ENERGY CONSERVATION USING A SOIL HEAT EXCHANGER-STORAGE SYSTEM IN A COMMERCIAL TYPE GREENHOUSE

by

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ABSTRACT

Because of the low thermal mass of a typical commercial greenhouse, the surplus heat captured by a greenhouse during the day is mostly ventilated to the outside, while during the night, auxiliary heat is required to maintain proper air temperature.

The soil within a greenhouse represents an important thermal mass, which is underused. By providing a suitable heat exchange surface, soil can become a relatively low cost storage material. Further, it has been shown that a higher root zone temperature will lead to a beneficial effect with regard to crop yield, while reducing the energy consumption. Therefore, soil heat storage is advantageous for soil grown crops.

A heat exchanger-storage system, using soil as a storage medium, was designed and built in a NORDIC type greenhouse. The greenhouse oriented east-west, is located at the Institut de technologie agro-alimentaire in La Pocatière, Québec, Canada.

The heat exchanger-storage system made of 26 non-perforated, corrugated plastic drainage pipes, 102 mm in diameter, was buried in the soil. Two rows of 13 pipes, 12 m long, were buried at 450 mm and 750 mm respectively. The pipes run parallel to the longitudinal axis of the greenhouse, and are spaced 450 mm apart. A 0.75 kW blower was provided to circulate hot air collected in the greenhouse,

through the pipes at a flowrate of 0.91 m^3/s. The heat stored was recovered both by convection at the soil surface and by forced convection in the exchanger pipes.

The storage has a seasonal temperature fluctuation of 10°C. The system performance seems to be more influenced by greenhouse air temperature than by incident solar radiation. Values for the average coefficient of performance and pipe convective heat transfer coefficient were 3.6 and 12 $W/m^2 \cdot K$ respectively. Approximatly 30 % of the heat recovered from the storage is exchanged by convection at the soil surface. Results indicate that solar energy contributed to 58 % of the heating requirements from February to June and from September to December 1986. This contribution represents 33 % energy conservation. Further, the system seems to have a beneficial effect on crop growth and yield. For two consecutive growing seasons, soil grown tomato plants have produced yields of 25 kg/m^2; by comparison, average yields of 15 kg/m^2 are encountered in commercial greenhouses in Quebec. The payback period for the system is estimated at two years, depending on the cost and crop management practice.

RESUME

La faible masse thermique des serres de type commercial pose un problème de gestion efficace de l'énergie thermique qu'elles consomment. Pendant le jour, les surplus d'énergie solaire enterceptés sont évacués à l'extérieur alors que pendant la nuit, un apport énergétique externe doit être fourni.

Le sol d'une serre constitue une masse thermique importante mais sous utilisée. En augmentant la surface d'échange de chaleur, le sol pourrait constituer un matériau de stockage de chaleur relativement peu coûteux. De plus, il a été démontré qu'en chauffant le sol, il est possible d'augmenter les rendements des plantes cultivées à même le sol tout en diminuant la consommation d'énergie; le stockage de chaleur dans le sol pourrait permettre de profiter de ce double avantage.

Un système combiné d'échange et de stockage de chaleur a été mis en place dans une serre de type "NORDIQUE", orientée est-ouest et construite à l'Institut de technologie agro-alimentaire de La Pocatière. Le système comprend 26 tuyaux de plastique ondulé, non perforé, de 10 cm de diamètre, enfouis à 45 et 75 cm de la surface respectivement; l'espacement latéral est de 45 cm entre les tuyaux. L'air chaud est recueilli au faîte de la serre et est poussé à travers les tuyaux par un ventilateur ayant un débit de 0.91 m^3/s. La chaleur accumulée dans le sol peut être récupérée

par conduction vers la surface et par convection forcée dans les tuyaux.

Des fluctuations saisonnières de l'ordre de 10°C ont été enregistrées au niveau de l'ensemble de la masse thermique. La performance du système semble plus influencée par la température de l'air que par le rayonnement solaire. Le coefficient de performance moyen associé au système et le coefficient moyen d'échange convectif dans l'échangeur ont été respectivement de 3.6 et 12 W/m²K. Environ 30 % de l'énergie est récupérée directement à la surface du sol. Les résultats indiquent que l'énergie solaire a contribué à 58 % des besoins thermiques de la serre de février à juin et de septembre à décembre 1986. L'économie d'énergie réalisée serait de 33 % pour cette même période. De plus, le système pourrait avoir un effet bénéfique sur les rendements des cultures. Des rendements de l'ordre de 25 kg/m^2 ont été obtenus pour une production de tomates effectuée sur deux saisons consécutives; par comparaison, des rendements moyens de 15 kg/m^2 sont obtenus chez les producteurs en serre du Québec. Le délai de récupération de l'investissement pour ce système pourrait être inférieur à deux ans suivant les coûts et le type de régie de production.

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TABLE OF CONTENTS

	PAGE
ABSTRACT	ii
RESUME	iv
ACKNOWLEDGEMENT	vi
LIST OF TABLES	x
LIST OF FIGURES	xi
LIST OF SYMBOLS AND ABREVIATIONS	xiv
CHAPTER I. INTRODUCTION	1
1.1 Problem Description	1
1.2 Objectives	2
1.3 Scope of the Study	3
CHAPTER II. REVIEW OF LITERATURE	4
2.1 Review	4
2.2 Summary	12
CHAPTER III. THEORETICAL CONSIDERATIONS	13
CHAPTER IV. MATERIALS AND METHODS	24
4.1 Experimental Setup	24
4.2 Procedures	36
4.2.1 Soil Physical Properties	36
4.2.2 Air Velocity	36
4.2.3 Overall Heat Exchange Coefficients	39

4.2.3.1 Heat Loss Coefficients............ 39

4.2.3.2 Convective Heat Transfer Coefficient 39

4.2.4 Electrical Energy Used.................... 41

4.2.5 Daily Performance........................ 41

4.2.6 Operating Modes.......................... 43

4.2.6.1 Alternate cycles of active storage and recovery.................... 43

4.2.6.2 Active storage and passive recovery 43

4.2.6.3 Continuous Operation............... 43

4.2.7 Observations on the crops................ 43

4.2.8 Payback Estimation....................... 44

CHAPTER V. RESULTS AND DISCUSSION...................... 49

5.1 Soil Physical properties...................... 49

5.1.1 Soil Texture............................ 49

5.1.2 Soil Wet Bulk Density................... 49

5.1.3 Soil Specific Heat....................... 49

5.1.4 Soil Water Content...................... 52

5.2 Air Velocity................................. 52

5.2.1 Heat Exchanger.......................... 52

5.2.2 Heater Outlets.......................... 52

5.3 Heat Exchange Coefficients................... 56

5.3.1 Greenhouse Heat Loss Coefficients.......... 56

5.3.2 Convective Heat Transfer Coefficient....... 58

5.4 Electrical Energy Used....................... 59

5.5 System Performance........................... 59

5.5.1 Heat Storage and Recovery................ 60

5.5.2 Dehumidification-humidification of the air. 78

5.5.3 Heat Exchanger........................... 80

5.5.4 Greenhouse Energy Consumption............. 90

5.6 Tomato Crop................................... 97

5.7 Payback Period................................ 99

CHAPTER VI. CONCLUSIONS.............................. 101

CHAPTER VII. RECOMMENDATIONS......................... 106

REFERENCES... 107

APPENDICES... 112

A. Linear regression for the estimation of the average air temperature at the heater outlets.......... 113

B. Data and results obtained from a heat loss test... 116

C. Computer program for the calculation of the overall heat loss coefficient......................... 120

D. Daily Results..................................... 122

E. Example of raw, treated and compiled data......... 131

F. Computer Program.................................. 138

LIST OF TABLES

		PAGE
Table 4.1	Experimental greenhouse characteristics.....	25
Table 4.2	Heat exchanger pipe characteristics..........	26
Table 4.3	Data acquisition and control system characteristics..................................	30
Table 4.4	Schedule of events for equipment operation..	43
Table 4.5	Cost estimates for the payback period.......	46
Table 4.6	Payback period scenarios....................	47
Table 5.1	Texture of the soil bottom layer............	50
Table 5.2	Texture of the soil top layer...............	51
Table 5.3	Soil wet bulk density.......................	51
Table 5.4	Soil specific heat..........................	53
Table 5.5	Soil water content..........................	53
Table 5.6	Heat exchanger air velocity and flowrate....	54
Table 5.7	Heater outlets air velocity and flowrate....	54
Table 5.8	Voltage, current and electrical power.......	59
Table 5.9	Fluctuation of the heat storage and recovery parameters..................................	77
Table 5.10	Effect of the temperature differential on the COP and exchanger efficiency............	83
Table 5.11	Payback period estimation...................	100
Appendix		
Table A.1	Air temperatures at the heater outlets......	114
Table A.2	SAS linear regression program for the estimation of the heater outlet mean air temperature.....................................	115
Table A.3	Summarized SAS regression output for the estimation of the heater outlet mean air temperature.....................................	115

LIST OF FIGURES

PAGE

Figure 4.1 Greenhouse heat exchanger-storage system... 27

Figure 4.2 Greenhouse main equipments................. 28

Figure 4.3 Microcomputer system installed in the experimental greenhouse........................ 31

Figure 4.4 Temperature sensors installed in the northeast quadrant of the greenhouse........... 33

Figure 4.5 Temperature sensors installed in the western part of the greenhouse................. 34

Figure 4.6 Analog Device AD-590 temperature sensor.... 35

Figure 4.7 Stratagauge Troxler model no. 3411B....... 37

Figure 4.8 Pitot tube apparatus...................... 38

Figure 4.9 Flowchart for the computation of the overall heat loss coefficient................. 40

Figure 4.10 Flowchart for the computation of the daily performance.............................. 42

Figure 4.11 Layout of tomato plants in the greenhouse.. 48

Figure 5.1 Wind effect on the overall heat loss coefficient.................................. 57

Figure 5.2 Average thermal mass mean temperature fluctuation for the periods of September through November 1985 and 1986, and February through July 1986................. 61

Figure 5.3 Soil daily temperature variation during the storage phase in the spring of 1986........ 62

Figure 5.4 Soil daily temperature variation in the fall of 1985 with passive heat recovery.......... 64

Figure 5.5 Soil longitudinal temperature profile for mid-spring................................. 65

Figure 5.6 Soil longitudinal temperature profile at the beginning of summer........................ 66

Figure 5.7 Soil longitudinal temperature profile during heat recovery in the fall of 1986........... 68

Figure 5.8 Soil longitudinal temperature profile at the end of fall.......... 69

Figure 5.9 Daily variation of the temperature differential between the heat exchanger inlet and outlet.......... 70

Figure 5.10 Air longitudinal temperature profile in the exchanger pipes, after 4 hours of heat storage.......... 72

Figure 5.11 Air longitudinal temperature profile in the exchanger pipes, after 8 hours of heat storage.......... 73

Figure 5.12 Air longitudinal temperature profile in the exchanger pipes after 8 hours of heat recovery.......... 74

Figure 5.13 Soil-air temperature relationship.......... 75

Figure 5.14 Air relative humidity daily variation.......... 79

Figure 5.15 Daily variation of the coefficient of performance.......... 81

Figure 5.16 Effect of the temperature differential between the air at the blower inlet and the soil, on the COP.......... 84

Figure 5.17 Effect of the temperature differential between the soil and the greenhouse air, on the COP.......... 85

Figure 5.18 Effect of the temperature differential between the air at the blower inlet and the soil, on the efficiency.......... 87

Figure 5.19 Effect of the temperature differential between the soil and the greenhouse air on the efficiency.......... 88

Figure 5.20 Ratio of the heat recovered passively to the total heat recovered for the periods of February through July 1986 and September through November 1986.......... 89

Figure 5.21 Variation of the heat exchanger efficiency for the periods of September through November 1985 and 1986, and February through July 1986.......... 91

Figure 5.22 Effect of solar radiation on the solar contribution to the greenhouse heat load....... 92

Figure 5.23 Effect of the greenhouse air temperature on the solar contribution to the greenhouse heat load................................. 94

Figure 5.24 Effect of the soil temperature on the solar contribution to the greenhouse heat load.... 95

Figure 5.25 Variation in the contribution to the greenhouse heat load............................ 96

Figure 5.26 Tomato crop grown in the experimental greenhouse.................................... 98

LIST OF SYMBOLS AND ABREVIATIONS

A : soil surface absorptivity (0.82, Kreith and Kreider, 1978)

AF : greenhouse floor surface area (71.49 m^2)

AG : greenhouse roof and walls surface area (174.25 m^2)

AI : heater air inlet, cross sectionnal area (0.162 m^2)

AHU1 : absolute humidity difference between the air at the exchanger inlet and outlet for the first row of pipes (kg)

AHU2 : absolute humidity difference between the air at the exchanger inlet and outlet for the second row of pipes (kg)

AHUC : absolute humidity difference between the air at the exchanger inlet and outlet cumulated over 24 hours (kg)

AHUI : air absolute humidity at the exchanger inlet (kg vapor/m^3 humid air)

AHUO1 : air absolute humidity at the exchanger outlet for the first pipe row (kg vapor/m^3 humid air)

AHUO2 : air absolute humidity at the exchanger outlet for the second pipe row (kg vapor/m^3 humid air)

ASHRAE : American Society of Heating, Refrigerating and Air-Conditioning Engineers

AT : surface area of a pipe (5.31 m^2)

c : regression constant

CAF : air specific heat (kJ/kg·°C)

CDS_i : dry soil specific heat (kJ/kg·°C) (CDS_1 = 0.7678, CDS_2 = 0.6815)

COP : coefficient of performance

COPM : coefficient of performance (average over 24 hours)

COPR : coefficient of performance for the recovery phase

COPS : coefficient of performance for the storage phase

Cp : fluid specific heat (kJ/kg·°C)
(Cp_s = 1.0465 Cp_v = 1.84)

CPTI : air specific heat at the exchanger inlet (kJ/kg·°C)

CPTO1 : air specific heat at the exchanger outlet for the first row pipes (kJ/kg·°C)

CPTO2 : air specific heat at the exchanger outlet for the second row of pipes (kJ/kg·°C)

CPTM1 : air mean specific heat in the exchanger first row of pipes (kJ/kg·°C)

CPTM2 : air mean specific heat in the exchanger second row of pipes (kJ/kg·°C)

CPVH : specific heat of the evacuated humid air (kJ/kg·°C)

CPVQ : Conseil des productions végétales du Québec

Cs : humid air specific heat (kJ/kg·°C)

CS_i : moist soil specific heat (kJ/kg·°C)

CW : water specific heat (4.179 kJ/kg·°C)

DA : density of humid air in the greenhouse (kg/m^3)

DAF : density of humid air in the heater (kg/m^3)

DAV : density of humid air evacuated (kg/m^3)

DATI : density of humid air at the exchanger inlet (kg/m^3)

DATO1 : density of humid air at the exchanger outlet for the first row of pipes (kg/m^3)

DATO2 : density of humid air at the exchanger outlet for the second row of pipes (kg/m^3)

DATM1 : mean density of humid air in the exchanger first row of pipes (kg/m^3)

DATM2 : density of humid air at the exchanger outlet for the second row of pipes (kg/m^3)

DHU1 : absolute humidity removed from the air in the exchanger first row of pipes (kg)

DHU2 : absolute humidity removed from the air in the exchanger second row of pipes (kg)

DHUC : absolute humidity removed from the air circulated in the exchanger, cumulated over 24 hours (kg)

DIF. : differential

DSS_i : soil layer density (kg/m^3)
DSS_1 = 1340, DSS_2 = 1736

EA : vapor partial pressure (kPa)

ECC : thermal curtain energy conservation factor (0.72)

ERE : heat exchanger efficiency in the recovery mode

EREM : mean heat exchanger efficiency in the recovery mode

ES : saturated vapor pressure (kPa)

ESAF : saturated vapor pressure of the air circulated in the heater (kPa)

ESAV : saturated vapor pressure of the air evacuated (kPa)

ESE : heat exchanger efficiency in the storage mode

ESEM : mean heat exchanger efficiency in the storage mode

ESTI : saturated vapor pressure at the exchanger inlet (kPa)

ESTO1 : saturated vapor pressure at the exchanger outlet for the first row of pipes (kPa)

ESTO2 : saturated vapor pressure at the exchanger outlet for the second row of pipes (kPa)

FF : heater contribution to the greenhouse heat load

FG : top soil surface area (64.4 m^2)

FRT1 : air flowrate in the exchanger first row of pipes (0.454 m^3/s)

FRT2 : air flowrate in the exchanger selond row of pipes (0.464 m^3/s)

FRH : air flowrate in the heater (0.804 m^3/s)

HCE	:	convective heat transfer coefficient at the soil surface (0.0054 $kW/m^2 \cdot °C$)
HCT	:	heat exchanger convective heat transfer coefficient ($kW/m^2 \cdot °C$)
HCTM	:	mean heat exchanger convective heat transfer coefficient ($kW/m^2 \cdot °C$)
HT	:	air enthalpy (kJ/kg)
HTI	:	air enthalpy at the exchanger inlet (kJ/kg)
HTO1	:	air enthalpy at the exchanger outlet for the first row of pipes (kJ/kg)
HTO2	:	air enthalpy at the exchanger outlet for the second row of pipes (kJ/kg)
HU	:	air absolute humidity (kg water vapor/kg dry air)
HUC	:	absolute humidity of the air cumulated over 24 hours (kg water vapor/kg dry air)
HUF	:	absolute humidity of the air circulated through the heater (kg water vapor/kg dry air)
HUV	:	absolute humidity of the air evacuated to the outside (kg water vapor/kg dry air)
HUM1	:	absolute humidity added to the air passing in the exchanger first row of pipes (kg)
HUM2	:	absolute humidity added to the air passing in the exchanger second row of pipes (kg)
HUTI	:	air absolute humidity at the exchanger inlet (kg/kg dry air)
HUTO1	:	air absolute humidity at the exchanger outlet for the first row of pipes (kg/kg dry air)
HUTO2	:	air absolute humidity at the exchanger outlet for the second row of pipes (kg/kg dry air)
IBR	:	current used by the burner (5.9 A)
IC	:	current used by the blower (4.9 A)
ISC	:	solar radiation flux (mW/cm^2)
ISH	:	incident solar radiation (kJ/m^2)

ISHC	:	incident solar radiation cumulated over 24 hours (kJ/m^2)
IV	:	current used by the ventilator in low speed mode (3.2 A)
LF	:	artificial lighting system contribution to the greenhouse heat load
LH	:	water latent heat of vaporization (2501 kJ/kg)
M_{air}	:	mass of air (kg)
MA	:	air molecular weight (0.028966 kg/mole)
MW	:	water molecular weight (0.018016 kg/mole)
P	:	atmospheric pressure (101.325 kPa)
PE	:	greenhouse perimeter (37.2 m)
PF	:	heater power averaged on an hourly basis (kW)
PFM	:	rated heater power (36 kW)
PL	:	artificial lighting system power (1.9 kW)
QAUX	:	auxiliary heat used by the greenhouse (kJ)
QBR	:	electrical energy not used by the burner (kJ)
QBRC	:	electrical energy not used by the burner cumulated over 24 hours (kJ)
QC	:	electrical energy used by the blower (kJ)
QCC	:	electrical energy used by the blower cumulated over 24 hours (kJ)
QCF	:	convective heat transfer at the soil surface (kJ)
QES	:	sensible and latent heat exchanged in the pipes during storage (kJ)
QES1	:	sensible and latent heat exchanged in the first row of pipes during storage (kJ)
QES2	:	sensible and latent heat exchanged in the second row of pipes during storage (kJ)
QEST	:	sensible and latent heat exchanged in both row of pipes during storage (kJ)

QESTC : sensible and latent heat exchanged in the pipes during storage cumulated over 24 hours (kJ)

QET1 : sensible heat exchanged in the first row of pipes (kJ)

QET2 : sensible heat exchanged in the second row of pipes (kJ)

QETR1 : sensible heat recovered from the exchanger first row of pipes (kJ)

QETR2 : sensible heat recovered from the exchanger second row of pipes (kJ)

QETRT : sensible heat recovered from the exchanger (kJ)

QETRTC : sensible heat recovered from the exchanger cumulated over 24 hours (kJ)

QETS1 : sensible heat lost from the air in the exchanger first row of pipes (kJ)

QETS2 : sensible heat lost from the air in the exchanger second row of pipes (kJ)

QETST : sensible heat lost from the air in the exchanger (kJ)

QETSTC : sensible heat lost from the air in the exchanger cumulated over 24 hours (kJ)

QEX : sensible and latent heat exchanged in the pipes (kJ)

QEX1 : sensible and latent heat exchanged in the first row of pipes (kJ)

QEX2 : sensible and latent heat exchanged in the second row of pipes (kJ)

QF : heat supplied by the heater (kJ)

QFC : heat supplied by the heater cumulated over 24 hours (kJ)

QGF : heat gained from the soil by convection at the soil surface (kJ)

QGFC : heat gained from the soil by convection at the soil surface cumulated over 24 hours (kJ)

QGHL : greenhouse structure heat loss (kJ)

QIR : heat gained by the soil from the irrigation water (kJ)

QL : effective heat produced by the artificial lighting system (kJ)

QLE : excess heat produced by the artificial lighting system (kJ)

QLU : usable heat produced by the artificial lighting system (kJ)

QLUC : usable heat produced by the artificial lighting system cumulated over 24 hours (kJ)

QRF : heat recovered by convection at the soil surface (kJ)

QRFC : heat recovered by convection at the soil surface cumulated over 24 hours (kJ)

QRS : direct solar heat gain at the soil surface (kJ)

QRSC : direct solar heat gain at the soil surface cumulated over 24 hours (kJ)

QRT : sensible and latent heat recovered by the air passing in the exchanger pipes (kJ)

QRT1 : sensible and latent heat recovered by the air passing in the exchanger first row of pipes (kJ)

QRT2 : sensible and latent heat recovered by the air passing in the exchanger second row of pipes (kJ)

QRTT : sensible and latent heat recovered by the air passing in both pipe rows of the exchanger (kJ)

QRTTC : sensible and latent heat recovered by the air passing in the exchanger cumulated over 24 hours (kJ)

QSHL : greenhouse soil heat loss to the outside (kJ)

QSS : soil heat exchanged (kJ)

QSS1 : heat exchanged by the soil surface (kJ)

QSS2 : heat exchanged by the soil top layer (kJ)

QSS3 : heat exchanged by the soil bottom layer (kJ)

QSST	:	total heat exchanged by the soil thermal mass (kJ)
QSSTG	:	total heat gain by the soil thermal mass (kJ)
QSSTL	:	total heat lost by the soil thermal mass (kJ)
QTHL	:	greenhouse total heat loss (kJ)
QTHLC	:	greenhouse total heat loss cumulated over 24 hours (kJ)
QV	:	electrical energy not used by the ventilators (kJ)
QVC	:	electrical energy not used by the ventilators cumulated over 24 hours (kJ)
QVHL	:	sensible heat loss by ventilation (kJ)
R	:	universal gas constant (0.008314 kJ/mole·K)
RE	:	heat recovery efficiency
RH	:	air relative humidity (%)
RSR	:	ratio of the heat recovered by convection at the soil surface to the total heat recovered based on sensible heat
SAS	:	Statistical Analysis System
SE	:	heat storage efficiency
SF	:	solar contribution to the greenhouse heat load
SPT	:	static pressure in the exchanger (0.78 kPa)
SS	:	soil surface area (64.4 m^2)
T	:	temperature (°C)
TASD	:	temperature differential between the soil and the air inside the greenhouse (°C)
TB	:	time interval between data reports (s)
TC	:	circulator operating time (s)
TCC	:	cumulated circulator operating time (s)
TCE	:	air temperature at the heater central outlet (°C)
TCSD	:	temperature differential between the air at exchanger inlet and the soil (°C)

TCT	:	thermal curtain operating time (s)
TCTC	:	cumulated thermal curtain operating time (s)
TEMP.	:	temperature (°C)
TF	:	heater operating time (s)
TFC	:	cumulated heater operating time (s)
TFD	:	temperature differential between the heater inlet and outlet (°C)
TFM	:	average temperature between the heater inlet and outlet (°C)
TIM	:	inside daily average temperature (°C)
TIG	:	air inside temperature (°C)
TIH	:	air temperature at the heater inlet (°C)
TIOD	:	temperature differential between the inside and the outside of the greenhouse (°C)
TIOM	:	average temperature between the inside and the outside of the greenhouse (°C)
TL	:	lighting system operating time (s)
TLC	:	cumulated lighting system operating time (s)
TNO	:	temperature at the heater north side outlet (°C)
TOC	:	average temperature at the heater outlet (°C)
TOG	:	outside air temperature (°C)
TOHC	:	corrected air average temperature at the heater outlet (°C)
TOM	:	air daily average temperature outside the green-house (°C)
TOS	:	soil temperature outside the greenhouse (°C)
TOSM	:	mean soil temperature outside the greenhouse (°C)
TP	:	ventilation air inlet operating time (s)
TPC	:	ventilation air inlet cumulated operating time (s)
TS_{if}	:	final temperature of the ith soil layer (°C)

TS_{ii} : initial temperature of the ith soil layer (°C)

TSIC : initial warm soil temperature (25°C)

TSIF : inital cold soil temperature (12°C)

TSF : operating time saved on the heater (s)

TSS : soil temperature inside the greenhouse (°C)

TSS1 : temperature at the soil surface (°C)

TSS2 : temperature of the soil top layer (°C)

TSS3 : temperature of the soil bottom layer (°C)

TSSG : average soil temperature (°C)

TSSGM : daily average soil temperature (°C)

TSU : temperature at the heater south side outlet (°C)

TSV : operating time saved on ventilation (s)

TTD : temperature differential between the air passing through and the exchanger wall (°C)

TV : operating time of the ventilators (s)

TVGC : cumulated operating time of the ventilators in high speed (s)

TVBC : cumulated operating time of the ventilators in low speed (s)

TVH : humidity controled ventilator operating time (s)

TVHC : humidity controled ventilator cumulated operating time (s)

UG : overall heat loss coefficient ($kW/m^2 \cdot °C$)

UGM : mean overall heat loss coefficient ($kW/m^2 \cdot °C$)

UGO : overall heat loss coefficient without wind ($kW/m^2 \cdot °C$)

UGC : overall heat loss coefficient with the thermal curtain ($kW/m^2 \cdot °C$)

UGH : overall heat loss coefficient with hoods on ventilation outlets ($kW/m^2 \cdot °C$)

UGCH	:	overall heat loss coefficient with thermal curtain and hoods ($kW/m^2 \cdot °C$)
USM	:	greenhouse perimeter heat loss coefficient (0.00112 kW/m·°C, Lawand et al., 1985)
V	:	wind speed (km/h)
v	:	air velocity over the soil surface inside the greenhouse (0.045 m/s)
VAH	:	air velocity at the heater inlet (4.96 m/s)
VBR	:	burner supply voltage (120 V)
VC	:	blower supply voltage (240 V)
VG	:	greenhouse volume (242.7 m^3)
VM	:	average wind velocity during a test (km/h)
VS_i	:	soil layer volume (m^3) (VS_0 = 9.88 VS_1 = 19.76, VS_2 = 42.15)
VV	:	ventilators supply voltage (122 V)
WS_i	:	soil water content (kg of water/kg of soil) (WS_1 = 0.2371, WS_2 = 0.0879)
x	:	soil fraction exposed to solar radiation (0.5)

Subscripts:

0	:	at 0°C or at the soil surface	s	:	dry air
1	:	soil top layer	v	:	vapor
2	:	soil bottom layer	W	:	wall
f	:	final			
FL	:	fluid			
i	:	ith layer or initial			
I	:	inlet			
n	:	number of soil layers (2)			
O	:	outlet			

I INTRODUCTION

1.1 Problem Description

The high cost of energy has forced greenhouse owners and researchers to look for more efficient means of production. During the seventies solar energy was seen as a possible alternative for reducing fossil fuel consumption (Short et al., 1976; Maghsood, 1976; Lawand et al., 1974; Ingratta, 1978; Agriculture Canada, 1979; Ingratta, 1979; and others).

Since conventional greenhouses are not efficient in collecting and storing solar energy, attempts were made to optimize the structure for collection and to develop techniques for the storage of the excess solar heat entering a greenhouse (Lawand et al., 1974; Candura et Gusman, 1977; Wilson et al., 1977; Maes, 1978; Baird and Water, 1979). Excessive heat input situation due to the greenhouse effect, are often encountered in a greenhouse during daytime. Ventilation has to be used to evacuate the excess heat and maintain adequate temperatures, while at night, heat has to be supplied to the greenhouse. The storage of excess heat might represent a short term solution for the greenhouse industry's high heating costs, while the development of energy efficient structures might be seen as a long term goal.

Water, crushed stones and phase change materials have been proposed to store solar energy and have been used in experimental setup with limited success (Roberts and Mears, 1977; Staley et al., 1982; Audet and Paris, 1985), mainly due to the high capital cost involved for the storage installation, resulting into long payback periods. Furthermore, water, crushed stones and phase change materials have to be contained and imported into the greenhouse. However, soil a readily available material in greenhouses, is now considered as a possible heat storage media. The thermal properties are interesting and the costs involved are relatively low. The concept has been and is being evaluated in greenhouses located in mild climates (Portales et al., 1982; Staley et al., 1983; and Mori, 1978) and so far the results seem to be promising. Furthermore, the storage of heat in the soil of a greenhouse might have a beneficial effect on crops (Gosselin and Trudel, 1983).

The present study investigates the potential of a wet soil heat exchanger storage system for a commercial type greenhouse, in a cold climatic region.

1.2 Objectives

The objectives of the present study are:

a) To determine the efficiency of a soil heat exchanger storage system for different operating conditions.

b) To establish the contribution of solar energy, artificial lights and auxiliary heater to the total heat load of a commercial type greenhouse equipped with a wet soil heat exchanger-storage system.

c) To observe the impact of the system on tomato crops.

d) To estimate the payback period of the system for different situations.

1.3 Scope of the Study

The results of this study apply to a Nordic type greenhouse manufactured by Les Industries Harnois. The greenhouse is located in La Pocatière, Québec, Canada, at 47°21' north latitude, 70°02' west longitude and 30.5 m of altitude.

From 1951 to 1980 La Pocatière has received an average of 1952 hours of sunshine annually (Services de l'environnement atmosphérique, 1982). Corresponding to approximatly the same period, the average annual number of heating degree-days below 18°C, were 5036 (Services de l'environnement atmosphérique, 1982). The annual mean daily global solar radiation is approximatly 12.5 MJ/m^2 (Phillips, D.W. and D. Aston, 1980).

Care should therefore be taken in applying the results to different greenhouse structures, locations and climates.

II REVIEW OF LITERATURE

2.1 Review

The use of soil as a thermal buffer to cool or warm the air ventilated from agricultural buildings has been investigated over many years.

At the beginning, the attention was focussed on animal housing. Scott, et al. (1965) have studied the thermal and economic potential of a soil heat exchanger, made of buried pipes. These authors mentioned that such a system was first built in 1875; other systems were built thereafter, but the efficiency and the thermal behavior of these heat exchangers were not known or clearly understood. Their study permitted to establish and quantify the heat transfer mechanisms that takes place in the system.

Over the years, the technique has evolved and the Midwest Plan Service (1984) now offers a design guide for soil heat exchanger for energy conservation related to the ventilation of swine housing.

Recently, Puri (1986) has developed a mathematical model to simulate the dynamic response of soil in terms of heat and mass (moisture) transfer, in relation to a soil heat exchanger system. His study has shown that the soil moisture content is not significantly affected by the system; on the other hand, most of the heat transfer takes place over a pipe length equivalent to 50 diameters, and radial heat transfer takes place over a distance equivalent to 4 diameters.

From a general point of view, while Eckert (1976) has shown the potential of using soil as a seasonal heat storage material, Givoni (1977) has outlined the pro's and con's of doing so. Shelton (1975) has pointed out that only a small fraction of heat is lost by conduction from non insulated storage system buried in soil, this seems to favor the use of soil as a storage material. However, water infiltration into the storage due to a high water table can have a disastrous effect on the performance of such a storage system (Paris and Jacqmain, 1983).

The thermal behavior of a seasonal heat storage system made of verticaly buried pipes in soil was studied by Mustacchi et al. (1981). They found that the heat front moved over two meters after six months of storage. However, conclusions drawn on the thermal behavior of seasonal storage system do not necessarily apply to short term storage system.

Sinha et al. (1981) investigated the use of different diameters and types of pipe such as plastic and galvanized steel for soil heat exchanger. It appears that the pipe material has little effect on the heat transfer. This conclusion is very important since pipe material affects directly the cost of the system. The heat exchange was more efficient in a 30 cm diameter pipe than in a 46 cm one, most likely due to the greater turbulence encountered for the same air flowrate. The authors pointed out that heat transfer takes place over a maximum pipe length of 15 m and that pipe spacing should be equivalent to four or five pipe diameters.

Eckoff and Okos (1980) have studied different types of heat storage systems based on crushed stone, phase change material and soil. They concluded that the soil heat storage system is the less efficient, however, it is the most cost effective. Furthermore, it seems that a soil heat storage system is more efficient at low air velocity (3 m/s).

Walker and Buxton (1977) have conducted a theoretical study on the potential use of a soil heat exchanger system for greenhouse application. They concluded that such a system has no potential anywhere in the U.S.A., but the system under investigation has only one 30 m long pipe, buried outside the greenhouse perimeter, having its air intake located outside the greenhouse; therefore, forced convection through that pipe was the only means of exchanging heat with the greenhouse and conduction heat lost by the soil could not be recovered by the greenhouse.

Dale and Hammer (1983) have designed, built and tested a solar greenhouse equipped with a soil thermal storage system within the foundations of the greenhouse, and an external solar collector. The study's most interesting conclusion is that the external solar collector is unnecessary since the greenhouse structure plays that role without additionnal cost.

Richard et al. (1981) have simulated the thermal behavior of a greenhouse equipped with a soil heat exchanger system under the climatic conditions of Nova Scotia. The various test runs indicated a 25 % energy conservation and a payback period of approximatly one year, but the model used was simple, and the various assumptions used are not always encountered in a greenhouse.

Sibley and Raghavan (1984) have developped an empirical equation to determine forced convection heat transfer coefficient within non-perforated, corrugated plastic pipes, for various diameters. The following equation:

$$Nu = 0.230\ Re^{0.56}\ Pr^{0.3} \tag{2.1}$$

is said to be valid for the conditions listed below:

$$\begin{array}{l}
\text{Reynolds number (Re)} > 2300 \\
\text{Prandtl number (Pr)} : 0.71 \\
\text{diameter} \quad \varnothing : 102\ \text{mm} \\
2.2 \le \text{air velocity (m/s)} \le 9.6 \\
2.0 \le \text{wall temperature (°C)} \le 15.0 \\
7.9 \le \text{air inlet temperature (°C)} \le 23.1
\end{array}$$

This relationship seems to be more adequate for design purposes of heat exchanger systems than the ones based on smooth pipes, like for example, the one proposed by Colburn-Reynolds reported by the authors. However, the convective heat transfer coefficient derived from the equation cannot predict the heat transfer when condensation occurs in the pipes; this phenomena is likely to happen with air coming from a greenhouse. Nevertheless, the proposed relationship might be useful as a design tool.

Milburn and Aldrich (1979) have used the coefficient of performance (COP) concept related to heat pumps, in order to evaluate the performance of a heat storage system installed in a greenhouse and using crushed stones. They indicated that the system performance is more dependent on internal air temperature than on intercepted solar radiation. It seems interesting to use the COP concept in order to compare different thermal storage systems or different configurations or operating conditions of a soil heat exchanger-storage system.

By the end of 1981, more than 200 Japaneese greenhouse owners had equipped their greenhouses with soil heat exchanger-storage systems (Takakura et al., 1982). Yamamoto (1973) designed a soil heat exchanger-storage system made of three rows of earthen pipes buried at 64, 100 and 136 cm deep respectively. The spacing between the pipes was 36 cm. The system was capable of maintaining an average temperature of 10°C at night in the greenhouse without auxiliary heat source.

Sasaki and Itagi (1979) have conducted a similar experiment using one and two rows of pipes buried in the soil. The amount of thermal energy provided by the soil heat exchanger-storage system was found to be equivalent to eight times the amount of electrical energy used for its own operation. The results obtained have led the authors to conclude that the system was efficient and cost effective.

Sasaki et al. (1980) have obtained energy conservation factors ranging from 40 to 60 % in a greenhouse equipped with thermal curtain. The same authors (1981) also reported that up to 60 % of the heat exchange was due to latent heat. Therefore, the mass transfer due to humidification and dehumidification, should not be neglected in a thermal balance calculation.

Takakura and Yamakawa (1981) and Takakura et al. (1982) have developed a simplified heat exchange model, in order to simulate the thermal response of soil heat exchanger-storage systems under different operating conditions. Approximatly 20 to 30 % of the heat stored during the day is said to be recovered at the soil surface. Furthermore, the exchanger pipe thickness and the pipe material do not seem to have any significant effect on the exchanger performance; this confirms the conslusions of Sinha et al. (1981). According to this study, the optimum pipe diameter and horizontal/vertical spacing should be of 11 and 40 cm respectively.

The use of soil as a thermal buffer within greenhouses, was also studied in U.S.S.R. (Rabbimov et al., 1971; Vardiashvili and Kim, 1980; and others). Umarov et al. (1981) for example, obtained energy conservation factors ranging from 35 to 55 % depending on sunshine conditions. Since the technique is used in such a northern country effectively, it might be suitable for the Canadian greenhouse industry.

In Prince Edward Island, Caffell and Mackay (1981) have designed a seasonal heat storage system for a greenhouse, using 1080 m^3 of wet soil. No experimental result is reported; but simulations indicated that such a system could not store all the excess heat generated at peek times, unless an intermediate level of storage is provided.

Although the intermediate storage concept might be interesting from a thermal efficiency point of view, this concept might not be cost effective and adds to the complexity of the system.

Inspired by the Japaneese research works, Monk et al. (1983) and Staley et al. (1983) have built in southern B.C., a soil heat exchanger-storage system in a glass covered greenhouse equipped with a thermal curtain. Preliminary results show a 49 % energy conservation between April 23 and June 3. The authors noted that it was not necessary to reverse the air flow direction for heat recovery, since there was little horizontal temperature stratification in the thermal mass. For that same project, French (1987) estimated an overall energy conservation factor ranging from 20 to 25 %, which seems to be satisfactory for the prevaling conditions.

Further, an economic analysis done by Arcus Consulting Ltd. (1985) for Agriculture Canada, comparing different energy conservation techniques including soil heat storage, crushed stones heat storage, internal solar collector and thermal curtains, indicated that soil heat storage seems to be the most cost effective technique having an internal rate of return of 55 % based on an oil heated greenhouse.

Lawand et al. (1983) have studied a similar system in order to produce a design guide. The report includes an extensive literature review covering the theoretical and practical aspects related to soil heat exchanger-storage systems. Tests performed on a small scale experimental setup seem to indicate that the heat transfer rates were similar for either sand or loam. A 40 cm spacing between the pipes is said to be optimum; this confirms the conclusions of studies cited previously.

In their design guide, Lawand et al. (1985) recommend pipe spacing ranging from 40 to 60 cm, and a maximum pipe length of 15 m. An optimum air velocity of 2.0 m/s is suggested by the authors; however, this value has not been verified experimentaly. The system is said to have a dehumidifying effect on the air circulated in the exchanger; condensation rates between 0.256 and 0.383 l/h were obtained under the prevaling conditions of the experiment. The authors mentioned that by draining the condensate into the surrounding soil, heat transfer rates could be increased by 40 to 78 %. However, the use of perforated pipes could be detrimental to the system performance by draining excess irrigation water. Further, the use of perforated pipes could result in soil drying, which can be detrimental to soil grown crops and to heat transfer and storage. The authors acknowledge that further work should be carried out before any recommendations can be provided with regard to condensate disposal. It should also be pointed out that the design guide has not been tested for a commercial type greenhouse application.

2.2 Summary

Much of the review cited previously lead to anticipate that a soil heat exchanger-storage system installed within the perimeter of a greenhouse, can be efficient and cost effective. Studies indicate that the maximum length of such exchanger should range from 10 to 15 m, and that pipe spacing (10 cm in diameter) should be of 40 cm. As far as optimum air velocity is concerned, the studies seem to favor values under 5 m/s, but no precise conclusions are available. The same holds true for air dehumidification. The capacity of such a system to dehumidify air is acknowledged; however, no precise and problem free method for the removal of condensate is recommended. Although a design guide for soil heat exchanger-storage system was produced, no result was obtained from a typical commercial type greenhouse in Canada or in the U.S.A. However preliminary results and simulation studies acknowledge the energy conservation potential of the system.

III THEORETICAL CONSIDERATIONS

The evaluation of the heat exchanger-storage performance and of its impact on the greenhouse thermal energy consumption, was based on energy balance and standard heat transfer equations. In order to simplify the data analysis, the following assumptions were made:

1 - The soil physical properties remain constant for the duration of the study,

2 - Each soil layer is homogeneous,

3 - Only water content can affect the soil thermal properties for the temperature interval involved,

4 - Heat distribution in the soil is symmetrical along a perpendicular to the greenhouse longitudinal axis,

5 - The temperature profile is identical in each pipe.

From an energy balance point of view, the contribution of solar energy to the heat load of a greenhouse, can be calculated by substracting the amount of auxliliary heat used from the overall greenhouse heat requirements; therefore, a solar energy contribution ratio can be defined as:

$$SF = (QTHL - QAUX) / QTHL \qquad (3.1)$$

The total heat loss of the greenhouse should include the aerial, soil and ventilation portions, as indicated by:

$$QTHL = QGHL + QSHL + QVHL \qquad (3.2)$$

To compensate for the heat losses, heat is supplied by one or more of the following sources:

i) solar energy;

ii) auxiliary heat by a heater;

iii) irrigation water;

iv) and artificial lights.

Therefore,

$$QAUX = QF + QIR + QLU \tag{3.3}$$

Among these heat sources, the heat provided by the irrigation water is much smaller compared to the heat provided by the heating (Portugais and Paris, 1983) and artificial lighting systems, and therefore can be neglected.

$$QAUX = QF + QLU \tag{3.4}$$

Similarly, the heater contribution can be defined by:

$$FF = QF / QTHL \tag{3.5}$$

The thermal energy output of a heater can be expressed in terms of its power, therefore:

$$QF = PF \cdot TF \tag{3.6}$$

The average effective power of the heater can be estimated by:

$$PF = DAF \cdot VAH \cdot AI \cdot CAF \cdot (TOC - TIH) \qquad (3.7)$$

re-arranging:

$$QF = DAF \cdot VAH \cdot AI \cdot CAF \cdot (TOC - TIH) \cdot TF \qquad (3.8)$$

For artificial lighting, the contribution to the heat load is defined by:

$$LF = QLU / QTHL \qquad (3.9)$$

The heat released by the lamps can be evaluated by:

$$QL = PL \cdot TL \qquad (3.10)$$

However, when the ventilation is in operation, part of thermal energy released by the lamps is in excess, this excess heat can be estimated by:

$$QLE = PL_{\ell} \cdot TP \qquad (3.11)$$

provided that both the lamps and ventilation are operating simultaneously during the monitoring period. Therefore, the useful energy provided by the lamps is:

$$QLU = QL - QLE \tag{3.12}$$

At night, for steady state conditions, the heat losses of the greenhouse will be equal to the heat provided by the heating system, provided that the average top soil temperature is equal to the air temperature inside the greenhouse, in order to minimize the convective and radiative heat transfer between the soil and the air.

$$QGHL = UG \cdot AG \cdot (TIG - TOG) \cdot TB = PF \cdot TF \tag{3.13}$$

Re-arranging the terms, the greenhouse overall heat loss coefficient for the aerial section can be obtained:

$$UG = \frac{DAF \cdot VAH \cdot AI \cdot CAF \cdot (TOC - TIH) \cdot TF}{AG \cdot (TIG - TOG) \cdot TB} \tag{3.14}$$

if TF = TB, then:

$$UG = \frac{DAF \cdot VAH \cdot AI \cdot CAF \cdot (TOC - TIH)}{AG \cdot (TIG - TOG)} \tag{3.15}$$

It has been shown that the heat loss coefficient is directly proportional to the wind velocity (Sheard, 1978); therefore, the following empirical relationship can be used to evaluate the average overall heat loss coefficient for different wind velocities:

$$UG = UGO + c \cdot V \tag{3.16}$$

The heat losses from the storage can be evaluated using a relationship outlined in ASHRAE (1968):

$$QSHL = USM \cdot PE \cdot (TSSG - TOG) \cdot TB \tag{3.17}$$

If the soil within the greenhouse is divided into n elemental volumes the amount of heat stored in the soil can be expressed by:

$$QSS = \Sigma_{i=1}^{n} VS_i \cdot DSS_i \cdot CS_i \cdot (TS_{if} - TS_{ii}) \tag{3.18}$$

where the specific heat of each soil elemental volume is estimated from Munn (1966):

$$CS_i = CW \cdot WS_i + CDS_i \cdot (1 - WS_i) \tag{3.19}$$

Part of the heat stored is gained through a buried pipe heat exchanger, in which air is circulated; the amount of heat transfer in the form of sensible and latent heat is:

$$QES = DAT \cdot FR \cdot (HTI - HTO) \cdot TC \tag{3.20}$$

Some heat is also gained through solar radiation absorption by the soil surface, given by:

$$QRS = A \cdot x \cdot SS \cdot ISH \qquad (3.21)$$

where the amount of solar radiation received is based on the operation of the thermal curtain. The thermal curtain also acts as a shading device.

$$ISH = ISC \cdot (TB - TCT) \,/\, 100 \qquad (3.22)$$

Part of the heat stored in the soil, also comes from the convective heat transfer between the air and the soil surface, as defined by:

$$QGF = HCE \cdot AF \cdot (TIG - TSS) \cdot TB \qquad (3.23)$$

The convective heat transfer coefficient at the soil surface is estimated using an empirical relationship presented by Cormany and Nicolas (1985):

$$HCE = (5.0 + 3.5 \cdot v) \,/\, 1000 \qquad (3.24)$$

A thermal heat storage efficiency can be defined by:

$$SE = \frac{QSS}{QES + QRS + QGF} \qquad (3.25)$$

In terms of heat recovery from the storage, the heat reclaimed by the exchanger can be evaluated by:

$$QRT = DAT \cdot FR \cdot (HTO - HTI) \cdot TC \tag{3.26}$$

Part of the stored heat is also recovered ~~by air~~ at the soil surface:

$$QRF = HCE \cdot AF \cdot (TSS - TIG) \cdot TB \tag{3.27}$$

Assuming that the heat transfered from the soil to the air by radiation is neglegible, a thermal heat recovery efficiency can be defined by:

$$RE = \frac{QRT + QRF}{QSS} \tag{3.28}$$

The sensible heat exchange within the pipes of the exchanger can be evaluated by the following relationships:

$$QEX = AT \cdot HCT \cdot (T_F - T_W) \cdot TB = M_{air} \cdot Cs \cdot (T_I - T_O) \tag{3.29}$$

The convective heat transfer coefficient can be obtained by re-arranging the terms:

$$HCT = \frac{M_{air} \cdot Cs \cdot (T_I - T_O)}{AT \cdot (T_F - T_W) \cdot TB} \tag{3.30}$$

Since sensible heat is recovered passively at the soil surface and actively from the exchanger, the ratio of passive heat recovery to the total heat recovered is expressed by:

$$RSR = QRF / (QEX + QRF) \tag{3.31}$$

Chapman (1976), defined the efficiency of a heat exchanger when the fluid is heated by:

$$ERE = (T_O - T_I) / (TSIC - T_I) \tag{3.32}$$

when the fluid is cooled by the exchanger, the efficiency is expressed by:

$$ESE = (T_I - T_O) / (T_I - TSIF) \tag{3.33}$$

The heat exchanger-storage system can be considered as a heat pump. A coefficient of performance (COP) adjusted for the amount of electrical energy not used by the ventilators or the heater when the heat exchanger is in action, can be defined in terms of sensible heat by:

$$COPS = QES / (QC - QV) \tag{3.34}$$

for heat storage, and by:

$$COPR = QRT / (QC - QBR) \tag{3.35}$$

for heat recovery.

The electrical energy used by the heat exchanger blower is evaluated by:

$$QC = VC \cdot IC \cdot TC \tag{3.36}$$

The electrical energy not used by the heater burner is estimated from:

$$QBR = VBR \cdot IBR \cdot TSF \tag{3.37}$$

Since the heat recovered will not have to be supplied by the heater, the operating time saved on the heater can be evaluated from:

$$QRT + QRF = QF = PF \cdot TSF \tag{3.38}$$

re-arranging the terms:

$$TSF = (QRT + QRF) \ / \ PF \tag{3.39}$$

$$QBR = VBR \cdot IBR \cdot (QRT + QRF) \ / \ PF \tag{3.40}$$

Similarly, the electrical energy not used by the ventilators is:

$$QV = VV \cdot IV \cdot TSV \tag{3.41}$$

Regarding ventilation, the operation of the buried pipes heat exchanger storage system is the first ventilation stage, therefore the operating time saved on the ventilators is equal to the difference between the system blower and ventilators operating time.

$$TSV = TC - TV \tag{3.42}$$

by re-arranging:

$$QV = VV \cdot IV \cdot (TC - TV) \tag{3.43}$$

Since the air relative humidity inside the greenhouse can highly fluctuate, the physical properties of moist air will also fluctuate and can significantly differ from the properties of dry air. Moist air density can be computed from Rosenberg et al. (1983):

$$DA = MA \cdot (P - 0.378 \cdot EA) / (R \cdot T) \tag{3.44}$$

The vapor partial pressure is obtained from the definition of relative humidity:

$$RH = EA / ES \cdot 100 \tag{3.45}$$

re-arranging:

$$EA = RH \cdot ES / 100 \tag{3.46}$$

where the saturated vapor pressure is obtained from:

$$ES = 0.61078 \exp (17.269 \cdot T / (T + 237.30)) \tag{3.47}$$

The absolute humidity is defined by:

$$HU = 0.622 \cdot (RH \cdot ES / 100) / (1 - RH \cdot ES / 100) \tag{3.48}$$

The specific heat of moist air is estimated by:

$$Cs = Cp_S + Cp_V \cdot HU \tag{3.49}$$

and the enthalpy of moist air is obtained from:

$$HT = Cs \cdot (T - T_0) + HV \cdot LH \tag{3.50}$$

These theoritical considerations were translated into two computer programs, one to characterize the greenhouse heat loss with respect to wind conditions, and one to generate the performance indicators for various operating conditions. These topics are covered in the next section.

