     C.....
103     STORAT = QBASAL + WORK + QSHIV - QEVAP - SQUG
104     IF(DEBUG .EQ. 0.0) GO TO 120
105     WRITE(6,110) NCOUNT, STORAT, T(1)
106     110 FORMAT(14,5X,'STORAT =',F8.2,5X,'T(1) =',F8.4)
107     120 CONTINUE
108     C-----
109     C
110     CALL CONVRG(T,TN,STORAT,NCOUNT,FLAG,EPSI,NMAX)
111     C
112     C-----
113     IF(FLAG .EQ. 0.0) GO TO 1
114     IF(FLAG .EQ. 1.0) GO TO 1
115     IF(FLAG .EQ. 2.0) GO TO 11
116     11 RETURN
117     END

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DB6-G03432\*TPFS.MANS

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1      SUBROUTINE MAN
2      COMMON T(43),TUG(10),ACE(10),ARE(10),PCAB,TCAB,RM,PPCAB,
3      *QSHIV,DILAT,STRIC,TOTL,QLCG,C(41),TSET(43),ERROR(41),
4      *QEVP,WORK,QBASAL,TBF,QRSTOL,TSBF,TMBF,QDIF(10),QSWEAT,
5      *QRLEON,VRESP,HUMIN,HUMEXP,DEBUG,EPSI,NMAX,
6      *TW,EUG,CLO,CPG,G,SQUG,QSTOR,TUGAV,U,VCAB,STORAT,
7      *EMAX(10),QRSEN1,QRSEN2,QRSEN3,QRSEN5,QRSEN6,
8      *QSEN(10),QGRAD(10),HEVAP,HE,HE1,HECL,HR,HC,HCI,
9      *WARM,COLDS,SWEAT,QR,QD,QMAXTL,HCSAVE,MESAVE,
10     *QVAP1,QVAP2,QVAP,WARM(41),COLD(41),NCOUNT,TOTAL,TSTFP,FLAG,
11     *TN(40),SQUGA,SQUGW,R1,R2,P1,P2
12     DIMENSION BF(40),QMET(40),QLAT(10),QSWT(10),WTAREA(10)
13     DIMENSION FACTOR(40)
14     DIMENSION BFB(40),QB(40),WORKM(10),CHILM(10),SKINV(10),SKINC(10),
15     *      SKINS(10),QB1000(40),SKINR(10)
16     DATA CSW,SSW,PSW,CDIL,SDIL,PDIL,CCON,SCON,PCON,CCHIL, SCHIL, PCHIL
17     * /705,0,63.9,0,0,143.,9,20,0,0,2.78,2.78,0,0,0,0,0,25.7/
18     DATA BFB/99.3,0.265,0.287,3.18, 463.0,13.2,5.65,4.63,
19     * 0.925,1.26,0.221,0.550,0.925,1.26,0.221,0.550,
20     * 2.97,3.79,0.575,3.15, 2.97,3.79,0.575,3.15,
21     * 0.111,0.265,0.0442,2.21, 0.111, .265, .0442,2.21,
22     * 0.177, .0221, .055, 3.31, .177, .0221, .055, 3.31/
23     DATA QB1000/172.0,1.34,1.48,1.08, 610.,67.2,28.6,5.37,
24     * 4.70,6.40,1.14,0.875,4.70,6.40,1.14,.875,
25     * 15.0,19.2,2.89,2.15, 15.0,19.2,2.89,2.15,
26     * 0.54,1.34,0.202,0.336, .54,1.34,.202,.336,
27     * .875,.135,.268,.470, .875,.135,.268,.470/
28     DATA WORKM/0.0,0.3,0.04,0.04,0.3,0.3,0.005,0.005,0.005,0.005/
29     DATA CHILM/0.02,0.85,0.025,0.025,0.035,0.035,4*0.0/
30     DATA SKINR/0.0695,0.4935,2*0.0343,2*0.07525,2*0.09225,2*0.0167/
31     DATA SKINV/0.132,0.322,0.0475,0.0475,0.115,0.115,0.061,0.061,
32     * 0.05,0.05/
33     DATA SKINC/0.05,0.15,0.025,0.025,0.025,0.025,0.175,0.175,0.175,
34     * 0.175/
35     DATA SKINS/0.081,0.482,2*0.077,2*0.1095,2*0.0155,2*0.0175/
36     DATA FACTOR/3.04,25.14,30.43,0,0,3.02,10.48,43.67,0,0,
37     * 1.32,9.82,28.89,0,0,1.32,9.82,28.89,0,0,
38     * 9.93,13.68,70.57,0,0,9.93,13.68,70.57,0,0,
39     * 6.07,10.64,10.92,0,0,6.07,10.64,10.92,0,0,
40     * 15.44,19.52,15.55,0,0,15.44,19.52,15.55,0,0/
41     C .....
42     C
43     C SWEAT,SHIVER,CONSTRICTION,DILATION CALCULATIONS
44     C
45     C .....
46     C
47     C ESTABLISH THERMORECEPTOR OUTPUT
48     C
49     DO 80 I=1,40
50     ERROR(I) = T(I) - TSET(I)
51     WARM(I) = 0.0
52     COLD(I) = 0.0
53     IF(ERROR(I)) 20,40,60
54     20 COLD(I) = ERROR(I)
55     40 GO TO 80
56     60 WARM(I) = ERROR(I)

