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A STUDY OF THE PHYSIOLOGICAL RESPONSES OF HUMAN BEINGS IN ADAPTATION TO STRESS, IN DIFFERENT SIMULATED LABORATORY ENVIRONMENTAL CONDITIONS.

By

MICHEL SALIM MROUE

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Supervisor: Dr. E.J. Hamley

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ABSTRACT

A study in the search for the physiological responses in human beings in adaptation to stress, in different simulated laboratory environmental conditions with no protective clothing mainly for a short period of exposure.

Different groups of subjects were exposed to one of the following environmental conditions:

A - (at rest) ($1\frac{1}{2}$ hours) - 10°C above and below ambient temperature.

B - (2 hours)

(i) (at work) -	I	25°C	67% Rh
	II	30°C	50% Rh
	III	35°C	38% Rh
(ii)(at rest) -	I	25°C	80% Rh
	II	25°C	38% Rh
(iii)(at rest)	I	30°C	50% Rh
	II	35°C	38% Rh

C - (at rest) ($1\frac{1}{2}$ hours) - 40°C 25% Rh

D - (at rest) (2 hours)

(i), (ii) and (iii)

I	40°C	25% Rh
II	10°C	50% Rh

E - (at rest)(24 hours) - 40°C 25% Rh

F - Ambient Temperature.

From the analyses of urine, sweat and blood, it was found that incomplete adaptation has occurred, during which the physiological processes responded to the environmental changes in a conservative way to counteract the effects of serious stress in order to maintain

body homeostasis. Urine and blood analyses indicated certain similarities in processes and levels of the parameters under study and those clinically observed changes due to clinical disorders.

Parameters studied were:

Urine: Na^+, K^+, Cl^-, urea and creatinine.

Blood: Haemoglobin; P.C.V.; Red and white blood cell count.

Heart rate; blood pressure.

Skin and oral temperature.

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1. INTRODUCTION

1 INTRODUCTION

What is environmental stress?

To what extent, and within what precise limits, can the human body react physiologically to adapt to environmental stimuli?

To begin with, the word stress is misleading. To avoid confusion I would like to define the word stress as used throughout this thesis as a condition or state caused by an external stimulus, which upsets the human body from its normal balance of body functions.

To maintain homeostasis, (i.e. the constancy of the internal environment), adjustments of the physiological mechanisms and activities are made in response to any influence (from the external environment) on the body that tends to disturb its steady state and encourages survival in this external environment.

The compensatory responses of homeotherms to environmental stress caused by temperature changes are through acclimation and acclimatization. Acclimation consists of physiologically well-marked changes which occur in reaching equilibrium with controlled environmental conditions; while acclimatization refers to the adaptive changes which occur under more complex situations in nature.

The body homeostasis response to environmental stress is similar to the body response to a disease, where feedback control reactions tend to maintain internal constancy; at some limiting gradients their control reactions fail and the internal state changes abruptly, resulting in severe illness.

Although the body temperature of acclimated man is held in a narrow range, a lowered perspiration threshold, increased production of dilute sweat and improved vascular responses are the general effects of exposure to heat; similarly the ability to maintain high rates of heat production in cold climates is the most significant effect of acclimation to a cold environment.

Thus man's ability to survive and work in a hot or cold climate depends on physiological mechanisms and behavioural responses by which he can alter the effect of new environmental conditions so as to heat or cool the body to the zone of comfort. Thus the body acquires acclimation to the new external environment through these compensatory changes, and as a result the organism seeks to regain its normal physiological constants through the process of acclimatization.

To meet the challenge of climatic changes of heat and cold, this research was designed to study the physiological responses of the human body in adaptation to stress in different simulated environmental conditions and for different durations.

Many studies have been made based on long-term exposure to different environmental conditions in search for acclimatization, which is the process of adaption to an environment other than that to which the subject was accustomed and which, when completed, enables the subject to retain his capacity to live and work in the new environment without showing symptoms of distress.

This study was carried out to examine mainly the effects of short-term exposure to different environmental conditions, and to see whether acclimation had occurred during the exposure.

In our daily life we are exposed to great changes in temperature conditions between indoors and outdoors. This situation is similar to a short-term exposure. How well do we adapt to such changes? Can we accommodate properly and to what extent do the physiological systems respond in maintaining the operating equilibrium.

Keeping in mind the limitations to which this search was confined, the environmental conditions ranged as follows:

a - temperature	10°C	-	40°C
b - relative humidity	25%	-	80%

A selection of parameters were chosen guided by the work conducted previously on similar sorts of experiments.

They were as follows:

(i) Blood
- (a) - Haemoglobin
- (b) - Haematocrit
- (c) - Red and white cells count

(ii) Urine analysis
- (a) - Electrolytes Na^+, K^+ and Cl^-
- (b) - Urea
- (c) - Creatinine

(iii) Oral temperature

(iv) Skin temperature

(v) Heart rate

(vi) Blood pressure

(vii) Sweat rate

(a) - Na^+

(b) - K^+

Not all of these parameters were measured in any one experiment but different combinations were planned in designing the environmental condition and duration of each experiment to meet the availability of the necessary equipment and the willingness of the subject to provide samples for the parameters under study.

In an attempt to test the validity of the main findings, the work was extended to include 24 hours exposure under one environmental condition and to give us an insight to the level of acclimation acquired and to what extent the physiological system responded.

2. LITERATURE REVIEW

2. LITERATURE REVIEW

It was obvious that the effect of environment on man had been receiving a great amount of attention, and that any progress in this field of research required a modern fine control of climatic variables, to enable the investigators to study and predict the capacities and tolerance limits of people living in extreme weather conditions. Thus the idea of an environmental chamber with which climatic variables could be controlled was developed.

Experiments in climatic chambers were conducted in such a way that subjects were exposed to certain durations at certain environmental conditions to meet the requirements and the aims of the experiment under test. The physiological responses were measured in terms of heart rates, sweat rates, body temperature. The physiological responses due to the effect of the environment were measured by examining the differences in response between the initial pre-exposure state and the final end-exposure state.

Acclimatization in man to both heat and cold showed a variety of responses which indicated that fundamental physiological, biochemical and endocrinological changes took place which were not apparent prior to acclimatization.

Thus the purpose of this review is to present the physiological changes which occured during exposure to different environmental conditions and to give us an insight of what to expect by applying short-term exposure; to combine these theoretical expectations with the results obtained, to search for a deeper understanding of the mechanisms involved; and to open up the possibilities of useful diagnostic and therapeutic aids to overcome thermal stress.

Acclimatization and acclimation are adaptive changes that occur, in the former, under natural conditions when multiple factors are involved, where as the latter consists of changes that occur under laboratory conditions where only one factor is varied. (Prosser, 1970). Acclimation is the equilibrated steady state.

Repeated exposure to the same work and temperature would result in a progressive improvement in the performance of the task and acclimatization would occur rapidly. (Lichna., 1950, Robinson, et al. 1943, Wyndham, 1967).

In man acclimatization to cold environment is characterized by a decrease in shivering which is accompanied by a decrease in total oxygen consumption. (Davis 1961, 1967, 1963; Joy et al, 1962).

Water exchange through the kidney, skin and respiratory tract may range from 1-2 liters per day in individuals in a cool environment to about 10-12 liters/day in individuals working in hot environments. (Robinson and Wiegman, 1974).

Even when allowance is made for sweat loss, the urine flow at a given water load is halved when temperature is increased from 32 to 49°C. (Kenney and Miller, 1949).

The effect of kidney hemodynamics is one of the classic experiments where a decrease in renal blood flow from 695 ml/min at 21°C to 426 ml/min at 50° in five resting male subjects was shown (Radigan and Robinson, 1949). Also they reported that glomerular filtration rate dropped in the hot environment. Even moderate exercise in the heat was reported to cause a further decrease in glomerular filtration rate. (Smith et al., 1952).

Dehydration causes a marked renal conservation of water. Thus the decrease in urine flow during dehydration can be attributed to the decrease in glomerular filtration rate and to an increase in antidiuretic hormone (ADH) secretion. (Itoh, 1960.)

Salt outputs by the kidney and sweat glands were found to be reduced by increased mineral corticoid activity in response to salt deficiency. (Robinson et.al, 1955).

Salt depletion, induced by heavy and sustained sweating, is followed by decreased urinary output of water, sodium, potassium and chloride. (Ladell, 1964).

During heat exposure there was a decline in the urinary Na^+ and Cl^- concentration but an increase in K^+ concentration (Kanter, 1955). The decrease in renal NaCl was attributed to the decrease in glomerular filtration rate, supported by adreno-corticoid activity, while K^+ increase was due to rapid cellular dehydration with a large release of K^+ from cells. (Itoh, 1960).

Na^+/K^+ ratios decreased during acclimatization to heat, due to an increase in aldosterone activity. (Macfarlane 1956).

An increase in the excretion of urinary creatinine in subjects exposed to heat, was due to increased net loss of muscle creatine . Thus enhanced creatinine output was due to an increase in urinary nitrogen losses. (Streeten et al., 1960).

Sweating is one of the important factors that occur during acclimatization to heat stress. It provides a means of heat loss by surface evaporation of water. Sweating is the most effective

means of maintaining thermal regulation and hence evaporative cooling is found to increase as the environmental temperature increases.

Insensible perspiration, which is water reaching the skin surface by diffusion, constitutes a small proportion of body sweat. It increases with skin temperature, but decreases with an increase in water vapour pressure at the skin surface (Hale et al 1958). However, because it is a diffusate it is virtually solute free. (Ladell 1964). Sensible perspiration represents the true secretion of ecrine glands of the skin. Its composition has been reviewed by Robinson and Robinson (1954), Weiner and Hellman (1960) and Itoh (1960).

When the environmental temperature exceeds 29°C, evaporation from skin is increased by increased sweat secretion (Robinson and Wiegman, 1974), providing the evaporative cooling mechanism for the body. In hot humid climates sweat largely drips from the skin limiting the evaporative cooling effect and resulting in a smaller fall in body temperature, whereas in hot dry climates, the same increase in sweat production brings about a larger reduction in body temperature because the water is evaporated. (Fox, 1965).

Since sweating is the major source of heat loss, an increase in sweat rate would be a beneficial adaptation. The fact that sweat rate increased due to acclimatization has been confirmed by several workers (Moss, 1923; Adolf and Dill, 1938; Robinson et al., 1941; Wyndham, 1967; Ladell, 1957 and Eichna et al., 1954).

The important constituents of sweat, from the point of view of physiological responses to heat, are sodium, potassium and chloride ions. An increase in skin or body temperature produces an increase in the salt content of sweat, as does an increase in sweat rate (Robinson, 1968).

The chloride concentration in sweat was found to be affected by skin temperature, rectal temperature, sweat rate, and individual variations (Johnson, Pitts, and Consolazio, 1944). They found an increase in chloride concentration with an increase in rectal and skin temperatures. Lowering the skin temperature reduced the chloride concentration. They showed that sweat sodium concentration behaved like chloride concentration, but not potassium.

A decrease in sweat sodium concentration, during acclimatization of men working in the heat, was a feature of the acclimatization mechanism and beneficial to the maintenance of body fluid volume and composition. (Dill et al., 1933). These results were confirmed by Bass et al., 1955, where they attributed the decrease in sodium and chloride concentrations largely to the decrease in rectal and skin temperatures. They found that a more dilute sweat was produced during the acclimatization process and concluded that the sweat glands excreted more water relative to solutes as acclimatization progressed.

It was suggested that the decrease in sweat sodium concentration was due to the secretion of aldosterone in men exposed to heat (Kenney, 1963).

Some workers reported that the decrease in sweat rates was due to the sweat gland mechanism being fatigued. (Gerking and Robinson, 1946).

Ladell, 1951; Thaysen and Schwartz, 1955; Weiner and Hellman, 1960; Peter and Wyndham, 1966 also attributed the decline in sweat output to glandular fatigue.

Some investigators attributed the decline in sweat rates to a central nervous failure of the sweat mechanism (Wolkin et al., 1944; Kuno, 1956). Others suggested that the mechanism involves excessive skin hydration around sweat gland orifices, resulting in the occlusion of the sweat gland ducts and causing the reduction in sweat during heat exposure. (Randall and Peiss, 1957; Collins and Weiner, 1962).

On exposure to heat the onset of sweating was achieved when the rectal temperature of about 38°C was reached which took up to 20°C depending on the magnitude of heat stress and rate of work (Ladell, 1951). With hard work, sweating is not dependent upon body temperature (Robinson, 1959).

It is not clear whether the mechanism responsible for the decrease in sweat rate is an adaptive device on the part of the organism or a function of salt intake, but from the literature the general trend is directed towards peripheral changes rather than central nervous system fatigue.

Maintenance of a constant body temperature is a neat balance between heat production and heat loss. It demands a sensitive thermostat in the brain with a capacity not only to use the heat formed as a by-product of metabolism but also to increase the output of metabolic energy as required. Core temperature, measured at different sites such as the oesophagus,

tympanic membrane, ear canal, mouth and rectum, differ from one another, but behave in the same way when work rate or environment is changed, although the time relations and magnitudes of the changes may vary from site to site. (Piizonen, 1970).

The normal deep body temperature in man at rest is 35.8 - 37.7°C. This level is kept fairly constant by maintaining a balance between heat gain and heat loss. Investigators showed that over a wide range of environments the core temperature is independent of the environmental stress and it was kept at a level within the normal range (Nielson, 1938; Winslow and Gagge, 1941; Robinson, 1949; Wyndham et al., 1952 a, b; 1954; Astrand, 1952; Nielson and Nielson, 1962; Lind, 1962; 1963, a, b; Blockley, 1965; Saltin and Hermansen, 1966; Webb and Annis, 1967; 1968; Stolwijk, Saltin and Gagge, 1968). This was explained by the complicated physiological mechanisms of the body to keep the core temperature, the vital part which plays the main role in survival, constant. When this temperature increased or decreased to the extremes through illness or accident, the thermoregulatory mechanisms fail leading ultimately to death.

Skin temperature responds rapidly and sensitively when an individual is exposed to an environment warmer or colder than a neutral environment. Skin temperature has two characteristics (a) - rapid change in skin temperature when exposed to a different environment (Adolph, 1946); (b) - the final skin temperature during cold exposure is a function of air movement and ambient temperature and during heat exposure it is, in addition, a function of ambient humidity. Thus, skin temperature is lower when ambient

temperature is lower and skin temperature is higher during exposure to high temperatures and high humidities. (Goldman, Green and Iampietro, 1965; Iampietro, 1961; Iampietro, Bass and Buskork, 1958; Iampietro and Buskork, 1960; Iampietro, Chiles Higgins and Gibbons, 1969; Iampietro, Fiorica, Higgins, Mager and Goldman, 1966; Iampietro, Goldman, Buskirk and Bass, 1959; Iampietro, 1971).

On exposure to heat, skin temperature increased over the whole body and stabilized at a certain level, which is above the normal level, whereas upon exposure to cold the skin temperature dropped.

The adjustments of the cardio vascular system in response to heat, playsan important role in adaptation to heat stress. Several aspects of cardio vascular responses have been reviewed by Eisato, (1956), Thaiser, (1965), and Wyndham, (1973).

It was accepted that cardiac output increased on exposure to heat stress, and adjustment of the cardio vascular system to such exposure was confirmed by many investigators (Wyndham et al., 1954; Eichna et al., 1945; Kerslake, 1972).

A decrease in pulse rate was one of the most classical findings in repeated heat exposure. (Bean and Eichna, 1943; Robinson et al 1943; Eichna et.al., 1945; Horvath and Shelley, 1946; Eichna, 1950; Bass et al., 1955). This adjustment in cardiovascular response to heat was reported by many investigators (Wyndham et al., 1954; Eichna et al.; Kerslake, 1972) and confirmed by many investigators. (Scott, Bazett, and Mackie,1939; Bean and Eichna, 1943; Taylor, Henschel and Keys, 1943).

The increase in cardiac output and the decrease in diastolic pressure were the result of reduction in peripheral resistance by cutaneous vasodilation for purpose of thermal regulation during heat exposure. During heat there is initially an increase in plasma volume (Senay, 1965), whereas during cold exposure cutaneous vascoconstruction, for the purpose of reducing heat loss, causes an increase in blood pressure.

There is no doubt of the important role which the endocrine system plays in heat acclimatization, through the complex readjustments required by the body.

Aldosterone levels in urine are reported to be higher in summer than those in winter, due to the intermittent sweating during summer which enhances aldosterone production (Yoshimura, 1960).

Deprivation of salt brought an increase in aldosterone excretion (Biddle et al., 1955), and salt loading reduced it. (Thorn et al., 1957).

The aldosterone participates in the regulation of renal and sweat gland losses of salt during exposure to heat. The amount of aldosterone increases with an increase in sodium loss in sweat (Collins and Weiner, 1968). A fall of sodium levels in man increases the amount of renin and angiotensin in plasma (Brown et al., 1964), which in turn stimulates aldosterone secretion. Thus, lowered plasma sodium, raised potassium concentration, and the action of angiotensin II stimulates aldosterone excretion. (Blair - West et al., 1963). The aldosterone excretion

explains the mechanisms of sodium conservation taking place during heat, i.e. reduced sodium concentration in urine and sweat. (Streeten et al., 1960).

ADH or vasopressin (antidiuretic hormone) is secreted in urine and its production is stimulated by a fall in blood volume or an increase in osmotic pressure during exposure to heat. (Itoh, 1960). Vassopressin acts by activating adenyl-cyclase which increases renal cyclic AMP, resulting in more energy supplies to kidney cells and increasing permeability of distal tubule and collecting duct to water and sodium.

3. EXPERIMENTAL DESIGN AND PROTOCOL

Experimental Design and Protocol.

3.1 Experimental Design

In searching for a physiological indication in human beings as a response of adaptation to stress in different simulated laboratory environmental conditions, the following initial considerations governed the selection of experimental conditions:

(a) Safety and availability of subjects.

(b) The necessity of a medical doctor to collect large volumes of blood for different analysis, restricted the search, only for the study of packed cells volume and haemoglobin in some of the experiments.

(c) Random selections of temperatures and humidities, which are similar to many envionmental conditions on our planet.

(d) Correlation between the effects of two environmental conditions on the same subject.

(e) Short-term effects of different environmental conditions on working men.

(f) Short-term effects of different environmental conditions on resting subjects.

(g) Correlation between the effects of short-term exposures to two humidities on the same subjects.

3.2 Experiments

Restricting the research investigation to the above-mentioned factors the experiments were designed and conducted as follows:

Experiment A

A group of subjects was exposed to temperature of 10° C difference from ambient temperature, for a period of 1-1½ hours. Heart rate was recorded, sodium, potassium, and creatinine levels in urine were measured. Heart rate was recorded and samples of urine were collected at the beginning, mid-point, and end of exposure

Experiment B

This experiment consists of three parts:-

i. Different groups of subjects were exposed to three environmental conditions (25° C, 67% Rh), (30° C, 50% Rh) and (35° C, 38% Rh).

ii. A group of subjects was exposed to two humidities (80% Rh and 38% Rh) at a comfortable air temperature

iii. A group of subjects was exposed to two temperatures 30°C and 35° C at low humidity.

In these three parts heart rate was recorded and sodium, potassium levels were measured. Sweat rate was recorded in some of the conditions. Heart rate was recorded and samples of urine were collected thirty minutes before, forty minutes interval during, and thirty minutes after exposure. The period of exposure was 2 hours.

Experiment C

A group of subjects was exposed to one environmental condition 40° C, 25% Rh. Heart rate and packed cells volumes were recorded. The period of exposure was 1½ hours.

Experiment D

This experiment consists of three parts:-

i. A group of subjects was exposed to two environmental conditions 10° C, 50% Rh and 40° C, 25% Rh, for a short-term exposure. In this part urine samples were collected at the following times:

   a. pre-exposure sample
   b. end-exposure sample
   c. post-exposure sample.

   Heart rate was recorded and sodium, potassium, chloride, urea and creatinine levels of urine were measured.

ii. A group of subjects was exposed to two environmental conditions 10° C, 50% Rh and 40° C, 25% Rh for a short-term exposure. In this part urine samples were collected at the following times:

   a. early morning sample
   b. pre-exposure sample
   c. mid-exposure sample
   d. end-exposure sample
   e. post-exposure sample.

   Red and white blood cell count, haemoglobin packed cells volumes, heart rate were recorded and sodium, potassium, chloride, urea, creatinine levels of urine were measured.

iii. A group of children was exposed to two environmental conditions 10° C, 50% Rh and 40° C, 25% Rh, for a short-term exposure.

urine samples were collected at the following times:

a. pre-exposure sample

b. end-exposure sample

c. post-exposure sample.

Heart rate was recorded and sodium, potassium, urea, creatinine levels of urine were measured.

The period of each exposure in both conditions was 2 hours.

Experiment E

A group of subjects was exposed to one long-term environmental condition 40° c, 25% Rh and up to 24 hours. Sodium, potassium, chloride, urea, creatinine levels in urine were measured, in addition to the heart rate, blook pressure, surface skin temperature and packed cells volumes. Urine samples were collected at the beginning, then every four hours throughout, until four hours after the end of exposure.

Experiment F

A control experiment was conducted for resting and working conditions at room temperature. Sodium, potassium, chloride, urea, creatinine levels in urine were measured. The period of exposure was 2 hours.

The subjects reported to the laboratory wearing swimwear and were weighed and tested. The pre-exposure control sample was collected and heart rate was recorded. The subjects were asked to record the last time they emptied their bladders before coming for the experiment and then samples were collected as it was mentioned previously in the plan of each experiment.

In all experiments with the exception of Experiment B part i no work was done. The subjects were kept in the chamber for 1-24 hours depending on which experiment they were involved in. They were provided with a comfortable chair and nothing to do except what they wanted like reading and writing. In Experiment B part i subjects were set a light task, which involved the threading of a brush. (inserting nylon fibres into a metal holder).

At the end of the exposure, the subjects were removed from the chamber, thoroughly dried and reweighed. In all experiments with the exception of Experiment A and E a post exposure recording and samples were collected in accordance to the plan given before

For those subjects involved in the experiments where two different environmental conditions were used, they were asked to have a normal day after the first exposure and before the second different exposure.

All experiments with the exception of Experiment B part i were performed with subjects who had fasted overnight. No liquid was consumed on the morning of an experiment. The subjects were well acquainted with the methodology and aims of the experiments, and informal consent was obtained from each.

4. INSTRUMENTATION AND PROCEDURE

4.1 It is important for a modern clinical biochemist to apply and adapt automation in most of the clinical biochemistry tests, for the significance has been made in using such instruments in terms of accuracy, precision and analysis time. But the most important and vital part for a biochemist is to master handling these tests by simple basic concepts that are usually time consuming and elaborate procedures, which should be carried out with high efficiency.

4.2 Environmental Chamber

The chamber is a heat and sound insulated unit having a dimension of 4.72m x 2.92m x 3.10m (Figs.1 & 2), and facilities for manipulating the environmental conditions like temperature and relative humidities. The range of selection is for temperature $10^{o}C$ - $40^{o}C$ $\pm$ 1% C, and for relative humidity 20% - 95% $\pm$ 2.5%. (Figs 3&4) The chamber has cavities in the walls, ceiling and floor. Within these cavities are copper pipes that carry glycol solution (basically anti-freeze) which can be cooled or heated for heating or cooling the surface of the inner walls, ceiling and floor. The air is recirculated by a variable speed fan, which displaces 1500 cubic feet per minute. This air can be heated or cooled and humidified or dehumidified depending on the requirements within the range given previously. The fan speed can be controlled manually from zero to full output. It draws the recirculating air from the room through a filter and mixes a pre-determined amount of fresh air into the system. After passing through the fan the air can be humidified by steam injection. The steam being generated by two independently controlled immersion heaters. If dry air is required the dryer unit (silicair dryer

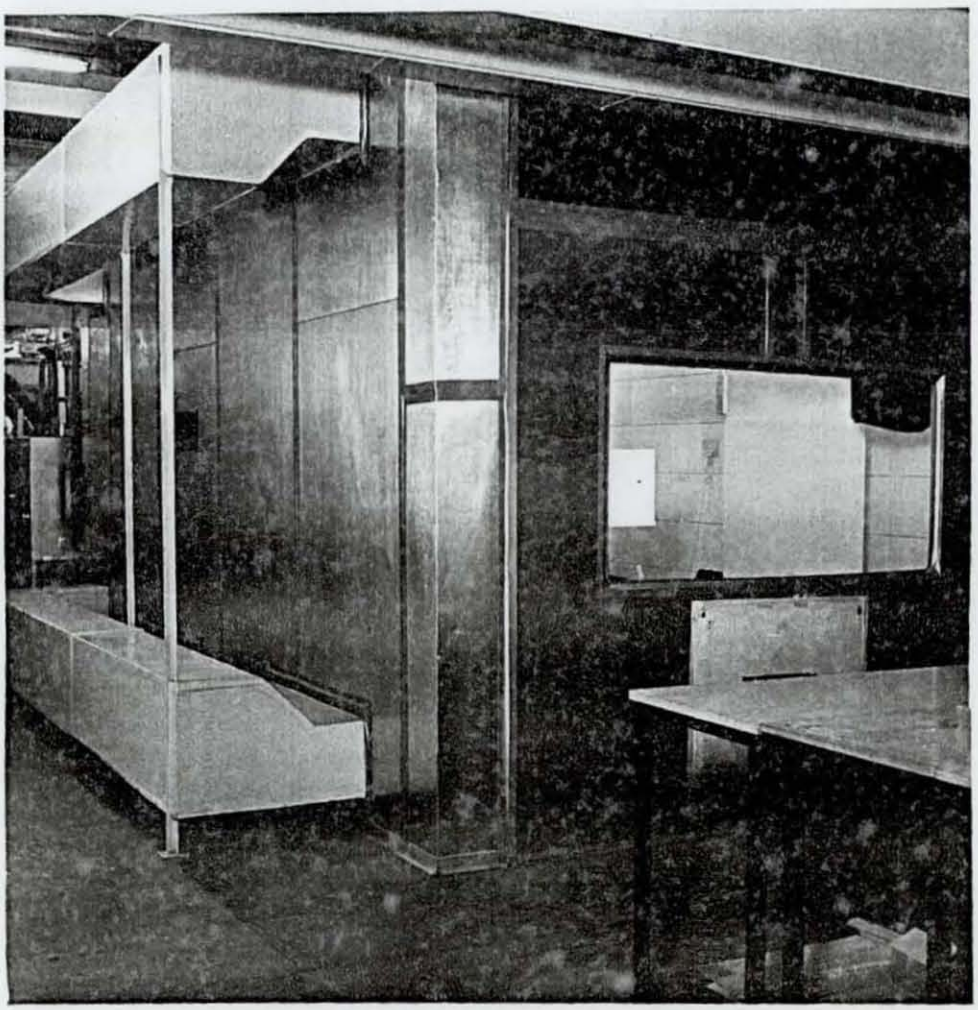


Fig. 1 - Environmental chamber. (External view).

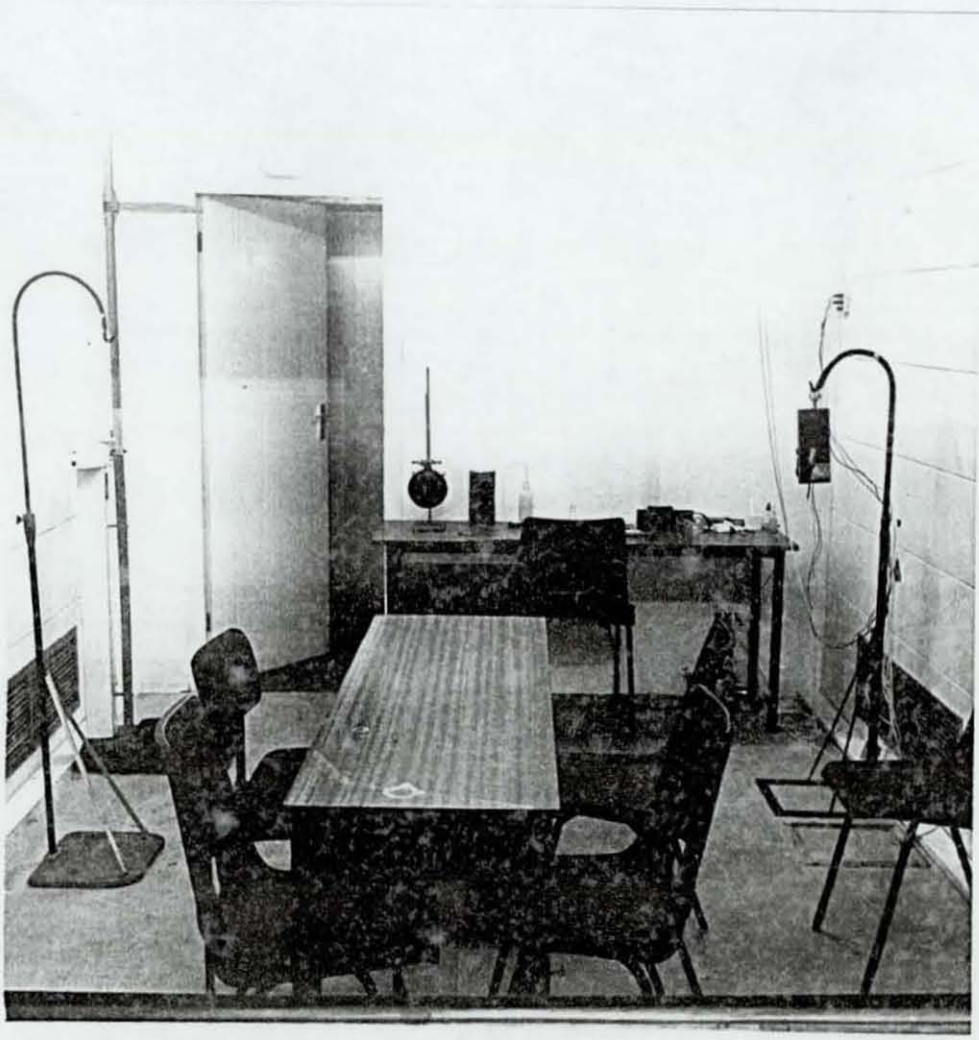


Fig. 2 - Environmental chamber (Internal view).

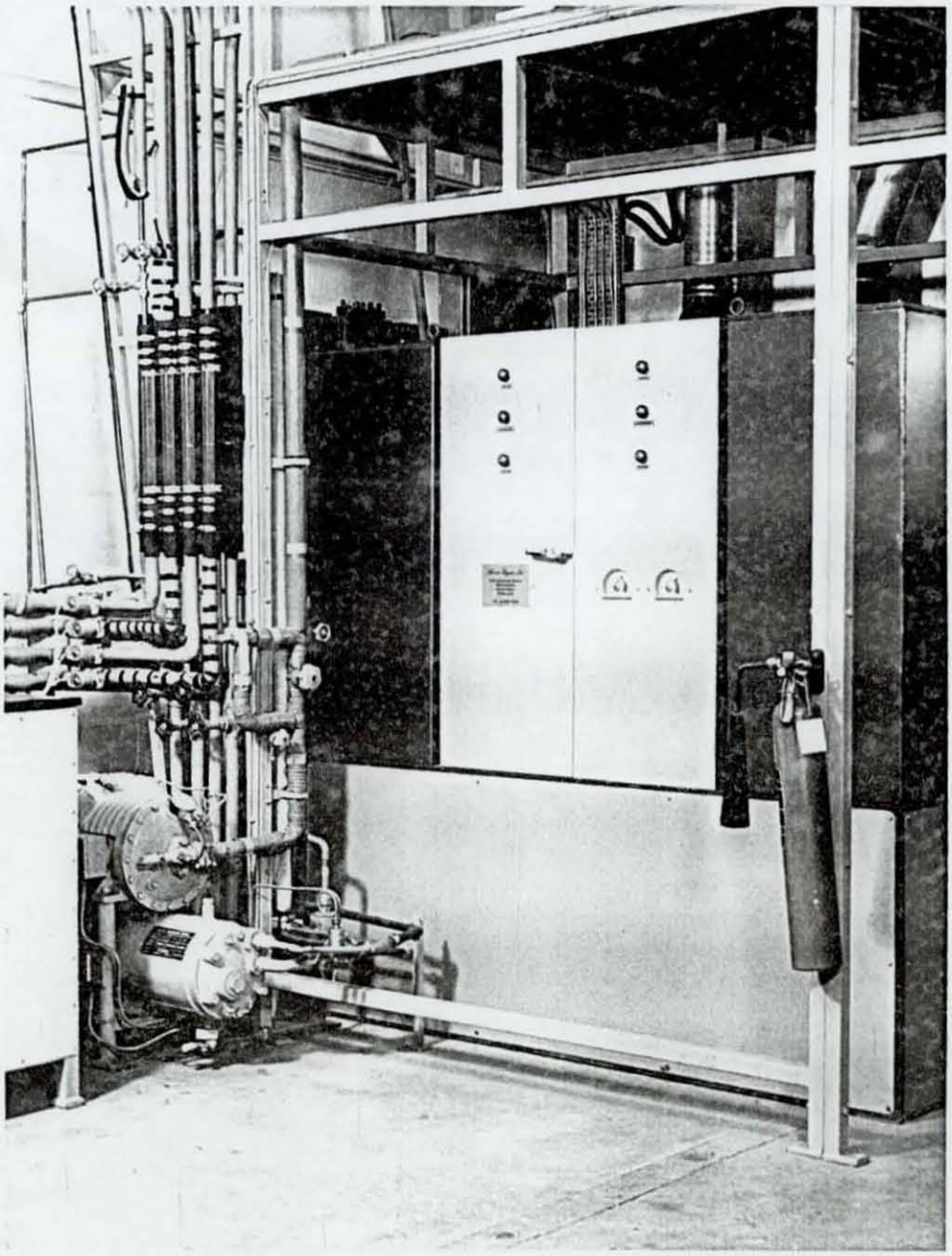


Fig. 3 - Drier and humidifier (Environmental chamber).

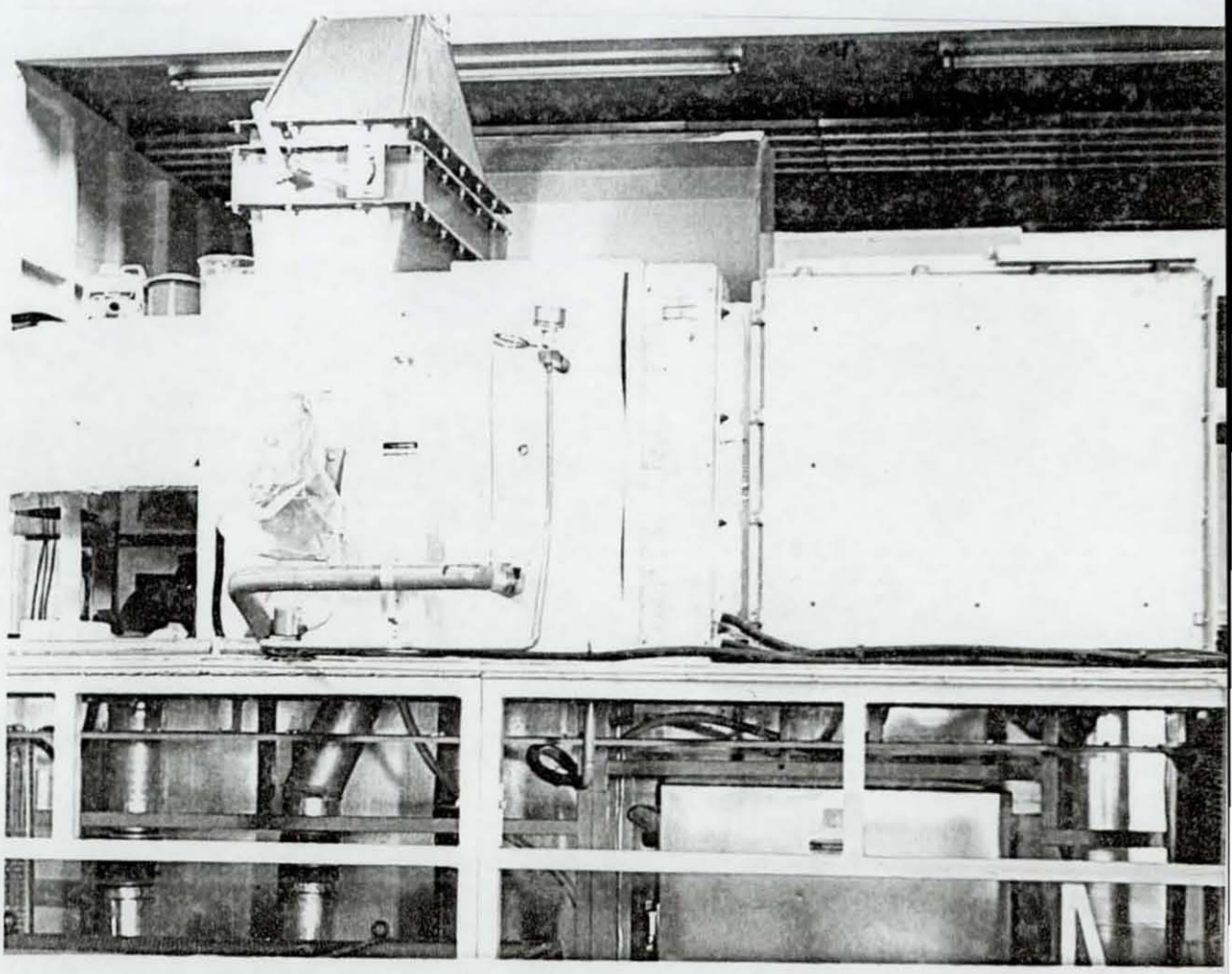


Fig 4 - Air heaters (Environmental chamber).

unit), which is composed of two silica gel banks; one of these in use will dry the air down to 20% Rh by extracting the moisture. Whilst one bank is being used the other is being dried out by passing heat through to the outside atmosphere. They automatically switch over as the one in use becomes saturated.

The liquid service unit comprises four circulator type pumps one for each of the four surfaces. (Fig. 5) Each circuit is controlled separately by a motorized mixing valve. This valve with its sensors and electronic control system allows the mixing of hot or cold liquid into the recirculating liquid system and maintains close temperature control.

The interior walls are covered by thin aluminium tiles. The floor is made up of a system of wooden joists through which the pipework runs and is insulated from the concrete base on which it stands. R.h, temperature and amount of fresh air can be controlled mannually or automatically. (Fig. 6)

Technical details of the environmental chamber

Room volume	$42.75 m^3$
Ventilation rate	0-55 air changes/hour (recirculation)
Fresh air circulation rate	0-25% recirculation
Temperature range	10-40 $\pm$ 1° C
Relative humidity range	20-95% $\pm$ 2.5%
Walls, ceiling and floor temperature range	0-50 $\pm$ 1° C
Air handling unit	0-0.71 m^3/sec. (variable speed fan)
Absorbent dryer	0.071 m^3/sec.

For operating instruction see Appendix. 10.3

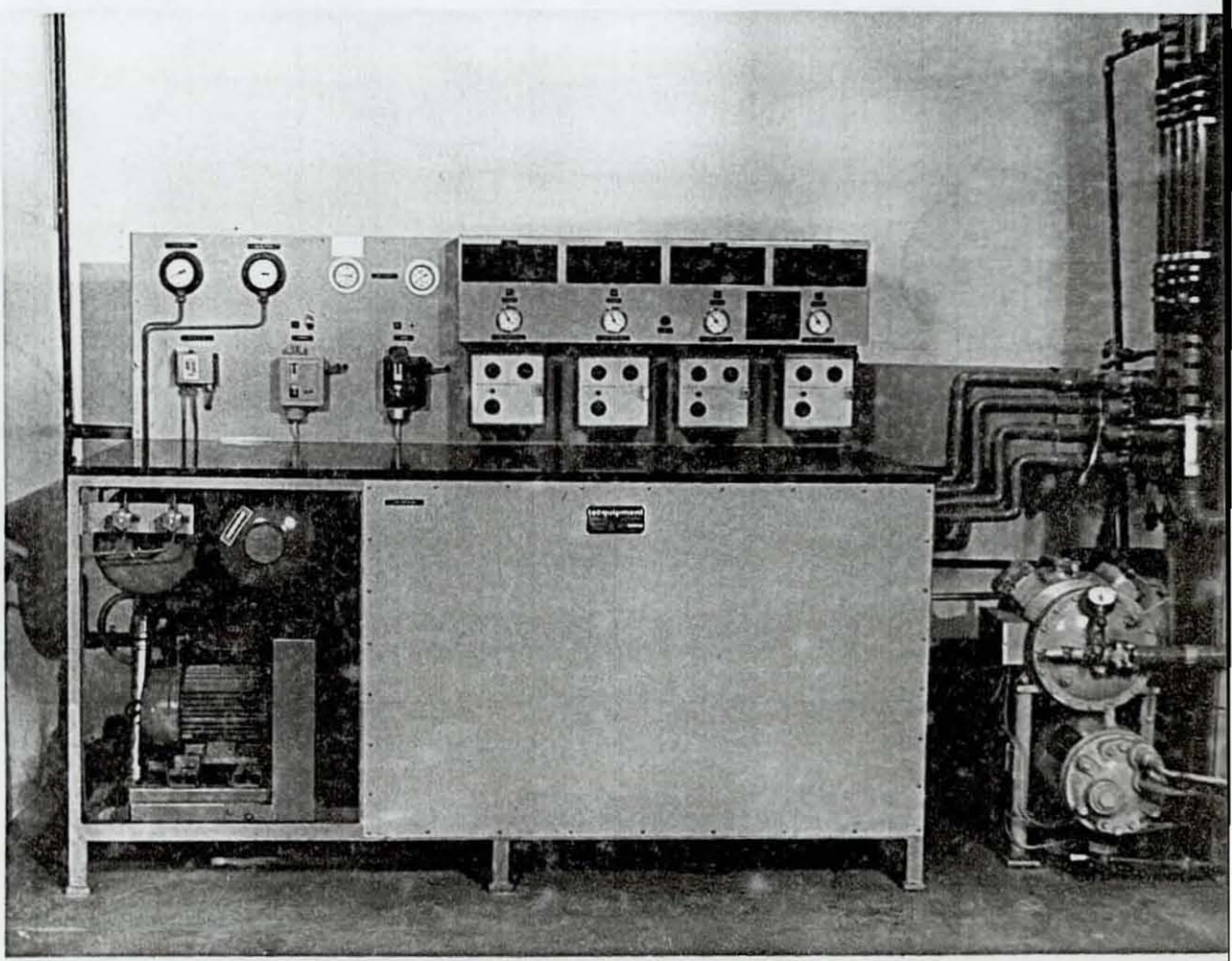


Fig. 5 - Fluid controls for the four parts of the environmental chamber (ceiling, walls and floor).

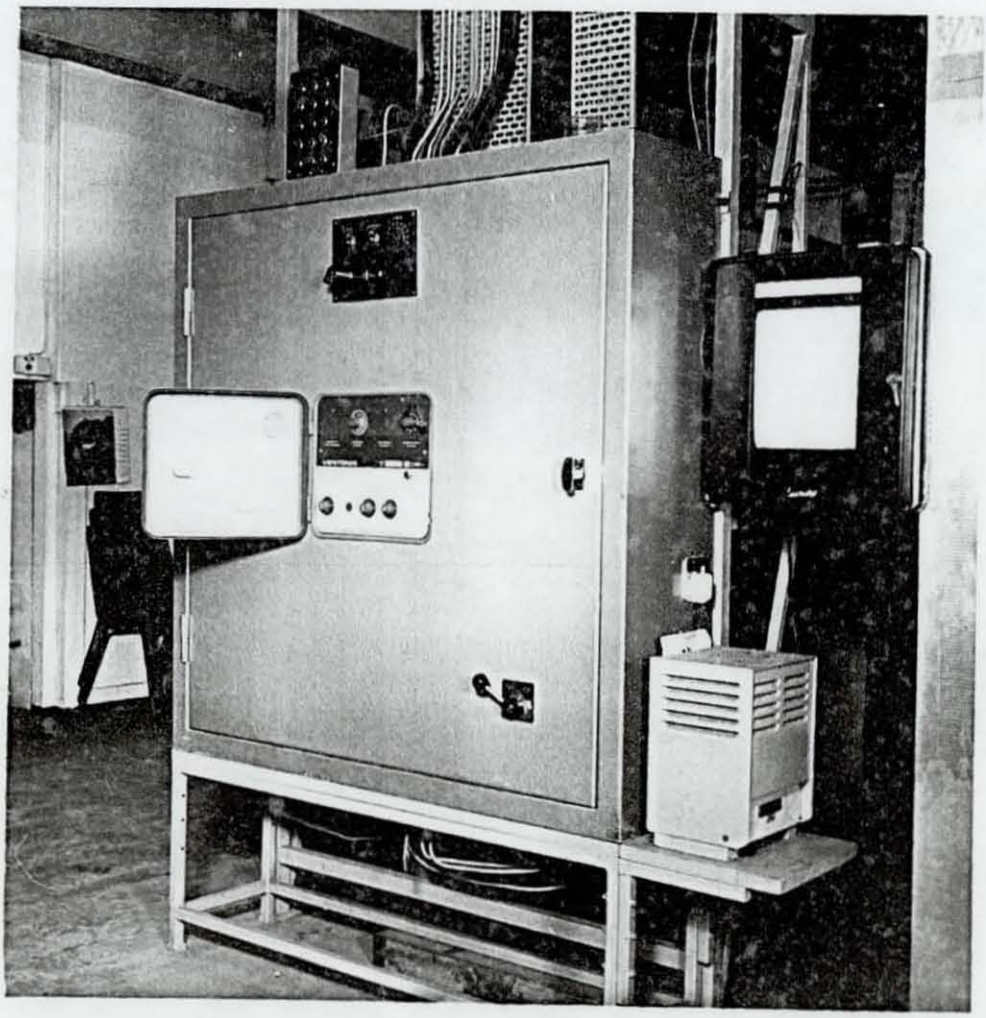


Fig. 6 - Main automatic and manual controls (Environmental chamber).

4.3 The Spectrophotometer

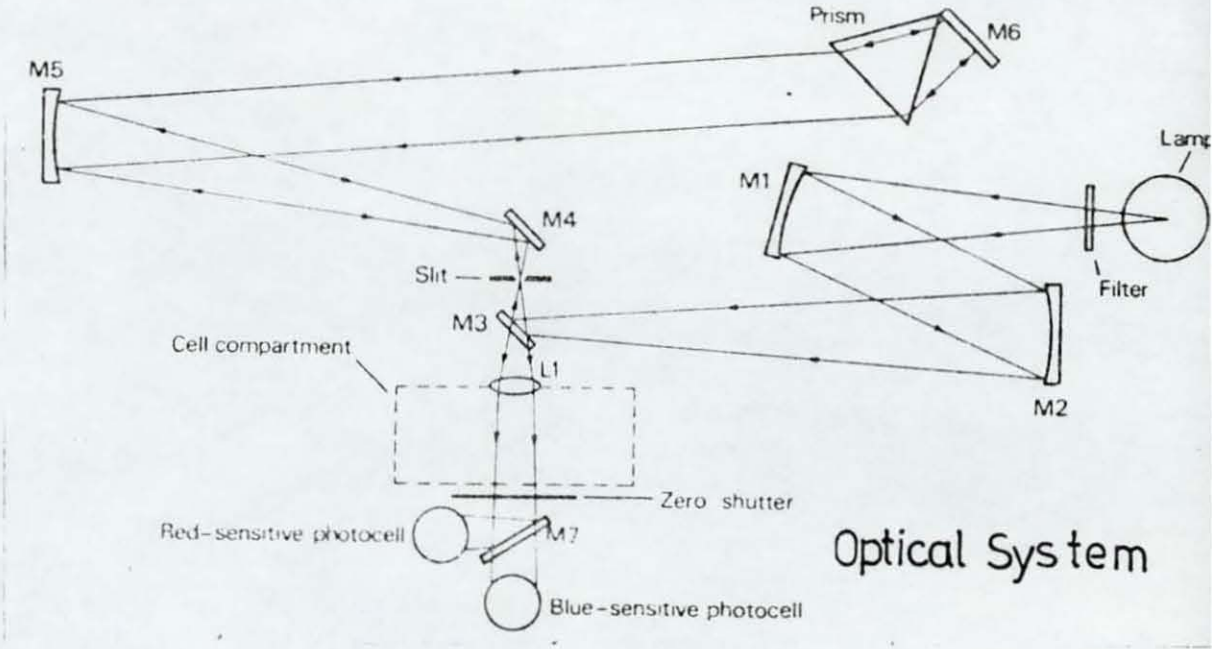
Classical spectrophotometer is by far the most useful instrumental methods of measurement in the clinical laboratory, and it will doubtless remain so for a long time to come. Basically we are making use of the properties of atoms and molecules to absorb or emit electromagnetic energy in one of the many areas of the total electromagnetic spectrum.

The spectrophotometer is an instrument used in photo-electric colorimetry, in which the instruments used are not colorimeters but absorptiometers, since it is the amount of light absorbed which is measured.

The Unicam S.P. 600 spectrophotometer (Fig. 7). It has two vacuum photocells,a red for above 620nm and a blue for below this. For operation instructions see Appendix 10.3.

Essential parts:

1. A power supply to furnish appropriately regulated electrical energy for the operation of the instrument.
2. A source of radiant energy, usually containing a large group of wavelengths e.g. a tungsten lamp.
3. A monochromator, which is a device for selecting the required range of radiant energy from the system, e.g. a filter prism, or diffraction grating.
4. A sample container to hold the material being measured e.g. a cuvette.
5. A detector system to detect the transmitted radiant energy and convert it into electrical energy so that it may be measured e.g. a photocell.



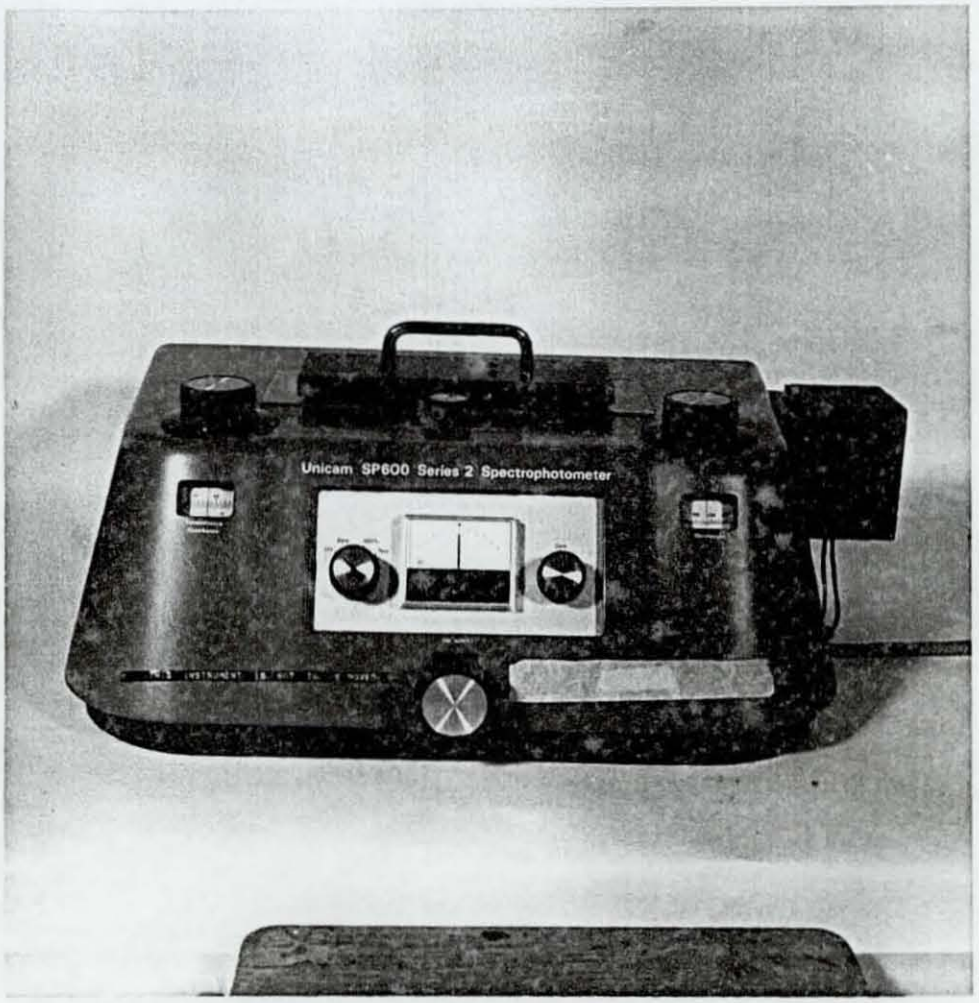


Fig. 7 - Spectrophotometer (Unicam Sp 600)

6. A readout device to present the electrical current in a manner that allows it to be measured in useful units e.g. a meter reading transmittance or absorbance.

4.4 Flame photometer.

The average clinical laboratory places great reliance on flame photometry for the measurement of sodium and potassium. (Fig. 8).

Flame emission photometry is based on the principle that atoms of many metallic elements given sufficient energy in one form or another will emit this energy at particular wavelengths that are characteristic for the element. Energy in flame photometry is supplied as heat or thermal energy.

A particular amount or quantum of thermal energy is absorbed by an orbital electron, thus allowing it to occupy a higher, more energetic but less stable orbit. Being unstable, the electron returns almost instantaneously to its previous base or ground state and emits this quantum of absorbed energy in the form of a photon of a particular wavelength. In the average flame, only about one per cent of the atoms present undergo this transformation and emission of energy.

The very small proportion of atoms that emit coupled with the relatively low intensity of emission of most elements rather severely limits the biological applications of this technique: sodium and potassium are the only elements that have sufficiently high intensities to be measured with reasonable ease. Calcium has a fairly low intensity emission, but if very sensitive instruments are used, it can be measured reasonably well.

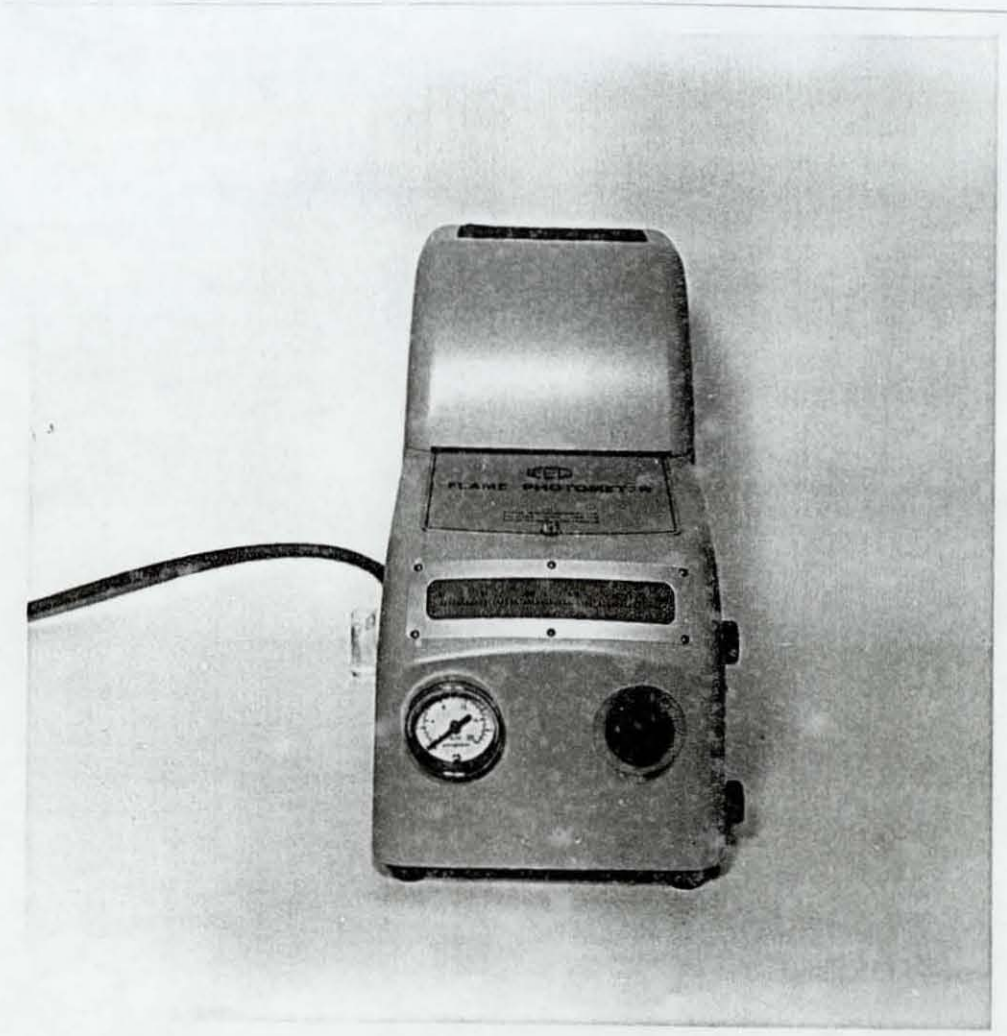


Fig. 8 - Flame photometer.

The flame photometer is used for measuring the concentrations of sodium and potassium in an unknown solution. These ions are estimated by reference to solutions of known concentration - the standard solutions. Suitable dilutions of standard solutions must be made in order to calibrate the instrument over the range of concentrations to be measured, the sensitivity of the method is:
Na - 2 p.p.m.; K - 3 p.p.m.

For methods and operating instructions see Appendix 10.2 and 10.3

4.5 Autoanalyzer

The main device used for the determination of Na^+, K^+, Cl^-, Urea and creatinine was a complete, serial, and continuous flow autoanalyzer labelled as Technicon S.M.A. (Sequential Multiple Analyzer) 6/60. (Fig. 9). The basic autoanalyzer consists of six modular units:

1. A sampler for picking up specimens to be analyzed.
2. A proportioning pump which maintains the flow of liquid in the system.
3. A dialyzer which produces a dialysate for analysis.
4. A heating bath for colour reaction development.
5. A spectrophotometer (colorimeter).
6. A recorder.

The S.M.A. 6/60 works on the principle of flame photometers.
For methods and operating procedure see Appendix 10.2 and 10.3.

Fig. 9 - Technicon S.M.A. 6/60 (Autoanalyzer).

4.6 Measurement of Environmental Conditions.

Environmental condition measurements were made during each exposure to ensure the chamber maintained the required conditions. The following equipment was utilized:

a. The Dry and Wet Bulb Temperatures.

The whirling hygrometer (Fig. 10) was used to measure wet and dry bulb temperatures. The hygrometer was whirled several times until a stable temperature was achieved. From the difference of these readings, the percentage relative humidity was found from psychrometric tables. Appendix 10.5.

b. The Globe Temperature.

The globe temperature is a measure of radiant temperature. The globe temperature was read from a globe thermometer which was correctly set up in an open area of the room (Fig. 10).

c. Air Movement.

This was measured by using a Kata thermometer of range 125-130° F. The time taken for the Kata thermometer to cool together with the Kata thermometer factor and the dry bulb temperature were used to estimate the air velocity from the nomogram. Appendix 10.5.

d. Light Laboratories

W.B.G.T. Index

Meter MIN_3 MK_5

It was a compact Min3lab (Fig. 11) which was used to give the basic environmental measurements mentioned in a, b, c.

For operating instructions see Appendix 10.3.