MATERIALS AND METHODS

4.1 Experimental Setup

A heat exchanger-storage system made of 26 non perforated, corrugated plastic drainage pipes, 102 mm in diameter, buried in the soil of a NORDIC type greenhouse, is shown in Figure 4.1. The first row consisting of 13 pipes, was buried at 450 mm and the second row at 300 mm below. The pipes run parallel to the horizontal east-west axis of the greenhouse, and were spaced at 450 mm apart. The characteristics of the greenhouse and pipes are listed in Tables 4.1 and 4.2 respectively.

The 0.75 kW Delhi blower shown in Figure 4.2, is used to circulate the air from the greenhouse into the pipes at 0.91 m^3/s. The blower was placed over a 6230 x 750 x 1240 mm plywood plenum on which the pipes were connected. The blower has its air intake over the thermal curtain near the ridge for daytime operation, and under the curtain for nightime operation. The air is discharged into the greenhouse from the 26 pipe outlets that emerge from the soil.

The greenhouse is equipped with a thermal curtain (Table 4.1) that can be used as a light shading device during summer. Two 2-speed ventilators, 610 mm in diameter, having a maximum capacity of 2.12 m^3/s, were used to control the temperature when the soil heat exchanger storage system can no longer remove enough heat. An auxiliary ventilator, 335 mm having a capacity of 0.63 m^3/s, was used to control the air relative humidity. A standard oil heater 36 kW in

Table 4.1 Experimental greenhouse[1] characteristics

Parts	Dimensions	Covering	Insulation	Surface Area (m^2)
South Wall	12.1 x 1.83	Polycarbonate[2] 6 mm	Thermal[3] Curtain	22.1
South Roof	12.1 x 3.53	Polycarbonate 6 mm	Thermal Curtain	42.7
North Roof	12.1 x 3.53	Polycarbonate 6 mm	Thermal Curtain	42.7
North Wall	12.1 x 1.83	Corrugated sheet metal	Polyurethane 76 mm	22.1
East Wall	- (top section)	Polycarbonate 6 mm	-	5.7
	0.95 x 6.50 (middle section)	Polypropylene[2] 5 mm	-	6.2
	1.2 x 6.50 (bottom section)	Corrugated sheet metal	Polyurethane 76 mm	6.6
West Wall	-	Corrugated sheet metal	Polyurethane 38 mm	18.5
Floor	12.1 x 6.50	-	-	78.7
Foundation	1.4 x 36.3	Reinforced concrete	Polystyrene 76 mm	50.8

1 "NORDIC" model constructed by Harnois Industries, oriented east-west.

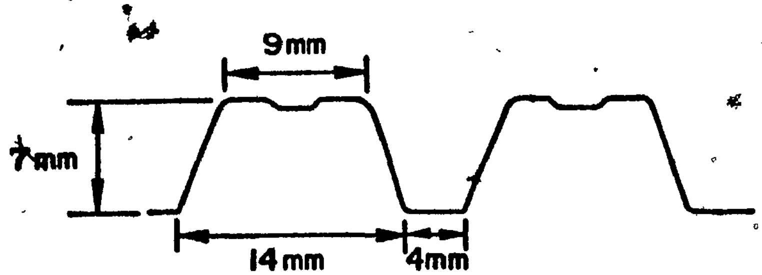
2 Hollow profile double skin plastic.

3 Single white diffusing plastic film.

Table 4.2 Heat exchanger pipe[1] characteristics

Thickness	:	1.0 mm
Inside diameter	:	102.0 mm
Outside diameter	:	110.0 mm
Mean inside diameter	:	105.5 mm
Corrugation height	:	7.0 mm
Base corrugation length	:	14.0 mm
Top corrugation total length	:	11.0 mm
Inter-corrugation length	:	4.0 mm
Top corrugation straight length	:	9.0 mm
Side corrugation length (estimated)	:	7.4 mm
Unit surface area	:	0.531 m^2/m

1 Non-perforated, corrugated drainage pipe



(From Lawand et al., 1985)

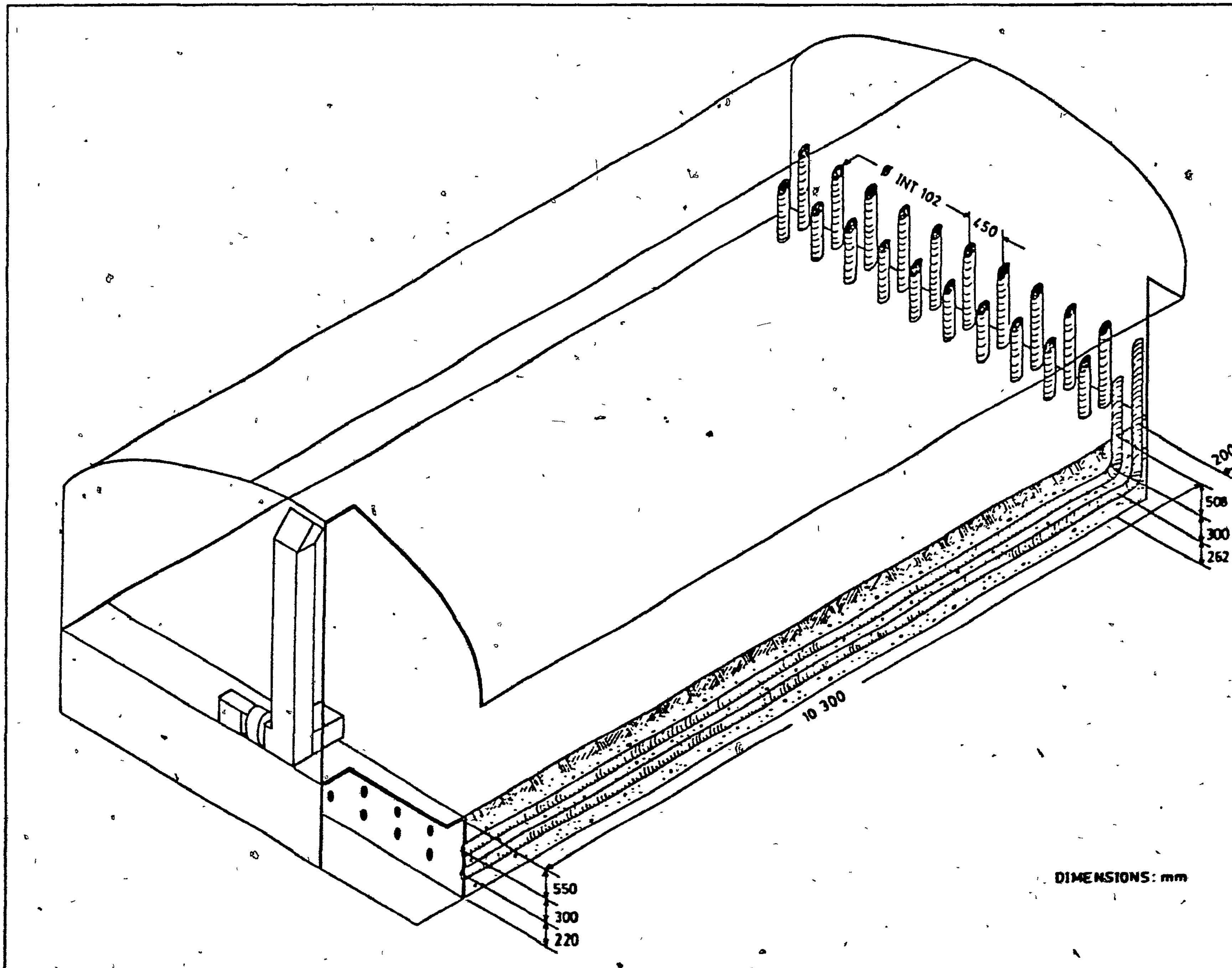
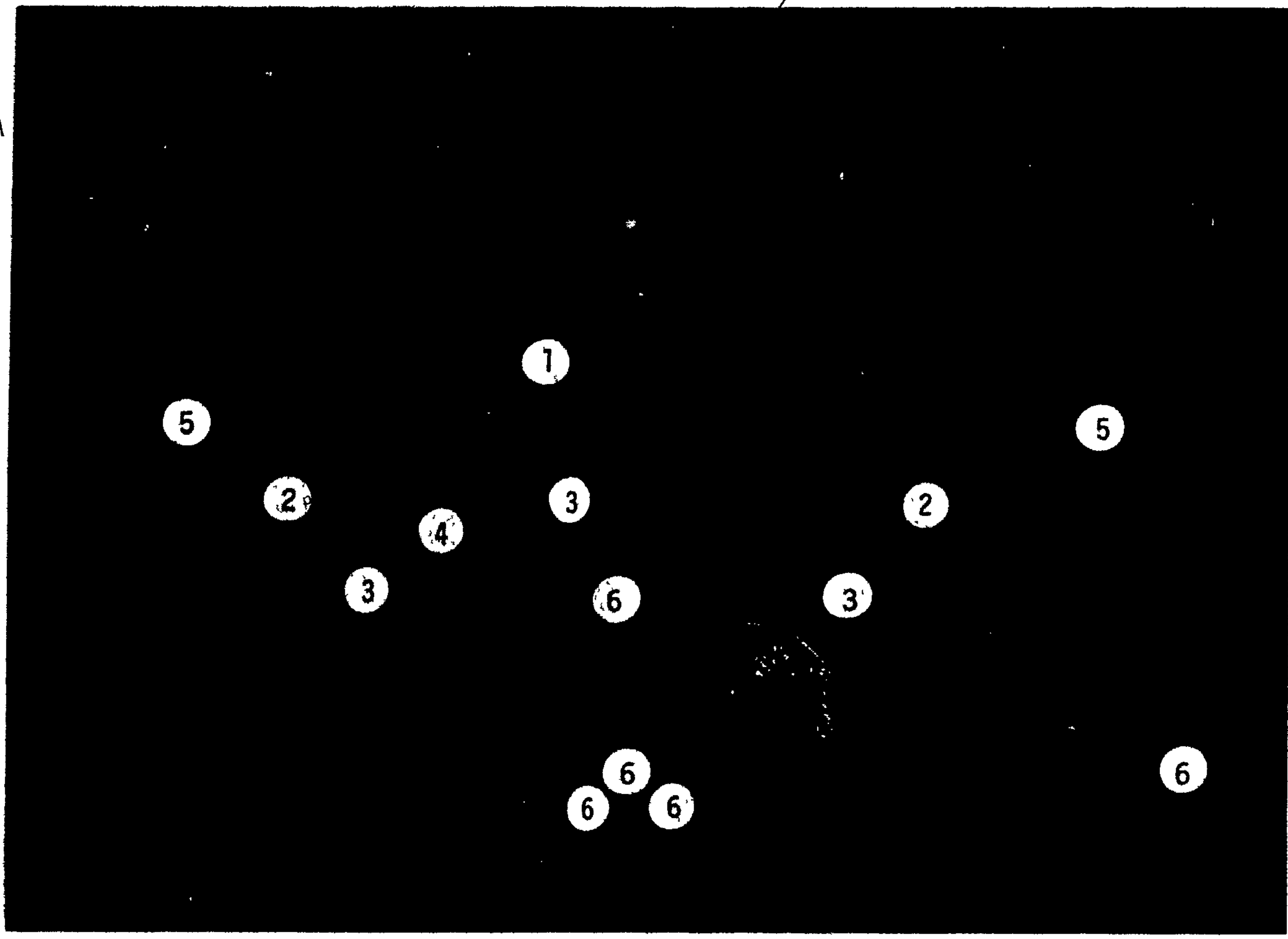


Figure 4.1 Greenhouse heat exchanger-storage system.



1: heat exchanger air inlet 2: ventilator 3: heater outlet
4: heater inlet 5: thermal curtain 6: support for sensors

Figure 4.2 Greenhouse main equipments.

capacity was used to heat the greenhouse and an adjacent service room. A drip irrigation system was used to irrigate and fertilize the crop, helping that way in maintaining a relatively constant humidity level in the soil. The system was controlled by three irrometers mounted in parallel; they activate a solenoid valve when the soil moisture level goes below a preset level. Supplemental lighting was provided in winter by four 400 W HPS lamps mounted under the thermal curtain in the greenhouse center along its longitudinal axis.

A microcomputer system was installed to control the greenhouse environment. The system shown in Figure 4.3, includes a Tandy microcomputer model # 26-3127 complete with Microsoft extended BASIC, 64 kilobytes of random access memory, a black and white video monitor, an audio cassette recorder for data storage, a Tandy dot matrix model # 26-1276 and a custom made data acquisition and control interface.

The system can report on the activity of 8 electrical equipments and perform data acquisition from 80 channels. The characteristics of the system are listed in Table 4.3. Hooked to the system are:

- one Lycor # LI-200SB pyranometer, mounted horizontaly in the greenhouse center over the thermal curtain at 2.5 m above ground,
- one Trade Wind Instruments # C72131 anemometer, mounted outside at 4.2 m above ground,

Table 4.3 Data Acquisition and control system characteristics

analog digital converter resolution	15 bits
conversion time per channel	300 ms
temperature sensor channels	64
miscellaneous sensor channels	16
control channels	8
system watchdog	1
real time clock	date, day, hour, minute, second and millisecond
expansion	1 port 10 bits
channel scanning rate	0 to 34 s
report frequency	user defined
computation	differences air relative humidity from dry and wet bulb temperatures
report output on monitor, printer or cassette	date, day, hour, minute, second report number number of scanning maximum value per channel minimum value per channel mean value per channel standard deviation per channel time of operation for each electrical equipment

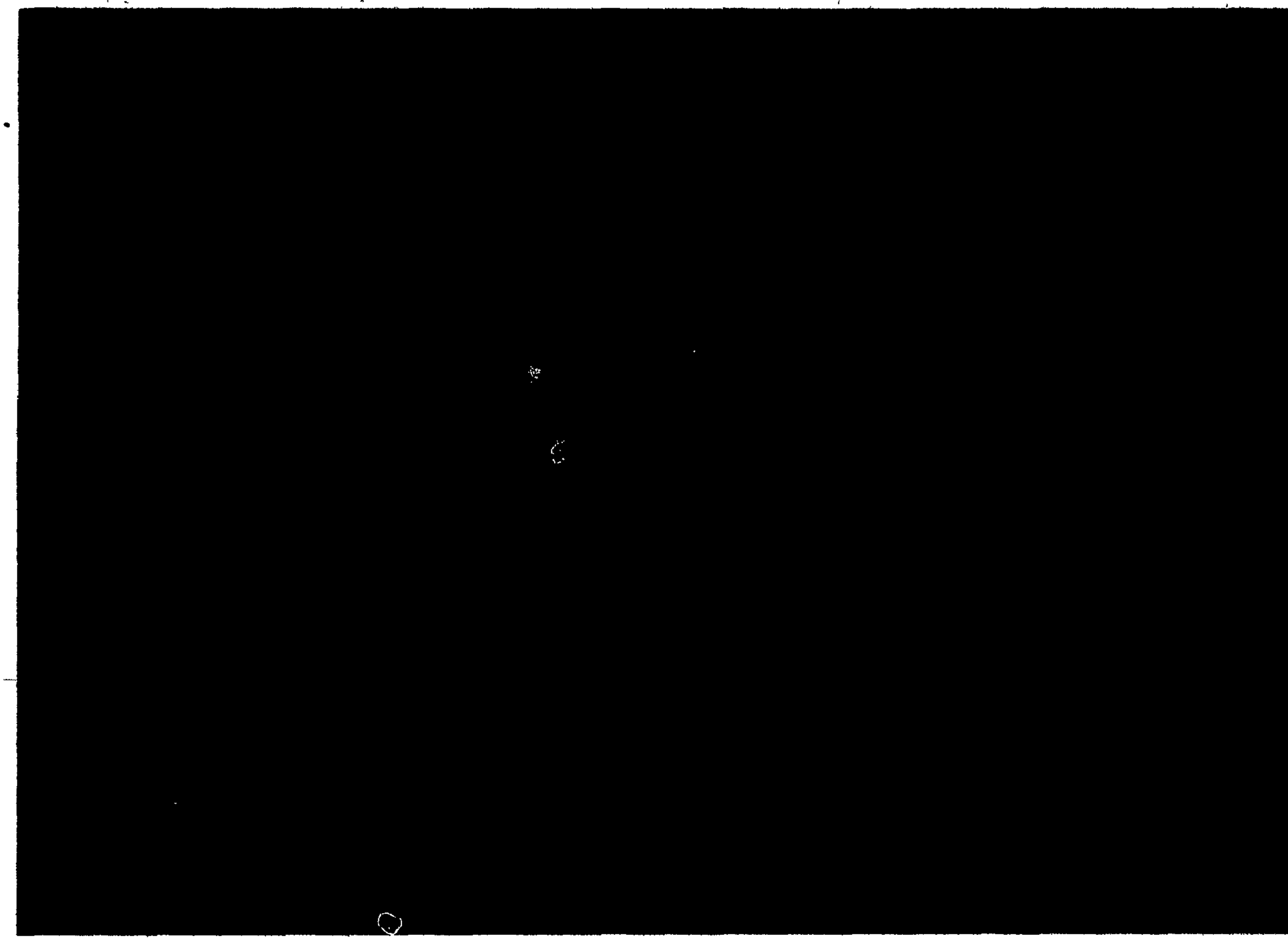


Figure 4.3 Microcomputer system installed in the experimental greenhouse.

- sixty Analog Device # AD-590, temperature sensors were installed as shown in Figures 4.4 and 4.5. A typical temperature sensor is shown in Figure 4.6.

The system was designed to use AD-590 converters as temperature sensors because of their linear response to temperature variation.

Not shown in Figures 4.4 and 4.5 are:

sensors T31 and T32H, measuring respectively the internal air dry and wet bulb temperatures; these sensors were installed in a ventilated box located in the greenhouse center, at 1.75 m above ground;

sensors T20, T47 and T48 measuring soil temperatures at one meter outside the foundations, were installed to correspond with depths identical to the ones shown in Figure 4.4 for T17, T18 and T19 respectively;

sensors T57 and T58 were located to measure air temperatures at the heater inlet and central outlet respectively;

sensors T28 and T29H were installed to obtain respectively the air dry and wet bulb temperatures at the exchanger inlet;

sensor T56 was used to measure the air temperature near the roof ridge in the western part of the greenhouse;

sensor T33 was located to measure the outside air temperature; this sensor was shielded from precipitation and sunshine and was located close to the anemometer.

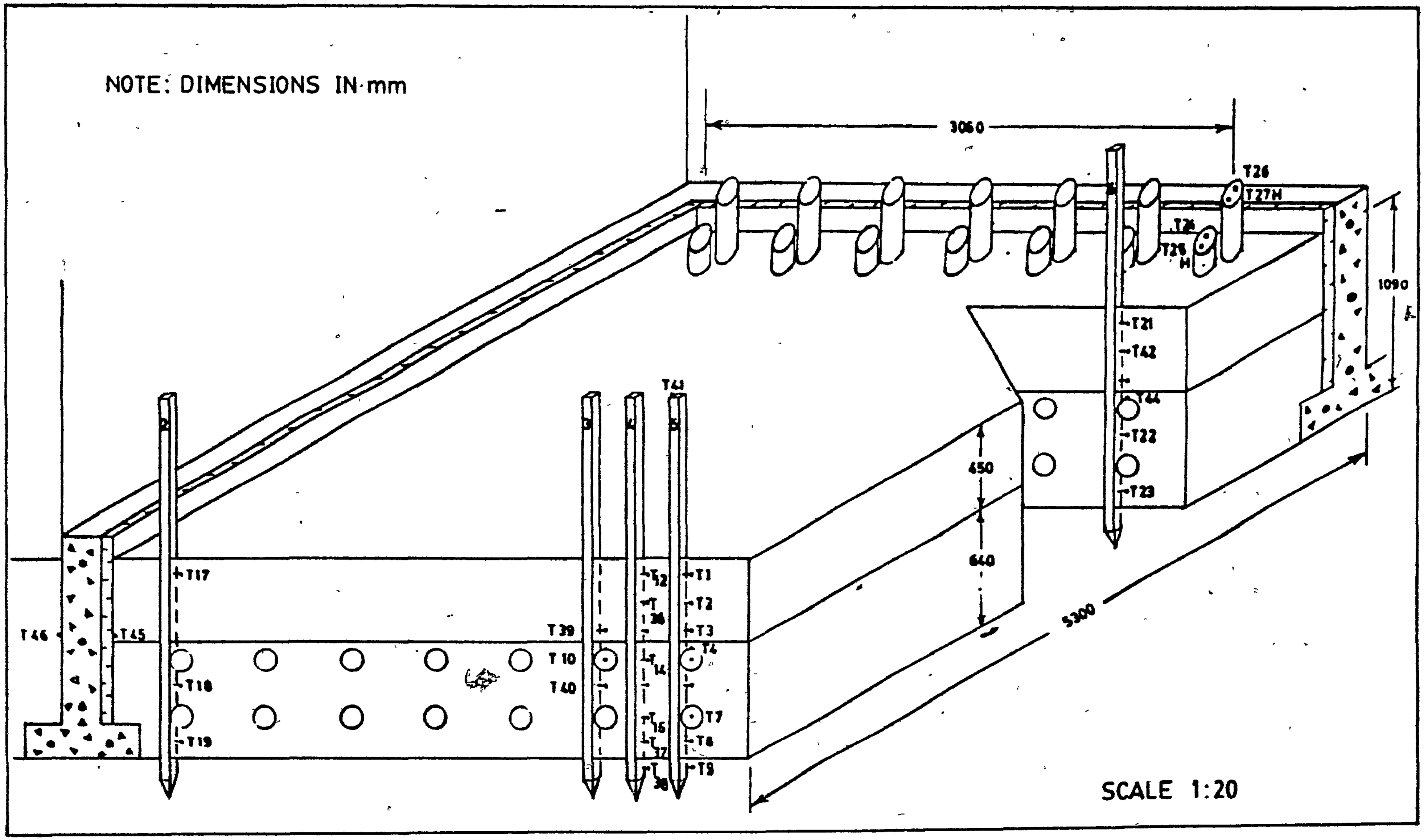


Figure 4.4 Temperature sensors installed in the northeast quadrant of the greenhouse.

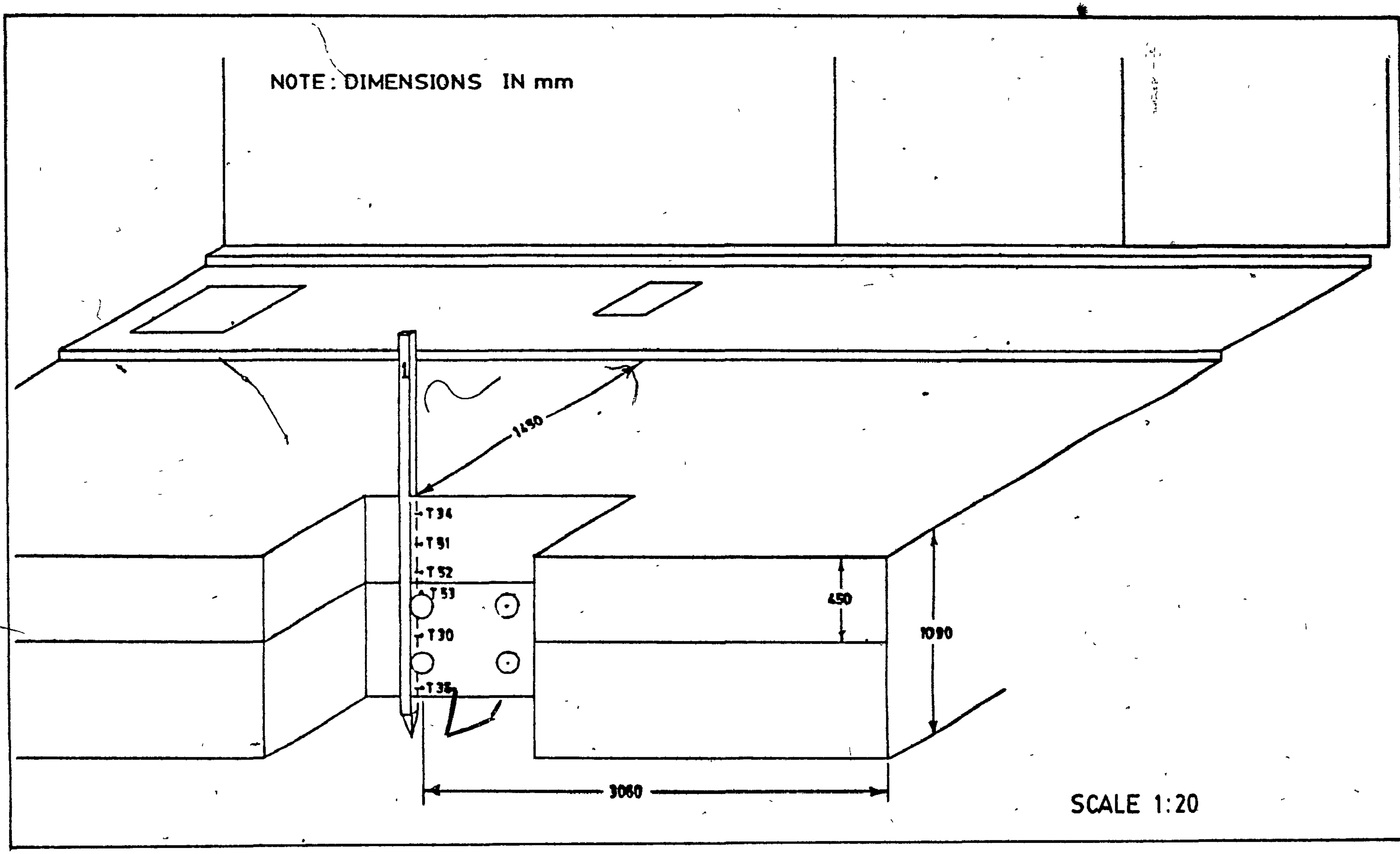


Figure 4.5 Temperature sensors installed in the western part of the greenhouse.

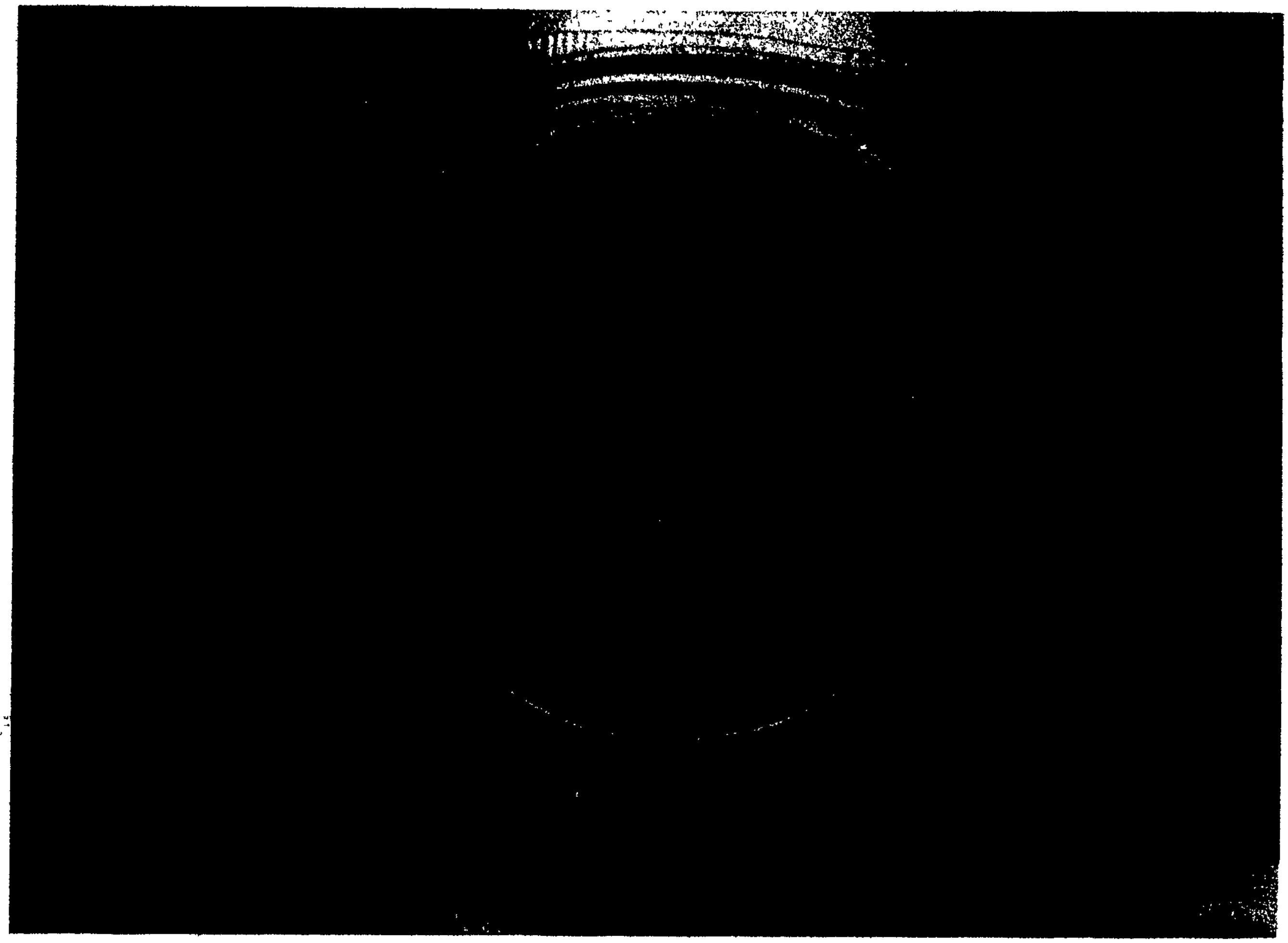


Figure 4.6 Analog Device AD-590 temperature sensor.

4.2 Procedure

4.2.1 Soil Physical Properties

The soil storage is made of two layers; the top layer consists of 450 mm of organic soil, whereas the bottom layer of 610 mm depth, is of mineral soil. Clay was encountered at approximatly 230 mm below the bottom layer.

A soil texture analysis was done for the two layers. Soil water contents, wet and dry bulk densities were measured using a Stratagauge Troxler model # 3411B shown in Figure 4.7, and by taking core samples at 20 sites picked at random. For each site, samples were collected at depths of 150, 300 and 600 mm.

For each layer, thermal capacity tests were conducted on composite samples, using standard methods outlined by Taylor and Jackson (1965). Soil water content was monitored at several times during the test period.

4.2.2 Air velocity

The air flow rates were adjusted for each buried pipes using a velometer (Alnor model Jr). Restrictions were adjusted in order to equalize the flow of air in each tube. A Pitot tube (Figure 4.8) was used to measure air velocities at five points in a cross-section of each pipe, as indicated in bulletin no. H-11 by Dwyer Instruments Inc. (1984). The same procedure was used to adjust and measure air velocities at

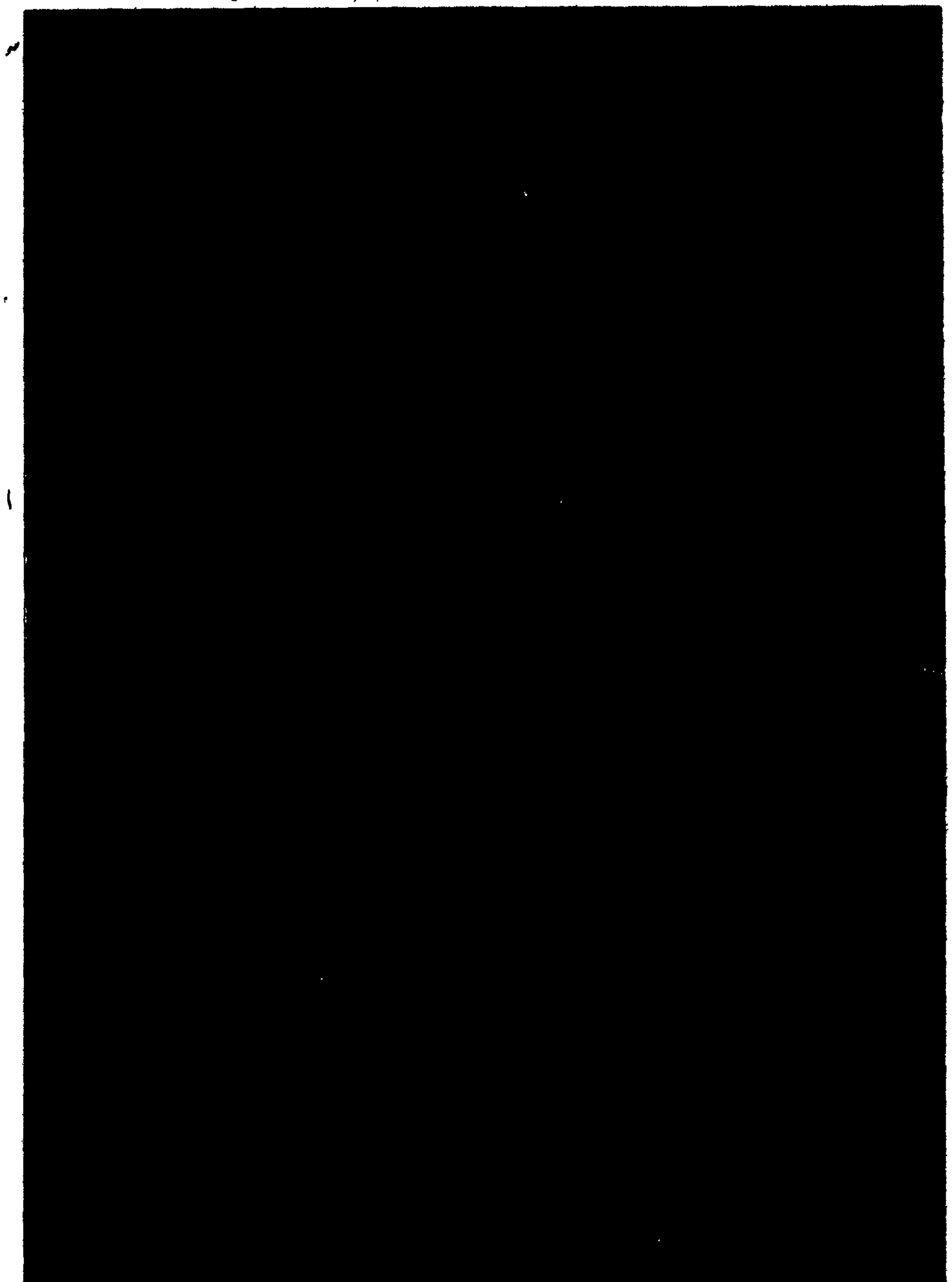


Figure 4.7 Stratagauge Troxler model no. 3411B.

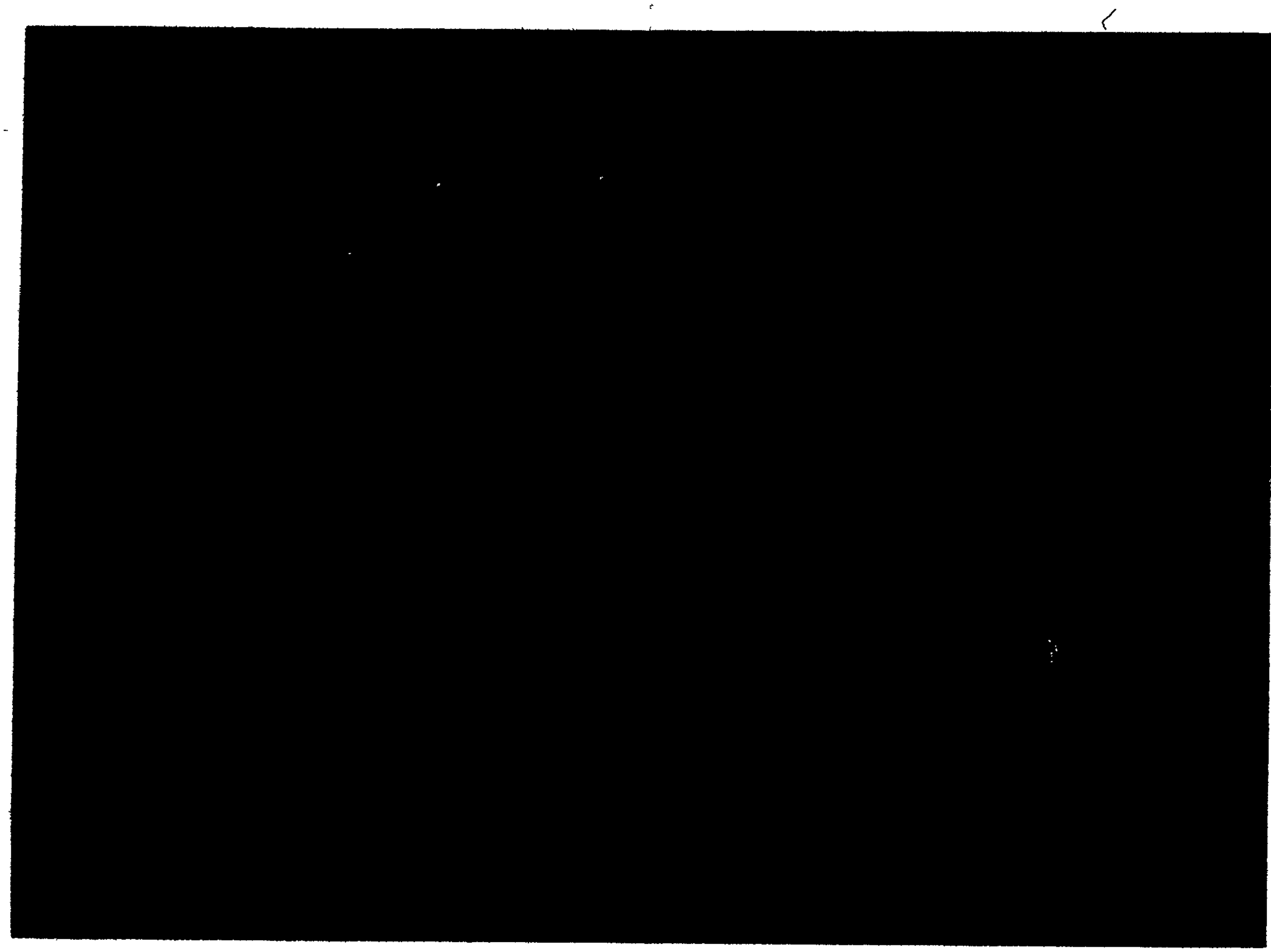


Figure 4.8 Pitot tube apparatus.

the heater outlet; twenty points in the outlet cross-section were measured.

4.2.3 Overall Heat Exchange Coefficients

4.2.3.1 Heat Loss Coefficients (UG)

Test runs were periodicaly conducted at night in order to evaluate the overall heat loss coefficients for the aerial portion of the greenhouse for different wind conditions.

Tests were also perfomed with and without hoods on ventilator outlets and thermal curtain. Inside and outside air temperatures, inside air relative humidity, air temperatures at the heater inlet and outlet and wind speed were measured over a period of a few hours, when steady state conditions were reached.

In order to minimize the heat transfer between the top soil and the surrounding air inside the greenhouse, the air temperature was maintained at the average temperature of the top soil. Figure 4.9 illustrates the computation process.

4.2.3.2 Convective Heat Transfer Coefficient

Over the test period, the air relative humidity and temperature measured at the exchanger inlet and outlets, and the air and wall temperatures in a pipe were continuously monitored. The estimation of the coefficient was based on sensible heat exchange, as indicated by equation 3.30.

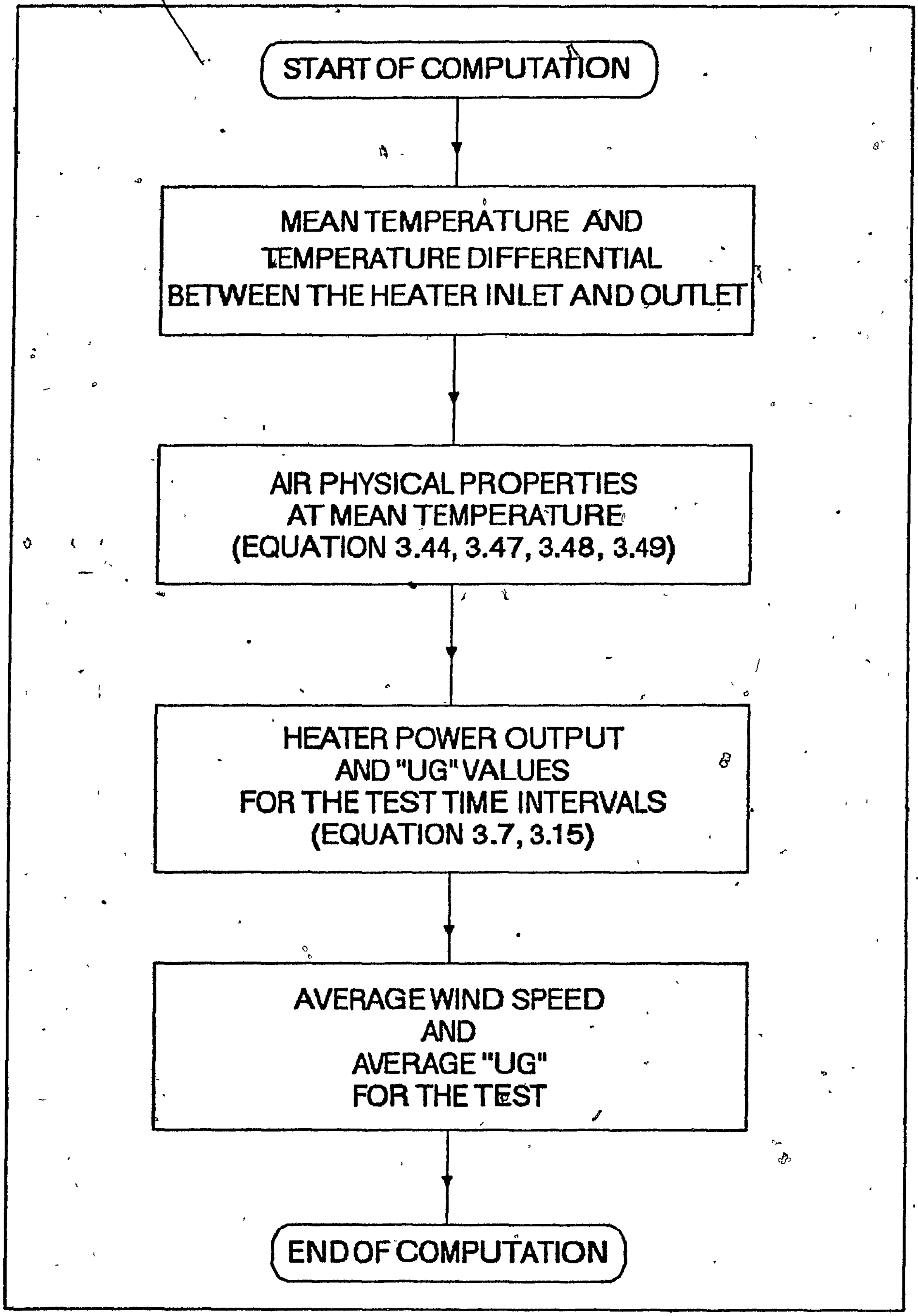


Figure 4.9 Flowchart for the computation of the overall heat loss coefficient.

4.2.4 Electrical Energy Used

The RMS voltages and currents were measured for each piece of equipment over a period of time, in order to evaluate the average power requirements.

The operating time was obtained from the computer reports on an hourly basis. The electrical energy used was calculated from these data, using equations 3.10, 3.11, 3.36, 3.40 and 3.43.

4.2.5 Daily performance

On an hourly basis, the following measurements were made to assess the thermal performance of the greenhouse and of the heat exchanger storage system:

- inside and outside soil temperatures,
- inside and outside air temperatures,
- temperatures at the inlet and outlet of the heater,
- inside air relative humidity,
- dry and wet bulb temperatures at the inlet and oulet of two pipes,
- inside pipe and pipe wall temperatures for one pipe,
- solar radiation inside the greenhouse measured on a horizontal plane,
- wind velocity,
- operating time for each piece of equipment.

The equipment inside the greenhouse were operated according to the schedule of events shown in Table 4.4, and the flowchart presented in Figure 4.10 illustrates the

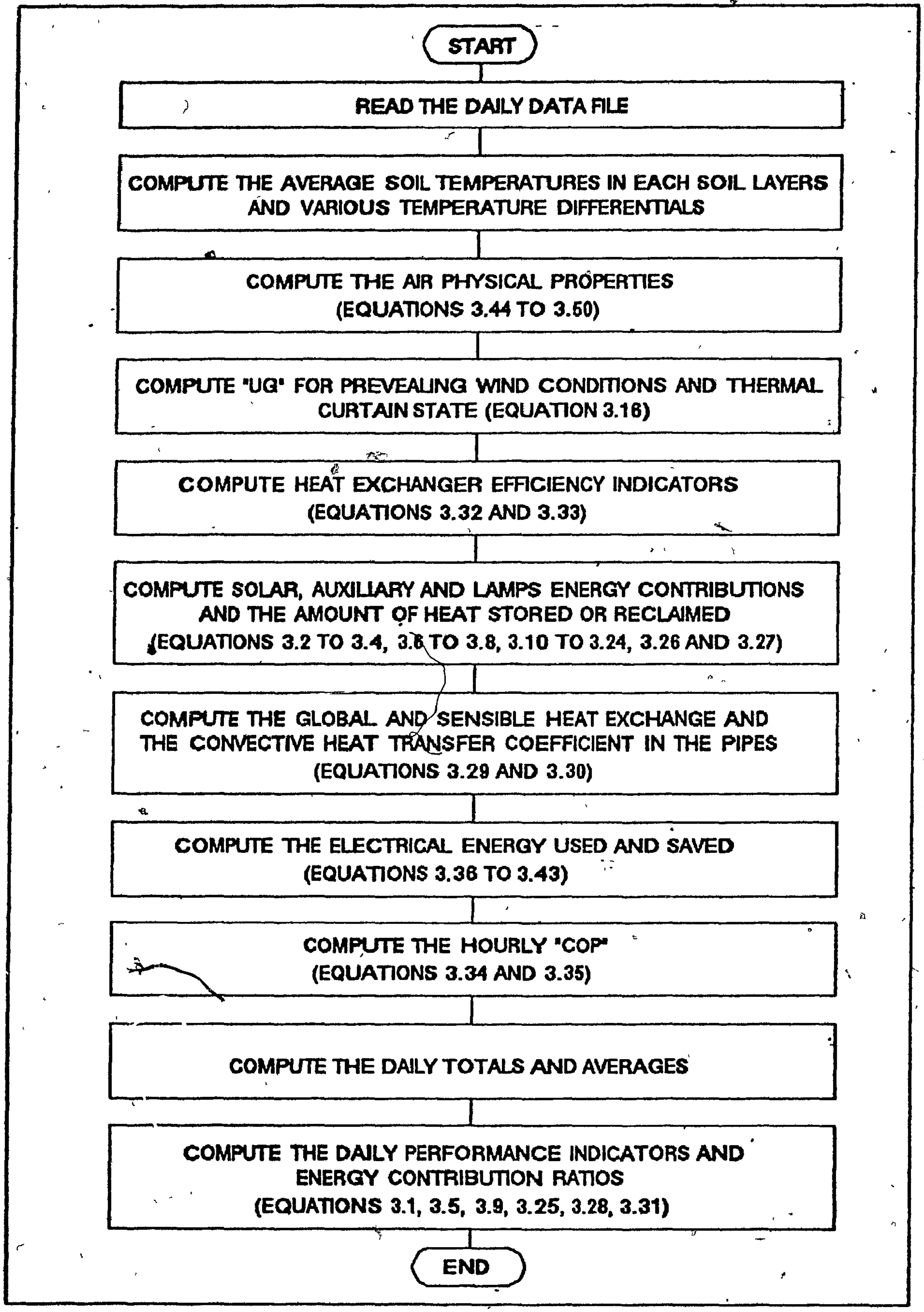


Figure 4.10 Flowchart for the computation of the daily performance.

different steps involved in the computation of the daily performance parameters.

Table 4.4 Schedule of events for equipment operation

Equipment	Controlling	Setpoint	Hysteresis	Test Period
Heater	TIG	15.0°C	1.0°C	Fall 1985
Heater	TIG	13.0°C	1.0°C	Spring 1986 Fall 1986
Blower	TCSD	different values	1.0°C	Fall 1985
Blower	|TCSD|	different values	1.0°C	Spring 1986 Fall 1986
Air Inlet	TIG	23.5°C	1.5°C	Entire
Air Exhaust (low speed)	TIG	25.0°C	1.0°C	Entire
Air Exhaust (high speed)	TIG	27.0°C	1.0°C	Entire
Auxiliary Fan	RH	80 %	5 %	Entire
Curtain	ISC	5.0	3.0	Entire
HPS Lamps	Time	6.00 to 22:00	-	Spring 1986 Fall 1986
Irrigation[1]	Irrometer	200 mbars	100 mbars	Entire

[1] Operating time not logged by the data acquisition sytem.

4.2.6 Operating Modes

Different modes of operation were tested over periods ranging from a few days to several weeks. For each mode, the measurements mentioned in section 4.2.5 were made.

4.2.6.1 Alternate cycles of active storage and recovery

During the day, the heat exchanger-storage system stored excess heat, and during the night, part of the stored heat was recovered actively by the system. The exchanger operation was based on air-soil temperature differentials (|TCSD|) ranging from 1 to 10°C.

4.2.6.2 Active storage and passive recovery

The system was put in operation during the day only to store excess heat. During the night, part of the stored heat was recovered passively by convection at the soil surface. The daytime operation was based on the temperature differentials (TCSD) described above in section 4.2.6.1.

4.2.6.3 Continuous Operation

The system was operating 24 hours a day (|TCSD|=0°C).

4.2.7 Observations on the crops

In order to get a plant response indicator in connection with the heat exchanger-storage system and the greenhouse operation, tomato plants were grown, because it is the largest vegetable greenhouse production in Québec (C.P.V.Q.). The Vendor cultivar was selected because of its popularity among greenhouse growers, when this study was undertaken.