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57      80 CONTINUE
58      C
59      C      INTEGRATE PEIPHERAL AFFRENTS
60      C
61      WARMS = 0.0
62      COLDS = 0.0
63      DO 90 I=1,10
64      K = 4*I
65      WARMS = WARMS + WARM(K)*SKINR(I)
66      COLDS = COLDS + COLD(K)*SKINR(I)
67      90 CONTINUE
68      C
69      C      DETERMINE EFFERENT OUTFLOW
70      C
71      SWEAT=(CSW*ERROR(I)+SSW*(WARMS-COLDS)+PSW*WARM(I)*WARMS)*R2
72      DILAT=CDIL*ERROR(I)+SDIL*(WARMS-COLDS)+PDIL*WARM(I)*WARMS
73      STRIC=-CCON*ERROR(I)-SCON*(WARMS-COLDS)+PCON*COLD(I)*COLDS
74      QSHIV=-CCHIL*ERROR(I)-SCHIL*(WARMS-COLDS)+PCHIL*COLD(I)*COLDS
75      C
76      C      ENSURE EFFERENT COMMANDS ARE POSITIVE
77      C
78      IF(SWEAT) 91,92,92
79      91 SWEAT= 0.0
80      92 IF(DILAT) 93,94,94
81      93 DILAT = 0.0
82      94 IF(STRIC) 95,96,96
83      95 STRIC = 0.0
84      96 IF(QSHIV) 97,98,98
85      97 QSHIV = 0.0
86      98 CONTINUE
87      C.....
88      C
89      C      CALCULATION OF RESPIRATORY EVAPORATIVE LOSS
90      C
91      C.....
92      VPIN = VPPCAB
93      HUMIN = 0.622*VPIN/(PCAB-VPIN)
94      TEXP = 86.9 + 0.066*TCAB + 57.4*HUMIN
95      VPEXP = VPP(TEXP)
96      HUMEXP = 0.622*0.8*VPEXP/(PCAB-0.8*VPEXP)
97      VRESP = (0.0415*PCAB*144.*30.)/(1544.*(TCAB*460.))
98      * (1.0 - 0.000*(14.7 - PCAB))*RM
99      QR = VRESP*(HUMEXP-HUMIN)*1040.
100     QLAT1 = 0.3860*QR
101     QLAT2 = 0.0860*QR
102     QLAT3 = 0.0287*QR
103     QLAT5 = 0.2380*QR
104     QLAT6 = 0.2630*QR
105     C.....
106     C
107     C      CALCULATION OF SWEAT EVAPORATIVE LOSS
108     C
109     C.....
110     QSWEAT = 0.0
111     BULL = 18.0
112     DO 100 I=1,10
113     J=4*I