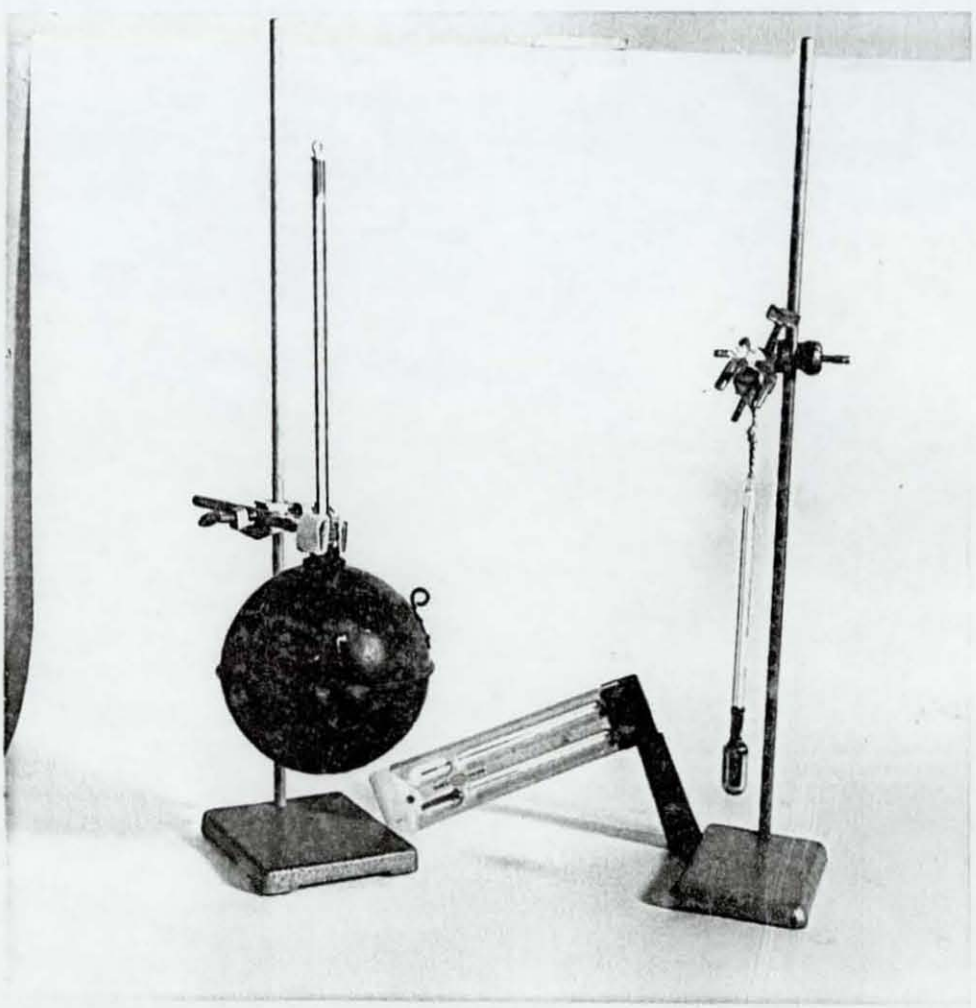


Fig.10 - Globe thermometer; wet and dry bulb thermometers, Kata thermometer.

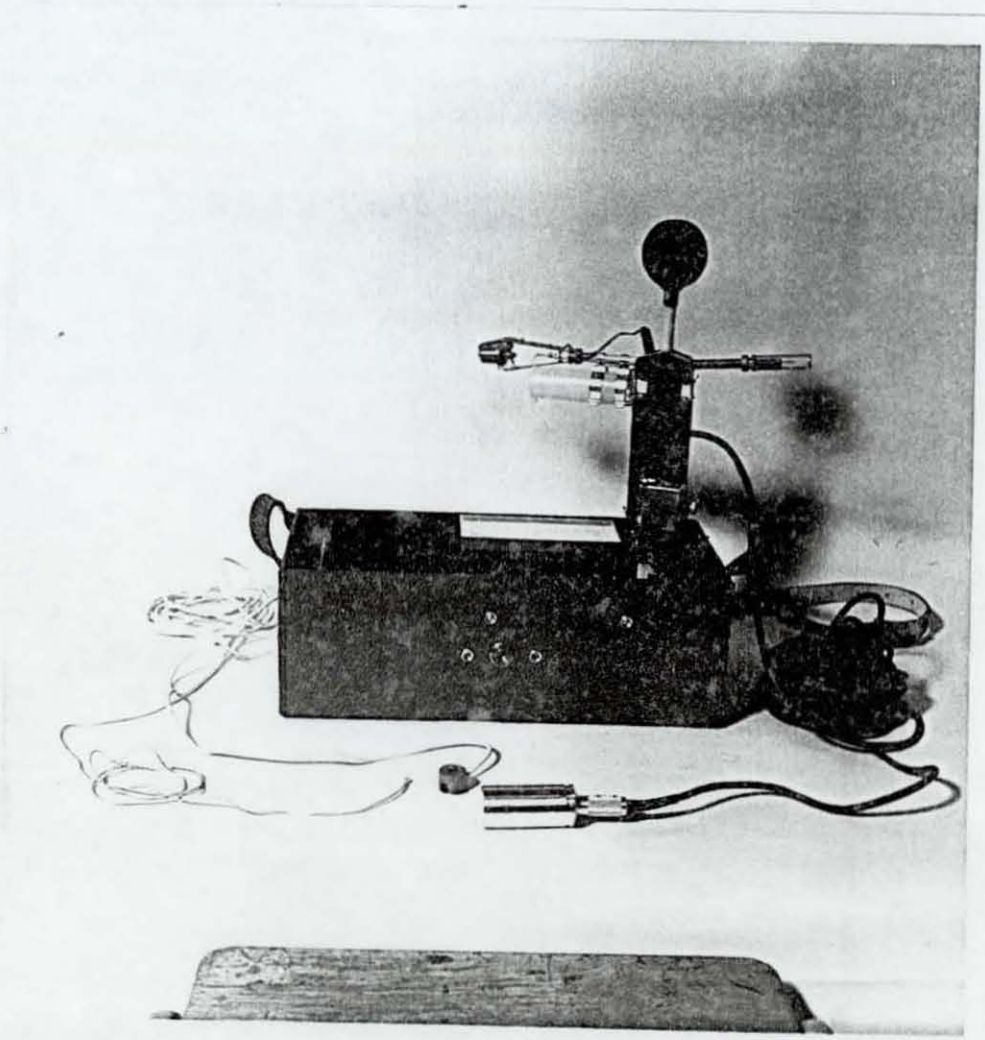


Fig.11 - Min 3 lab, with various probes.

4.7 Light Laboratories Thermometer

Apparatus used to record skin temperatures from subjects is shown in Fig. 12 . The dial scales are marked in divisions of 0.2°C and can be read easily to 0.1°C, estimation to 0.05°C being possible. The black knob on the dial units, on rotation by hand, switch to the thermistor, which is indicated by the number in the vertical rectangle which lights up in the white base. The thermistors and the measurement units into which their leads plug are supplied in matched sets as the light electric thermometer. The thermistor used was calibrated and it showed that thermistor 6 required deduction of 1.9°C over the range of its readings during the experiment. (Burry 1976)

4.8 In addition to the main instruments used in this research the following apparatus was used.

a. Capillary haematocrit tube
b. Special centrifuge for capillary tubes (Fig.13)
c. Haematocrit reader (Fig.13)
d. Microscope
e. Red cell and white cell counting chamber
f. Blood lancet
g. Stethoscope and sphygmomanometer
h. Electro-cardiograph (Fig.14)
i. Pipettes, flasks, beakers, tubes
j. Microburette
k. Scale for weighing persons upto 150 kg. (Herbert and Son)
l. Medical thermometer.

4.9 Sample Collection

Although instrumentation has a major role in terms of accuracy, precision and analysis time, sample collection plays an important

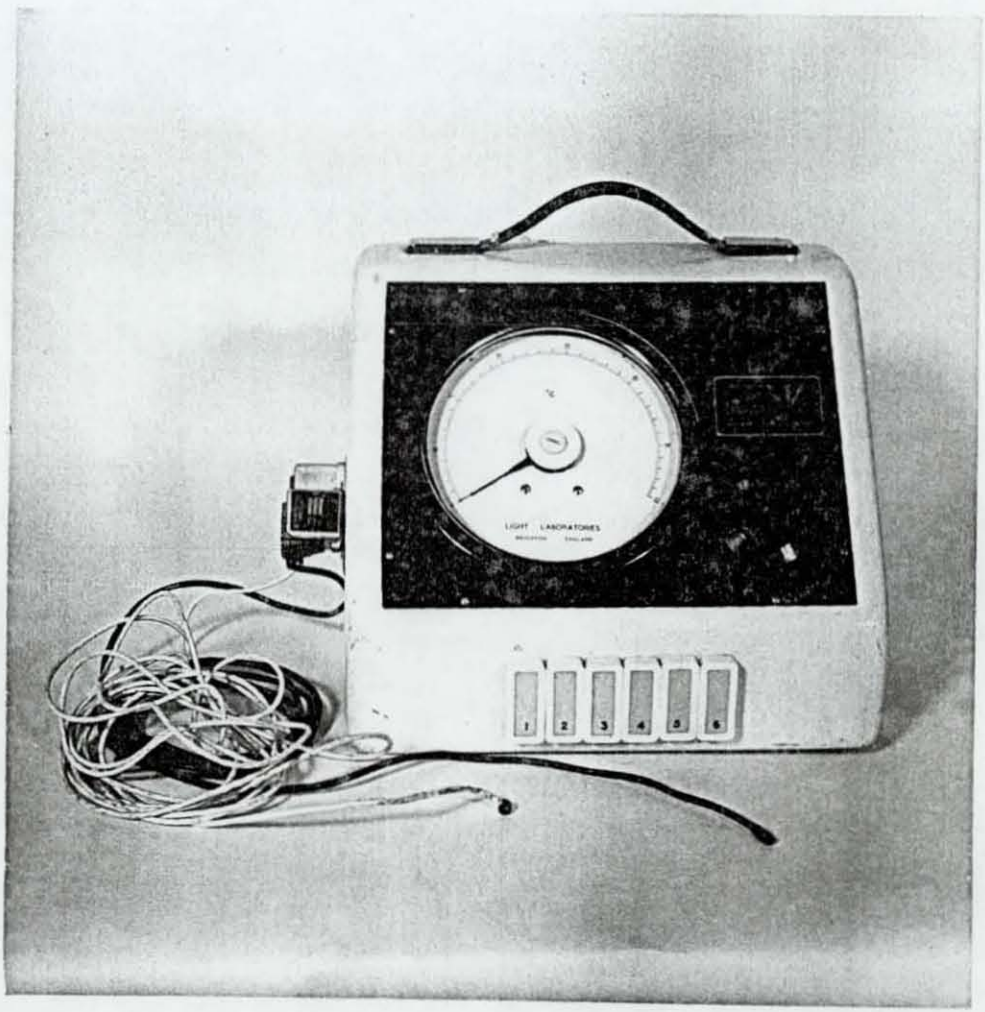


Fig. 12 - Electric thermometer (Light laboratories) with probes.

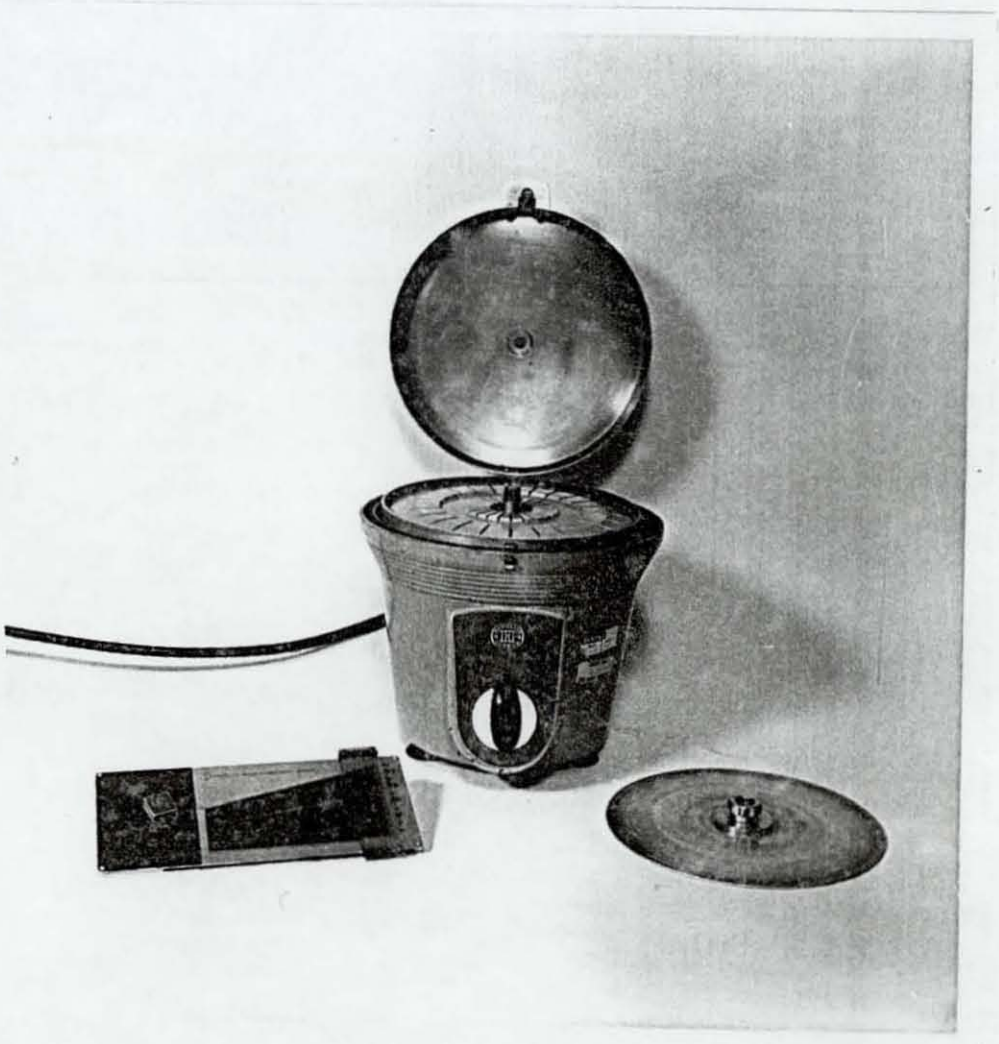


Fig.13 -Haematocrit centrifuge and reader.

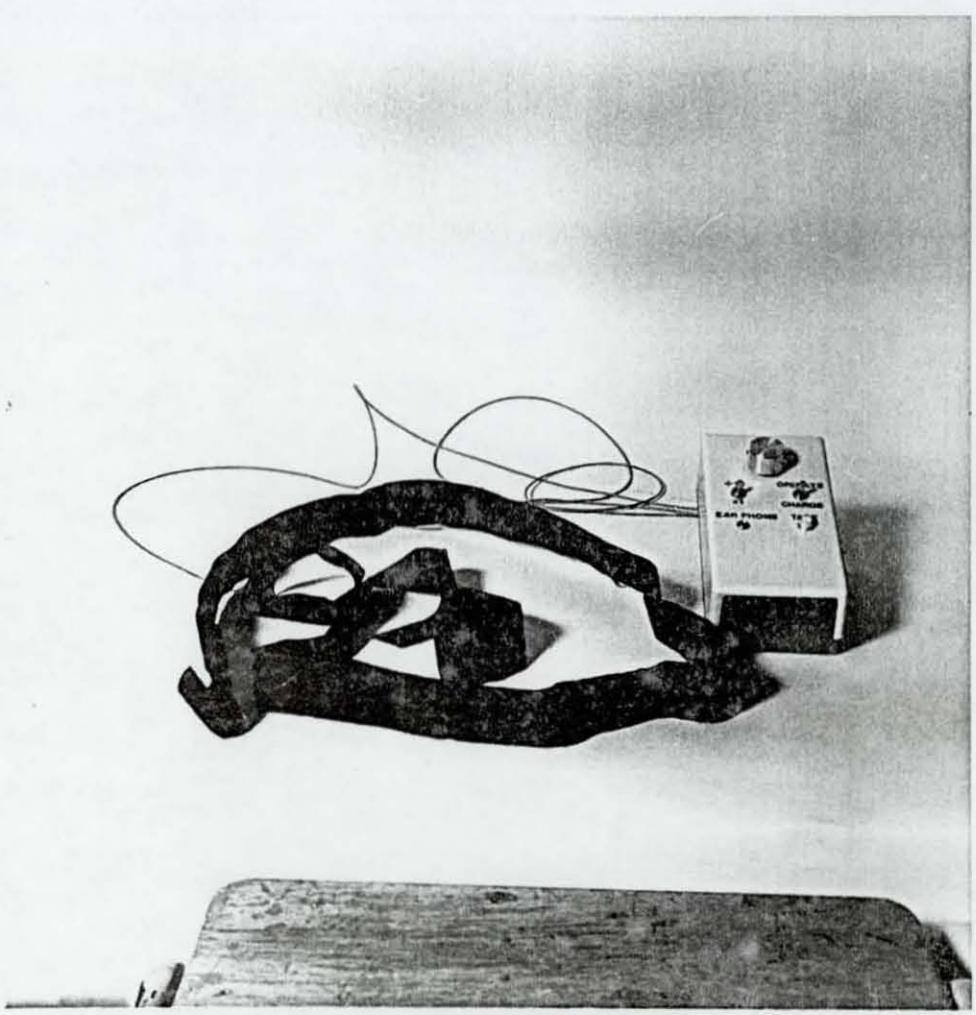


Fig. 14- Heart rate reader (ECG).

role in the final results, which are accurate, if handling the specimen, which is the first step in all clinical biochemical analyses, is correctly carried out.

1. Urine Samples.

Urine samples were collected from all subjects in accordance to the plan of each experiment. The collection of samples was timed because timed specimens are necessary to measure the rate of excretion of a substance. Urine samples were kept at -10°C overnight for analysis the following day. The frozen state was used for keeping the urine samples because microbial growth is completely inhibited at this state. Concentrated HCl was used as a preservative for the urine samples. For the purpose of analysis portions of urine samples were diluted 1/100 and 1/200 for the use of the flame photometer whereas the same sample was diluted 1/10 and 1/20 for the use of the autoanalyzer. The addition of HCl negates the value of the chloride analysi in experiment E.

For methods applied in measuring Na^+, K^+, Cl^-, urea, creatinine see Appendix 10.2.

2. Sweat.

Sweat was collected by attaching a pre-weighed ashless filter paper (Whatman 541) of known area to both subject's sub-scapulas. The area of the sub-scapula to be used was first cleaned with pieces of ashless filter paper moistened with de-ionised water. On removal, they were quickly transferred into a pre-weighed dish and re-weighed. Ten ml of de-ionised water was then added to disolve the paper into a fine pulp. The liquid from the resulting pulp was then filtered through a Gooch crucible and the filtrate was stored.

Blank determinations for sweat, sodium and potassium were done in the same manner as the test-sample. Blank readings were deducted for

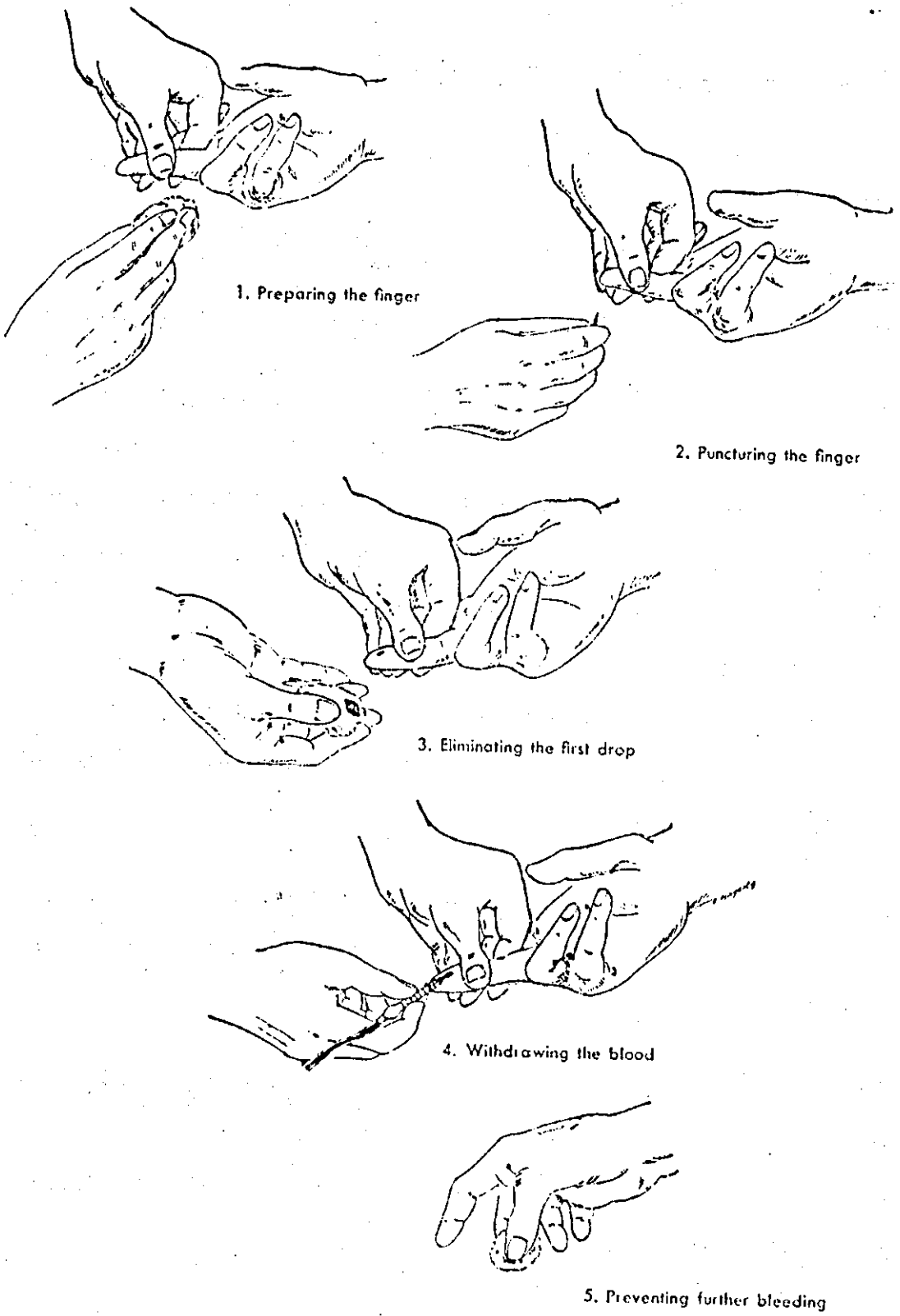


Fig. 15 - Blood collection by finger puncture.

each ion from the sweat values.

For methods of measuring sweat rate and ionic concentration of sweat see Appendix 10.2.

3. Blood Sample.

An extremely old technique for obtaining blood is the puncture wound of the capillaries and the finger puncture is the most used.

The fingertip is cleansed with a sterile gauze pad or sponge, moistened with 70% alcohol, leaving no moisture. The blood will form full rounded drops. By means of a loose wrist motion the finger is punctured with a sterile disposable lancet. The puncture is made by firmly grasping the finger and making a quick deliberate stab to a depth of about 3 mm into the finger. It is better to induce a good puncture rather than make the patient apprehensive by having to do a repeat. A deep puncture is no more painful than a superficial one.

The first drop of blood containing tissue juices and foreign matter, is always wiped off. The diluted and contaminated drop of blood would give unreliable results.

Free-flowing blood should be used for examination, although gentle pressure may be applied if needed to enhance the flow of blood. Never exert heavy pressure, because that may cause the flow of tissue juices in the blood.

After the required amount of blood has been taken, an antiseptic pad, 70% alcohol, is placed on the puncture. The patient may be instructed to apply pressure to the wound until the bleeding has ceased. (See Fig. 15)

For methods and for blood analysis see Appendix 10.2.

4.10 Many measurements in clinical laboratories are facilitated by the use of instruments, some relatively simple, and others quite complicated. Upon the great request for rapid analysis and detection of early clinical abnormalities more and more instruments are being developed and automation in one form or another is increasing quickly. From here the problem emerges that a clinical biochemist should not depend totally on machineswithout complete understanding of the basics on which these machines were built.

Having this in mind when the plan for this research work was designed, it was purposely, made in such a way that all tests should be carried out by the most up to date, sophisticated instruments, when available in addition to the routine manual clinical biochemistry tests. The use of the fundamental manual procedures together with commonsense and practice helps the clinical biochemist to master and understand the functioning of the more highly complicated machines in his field of work and above all solving any problems arising from the use of instruments and the meaningful interpretation of the results.

Accuracy and precision.

Accuracy is the deviation of an estimate from the true value whereas precision is the exactness in the repeated determination of a test. A quality control includes more than tabulating the results from a series of standards and controls. Factors to be taken into consideration include methodology and instrumentation and proficiency

of personnel. Belk and Sunderman (1947); Wooten and King (1953), reported the need of quality control in clinical diagnostic laboratories, due to the results they obtained from surveys in which wide variation in blood analysis was obtained by different laboratories.

In assessing the allowable variation in results, factors such as diet, economic level, geographic location, social life and climate in addition to the methodology and instrumentation applied are of great importance in determining what is generally acceptable as normal values.

To ensure the reliability of the results obtained several points have been considered:

1. Each calculation was checked twice.
2. Each instrument was recalibrated against known standards and its calibration curves rechecked before use with a known value against the originals.
3. Accuracy of the weighing scales in the climatic chamber was tested by a standard mass on each occasion.
   The result showed that the scales used were not influenced by the heat and humidity applied during exposure. The makers confirmed that they would not expect any changes due to the range of conditions used in these experiments.
4. The result obtained by the flame photometer was calibrated periodically by using split

volume test samples through an autoanalyzer. The differences in readings for these samples were found to be insignificant.

5. Preliminary experience in blood pressure measurement was obtained by teaching films at Nottingham Medical School and by practice on human beings where the readings obtained were compared to the readings obtained by two clinically experienced people. However in the absence of automatic sphygmomanometer cuffs and arterial needle pressure gauges no better calibration of blood pressure was possible nor was found to be necessary.
6. Errors in packed cell volumes were reduced by using capillary tube haematocrits and reading with magnifying lens against a black grid of high contrast and good illumination.
7. Errors in blood cell counts were reduced by careful control of dilutant volume on both the white and red cell pipettes. In all cases this was ensured by allowing sufficient for the technique and discarding any sampling in which the volumes appeared to be in doubt or where the capillarity of the pipettes was not sufficiently good to allow easy flow of the blood sample. By practice it was found that consistent readings were obtained when time was taken to repeat a blood sample with a new pipette whenever there

was doubt of the measurements. The counting chamber samples were repeated often enough to give three consistent readings.

8. Urine samples were repeated twice on different aliquots and when the measurements differed a further pair of aliquots were taken. This technique though time consuming gave high consistency in the measurements and whenever possible urine samples were set aside and reassessed next day.

5. RESULTS

5.1 Statistics deal with techniques for collecting, analyzing, and drawing conclusions from data. However a proper statistical interpretation should take into consideration the variability present in all instruments and methods.

In order to obtain a meaningful interpretation of the data obtained, the mean and standard deviation were applied to all of the results obtained. T-test, the correlation coefficient (Computer programme Ƶ 202 Department of Human Sciences), and the Cusum Technique (Woodwood, Rh and Goldsmith, PP), were calculated and used where applicable.

It is worth mentioning that the pre-exposure sample represents the control values of parameters before the subject was exposed to the environmental condition under study.

5.2 Subjective Report.

As a part of the experiment where the subjects were exposed to two environmental conditions hot and cold, some of the subjects selected at random, were asked to express the extent to which they 'felt' the factors mentioned in Tables S_1 and S_2 and the overall impressions are dealt with in the 'discussions'.

5.2.1 HOT

Subject	pre-exposure	During exposure								Post-exposure		
	Fear	Nervousness	Uncomfortable	Claustrophobia	Sleepiness	Ability to concentrate	Headache	Dizziness	Thirst	Headache	Tiredness	Cold
A	++	+	++	0	+	0	+	+	++	+	+	+
B	+	+	++	0	+	0	+	0	++	+	0	+
C	+	+	++	0	+	0	+	0	++	0	0	+
D	+	+	+++	++	+	0	+	+	++	+++	++	+
E	+	+	+	0	+	0	+	0	++	0	+	+
F	+	+	-	0	+	0	+	0	++	0	0	+
G	X	+	++	0	+	0	+	0	++	0	0	+
H	X	+	+	0	+	0	+	0	++	0	+	+
I	+	+	++	0	+	0	+	0	++	+	+	+
J	X	+	+	0	+	0	+	0	++	+	+	+

Table S_1

Key to Table S_1 :

+	mild	0 nil
++	strong	X Indifferent.
+++	very strong	

5.2.2. COLD

	pre-exposure	During exposure							post-exposure	
Subject	Fear	Uncomfortable	Cold hand	Cold feet	Pins and needles	Shivering	Headache	Tiredness	Cold	Headache
A	+	+	++	++	0	+	0	0	+	0
B	+	+	++	++	+	+	0	0	+	0
C	+	+	++	++	0	+	0	0	+	0
D	+	+	++	++	0	++	0	0	+	0
E	+	+	++	++	0	+	0	0	+	0
F	+	+	++	++	+	+	0	0	+	0
G	+	+	++	++	+	+	0	0	+	0
H	+	+	++	++	0	+	0	0	+	0
I	+	+	++	++	0	+	0	0	+	0
J	+	+	++	++	0	+	0	0	+	0

Table S_2

Key to Table S_2: + mild ++ strong 0 nil

5.3 Experiment A. (10° above and 10° below ambient temperature at rest).

5.3.1 Urine, Na^+, K^+, Na^+/K^+ and creatinine values showed an increase during the two different exposures. (Fig. 16) (Tables 3,6). The values obtained for the t-test comparing the results of the two exposures showed a significant difference for Na^+, K^+ and Na^+/K^+ at 5% level ($t \leq 1.9$), whereas creatinine values showed insignificant difference ($t \leq 2.8$).

5.3.2 The mean heart rate (beats/minute) showed at 10°C above ambient temperature, that there was an initial increase followed by a decrease in the level. (Table 1) (Fig. 17). At 10°C below ambient, however, the level went down throughout the experiment (Table 5) (Fig. 17). Statistically there was a significant difference between the values obtained in the two experiments, ($t \leq 1.9$) for the 4 first readings, whereas the last three readings showed no significant difference ($t \leq 4.09$).

5.4 Experiment B

5.4.1	B(i) - at work	I	25° C	67% Rh
		II	30° C	50% Rh
		III	35° C	38% Rh

5.4.1.1 Urine Na^+ and K^+ increased initially but showed little decrease in values towards the end of exposure. (Fig. 18) (Tables 10, 17, 25). Urine Na^+/K^+ increased initially during exposure I and II followed by a decrease, while during exposure III it showed some fluctuation in value. (Fig. 18) (Tables 10,17,25)

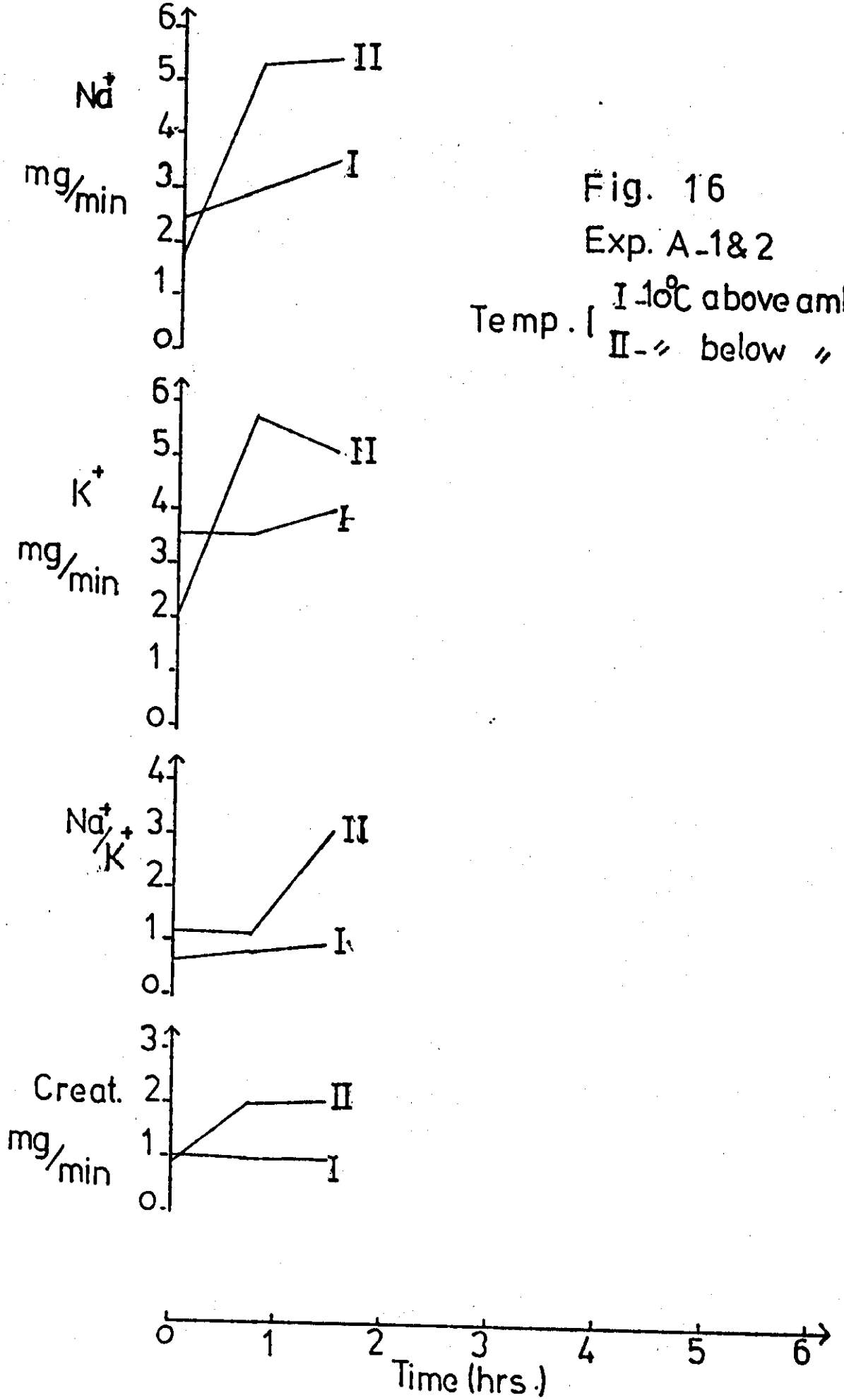


Fig. 16
Exp. A-1&2
Temp. I I-10°C above ambient
II-" below "

Tab. 3 & 6

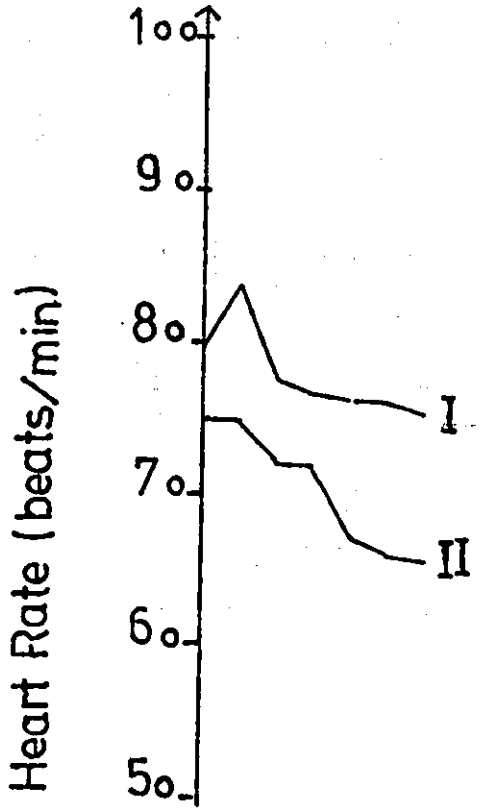
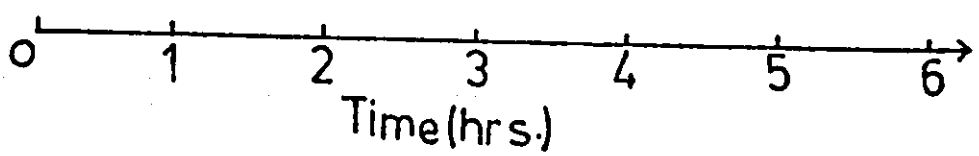


Fig. 1.7
Exp. A-1 & 2
Temp. { I-1°C above ambient
II- " below "



Tab. 2 & 5

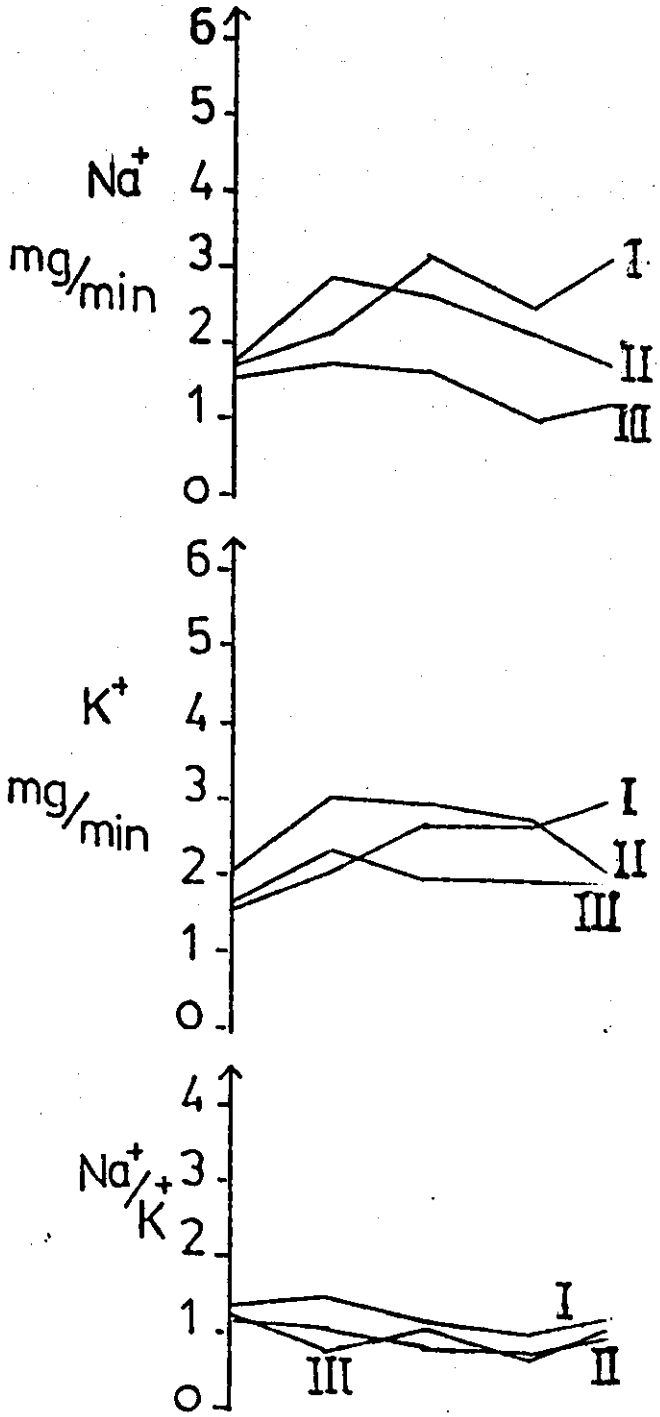


Fig. 18
Exp. B-(i)
I 25°C 67%RH
II 30" 50 "
III 35 " 38 "

Tab. 10,17 & 25

correlation coefficient r showed relationship between Na^+ and K^+ values at the first 3 stages of experiment I, where $r = 0.802, 0.728, 0.648$. During the last two stages of the experiment $r \leq 0.39$.

During exposure II value of r for the correlation between Na^+ and K^+ was as follows:

$r = 0.60, 0.57, 0.72$ and 0.61 while r value for the last stage of the experiment was = 0.23.

During exposure III $r = 0.71, 0.52, 0.54$ at the stages of pre-exposure, exposure and post exposure for Na^+ and K^+ respectively, while r for the two first samples during exposure was equal to 0.32, and 0.21.

5.4.1.2 Chloride values followed the same trend in increasing during the first 80 minutes of the exposure and decreasing thereafter. (Tables 18,26).

5.4.1.3 Heart rates for subjects under experiment part I decreased throughout the exposure, whereas in part II the heart rates increased for the first 40 minutes and decreased thereafter during the exposure (Fig. 19) (Tables 9, 16, 24).

5.4.1.4 Eardrum temperature increased initially during experiments I and II and decreased in experiment III. Forehead and chest temperature decreased during the three exposures. (Fig. 19) (Tables 9, 16, 24).

5.4.1.5 Sweat Na^+ and K^+ decreased noticeably during the second half of the exposures. Sweat rate remained constant

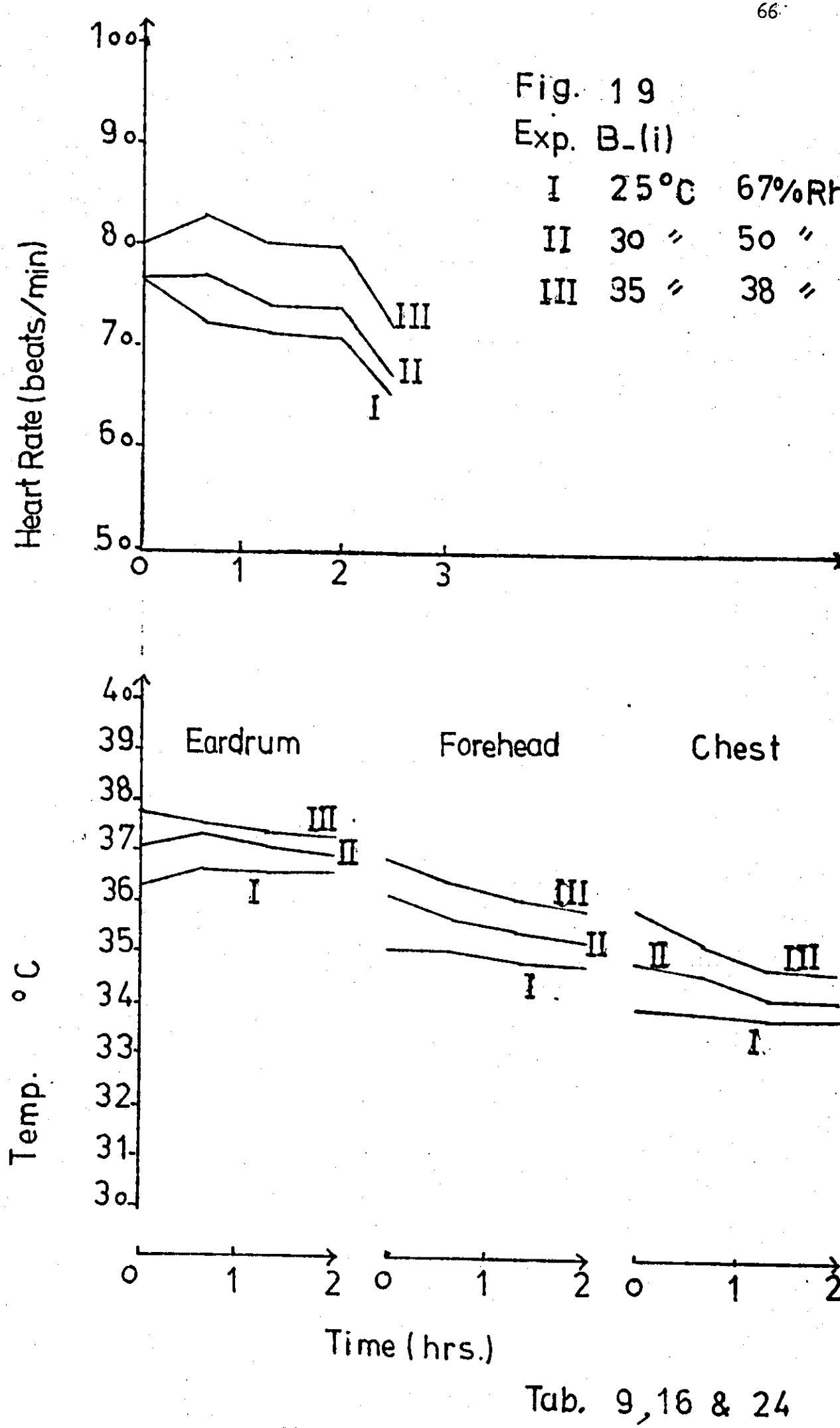


Fig. 19
Exp. B-(i)
I 25°C 67%RH
II 30 " 50 "
III 35 " 38 "
Heart Rate (beats/min)
100
90
80
70
60
50
0
1
2
3
III
II
I
Temp. °C
40
39
38
37
36
35
34
33
32
31
30
Eardrum
Forehead
Chest
III
II
I
0
1
2
Time (hrs.)

Tab. 9, 16 & 24

during exposure I (Plot I Fig. 25) while it decreased during exposures II, II (Figs. 24, 25) (Tables 12, 19, 27). Na^+/K^+ ratio was increased during the three exposures (Fig. 25) (Tables 12, 19, 27). Comparing exposure I to II statistically, sweat Na^+ and K^+ were significantly different at 5% level ($t \leq 2.3$). Sweat rate showed a significant difference during the first hour of exposure ($t \leq 2.35$).

Sweat Na^+ and K^+ values of exposures I and III indicated a significant difference between the two conditions (at 5% level values of $t \leq 2.2$). There is a significant difference ($t \leq 1.5$) in sweat Na^+ and K^+ and sweat rate between exposure II and III.

5.4.2	Experiment B (ii)	I	25°C	80% Rh
	(at rest)	II	25°C	38% Rh.

5.4.2.1 Urine Na^+, K^+, Na^+/K^+ ratio and creatinine increased in the first forty minutes of exposure I (Fig. 20). Na^+ decreased after 40 minutes while K^+ increased, and creatinine remained more or less constant (Fig. 20) (Tables 33, 35, 39, 41).

Chloride showed the same trend as Na^+ in increasing during the first 40 minutes followed by a decrease thereafter. (Tables 34, 40). Statistically there is a significant difference among all 5 variables between the two exposures (at 5% level $t \leq 1.9$).

5.4.2.2 Heart rate decreased throughout the experiment in both exposures. (Tables 32, 38) (Fig. 21). T-test, where $t \leq 1.7$, indicates a significant difference in heart rate between the two exposures.

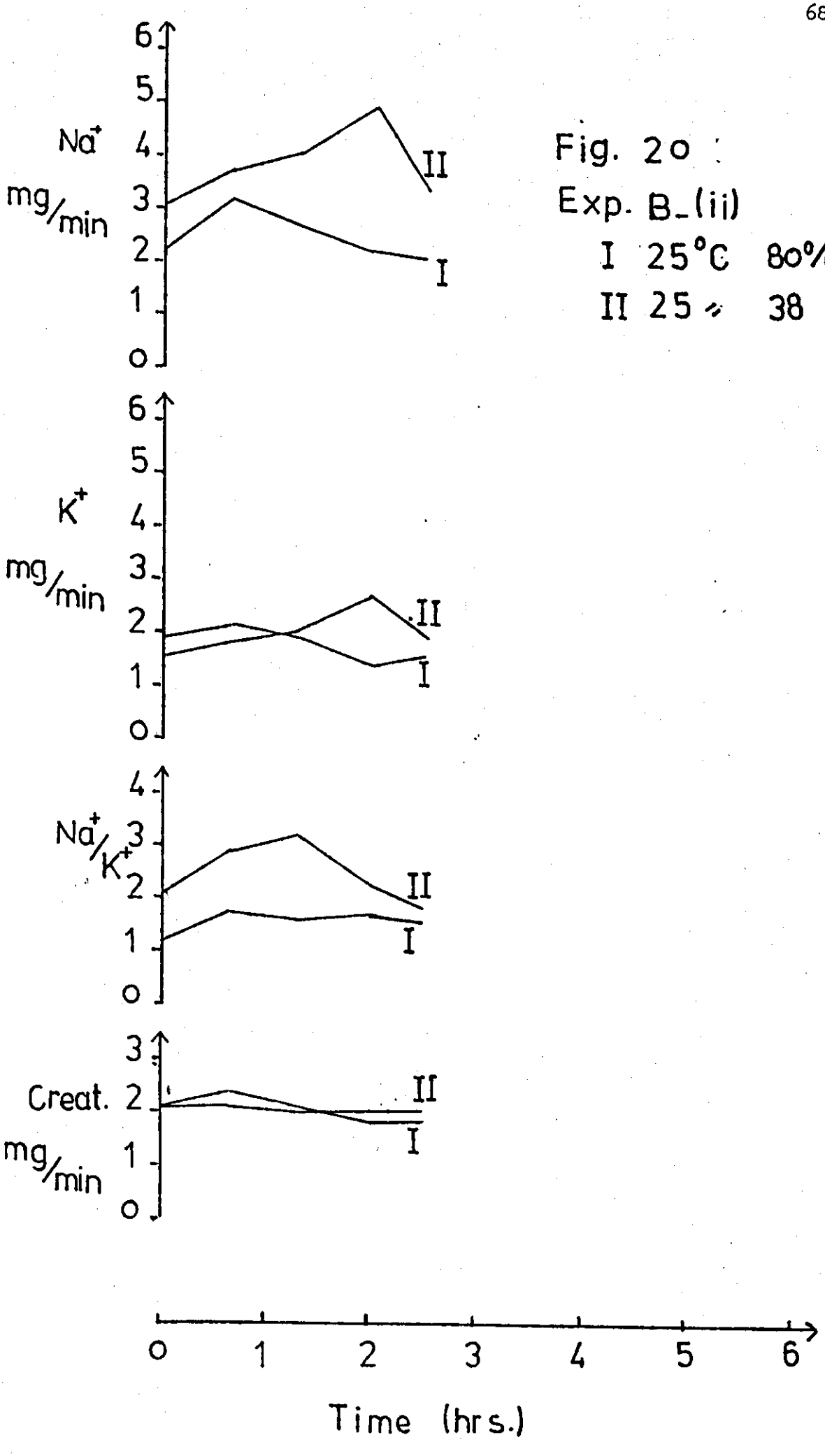


Fig. 20 :
Exp. B_(ii)
I 25°C 80%Rh
II 25 " 38 "

Tab. 33 & 39

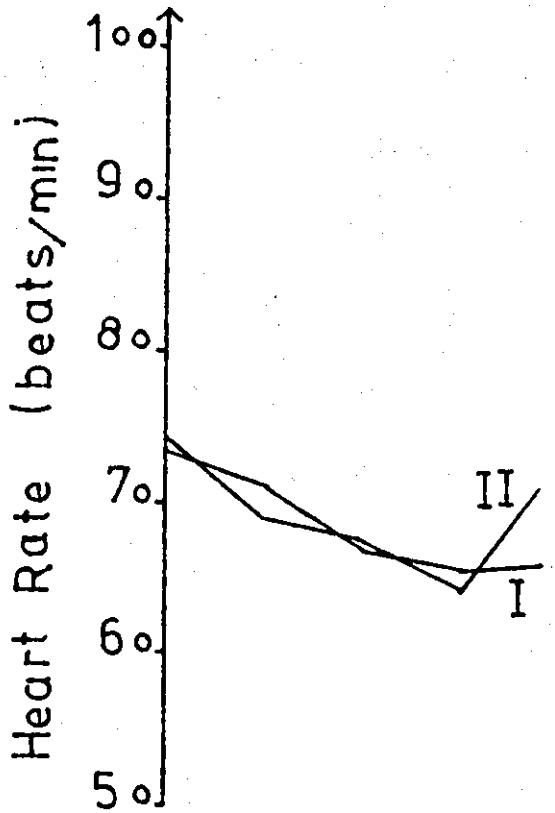


Fig. 21
Exp. B (ii)
I 25°C 80%Rh
II 25 = 38 =

Tab. 32 & 38

5.4.2.3 Sweat rate and Na^+ and K^+ in sweat and Na^+/K^+ values were higher during the humid conditions than those of the dry conditions. (Tables 36, 42). The difference was statistically significant at 5% level ($t \leq 1.84$).

5.4.3 Experiment B(iii) (at rest) I 30°C 50% Rh
II 35°C 38% Rh

5.4.3.1 During exposure I Na^+ and Na^+/K^+ values increased initially while K^+ value decreased and creatinine value showed little variability (Table 46) (Fig. 22). During exposure II Na^+, K^+, and Na^+/K^+ increased initially while creatinine remained fairly constant. (Tables 52, 53) (Fig. 22). Chloride concentration showed little variability during either exposures (Tables 47,52). Statistically there was a significant difference at 5% level ($t \leq 1.89$), between the two conditions.

5.4.3.2 Results of part I and II showed an increase in heart rate about 80 minutes after the beginning of exposure followed by a decrease in the values thereafter (Fig. 23) (Tables 45,51).

5.4.3.3 Na^+ and K^+ in sweat and sweat rate decreased in both conditions. Na^+/K^+ value remained fairly constant during condition I but increased during condition II (Figs. 24,25) (Tables 49, 54). The values obtained during the two exposures were significantly different ($t \leq 1.80$).

5.5 Experiment -C- (at rest) 40°C, 25% Rh.

Heart rate increased 45 minutes after the beginning of the exposure followed by a decrease, (Table 57) (Fig. 26). Packed cells volume showed a little increase by the end of the exposure (Table 57).