For every production stage, from seedling to fruit harvest, the crop was managed according to the C.P.V.Q.

(1984) recommendations. The fertilization schedule proposed in that same reference, was followed. Fertilizers were added directly to the irrigation system, and provided to each plant through a standard drip irrigation micro-tube. The fertilizer injector has a fixed injection proportion of one liter of liquid fertilizer for every 128 liters of irrigated water. Irrigation was controlled by the use of three irrometers mounted in parallel as described in section 4.1. The irrometers were preset to activate the irrigation system whenever the tension went below 200 mbars.

The plants were soil grown according to the plant layout presented in Figure 4.11; the rooting depth extended from 15 to 30 cm below the soil surface. Yields were measured on soil grown tomato plants. These yields were compared to the average yields obtained by Quebec greenhouse owners.

4.2.8 Payback Estimation

The payback period for various scenarios was estimated using the procedure outlined by Perry and Robertson (1980). These scenarios involved different initial capital costs, auxiliary heating costs in connection with different energy sources, operating costs and plant productivity, for a commercial type greenhouse having a surface area of 179 m^2, producing 3560 kg of tomato annually. An inflation rate of 4 % and an energy conservation factor of 33 % were used in the calculations. The costs are detailed in Table 4.5 and the scenarios are presented in Table 4.6.

Table 4.5 Cost estimates for the payback period

DESCRIPTION	COST[1] ($)
Material: 52 pipes twelve meters long, 0.70 $/m	440
Plenum	160
Two ventilators	400
Two thermostats	200
Inlet pipe	100
Two dampers	200
Connection to the electrical circuit (manpower: two hours)	100
Total	1600
Installation: Manpower for excavation 16 hours at 40 $/hour	640
Manpower for installation 15 days at 80 $/day	1200
Total	1840
Material plus Installation:	3440
Operation: Electricity, 3080 kWh at 0.0396 $/kWh	122
Maintenance over a ten year period	100
Heating: Heat load 52320 kWh	
Heat source: heating oil at 0.037 $/kWh	1936
natural gas at 0.029 $/kWh	1507
wood chips at 0.008 $/kWh	419
Productivity: 960 kg increase[2] in yield at 3.50 $/kg	3360

1 1986

2 Based on two tomato crops

Table 4.6 Payback period scenarios

SCENARIO #	AUXILIARY HEAT SOURCE	INITIAL CAPITAL COST ($)	OPERATING COST ($)	PLANT PRODUCTIVITY CONSIDERED
1	Heating oil	1593[1]	0[3]	No
2	Heating oil	3433[2]	0	No
3	Heating oil	1593	222	No
4	Heating oil	3433	222	No
5	Heating oil	3433	222	Yes[4]
6	Natural gas	3433	222	Yes
7	Wood chips	3433	222	Yes

[1] The greenhouse owner buys and installs the material required for the heat exchanger-storage system.

[2] The greenhouse owner buys the material and pays for the installation of the heat exchanger-storage system.

[3] The heat exchanger-storage system blower replaces the standard fan jet normally found in a greenhouse.

[4] The increase in plant yield is assumed to be 960 kg.

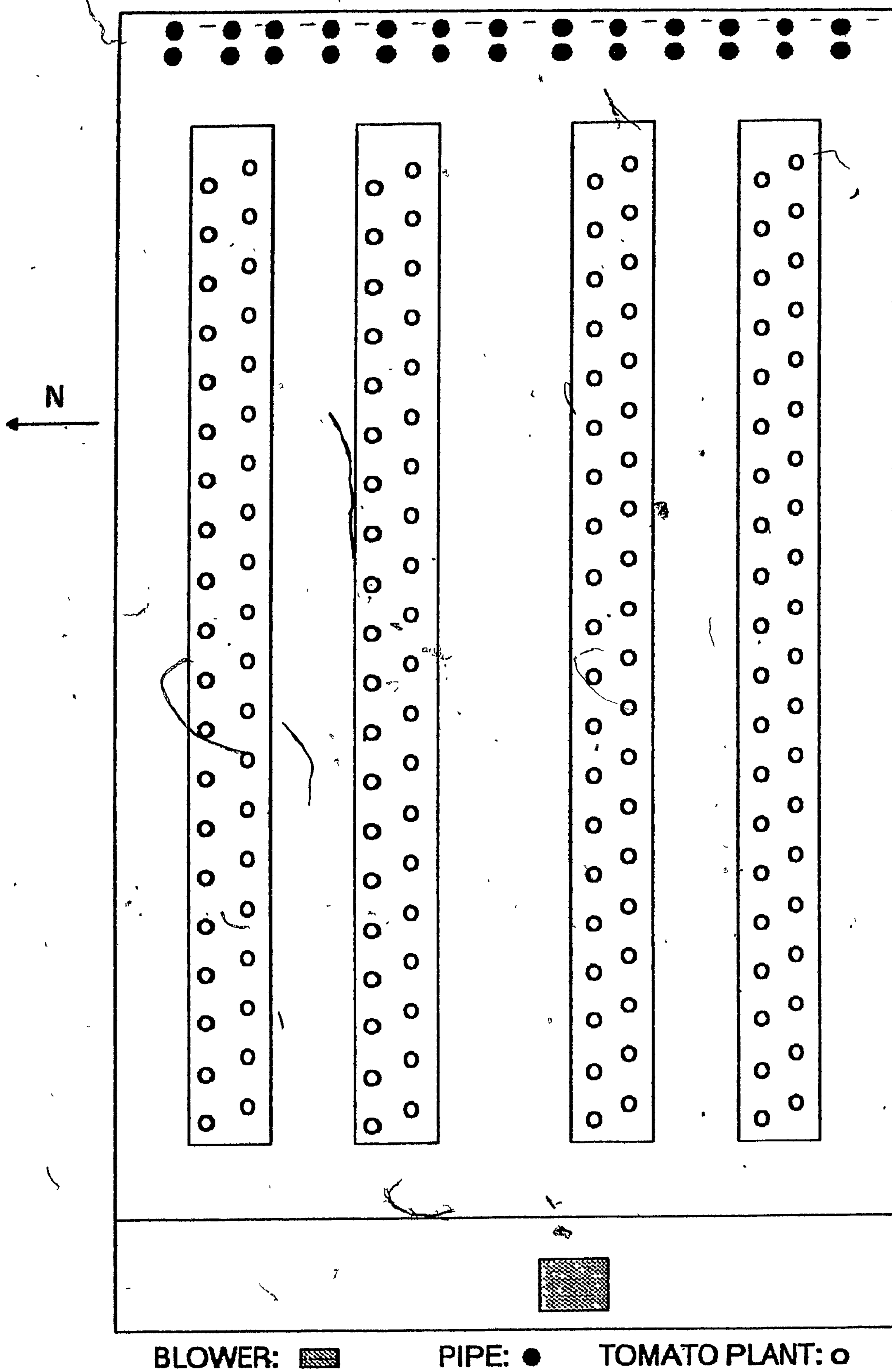


Figure 4.11 Layout of tomato plants in the greenhouse.

V RESULTS AND DISCUSSION

5.1 Soil Physical Properties

5.1.1 Soil Texture

A soil texture analysis was perfomed on the two soil layers forming the thermal mass; the bottom layer accounting for approximatly 2/3 of the thermal, more samples were taken from this layer; sampling was done at 65 and 95 cm below the soil surface in the bottom layer and at 15 cm in the top layer. The results are shown in Tables 5.1 and 5.2. These results indicate that the bottom layer is made of sand and the top layer is made of sandy loam. Both layers are quite homogeneous.

5.1.2 Soil Wet Bulk Density

The average soil wet bulk densities obtained from different sampling are shown in Table 5.3. The top layer being more easily accessible, more samples were taken in this layer. The average density of the bottom layer is higher than that of the top layer, since the top layer was tilled and loosened prior to each crop planting. For both layers the density distribution is uniform.

5.1.3 Soil Specific Heat

The soil specific heat values obtained from dried composite samples coming from both soil layers, are shown in

Table 5.1 Texture of the soil bottom layer

Sample #	Sand (%)	Silt (%)	Clay (%)
1	93.0	4.4	2.6
2	93.2	3.2	3.6
3	93.3	3.2	3.5
4	92.0	4.0	4.0
5	94.0	2.5	3.5
6	91.8	3.6	4.5
7	96.7	0.8	2.5
8	95.7	1.7	2.6
9	97.3	0.2	2.5
10	96.4	0.0	3.6
11	96.9	0.6	2.5
12	96.5	1.0	2.5
Mean	94.7	2.1	3.2
S.D.	2.1	1.6	0.7
C.V. (%)	2.2	78.0	23.4

Table 5.2 Texture of the soil top layer

Sample #	Sand (%)	Silt (%)	Clay (%)
1	62.5	13.4	14.1
2	62.5	15.1	12.4
3	68.6	21.0	10.4
4	70.6	17.0	12.4
Mean	66.0	16.6	12.3
S.D.	4.2	3.3	1.5
C.V. (%)	6.3	19.6	12.3

Table 5.3 Soil wet bulk density

Layer	Number of samples	Average bulk density (kg/m^3)	Standard deviation	Coefficient of variation (%)
Sandy loam	47	1340	51	3.8
Sand	40	1736	40	2.3

Table 5.4. These results are in agreement with values generally encountered in the literature, for these types of soil (Baver, 1940; Van Wijk, 1963; Lawand et al., 1983).

5.1.4 Soil Water Content

Table 5.5 shows the average water content on a dry basis, for each soil layer. In this case, based on the coefficient of variation, the distribution is not as uniform as it was for soil wet bulk density, especially in the sandy layer. Because of its higher water retention capacity, the top layer had a higher water content.

5.2 Air Velocity

5.2.1 Heat Exchanger

The air flowrates in the exchanger were equalized prior to the velocity measurements; these measurements were taken before the start of the test period. The values of the average air velocity for each pipe are listed in Table 5.6. The air velocities were relatively uniform, except for one pipe (A11), for which the air flowrate could not be adjusted, most likely due to an obstruction or pipe deformation.

5.2.2 Heater Outlets

The heater was equipped with three air outlets; the air flowrates in these outlets could not be perfectly equalized. The average air velocities for each outlet are listed in Table 5.7. The hot air from the heater was distributed in

Table 5.4 Soil specific heat

Layer	Number of samples	Mean specific heat (kJ/kg·°C)	Standard deviation (kJ/kg·°C)	Coefficient of variation (%)
Sandy Loam	24	0.77	0.14	18
Sand	20	0.68	0.06	9

Table 5.5 Soil water content

Layer	Number of samples	Mean water contents (% weight)	Standard deviation (% weight)	Coefficient of variation (%)
Sandy Loam	24	23.7	4.3	18
Sand	24	8.8	4.1	47

Table 5.6 Heat exchanger air velocity and flowrate

Pipe #	Velocity (m/s)	Flowrate (m^3)	Pipe #	Velocity (m/s)	Flowrate (m^3/s)
A 1	4.1	0.032	B 1	3.9	0.031
A 2	4.0	0.032	B 2	4.1	0.032
A 3	3.9	0.030	B 3	3.9	0.031
A 5	3.3	0.026	B 5	3.6	0.028
A 6	4.1	0.032	B 6	3.9	0.030
A 7	3.9	0.031	B 7	3.8	0.030
A 8	4.1	0.032	B 8	4.2	0.033
A 9	3.9	0.031	B 9	3.9	0.031
A10	3.9	0.031	B10	3.9	0.031
A11	2.7	0.021	B11	3.9	0.031
A13	3.9	0.031	B13	3.7	0.029
Mean	3.81	0.0349		3.90	0.0357
Standard deviation	0.40			0.21	
C.V.(%)	11			5.23	

Table 5.7 Heater outlet air velocity and flowrate

Outlet	Velocity (m/s)	Flowrate (m^3/s)
South	2.8	0.29
Center	3.3	0.33
North	2.4	0.24

the greenhouse through perforated polyethylene tubes. One of these tubes was located over the soil along the north wall. The second one was located on the greenhouse center line. The third one was installed along the south wall.

In order to minimize the total number of sensors used, two temperature sensors were used for the evaluation of the amount of heat provided by the heater. One sensor was installed at the heater air inlet, the other was installed at the central outlet. Since temperature differences were found among the three air outlets, the air temperature measured in the central outlet could not be used directly in equation 3.8 to compute the amount of heat provided by the heater. Therefore, the air temperature measured in the central outlet had to be adjusted in order to be representative of the average air temperature coming from the three oulets. To do that, test runs were conducted and air temperatures from each outlet were measured. A linear regression equation was derived from temperature measurements obtained during the test runs.

$$TOC = 1.0101 + 0.9527 \cdot TCE \qquad (5.1)$$

This empirical equation predicted the average temperature of the air coming from the heater, from the air temperature of the central outlet. The results of the statistical analysis are presented in Appendix A.

5.3 Heat Exchange Coefficients

5.3.1 Greenhouse Heat Loss Coefficients

Results from the heat loss test runs performed on selected nights throughout the study period, are shown in Figure 5.1; from the figure, it can be seen that the overall heat loss coefficient varies linearly with wind velocity. The use of the thermal curtain decreases the overall heat loss coefficient by 28 to 30 %, which results in an energy conservation factor of the same magnitude. The use of hoods on ventilator outlets results in a decrease of the overall heat loss coefficient by 16 to 28 %, likely by reducing air infiltration. An example of the data obtained during a heat loss test run and the computer program used to compute the data are listed in Appendix B and C respectively.

The parameters UG, UGH, UGC and UGHC stand respectively for the overall heat loss coefficients without the thermal curtain and hoods (equation 5.2), without the curtain but with hoods, with the thermal curtain but without hoods (equation 5.3), and with both the curtain and the hoods.

To simplify the computations when the thermal curtain was on, 72 % of the UG value corresponding to a given wind condition without the thermal curtain, was used; which yields a conservative estimate of the heat losses. Furthermore, four test runs made at different periods without wind, thermal curtain or hoods, have yielded a UG value of 0.0051 $kW/m^2 \cdot °C$, which is lower than the UG value predicted by the linear regression equation 5.2. It seems that the

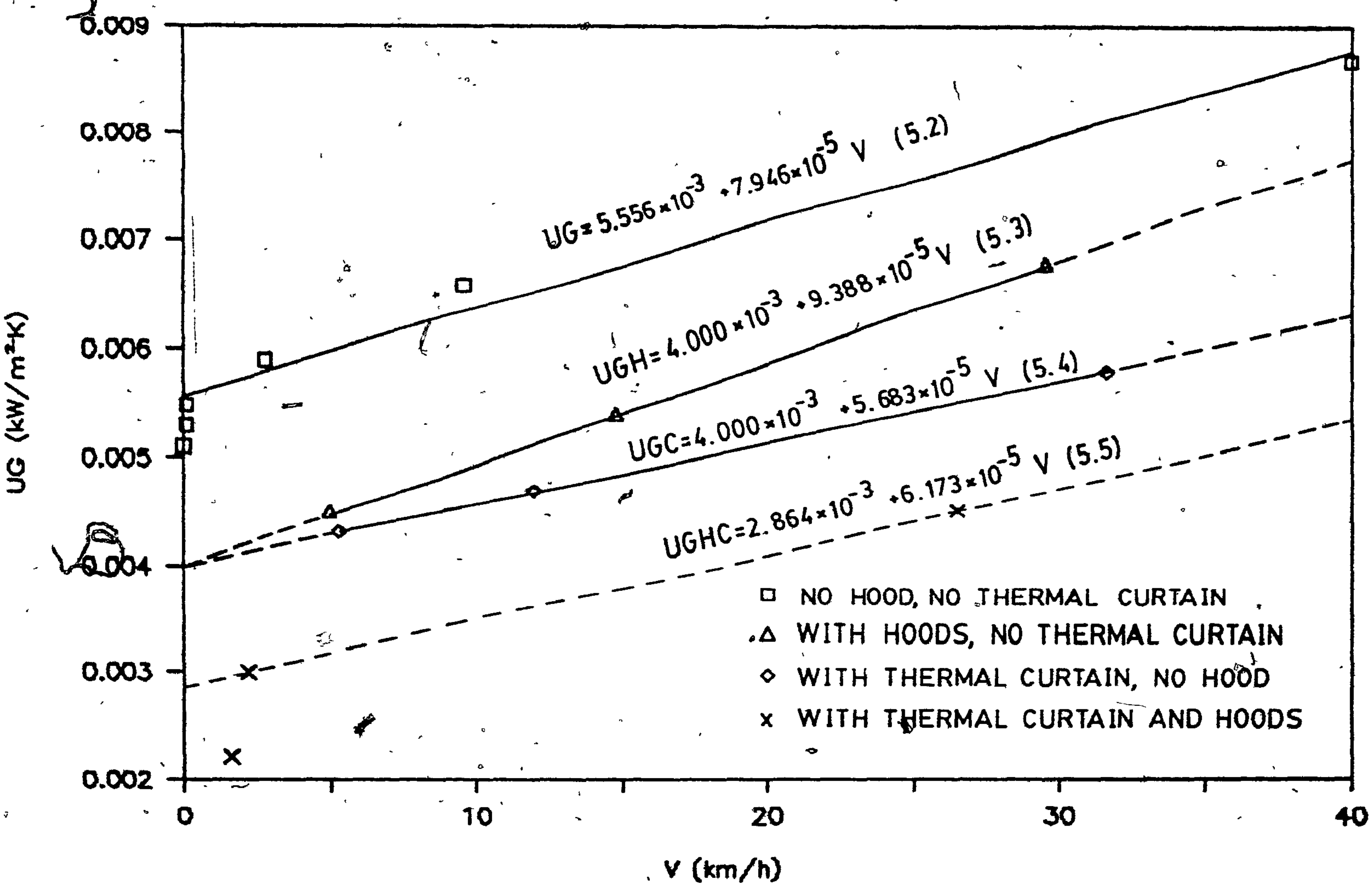


Figure 5.1 Wind effect on the overall heat loss coefficient.

infiltration heat losses are relatively important, since the greenhouse is exposed to wind conditions; because of that, a UG value of 0.0051 was used in order to prevent the over estimation of the greenhouse heat losses, which would contribute to the over estimation of the solar contribution to the greenhouse heat load.

5.3.2 Convective Heat Transfer Coefficient

The convective heat transfer coefficient in the heat exchanger has been estimated from the empirical equation given by Sibley and Raghavan (1984), for the temperature conditions encountered on the 86-12-01, the value obtained is 0.015 $kW/m^2 \cdot K$.

For the same conditions, the value computed from the experimental data using equation 3.30 was 0.013 $kW/m^2 \cdot K$, based on sensible heat exchange. The difference might be explained by the fact that the empirical equation of Sibley and Raghavan was derived from the data obtained with a laboratory setup using relatively dryer air; in this case, the air circulating in the heat exchanger storage system was at 80 % (average) air relative humidity. Therefore, the physical properties of air and the heat transfer mechanisms involved are not likely to be the same. An average value of 0.012 $kW/m^2 \cdot K$ was obtained for the spring and fall of 1986 test periods (Appendix D).

5.4 Electrical Energy Used

Measurements taken on the electrical equipments are presented in Table 5.8. However, these values do not account for variations in the electricity supply.

Table 5.8 Voltage, current and electrical power

Equipment	Voltage (V)	Current (A)	Power (W)
Blower	240	4.9	1.76
Ventilator Low Speed	122	3.2	390
Ventilator High Speed	121	6.0	726
Ventilator Humidity	123	5.5	677
Burner	123	5.9	725
High Pressure Sodium Lamps	122	3.9[1]	475

1 estimated

5.5 System performance

All the data collected were processed on a daily basis, using the "Lotus 1-2-3" software. Pretreated and compiled data account for 800 pages of computer output, and therefore, these pages are not included in the thesis. However, these data are available for consultation on the I.T.A. La Pocatière premise. For illustration, raw, pretreated and compiled data for a given day are presented in Appendix E.

The computer program used to process the data is listed in Appendix F.

5.5.1 Heat Storage and Recovery

During the test period, the thermal mass had seasonal temperature fluctuations of approximatly 10°C, as shown in Figure 5.2. During the fall period, the thermal mass temperature decreased gradually down to a temperature slightly above the minimum air temperature maintained (13 to 15°C). In the spring, during the storage phase, the higher rates of temperature increase were encountered in April and May. In summer, since the ventilators work more often and the thermal mass temperature is high, the efficiency of the exchanger decreases and the rate of temperature increase decreased.

In early summer, the average soil temperature went up to 24°C. This increase in temperature as compared with a conventionnal greenhouse, could have a positive impact on plant yield, provided that the root zone has a good thermal contact with the thermal mass.

For a typical spring day, the temperature of the soil layers has a sine wave type variation. The curves corresponding to the top and bottom layers of soil, show that the system has a significant effect on soil temperature (Figure 5.3). The system was operated during the day for heat storage and at night, for heat recovery.

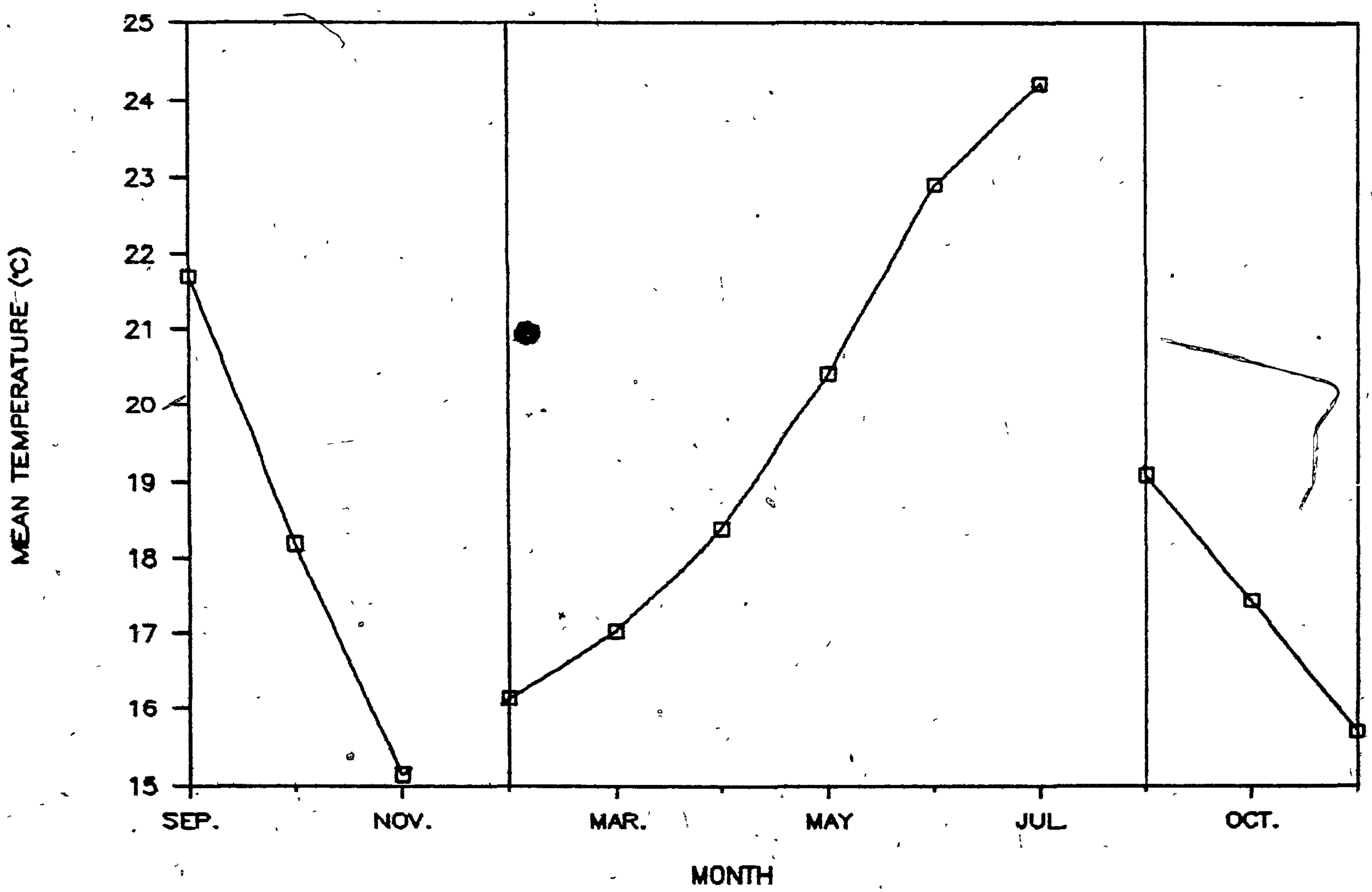


Figure 5.2 Average thermal mass mean temperature fluctuation for the periods of September through November 1985 and 1986, and February through July 1986.

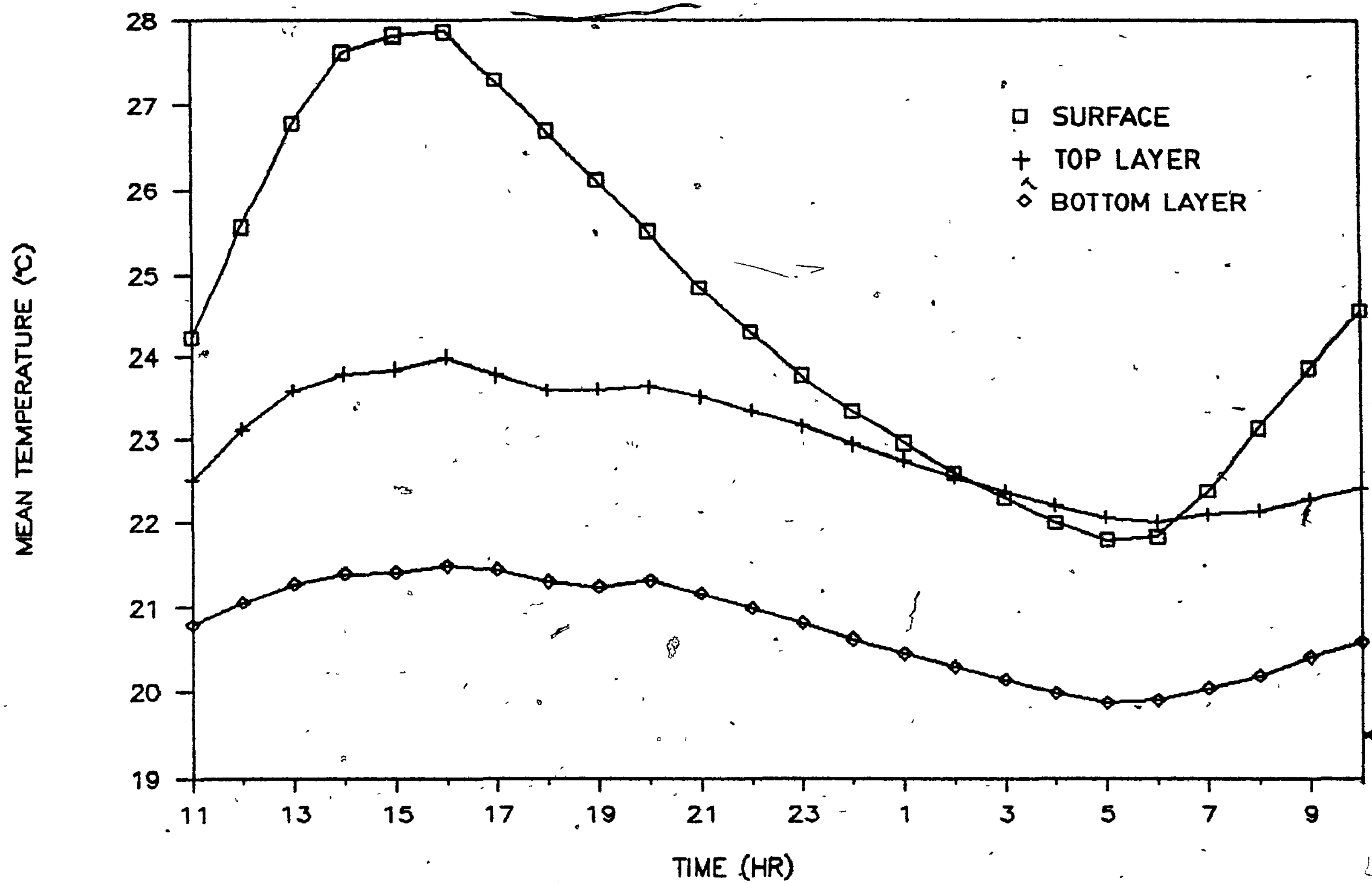


Figure 5.3 Soil daily temperature variation during the storage phase in the spring of 1986.

The soil temperature variation at the surface has a higher amplitude than the one observed for the bottom layer, since top soil also absorbs directly part of the incident solar radiation. During the night, the temperature at the soil surface goes below the temperature of the top layer; therefore, some stored heat migrated to the soil surface and is released to the greenhouse.

The daily variation in soil temperature for a given day during the first fall test period is shown in Figure 5.4, the system was then operated during daytime only for heat storage. During nightime, heat is gradually lost from the soil layers, since the soil temperature is higher than the air temperature inside the greenhouse, part of that heat is recovered passively inside the greenhouse.

During spring, the temperature is relatively uniform throughout the thermal mass. By mid-spring, the temperature differentials between the west end and the east end of the thermal mass are approximatly 1.5 and 0.5°C for the bottom and top layer of soil respectively (Figure 5.5). By early summer, the temperature differentials become negligible for the top layer and approximatly 1°C for the bottom one (Figure 5.6).

Soil surface temperatures measured in the center of the greenhouse are consistantly higher than the ones measured close to the west end and east end for the greenhouse; this is likely to be due to the shading effect of the end walls on these area in early morning and late afternoon.

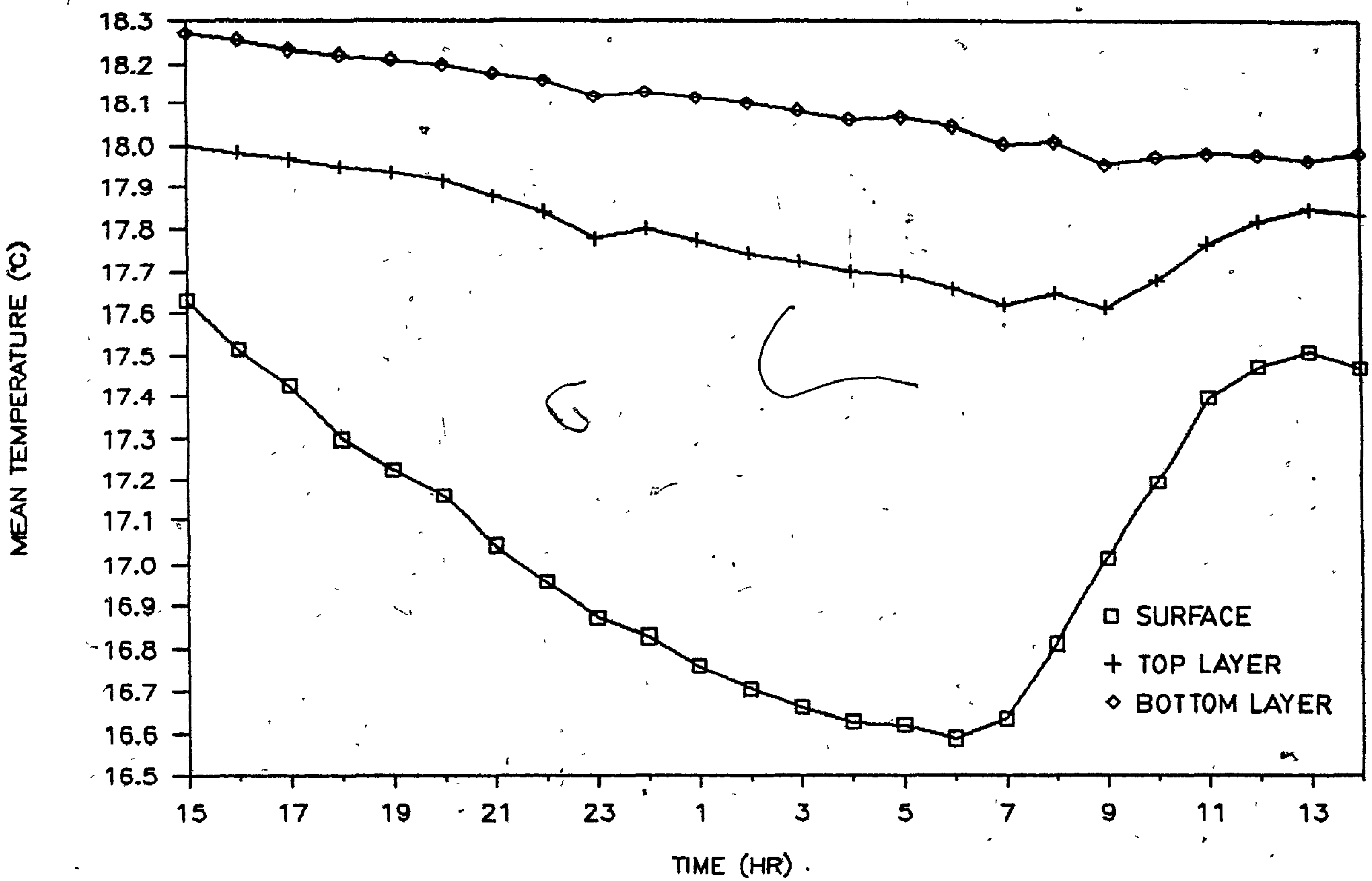


Figure 5.4 Soil daily temperature variation in the fall of 1985 with passive heat recovery.

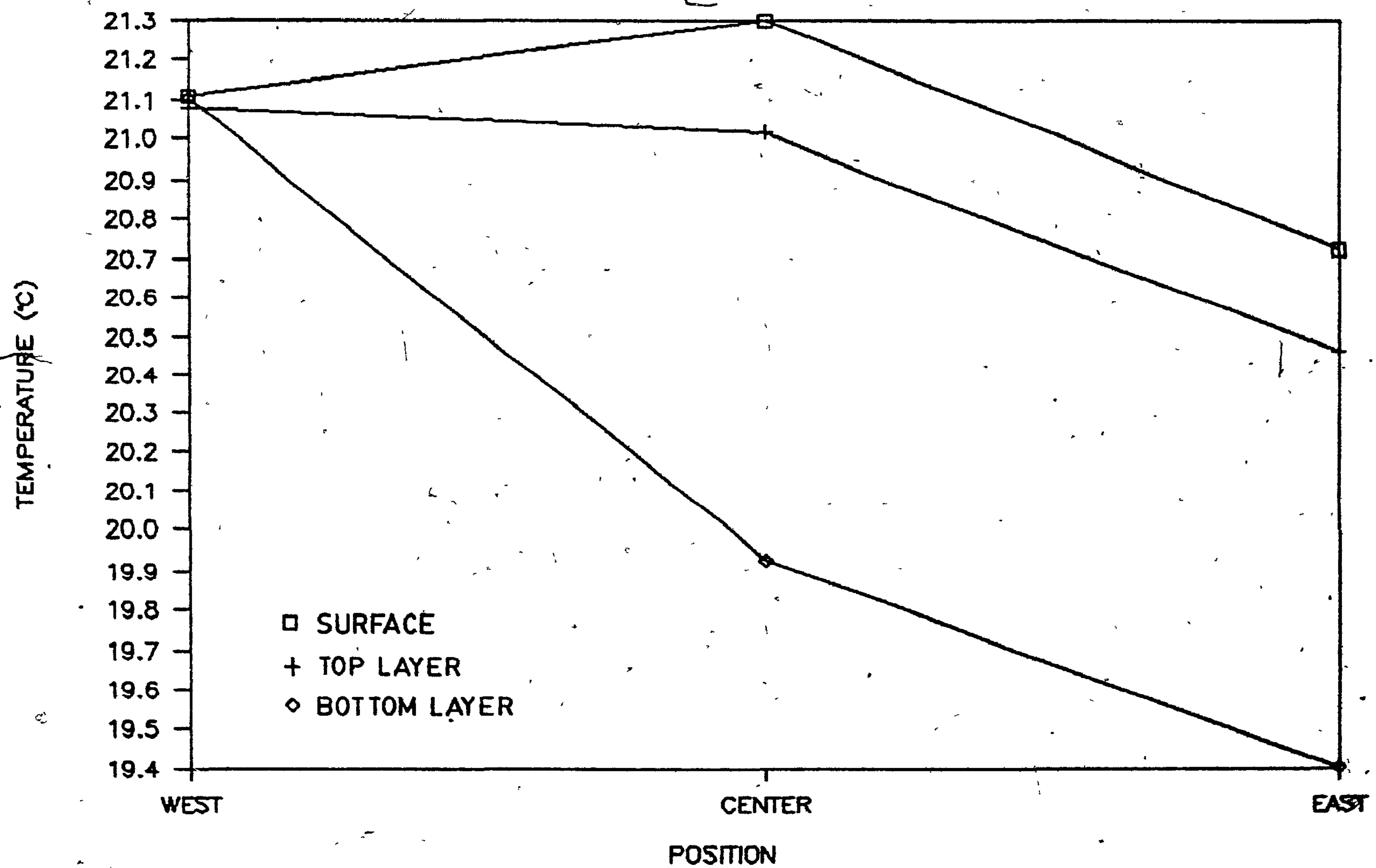


Figure 5.5 Soil longitudinal temperature profile for mid-spring.

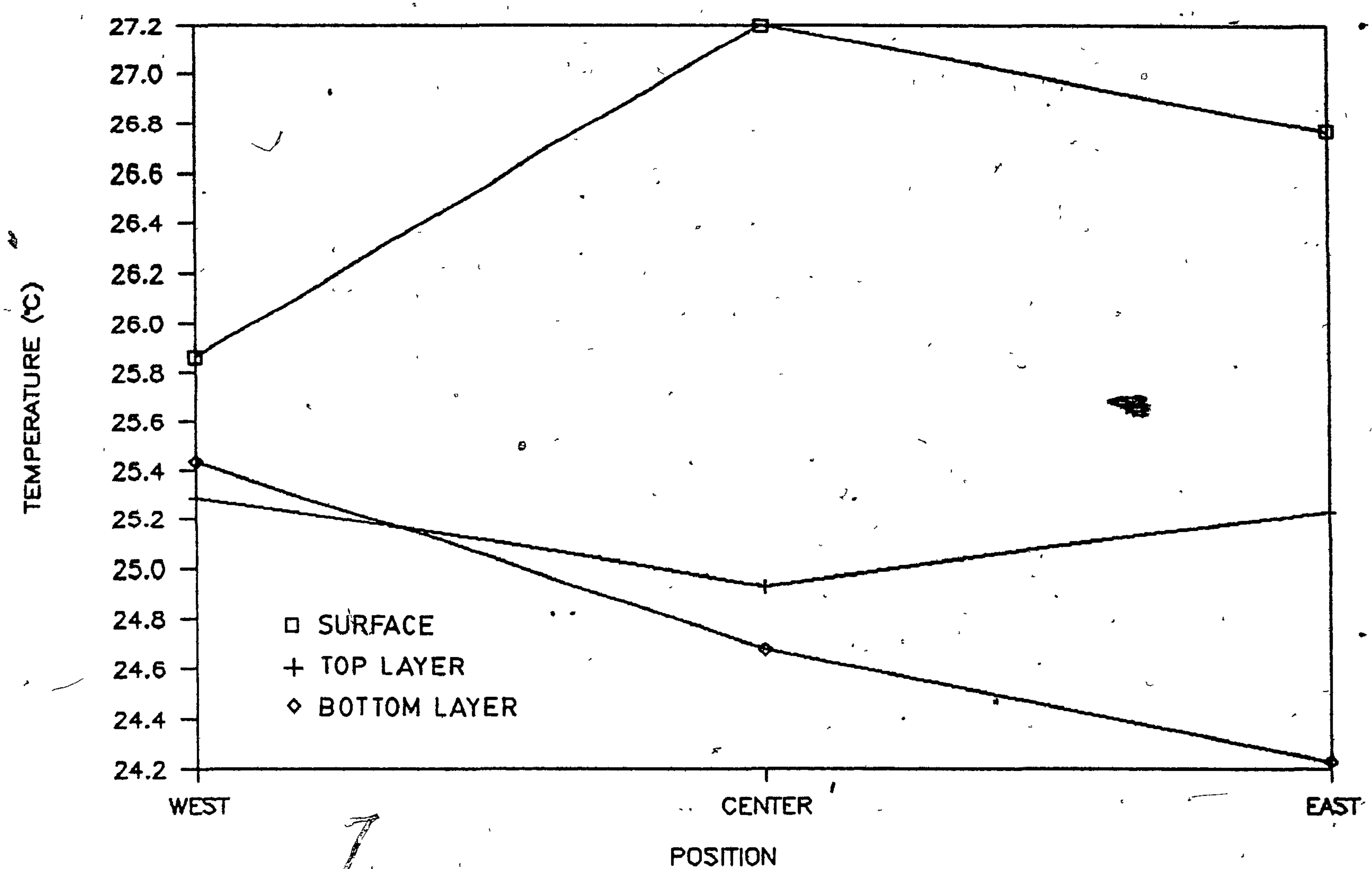


Figure 5.6 Soil longitudinal temperature profile at the beginning of summer.

In order to assess the effect of active and passive heat recovery on the heat exchanger-storage system performance, the system was operated day and night whenever excess heat was available, during the second fall test period. The soil longitudinal temperature profile had somewhat the same pattern (Figure 5.7). However, the temperature of the bottom layer was 1°C higher than that of the top layer. By mid-season, the temperature differentials between the west end and the east end of the thermal mass were in the order of 2°C. By early winter, the temperature differential increased up to 5°C. The soil surface temperature somewhat followed the same pattern as for the top layer of soil (Figure 5.8). On the overall, there was little horizontal temperature stratification in the thermal mass.

The air temperature differentials between the exchanger inlet and outlets seems to follow the same pattern as the air inside the greenhouse does (Figure 5.9).

For a typical sunny day in spring, the temperature differential during the day is higher for the bottom row of pipes as compared with the top row, since the soil surrouding the pipes is colder in the bottow layer; for the same reason, the temperature differential obtained at night is lower for that same row; nevertheless, this temperature differential is relatively constant. The capacity of the system to recover heat at night is limited by the low temperature differentials (between 3 and 5°C) encountered. The maximum and minimum temperature conditions imposed by the crop

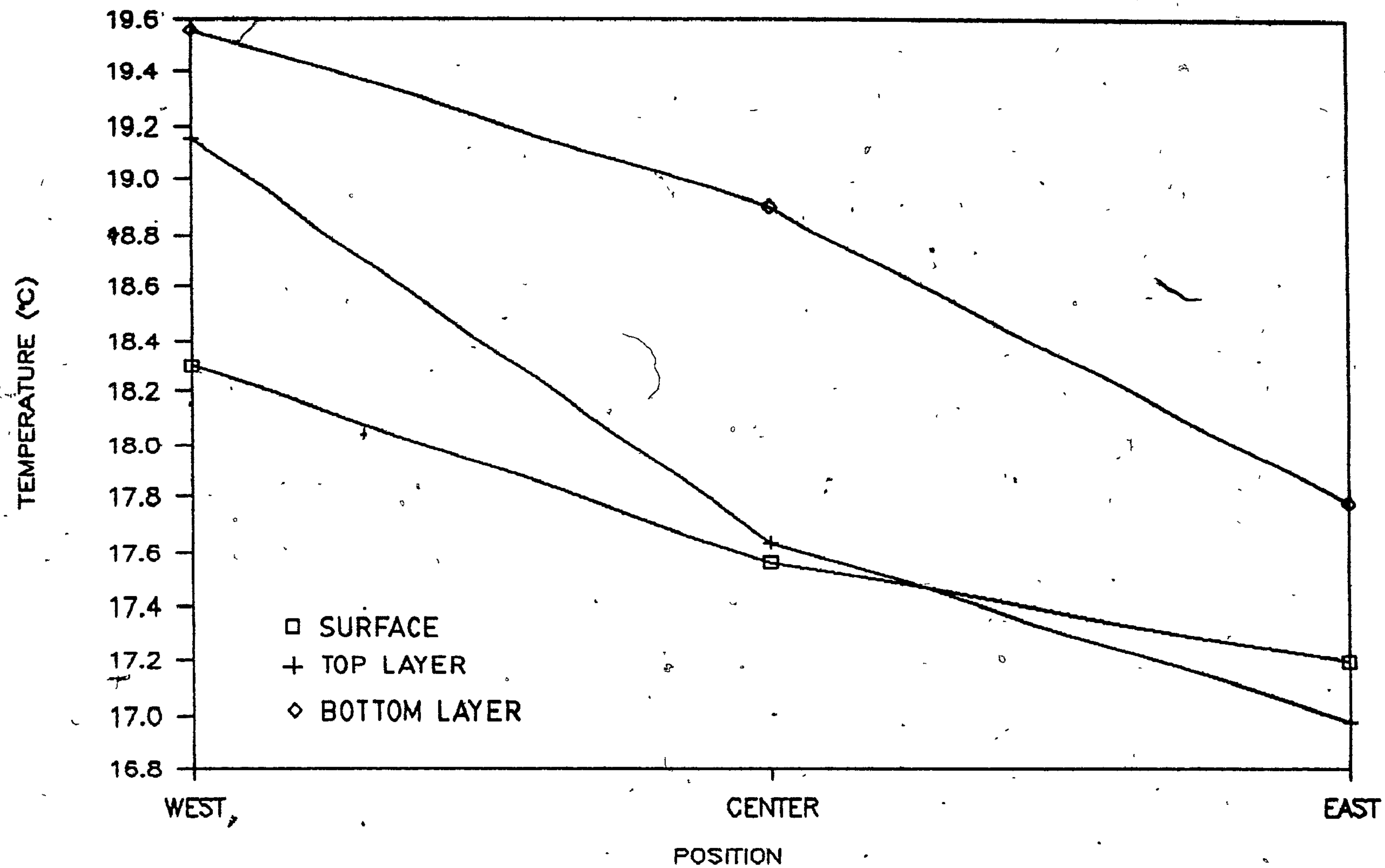


Figure 5.7 Soil longitudinal temperature profile during heat recovery in the fall of 1986.

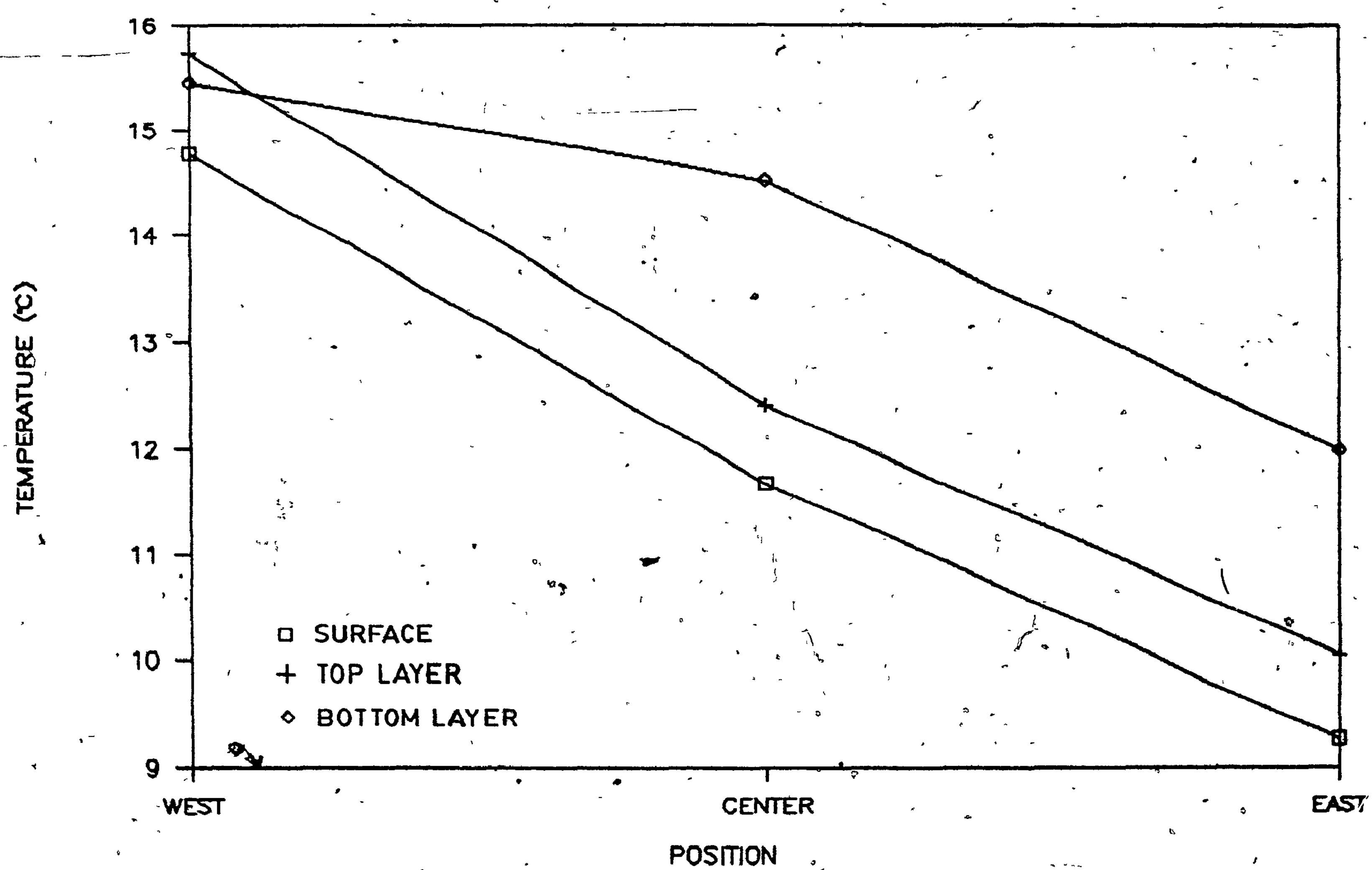


Figure 5.8 Soil longitudinal temperature profile at the end of fall.