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114      QSWT(I) = SKINS(I)*(SWEAT*EXP(ERROR(J)/BULL) - RI)*1.0
115      IF(QSWT(I) .LT. 0.0) QSWT(I) = 0.0
116      QSWEAT = QSWEAT + QSWT(I)
117      WTAREA(I) = QSWT(I)/EMAX(I)
118      IF(WTAREA(I) .GT. 1.00) WTAREA(I) = 1.000
119      100 CONTINUE
120      C.....
121      C
122      C      CALCULATION OF SKIN DIFFUSION EVAPORATIVE LOSS
123      C
124      C.....
125      QD = 0.0
126      DO 120 I=1,10
127      QDIF(I) = 2.8*ACE(I)*(VPP(TUG(I))-VPP(CAB)
128      * ((VCAB/PCAB)**0.15)*(1.0 - WTAREA(I))
129      IF(QDIF(I) .GT. 0.06*EMAX(I)) QDIF(I) = 0.06*EMAX(I)
130      QD = QD + QDIF(I)
131      120 CONTINUE
132      C.....
133      C
134      C      CALCULATION OF TOTAL EVAPORATIVE LOSSES
135      C
136      C.....
137      DO 130 I=1,10
138      QLAT(I) = QDIF(I) + QSWT(I)
139      IF(QLAT(I) .GT. EMAX(I)) QLAT(I) = EMAX(I)
140      130 CONTINUE
141      QEVAP = QR + QD + QSWEAT
142      C.....
143      C
144      C      BLOOD FLOW CALCULATIONS
145      C
146      C.....
147      DO 190 I=1,40
148      190 QB(I) = QB1000(I)/1000.0
149      DO 200 I=1,10
150      N=4*I-3
151      BF(N)=BFB(N)
152      QMET(N)=QB(N)*QBASAL
153      QMET(N+1)=QB(N+1)*QBASAL+WORKM(I)*WORK+CHILM(I)*QSHIV
154      BF(N+1)=BFB(N+1)+(QMET(N+1)-QB(N+1)*QBASAL)/1.3
155      QMET(N+2)=QB(N+2)*QBASAL
156      BF(N+2)=BFB(N+2)
157      QMET(N+3)=QB(N+3)*QBASAL
158      BF(N+3)=((BFB(N+3)+SKINV(I)*DILAT)/(1.0+SKINC(I)*STRIC)
159      * EXP(ERROR(N+3)/18.0)*1.0
160      200 CONTINUE
161      TSBF=BF(4)+BF(8)+BF(12)+BF(16)+BF(20)+BF(24)+BF(28)+BF(32)+BF(36)
162      +BF(40)
163      TMBF=BF(2)+BF(6)+BF(10)+BF(14)+BF(18)+BF(22)+BF(26)+BF(30)
164      +BF(34)+BF(38)
165      C-----
166      C      CHECK FOR NEGATIVE BLOOD FLOW
167      C-----
168      DO 220 I=1,40
169      220 IF(BF(I).LT.0.0)BF(I)=0.0
170      C.....

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171 C
172 IF (FLAG .EQ. 1.0) GO TO 350
173 C
174 C CALCULATE NEW TEMPERATURES FROM STEADY STATE HEAT BALANCE
175 C
176 C-----
177 C-----
178 C CALCULATE TEMP OF HEAD CORE,T(1), AND TRUNK CORE,T(5).
179 C-----
180 TN(1)=(QMET(1)-QLAT1-QRSEN1+BF(1)*T(4)+FACTOR(1)*T(2))/
181 * (BF(1)+FACTOR(1))
182 TSTEP=TN(1) - T(1)
183 TN(5)=(QMET(5)-QLAT5-QRSEN5+BF(5)*T(4)+FACTOR(5)*T(6))/
184 * (BF(5)+FACTOR(5))
185 C-----
186 C CALCULATE TEMPERATURES OF REMAINING CORES --ARM(9+13),LEG(17+21),
187 C HAND(25+29),AND FOOT(33+37)
188 C-----
189 DO 260 I=9,37,4
190 TN(I)=(QMET(I)+BF(I)*T(4)+FACTOR(I)*T(I+1))/(BF(I)+FACTOR(I))
191 260 CONTINUE
192 C-----
193 C CALCULATE THE TEMPERATURES OF THE MUSCLE --HEAD(2),TRUNK(6),ARM(10+
194 C 14),LEG(18+22),HAND(26+30),FOOT(34+38)
195 C-----
196 TN(2)=(QMET(2)-QLAT2-QRSEN2+FACTOR(1)*T(1)+FACTOR(2)*T(3)+
197 * BF(2)*T(4))/(BF(2)+FACTOR(1)+FACTOR(2))
198 TN(6)=(QMET(6)-QLAT6-QRSEN6+FACTOR(5)*T(5)+FACTOR(6)*T(7)+
199 * BF(6)*T(4))/(BF(6)+FACTOR(5)+FACTOR(6))
200 DO 280 I=10,38,4
201 TN(I)=(QMET(I)+FACTOR(I-1)*T(I-1)+FACTOR(I)*T(I+1)+
202 * BF(I)*T(4))/(BF(I)+FACTOR(I-1)+FACTOR(I))
203 280 CONTINUE
204 C-----
205 C CALCULATE TEMPERATURES OF THE FAT LAYER --HEAD(3),TRUNK(7),ARM(11+15),
206 C LEG(19+23),HAND(27+31),FOOT(35+39)
207 C-----
208 TN(3)=(QMET(3)-QLAT3-QRSEN3+FACTOR(2)*T(2)+FACTOR(3)*T(4)+
209 * BF(3)*T(4))/(BF(3)+FACTOR(2)+FACTOR(3))
210 DO 300 I=7,39,4
211 TN(I)=(QMET(I)+FACTOR(I-1)*T(I-1)+FACTOR(I)*T(I+1)+
212 * BF(I)*T(4))/(BF(I)+FACTOR(I-1)+FACTOR(I))
213 300 CONTINUE
214 C-----
215 C CALCULATE TEMPERATURES OF THE SKIN --HEAD(4),TRUNK(8),ARM(12+16),
216 C LEG(20+24),HAND(28+32),FOOT(36+40)
217 C-----
218 DO 320 I=4,40,4
219 J=I/4
220 TN(I)=(QMET(I)-QLAT(J)-QRSEN(J)-QGRAD(J)+FACTOR(I-1)*T(I-1)+
221 * BF(I)*T(4))/(BF(I)+FACTOR(I-1))
222 320 CONTINUE
223 C-----
224 C CALCULATE TEMP OF CENTRAL BLOOD --(41)
225 C-----
226 350 SQCONV = 0.0
227 TBF=0.0

```