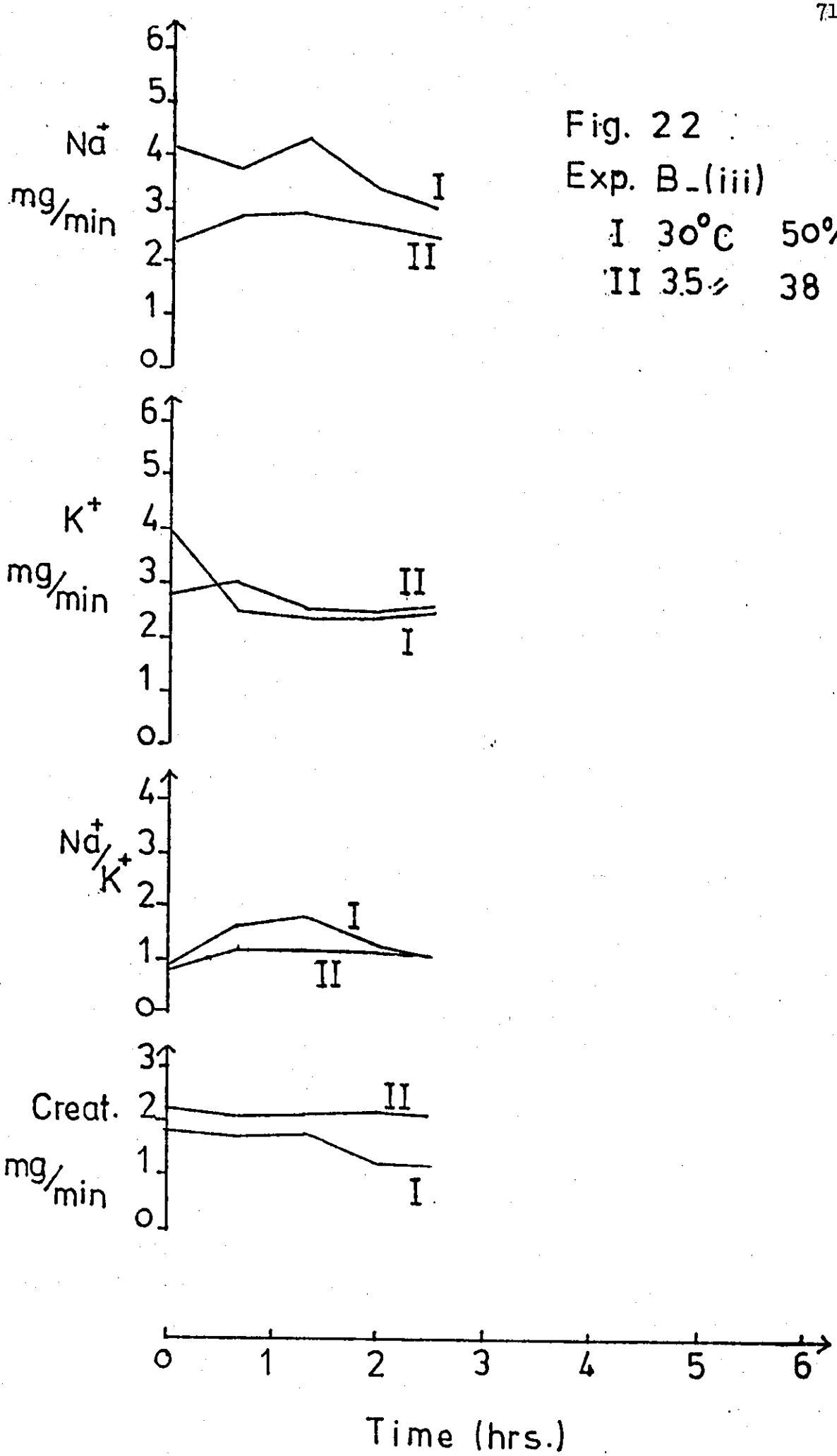


Fig. 22

Exp. B_(iii)

I 30°C 50%Rh

II 35 " 38 "

Tab. 46, 48, 52 & 53

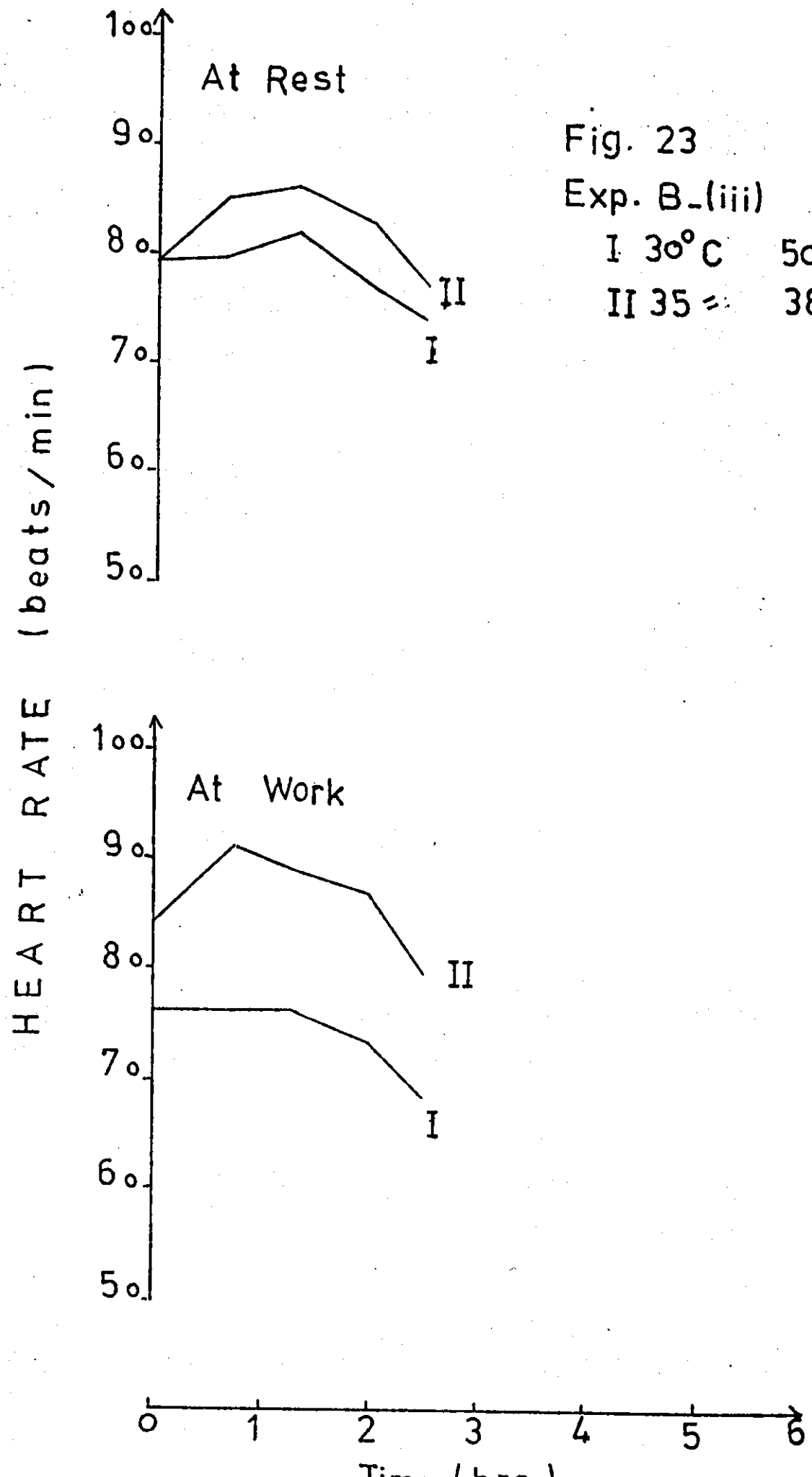


Fig. 23
Exp. B-(iii)
I 30°C 50%Rh
II 35 " 38 "

Tab. 21, 24, 45 & 51

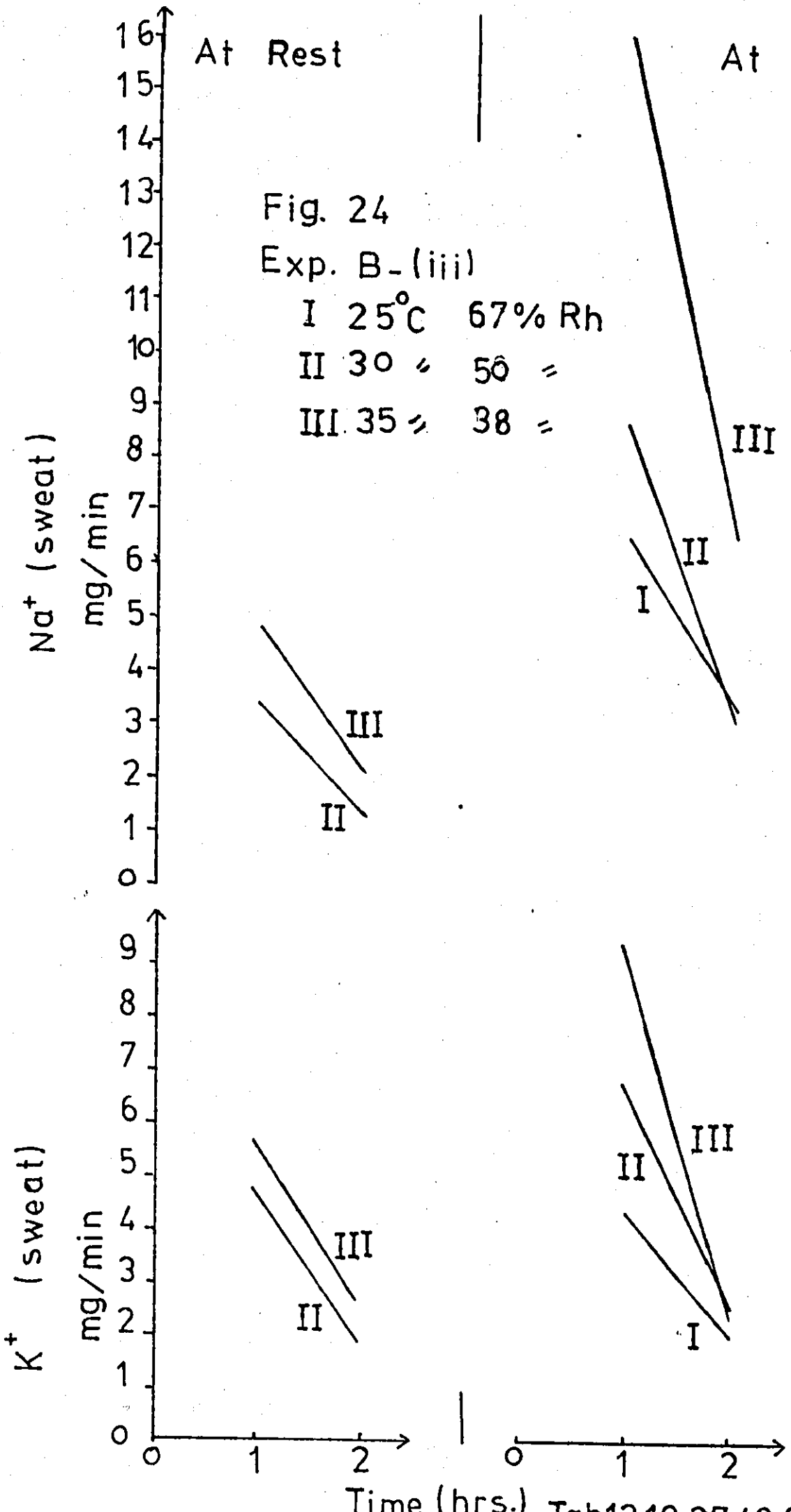
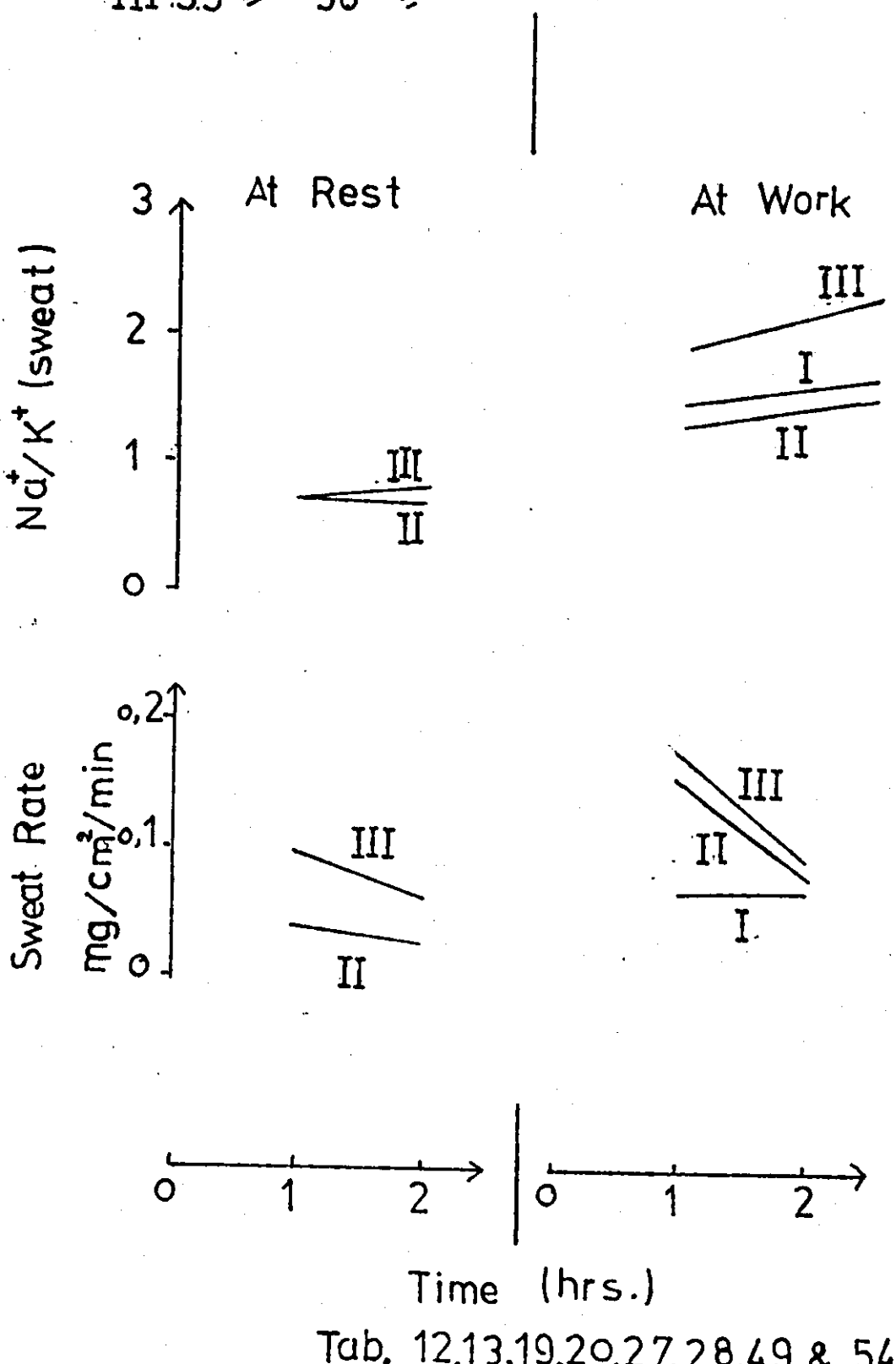

At Rest
At Work
Fig. 24
Exp. B-(iii)
I 25°C 67% Rh
II 30 " 50 "
III 35 " 38 "
Na+ (sweat) mg/min
K+ (sweat) mg/min
Time (hrs.)
I
II
III

Fig. 25
Exp. B_ (iii)
I 25°C 67% Rh
II 30 " 50 "
III 35 " 38 "



Tab. 12,13,19,20,27,28,49 & 54

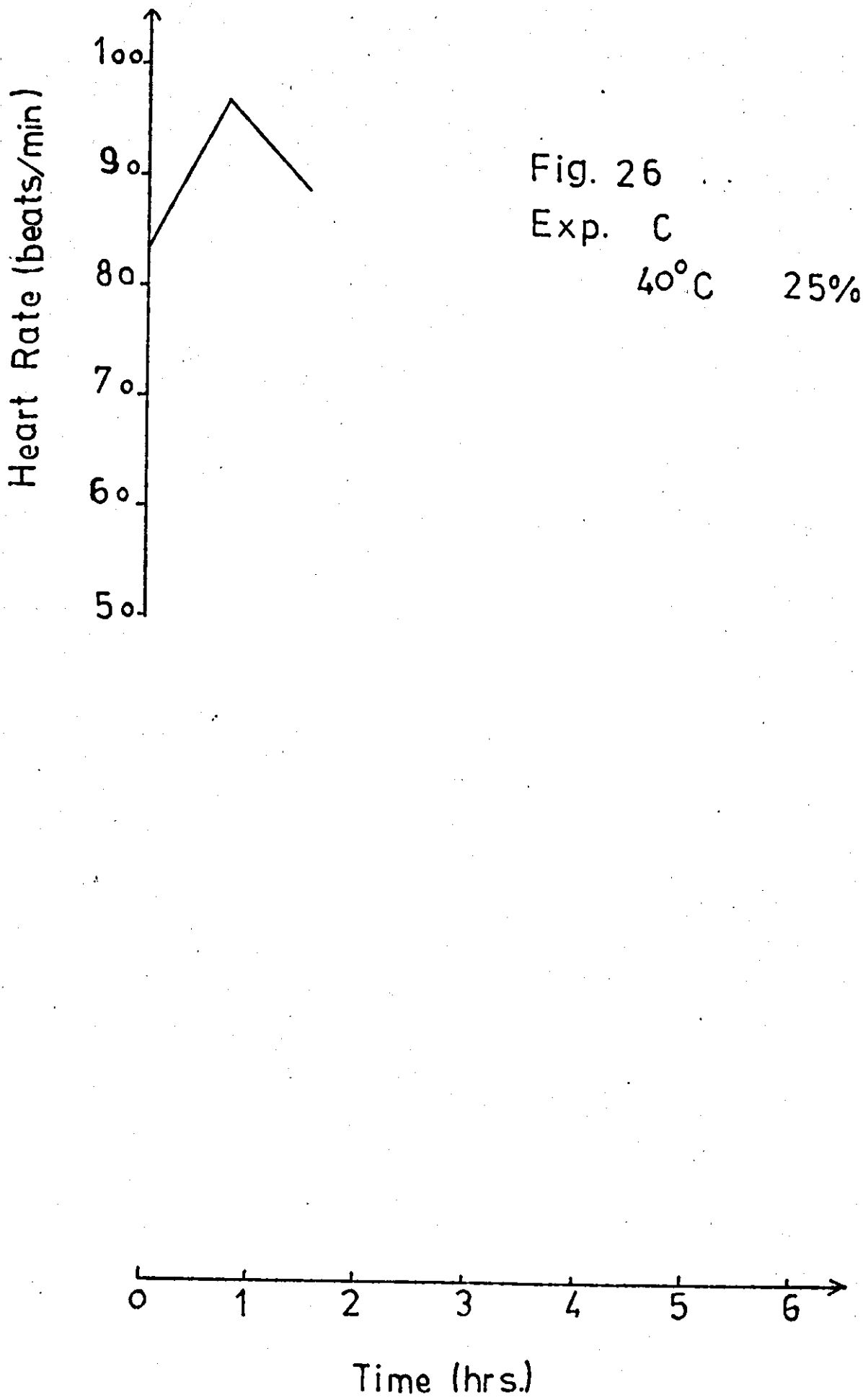


Fig. 26
Exp. C
40°C 25%Rh

Tab. 57

5.6 Experiment D. (at rest)

5.6.1	D(i)	I	40°C	25% Rh
		II	10°C	50% Rh

5.6.1.1 Urine Na^+, K^+ and Na^+/K^+ showed an increase by the end of exposure. (Fig. 27) (Tables 61,66). Creatinine (Fig. 27) and creatinine/Kg(bodyweight) were fairly constant in both parts (Tables 62, 67). Urea and chloride followed the same pattern in increasing during exposure (Tables 62, 67 and Tables 61, 66 respectively). Correlation coefficient r in experiment I indicates that there is a correlation between Na^+ and K^+ and Na^+ and Cl^- and K^+ and Cl^-.

Exposure I r = to	Stage 1	Stage 2	Stage 3
Na^+-K^+	0.86	-	-
Na^+-Cl^-	0.94	0.81	0.80
K^+-Cl^-	0.893	0.59	-
Exposure II			
	0.64	-	-
	0.97	0.92	0.57
	0.77	-	0.68

t value $\leqslant$ 1.34 indicates that there is a significant difference in values of creatinine between exposure I and II at 5% level. There is a significant difference at 5% level in K^+ and Na^+/K^+ during exposure t $\leqslant$ 2.20 at 5% level.

5.6.1.2 Minute urine volume showed little increase during exposure I and a noticeable increase in exposure II (Fig. 28) (Tables 60,65).

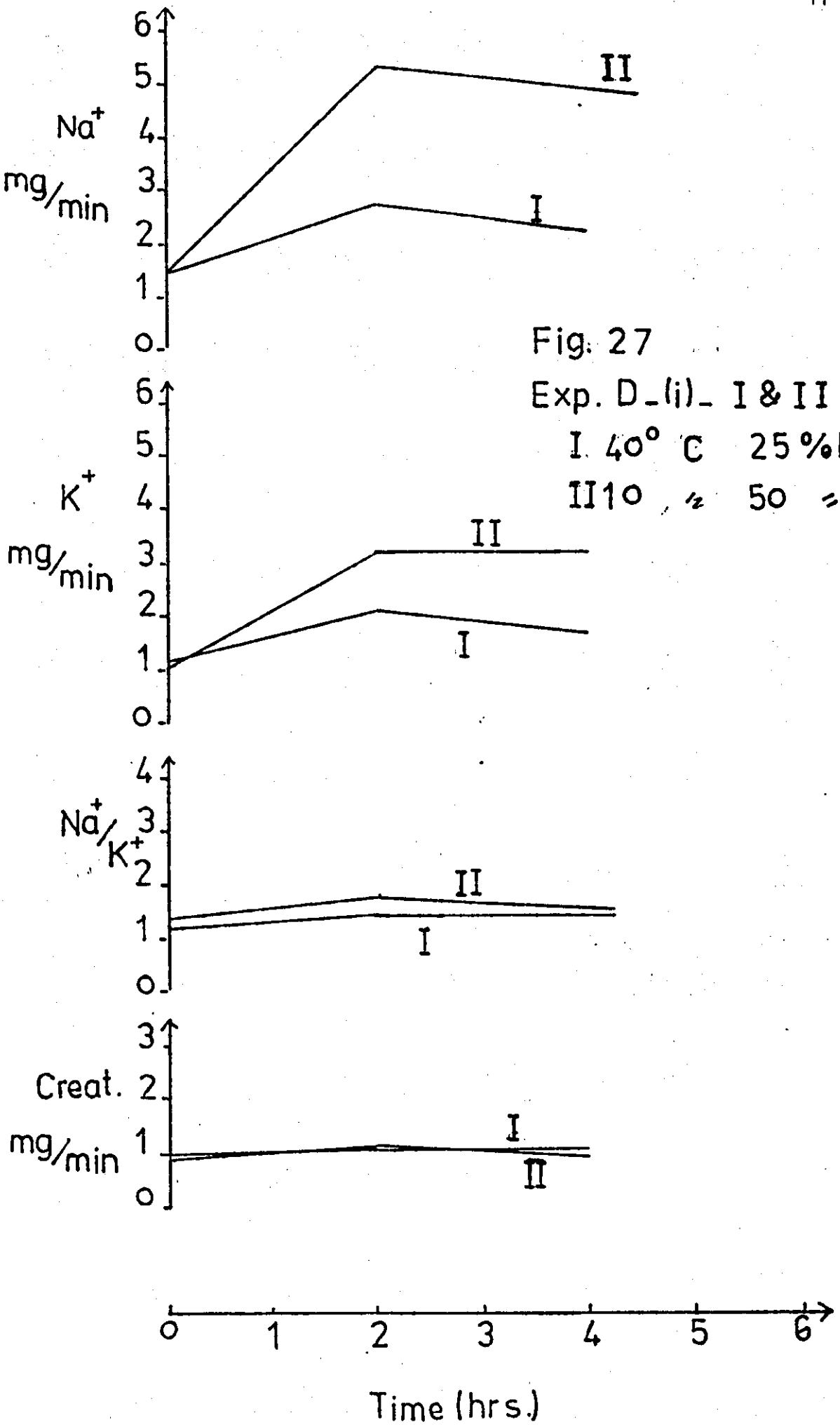


Fig. 27
Exp. D_(i)_ I & II
I 40° C 25 %Rh
II 10 " " 50 "

Tab. 61, 62, 66 & 67

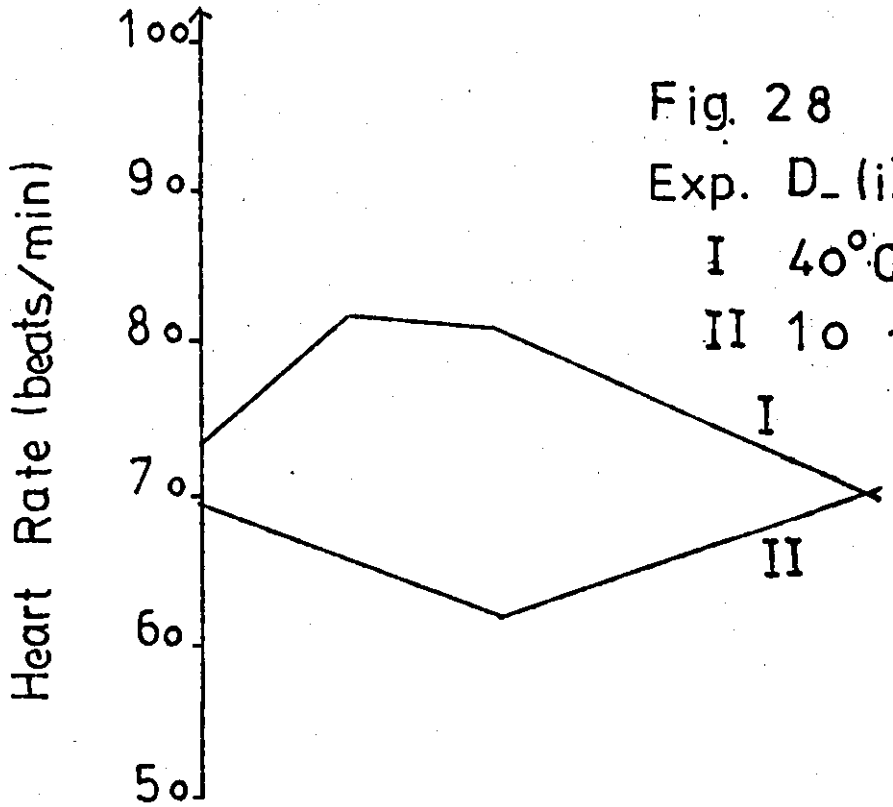
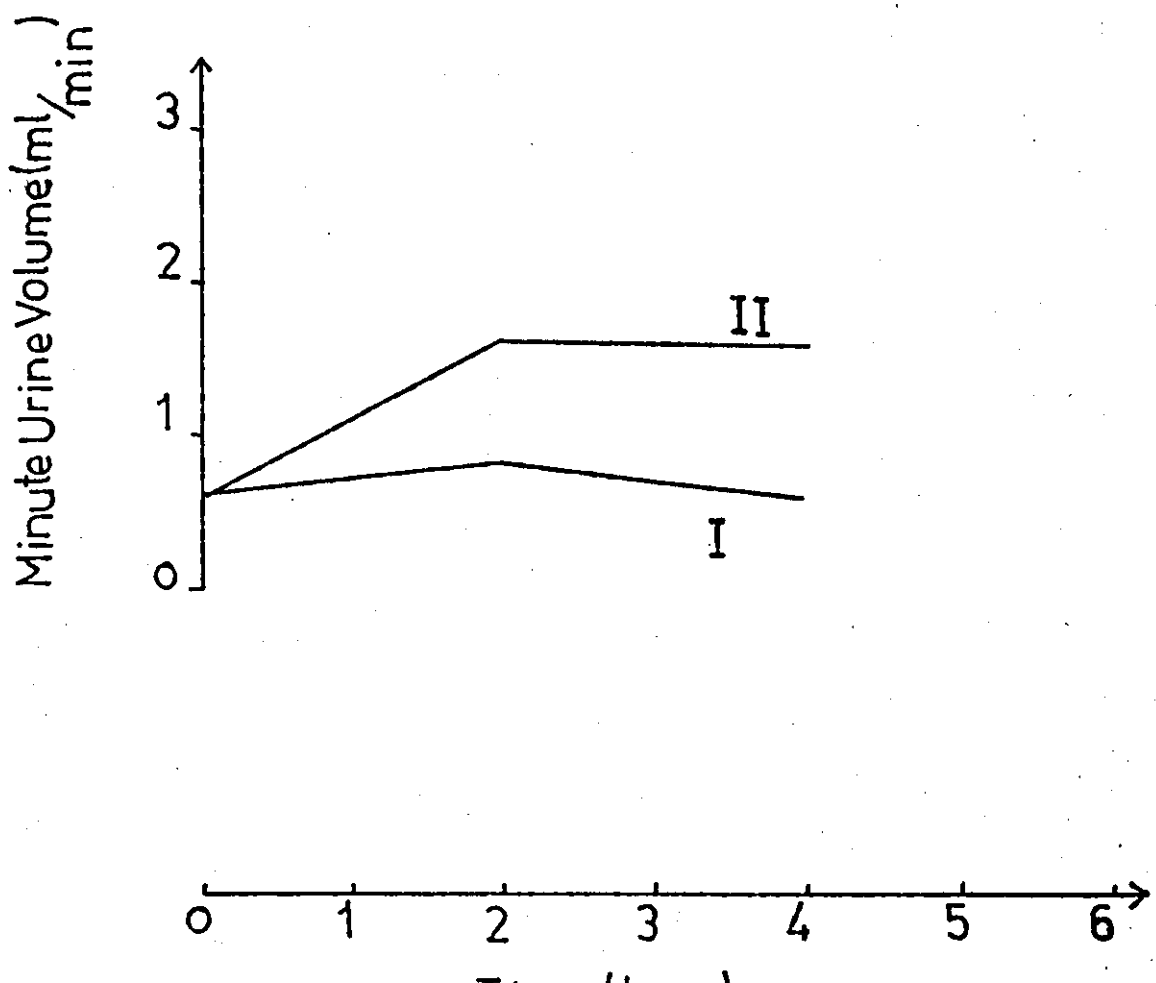


Fig. 28
Exp. D_(i)_I & II
I 40°C 25%Rh
II 10 " 50 "



Tab. 60 & 65

5.6.1.3 Heart rate increased noticeably in exposure I (Fig. 28) followed by a decrease at the end of the experiment. (Table 60)

. . . In part II heart rate decreased throughout the experiment. (Table 65) (Fig. 28).

5.6.2	D(ii)	I	40°C	25% Rh
		II	10°C	50% Rh

5.6.2.1 Urine sodium decreased during exposure I while K^+ and Na^+/K^+ increased and creatinine remained fairly constant (Fig. 29) (Table 72). Chloride values increased initially followed by a decrease at mid-exposure. (Table 42). Urea values remained fairly constant (Table 71). Creatinine/Kg (body weight) remained constant (Table 73).

For exposure I

Stage one r =	Na^+-K^+; r = 0.87	Na^+-Cl^-; r =	K^+-Cl^-
Stage two r =	- ;	-	;r = 0.57 "
Stage three r =	- ; r = 0.65 "	;	-
Stage four r =	- ; r = 0.79 "	;	
Stage five r= 0.92 "	; r = 0.97 "	; r= 0.95	

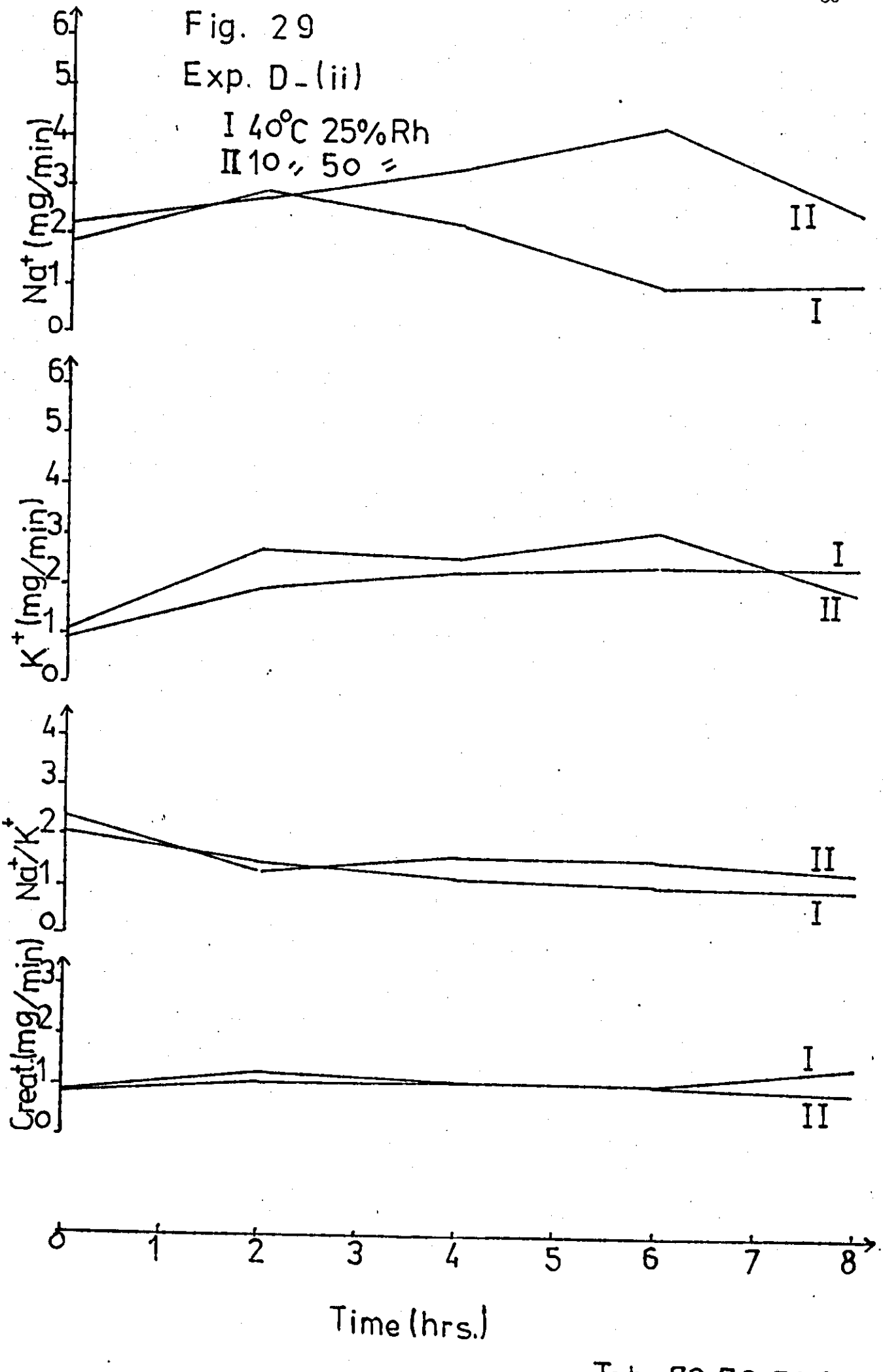
Urine Na^+, K^+ and Na^+/K^+ increased in value in part II during the exposure (Fig. 31) (Table 79). Creatinine values were fairly constant (Fig. 29) (Table 80). Urea and Chloride values increased during exposure (Tables 78, 79). Creatinine/Kg (body weight) was fairly constant (Table 80). The values of r

Fig. 29

Exp. D-(ii)

I 40°C 25%Rh

II 10 " 50 "



Tab. 72, 73, 79 & 80

(correlation coefficient)for experiment II are as follows:

Stage one	r = 0.86 Na^+-K^+;	r = 0.94 Na^+-Cl^-;	r = 0.76 K^+-Cl^-
Stage two	r = 0.70 " ;	r = 0.95 " ;	r = 0.75 "
Stage three	r = 0.57 " ;	r = 0.80 " ;	r = 0.61 "
Stage four	- ;	r = 0.61 " ;	-
Stage five	r = 0.79 " ;	r = 0.95 " ;	r = 0.85 "

There was a significant difference in Na^+, K^+, Na^+/K^+ and creatinine between the two exposures at 5% level where $t \leq 2.2$.

5.6.2.2 Minute urine volume showed a decrease toward the end of exposure I while it increased during exposure II. (Fig. 30) (Table 71, 78).

5.6.2.3 Heart rate increased 60 minutes after the beginning of exposure I followed by a decrease thereafter. In part II, however, there was a continuous decrease in heart rate values. (Fig. 30) (Tables 70, 77).

5.6.2.4 Blood analysis in part I showed fairly constant haemoglobin values, a decrease in P.C.V., a decrease in red blood count, and an increase in white blood count. (Table 74).

In part II, blood analysis showed a little increase in haemoglobin, an increase in P.C.V., an increase in red blood cell count and an increase in white blood count. (Table 81).

5.6.3	D(iii)	I	40°C	25% Rh
		II	10°C	50% Rh.

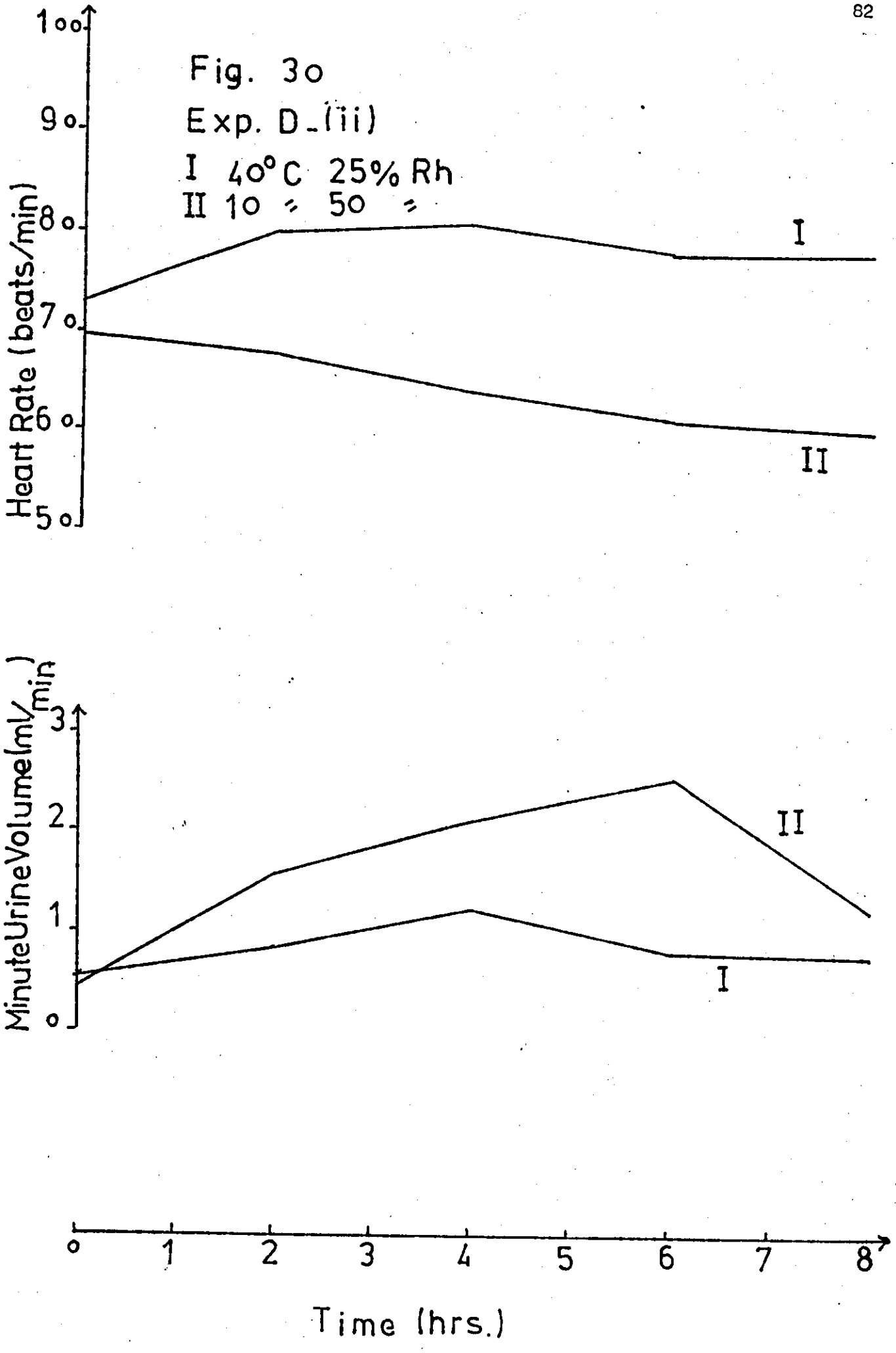
5.6.3.1 Urine Na^+, K^+ and Na^+/K^+ decreased during exposure I, while creatinine remained constant. (Fig. 31) (Tables 87,88).

Fig. 30

Exp. D-(ii)

I 40°C 25% Rh

II 10 " 50 "



Tab. 70, 71, 77 & 78

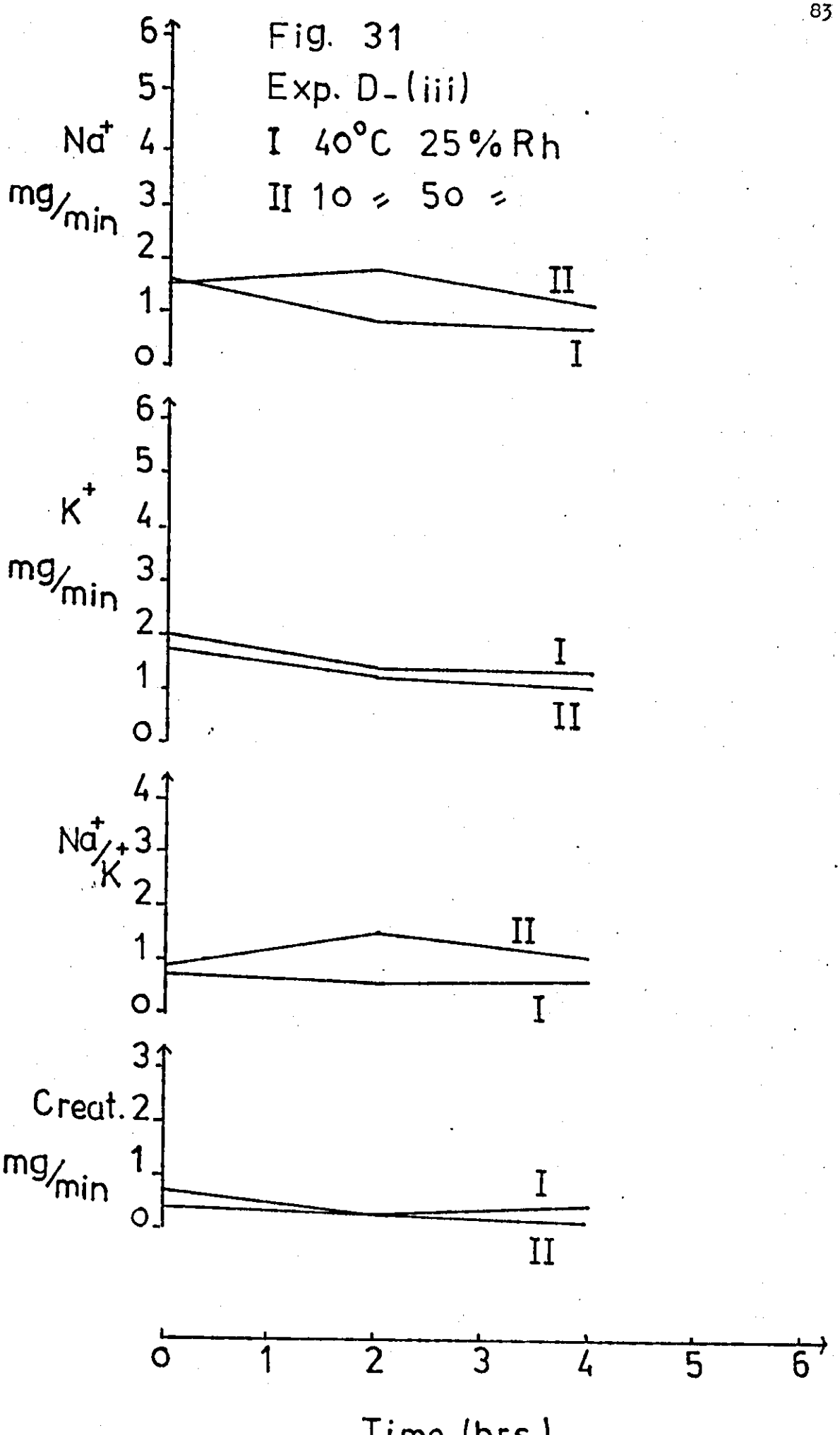


Fig. 31
Exp. D-(iii)
I 40°C 25% Rh
II 10 " 50 "
Na+ mg/min
K+ mg/min
Na+/K+
Creat. mg/min
II
I
Time (hrs.)

Tab. 87 & 88

Urea and creatinine/body weight decreased in value during exposure I (Table 88). r for Na^+-K^+ at stage three of experiment I = - 0.619.

During exposure II urine Na^+ and Na^+/K^+ increased while K^+ and creatinine decreased. (Fig. 31) (Tables 87,88). Urea and creatinine/Kg bodyweight)decreased in value during exposure II (Table 88). Correlation coefficient r for exposure II is equal to -0.60 for Na^+-K^+ at stage one of the experiment; r = -0.59 at stage two of the experiment.

Significant difference in Na^+, K^+, $Na^+/K+$ and creatinine values indicated by the value of t obtained $t \leq 2.0$ at 5% level.

5.6.3.2 Minute urine volume was constant during exposure I (Fig. 32) (Table 86), while it increased during exposure II (Fig. 32) (Table 86).

5.6.3.3 Heart rate increased during experiment I and decreased during experiment II. (Fig. 32) (Table 85).

There was a significant difference in heart rate between the two exposures indicated by value of $t \leq 2.3$ at 5% level.

5.7 Experiment E (at rest) 40°C 25% Rh
24 hours exposure.

5.7.1 Urine Na^+ and creatinine decreased in value for the first 8 hours of exposure (Fig. 33), while K^+ continued to decrease in value and Na^+/K^+ continued to increase for the first 18 hours and then decreased after. (Fig. 33) (Tables 100, 101). Addition of HCl negates the values obtained for chloride which

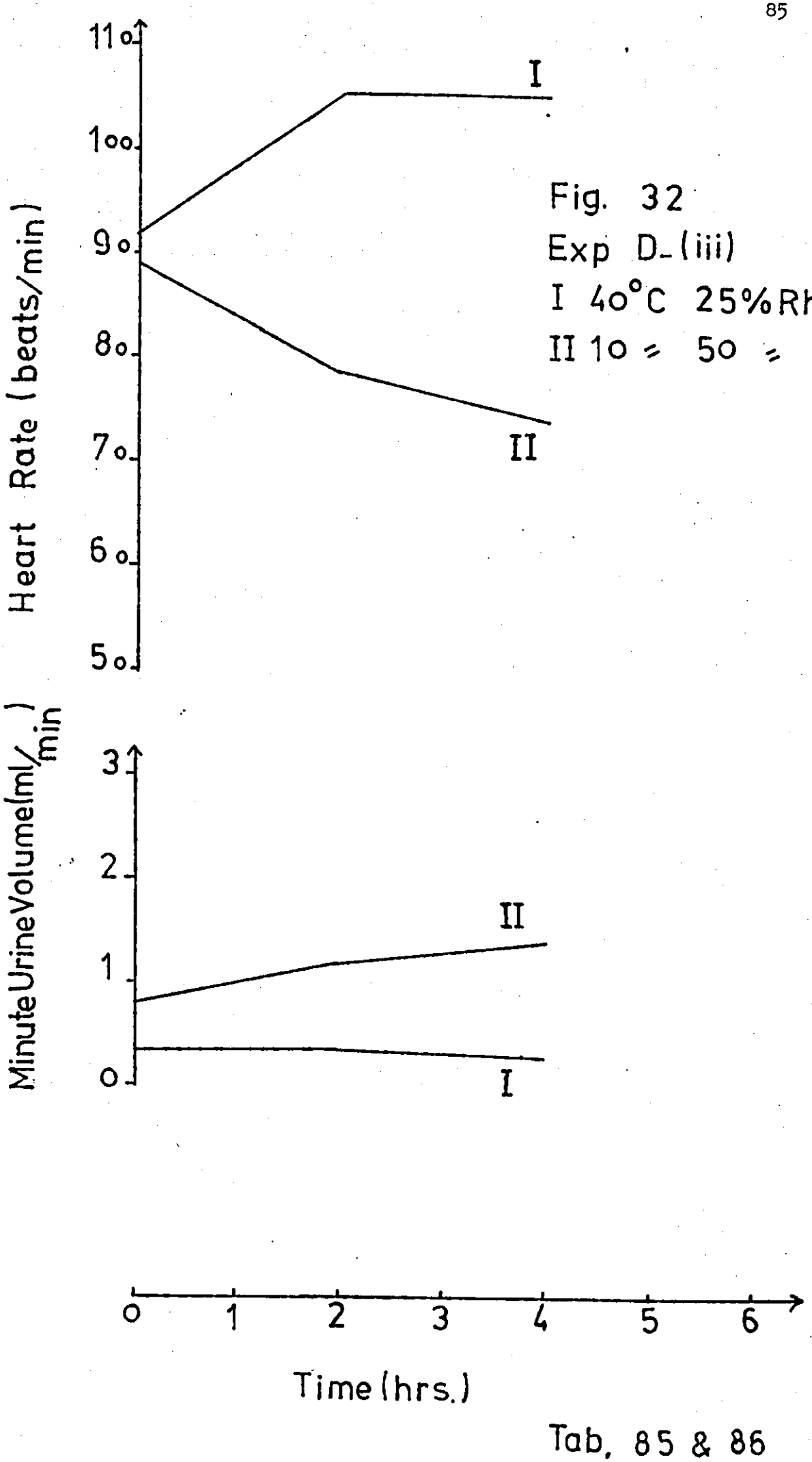


Fig. 32
Exp D-(iii)
I 40°C 25% Rh
II 10 " 50 "

Tab, 85 & 86

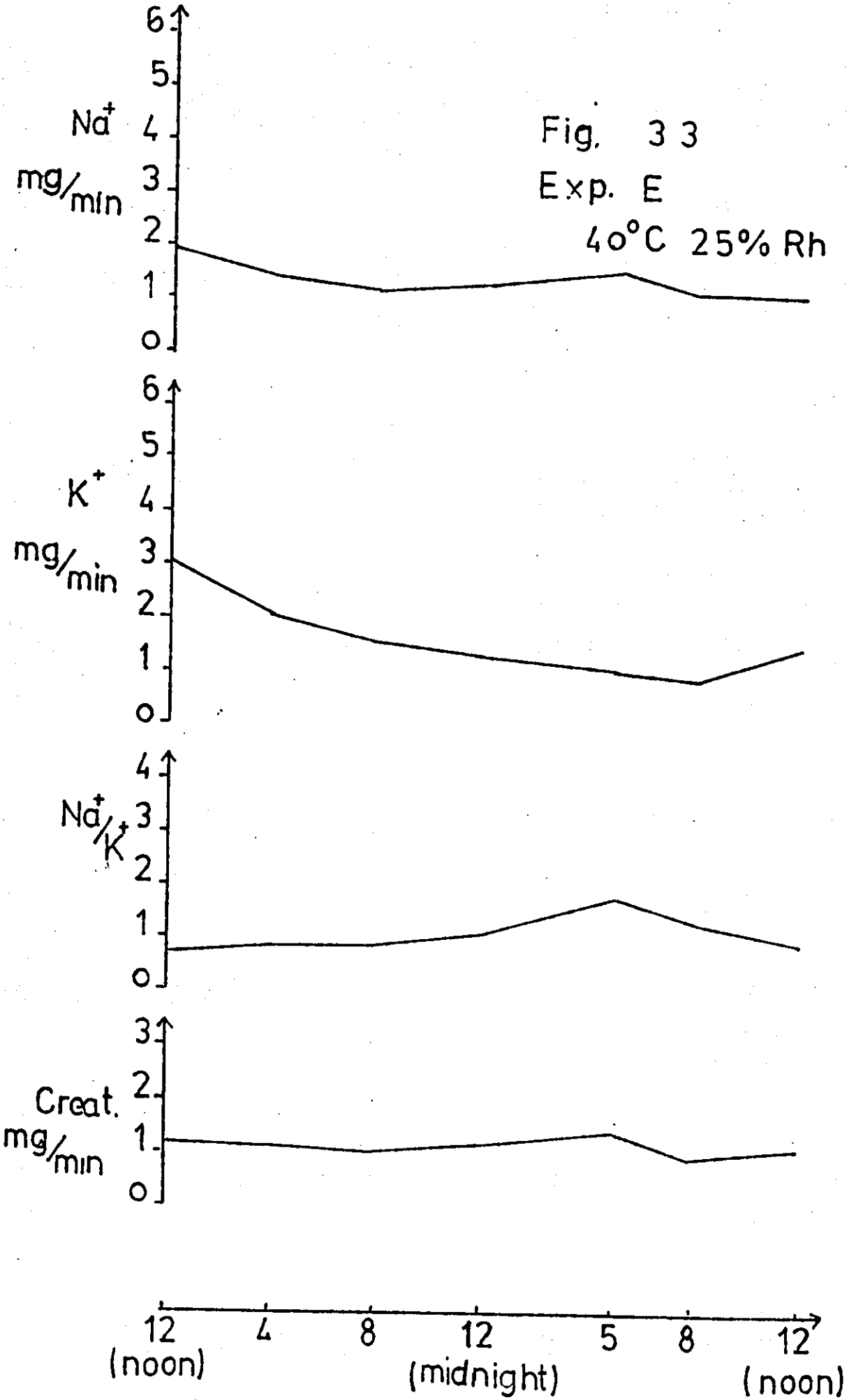


Fig. 33
Exp. E
40°C 25% Rh

Tab. 100&103

initially decreased, but showed an increase towards the end of the exposure (Table 101). Urea values were fluctuating during the exposure (Table 102), while creatinine/Kg (body weight) showed a decrease with a narrow range of fluctuation during the exposure . (Table 103).

Correlation coefficient r shows the following values for r:

	Time						
	12	4	8	12	5	8	12
Na^+-K^+	0.53	-	-	-	-	-	-
Na^+-Cl^-	0.89	0.65	0.70	0.96	0.85	0.94	-
K^+-Cl^-	0.73	-	-	0.58	-	-	-
Creat.- urea	0.86	0.70	0.80	-	0.94	0.73	0.97

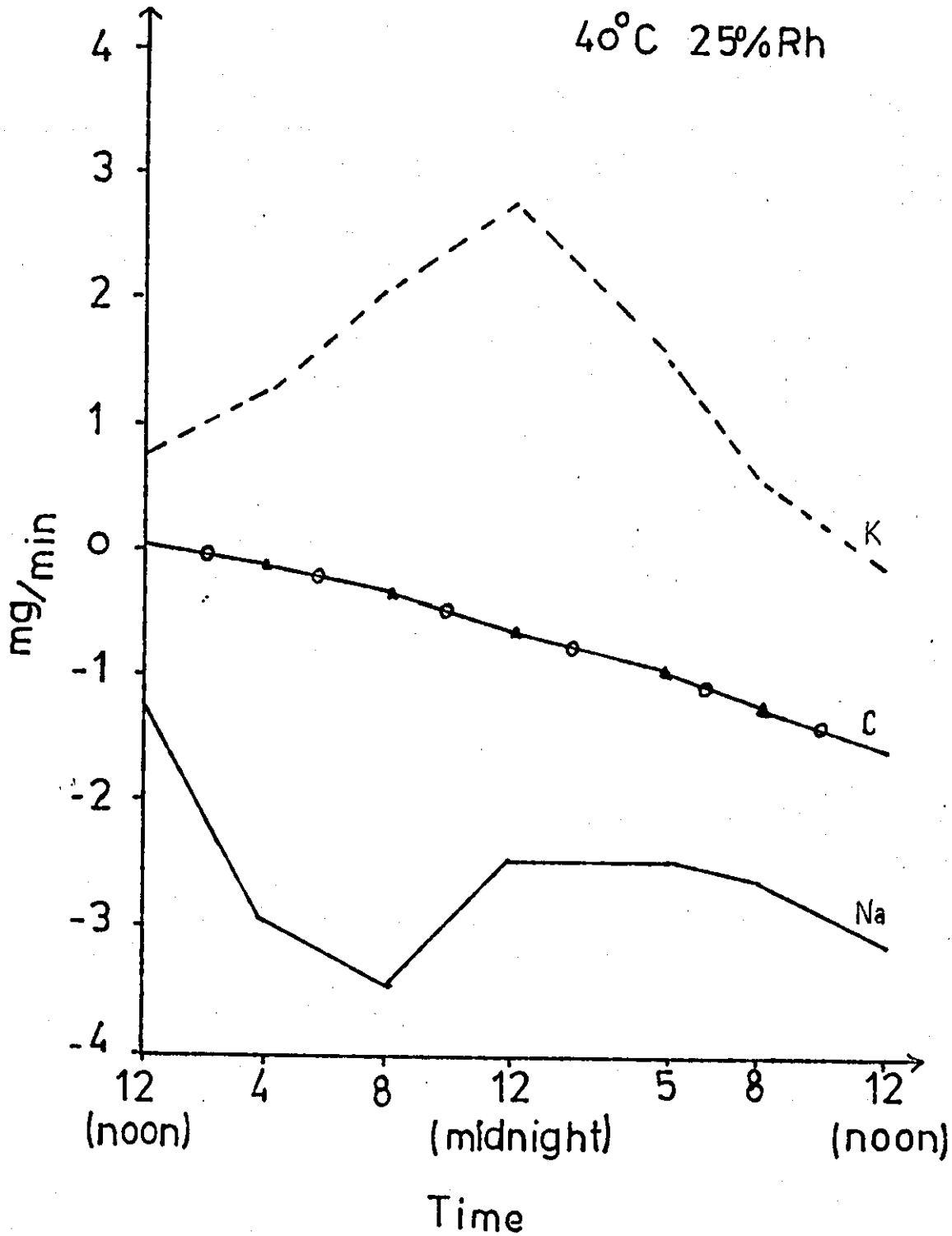
Application of the cusum techniques for Na^+, K^+ and creatinine values showed that the main change in the value of the parameters occured during the early hours of the exposure. (Figs. 34, 35, 36, 37, 38, 39, 40, 41, 42).

5.7.2 Minute urine volume showed a little decrease in value during exposure (Fig. 43) (Table 92).

5.7.3 Heart rate during experiment E showed some fluctuation by increasing at the early stage of the experiment followed by a decrease and an increase in the value towards the end of the experiment. (Fig. 43) (Table 98). This same pattern was followed by blood pressure. (Table 98).

5.7.4 P.C.V. decreased at the early stages of the experiment, followed by a fairly constant level towards the end of the exposure (Table 99).

Fig. 34
Exp. E
40°C 25%Rh



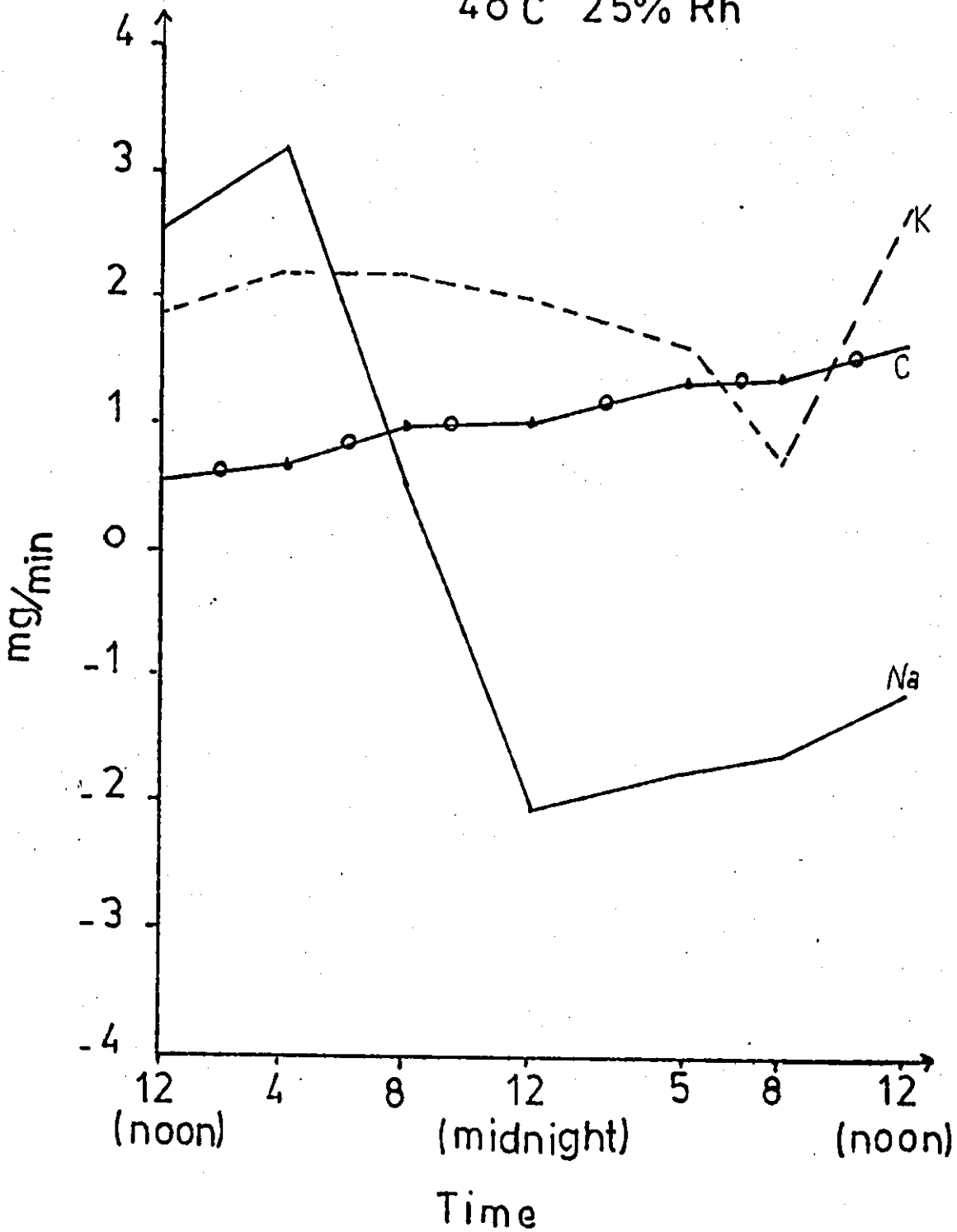
Subject 133

Na^+

K^+

Creat

Fig. 35
Exp. E
40°C 25% Rh



Subject 134

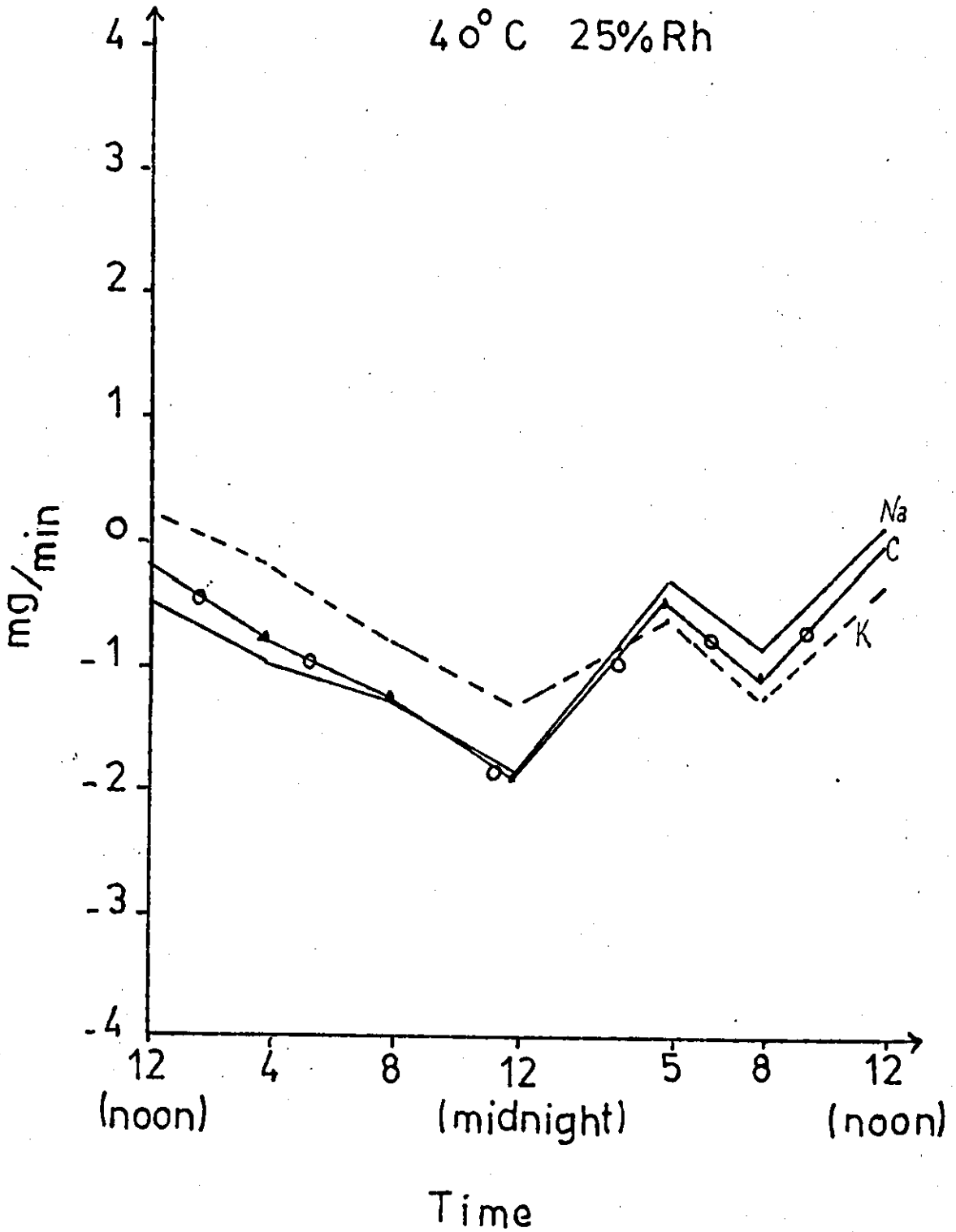
Na^+

K^+

Creat.