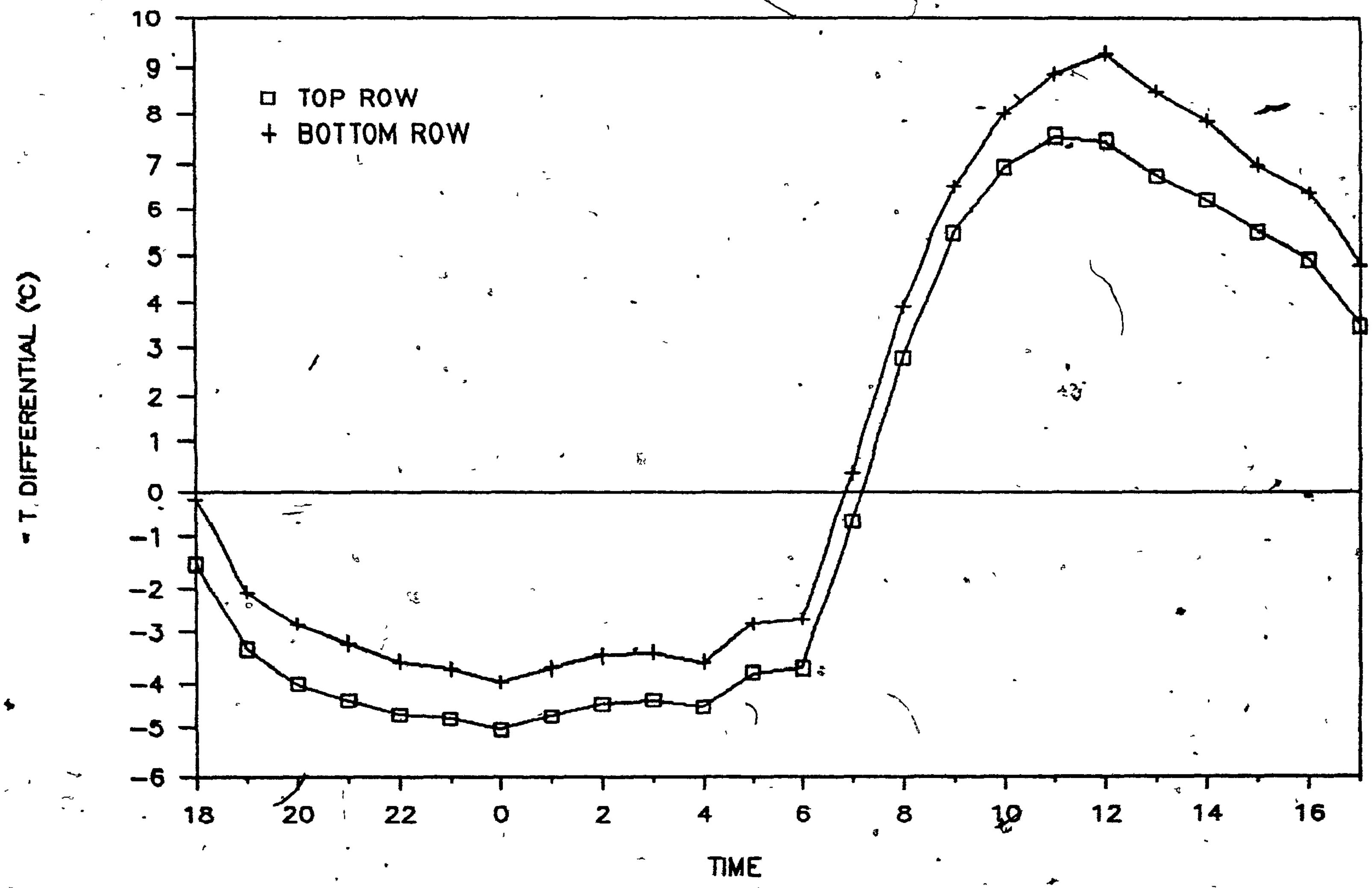


Figure 5.9 Daily variation of the temperature differential between the heat exchanger inlet and outlet.

prevent the operation of the system at higher temperature differentials.

During heat storage, after 4 hours of operation, the air temperature inside the pipes decreases rapidly between the pipe inlet, located at the west end of the greenhouse, and the pipe center, a temperature drop of 6°C was recorded. Between the pipe center and the pipe outlet, located at the east end of the greenhouse, the decrease was less steep, and the value was 2°C (Figure 5.10).

After 8 hours of operation, a similar profile is observed (Figure 5.11). As shown in Figures 5.10 and 5.11, it appears that the air circulated in the heat exchanger looses approximatly the 2/3 of its heat content in the first 5 meters of pipe. Since the top layer of soil is warmer than the bottom layer, the temperature differential between the air and soil rapidly approaches zero.

For heat recovery, the situation is reversed (Figure 5.12). After 8 hours of operation, the air-soil temperature differential being higher for the top row of pipes as compared with the bottow row, the heat exchange takes place on the full length of the top row pipes.

There is a good correlation (Figure 5.13) between the average soil temperature and the average air temperature inside the greenhouse. This further confirms that the system performance is limited by the maximum and minimum temperature conditions imposed by the crop. The soil temperature could get higher provided that a higher air temperature

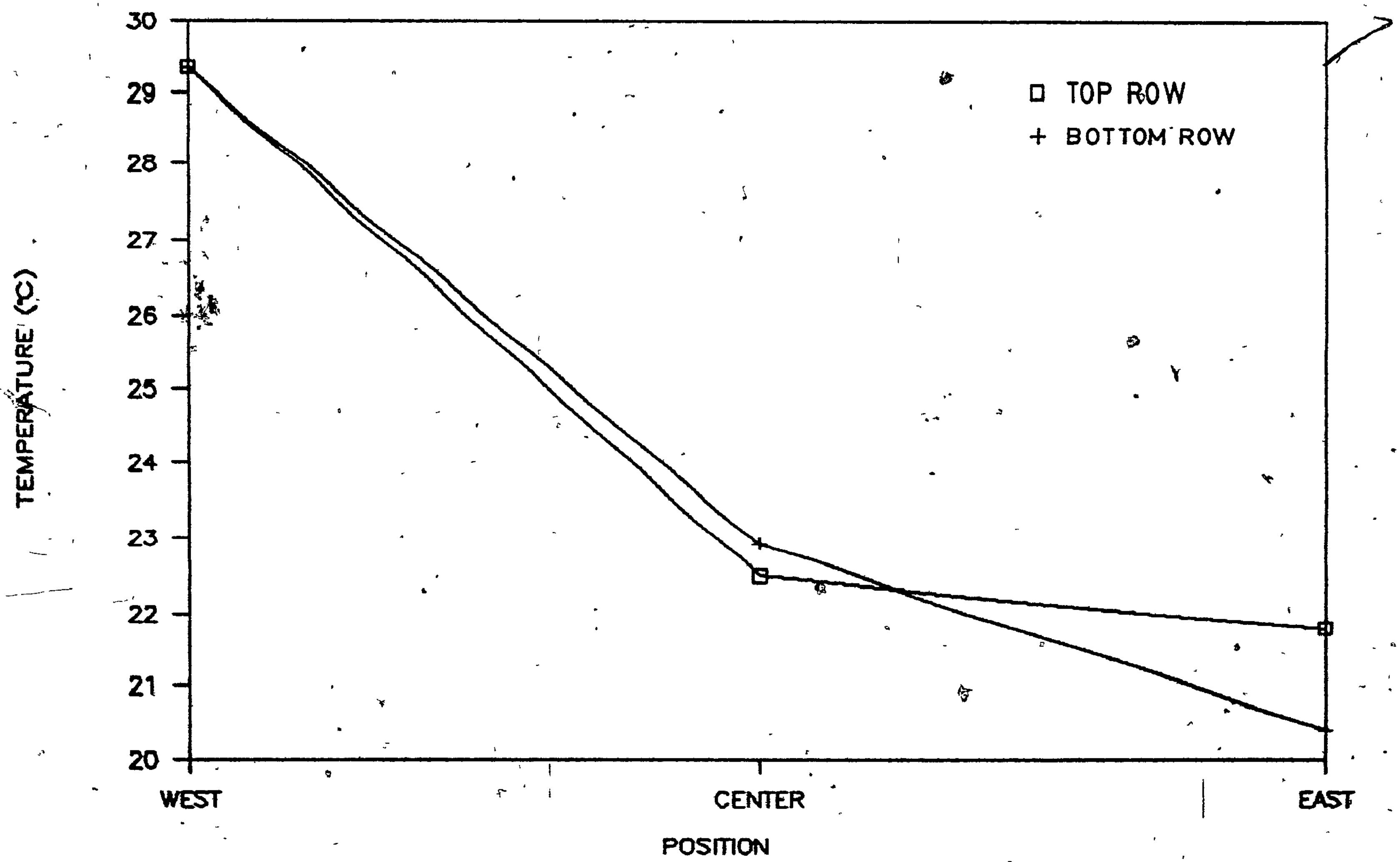


Figure 5.10 Air longitudinal temperature profile in the exchanger pipes, after 4 hours of heat storage.

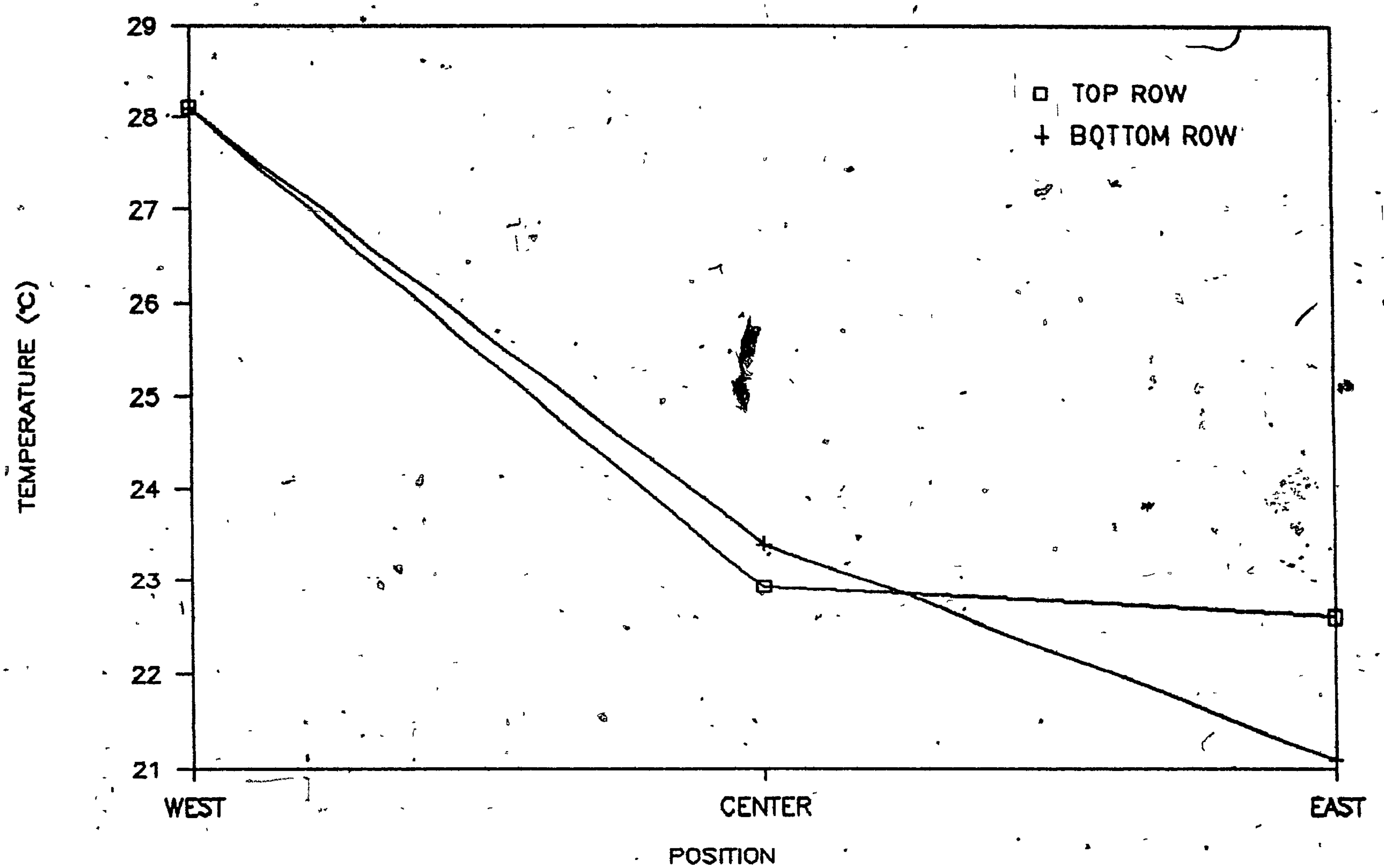


Figure 5.11 Air longitudinal temperature profile in the exchanger pipes, after 8 hours of heat storage.

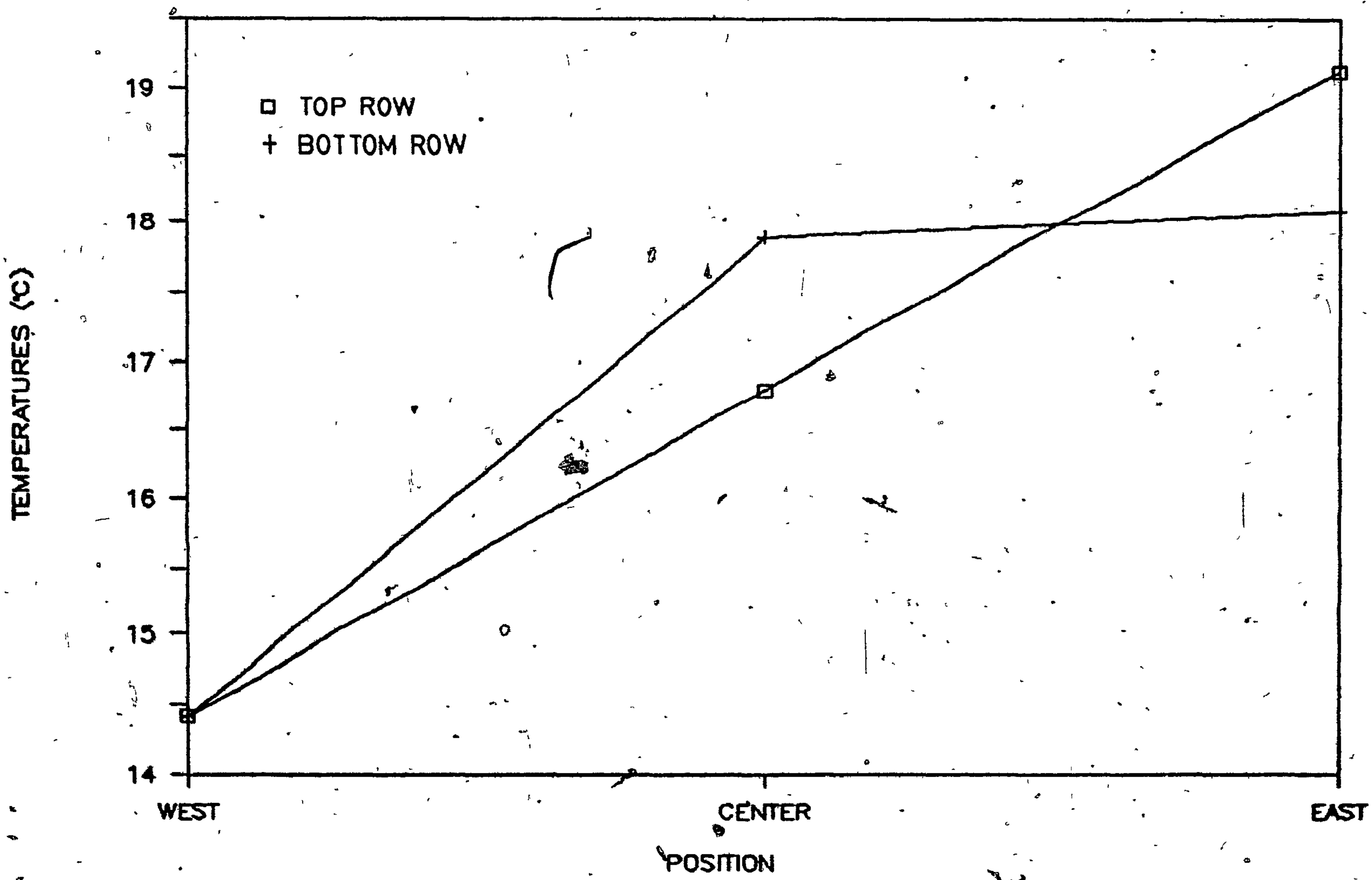


Figure 5.12 Air longitudinal temperature profile in the exchanger pipes after 8 hours of heat recovery.

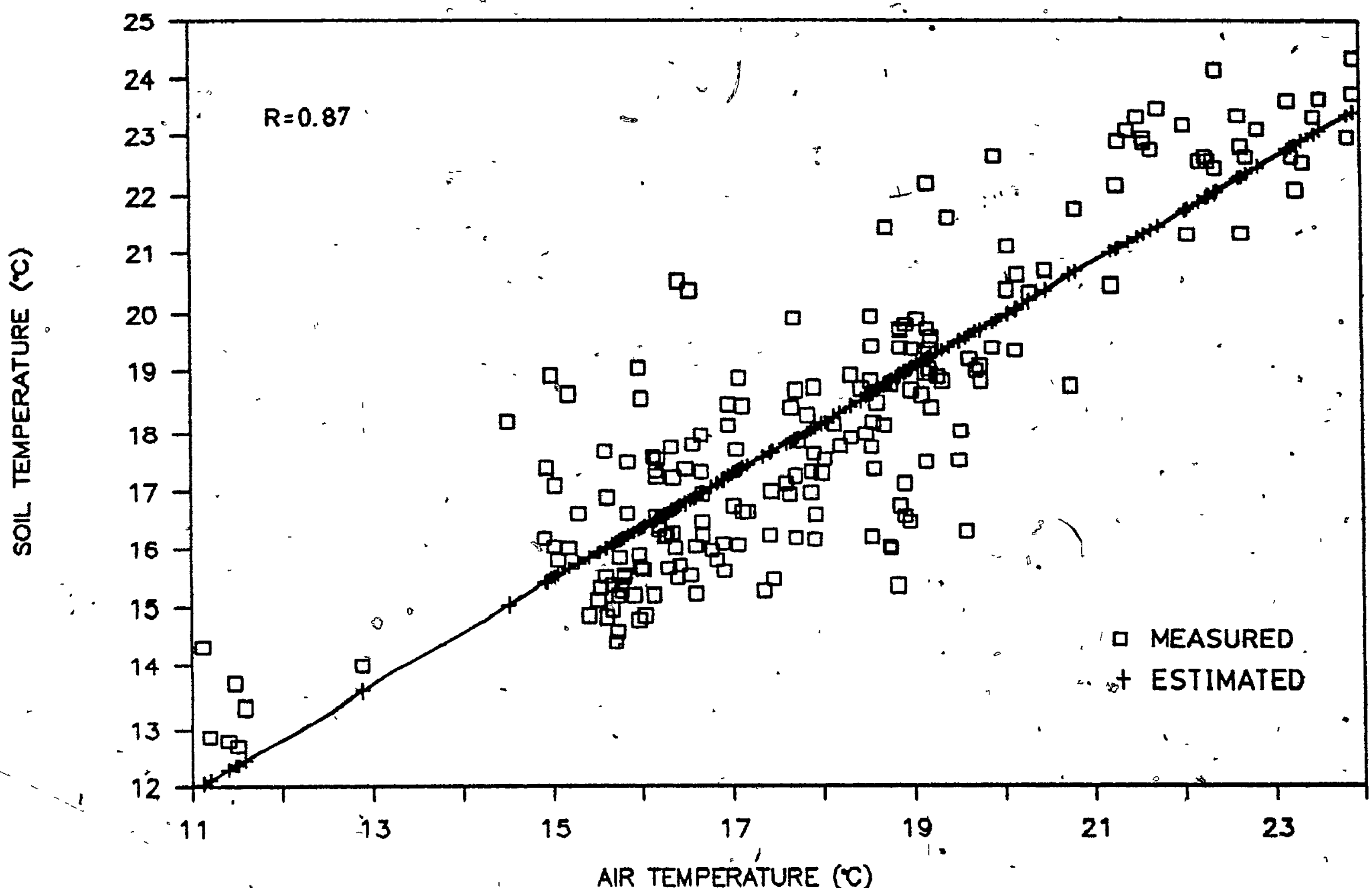


Figure 5.13 Soil-air temperature relationship.

could be allowed inside the greenhouse during the day. On the other hand, a lower air temperature at night would result in more heat recovered from the storage.

The previous results indicate that heat was stored and retreived from the thermal mass, but they do not give any indication on the efficiency of these operations. To find out, heat storage (SE) and recovery (RE) efficiency parameters were computed from equations 3.25 and 3.28 respectively; however, these parameters did not turn out to be good indicator of the system performance. Results for the month of May, shown in Table 5.9, extracted from Appendix D, indicate that these two parameters seem to fluctuate randomly. There is no apparent relationship between these two parameters and other system performance indicators.

Two apparent reasons might explain this fact. Firstly, the soil water content has not remained constant throughout the test period. For example, prior to each crop planting the soil was washed through, to decrease the salt content. The irrigation of plants was not perfectly uniform, resulting in soil water content spacial variability, mostly in the sand layer (Table 5.4). The soil water content of the top layer is affected by the amount of solar energy intercepted at the surface, as more energy is received, more evaporation heat losses take place. Since the soil thermal properties are highly dependent on the soil water content, it does not seem to be appropriate to assume that the soil water content remained constant on a daily basis. Secondly,

Table 5.9 Fluctuation of the heat storage and recovery parameters (May 1986)

Date	Greenhouse Heat Loss (kJ)	Solar Energy (kJ/m²)	Mean Soil Temp. (°C)	Storage Thermal Efficiency	Recovery Thermal Efficiency
01/05/86	840145	8794	19.0	0.58	0.50
02/05/86	1075260	14425	18.8	0.53	0.49
03/05/86	1117965	15772	19.4	0.48	0.37
04/05/86	705140	4346	18.9	0.55	0.79
05/05/86	766120	14606	18.5	0.54	0.66
07/05/86	758389	8411	17.3	0.72	0.83
08/05/86	800104	18570	18.2	0.48	0.37
09/05/86	467592	12669	19.4	0.57	0.35
10/05/86	467592	12669	19.4	0.57	0.35
11/05/86	1090588	17857	18.7	0.51	0.57
12/05/86	725217	19826	19.4	0.47	0.45
13/05/86	498945	19487	20.4	0.46	0.73
14/05/86	307479	19769	21.3	0.40	0.52
15/05/86	251637	14463	22.1	0.44	0.28
16/05/86	335847	11189	22.6	0.46	0.32
17/05/86	326645	13073	23.0	0.49	0.32
26/05/86	409772	22566	21.3	0.17	0.19
27/05/86	312650	17385	22.5	0.44	0.31
28/05/86	434188	18020	22.6	0.43	0.44
29/05/86	289021	13210	22.6	0.52	0.39
30/05/86	496851	15261	22.6	0.47	0.41
31/05/86	727238	19794	23.1	0.41	0.50

there is a time lag between the heat exchange from the pipes and the temperature variation within the thermal mass, due to the soil thermal diffusivity.

For example during heat recovery, the soil temperature in the bottom layer can continue to increase even if the soil temperature in the top layer has started to decrease.

A piezometer was installed in the greenhouse in order to monitor a potential water table inside the greenhouse thermal mass, that could affect the system performance. Regular measurements have indicated that the water table remained below the greenhouse footing and therefore, did not affect the thermal mass.

5.5.2 Dehumidification-humidification of the air

As shown in Figure 5.14, at night, the air relative humidity inside the greenhouse remains almost constant at approximatly 80 %. In the morning, when the thermal curtain is opened, the relative humidity level increases temporarily, as the air temperature increases, the air relative humidity decreases gradually.

The air relative humidity at the exchanger inlet follows a pattern similar to the air relative humidity inside the greenhouse. However, the relative humidity at the inlet is lower than that of the air inside the greenhouse, since the air temperature at the exchanger inlet is higher than the one inside the greenhouse.

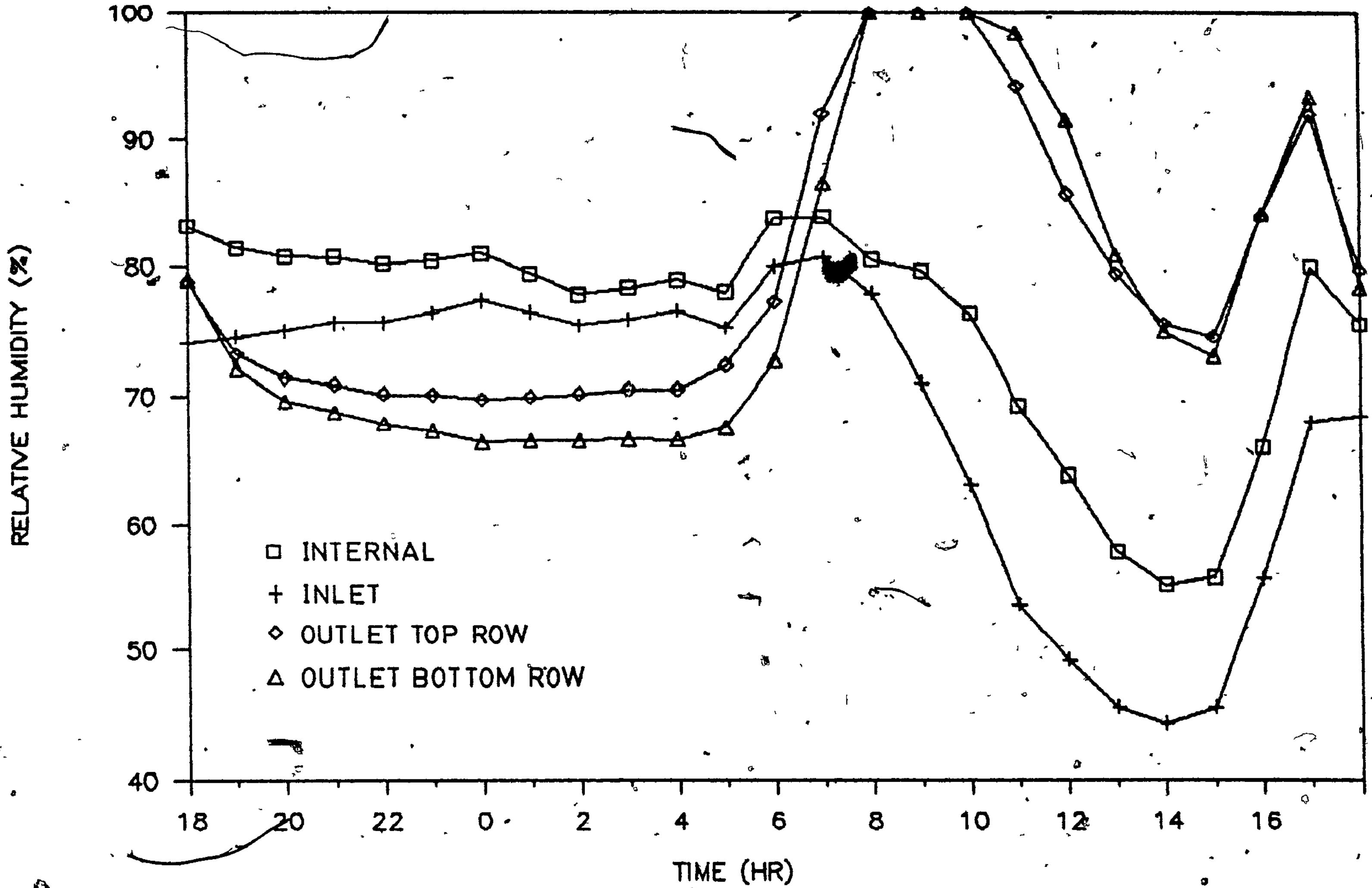


Figure 5.14 Air relative humidity daily variation.

At night, the air relative humidity at the exchanger outlet is lower than that of the inlet, since air is warmed as it gets through the exchanger; nevertheless, the relative humidity is almost constant. During the day, a pattern similar to the one obtained for the air inside the greenhouse is observed. The air relative humidity is higher at the outlet than at the inlet, since air is cooled as it gets through the exchanger. In the morning, saturation and condensation occur as long as the air relative humidity inside the greenhouse stays high. This is likely to happen when the thermal curtain opens; an important mass of saturated air is then introduced in the greenhouse and in the heat exchanger. As the air temperature increases in the greenhouse, the air relative humidity gradually decreases.

Visual inspections confirmed that the system dehumidifying effect is not negligible, mostly with the lower pipes located near the perimeter of the greenhouse. During spring and fall, important amounts of condensate were drained in the soil via the plenum floor. However, these amounts were not measured.

5.5.3 Heat Exchanger

A typical daily variation of the coefficient of performance (COP) computed from equations 3.34 and 3.35, is shown in Figure 5.15. At night, during heat recovery, the average COP is approximatly 4.0; however, at sunset and sunrise, the COP decreases below 1.0, and the system becomes inefficient.

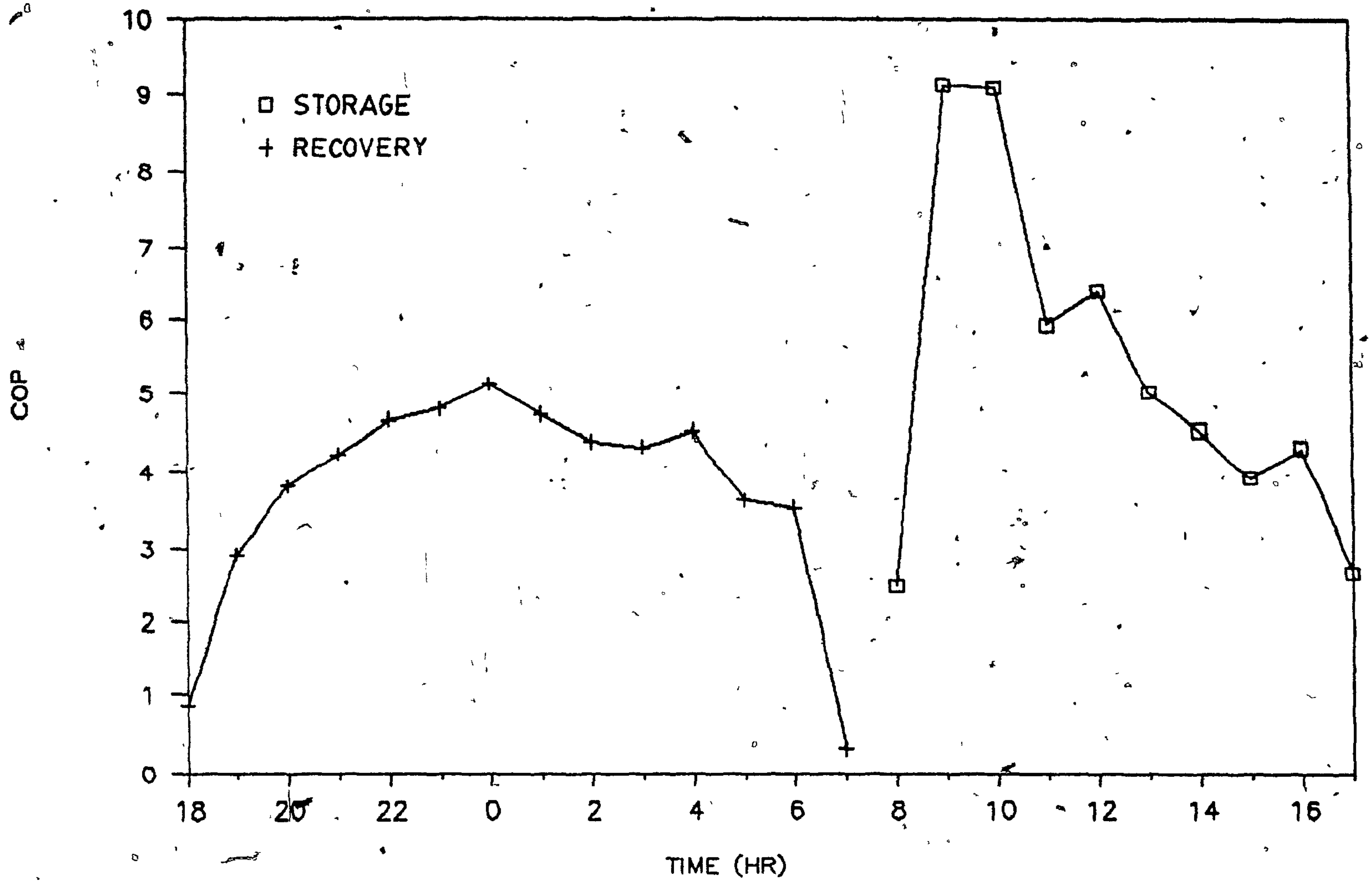


Figure 5.15 Daily variation of the coefficient of performance.

During daytime, the COP gradually decreases as more heat is stored in the thermal mass and somewhat follows a pattern of variation similar to the air temperature differential between the heat exchanger inlet and outlet.

The system operation was controlled by the temperature differential between the air in the upper part of the greenhouse near the heat exchanger inlet, and the soil. The higher the absolute differential, the higher the COP (Figure 5.16). A temperature differential above 6°C seems to be adequate for an efficient operation of the system.

The COP seems to be more influenced by the temperature differential between the air in the lower part of the greenhouse (below the thermal curtain position) and the soil (Figure 5.17), than by the temperature differential between the air in the upper part (above the thermal curtain position) and the soil, the coefficients of correlation being higher for the first case (Table 5.10).

When the thermal curtain is in operation, the system has its air intake below the curtain. This can explain the fact that a better correlation is obtained between the COP and the temperature differential between the air in the lower part of the greenhouse and the soil, for heat recovery. During heat storage, it seems that air from both the upper and lower part of the greenhouse west end, are mixed and circulated through the exchanger.

It is likely that a higher COP would be obtained if the air intake would be spread along the horizontal axis of the

Table 5.10 Effect of the temperature differential on the COP and on the heat exchanger efficiency

Parameter	Mode	Coefficient of correlation Temperature differentials Upper Part[1]	Lower Part[2]
COP	Storage	0.60	0.86
COP	Recovery	0.92	0.95
Efficiency	Storage	0.97	0.64
Efficiency	Recovery	0.95	0.99

1 between the air above the thermal curtain and the soil

2 between the air under the thermal curtain and the soil

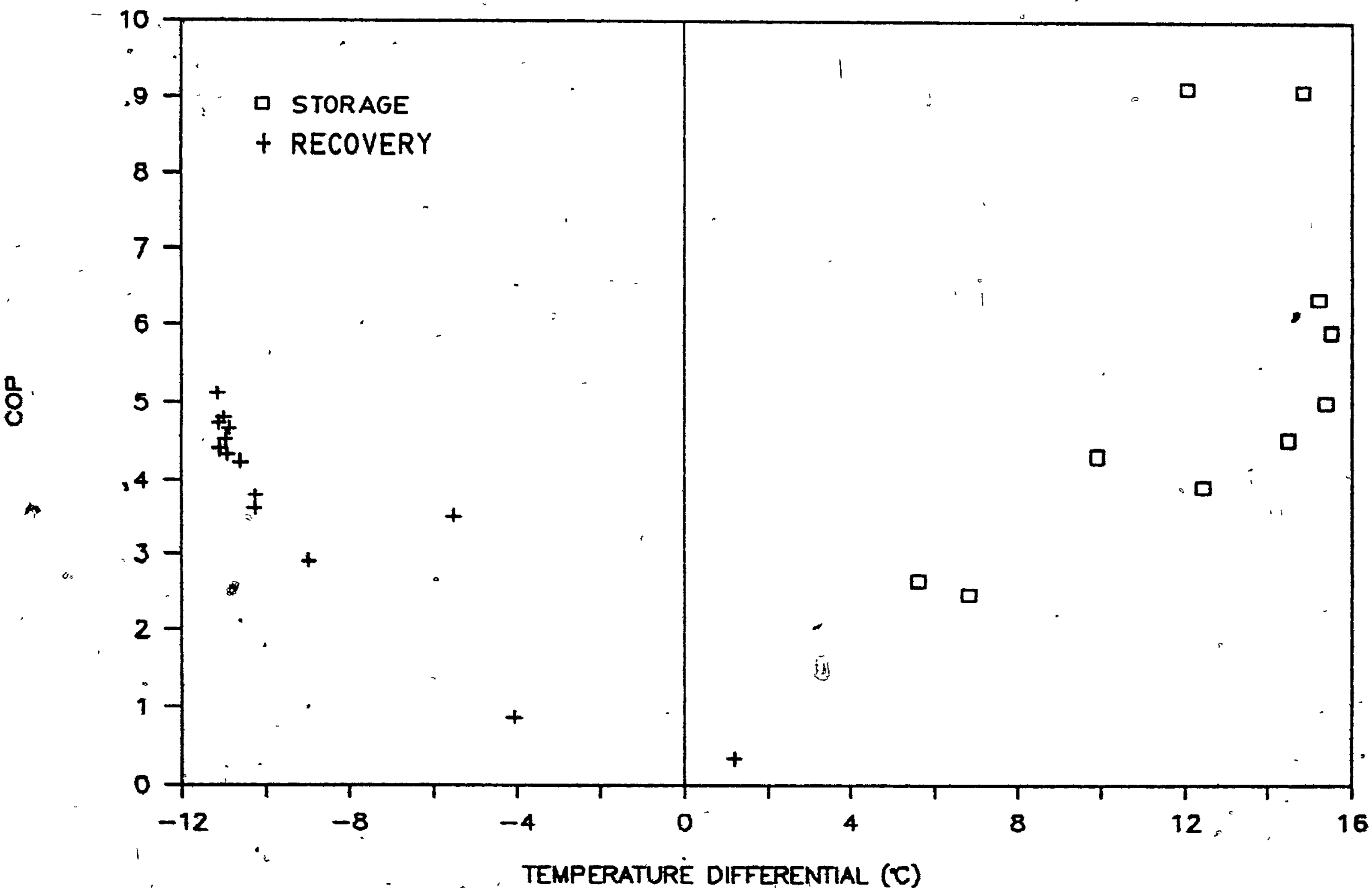


Figure 5.16 Effect of the temperature differential between the air at the blower inlet and the soil, on the COP.

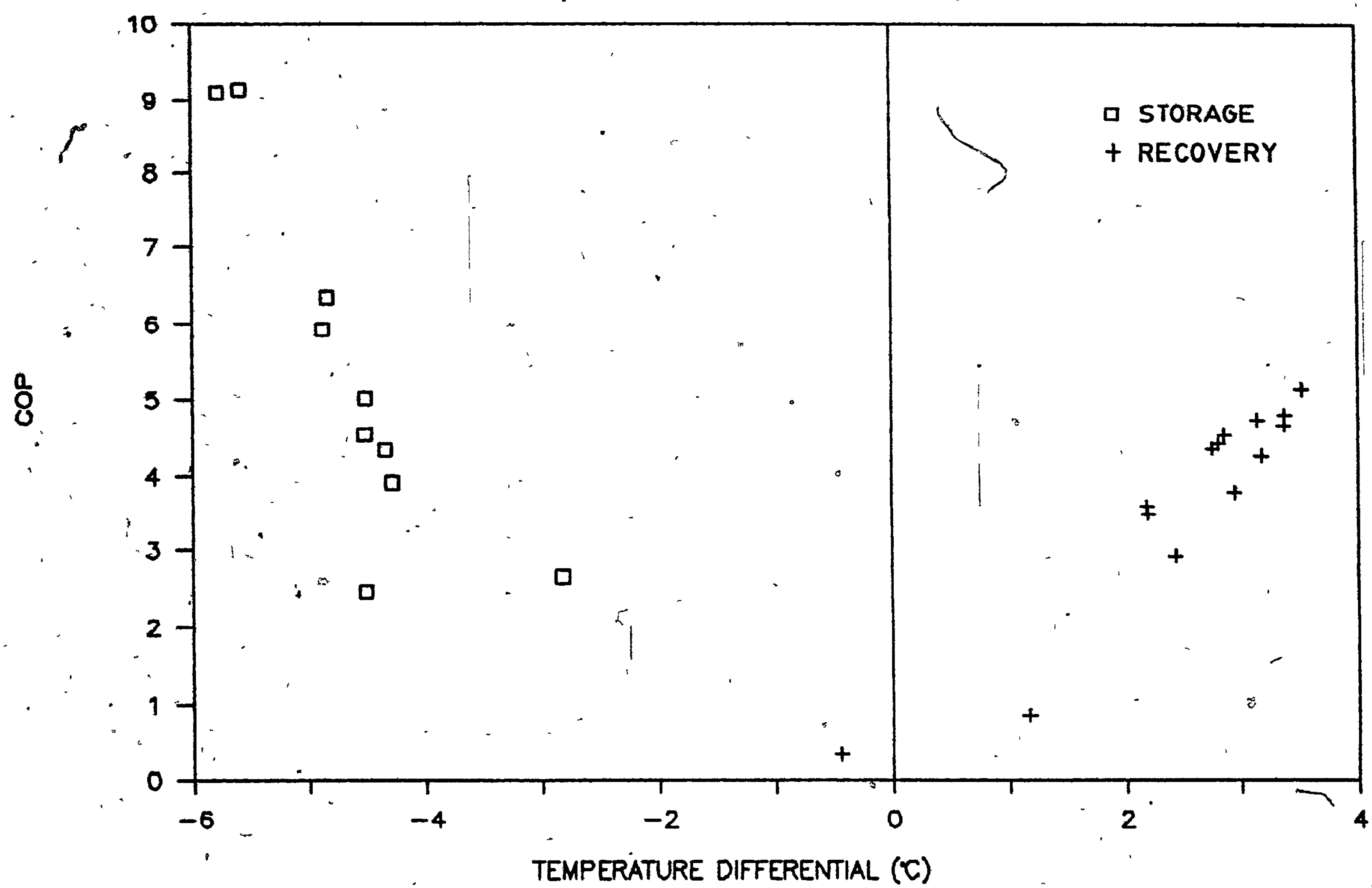


Figure 5.17 Effect of the temperature differential between the soil and the greenhouse air, on the COP.

greenhouse near the roof ridge. This would also result in a better correlation between the COP and the temperature differential between the air above the curtain and the soil.

Observations similar to those stated for COP, also apply to the heat exchanger efficiency computed from equations 3.32 and 3.33 (Figures 5.18 and 5.19). However, for heat storage, the correlation between the efficiency and temperature differential between the air in the upper ~~part~~ of the greenhouse and the soil, is higher than the one obtained between the efficiency and the temperature differential between the air in the lower part and the soil. The higher the temperature in the upper part, the higher is the temperature at the exchanger inlet; since the exchanger efficiency is computed (equation 3.33) from parameters such as the inlet temperature, the correlation is likely to be high between the efficiency and the temperature differential between the air from the upper part and the soil. For the same reason, during heat recovery, the correlation between the efficiency and the temperature differential between the air from the lower part and the soil, is likely to be high.

Figure 5.20 shows the ratio of the amount of energy recovered at the soil surface, over the total amount of energy recovered from both the soil surface and the heat exchanger, during the spring and fall of 1986 test periods.

From February to mid-April, the exchanger was operated during the day only, in order to rapidly increase the soil temperature for crop benefit. From mid-April to mid-June,

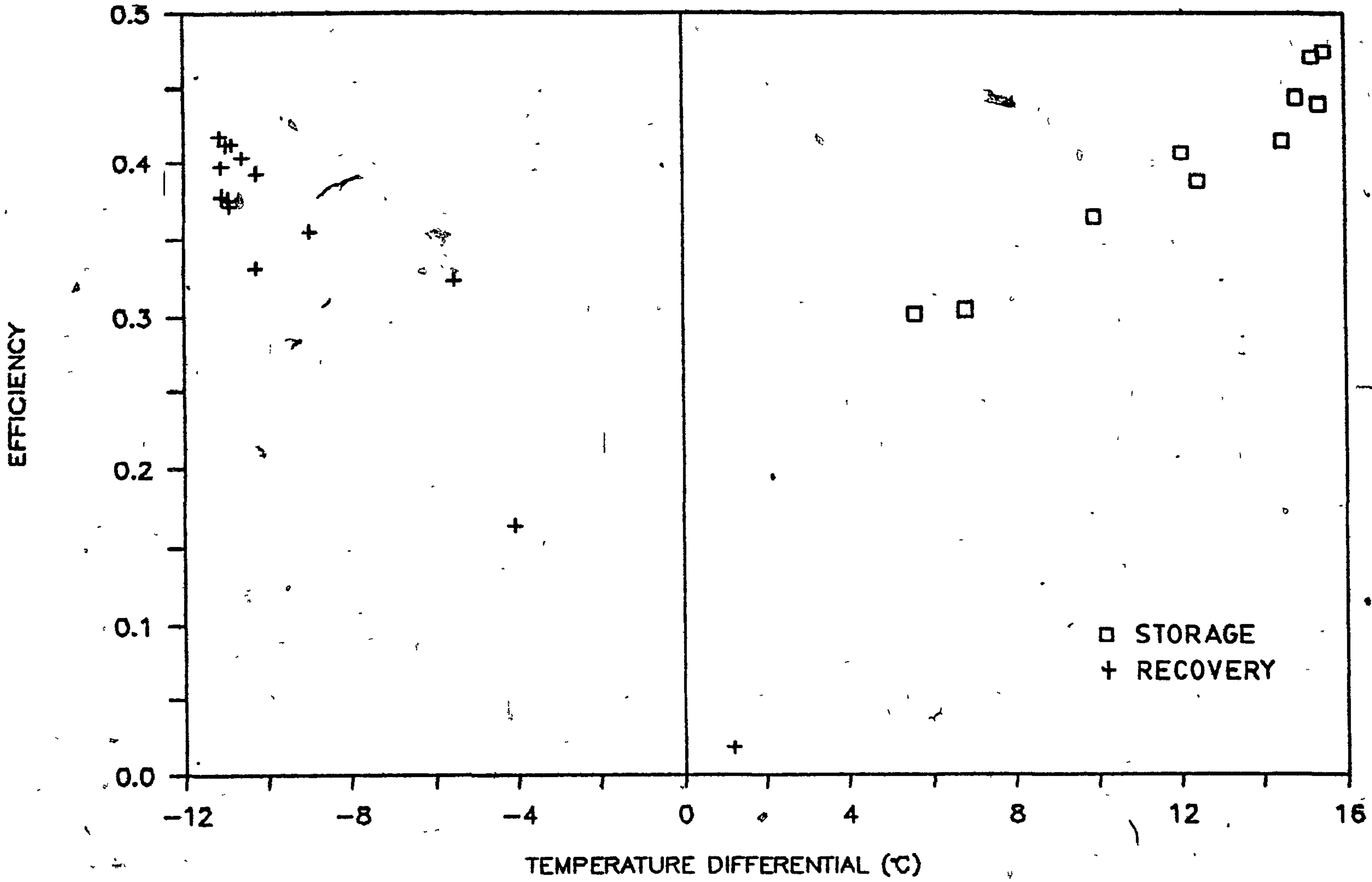


Figure 5.18 Effect of the temperature differential between the air at the blower inlet and the soil, on the efficiency.

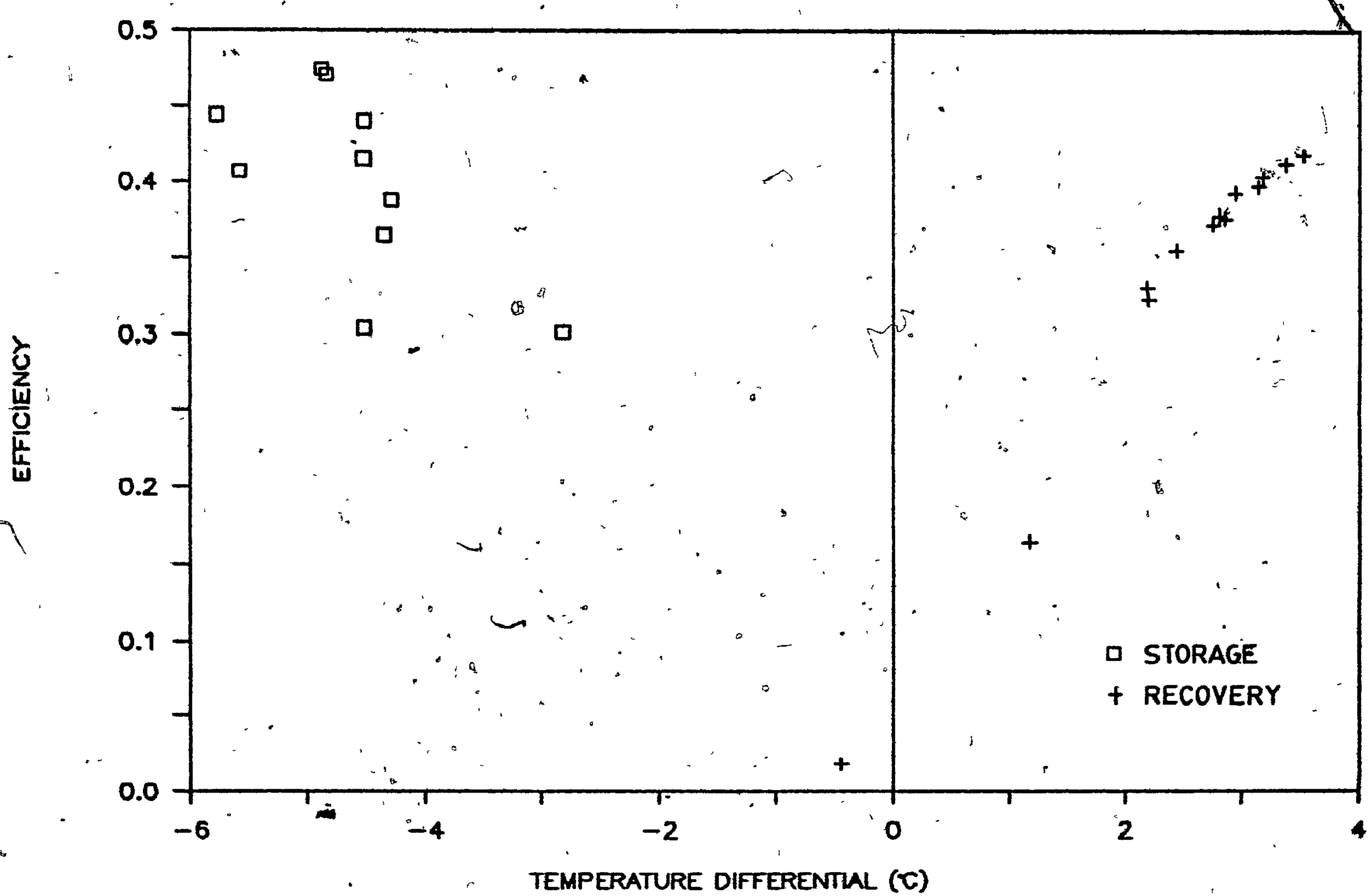


Figure 5.19 Effect of the temperature differential between the soil and the greenhouse air on the efficiency.