```
228      DO 340 I=1,40
229      SQCONV=SQCONV+BF(I)*T(I)
230      TBF=TBF+BF(I)
231      340 CONTINUE
232      T(41)=SQCONV/TBF
233      C-----CALCULATE AVERAGE SKIN TEMPERATURE(42) BASED ON PERCENTAGE OF
234      C TOTAL SKIN AREA FOR EACH SKIN NODE * THAT NODES TEMPERATURE
235      C-----
236      T(42)=0.07*T(4)+0.3602*T(8)+0.06705*T(12)+0.06705*T(16)+0.1587*
237      .      T(20)+0.1587*T(24)+0.025*T(28)+0.025*T(32)+0.0343*T(36)+
238      .      0.0343*T(40)
239      T(43)=0.02325*T(2)+0.549*T(6)+0.0527*T(10)+0.0527*T(14)+0.1592*
240      .      T(18)+0.1592*T(22)+0.00115*T(26)+0.00115*T(30)+0.00115*
241      .      T(34)+0.00115*T(38)
242      RETURN
243      END
244
```

```

DB6-G03432*TPFS*CONVRG
1      SUBROUTINE CONVRG(T,TN,STORAT,NCOUNT,FLAG,EPSI,NMAX)
2      DIMENSION TLOW(41),TLOW1(41),TLOW2(41),THIGH(41),THALF(41),
3      *          T(41),TN(40)
4      C.....
5      C
6      C      CONVERGENCE OF THERMAL MODEL TO STEADY STATE
7      C      BY METHOD OF SUCCESSIVE SUBSTITUTION OF TEMP
8      C      FOLLOWED BY HALF-INTERVAL CONVERGENCE METHOD
9      C
10     C          FLAG = 0.0    SUCCESSIVE SUBSTITUTION METHOD
11     C          FLAG = 1.0    HALF-INTERVAL METHOD
12     C          FLAG = 2.0    CONVERGENCE OBTAINED
13     C          RETURN TO MAIN PROGRAM
14     C
15     C.....
16     C
17     C      INITIALIZATION
18     C
19     C          IF(NCOUNT .GT. 1) GO TO 2
20     C          DO 1 I=1,41
21     C          TLOW(I) = 0.0
22     C          TLOW1(I) = 0.0
23     C          TLOW2(I) = 0.0
24     C          THIGH(I) = 0.0
25     C          THALF(I) = 0.0
26     C          1 CONTINUE
27     C          2 IF(ABS(STORAT) .LT. EPSI) GO TO 110
28     C          IF(FLAG .EQ. 1.0) GO TO 75
29     C          IF(NCOUNT .EQ. NMAX) GO TO 100
30     C
31     C      DETERMINE IF NCOUNT IS ODD OR EVEN
32     C      IF NC = 0, NCOUNT IS EVEN
33     C
34     C      NC = (NCOUNT/2)*2 - NCOUNT
35     C
36     C      DETERMINE IF STORAT HAS CHANGED SIGN
37     C
38     C          IF(NCOUNT .EQ. 1) STLOW = 0.0
39     C          IF(STLOW*STORAT .LT. 0.0) GO TO 30
40     C          STLOW = STORAT
41     C
42     C      SAVE PREVIOUS VALUES OF T AND STORAT FOR LAST TWO ITERATIONS
43     C
44     C          IF(NC .EQ. 0) GO TO 10
45     C          DO 5 I=1,41
46     C          5 TLOW1(I) = T(I)
47     C          STLOW1 = STORAT
48     C          GO TO 25
49     C          10 DO 20 I=1,41
50     C          20 TLOW2(I) = T(I)
51     C          STLOW2 = STORAT
52     C          GO TO 25
53     C
54     C      METHOD OF SUCCESSIVE SUBSTITUTION
55     C
56     C          25 DO 28 I=1,40

```