Fig. 36

Exp. E



Subject 135

Na⁺

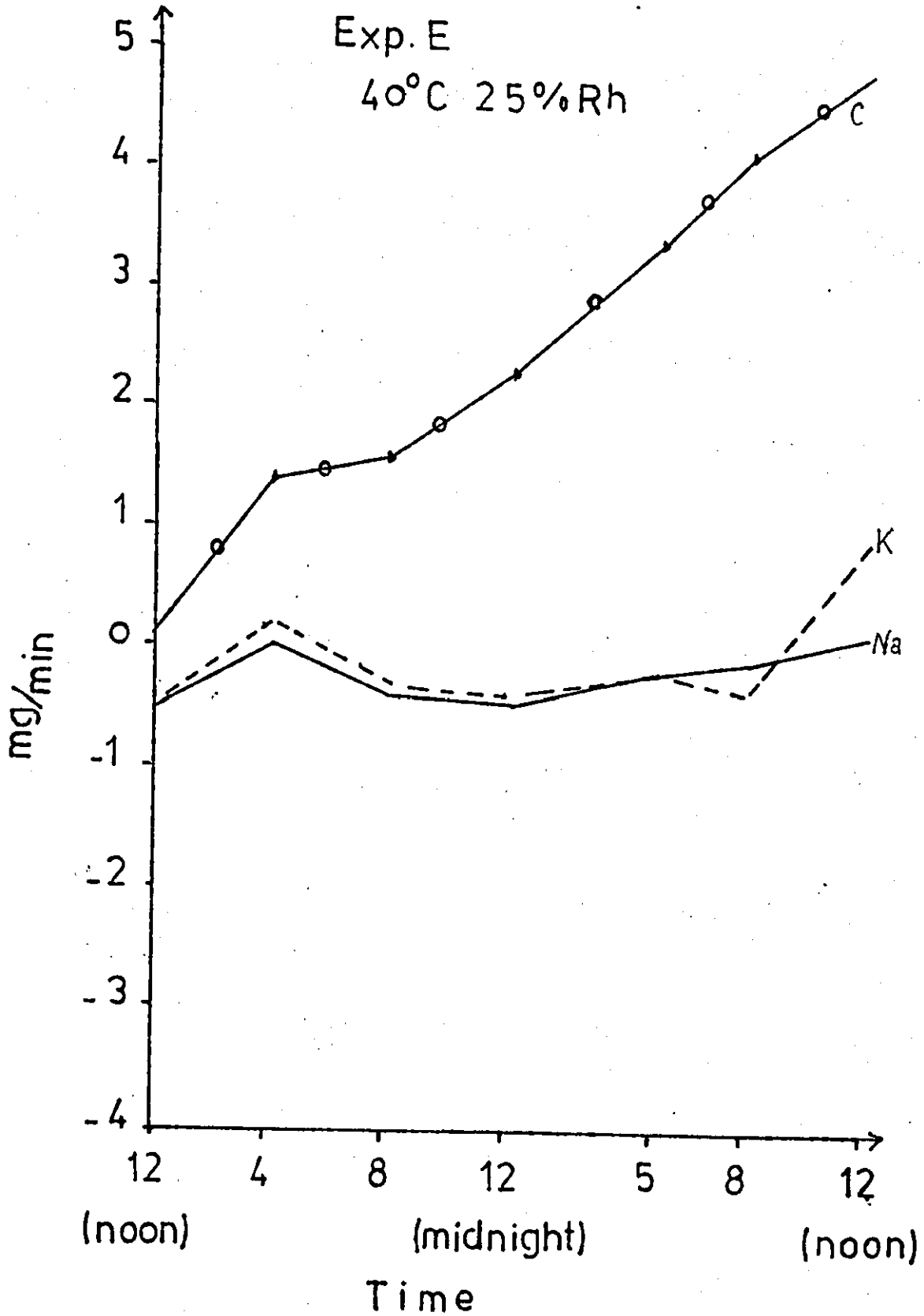
K⁺

Creat.

Fig. 37

Exp. E

40°C 25% Rh



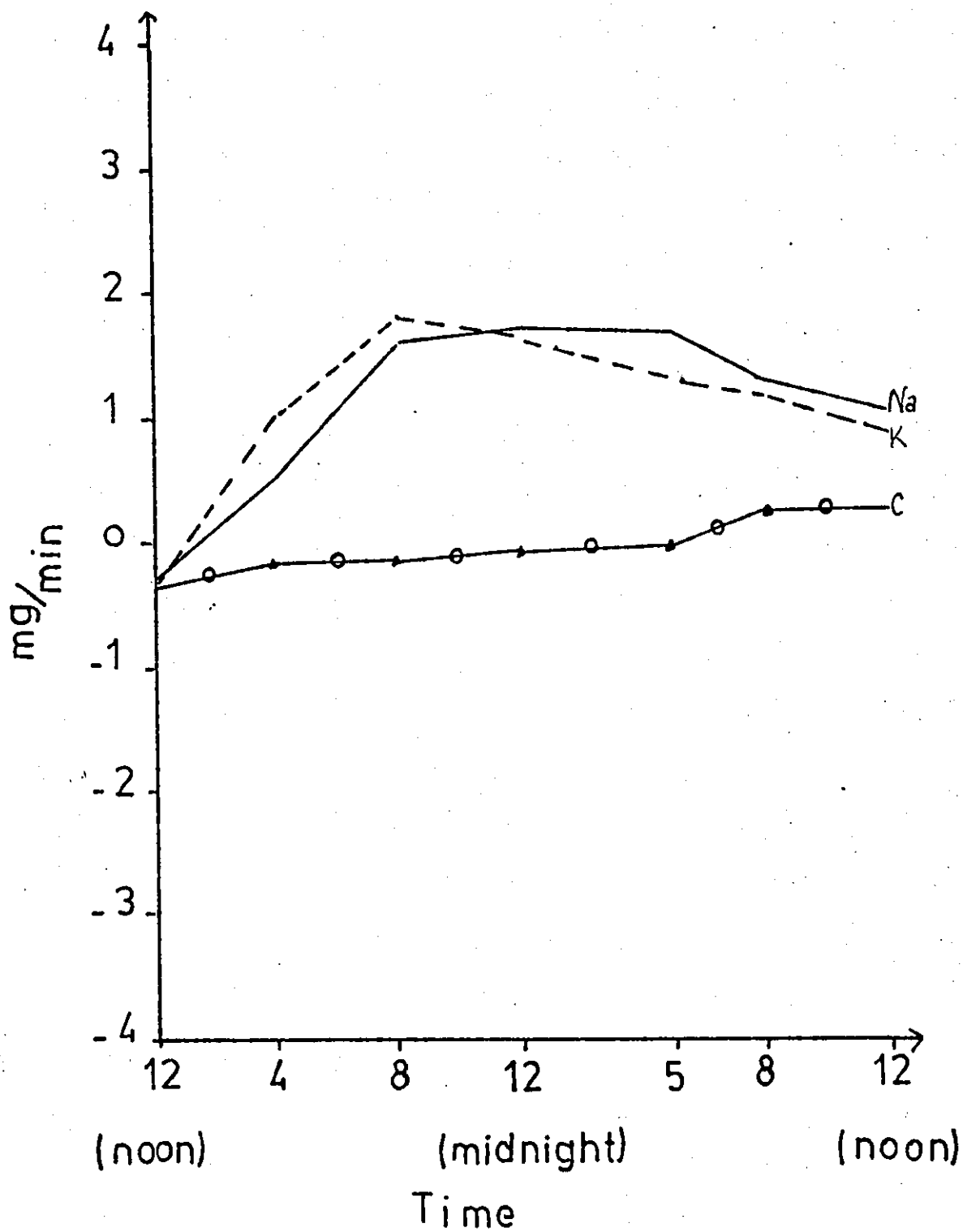
Subject 136

Na^+

K^+

Creat.

Fig. 38
Exp. E
40°C 25% Rh



Subject 137

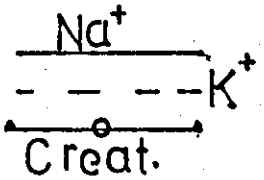
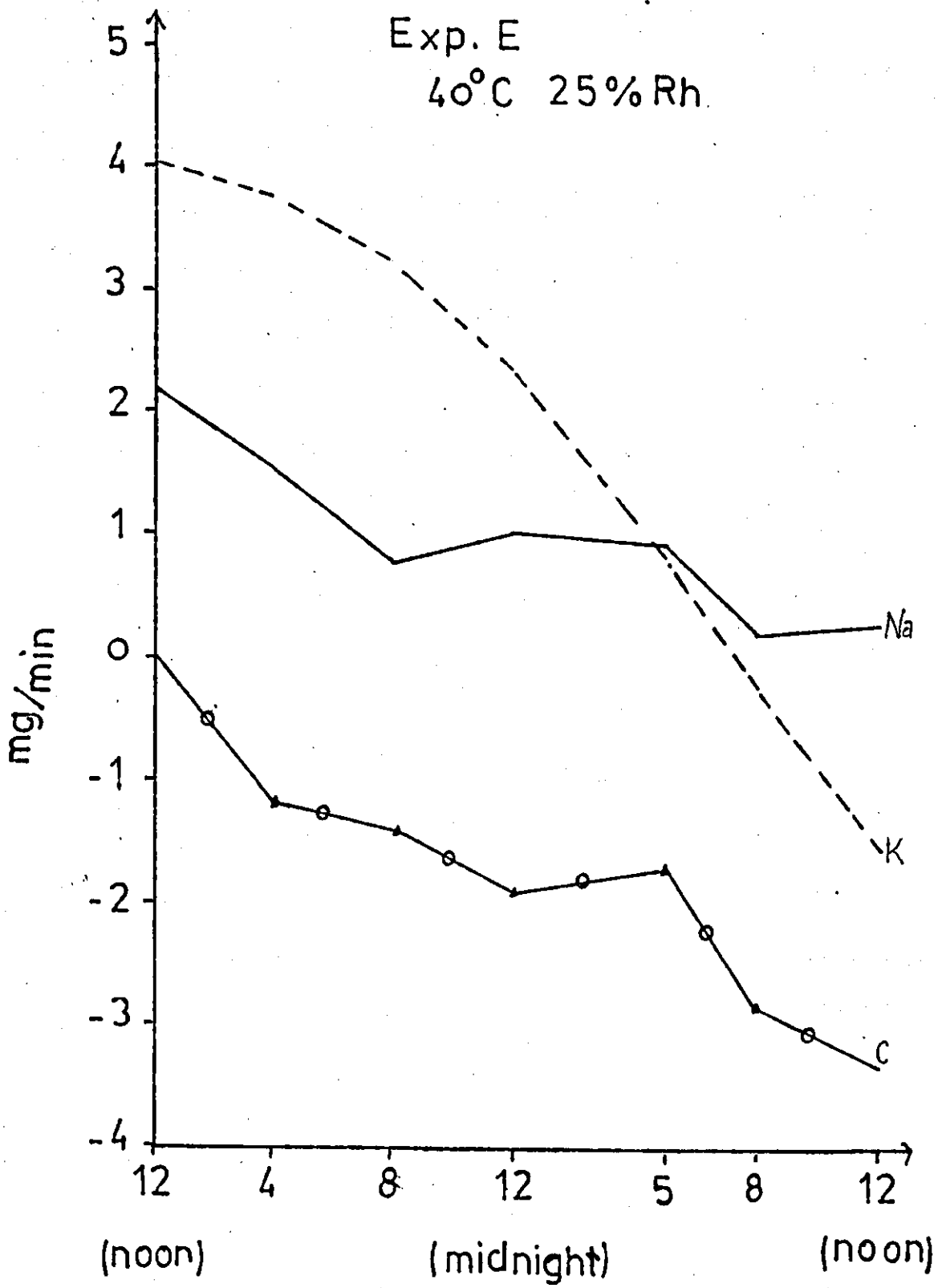


Fig. 39
Exp. E
40°C 25% Rh



Subject 138

Na^+

K^+

Creat.

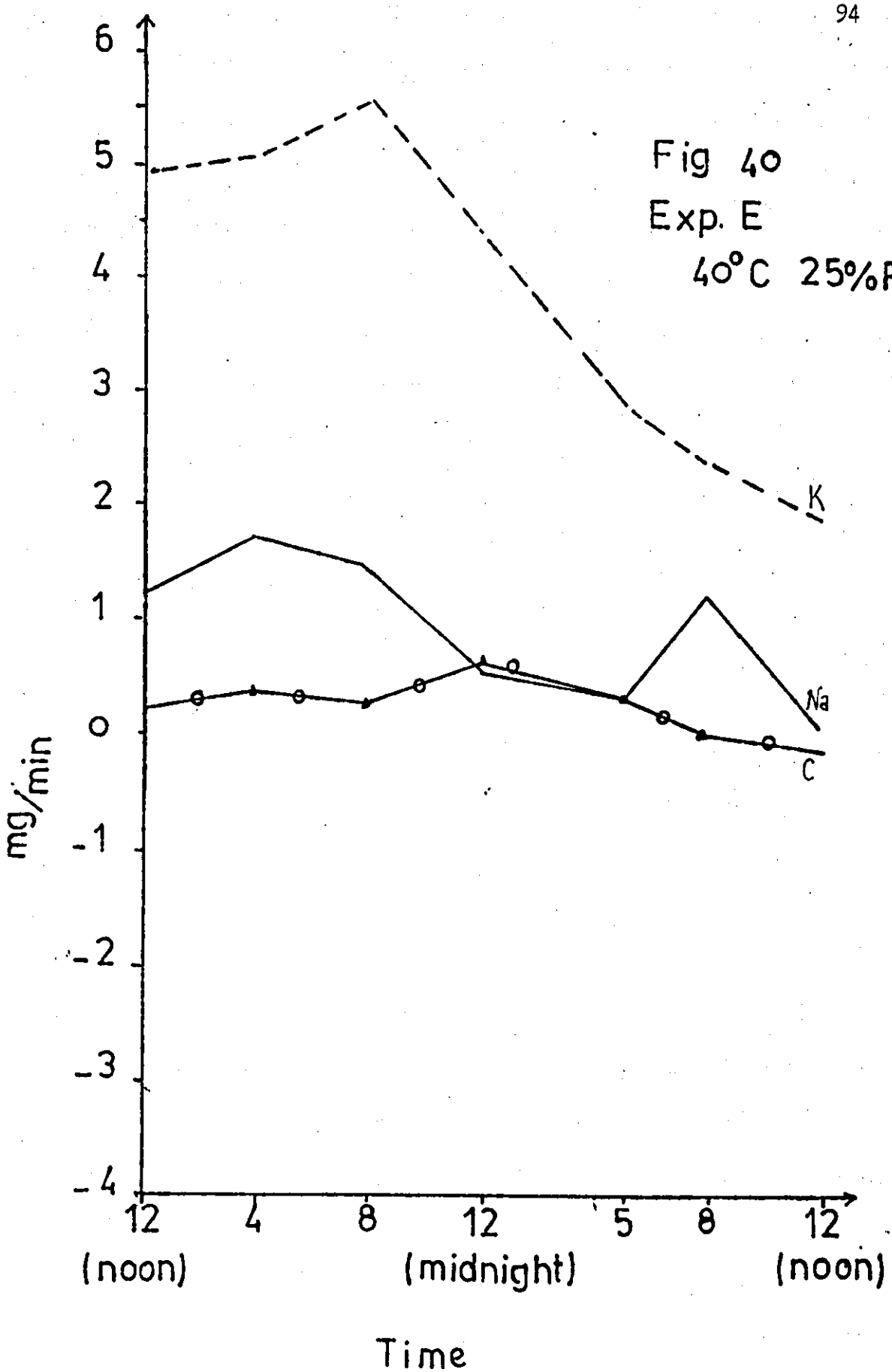


Fig 40
Exp. E
40°C 25%Rh

Subject 139

Na^+

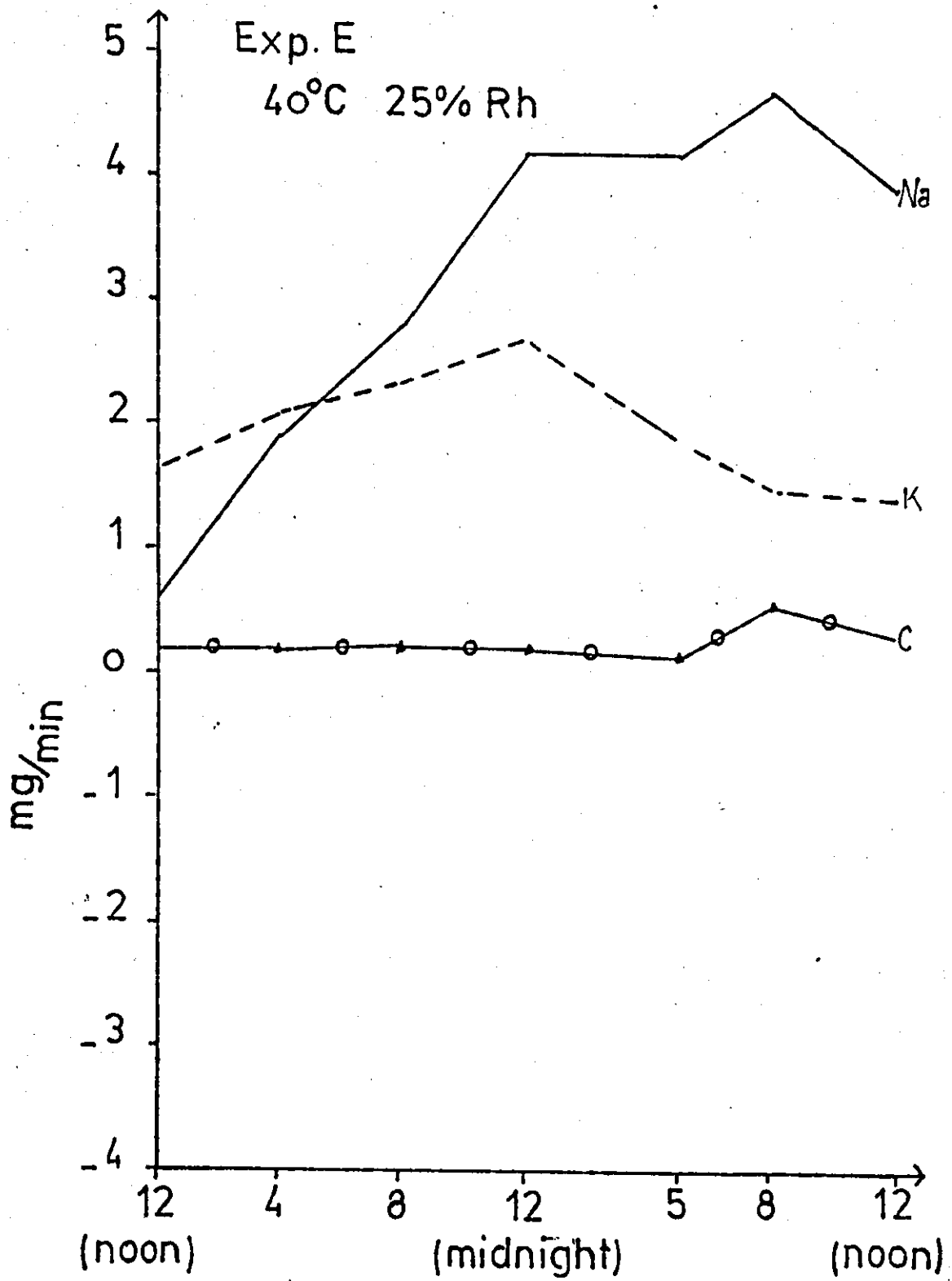
K^+

Creat.

Fig 41

Exp. E

40°C 25% Rh



Subject 140

Na^+

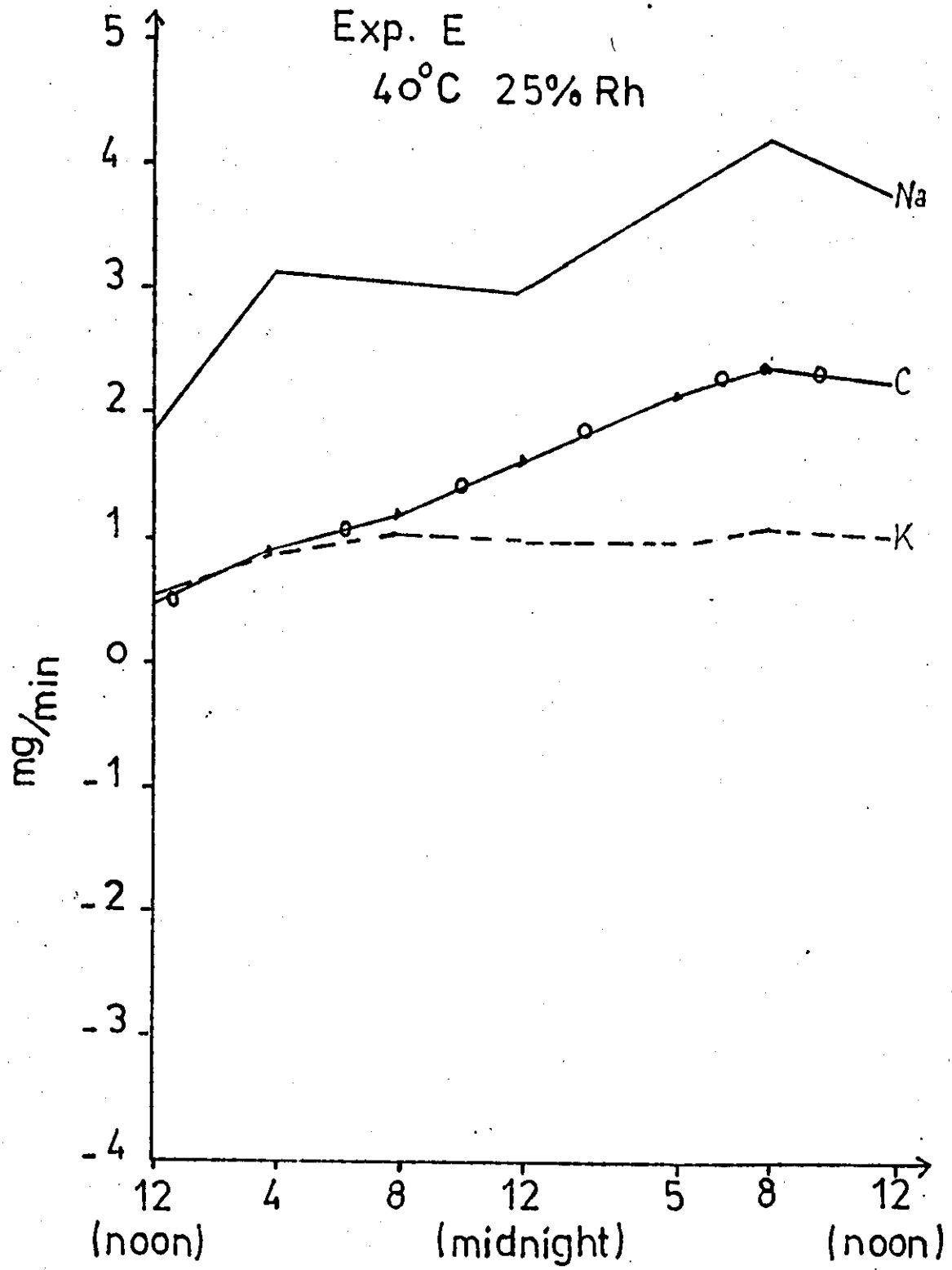
K^+

Creat.

Fig. 42

Exp. E

40°C 25% Rh



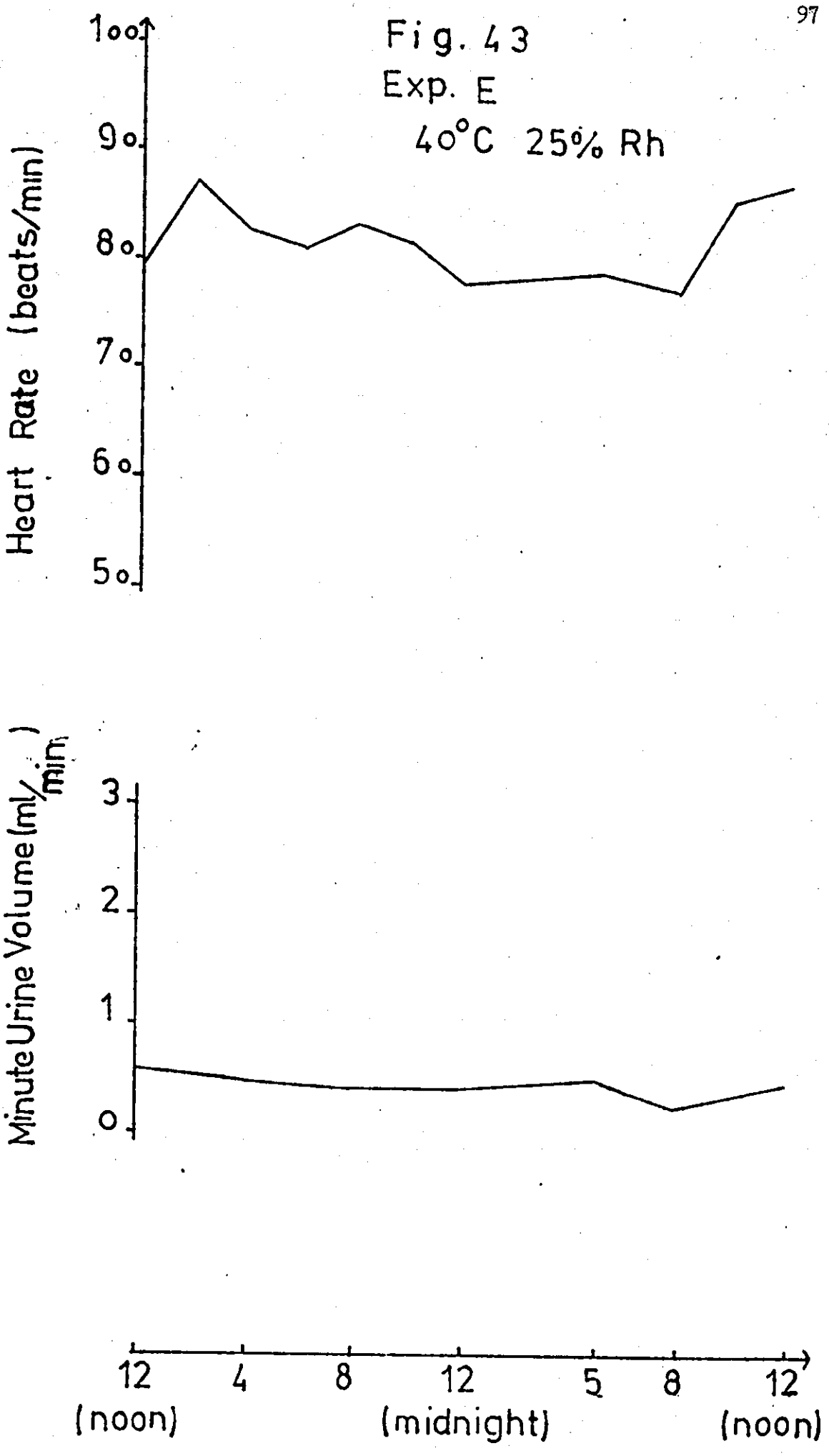
Subject 141

Na^+

K^+

Creat.

Fig. 43
Exp. E
40°C 25% Rh



Tab. 93 & 97

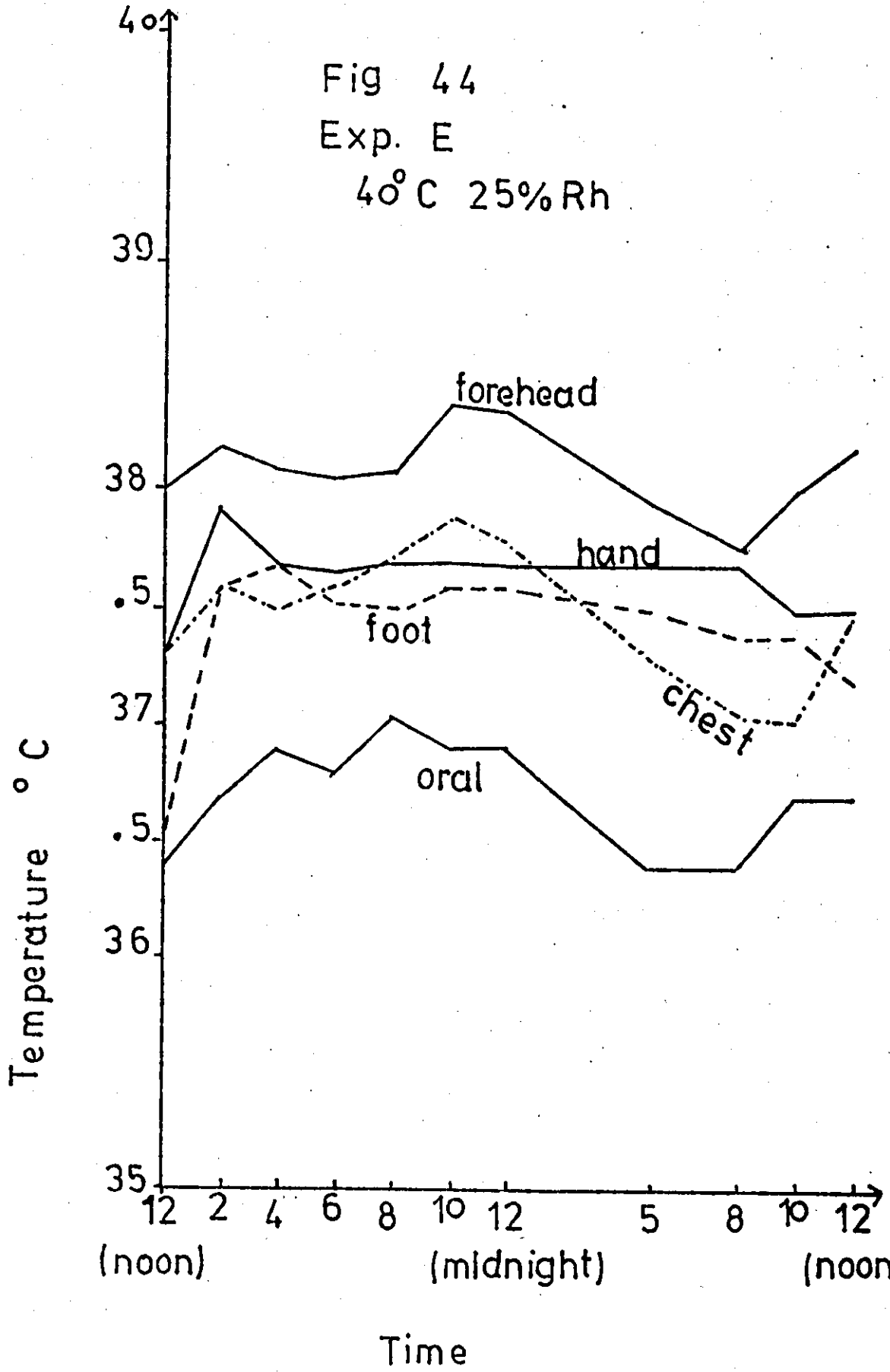
5.7.4 Skin temperature showed a decrease in value after it increased initially in the early hours of the exposure. (Fig. 44) (Tables 94, 95). Oral temperature was fluctuating with a slight decrease in value towards the end of the experiment (Fig. 44) (Table 96).

5.8 Experiment -F- Ambient temperature and humidity.

5.8.1 This control experiment showed a slight variability in Na^+, K^+, Na^+/K^+, Cl^-, urea, creatinine and creatinine/body weight)values obtained from resting subjects I and subject set a light task II at ambient temperature. (Fig. 45) (Tables 106, 107).

5.9 It is worth mentioning that in dealing with the results the interpretation was founded on the mean values obtained from each experiment. It was noticed that a significant standard deviation was obtained in most of the experiments and this is mainly due to the different reactions of the subjects to such experiments. Unfortunately the subjects taking part can never be considered as a random sample, because it depends on the willingness of the subjects to participate. To overcome diurnal variation, subjects who had to attend two exposures, came at the same time of the day to take part in the experiment in both conditions. In the statistical interpretation t values were taken at the 5% level while r for correlation coefficient was considered for those values $\geq \pm 0.5$ (Snedecor and Cochran 1957).

Fig 44
Exp. E
40° C 25% Rh



Tab. 94,95 & 96

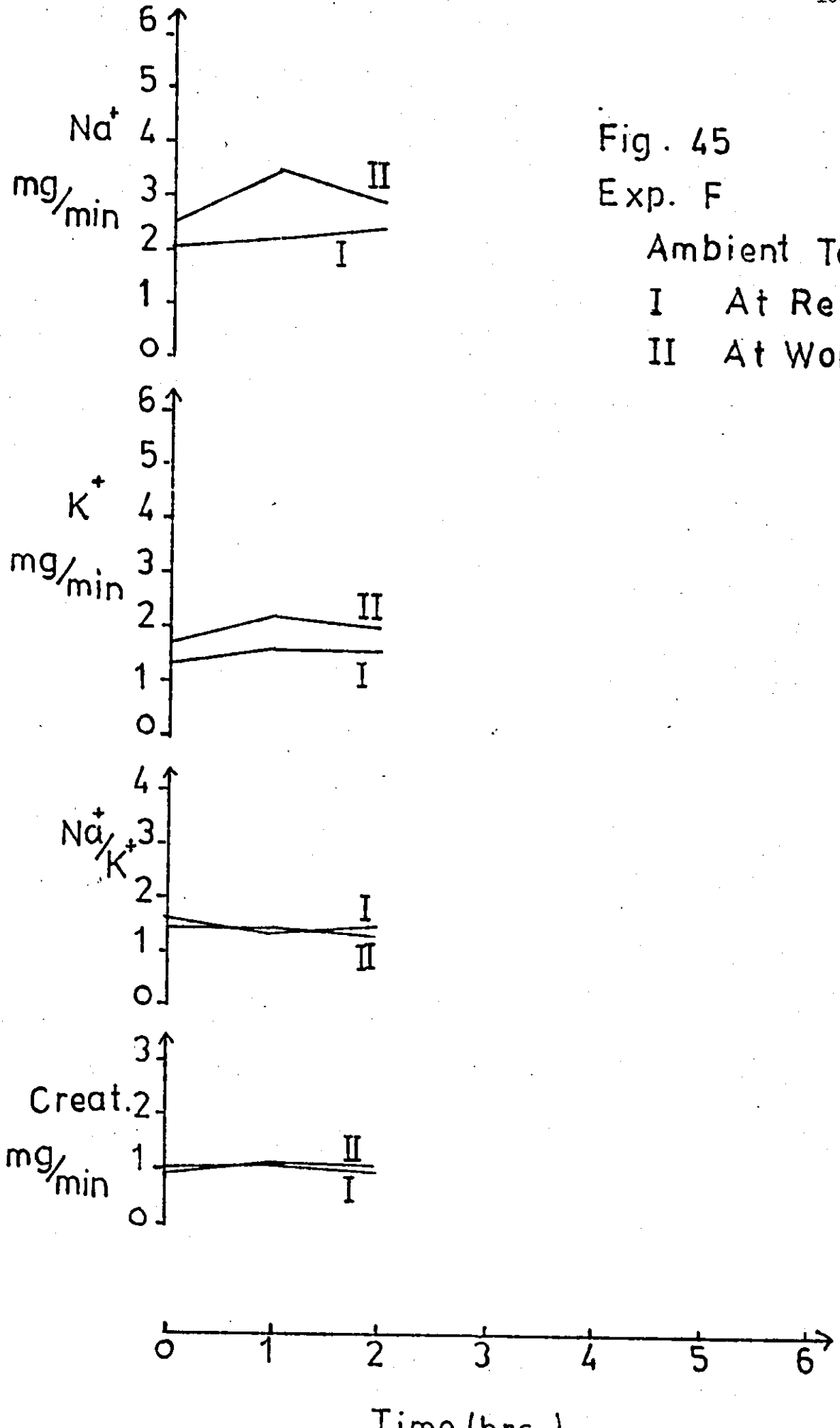


Fig. 45
Exp. F
Ambient Temp.
I At Rest
II At Work

Tab. 106 & 107

6. DISCUSSION

6.1 Introduction

The aim of this investigation was to study the physiological response of human beings in their adaptation to different environmental conditions created in a climatic chamber.

The experiments were designed and applied in such a way to give a clear idea about the variability of the psychological responses in addition to the biochemical and physiological responses to environmental stress.

In an attempt to reach a better understanding of the results obtained, the discussion is divided into:

a - Subjective report

b - General discussion of the biochemical and physiological responses

c - General comments

d - The similarities as a result of the various analyses obtained, between processes of physiological adaptation operating and these clinically observed changes due to known clinical disorders.

e - Accuracy and precision.

6.2 Subjective report

The subjective report reflects the direct psychological and physiological responses of the people involved (5.2). This is of great importance because it will help to understand the tolerance of human beings to similar conditions.

In general there was a fear of the so called "Hot chamber" which was reflected on the raised pulse rate before entering the chamber among subjects (Tables 2, 9, 16, 24, 32, 38, 45, 51, 57, 60, 70, 85, 97). During exposure all subjects found it very difficult to concentrate on whatever they were planning to do e.g. academic work, playing games, or writing letters, with a general atmosphere of quietness, sleepiness (observed perfectly with children who slept during exposure) and the main question which was frequently asked by all subjects "what is the time now?". This discomfort in the hot chamber was mainly due to the dehydration observed, by a feeling of dizziness by some subjects, and the decrease in minute urine volume (Figs. 28, 32, 43), and salt loss observed in sweat and urine (5.3.1, 5.4.1.1, 5.4.1.2, 5.4.1.5, 5.4.2.1, 5.4.2.3, 5.4.3.1, 5.4.3.3, 5.6.1.1, 5.6.1.2, 5.6.2.1, 5.6.2.2, 5.6.3.1, 5.6.3.2, 5.7.1, 5.7.2, 5.7.3).

No experimental data to support the feelings of apprehension was obtained, because it was not practicable to achieve or observe at the same time while conducting the biochemical and physiological tests under study.

Adaptation was observed by the comfort some of the subjects started to feel towards the end of exposure by the false feelings these subjects gathered about the drop in temperature and humidity of the chamber.

During cold exposure there was a fear of the cold, not because the temperature was low, but because of the idea that the subjects had to stay in such a cold environment wearing only swimwear. This was shown by the increase in heart rate during the pre-exposure stage (Tables 5, 65, 77, 85).

Heat conservation can be achieved during cold exposure by cutaneous vasoconstriction and by a layer of subcutaneous fat which provides excellent insulation. During the cold exposure the subjects sat 'folded up' with bent knees in an attempt to decrease the exposed surface area of the body to conserve heat. Their pale bodies were an indication of cutaneous vasoconstriction in an attempt to reduce the amount of heat transferred by the blood from the body core to the body surface.

'Pins and needles' feelings in the subjects' legs and particularly the feet were due to cold, vasodilation occurs on exposure of these parts to moderate cold 5-10°C when the body is generally warm.

No recognized psychological tests were carried out for various reasons such as the many numbers of the other parameters to be studied, the inability of stopping the interference of the technician for technical reasons during the exposure, the fact that on certain occasions more than one subject had to take part at the same time and the unwillingness of some subjects to get involved in such tests.

6.3 General discussion

"The organism is only a living machine constructed in such a way that on the one hand there is full communication between the external environment and the milieu interieur . . ." (Claude Bernard 1865).

Thus complex physiological processes involving the different vital organs of the human body work cooperatively to maintain the homeostasis of the internal systems.

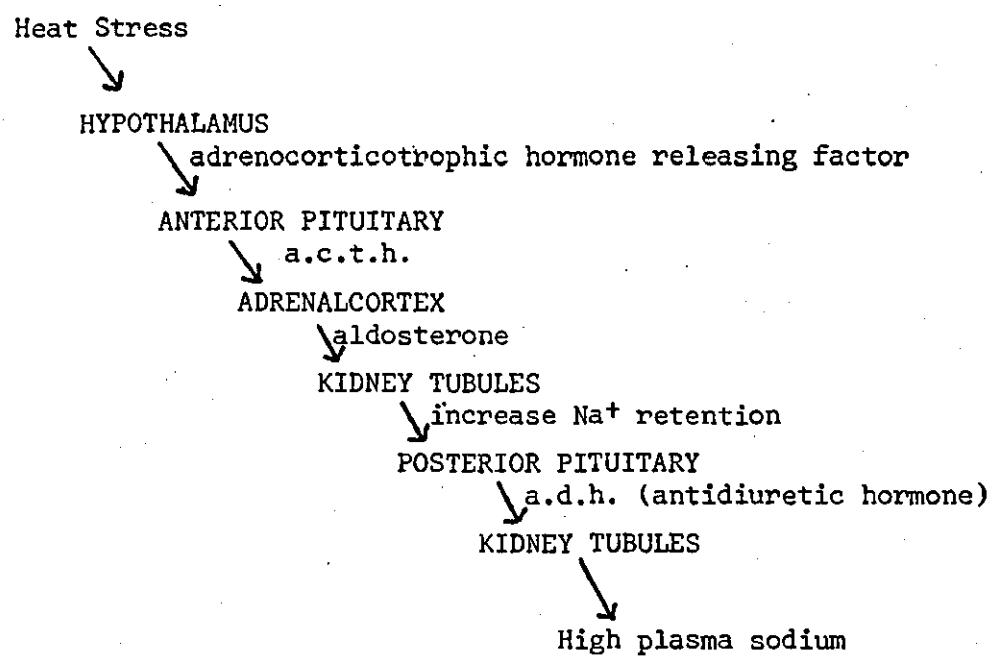
To simplify dealing with the data the discussion will deal with the hot and cold environmental conditions separately.

6.3.1 Hot environment

The general trend during short-term exposure was an initial rise in urinary sodium and chloride levels which declined in such a way that the more severe the heat stress the lower the level (5.3.1, 5.4.1, 5.4.12, 5.4.2.1, 5.4.3.1, 5.6.1.1, 5.6.2.1, 5.6.3.1, 5.7.1). This was in agreement with the literature (Kanter, 1955; Itoh, 1960). The delay in the decline of the levels of these parameters (Tables 39, 46, 52) indicated that the subjects took longer to acclimatize. The reason behind the initial rise in the levels of Na^+, Cl^- was that the subjects were not acclimatized to the environmental conditions during the first period of the exposure. Such delays in the conservative acclimatization response to the environmental changes was attributed to age, sex, physical fitness, race and habitat, all of which played an important role in defining the limits at which such adaptive mechanisms were triggered, and which vary in different subjects.

There was a decline in urinary minute volume upon exposure to heat (5.6.1.2, 5.6.2.2, 5.6.3.2, 5.7.2) (Figs. 28, 30, 32 and 43), due to water conservation mechanisms which were stimulated and water was reabsorbed at the level of the distal tubule via the action of anti-diuretic hormone. A similar result was obtained by Itoh, 1960; Collin and Weiner, 1968.

Salt and water balance are affected greatly in conditions of heat stress, which might lead to distinctive changes in the distribution of the electrolytes between the cells and the extracellular fluid, changes in osmotic pressure, acid-base balance, kidney function, and water balance. On the other hand the human body possesses remarkable adaptability in such a way that the physiological mechanisms involved are so flexible that they operate efficiently within a wide range of environmental changes in order to counteract the effects of serious stress. The mechanisms causing these physiological responses to conserve water and salt could be suggested as follows:



although the mechanism has been suggested for Na^+ reabsorption, sodium cannot be reabsorbed without accompanying cation, Cl^-, and water (Wright, 1971).

Many workers have suggested that salt deficit increases aldosterone output (Collins and Weiner, 1968; Collins, Hellman,

Jones and Lunnon, 1955). This is supported by evidence that aldosterone contributes to the renal conservation of Na^+ and Cl^- and that aldosterone secretion increases during heat exposure (Collin and Weiner, 1968; Itoh, 1960, Hellman et al., 1956).

Potassium exhibited a similar trend to Na^+ which is attributed to a certain adjustment probably occuring to maintain the sodium/potassium ratio (Figs. 16, 18, 20, 22, 27, 29, 31, 33). Aldosterone in retaining Na^+ results in an effective secretion of potassium (Bass et al., 1955), however this contradicts the level of K^+ obtained in this research which might be attributed to the stimulation of growth hormone through stress and excitement, and this caused retention of potassium.

In the present studies urine Na^+/K^+ decreased during heat exposures (Figs. 16, 18, 20, 22, 27, 29, 31, 33) suggesting that aldosterone was secreted and indicating acclimatization to hot conditions. This confirms the suggestion in the literature that aldosterone lowers Na^+/K^+ during heat acclimatization (Macfarlane, 1956; Robinson et al., Collins, Hellman, Jones and Lunnon, 1955).

Creatinine acts as a good reliable indicator of renal function and the relatively constant levels obtained (Figs. 16, 20, 22, 27, 29, 31, 33) in this study reflect the neutralizing effect produced by reduced glomerular filtration rate by the kidney. This due to the fact that there was insufficient stress to cause interference with kidney function or to increase creatinine production by the muscles on exposure to heat stress (Streeton et al., 1960).

The elevated urea values would be due to excessive protein broken down as a result of stress. (5.6.1, 5.6.2.1, 5.6.3.1, 5.7.1).

Results obtained in this study indicated that sweat rate, and Na^+, K^+ levels in sweat declined during the second hour of exposure (5.4.3.2) and (Figs. 24,25). This was similar to the findings of Peter and Wyndham, 1966; Wyndham, 1954; Bass et al., 1955; Allan and Wilson, 1971. The sweat rate and Na^+ K^+ values are higher in exposures where work was achieved (Figs. 24, 25). The decrease was attributed to sweat gland fatigue (Peter and Wyndham, 1966). The results obtained (5.4.1.5, 5.4.2.3, 5.4.3.3), confirmed the indication of conservation mechanisms operating to prevent salt depletion. This is an adaptive mechanism to reduce salt loss which has been confirmed by several workers (Moss, 1923; Adolf and Dill, 1938; Robinson et al., 1941; Wyndham, 1967; Ladell, 1957; Eichna et al., 1954 and Dill et al., 1933). It is likely that renin-angiotensin mechanism of mineral corticoid is involved when salt losses are large causing a low Na^+ level thus enhancing aldosterone secretion in men exposed to heat (Brown et al., 1964). It was suggested that the decrease in sweat sodium concentration was due to the secretion of aldosterone (Kenney, 1963; Collins and Weiner, 1968).

Thus the kidney and the sweat gland are capable of making remarkable adaptive changes in their salt output to changes in the salt balance of the body (Figs. 16, 18, 20, 22, 24, 25, 27, 29, 31, 33). In response to gradual salt depletion by sweating, the kidney may quickly begin to reduce salt output and complete

adaptation rapidly while the sweat glands reduce the salt concentration of sweat more slowly. These conservational responses are brought about by the increased adrenal corticol activity, in which kidney and sweat glands reduce salt output in response to salt deficiency in the blood.

Changes in blood and circulation during exposure to heating is another physiological adaptive mechanism, to maintain homeothermy. The reduction in packed cells volume indicated an increase in plasma volume. This is also reflected with the haemoglobin values and red blood cells count (5.6.2.3). The results showed that a fundamental change has taken place between the two components of blood i.e. cells and plasma. Either the cells decreased in number, a hypothesis which is not tenable because one must postulate where the cells could go, or the plasma volume has increased, which is a more probable answer for the results obtained. The findings in this study indicated a change in the blood composition towards haemodilution. An increase in white blood count could be attributed to the stimulation of the mobilization of body defenses against elevation in temperature (Table 74) and may be a part of the same mechanism by which most conditions of stress cause an increase in white cell counts.

Heart rate increased initially on exposure to the chamber and then decreased throughout the exposure periods. (Figs. 17, 19, 21, 23, 26, 28, 30, 32, 43). The initial increase could be attributed to a) the initial fear among the subjects of the experiment, b) an adrenalin response to the stress condition

causing vasodilation, reduction of peripheral arterial resistance and increase in blood flow to the skin.

Increase in heart rate was due to a general rise in temperature since impulses are under the same influence of agents that raise body temperature. When a general rise in the temperature of the body occurs the rate of passage of the cardiac impulses along the conductive system are increased which increases the heart rate. The observed decrease in the heart rates to a relatively constant level during the exposure, indicates an improvement in the cardiovascular responses to heat stress and is in agreement with many workers (Eichna et al., 1945; Bass et al., 1955; Wyndham et al., 1964).

The cutaneous vasodilation decreases the peripheral resistance and lowers the diastolic pressure, thus lowering blood pressure (Table 98) and heart rate (Figs. 17, 19, 21, 23, 26, 28, 30, 32, 43). All of these cardiovascular adjustments were to help the body to meet the stressful conditions with the least side effects throughout the acclimation process. These cardiovascular adjustments were also confirmed in the literature. (Scott, Bagett, and Mackie, 1939; Bean and Eichna, 1943; Taylor, Henshel and Key, 1943).

The deep body temperature is maintained at an approximately constant level by the balance between heat gained and heat lost by the body (Table 96 and Nielson, 1938; Webb and Annis, 1967; 1968; Åstrand, 1952; Wyndham et al., 1952a, b; 1954; Robinson, 1949), (Fig. 44).

The skin is the one physiological factor which responds immediately to all environments, and therefore is a useful indicator of the effects of thermal environment on man's ability to perform in and tolerate the changes in environmental conditions. The results obtained (Figs. 19, 44) (5.4.1.4, 5.7.4), indicate initial increase followed by a decrease caused by cooling effect due to evaporation. Thus in dry heat the evaporation of sweat maintained the stabilized level of skin temperature despite an environmental temperature which was higher. The environment and core temperature interact at the skin in such a way as to maintain homeostasis of the central body temperature. Temperature regulation seems to be governed by thermoresponsiveness in the anterior hypothalamus which controls the heat loss by means of adaptive mechanisms such as vasodilation of the skin and the sweating mechanisms. In the passive phase this is by simple heat loss from the skin to the cooler environment. In the active phase this is by sweat mechanisms requiring the hypothalamus to operate as a mineralcorticoid regulator over skin and kidney in the control of sweat and urine electrolytes.

6.3.2 Cold Environment

It is very interesting to see that the trend in Na^+, K^+ and Cl^- values tends to rise in accordance with urine minute volume as would be expected as a result of cold induced diuresis. (5.3.1, 5.6.1.1, 5.6.2.1, 5.6.3). This confirmed the fact that cold induced diuresis suppressed aldosterone secretion and thus sodium levels should be increased throughout the exposure. This appears to contradict the observations obtained on certain

individuals in this study (Tables 66, 79, 87). The answer for this contradiction can be explained by the fact that growth hormone which was stimulated by the cold exposure enhanced retention of Na^+, K^+ and Cl^-. The idea of endocrinological adjustment is supported by Davis et al., 1955, 1960.

The initial slight increase in the urinary creatinine (Figs. 16, 27, 29) is due to an increase in muscular activity by shivering to increase body temperature. This finding of the fact that shivering and its consequent thermogenesis, would increase with decreasing ambient temperature has been reported by many workers (Seift, 1932; Adolf and Molnar, 1946; Hemingway, 1953; Horvath, Spurr, Hutt, and Hamilton, 1956; Iampietro, Vaughan, Goldman, Kreider, Masucci and David, 1960).

Increased metabolism may also be stimulated by the production of thyroxine (Goldstein - Golaire et al., 1970), in order to increase heat production during acclimatization process (Poe and Davis, 1962). Adrenalin may also be increased which will increase heat production by increasing muscular activity, together with an increase in noradrenalin level. This has been reported by Smith, 1962.

The initial increased values of urea could be attributed to protein broken down as a result of stress (5.6.1.1, 5.6.2.1).

Blood analyses showed that P.C.V. increased, haemoglobin remained almost constant and red blood cell count increased (Table 81). All of these values suggest an effective decrease in plasma volume. This decrease in volume would be the result of

diuresis as well as shift in plasma volume. The increase in the white cell count suggests a general defense mechanism against stressful conditions (Table 81).

Application of cold to the body surface is followed by peripheral venous constriction and decreased peripheral blood flow. Heat loss is reduced by cutaneous vascoconstriction. This helps by decreasing the amount of heat transferred by the blood from the internal body core tc the body surface. The cutaneous vasoconstriction will raise blood pressure during exposure to cold (Samson Wright, 1961; Wakin et al., 1952). The results showed heart rate was decreased (Figs. 17, 28, 30, 32) due to the peripheral vasoconstriction reducing the blood flow to skin and thus reducing the need fcr the heart pumping action. Increased secretion of adrenalin and noradrenalin may also occur during exposure to cold and would contribute further to the rise in blood pressure, and would mask the decrease in pulse rate and thus will account for the different heart rate levels observed in some individuals. These findings of heart rate changes during cold exposure are similar to what is reported in the literature. (Murphy, 1959; Hookard, Stormont, 1941; Prec, Rosenman, Brawn, Rodbard and Katz, 1949; Sabiston, Theilen and Gregg, 1955).

6.4 General Comment

The physiological processes which occurred during the two exposures of heat and cold indicate on the one hand the processes involved and on the other the ability of these processes to regulate and to express their adaptive mechanisms in maintaining body constancy according to environmental needs. Thus the physiological responses to heat are:

a - Temperature increase

b - Increase in cellular metabolic exchange which means an increase in the rate of general metabolism

c - Vasodilation

d - A general change in blood flow.

The physiological responses to cold are:

a - Physical regulation mainly to reduce the heat loss from the body surface (a conservation of body heat).

b - Metabolic regulation, in which the endocrine and autonomic system are involved to alter heat production in the body.

Acclimatization is a necessary factor in man's ability to withstand environmental strain, and to maintain body homeostasis. Among those regulatory mechanisms involved is the need to maintain relative constancy of the deep body temperature upon which normal metabolic function depends. This relatively constant body temperature is maintained by self-activated reactions keeping an equilibrium between heat production and heat loss; this operates as the body's thermostat.

The above example is one of many concerned with regulating mechanisms which act to maintain the constancy of the internal environment. The physiological response to any change in environmental conditions may produce changes in total heat production, skin temperature, heart rate, and sweat secretion. These involve the endocrine system in its role in the physiological adjustments of the homeostatic state of the body.

Adaptation to hot and cold environmental conditions might be attributed to three factors: (i) genetic, (ii) physiological and (iii) cultural.

Genetically determined variations are transmitted in the genotype. These genetic features are expressed in the general morphology of the human body within the limitations of its sex. All of the factors must be considered advantageous as they have appeared by natural selection in a specific type of environment.

The physiological features allow the flexibility by which the body can adapt remarkably rapidly to ambient changes in the thermal environment.

The cultural features are concerned with behaviour and have been evolved to allow survival more successfully in the extremes of environmental conditions where neither the genetic nor physiological features of the body have evolved. The development of such behavioural characteristics as clothing, housing and formalized habits of life have allowed human migration to new environments with conditions that are frequently incompatible with life. Obviously an important part of the cultural features is the ingenuity and intelligence of man.

Results obtained in this study indicate an incomplete adaptability to rapid changes in the thermal environment. Acclimation is a slow process and when incomplete can be detected by physiological responses to changes in environmental conditions. These tend to show an initial rise in most physiological parameters followed by a decline to approximately normal pre-exposure levels. In some occasions the continuing exposure may result in a continuing small change in the physiological parameter and frequently indicates that the body has established a new level of acclimation. A remarkable feature of the results was the variation among subjects as each adapted to changes in the environmental condition. It seems that acclimation or complete adaptation cannot be achieved until after prolonged exposure or repeated exposures to the new environmental conditions. Perhaps this is a similar process to immunization and acclimation, like immunization, requires sufficient time and exposure for the various adaptive processes of the body to reorganize and acclimatize to the new conditions. In both cases physiological parameters show abnormal values during the transition period and may be incomplete if the exposure is extreme or too short. However it also seems that acclimation is more similar to 'temporary' immunity since it readjusts quite soon when the body is withdrawn from the conditions which caused it. This is seen in most forms of environmental acclimation and the time to readjust varies with the particular condition studied. In man thermal acclimation is rapid and within the experimental conditions of this study, it may well be only a few hours but in more extreme changes such as a trip to the Sahara from winter time England it may take a few days. However in both cases the initial adaptive responses appear to begin in only 45 minutes!!

This suggests that one of the physiological parameters might be used as an index of acclimatization. Kerslake (1972) has said "A good Index is a map, not an aerial photograph, and its scale and content should be chosen in relation to its application. Its precision should match that of the data with which it will be used". Under the conditions of this study, creatinine is a reliable index of heat stress due to the fact that the creatinine levels reflect these processes best.

However a 'Comfort index' would be most valuable in this type of research. Some observations during the adaptation phases reflected decline in the parameters that continued below normal pre-exposure levels. Also several aspects of 'comfort' were mentioned by the subjects during exposure. Obviously a personality index which includes behaviour, might give some insight to this and allow some form of correlation between exposure, sex, age and personal characteristics. However personality alone is insufficient as we are concerned with the feeling of 'well-being' or comfort in the new environment. This might then be related to the stages in adaptation and differentiate between claustrophobic effects and other forms of stress experienced during the exposure period. Frequently in people who complained of claustrophobia there was a decline in these complaints towards the end of the test period and this was more rapid when the victims were able to know and see the time left for the test. This is only one aspect of comfort and was quite variable between subjects. Few people made no comment or appeared to be unaffected by the experiments; most people expressed an opinion best described as a description of comfort or its lack. The components of a comfort index are too varied to quantify in this study but a table of 'comments' is given in the

results (5.2.1, 5.2.2). Certainly the biggest part of a comfort index must relate to psychophysiological factors. These must include irritability, fatigue, the ability to concentrate, and social effects such as cooperation. Some of these factors may be measured by work productivity and quality control tests as used in industry and commerce by setting suitable work tasks as a part of the exposure period. Unfortunately no such tests were included in this study as the experimental chamber was poorly designed for this purpose. In an attempt to conduct a pilot experiment of this in the task of assembling brushes, the results indicate that exposure to 10°C above or below acclimation causes a decrease in work rate, but the tests were too few to give significant results.

The need for a heat index has been discussed earlier, this study highlights the need also for a cold index. As in the hot exposure urinary creatinine was also found to reflect the effects of adaptation to cold. A good cold index should be one which includes a subjective thermal sensation scale as a direct measure of the state of comfort or discomfort eg.