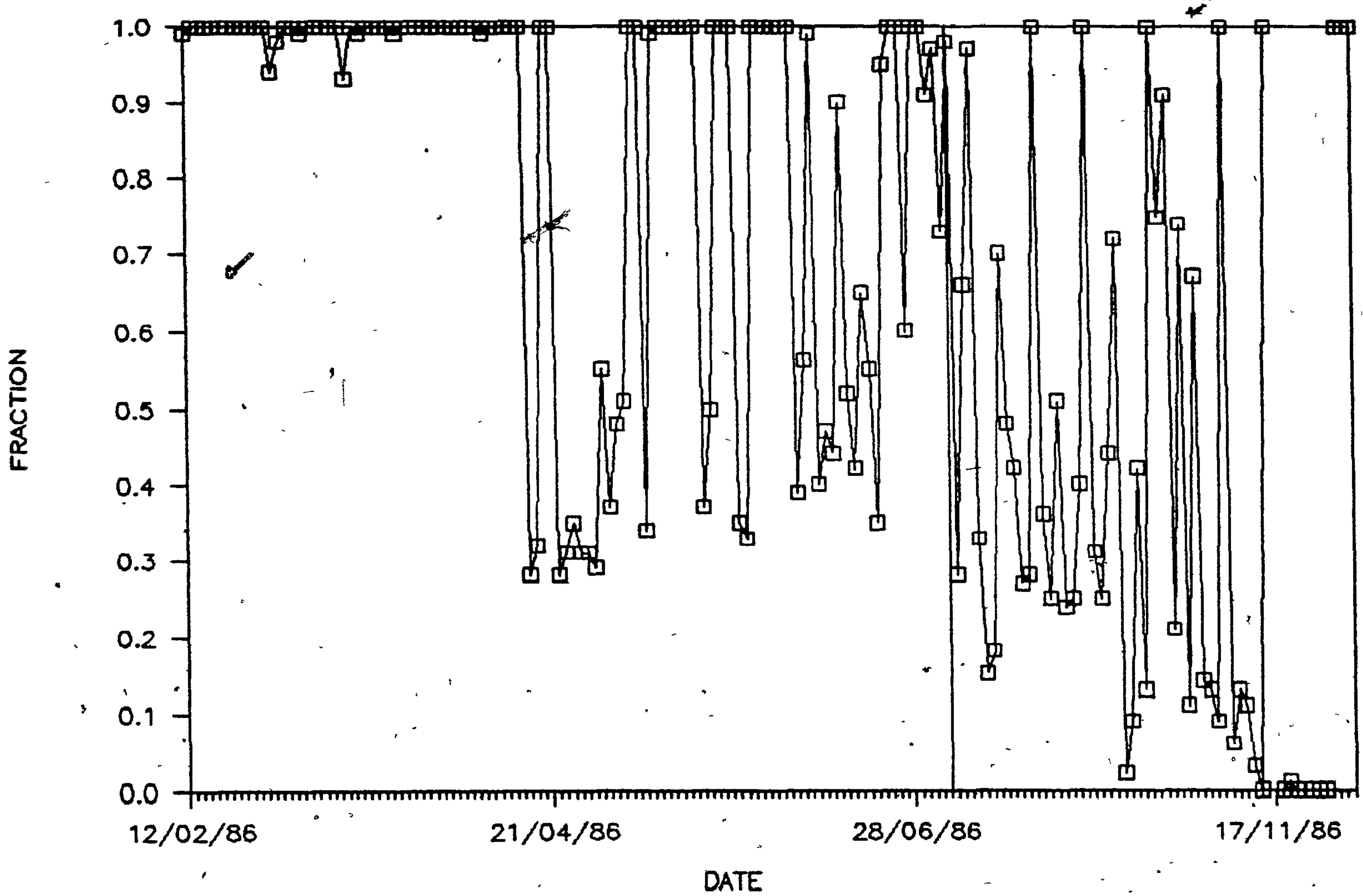


Figure 5.20 Ratio of the heat exchanger efficiency for the periods of February through July 1986 and September through November 1986.

the exchanger was operated day and night whenever the temperature differential between the air and the soil was sufficiently high. For that period, approximatly 40 % of the heat was recovered from the soil surface. This contribution went from approximatly 30 % in April to 50 % in June. During the Fall, the soil being colder, the contribution was estimated at 20 %, going from 50 % in September to 10 % in November.

Therefore, passive recovery at the soil surface seems to be substantial, provided that the convective heat transfer coefficient at the soil surface used, is a good estimate.

The heat exchanger efficiency is maximum in winter and in late fall for heat storage, since the thermal mass is relatively cool. As the temperature in the thermal mass increase, the efficiency decreases. On the contrary, for heat recovery, the efficiency becomes maximum in summer, since the soil is warmer (Figure 5.21).

5.5.4 Greenhouse Energy Consumption

The solar energy contribution to the greenhouse heat load computed from equation 3.1, does not seem to be as much influenced by solar radiation (Figure 5.22) as initially expected. However, as solar radiation increases, the exchanger cannot extract all of the surplus heat that is available and therefore, the ventilation is activated to evacuate some of the heat, maintaining that way an acceptable temperature for the plants.

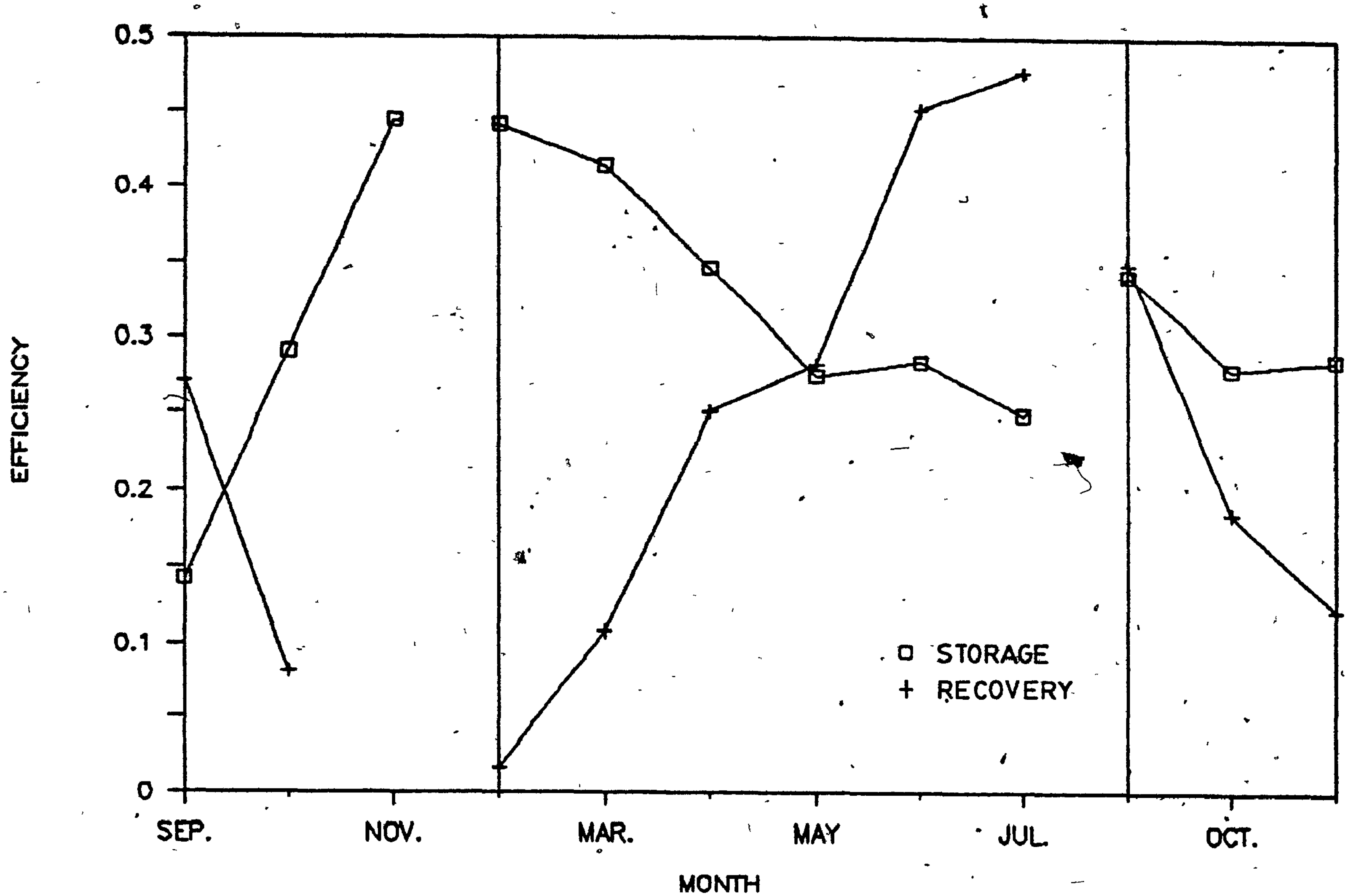


Figure 5.21 Variation of the heat exchanger efficiency for the periods of September through November 1985 and 1986, and February through July 1986.

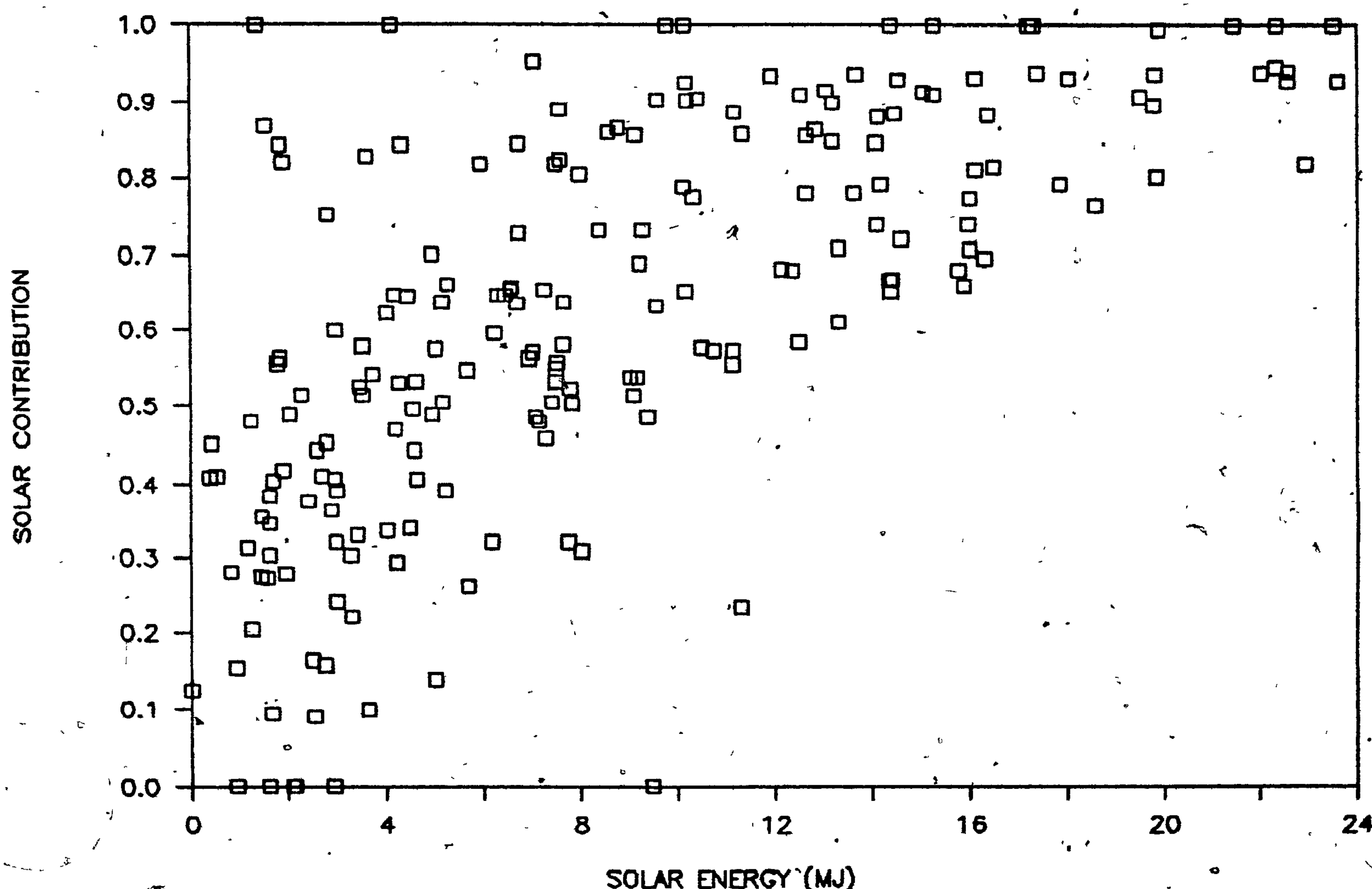


Figure 5.22 Effect of solar radiation on the solar contribution to the greenhouse heat load.

The same comment also applies for the air temperature in the lower part of the greenhouse, which follows a pattern of variation similar to solar radiation up to 21°C to 23°C, corresponding to the activation of the first ventilation stage (Figure 5.23).

There is a closer relationship between the average soil temperature and the solar contribution to the greenhouse heat load. Since the soil acts as a thermal mass, the warmer the soil, the more heat that can be recovered at night, resulting into more energy conservation on heating (Figure 5.24).

It appears that almost a 100 % of the greenhouse heat load can be provided by solar energy when the temperature of the thermal mass gets above 21°C. However, above 21°C, the stored heat is not used quite efficiently. For example, the temperature of the air inside the greenhouse at night has a tendency to remain higher than the minimum level recommended for a given crop.

Figure 5.25 shows that from March to July. The solar contribution went from 50 % to 100 %. One should note that the conventional greenhouses located in the La Pocatière region require auxiliary heat at night, even during summer. During the following fall season, the contribution decreased from 90 % to 30 % by the end of November 86.

From February to June and from September to November 1986, the overall solar contribution was estimated at 58 %; on the other hand, the contribution of the artificial

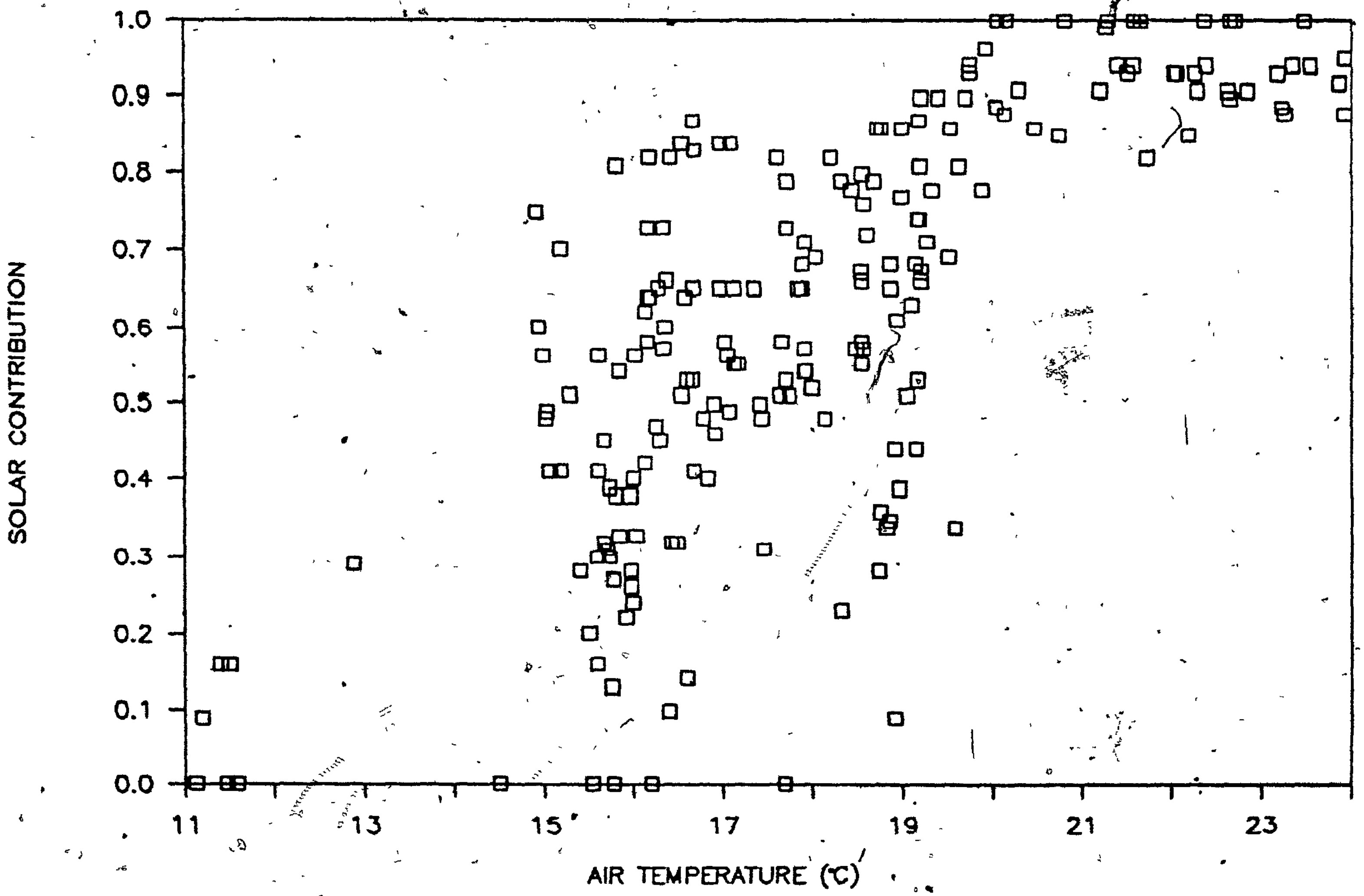


Figure 5.23 Effect of the greenhouse air temperature on the solar contribution to the greenhouse heat load.

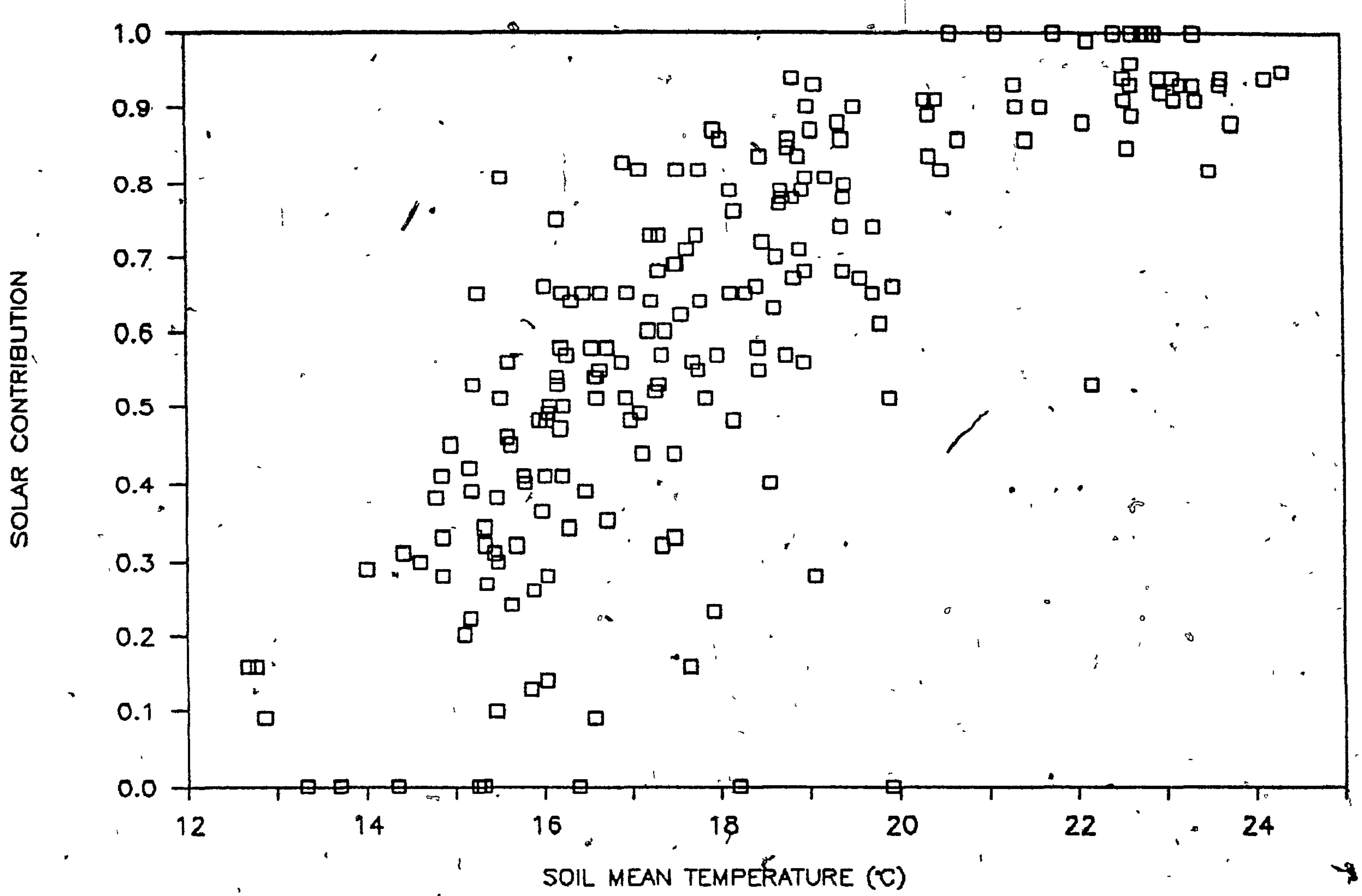


Figure 5.24 Effect of the soil temperature on the solar contribution to the greenhouse heat load.

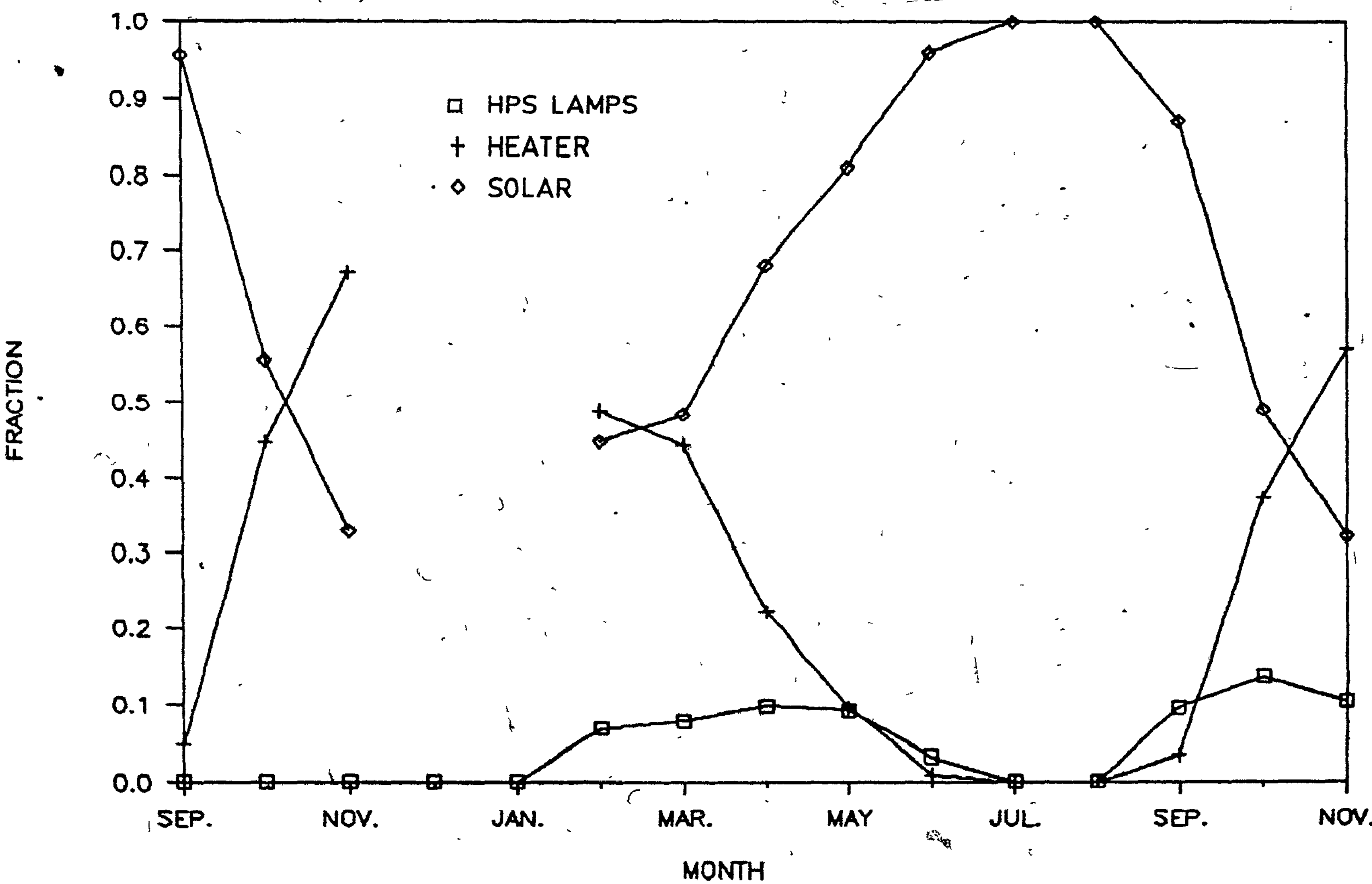


Figure 5.25 Variation in the contributions to the greenhouse heat load.

lighting system (equation 3.9) and the contribution of the heater (equation 3.5) were 7 % and 35 % respectively. Knowing that a conventionnal greenhouse gets 20 % to 25 % of its heating requirement from solar energy, the system might have resulted in an energy conservation of over 33 %.

One should note that the resulting performance of the system might not be representative of the full potential of the system, since it was not operated based on optimum conditions, as they are not known.

5.6 Tomato Crop

The tomato crops (Figure 5.26) were grown during the test period. The average yields were 7.4 kg/m^2 during the fall of 85 and 86, and 17.9 kg/m^2 during the spring of 1986, resulting in an overall yield of 25.3 kg/m^2. The crops were subjected to the conditions recommended by the C.P.V.Q. (1984), except for the spring nightime temperature which was maintained 2°C lower than the minimum temperature recommended.

In Quebec, the average yields for a greenhouse grown tomato crop are approximatly 5 and 10 kg/m^2 for the fall and the spring crop respectively, which accounts for a total of 15 kg/m^2 for both season.

However, even if standard conditions were imposed to the crop during the experiment, the higher yields obtained in the experimental greenhouse as compared with the provincial average, are not necessarily due to the soil heat

Figure 5.26 Tomato crop grown in the experimental greenhouse.

exchanger-storage system. Favorable climatic conditions, the use of a high light transmission glazing, the use of a microcomputer to control the greenhouse climate and the use of four HPS lamps might also have contributed to the higher yields. Therefore, the effect of the system on the crop yields cannot be assessed.

However, the general appearance of the plants and the stem and leaf dimensions, seem to indicate that the soil stored heat had a positive impact on the crops, but again this observation has not been verified experimentaly.

5.7 Payback period

The payback period estimates were computed according to different scenarios based on a commercial type greenhouse operation, as described in section 4.2.8. These estimates are presented in Table 5.11.

It can be seen that the payback period is strongly influenced by the capital cost involved and the system impact on plant productivity. The system becomes less cost effective when the capital cost involves the installation of the system and when the system does not contribute to enhance plant productivity, as it would be for plants grown on benches for example. On the other hand, a greenhouse owner installing himself the system could get a payback period of approximatly two years, based on energy conservation alone; further, the payback period could get below twelve months if the system enhances plant yields, as it appears to do for a soil grown tomato crop.

Table 5.11 Payback period estimation

Scenerio #	Auxiliary Heat Source	Initial Capital Cost ($)	Operation Cost ($)	Higher Plant Productivity Considered	Payback Period (years)
1	Heating oil	1593	0	No	2.2
2	Heating oil	3433	0	No	4.6
3	Heating oil	1593	222	No	2.6
4	Heating oil	3433	222	No	5.5
5	Heating oil	3433	222	Yes	0.9
6	Natural gas	3433	222	Yes	0.9
7	Wood chips	3433	222	Yes	1.0

VI SUMMARY AND CONCLUSIONS

The use of soil as a thermal mass inside a greenhouse has been studied in many countries, and many Japaneese greenhouse owners have installed soil heat exchanger storage systems in their greenhouses to lower their production costs. The technique seems to be cost effective in countries having a mild climate, but would the technique be interesting if implemented in colder climate?

The following conclusions can be drawn from the experiments conducted on such a system installed in a commercial type greenhouse located in La Pocatière, Québec.

During the test period, a seasonal temperature fluctuation of the thermal mass of approximatly 10°C was recorded. By early summer, the average temperature was 24°C, and by late fall, it decreased down to approximatly 15°C.

The temperature is relatively uniform throughout the thermal mass. Over a 10 m length, the average temperature differential between the west and the east end of the storage was 2°C.

An important fraction of the heat exchange takes place in the first five meters of the heat exchanger.

The average temperature of thermal mass correlates well to the average temperature of the air inside the greenhouse. Therefore, the system performance is limited by the maximum and minimum temperature conditions imposed by the crop. The effect of temperature being cumulative for a plant, the amount of heat stored and recovered might be improved if higher and lower temperatures were allowed for daytime and nightime respectively, as compared with those generally recommended; however, that approach would require more sophisticated means of temperature control (based on temperature integration), which are not readily available right now.

On a daily basis, the system efficiency parameters in terms of heat exchange, and temperature fluctuation in the thermal mass, did not turn out to be good indicators of the system performance.

From February to December 1986, the coefficient of performance (COP) of the system was 3.6. Therefore, the system used efficiently the electrical energy consumed for its own operation; however, the system becomes not efficient around sunset and sunrise and should not be operated for temperature differential between the air near the roof ridge and the soil, lower than 6°C. The system performance is better during heat storage than during heat recovery. The COP might probably increase provided that heat is collected along the full length of the greenhouse.

When the system is used for heat recovery, approximatly 30 % of the heat is recovered passively at the soil surface. The passive recovery of heat seems to be the appropriate mode of heat recovery during fall operation. For heat recovery, the maximum efficiency was encountered during summer. The average convective heat transfer coefficient in the heat exchanger is 0.012 $kW/m^2 \cdot K$, this value is similar to those listed in the literature, but for lower air velocities than the one used.

The use of a plastic mulch over the soil surface would likely increase the system efficiency, by reducing the evaporation heat loss from the storage.

The heat exchanger has a dehumidifying effect on the air circulated in the pipes. Visual observations as well as results confirmed this conclusion. In order to efficiently dehumidify the air, a slope should be provided to the pipes, so that the condensate would be drained in the soil while flowing in the plenum. However, more reliable results have to be obtained to further assess this aspect.

The solar energy contribution to the greenhouse heat load seems to be more influenced by the average soil temperature than by the average temperature of the air inside the greenhouse or by the solar radiation entering the greenhouse. This contribution has been estimated to be approximatly 100 % for a thermal mass temperature above 21°C.

For a typical operation (from February to June and from September to December 1986), the solar energy contribution to the greenhouse heat load was estimated at 58 % (excluding summer operation). For the same period, the contribution of the artificial lighting system and of the heater were 7 % and 35 % respectively. Knowing that solar energy normaly contributes from 20 % to 25 % of a greenhouse total heat load, the system provided a 33 % energy conservation.

More accurate estimates would require the comparison of energy consumptions between a control greenhouse and a similar greenhouse equipped with the soil heat exchanger-storage system, over a few years of operation.

From an agronomic point of view, the overall yield for the soil grown tomato crops has been 25.3 kg/m^2. Acording to the C.P.V.Q. (1984), the average yield in Québec for greenhouse produced tomatoes is 15 kg/m^2. However, the difference in yields, mostly observed on the spring crop, could be attributable in part to causes other than the high soil temperature related to heat storage. The effect of the soil heat exchanger storage system on the crop could not be measured, since no control greenhouse was available. However, qualitative observations made on the crop seems to indicate that the soil stored heat was beneficial to the plants.

A rough economic calculation indicates that for a commercial greenhouse heated with fuel oil, in which tomatoes are produced, the payback period for such a system would be two years, if the system is built by the greenhouse owner. Furthermore, if some increase in the yield due to the system is accounted for, the payback period decreases down to approximatly one year. However, a complete economic analysis should be done in order to verify that aspect.

It seems that this new energy conservation technique could be as easily implemented in existing greenhouses as in newly constructed ones. In addition to the energy savings obtained by reducing the nightime temperature and by recovering some of the stored heat, savings are also obtained on the electrical energy used for ventilation, since the air evacuation needs are reduced. It should also be noted that the experimental greenhouse was not equipped with a fan jet, since the heat exchanger blower was anticipated to play a similar role.

Such a system, might be effectively used in combination with an artificial lighting system. The heat released by it would delay the need to recover the stored heat, and extend the usefulness of the thermal mass. Furthermore, some of the excess heat released by the lighting system during the day, could also be stored. Such a storage system might also be used effectively in combination with a CO_2 enrichment system, since air evacuation needs are reduced. Burning gas enrichment systems also released a significant quantity of excess heat that could be stored for later use.

The soil heat exchanger-storage system seems to be appropriate for greenhouses located in cold climate, and could be adapted for different greenhouse production schemes, in order that soilless crop root zone could also benefit from the stored heat.

RECOMMENDATIONS

Because of the limitations of the present study, further investigations are required in order to assess all the impacts of this new technique. For example:

a study on the dehumidifation effect of the system could be performed on a laboratory setup, in order to quantify the sensible heat transfer and the amount of condensate generated for different air temperature and humidity conditions;

a comparative study between a control greenhouse and a greenhouse equipped with the system could be done, in order to evaluate the overall impacts on energy consumption and on crop yield, for different production schemes;

an economical study could be conducted, in order to determine the conditions that would guarantee the cost effectiveness of the system;

a mathematical model could be developped in order to simulate the thermal behavior of the system for different operating conditions;

comparison tests could be performed with and without a plastic mulch on the soil surface, in order to find out which approach is best;

a study could be done in order to evaluate the impacts of a soil heat exchanger storage system in combination with an artificial lighting system and/or with a CO_2 enrichment system.

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APPENDICES

APPENDIX A

Linear regression for the estimation of the average air temperature at the heater outlets

The average temperature of the air from the heater outlets (TOC) can be predicted from the following empirical equation based on the center outlet temperature (TCE) measurement:

$$TOHC = 1.0101 + 0.9527 \cdot TCE \qquad (5.1)$$

The Tables A.1, A.2 and A.3 show the data obtained from two test runs, the SAS program for computing the regression parameters and the summarized SAS regression analysis output.

Table A.1 Air temperature at the heater outlets

TNO[1] (°C)	TCE[2] (°C)	TSU[3] (°C)	TNO[1] (°C)	TCE[2] (°C)	TSU[3] (°C)
46.0	50.5	50.5	51.5	58.2	60.0
28.5	31.8	33.0	42.0	47.5	49.5
30.5	34.5	35.0	28.0	31.5	33.5
49.5	48.0	45.0	56.0	62.0	63.0
31.0	34.0	34.5	52.0	58.0	59.0
27.0	31.0	33.0	48.5	53.0	53.0
54.0	60.7	62.0	57.5	64.0	65.0
56.0	64.2	66.0	48.5	57.2	59.5
42.5	50.5	53.0	37.5	44.2	46.0
36.0	41.0	42.5	38.0	42.5	44.0
43.5	47.0	48.0	47.5	51.5	52.2
51.0	55.8	56.5	53.0	58.5	59.5
55.0	61.0	62.0	56.5	63.0	64.0
58.0	65.0	66.0	59.5	66.5	68.5
58.0	66.0	68.0	51.0	60.0	62.5
45.0	54.0	56.0	42.0	47.5	48.0
35.5	42.5	42.0	37.0	40.5	42.5
39.0	44.0	46.0	44.0	49.0	51.0
48.0	53.5	54.0	50.5	56.5	58.0
54.0	59.0	60.0	55.5	62.0	63.5
57.5	64.0	65.0	58.5	66.0	67.0
58.0	66.0	67.0	54.0	60.7	61.0
45.0	53.0	55.5	41.5	47.0	47.5
35.0	41.5	43.5	35.5	40.5	42.0
40.0	43.5	44.5	43.0	48.0	50.0
47.5	52.0	53.0	50.0	56.0	57.5
53.0	59.0	59.5	56.5	64.0	65.5
58.0	65.5	66.5	59.5	67.0	68.0
59.0	67.0	68.5	23.0	23.0	23.0
23.0	23.0	23.0	23.0	22.8	22.8
22.8	22.8	22.8	22.5	22.5	22.5
23.0	23.5	23.5	23.0	23.5	23.5
23.0	23.2	23.2	23.0	23.2	23.2
23.0	23.2	28.2			

1 outlet located along the north wall

2 oulet located on the greenhouse center line

3 outlet located along the south wall

Table A.2 SAS linear regression program for the estimation of the heater oulet mean air temperature

```
DATA TEMP;
INPUT TNO 9-12 TCE 18-21 TSU 27-30;
TOC=(TNO+TCE+TSU)/3;
CARDS;
PROC GLM DATA=TEMP;
MODEL TOC=TCE;
TITLE "LINEAR REGRESSION ON OUTPUT TEMPERATURE";
RUN;
QUIT;
```

Table A.3 Summarized SAS output for the estimation of the heater outlet mean air temperature

Parameter	Estimate	Probability	R^2
Model		(Pr>F)=0.0001	0.999165
Intercept	1.010101937	(Pr>|T|)=0.0001	
Slope	0.952654034	(Pr>|T|)=0.0001	

APPENDIX B

Data and results obtained from a heat loss test

Variables numbered from 1 to 73 and control actions numbered 1 and 2 are identified in Appendix E.

HEURES:	17	17	18	18	18	18	18	18	18	18	18	18	18	18	19	19	19	19	19	19	19	19	19	19
MINUTES:	50	55	0	5	10	15	20	25	30	35	40	45	50	55	0	5	10	15	20	25	30	35	40	45
BILAN #:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
TOT,ECHANT	12	9	8	9	8	9	9	8	9	8	9	8	9	9	8	9	8	9	9	8	9	8	9	8
DUREE:	284.9	311.2	285.9	310.3	285.0	311.2	310.6	285.3	310.3	285.7	310.3	285.2	310.0	311.2	285.1	310.1	284.9	311.1	310.5	285.0	311.0	285.0	310.3	284.9
DATE: 16-Nov-86																								
VARIABLES:	HPE#1	HPE#2	HPE#3	HPE#4	HPE#5	HPE#6	HPE#7	HPE#8	HPE#9	HPE#10	HPE#11	HPE#12	HPE#13	HPE#14	HPE#15	HPE#16	HPE#17	HPE#18	HPE#19	HPE#20	HPE#21	HPE#22	HPE#23	HPE#24
1	18.2	18.3	18.3	18.3	18.4	18.4	18.5	18.6	18.6	18.6	18.6	18.7	18.7	18.7	18.7	18.8	18.8	18.8	18.8	18.9	18.9	18.9	18.9	18.9
2	16.1	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.1	16.2	16.2	16.2	16.1	16.2
3	15.8	15.9	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8
4	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7
5	19.6	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	19.9	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
6	25.4	25.5	25.5	25.6	25.5	25.6	25.7	25.6	25.6	25.5	25.8	25.5	25.4	25.4	25.5	25.4	25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5
7	15.9	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0
8	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7
9	15.3	15.3	15.3	15.2	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.2	15.3	15.2	15.3	15.3	15.3	15.3	15.3
10	14.6	14.7	14.8	14.8	14.7	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.7	14.8	14.8	14.7	14.7	14.8
11	15.6	15.6	15.6	15.6	15.6	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.7	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8
12	65.9	65.9	65.9	65.9	65.9	65.9	65.9	65.9	65.9	65.9	65.9	65.9	65.9	65.9	65.9	65.9	66.0	65.9	65.9	66.0	66.0	66.0	66.0	66.0
13	15.3	15.3	15.3	15.3	15.4	15.4	15.3	15.3	15.3	15.3	15.4	15.3	15.3	15.4	15.3	15.3	15.3	15.3	15.3	15.4	15.3	15.3	15.3	15.3
14	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.1	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2
15	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1
16	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.1	16.1	16.0	16.1	16.1	16.1	16.2	16.1	16.1	16.1	16.2	16.1	16.1	16.1	16.2	16.2
17	13.0	12.9	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	12.9	12.9	13.0	13.0	12.9	12.9	12.9	12.9	12.9	12.9	12.9	12.9
18	12.6	12.6	12.7	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6
19	-2.7	-2.7	-2.7	-2.8	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.8	-2.7	-2.8	-2.7	-2.7	-2.7	-2.7	-2.7	-2.8	-2.7
20	14.8	14.8	14.8	14.8	14.7	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8
21	15.3	15.2	15.3	15.2	15.3	15.3	15.3	15.2	15.3	15.3	15.3	15.2	15.2	15.2	15.2	15.3	15.2	15.3	15.2	15.2	15.2	15.2	15.2	15.2
22	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
23	13.0	13.5	13.7	13.5	13.6	13.9	14.1	13.6	13.6	13.9	14.0	13.6	13.7	13.9	13.6	13.6	13.8	13.9	13.6	13.8	14.0	13.8	13.6	13.8
24	11.5	11.9	12.4	12.2	12.2	12.6	12.7	12.3	12.4	12.5	12.6	12.2	12.3	12.6	12.2	12.1	12.4	12.5	12.2	12.3	12.6	12.3	12.1	12.4
25	12.5	12.9	13.6	13.3	13.2	13.9	14.0	13.3	13.2	13.8	13.8	13.2	13.4	13.9	13.4	13.2	13.7	13.8	13.2	13.5	14.0	13.5	13.2	13.7
26	11.5	11.9	12.4	12.2	12.1	12.6	12.7	12.2	12.1	12.6	12.6	12.1	12.2	12.5	12.2	12.1	12.4	12.4	12.1	12.3	12.6	12.2	12.1	12.4
27	15.2	15.0	15.1	15.2	15.0	15.0	15.2	15.2	15.1	15.1	15.2	15.4	15.1	15.1	15.2	15.1	15.1	15.2	15.2	15.0	15.1	15.2	15.1	15.1
28	15.1	15.0	15.2	15.0	15.0	15.1	15.1	15.0	15.1	15.2	15.1	15.0	15.1	15.1	15.0	15.0	15.1	15.1	15.0	15.0	15.1	15.0	15.0	15.1
29	15.3	15.3	15.3	15.3	15.4	15.4	15.4	15.3	15.3	15.3	15.4	15.4	15.3	15.4	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3
31	12.6	17.2	16.0	15.2	17.5	17.5	15.9	14.9	17.4	17.1	15.7	15.6	17.4	16.1	15.1	17.3	17.0	15.6	15.9	17.6	16.4	15.2	17.1	16.8
32	-2.4	13.9	13.4	12.8	14.0	14.2	13.4	12.8	13.9	14.0	13.2	12.9	14.0	13.4	12.7	13.7	13.9	13.1	13.0	14.1	13.5	12.8	13.6	13.7
33	17.2	-2.5	-2.5	-2.6	-2.6	-2.5	-2.5	-2.6	-2.6	-2.6	-2.6	-2.5	-2.6	-2.6	-2.6	-2.7	-2.7	-2.7	-2.7	-2.8	-2.8	-2.8	-2.7	-2.8
34	15.6	17.1	17.1	17.1	17.1	17.1	17.2	17.1	17.2	17.2	17.2	17.2	17.2	17.2	17.1	17.2	17.2	17.2	17.2	17.1	17.2	17.2	17.2	17.1
35	16.2	15.6	15.6	15.6	15.6	15.6	15.7	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.7	15.6	15.6	15.6	15.6	15.6	15.6
36	16.1	16.2	16.2	16.2	16.2	16.2	16.3	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.1	16.2	16.2	16.2	16.2	16.2	16.2	16.2
37	16.2	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1
38	15.5	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2
39	15.3	15.5	15.6	15.5	15.6	15.5	15.5	15.5	15.5	15.5	15.6	15.5	15.5	15.5	15.5	15.7	15.5	15.5	15.6	15.5	15.5	15.5	15.5	15.5
40	15.1	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.3	15.2	15.2	15.3	15.2	15.3	15.3	15.3	15.3	15.3
41	15.0	16.2	16.2	15.5	16.2	16.9	16.9	15.5	16.1	16.7	16.1	15.5	16.5	16.3	15.6	16.1	16.7	16.1	15.6	16.7	16.5	15.7	16.1	16.6
42	63.4	15.1	15.0	15.1	15.0	15.1	15.1	15.1	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.1	15.0	15.0	15.0	15.0	15.0	15.0
43	14.4	63.4	63.4	63.4	63.4	63.4	63.4	63.4	63.4	63.4	63.4	63.4	63.4	63.4	63.4	63.4	63.4	63.4	63.4	63.4	63.4	63.4	63.4	63.4
44	11.5	14.5	14.4	14.5	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4
45	2.4	11.5	11.4	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5
46	3.7	2.4	2.4	2.4	2.4	2.5	2.4	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.5	2.4	2.4	2.4	2.4
47	1.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7
48	11.9	1.7	1.7	1.6	1.6	1.7	1.7	1.7	1.6	1.6	1.7	1.6	1.6	1.6	1.6	1.6	1.7	1.6	1.6	1.6	1.7	1.7	1.7	1.6
49	16.9	12.7	13.0	12.7	12.8	13.5	13.3	12.7	12.8	13.3	13.1	12.6	13.0	13.1	12.8	12.7	13.2	13.0	12.6	13.2	13.2	12.6	12.5	13.0
50	15.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	17.0	16.9	16.9	16.9	16.9	16.9	16.9	16.9

117

HEURES:	17	17	18	18	18	18	18	18	18	18	18	18	18	18	19	19	19	19	19	19	19	19	19	19
MINUTES:	50	55	0	5	10	15	20	25	30	35	40	45	50	55	0	5	10	15	20	25	30	35	40	45
BILAN #:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
TOT.ECHANT	12	9	8	9	8	9	9	8	9	8	9	8	9	9	8	9	8	9	9	8	9	8	9	8
DUREE:	284.3	311.2	285.9	310.3	285.0	311.2	310.6	285.3	310.3	285.7	310.3	285.2	310.0	311.2	285.1	310.1	284.9	311.1	310.5	285.0	311.0	285.0	310.3	284.9
DATE: 16-Nov-86																								
VARIABLES:	HPE#1	HPE#2	HPE#3	HPE#4	HPE#5	HPE#6	HPE#7	HPE#8	HPE#9	HPE#10	HPE#11	HPE#12	HPE#13	HPE#14	HPE#15	HPE#16	HPE#17	HPE#18	HPE#19	HPE#20	HPE#21	HPE#22	HPE#23	HPE#24
51	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9
52	12.5	15.8	15.9	16.0	15.9	15.8	15.8	15.8	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.8	15.9	15.9	15.9	15.9	15.9	15.9
53	29.1	13.3	13.7	13.2	13.5	14.2	13.9	13.2	13.5	14.2	13.8	13.3	13.8	14.0	13.3	13.5	14.2	13.8	13.3	14.0	14.2	13.5	13.4	14.1
54	13.6	34.5	22.5	21.8	41.2	28.9	19.9	19.8	38.7	27.4	19.5	28.1	34.0	22.0	20.5	39.0	27.4	19.4	31.4	34.6	22.7	19.8	37.4	26.8
55	15.4	15.8	16.0	15.3	16.0	17.1	16.5	15.4	16.0	16.8	16.1	15.4	16.6	16.6	15.5	15.9	16.6	15.9	15.3	16.6	16.4	15.4	15.8	16.6
56	33.0	17.7	16.3	15.1	18.1	18.2	16.0	14.8	17.7	17.5	15.7	15.6	17.9	16.3	14.9	17.7	17.5	15.6	16.1	18.3	16.6	15.1	17.5	17.3
57	24.4	37.0	24.0	24.4	45.7	30.6	21.4	22.3	43.2	29.1	21.0	32.3	36.7	23.6	23.0	43.4	29.1	20.9	36.0	36.9	24.2	22.0	41.6	28.4
58	28.0	24.7	24.8	24.7	24.7	24.8	25.0	24.7	24.8	24.6	25.0	24.5	24.5	24.5	24.5	24.5	24.5	24.6	24.4	24.7	24.6	24.5	24.5	24.5
59	2.5	31.8	21.2	21.2	38.2	26.9	19.0	19.4	36.1	25.6	18.6	27.3	31.5	20.9	20.1	36.3	25.6	18.6	30.3	31.9	21.5	19.3	34.9	25.1
60	1.9	1.4	1.1	1.3	1.3	0.7	-0.1	1.1	1.2	1.6	0.1	2.2	2.0	2.1	2.0	2.1	2.1	1.8	2.3	1.4	1.4	2.1	2.1	2.2
61	74.2	1.0	0.7	0.9	1.0	0.4	-0.3	0.8	1.6	1.4	1.5	4.8	3.8	6.0	1.9	2.2	4.4	1.9	3.3	1.3	1.6	1.8	1.7	1.6
62	98.5	69.3	74.9	76.9	68.1	70.3	75.8	78.8	68.3	71.4	75.7	74.4	68.8	73.7	76.1	67.7	70.6	75.1	72.7	67.8	72.6	75.6	68.2	70.9
63	83.8	100.2	100.5	98.3	99.6	100.8	98.8	98.0	99.8	101.1	98.6	96.2	100.0	100.5	97.7	99.2	100.3	99.6	97.8	99.8	100.1	97.5	99.8	100.5
64	88.3	82.8	85.9	85.8	85.3	85.7	85.5	85.7	87.3	86.1	85.3	85.1	84.6	85.7	84.8	84.3	84.8	84.5	85.0	84.2	84.7	84.5	84.2	84.9
65	-0.4	88.5	87.2	88.8	89.0	86.7	87.1	88.6	88.6	86.8	86.9	88.4	87.8	86.0	87.1	88.1	86.2	85.6	87.6	87.1	85.2	86.6	87.8	86.1
66	17.6	1.6	0.4	-0.5	1.9	1.8	0.3	-0.8	1.7	1.4	.0	-0.2	1.7	0.4	-0.7	1.5	1.3	-0.1	0.1	1.8	0.6	-0.6	1.2	1.0
67	89.0	19.3	7.8	3.3	27.5	12.4	5.4	7.5	25.5	11.6	5.3	16.7	18.8	7.3	8.1	25.6	11.6	5.3	19.9	18.6	7.6	6.9	24.1	11.1
68	82.4	90.0	90.4	90.2	90.2	90.8	91.5	90.4	90.4	89.9	91.4	89.4	89.5	89.7	89.5	89.4	89.4	89.8	89.1	90.1	90.1	89.4	89.4	89.3
69	1.3	90.8	91.1	90.9	90.9	91.5	92.3	91.2	91.1	90.7	92.2	90.1	90.2	90.4	90.3	90.1	90.2	90.5	89.9	90.9	90.9	90.2	90.3	90.1
70	83.6	0.8	0.6	0.8	0.7	0.4	0.1	0.7	0.6	0.9	0.2	1.2	1.1	1.0	1.1	1.2	1.2	0.9	1.3	0.8	0.8	1.2	1.2	1.3
71	2.2	84.7	84.9	84.7	84.8	85.4	86.1	85.0	85.0	84.6	85.8	84.0	84.0	84.0	84.0	84.0	83.9	84.3	83.7	84.7	84.7	84.1	84.2	84.0
72	17.6	1.5	1.4	1.6	1.4	1.1	1.1	1.6	1.5	1.2	1.2	1.8	1.3	1.2	1.6	1.5	1.2	1.2	1.6	1.2	1.1	1.5	1.5	1.2
73	2.7	19.7	18.5	17.7	20.1	20.0	18.4	17.4	20.0	19.7	18.3	18.1	20.0	18.8	17.7	19.9	19.7	18.4	18.6	20.4	19.2	18.0	19.8	19.6
		2.1	1.5	1.9	1.9	1.1	1.2	1.9	1.9	1.2	1.4	2.2	1.7	1.2	1.8	1.9	1.3	1.3	2.0	1.5	1.1	1.7	1.9	1.3
COMMANDES	DUREE:																							
1	253.8	0.0	0.0	202.6	107.7	0.0	0.0	177.4	107.8	0.0	0.0	259.9	0.0	0.0	177.3	107.9	0.0	25.3	259.9	0.0	0.0	151.8	107.8	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

118

DATE: 16-Nov-86

TEST DE DEPERDITION THERMIQUE

HEURES:	15	15	15	15	16	16	16	16	16	16	16	16
MINUTES:	42	47	52	57	2	7	12	17	22	27	32	37
BILAN #:	1	2	3	4	5	6	7	8	9	10	11	12
TOT.ECHANT	12	8	9	8	9	8	9	8	9	8	8	9
DUREE:	288.4	289.7	313.9	288.2	313.4	288.8	313.8	288.0	314.5	287.9	288.1	313.8
CALCULS:	HRE#1	HRE#2	HRE#3	HRE#4	HRE#5	HRE#6	HRE#7	HRE#8	HRE#9	HRE#10	HRE#11	HRE#12
V	2.2	1.8	2.1	1.7	2.8	3.8	1.5	1.8	1.4	2.9	3.0	2.2
TOHC	20.5	18.2	18.0	36.4	27.3	21.8	18.7	34.4	26.7	20.4	17.9	20.7
TFH	18.2	16.6	16.2	27.0	22.1	18.7	16.7	25.8	22.3	18.4	16.5	17.8
TFD	4.7	3.3	3.6	18.8	9.3	4.5	4.0	17.2	8.8	4.1	2.7	5.9
ESAF	2.09	1.89	1.84	3.56	2.75	2.16	1.90	3.32	2.70	2.11	1.88	2.03
HUF	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01
DAF	1.19	1.20	1.20	1.15	1.17	1.19	1.20	1.15	1.17	1.19	1.20	1.19
CAF	1.07	1.06	1.06	1.08	1.07	1.07	1.06	1.07	1.07	1.07	1.06	1.07
PF	6.7	5.2	5.6	20.6	11.2	6.5	6.0	19.8	10.7	6.1	4.7	7.9
UG	0.0021	0.0017	0.0018	0.0060	0.0032	0.0020	0.0019	0.0056	0.0031	0.0019	0.0015	0.0026

HEURES:	16	16	16	16	17	17	17	17	17	17	17	17
MINUTES:	42	47	52	57	2	7	12	17	22	27	32	37
BILAN #:	13	14	15	16	17	18	19	20	21	22	23	24
TOT.ECHANT	8	9	8	9	8	9	8	9	8	8	9	8
DUREE:	288.5	313.7	288.3	314.6	288.0	313.8	288.1	314.7	288.2	288.2	314.5	288.0
CALCULS:	HRE#13	HRE#14	HRE#15	HRE#16	HRE#17	HRE#18	HRE#19	HRE#20	HRE#21	HRE#22	HRE#23	HRE#24
V	0.6	5.5	0.7	1.6	2.8	4.9	1.7	2.2	1.5	1.9	1.1	1.5
TOHC	32.6	23.2	18.9	17.2	31.2	27.8	20.6	17.7	21.1	42.7	29.8	21.8
TFH	25.3	20.1	17.3	16.0	23.7	22.8	18.4	16.4	18.0	31.8	24.6	19.5
TFD	14.6	6.2	3.3	2.4	15.0	9.9	4.4	2.7	6.4	23.5	10.4	4.5
ESAF	3.23	2.35	1.97	1.81	2.93	2.77	2.11	1.86	2.06	4.49	3.10	2.27
HUF	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01
DAF	1.16	1.18	1.20	1.20	1.16	1.17	1.19	1.20	1.19	1.13	1.16	1.19
CAF	1.07	1.07	1.06	1.06	1.07	1.07	1.07	1.06	1.07	1.08	1.07	1.07
PF	16.5	8.1	5.3	4.3	16.9	11.9	6.4	4.6	8.4	24.9	12.3	6.4
UG	0.0047	0.0024	0.0016	0.0014	0.0052	0.0035	0.0020	0.0015	0.0027	0.0069	0.0034	0.0019

Cumulatif:

TB = 6888.9
TF = 1050.1
TCT = 0.0

Moyennes:

VM = 2.2
UGM = 0.0030

APPENDIX C

Computer program for the calculation of the overall heat loss coefficient

The program was written for the data management software "Lotus 1-2-3".