```

57      28 Y(I) = TN(I)
58      GO TO 95
59      C
60      C      INITIALIZATION OF HALF-INTERVAL CONVERGENCE METHOD
61      C
62      30 ICOUNT = 0
63      DO 35 I=1,41
64      35 THIGH(I) = Y(I)
65      IF(NC .EQ. 0) GO TO 45
66      DO 40 I=1,41
67      TLOW(I) = TLOW1(I)
68      STLOW = STLOW1
69      IF(TLOW(I) .NE. 0.0) GO TO 40
70      TLOW(I) = T(I)
71      STLOW = STORAT
72      40 CONTINUE
73      GO TO 55
74      45 DO 50 I=1,41
75      TLOW(I) = TLOW2(I)
76      STLOW = STLOW2
77      IF(TLOW(I) .NE. 0.0) GO TO 50
78      TLOW(I) = TLOW1(I)
79      STLOW = STLOW1
80      50 CONTINUE
81      55 ITER = ALOG(ABS(STLOW-STORAT)/EPSI)/ALOG(2.0) + 3.0
82      C
83      C      HALF-INTERVAL ITERATION
84      C
85      60 ICOUNT = ICOUNT + 1
86      IF(ICOUNT .GT. ITER) GO TO 100
87      DO 65 I=1,41
88      65 THALF(I) = (THIGH(I) + TLOW(I))/2.0
89      DO 70 I=1,41
90      70 Y(I) = THALF(I)
91      GO TO 98
92      75 IF(STLOW*STORAT .LT. 0.0) GO TO 85
93      DO 80 I=1,41
94      80 TLOW(I) = THALF(I)
95      STLOW = STORAT
96      GO TO 60
97      85 DO 90 I=1,41
98      90 THIGH(I) = THALF(I)
99      GO TO 60
100     C
101     C      RETURN COMMANDS
102     C
103     95 FLAG = 0.0
104     RETURN
105     98 FLAG = 1.0
106     RETURN
107     100 FLAG = 2.0
108     WRITE(6,105) NCOUNT, STORAT
109     105 FORMAT('*****CONVERGENCE NOT OBTAINED*****',4X,'NCO,NT =',
110     * 14,4X,'STORAT =',F8.2)
111     RETURN
112     110 FLAG = 2.0
113     WRITE(6,115) NCOUNT, STORAT

```

```

114          115 FORMAT(// '!!!! CONVERGENCE!!!!'      N_COUNT =',
115          *14.4X, 'STORAT =', F6.2)
116          RETURN
117          END

```

-G03432\*TPFS\*VPPS

```

1          FUNCTION VPP(T)
2          C .....
3          C
4          C          FUNCTION TO CALCULATE VAPOR PRESSURE OF WATER AT T
5          C          T=TEMP DEG F
6          C          VPP=VAPOR OF WATER PSIA
7          C
8          C .....
9          X=647.27-(T+460.)/1.8
10         TEMP=X*1.8/(T+460.)*(3.244+5.868E-3*X+1.170E-8*X**3)/(1.+2.188E-3
11         *X)
12         VPP=3207./10.**TEMP
13         RETURN
14         END

```

-G03432\*TPFS\*SSDATA