Change in dry bulb from acclimation level	Scale of direct measure of comfort or discomfort		Suggested change in creatinine to be observed
0°C	0	comfortable	0-5%
5°C	1	cool	5-10%
10°C	2	cold	10-25%
15°C	3	very cold	25-40%
-	4	unbearable cold	outside this experiment.

It is interesting to notice that the 5°C or scale 1 conditions are identical in effect with normal diurnal changes.

Such an index should include in addition the speed of air movement. I suggest that a mathematical approach for such a cold index should involve a correlation between creatinine level, mean skin temperature and dry bulb temperature.

6.5 Clinical diagnosis

It is very striking that certain similarities exist between the processes of physiological adaptation and clinically observed changes due to known clinical disorders.

The immediate clinical consequences of water and sodium disturbance are changes in extracellular osmolality. If sodium balance is disturbed without a corresponding change in water, a change in plasma osmolality will occur. This change in the subjects in this study was coincident with reported feelings of headache and minor disorientation in the response to the request for comments about "comfort". Headache and confusion are also common symptoms in the early stages of two clinical conditions caused by sodium and water imbalance these are: hyponatraemia, causing cellular overhydration and hypernatraemia causing cellular dehydration of cerebral cells leads to the symptoms of headache and confusion which in worse stages can lead to coma.

Aldosterone production increases due to low plasma sodium levels. This is an attempt to conserve plasma sodium. The clinical effects of shock, heart failure and liver cirrhosis are due to a decrease in sodium excretion which lead to an increase in aldosterone production. Clinically a high level of urinary sodium is associated with dehydration as can be seen in addison disease, and the digestive disturbance of vomitting and diarrhea.

Decreased values of urinary potassium are frequently associated clinically with Addison's disease, acute infections, pneumonia, uremia and acute bronchial asthma. Increased values of potassium are associated with severe diarrhea, diabetes and malignant growth. It is probable that the subjects in these studies were not exposed to potassium variation for sufficient time for these symptoms to occur at an observable level except for respiratory discomfort and slight tendencies to cough and to clear the throat coincidental with reading of low urinary potassium. However this was more easily associated with dry atmosphere conditions rather than potassium depletion.

Decreased values of chloride are associated with prostatic obstruction, nephritis, cardiac conditions, hyperventilation, and increased values of chloride are associated with Addison's disease, fevers, heat cramps, diarrhea, vomitting and profuse sweating. Certainly in this study the symptoms of hyperventilation and more than predictable sweating occurred in the two changes in urinary chloride. However the other clinical symptoms, particularly heat cramps were not observed in these experiments due to the short periods of exposure (even after 24 hours). The non-electrolyte observations must be considered in the same way. The variations observed while significant were always within the durations of the experiments and recovered to pre-test levels rapidly. The clinical conditions associated with diagnostic observations are invariably associated with long duration unrelieved changes in the materials measured and thus have a clinical significance.

Although changes in blood composition occurred, the range of changes observed were still within the normal range for healthy people

given in Documenta Geigy. The most striking feature was the quick response of the white cells, which provide defense mechanisms for the body. The total white cell count increased in response to the initial rise in body temperature in adaptation to the environmental changes. This rise gradually decreased with continued exposure but remained elevated about the pre-test level until the return to pre-test environmental conditions. Unfortunately it was not possible to persuade these subjects to give sufficient blood samples to study this in greater detail. It may be that this white cell response can be related more closely to exposure as the increased count appears to be transient with the exposure. Reference to the results in hot and cold shows that there was a more marked change in cold exposure than in hot. Further use of these results would require differential counts to determine which leucocytes are most responsive to the environmental changes and to see to what extent this is similar to such clinical cases as shock or whether this is a simple nondescript stress response.

The rise in the temperature which results in vasodilation is initiated by the body temperature regulating centres. These act like a thermostat. This rise in temperature is similar to the situation with bacterial and viral infections in which profound vascoconstriction occurs followed by shiverings. Following this the temperature rises to a new level which is the state of fever. Once the new temperature reaches the skin, vessels will dilate and the human being will appear flushed. When the infection is terminated the body temperature returns to normal causing a marked sweating to enable heat to be lost quickly.

An important feature which is worth mentioning because of its clinical importance is that in the hot exposure (40°C) after the initial sweat period, the body retained water especially during the twenty four hours exposure. Retaining this fluid resulted in the observed constant level of packed cells volume. This retention of water caused haemodilution of the blood. When this diluted blood perfused the cranial circulation, diffusion of water into cerebral fluid occurred causing cerebral oedema, resulting in the characteristic symptoms of headache and mental confusion/disorientation.

While the purposes of this study have been to observe normal responses to laboratory experiments in normal people, the results can be seen from the foregoing discussion to have similar causes to many clinical symptoms. Perhaps the major mechanisms involved are directly related in the transient conditions of these experiments and the unrelieved continued conditions in clinical disorders. Thus it may be possible to predict physiological abnormalities which may occur to normal people over-exposed to environmental conditions to which they cannot acclimate and suggest that an inability to acclimate has a direct parallel with clinical malfunction and may need similar therapeutic treatment for recovery.

7. CONCLUSION

7. The effects of heat and cold on the physiological systems has been shown in this study. As seen in the results the physiological processes involved counteract the effects of stress due to environmental changes through adaptation to keep the body homeostasis.

1. Incomplete adaptation was observed during the short-term exposures. Freaturesof adaptation observed were:

I Hot

(i) Conservation of salt indicated by reduction of urinary Na^+ and Cl^- concentration. Similar reduction of urinary K^+ was achieved. Reduction in sweat Na^+ and K^+ was observed.

(ii) Decrease in urinary minute volume.

(iii) Decrease in Na^+/K^+ ratio.

(iv) Gradual decrease in heart rate.

(v) Decrease in sweat rate during exposure.

(vi) Decrease in skin temperature.

(vii) Decrease in P.C.V. and red blood cell count together with an increase in white blood cell count.

II Cold

(i) Initial increase in Na^+, K^+ and Cl^- levels due to cold induced diuresis followed by a decrease due to conservative mechanisms operating.

(ii) Increase in urinary minute volume.

(iii) Decrease in heart rate.

(iv) Increase in haemoglobin, P.C.V., red blood cell and white blood cell counts.

2. Na^+, K^+, Na^+/K^+ were a direct reflection of the environmental conditions. The higher the temperature and humidity the higher the values of these parameters.

3. Sweat Na^+, K^+ and sweat rate were higher at high temperature and humidity. The values of these parameters were higher with subjects at work than those at rest.

4. Heart rate levels increased with temperature. Subjects at work showed higher heart rates than those at rest.

5. 24 hours exposure showed fluctuations similar to diurnal variation, with more retention of Na^+, K^+, Cl^- and water.

6. After initial increases in skin temperature, little variability was shown during the last 6-8 hours of the 24 hours exposure.

7. Creatinine values showed little variability during all exposures.

8. Urea values were fluctuating during the exposures with an initial increase at the beginning of each exposure.

9. There were similarities between the changes noticed in this study and changes associated with clinical disorders.

8. RECOMMENDATION FOR FURTHER WORK

8. If further work is to be conducted in this field of study, I suggest the following points:

1. Further direct study is needed of the mechanisms of sweat gland function and of the effect of hormones of the adrenal cortex on both sweat gland and kidney, to understand the differences in the handling of salt by these two organs. Such experiments must take into consideration both the amount of salt consumed by subjects during exposure and their habitual use of salt as a flavouring material.

2. More investigation should be carried out in order to find the effect of short or long exposure to heat and cold on 17-Ketosteroids and 17-hydroxycorticosteroids in an attempt to obtain an index of stress. Such studies should be carried out many times on the same subjects using a rather constant diet and taking into consideration sex, age, race, nutrition or body size and behaviour characteristics of the subjects.

3. Further to this study and to previous studies the role and involvement of the endocrines in adaptation to heat and cold is very close. Such involvement leads one to postulate that since heat and cold affect endocrine activity then a change in hormone level due to a change in environmental condition will lead to a change in metabolic pathway generally and the activity of the enzyme activated by the hormone under study in particular. Thus an intensive enzymological study should be carried out in search of the effect of changes in environmental conditions on enzymes.

Eventually one must aim at a general "autonomic" description of the process of acclimatization. It is obvious that acclimation,

when complete, involves a dynamic equilibrium between the environment and the organism in a way that biochemical analyses of hormones and enzyme systems cannot describe completely. Many environmental factors operate through psychological responses which act via the autonomic system and only much later may be associated with hormonal changes. At the present time there are too few measurements of general autonomic response available and future research must be devoted to developing more methods.

ADDENDUM

This equation could cover the interrelationship of a 'cold index'.

$$\% \text{ Creatinine} = C \times T + C \times M.S.T. + C \times T_D + F$$

% Creatinine	=	the percentage of the difference in creatinine level between 24 hours sample and exposure sample
C	=	constant
T	=	exposure Temperature (C)
M.S.K.	=	Mean Skin Temperature during exposure
T_D	=	Difference in Temperature between subject's acclimation temperature and experimental temperature
F	=	function of humidity and air velocity

The final form of this equation will be reached by a standard partial regression coefficient, of each of the parameters involved.

9. REFERENCES

REFERENCES

Abramson, D.I. (1961) - Changes in blood flow oxygen uptake and tissue temperatures produced by the topical application of wet heat. Arch. Phys. Med. 42: 305-18.

Adam, J.M. (1960) - Physiological responses to hot environments. Med. Res. Counc. Spec. Rep. (London) 298:180-201.

Adam, J.M. and Ellis, F.P. (1960) - The effects of environmental stress: measurements on artificially acclimatized men. Med. Res. Counc.Sp Rep.(London) 298: 39-74.

Adams, T. (1960) - The control body temperature. USAF Arctic Acromed. Lab. TR 59, 21:1-32.

Adolf, E.F. and Dill, D.B. (1938) - Observations on water metabolism in the desert. Am. J. Physiol. 123: 369:377.

Allan, J.R. and Wilson, C.G. (1971) - Influence of acclimatization on sweat sodium concentration. J. Appl. Physiol. 30(5): 708-712.

Andersen, K.P. (1960) - (Adaptation to cold: comparative physiology). Nord. Med. 64: 994-1002

Arnett, E.L. and Watts, P.T. (1960) - Calecholamine excretion in men exposed to cold. J. Appl. Physiol. 15: 499-500.

Astrand, P.O. and Rodahl, K. (1970) - Textbook of work Physiology. McGraw-Hill, New York.

Auerbach, T. (1962) - On the problem of the concept of disease. Z. Aerzti Fortbild.(Berlin) 56: 1116-20.

Azer, N.Z., McNall, P.E. and Leunch, C. (1972) - Effect of heat stress on performance. Ergonomics. 13(6): 681-691.

Azuma, T. (1961) - Studies of cold tolerance. Endocr. Jap. 8: 50-6.

Baker, D.G. (1960) - Influence of cold exposure on electrolyte metabolism. Fed. Proc. 19 (supply 5): 125-30.

Baldwin, E. (1967) - Dynamic Aspects of Biochemistry. (5th Ed.) Cambridge University Press.

Barltrop, D. (1954) - The relation between body temperatur and respiration. J. Physiol. 124:19-20

Bartter, F.C. (1956) - Metabolism. 5: 369.

Bass, D.E. (1963) - In Temperature - Its measurement and control in science and Industry. Vol.3, Part 3, Reinhold Publication, N.Y.

Bass, D.E., Kleeman, C.R., Quinn, M., Henschel, A. and Hegnauer, A.H. (1955) - Mechanisms of acclimatization to heat in man. Medicine. 34:323-380.

Belding, H.S. (1962) - Hazards to health - work in hot weather. New Engl. J. Med. 266:1052-4.

Belding, H.S. (1960) - Laboratory simulation of a hot industrial job to find effective heat stress and resulting physiological strain. Am. Ind. Hyg. Assoc. J. 21:25-31.

Belk, W.P. and Sunderman, F.W. (1947) - A survey of the accuracy of chemical analyses in clinical laboratories. Am. J. Clin. Path. 17: 853-61.

Beller, G.A. et al. (1975) - Changes in serum and sweat magnesium levels during work in the heat. Ann. Space Envir. Med. 46(5):709-12.

Benzinger, T.H. (1960) - The sensory receptor organ and quantitative mechanism of human temperature control in warm environments. Fed. Proc. 19 (Supply 5): 32-43.

Benzinger, T.H. (1961) - The Thermostatic control of human metabolic heat production. Proc. Nat. Acad. Sci. (USA). 47: 730-9.

Bertrand, E. (1976) - Adaptation to heat, especially concerning sodium equilibrium and hemodynamics. Semaine des Hopitaux de Paris. 52 (35): 1937-42.

Blair-West, J.R., Coghlan, H.P., Denton, D.A. Goding, J.R., Wintour, M. and Wright, R.D. (1963). - The control of aldosterone secretion Recent Progr. Hormone Res. 19:311-383

Botsford, J.H. (1971) - A wet globe thermometer for environmental heat measurement. Am. Ind. Hyg. Assoc. J. 32: 5-10.

Botzum, G.D. and Dorsey, C.P.- (1974) Determination of job heaviness and heat exposure in two industrial tasks. Am. Ind. Hyg. Assoc. J. 362-365.

Bratschi, G.W. - An investigation of human mental and moter responses to heat stress. U.S. Government Report A.D. 669-699.

Brebner, D.F. (1961) - The effect of altering the skin temperature of the legs on the forearm sweat rate. J. Physiol. 157: 363-9.

Brown, J.J., Davies, A.F.L. - and Robertsen, J.I.S. (1964) Influence of Na deprivation and loading on the plasma renin in men. J. Physiol. 173: 408.

Brück, K. (1976) - Cold adoption in man, In: Jansky, L and Musacchia, X.J. (Editors) Regulations of depressed metabolism and thermogenesis. SPrigfield Ill. Thomas.

Burns, D.M. and - Physics for Biology and Premedical
MacDonald, S.G.G. (1970) Students. London: Addison Wesley.

Burton, A.C. and - Man in a Cold Environment.
Edholm, O.G. (1955) London: Arnold.

Cantarow, A., and - Biochemistry. Saunders Publ.
Shepartz, B. (1965)

Carlson, L.D. (1960) - Human tolerance to cold. J. Occup. Med. 2: 129-31.

Carlson, L.D. and - Human acclimatization to cold, a
Tunish, H.C. (1960) selected annotated bibliography of the concepts of adaptation and acclimatization as studied in man. USAF Arctic Acromed. Lab. TR 59-18: 1-133.

Carlsten, A., Gustafson, A. - Hemodynamic influence of warm and
and Werko, L. (1961) dry environment in man with and without rheumatic heart disease. Acata Med. Scand. 169: 411-417.

Chaffee, R.R.J. and - Temperature acclimation in birds
Roberts, J.C. (1971) and mammals. Ann. Rev. Physiol. 33: 155-202.

Chapman, E.S. et al. (1976) - Protein changes in response to temperature stress in Papulaspora thermophila. Mycologia (New York) 68 (3): 678:81.

Chiles, W.D. (1958) - Effect of elevated temperatures on performance of a complex mental task. Ergonomics. 2(1): 89-96.

Clans Walker, J. et al (1974) - Physiological responses to cold stress in healthy subjects and in subjects with cervical cord injuries. Arch. Phys. Med. Rehabil. 55 (11): 393-400.

Collins, K.J., Hellamn, K., Jones, R.M., and Lunnon,B.J. (1955) - Aldosterone activity in the urine of men exposed to hot environments. J. Endocrinol. 13:8.

Collins, K.J. and Weiner,J.S. (1968) - Endocrinclogical aspects of exposure to high environmental temperatures. Physiol. Reviews. 48 (4): 785-839.

Collins, K.J. and Weiner,J.S. (1962) - Observation on arm bag suppression of sweating and its relation to thermal sweat gland 'fatigue' J. Physiol 161: 538-556.

Conn,E.E. and Stumph, P.K. (1972) - Outlines of Biochemistry. Wiley.

Conn, J.W. (1949) - The mechanism of acclimatization to heat. Advances in Internal Med. 3: 373-393.

Conn, J.W., Louis, L.H., Johnston, W.W. and Johnston, B.J. (1948) - The electrolyte content of thermal sweat as an index of adrenal cortical function. J. Clin. Invest. 27: 529.

Cooper, K.E. (1961) - The Circulation in hypothermia. Brit. Med. Bull. 17: 48-51.

Cotes, J.E. and Meade, F. (1958) - Ventilatory response to a rise in body temperature in relation to other physiological variables. J. Physiol. 140: 55p.

Courau, P.J. (1962) - Work in the presence of heat. Can. Med. Interprof. 2:37-46.

Damato, A.N., Lau, S.H., Stein, E., Haft,G.I., Kosowsky, B. and Cohen, S.I. (1968) - Cardiovascular response to acute thermal stress (hot dry environment) in unacclimatized normal subjects. Am. Heart J. 769-774.

Davidsohn, I. and Henry,J.B. (Eds.) (1969) - Todd-Sanford Clinical Diagnosis by Laboratory Methods. 14th Edition. W.B. Saunders Company.

Davis, T.R. (1961) - Chamber cold acclimatization in man. J. Appl. Physiol. 16: 1011-5.

Davis, T.R. (1961) - Chamber cold acclimatization in man. U.S. Army Med. Res. Lab. Rep. 475:1-8.

Davis, T.R. (1961) - The effect of heat acclimatization on artificial and natural cold acclimatization in man. U.S. Army' Med. Res. Lab. Rep. 495:1-7.

Davis, T.R. (1974) - Effects of cold on animals and man. Prog. in Biometerology. 1(1A): 215-27, 633-4.

Davis, T.R. (1974) - Effects of heat on animals and man. Prog. in Biometerology. 1(1A): 228-38, 635-7.

Davis, T.R. (1960) - Experimental cold acclimatization in man. U.S. Army Med. Res. Lab. Rep. 457:1-8.

Davis, T.R. (1961) - Seasonal acclimatization to cold in man. J. Appl. Physiol. 16: 231-4.

Davis, T.R. and Joy, R.J. (1961) - Natural and artificial cold acclimatization in man. U.S. Army Med. Res. Lab. Rep. 474: 62-84.

Davydovsky, (1964) - Adaptive processes in pathology. Medical biological aspect of the problem. Cesk Hg. 9: 328-35.

Delahate, R.P. and Gavanoll, J. (1961) - Acclimatization reactions and reaction to acclimatization to the Sahara climate. Bull. Soc. Med. Milit. France. 55: 302-11.

Depocas, F. (1961) - Biochemical changes in exposure and acclimation to cold environments. Brit. Med. Bull. 17: 25-31.

Dexter, E.M. (1974) - Mechanism of Body Functions. 2nd Edition. Prentice-Hall, Inc.

Dill, D.B. (1938) - Life, Heat and Altitude. Cambridge, Mass., Harvard University Press.

Dill, D.B. et al. (1973) - Responses of men and women to two hour walks in desert heat. J. Appl. Physiol. 35: 231-5.

Dobson, R.L. (1960) - The effect of repeated episodes of sweating, on the human eccrine sweat glands. J. Invest.Dermatol. 35: 195-198.

Dobzhansky, T. (1961) - Adaptation in man and animals, a synthesis. Am. NY Acad. Sci. 91:634-6.

Drinkwater, B.L. et al. (1976) - Thermoregulatory response of women to intermittent work in the heat. J. Appl. Physiol. 41(1): 57-61.

Dugal, L.P. (1961) - Environmental physiology research supported by the Canadian Defence Research Board. U.S. Army Med. Res. Lab. Rep. 474: 7-15.

Eberchard, A. et al. (1972) - Immunological analysis in persons working in high temperature environment. Acta Physiol.Pol. 23:327-35.

Edholm, O.G. (1959) - Adaptation of man and animals to their environment. Proc. Roy. Soc. Med. 52: 680.

Edholm, O.G. (1960) - (Some effects of cold on man). Dia. Med. 32: 896-906.

Edholm, O.G. and Bacharach, A.L. (1965) - The Physiology of Human Survival. Academic Press.

Edwards, M. and Burton, A.C. (1960) - Correlation of heat output and blood flow in the finger, especially in cold-induced vasodilation. J. Appl. Physiol. 15: 201-8.

Edwards, M. and Burton, A.C. (1960) - Temperature distribution over the human head, especially in the cold. J. Appl. Physiol. 15: 209-11.

Eichna, L.W., Bean, W.B., Ashe, W.F. and Nelson, N. (1945). - Performance in relation to environmental temperature. Bull. John Hopk. Hosp. 76: 25-58.

Eichna, L.W. and Others (1950) - Thermal regulation during acclimatization to hot dry environment Am. J. Physiol. 163: 585.

Eisalo, A. (1956) - Effects of the Finnish sauna on circulation. Studies on healthy and hypertensive subjects. Ann. Med. Exptl. Biol. Fennial, Helsinki, 34, Suppl. 4: 7-96.

Ellis, F.P. (1960) - The upper limits of tolerance of environmental stress. Med. Res. Counc. Spec. Rep. (London) 298:158-79.

Erler, C. Von (1961) - Physiology and pharmacology of temperature regulation. Pharmacol. Rev. 13: 361-98.

Fanger, P.O. (1970) - Thermal Comfort. Danish Technical.

Farrell, G.L., Rosnagle, R.S. and Rausckolls, E.W. (1956) - Increased aldosterone secretion in response to blood loss. Circulate. Res. 4: 606-611.

Finberg, J.P. et al. (1974) - Plasma renin activity after acute heat exposure in non acclimatized and naturally acclimatized man. J. Appl. Physiol. 36: 519-23.

Fletcher, K.A., Leithead, C.S., Deegan, M.A., Pallister, T., Lind, A.R. and Macgrath, B.G. (1961) - Aldosterone secretion in acclimatisation to heat. Ann. Trop. Med. Parasitol. 55: 498-504.

Fox, R.H. (1965) - Heat in The Physiology of Human Survival, edited by Edholm, O.G. and Bacharach, A.C. Academic Press. London. New York.

Fox, R.H. and Goldsmith, P. (1963) - Acclimatization to heat in man by controlled elevation of body temperature. J. Physiol. 166: 530-47.

Frada, G. (1959) - Influence of stress and environmental hyperthermia on renal function. Boll. Soc. Ital. Biol. Sper. 35: 1586-8.

Francis, T. (Jr.) (1961) - Biological aspects of environment. Indust. Med. Sury. 30: 374-9.

Frewin, D.B. et al. (1973) - The effect of heat, cold and exercise on plasma dopamine - beta - hydroxylase, activity in man. Can. J. Physiol. Pharmacol. 51:986-9.

Fric. J. (1959) - Effect of cold on changes in circulation rates as measured by means of an oxemetric method. Cerk. Fysiol. 8: 401-2.

Furman, K.I. and Beer, G. (1963) - Dynamic changes in sweat electrolytes composition induced by heat stress as an indication of acclimatization and aldosterone activity. Clin. Sci. 24: 7-12.

Fusco, M.M. (1961) - Interaction of central and peripheral factors in physiological temperature regulation. Am. J. Physiol. 200: 572-80.

Gabter, W.A. et al. (1973) - Effects of high altitude exposure on components of blood and urine in mountaineers. In. J. Biometeor. 18: 23-32.

Ganong, W.F. (1973) - Review of Medical Physiology 6th Edition. Lange Medical Publications.

Gary, S.K. et al. (1972) - The increased percentage of megathrombocytes in various clinical disorders. Ann. Inten. Med. 77: 361-9.

Gerkings, S.D. and Robinson, S. (1946) - Decline in the rate of sweating of men working in severe heat. Am. J. Physiol. 147: 681-686.

Giec, L. (1961) - The effect of humid heat on the electrolyte water balance in man. Acta Med. Pol. 2: 346-51.

Gisolfi, C.V. (1973) - Work-heat tolerance derived from interval training. J. Appl. Physiol. 35: 349-54.

Givoni, B. et al. (1973) - Predicting effects of heat acclimatization on heart rate and rectal temperature. J. Appl. Physiol. 35: 875-879.

Gonzalez, R.R. et al. (1974) - Heat acclimation and decline in sweating during humidity transients. J. Appl. Physiol. 36: 419-25.

Green, J.H. (1972) - An Introduction to Human Physiology. Oxford Medical Publications.

Grether, W.F. (1971) - Effect of combined heat, noise and vibration stress on human performance and physiological functions. Aerospace Medicine 42(10): 1092-1097.

Grether, W.F. (1972) - A further study of combined heat, noise and vibration stress. Aerospace Medicine. 43(6): 641-645.

Grether, W.F. (1973) - Human performance at elevated environmental temperatures. Aerospace Medicine. 44(7): 747-755.

Grollman, S. (1974) - The human body. 3rd Edition. Macmillan Publishing Co. Inc.

Guyton, A.C. (1972) - Structure and Function of the Nervous System. London: W.B. Saunders.

Gwozdz, B. (1962) - (Level of 17-hydroxycorticosteroids (17-OHST) in the blood of human subjects exposed to thermal stress). Endokr. Pol. 13: 275-86.

Hajjakova, M. (1962) - Excretion of vitamin B, in sweat during work in a hot environment. Cesk Gastroent Vyz. 15: 95-101.

Haldane, J.S. (1905) - The influence of high air temperature. NIJ Hyg. Camb. 5: 494-513.

Hale, F.C. Westland, R.A. and Taylor, C.L. (1958) - Barometric and Vapor pressure influences on insensible weight loss. J. Appl. Physiol. 12: 20-28.

Hale, H.B. and Ellis, J.P. (1962) - Excretion trends in men undergoing deacclimatization to heat. J. Appl. Physiol. 17: 456-60.

Hall, S.A. (1971) - Heat stress in outdoor manual workers in East Africa. Ergonomics 14: 91-4.

Hannon, J.P. (1960) - Plasma electrolyte changes during simulated Arctic survival conditions. U.S. Armed Forces Med. J. 11:676-81.

Hardy, J.D. (1961) - Physiology of temperature regulation. Physiol. Rev. 41: 521-606.

Harper, H.A. (1971) - Physiological Chemistry. Lange Medical Publications.

Harper, H.A. (1965) - Review of Physiological Chemistry. Blackwell Scientific Publ. Oxford.

Hart, J.S. (1960) - Energy metabolism during exposure to cold. Fed. Proc. 19 (supply 5): 15-19.

Hellman, K., Collins, K.J., Gray, C.H., Jones, R.M., Lunnon, J.B. and Weiner, J.S. (1956) - J. Endicrinol. 14: 209. Aldosterone activity in the Urine of man exposed to hot environments.

Henry, R.J., Cannon, D.C., and Winkelman, J.W. (1974) - Clinical Chemistry - Principles and Technics. 2nd Edition. Harper and Row, Publishers.

Hertig, B.A. (1971) - Human physiological responses to heat stress, males and females compared. J. Physiol. (Paris) 63(3): 270-273.

Hertzman, A.B. (1959) - Vasomotor regulation of cutaneous circulation. Physiol. Rev. 39:280-306.

Hoar, W.S. (1966) - General and Comparative Physiology. Prentice-Hall, Inc.

Horvath , S.M. and Howell, C.D., (1964) - Organ systems in adaptation: The cardiovascular system, in Handbook of Physiology section 2: circulation. Eds. Hamilton, W.F. and Dow, P. Washington.

Hunter, J.C. (1961) - Effect of environmental hyperthermia, on man and other mamals - a review. Milit. Med. 126: 273-81.

Iampietro, P.F. (1961) - Prediction of skin temperature of men in the cold. J. Appl. Physiol. 16: 405-8.

Iampietro, P.F. (1959) - Response of negro and white males to cold. J. Appl. Physiol. 14:798-800.

Iampietro, P.F. (1971) - Temperature and tolerance during exposure to hot and cold environments. J. Physiol (Paris). 63:282-4.

Iampietro. P.F. and Vaughan, J.A. (1960) - Heat production from shivering. J. Appl. Physiol. 15: 632-4.

Irving, L. (1960) - Human adaptation to cold. Nature (London). 185: 572-4.

Ismail-Beigi, F. and Edelman, I.S. (1970) - Mechanism of calorigenic action of thyroid hormone: role of sodium transport. Fed. Proc. 29 (1881): 582.

Itoh, S. (1960) - Physiological responses to heat in Essential Problems in Climatic Physiology. Eds. Yoshimura, H., Ogata, K. and Itoh, S. Kyoto: Naukodo.

Johnson, R.E., Pitts, G.C., and Consolazio, F.C. (1944) - Appl. J. Physiol. 142: 253. Work in heat as affected by intake of water salt and glucose.

Jones, R.D. (1970) - Effect of thermal stress on human performance - a review and critique of existing methodology. Human Eng. Labs. Aberdeen Proving ground Maryland Tech. Mun. 11-70.

Kamon, E. et al. (1976) - Physiologic limits to work in the heat and evaporative coefficient for women. J. Appl. Physiol. 41(1): 71-6.

Keele, C.A. and Neil, E. (1973) - Samson Wright's Applied Physiology Oxford Medical Publication.

Keidal, W.D. (1961) - (Ranke's adaptation theory). Z. Biol 112: 411-25.

Kenney, R.A. (1963) - Renal function under tropical condition. Intern. Rev. Med. 2: 294-328.

Kenney, R.A. and Miller,D.H. (1949) - Effects of environmental temperature on water output and the pattern of chloride excretion. Acta. Med. Scand. 135: 87-90.

Kerslake, D. Mck. (1972) - The Stress of Hot Environments. Cambridge University Press.

King, B.A. (1962) - Temperature regulation and acclimatization. Thoughts on heat illness. The clinical features of salt-depletion heat exhaustion . Proc. Mine Med. Officers. Ass 42: 6-13.

Koroxenidis, G.T., Shepherd, J.T. and Marshall, R.J. (1961) - Cardiovascular response to acute heat stress. J. Appl. Physiol. 16: 869-872.

Kozlowski, S. et al. (1972) - Changes in blood vasopressin (ADH) level in man during short-term exposure in high ambient temperatures. Pol. Arch. Med. Wewn.48: 251-6.

Kuch, W. and Jennings, B.H. - Is humidity important in the temperature comfort range. ASHRAE J. 2(4): 63.

Laborit, H. (1959) - Opinions concerning fatigue and the adaptation of man to heat: acquired results and current trend of research in the Navy. Rev. Med. Na. 14: 217-36.

Ladell, W.S.S. (1951) - Assessment of group acclimatization to heat and humidity. J. Physiol 115: 296-312.

Ladell, W.S.S. (1957) - Disorder due to heat. Trans. Roy. Soc. Trop. Med., and Ayg. 51: 189-207.

Ladell, W.S.S. (1964) - Terrestrial animals in humid heat: man, in Handbook of Physiology, Section 4: Adaptation to the Environment. Eds. Dill, D.B., Adolph, E.F. and Wilber, C.G. Washington.

Lambert, G and Ruffee, J. (1960) - The adaptation of the organism and life in the warm countries. Toulouse Med. 61: 567-92.

Landis, E.M., Long, W.L., Dunn, J.W., Jackson, C.L. and Meyer, U. (1926) - Studies on the effects of baths on man. III Effects of hot baths on respiration, blood and urine. Am. J. Physiol. 76:35-48.

Langley, W. and Evans, M. (1936) - The determination of creatinine with sodium 3, 5 dinitrobenzoate. J. Biol. Chem. 115: 333-341.

Latièr, V.G. and Weiss, B. (1960) - Behaviour in the cold after acclimatization. Science.131:1891-2.

Le Blanc, J. (1962) - Peripheral circulation in cold climate. Amer. Heart J. 63: 287-9.

Le Blanc, J. et al. (1975) - Autonomic nervous system and adaptation to cold in man. J. Appl. Physiol. 39(2): 181-6.

Lehmann, G. (1960) - Physiological bases of human work in high temperatures. Concours. Med. 82:2383-8.

Leithead, C.S. (1963) - Water and electrolyte metabolism in the heat. Fed. Proc. 22(1): 901-904.

Leithead, C.S. and Lind, A.R. (1964) - Heat Stress and Heat Disorders. Philadelphia, P2: Davis. p. 304.

Levi, L. (1971) - Definition and evaluation of Stress. Publ. F.K. 7-14. (Oslo). Schathauer Verbag, Stuttgart, New York.

Lewis, S.M. et al., (1971) - Effect of anticoagulants and containers (glass and plastic) on the blood count. Lab. Pract. 20: 787-92.

Liddle, G.W., Bartter, F.C., Duncan, L.E., Baber, J.K. and Delea, C. (1955) - Mechanism regulating aldosterone production in man. J. Clin. Invest. 34: 949-950.

Lind, A.R. (1960) - The effect of heat on the industrial worker. Ann. Occup. Hyg. 2: 190-207.

Lind, A.R., (1964) - Heat Stress and Heat Disorders. Leithead, C.S. and Lind, A.R. London: Churchill.

Lind, A.R. (1963) - Physiological effect of continuous or intermittent work in the heat. J. Appl. Physiol. 18(1): 57-60.

Linden, R.J. (Ed.) (1974) - Recent Advances in Physiology. 9th Edition. Churchill Livingstone.

Lloyd, D.P. (1961) - Temperature and the action of sweat glands. Proc. Nat. Acad. Sci. (USA) 47: 358-62.

Love, A.H. (1962) - The relationship between the onset of sweating and vasodilation in the forearm during body heating. J. Physiol. 162: 121-8.

Lovett-Doust, J.W. (1973) - Metabolic control of body temperature in man. Int. Pharmacopyschiatry. 8(4): 239-244.

McArdle, B., Dunham,W., Hollong, H.E., Ladell, W.S.S. Scott, J.W., Thomson, M.L. and Weiner, J.S. (1947) - The production of the physiological effects of warm and hot environments. Rep. N. RNP 47/391, Med. Res. Council, London.

McCance, R.A. (1938) - Effect of salt deficiency on the volume of the extracellular fluids, and on the composition of sweat,saliva, gastric juice and cerebrospinal fluid. J. Physiol. 92: 208-218.

McCance, R.A. et al., (1971) - The response of normal men and women to changes in their environmental temperatures and ways of life. Philos. Trans. Roy. Soc. London 259: 533-65.

Macfarlane, W.V. (1974) - Acclimatization and adaption to thermal stress. in Progress in Biometeorology. (Amsterdam). Swets and Zeitlinger.

Macfarlane, W.V. (1956) - Urinary sodium-potassium ratios in hot environments. The Medical J. of Australia. 2: 139-140.

Macfarlane, W.V., and Robinson, K.W. (1957) - Decrease in human excretion of 17-ketogenic steroids and 17-ketosteroids with increasing ambient temperature. J. Appl. Physiol. 11(2): 199-200.

MacGraith, B.G. (1959) - Life in Hot Climate. Trans. Med. Soc. (London) 75: 45-55.

McIntyre, D.A. and Griffiths, I.D. (1975) - Subjective Response to Atmospheric Humidity. Envrion. Res. , 9:66-75.

McKarns, J.S. and Briefs, R.S. (1966) - Nomographs give refined estimates of heat stress index. Heating, piping and air conditioning. Jan: 113-116.

McNall, P.E. Jr., and Ryan, P.W. (1968) - Water consumption during 24 hour exposure to hot humid environment. ASHRAE J. March.

MacPherson, R.K. (1956) - Effects of environmental heat stress on diurnal variation in body temperature. J. Physiol. 137:66.

MacPherson, R.K. (1960) - Physiological responses to hot Environments. Med. Res. Council Special Rep. Sci. No. 298. HMSO London.

MacPherson, R.K. (1973) - Thermal stress and thermal comfort. Ergonomics. 16(5): 611-613.

Maher, J.T., Bass, D.E., Heistad, D.D., Angelakos, E.T. and Hartley, L.H. (1972) - Effect of posture on heat acclimazation in man. J. Appl. Physiol. 33:8-13.

Marcus, P. (1972) - Heat acclimatization by exercise-induced elevation of body temperature. J. Appl. Physiol. 33: 283-8.

Mefferd, R.B. (Jr.) (1959) - Adaptive changes to moderate seasonal heat in human subjects. J. Appl. Physiol. 14: 995-6.

Mellette, Hutt, et al. (1951) - Diurnal variation on Body Temperatures J. Appl. Physiol. 3: 665.

Merck, E. (1970) - Clinical Laboratory Medico-Chemical Investigation Methods. Darmstadt, June 1970.

Meyerstein, N. et al. (1974) - Effect of controlled heat acclimation on the human red blood cell. Aerospace Medicine. 45: 727-9.

Miller, S.E. and Weller, J.M. (1971) - Textbook of Clinical Pathology. W. & W. Co. Baltimore, Maryland, USA.

Mitchell, D. et al. (1976) - Acclimatization in a hot, humid environment: energy exchange, body temperature and sweating. J. Appl. Physiol. 40(5): 768-78.

Molotkov, O.V. et al. (1972) - Effect of heat on corticosterone level and binding capacity of blood plasma proteins. Biol. Med. 73:44-7.

Morimotto, T. et al. (1974) - Seasonal difference in responses of body fluids to heat stress. Jap. J. Physiol. 24 (3): 249-62.

Morrison, D.F. (1967) - Multivariate statistical Methods. McGraw-Hill. Publ.

Moses, J.B. (1960) - The physiological effects of heat, Indust. Med. Sury. 29: 20-3.

Moss, K.J. (1923-1924) - Proc. Roy. Soc. B95: 181. In Peter, J. and Wyndham C.H. (1966). Activity of the human eccrine sweat gland during exercise in a hot humid environment before and after acclimatisation. J. Physiol. 187:583-594.

Murphy, A.J. (1960) - The physiological effects of cold application. Phys. Ther. Rev. 40:112-5.

Murray, R.H. and McCally, M. (1973) - Combined environmental stresses, in, Bioastronautics Data Book. Scientific and Technical information office. NASA, Washington D.C. Ch. 19.

Mutchler, J.E. et al. (1976) - An improved method for monitoring heat stress levels in the workplace. Am. Ind. Hyg. Assoc. J. 37(3):151-64.

Nadel, E.R. et.al. (1974) - Mechanisms of thermal acclimation to exercise and heat J. Appl .Physiol. 37(4): 515-20.

Nelms, J.D. et al. (1972) - A self-regulating method for rapid acclimatization to heat. J. Physiol. 221: 2P-3P.

Nevins, R.G., Rohles, F.H., Springer, W. and Feyerherm, A.M. (1966) - A temperature-humidity chart for thermal comfort of seated persons. ASHRAE J. April. 55-61.

Newburgh, L.H. (1968) - Physiology of Heat Regulation. London: Hafner.

Newman, M.T. (1961) - Biological adaptation of man to his environment: heat, cold, altitude, and nutrition, Am. NY Acad. Sci. 91: 617-33.

Ordinanz, W. (1970) - Work in hot environments and protection against heat. Iron and Steel Institute, London.

Palma, G. (1962) - Thermal comfort and acclimatization to cold in a subanarctic environment. Med. J. Aust. 49(1): 9-12.

Parab, P.L. et.al. (1973) - Diurnal variations in the composition of blood and urine in Indians from warm and humid climate. Indian J. Med. Sci. 27:836-42.

Passmore, R. and Rcbson, J.S. (Editors) (1976) - A Companion to medical studies - in three volumes, 2nd Edition. Blackwell Scientific Publications.

Pearcy, M. (1956) - Effects of dehydration, salt depletion and pitressin on sweat rate and urine flow. J. Appl .Physiol. 8: 621-626.

Peter, J. and Wyndham, C.H. (1966) - Activity of the human eccrine sweat gland during exercise in a hot humid environment before and after acclimatization. J. Physiol. 187: 583-594.

Pitts, G.C, Johnson, R.E., and Consolazio, C.F. (1944) - Work in the heat as affected by intake of water, salt and glucose. Am. J. Physiol. 142: 253.

Platner, W.S. (1960) - Electrolytes in acclimation to cold. Fed. Proc. 19 (Supply 5): 130-5.

Plonski, J. (1959) - Effect of high temperature on the human organism. Effect of humid heat on physical work capacity. Pol. Tyg. Lek. 14: 2163-6

Polis, B.D. et al. (1974) - The effect of cold on the composition of phospholipids of the blood plasma of healthy atheletes. Proc. Soc. Exp. Biol. Med. 145: 70-73.

Prosser, C.L, (1964) - Comparative physiology and biochemistry status and prospects. VR Comp. Biochem. Physiol. 11: 379-86.

Prosser, C.L. (1969) - Principles and general concepts of adaption. Environmental Res. 2: 404-16.

Radigan, L.R. and Robinson, S. (1949) - Effect of environmental heat stress and exercise on renal blood flow and filtration rate. J. Appl. Physiol. 2: 185-191.

Randall, W.C. and Peis, C.N. (1957) - The relationship between skin hydration and suppression of sweating. J. Invest. Dermatol. 28: 435-441.

Randall, W.C., Peiss, C.N. and Rawson, R.O. (1958) - Simultaneous recruitment of sweating and perception of warmth in man. J. Appl. Physiol. 12: 385-389.

Rawson, R.O. (1961) - Vascular and sweating responses to regional heating of the body surface J. Appl. Physiol. 16: 1006-10.

Raymond, V. (1959) - Work in heat. Arch. Mal. Prof. 20: 797-804.

Richards, S.A. (1973) - Temperature Regulation, Wykeham Publications (London) Ltd.

Robertshaw, D. (1974) - Environmental Physiology. London: Butterworths.

Robinson, S. (1968) - Physiological adjustments to heat in Physiology of Heat Regulation, Ed. Newburgh, L.H. Hafner Publ. Co.

Robinson, S. (1959) - Work as a stimulus for sweating in man. Fed. Proc. 18:129.

Robinson, S., Dill, D.B., Wilson, J.W., and Nielson, M (1941) - Adaptation of white men and negroes to prolonged work in the heat. Am. J. Trop. Med. 21: 261-287.

Robinson, S., Gerking, S.D. Turrell, E.S. and Kincaid, R.K. (1950) - J. Appl. Physiol. 2: 654. Effect of skin temperature on salt concentration of sweat.

Robinson, S., Kincaid, R.K. and Rhamy, R.K. (1950) - Effects of salt deficiency on the salt concentrations in sweat. J. Appl. Physiol. 3: 55-62.

Robinson, S., Nicholas, J.R., Smith, J.H., Daly, W.J., and Pearcy, M. (1955) - Time relation of renal and sweat gland adjustments to salt deficiency. J. Appl. Physiol. 8: 159.

Robinson, S. and Robinson, A.H. (1954) - Chemical composition of sweat. Physiol Rev. 34: 202-222.

Robinson, S., Turrell, E.S., Belding, H.S., and Harvath, S.M. (1943) - Rapid acclimatisation to work in hot climate. Am. J. Physiol. 140:168-176.

Robinson, S. and Wiegman, D.I. (1974) - Heat and Humidity in Environmental Physiology, edited by Slonim, N.B.

Rowell, L.B. (1974) - Human Cardiovascular adjustments to exercise and thermal stress. Physiol. Rev. 54: 75-159

Rowell, L.B., Kraning II, K.K., Kennedy, J.W. and Evans, T.O. (1967) - Central circulatory responses to work in dry heat before and after acclimatization. J. Appl.Physio 22: 509-518.

Saltin, B. and Hermansen, L. (1966) - Esophagal, rectal and muscle temperature during exercise. J. Appl. Physiol. 21: 1757-1762.

Saxton, C. (1975) - Respiration during heat stress. Aviat. Space Environ. Med. 46(1): 41-46.

Schaff, C. (1961) - Respective effect of muscular work and environmental temperature on the rectal temperature and sweating during work in hot conditions. C.R. Soc. Biol. (Paris) 155: 1112-6.

Schales, O. and Schales, S.S. (1941) - A simple and accurate method for the determination of chloride in biological fluids. J. Biol. Chem. 140: 879-884.

Sellers, E. (1960) - Work in cold environments: cold and its influence on workers. J. Occup. Med. 2: 115-7.

Selye, H. (1971) - The evolution of stress concept - stress and cardiovascular disease in Society, Stress and disease. Vol. 1 L. Levi (Editor), Ch. 28.

Senay, L.C. (Jr.,) (1972) - Changes in plasma volume and protein content during exposures of working men to various temperatures before and after acclimatization to heat. Separation of the roles of cutaneous and skeletal muscle circulation. J. Physiol. (London) 224: 61-81.

Senay, L.C. et al. (1976) - Acclimatization in a hot, humid environment: body fluid adjustments. J. Appl. Physiol. 40(5): 786-96.

Shinski, G.E. (1972) - Peripheral blood indices under normal conditions. Lab. Delo. 5: 264-7.

Schvartz, E. et al. (1972) - Acclimatization to severe dry heat by brief exposures to humid heat. Ergonomics. 15: 563-71.

Shvartz, E. et al. (1973) - A comparison of three methods of acclimatization to dry heat. J. Appl. Physiol.34: 214-9.

Shvartz, E. et al. (1972) - Natural acclimatization to work in severe heat. Aerospace Medicine, 43: 637-40.

Shvartz, E. et al. (1975) - Orthostatism and heat acclimation. J. Appl. Physiol. 39(4): 590-5.

Shvartz, E. et al. (1973) - Physique and heat tolerance in hot dry and hot humid environment. J. Appl. Physiol. 34: 799-803.

Schvartz, E. and Magazanik, A.- Tolerance to heat following cold stress. Aerospace Medicine. 44(7): 725-729.

Smiles, K.A. and Robinson, S. - (1971) Sodium ion conservation during acclimatization of men to work in the heat. J. Appl. Physiol. 31: 63-69.

Smith, J.H., Robinson, S. and Pearcy, M. (1952) - Renal responses to exercise, heat and dehydration. J. Appl. Physiol. 4(8): 659-665.

Smith R.E. (1962) - Cold acclimation on altered steady state. Jama. 179: 948-54.

Snedecor, G.W. and Cochran, W.G. (1967) - Statistical Methods. 6th Edition. Iowa State University Press.

Sokolov, V.V. et al.(1972) - Peripheral blood indices in healthy people. Lab. Delo. 5: 259-61.

Steintz, J. and Türkand, H. (1940) - The determination of the glomerular filtration by the endogenous creatinin cleatance. J. Clin. Invest. 19: 285-298.

Streeten, D.H.P., Conn, J.W., Louis, L.H., Fajans, S.S., Seltzer, H.S., Johnson, R.D., Gittler, R.D. and Dube, A.H. (1960) - Secondary aldosteronism: Metabolic andadrenocortical responses of normal men to high environmental temperatures. Metabolism 9(12): 1071-1092.

Suggs, C.W. and Splinter, W.E. (1961) - Some physiological responses of man to workload and environment. J. Appl. Physiol. 16: 413-420.

Sulman, F.G., Danon, A., Pfeifer,Y., Tal. E. and Weller, C.P. (1970) - Urinalysis of patients suffering from climatic heat stress (Sharav). Int. J. Biometeor. 14(1): 45-53.

Tanaka, M. (1972) - Experimental studies in human reaction to cold with reference to differences between males and females. Bull. Tokyo, Med. Dent. Univ.19:1-18.

Tashpulatov, R.I.V. et al. (1971) - Microbiological and immunological studies of the human oranism in Antarctic conditions. 3. Dynamics of hematopoiesis during a polar expedition. Zh. Mikrobiol. Epidemiol. Immunobiol. 48: 51-3.

Thauer, R. (1964) - Circulatory adjustments to climatic requirements in Handbook of Physiology Section 2: Circulation. Eds. Hamilton, W.F. and Dow. P. Washington.

Thayson, J.H. and Schwartz,I. (1955) - Fatigue of the sweat gland. J. Clin. Invest. 34: 1719-1726.

Thompson and King (Eds.) (1970) - Biochemical Disorder in Human Disease. Churchill.

Thorn, G.W., Ross, E.J., Crabbi, J. and Vant Hoff. (1957) - Studies on aldosterone secretion in me Brit. Med. J. 2: 955-966.

Totel, G.L. (1974) - Physiological responses to heat of resting men with impaired sweating capacity. J. Appl. Physiol. 37(3): 346-52.

Tsugawa, K. (1976) - Direct adaption of cells to temperature: similar changes of LDH isozyme patterns by in vitro and in situ adaption in xenopus laevis. Comparative Biochemistry and Physiology B: Comparative Biochemistry. (London) 55(2): 259-63.

Van Beaumont, W. et al. (1974) - Plasma fluid and blood constituent shifts during heat exposure in resting men. Aerospace Medicine. 45:176-81.

Varley, M. (1967) - Practical Clinical Biochemistry. London: William Heinemann. Medical Books.

Veighte, J.H. (1961) - Body Cooling and response to heat. J. Appl. Physiology. 16: 235-8.

Ventsenostsev, B.B. (1971) - Blood changes in polar workers in the antarctic. Klin. Med. (Moscow). 49: 40-4.

Wagner, J.A. et al. (1972) - Heat tolerance and acclimatization to work in the heat in relation to age. J. Appl. Physiol. 33: 616-22.

Wagner, R. (1961) - (On the history of the problem of biological regulation) Med. Klin. 56: 337-40.

Wakashim, M. (1974) - Immunochemical analysis of immunoglobulin in normal human urine. Jpn. J. Nephrol.16(2): 83-93.

Wakin, K.G. (1959) - Physiologic alteration produced by heat and cold. Med. Arts. Sci. 13: 126-38.

Wakim, K.O. - Bodily reactions to high temperatures. Anaesthesiology 25(4): 532-548.

Walters J.D. - Hot environments - measurement and tolerance estimation. Ann. Occup. Hyg. 17(3-4): 255-264.

Webb, P. (1959) - Human thermal tolerance and protective clothing. Am. NY Acad. Sci. 82: 714-23.

Weidenbacker, R.A. (1960) - Does heat cause relaxation? Phys. Ther. Rev. 40: 261-5.

Weiner, J.S. and Hellman, K. (1960) - The sweat glands. Biol. Rev. 35: 141-178.

Weiner, J.S. and Lourie, J.A. (1969) - Human Biology. IBR Handbook No. 9.

Weiner, J.S. and Van Heyningen, R.E. (1952) - Salt losses of men working in hot enivronments Brit. J. Indust. Med. 9: 56-64.

Weiss, A.K. (1960) - Factors which affect cold acclimatization. Fed. Proc. 19 (Supply 5): 137-8.

Welch, R.B. et al.(1971) - The measurement of fatigue in hot working conditions. Ergonomics 14: 85-90.

Wells, C.L. et al. (1973) - Heat stress responses related to the menstrual cycle J. Appl. Physiol. 35:1-5.

Whiltow, G.C. (1961) - Flow of blood in the forearm of persons acclimatized to heat. Nature (London) 1922: 759-60.

White, W.L., Enckson, M.M. and Stevens, S.C., (1970) - Chemistry for Medical Technologists. 3rd Edition. The C.V. Mosby company, St. Louis.

Wilcott, R.L. (1963) - Effect of high environmental temperature on sweating and skin resistance. J. Comp. Physiol. Psychol. 56: 778-82.

Wilkinson, R.T. and Fox, R.N. (1964) - Psychological and physiological responses to raised body temperature. J. Appl. Physiol. 19(2): 287-291.

Williams, C.G., Bredall, G.A.G., Wyndham, C.H., Strydam, N.B., Morrison, J.F., Peter, J., Fleming, P.W. and Ward, J.S. (1962) - Circulatory and metabolic reactions to work in heat. J. Appl. Physiol. 17: 625-38.

Winkel, P. et al. (1974) - The short term day-to-day variation in serum constituents in healthy subjects. Z. Klin. Chem. Klin. Biochem. 12(5): 269-70.

Wissler, E.H. (1961) - Steady state temperature distribution in man. J. Appl. Physiol. 16: 734-40.

Wolkin, J., Goodman, J.I. and Kelley, W.E. (1944) - Failure of the sweat mechanism in the desert. Thermogenic anhydrosis. J. Am. Med.Ass. 124: 478-482.

Woodward, R.H. and Goldsmith, P.L. - Cumulative Sum Techniques. I.C.I. Monograph, No. 3.

Wooten, G.F. et al. (1973) - Plasma dopamine -hydroxylase activity, Elevation in man during cold pressor test and exercise Arch. Neurol. 28: 103-6.

Wright, S. (1971) - Samson Wright's Applied Physiology. 12th Edition. Revised by C.A. Keele and E. Neil. Oxford University Press.

Wyndham, C.H. (1969) - Adaptation to heat and cold. Environmental Res. 2: 442-69.

Wyndham, C.H. (1967) - Effects of acclimatisation on the sweat rate/rectal temperature relation. J. Appl. Physiol. 22: 27-30.

Wyndham, C.H. (1973) - The physiology of exercise under heat stress. Ann. Rev. Physiol 35: 193-220.

Wyndham, C.H. et al. (1976) - Acclimatization in a hot, humid environment: cardiovascular adjustments. J. Appl. Physiol. 40(5): 779-85.

Wyndham, C.H., Allan, A.McD., Bredell, G.A. and Andrew, R. (1967) - Assessing the heat stress and establishing the limits for work in a hot mine. Br. J. Ind. Med. 24: 255-271.

Wyndham, C.H. and Strydom, N.B. (1965) - Criteria for physiological limits for work in heat. J. Appl. Physiol. 20(1): 37-45.

Wyndham, C.H., Strydom, N.B. Morrison, J.F., Du Toit, F.D. and Kraan, J.G. (1954) - Responses of unacclimatised men under stress of heat and work. J. Appl. Physiol. 6: 681-686.

Yordanova, L. and Gotsev, T. (1971) - Alterations in the enzyme activity of students with increased body temperature during examinations. J. Physiol. (Paris) 63(3):463-464.

Yoshimura, H. (1960) - Acclimatisation to heat and cold. In Essential Problems in Climatic Physiology edited by Yoshimura, H., Ogata, K. and Itoh, S. Kyoto: Nankodo, p. 61-106.

Young, J.Z. (1971) - Introduction to the Study of Man. Oxford University Press.

Zilva, J.F. and Pannall, P.R. (1975) - Clinical Chemistry in Diagnosis and Treatment 2nd Edition. Lloyd-Like (Medical Books) Ltd.

10. APPENDIX

10.1 EXPERIMENTAL DATA

Experiment-A-

Table 1

Experiment A-1

Dry Bulb	29°C
Wet Bulb	19°C
Rh %	40
Globe Temperature	29°C
Kata factor	442
Kata Range	125-130
Cooling Time	63 seconds
Air Velocity	0.1-0.4 m/sec.

Table 1: Environmental conditions for Experiment A-1 conducted at 10° C above ambient temperature.

Table 2

Experiment A-1

Subject Code No.		(Beats/min) pre-exposure	During Exposure (Time in Minutes) 0	15	30	45	60	75	90
1	Female		72	84	75	81	75	87	75
2	"		78	81	81	72	81	75	81
3	"		84	72	84	81	81	66	90
4	"		78	105	84	90	84	72	78
5	"		90	96	87	81	90	90	90
6	"		78	84	72	66	66	66	66
7	Male		72	75	72	78	69	69	69
8	"		69	75	72	81	66	72	69
9	"		72	69	60	60	63	63	57
10	"		78	87	78	69	75	90	78
11	"		96	90	78	78	84	84	72
12	"		90	90	96	96	84	84	84
$\bar{X}_{Total}$			79.95	84	78.2	77.7	76.5	76.5	75.7
$S.D._{Total}$			8.52	10.47	9.17	9.94	8.8	9.94	9.8
$\bar{X}_{F}$			80	87	80.5	78.5	79.5	76	80
$S.D._{F}$			6.196	11.6	5.82	8.31	8.21	10.33	9.2
$\bar{X}_{M}$			79.5	81	76	77	73.5	77	71.5
$S.D._{M}$			11.02	9.09	11.79	12.09	9.04	10.50	9.1

Table 2: Heart Rate, means and standard deviation for the whole group and for Females (F), Males (M), separately, for experiment conducted at 10° C above ambient temperature. Experiment A-1.

Table 3

Experiment A-1

Subject Code No.		pre-exposure (control)(mg/min) Na^+	K^+	Na^+/K^+	Creatinine
1	Female	0.805	1.11	0.725	0.58
2	"	0.882	1.170	0.75	0.93
3	"	5.279	3.629	1.45	0.98
4	"	0.299	0.342	0.87	0.06
5	"	0.997	0.812	1.22	0.60
6	"	3.246	4.783	0.67	1.31
7	Male	1.235	3.497	0.35	0.593
8	"	1.934	3.123	0.61	0.74
9	"	2.58	5.09	0.50	1.8
10	"	4.59	5.78	0.79	1.64
11	"	2.935	9.95	0.29	1.87
12	"	5.329	4.49	1.18	1.29
$\bar{X}_T$		2.50	3.64	0.78	1.03
$S.D._T$		1.79	2.70	0.35	0.55
$\bar{X}_F$		1.91	1.97	0.94	0.74
$S.D._F$		1.94	1.79	0.31	0.43
$\bar{X}_M$		3.10	5.32	0.62	1.32
$S.D._M$		1.56	2.47	0.32	0.54

Exposure period							
Sample I (mg/min)				Sample II (mg/min)			
Na^+	K^+	Na^+/K^+	Creatinine	Na^+	K^+	Na^+/K^+	Creatinine
1.507	2.23	0.67	0.75	1.619	2.08	0.77	0.72
3.078	3.510	0.87	0.68	3.619	4.489	0.80	0.48
6.713	2.028	3.31	0.46	4.504	2.020	2.22	0.05
1.163	1.258	0.92	0.27	10.33	9.20	1.12	2.225
0.949	0.935	1.01	0.64	1.429	1.368	1.04	0.56
4.489	6.290	0.71	1.06	5.929	8.598	0.68	1.24
0.919	3.142	0.29	0.523	0.288	0.800	0.36	0.21
6.495	10.446	0.62	2.75	5.368	8.921	0.60	1.55
1.59	2.96	0.53	1.07	2.39	3.95	0.60	1.36
2.941	4.68	0.62	1.21	2.95	3.77	0.78	1.20
1.245	3.64	0.34	1.05	1.656	4.05	0.40	1.20
5.635	2.74	2.05	1.65	3.70	1.082	3.41	1.46
3.06	3.65	0.99	1.01	3.64	4.19	1.06	1.02
2.22	2.58	0.85	0.66	2.69	3.09	0.88	0.63
2.98	2.70	1.24	0.64	4.57	4.62	1.105	0.87
2.27	1.97	1.01	0.26	3.30	3.48	0.57	0.76
3.13	4.60	0.74	1.37	2.72	3.76	1.02	1.16
2.38	2.94	0.65	0.76	1.74	2.92	1.17	0.48

Table 3: Na^+, K^+, Na^+/K^+, and creatinine values (mg/min) in urine of 12 subjects for experiment conducted at 10° C above ambient temperature, in addition to the mean, standard deviation for the whole group and for Females (F), Males (M) separately. Experiment A-1.

Table 4

Experiment A-2.

Dry Bulb	10°C
Wet Bulb	8.5°C
Rh %	50%
Globe temperature	10°C
Kata factor	442
Kata range	125-130
Cooling time	38 seconds
Air velocity	0.1-0.3 m/sec.

Table 4 : Environmental conditions for Experiment A-2 conducted at 10° below ambient temperature.

Table 5

Experiment A-2

Subject Code No		(Beats/Min) pre-exposure	During Exposure (Time in Minutes) 0	15	30	45	60	75	90
1	Female		72	78	72	72	72	68	65
2	"		90	84	74	78	54	54	54
3	"		84	74	78	78	72	72	72
4	"		72	80	78	80	78	78	72
5	"		90	90	102	90	84	80	80
6	"		78	96	90	90	80	78	78
7	Male		68	66	60	60	60	54	54
8	"		60	60	60	60	60	60	60
9	"		60	54	54	54	48	54	54
10	"		72	80	72	74	68	64	64
11	"		78	70	62	60	60	65	65
12	"		84	74	72	72	74	74	74
$\overline{X}_T$			75.6	75.5	72.8	72.3	67.5	66.7	66
$S.D._T$			10.2	11.9	13.4	11.8	11.09	9.78	9.2
$\overline{X}_F$			81	83.6	82.3	81.3	73.3	71.6	70.1
$S.D._F$			8.27	8.14	11.4	7.2	10.5	9.75	9.5
$\overline{X}_M$			70.3	67.3	63.3	63.3	61.6	61.8	61.8
$S.D._M$			9.66	9.43	7.2	7.8	8.8	7.6	7.6

Table 5: Heart rate means and standard deviation for the whole group and for Females (F), Males (M) separately, for experiment conducted at 10° C below ambient temperature. Experiment A-2.