SRVTST

```
A93: 'FORMULAS FOR SRVTST
A95: ^V
B95: @IF(B67<0,0,B67)
A96: ^VM
B96: @AVG(B95..Y95)
A97: ^TB
B97: @SUM(C5..Y5)
A98: ^TF
B98: @SUM(B82..Y82)
A99: ^TCT
B99: @SUM(B83..Y83)
A106: ^TOHC
B106: 1.010102+0.95265*B63
A116: ^TFM
B116: (F1) (TOHC+B$62)/2
A117: ^TFD
B117: +TOHC-B62
A118: ^ESAF
B118: 0.61078*@EXP((17.269*TFM)/(TFM+237.3))
A119: ^HUF
B119: ($MW/$MA*B68/100*ESAF)/(101.3171-(B68/100*ESAF))
A120: ^DAF
B120: +$MA/$R*($P-(1-0.622*DAH)*ESAF*B68/100)/(TFM+273.15)
A121: ^CAF
B121: +$CPA+$CPV*DAH
A122: ^PF
B122: @IF(+DAF*$VAH*$AI*CPF*TFD>=0,+DAF*$VAH*$AI*CPF*TFD,0)
A123: ^UG
B123: +PF/($AG*(B37-B39))
A124: ^UGM
B124: @AVG(C123..Y123)
```

APPENDIX D

Daily Results

DATE	TFC	TCC	TPC	TVGC	TVDC	TVHC	TCTC	TLC	QLC	QLEC	QLUC	QFC	QTHLC	QSSTGC	QSSTLC	QESTC	QRTTC	QRSC	TSCC	QRFC	QGFC	QCC	QVC	QBPC
20/09/85	0	86371	62323	5130	38705	1284	0	0	0	0	0	0	171566	85318	139305	75934	850611	268234	10159	23983	2746	101572	18304	731
21/09/85	4133	33770	15278	0	4908	13177	0	0	0	0	0	79703	818907	135801	229237	43221	220526	253447	9599	70558	4569	39713	-11083	1458
27/09/85	0	7677	1389	0	341	43448	0	0	0	0	0	0	735561	38768	44402	0	22546	109108	4132	27967	1521	9028	2817	782
05/10/85	24841	11550	5197	0	13053	14747	43724	0	0	0	0	324583	656896	80804	93449	33353	2072	136876	5184	30381	11130	13583	2748	599
06/10/85	25702	21393	7291	0	4685	2567	43723	0	0	0	0	290847	852174	152465	182988	47231	1213	174236	6599	51922	10062	25158	6878	1023
08/10/85	5132	0	105	0	2041	33234	43732	0	0	0	0	92303	211084	21819	161316	0	0	48933	1853	96501	0	0	0	1898
09/10/85	28851	0	0	0	157	41404	44653	0	0	0	0	396483	358095	20481	89699	0	0	24706	936	81549	0	0	0	1604
11/10/85	73692	22178	13489	0	0	3088	43732	0	0	0	0	420397	1002315	211406	75398	120749	2123	202290	7661	40409	27535	26081	8516	803
12/10/85	84873	3454	0	0	0	6627	43743	0	0	0	0	558454	937507	10696	201554	2869	0	44887	1700	65244	0	4061	1326	1283
14/10/85	79189	0	0	0	0	10593	43718	0	0	0	0	567856	672142	27028	57923	0	0	24592	931	48788	0	0	0	959
18/10/85	28559	10339	9407	0	7572	15725	47257	0	0	0	0	150889	340781	146578	101842	44052	2139	199117	7541	48362	25842	12159	2807	956
19/10/85	20637	17114	6089	0	876	2939	47232	0	0	0	0	234272	856698	159807	167172	55144	0	178256	6751	63443	15828	20126	6796	1248
21/10/85	30476	26329	9549	0	4558	107	47216	0	0	0	0	289657	801157	186943	117047	87972	912	202853	7683	52442	19121	30962	8360	1031
22/10/85	22606	27343	21975	0	2967	1480	47223	0	0	0	0	218340	632788	202672	149570	117775	935	192084	7275	56544	21825	32156	9361	1112
23/10/85	16943	27730	20127	0	4345	6643	46411	0	0	0	0	198736	439935	155718	164086	74821	493	150051	5683	58473	17623	32611	8900	1131
28/10/85	55584	24960	8592	0	296	0	47363	0	0	0	0	536418	1472689	217565	63438	84359	0	177096	6707	36513	21801	29353	9585	718
29/10/85	47779	0	0	0	0	2922	48221	0	0	0	0	426625	1060120	39459	177802	0	0	78820	2985	63882	2410	0	0	1256
30/10/85	49049	24727	18620	0	0	1205	48240	0	0	0	0	428353	1058118	216304	60483	121319	57	164888	6245	39207	23037	29079	9495	771
31/10/85	47134	13226	64489	0	0	2123	48290	0	0	0	0	398719	1055135	138474	198724	45632	179	106665	4040	52680	14216	15554	5079	1036
01/11/85	42443	0	0	0	0	4910	48536	0	0	0	0	449340	878467	32077	110060	0	0	54085	2048	52243	0	0	0	1027
02/11/85	47681	0	0	0	0	4610	48817	0	0	0	0	449417	924075	46930	80272	0	0	60454	2290	27422	726	0	0	589
03/11/85	57262	5624	0	0	0	3592	48906	0	0	0	0	529447	1251630	129682	97851	12444	0	93660	2547	19899	17879	6614	2160	391
05/11/85	65560	0	0	0	0	1399	49022	0	0	0	0	685886	1160406	26210	72029	0	0	14384	545	17141	0	0	0	337
08/11/85	47629	16569	5085	0	0	1021	51622	0	0	0	0	395205	1114597	177647	157627	65863	0	118066	4472	27954	21494	19485	6362	550
11/11/85	68160	12685	8840	0	0	482	51615	0	0	0	0	772763	1686006	114935	233098	59541	259	98903	3746	46785	12971	14918	4871	929
14/11/85	56852	15724	18739	0	0	0	51616	2286	4343	815	3528	522970	1560278	244002	101050	65730	6143	139349	5278	25782	17620	18492	6038	507
15/11/85	59610	20314	20779	0	0	0	51690	0	0	0	0	609090	1679844	272812	186763	112751	870	136652	5175	35337	14435	23890	7801	695
16/11/85	74850	0	86378	0	0	0	51724	0	0	0	0	644096	1233920	27353	166784	0	0	32812	1243	35195	0	0	0	692
18/11/85	72035	0	0	0	0	0	53424	0	0	0	0	630394	1064679	12642	131329	0	0	10378	393	27891	0	0	0	549
20/11/85	83755	8437	5	0	54	0	53567	0	0	0	0	1044259	1044441	146121	147306	32216	108	77485	2935	29381	24436	9922	3240	578
21/11/85	87659	0	0	0	0	0	53605	0	0	0	0	1129617	1047056	54091	154829	0	0	55205	2091	83206	0	0	0	1636
22/11/85	86407	0	0	0	0	0	53617	0	0	0	0	1271522	1209080	63510	113923	0	0	56483	2139	43646	989	0	0	858
23/11/85	83966	0	0	0	0	0	53647	0	0	0	0	1223934	1116552	66088	100321	0	0	55771	2112	29439	379	0	0	579
26/11/85	13519	16633	189	0	0	0	0	0	0	0	0	1263784	1791499	223709	236654	36572	17774	111956	4240	67124	18786	19560	6387	1353
27/11/85	16578	134	0	0	0	0	0	0	0	0	0	1552835	1714731	59352	106179	213	0	44054	1668	34706	149	158	52	683
28/11/85	18861	2719	0	0	0	0	0	0	0	0	0	1579009	1889873	113438	143083	9424	0	66209	2508	34441	3229	3198	1044	677
29/11/85	15045	4118	0	0	0	0	0	0	0	0	0	1357811	1616161	93541	107837	14875	0	72812	2758	37465	4381	4842	1581	737
12/02/86	20369	13470	0	0	0	0	51195	58209	110596	0	110596	815704	2114253	137909	180276	29044	2901	183438	6947	37729	267	15841	5172	749
13/02/86	18613	19302	81	0	0	0	50616	58233	110642	153	110489	763643	1678264	247618	257843	80666	4846	188935	7156	38054	10589	22699	7412	748
14/02/86	22603	5417	0	0	0	0	17867	58241	110658	0	110658	939040	1724117	73183	118522	3757	6000	138080	5230	27673	1131	6371	2080	544
15/02/86	15147	23714	54	0	0	0	49889	58225	110627	102	110525	637527	1506807	302332	280621	134645	2555	206923	7837	39331	16084	27888	9106	774
16/02/86	37259	18826	779	0	0	28820	33076	58226	110630	1480	109150	1539676	1595212	331401	359553	115077	4112	250247	9478	74562	15411	22139	7229	1466
17/02/86	14356	21983	1637	0	0	0	50394	58213	110604	3110	107494	638070	1508488	293136	317289	158057	0	195976	7422	51400	13307	25852	8441	1011
18/02/86	21053	0	0	0	0	0	0	58223	110623	0	110623	967372	1548237	17726	103304	0	0	86917	3292	30190	0	0	0	594
19/02/86	13026	26218	456	0	0	0	49003	58239	110654	866	109788	573963	1479879	399648	326777	130414	5210	238583	9036	35744	22672	30832	10068	703
20/02/86	9614	22514	5314	0	0	0	50142	58229	110635	10097	100538	445628	1147452	284392	346674	574692	0	206397	7809	50101	13564	26476	8645	985
21/02/86	17891	0	0	0	0	0	48830	57434	109125	0	109125	796693	1194423	53161	130830	0	0	31424	3008	11536	2301	0	0	227
24/02/86	13369	21887	4323	0	0	0	48687	58194	110568	8206	102363	607094	1374758	209371	328162	81435	6546	187130	7087	46138	6702	25740	8405	907
25/02/86	15949	6269	0	0	0	0	48980	58238	110652	0	110652	740043	1599784	32010	217614	8524	6343	111352	4217	31108	325	7373	2407	612
28/02/86	20800	20981	1941	0	0	0	51125	58221	110620	3688	106932	782646	2553591	349612	133412	102488	6337	268577	10172	9244	34141	24674	8057	193
01/03/86	12788	22240	7056	0	592	0	50875	58244	110664	13407	97258	519332	1333370	292617	196959	135936	3394	242225	9174	24071	31391	26154	8313	481
01/03/86	10551	26833	12740	0	2664	0	51696	58238	110652	24207	86446	468801	1295966	355424	255670	152265	4085	294639	11159	40649	34989	31556	9281	800
04/03/86	8083	7293	269	0	0	0	61611	58212	110603	511	110092	384759	1054717	107181	311093	25008	2009	113022	4280	67536	11989	8576	2800	1328
05/03/86	16623	15470	0	0	0	0	51155	58214	110607	0	110607	721121	1845250	213479	163794	51996	6293	198392	7514	30292	20806	18193	5941	599

123

DATE	TFC	TCC	TPC	TVGC	TVBC	TVHC	TCTC	TLC	QLC	QLEC	QLUC	QFC	QTHLC	QSSTGC	QSSTLC	QESTC	QRTTC	QRSC	ISCC	QRFC	QGFC	QCC	QVC	QBRC
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09/03/86	25938	7831	1049	0	0	0	50422	58223	110623	1989	108634	1142938	1696360	48742	241058	36689	0	150579	5703	33708	3343	9210	3007	663
10/03/86	28033	0	0	0	0	0	0	58200	110580	0	110580	1290435	1948433	6811	69466	0	0	21943	831	2519	8593	0	0	50
11/03/86	21228	0	0	0	0	0	0	57022	108341	0	108341	972109	1552163	33974	51921	0	0	43135	1634	0	15644	0	0	0
12/03/86	14808	19407	0	0	0	27	48964	57377	109017	0	109017	627420	1353168	162874	95029	40335	9769	192516	7291	16919	17191	22822	7452	333
14/03/86	19308	0	0	0	0	5919	51068	58196	110572	0	110572	892550	1288550	27360	65568	0	0	87221	3303	15879	1300	0	0	312
15/03/86	12776	14850	0	0	0	8233	51027	58191	110564	0	110564	605665	1034825	233973	80432	75306	8491	211753	8020	12360	24034	17463	5702	261
19/03/86	11822	14499	349	27	107	1857	47862	58264	110701	663	110038	514003	1472673	155169	124391	52823	17366	277045	10493	51115	7071	17050	5526	1005
21/03/86	17954	22412	2523	0	0	1293	48058	58261	110696	4794	105902	662289	2397047	294538	168264	101652	13527	326904	12381	71622	22318	26357	8606	1425
23/03/86	11279	23386	12583	0	268	5409	49229	58227	110631	23908	86722	508935	1336462	288376	117894	111120	17228	294228	11143	60067	24262	27503	8878	1181
24/03/86	13602	17813	5395	0	53	3048	48399	56462	107278	10251	97028	587098	1326853	178918	228147	66084	18987	247802	9385	79876	15888	20948	6820	1571
25/03/86	8143	18663	3436	0	0	162	48308	58226	110629	6529	104100	379408	1130454	217637	198347	96852	12569	284011	10756	66743	27466	21948	7167	1317
26/03/86	3038	9242	1260	0	0	54	46357	58194	110569	2394	108175	152388	752259	66956	206005	37361	5879	173590	6574	76757	8167	10868	3549	1512
27/03/86	9450	19213	3440	0	0	458	44916	58224	110626	6536	104090	432844	1104116	240379	180955	107435	4363	240538	9110	76894	21687	22595	7378	1523
28/03/86	13304	26587	14632	0	0	0	50234	58256	110687	27800	82887	597671	889083	296505	145178	160736	759	298677	11312	63179	27530	31266	10209	1243
29/03/86	3873	25528	13376	0	215	0	46586	58235	110646	25795	84851	197640	769354	278243	211427	141500	3347	252861	9577	67921	31627	30021	9720	1336
30/03/86	1747	23762	19418	0	1449	215	44157	58211	110600	36894	73706	90285	752524	252380	225524	133412	3742	334085	12653	67500	30143	27944	8568	1331
31/03/86	2936	31743	23337	0	2999	0	49955	58201	110582	44341	66241	144189	662148	251258	217740	150329	2662	321052	12159	79596	30684	37329	11037	1565
01/04/86	832	33428	17971	0	5577	189	45825	58249	110674	34144	76529	48158	572672	257416	215240	137396	5738	360215	13642	70674	26942	39311	10695	1390
02/04/86	4813	33517	16684	0	2760	1935	45924	58239	110654	31700	78954	236495	950771	247840	211988	126601	8584	379184	14361	87633	19793	39416	11811	1726
03/04/86	3607	32651	16010	0	375	403	45048	57056	108407	30419	77988	180746	985745	239870	200148	103128	9836	372399	14104	90212	17776	38398	12394	1774
04/04/86	7294	31479	18407	0	782	0	45392	58211	110601	34973	75628	336434	1182591	258592	222397	98637	12103	379774	14383	92252	18273	37019	11788	1814
05/04/86	7484	29112	18355	0	1665	81	45367	58252	110679	34874	75805	337118	1058444	243305	227485	97406	9009	351865	13326	92037	20908	34236	10540	1810
06/04/86	9441	0	0	0	0	3770	54924	58207	110594	0	110594	444773	769108	0	248060	0	0	51780	1961	124064	0	0	0	2140
08/04/86	13201	160	0	0	0	622	43244	58250	110676	0	110676	526177	949465	24320	90150	0	320	90629	3432	74597	0	188	61	1467
09/04/86	12419	296	0	0	0	4788	14798	58204	110587	0	110587	607021	1053858	136634	172398	0	3848	204645	7751	65731	1162	349	114	1305
13/04/86	7187	30503	13780	0	1122	699	44427	58248	110671	26182	84490	324768	981877	316427	31178	130183	8937	330271	12508	18385	47317	35871	11282	362
14/04/86	4237	33111	26286	0	3154	241	42384	58204	110588	49322	61266	197149	846909	324298	192943	153627	3182	430735	16313	39718	50833	38938	11503	781
15/04/86	5223	36291	18257	0	187	0	46066	58226	110630	34688	75943	244758	941730	288626	222849	125897	7894	419392	15884	57933	26922	42678	13864	1139
16/04/86	3755	35683	22045	0	161	53	44065	58236	110648	41886	68762	174309	826579	278407	223635	120357	11175	422299	15994	66577	25633	41963	13641	1309
17/04/86	3783	35960	13714	0	134	269	43803	58219	110616	26057	84559	178346	1006117	258793	220903	88408	19284	421756	15973	73864	16001	42288	13757	1453
18/04/86	1995	86378	30335	0	6051	0	43730	58202	110584	57351	53233	96529	805075	323202	329014	164579	401496	435442	16492	76560	31248	101581	30845	5376
19/04/86	380	86398	30335	0	6051	0	43746	58214	110606	57351	53255	25788	668395	331412	273222	165203	329385	432067	16364	67187	31248	101604	30853	4185
20/04/86	3967	18435	11886	27	1228	3508	52607	14876	28265	0	28265	200178	531780	186934	233694	63822	5290	185866	7039	88124	18294	21680	6608	1733
21/04/86	3328	32302	13443	0	134	0	45234	58166	110515	25542	84973	141861	1091497	294473	105973	103616	8619	374659	14189	49186	30882	37987	12352	967
22/04/86	3170	86372	19026	0	348	375	44210	58162	110509	36150	74359	161294	1037301	328527	293966	151964	346797	422575	16004	69475	27111	101573	33033	4843
23/04/86	1747	86411	17697	0	187	107	41423	58209	110597	33625	76972	90479	885600	309147	307322	133848	342542	425520	16116	74697	22538	101619	33110	4707
24/04/86	0	86376	268	0	0	8783	44843	58163	110509	509	110000	0	707122	156930	366959	19315	505910	178063	6744	103492	7059	101578	33168	5867
25/04/86	188	86402	268	0	0	8059	44080	58180	110543	509	110034	11875	668869	124753	284059	19315	521258	157471	5964	84821	7059	101609	33179	5346
26/04/86	568	49138	0	0	0	538	48518	58169	110522	0	110522	40185	606887	74867	217912	0	373817	74650	2827	68049	1811	57786	18869	4355
27/04/86	671	47852	3622	0	0	1346	37764	58160	110503	6882	103621	37359	726445	178459	144962	61816	303999	211325	8004	45934	24545	56274	18375	3147
28/04/86	215	54603	13128	0	241	1984	45075	58147	110480	24942	85537	12205	714622	305274	241207	181446	144947	339215	12847	43694	31625	64213	20875	1566
29/04/86	1995	73691	17351	0	8483	10192	42493	58193	110566	32967	77599	117472	669333	292012	330797	147813	313177	351820	13325	80267	39061	86660	25040	4281
30/04/86	0	63049	31752	0	13348	0	40607	58179	110540	60297	50243	0	326323	303978	200944	200880	119812	372222	14097	43880	45594	74146	19085	1801
01/05/86	349	57640	6561	0	1234	858	45187	58184	110549	12466	98082	15008	840145	185524	242359	72333	143395	232194	8794	61083	15474	67784	21660	2365
02/05/86	5496	29786	13678	0	1179	0	44131	58196	110573	25987	84586	272041	1075260	275476	145377	116350	8066	380886	14425	71315	21682	35028	10985	1403
03/05/86	5922	29875	19847	0	1316	0	45293	58224	110625	37709	72916	284059	1117965	269274	220416	121547	5715	416434	15772	81645	22661	35133	10967	1606
04/05/86	0	58810	0	0	0	0	48543	58185	110552	0	110552	0	705140	65625	353591	4394	373230	114743	4346	95820	1133	69160	22583	5463
05/05/86	2818	24061	16833	0	1067	1717	40688	55605	105650	31983	73667	140668	766120	283904	90569	112695	11667	385654	14606	59092	22932	28296	8830	1172
07/05/86	1529	22689	910	0	0	2094	46502	58179	110541	1728	108812	95703	758389	222622	96779	63256	7903	222078	8411	79871	25973	26682	8712	1571
08/05/86	2496	35125	25839	0	5901	80	38631	57122	108532	47121	61411	127392	800104	344795	183798	189412	6745	490335	18570	67189	45731	41307	11222	1321
09/05/86	883	39311	24773	0	4034	0	40916	25067	47628	35993	11636	56159	467592	292343	249671	143468	4895	334523	12669	88116	35841	46229	13546	1733
10/05/86	883	39311	24773	0	4034	0	40916	25067	47628	35993	11636	56159	467592	292343	249671	143468	4895	334523	12669	88116	35841	46229	13546	1733
[illegible]5/86	2865	31829	16999	1336	11660	0	41412	46941	89188	24316	64872	162691	1090588	316463	153738	113032	22000	471504	17857	86922	35776	37431	7765	1789
[illegible]5/86	1631	36226	25966	32	5149	107	39542	44046	83687	29278	54409	89669	725217	304229	213499	88246	33869	523481	19826	96277	33271	42602	11933	1902

124

DATE	TFC	TCC	TPC	TVGC	TVBC	TVHC	TCTC	TLC	BLC	BLEC	BLUC	DFC	BTHLC	BSSTGC	BSSTLC	BESTC	BRTTC	BRSC	ISCC	BRFC	BGFC	BCC	BVC	BBRC
13/05/86	0	75318	34330	5917	21506	0	37749	56403	107166	64051	46314	0	498945	299309	232878	90589	330272	514534	19487	63005	40695	88573	20664	3358
14/05/86	0	62600	43130	9701	29032	80	39362	47706	90642	58473	32168	0	307479	261456	168152	89720	205301	521982	19769	43454	33992	73712	12921	1725
15/05/86	0	43772	43879	10052	25909	0	40545	56878	108067	78697	29370	0	251637	207721	141838	62297	94189	301894	14463	39335	25563	51476	6859	774
16/05/86	0	44298	39001	2537	17432	0	40902	58149	110483	72425	38058	0	335847	166221	139575	57729	93001	295423	11189	44214	11020	52095	10317	870
17/05/86	0	40395	44166	10750	30743	0	43369	58190	110561	83214	27347	0	326645	208964	135323	58534	82631	345189	13073	43938	21919	47585	3706	864
19/05/86	107	63526	0	0	0	1366	53686	58187	110555	0	110555	8791	760589	44882	326131	0	691957	48818	1849	133780	0	74707	24394	7431
20/05/86	1507	62623	0	0	0	5769	47891	58200	110580	0	110580	96988	693175	170927	273760	0	741034	131419	4977	115127	0	73644	24047	6856
26/05/86	0	46219	44646	0	20798	0	36198	27345	51956	22622	29335	0	409772	111827	283855	35626	112515	595821	22566	54273	19309	54353	9762	1067
27/05/86	0	43820	48819	3396	26479	321	40425	29525	56098	37347	18751	0	312650	217953	153102	24050	172231	459038	17385	48106	10496	51533	6659	946
28/05/86	0	39477	43112	1573	22434	321	40626	29543	56132	26502	29630	0	434188	217953	184463	24473	167183	475796	18020	81194	9915	46424	6544	1597
29/05/86	0	28408	25120	100	17449	271	40255	46311	87991	44241	43750	0	289021	188021	179899	3121	173193	348798	13210	70558	10542	33407	4200	1300
30/05/86	0	27290	35334	100	17639	0	41394	46518	88384	43514	44870	0	496851	196625	168999	2701	178921	402940	15261	65422	12803	32094	3706	1209
31/05/86	0	22796	34188	0	13312	0	37181	58132	110488	64958	45530	0	727238	220202	223549	15446	131282	522629	19794	112675	2915	26808	3642	2216
02/06/86	0	75967	33424	0	9504	0	35393	27	51	47	3	0	901473	340206	293886	103865	270218	620929	23516	100663	9025	89337	25522	5126
03/06/86	0	65881	32011	0	10308	0	47090	2274	4320	47	4272	0	613809	254704	261528	179571	147340	524774	19875	93837	5331	77476	21309	3316
10/06/86	0	40939	39093	2162	22905	643	39517	0	0	0	0	0	330073	190614	167648	127428	9694	403173	15269	64606	10057	48145	6925	1279
11/06/86	0	76609	36635	0	12304	0	36331	0	0	0	0	0	809352	315315	325211	160786	279410	589017	22338	102247	5881	90092	24693	5054
12/06/86	0	75517	26728	0	15592	402	52156	0	0	0	0	0	545818	183251	333255	102007	280014	380131	14397	112361	0	80808	23011	4733
13/06/86	0	54983	14346	0	4702	80	42025	0	0	0	0	0	573143	153578	112692	45741	271485	258499	9790	70656	12911	64660	19300	3170
14/06/86	0	47733	41337	960	31004	0	39768	0	0	0	0	0	332273	379939	316934	155912	42679	566548	21457	75370	11246	56134	6424	1649
15/06/86	0	68779	44415	13637	28186	938	37422	0	0	0	0	0	403011	252854	326921	139275	181585	456925	17305	67092	7164	80084	15588	2534
17/06/86	0	67289	27088	0	9188	0	34403	0	0	0	0	0	641195	243917	281899	92502	216925	454279	17205	80009	5749	79131	22311	3815
18/06/86	0	58404	39562	0	17150	0	0	28967	55037	16916	38121	0	655623	458454	410466	135396	109889	596232	22581	101746	7197	68683	15842	3081
19/06/86	134	64594	43030	27	23465	0	0	26630	50597	18125	32472	9780	590762	333089	299607	136585	172541	623118	23599	115826	6232	75963	15794	4122
20/06/86	1285	66036	44322	11386	28122	0	0	14932	[illegible]	367	28003	84052	617815	199023	239238	237976	466194	605574	22935	121912	7517	77653	14559	6866
21/06/86	0	47120	46156	10595	22586	0	0	14941	28388	1177	27211	0	316513	487675	436586	107203	46047	397447	15053	97809	11455	55413	9421	2031
22/06/86	0	43186	47509	14887	32753	0	0	14956	28446	4413	24004	0	201987	343843	279337	104849	27029	373225	14135	59169	12582	50787	4006	1164
23/06/86	0	38772	41043	107	16865	0	0	14943	28892	3758	24634	0	260117	423293	374201	74203	45337	275375	10429	63290	4468	45595	8412	1245
24/06/86	0	45773	21772	0	347	0	0	14959	28422	0	28422	0	635844	232954	408873	45420	225017	186610	7068	121310	3505	53829	17444	3902
26/06/86	0	44136	47979	7797	25331	0	0	14928	28362	4121	24242	0	359704	353947	435688	109715	62353	[illegible]	16121	83801	3175	51904	7221	1648
27/06/86	0	33153	35263	214	16042	0	0	14977	28456	0	28456	0	403909	269821	259709	83319	54725	383910	14540	94201	3767	38988	6571	1855
30/06/86	0	44933	42019	21294	30344	827	0	14994	28489	714	27725	0	459852	471177	281131	112573	92560	581493	22023	75796	8232	52841	5602	1630
01/07/86	0	46424	49490	21432	35073	827	0	14969	28441	8163	20278	0	385219	473090	334510	112921	98113	589579	22329	90608	6153	54594	4359	1834
02/07/86	0	42882	37456	6860	19601	0	0	14975	28453	0	28453	0	457329	291859	323572	72171	116788	361129	13677	109556	640	50429	8940	2948
06/09/86	0	22639	17201	0	6768	0	54905	58195	110571	32622	77899	0	552863	94175	158478	117197	0	227253	8607	50930	16603	26624	6094	1023
07/09/86	0	43547	14870	0	1337	0	55471	58179	110541	28253	82288	0	745128	147954	215449	111279	124593	200253	7584	48385	18799	51211	16299	3426
08/09/86	0	43229	28983	0	4547	0	52252	58174	110531	55068	55463	0	621606	233256	160292	215454	16968	331163	12542	54762	36241	50838	14854	1628
12/09/86	0	29515	21585	0	160	81	48731	36174	68731	3622	65109	0	645692	250246	100351	215015	952	348767	13209	37587	49754	34710	11272	760
14/09/86	0	46806	11107	0	54	80	48959	58197	110575	21103	89472	0	[illegible]	217650	281257	156324	107174	269540	10208	59414	26958	55043	17953	3540
16/09/86	0	63393	17208	0	1845	888	51166	28474	54101	1299	52801	0	827710	260253	257280	251564	129101	315225	11939	30586	48554	74550	23634	4124
17/09/86	0	68584	18384	0	1530	1394	49200	32578	61899	5145	56754	0	782895	233913	284271	175465	192850	268855	10182	46491	41853	80655	28749	5003
19/09/86	1450	69313	15979	0	268	1050	48909	37610	71460	9211	62249	111666	821831	87437	167887	548159	48127	267698	10139	72218	38256	81512	26513	2036
20/09/86	1583	72252	17438	53	2924	0	50377	58169	110521	33132	77389	114762	854929	132036	146958	473170	117949	273071	10342	76367	46384	84968	26622	3157
21/09/86	965	56911	21297	54	3375	1475	49142	24957	47418	17418	30001	74246	729847	131434	148500	385357	119044	299843	11356	74087	42442	66927	20558	3449
22/09/86	0	32592	0	0	0	1365	74827	49207	93493	0	93493	0	698750	26857	242988	17881	106583	40632	1539	52241	2946	38328	12515	3850
23/09/86	0	34754	536	0	0	804	54172	58164	110513	1018	109495	0	636925	167447	92861	35378	87630	95686	3624	40024	30389	40871	13345	2786
03/10/86	0	13545	7002	0	298	651	64942	65389	124238	13303	110935	0	237066	205236	142638	103803	0	122676	4646	95077	18215	15929	5087	1870
04/10/86	0	55135	16082	0	0	245	53351	51296	97463	3953	93510	0	653699	342292	389567	226714	263635	241427	9144	86544	35609	64839	21172	4689
05/10/86	0	71426	2632	0	0	54	73341	61986	117774	684	117090	0	650682	80355	441195	56398	356609	50443	1910	97243	8149	88997	27428	7713
08/10/86	246	33550	2335	0	0	2532	58226	47041	89379	211	89167	17032	606374	246425	79360	61195	57576	200741	7603	39777	33929	39455	12883	1530
09/10/86	2017	71020	10829	0	0	407	54182	37911	72031	0	72031	147042	811685	351490	274925	117189	299999	245530	9299	50067	45567	83520	27272	4090
10/10/86	2725	76239	9370	0	0	163	54099	60063	114120	13130	100990	172379	879921	329827	301634	115871	365426	243691	9229	55610	46945	89657	29276	4295
11/10/86	0	58212	13283	0	54	463	55148	65437	124330	25238	99092	0	546097	332280	291445	110313	119210	198052	7501	57085	37226	68458	22333	2818
12/10/86	0	0	0	0	0	870	65453	65458	124370	0	124370	0	[illegible]	248209	302340	0	0	42501	1610	193176	0	0	0	3799

125

DATE	TFC	TCC	TPC	TVGC	TVBC	TVHC	TCTC	TLC	QLC	QLEC	QLUC	QFC
15/10/86	1745	42448	0	0	0	1987	72963	65399	124257	0	124257	121941
16/10/86	3247	57740	489	0	0	952	55349	59153	112391	859	111532	192957
17/10/86	2015	46332	7606	0	0	3427	59784	61868	117550	14451	103099	130610
18/10/86	1500	33101	4429	0	0	654	58510	65443	124341	8415	115927	108913
23/10/86	7333	50682	0	0	0	10398	62301	65409	124278	0	124278	481861
24/10/86	7308	73966	1248	0	0	1660	55758	65428	124314	2372	121942	411867
25/10/86	2013	20720	0	0	0	0	58310	65420	124298	0	124298	178037
26/10/86	8417	41521	0	0	0	1389	85987	65433	124323	0	124323	557153
27/10/86	608313	0	0	0	0	5910	676834	65418	124295	0	124295	3064252
28/10/86	3158	1115	0	0	0	5940	70013	65413	124286	0	124286	219002
29/10/86	2779	7615	0	0	0	4305	69438	65404	124268	0	124268	183734
31/10/86	6488	33254	1004	0	0	897	66609	58677	111486	1864	109622	377263
01/11/86	5095	10998	0	0	0	300	79325	65462	124378	0	124378	321578
02/11/86	6839	61253	815	0	0	680	61054	65465	124383	1549	122834	384984
03/11/86	6807	5471	0	0	0	1362	67500	65425	124308	0	124308	391016
04/11/86	13188	67766	0	0	0	245	60407	65457	124369	0	124369	961330
05/11/86	11076	65053	0	0	0	0	72483	65404	124268	0	124268	566153
07/11/86	5121	41150	0	0	0	217	64045	65421	124300	0	124300	319613
08/11/86	2126	0	0	0	0	0	79581	65439	124334	0	124334	191528
10/11/86	9704	68537	0	0	0	491	61349	65440	124337	0	124337	533360
[illegible]	11953	15258	0	0	0	709	68846	65450	124355	0	124355	1040484
[illegible]	10694	22994	0	0	0	163	61621	65423	124304	0	124304	879788
[illegible]	20414	60255	0	0	0	0	64490	65424	124305	0	124305	980147
[illegible]	15955	37781	0	0	0	0	61870	65451	124358	0	124358	777872
15/11/86	10761	4196	0	0	0	109	66943	65441	124338	0	124338	579735
[illegible]	8267	0	0	0	0	0	70356	63621	120880	0	120880	488923
[illegible]	16579	71414	0	0	0	0	62575	62622	118981	0	118981	835782
[illegible]	20521	60087	0	0	0	0	71171	65454	124363	0	124363	1020530
[illegible]	21448	8770	0	0	0	0	76557	65419	124297	0	124297	982275
[illegible]	26221	10701	0	0	0	0	69466	65436	124328	0	124328	1149220
[illegible]	14739	2449	0	0	0	0	71136	65456	124366	0	124366	719192
[illegible]	13905	11414	0	0	0	109	64837	65431	124318	0	124318	653142
[illegible]	12782	11818	0	0	0	0	62524	65435	124365	0	124365	588568
26/11/86	11521	17881	3277	0	0	136	64025	65380	124223	6226	117997	560945
27/11/86	14735	10153	0	0	0	0	62539	65389	124239	0	124239	639150
[illegible]	14010	6546	0	0	0	0	75320	65432	124321	0	124321	622494
[illegible]	18765	21030	0	0	0	0	60456	65320	124109	0	124109	784316

DATE	QTHLC	QSSTGC	QSSTLC	QESTC	QRTTC	QRSC	ISCC	QRFC	QGFC	QCC	QVC	QMC
15/10/86	554016	87651	239901	6634	201143	47401	1795	72347	2943	49918	16300	4636
16/10/86	715626	198150	145062	77708	168211	133028	5030	50368	20347	67902	22172	4043
17/10/86	661050	288970	156791	367104	192879	170930	6474	54345	37496	54721	17868	2455
18/10/86	635406	271511	163471	384434	45725	166903	6321	44269	43160	38927	12711	1205
23/10/86	892557	131255	74994	17857	225860	163217	6182	2306	27960	59601	19462	1954
24/10/86	1143044	265727	147183	82408	328800	198401	7514	12803	50313	86984	28403	2681
25/10/86	855150	105976	225562	12954	81792	110414	4182	19011	20643	24366	7956	888
26/10/86	779375	9639	136412	0	242929	338	13	12829	6462	48829	15944	2017
27/10/86	4383394	20996	48351	0	0	41398	1568	138250	18095	0	0	2719
28/10/86	587935	39529	57092	0	5120	50556	1915	358	29525	1311	428	9
29/10/86	648986	109426	24855	0	14897	91801	3477	337	40183	8956	2924	7
31/10/86	964654	104970	252406	55370	151188	120696	4571	11050	29062	39106	12769	1056
01/11/86	723941	41190	101676	11045	14006	43084	1632	7741	17458	12933	4223	205
02/11/86	990196	206226	216223	63145	307142	131211	4969	12727	38917	72033	23521	2354
03/11/86	939064	32479	106506	1638	13810	73914	2799	4287	17576	6434	2101	126
04/11/86	1261995	196786	163914	29895	375763	132673	5025	22338	28912	79693	26022	3057
05/11/86	1161125	94116	280707	45189	357586	78563	2975	17033	22572	76502	24900	2670
07/11/86	913239	110983	113600	2920	177547	93687	3548	4899	27728	48392	15801	1133
08/11/86	573241	8412	54564	0	0	11490	435	783	18823	0	0	15
10/11/86	1105316	221174	214701	44462	354597	122742	4649	8551	31358	80600	26318	2761
[illegible]	968852	21302	31229	0	81024	55279	2094	3265	9757	17943	5859	482
[illegible]	1114798	75612	73205	13	81942	96562	3657	2335	17701	27041	8830	431
[illegible]	1626224	20010	83535	0	346592	79175	2999	3876	7224	70860	23138	2727
[illegible]	1527644	5385	48634	0	169660	71460	2708	167	12942	44430	14508	834
15/11/86	1127647	34033	53544	0	8356	63961	2422	28	27185	4934	1611	1
[illegible]	887544	21299	21873	0	0	31024	1175	0	29265	0	0	0
[illegible]	1435296	128871	19125	6267	296052	106634	4039	0	28892	83983	27423	1728
[illegible]	1437066	7180	86024	0	299923	33216	1258	1361	6548	70662	23073	1864
[illegible]	1684603	108852	19985	34087	13709	42864	1623	0	81981	10314	3368	48
[illegible]	1400842	72108	108160	30585	568	67289	2548	0	41466	12584	4109	0
[illegible]	1165178	15458	68818	0	4988	38230	1448	0	45547	2879	948	4
[illegible]	1219384	71806	17596	2151	13462	76636	2902	0	47606	13423	4383	9
[illegible]	1170055	56565	111635	17699	8659	79377	3006	0	44526	13898	4538	3
26/11/86	1026673	267411	27353	84802	0	118845	4501	0	68223	21028	6866	0
27/11/86	1367678	23529	191402	5671	7757	69034	2615	138	27540	11940	3899	3
[illegible]	1154889	75666	79175	6555	0	38769	1468	442	33027	7698	2513	9
[illegible]	1627347	146508	116339	26313	7941	121732	4610	797	28686	24731	8875	16

126

DATE	DETSIC	DETRIC	DHUC	HUC	TOSR	TSSIR	TSSGR	T100M	TIN	TON	NCTR	SE	RE	COPSR	COPRR	FF	LF	SF	ESR	ESER	ERER
20/09/85	137916	13168	1.63	338.19	17.7	23.3	22.8	1.8	22.7	20.9	0.0060	0.25	0.27	1.2	0.4	0.00	0.00	1.00	0.65	0.13	0.15
21/09/85	75931	3586	0.79	95.34	14.7	21.4	21.6	9.3	19.4	10.1	0.0060	0.45	0.32	1.5	0.9	0.10	0.00	0.90	0.95	0.15	0.30
27/09/85	0	11792	0.04	2.82	12.6	21.0	20.6	7.1	20.2	13.1	NA	0.35	0.90	NA	1.5	0.00	0.00	1.00	0.70	NA	0.36
05/10/85	46176	65	0.02	6.41	11.5	19.6	19.9	7.3	19.1	11.8	0.0070	0.45	0.33	2.7	0.2	0.49	0.00	0.51	1.00	0.21	0.00
06/10/85	71759	1057	0.00	10.48	10.2	19.8	19.9	9.2	18.5	9.3	0.0083	0.66	0.28	3.1	0.7	0.34	0.00	0.66	1.00	0.23	0.20
08/10/85	0	0	0.00	0.00	10.5	17.9	18.9	2.2	15.0	12.8	NA	0.45	0.60	NA	NA	0.44	0.00	0.56	1.00	NA	NA
09/10/85	0	0	0.00	0.00	11.0	17.0	18.2	4.1	14.5	10.5	NA	0.83	0.91	NA	NA	1.00	0.00	0.00	1.00	NA	NA
11/10/85	132495	433	0.00	7.94	7.1	18.0	18.4	13.0	17.7	4.6	0.0113	0.60	0.54	7.1	0.6	0.42	0.00	0.58	0.99	0.38	0.13
12/10/85	6408	0	0.00	1.27	6.3	18.0	18.6	12.7	16.0	3.3	0.0069	0.22	0.32	1.0	NA	0.60	0.00	0.40	1.00	0.16	NA
14/10/85	0	0	0.00	0.00	8.2	17.1	17.7	8.5	15.6	7.1	NA	1.00	0.84	NA	NA	0.84	0.00	0.16	1.00	NA	NA
18/10/85	52079	263	0.00	4.63	8.2	17.7	17.7	3.9	17.1	13.1	0.0095	0.54	0.48	4.9	0.2	0.44	0.00	0.56	0.99	0.28	NA
19/10/85	71040	0	0.00	7.00	7.3	17.8	17.7	9.7	16.3	6.6	0.0087	0.64	0.38	3.9	NA	0.27	0.00	0.73	1.00	0.31	NA
21/10/85	116692	0	0.00	12.86	6.4	17.6	17.8	8.4	16.6	8.1	0.0089	0.60	0.45	4.0	NA	0.36	0.00	0.64	1.00	0.31	NA
22/10/85	131839	0	0.28	8.04	6.7	18.0	18.1	8.2	17.0	8.8	0.0089	0.61	0.38	4.7	NA	0.35	0.00	0.65	1.00	0.31	NA
23/10/85	100908	75	0.00	11.10	6.8	18.3	18.4	6.1	17.1	11.0	0.0084	0.64	0.36	3.1	0.4	0.45	0.00	0.55	1.00	0.27	0.05
28/10/85	108579	0	0.00	10.78	4.5	16.6	17.2	16.0	16.2	0.1	0.0100	0.77	0.58	4.3	NA	0.36	0.00	0.64	1.00	0.32	NA
29/10/85	0	0	0.00	0.00	4.1	16.8	17.4	13.4	14.9	1.5	NA	0.49	0.36	NA	NA	0.40	0.00	0.60	1.00	NA	NA
30/10/85	127237	9	0.65	5.01	3.8	16.8	17.2	14.4	16.4	1.9	0.0105	0.70	0.65	6.2	0.3	0.40	0.00	0.60	1.00	0.37	0.02
31/10/85	56452	0	0.26	5.25	3.2	17.3	17.6	14.4	16.1	1.8	0.0087	0.83	0.27	4.9	NA	0.38	0.00	0.62	1.00	0.36	NA
01/11/85	0	0	0.00	0.00	5.0	16.6	17.1	10.3	15.0	4.7	NA	0.59	0.47	NA	NA	0.51	0.00	0.49	1.00	NA	NA
02/11/85	0	0	0.00	0.00	5.4	16.1	16.6	11.5	15.3	3.8	NA	0.77	0.34	NA	NA	0.49	0.00	0.51	1.00	NA	NA
04/11/85	19020	0	0.00	2.71	4.6	16.2	16.6	16.4	16.2	-0.2	0.0075	1.00	0.20	2.7	NA	0.42	0.00	0.58	1.00	0.30	NA
05/11/85	0	0	0.00	0.00	5.3	15.7	16.0	11.7	15.2	3.5	NA	1.00	0.24	NA	NA	0.59	0.00	0.41	1.00	NA	NA
08/11/85	75956	0	0.23	5.29	4.3	16.5	16.2	12.8	16.3	3.4	0.0100	0.86	0.18	4.8	NA	0.35	0.00	0.65	1.00	0.38	NA
11/11/85	72489	0	0.22	6.79	1.4	16.9	16.6	23.5	15.8	-7.7	0.0109	0.67	0.20	5.4	NA	0.46	0.00	0.54	1.00	0.41	NA
14/11/85	87864	0	0.34	12.88	1.9	16.6	16.0	19.0	16.4	-2.6	0.0096	1.00	0.26	5.9	NA	0.34	0.00	0.66	1.00	0.41	NA
15/11/85	127615	0	0.20	8.65	1.8	16.8	16.3	20.5	16.2	-4.4	0.0124	1.00	0.19	7.1	NA	0.36	0.00	0.64	1.00	0.44	NA
16/11/85	0	0	0.00	0.00	1.9	16.1	16.0	17.3	15.0	-2.2	NA	0.83	0.21	NA	NA	0.52	0.00	0.48	1.00	NA	NA
18/11/85	0	0	0.00	0.00	2.1	15.9	15.8	14.1	15.1	0.9	NA	1.00	0.21	NA	NA	0.59	0.00	0.41	1.00	NA	NA
20/11/85	38328	0	0.00	2.91	3.7	15.7	15.3	10.8	15.5	4.7	0.0082	1.00	0.20	4.2	NA	1.00	0.00	0.00	1.00	0.39	NA
21/11/85	0	0	0.00	0.00	2.0	13.6	14.3	13.5	11.1	-2.4	NA	0.98	0.54	NA	NA	1.00	0.00	0.00	1.00	NA	NA
22/11/85	0	0	0.00	0.00	1.9	12.8	13.7	15.5	11.5	-4.0	NA	1.00	0.38	NA	NA	1.00	0.00	0.00	1.00	NA	NA
23/11/85	0	0	0.00	0.00	1.9	12.5	13.3	14.1	11.6	-2.5	NA	1.00	0.29	NA	NA	1.00	0.00	0.00	1.00	NA	NA
26/11/85	55142	1697	0.00	13.56	1.1	14.3	14.0	20.1	12.9	-7.2	0.0069	1.00	0.29	2.6	0.4	0.71	0.00	0.29	0.98	0.33	NA
27/11/85	308	0	0.00	0.04	1.1	12.2	12.9	16.2	11.2	-5.0	NA	1.00	0.33	2.0	NA	0.91	0.00	0.09	1.00	0.59	NA
29/11/85	9937	0	0.07	0.33	0.5	12.3	12.8	20.8	11.4	-9.4	0.0113	1.00	0.24	3.6	NA	0.84	0.00	0.16	1.00	0.57	NA
[illegible]	14946	0	0.10	0.22	0.1	12.5	12.7	19.8	11.5	-8.3	0.0105	1.00	0.35	4.5	NA	0.84	0.00	0.16	1.00	0.64	NA
[illegible]/86	53574	358	0.00	11.06	-3.8	17.1	15.6	26.2	16.0	-10.2	0.0099	0.65	0.21	2.2	0.6	0.39	0.05	0.56	0.99	0.44	0.03
[illegible]	112246	0	0.34	16.59	-3.7	17.6	16.0	25.9	16.8	-9.1	0.0103	0.88	0.15	4.7	NA	0.46	0.07	0.48	1.00	0.46	NA
[illegible]/86	8445	0	0.00	3.98	-3.6	16.5	15.2	22.9	15.7	-7.1	0.0044	0.51	0.23	0.9	NA	0.54	0.06	0.39	1.00	0.24	NA
[illegible]/86	164766	0	0.69	16.87	-3.5	18.1	16.2	25.5	17.4	-8.1	0.0111	0.85	0.14	6.6	NA	0.42	0.07	0.50	1.00	0.48	NA
[illegible]/86	132723	0	0.21	11.53	-3.6	18.0	16.4	26.7	16.2	-10.5	0.0102	0.87	0.21	8.1	NA	0.97	0.07	0.00	1.00	0.47	NA
[illegible]/02/86	178172	0	0.29	12.15	-4.1	18.8	16.9	26.5	17.6	-8.9	0.0129	0.80	0.16	8.9	NA	0.42	0.07	0.51	1.00	0.53	NA
[illegible]/02/86	0	0	0.00	0.00	-3.6	16.5	15.5	20.7	15.6	-5.1	NA	0.20	0.29	NA	NA	0.62	0.07	0.30	1.00	NA	NA
[illegible]/02/86	179196	0	0.00	24.75	-3.2	18.3	16.6	24.0	17.9	-6.1	0.0118	1.00	0.11	5.9	NA	0.39	0.07	0.54	1.00	0.49	NA
20/02/86	194090	0	143.31	0.77	-3.2	19.1	17.3	18.9	18.0	-0.9	0.0155	0.36	0.14	31.0	NA	0.39	0.09	0.52	1.00	0.52	NA
[illegible]/02/86	0	0	0.00	0.00	-2.4	16.3	15.6	22.1	16.0	-6.1	NA	0.65	0.09	NA	NA	0.67	0.09	0.24	1.00	NA	NA
24/02/86	127693	0	0.11	22.88	-2.3	18.6	17.0	24.2	17.4	-6.8	0.0101	0.76	0.14	4.0	NA	0.44	0.07	0.48	1.00	0.40	NA
25/02/86	19469	0	0.06	6.86	-2.1	17.2	16.2	23.4	16.2	-7.2	0.0084	0.27	0.14	1.7	NA	0.46	0.07	0.47	1.00	0.31	NA
28/02/86	147889	548	0.13	22.59	-3.1	16.6	15.3	24.6	17.3	-7.2	0.0124	0.86	0.07	6.1	0.8	0.31	0.04	0.65	0.94	0.53	0.00
01/03/86	178308	408	0.00	21.32	-2.9	17.7	16.2	22.6	17.9	-4.7	0.0119	0.71	0.12	6.7	0.7	0.39	0.07	0.54	0.98	0.47	0.09
03/03/86	221019	4	0.00	32.55	-2.9	18.7	17.3	23.0	18.6	-4.4	0.0128	0.74	0.16	6.4	0.1	0.36	0.07	0.57	1.00	0.46	0.01
04/03/86	40183	0	0.09	7.40	-2.6	18.3	17.3	16.6	16.7	0.0	0.0132	0.71	0.22	4.6	NA	0.36	0.10	0.53	1.00	0.46	NA
[illegible]/03/86	85044	161	0.00	16.67	-2.0	17.5	16.6	29.1	17.2	-12.0	0.0105	0.79	0.19	4.7	0.3	0.39	0.06	0.55	0.99	0.37	0.02