```

1          1 360.
2          2 283.
3          3 0.0
4          4 2.0
5          5 75.
6          6 75.
7          7 52.
8          8 17.5
9          9 14.7
10         10 1.0
11         11 .9
12         12 .9
13         13 .22

```

## SAMPLE RUN #1

```

>@PREP
FURPUR 0026-07/16-09:24
>@MAP THERM
MAP 0026-07/16-09:25 -(0,)

START=014606, PRDG SIZE(I/D)=6593/3863
SYS$ORLIB$. LEVEL 69
END OF COLLECTION - TIME 4.134 SECONDS
>@XQT

```

41-NODE THERMOREGULATORY STEADY STATE MODEL  
REFER TO SE-AGS USER GUIDE TIR 741-MED-4015

TO OBTAIN OUTPUT LISTS 1 - 6 WRITE "Y" UNDER APPROPRIATE NUMBER, THEN CR

1	2	3	4	5	6
---	---	---	---	---	---

```

>Y Y Y Y Y Y

```

DO YOU WISH A LISTING OF INPUT PARAMETERS? (Y/N) CR

```

>Y

```

INPUT PARAMETERS SET TO FOLLOWING VALUES:

INDEX	NAME	VALUE
1	RM =	283.000
2	QBASAL=	283.000
3	UEFF =	22.000
4	PDS =	2.000
5	TCAB =	75.000
6	TW =	75.000
7	TDEWC =	52.000
8	VCAB =	30.000
9	PCAB =	14.700
10	G =	1.000
11	CLOV =	.300
12	EUG =	.950
13	CPG =	.220

## APPENDIX 2

## SAMPLE RUNS

SAMPLE RUN #1: The following features are illustrated: a) Use of the "@PREP", "@MAP THERM", and "@XGT" commands in order to collect compiled elements and execute prog am, b) Internally stored input parameter values are listed following second prompt, c) The response to change the first and fourth input parameters (note the "READ ERROR" that occurred when a value of 4. was entered which was outside the allowable range), and d) Output lists #1-6 corresponds to those specified following first prompt.

SAMPLE RUN #2: The following features are illustrated: a) Use of the "@ADD SSDATA" command following third prompt to enter a string of data from an external element, b) Input parameters may still be changed after the initial input, and c) Output lists #2 and 4 correspond to those specified following first prompt.

## SAMPLE RUN #1 - continued

TO CHANGE INPUT, ENTER INDEX NO. (1-15); VALUE (I2,E15.5)  
 ◆◆◆WHEN LIST IS COMPLETED TYPE "-1", THEN CR◆◆◆  
 > 1 1200.  
     ◆◆◆ 1 1200.0000  
 > 4 4.  
     ◆◆◆READ ERROR◆◆◆PLEASE TRY AGAIN◆◆◆  
 > 4 1.  
     ◆◆◆ 4 1.0000  
 >-1

INPUT PARAMETERS SET TO FOLLOWING VALUES:

INDEX	NAME	VALUE
1	RM =	1200.000
2	QBASAL =	283.000
3	UEFF =	22.000
4	POS =	1.000
5	TCAB =	75.000
6	TW =	75.000
7	TDEWC =	52.000
8	VCAB =	30.000
9	PCAB =	14.700
10	G =	1.000
11	CLOV =	.300
12	EUG =	.950
13	CPG =	.220

!!!!CONVERGENCE!!!!!! NDCOUNT = 73 STORAT = .24

EVAPORATIVE LOSS RATE AT STEADY STATE  
(GMS/HR)

RESPIRATION:	32.07	
SKIN DIFFUSION:	8.16	DIFF MAX: 31.99
SWEAT:	199.54	
TOTAL INSENSIBLE LOSS:	40.24	