Table 6

Experiment A-2

Subject Code No.		pre-exposure (control) mg/min)			
		Na^+	K^+	Na^+/K^+	Creatinine
1	Female	2.78	2.88	0.96	1.27
2	"	0.829	0.708	1.17	0.69
3	"	0.865	0.34	2.54	0.34
4	"	0.33	0.107	3.08	0.19
5	"	0.23	0.47	0.48	0.58
6	"	2.13	1.54	1.38	0.99
7	Male	1.72	3.31	0.51	0.48
8	"	1.58	2.49	0.63	0.48
9	"	2.42	5.62	0.43	1.71
10	"	3.71	3.11	1.19	1.62
11	"	1.27	0.866	1.46	1.19
12	"	4.057	4.39	0.92	1.59
$\bar{X}_T$		1.82	2.15	1.22	0.92
$S.D._T$		1.24	1.76	0.82	0.53
$\bar{X}_F$		1.19	1.007	1.60	0.67
$S.D._F$		1.03	1.04	0.99	0.40
$\bar{X}_M$		2.45	3.29	0.85	1.17
$S.D._M$		1.17	1.62	0.40	0.56

Exposure period							
Sample I (mg/min)				Sample II (mg/min)			
Na^+	K^+	Na^+/K^+	Creatinine	Na^+	K^+	Na^+/K^+	Creatinine
7.46	8.22	0.90	1.86	5.11	4.34	1.17	1.30
0.921	0.489	1.88	0.64	2.13	0.78	2.73	0.91
8.177	4.56	1.79	2.74	8.003	1.13	7.08	2.89
10.30	3.74	2.75	4.8	4.98	0.34	14.64	1.76
1.07	2.04	0.52	0.88	1.56	0.53	2.94	1.39
2.99	1.88	1.59	1.17	2.17	1.09	1.99	0.92
7.97	15.5	0.51	2.60	15.82	25.7	0.61	4.75
11.86	19.7	0.60	4.02	10.67	16.39	0.65	5.02
1.34	3.43	0.39	1.20	1.50	3.04	0.49	1.32
3.65	3.32	1.09	1.49	4.06	3.44	1.18	1.14
2.53	2.15	1.17	1.43	3.58	4.04	0.886	1.27
6.84	5.32	1.28	2.24	7.09	2.16	3.28	3.57
5.42	5.86	1.20	2.08	5.55	5.24	3.13	2.18
3.79	5.89	0.70	1.27	4.28	7.76	4.06	1.49
5.15	3.48	1.57	2.01	3.99	1.36	5.09	1.54
4.005	2.73	0.78	1.56	2.49	1.48	5.10	0.77
5.69	8.23	0.84	2.16	7.12	9.12	1.18	2.84
3.94	7.44	0.38	1.05	5.32	9.70	1.05	1.82

Table 6: Na^+, K^+, Na^+/K^+ and creatinine values (mg/min) in urine of 12 subjects for experiments conducted at 10° C below ambient temperature in addition to mean, standard deviation for the whole group, and for Females (F), Males (M) separtely. Experiment A-2.

Experiment-B-

Table 7

Experiment B-(i) Part I

Dry Bulb	25°C
Wet Bulb	20.5°C
Rh %	67

Table 7: Environmental conditions for Experiment B-(i) Part I. (at work)

Table 8

Experiment-B-(i) Part I

Subject Code No.	Age (Years)	Height (cm)	Weight (Kg)	Surface area (m^2)
13	17	178	63	1.78
14	29	178	82	1.99
15	24	179	80	1.98
16	20	169	66	1.75
17	18	188	70	1.94
18	23	179	81	1.99
19	33	179	76	1.94
20	27	180	69	1.87
21	16	173	63.5	1.75
22	37	172	62.5	1.72
23	21	184	82	2.04
24	22	173	65	1.76
25	27	176	69	1.82
26	24	174	65	1.78
27	40	166	60	1.67
28	53	183	87	2.08
29	22	172	52	1.59
30	24	172	61.5	1.71
31	24	181	65.5	1.84
32	22	177	75	1.90
$\overline{X}$	26.15	176.65	69.75	1.84
S.D.	8.83	5.35	9.14	0.13

Table 8: Age, height, weight, and surface area, in addition to the mean and standard deviation for subjects under Experiment -B-(i) Part I (at work).

Table 9

Experiment B-(i) Part I

Subject Code No.	Heart Rate (Beats/min)					Eardrum temperature				Forehead temperature				Chest temperature			
	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	3	4
13	98	76	100	86	75	36.4	36.7	37.2	37	35.4	35.3	34.7	34.3	34.5	34.2	33.9	33.9
14	70	79	70	73	63	36.7	36.5	36.6	36.8	34.5	34.2	34.2	34	32	32.1	32.4	32.6
15	66	66	72	66	60	36.7	37	36.8	36.8	35.4	35.4	35	35.1	34.6	34.4	34.1	34.1
16	80	50	56	54	58	36.8	36.8	36.8	36.8	35.2	35.2	35	34.4	34.8	34.8	34.6	34.3
17	96	92	89	84	96	35.8	36.3	36.2	36.6	35.1	35.7	35.4	35.7	34.4	34.6	34.5	34.8
18	66	64	60	70	61	35.9	36.1	36	36	35	34.6	34.1	34.2	33.1	33.2	33.4	33.8
19	82	83	82	79	76	36.4	36.4	36.9	36.5	36.3	35.6	35.6	35.5	34.4	33.6	33.5	33.4
20	80	71	66	66	59	36	36.5	36.4	36.6	35.4	35.0	35	35.2	34.8	34.3	34.5	34.7
21	75	72	70	66	62	36.7	36.9	36.8	36.8	35.8	34.8	34.8	35	34.8	34.3	34.2	34.3
22	88	80	82	76	76	36.8	37.5	37.2	37	35.7	35.8	35.3	35.2	34.5	34.7	34.6	34.6
23	68	66	74	82	60	36	36.8	36.7	36.4	34.8	35.2	35	35	32.6	33	33.2	33.2
24	74	70	69	63	58	36.2	36.6	36.5	36.4	34.2	34.9	34.3	34.6	33.8	34	33.9	33.8
25	75	68	67	66	60	36.3	36.8	36.5	36.5	34.9	35.2	35.1	35	34	33.6	32.6	32.6
26	60	60	55	58	54	36.8	36.8	36.5	36.2	35.2	35.4	35	34.8	34.8	34.8	34.3	34.1
27	78	100	100	99	72	37	37	37.3	37.1	35.6	35.5	35.1	34.9	34.3	34.4	34.4	34.6
28	80	68	66	66	52	36	36.4	36.4	36.7	35.1	34.5	34.6	34.2	33.8	32.8	31.9	31.6
29	76	62	60	58	60	36.3	36.6	36.8	36.5	35.1	35.2	35.4	35	34.5	34.5	34.8	34.8
30	74	68	62	69	64	35.9	36.8	36.9	36.9	35.1	35.4	35.3	34.8	32.8	32.8	32.8	32.8
31	84	88	73	79	78	36.3	36.6	36.6	36.5	34.9	35.0	34.9	35.1	34.6	34.8	34.8	35
32	70	74	66	63	64	36.6	36.9	36.6	36.4	35.2	34.9	34.2	34.4	34.2	34.8	34.4	34.4

$\bar{X}$	77	72.8	71.7	71.1	65.4	36.3	36.7	36.6	36.6	35.1	35.14	34.9	34.8	34.06	33.9	33.8	33.8
S.D.	9.6	11.69	12.52	11.09	10.4	0.36	0.30	0.32	0.28	0.45	0.40	0.43	0.45	0.81	0.81	0.86	0.90

Table 9: Heart rate, eardrum temperature, forehead temperature and chest temperature, mean and standard deviation for experiment conducted at 25° C 68% Rh. Experiment B-(i) Part I. (at work)

1 - pre-exposure

2,3,4 - during exposure at 40 minute intervals

5 - post exposure.

Table 10

Experiment B-(i) Part I

Subject Code No.	pre-exposure (control) 0 time			exposure period: 40 minutes			80 minutes			120 minutes			post-exposure		
	Na^+	K^+	Na^+/K^+	Na^+	K^+	Na^+/K^+	Na^+	K^+	Na^+/K^+	Na^+	K^+	Na^+/K^+	Na^+	K^+	Na^+/K^+
13	2.48	1.73	1.43	2.88	2.20	1.30	3.15	2.52	1.25	2.78	1.87	1.48	3.5	1.98	1.76
14	3.63	2.81	1.29	5.23	3.18	1.6	2.71	2.33	1.16	2.63	4.14	0.63	1.79	2.29	0.78
15	0.4	0.13	3.07	0.40	0.13	3.07	19.9	7.17	2.77	7.92	3.9	2.03	7.9	3.9	2.02
16	0.86	1.05	0.81	2.85	3.23	0.88	1.95	3.09	0.63	1.29	2.94	0.43	1.81	3.93	0.46
17	1.43	1.75	0.81	2.04	3.85	0.529	4.14	7.82	0.52	0.38	1.05	0.36	2.66	9.28	0.28
18	1.59	1.1	1.44	1.27	2.10	0.60	1.10	4.5	0.24	1.72	2.4	0.71	1.33	1.5	0.88
19	0.36	0.12	3	0.36	0.12	3	0.36	0.12	3	2.08	1.5	1.38	6.11	3.2	1.90
20	3.91	3.07	1.27	1.04	0.38	2.73	2.62	1.29	2.03	2.21	1.38	1.60	2.6	0.68	3.82
21	0.84	1.26	0.66	1.55	2.43	0.63	1.52	3.81	0.39	1.94	6.35	0.30	1.1	1.5	0.73
22	1.69	0.82	2.06	0.66	0.41	1.60	1.26	1.61	0.78	2.28	4.24	0.53	4.6	3.2	1.43
23	2.8	3.1	0.90	3.30	3.76	0.87	3.37	3.5	0.96	4.60	4.22	1.09	5.27	4.52	1.16
24	0.25	0.66	0.37	0.72	1.22	0.59	0.81	1.62	0.5	0.88	2.00	0.44	0.66	1.41	0.46
25	2.48	2.66	0.93	2.03	1.84	1.10	3.61	3.29	1.09	2.68	3.5	0.76	2.7	3.39	0.79
26	2.73	1.47	1.85	4.92	1.88	2.61	4.73	2.74	1.72	5.46	3.43	1.59	3.84	2.2	1.74
27	2.93	2.97	0.98	6.58	4.77	1.37	5.22	3.18	1.64	5.45	3.17	1.71	5.08	3.38	1.50

28	1.76	1.43	1.23	2.16	1.76	1.22	3.11	2.24	1.38	2.73	1.97	1.38	2.44	1.67	1.46
29	2.08	1.50	1.38	0.55	0.20	2.75	0.68	1.1	0.61	1.01	0.8	1.26	0.68	0.40	1.7
30	0.56	1.93	0.29	2.54	3.66	0.69	0.26	0.48	0.54	0.74	1.89	0.39	6.04	6.32	0.95
31	1.51	0.41	3.68	1.51	0.41	3.68	1.51	0.41	3.68	1.51	1.39	1.08	1.35	3.65	0.36
32	2.04	2.27	0.89	2.26	3.51	0.64	2.67	3.16	0.84	2.96	2.84	1.04	3.48	2.07	1.68
$\bar{X}$	1.81	1.61	1.41	2.24	2.05	1.57	3.23	2.79	1.28	2.66	2.74	1.009	3.24	3.02	1.29
S.D.	1.07	0.95	0.90	1.70	1.46	1.01	4.17	2.00	0.94	1.88	1.38	0.52	2.03	2.04	0.81

Table 10: Na^+, K^+, Na^+/K^+ values in urine (mg/min) and their means, standard deviations for experiment conducted at 25° C 68% Rh. Experiment B-(i) Part I (at work).

Table 11

Experiment B-(i) Part I

Subject Code No.	pre-exposure	exposure period 1	2	3	post exposure
13	4.4	6.8	8.9	5.7	4.9
14	7.9	12.6	7.91	8.72	13.08
16	2.15	6.77	5.69	5.13	7.39
17	2.99	5.37	11.91	1.53	10.36
23	2.5	4.7	5.6	3.7	3.1
25	4.5	3.87	7.6	6.76	6.73
27	5.01	14.76	9.73	10.08	11.40
28	3.25	4.03	6.07	5.52	4.57
$\overline{X}$	4.08	7.36	7.92	5.89	7.69
S.D.	1.84	4.09	2.20	2.69	3.57

Table 11: Chloride in urine mg/min (at work), means and standard deviation. Experiment B-(i) Part I

1. 40 minutes after the beginning of the exposure
2. 80 minutes after the beginning of the exposure
3. 120 minutes after the beginning of the exposure.

Table 12

Experiment B-(i) - Part I

Subject Code No.	Sweat Rate mg/cm^2/min		Na^+ mg/min		K^+ mg/min	
	1	2	1	2	1	2
13	0.08	0.09	4.65	2.40	3.25	1.85
14	0.15	0.03	23.29	4.3	9.08	2.31
16	0.01	0.02	0.35	1.24	0.91	1.96
17	0.01	0.03	2.80	1.75	5.54	2.19
23	0.03	0.04	3.35	2.32	2.82	1.15
25	0.004	0.08	2.18	1.24	0.71	0.36
27	0.05	0.06	4.49	2.33	6.58	1.76
28	0.26	0.27	12.68	11.36	5.87	4.61
$\bar{X}$	0.074	0.077	6.72	3.36	4.34	2.02
S.D.	0.080	0.081	7.62	3.37	2.92	1.22

Table 12: Sweat rate and Na^+, K^+ concentration in sweat. (at work) Mean and standard deviation. Experiment B-(i) - Part I.

1. mid-exposure
2. end-exposure

Table 13

Experiment B-(i) - Part I

Subject Code No.	Na^+/K^+	
	1	2
13	1.43	1.29
14	2.56	1.86
16	0.38	0.63
17	0.50	0.79
23	1.18	2.01
25	3.11	3.44
27	0.68	1.32
28	2.16	2.46
$\bar{X}$	1.5	1.72
S.D.	1.01	0.92

Table 13: Na^+/K^+ in sweat (mg/min) (at work)
Mean and standard deviation.
Experiment B-(i) - Part I.

1. mid-exposure.
2. end-exposure.

Table 14

Experiment B-(i) Part II

Dry Bulb	30°C
Wet Bulb	22.2°C
%·Rh	50%

Table 14: Environmental conditions for Experiment B-(i) - Part II

Table 15

Experiment B-(i) Part II

Subject code no.	Age (years)	Height cm.	Weight Kg	Surface area (m^2)
33	22	182	62	1.80
24	65	168	58	1.65
35	20	177	67.5	1.82
36	19	182	74.5	1.95
37	24	173.5	74.5	1.88
38	29	175	76.5	1.91
39	16	188	77.5	2.02
40	24	182.5	74	1.94
41	29	163	57	1.60
42	26	170	60.5	1.69
43	37	173	85	1.98
44	30	180	80	1.99
45	24	172	66.5	1.78
46	19	180	95.5	2.14
47	35	175	71	1.85
48	24	180	73.5	1.92
49	21	171	66.5	1.77
50	44	184	80	2.02
51	30	172	71.5	1.84
52	32	183	78.5	2.00
$\bar{X}$	28.5	176.5	72.5	1.87
S.D.	11	6.31	9.43	0.13

Table 15: Age, height, weight, and surface area in addition to the mean and standard deviation for subjects under Experiment B-(i) Part II (at work).

Table 16

Experiment B-(i) Part II

Subject Code No.	Heart rate (Beats/min)					Eardrum temperature				Forehead temperature				Chest temperature			
	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	3	4
33	72	78	76	72	70	37.1	37.4	37.2	37	37.2	36.8	36.4	36.2	36.6	36.1	35.5	35.6
34	71	71	76	74	70	36.1	37.2	37.3	37.4	35.6	35.1	34.7	34.6	34.7	34.2	33.9	33.8
35	98	91	90	88	81	36.9	37.2	37	36.7	36.3	35.8	35.6	35.6	35.1	34.9	35	34.8
36	70	78	75	74	64	37.6	37.7	37.2	37	36.6	35.9	35.8	36.1	34.2	34.3	34.1	34.3
37	69	68	70	68	62	36.8	37	36.6	36.6	35.7	35.8	35.6	35.3	33.8	33.2	33.2	33
38	67	62	64	60	70	37.2	37	37.2	36.8	36.2	35.6	35.8	35.6	34.9	33.4	32.8	33
39	78	78	84	87	72	37.5	37.6	37.2	37.1	36.8	36.3	35.7	35.6	35.8	35.9	34.8	34.8
40	66	64	65	63	48	37.2	37.7	37.4	37.2	36.3	36.4	36.2	35.6	35.6	35.1	34.2	34.3
41	76	84	83	81	78	37.5	37.8	37.6	37.4	36.7	37	36.9	36.4	35.6	35.5	35.7	35.5
42	94	96	89	90	80	37.5	37.6	37.1	36	35.4	33.9	34	34	35	34.5	34.5	33.8
43	80	78	80	74	72	36.2	38.0	37.3	37.7	35.4	35	34.7	34.6	33.3	33.5	32.8	33.8
44	75	75	71	70	62	37.6	37.4	37	37.2	37	35.7	35.6	35.1	34.7	34.9	34.5	34.9
45	78	71	76	71	68	37.5	37.0	37	36.9	36.3	35.4	35.6	35.8	35.4	35.6	35.3	35.3
46	80	72	72	78	66	37.1	37.2	36.9	36.8	36	35.5	35.3	35.2	34.2	34.8	35.2	34.2
47	76	78	71	66	62	37.1	37.4	37.2	37.1	36.3	36	35.7	35.7	35.5	35.3	34.8	34.2

48	76	82	68	65	60	37	37.1	36.9	36.8	35.8	35.3	34.6	34.7	35.6	34.5	34.3	33.8
49	79	74	69	70	63	37.4	37.6	37.3	37.2	36.9	36.4	36.5	36.5	34.5	33.9	33	33
50	76	69	65	68	62	37	37.3	37.1	36.8	36.3	36.3	36.2	35.6	34.2	34.2	33.7	33.7
51	96	108	88	92	76	37.2	37.6	37.5	37.5	36.3	35.8	34.7	34.3	34.6	35.1	34.4	34.8
52	76	71	67	84	72	37.4	37.3	36.9	36.4	36.6	35.7	35.2	35.2	34.9	34.8	34.1	34.4
$\bar{X}$	77.65	77.4	74.9	74.7	67.9	37.14	37.40	37.14	36.9	36.28	35.78	35.5	35.38	34.91	34.68	34.29	34.25
S.D.	8.91	10.95	8.26	9.39	7.91	0.41	0.28	0.23	0.39	0.51	0.68	0.73	0.68	0.77	0.80	0.86	0.78

Table 16: Heart rate, eardrum temperature, forehead temperature, and chest temperature, mean and standard deviation for experiment conducted at 30° C 50% Rh. Experiment B-(i) Part II (at work).

1 - pre-exposure
2,3,4 - during exposure at 40 minute intervals.
5 - post-exposure

Table 17

Experiment B-(i) Part II

Subject Code No.	pre-exposure (control) 0-time Na^+	K^+	Na^+/K^+	Exposure period: 40 minutes Na^+	K^+	Na^+/K	60 minutes Na^+	K^+	Na^+/K^+	120 minutes Na^+	K^+	Na^+/K^+	post-exposure Na^+	K^+	Na^+/K^+
33	1.70	0.60	2.83	2.88	1.56	1.84	1.59	1.23	1.29	1.44	1.22	1.18	1.84	0.98	1.87
34	0.59	0.66	0.89	1.69	1.65	1.02	2,11	1.8	1.17	1.41	1.50	0.94	1.73	1.53	1.13
35	3.0	2.26	1.32	5.73	7.5	0.76	6.80	7.7	0.88	4.40	5.1	0.86	1.27	1.76	0.72
36	1.21	1.38	0.87	2.33	2.66	0.87	3.54	3.75	0.94	2.65	3.86	0.68	1.78	3.03	0.58
37	5.16	6.58	0.78	3.15	5.10	0.61	3.57	5.45	0.65	4.46	6.85	0.65	3.61	4.45	0.81
38	1.53	0.78	1.96	1.66	3.2	0.51	2.4	3.5	0.68	3.20	1.8	1.77	1.5	1.5	1
39	0.31	2.30	0.13	5.15	2.7	1.9	3.48	1.5	2.32	1.71	1.89	0.90	0.3	2.15	0.13
40	1.77	1.22	1.45	2.52	1.76	1.43	1.57	2.08	0.75	1.57	2.97	0.52	0.79	2.2	0.35
41	0.76	1.67	0.45	1.24	2.71	0.45	1.81	3.02	0.59	1.68	3.98	0.42	1.01	2.58	0.39
42	0.72	0.79	0.91	0.72	0.79	0.91	0.72	0.79	0.91	1.15	1.07	1.07	1.17	0.60	1.95
43	1.28	1.18	1.08	6.61	5.74	1.15	3.82	3.44	1.11	2.45	2.74	0.89	2.2	2.56	0.85
44	1.91	1.33	1.43	2.95	1.60	1.84	3.07	2.15	1.42	2.82	2.04	1.38	3.10	1.99	1.05
45	2.94	2.05	1.43	2.83	3.00	0.94	4.04	3.38	1.19	3.97	4.67	0.85	3.12	3.32	0.93

46	3.48	2.72	1.27	5.6	4.3	1.30	4.4	3.7	1.18	1.79	2.30	0.77	1.82	2.12	0.85
47	0.37	1.78	0.20	1.10	2.21	0.34	1.05	2.22	0.47	0.60	1.8	0.33	1.46	0.82	1.78
48	3.11	0.89	3.49	3.21	1.22	2.54	3.33	3.43	0.97	3.59	1.5	2.39	3.24	1.21	2.6
49	0.59	0.2	2.95	1.34	0.81	1.65	1.08	1.44	0.75	0.82	1.72	0.47	0.32	1.32	0.24
50	2.92	3.98	0.73	4.62	4.42	1.04	2.73	1.80	1.5	2.17	3.13	0.69	1.22	2.20	0.55
51	0.53	2.1	0.25	2.23	1.6	1.39	1.79	3.35	0.53	1.3	2.18	0.59	4.4	2.01	2.18
52	2.16	6.33	0.34	1.89	6.60	0.28	1.38	4.27	0.32	1.06	3.98	0.26	0.93	3.91	0.23
$\bar{X}$	1.80	2.04	1.23	2.96	3.10	1.13	2.71	3	0.98	2.21	2.81	0.88	1.84	2.11	1.01
S.D.	1.20	1.74	0.93	1.70	1.93	0.59	1.46	1.61	0.45	1.18	1.50	0.50	1.11	0.99	0.70

Table 17: Na^+, K^+, Na^+/K^+ values (mg/min) in urine, and their means standard deviation for experiment conducted at 30°C 50% Rh. Experiment B-(i) Part II (at work).

Table 18

Experiment B-(i) Part II

Subject Code No.	pre-exposure	1	2	3	post-exposure
33	2.11	3.40	4.12	2.42	1.90
34	1.28	3.28	3.94	4.56	2.11
35	1.55	1.37	1.56	1.53	1.22
36	3.8	6.82	10.9	9.39	7.2
37	7.91	8.91	9.24	11.4	8.45
43	2.72	8.60	15.27	7.99	5.31
44	6.03	3.55	4.85	6.03	5.82
45	5.62	5.96	7.39	9.36	6.62
$\bar{X}$	3.87	5.23	7.15	6.58	4.82
S.D.	2.40	2.74	4.47	3.54	2.72

Table 18: Chloride in urine (mg/min), mean and standard deviation Experiment B-(i) Part II (at work).

1. 40 minutes after the beginning of the exposure.
2. 80 minutes after the beginning of exposure.
3. 120 minutes after the beginning of exposure.

Table 19

Experiment B-(i) Part II

Subject Code No.	Sweat Rate mg/cm^2/min		Na^+ mg/min		K^+ mg/min	
	1	2	1	2	1	2
33	0.161	0.079	8.53	3.4	6.25	2.45
34	0.109	0.066	15.76	2.86	5.9	0.8
35	0.198	0.003	5.73	4.48	7.25	5.87
36	0.181	0.062	5.32	0.62	6.09	1.37
37	0.57	0.03	5.10	0.59	7.70	1.75
43	0.272	0.100	10.9	3.2	6.62	0.85
44	0.128	0.078	5.34	1.9	7.41	3.91
45	0.226	0.243	13.8	8.34	7.29	4.11
$\bar{X}$	0.166	0.082	8.81	3.17	6.81	2.64
S.D.	0.068	0.071	4.22	2.48	0.68	1.82

Table 19: Sweat rate and Na^+, K^+ concentration in sweat (at work). Mean and standard deviation. Experiment B-(i) Part II.

1. mid-exposure.
2. end-exposure.

Table 20

Experiment B-(i) Part II

Subject Code No.	Na^+/K^+ 1	2
33	1.36	1.38
34	2.67	3.53
35	0.79	0.76
36	0.87	0.45
37	0.66	0.33
43	1.64	3.76
44	0.72	0.48
45	1.89	2.02
$\bar{X}$	1.32	1.58
S.D.	0.71	1.38

Table 20: Na^+/K^+ in sweat (mg/min) (at work). Mean and standard deviation. Experiment B-(i) Part II

1. mid-exposure.
2. End-exposure.

Table 21

Experiment B-(i) Part II

Subject Code No.	Heart rate (Beats/min) 1	2	3	4	5
33	72	78	76	72	70
34	71	71	76	74	70
35	98	91	90	88	81
36	70	78	75	74	64
37	69	68	70	68	62
43	80	78	80	74	72
44	75	75	71	70	62
45	78	71	76	71	68
$\bar{X}$	76.62	76.25	76.75	73.87	68.62
S.D.	9.47	7.08	6.20	6.10	6.30

Table 21: Heart rate, mean and standard deviation.
Experiment B-(i) Part II at work.

1 . pre-exposure
2,3,4,- during exposure at 40 minute. intervals
5 post-exposure.

Table 22

Experiment B-(i) Part III

Dry Bulb	30°C
Wet Bulb	23.3°C
Rh %	38

Table 22: Environmental conditions for Experiment B-(i) Part III.

Table 23

Experiment B-(i) Part III

Subject Code No.	Age (years)	Height (cm)	Weight (Kg)	Surface area (cm^2)
53	22	177	62	1.76
54	35	172	63	1.74
55	21	179.5	71.5	1.9
56	20	180	68	1.86
57	23	178	74	1.91
58	39	177	84	2.02
59	42	197	97.5	2.31
60	21	180	64	1.81
61	25	179	55.5	1.70
62	23	161	61.5	1.64
63	39	174	73	1.87
64	17	181	66	1.84
65	31	178	79	1.96
66	57	169	65	1.74
67	21	185	74.5	1.97
68	19	184	74.5	1.96
69	36	177	77.5	1.94
70	31	174	68	1.81
71	21	177	70	1.85
72	19	180	74	1.92
$\bar{X}$	28.1	177.97	71.12	1.87
S.D.	10.38	6.92	9.25	0.14

Table 23: Age, height, weight and surface area in addition the mean and standard deviation for subjects under Experiment B-(i) Part III (at work)

Table 24

Experiment B-(i) Part III

Subject Code No.	Heart rate (Beats/min)					Eardrum temperature				Forehead temperature				Chest temperature			
	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	3	4
53	68	90	90	98	68	37.8	37.4	38	38	37.2	36.8	36.8	36.6	37.1	36	36.3	36.4
54	83	94	81	78	81	38	37.5	37.5	37.7	37.5	36.6	36.2	36.3	36.5	35.9	35.9	35.4
55	80	81	83	88	72	37.5	37.6	37.4	37	36.5	36.6	35.5	35.2	35.4	35.3	35.3	35.5
56	94	95	94	89	92	38.3	38.2	38	37.6	37.8	37.5	37.2	37	37.3	37	36.8	36.6
57	68	64	64	64	66	37.6	37.5	37.5	37.4	37.3	36	35.7	35.2	36.8	35.2	34.2	34
58	86	80	76	73	78	37.7	37.8	37.5	37.2	36.4	36.2	35.6	35.6	35.5	35.4	35	34.7
59	70	74	74	76	68	37.3	37.3	37.1	37.2	36.9	35.8	36.3	36.3	35.5	34.6	32.6	32.4
60	86	86	86	86	80	37.4	37.4	37.4	37.2	36	35.5	35.5	35.5	36.3	35.2	35.4	35.3
61	88	100	84	87	78	38.0	37.8	37.7	37.4	37.5	37.2	37	36.7	35.3	35.4	35	35
62	84	84	78	64	50	38	37.9	37.9	37.8	37	37	37.1	37	36.2	35.5	35.4	35.6
63	86	100	100	88	86	38.3	38.1	37	38	37.5	36.7	36.2	36.1	35.7	34.2	33.5	33.4
64	84	81	79	78	63	36.6	37.2	37	36.6	36.2	35.8	35.3	35.3	36.1	35.5	35.2	35.2
65	84	84	86	82	82	36.4	36.4	36.4	36.8	35.5	35.4	34.8	35	34	33.6	34.1	33.4
66	100	104	101	96	92	37.8	37.6	37.2	37.2	37	36.8	35.9	35.8	34.7	35	34	33.7
67	68	70	70	70	68	37.7	37.4	36.9	37	37.3	36.9	36	36.1	35.5	34.4	33.4	34.1

68	74	70	70	74	62	38.4	38	37.8	37.2	37.8	36.6	35.9	35.8	36.9	35.3	34.9	34.9
69	90	96	86	82	72	38.1	38	38.2	38.1	37.3	37.2	37.6	37.6	35.2	35.1	34.8	34.6
70	62	76	68	84	60	37.3	37.5	37	36.8	36.8	36.2	36.8	35.9	34.4	33.4	34.1	33.4
71	76	70	76	83	68	37.9	37.8	37.8	37.5	36.9	36.9	36.5	36.4	37.4	36.7	36.2	35.9
72	78	72	69	66	60	38	38	37.8	37.6	36.5	35.4	34.7	34.3	36.6	36.2	35.5	35.6
$\overline{X}$	80.45	83.55	80.75	80.3	72.3	37.7	37.62	37.4	37.36	36.94	36.45	36.13	35.98	35.92	35.24	34.88	34.75
S.D.	9.82	11.79	10.39	9.79	11.15	0.52	0.40	0.45	0.42	0.61	0.63	0.79	0.79	0.96	0.90	1.06	1.11

Table 24: Heart rate, eardrum temperature, forehead temperature, chest temperature, and mean, standard deviation for experiment conducted at 35° C 38% Rh. Experiment B-(i) Part III. (at work)

1 - pre-exposure

2,3,4 - during exposure at 40 minute: intervals

5 - post-exposure.

Table 25

Experiment B-(i) Part III

Subject Code No.	pre-exposure (control) 0 Time			Exposure period: 40 minutes			80 minutes			120 minutes			post-exposure		
	Na^+	K^+	Na^+/K^+	Na^+	K^+	Na^+/K^+	Na^+	K^+	Na^+/K^+	Na^+	K^+	Na^+/K^+	Na^+	K^+	Na^+/K^+
53	1.91	0.98	1.94	1.16	1.68	0.69	0.63	1.03	0.61	0.57	0.86	0.66	0.54	0.78	0.69
54	0.45	0.89	0.50	1.27	1.03	1.23	1.36	3.21	0.42	1.11	3.02	0.36	1.53	3.08	0.49
55	1.80	2.10	0.85	2.12	3.1	0.68	2.15	2.79	0.77	2.64	3.84	0.68	2.94	4.63	0.63
56	4.28	1.81	2.36	3.28	1.69	1.94	3.29	1.46	2.25	2.97	1.56	1.90	3.18	1.51	2.10
57	1.30	0.9	1.44	0.95	2.25	0.42	0.98	2.10	0.46	0.98	2.10	0.46	0.90	1.4	0.64
58	1.72	1.25	1.37	1.17	2.92	0.40	2.12	1.95	1.08	0.52	1.62	0.32	1.61	1.54	1.04
59	5.45	5.143	1.05	1.72	3.64	0.47	4.49	1.75	2.56	0.5	2.1	0.23	0.59	1.75	0.33
60	1.66	3.55	0.46	2.62	2.9	0.90	1.77	3.1	0.57	1.18	4.1	0.28	1.39	2.8	0.49
61	0.45	1.72	0.26	1.2	2.11	0.56	1.53	2.61	0.58	1.31	2.08	0.62	0.62	1.91	0.32
62	0.59	0.114	5.17	0.33	1.19	0.27	0.47	1.13	0.41	0.88	1.25	0.70	0.96	0.11	8.72
63	1.49	2.01	0.74	1.64	2.19	0.74	1.61	2.31	0.69	1.06	1.84	0.57	1.1	1.78	0.61
64	1.06	2.24	0.47	1.56	2.64	0.59	0.88	1.88	0.46	1.13	2.59	0.43	1.29	2.89	0.44
65	0.52	0.54	0.96	1.12	1.87	0.59	1.15	2.2	0.52	1.18	2.52	0.46	1.39	2.24	0.62
66	0.31	0.8	0.38	0.32	1.11	0.28	0.35	1.11	0.31	0.27	1.08	0.25	0.32	1.39	0.23
67	0.34	1.12	0.30	3.55	1.61	2.20	3.78	2.31	1.63	0.56	1.53	0.36	0.84	1.47	0.57

68	2.07	0.68	3.04	0.53	2.51	0.20	0.81	2.44	0.33	1.32	1.68	0.78	1.81	1.16	1.56
69	0.58	0.45	1.28	2.53	7.21	0.35	1.13	2.26	0.5	0.29	0.73	0.39	0.51	1.63	0.31
70	1.37	2.59	0.52	1.26	1.07	1.17	1.19	0.16	7.43	1.76	3.07	0.57	1.54	2.81	0.54
71	0.91	2.07	0.43	3.67	2.39	1.53	2.47	3.04	0.8	1.87	3.5	0.53	1.54	2.7	0.57
72	4.69	3.62	1.29	4.71	3.39	1.38	1.98	2.53	0.78	0.84	0.24	3.5	2.45	3.52	0.69
$\bar{X}$	1.64	1.72	1.24	1.83	2.43	0.82	1.70	2.06	1.15	1.14	2,06	0.70	1.35	2.05	1.07
S.D.	1.48	1.25	1.18	1.20	1.36	0.56	1.10	0.78	1.60	0.71	1.04	0.74	0.78	1.03	1.85

Table 25: Na^+, K^+, Na^+/K^+ values in urine and their means, standard deviation for experiment conducted at 35° C 38% Rh Experiment B-(i) Part III (at work).

Table 26

Experiment B-(i) Part III

Subject Code No.	pre-exposure	1	2	3	post-exposure
53	2.35	2.09	1.77	1.47	1.53
54	9.39	5.76	5.95	5.28	5.55
55	5.05	5.66	8.29	7.11	5.80
56	7.15	5.68	6.30	5.60	5.95
63	3.08	3.64	5.42	2.67	2.93
64	3.15	3.95	2.95	4.16	4.93
65	1.91	4.11	3.74	2.66	2.10
66	0.73	0.85	0.97	0.94	1.02
$\bar{X}$	4.10	3.96	4.42	3.73	3.72
S.D.	2.91	1.78	2.48	2.16	2.05

Table 26: Chloride in urine (mg/min). Mean and standard deviation. Experiment B-(i) Part III (at work).

1. 40 minutes after the beginning of the exposure.
2. 80 minutes after the beginning of the exposure.
3. 120 minutes after the beginning of the exposure.

Table 27

Experiment B-(i) Part III

Subject Code No.	Sweat Rate 1	Sweat Rate 2	Na^+ 1	Na^+ 2	K^+ 1	K^+ 2
53	0.078	0.005	3.38	0.98	1.69	0.39
54	0.191	0.015	20.20	9.98	24.53	3.39
55	0.238	0.039	15.04	2.32	13.47	2.19
56	0.074	0.071	12.72	6.49	7.19	3.35
63	0.188	0.096	16.19	6.55	9.46	2.54
64	0.246	0.065	14.97	3.88	7.02	2.11
65	0.226	0.217	42.33	18.73	10.02	4.55
66	0.262	0.257	4.72	3.51	2.29	1.83
$\bar{X}$	0.187	0.095	16.19	6.55	9.45	2.54
S.D.	0.073	0.092	12.01	5.67	7.23	1.24

Table 27: Sweat rate and Na^+, K^+ concentration in sweat (at work) Mean and standard deviation. Experiment B-(i) Part III

1 - mid-exposure.

2 - end-exposure.

Table 28

Experiment B-(i) Part III

Subject Code No.	Na^+/K^+ 1	2
53	2	2.51
54	0.82	2.94
55	1.11	1.05
56	1.76	1.93
63	1.71	2.57
64	2.13	1.83
65	4.22	4.11
66	2.06	1.91
$\bar{X}$	1.97	2.35
S.D.	1.01	0.91

Table 28: Na^+/K^+ in sweat (mg/min) (at work). Mean and standard deviation. Experiment B-(i) Part III

1. mid-exposure.

2. end-exposure.

Table 29

Experiment B-(i) Part III

Subject Code No.	Heart Rate (Beats/min) 1	2	3	4	5
53	68	90	90	98	68
54	83	94	81	78	81
55	80	81	83	88	72
56	94	95	94	89	92
63	86	100	100	88	86
64	84	81	79	78	63
65	84	84	86	82	82
66	100	104	101	96	92
$\bar{X}$	84.87	91.12	89.25	87.12	79.5
S.D.	9.46	8.65	8.44	7.51	10.84

Table 29: Heart rate, mean and standard deviation.
Experiment B-(i) Part III (at work).

1 - pre-exposure

2,3,4-during exposure at 40 minute intervals

5 - post-exposure.

Table 30

Experiment B-(ii) Part I

Dry Bulb	25°C
Wet Bulb	22.2°C
Rh %	80

Table 30: Environmental conditions for Experiment B-(ii) Part I (at rest).

Table 31

Experiment B-(ii) Part I and Part II

Subject Code No.	Age (years)	Height (cm)	Weight (Kg)	Surface area (m^2)
73	23	173	63.1	1.73
74	25	174.3	73	1.87
75	24	175.4	70	1.85
76	26	180.5	80.4	2.00
77	23	169.7	56	1.65
78	25	173.5	63.7	1.77
79	26	173.5	71.8	1.85
80	17	179.7	63.2	1.80
$\bar{X}$	23.62	174.97	67.65	1.81
S.D.	2.92	3.57	7.61	0.10

Table 31: Age, height, weight and surface area, in addition the mean and standard deviation for subjects under Experiment B-(ii) Part I and Part II (at rest).

Table 32

Experiment B-(ii) Part I

Subject Code No.	pre-exposure	Heart rate (Beats/min) 1	2	3	post-exposure
73	60	62	58	55	60
74	70	62	56	60	65
75	56	50	47	52	55
76	70	68	68	68	68
77	100	100	100	85	80
78	60	56	56	56	56
79	80	92	80	75	75
80	94	80	74	74	70
$\bar{X}$	73.75	71.25	67.37	65.62	66,12
S.D.	16.29	17.7	17.02	11.72	8.90

Table 32: Heart rate, mean and standard deviation. Experiment B-(ii) Part I (at rest).

1,2,3, - during exposure at 40 minute intervals.

Table 33

Experiment B-(ii) Part I

Subject Code No.	Na^+ (mg/min) 1	2	3	4	5
73	1.69	4.02	3.59	2.59	1.9
74	0.69	0.72	0.53	0.32	0.41
75	1.13	1.63	1.42	1.18	1.08
76	3.68	6.05	5.1	3.9	3.5
77	2.60	2.69	2.71	2.88	2.70
78	3.76	3.30	3.1	2.67	2.91
79	3.55	5.16	4.08	3.06	3.33
80	1.18	2.20	1.63	1.24	1.15
$\bar{X}$	2.28	3.22	2.77	2.23	2.12
S.D.	1.26	1.79	1.51	1.19	1.15

K^+ (mg/min)					Na^+/K^+				
1	2	3	4	5	1	2	3	4	5
1.52	3.97	3.38	2.11	1.8	1.11	1.01	1.06	1.22	1.05
1.13	0.55	0.21	0.18	0.16	0.61	1.30	2.52	1.77	2.56
0.69	0.70	0.95	0.61	0.45	1.63	2.32	1.49	1.93	2.4
1.37	2.20	2.35	1.94	1.61	2.68	2.75	2.17	2.01	2.17
2.27	1.09	0.96	0.94	1.72	1.14	2.46	2.82	3.06	1.56
4.26	4.32	3.9	3.05	3.62	0.88	0.76	0.79	0.87	0.80
2.76	2.37	1.96	1.41	1.82	1.28	2.17	2.08	2.17	1.82
1.86	1.81	1.53	1.04	1.7	0.63	1.21	1.06	1.19	0.67
1.98	2.12	1.905	1.41	1.60	1.24	1.74	1.62	1.77	1.62
1.12	1.41	1.26	0.92	1.04	0.67	0.75	0.83	0.69	0.73

Table 33: Na^+, K^+ and Na^+/K^+ values in urine. Mean and standard deviation Experiment B-(ii) Part I (at rest).

1 - pre-exposure

2,3,4,- during exposure at 40 minute intervals

5 - post-exposure.

Table 34

Experiment B-(ii) Part I

Subject Code No.	Cl^- (mg/min) 1	2	3	4	5
73	3.31	5.62	5.4	4.59	3.92
74	2.53	1.94	1.71	1.20	1.82
75	2.40	2.14	3.11	1.51	1.41
76	8.78	10.42	9.62	6.70	6.3
77	4.35	5.75	6.21	5.18	4.93
78	9.03	5.79	5.11	4.42	5.61
79	6.28	7.23	4.32	3.81	5.21
80	2.64	4.04	3.69	2.14	2.19
$\bar{X}$	4.91	5.36	4.89	3.69	3.92
S.D.	2.77	2.75	2.37	1.92	1.88

Table 34: Chloride in urine. Mean and standard deviation. Experiment B-(ii) Part I (at rest).

1 - pre-exposure.

2,3,4, - during exposure at 40 minute intervals.

5 - post-exposure.

Table 35

Experiment B(ii) Part I

Subject Code No.	Creatinine (mg/min) 1	2	3	4	5
73	0.74	1.45	0.98	0.78	0.75
74	0.96	0.88	0.74	0.61	0.82
75	0.78	1.88	2.1	1.51	1.12
76	1.95	2.24	2.32	2.02	1.73
77	2.33	1.98	1.71	2.09	2.12
78	5.57	4.74	4.15	3.89	4.62
79	3.10	4.34	2.51	1.97	2.11
80	1.93	2.22	2.48	1.75	1.81
$\bar{X}$	2.17	2.46	2.12	1.82	1.88
S.D.	1.60	1.35	1.05	1.00	1.23

Table 35: Creatinine in urine. Mean and standard deviation. Experiment B-(ii) Part I (at rest).

1 - pre-exposure

2,3,4, - during exposure at 40 minute intervals.

5 - post-exposure.

Table 36

Experiment B-(ii) Part I

Subject Code No.	Sweat Rate $mg/cm^2/min$	Na^+ mg/min	K^+ mg/min	Na^+/K^+
73	0.04	0.08	0.02	4
74	0.4	9.1	2.8	3.25
75	0.18	3.75	0.79	4.74
76	0.2	2.9	0.5	5.8
77	1.29	3.67	3.12	1.17
78	0.15	2.67	2.18	1.22
79	0.71	3.04	4.36	0.69
80	0.78	3.87	6.41	0.60
$\overline{X}$	0.46	3.63	2.52	2.68
S.D.	0.42	2.51	2.15	2.02

Table 36: Sweat rate, and Na^+, K^+, Na^+/K^+ values in sweat. Mean and standard deviation. Experiment B-(ii) Part I (at rest).

Table 37

Experiment B-(ii) Part II

Dry Bulb	25°C
Wet Bulb	15.5°C
Rh %	38

Table 37: Environmental conditions for Experiment B-(ii) Part II (at rest).

Table 38

Experiment B-(ii) Part II

Subject Code No.	pre-exposure	Heart Rate (Beats/min) 1	2	3	post-exposure
73	68	66	62	59	65
74	54	46	46	41	51
75	60	55	52	49	58
76	82	76	70	68	78
77	100	100	98	94	90
78	70	66	66	60	68
79	80	82	82	84	84
80	82	68	64	62	76
$\bar{X}$	74.5	69.8	67.5	64.6	71.2
S.D.	14.5	16.5	16.4	17.3	13.1

Table 38: Heart rate, mean and standard deviation. Experiment B-(ii) Part II (at rest).

Table 39

Experiment B-(ii) Part II

Subject Code No.	Na^+ (mg/min) 1	2	3	4	5
73	3.02	8.37	10.21	14.76	5.12
74	1.08	1.74	1.92	2.29	1.34
75	3.94	3.84	4.15	4.93	3.72
76	1.71	1.85	2.22	2.61	1.78
77	5.08	4.82	4.63	4.12	4.52
78	4.89	4.95	4.95	4.96	4.81
79	3.89	3.49	3.23	4.12	3.92
80	1.16	1.29	1.34	1.50	1.21
$\overline{X}$	3.09	3.79	4.08	4.91	3.30
S.D.	1.61	2.32	2.80	4.17	1.61

K^+ (mg/min)					Na^+/K^+				
1	2	3	4	5	1	2	3	4	5
1.51	5.06	6.81	9.15	4.61	2	1.65	1.49	1.61	1.11
0.65	0.65	0.77	0.97	0.82	1.66	2.67	2.49	2.36	1.63
1.88	0.86	0.84	0.81	1.32	2.09	4.46	4.94	6.08	2.81
0.89	0.89	1.31	1.76	1.11	1.92	2.07	1.69	1.48	1.60
1.79	1.37	1.06	1.49	1.53	2.83	5.60	4.36	2.76	2.95
1.26	0.86	0.54	2.53	1.81	3.88	5.75	9.16	1.96	2.65
2.81	2.97	2.97	2.99	2.90	1.38	1.17	1.08	1.37	1.35
1.97	2.23	2.18	2.17	1.75	0.58	0.57	0.61	0.69	0.69
1.59	1.86	2.05	2.73	1.98	2.04	2.99	3.22	2.28	1.84
0.68	1.52	2.09	2.69	1.22	0.98	2.01	2.84	1.65	0.84

Table 39: Na^+, K^+ and Na^+/K^+ values in urine. Mean and standard deviation. Experiment B-(ii) Part II.

1 - pre-exposure

2,3,4,- during exposure at 40 minute intervals.

5 - post-exposure.

Table 40

Experiment B-(ii) Part II

Subject Code No.	Cl^- mg/min 1	2	3	4	5
73	4.15	14.79	18.71	25.84	12.6
74	2.46	3.94	4.21	3.75	2.82
75	5.01	4.60	4.11	5.65	5.71
76	1.90	3.12	3.81	4.09	2.23
77	9.33	7.01	6.76	5.93	7.32
78	5.99	6.58	6.74	6.33	5.71
79	5.84	5.28	4.91	5.89	5.93
80	2.87	3.43	4.67	6.72	3.71
$\bar{X}$	4.69	6.09	6.74	8.02	5.75
S.D.	2.42	3.78	4.96	7.27	3.26

Table 40: Chloride in urine. Mean and standard deviation. Experiment B-(ii) Part II (at rest).

1 - pre-exposure

2,3,4,- during exposure at 40 minute intervals.

5 - post-exposure.

Table 41

Experiment B-(ii) Part II

Subject Code No.	Creatinine (mg/min) 1	2	3	4	5
71	0.24	1.05	1.11	1.17	0.71
74	0.60	0.92	1.01	1.08	0.92
75	0.92	0.57	0.81	1.12	1.15
76	1.13	1.31	1.40	1.50	1.23
77	2.91	2.84	1.96	1.52	2.33
78	4.96	4.74	4.08	3.89	4.27
79	3.62	3.07	2.96	4.05	3.91
80	2.33	2.59	2.77	1.67	1.54
$\bar{X}$	2.08	2.13	2.01	2	2.01
S.D.	1.65	1.42	1.15	1.23	1.37

Table 41: Creatinine in urine. Mean and standard deviation. Experiment B-(ii) Part II (at rest).

1 - pre-exposure

2,3,4 - during exposure at 40 minute intervals

5 - post-exposure.

Table 42

Experiment B-(ii) Part II

Subject Code No.	Sweat Rate mg/cm^2/min	Na^+ mg/min	K^+ mg/min	Na^+/K^+
73	0.026	0.03	0.06	0.5
74	0.18	2.69	0.16	16.81
75	0.14	4.50	1.5	3
76	0.28	1.44	0.5	2.88
77	0.05	1.46	1.77	0.82
78	0.04	1.32	1.52	0.86
79	0.08	0.96	1.14	0.84
80	0.06	1.12	0.98	1.14
$\bar{X}$	0.107	1.69	0.95	3.35
S.D.	0.08	1.35	0.64	5.52

Table 42 : Sweat rate, Na^+, K^+ and Na^+/K^+ values in sweat. Mean and standard deviation. Experiment B-(ii) Part II (at rest).

Table 43

Experiment B-(iii)Part I

Dry Bulb	30°C
Wet Bulb	22.2°C
Rh %	50

Table 43: Environmental conditions for Experiment B-(iii) Part I. (at rest)

Table 44

Experiment B-(iii) - Part I and Part II

Subject Code No.	Age (years)	Height (cm)	Weight (Kg)	Surface area (m^2)
81	25	173.5	70.60	1.79
82	26	183.6	68.30	1.90
83	30	173.7	64.55	1.70
84	20	172.5	70.85	1.85
85	26	174	75.40	1.94
86	21	172.6	66.25	1.82
87	28	185	79.45	2.06
88	32	183.4	84	2.08
$\overline{X}$	26	177.2	72.41	1.89
S.D.	4.1	5.6	6.71	0.13

Table 44: Age, height, weight and surface area in addition to the mean, standard deviation for subjects under Experiment B-(iii) Part I and Part II (at rest).

Table 45

Experiment B-(iii) Part I

Subject Code No.	Heart rate (Beats/min) pre-exposure	1	2	3	post-exposure
81	84	86	86	84	80
82	75	78	80	80	78
83	92	80	80	76	76
84	77	80	85	72	70
85	68	66	75	70	65
86	75	72	72	71	70
87	86	88	90	86	80
88	80	86	88	80	80
$\overline{X}$	79.62	79.5	82	77.3	74.8
S.D.	7.53	7.5	6.34	6.06	5.79

Table 45: Heart rate, mean and standard deviation.
Experiment B-(iii) Part I (at rest).

1, 2,3, during exposure at 40 minute intervals.

Table 46

Experiment B-(iii) Part I

Subject Code No.	Na^+ (mg/min) 1	2	3	4	5
81	7.00	5.68	5.55	5.47	5.24
82	6.59	6.38	7.32	4.31	3.21
83	2.45	2.01	1.88	1.51	2.31
84	11.22	6.05	5.61	8.42	7.76
85	2.52	2.64	4.71	2.34	2.20
86	1.49	2.65	3.76	1.89	1.61
87	1.20	2.51	2.89	1.40	1.37
88	1.60	2.58	3.25	2.27	1.73
$\bar{X}$	4.25	3.81	4.37	3.45	3.17
S.D.	3.62	1.86	1.76	2.46	2.22

K^+ (mg/min)					Na^+/K^+				
1	2	3	4	5	1	2	3	4	5
5.37	3.18	3.02	2.59	2.41	1.30	1.78	2.14	2.11	2.17
4.04	2.20	2.11	1.70	2.62	1.63	2.9	3.46	2.53	1.22
2.53	1.43	1.61	1.98	2.56	0.96	1.40	1.16	0.76	0.90
9.24	2.58	3.34	4.69	4.54	1.21	2.34	1.67	1.79	1.70
4.44	4.45	3.77	2.36	2.89	0.56	0.59	1.24	0.99	0.76
1.42	2.03	2.22	2.4	1.81	1.04	1.30	1.69	0.78	0.88
1.61	1.38	1.25	1.12	1.41	0.74	1.81	2.31	1.25	0.97
3.64	3.25	2.67	2.5	2.11	0.43	0.79	1.21	0.90	0.81
4.03	2.56	2.49	2.41	2.54	0.98	1.61	1.86	1.38	1.17
2.51	1.03	0.86	1.04	0.93	0.39	0.76	0.77	0.67	0.50

Table 46: Na^+, K^+ and Na^+/K^+ values in urine. Mean and standard deviation. Experiment B-(iii) Part I (at rest).

1 - pre-exposure

2,3,4,- during exposure at 40 minute intervals.

5 - post-exposure.

Table 47

Experiment B-(iii) Part I

Subject Code No.	Cl^- (mg/min) 1	2	3	4	5
81	3.1	3.88	3.80	3.80	3.68
82	12.17	10.65	7.67	6.78	8.81
83	6.8	6.30	5.37	4.91	4.33
84	21.17	7.39	8.73	13.42	13.61
85	6.16	5.60	5.31	4.76	3.26
86	2.92	4.18	3.92	3.49	2.61
87	3.18	4.10	5.13	2.85	2.53
88	3.32	4.09	4.37	3.55	3.05
$\bar{X}$	7.35	5.77	5.53	5.44	5.23
S.D.	6.40	2.34	1.77	3.44	3.94

Table 47: Chloride in urine, mean and standard deviation. Experiment B-(iii) Part I (at rest).

1 - pre-exposure

2,3,4,- during exposure at 40 minute intervals

5 - post-exposure.

Table 48

Experiment B-(iii) Part I

Subject Code No.	Creatinine (mg/min) 1	2	3	4	5
81	0.85	0.87	0.78	0.61	0.75
82	1.06	1.15	1.21	1.02	1.08
83	1.30	1.03	0.97	0.88	0.73
84	3.38	1.64	1.37	1.35	1.72
85	1.47	1.60	1.67	1.07	0.93
86	0.95	1.51	1.54	1.38	1.21
87	3.88	4.22	4.32	2.15	2.08
88	2.00	2.26	2.41	1.71	1.82
$\bar{X}$	1.86	1.78	1.78	1.27	1.29
S.D.	1.15	1.07	1.13	0.48	0.51

Table 48: Creatinine in urine, mean and standard deviation. Experiment B-(iii) Part I (at rest).

1 - pre-exposure

2,3,4, - during exposure at 40 minute intervals.

5 - post-exposure.

Table 49

Experiment B-(iii) Part I

Subject Code No.	Sweat Rate mg/cm^2/min		Na^+ mg/min		K^+ mg/min		Na^+/K^+	
	1	2	1	2	1	2	1	2
81	0.048	0.106	5.76	2.45	6.47	2.84	0.89	0.86
82	0.078	0.005	1.96	1.31	3.33	1.97	0.58	0.66
83	0.126	0.018	4.97	0.96	5.40	1.65	0.92	0.58
84	0.004	0.011	0.38	1.06	0.81	1.64	0.46	0.64
85	0.030	0.05	2.72	3.11	4.12	3.63	0.66	0.85
86	0.046	0.008	4.86	0.77	6.6	0.49	0.73	1.57
87	0.02	0.012	4.24	0.21	4.1	0.92	1.03	0.22
88	0.042	0.040	2.95	0.62	8.24	2.63	0.35	0.23
$\bar{X}$	0.049	0.031	3.48	1.31	4.88	1.97	0.70	0.70
S.D.	0.037	0.034	1.79	0.97	2.30	1.03	0.23	0.42

Table 49: Sweat rate, Na^+, K^+ and Na^+/K^+ values in sweat. Mean and standard deviation. Experiment B-(iii) Part I (at rest).

1 - mid-exposure.
2 - end-exposure.

Table 50

Experiment B-(iii) Part II

Dry Bulb	30°C
Wet Bulb	23.3°C
Rh %	38

Table 50: Environmental conditions for Experiment B-(iii) Part II (at rest).

Table 51

Experiment B-(iii) Part II

Subject Code No.	pre-exposure	Heart rate (Beats/min) 1	2	3	post-exposure
81	78	86	80	78	78
82	72	78	80	80	75
83	92	98	100	90	85
84	80	80	80	80	68
85	64	64	64	63	63
86	84	98	100	88	76
87	90	94	94	90	90
88	76	88	90	96	85
$\bar{X}$	79.5	85.75	86	83.12	77.5
S.D.	9.24	11.58	12.3	10.24	9.08

Table 51: Heart rate, mean and standard deviation.
Experiment B-(iii) Part II at rest.

1,2,3, - during exposure at
40 minute intervals.

Table 52

Experiment B-(iii) Part II

Subject Code No.	Na^+ (mg/min) 1	2	3	4	5
81	4.78	4.19	4.11	3.74	3.52
82	2.67	3.18	3.45	3.71	3.12
83	2.15	1.91	1.82	1.65	1.95
84	4.51	5.05	4.88	5.42	5.71
85	2.66	2.0	1.76	1.44	1.97
86	0.64	2.15	2.18	2.20	1.31
87	0.97	1.68	1.79	1.55	1.26
88	1.57	3.65	3.88	1.92	1.72
$\bar{X}$	2.49	2.92	2.98	2.70	2.57
S.D.	1.51	1.23	1.24	1.43	1.50

K^+ (mg/min)					Na^+/K^+				
1	2	3	4	5	1	2	3	4	5
2.92	1.66	1.60	1.54	1.44	1.63	2.52	2.56	2.44	2.44
3.16	2.49	2.31	1.92	2.81	0.84	1.27	1.49	1.93	1.11
2.78	1.57	1.21	1.35	1.93	0.77	1.21	1.50	1.22	1.01
5.56	7.00	4.89	5.35	6.81	0.81	0.72	0.99	1.01	0.83
4.11	5.76	4.61	3.39	3.21	0.64	0.34	0.38	0.42	0.61
1.30	1.75	2.21	3.17	1.79	0.49	1.22	0.98	0.69	0.73
1.13	1.29	1.62	2.1	1.53	0.85	1.30	1.10	0.73	0.82
2.08	2.96	3.10	1.35	1.31	0.75	1.23	1.25	1.42	1.31
2.86	3.06	2.69	2.52	2.60	0.84	1.22	1.28	1.23	1.10
1.45	2.14	1.39	1.38	1.82	0.33	0.62	0.62	0.67	0.58

Table 52: Na^+, K^+, and Na^+/K^+ values in urine. Mean and standard deviation. Experiment B-(iii) Part II (at rest).

1 - pre-exposure

2,3,4, - during exposure at 40 minute intervals

5 - post-exposure.

Table 52a

Experiment B-(iii) Part II

Subject Code No.	Cl^- (mg/min) 1	2	3	4	5
81	8.32	5.33	5.12	4.94	4.83
82	7.30	6.12	5.64	6.94	7.12
83	6.7	6.25	5.89	4.85	4.62
84	2.10	7.39	6.22	11.40	12.1
85	8.1	6.15	4.73	3.80	4.66
86	2.68	5.14	5.43	6.56	3.21
87	3.10	4.06	4.29	4.40	3.73
88	4.06	3.57	3.61	3.87	3.92
$\bar{X}$	7.65	5.50	5.11	5.84	5.52
S.D.	5.83	1.24	0.86	2.52	2.90

Table 52a: Chloride in urine. Mean and standard deviation. Experiment B-(iii) Part II (at rest).