DATE	QETSIC	QEIRTC	DHUC	HUC	TOSM	TSSIM	TSSGM	TIODM	TIM	TOM	HCTM	SE	RE	COPSM	COPRM	FF	LF	SF	RSR	ESEM	EREM
09/03/86	55442	0	0.00	0.28	-2.6	16.9	15.9	27.2	16.0	-11.2	0.0141	0.26	0.14	5.9	NA	0.67	0.06	0.26	1.00	0.59	NA
10/03/86	0	0	0.00	0.00	-2.5	15.2	14.9	25.0	15.4	-9.6	NA	0.22	0.04	NA	NA	0.66	0.06	0.28	1.00	NA	NA
11/03/86	0	0	0.00	0.00	-2.1	15.2	14.6	21.8	15.7	-6.1	NA	0.58	0.00	NA	NA	0.63	0.07	0.30	NA	NA	NA
12/03/86	73920	0	0.00	17.58	-1.8	16.9	15.6	25.6	16.9	-8.7	0.0084	0.65	0.18	2.7	NA	0.46	0.08	0.46	1.00	0.34	NA
14/03/86	0	0	0.00	0.00	-1.4	16.4	15.2	17.5	15.9	-1.6	NA	0.31	0.24	NA	NA	0.69	0.09	0.22	1.00	NA	NA
15/03/86	86945	899	0.83	9.94	-1.2	17.1	15.5	18.6	17.4	-1.1	0.0095	0.75	0.16	6.0	0.7	0.59	0.11	0.31	0.93	0.45	0.08
19/03/86	88234	0	0.74	22.62	-0.5	18.3	16.7	20.6	17.0	-3.6	0.0117	0.46	0.41	4.3	NA	0.35	0.07	0.58	1.00	0.47	NA
21/03/86	160936	858	0.00	31.60	-2.2	19.4	17.3	24.9	17.9	-7.0	0.0132	0.65	0.43	6.0	0.7	0.28	0.04	0.68	0.99	0.47	0.18
23/03/86	177881	0	0.16	36.95	-0.8	19.6	17.7	19.8	18.5	-1.3	0.0115	0.67	0.51	5.7	NA	0.38	0.06	0.55	1.00	0.39	NA
24/03/86	108285	0	1.12	26.98	-1.0	20.0	18.1	23.9	18.1	-5.8	0.0120	0.54	0.35	5.0	NA	0.44	0.07	0.48	1.00	0.36	NA
25/03/86	135039	237	0.00	22.69	-1.0	19.7	18.0	18.8	18.5	-0.4	0.0110	0.53	0.34	5.9	1.1	0.34	0.09	0.57	1.00	0.39	0.34
26/03/86	54130	103	0.00	9.72	-0.5	19.9	18.3	11.5	17.8	6.4	0.0082	0.31	0.37	4.9	0.8	0.20	0.14	0.65	1.00	0.28	0.00
27/03/86	122248	563	3.50	13.58	-0.3	19.4	17.8	18.3	17.7	-0.6	0.0125	0.65	0.43	8.8	0.9	0.39	0.09	0.51	0.99	0.45	0.15
28/03/86	204547	0	0.00	22.32	-0.3	19.4	17.9	12.1	18.3	6.2	0.0133	0.61	0.44	7.3	NA	0.67	0.09	0.23	1.00	0.44	NA
29/03/86	165546	12	1.77	16.65	-0.1	20.2	18.6	12.9	19.1	6.2	0.0127	0.65	0.32	7.1	0.0	0.26	0.11	0.63	1.00	0.36	NA
30/03/86	177653	182	0.38	23.48	-0.2	20.5	18.8	9.9	19.3	9.5	0.0121	0.51	0.30	5.8	0.2	0.12	0.10	0.78	1.00	0.34	NA
31/03/86	216477	0	0.41	32.14	1.0	20.6	19.0	10.0	19.2	9.2	0.0134	0.50	0.37	5.5	NA	0.22	0.10	0.68	1.00	0.37	NA
01/04/86	210373	0	0.00	35.09	4.2	21.2	19.4	9.0	19.9	10.9	0.0131	0.49	0.33	4.5	NA	0.08	0.13	0.78	1.00	0.35	NA
02/04/86	191588	130	0.05	32.50	1.8	21.2	19.6	14.2	19.2	5.1	0.0123	0.47	0.41	4.5	0.1	0.25	0.08	0.67	1.00	0.30	NA
03/04/86	176632	0	0.00	35.81	1.3	21.4	19.7	15.3	19.2	3.8	0.0122	0.49	0.45	4.0	NA	0.18	0.08	0.74	1.00	0.30	NA
04/04/86	171129	0	0.00	36.35	0.6	21.1	19.7	18.8	18.9	0.1	0.0120	0.52	0.41	3.8	NA	0.28	0.06	0.65	1.00	0.31	NA
05/04/86	166975	0	0.00	34.03	0.1	21.1	19.8	17.7	18.9	1.3	0.0127	0.52	0.40	3.8	NA	0.32	0.07	0.61	1.00	0.31	NA
06/04/86	0	0	0.00	0.00	0.9	19.7	19.1	12.2	16.0	3.8	NA	0.00	0.50	NA	NA	0.58	0.14	0.28	1.00	NA	NA
08/04/86	328	0	0.00	0.25	0.8	18.1	17.5	14.3	15.9	1.6	NA	0.27	0.83	NA	NA	0.55	0.12	0.33	1.00	0.28	NA
09/04/86	0	604	0.00	1.18	0.7	18.4	17.3	14.3	16.5	2.2	NA	0.66	0.38	NA	1.9	0.58	0.10	0.32	0.99	NA	0.25
11/04/86	186089	0	0.18	29.39	2.8	[illegible]	16.2	13.0	18.5	5.5	0.0116	0.62	0.59	5.0	NA	0.33	0.09	0.58	1.00	0.41	NA
14/04/86	247109	0	0.00	43.58	2.9	19.2	17.5	13.7	19.5	5.8	0.0122	0.51	0.21	5.2	NA	0.23	0.07	0.69	1.00	0.42	NA
15/04/86	237864	0	0.07	50.20	2.7	20.1	18.4	13.6	19.2	5.6	0.0130	0.50	0.26	4.0	NA	0.26	0.08	0.66	1.00	0.37	NA
16/04/86	225043	0	0.00	49.76	3.1	20.5	18.9	12.2	19.3	7.0	0.0122	0.49	0.30	4.2	NA	0.21	0.08	0.71	1.00	0.34	NA
17/04/86	195152	0	0.02	52.69	3.4	20.9	19.4	13.2	19.2	6.0	0.0124	0.49	0.33	3.3	NA	0.18	0.08	0.74	1.00	0.32	NA
18/04/86	263750	196791	0.83	114.85	3.2	21.0	19.2	14.0	19.6	5.6	0.0186	0.51	0.83	5.3	3.7	0.12	0.07	0.81	0.28	0.40	0.34
19/04/86	271597	145606	0.83	110.17	3.8	21.2	19.3	11.2	20.1	8.9	0.0196	0.53	0.78	4.9	2.9	0.04	0.08	0.88	0.32	0.38	0.27
20/04/86	114179	0	0.00	23.84	5.8	20.0	18.7	9.0	17.9	8.9	0.0106	0.70	0.38	3.7	NA	0.38	0.05	0.57	1.00	0.33	NA
21/04/86	189905	0	0.00	41.02	5.6	19.2	18.1	11.4	18.7	7.3	0.0116	0.58	0.46	3.7	NA	0.13	0.08	0.79	1.00	0.34	NA
22/04/86	235012	176791	0.81	94.62	4.0	20.3	18.7	15.8	19.0	3.2	0.0191	0.55	0.84	5.9	3.3	0.16	0.07	0.77	0.28	0.35	0.32
23/04/86	233690	164635	0.36	103.42	4.5	20.8	19.0	12.8	19.2	6.4	0.0179	0.53	0.78	5.2	3.3	0.10	0.09	0.81	0.31	0.36	0.31
24/04/86	52295	194805	0.00	120.40	5.4	19.9	18.5	9.8	17.8	7.2	0.0224	0.77	0.81	3.4	2.6	0.00	0.16	0.84	0.25	0.20	0.26
25/04/86	48991	186998	0.00	128.40	6.0	18.5	17.5	8.9	16.2	7.3	0.0069	0.68	0.96	3.4	2.4	0.02	0.16	0.82	0.31	0.22	0.22
26/04/86	0	153397	0.00	76.20	5.7	16.9	16.2	8.0	14.9	6.9	NA	0.98	1.00	NA	2.7	0.07	0.18	0.75	0.31	NA	0.22
27/04/86	47785	114095	4.97	67.24	5.4	16.5	15.5	10.5	15.8	5.3	0.0091	-0.60	1.00	11.1	2.3	0.05	0.14	0.81	0.29	0.49	0.18
28/04/86	235547	35929	0.34	66.19	7.7	19.9	18.0	8.7	19.5	10.9	0.0101	0.55	0.33	7.1	1.8	0.02	0.12	0.86	0.55	0.39	0.17
29/04/86	228958	137418	1.80	98.79	7.0	19.2	17.6	9.6	17.9	8.4	0.0157	0.54	0.66	5.9	2.8	0.18	0.12	0.71	0.37	0.38	0.26
30/04/86	321868	47708	0.55	78.92	9.4	20.7	18.8	5.0	20.7	15.8	0.0115	0.49	0.46	5.1	2.1	0.00	0.15	0.85	0.48	0.43	0.21
01/05/86	152152	59154	0.52	62.01	9.6	20.6	19.0	8.1	19.2	11.1	0.0141	0.58	0.50	2.2	2.7	0.02	0.12	0.87	0.51	0.27	0.28
02/05/86	188235	0	0.06	35.51	6.7	20.0	18.8	16.4	18.5	2.1	0.0114	0.53	0.49	4.3	NA	0.25	0.08	0.67	1.00	0.34	NA
03/05/86	203062	0	0.00	38.80	6.0	20.6	19.4	16.9	18.9	2.0	0.0114	0.48	0.37	4.4	NA	0.25	0.07	0.68	1.00	0.34	NA
[illegible]/05/86	18302	181941	0.00	68.76	6.3	19.9	18.9	11.0	17.1	6.0	0.0238	0.55	0.79	0.5	3.1	0.00	0.16	0.84	0.34	0.13	0.32
[illegible]	181331	507	0.00	35.59	6.6	19.7	18.5	12.1	18.6	6.5	0.0128	0.54	0.66	5.7	0.3	0.18	0.10	0.72	0.99	0.37	NA
[illegible]/86	99407	0	0.17	18.86	6.7	17.8	17.3	9.5	16.2	6.7	0.0096	0.72	0.83	3.7	NA	0.13	0.14	0.73	1.00	0.31	NA
[illegible]/05/86	275339	0	1.96	45.01	6.9	19.2	18.2	12.1	18.6	6.5	0.0115	0.48	0.37	6.4	NA	0.16	0.08	0.76	1.00	0.40	NA
[illegible]/05/86	241552	0	0.02	45.40	8.8	20.6	19.4	7.7	19.0	11.3	0.0120	0.57	0.35	4.1	NA	0.12	0.02	0.86	1.00	0.35	NA
[illegible]/05/86	241552	0	0.02	45.40	8.8	20.6	19.4	7.7	19.8	11.3	0.0120	0.57	0.35	4.1	NA	0.12	0.02	0.86	1.00	0.35	NA
[illegible]/05/86	183760	0	0.40	40.39	7.5	19.2	18.7	11.6	17.7	6.2	0.0106	0.51	0.57	4.0	NA	0.15	0.06	0.79	1.00	0.32	NA
[illegible]/05/86	231239	442	0.00	72.34	8.3	20.4	19.4	9.9	18.6	8.6	0.0118	0.47	0.45	3.2	0.1	0.12	0.08	0.80	1.00	0.31	NA

DATE	QETSTC	QETRTC	QHUC	HUC	TOSM	TSSIN	TSSGM	TIODM	TIN	TON	NCTN	SE	RE	COPSN	COPRN	FF	LF	SF	RSN	ESEN	EREN
13/05/86	295750	106946	0.00	160.98	10.4	21.9	20.4	8.0	21.2	13.3	0.0161	0.46	0.73	2.4	2.9	0.00	0.09	0.91	0.37	0.36	0.33
14/05/86	284649	44237	0.00	140.34	13.2	22.9	21.3	3.9	22.7	18.8	0.0122	0.40	0.52	2.0	1.8	0.00	0.10	0.90	0.50	0.32	0.31
15/05/86	223367	0	0.00	102.14	14.6	23.7	22.1	3.0	23.3	20.3	0.0111	0.44	0.28	1.4	NA	0.00	0.12	0.88	1.00	0.26	NA
16/05/86	176202	0	0.00	83.53	15.4	24.2	22.6	4.0	23.2	19.3	0.0101	0.46	0.32	1.3	NA	0.00	0.11	0.89	1.00	0.21	NA
17/05/86	201397	0	0.00	90.47	16.4	24.5	23.0	3.0	23.9	20.9	0.0111	0.49	0.32	1.2	NA	0.00	0.08	0.92	1.00	0.25	NA
19/05/86	1343	244050	0.00	157.02	11.0	20.5	20.4	8.4	16.5	8.1	0.0208	0.92	1.00	NA	3.3	0.01	0.15	0.84	0.35	0.03	0.42
20/05/86	181	233472	0.00	180.76	9.5	18.6	18.6	7.7	15.2	7.5	0.0108	1.00	1.00	NA	3.4	0.14	0.16	0.70	0.33	0.03	0.30
26/05/86	301948	0	0.00	153.06	14.5	23.1	21.3	5.3	22.1	16.7	0.0122	0.17	0.19	1.3	NA	0.00	0.07	0.93	1.00	0.33	NA
27/05/86	224297	0	0.00	147.25	16.4	24.5	22.5	3.6	23.4	19.6	0.0115	0.44	0.31	0.9	NA	0.00	0.06	0.94	1.00	0.25	NA
28/05/86	206572	0	0.00	138.07	16.3	24.4	22.6	5.6	22.3	16.7	0.0113	0.43	0.44	0.8	NA	0.00	0.07	0.93	1.00	0.26	NA
29/05/86	137879	0	0.00	120.55	14.9	24.0	22.6	3.3	22.2	18.9	0.0121	0.52	0.39	0.6	NA	0.00	0.15	0.85	1.00	0.25	NA
30/05/86	134564	98	0.00	121.59	15.2	23.9	22.6	6.1	22.3	16.2	0.0123	0.47	0.41	1.0	0.2	0.00	0.09	0.91	1.00	0.26	0.03
31/05/86	147145	0	0.00	104.11	16.0	24.7	23.1	9.0	21.4	12.4	0.0114	0.41	0.50	1.8	NA	0.00	0.06	0.94	1.00	0.30	NA
07/06/86	251225	159990	0.66	65.31	13.5	23.6	21.8	10.5	20.8	10.3	0.0187	0.42	0.89	5.1	4.4	0.00	0.00	1.00	0.39	0.31	0.46
09/06/86	276194	74784	1.55	45.96	15.0	23.9	22.2	7.1	21.3	14.1	0.0102	0.36	0.64	4.7	2.1	0.00	0.01	0.99	0.56	0.29	0.34
10/06/86	219348	422	0.00	42.37	16.6	24.0	22.4	3.5	22.4	18.9	0.0106	0.35	0.39	2.9	0.4	0.00	0.00	1.00	0.99	0.26	NA
11/06/86	249776	154543	0.41	79.10	16.4	24.5	22.8	10.4	21.7	11.2	0.0189	0.42	0.79	4.0	4.1	0.00	0.00	1.00	0.40	0.29	0.50
12/06/86	167564	128277	0.00	76.71	16.8	24.7	22.9	7.4	21.3	13.9	0.0110	0.38	0.72	3.4	2.4	0.00	0.00	1.00	0.47	0.30	0.40
13/06/86	97657	90525	0.00	84.02	14.3	21.8	21.1	7.3	20.1	12.8	0.0116	0.48	1.00	3.4	2.0	0.00	0.00	1.00	0.44	0.36	0.30
14/06/86	273783	8467	0.12	63.13	18.3	24.6	22.6	3.9	22.2	18.8	0.0115	0.52	0.26	3.3	1.2	0.00	0.00	1.00	0.90	0.32	0.23
15/06/86	235138	61741	3.30	84.83	18.8	25.3	23.3	4.5	23.5	19.0	0.0114	0.42	0.39	3.1	1.8	0.00	0.00	1.00	0.52	0.25	0.41
17/06/86	176428	113182	0.00	68.11	16.1	24.2	22.9	7.3	21.6	14.2	0.0100	0.44	0.69	2.8	2.9	0.00	0.00	1.00	0.42	0.26	0.45
18/06/86	236430	54894	0.01	60.22	17.8	24.4	23.0	7.4	21.6	14.2	0.0154	0.62	0.38	3.1	3.1	0.00	0.06	0.94	0.65	0.27	0.44
19/06/86	234481	93746	0.01	66.42	18.8	24.8	23.3	6.8	21.5	14.7	0.0142	0.43	0.70	3.1	3.7	0.02	0.05	0.93	0.55	0.28	0.47
20/06/86	219718	227214	4.93	76.24	19.6	25.2	23.5	6.2	21.7	15.5	NA	0.23	1.00	13.0	5.3	0.14	0.05	0.82	0.35	0.53	1.00
21/06/86	199748	5466	0.00	53.48	19.9	25.2	23.4	3.1	22.6	19.5	0.0110	0.94	0.24	2.4	2.9	0.00	0.09	0.91	0.95	0.24	0.44
22/06/86	193538	0	0.05	47.18	20.1	25.3	23.8	1.7	23.9	22.2	0.0107	0.70	0.21	2.2	NA	0.00	0.12	0.88	1.00	0.23	NA
23/06/86	161887	0	0.00	53.57	18.9	24.6	23.1	3.0	22.8	19.9	0.0112	1.00	0.17	1.9	NA	0.00	0.09	0.91	1.00	0.23	NA
[illegible]/06/86	81641	81178	0.06	64.69	16.5	23.5	22.6	7.2	19.9	12.8	0.0165	0.99	0.50	2.3	2.9	0.00	0.04	0.96	0.60	0.21	0.42
28/06/86	225395	0	0.00	72.37	18.8	25.6	23.6	3.8	23.2	19.3	0.0127	0.66	0.19	2.4	NA	0.00	0.07	0.93	1.00	0.26	NA
29/06/86	166736	135	0.00	55.74	18.0	24.7	23.2	4.6	22.0	17.4	0.0123	0.57	0.36	2.6	0.2	0.00	0.07	0.93	1.00	0.24	NA
30/06/86	237720	7106	0.00	84.21	19.4	25.6	23.7	4.0	23.5	19.5	0.0121	0.67	0.29	2.5	1.4	0.00	0.06	0.94	0.91	0.26	0.46
01/07/86	237227	2637	0.00	87.63	21.0	26.5	24.3	3.1	23.9	20.8	0.0111	0.67	0.28	2.3	0.6	0.00	0.05	0.95	0.97	0.24	0.27
02/07/86	144757	40330	1.00	57.63	20.0	25.7	24.1	4.7	22.4	17.7	0.0129	0.67	0.46	3.2	3.5	0.00	0.06	0.94	0.73	0.25	0.68
06/09/86	82210	1073	13.42	0.31	13.8	21.5	20.7	7.2	20.5	13.2	0.0075	0.26	0.33	4.7	0.5	0.00	0.14	0.86	0.98	0.18	0.07
07/09/86	72770	125825	21.25	0.02	12.8	20.9	20.4	10.4	20.1	9.7	0.0190	0.45	0.81	6.3	4.4	0.00	0.11	0.89	0.28	0.23	0.46
08/09/86	153094	28002	28.16	0.39	12.0	20.9	20.3	7.4	20.3	12.9	0.0086	0.40	0.52	5.3	1.8	0.00	0.09	0.91	0.66	0.25	0.22
[illegible]/09/86	160449	1069	17.81	0.00	11.4	19.3	19.0	6.3	19.7	13.4	0.0121	0.41	0.39	8.4	0.9	0.00	0.10	0.90	0.97	0.33	0.20
14/09/86	99905	120606	31.26	0.00	10.2	20.2	19.5	10.2	19.2	9.0	0.0169	0.48	0.64	7.6	5.6	0.00	0.10	0.90	0.33	0.24	0.41
16/09/86	154384	179126	64.13	1.83	9.3	19.2	18.8	11.2	19.8	8.5	0.0217	0.42	0.82	9.1	4.7	0.00	0.06	0.94	0.15	0.30	0.43
17/09/86	92410	207920	47.83	0.06	8.7	19.9	19.1	10.6	19.8	9.1	0.0211	0.48	0.89	7.3	4.2	0.00	0.07	0.93	0.18	0.22	0.42
19/09/86	3[illegible]996	31300	87.94	8.19	9.5	19.3	18.9	10.8	18.3	7.5	0.0089	0.10	0.62	11.7	1.5	0.14	0.08	0.79	0.70	0.66	0.34
20/09/86	257833	84136	88.24	14.21	8.6	19.3	18.7	11.8	18.4	6.6	0.0028	0.17	1.00	14.1	2.3	0.13	0.09	0.78	0.48	0.76	0.40
21/09/86	201070	101309	77.14	9.00	8.2	19.7	18.8	9.6	18.8	9.2	0.0111	0.18	1.00	13.1	3.4	0.10	0.04	0.86	0.42	0.69	0.63
22/09/86	6448	143497	25.98	0.00	8.5	18.1	17.9	10.1	16.7	6.6	0.0262	0.44	0.81	4.2	4.4	0.00	0.13	0.87	0.27	0.11	0.38
23/09/86	14070	101655	20.49	0.76	8.5	17.0	16.9	8.6	16.7	8.1	0.0117	1.00	1.00	3.1	2.8	0.00	0.17	0.83	0.28	0.15	0.25
01/10/86	5[illegible]750	0	17.68	0.00	10.4	21.5	22.2	3.7	19.2	15.5	0.0075	0.84	0.67	8.5	NA	0.00	0.47	0.53	1.00	0.22	NA
04/10/86	134939	151879	43.97	45.90	9.2	20.2	21.4	10.3	18.7	8.5	0.0182	0.68	0.61	10.7	4.3	0.00	0.14	0.86	0.36	0.33	0.36
[illegible]/10/86	34105	294923	39.57	38.95	7.2	19.1	20.5	11.9	16.4	4.5	0.0247	0.70	0.89	6.9	4.3	0.00	0.18	0.82	0.25	0.24	0.35
[illegible]/10/86	115480	38032	6.89	35.37	7.5	17.8	17.1	9.2	17.6	8.4	0.0098	0.83	0.98	3.3	1.9	0.03	0.15	0.82	0.51	0.38	0.17
[illegible]	170600	157904	4.99	76.86	5.4	17.8	17.2	13.9	17.7	3.8	0.0099	0.86	-0.76	5.7	3.1	0.18	0.09	0.73	0.24	0.36	0.25
[illegible]	194775	162763	3.46	108.83	4.3	18.3	17.5	15.1	18.0	2.9	0.0094	0.81	0.72	4.3	3.2	0.20	0.11	0.69	0.25	0.36	0.26
[illegible]	159780	86226	6.79	48.34	4.7	18.8	17.8	8.9	18.2	9.3	0.0093	0.96	0.49	5.0	2.4	0.00	0.18	0.82	0.40	0.32	0.21
[illegible]	0	0	0.00	0.00	6.5	23.5	19.9	0.4	17.7	17.3	NA	1.00	0.64	NA	NA	0.00	1.00	0.00	1.00	NA	NA

129

DATE	QETSTC	QETRTC	DHUC	HUC	TOSM	TSSIM	TSSGM	TIODM	TIM	TOM	HCTM	SE	RE	COPSM	COPRM	FF	LF	SF	RSR	ESEM	EREM
15/10/86	1168	163392	21.25	24.37	7.1	17.7	16.9	10.3	15.6	5.4	0.0328	1.00	0.98	3.8	3.7	0.22	0.22	0.56	0.31	0.13	0.29
16/10/86	47311	155190	30.89	16.05	6.0	17.1	16.3	13.2	16.3	3.1	0.0114	0.86	1.00	9.7	2.8	0.27	0.16	0.57	0.25	0.33	0.24
17/10/86	113442	70494	95.06	42.07	5.1	17.6	16.7	12.2	17.1	4.9	0.0111	0.50	0.80	18.6	2.0	0.20	0.16	0.65	0.44	0.37	0.17
18/10/86	115295	16983	101.62	9.79	5.4	17.9	17.0	8.7	17.9	9.2	0.0072	0.46	0.37	11.8	1.8	0.17	0.18	0.65	0.72	0.28	0.14
23/10/86	39666	97074	0.63	53.41	4.7	15.7	15.7	16.1	16.4	0.3	0.0083	0.63	1.00	2.8	2.0	0.54	0.14	0.32	0.02	0.27	0.19
24/10/86	134244	123521	0.02	95.33	3.5	16.6	16.2	17.5	17.7	0.2	0.0090	0.80	0.93	4.3	2.0	0.36	0.11	0.53	0.09	0.38	0.17
25/10/86	23744	25728	2.34	26.35	3.9	16.6	16.5	13.1	16.7	3.6	0.0065	0.74	0.20	4.9	1.7	0.21	0.15	0.65	0.42	0.25	0.17
26/10/86	462	89719	0.00	53.95	3.4	15.9	15.9	16.1	15.8	-0.3	NA	1.00	0.75	NA	1.7	0.71	0.16	0.13	0.13	0.12	0.16
27/10/86	0	0	0.00	0.00	4.1	15.3	15.4	12.5	15.8	3.3	NA	0.35	1.00	NA	NA	0.70	0.03	0.27	1.00	NA	NA
28/10/86	0	119	0.00	1.82	5.2	15.3	15.2	10.1	16.1	6.1	NA	0.49	0.01	NA	0.1	0.37	0.21	0.42	0.75	NA	0.00
29/10/86	17169	32	0.00	12.31	6.1	15.4	15.2	10.9	16.6	5.7	0.0069	0.83	0.01	NA	0.2	0.28	0.19	0.53	0.91	0.25	0.00
31/10/86	77262	42632	0.00	49.36	3.0	16.4	16.1	15.7	16.9	1.2	0.0090	0.51	0.21	5.0	2.1	0.39	0.11	0.50	0.21	0.30	0.19
01/11/86	22472	2676	1.15	9.78	3.7	15.5	15.5	12.3	15.8	3.5	0.0101	0.58	0.10	3.2	1.0	0.44	0.17	0.38	0.74	0.31	0.10
02/11/86	76803	106947	1.14	79.13	3.0	16.3	16.1	18.0	17.1	-1.0	0.0093	0.88	0.55	4.7	2.0	0.39	0.12	0.49	0.11	0.32	0.18
03/11/86	4054	2133	0.14	5.18	2.5	15.9	15.6	15.4	16.3	0.9	0.0036	0.35	0.06	2.6	1.0	0.42	0.13	0.45	0.67	0.20	0.13
04/11/86	58511	133106	0.00	99.01	2.3	16.4	16.0	21.5	16.6	-4.9	0.0098	1.00	0.95	3.5	2.1	0.76	0.10	0.14	0.14	0.36	0.18
05/11/86	66158	117948	0.00	95.51	1.4	16.5	16.2	21.0	16.7	-4.3	0.0094	0.64	0.48	5.3	2.0	0.49	0.11	0.41	0.13	0.27	0.17
07/11/86	26901	52703	0.30	54.27	1.4	15.8	15.5	14.9	16.5	1.6	0.0077	0.89	0.51	3.3	1.2	0.35	0.14	0.51	0.09	0.35	0.11
08/11/86	0	0	0.00	0.00	2.3	15.1	15.0	11.7	15.7	4.0	NA	0.28	0.01	NA	NA	0.33	0.22	0.45	1.00	NA	NA
10/11/86	69304	131849	0.01	90.05	2.2	16.1	15.8	20.3	16.8	-3.5	0.0085	1.00	0.65	4.0	2.2	0.48	0.11	0.40	0.06	0.29	0.19
11/11/86	0	21759	0.00	21.64	1.6	15.7	15.3	16.8	15.8	-1.0	NA	0.35	0.79	NA	1.0	1.00	0.13	0.00	0.13	NA	0.08
[illegible]/11/86	23768	19595	0.00	31.86	1.5	15.9	15.5	18.4	16.4	-2.0	0.0073	0.66	0.30	0.1	1.1	0.79	0.11	0.10	0.11	0.29	0.11
[illegible]/11/86	0	134811	0.00	75.95	0.9	15.6	15.4	27.3	15.7	-11.6	NA	0.23	1.00	NA	1.9	0.60	0.08	0.32	0.03	NA	0.16
14/11/86	421	42264	0.00	46.51	0.4	15.2	14.9	19.7	15.6	-4.1	NA	0.06	0.87	NA	0.9	0.51	0.08	0.41	0.00	0.20	0.08
15/11/86	5873	0	0.00	5.35	0.6	15.1	14.8	17.9	16.0	-2.0	0.0042	0.37	0.00	NA	NA	0.51	0.11	0.38	1.00	0.19	NA
16/11/86	0	0	0.00	0.00	0.5	14.8	14.4	15.5	15.7	0.2	NA	0.35	0.00	NA	NA	0.55	0.14	0.31	NA	NA	NA
18/11/86	42830	87878	0.09	90.19	0.3	15.1	14.9	26.3	16.0	-10.2	0.0084	0.91	1.00	1.3	1.3	0.58	0.08	0.33	0.00	0.31	0.12
19/11/86	0	93425	0.00	74.80	-0.8	15.3	15.1	28.3	15.5	-12.8	NA	0.18	1.00	NA	1.4	0.71	0.09	0.20	0.01	NA	0.12
21/11/86	44710	2046	0.00	9.34	-0.8	16.4	15.3	24.7	18.8	-5.9	0.0111	0.68	0.10	6.0	1.1	0.58	0.07	0.34	0.00	0.48	0.13
22/11/86	55828	0	0.25	11.31	-1.1	17.7	16.6	27.9	18.9	-9.0	0.0095	0.52	0.00	3.4	NA	0.82	0.09	0.09	NA	0.30	NA
23/11/86	3013	194	0.00	2.90	-0.8	17.4	16.0	21.7	18.7	-3.0	0.0039	0.18	0.00	NA	0.7	0.62	0.11	0.28	0.00	0.12	0.07
24/11/86	26092	477	0.00	14.18	-0.3	17.3	16.0	19.5	18.8	-0.7	0.0065	0.57	0.03	0.5	0.6	0.54	0.10	0.36	0.00	0.21	0.07
25/11/86	49302	129	0.00	16.24	-0.3	17.6	16.5	20.7	19.0	-1.7	0.0096	0.40	0.00	4.1	0.2	0.50	0.11	0.39	0.00	0.24	0.06
26/11/86	120384	0	0.00	16.70	-0.2	17.5	16.3	19.5	19.6	0.1	0.0118	0.98	0.00	6.0	NA	0.55	0.11	0.34	NA	0.44	NA
27/11/86	32762	0	0.24	13.97	-0.2	18.1	17.1	19.8	18.9	-0.8	0.0127	0.23	0.00	1.7	NA	0.47	0.09	0.44	1.00	0.26	NA
28/11/86	22941	0	0.00	6.56	-0.2	17.9	16.7	17.4	18.9	1.4	0.0122	0.97	0.01	1.2	NA	0.54	0.11	0.35	1.00	0.29	NA
01/12/86	94246	0	0.00	30.86	-2.0	18.3	17.5	29.1	19.2	-10.0	0.0127	0.83	0.01	2.3	NA	0.48	0.08	0.44	1.00	0.33	NA

APPENDIX E

Example of raw, treated
and compiled data

MONTH	DAY	#	HR.	MIN.	SEC.
04	18	05	18	12	26.143

REPORT	SAMPLES	PERIOD
1	135	3599.79

LEGEND

\# : DAY OF THE WEEK
VAR : VARIABLE
MAX : MAXIMUM VALUE
MIN : MINIMUM VALUE
STD : STANDARD DEVIATION

VAR	MAX	MIN	MEAN	STD	SENSOR IDENTIFICATION
1	25.45	24.53	24.92	0.20	T1
2	22.63	21.90	22.15	0.07	T2
3	22.29	21.71	21.80	0.08	T3
4	21.58	20.70	21.05	0.20	T4
5	24.53	23.89	24.28	0.16	NOT USED
6	25.66	25.04	25.12	0.08	AIR INLET STATUS
7	21.77	20.50	21.11	0.38	T7
8	20.23	20.09	20.14	0.02	T8
9	19.76	18.59	19.29	0.09	T9
10	21.06	19.59	20.27	0.43	T10
11	25.22	24.13	24.57	0.23	T12
12	12.77	12.43	12.49	0.04	NOT USED
13	21.72	21.38	21.54	0.03	T14
14	9.49	0.00	9.18	0.38	δT INSIDE-OUTSIDE
15	20.60	20.49	20.53	0.02	T16
16	22.43	21.79	22.11	0.14	T17
17	17.43	16.80	17.00	0.07	T18
18	14.90	14.19	14.46	0.07	T19
19	3.64	2.47	2.94	0.23	T20
20	24.14	23.38	23.66	0.15	T21
21	20.30	19.89	20.06	0.03	T22
22	17.86	17.37	17.54	0.04	T23
23	21.80	21.03	21.39	0.22	T24
24	19.72	18.02	18.86	0.46	T25
25	20.50	19.75	20.08	0.19	T26
26	18.51	16.84	17.65	0.47	T27
27	22.17	18.44	19.89	0.98	T28
28	18.51	15.55	16.87	0.81	T29
29	22.98	22.36	22.60	0.12	T30
30	20.41	18.23	19.44	0.52	T31
31	18.46	16.63	17.54	0.50	T32
32	7.26	4.32	5.69	0.76	T33
33	23.84	23.15	23.37	0.12	T34
34	21.34	20.92	21.25	0.06	T35
35	23.30	22.71	22.85	0.06	T36
36	20.69	19.93	20.24	0.07	T37
37	19.46	19.30	19.35	0.02	T38
38	21.55	21.26	21.49	0.04	T39
39	21.39	21.05	21.21	0.03	T40
40	23.67	20.10	21.55	1.06	T41
41	21.97	21.22	21.48	0.08	T42
42	21.23	20.69	20.77	0.05	NOT USED
43	21.07	20.41	20.54	0.08	T44

44	14.24	14.15	14.19	0.02	T45
45	5.57	4.70	5.00	0.08	T46
46	3.83	3.20	3.46	0.06	T47
47	5.25	5.00	5.04	0.03	T48
48	24.11	23.27	23.49	0.08	T50 NOT USED
49	22.99	22.34	22.56	0.06	T51
50	22.90	22.61	22.75	0.03	T52
51	22.69	21.17	21.80	0.39	T53
52	25.77	25.52	25.66	0.04	T54 NOT USED
53	23.69	22.63	22.99	0.20	T55 NOT USED
54	21.15	12.92	16.54	2.81	T56
55	20.30	18.51	19.40	0.42	T57
56	21.33	19.30	20.26	0.52	T58
57	26.03	25.28	25.56	0.08	LIGHTING SYSTEM STATUS
58	26.38	25.62	25.94	0.16	T60 NOT USED
59	10.21	3.10	5.05	1.98	PYRANOMETRER
60	27.08	-0.03	9.53	4.07	ANEMOMETER
61	86.11	78.47	83.13	1.12	RH AMBIANT
62	75.98	68.88	73.98	0.96	RH PIPES INLET
63	82.79	74.80	78.79	2.00	RH PIPES OUTLET 1
64	83.85	73.64	78.92	2.49	RH PIPES OUTLET 2
65	4.58	0.07	2.75	1.12	δT RIDGE-SOIL
66	1.49	0.62	0.86	0.18	δT HEATER
67	93.67	93.27	93.38	0.05	LOUVER STATUS
68	94.02	25.09	40.68	28.72	CURTAIN STATUS
69	26.13	25.74	25.87	0.06	CIRCULATOR STATUS
70	88.88	88.26	88.33	0.06	VENTILATION STATUS
71	0.40	-2.61	-1.50	0.76	δT PIPES ROW 1
72	14.62	12.91	13.75	0.30	δT INSIDE-OUTSIDE
73	1.78	-1.40	-0.19	0.79	δT PIPES ROW 2

CO	PERIOD	
1	0	HEATING
2	3593.80	STORAGE/RECOVERY
3	0	AIR INLET
4	0	VENTILATION LOW SPEED
5	0	VENTILATION HIGH SPEED
6	0	VENTILATION HUMIDITY
7	2789.14	THERMAL CURTAIN
8	3593.80	SODIUM LAMPS

CO: COMMAND NO.

PERIOD: OPERATING TIME IN SECONDES

RH: RELATIVE HUMIDITY

δT: TEMPERATURE DIFFERENCE

V.: SPEED

HEURES:	18	19	20	21	22	23	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
MINUTES:	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
BILAN #:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
TOT.ECHANT	135	131	131	131	131	131	131	131	131	131	131	131	131	131	131	131	132	131	132	131	132	131	132	131
DUREE:	3599.8	3598.9	3599.8	3598.0	3599.8	3601.0	3600.2	3598.4	3601.0	3600.3	3598.4	3599.0	3599.7	3598.1	3595.3	3590.2	3615.0	3587.7	3615.6	3587.2	3612.2	3585.9	3612.3	3590.2
DATE: 18-Apr-85																								
VARIABLE#:	HRE#1	HRE#2	HRE#3	HRE#4	HRE#5	HRE#6	HRE#7	HRE#8	HRE#9	HRE#10	HRE#11	HRE#12	HRE#13	HRE#14	HRE#15	HRE#16	HRE#17	HRE#18	HPE#19	HPE#20	HRE#21	HRE#22	HPE#23	HRE#24
HEURES:	18	19	20	21	22	23	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
MINUTES:	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
BILAN #:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
TOT.ECHANT	135	131	131	131	131	131	131	131	131	131	131	131	131	131	131	131	132	131	132	131	132	131	132	131
DUREE:	3599.8	3598.9	3599.8	3598.0	3599.8	3601.0	3600.2	3598.4	3601.0	3600.3	3598.4	3599.0	3599.7	3598.1	3595.3	3590.2	3615.0	3587.7	3615.6	3587.2	3612.2	3585.9	3612.3	3590.2
DATE: 18-Apr-85																								
VARIABLE#:	HRE#1	HRE#2	HRE#3	HRE#4	HRE#5	HPE#6	HRE#7	HRE#8	HRE#9	HRE#10	HRE#11	HRE#12	HRE#13	HRE#14	HPE#15	HRE#16	HRE#17	HRE#18	HPE#19	HRE#20	HRE#21	HRE#22	HRE#23	HPE#24
1	24.92	24.18	23.43	22.79	22.23	21.71	21.27	20.98	20.87	20.77	20.75	20.75	20.77	20.79	21.41	21.93	23.02	24.11	25.3	26.51	26.87	25.84	26.75	26.55
2	22.15	22.27	22.32	22.28	22.25	22.18	22.06	21.9	21.74	21.58	21.42	21.25	21.11	20.95	20.8	20.66	20.64	20.65	20.75	20.94	21.16	21.43	21.73	21.97
3	21.8	21.82	21.77	21.7	21.66	21.49	21.32	21.19	21.07	20.94	20.81	20.62	20.57	20.43	20.41	20.37	20.48	20.54	20.62	20.73	20.83	20.95	21.06	21.18
4	21.05	20.41	19.9	19.52	19.2	18.91	18.64	18.46	18.3	18.17	18.01	17.94	17.86	18.27	19.01	19.83	20.53	20.87	21.27	21.5	21.53	21.65	21.68	21.57
5	24.28	23.35	22.22	21.31	20.55	19.98	19.51	19.2	18.96	18.84	18.73	18.71	18.82	19.04	19.66	20.21	21.31	22.15	23.16	24.52	25.73	26.64	27.27	27.53
6	25.12	25.03	25.03	25.02	25.01	25	24.99	25	24.99	24.99	25	25.03	25.35	26.01	25.85	25.4	25.27	25.28	25.28	25.34	25.33	25.34	25.46	25.64
7	21.11	20.03	19.37	18.93	18.55	18.27	17.97	17.88	17.77	17.7	17.5	17.62	17.46	18.64	20.48	21.65	22.75	22.91	23.43	23.55	23.56	23.41	23.31	22.84
8	20.14	20.02	19.87	19.72	19.59	19.45	19.34	19.24	19.14	19.04	18.95	18.87	18.79	18.77	18.84	19.04	19.31	19.42	19.49	19.64	19.75	19.83	19.9	19.95
9	19.29	19.34	19.34	19.34	19.33	19.29	19.27	19.22	19.18	19.14	19.03	19.06	19.09	19.15	19.13	19.05	18.98	18.94	18.94	18.96	18.93	19.01	19.05	19.09
10	20.27	19.04	18.34	17.85	17.39	17.25	16.92	16.8	16.69	16.6	16.37	16.49	16.47	17.75	19.45	21.04	22.1	22.48	22.97	23.05	23.08	22.91	22.83	22.3
11	24.57	23.69	22.82	22.1	21.48	20.95	20.48	20.06	19.71	19.45	19.24	19.07	18.96	19.14	20.11	21.63	22.95	24.47	25.83	26.63	26.36	26.12	25.95	25.82
12	12.49	12.55	12.6	12.61	12.61	12.57	12.53	12.46	12.36	12.27	12.15	12.02	11.92	11.81	11.69	11.59	11.52	11.48	11.47	11.49	11.54	11.61	11.7	11.79
13	21.54	21.5	21.38	21.21	21.02	20.82	20.61	20.4	20.21	20.02	19.84	19.68	19.52	19.38	19.3	19.33	19.49	19.69	19.9	20.14	20.36	20.55	20.72	20.86
14	9.18	9.19	9.19	9.22	9.24	9.27	9.31	9.36	9.4	9.44	9.5	9.53	9.57	9.6	9.64	9.66	9.64	9.61	9.57	9.55	9.49	9.47	9.44	9.4
15	20.53	20.53	20.45	20.32	20.16	20	19.82	19.63	19.46	19.28	19.12	18.96	18.82	18.69	18.6	18.61	18.72	18.9	19.06	19.23	19.43	19.61	19.78	19.92
16	22.11	21.58	21.06	20.55	20.1	19.69	19.33	19.02	18.81	18.7	18.57	18.51	18.54	18.73	19.09	19.31	20.01	20.43	20.54	20.71	21.09	21.44	21.71	21.92
17	17	16.67	16.26	15.89	15.6	15.34	15.11	14.91	14.72	14.57	14.42	14.29	14.25	14.33	14.7	15.28	15.96	16.42	16.67	16.78	16.79	16.77	16.85	17.09
18	14.46	14.27	14.02	13.82	13.65	13.43	13.25	13.11	12.99	12.9	12.82	12.73	12.71	12.77	13.07	13.44	13.87	14.13	14.25	14.33	14.31	14.26	14.29	14.44
19	2.94	1.93	0.89	0.15	-0.49	-0.95	-1.26	-1.49	-1.69	-1.87	-2.04	-2.2	-2.22	-2.05	-0.2	3.13	7.3	5.35	4.71	4.75	4.92	5.15	5.22	5.24
20	23.66	23.03	22.32	21.7	21.17	20.68	20.27	19.89	19.54	19.26	19	18.77	18.64	18.8	19.42	20.41	21.29	22.24	23.61	24.52	24.74	24.76	24.78	24.76
21	20.06	20.05	19.99	19.89	19.79	19.7	19.59	19.49	19.39	19.31	19.22	19.15	19.06	19.01	19.02	19.14	19.39	19.59	19.67	19.75	19.88	20.01	20.11	20.2
22	17.54	17.42	17.29	17.2	17.11	17.09	17.08	17.08	17.08	17.14	17.19	17.21	17.31	17.59	17.84	17.49	17.6	17.69	17.71	17.69	17.56	17.72	17.85	17.93
23	21.39	20.73	20.23	19.97	19.63	19.47	19.25	19.13	19.02	18.93	18.77	18.78	18.75	19.36	20.29	21.24	21.86	21.79	22.32	22.57	22.65	22.61	22.55	22.32
24	18.66	17.52	16.9	16.56	16.22	16.01	15.77	15.69	15.61	15.56	15.43	15.64	16.21	18.48	21.07	21.79	22.16	21.12	20.61	20.04	19.6	19.42	20.61	21.38
25	20.08	19.49	19.1	18.8	18.57	18.41	18.22	18.1	18	17.93	17.81	17.81	17.79	18.28	19.21	20.16	20.8	20.42	20.46	20.82	21.34	21.1	21.12	20.96
26	17.65	16.27	15.62	15.24	14.92	14.71	14.43	14.35	14.26	14.21	14.1	14.21	14.78	16.83	19.21	20.23	20.95	20.23	19.5	18.57	18.03	17.83	19.26	20.21
27	19.89	17.41	16.26	15.58	14.99	14.69	14.22	14.41	14.56	14.53	14.24	15	15.07	18.7	23.13	26.69	28.82	29.32	23.76	23.34	28.87	28.1	27.51	25.8
28	16.87	14.64	13.63	13.09	12.55	12.34	12.01	12.08	12.11	12.13	11.94	12.49	13.07	16.55	20.36	22.67	23.34	22.17	21.72	20.72	20.11	19.72	20.39	21.41
29	22.6	22.11	21.56	20.97	20.48	20.03	19.6	19.21	18.88	18.58	18.3	18.09	17.9	17.82	18.06	18.61	19.33	19.95	20.51	21.01	21.33	21.68	21.88	22.07
30	19.44	17.84	16.96	16.37	15.87	15.57	15.16	15.31	15.45	15.36	15.12	15.67	15.61	18.31	22.67	24.12	24.87	24.41	24.63	24.52	24.78	24.67	24.65	23.47
31	17.54	15.94	14.93	14.37	13.83	13.59	13.26	13.23	13.2	13.17	13	13.41	13.98	16.56	20.26	21.53	21.77	20.36	19.84	18.88	18.61	18.61	20.28	20.94
32	5.69	3.4	2.59	1.9	1.05	0.26	-0.37	-0.28	-0.66	-1.35	-1.46	-1.51	0.15	4.48	6.97	8.34	8.79	9.76	10.81	13	14.67	15.6	16.63	15.59
33	23.37	22.93	22.41	21.92	21.47	21.11	20.79	20.49	20.28	20.12	20	19.9	19.86	19.81	20.14	20.85	21.7	22.5	23.3	23.37	24.05	24.15	24.14	24.13
34	21.25	21.03	20.78	20.54	20.32	20.06	19.91	19.6	19.4	19.23	19.09	18.91	18.82	18.76	18.94	19.2	18.57	19.81	20.04	20.22	20.23	20.55	20.62	20.7
35	22.85	22.38	23.04	23.04	22.99	22.88	22.74	22.58	22.42	22.24	22.07	21.88	21.71	21.57	21.43	21.34	21.31	21.26	21.54	21.6	22.05	22.41	22.52	22.53
36	20.24	20.26	20.23	20.17	20.08	19.98	19.9	19.79	19.68	19.59	19.48	19.37	19.29	19.2	19.15	19.15	19.2	19.32	19.4	19.43	19.5	19.7	19.8	19.87
37	19.35	19.39	19.4	19.41	19.4	19.4	19.37	19.34	19.31	19.27	19.23	19.19	19.14	19.1	19.06	19.02	19.03	19.03	19.05	19.09	19.11	19.15	19.19	19.22
38	21.49	21.52	21.51	21.47	21.43	21.38	21.31	21.24	21.16	21.08	20.98	20.88	20.87	21.05	21.13	20.66	20.6	20.63	20.67	20.75	20.85	20.35	21.05	21.12
39	21.21	21.06	20.83	20.59	20.35	20.13	19.92	19.71	19.52	19.34	19.18	19.04	18.9	18.82	18.87	19.08	19.41	19.66	19.91	20.15	20.35	20.54	20.63	20.73
40	21.55	19.26	18.04	17.39	16.82	16.41	15.76	15.6	15.63	15.68	15.42	16	18	22.91	27.5	29.63	30.99	30.93	31.25	31.2	30.23	23.36	23.5	25.55
41	21.48	21.62	21.63	21.68	21.61	21.52	21.4	21.25	21.09	20.93	20.76	20.59	20.41	20.26	20.11	20.03	20.1	20.2	20.39	20.67	20.33	21.24	21.52	21.87
42	20.77	20.82	20.85	20.86	20.88	20.82	20.76	20.72	20.69	20.63	20.58	20.49	20.44	20.37	20.39	20.37	20.45	20.5	20.51	20.55	20.64	20.59	20.77	20.66