TOTAL SKIN LOSS:	207.70	SKIN EVAP. MAX: 533.20
TOTAL EVAP. LOSS:	239.78	
WETTED AREA(%) FOR:		
SKIN DIFF:	1.53	
SWEAT:	37.42	
SWEAT + DIFF:	38.95	
DRIP:	.00	WETNESS/DRIVE: .0817

## SAMPLE RUN #1 - continued

TEMPERATURES -- DEG F		BLOOD FLOW - L/MIN	
HEAD CORE:	99.07	SKIN:	.90
TRUNK CORE:	99.41	MUSCLE:	4.35
CENTRAL BLOOD:	99.08	TOTAL:	9.62
AVG MUSCLE:	93.76		
AVG SKIN:	99.41		

HEAT BALANCE (BTU/HR)			
QBASAL:	283.00	QSENS:	448.75
QWORK:	715.26	QEVAP:	549.27
QSHIV:	.00	STORAT:	.24
		QSTOR(BTU):	307.48

CONTROLLER SIGNALS			
SWBAT:	457.83	WARM(1):	.54
QSHIV:	.00	COLD(1):	.00
DILAT:	88.34	WARMS:	.70
STRIC:	.00	COLDS:	-.51

BODY SURFACE TEMPERATURES - DEG F						
	HEAD	TRUNK	ARMS	LEGS	HANDS	FEET
SKIN:	94.18	91.50	94.04	94.99	96.83	96.33
CLOTHING:	94.18	87.13	88.44	89.27	96.83	96.33

HEAT TRANSFER COEFFICIENTS	
CONDUCTION:	
TOTAL BODY(BTU/HR):	191.88
FORCED CONVECTION COEF.,HC:	.51
NATURAL CONVECTION COEF.,HC1:	.33
RADIATION:	
TOTAL BODY(BTU/HR):	235.37
RADIATION COEF.,HR:	.56
MAXIMUM EVAPORATION:	
TOTAL BODY(BTU/HR):	1221.42
FORCED CONVECTION COEF.,HE:	.00
NATURAL CONVECTION COEF.,HE1:	77.01
CLOTHING COEF.,HECL:	2978.74
COMBINED COEF.,HEVAP:	293.06

DO YOU WISH TO START NEW RUN? (Y/N) OR  
>N

## SAMPLE RUN #2

41-NODE THERMOREGULATORY STEADY STATE MODEL  
REFER TO GE-AGS USER GUIDE TIR 741-MED-4015

TO OBTAIN OUTPUT LISTS 1 - 6 WRITE "Y" UNDER APPROPRIATE NUMBER, THEN CR  
1 2 3 4 5 6  
>N Y N Y N N

DO YOU WISH A LISTING OF INPUT PARAMETERS? (Y/N) CR

>N  
TO CHANGE INPUT, ENTER INDEX NO. (1-15), VALUE (I2.E15 F)  
◆◆◆WHEN LIST IS COMPLETED TYPE "-1", THEN CR◆◆◆

>@ADD \$SDATA  
◆◆◆ 1 360.0000  
◆◆◆ 2 283.0000  
◆◆◆ 3 .0000  
◆◆◆ 4 2.0000  
◆◆◆ 5 75.0000  
◆◆◆ 6 75.0000  
◆◆◆ 7 52.0000  
◆◆◆ 8 17.5000  
◆◆◆ 9 14.7000  
◆◆◆ 10 1.0000  
◆◆◆ 11 .9000  
◆◆◆ 12 .9000  
◆◆◆ 13 .2200  
> 1 500.  
◆◆◆ 1 500.0000  
> 3 22.  
◆◆◆ 3 22.0000  
>11 0.5  
◆◆◆ 11 .5000  
>-1

## SAMPLE RUN #2 - continued

INPUT PARAMETERS SET TO FOLLOWING VALUES:

INDEX	NAME	VALUE
1	RM =	500.000
2	QBASAL =	283.000
3	UEFF =	22.000
4	PDS =	2.000
5	TCAB =	75.000
6	TW =	75.000
7	TDEWC =	52.000
8	VCAB =	17.500
9	PCAB =	14.700
10	G =	1.000
11	CLOV =	.500
12	EUG =	.900
13	CPG =	.220

!!!!CONVERGENCE!!!! NDCOUNT = 16 STORAT = -.23

TEMPERATURES - DEG F		BLOOD FLOW - L/MIN	
HEAD CORE:	98.59	SKIN:	.38
TRUNK CORE:	98.73	MUSCLE:	1.17
CENTRAL BLOOD:	98.39	TOTAL:	5.92
AVG MUSCLE:	94.66		
AVG SKIN:	98.73		

CONTROLLER SIGNALS			
SWEAT:	127.03	WARM(1):	.06
QSHIV:	.00	COLD(1):	.00
DILAT:	20.90	WARMS:	1.17
STRIC:	.00	COLDS:	-.12

DO YOU WISH TO START NEW RUN? (Y/N) OR  
>N