1 - pre-exposure

2,3,4, - during exposure at 40 minute intervals

5 - post-exposure.

Table 53

Experiment B-(iii) Part II

Subject Code No.	Creatinine (mg/min) 1	2	3	4	5
81	0.61	1.21	0.98	0.87	o.73
82	1.38	1.26	1.13	1.39	1.35
83	0.88	0.96	0.98	1.11	0.91
84	3.56	1.75	1.71	1.67	1.82
85	1.55	1.35	1.42	1.47	1.49
86	3.27	2.90	3.11	3.18	3.16
87	2.62	3.42	3.41	3.38	3.10
88	4.55	4.07	4.81	5.22	4.61
$\bar{X}$	2.30	2.11	2.19	2.28	2.14
S.D.	1.41	1.17	1.41	1.50	1.34

Table 53: Creatinine in urine. Mean and standard deviation. Experiment B-(iii) Part II (at rest).

1 - pre-exposure

2,3,4, - during exposure at 40 minute intervals

5 - post-exposure.

Table 54

Experiment B-(iii) Part II

Subject Code No.	Sweat Rate mg/cm^2/min		Na^+ mg/min		K^+ mg/min		Na^+/K^+	
	1	2	1	2	1	2	1	2
81	0.185	0.069	9.48	3.81	7.72	3.32	1.22	1.14
82	0.145	0.193	4.79	5.05	6.45	4.33	0.74	1.16
83	0.018	0.125	2.56	1.29	2.82	2.44	0.90	0.52
84	0.025	0.050	0.62	0.88	1.31	2.72	0.47	0.32
85	0.128	0.037	3.48	1.55	6.42	3.29	0.54	0.47
86	0.027	0.024	7.8	1.67	8.68	1.32	0.89	1.26
87	0.056	0.026	6.82	1.54	6.62	1.31	1.03	1.17
88	0.051	0.118	3.04	1.59	5.5	3.03	0.55	0.524
$\bar{X}$	0.091	0.080	4.82	2.17	5.69	2.72	0.79	0.82
S.D.	0.067	0.059	2.98	1.45	2.46	1.02	0.26	0.39

Table 54: Sweat rate, Na^+, K^+ and Na^+/K^+ values in sweat. Mean and standard deviation. Experiment B-(iii) Part II (at rest)

1 - mid-exposure
2 - end-exposure.

Experiment -C-

Table 55

Experiment C-

Dry Bulb	40°C.
Wet Bulb	23.3°C
Rh %	25

Table 55: Environmental conditions for Experiment-C-.

Table 56:

Experiment C

Subject Code No.	Sex	Age (years)	Height (cm)	Weight (Kg)	Surface area (m^2)	Weight (Kg) end-exposure
89	M	24	1.88	88	2.14	87.45
90	M	24	1.73	70.20	1.82	69.75
91	M	23	1.72	76	1.88	75.6
92	M	22	1.81	76.3	1.96	75.7
93	M	23	1.79	74.7	1.92	74.2
94	M	27	1.82	84.5	2.04	84.0
95	M	22	1.82	80.2	2.00	79.9
96	M	38	1.77	73.2	1.89	72.8
97	M	23	1.81	68.3	1.86	67.85
98	M	22	1.67	62.7	1.69	62.45
99	M	23	1.74	67	1.76	66.65
100	F	23	1.68	54.9	1.60	54.4
101	F	21	1.60	49.32	1.49	49.2
102	F	20	1.60	60.50	1.62	60.2
103	F	21	1.73	81.5	1.94	81.3
104	F	21	1.64	47.2	1.47	46.75
$\bar{X}$		23.5	1.73	69.6	1.81	69.25
S.D.		4.17	0.08	12.13	0.196	12.09

Table56: Age, height, weight, surface area. Mean and standard deviation for subjects under experiment-C.

Table 57:

Experiment -C-.

Subject Code No.	Heart Rate pre-exposure	Heart Rate mid-exposure	Heart Rate end-exposure	P.C.V. (haematocrit) pre-exposure %	P.C.V. (haematocrit) end-exposure %
89	88	112	108	43	44
90	76	104	96	41	42
91	88	88	76	44	44
92	81	96	100	41	42
93	120	128	124	46	45
94	104	116	112	42	44
95	100	120	116	45	45
96	76	96	96	44	43
97	64	80	72	40	41
98	104	116	88	44	45
99	84	88	80	44	44
100	68	88	76	42	39
101	68	73	62	40	41
102	64	68	64	39	39
103	58	78	62	39	41
104	88	104	90	42	42
$\overline{X}$	83.18	97.18	88.8	42.25	42.56
S.D.	17.34	17.97	19.75	2.14	1.99

Table 57: Heart rate, PCV values for subjects under Experiment -C-.

Experiment -D-

Table 58

Experiment D-(i) Part I

Dry Bulb	40°C
Wet Bulb	23.3°C
Rh	25%
Kata factor	125-130
Cooling time	2 mins. 42 secs.
Globe temperature	40°C
Velocity of air	0.2-0.3 m/sec.

Table 58: Environmental conditions for Experiment D-(i) Part I.

Table 59

Experiment D-(i) Part I

Subject Code No.	Sex	Age (years)	Height (cm)	Weight (Kg)		Surface area (m^2)
				1	2	
105	M	27	174	69.6	69.15	1.83
106	M	24	169.5	63.8	63.3	1.73
107	M	25	184.5	76.05	75.45	1.98
108	M	25	173	69.2	68.5	1.82
109	F	22	169.5	70.9	70.07	1.81
110	F	28	173.1	80.55	80.1	1.93
111	F	22	163.4	63.65	63.5	1.68
$\overline{X}$		24.7	172.3	70.53	70.01	1.82
S.D.		2.2	6.4	6.14	6.08	0.10

Table 59: Age, height, weight, surface area, mean and standard deviation of subjects under experiment D-(i) Part I.

1 - pre-exposure.
2 - end-exposure.

Table 60

Experiment D-(i) Part I

Subject Code No.	Heart Rate (Beats/min) 1	2	3	4	Urine minute volume ml/min 1	2	3	4
105	75	82	80	70	0.73	-	0.55	0.30
106	65	74	70	68	0.52	-	1.07	0.73
107	82	90	86	75	0.67	-	0.60	0.61
108	60	75	90	68	0.97	-	1.66	0.76
109	73	76	75	67	0.58	-	0.74	0.90
110	76	84	80	70	0.66	-	0.72	0.33
111	82	93	87	72	0.58	-	0.54	0.68
$\bar{X}$	73.2	82	81.1	70	0.67	-	0.84	0.61
S.D.	8.2	7.5	7.08	2.76	0.14	-	0.40	0.22

Table 60: Heart rate and urine minute volume values, mean and standard deviation for subjects under Experiment D-(i) Part I.

1 - pre-exposure.
2 - mid-exposure.
3 - end-exposure.
4 - post-exposure.

Table 61
Experiment D-(i) Part I

Subject Code No.	Na^+ (mg/min)			K^+ mg/min			Na^+/K^+			Cl^- (mg/min)		
	1	2	3	1	2	3	1	2	3	1	2	3
105	0.98	1.88	0.84	1.19	1.46	1.73	0.82	1.28	0.48	1.97	4.36	1.91
106	1.16	3.41	2.18	1.23	2.10	1.29	0.94	1.62	1.68	1.93	6.23	4.12
107	2.91	2.33	2.12	2.17	3.56	2.19	1.34	0.65	0.96	4.09	2.78	4.4
108	1.44	4.65	3.33	0.91	1.55	1.06	1.58	3	3.14	2.49	8.41	5.8
109	1.72	3.03	4.20	1.01	2.66	1.70	1.70	1.13	2.47	1.94	5.03	7.05
110	1.41	2.08	0.75	1.04	1.64	1.60	1.35	1.26	0.46	2.18	5.29	3.26
111	0.51	1.96	2.42	0.69	2.06	2.61	0.73	0.95	0.92	0.69	3.94	7.73
$\bar{X}$	1.44	2.76	2.26	1.17	2.14	1.74	1.20	1.41	1.44	2.18	5.14	4.89
S.D.	0.75	1.01	1.24	0.47	0.74	0.52	0.38	0.76	1.03	1.01	1.80	2.07

Table 61: Na^+, K^+, Na^+/K^+, Cl^- values in urine, mean and standard deviation for subjects under Experiment D-(i) Part I.

1 - pre-exposure; 2 - end-exposure; 3 - post-exposure. (control)

Table 62

Experiment D-(i) Part I

Subject Code No.	Urea mg/min			Creatinine mg/min			Creatinine/Bodyweight mg/min/Kg		
	1	2	3	1	2	3	1	2	3
105	9.78	7.04	5.21	1.22	0.98	0.97	0.017	0.014	0.013
106	9.12	15.72	10.8	0.98	1.12	1.16	0.015	0.017	0.018
107	14.76	14.73	15.02	1.19	1.26	1.32	0.015	0.016	0.017
108	10.23	15.44	11.268	0.73	1.18	1.08	0.010	0.017	0.015
109	14.69	16.16	17.13	0.96	0.80	0.93	0.013	0.011	0.013
110	11.03	12.30	7.98	0.74	1.06	1.04	0.009	0.013	0.012
111	6.17	11.11	12.36	0.80	1.02	1.06	0.012	0.0160	0.0168
$\bar{X}$	10.82	13.21	11.39	0.94	1.06	1.08	0.013	0.014	0.015
S.D.	3.06	3.30	4.02	0.20	0.14	0.12	0.002	0.002	0.002

Table 62: Urea, creatinine and creatinine/bodyweight values in urine, mean and standard deviation for subjects under Experiment D-(i) Part I.

1 - pre-exposure (control); 2 - end-exposure; 3 - post-exposure.

Table 63

Experiment D-(i) Part II

Dry Bulb	10°C
Wet Bulb	5.5°C
Rh	50%
Kata factor	484
Kata range	125-130
Cooling time	45 secs.
Globe temperature	10°C
Velocity of air	0.1-0.3 m/sec.

Table 63: Environmental conditions for Experiment D-(i) Part II.

Table 64

Experiment D-(i) Part II

Subject Code No.	Height (cm)	Weight Kg		Surface area (m^2)
		1	2	
105	174	69.7	69.6	1.83
106	169	63.15	62.9	1.73
107	184.5	76.3	75.9	1.98
108	173	69.15	69.05	1.82
109	169.5	70.7	70.45	1.81
110	173.1	80.55	80.7	1.93
111	163.4	63.2	63.0	1.68
$\overline{X}$	172.35	70.43	70.22	1.82
S.D.	6.46	6.46	6.44	0.10

Table 64: Height, weight, surface area and mean, standard deviation for subjects under Experiment D-(i) Part II.

1 - pre-exposure.
2 - end-exposure.

Table 65

Experiment D-(i) Part II

Subject Code No.	Heart Rate (Beats/min) 1	2	3	4	Urine minute volume mg/ml 1	2	3	4
105	70	75	65	70	1.23	-	1.21	0.96
106	68	62	60	65	0.35	-	1.02	1.35
107	72	70	70	75	0.55	-	3.48	2.52
108	60	55	53	62	0.37	-	0.69	1.10
109	70	63	62	71	0.37	-	1.43	2.55
110	73	70	65	70	1.07	-	2.74	2.02
111	75	65	62	78	0.44	-	0.95	0.78
$\bar{X}$	69.71	65.71	62.4	70.14	0.62	-	1.64	1.61
S.D.	4.85	6.51	5.2	5.45	0.36	-	1.04	0.74

Table 65: Heart rate, urine minute volume, mean and standard deviation for subjects under Experiment D-(i) Part II.

1 - pre-exposure.(Control)
2 - mid-exposure.
3 - end-exposure.
4 - post-exposure.

Table 66

Experiment D-(i) Part II

Subject Code No.	Na^+ (mg/min)			K^+ (mg/min)			Na^+/K^+			Cl^- (mg/min)		
	1	2	3	1	2	3	1	2	3	1	2	3
105	2.29	4.71	2.68	1.29	4.67	3.50	1.77	1.00	0.76	3.69	9.94	6.01
106	1.53	6.00	4.79	1.32	3.27	4.02	1.15	1.83	1.19	2.74	9.65	12.10
107	1.53	6.34	5.09	1.18	3.27	3.45	1.29	1.93	1.47	2.39	12.93	10.78
108	1.57	3.29	6.52	1.09	1.44	2.51	1.44	2.28	2.59	2.52	6.69	10.77
109	0.95	7.34	7.04	0.95	2.86	4.38	1	2.56	1.60	1.59	12.24	13.56
110	1.73	6.63	4.70	0.83	3.93	3.02	2.08	1.68	1.55	2.44	12.41	8.91
111	0.57	3.44	3.43	0.79	3.33	1.79	0.72	1.03	1.91	0.67	7.44	5.52
$\bar{X}$	1.45	5.39	4.89	1.06	3.25	3.23	1.35	1.75	1.58	2.29	10.18	9.66
S.D.	0.55	1.59	1.54	0.21	0.99	0.88	0.46	0.58	0.57	0.94	2.4	3.01

Table 66: Na^+, K^+, Na^+/K^+, Cl^- values, mean and standard deviation for subjects under Experiment D-(i) Part II.

1 - pre-exposure (control)
2 -- end-exposure
3 - post-exposure.

Table 67

Experiment D-(i) Part II

Subject Code No.	Urea (mg/min) 1	2	3	Creatinine (mg/min) 1	2	3	Creatinine/body weight mg/min/Kg 1	2	3
105	15.17	13.46	12.89	1.011	0.915	0.35	0.014	0.012	0.004
106	7.45	16.04	17.07	0.77	1.28	1.20	0.012	0.02	0.019
107	13.35	24.07	19.38	1.10	1.46	1.28	0.014	0.019	0.016
108	11.97	17.33	21.57	0.966	1.132	1.024	0.014	0.016	0.015
109	8.82	20.55	20.05	0.698	0.99	0.934	0.009	0.014	0.013
110	12.74	19.46	15.58	0.809	1.00	0.958	0.009	0.012	0.011
111	7.59	14.62	11.800	0.942	1.068	1.115	0.014	0.016	0.017
$\bar{X}$	11.05	17.93	16.90	0.89	1.11	0.98	0.012	0.015	0.013
S.D.	2.99	3.69	3.69	0.14	0.19	0.30	0.002	0.003	0.004

Table 67: Urea, creatinine, creatinine/body weight, values in urine, mean, and standard deviation for subjects under Experiment D-(i) Part II.

1 - pre-exposure; 2 - end-exposure; 3 - post-exposure. (Control)

Table 68

Experiment D-(ii) Part I

Dry Bulb	40°C
Wet Bulb	23.3°C
Rh	25%
Kata factor	484
Kata range	125-130
Cooling time	2 mins. 42 sec.
Globe temperature	40°C
Velocity of air	0.1-0.3 m/sec.

Table 68: Environmental conditions for Experiment D-(ii) Part I.

Table 69

Experiment D-(ii) Part I

Subject Code No.	Sex	Age (years)	Height (cm)	Weight Kg 1	Weight Kg 2	Surface area (m^2)
112	M	27	177.5	71.6	70.85	1.88
113	F	22	169	69.65	69.50	1.79
114	F	22	166	56.6	56.55	1.62
115	F	22	152	52.35	52.15	1.47
116	F	26	163.5	63.65	63.55	1.69
117	F	24	171	86.15	85.65	1.98
118	M	33	173.5	81.8	81.45	1.96
119	M	30	174	71.25	70.3	1.84
120	M	27	177	81.35	81.0	1.98
121	F	40	163	58.35	58.0	1.61
122	F	29	161	51.4	50.9	1.51
123	F	23	155	53.75	53.45	1.50
124	M	19	162	59.6	59.25	1.63
125	M	23	164	58.4	58.15	1.63
$\bar{X}$		26.2	166.3	65.42	65.0	1.72
S.D.		5.4	7.76	11.63	11.55	0.18

Table 69: Age, height, weight, surface area, mean and standard deviation for subjects under Experiment D-(ii) Part I.

1 - pre-exposure.
2 - end-exposure.

Table 70

Experiment D-(ii) Part I

Subject Code No.	Heart Rate (Beats/min) 1	2	3	4	5
112	70	75	78	78	74
113	66	68	75	70	68
114	80	86	86	86	84
115	90	92	95	87	85
116	69	78	80	72	72
117	71	74	73	73	73
118	82	88	90	88	88
119	74	78	78	75	72
120	80	104	92	92	88
121	72	78	80	74	74
122	65	75	78	72	69
123	67	75	80	76	72
124	72	78	80	80	76
125	64	72	75	78	78
$\bar{X}$	73	80.07	81.42	78.64	76.6
S.D.	7.4	9.42	6.72	6.95	6.8

Table 70: Heart rate, mean and standard deviation for subjects under Experiment D-(ii) Part I.

1 - pre-exposure.
2,3,4, - during exposure at 30 minute intervals.
5 - end-exposure.

Table 71

Experiment D-(ii) Part I

Subject Code No.	Urine Volume (mls)					Minute Urine Volume (ml/min)					Urea (mg/min)				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
112	465	435	80	30	60	0.83	2.28	1.33	0.5	0.5	19.8	24.8	16.6	8.7	12.1
113	365	40	50	60	65	0.75	0.33	0.83	1	0.54	19.8	8.2	19.5	25.9	13.4
114	175	105	45	40	105	0.36	0.95	0.75	0.66	0.87	6.5	8.8	9.4	9.0	12.92
115	70	65	145	45	120	0.66	0.34	2.41	0.75	1	6.24	2.2	9.1	6.2	16.9
116	175	85	15	65	40	0.34	0.40	0.25	1.08	0.33	8.4	9.4	5.8	12.0	6.2
117	442	120	140	40	350	0.90	0.75	2.33	0.66	2.91	17.0	9.9	15.9	9.07	52.1
118	170	15	25	20	62	0.35	0.55	0.41	0.33	0.51	8.4	12.1	10.1	7.7	11.6
119	280	52.5	30	40	90	0.59	0.75	0.5	0.66	0.75	14.6	16.02	13.4	14.6	14.4
120	255	25	25	18	48	0.42	0.35	0.41	0.3	0.4	14.1	9.26	11.9	8.37	14.7
121	405	360	245	15	70	0.89	2.57	4.08	0.25	0.58	4.5	9.1	8.8	3.5	6.3
122	225	60	110	180	130	0.50	0.46	1.83	3	1.08	9.2	10.1	14.5	17.4	12.1
123	225	200	55	65	85	0.48	1.11	0.91	1.08	0.7	3.01	22.3	7.6	12.7	10.5

124	110	32	45	15	45	0.25	0.35	0.75	0.25	0.375	6.8	8.6	20.7	5.2	6.4
125	233	48	37	70	35	0.44	0.76	0.61	1.16	0.29	9.8	9.6	13.7	30.7	2.0
$\bar{X}$	256.7	117.3	74.7	50.2	93.2	0.554	0.853	1.248	0.83	0.77	10.5	11.4	12.6	12.2	13.68
S.D.	121.4	128.6	64.5	42.0	79.5	0.217	0.711	1.07	0.70	0.66	5.5	5.8	4.4	7.8	11.79

Table 71: Urine volume, minutes urine volume, and urea values in urine for subjects under Experiment D-(ii) Part I.

1 - early morning sample
2 - pre-exposure sample
3 - mid-exposure sample
4 - end-exposure sample
5 - post-exposure sample.

Table 72

Experiment D-(ii) Part I

Subject Code No.	Na^+ (mg/min)					K^+ (mg/min)					Na^+/K^+					Cl^- (mg/min)				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
112	3.911	6.42	3.61	2.10	2.4	0.89	2.92	3.32	3.23	1.45	3.58	2.27	1.08	0.65	1.65	3.50	9.01	4.39	2.44	2.65
113	3.68	1.01	3.58	3.21	2.19	1.58	1.02	2.04	3.45	1.98	2.32	0.99	1.75	0.93	1.10	5.76	2.39	6.02	6.87	3.59
114	1.32	13.60	2.46	2.26	2.89	0.43	2.74	1.52	1.64	1.72	3.06	4.96	1.61	1.37	1.68	1.89	4.06	4.4	4.8	5.6
115	1.22	0.41	1.66	1.48	1.21	1.14	0.74	2.83	1.61	2.73	1.07	0.54	0.58	0.91	0.44	1.60	1.00	5.2	3.0	2.5
116	0.88	1.61	0.60	1.12	0.67	0.42	1.20	1.15	3.34	1.10	2.09	1.34	0.52	0.33	0.60	1.21	3.58	2.1	3.5	2.1
117	2.51	3.22	4.61	3.26	8.5	1.71	1.60	3.01	1.64	10.14	1.46	2.01	1.53	1.98	0.83	3.6	6.06	8.9	5.0	19.5
118	1.16	1.78	1.55	1.08	1.92	1.07	3.01	2.50	2.09	2.30	1.08	0.59	0.62	0.51	0.83	1.18	3.05	2.37	2.12	3.99
119	3.92	3.67	1.8	3.07	3.29	1.41	4.51	2.42	3.85	4.36	2.78	0.81	0.74	0.79	0.75	5.18	6.91	3.45	5.99	6.75
120	0.61	0.42	0.47	0.46	0.46	2.32	3.43	3.90	3.07	2.31	0.26	0.12	0.11	0.14	0.19	1.94	2.35	2.33	2.05	1.91
121	1.39	1.24	1.96	0.81	1.32	0.69	0.9	0.79	0.42	1.15	2.01	1.37	2.48	1.92	1.14	1.67	2.82	3.90	1.12	2.03
122	2.56	1.26	2.73	3.44	1.88	0.62	1.20	3.86	4.57	1.98	4.12	1.05	0.70	0.75	0.94	1.86	1.71	6.5	6.48	2.9
123	0.55	2.8	0.33	0.64	1.09	0.23	2.34	0.99	2.53	2.13	2.39	1.19	0.33	0.25	0.511	1.5	3.77	3.25	2.56	1.81

124	0.67	1.32	3.87	1.42	1.39	0.50	0.82	1.99	0.59	1.08	1.34	1.60	1.94	2.40	1.28	0.74	0.78	2.41	0.28	0.5
125	1.11	1.57	1.74	3.84	0.48	0.62	0.90	0.95	2.14	0.27	1.79	1.74	1.83	1.79	1.77	1.85	2.99	2.03	5.67	1.54
$\bar{X}$	1.82	2.88	2.21	2.01	2.12	0.97	1.94	2.24	2.44	2.47	2.09	1.47	1.13	1.05	0.97	2.38	3.60	4.08	3.70	4.09
S.D.	1.24	3.46	1.32	1.16	2.02	0.59	1.19	1.07	1.21	2.4	1.05	1.16	0.71	0.71	0.48	1.52	2.30	2.00	2.09	4.72

Table 72: Na^{+}, K^{+}, Na^{+}/K^{+}, and Cl^{-} values in urine, mean and standard deviation for subjects under Experiment D-(ii) Part I.

1 - early morning sample; 2 - pre-exposure sample; 3 - mid-exposure sample;
4 - end-exposure sample; 5 - post-exposure sample.

Table 73

Experiment D-(ii) Part I

Subject Code No.	Creatinine (mg/min)					Creatinine/Kg (Body weight) (mg/min/Kg)				
	1	2	3	4	5	1	2	3	4	5
112	0.92	1.26	1.05	0.56	0.56	0.012	0.017	0.014	0.007	0.007
113	1.15	0.54	1.03	1.46	0.021	0.016	0.007	0.014	0.021	0.016
114	0.67	0.86	0.73	0.78	0.97	0.011	0.015	0.013	0.013	0.017
115	0.53	0.20	0.75	0.52	1.36	0.010	0.003	0.014	0.009	0.026
116	0.81	0.91	0.58	0.94	0.80	0.012	0.014	0.009	0.014	0.012
117	0.88	0.73	1.10	0.91	8.52	0.010	0.008	0.012	0.010	0.098
118	1.28	2.00	1.36	1.22	1.44	0.015	0.024	0.016	0.014	0.017
119	1.07	1.56	1.47	1.50	1.28	0.015	0.021	0.02	0.021	0.017
120	1.15	1.25	1.59	1.15	1.36	0.014	0.015	0.019	0.014	0.016
121	0.52	0.85	0.34	0.45	0.76	0.008	0.014	0.005	0.007	0.013
122	0.58	0.84	0.71	0.81	0.69	0.01	0.016	0.013	0.015	0.013
123	0.162	1.53	0.656	0.95	1.13	0.003	0.02	0.012	0.017	0.021

124	0.78	1.18	2.73	0.68	1.08	0.013	0.019	0.045	0.011	0.018
125	0.77	1.43	1.26	2.7	0.11	0.013	0.02	0.02	0.04	0.001
$\bar{X}$	0.80	1.08	1.09	1.04	1.43	0.011	0.015	0.0161	0.015	0.020
S.D.	0.30	0.46	0.59	0.57	2.08	0.003	0.005	0.09	0.008	0.022

Table 73: Creatinine and creatinine/Kg(body weight) values in urine, and mean and standard deviation for subjects under Experiment D-(ii) - Part I.

1 - early morning sample; 2 - pre-exposure sample; 3 - mid-exposure sample; 4 - end-exposure sample; 5 - post-exposure sample.

Table 74

Experiment D-(ii) Part I

Subject Code No.	Haemoglobin g/100 ml			P.C.V. (Haematocrit) %			Red Blood Count x 10^6 cell/mm^3			White Blood Count x 10^3 cell/mm^3		
	1	2	3	1	2	3	1	2	3	1	2	3
112	14.2	14.5	13.5	46	45	45	6.31	6.28	6.25	10.5	10.40	10.3
113	13.0	12.9	12.3	45	43	42	4.55	4.32	4.28	7.46	7.20	7.13
114	14.5	13.9	12.9	42	40.5	40.5	4.28	4.22	4.16	7.15	7.04	6.93
115	13.0	13.2	13.8	44.5	40	40	4.78	4.53	4.99	8.4	8.41	8.3
116	12.5	12.3	12.3	38	37	37	4.31	4.20	4.18	10.1	10.50	9.88
117	14.32	14.55	15.47	45	46	46	4.67	4.82	4.9	7.63	8.94	9.32
118	12.6	13.5	13.1	44	43.5	43.5	6.18	6.12	6.10	8.85	8.82	7.99
119	14.5	13.2	12.8	43	42	42	4.66	4.60	4.37	6.98	6.95	6.86
120	15.4	15.3	15.5	45	43	41	5.12	5.14	5.11	5.65	8.32	6.32
121	14.28	13.9	13.8	39	38	38	4.72	4.59	4.50	7.98	9.12	8.23
122	12.22	12.46	12.4	42	43.5	42	4.83	4.84	4.80	8.31	7.95	7.98
123	14.0	13.92	13.88	42.5	42	42	4.65	4.55	4.50	5.30	5.70	5.45

124	15.3	14.2	14.8	45.9	43.5	43	5.13	5.10	5.15	5.20	4.60	6.50
125	13.2	15.1	16.2	42	47	48	5.88	6.2	6.20	5.70	10.7	6.70
$\overline{X}$	13.85	13.78	13.76	43.1	42.3	42.14	5.005	4.96	4.96	7.51	8.17	7.71
S.D.	0.97	0.91	1.27	2.4	2.8	2.9	0.65	0.72	0.73	1.67	1.7	1.41

Table 74: Haemoglobin, haematocrit values, red and white blood cells count, mean and standard deviation for subjects under Experiment D-(ii) Part I.

1 - pre-exposure.
2 - mid-exposure.
3 - end-exposure.

Table 75

Experiment D-(ii) Part II

Dry Bulb	10°C
Wet Bulb	5.5°C
Rh	50%
Kata factor	484
Kata range	125-130
Cooling time	43 seconds
Globe temperature	10°C
Velocity of air	0.1-0.3 m/sec.

Table 75: Environmental conditions for Experiment D-(ii) Part II.

Table 76

Experiment D-(ii) Part II

Subject Code No.	Sex	Age (years)	Height (cm)	Weight (Kg) 1	Weight (Kg) 2	Surface area(m^2)
112	M	27	177.5	71.6	71	1.88
113	F	22	169	69.4	68.8	1.79
114	F	22	166	57.7	57.1	1.63
115	F	22	152	52.15	51.7	1.47
116	F	26	163.5	63.8	63.6	1.69
117	F	24	171	86.3	86.1	1.98
118	M	33	173.5	81.9	81.5	1.96
119	M	30	174	71.25	70.6	1.84
120	M	27	177	81.4	81.15	1.98
121	F	40	163	58.3	58.1	1.61
122	F	29	161	51.1	50.5	1.51
123	F	23	155	53.6	53.4	1.5
124	M	19	162	59.6	59.4	1.63
125	M	23	164	58.15	58	1.63
$\overline{X}$		26.2	166.3	65.4	65.06	1.72
S.D.		5.4	7.76	11.67	11.68	0.18

Table 76: Age, height, weight, surface area, mean and standard deviation for subjects under Experiment D-(ii) Part II.

Table 77

Experiment D-(ii) Part II

Subject Code No.	Heart Rate (Beats/min) 1	2	3	4	5
112	73	70	68	68	65
113	70	65	62	60	60
114	75	78	69	69	67
115	78	76	72	62	65
116	65	68	64	62	60
117	64	60	58	58	58
118	76	77	73	69	68
119	68	64	60	58	55
120	75	72	70	68	65
121	70	65	65	60	62
122	68	67	63	59	57
123	65	62	60	60	60
124	68	66	60	55	55
125	60	58	58	55	57
$\bar{X}$	69.6	67.71	64.4	61.64	61
S.D.	5.22	6.21	5.15	4.95	4.38

Table 77: Heart rate, mean and standard deviation for subjects under Experiment D-(ii) - Part II.

1 - pre-exposure
2,3,4 - during exposure at 30 minute intervals
5 - end-exposure.

Table 78

Experiment D-(ii) Part II

Subject Code No.	Urine volume (mls)					Minute urine volume (ml/min)					Urea (mg/min)				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
112	295	235	135	280	90	0.60	1.30	2.25	4.66	0.75	16.76	21.62	20.12	22.4	13.41
113	370	130	190	115	60	0.59	0.72	3.16	1.91	0.5	14.65	16.73	26.23	21.51	10.14
114	130	540	45	65	50	0.26	3.12	0.75	1.08	0.41	2.91	10.67	9.04	11.31	5.10
115	640	300	150	70	80	1.09	1.87	2.5	1.16	0.66	19.56	40.18	14.40	17.01	8.8
116	160	110	30	50	50	0.33	0.56	0.5	0.83	0.41	6.85	8.02	6.032	9.15	6.37
117	285	60	105	150	95	0.55	0.92	1.75	2.5	0.79	13.12	16.17	16.70	13.05	12.87
118	370	25	85	100	160	0.69	0.62	1.41	1.66	1.33	8.67	7.46	13.60	14.40	13.68
119	125	266	45	65	85	0.30	0.38	0.75	1.08	0.70	10.53	10.67	17.15	18.59	14.15
120	265	25	45	105	65	0.44	0.35	0.75	1.75	0.54	16.55	9.41	18.45	34.3	13.29
121	180	135	305	105	65	0.33	1.92	5.08	1.75	0.54	4.39	14.63	9.14	5.98	5.64
122	190	105	165	205	85	0.4	0.77	2.75	3.41	0.70	10.32	14.28	16.5	17.8	12.77
123	230	110	145	60	50	0.43	0.81	2.41	1	0.41	12.83	10.84	11.86	10.32	6.99

124	180	35	25	50	75	0.37	0.31	0.41	0.83	0.62	12.61	11.57	11.17	16.93	12
125	200	120	345	700	265	0.39	1.5	5.75	11.66	2.2	7.53	20.25	24.8	19.59	16.9
$\bar{X}$	258.5	139.7	129.6	151.4	91.07	0.48	1.08	2.15	2.52	0.75	11.23	15.17	15.37	16.59	10.8
S.D.	135.2	140.02	99.1	170.7	57.4	0.21	0.79	1.65	2.84	0.47	4.84	8.38	5.8	7.009	3.68

Table 78: Urine volume, minute urine volume, urea values in urine, mean and standard deviation for subjects under Experiment D-(ii) Part II.

1 - early morning sample
2 - pre-exposure sample
3 - mid-exposure sample
4 - end-exposure sample
5 - post-exposure.sample.

Table 79

Experiment D-(ii) Part II

Subject Code No.	Na^+ (mg/min)					K^+ (mg/min)					Na^+/K^+					Cl^- (mg/min)				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
112	3.41	4.83	1.18	0.75	2.68	1.15	1.99	2.28	1.09	1.31	2.96	2.42	0.51	0.68	2.04	4.46	6.89	4.86	6.28	3.93
113	4.20	3.65	4.65	5.02	1.80	1.48	2.05	2.06	2.27	1.74	2.83	1.78	2.25	2.21	1.03	5.94	6.50	8.19	8.92	3.45
114	0.99	2.51	3.51	5.13	1.37	0.36	4.13	2.25	3.17	1.9	2.75	0.60	1.56	1.61	0.72	1.48	5.75	5.74	8.71	2.75
115	5.81	6.03	1.55	1.42	0.64	3.88	11.61	3.45	7.89	1.15	1.49	0.51	0.44	0.17	0.55	5.81	9.57	5.05	6.86	1.72
116	0.86	1.94	1.70	2.70	1.01	0.38	1.67	1.85	2.41	0.89	2.26	1.16	0.91	1.12	1.13	1.26	3.96	4.05	6.08	2.46
117	1.83	3.71	5.31	3.33	3.42	1.53	4.04	4.99	2.83	2.13	1.19	0.91	1.06	1.17	1.60	2.59	6.84	9.67	7.35	5.50
118	2.42	2.62	6.83	7.05	6.16	0.94	2.40	5.28	6.06	5.09	2.57	1.09	1.29	1.16	1.21	2.50	4.78	10.8	12.94	11.8
119	1.53	1.17	3.29	5.62	3.98	0.60	1.36	2.08	3.68	2.21	2.55	0.86	1.58	1.52	1.80	1.58	2.08	5.71	9.75	5.87
120	2.3	1.55	4.72	5.62	2.98	0.70	1.35	1.96	3.35	1.29	3.28	1.14	2.40	1.67	2.31	2.51	2.60	5.63	13.89	5.01
121	0.94	3.97	2.45	1.52	1.86	0.46	1.50	0.79	1.02	1.37	2.04	2.64	3.10	1.49	1.35	0.83	5.58	5.94	3.28	3.61
122	1.18	1.43	3.28	3.68	2.14	0.71	1.80	3.76	3.99	2.24	1.66	0.79	0.87	0.92	0.95	0.97	2.23	6.33	7.25	3.10
123	1.28	1.08	0.88	1.93	0.80	0.36	0.69	1.79	2.16	1.91	3.55	1.56	0.49	0.89	0.41	2.04	3.	5.89	3.47	1.06

124	1.37	0.84	2.26	5.26	2.93	0.60	0.89	0.76	1.83	1.65	2.28	0.94	2.97	2.87	1.77	1.95	1.45	2.73	4.79	3.36
125	1.21	3.79	5.55	10.72	4.24	1.14	3.28	2.69	2.73	2.66	1.06	1.15	2.06	3.92	1.59	2.14	6.43	12.43	9.09	7.09
$\bar{X}$	2.09	2.79	3.36	4.26	2.57	1.02	2.76	2.57	3.17	1.96	2.31	1.25	1.53	1.52	1.31	2.57	4.83	6.64	7.76	4.33
S.D.	1.45	1.57	1.82	2.66	1.53	0.91	2.75	1.35	1.86	1.02	0.75	0.63	0.89	0.95	0.56	1.65	2.35	2.68	3.11	2.7

Table 79: Na^+, K^+, Na^+/K^+ and Cl^- values in urine, mean and standard deviation for subjects under Experiment D-(ii) Part II.

1 - early morning sample
2 - pre-exposure sample
3 - mid-exposure sample
4 - end-exposure sample
5 - post-exposure sample.

Table 80

Experiment D-(ii) Part II

Subject Code No.	Creatinine (mg/min) 1	2	3	4	5	Creatinine/Kg (Body weight) mg/min/Kg 1	2	3	4	5
112	1.09	1.19	1.07	1.20	1.13	0.015	0.016	0.015	0.016	0.015
113	1.00	1.02	1.14	1.04	1.06	0.014	0.014	0.016	0.015	0.015
114	0.24	0.93	0.81	0.91	0.90	0.004	0.016	0.014	0.015	0.015
115	1.24	2.12	0.91	1.13	0.65	0.023	0.040	0.017	0.021	0.012
116	0.76	1.12	0.71	0.87	0.71	0.011	0.017	0.011	0.0137	0.011
117	0.86	0.93	1.02	0.76	1.19	0.0106	0.0107	0.0118	0.0089	0.0132
118	1.31	1.06	1.46	1.60	1.55	0.016	0.013	0.017	0.019	0.018
119	0.97	1.45	1.51	1.29	1.17	0.01	0.02	0.021	0.018	0.016
120	1.22	1.01	1.42	1.73	1.13	0.015	0.012	0.017	0.021	0.013
121	0.46	1.72	0.86	0.65	0.69	0.007	0.029	0.014	0.0112	0.0119
122	0.62	0.85	0.69	0.74	0.66	0.012	0.016	0.013	0.014	0.012

123	0.66	0.66	0.75	0.75	0.63	0.012	0.012	0.014	0.013	0.011
124	0.89	0.96	0.95	1.22	1.02	0.015	0.016	0.016	0.02	0.017
125	0.82	1.97	1.31	1.001	0.955	0.014	0.033	0.022	0.017	0.016
$\overline{X}$	0.86	1.21	1.04	1.06	0.96	0.012	0.018	0.015	0.015	0.014
S.D.	0.30	0.43	0.28	0.32	0.27	0.004	0.008	0.003	0.003	0.002

Table 80: Creatinine and Creatinine/Kg (Body weight) values in urine and mean, standard deviation for subjects under Experiment D-(ii) Part II.

1 - early morning sample
2 - pre-exposure sample
3 - mid-exposure sample
4 - end-exposure sample
5 - post-exposure.sample.

Table 81

Experiment D-(ii) Part II

Subject Code No.	Haemoglobin g/100 ml			P.C.V. (Haematocrit) %			Red Blood Count x 10^6 cells/mm^3			White Blood Count x 10^3 cells/mm^3		
	1	2	3	1	2	3	1	2	3	1	2	3
112	14.9	16.4	17.4	46	48	48.5	5.44	5.65	5.72	9.85	10.23	11.37
113	14.3	14.5	14.1	42	42	43	4.68	4.72	4.80	6.32	5.89	7.33
114	14.8	15.1	15.4	41	42	44	4.62	5.02	5.43	8.34	8.52	7.90
115	12.9	13.5	13.6	43	44	44	4.82	4.88	4.89	6.7	7.05	7.1
116	12.8	12.9	12.9	39	40	40	4.42	4.63	4.70	9.8	9.6	9.8
117	14.7	14.82	14.6	45	46	46	4.82	5.11	5.09	8.1	8.3	7.2
118	13.8	13.9	13.9	41.5	42	42	5.25	5.28	5.3	7.4	7.9	7.9
119	14.4	15.4	15.7	42	44	46	4.90	5.30	5.5	7.7	7.9	7.9
120	15.1	15.3	15.3	43	45	45	5.2	5.35	5.40	6.7	6.9	6.5
121	14.0	13.8	13.8	40	40	40	5.3	5.3	5.35	7.4	7.5	7.5
122	12.6	12.7	12.5	39	42	43	5.1	5.2	4.95	6.9	8.3	7.80
123	14.3	14.5	13.9	43	44	44	5.1	4.9	4.9	5.5	5.9	5.1

124	15.4	15.7	15.8	45	46	46.5	5.8	5.9	5.6	6.4	7.1	6.8
125	13.6	13.8	13.9	42	41.5	42	4.72	5.25	5.28	5.5	6.3	6.7
$\bar{X}$	14.1	14.45	14.48	42.25	43.32	43.8	5.01	5.17	5.20	7.32	7.67	7.63
S.D.	0.88	1.07	1.30	2.13	2.36	2.43	0.37	0.34	0.31	1.35	1.28	1.48

Table 81: Haemoglobin, haematocrit values, red and white blood cell count, mean and standard deviation for subjects under Experiment D-(ii) Part II.

1 - pre-exposure
2 - end-exposure.
3 - post-exposure.

Table 82

Experiment D-(iii) Part I

Dry Bulb	40°C
Wet Bulb	23.3°C
Rh	25%
Kata factor	484
Kata range	125-130
Cooling time	160 seconds
Globe temperature	40°C
Velocity of air	0.2-0.3 m/sec.

Table 82: Environmental conditions for Experiment D-(iii) Part I.

Table 83:

Experiment D-(iii) Part II

Dry Bulb	10°C
Wet Bulb	5.5°C
Rh	50%
Kata factor	484
Kata range	125-130
Cooling time	45 seconds
Globe temperature	10°C
Velocity of air	0.1-0.3 m/sec.

Table 83: Environmental conditions for Experiment D-(iii) Part II.

Table 84

Experiment D-(iii) Part I and Part II

Subject Code No.	Sex	Age (years)	Height (cm)	Weight (Kg)
126	M	11	140	34.4
127	M	13	146	32.9
128	M	12	144	32.4
129	F	10	142	40.2
130	F	8	130	23.2
131	F	9	138	44.6
132	F	8	137	36
$\overline{X}$		10.14	139.5	34.8
S.D.		1.95	5.28	6.7

Table 84: Age, height, weight, mean and standard deviation for subjects under experiment D-(iii) Part I and II.

Table 85:

Experiment D-(iii) Part I and II

Subject Code No.	Heart Rate (Beats/min) Part I 1	Part I 2	Part I 3	Part II 1	Part II 2	Part II 3
126	84	90	92	70	72	64
127	88	96	112	82	66	66
128	86	102	90	84	66	72
129	94	110	104	86	74	66
130	92	120	106	92	80	72
131	102	120	116	104	98	88
132	100	100	112	106	96	90
$\bar{X}$	92.2	105.4	104.5	89.1	78.8	74
S.D.	6.8	11.64	10.1	12.6	13.3	10.7

Table 85: Heart rate, mean and standard deviation for subjects under Experiment D-(iii) Part I and II.

1 - pre-exposure
2 - end-exposure
3 - post-exposure.

Table 86

Experiment D-(iii) Part I and II

Subject Code No.	Urine Volume (ml)						Minute Urine Volume (ml/min)					
	Part I			Part II			Part I			Part II		
	1	2	3	1	2	3	1	2	3	1	2	3
126	30	45	35	105	225	110	0.33	0.37	0.29	1.105	1.87	0.91
127	175	140	45	140	300	305	0.36	1.16	0.37	1.55	2.5	2.54
128	20	25	30	30	75	325	0.23	0.20	0.25	0.31	0.62	2.7
129	45	30	45	25	50	180	0.45	0.25	0.37	0.41	0.41	1.5
130	30	20	25	175	175	80	0.31	0.16	0.20	0.97	1.45	0.66
131	25	15	45	130	70	100	0.22	0.12	0.37	0.72	0.58	0.83
132	80	35	65	115	115	95	0.66	0.29	0.54	0.63	0.95	0.79
$\bar{X}$	57.8	44.2	41.4	102.8	144.2	170.7	0.36	0.26	0.34	0.81	1.19	1.41
S.D.	55.4	43.3	13.1	56.03	92.8	103.7	0.15	0.36	0.11	0.43	0.77	0.86

Table 86: Urine volume, minute urine volume, mean and standard deviation for subjects under Experiment D-(iii) Part I and II.

1 - pre-exposure
2 - end-exposure
3 - post-exposure.

Table 87

Experiment D-(iii) Part I and II

Subject Code No.	Part I									Part II								
	Na^+(mg/min)			K^+(mg/min)			Na^+/K^+			Na^+(mg/min)			K^+(mg/min)			Na^+/K^+		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
126	1.57	1.034	0.85	1.82	1.61	1.80	0.86	0.64	0.47	2.79	2.15	0.80	1.99	2.12	1.11	1.40	1.01	0.72
127	1.79	0.69	0.58	2.16	2.91	1.31	0.82	0.23	0.44	2.07	3.33	0.70	2.06	2.34	1.78	1.00	1.42	0,39
128	0.45	1.26	0.73	1.61	2.15	1.32	0.27	0.58	0.55	1.04	2.58	3.7	1.30	1.58	2.11	0.8	1.63	1.75
129	1.67	1.26	0.81	2.32	0.92	2.43	0.71	1.36	0.33	1.89	1.97	1.37	2.05	1.43	2.05	0.92	1.37	0.66
130	0.79	0.18	0.56	2.58	1.13	1.01	0.30	0.15	0.55	1.07	1.40	0.61	1.52	0.68	0.46	0.70	2.05	1.32
131	0.61	0.12	0.74	0.94	0.53	0.83	0.64	0.82	0.89	1.22	0.67	0.34	2.9	0.95	0.52	0.42	0.70	0.65
132	4.5	1.54	1.18	2.67	1.11	0.99	1.68	1.38	1.19	0.96	0.70	0.91	0.64	0.26	0.39	1.5	2.69	2.33
$\bar{X}$	1.62	0.86	0.77	2.01	1.48	1.38	0.75	0.65	0.63	1.57	1.82	1.20	1.78	1.33	1.06	0.96	1.55	1.11
S.D.	1.37	0.55	0.20	0.60	0.81	0.55	0.47	0.52	0.3	0.69	0.97	1.14	0.71	0.75	0.67	0.38	0.66	0.71

Table 87: Na^+, K^+, Na^+/K^+ values in urine, mean and standard deviation for subjects under Experiment D-(iii) Part I and II

1 - pre-exposure
2 - end-exposure
3 - post-exposure.

Table 88

Experiment D-(iii) Part I and II

Subject Code No.	Part I: Urea (mg/min) 1	2	3	Part I: Creatinine (mg/min) 1	2	3	Part I: mg/min/Kg Creatinine/Kg 1	2	3	Part II: Urea (mg/min) 1	2	3	Part II: Creatinine (mg/min) 1	2	3	Part II: mg/min/Kg Creatinine/Kg 1	2	3
126	4.99	3.91	5.60	0.38	0.30	0.51	0.011	0.008	0.014	11.14	9.67	4.84	0.39	0.23	0.16	0.011	0.006	0.004
127	11.63	9.38	6.70	0.71	0.41	0.48	0.021	0.012	0.01	14.18	11.10	7.93	0.49	0.26	0.17	0.014	0.008	0.005
128	3.64	6.37	5.79	0.35	0.53	0.52	0.011	0.016	0.016	4.46	8.47	8.45	0.36	0.41	0.25	0.011	0.012	0.007
129	10.21	6.00	11.88	0.58	0.26	0.88	0.014	0.006	0.02	9.35	9.05	10.62	0.54	0.39	0.39	0.013	0.009	0.009
130	9.51	7.10	6.85	0.36	0.28	0.30	0.015	0.012	0.013	14.12	7.87	5.04	0.62	0.34	0.21	0.026	0.014	0.008
131	8.48	4.68	8.46	0.48	0.31	0.58	0.01	0.006	0.013	16.99	12.25	7.10	0.86	0.60	0.30	0.018	0.0132	0.006
132	10.15	4.93	5.07	0.49	0.25	0.29	0.013	0.007	0.008	5.67	1.955	4.94	0.30	0.14	0.26	0.008	0.004	0.007
$\bar{X}$	8.37	6.06	7.19	0.47	0.33	0.50	0.013	0.009	0.013	10.84	8.62	6.98	0.50	0.33	0.24	0.014	0.009	0.006
S.D.	2.9	1.82	2.34	0.13	0.10	0.19	0.003	0.003	0.003	4.64	3.30	2.19	0.10	0.14	0.07	0.005	0.003	0.001

Table 88: Urea, creatinine, creatinine/Body weight values in urine, mean and standard deviation for subjects under Experiment D-(iii) Part I and II.

1 - pre-exposure
2 - end-exposure
3 - post-exposure.

Experiment -E-

Table 89

Experiment -E-

Dry Bulb	40°C
Wet Bulb	23.3°C
Rh	25%
Kata factor	484
Kata range	125-130
Cooling time	2 min. 43 sec.
Globe temperature	40°C
Velocity of air	0.2-0.3 m/sec.

Table 89: Environmental conditions for Experiment-E.

Table 90

Experiment -E-

Subject Code No.	Sex	Age (years)	Height (cm)	Weight (Kg)	Surface area (m^2)
133	F	23	155	52.8	1.49
134	M	23	166.5	59.6	1.65
135	F	41	160	54.30	1.55
136	M	35	176.5	65.2	1.79
137	M	27	174	71.4	1.85
138	M	23	178.3	84.3	2.02
139	M	23	167.5	65.8	1.73
140	F	19	160	63.1	1.65
141	F	20	166	63.6	1.70
$\overline{X}$		26	167.08	64.4	1.71
S.D.		7.31	7.98	9.4	0.15

Table 90: Age, height, weight, surface area, mean and standard deviation for subjects under Experiment -E-.

Table 91

Experiment -E-

Subject Code No.	Water intake (ml)	urine output (ml)	
		1	2
133	2700	975	140
134	2700	770	235
135	4000	1125	260
136	4350	525	276
137	3125	549	200
138	3750	1265	355
139	3100	685	230
140	3400	720	275
141	3900	545	100
$\overline{X}$	3447.2	795.4	230.1
S.D.	587.4	268.4	76.3

Table 91: Total water intake, and urine output in 24 hours for subjects under Experiment -E-

1 - Total urine output in 24 hours.
2 - Volume of urine output 4 hours after the end of exposure.

Table 92:

Experiment -E-

Subject Code No.	Time: pre-exposure Midday 12	2	4	6	8	10	12	5	8	10	end-exposure Midday 12
	Body weight (Kg)										
133	52.8	53.1	52.8	52.5	52.8	52.7	52.55	52.1	51.7	51.8	51.7
134	59.6	58.8	59.5	59.4	59.8	59.6	59.8	59.0	58.7	58.9	58.9
135	54.35	54.9	54.9	55.1	55.4	55.6	55.4	54.8	54	54	54.1
136	65.2	65.4	65.9	65.75	65.6	65.8	66.1	65.6	65.4	64.85	64.7
137	71.4	71.0	70.7	70.75	70.5	70.7	70.9	70.5	70.4	70.3	70.2
138	84.3	84.2	84.7	85.3	85.1	85.4	84.8	84.2	84.1	83.8	83.9
139	65.8	65.9	65.6	65.5	66	66.1	65.8	65	64.75	64.6	65.05
140	63.1	63.2	63	63	62.8	62.4	63.1	62.5	62.4	62.4	62.5
141	63.6	63.8	63.6	63.65	63.45	64.1	64.1	63.1	62.9	63.1	63.1
$\overline{X}$	64.4	64.4	64.5	64.5	64.6	64.7	64.6	64.08	63.8	63.75	63.79
S.D.	9.4	9.2	9.3	9.5	9.4	9.5	9.2	9.4	9.55	9.4	9.4

Table 92: Body weight, during 24 hours exposure, mean and standard deviation for subjects under Experiment-E-

Table 93

Experiment -E-.

Subject Code No.	Time: pre-exposure Midday 12		4		8		12		5		8		end-exposure Midday 12	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
133	75	0.83	350	1.45	130	0.54	160	0.66	120	0.4	65	0.36	75	0.31
134	160	0.66	95	0.39	110	0.45	95	0.39	120	0.40	55	0.30	135	0.56
135	115	0.58	95	0.39	105	0.43	80	0.33	440	1.46	30	0.16	260	1.08
136	55	0.15	120	0.5	30	0.12	65	0.27	105	0.35	50	0.27	100	0.41
137	14	0.23	130	0.54	100	0.41	70	0.29	110	0.36	60	0.33	65	0.27
138	145	1	60	0.25	220	0.91	225	0.93	330	1.1	55	0.30	230	0.95
139	50	1.11	130	0.54	90	0.37	140	0.58	80	0.26	80	0.44	115	0.47
140	35	0.58	120	0.50	125	0.52	155	0.64	115	0.38	85	0.47	85	0.35
141	20	0.66	110	0.45	80	0.33	80	0.33	120	0.4	70	0.38	65	0.27
$\overline{X}$	74.3	0.64	134.4	0.55	110	0.45	118.8	0.49	171.1	0.56	61.1	0.33	125.5	0.51
S.D.	53.7	0.31	83.7	0.34	50.6	0.21	54.3	0.22	124.9	0.41	16.5	0.09	71.9	0.29

Table 93: Urine volume (ml), minute urine volume (ml/min), mean and standard deviation for subjects under Experiment-E-for 24 hours exposure.

A - urine volume at that time of the day
B - minute urine volume at that time of the day.

Table 94

Experiment -E-

Subject Code No.	pre-exposure Midday 12		2		4		6		8	
	F	C	F	C	F	C	F	C	F	C
133	37.9	37.7	37.9	37.1	38.1	37.4	38	37.5	37.9	36.8
134	37.1	37.7	38.3	37.5	37.9	38.3	38.1	38.4	38.3	38.7
135	38.6	38.6	38.8	38.6	39.8	39	40	39.2	39.6	39
136	37.8	37.8	38.2	37.4	37.8	37.2	37.8	37.2	38	37.2
137	38.2	36.8	37.6	37.4	37.8	37.4	36.9	37.2	37.4	37.4
138	38.2	37.8	39.2	38	39	37.8	39.4	38	38.8	38
139	38.2	37.4	38.6	38.2	38	37.4	38	37.6	37.8	37.8
140	38	36.4	37.4	37	37.2	37	36.9	36.8	38	37.8
141	38	36.2	38	37.4	37.8	36.8	37.5	36.6	37.6	36.9
$\bar{X}$	38	37.3	38.2	37.6	38.1	37.5	38.06	37.6	38.1	37.73
S.D.	0.40	0.76	0.57	0.53	0.77	0.68	1.03	0.81	0.67	0.75

Time

10		12		5		8		10		end-exposure Midday 12	
F	C	F	C	F	C	F	C	F	C	F	C
37.9	37.2	38	37.4	37	36	36.8	36.1	37.9	37.4	37.9	37.2
36.5	38.7	37.9	38.5	37.9	37.7	37.9	38	38.5	38.3	38.5	38.7
39.4	39	39.4	39	39.2	38.8	39.0	38.2	39	38.6	39	38.6
38.2	37.6	38.8	38.2	37.4	37.4	38	37.4	38	36.7	38.2	36.8
39	38.2	38	37.6	38.4	37.8	37.2	36.8	37.6	37.2	38.8	38.2
39	38.2	38.8	37.8	39	37.8	38.2	37.4	39	38	38.4	37.2
38.6	37.8	38.8	38.2	38	37.4	38.2	37.4	38.8	38	38.2	37.4
38.4	38.2	38.2	37.8	37.6	37	37.2	36.4	36.6	36.6	37.4	37.0
38.5	36.8	37.6	36.2	37.4	35.8	37	36.8	37	35.9	37.4	36.6
38.38	37.9	38.3	37.8	37.98	37.3	37.7	37.16	38.04	37.14	38.2	37.52
0.84	0.64	0.58	0.78	0.74	0.93	0.71	0.70	0.86	0.89	0.55	0.78

Table 94: Forehead and chest temperature (°C) mean and standard deviation for subjects under Experiment -E- for 24 hours exposure.

F Forehead temperature at that time of the day.
C Chest temperature at that time of the day.

Table 95

Experiment -E-

Subject Code No.	pre-exposure Midday 12		2		4		6		8	
	H	F	H	F	H	F	H	F	H	F
133	38.3	36.8	38.7	37.4	39	37.6	38.5	37.5	37.5	36.5
134	36.9	35.2	37.5	37	37.7	37.5	37.6	37.3	37.9	38
135	38.4	36.8	39.4	39.8	39	39.8	39.4	39.2	39.2	39.2
136	38.2	37.6	38.2	38.4	37.8	38.2	38	38.4	37.2	37.6
137	37.6	37	38	37.6	38	37.6	37.5	37.2	38	37.0
138	37	36	38.4	37.8	38.2	37.6	38	37.6	38.2	37.2
139	37	36.6	37.8	37.4	37.2	37.2	37.4	37.2	37.6	37.8
140	36.4	36	36.8	36.8	36.6	37	36.6	37	37.4	37.2
141	36.2	36.6	36.8	36.8	36	36.8	36	36.5	36.6	36.8
$\overline{X}$	37.3	36.5	37.9	37.6	37.7	37.7	37.66	37.54	37.7	37.5
S.D.	0.82	0.69	0.85	0.94	1.00	0.88	0.99	0.80	0.72	0.78

Time	10		12		5		8		10		end-exposure Midday 12	
	H	F	H	F	H	F	H	F	H	F	H	F
	38.4	37.5	38.1	37	36.9	36.9	37.3	37.2	38	37.6	37.7	37.1
	36.9	37.1	37.7	37.8	37.3	37.5	37.1	37.7	37.8	37.5	37.9	37.3
	38.4	38.8	39	38.4	39	38.6	39.2	38.6	39.4	38.6	39.1	38.6
	38.2	38.5	38.4	38.8	36.8	37.8	37.4	38	36.8	37.4	37.2	38
	38.4	37.9	37.8	38	37.2	38	37.4	37.2	37.8	37.2	38	37.4
	38	37.6	37	37.8	37.8	37	37	36.8	37.8	37.6	37.4	37.6
	37.2	36.2	38	38.2	37	38	37.2	38	37.6	38	37.2	37.2
	37.8	37.6	37.6	37.2	37	37	37	37	36.8	36.6	36.9	36.2
	36.2	37.2	35.8	35.2	36.2	36.8	35.8	36.4	36.4	36.4	36.4	36.2
	37.7	37.6	37.71	37.6	37.2	37.5	37.2	37.4	37.5	37.4	37.5	37.2
	0.78	0.76	0.90	1.05	0.78	0.62	0.87	0.69	0.88	0.66	0.77	0.71

Table 95: Hand and foot temperature (°C), mean and standard deviation for subjects under Experiment E for 24 hours exposure.

H Hand temperature at that time of the day
F Foot temperature at that time of the day

Table 96

Experiment-E-

Subject Code No.	time										
	pre-exposure Midday 12	2	4	6	8	10	12	5	8	10	end-exposure Midday 12
133	36.8	36.8	37.2	37.1	37.4	37.1	37.1	36.1	36.7	37.1	37.1
134	36.7	36.8	37.1	37.2	37.2	37.1	37	36.6	36.7	36.6	36.6
135	36.4	36.5	36.5	36.7	37.1	37.2	37.2	36.9	36.9	37.1	37.1
136	36.5	37	37	36.5	36.8	36.8	36.8	36.5	36.5	36.6	36.6
137	36.8	36.8	37.2	36.8	36.8	37.1	37	36.5	36	36.5	36.6
138	36.4	36.7	37.2	37.3	37.5	37	36.9	36.2	36.4	36.6	36.6
139	35.6	36.5	36.2	36.7	37.3	37	36.7	36.4	36.4	36.7	35.7
140	36.7	36.8	37	36.7	36.6	37.1	37.2	37	36	37	37.2
141	36.5	37	37	36.7	36.7	36.5	36.4	36	36.4	36.4	37.1
$\overline{X}$	36.4	36.7	36.9	36.8	37.04	36.9	36.9	36.4	36.4	36.7	36.7
S.D.	0.36	0.18	0.35	0.27	0.32	0.21	0.25	0.33	0.30	0.26	0.46

Table 96: Oral temperature (^{o}C) mean and standard deviation for subjects under Experiment-E-for 24 hours exposure.

Table 97.