HEURES:	18	19	20	21	22	23	0	1	2	3	4	5
MINUTES:	12	12	12	12	12	12	12	12	12	12	12	12
BILAN #:	1	2	3	4	5	6	7	8	9	10	11	12
TOT.ECHANT	135	131	131	131	131	131	131	131	131	131	131	131
DUREE:	3593.8	3598.9	3599.8	3598.0	3599.8	3601.0	3600.2	3598.4	3601.0	3600.3	3598.4	3599.0
DATE: 18-Apr-85												
VARIABLES:	HPE01	HPE02	HPE03	HPE04	HPE05	HPE06	HPE07	HPE08	HPE09	HPE010	HPE011	HPE012
42	20.54	20.28	20.05	19.88	19.73	19.59	19.45	19.36	19.26	19.2	19.11	19.04
44	14.13	14.22	14.24	14.27	14.23	14.33	14.35	14.38	14.38	14.39	14.39	14.37
45	5	5.03	5.04	5.05	5.05	5.06	5.04	5.01	4.98	4.94	4.89	4.84
46	3.46	3.43	3.47	3.47	3.45	3.47	3.48	3.49	3.5	3.51	3.5	3.51
47	5.04	5.06	5.09	5.07	5.01	4.92	4.8	4.67	4.53	4.39	4.25	4.12
48	23.49	23.33	22.84	22.21	21.5	20.81	20.1	19.47	18.91	18.45	18.1	17.83
49	22.56	22.67	22.72	22.76	22.78	22.68	22.59	22.49	22.38	22.26	22.12	21.95
50	22.75	22.68	22.51	22.32	22.13	21.92	21.72	21.51	21.32	21.14	20.96	20.78
51	21.8	20.67	19.89	19.36	18.9	18.54	18.19	18	17.83	17.71	17.49	17.51
52	25.66	25.5	24.94	24.13	23.22	22.31	21.44	20.64	19.92	19.29	18.76	18.32
53	22.93	22.28	21.49	20.69	19.92	19.21	18.58	18.05	17.59	17.23	16.95	16.73
54	16.54	11.31	9.66	8.95	8.38	7.96	7.55	7.36	7.18	7.21	7.03	7.59
55	19.4	17.66	16.68	16.1	15.55	15.32	14.84	15.42	15.93	15.71	15.41	16.46
56	20.26	19.41	17.34	16.71	16.16	15.86	15.36	18.84	22.28	20.26	20.2	23.64
57	25.56	25.56	25.58	25.57	25.59	25.59	66.07	91.72	91.66	91.63	91.63	91.63
58	25.94	25.18	24.09	22.91	21.77	20.74	19.77	18.92	18.23	17.67	17.22	16.88
59	5.05	2.41	2.23	2.29	2.42	1.87	1.72	1.66	1.65	1.63	1.62	2.57
60	9.53	9.05	4.71	2.9	3.89	-0.53	-0.54	-0.54	-0.55	-0.56	-0.53	-0.32
61	83.13	81.39	80.76	80.67	80.1	80.41	80.96	79.39	77.83	78.34	78.94	78
62	73.98	74.42	74.89	75.52	75.59	76.38	77.37	76.42	75.37	75.79	76.54	75.16
63	78.79	73	71.31	70.84	70.17	70.06	69.77	69.93	70.12	70.47	70.49	72.19
64	79.92	71.99	69.67	68.73	67.81	67.22	66.38	66.54	66.52	66.63	66.56	67.51
65	2.75	6.11	7.63	8.25	8.74	9.13	9.53	9.72	9.91	9.93	10.16	9.62
66	0.86	0.75	0.66	0.61	0.61	0.54	0.53	3.42	6.35	4.55	4.79	7.18
67	93.38	93.71	93.54	93.39	93.53	93.15	92.97	93.07	92.91	92.89	92.91	92.9
68	40.68	25.07	25.04	25.02	25.02	24.99	24.97	24.97	24.96	24.96	24.95	25.01
69	25.87	25.8	25.78	25.75	25.75	25.76	25.74	25.73	25.73	25.73	25.73	25.74
70	88.33	88.24	88.26	88.27	88.19	88.42	88.46	88.46	88.43	88.43	88.36	88.44
71	-1.5	-3.32	-4.03	-4.39	-4.7	-4.79	-5.03	-4.73	-4.46	-4.39	-4.53	-3.79
72	13.75	14.44	14.37	14.47	14.81	15.31	15.53	15.59	16.11	16.71	16.58	17.17
73	-0.19	-2.09	-2.84	-3.22	-3.57	-3.72	-3.99	-3.69	-3.45	-3.4	-3.57	-2.82
COMMANDES	DUREE:											
1	0	0	0	0	0	0	0	322.1101	460.7298	295.1700	536.9100	379.6298
2	3593.8099	3598.900	3599.830	3597.979	3599.849	3601.040	3600.219	3598.410	3601.009	3600.310	3598.430	3599.049
3	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
7	2789.1499	3598.900	3599.830	3597.979	3599.849	3601.040	3600.219	3598.410	3601.009	3600.310	3598.430	3599.049
8	3593.8099	3598.900	3599.830	3597.979	3599.849	3601.040	1427.159	0	0	0	0	0

HEURES:	6	7	8	9	10	11	12	13	14	15	16	17
MINUTES:	12	12	12	12	12	12	12	12	12	12	12	12
BILAN #:	13	14	15	16	17	18	19	20	21	22	23	24
TOT.ECHANT	131	131	131	131	132	131	132	131	132	131	132	131
DUREE:	3599.7	3598.1	3595.3	3590.2	3615.0	3587.7	3615.6	3587.2	3612.2	3585.9	3612.3	3590.2
VARIABLES:	HPE013	HPE014	HPE015	HPE016	HPE017	HPE018	HPE019	HPE020	HPE021	HPE022	HPE023	HPE024
42	18.39	19.14	19.45	20.03	20.47	20.13	20.5	20.72	20.83	20.93	20.97	20.9
44	14.36	14.34	14.31	14.3	14.28	14.25	14.22	14.21	14.19	14.21	14.21	14.22
45	4.79	4.74	4.67	4.64	4.63	4.63	4.65	4.67	4.71	4.74	4.78	4.82
46	3.65	3.95	4.2	3.68	3.61	3.61	3.62	3.63	3.65	3.66	3.66	3.66
47	3.98	3.86	3.74	3.66	3.67	3.83	4.1	4.38	4.63	4.83	5.03	5.16
48	17.63	17.44	17.32	17.53	18.16	18.98	19.63	20.22	20.82	21.47	22.05	22.56
49	21.84	21.71	21.61	21.49	21.42	21.34	21.31	21.35	21.43	21.54	21.65	21.78
50	20.61	20.47	20.4	20.43	20.55	20.71	20.91	21.1	21.28	21.46	21.58	21.69
51	17.46	18.38	19.81	21.25	22.37	22.92	23.36	23.53	23.58	23.48	23.4	23.64
52	17.97	17.7	17.56	17.74	18.3	19.1	20.02	21.08	22.25	23.44	24.5	25.29
53	16.67	16.86	17.25	19.72	20.35	20.89	22.36	24.34	24.83	25.53	25.66	25.13
54	12.3	19.06	24.99	30.59	33.93	35.05	35.07	35.5	34.76	32.82	30.43	26.26
55	15.18	17.88	22.17	25.24	26.93	26.79	27.35	26.02	25.72	25.56	25.57	24.36
56	15.8	18.26	22.44	25.44	29.11	34.16	33.64	27.78	27.1	26.03	24.76	25.41
57	91.62	91.65	39.99	25.6	25.54	25.51	25.51	25.51	25.51	25.5	25.5	25.52
58	16.62	16.41	16.62	20.41	19.26	19.83	21.96	23.78	24.43	26.38	26.97	27.03
59	9.11	19.85	32.32	42.24	53.95	60.44	64.1	64.31	50.56	43.05	29.28	16.08
60	0.49	1.4	2.79	3.18	8.46	6.95	5.84	5.5	3.2	2.5	1.61	1.99
61	83.85	83.96	80.46	79.64	76.3	69.24	63.94	57.89	55.26	55.85	66.01	79.92
62	79.94	80.61	77.9	70.92	63.11	53.66	45.19	45.61	44.35	45.59	55.75	67.93
63	77.27	92.08	107.16	104.96	102.55	94.32	85.81	79.39	75.5	74.38	84.02	92.06
64	72.57	86.63	99.99	101.19	101.27	98.28	91.55	80.84	74.86	72.84	84.16	93.45
65	5.01	1.66	7.15	13.1	16.34	17.36	17.36	17.81	17.1	15.1	12.58	8.33
66	0.62	0.37	0.27	0.2	2.18	7.37	6.29	1.76	1.38	1.3	1.19	1.05
67	92.82	92.91	93.22	93.29	93.36	93.36	93.52	93.41	93.39	93.37	93.52	93.37
68	67.55	93.72	93.93	94.17	94.13	94.16	94.29	94.34	94.32	94.43	94.36	94.31
69	25.88	26	25.97	26.03	26.12	26.2	26.21	26.29	26.34	26.23	26.26	26.15
70	88.43	88.55	88.54	88.57	88.55	88.74	88.83	88.92	88.98	88.98	88.93	88.84
71	-3.68	-0.66	2.84	5.46	6.96	7.54	7.45	6.77	6.22	5.49	4.95	3.48
72	15.46	13.83	15.69	15.78	16.07	14.64	13.88	11.63	10.11	8.86	8.22	7.38
73	-2.71	0.41	3.91	6.53	8.01	8.9	9.3	8.53	7.83	7	6.39	4.84
COMMANDES												
1	0	0	0	0	0	0	0	0	0	0	0	0
2	3599.680	3598.149	3595.260	3590.239	3614.990	3587.679	3615.609	3587.180	3612.160	3585.87	3612.329	3590.219
3	0	0	669.9299	3590.239	3187.500	3078.450	3294.739	3478.849	3612.160	3505.780	3612.329	2305.25
4	0	0	0	0	347.7601	859.3601	1125.379	1365.589	1229.700	909.8298	213.7800	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
7	1345.520	0	0	0	0	0	0	0	0	0	0	0
8	0	0	2787.429	3590.239	3614.990	3587.679	3615.609	3587.180	3612.160	3585.87	3612.329	3590.219

135

DATE: 18-Apr-86

HEURES:	18	19	20	21	22	23	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
MINUTES:	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
CALCUL #	HRE#1	HRE#2	HRE#3	HRE#4	HRE#5	HRE#6	HRE#7	HRE#8	HRE#9	HRE#10	HRE#11	HRE#12	HRE#13	HRE#14	HRE#15	HRE#16	HRE#17	HRE#18	HRE#19	HRE#20	HRE#21	HRE#22	HRE#23	HRE#24
TCS	3.8	3.5	3.2	2.9	2.7	2.5	2.3	2.2	2.1	2.0	1.9	1.8	1.8	1.9	2.6	4.2	4.9	4.3	4.1	4.3	4.4	4.5	4.6	4.7
TSS1	23.0	22.4	21.8	21.2	20.7	20.3	19.9	19.6	19.3	19.2	19.0	18.9	18.8	19.0	19.5	20.1	21.0	21.8	22.4	22.9	23.1	23.2	23.3	23.4
TSS2	20.7	20.6	20.3	20.1	19.9	19.6	19.4	19.2	19.1	18.9	18.8	18.7	18.6	18.6	18.8	18.9	19.3	19.5	19.7	19.8	20.0	20.2	20.3	20.5
TSS3	18.1	17.9	17.6	17.3	17.1	16.9	16.7	16.5	16.4	16.3	16.1	16.0	16.0	16.0	16.2	16.6	17.0	17.3	17.5	17.7	17.7	17.8	17.9	18.0
TSS6	20.6	20.3	19.9	19.5	19.2	18.9	18.7	18.5	18.3	18.1	18.0	17.9	17.8	17.9	18.2	18.5	19.1	19.5	19.9	20.1	20.3	20.4	20.5	20.7
TOHC	20.3	18.5	17.5	16.9	16.4	16.1	15.6	18.9	22.2	20.3	20.2	23.5	16.1	18.4	22.4	25.2	28.7	33.5	33.1	27.5	26.8	26.6	26.5	25.2
TFD	0.9	0.9	0.8	0.8	0.8	0.8	0.8	3.5	6.3	4.6	4.8	7.1	0.9	0.5	0.2	.0	1.8	6.8	5.7	1.4	1.1	1.0	0.9	0.8
TFM	19.9	19.1	17.1	16.5	16.0	15.7	15.2	17.2	19.1	18.0	17.8	20.0	15.6	18.1	22.3	25.2	27.8	30.2	30.2	26.7	26.3	26.1	26.0	24.8
TCSD	-4.1	-9.0	-10.2	-10.6	-10.9	-11.0	-11.1	-11.1	-11.1	-10.9	-10.9	-10.3	-5.5	1.2	6.8	12.0	14.8	15.5	15.2	15.4	14.5	12.4	9.9	5.6
TASD	1.2	2.4	2.9	3.2	3.4	3.4	3.5	3.1	2.8	2.8	2.9	2.2	2.2	-0.4	-4.5	-5.6	-5.8	-4.9	-4.8	-4.5	-4.5	-4.3	-4.3	-2.8
~~TIOH~~	~~12.6~~	~~10.6~~	~~9.8~~	9.1	8.5	7.9	7.4	7.5	7.4	7.0	6.8	7.1	7.9	11.4	14.8	16.2	16.8	17.1	17.8	18.8	19.7	20.2	20.7	15.7
TIOB	13.8	14.4	14.4	14.5	14.8	15.3	15.5	15.6	16.1	16.7	16.6	17.2	15.5	13.8	15.7	15.8	16.1	14.7	13.9	11.6	10.1	8.9	8.2	7.6
TTD	-0.4	-1.3	-1.6	-1.7	-1.9	-1.8	-1.9	-1.7	-1.5	-1.4	-1.5	-1.1	-0.9	0.8	2.7	4.1	4.8	4.7	4.8	4.5	4.2	3.7	3.4	2.5
ESAF	2.32	2.08	1.95	1.88	1.81	1.79	1.73	1.96	2.21	2.06	2.04	2.34	1.77	2.08	2.69	3.21	3.74	4.28	4.29	3.51	3.41	3.38	3.37	3.13
HUF	0.0121	0.0106	0.0098	0.0094	0.0091	0.0089	0.0087	0.0097	0.0107	0.0101	0.0101	0.0114	0.0093	0.0109	0.0136	0.0161	0.0180	0.0188	0.0173	0.0127	0.0118	0.0118	0.0140	0.0157
BAF	1.18	1.19	1.20	1.20	1.20	1.20	1.21	1.20	1.19	1.19	1.19	1.18	1.20	1.19	1.17	1.15	1.14	1.13	1.13	1.15	1.16	1.16	1.15	1.16
CPF	1.07	1.07	1.06	1.06	1.06	1.06	1.06	1.06	1.07	1.07	1.06	1.07	1.06	1.07	1.07	1.08	1.08	1.08	1.08	1.07	1.07	1.07	1.07	1.08
PF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	6.4	4.7	4.9	7.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ESAV	1.46	1.28	1.21	1.16	1.11	1.07	1.03	1.04	1.03	1.00	0.99	1.01	1.06	1.35	1.69	1.84	1.92	1.95	2.03	2.17	2.30	2.37	2.45	2.29
HUV	0.0075	0.0065	0.0061	0.0058	0.0055	0.0053	0.0052	0.0051	0.0050	0.0049	0.0048	0.0049	0.0055	0.0070	0.0084	0.0092	0.0091	0.0084	0.0081	0.0078	0.0079	0.0082	0.0101	0.0114
BAV	1.22	1.23	1.24	1.24	1.24	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.23	1.21	1.20	1.20	1.20	1.20	1.19	1.19	1.19	1.18	1.18
CPVH	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.07	1.07
ESTI	2.32	1.93	1.85	1.77	1.70	1.67	1.62	1.64	1.66	1.65	1.62	1.71	1.71	2.16	2.83	3.50	3.96	4.08	4.18	4.08	3.98	3.80	3.67	3.32
HUTI	0.0106	0.0031	0.0085	0.0083	0.0079	0.0079	0.0077	0.0077	0.0077	0.0077	0.0077	0.0079	0.0085	0.0108	0.0137	0.0155	0.0156	0.0136	0.0128	0.0116	0.0109	0.0107	0.0127	0.0141
BATI	1.19	1.21	1.21	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.20	1.17	1.16	1.15	1.15	1.15	1.15	1.16	1.16	1.16	1.16
CPTI	1.07	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.07	1.07	1.08	1.08	1.07	1.07	1.07	1.07	1.07	1.07	1.07
HTI	47.8	41.4	38.7	37.2	35.8	35.3	34.4	34.6	34.7	34.8	34.3	35.7	37.1	46.9	59.1	67.5	70.1	65.5	63.8	60.2	58.1	56.8	61.3	62.8
AHUI	0.0127	0.0110	0.0104	0.0100	0.0097	0.0096	0.0095	0.0095	0.0094	0.0094	0.0094	0.0096	0.0103	0.0129	0.0161	0.0179	0.0180	0.0157	0.0147	0.0133	0.0126	0.0125	0.0148	0.0164
ESTO1	2.55	2.45	2.38	2.33	2.29	2.26	2.23	2.22	2.20	2.19	2.17	2.17	2.16	2.25	2.38	2.52	2.62	2.61	2.70	2.74	2.75	2.74	2.74	2.70
HUTO1	0.0126	0.0112	0.0106	0.0103	0.0100	0.0099	0.0097	0.0097	0.0096	0.0096	0.0095	0.0098	0.0104	0.0130	0.0150	0.0159	0.0165	0.0155	0.0145	0.0136	0.0130	0.0128	0.0144	0.0156
BATO1	1.17	1.18	1.18	1.18	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.18	1.18	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17
CPTO1	1.07	1.07	1.07	1.07	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.07	1.07	1.07	1.08	1.08	1.07	1.07	1.07	1.07	1.07	1.07	1.08
HTO1	54.3	50.0	48.1	47.1	46.1	45.4	44.8	44.5	44.3	44.2	43.8	44.4	46.1	53.1	59.2	62.6	64.8	62.2	60.3	58.3	56.8	56.2	60.3	63.1
AHUO1	0.0148	0.0132	0.0125	0.0122	0.0119	0.0117	0.0115	0.0115	0.0114	0.0114	0.0113	0.0116	0.0124	0.0153	0.0176	0.0186	0.0193	0.0181	0.0170	0.0159	0.0152	0.0150	0.0168	0.0182
ESTO2	2.35	2.27	2.21	2.17	2.14	2.12	2.09	2.08	2.06	2.05	2.04	2.04	2.04	2.10	2.23	2.36	2.46	2.40	2.41	2.46	2.49	2.50	2.51	2.48
HUTO2	0.0116	0.0102	0.0096	0.0093	0.0090	0.0089	0.0086	0.0086	0.0085	0.0085	0.0084	0.0086	0.0092	0.0114	0.0140	0.0148	0.0155	0.0148	0.0138	0.0124	0.0117	0.0114	0.0132	0.0146
BATO2	1.18	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.20	1.20	1.20	1.20	1.19	1.19	1.18	1.17	1.17	1.17	1.17	1.17	1.18	1.18	1.17	1.17
CPTO2	1.07	1.07	1.05	1.05	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07
HTO2	50.4	46.2	44.3	43.2	42.3	41.7	41.0	40.7	40.5	40.4	40.0	40.3	41.9	48.0	55.5	58.8	61.0	59.0	56.5	53.4	51.7	51.0	55.7	58.9
AHUO2	0.0137	0.0121	0.0114	0.0111	0.0108	0.0106	0.0103	0.0103	0.0102	0.0102	0.0101	0.0103	0.0110	0.0135	0.0165	0.0174	0.0181	0.0174	0.0163	0.0147	0.0137	0.0134	0.0155	0.0171
BATH1	1.18	1.19	1.20	1.20	1.20	1.20	1.21	1.21	1.21	1.21	1.21	1.20	1.20	1.19	1.17	1.16	1.16	1.16	1.16	1.16	1.16	1.17	1.16	1.16
BATH2	1.19	1.20	1.20	1.20	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.19	1.18	1.17	1.16	1.16	1.16	1.16	1.17	1.17	1.17	1.17
CPTH1	1.07	1.07	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.07	1.07	1.08	1.08	1.07	1.07	1.07	1.07	1.07	1.07	1.07
CPTH2	1.07	1.06	1.05	1.06	1.05	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.07	1.07	1.07	1.08	1.07	1.07	1.07	1.07	1.07	1.07	1.07
UG	0.0038	0.0034	0.0031	0.0030	0.0031	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0036	0.0041	0.0043	0.0043	0.0048	0.0047	0.0045	0.0045	0.0043	0.0042	0.0042	0.0042
ESE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.30	0.41	0.45	0.47	0.47	0.44	0.42	0.39	0.37	0.30
EEE	0.17	0.35	0.39	0.40	0.41	0.41	0.42	0.40	0.38	0.37	0.38	0.33	0.32	0.02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
QL	6928	6838	6940	6936	6840	6842	2712	0	0	0	0	0	0	0	5296	6821	6868	6817	6870	6816	6863	6813	6863	6821
QLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	987	6821	6056	5849	6260	6610	6863	6661	6863	4380
QLU	6928	6838	6840	6836	6840	6942	2712	0	0	0	0	0	0	0	4309	0	812	968	610	206	0	152	0	2441
QF	0	0	0	0	0	0	0	13005	23074	16884	17778	25788	0	0	0	0	0	0	0	0	0	0	0	0
QGNL	32403	30741	28049	27139	28406	26899	27279	27371	28304	29353	29109	30168	34835	35824	41919	42435	~48560	42609	39773	32803	27365	23470	21478	19880

136

DATE: 19-Avr-..

HEURES:	18	19	20	21	22	23	0	1	2	3	4	5
MINUTES:	12	12	12	12	12	12	12	12	12	12	12	12
CALCUL :	HRE#1	HRE#2	HRE#3	HRE#4	HRE#5	HRE#6	HRE#7	HRE#8	HRE#9	HRE#10	HRE#11	HRE#12
QSHL	2237	2530	2598	2645	2729	2804	2858	2808	2839	2920	2914	2905
QV-L	0	0	0	0	0	0	0	0	0	0	0	0
QTHL	34641	33271	30646	29776	31134	29703	30137	30179	31143	32273	32023	33072
QSS1	NA	-12315	-12732	-11699	-10262	-9080	-7932	-7062	-5357	-3583	-3409	-2366
QSS2	NA	-7653	-9775	-10089	-8732	-9428	-8801	-8071	-6853	-5531	-5810	-5357
QSS3	NA	-16101	-20201	-18814	-15980	-15799	-14171	-12241	-11156	-8985	-8442	-7960
QSST	NA	-36104	-42709	-40592	-34974	-34306	-30904	-27374	-23366	-18099	-17661	-15683
QSSTG	NA	0	0	0	0	0	0	0	0	0	0	0
QSSTL	NA	36104	42709	40592	34974	34306	30904	27374	23366	18099	17661	15683
QEI1	-12629	-17019	-18786	-19645	-20510	-20289	-20650	-19713	-19124	-18820	-18979	-17323
QEI2	-5207	-9707	-11516	-12271	-13339	-13151	-13367	-12451	-11783	-11426	-11776	-9479
QES1	0	0	0	0	0	0	0	0	0	0	0	0
QES2	0	0	0	0	0	0	0	0	0	0	0	0
QRT1	12629	17019	18786	19645	20510	20289	20650	19713	19124	18820	18979	17323
QRT2	5207	9707	11516	12271	13239	13151	13367	12451	11783	11426	11776	9479
QEST	0	0	0	0	0	0	0	0	0	0	0	0
QRTT	17836	26726	30303	31916	33849	33439	34017	32163	30907	30246	30755	26802
ISC	24	0	0	0	0	0	0	0	0	0	0	0
QRS	631	0	0	0	0	0	0	0	0	0	0	0
QCF	4931	6333	6710	6748	6763	6578	6618	5936	5389	5275	5378	4458
QFF	4931	6333	6710	6748	6763	6578	6618	5936	5389	5275	5378	4458
QGF	0	0	0	0	0	0	0	0	0	0	0	0
QC	4226	4232	4233	4231	4233	4235	4234	4232	4235	4234	4232	4232
QV	1380	1382	1382	1382	1382	1383	1382	1382	1383	1383	1382	1382
QET1	-3095	-6896	-8395	-9156	-9821	-10001	-10534	-9878	-9340	-9214	-9489	-7909
QET2	-401	-4421	-6054	-6872	-7656	-7964	-8571	-7902	-7371	-7286	-7651	-6016
QETS1	0	0	0	0	0	0	0	0	0	0	0	0
QETS2	0	0	0	0	0	0	0	0	0	0	0	0
QETR1	3095	6836	8395	9156	9821	10001	10534	9878	9340	9214	9489	7909
QETR2	401	4421	6054	6872	7656	7964	8571	7902	7371	7286	7651	6016
QETST	0	0	0	0	0	0	0	0	0	0	0	0
QETRT	3496	11317	14449	16028	17477	17965	19105	17780	16711	16500	17140	13925
QBR	166	347	416	448	477	483	506	466	435	428	443	362
HCT	NA	0.0207	0.0208	0.0211	0.0212	0.0220	0.0222	0.0235	0.0249	0.0257	0.0254	0.0303
AHU1	-3.36	-3.48	-3.55	-3.57	-3.63	-3.48	-3.40	-3.32	-3.32	-3.26	-3.21	-3.23
AHU2	-1.67	-1.74	-1.76	-1.72	-1.81	-1.62	-1.45	-1.38	-1.35	-1.25	-1.23	-1.03
BHU1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BHU2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HUM1	3.35	3.48	3.55	3.57	3.63	3.48	3.40	3.32	3.32	3.26	3.21	3.23
HUM2	1.67	1.74	1.76	1.72	1.81	1.62	1.45	1.38	1.35	1.25	1.23	1.03
BHU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HUM	5.03	5.21	5.31	5.29	5.45	5.09	4.85	4.70	4.67	4.51	4.44	4.25
COPS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
COPR	0.9	2.9	3.8	4.2	4.7	4.8	5.1	4.7	4.4	4.3	4.5	3.6

HEURES:	6	7	8	9	10	11	12	13	14	15	16	17
MINUTES:	12	12	12	12	12	12	12	12	12	12	12	12
CALCUL :	HRE#13	HRE#14	HRE#15	HRE#16	HRE#17	HRE#18	HRE#19	HRE#20	HRE#21	HRE#22	HRE#23	HRE#24
QSHL	2649	2007	1677	1526	1553	1461	1363	1062	842	686	585	714
QV-L	0	0	0	0	0	0	0	0	0	0	0	0
QTHL	37484	37831	43595	43961	50113	44071	41136	33866	28207	24156	22063	20594
QSS1	-661	2992	10436	13533	17881	15759	13428	9706	4453	3201	2261	1835
QSS2	-2540	70	5949	7097	15411	10228	5670	5879	7514	7236	7097	7966
QSS3	-4040	2472	16945	23156	32442	22251	13869	10312	5608	4040	6392	10312
QSST	-7241	5534	33330	43785	65735	48238	32968	25997	17575	14477	15750	19913
QSSTG	0	5534	33330	43785	65735	48238	32968	25897	17575	14477	15750	19913
QSSTL	7241	0	0	0	0	0	0	0	0	0	0	0
QEI1	-17758	-12268	-156	9201	9820	6269	6711	3693	2533	1240	1825	-447
QEI2	-9754	-2154	7049	16767	17448	12472	14205	13144	12547	11216	10879	7561
QES1	0	0	0	9201	9820	6269	6711	3693	2533	1240	1825	0
QES2	0	0	7049	16767	17448	12472	14205	13144	12547	11216	10879	7561
QRT1	17758	12268	156	0	0	0	0	0	0	0	0	447
QRT2	9754	2154	0	0	0	0	0	0	0	0	0	0
QEST	0	0	7049	25969	27267	18741	20916	16837	15079	12456	12704	7561
QRTT	27512	14422	156	0	0	0	0	0	0	0	0	447
ISC	158	639	1086	1441	1874	2093	2242	2232	1750	1468	982	502
QRS	4172	16863	28688	38051	49491	55265	59189	58923	46219	38772	25924	13253
QCF	4498	945	-4414	-5519	-5408	-3684	-3206	-2440	-2382	-2000	-2115	-81
QFF	4498	945	0	0	0	0	0	0	0	0	0	0
QGF	0	0	4414	5519	5408	3684	3206	2440	2382	2000	2115	81
QC	4233	4231	4228	4222	4251	4219	4252	4219	4248	4217	4248	4222
QV	1382	1382	1381	1379	1255	1048	956	853	915	1028	1305	1379
QET1	-7701	-1371	5844	11117	14230	15265	15173	13699	12680	11125	10119	7095
QET2	-5824	893	8252	13626	16774	18462	19418	17651	16341	14520	13369	10097
QETS1	0	0	5844	11117	14230	15265	15173	13699	12680	11125	10119	7095
QETS2	0	893	8252	13626	16774	18462	19418	17651	16341	14520	13369	10097
QETR1	7701	1371	0	0	0	0	0	0	0	0	0	0
QETR2	5824	0	0	0	0	0	0	0	0	0	0	0
QETST	0	893	14096	24743	31004	33727	34591	31350	29022	25646	23487	17192
QETRT	13525	1371	0	0	0	0	0	0	0	0	0	0
QBR	354	46	0	0	0	0	0	0	0	0	0	0
HCT	0.0326	NA	0.0087	0.0110	0.0119	0.0132	0.0127	0.0124	0.0122	0.0121	0.0121	0.0115
AHU1	-3.45	-3.96	-2.36	-1.03	-2.14	-3.91	-3.68	-4.20	-4.20	-4.04	-3.42	-3.01
AHU2	-1.19	-1.04	-0.61	0.83	-0.26	-2.87	-2.56	-2.18	-1.84	-1.59	-1.29	-1.21
BHU1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BHU2	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HUM1	3.45	3.96	2.36	1.03	2.14	3.91	3.68	4.20	4.20	4.04	3.42	3.01
HUM2	1.19	1.04	0.61	0.00	0.26	2.87	2.56	2.18	1.84	1.59	1.29	1.21
BHU	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HUM	4.65	5.00	2.97	1.03	2.40	6.78	6.24	6.38	6.04	5.63	4.70	4.22
COPS	NA	NA	2.5	9.1	9.1	5.9	6.3	5.0	4.5	3.9	4.3	2.7
COPR	3.5	0.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

TFC =	1995	TCTC =	43730	QTHLC =	805075	ISCC =	16492	QETSTC =	265750	TSSGN =	19.2	RE =	0.83	RSR =	0.28
TCC =	86378	TLC =	58202	QSSTGC =	323202	QREC =	76560	QETRTC =	196791	TIDDN =	14.0	COPSM =	5.3	ESEM =	0.40
TPC =	30335	QLC =	110584	QSSTLC =	329014	QGFC =	31248	BHUC =	0.83	TIN =	19.6	COPRM =	3.7	EREM =	0.34
TVGC =	0	QLEC =	57351	QESTC =	164579	QCC =	101581	HUC =	114.85	TON =	5.6	FF =	0.12		
TVBC =	6051	QLUC =	53233	QRTTC =	401496	QVC =	30845	TOSM =	3.2	HCTM =	0.0186	LF =	0.07		
TVHC =	0	QFC =	96529	QRSC =	435442	QBRC =	5376	TSSIM =	21.0	SE =	0.51	SF =	0.81		

137

APPENDIX F

Computater program

The program was written for the data management software "Lotus 1-2-3".

COMPUTATION FORMULA

```
 A94: 'GENERAL COMPUTATION FORMULAS
 A96: ^TOS
 B96: (F1) (B26+B54+B53)/3
 A97: ^TSS1
 B97: (F1) ((B40+B18+B27)/3+B23)/2
 A98: ^TSS2
 B98: (F1) ((B56+B57+B9+B10+B48+B49)/6+(B23+B24)/2)/2
 A99: ^TSS3
 B99: (F1) ((B36+B41+B46+B15+B28+B29)/6+(B24+B25)/2)/2
A100: ^TSSG
B100: (F1) (TSS1*2+TSS2*2+TSS3*2)/6
A101: ^TOHC
B101: (F1) 0.9979+0.95284*B63
A102: ^TFD
B102: (F1) +TOHC-B62
A103: ^TFM
B103: (F1) (TOHC+B62)/2
A104: ^TCSD
B104: (F1) +B61-TSSG
A105: ^TASD
B105: (F1) +TSSG-B37
A106: ^TIOM
B106: (F1) (B39+B37)/2
A107: ^TIOD
B107: (F1) +B37-B39
A108: ^TTD
B108: (F1) (B30+B34)/2-B11
A110: ^ESAF
B110: (F2) 0.61078*@EXP((17.269*TFM)/(TFM+237.3))
A111: ^HUF
B111: (F4) ($MW/$MA*(@IF(B68>100,100,B68))/100*ESAF)/
           ($P-((@IF(B68>100,100,B68))/100*ESAF))
A112: ^DAF
B112: (F2) +$MA/$R*($P-(1-0.622*HUF)*ESAF*(@IF(B68>100,
           100,B68))/100)/(TFM+273.15)
A113: ^CPF
B113: (F2) +$CPA+$CPV*HUF
A114: ^PF
B114: (F1) @IF(B82=0,0,(DAF*$VAH*$AI*CPF*TFD))
A115: ^ESAV
B115: (F2) 0.61078*@EXP((17.269*TIOM)/(TIOM+237.3))
A116: ^HUV
B116: (F4) ($MW/$MA*(@IF(B68>100,100,B68))/100*ESAV)/($P-
           ((@IF(B68>100,100,B68))/100*ESAV))
A117: ^DAV
B117: (F2) +$MA/$R*($P-(1-0.622*HUV)*ESAV*(@IF(B68>100,100,
           B68))/100)/(TIOM+273.15)
A118: ^CPVH
B118: (F2) +$CPA+$CPV*HUV
A119: ^ESTI
B119: (F2) 0.61078*@EXP((17.269*B34)/(B34+237.3))
A120: ^HUTI
```

```
B120: (F4) ($MW/$MA*(@IF(B69>100,100,B69))/100*ESTI)/
           ($P+$SPT-((@IF(B69>100,100,B69))/100*ESTI))
A121: ^DATI
B121: (F2) +$MA/$R*($P+$SPT-(1-0.622*HUTI)*ESTI*(@IF(B69>
           100,100,B69))/100)/(B34+273.15)
A122: ^CPTI
B122: (F2) +$CPA+$CPV*HUTI
A123: ^HTI
B123: (F1) +CPTI*B34+HUTI*$LH
A124: ^AHUI
B124: (F4) +$MW*ESTI*(@IF(B69>100,100,B69))/
           (100*$R*(B34+273.15))
A125: ^ESTO1
B125: (F2) 0.61078*@EXP((17.269*B30)/(B30+237.3))
A126: ^HUTO1
B126: (F4) ($MW/$MA*(@IF(B70>100,100,B70))/100*ESTO1)/
           ($P-((@IF(B70>100,100,B70))/100*ESTO1))
A127: ^DATO1
B127: (F2) +$MA/$R*($P-(1-0.622*HUTO1)*ESTO1*(@IF(B70>100,
           100,B70))/100)/(B30+273.15)
A128: ^CPTO1
B128: (F2) +$CPA+$CPV*HUTO1
A129: ^HTO1
B129: (F1) +CPTO1*B30+HUTO1*$LH
A130: ^AHUO1
B130: (F4) +$MW*ESTO1*(@IF(B70>100,100,B70))/
           (100*$R*(B30+273.15))
A131: ^ESTO2
B131: (F2) 0.61078*@EXP((17.269*B32)/(B32+237.3))
A132: ^HUTO2
B132: (F4) ($MW/$MA*(@IF(B71>100,100,B71))/100*ESTO2)/
           ($P-((@IF(B71>100,100,B71))/100*ESTO2))
A133: ^DATO2
B133: (F2) +$MA/$R*($P-(1-0.622*HUTO2)*ESTO1*(@IF(B71>100,
           100,B71))/100)/(B32+273.15)
A134: ^CPTO2
B134: (F2) +$CPA+$CPV*HUTO2
A135: ^HTO2
B135: (F1) +CPTO2*B32+HUTO2*$LH
A136: ^AHUO2
B136: (F4) +$MW*ESTO2*(@IF(B71>100,100,B71))/
           (100*$R*(B32+273.15))
A137: ^DATM1
B137: (F2) (DATI+DATO1)/2
A138: ^DATM2
B138: (F2) (DATI+DATO2)/2
A139: ^CPTM1
B139: (F2) (CPTI+CPTO1)/2
A140: ^CPTM2
B140: (F2) (CPTI+CPTO2)/2
A141: ^UG
B141: (F4) (B5-B88)/B5*@IF(B67<0.1,0.0051,
           (5.556158*10^-3+7.945778*10^-5*B67))+B88/B5*$ECC*
           @IF(B67<0.1,0.0051,(5.556158*10^-3+7.945778*
```

```
                 10^-5*B67))
A142:   ^ESE
B142:   (F2)  @IF(B83=0#OR#(B34-(B30+B32)/2)<0,@NA,
              (B34-(B30+B32)/2)/(B34-$TSIF))
A143:   ^ERE
B143:   (F2)  @IF(B83=0#OR#(B30+B32)/2-B34<0,@NA,((B30+B32)/
              2-B34)/($TSIC-B34))
A144:   ^QL
B144:   (F0)  +$PL*B89
A145:   ^QLE
B145:   (F0)  +QL*B84/B5
A146:   ^QLU
B146:   (F0)  +QL-QLE
A147:   ^QF
B147:   (F0)  +PF*B5
A148:   ^QGHL
B148:   (F0)  +UG*$AG*(B37-B39)*B5
A149:   ^QSHL
B149:   (F0)  +$USM*$PE*(TSSG-B39)*B5
A150:   ^QVHL
B150:   (F0)  +DAV*$CPV*$FRH*(B37-B39)*B86
A151:   ^QTHL
B151:   (F0)  +QGHL+QSHL+QVHL
A152:   ^QSS1
B152:   (F0)  @NA
A153:   ^QSS2
B153:   (F0)  @NA
A154:   ^QSS3
B154:   (F0)  @NA
A155:   ^QSST
B155:   (F0)  @NA
A156:   ^QSSTG
B156:   (F0)  @IF(QSST<0,0,QSST)
A157:   ^QSSTL
B157:   (F0)  @IF(QSST<0,@ABS(QSST),0)
A158:   ^QEX1
B158:   (F0)  +DATI*$FRT1*(HTI-HTO1)*B83
A159:   ^QEX2
B159:   (F0)  +DATI*$FRT2*(HTI-HTO2)*B$83
A160:   ^QES1
B160:   (F0)  @IF(QEX1<0,0,QEX1)
A161:   ^QES2
B161:   (F0)  @IF(QEX2<0,0,QEX2)
A162:   ^QRT1
B162:   (F0)  @IF(QEX1<0,@ABS(QEX1),0)
A163:   ^QRT2
B163:   (F0)  @IF(QEX2<0,@ABS(QEX2),0)
A164:   ^QEST
B164:   (F0)  +QES1+QES2
A165:   ^QRTT
B165:   (F0)  +QRT1+QRT2
A166:   ^ISC
B166:   (F0)  @IF((B66-$COR)<0,0,(B66-$COR)*(B5-B88)/100)
A167:   ^QRS
```

```
B167: (F0) +$A*$X*$SS*ISC
A168: ^QCF
B168: (F0) +$HCE*$AF*(TSS1-B$37)*B$5
A169: ^QRF
B169: (F0) @IF(QCF<0,0,QCF)
A170: (D1) ^QGF
B170: (F0) @IF(QCF<0,@ABS(QCF),0)
A171: ^QC
B171: (F0) +$VC*$IC*B83/1000
A172: ^QV
B172: (F0) @IF((B83-B85)<0,0,($VV*$IV*(B83-B85)/1000))
A173: ^QET1
B173: (F0) +DATM1*CPTM1*$FRT1*(B34-B30)*B83
A174: ^QET2
B174: (F0) +DATM2*CPTM2*$FRT2*(B34-B32)*B83
A175: ^QETS1
B175: (F0) @IF(QET1<0,0,QET1)
A176: ^QETS2
B176: (F0) @IF(QET2<0,0,QET2)
A177: ^QETR1
B177: (F0) @IF(QET1<0,@ABS(QET1),0)
A178: ^QETR2
B178: (F0) @IF(QET2<0,@ABS(QET2),0)
A179: ^QETST
B179: (F0) +QETS1+QETS2
A180: ^QETRT
B180: (F0) +QETR1+QETR2
A181: ^QBR
B181: (F0) +$VBR*$IBR*(QETRT+QRF)/$PFM/1000
A182: ^HCT
B182: (F4) @IF(@ABS(TTD)<=0.8#OR#B83=0,@NA,
           @IF((QET1/(13*$AT*TTD*B83))<0,@NA,(QET1/
           (13*$AT*TTD*B83))))
A183: ^AHU1
B183: (F2) (AHUI-AHUO1)*$FRT1*B83
A184: ^AHU2
B184: (F2) (AHUI-AHUO2)*$FRT2*B83
A185: ^DHU1
B185: (F2) @IF(AHU1<0,0,AHU1)
A186: ^DHU2
B186: (F2) @IF(AHU2<0,0,AHU2)
A187: ^HUM1
B187: (F2) @IF(AHU1<0,@ABS(AHU1),0)
A188: ^HUM2
B188: (F2) @IF(AHU2<0,@ABS(AHU2),0)
A189: ^DHU
B189: (F2) +DHU1+DHU2
A190: ^HUM
B190: (F2) +HUM1+HUM2
A192: ^COPS
B192: (F1) @IF((QC-QV)<=0#OR#QEST<=0,@NA,(QEST/(QC-QV)))
A193: ^COPR
B193: (F1) @IF((QC-QBR)<=0#OR#QETRT<=0,@NA,(QETRT/(QC-QBR)))
A195: 'ISNA ESE
```

```
B195: @ISNA(ESE)
A196: 'ISNA ERE
B196: @ISNA(ERE)
A197: 'ISNA HCT
B197: @ISNA(HCT)
A198: 'ISNA COPS
B198: @ISNA(COPS)
A199: 'ISNA COPR
B199: @ISNA(COPR)
A200: 'SUM(HCT)=
B200: @SUM(B197..Y197)
A201: 'HCT C
B201: @IF(@ISNA(HCT)=0,HCT,0)
A202: 'COPS C
B202: @IF(@ISNA(COPS)=0,COPS,0)
A203: 'COPR C
B203: @IF(@ISNA(COPR)=0,COPR,0)
A204: 'ESE C
B204: @IF(@ISNA(ESE)=0,ESE,0)
A205: 'ERE C
B205: @IF(@ISNA(A143)=0,A143,0)
A206: 'MOY. HCT:
B206: @IF(B200=24,@NA,@SUM(B201..Y201)/(24-B200))
A209: "TFC =
B209: (F0) @SUM(B$82..Y$82)
A210: "TCC =
B210: (F0) @SUM(B$83..Y$83)
A211: "TPC =
B211: (F0) @SUM(B$84..Y$84)
A212: "TVGC =
B212: (F0) @SUM(B$86..Y$86)
A213: "TVBC =
B213: (F0) @SUM(B$85..Y$86)-TVGC
A214: "TVHC =
B214: (F0) @SUM(B$87..Y$87)
A215: "TCTC =
B215: (F0) @SUM(B$88..Y$88)
A216: "TLC =
B216: (F0) @SUM(B$89..Y$89)
A217: "QLC =
B217: (F0) @SUM(B$144..Y$144)
A218: "QLEC =
B218: (F0) @SUM(B$145..Y$145)
A219: "QLUC =
B219: (F0) @SUM(B$146..Y$146)
A220: "QFC =
B220: (F0) @SUM(B$147..Y$147)
A221: "QTHLC =
B221: (F0) @SUM(B$151..Y$151)
A222: "QSSTGC =
B222: (F0) @SUM(C$156..Y$156)
A223: "QSSTLC =
B223: (F0) @SUM(C$157..Y$157)
A224: "QESTC =
```

```
B224: (F0) @SUM(B$164..Y$164)
A225: "QRTTC =
B225: (F0) @SUM(B$165..Y$165)
A226: "QRSC =
B226: (F0) @SUM(B$167..Y$167)
A227: "ISCC =
B227: (F0) @SUM(B$166..Y$166)
A228: "QRFC =
B228: (F0) @SUM(B$169..Y$169)
A229: "QGFC =
B229: (F0) @SUM(B$170..Y$170)
A230: "QCC =
B230: (F0) @SUM(B$171..Y$171)
A231: "QVC =
B231: (F0) @SUM(B$172..Y$172)
A232: "QBRC =
B232: (F0) @SUM(B$181..Y$181)
A233: "QETSTC =
B233: (F0) @SUM(B$179..Y$179)
A234: "QETRTC =
B234: (F0) @SUM(B$180..Y$180)
A235: "DHUC =
B235: (F2) @SUM(B$189..Y$189)
A236: "HUC =
B236: (F2) @SUM(B$190..Y$190)
A237: "TOSM =
B237: (F1) @AVG(B$96..Y$96)
A238: "TSS1M =
B238: (F1) @AVG(B$97..Y$97)
A239: "TSSGM =
B239: (F1) @AVG(B$100..Y$100)
A240: "TIODM =
B240: (F1) @AVG(B$107..Y$107)
A241: "TIM =
B241: (F1) @AVG($B$37..$Y$37)
A242: "TOM =
B242: (F1) @AVG($B$39..$Y$39)
A243: "HCTM =
B243: (F4) +$B$206
A244: "SE =
B244: (F2) @IF(QSSTGC/(QESTC+QRSC+QGFC)>1,1,QSSTGC/
           (QESTC+QRSC+QGFC))
A245: "RE =
B245: (F2) @IF((QETRTC+QRFC)/QSSTLC>1,1,(QETRTC+QRFC)/
           QSSTLC)
A246: "COPSM =
B246: (F1) +$D$206
A247: "COPRM =
B247: (F1) +$F$206
A248: "FF =
B248: (F2) @IF(QFC/QTHLC>1,1,+QFC/QTHLC)
A249: "LF =
B249: (F2) @IF(+QLUC/QTHLC>1,1,QLUC/QTHLC)
A250: "SF =
```

```
B250: (F2) @IF(1-FF-LF<0,0,1-FF-LF)
A251: "RSR =
B251: (F2) +$QRFC/($QETRTC+$QRFC)
A252: "ESEM =
B252: (F2) @IF(H206>1,1,H206)
A253: "EREM =
B253: (F2) @IF(J206>1,1,J206)
```