Experiment-E-

Subject Code No.	Time (Beats/min) pre-exposure Midday 12	2	4	6	8	10	12	5	8	10	end-exposure Midday 12
133	78	81	84	78	87	80	74	91	95	96	90
134	67	73	85	74	74	68	77	82	78	87	79
135	80	96	88	100	92	92	92	104	100	104	104
136	88	80	70	76	76	84	68	66	62	68	76
137	86	88	88	88	80	92	70	68	80	80	80
138	76	92	92	84	82	86	86	76	72	82	92
139	76	86	72	72	84	80	84	80	82	88	100
140	86	100	88	84	80	80	80	78	66	80	80
141	82	88	82	76	100	76	72	70	66	90	88
$\bar{X}$	79.8	87.1	83.2	81.3	83.8	82	78.1	79.4	77.8	86.1	87.6
S.D.	6.5	8.3	7.5	8.7	8.1	7.6	8.03	12.03	13.1	10.3	9.8

Table 97 : Heart rate (Beats/min), mean and standard deviation for subjects under Experiment-E-for 24 hours exposure.

Table 98

Experiment -E-

Subject Code No.	Time: pre-exposure Midday 12	4	8	12	5	8	end-exposure Midday 12
	Blood pressure mm H.g						
133	92/63	100/75	98/70	102/78	102/78	100/78	100/75
134	110/88	104/76	98/76	98/74	104/78	98/72	100/78
135	110/70	100/60	100/80	100/80	100/78	90/75	90/70
136	100/50	90/50	90/64	90/60	90/50	90/50	90/48
137	100/60	100/64	100/78	100/70	90/50	100/60	100/76
138	120/70	100/60	100/65	100/70	90/50	100/50	100/60
139	92/68	100/70	104/66	108/80	108/70	100/68	100/64
140	90/60	90/50	90/50	80/44	90/40	90/50	90/50
141	100/60	100/60	92/64	88/52	90/60	90/60	100/60
$\bar{X}$	102/65	98/63	97/68	96/67	96/62	95/63	97/65
S.D.	10/10	5/10	5/9	9/12	7/15	5/11	5/11

Table 98: Blood pressure (mm, Hg), mean and standard deviation for subjects under Experiment -E- for 24 hours exposure.

Table 99

Experiment E

Subject Code No.	Time: pre-exposure Midday 12	Haematocrit % 4	8	12	5	8	end-exposure Midday 12
133	41	41	39	39	41	40	41
134	44	43	42	42	44	44	44
135	41	40.5	39	39	41	41	40
136	43	43	41	40	43	42	42
137	42	42	40	40	40	42	42
138	42	40	40	41	43	43	42
139	42	42	41	40	40	40	42
140	39	39	39	40	40	38	38
141	40	40	39	42	40	39	40
$\bar{X}$	41.5	41.1	40	40.3	41.3	41	41.2
S.D.	1.5	1.4	1.1	1.1	1.5	1.9	1.7

table 99: Haematocrit values (%), mean and standard deviation for subjects under Experiment -E- for 24 hours exposure.

Table 100

Experiment-E-

Subject Code No.	Pre-exposure Midday Na^+	Pre-exposure Midday K^+	Pre-exposure Midday $N+/K+$	4 Na^+	4 K^+	4 $Na^+/K+$	8 Na^+	8 K^+	8 $Na^+/K+$
133	0.68	2.41	0.31	0.10	2.22	0.04	1.41	2.47	0.57
134	2.75	3.90	0.70	0.91	2.32	0.39	0.11	1.97	0.05
135	0.63	1.22	0.51	0.63	0.43	1.45	0.77	0.43	1.79
136	0.29	0.53	0.54	1.48	1.92	0.77	0.35	0.48	0.72
137	0.49	0.96	0.51	1.56	2.96	0.52	1.72	2.24	0.76
138	3.24	6.02	0.53	0.37	1.73	0.21	0.25	1.39	0.17
139	2.50	7.69	0.32	1.75	3.60	0.48	1.06	2.49	0.42
140	3.04	3.10	0.98	3.34	1.91	1.74	3.22	1.76	1.82
141	3.81	1.47	2.59	3.17	1.29	2.45	1.92	1.12	1.71
$\bar{X}$	1.93	3.03	0.77	1.47	2.04	0.89	1.20	1.59	0.89
S.D.	1.39	2.45	0.70	1.14	0.91	0.80	0.99	0.79	0.70

Time									end-exposure Midday		
	12			5			8			12	
Na^+	K^+	Na^+/K^+	Na^+	K^+	Na^+/K^+	Na^+	K^+	Na^+/K^+	Na^+	K^+	Na^+/K^+
2.91	2.34	1.24	1.85	0.46	4.02	1.71	0.67	2.55	1.40	0.92	1.52
0.17	1.70	0.1	0.52	1.72	0.30	0.37	1.07	0.34	0.81	2.85	0.28
0.59	0.39	1.51	2.73	1.72	1.58	0.49	0.29	1.68	2.24	1.85	1.21
0.79	1.05	0.75	1.06	1.30	0.81	1.01	0.93	1.08	1.10	2.43	0.45
0.73	1.27	0.57	0.62	1.11	0.55	0.24	1.24	0.19	0.36	1.18	0.30
1.24	1.09	1.13	0.85	0.55	1.54	0.35	0.22	1.59	1.10	0.64	1.71
0.32	1.64	0.19	1.09	1.21	0.90	0.95	2.28	0.41	0.13	2.2	0.05
3.74	1.80	2.07	2.37	0.66	3.59	2.88	1.09	2.64	1.60	1.38	1.15
1.86	0.93	2	2.72	0.87	3.12	2.37	1.17	2.02	1.46	0.82	1.78
1.37	1.35	1.06	1.53	1.06	1.82	1.15	0.99	1.38	1.13	1.58	0.93
1.23	0.57	0.72	0.89	0.47	1.39	0.95	0.60	0.93	0.64	0.78	0.67

Table 100: Na^+, K^+ values (mg/min) in urine, Na^+/K^+, mean and standard deviation for subjects under Experiment -E- for 24 hours exposure.

Table 101

Experiment -E-

Subject Code No.	Time: pre-exposure Midday 12	4	8	12	5	8	end-exposure Midday 12
133	2.71	3.46	3.45	4.72	2.31	2.49	2.39
134	2.83	1.10	1.57	1.31	1.36	1.51	3.84
135	0.89	0.70	1.01	0.9	4.47	0.67	3.95
136	0.54	1.87	0.40	1.14	1.81	0.91	1.28
137	0.77	1.97	2.09	0.90	1.01	0.82	0.88
138	5.17	0.81	2.25	2.5	2.1	0.72	3.4
139	5.11	1.68	0.41	0.84	0.56	1.13	7.82
140	4.62	4.99	4.01	5.12	3.15	3.68	2.43
141	4.77	3.31	2.71	2.59	3.00	3.64	2.61
$\bar{X}$	3.04	2.21	1.98	2.22	2.19	1.73	3.17
S.D.	1.95	1.43	1.27	1.66	1.20	1.22	2.0

Table 101: Chloride values (mg/min) in urine, mean and standard deviation for subjects under Experiment -E- for 24 hours exposure.

Table 102

Experiment -E-

Subject Code No.	Time: pre-exposure Midday 12	4	8	12	5	8	end-exposure Midday 12
133	7.55	7.61	7.28	9.92	8.13	7.80	7.20
134	12.68	9.29	12.05	11.21	15.0	8.4	14.3
135	7.67	6.65	6.53	5.79	26.13	3.58	22.75
136	3.94	14.166	4.21	8.52	13.44	10.90	12.10
137	8.62	18.72	14.8	11.55	13.51	14.74	12.4
138	18.3	7.08	15.18	13.06	23.11	8.74	15.99
139	16.79	12.48	8.05	1.39	8.92	9.22	10.45
140	13.06	14.01	13.42	16.01	11.43	13.9	9.22
141	17.75	12.48	10.51	12.63	12.19	11.41	7.08
$\overline{X}$	11.81	11.38	10.22	10.0	14.65	9.85	12.38
S.D.	5.14	4.03	3.91	4.33	6.10	3.37	4.91

Table 102: Urea values (mg/min) in urine, mean and standard deviation for subjects under Experiment -E- for 24 hours exposure.

Table 103

Experiment -E-

Subject Code No.	Time: pre-exposure Midday 12 A	B	4 A	B	8 A	B	12 A	B	5 A	B	8 A	B	end-exposure Midday 12 A	B
133	1.13	0.02	0.93	0.017	0.81	0.015	0.83	0.015	0.79	0.015	0.80	0.015	0.70	0.13
134	1.58	0.02	1.21	0.02	1.35	0.022	1.09	0.018	1.35	0.022	1.014	0.017	1.41	0.024
135	0.87	0.016	0.64	0.011	0.65	0.012	0.56	0.010	2.75	0.050	0.37	0.006	2.26	0.041
136	0.68	0.010	1.81	0.027	0.61	0.009	1.28	0.019	1.55	0.023	1.93	0.018	1.28	0.019
137	0.76	0.010	1.45	0.02	1.15	0.016	1.26	0.017	1.24	0.017	1.48	0.02	1.13	0.015
138	1.86	0.022	0.56	0.006	1.55	0.018	1.30	0.015	1.95	0.023	0.69	0.008	1.38	0.016
139	1.53	0.02	1.38	0.02	1.08	0.016	1.65	0.025	0.82	0.012	0.98	0.015	0.87	0.013
140	1.06	0.016	0.85	0.013	0.92	0.014	0.81	0.012	0.80	0.012	1.23	0.019	0.62	0.009
141	1.40	0.022	1.21	0.019	1.14	0.017	1.21	0.019	1.41	0.022	1.05	0.016	0.72	0.011
$\overline{X}$	1.20	0.017	1.11	0.017	1.02	0.015	1.11	0.016	1.40	0.021	0.98	0.014	1.15	0.017
S.D.	0.40	0.004	0.40	0.006	0.31	0.003	0.32	0.004	0.63	0.011	0.32	0.004	0.51	0.009

Table 103: Creatinine values in urine (mg/min), and creatinine/body weight (mg/min/Kg), mean and standard deviation for subjects under Experiment -E- for 24 hours exposure.

A Creatinine value at that time of the day
B Creatinine/Body weight value at that time of the day.

Table 104

Experiment -E-

Subject Code No.	mg/min Na^+	mg/min K^+	Na^+/K^+	mg/min Cl^-	mg/min Urea	mg/min Creatinine	mg/min/Kg Creatinine/Body weight	ml/min minute urine volume
133	1.88	1.66	1.13	3.57	9.98	1.08	0.020	0.63
134	0.23	1.97	0.11	1.91	11.77	1.03	0.021	0.45
135	1.13	0.96	1.17	1.85	11.06	1.16	0.021	0.68
136	0.85	1.10	0.77	1.05	7.94	0.50	0.007	0.291
137	0.63	1.43	0.44	1.27	13.26	1.16	0.016	0.36
138	1.01	1.96	0.51	2.46	15.8	1.80	0.021	0.79
139	1.25	2.74	0.456	1.15	10.45	1.21	0.018	0.46
140	2.36	1.46	1.61	3.50	11.78	0.85	0.013	0.48
141	1.93	0.93	2.07	3.06	10.45	0.83	0.013	0.37
$\bar{X}$	1.25	1.57	0.91	2.20	11.38	1.06	0.016	0.50
S.D.	0.68	0.58	0.63	0.99	2.20	0.35	0.004	0.16

Table 104: The total 24 hour sample values for Na^+, K^+, Cl^-, Na^+/K^+, urea, creatinine, creatinine/body weight, and minute urine volume for subjects under Experiment -E- for 24 hours exposure.

Experiment -F-

Table 105

Experiment F- Part I and II

Subject Code No.	Sex	Age (years)	Height (cm)	Weight (Kg)	Surface area (m^2)
142	M	27	174	71.2	1.83
143	M	26	181	67.35	1.86
144	F	25	157	53.25	1.51
145	M	25	173	69.4	1.82
$\overline{X}$		25.75	171.25	65.3	1.75
S.D.		0.95	10.14	8.18	0.16

Table 105: Age, height, weight, surface area, mean and standard deviation for subjects under Experiment-F-Part I and II.

I - resting condition
II - working condition.

Table 106

Experiment F - Part I and II

Subject Code No.	Na^+ (mg/min) 1 I	1 II	2 I	2 II	3 I	3 II	K^+ (mg/min) 1 I	1 II	2 I	2 II	3 I	3 II
142	3.24	3.7	3.83	4.74	3.8	2.95	1.72	2.90	1.87	2.87	1.91	1.91
143	2.018	4.03	2.18	5.31	2.48	4.90	1.12	2.32	1.56	2.73	1.58	2.97
144	1.74	0.65	1.72	0.63	1.93	0.42	1.45	0.66	1.92	1.71	1.76	1.45
145	1.41	2.0	1.34	3.4	1.6	3.5	0.92	1.08	1.11	1.76	1.15	1.93
$\bar{X}$	2.10	2.59	2.26	3.51	2.45	2.90	1.30	1.74	1.61	2.26	1.6	2.06
S.D.	0.79	1.5	1.09	2.01	0.96	1.8	0.35	1.04	0.37	0.61	0.32	0.64

Na^+/K^+						Cl^- (mg/min)					
1		2		3		1		2		3	
I	II	I	II	I	II	I	II	I	II	I	II
1.88	1.27	2.04	1.65	1.98	1.54	5.02	7.15	5.95	7.78	4.84	6.87
1.80	1.73	1.39	1.94	1.56	1.64	5.16	6.63	7.4	7.94	4.90	8.19
1.2	0.98	0.89	0.36	1.09	0.28	4.91	2.14	5.7	3.77	4.2	3.14
1.53	1.85	1.20	1.93	1.39	1.81	3.48	5.4	3.19	6.01	2.97	6.82
1.60	1.45	1.38	1.47	1.50	1.31	4.64	5.3	5.56	6.12	4.22	6.25
0.30	0.40	0.48	0.75	0.37	0.70	0.78	2.24	1.74	2.40	0.89	2.17

Table 106: Na^+, K^+, Na^+/K^+, Cl^- values in urine, mean and standard deviation for subjects under Experiment -E-

1 - pre-exposure
2 - mid-exposure
3 - end-exposure
I - resting condition
II - working condition.

Table 107

Experiment -F-

Subject Code No.	Urea (mg/min)						Creatinine (mg/min)						Creatinine/Body weight (mg/min/Kg)					
	1		2		3		1		2		3		1		2		3	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
142	9.95	10.26	10.107	9.09	9.32	9.62	0.896	0.91	0.952	1.1	0.900	1.22	0.012	0.012	0.013	0.015	0.012	0.017
143	12.185	15.84	13.8	15.12	12.16	17.31	1.47	1.22	1.46	1.36	1.16	1.18	0.021	0.018	0.021	0.02	0.017	0.017
144	12.21	11.90	13.4	14.9	11.8	10.2	0.72	0.73	0.76	0.82	0.81	0.85	0.013	0.013	0.014	0.015	0.015	0.015
145	7.13	9.58	8.44	11.71	12.62	15.6	0.97	0.96	1.07	1.14	1.02	1.10	0.013	0.013	0.015	0.016	0.014	0.015
$\bar{X}$	10.36	11.89	11.43	12.7	11.47	13.18	1.012	0.95	1.06	1.10	0.97	1.08	0.014	0.014	0.015	0.0165	0.0145	0.016
S.D.	2.4	2.8	2.5	2.8	1.47	3.8	0.32	0.20	0.29	0.22	0.15	0.16	0.004	0.002	0.003	0.002	0.002	0.011

Table 107: Urea, creatinine values in urine, creatinine/body weight, mean and standard deviation for subjects under Experiment -F-

1 - pre-exposure
2 - mid-exposure
3 - end-exposure
I - resting condition
II - working condition.

10.2 METHOD

A Sodium, Potassium (Flame photometer)

(Based on the method used by the Department of Human Biology, Loughborough University of Technology).

Preparation of the Standards

a. Molar solutions of NaCl (58.46 g/ℓ) and KCl (74.56 g/ℓ) were made up and stored in polythene bottles.

b. Stock solutions were made up

1. Diluted NaCl 10:50 - 200 *mM* Stock soln.
2. Diluted KCl 10:100 - 100 *mM* Stock soln.

c. A Standarization series was prepared as follows:

	Stock Na 200 mM/ℓ	Stock K 100 mM/ℓ	Na and K content mM/ℓ
1.	1.25	2.5	0.25
2.	2.5	5.0	0.50
3.	3.75	7.5	0.75
4.	5.0	10.0	1.0
5.	7.5	15.0	1.5

All solutions were made up to 1 litre with deionized water.

Calibration

The galvonometer scale is linear, and readings are proportional to the current generated in the photocell. The relationship of flame intensity to solution concentration is not necessarily linear. Thus, calibration curves were constructed using the above standards. The instrument

was calibrated to read 80 with the highest standard concentration prepared. The range chosen 0-80. Sample solutions that did not lie within this range were further diluted. The lowest convenient range was used, since interference effects are less marked at low concentrations.

Urine Samples

Urine samples were diluted 1:100 for Na and 1:200 for K. When any of the samples were too concentrated and the scale reading fell outside the range, the Urine sample was further diluted as required and the dilution was taken into account when calculating the ion concentration in milligrams per minute.

Calculation

1. Calibrate photometer with the standards prepared, using appropriate filter. Plot calibration curves for each ion. (There is a different curve for Na and K).

2. The flame photometer readings of the samples were converted to mM/ℓ from the calibration curve for Na and K.

3. Multiply by dilution to give correct mM/ℓ for each sample.

4. Ion concentration (mM/ℓ) x atomic weight $Na^+_{K^+}$ (gm)

$$= \quad mg/\ell$$

5. Urine Volume $(m\ell)$ % Time (minutes) $= \quad m\ell/min$

6. $\frac{mg/\ell}{1000}$ x $m\ell/min$ x mg/min concentrations.

B Chloride Test (Titrimetric method)

This test is a modified version of the shales and shales method 1941 by SCIAVO.

Reagents

Reagent	:	Mercuric nitrate
Indicator	:	Diphenyl carbazone
Diluted nitric acid		
Standard	:	Chloride 100 mEq/ℓ

Procedure:

a. Urine was not diluted.

b. All reagents were brought up to room temperature.

c. The sample and standard were made up as follows:

Beakers (25-50) mℓ)		Sample	Standard
Specimen (urine)	mℓ	0.2	-
Standard	mℓ	-	0.2
Diluted nitric acid	mℓ	1	1
Indicator	drops	10	10

Mixed well and titrated adding with a microburette (calibrated in 0.01 mℓ) the titrating reagent drop by drop . Mixed until a pale persistent violet colour was obtained: the amount of reagent added was recorded in mls.

Calculations

$$\frac{\text{ml of reagent for the sample}}{\text{ml of reagent for the standard}} \times 100 = \text{Cl mE q/l}$$

$$\frac{\text{Cl mEq/l} \quad \text{Urine minute volume (ml/min)} \times \text{atomic weight of Cl}}{1000}$$

= Cl concentration in urine mg/min

C Creatinine Test

The estimation of creatinine has been done by a method by I.S.V.T. SCLAVO, which is a modification of the method developed by Henry 1968.

Principle

Reaction of picric acid with urine creatinine in an alkaline solution lead to the formation of a red-orange complex photometrically measurable.

Reagents

1. Deproteinizing reagent.
2. Chromogen prepared just before use in the experiment by mixing equal volumes of the sodium hydroxide and picric acid provided. Stability of chromogen lasts for 8 hours if kept at room temperature and away from direct sunlight.
3. Standard was ready to use.

Procedure

1. The reagents were brought up to room temperature.

2. The urine samples were diluted 0.1:5 with distilled water.

3. The sample, standard and the blank were prepared as follows:

(in test tubes)		Sample	Standard	Blank
Urine	*mℓ*	1	-	-
Standard	*mℓ*	-	0.1	-
Distilled water	*mℓ*	-	0.4	0.5
Deproteinizing reagent	*mℓ*	2	1	1

4. The blank and the standard test tubes were ready.

5. The sample test tube was mixed well and allowed to stand for 5 minutes. The test tube was then centrifuged at 3000-6000 r.p.m. for 10 minutes.

6. The clear supernatant was then transferred to a clean test tube. From the clear supernatant 1.5 *mℓ* was transferred to another tube.

7. Chromogen was now prepared and 1.5 *mℓ* was added to each of the sample, standard and blank. The tubes were all mixed well and incubated at room temperature (22° C to 28° C) for 30 minutes avoiding direct sunlight.

8. A spectrophotometer was used to read the optical density of the samples and standard at 525 *nm* against the blank.

Calculation

$$\frac{\text{O.D. sample}}{\text{O.D. standard}} \times 100 = \text{creatinine in } mg/100\ m\ell$$

$$\frac{\text{creatinine } (mg/100\ m\ell \times \text{urine minute volume } (m\ell/min)}{100}$$

= creatinine in *mg* per min.

D Urea Test

The estimation of urea in urine was based on berthelot urease method and modified by I.S.V.T. SCALVO.

Principle

Urease catalyses hydrolysis of urea to ammonium carbonate. The ammonium ions prcduced react with phenol and hypochlorite in the presence of nitroprusside to form a blue indophenol. The cclour developed is proportional to the concentration of urea.

Reagents:

1. Standard
2. Urease
3. Reagent F (phenol and Nitroprusside)
4. Reagent I (Hypochlorite and Sodium hydroxide)

Stability of reagents F and I: 3 months (in a dark bottle).

Procedure: - Urine was diluted 1:100 with distilled water.
- Reagents were brought up to room temperature.
- Sample, standard and blank tubes were prepared as follows:

Test tubes		Sample	Standard	Blank
0 specimen	mℓ	0.02	-	-
1 standard	mℓ	-	0.02	-
2 Urease	mℓ	0.2	0.2	0.2

Mixed well, and incubated for 10 minutes at 37^{o} in a water bath

Test tubes		Sample	Standard	Blank
3 Diluted Reagent F	mℓ	5	5	5
4 Diluted Reagent I	mℓ	5	5	5

Mixed well after addition of each reagent and incubated for 10 minutes at 37° C in a water bath.

Spectrophometer was used to read the optical density of all tubes at 580 *nm* against the blank.

Calculation

$$\frac{\text{O.D. sample}}{\text{O.D. standard}} \times 3 = \text{urea } g/d\ell \text{ of urine}$$

urea $(mg/m\ell)$ x urine minutes volume $m\ell/min$

= urea mg/min

E Estimation of sodium, potassium, chloride, Urea and Creatinine using Auto analyzer SMA 6/60

Reagents

Sodium and Potassium: 0.25 N lithium sulphate in 0.25 M sulphuric acid + brij 35.

Chloride : 0.25 M nitric acid + brij 35. Mercuric thiocyanate and ferric nitrate in methanolic nitric acid.

Urea : Ferric Chloride and orthophosphoric acid in 20% sulphuric acid Diacetyl menoxime and thioseme carbazide in water + brij 35.

Creatinine	:	saturated picric acid solution.
		0.5 *N* sodium hydroxide 1.8% w/v
		sodium chloride + brij 35.

Methods:

1. Sodium and Potassium: The sample is diluted in lithium sulphate. The sodium, potassium and lithium ions dialyse into a water recipient stream which, after a time delay, is sprayed by an atomiser into the flame of a flame photometer. In the flame, the ions emit a wavelength of light characteristic of the element concerned, whose intensity is proportional to the concentration of that element. A photocell detects the light output and the outputs of the sodium and potassium photocells are balanced against the lithium photocell in order to eliminate fluctuations caused by variations in flame.

2. Chloride: The sample is diluted in water and dialysed into dilute nitric acid. Colour reagent which contains mercuric thiocyanate and ferric nitrate is added to this stream. The chloride ions displace thiocyanate ions forming mercuric chloride and the thiocyanate ions react with the ferric ions to produce the red/brown coloured ferric thiocyanate which has an absorbance maximum at 480 *nm*.

3. Urea: The sample is diluted in water and the urea dialyses into the colour reagent recipient stream. Acid is added and a condensation reaction takes place between the urea and the diacetul menoxime in the colour reagent. The condensation product is pink coloured with a maximum absorbance at 520 *nm*.

4. Creatinine: The plasma is diluted with saline and dialysed into water. A solution of 0.5 *N* sodium hydroxide is added, followed by saturated picric acid. Creatinine forms a red colour with alkaline picrate with a maximum absorbance at 505 *nm*.

Calculation

a. Readings of samples from auto analyzer in *m* moles/litre.

b. Multiply by dilution to give correct *m* moles/litre for each sample.

c. *m* moles/litre x atomic weight = *mg/litre*.

d. Urine vol % time = *ml/min*.

e. $\frac{mg/l}{1000}$ x *ml/min* = *mg/min*

Calibration of the S.M.A. 6/60

The chloride linearity was set daily using aqueous standards. Every 10 samples used a serum standard (wellcome Autoset M) for all channels, while wellcome Autoset H and "Armitrol" were used as control sera at positions 5 and 9. If the values fell outside the pre-determined limits, then that batch of 10 samples would be repeated.

F Blood count a. white cell count

b. red cell count

(Based on methold used by the Department of Human Biology)

Collection of sample

Immerse the hand in waterbath at 48° C or in a bucket of

of "warm" water to arterialise the blood. Quickly dry a finger a puncture the finger-tip skin using a sterile disposable lancet. Do not squeeze the finger but let a drop of blood form by natural blood pressure. Reject the first drop then collect the next drop by capillarity or minimum suction into a clean haemogytometer "red pebble" pipette.

a. White cell count (the number of white cells contained in 1 mm^3 of blood):

Diluting fluid: 2% glacial acetic, to lyse red cells, tinged with methylene blue, to stain the white cells.

Method: Dilute 0.02 $m\ell$ of blood in 0.38 $m\ell$ diluting fluid to make a 1 in 20 dilution. Mix for 2 minutes and fill counting -chamber by means of a pasteur pipette. Count white cells in white cell counting areas.

Calculation: If N cells are counted in 0.1 mm^3 then the bucocyte count per mm^3 = N x 10 x 20 (dilution)

= N x 200 cells/mm^3

Range: 6×10^3 to 12×10^3 cells/mm^3 depending on state of health and exposure to common infectious conditions.

b. Red cell count: (the number of red blood cells contained in 1 mm^3 of blood)

Diluting fluid: Hayems fluid has been used which was:-

Mercuric chloride - 0.59 g

Sodium sulphate - 5.0 g

Sodium chloride - 1.0 g

Distilled water to 200 $m\ell$

This fluid is isotonic, of high specific gravity to prevent the cells from settling too quickly and to prevent "rouleau formation" and the formation of bacterial growth, which might cause cell wall damage.

Method: Dilute 0.2 *mℓ* blood in 4 *mℓ* diluting fluid to make a 1 in 200 dilution. Mix for 2 minutes and fill counting chamber. Count red cells in 5 squares of red cell counting areas.

Calculation: If *N* cells are counted in 80 small square 0.1 *mm* in depth (0.02 mm^3 in volume), then red-cell count in millions per mm^3.

$$= N \times 1/0.02 \times 200 \text{ (dilution)}$$

$$= N \times 10{,}000$$

Range: 4.3 x 10% to 5.9 x 10^6 cells/mm^3 depending on nutrition iron state, generally activity level, sex and point in menstrual cycle.

G Measurement of haemoglobin using a photoelectric colorimeter (Based on method used by the Department of Human Biology)

Collection of sample: Same procedure as in blood count (F) was used.

The cyanmethaemoglobin method

The basis of the method is to dilute blood in a solution containing potassium cyanide and potassium ferricyanide (Drabkin's Reagent). Haemoglobin, methaemoglobin and

carboxyhaemoglobin (but not sulphaemoglobin) are all rapidly converted to cyanmethaemoglobin. The absorbance of the solution is then measured in a photoelectric colorimeter at a wavelength of 540 *nm*.

Reagents:

This is based on Drabkin's cyanide-ferricyanide solution. Modification as recommended by van Kampen and Zijlstra.

Potassium ferricyanide	200	*mg*
Potassium cyanide	50	*mg*
Potassium dihydrogen phosphate	140	*mg*
Nonidet P 40 (Shell Chemical Co)	1	*mℓ*
or Sterox SE	0.5	
Distilled water to	1 litre	

The pH of the solution should be adjusted to 7.0-7.4, and if stored at room temperature in a black painted polythene bottle the solution keeps for several months.

Method:

0.02 *mℓ* of blood is added to 4 *mℓ* of reagent. The tube containing the solution is stoppered with a rubber bung and inverted several times. After being allowed to stand at room temperature for a sufficient period of time to ensure the completion of the reaction, the solution of cyanmethaemoglobin is ready to be compared with the standard in a photoelectric colorimeter, at 540 *nm* against a reagent blank. An ampoule of cyanmethaemoglobin standard (brought to room temperature if previously stored in a refrigerator) is opened and the optical density of the solution is

measured in the same photoelectric colorimeter against the blank. The standard should be discarded at the end of the day, and during the day must be kept in the dark.

Calculation

$$\text{Haemoglobin } (g/100m\ell) = \frac{\text{O.D. blood sample}}{\text{O.D. standard}} \times \frac{\text{conc. st } (mg/100\ m\ell) \times \text{dilution factor}}{1000}$$

H Packed Cell Volume P.C.V.
(Based on method used by Department of Human Biology)

Method:

For the standard method capillary tubes are available which are 75 *mm* in length and have an internal diameter of about 1*mm*. They can be obtained plain or coated inside with a layer of heparin. The latter type is suitable for the direct collection of capillary blood. A plain tube is used for anticoagulated venous blood. The blood is allowed to enter the tube by capillarity, leaving at least 15 *mm* unfilled. The tube is then sealed by heating the dry end of the tube rapidly in a fine flame, e.g. the pilot light of a bunsen burner, combined with rotation, or by the use of a plastic seal. After centrifugation for 5 minutes the PCV can be measured using a reading device.

Normal range for PCV (haematocrit) value:

Men	40 - 54%
Women	35 - 44%
Children 8-12	37 - 44%

I SWEAT RATE

(Based on the method used by the Department of Human Biology)

1. Two pieces of filter paper (total surface area 47.49 cm^2) placed in a petri dish was weighed on an analytical balance (with the lid of the petri dish). Care was taken that the petri dish was absolutely clean.
2. At all times the filter paper was handled with a clean forcep.
3. The petri dish was labelled with black marker pen. Paper labels were not used.
4. When in the chamber, the filter paper was removed with a forcep and placed over the right and left scapulae, of the subject.
5. Each filter paper was covered with a square plastic sheet (washed in distilled water and blotted dry) and fixed in place with adhesive strapping.
6. After a certain time period, the wet filter papers were removed with a forcep and transferred into their original petri dish. The lid was placed on. The petri dish was immediately weighed.
7. Same procedure was followed when fresh filter paper was placed on the scapulae of the subjects. The weighed filter papers in the petri dish was prepared in advance for each time period.
8. The difference in weight of the petri dish with the filter paper gave the amount of sweat collected in grams.

Calculation

Petri dish + filter paper + sweat - petri dish + filter paper = sweat in gms.

Sweat in gms./1000/47.49/time = sweat rate in mg/cm^2/time.

J THE DETERMINATION OF THE IONIC CONCENTRATION OF SWEAT

1. After the weight of the sweat collected was determined, the sweat filter papers were transferred to a container (small beaker) containing 10 mls of distilled water.
2. The filter papers were macerated to a fine pulp in the container.
3. The liquid from the resulting pulp was filtered through a Gooch crucible and the filtrate collected in a test tube.
4. The filtrate was analysed for Na and K by flame photometry (procedure already described).
5. Before analysis, suitable dilutions of the filtrate was prepared : 1:5 for both Na and K.
6. A blank solution was prepared by macerating the same weight of filter paper in 10 mls. of distilled water, filtered and analysed in the same manner.
7. The blank scale readings for each ion was deducted from the sweat analysis readings for each ion.

Calculations.

1. The flame photometer readings (corrected) were converted to mM/l from the calibration curves.
2. Correction factor was found:

X - weight of sweat collected in grams.

Correction factor (CF) = $\frac{10 + X}{X}$

3. Determination of Na and K concentrations in mg/min.

Corrected FP reading (mM/l) x Dilution (5) x CF x weight of Na (23g) or K (39.1 g) x sweat rate in mg/min / 1000 = Ion concentration in mg/min.

10.3 OPERATING INSTRUCTIONS

A

PYE UNICAM

UNICAM SP 600 SERIES 2 SPECTROPHOTOMETER

Procedure:

1. Turn main switch to zero.
2. Allow 10 minutes for the instrument to become stabilized.
3. Select an appropriate photocell:

   335-400 *nm* Blue photocell with filter in position 2

   400-625 *nm* Blue photocell with filter in position 1

   625-1000 *nm* Red photocell with filter in position 1
4. Bring meter needle to zero with the zero control.
5. Set wavelength control to required wavelength.
6. Turn main switch to 100% with blank or solvent in the light beam. Bring the meter needle to zero with the slit control.
7. Switch to test. Move sample into light beam and bring meter needle to zero with the transmittance control.
8. Read off the transmittance or absorbance of the sample from the dial.
9. Repeat the above sequence from operation (6) whilst sample is being measured.
10. In between sets of readings turn the main switch back to zero and check, then to 100% and check as in (6)

B Flame photometer

1. Turn the sensitivity control fully anti-clockwise.
2. Select and insert the appropriate optical filter for the ion under test.
3. Switch the instrument ON, ensuring that the galvanometer is unclamped.
4. Move aside the mica window and insert a lighted taper above the burners.
5. Turn on the gas supply to light the flame, withdraw the taper and close the window.
6. Switch on the compressor. Adjust the air control to give a reading of 10 p.s.i. on the pressure gauge. The flame will tend to be noisy when starting from cold and the instrument should be left for a few minutes to stabilize.
7. Slide a beaker of distilled water into the sample recess.
8. Adjust the gas control to produce a flame with one large central blue cone.
9. With the distilled water sample still in position, slowly close the gas control until ten separate blue flame cones just form. This provides a reference level for all subsequent settings; the control settings may be left undisturbed by turning the gas and air supplies off after use at their sources and not at the instrument. Thus little, if any readjustments should be necessary for subsequent operation. Do not adjust the gas supply to alter the sensitivity of the instrument.
10. Set the galvanometer to zero by means of the "zero" control against a reagent "blank" solution.

11. Replace the reagent blank by a standard solution of the concentration corresponding to a reading of 80 on the calibration curve in use and adjust the sensitivity control to give approximately full-scale deflection.
12. Reset the zero against the blank solution.
13. These two settings may need to be rechecked back and forth until both read correctly.
14. Check the zero reading with the reagent blank.
15. Present in turn each standard solution prepared and note the readings. For the calibration curve plot meter readings on the ordinate and concentrations on the abscissa.

N.B. Use correct filter for each standard, also wash instrument through with the distilled water before presenting a different standard.

When the instrument has been calibrated for all the test ions you may proceed with your experiment.

C W.B.G.T. Index Meter Min 3 MK5

a. On the top panel will be found the following controls:
   1. Toggle switch marked (Instrument)
   2. " " " (Fan)
   3. Rotary pointed knob marked.
   4. press switch marked (Battery)
   5. Jack socket marked
b. Switch on the instrument batteries by means of the toggle switch marked "Instrument ON".

c. With the pointed knob set to "probe and test", check the batteries by pressing the "battery test" switch.

d. The meter pointed should fall inside the red segment on the right of the meter scale.*

* If it fails batteries should be changed.

e. To measure Wet Bulb Temperatures,turn pointed knob to position "W", read off temperature on top scale.

f. To measure Dry Bulb Temperatures, turn pointed knob to position "D", read off temperature from top scale

g. To measure Radiation Globe Temperatures, turn pointed knob to position "G" and read temperature on top scale.

h. To read combined WBGT Index, turn pointed knob to WBGT and read from the second scale coloured red.

D Auto Analyzer SMA 6/60

1. Switch instrument power to "ON".

2. Switch on pumps and turn the wash valves to reagents.

3. Connect sodium and potassium lines to the side arm of the flame photometer de-bubbler.

4. When reagents have been pumping for at least 10 minutes, set colorimeter energy levels as follows:

(i) Switch function switch of programmer module to "Energy-R".

(ii) Set meter to read 50 (mid-scale) with colorimeter reference aperture.

(iii) Switch function switch to "Energy-S" and set each channel to 50 on the meter with the appropriate colorimeter aperture.

(iv) Switch function switch tc "Record".

5. Set base lines for each channel with "Baseline" knob on programmer.

6. Disconnect top line of flame photometer de-bubbler. Turn "Air ATOMISER" anti-clockwise until flame starts to make a noise. Turn the knob clockwise until the air pressure gauge reads 19 p.s.i. and then adjust the knob until the size of the air and liquid segments in the top line of the de-bubbler is equal. Re-connect the top line of the de-bubbler.

7. Set chloride expansion as follows:

(i) Place three high chloride expansion standards alternately with three low standards on sample turntable.

(ii) Switch on sampler when silver segment of timing cam on programmer is opposite the marker.

(iii) When the first high standard comes through, set the chloride to 160 mark on chart recorder with the "calibration" knob.

(iv) Set first low standard to 70 on the chart recorder with Cl EXP knob on programmer sub-panel.

(v) Switch to manual advance and follow the chloride peak. When chloride reaches maximum pen deflection on the second high standard switch EXP/NORM switch to EXP.

(vi) If pen position alters, re-set with EXP/CAL knob to original position.

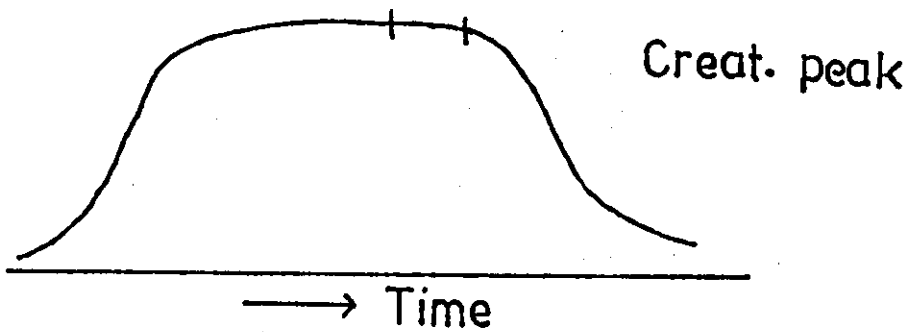
(vii) Re-set advance to AUTO and Re-set next low chloride as before, if necessary.

(viii) The third high and low chloride standards are for checking and re-setting as necessary.

8. Set Technilogger to required number m - 1 (i.e. if starting at no. 21 set to 20) and leave on standby.
9. Sample three wellcome II's and set to appropriate values with "calibration" knob on programmer. Switch on teletype.
10. On last WII switch logger from Standby to Operate.
11. When first test comes through ensure that the teletype prints out correctly and in the right position.

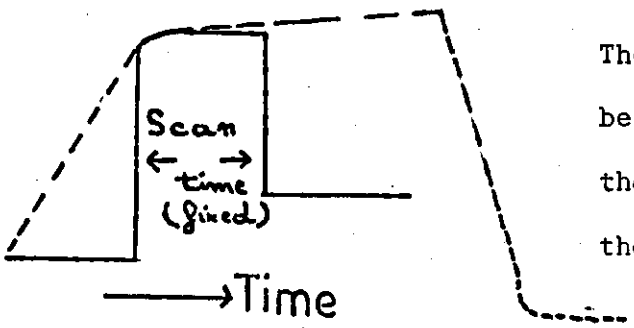
PHASING

1. Place WII unassayed serum on sampler turntable as follows:
   WII, WII, water wash, WII, WII, water wash, etc.
2. Start sampling as normal.
3. Switch to "manual" and advance to "creat".
4. Allow the creatinine peak to draw on the chart recorder and adjust the knurled outer wheel of the timing wheel until the "creat" segment of the wheel coincides with the last third of the creatinine plateau



5. Advance to the channel shown on timing wheel and switch to "Auto".
6. Watch the TCO_2 peak and assess whether the coil needs to be bigger or smaller.

N.B. If the slope is on the frontof the peak the coil size should be decreased and vice versa. Do not forget that the peak is moved to suit the timing.



The dotted line needs to be moved forwards so that the scan takes place over the last third of the peak.

7. Alter the TCO_2 coil as necessary. This channel is phased first because the phasing coil is at the beginning of the manifold so that any alteration takes time to come out at the colorimeter.
8. Alter the other channels in a similar way as required.

E Environmental Chamber

1. Switch on mains water supply.
2. Turn on main isolater switch.
3. Select 'Billman Switch' and or 'silican' liquid services'.
4. Switch on Isolater on 'Billman' Unit.
5. Press start button on fan dial up to 90-95%.
6. Adjust fresh air dial to the amount of fresh air required.
7. Set up the conditions required:- 10^{o}-40^{o} C $\pm$ 1% C and for Rh 20%-95% $\pm$ 2.5%. Any of the conditions required could be controlled automatically or manually by adjusting the knobs to the proper position.
8. Take reading outside and inside chamber.

N.B. Few adjustments using the controls could be necessary at a time depending on the general environmental condition.

10.4 INSTRUCTIONS AND FORMS OF SUBJECT'S DATA

Instructions to Volunteers

A research investigation at the Department of Human Sciences at Loughborough University of Technology, to find whether there is a physiological indication in human beings as a response of adaptation to stress in different simulated laboratory environmental conditions.

1. If you accept to volunteer as a subject for this research work you should be aware of the following:
   a. It is your right to know about the experimental procedures.
   b. You are able to withdraw from the experiment at any time.
   c. The experimentor will respect the confidentiality of any personal information the subject may give.
   d. You should be prompt and follow the timetable assigned to you.

2. Your participation in the research starts on
   AT

3. Record the last time you empty your bladder ..... am/pm .....
   time date

4. Empty your bladder when you get up in the morning
   ..... am/pm .....
   time date
   keep/discard this urine.

5. Don't empty your bladder until you start the experiment
   at a.m.

Please be sure that:

a. Avoid alcoholic intake the night before the experiment.

b. Don't take any stimulant or drugs.

c. other:

Thank you

M.S. MROUE

Confidential

Subject code no:

Date:

1. Surname: Mr./Mrs./Miss
2. First names:
3. Date of Birth:
4. Nationality
5. Are you in good health?
6. Are you at present under medical treatment of any kind?
7. Please add here other things which you may think are important and may influence the experiment.

M.S. MROUE

Research student.

Research work by M.S. MROUE

Name:	Sex:
Age:	Height:
Nationality:	Weight:
Habitat:	Date of experiment:

Time in mins.
Dry bulb
Wet bulb
Relative humidity
Kata factor
Cooling time
Kata range
Velocity of air
Globe temp.

Side effects:
Headache
Dizziness
Others:

Personal note concerning the subject:

Name : D. of B.: M/F Height : Weight :	Time	Intake	Output	Weight	Temperature					Heart rate	BP	Haematocrit	
					Forehead	Chest	Hand	Foot	Internal				
Dry bulb													
Wet bulb													
R H													
Cooling time													
Kata factor													
Kata range													
Air velocity													
Globe temp.													
Environmental conditions													
a Around Chamber													
Dry bulb													
Wet bulb													
R H													
b External													
Dry bulb													
Wet bulb													
RH													
Date													

M.S. MROUE
LOUGHBOROUGH UNIVERSITY OF TECHNOLOGY
3 FALKNER COURT
LOUGHBOROUGH LEICS. LE11 3TU

Date of Experiment

Sample	Na	K	Cl	CO_2	Urea	Creatinine

Time (min)						
Vol (ml)						
Ml/min						
Na 22.991X	mg/l	mg/min	mg/l	mg/min	mg/l	mg/min
K 39.100X	mg/l	mg/min	mg/l	mg/min	mg/l	mg/min
Cl 35.457X	mg/l	mg/min	mg/l	mg/min	mg/l	mg/min
Urea 60.027X	mg/l	mg/min	mg/l	mg/min	mg/l	mg/min
µ mole ——— m mole						
Creatinine 113.068X	mg/l	mg/min	mg/l	mg/min	mg/l	mg/min
Wt (Kg)						
mg/min/Kg						

Name sex M/F	
D.of B.	
Height	
Time	
Weight	
Na	mg/mins
K	
Urea	
Creati-nine	
Forehead	
Chest	
Hand	
Foot	
Internal	
Heart rate	
BP	
Haematocrit	
Intake	
Output	

10.5 EXPERIMENTAL CHARTS

Conversion of Temperature Units (Fahrenheit/Centigrade)*

Examples: +23°F = −5.00°C; 99.4°F = 37.44°C; 117°F = 47.22°C; 1210°F = 654.4°C

Fahrenheit – Centigrade

−59 to +79°F (1°F intervals)

	0	1	2	3	4	5	6	7	8	9
−50	−45.56	−46.11	−46.67	−47.22	−47.78	−48.33	−48.89	−49.44	−50.00	−50.56
−40	−40.00	−40.56	−41.11	−41.67	−42.22	−42.78	−43.33	−43.89	−44.44	−45.00
−30	−34.44	−35.00	−35.56	−36.11	−36.67	−37.22	−37.78	−38.33	−38.89	−39.44
−20	−28.89	−29.44	−30.00	−30.56	−31.11	−31.67	−32.78	−32.78	−33.33	−33.89
−10	−23.33	−23.89	−24.44	−25.00	−25.56	−26.11	−26.67	−27.22	−27.78	−28.33
−00	−17.78	−18.33	−18.89	−19.44	−20.00	−20.56	−21.11	−21.67	−22.22	−22.78
+00	−17.78	−17.22	−16.67	−16.11	−15.56	−15.00	−14.44	−13.89	−13.33	−12.78
10	−12.22	−11.67	−11.11	−10.56	−10.00	− 9.44	− 8.89	− 8.33	− 7.78	− 7.22
20	− 6.67	− 6.11	− 5.56	− 5.00	− 4.44	− 3.89	− 3.33	− 2.78	− 2.22	− 1.67
30	− 1.11	− 0.56	0.00	+ 0.56	+ 1.11	+ 1.67	+ 2.22	+ 2.78	+ 3.33	+ 3.89
40	+ 4.44	+ 5.00	+ 5.56	+ 6.11	+ 6.67	+ 7.22	+ 7.78	+ 8.33	+ 8.89	+ 9.44
50	+10.00	+10.56	+11.11	+11.67	+12.22	+12.78	+13.33	+13.89	+14.44	+15.00
60	+15.56	+16.11	+16.67	+17.22	+17.78	+18.33	+18.89	+19.44	+20.00	+20.56
70	+21.11	+21.67	+22.22	+22.78	+23.33	+23.89	+24.44	+25.00	+25.56	+26.11

80.0 to 109.9°F (1/10°F intervals)

	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
80.	26.67	26.72	26.78	26.83	26.89	26.94	27.00	27.06	27.11	27.17
81.	27.22	27.28	27.33	27.39	27.44	27.50	27.56	27.61	27.67	27.72
82.	27.78	27.83	27.89	27.94	28.00	28.06	28.11	28.17	28.22	28.28
83.	28.33	28.39	28.44	28.50	28.56	28.61	28.67	28.72	28.78	28.83
84.	28.89	28.94	29.00	29.06	29.11	29.17	29.22	29.28	29.33	29.39
85.	29.44	29.50	29.56	29.61	29.67	29.72	29.78	29.83	29.89	29.94
86.	30.00	30.06	30.11	30.17	30.23	30.28	30.33	30.39	30.44	30.50
87.	30.56	30.61	30.67	30.72	30.78	30.83	30.89	30.94	31.00	31.06
88.	31.11	31.17	31.22	31.28	31.33	31.39	31.44	31.50	31.56	31.61
89.	31.67	31.72	31.78	31.83	31.89	31.94	32.00	32.06	32.11	32.17
90.	32.22	32.28	32.33	32.39	32.44	32.50	32.56	32.61	32.67	32.72
91.	32.78	32.83	32.89	32.94	33.00	33.06	33.11	33.17	33.22	33.28
92.	33.33	33.39	33.44	33.50	33.56	33.61	33.67	33.72	33.78	33.83
93.	33.89	33.94	34.00	34.06	34.11	34.17	34.22	34.28	34.33	34.39
94.	34.44	34.50	34.56	34.61	34.67	34.72	34.78	34.83	34.89	34.94
95.	35.00	35.06	35.11	35.17	35.22	35.28	35.33	35.39	35.44	35.50
96.	35.56	35.61	35.67	35.72	35.78	35.83	35.89	35.94	36.00	36.06
97.	36.11	36.17	36.22	36.28	36.33	36.39	36.44	36.50	36.56	36.61
98.	36.67	36.72	36.78	36.83	36.89	36.94	37.00	37.06	37.11	37.17
99.	37.22	37.28	37.33	37.39	37.44	37.50	37.56	37.61	37.67	37.72
100.	37.78	37.83	37.89	37.94	38.00	38.06	38.11	38.17	38.22	38.28
101.	38.33	38.39	38.44	38.50	38.56	38.61	38.67	38.72	38.78	38.83
102.	38.89	38.94	39.00	39.06	39.11	39.17	39.22	39.28	39.33	39.39
103.	39.44	39.50	39.56	39.61	39.67	39.72	39.78	39.83	39.89	39.94
104.	40.00	40.06	40.11	40.17	40.22	40.28	40.33	40.39	40.44	40.50
105.	40.56	40.61	40.67	40.72	40.78	40.83	40.89	40.94	41.00	41.06
106.	41.11	41.17	41.22	41.28	41.33	41.39	41.44	41.50	41.56	41.61
107.	41.67	41.72	41.78	41.83	41.89	41.94	42.00	42.06	42.11	42.17
108.	42.22	42.28	42.33	42.39	42.44	42.50	42.56	42.61	42.67	42.72
109.	42.78	42.83	42.89	42.94	43.00	43.06	43.11	43.17	43.22	43.28

110 to 299°F (1°F intervals)

	0	1	2	3	4	5	6	7	8	9
110	43.33	43.89	44.44	45.00	45.56	46.11	46.67	47.22	47.78	48.33
120	48.89	49.44	50.00	50.56	51.11	51.67	52.22	52.78	53.33	53.89
130	54.44	55.00	55.56	56.11	56.67	57.22	57.78	58.33	58.89	59.44
140	60.00	60.56	61.11	61.67	62.22	62.78	63.33	63.89	64.44	65.00
150	65.56	66.11	66.67	67.22	67.78	68.33	68.89	69.44	70.00	70.56
160	71.11	71.67	72.22	72.78	73.33	73.89	74.44	75.00	75.56	76.11
170	76.67	77.22	77.78	78.33	78.89	79.44	80.00	80.56	81.11	81.67
180	82.22	82.78	83.33	83.89	84.44	85.00	85.56	86.11	86.67	87.22
190	87.78	88.33	88.89	89.44	90.00	90.56	91.11	91.67	92.22	92.78
200	93.33	93.89	94.44	95.00	95.56	96.11	96.67	97.22	97.78	98.33
210	98.89	99.44	100.0	100.6	101.1	101.7	102.2	102.8	103.3	103.9
220	104.4	105.0	105.6	106.1	106.7	107.2	107.8	108.3	108.9	109.4
230	110.0	110.6	111.1	111.7	112.2	112.8	113.3	113.9	114.4	115.0
240	115.6	116.1	116.7	117.2	117.8	118.3	118.9	119.4	120.0	120.6
250	121.1	121.7	122.2	122.8	123.3	123.9	124.4	125.0	125.6	126.1
260	126.7	127.2	127.8	128.3	128.9	129.4	130.0	130.6	131.1	131.7
270	132.2	132.8	133.3	133.9	134.4	135.0	135.6	136.1	136.7	137.2
280	137.8	138.3	138.9	139.4	140.0	140.6	141.1	141.7	142.2	142.8
290	143.3	143.9	144.4	145.0	145.6	146.1	146.7	147.2	147.8	148.3

300 to 1890°F (10°F intervals)

	0	10	20	30	40	50	60	70	80	90
300	148.9	154.4	160.0	165.6	171.1	176.7	182.2	187.8	193.3	198.9
400	204.4	210.0	215.6	221.1	226.7	232.2	237.8	243.3	248.9	254.4
500	260.0	265.6	271.1	276.7	282.2	287.8	293.3	298.9	304.4	310.0
600	315.6	321.1	326.7	332.2	337.8	343.3	348.9	354.4	360.0	365.6
700	371.1	376.7	382.2	387.8	393.3	398.9	404.4	410.0	415.6	421.1
800	426.7	432.2	437.8	443.3	448.9	454.4	460.0	465.6	471.1	476.7
900	482.2	487.8	493.3	498.9	504.4	510.0	515.6	521.1	526.7	532.2
1000	537.8	543.3	548.9	554.4	560.0	565.6	571.1	576.7	582.2	587.8
1100	593.3	598.9	604.4	610.0	615.6	621.1	626.7	632.2	637.8	643.3
1200	648.9	654.4	660.0	665.6	671.1	676.7	682.2	687.8	693.3	698.9
1300	704.4	710.0	715.6	721.1	726.7	732.2	737.8	743.3	748.9	754.4
1400	760.0	765.6	771.1	776.7	782.2	787.8	793.3	798.9	804.4	810.0
1500	815.6	821.1	826.7	832.2	837.8	843.3	848.9	854.4	860.0	865.6
1600	871.1	876.7	882.2	887.8	893.3	898.9	904.4	910.0	915.6	921.1
1700	926.7	932.2	937.8	943.3	948.9	954.4	960.0	965.6	971.1	976.7
1800	982.2	987.8	993.3	998.9	1004	1010	1016	1021	1027	1032

Examples: −14°C = +6.8°F; 38.3°C = 100.9°F; 89°C = 192.2°F; 550°C = 1022°F

Centigrade – Fahrenheit

−59 to 0°C (1°C intervals)

	0	1	2	3	4	5	6	7	8	9
−50	−58.0	−59.8	−61.6	−63.4	−65.2	−67.0	−68.8	−70.6	−72.4	−74.
−40	−40.0	−41.8	−43.6	−45.4	−47.2	−49.0	−50.8	−52.6	−54.4	−56.
−30	−22.0	−23.8	−25.6	−27.4	−29.2	−31.0	−32.8	−34.6	−36.4	−38.
−20	− 4.0	− 5.8	− 7.6	− 9.4	−11.2	−13.0	−14.8	−16.6	−18.4	−20.
−10	+14.0	+12.2	+10.4	+ 8.6	+ 6.8	+ 5.0	+ 3.2	+ 1.4	− 0.4	− 2.
−00	+32.0	+30.2	+28.4	+26.6	+24.8	+23.0	+21.2	+19.4	+17.6	+15.

0 to 49.9°C (1/10°C intervals)

	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
+0.	32.00	32.18	32.36	32.54	32.72	32.90	33.08	33.26	33.44	33.
1.	33.80	33.98	34.16	34.34	34.52	34.70	34.88	35.06	35.24	35.
2.	35.60	35.78	35.96	36.14	36.32	36.50	36.68	36.86	37.04	37.
3.	37.40	37.58	37.76	37.94	38.12	38.30	38.48	38.66	38.84	39.
4.	39.20	39.38	39.56	39.74	39.92	40.10	40.28	40.46	40.64	40.
5.	41.00	41.18	41.36	41.54	41.72	41.90	42.08	42.26	42.44	42.
6.	42.80	42.98	43.16	43.34	43.52	43.70	43.88	44.06	44.24	44.
7.	44.60	44.78	44.96	45.14	45.32	45.50	45.68	45.86	46.04	46.
8.	46.40	46.58	46.76	46.94	47.12	47.30	47.48	47.66	47.84	48.
9.	48.20	48.38	48.56	48.74	48.92	49.10	49.28	49.46	49.64	49.
10.	50.00	50.18	50.36	50.54	50.72	50.90	51.08	51.26	51.44	51.
11.	51.80	51.98	52.16	52.34	52.52	52.70	52.88	53.06	53.24	53.
12.	53.60	53.78	53.96	54.14	54.32	54.50	54.68	54.86	55.04	55.
13.	55.40	55.58	55.76	55.94	56.12	56.30	56.48	56.66	56.84	57.
14.	57.20	57.38	57.56	57.74	57.92	58.10	58.28	58.46	58.64	58.
15.	59.00	59.18	59.36	59.54	59.72	59.90	60.08	60.26	60.44	60.
16.	60.80	60.98	61.16	61.34	61.52	61.70	61.88	62.06	62.24	62.
17.	62.60	62.78	62.96	63.14	63.32	63.50	63.68	63.86	64.04	64.
18.	64.40	64.58	64.76	64.94	65.12	65.30	65.48	65.66	65.84	66.
19.	66.20	66.38	66.56	66.74	66.92	67.10	67.28	67.46	67.64	67.
20.	68.00	68.18	68.36	68.54	68.72	68.90	69.08	69.26	69.44	69.
21.	69.80	69.98	70.16	70.34	70.52	70.70	70.88	71.06	71.24	71.
22.	71.60	71.78	71.96	72.14	72.32	72.50	72.68	72.86	73.04	73.
23.	73.40	73.58	73.76	73.94	74.12	74.30	74.48	74.66	74.84	75.
24.	75.20	75.38	75.56	75.74	75.92	76.10	76.28	76.46	76.64	76.
25.	77.00	77.18	77.36	77.54	77.72	77.90	78.08	78.26	78.44	78.
26.	78.80	78.98	79.16	79.34	79.52	79.70	79.88	80.06	80.24	80.
27.	80.60	80.78	80.96	81.14	81.32	81.50	81.68	81.86	82.04	82.
28.	82.40	82.58	82.76	82.94	83.12	83.30	83.48	83.66	83.84	84.
29.	84.20	84.38	84.56	84.74	84.92	85.10	85.28	85.46	85.64	85.
30.	86.00	86.18	86.36	86.54	86.72	86.90	87.08	87.26	87.44	87.
31.	87.80	87.98	88.16	88.34	88.52	88.70	88.88	89.06	89.24	89.
32.	89.60	89.78	89.96	90.14	90.32	90.50	90.68	90.86	91.04	91.
33.	91.40	91.58	91.76	91.94	92.12	92.30	92.48	92.66	92.84	93.
34.	93.20	93.38	93.56	93.74	93.92	94.10	94.28	94.46	94.64	94.
35.	95.00	95.18	95.36	95.54	95.72	95.90	96.08	96.26	96.44	96.
36.	96.80	96.98	97.16	97.34	97.52	97.70	97.88	98.06	98.24	98.
37.	98.60	98.78	98.96	99.14	99.32	99.50	99.68	99.86	100.0	100.
38.	100.4	100.6	100.8	100.9	101.1	101.3	101.5	101.7	101.8	102.
39.	102.2	102.4	102.6	102.7	102.9	103.1	103.3	103.5	103.6	103.
40.	104.0	104.2	104.4	104.5	104.7	104.9	105.1	105.3	105.4	105.
41.	105.8	106.0	106.2	106.3	106.5	106.7	106.9	107.1	107.2	107.
42.	107.6	107.8	108.0	108.1	108.3	108.5	108.7	108.9	109.0	109.
43.	109.4	109.6	109.8	109.9	110.1	110.3	110.5	110.7	110.8	111.
44.	111.2	111.4	111.6	111.7	111.9	112.1	112.3	112.5	112.6	112.
45.	113.0	113.2	113.4	113.5	113.7	113.9	114.1	114.3	114.4	114.
46.	114.8	115.0	115.2	115.3	115.5	115.7	115.9	116.1	116.2	116.
47.	116.6	116.8	117.0	117.1	117.3	117.5	117.7	117.9	118.0	118.
48.	118.4	118.6	118.8	118.9	119.1	119.3	119.5	119.7	119.8	120.
49.	120.2	120.4	120.6	120.7	120.9	121.1	121.3	121.5	121.6	121.

50 to 199°C (1°C intervals)

	0	1	2	3	4	5	6	7	8	9
50	122.0	123.8	125.6	127.4	129.2	131.0	132.8	134.6	136.4	138.
60	140.0	141.8	143.6	145.4	147.2	149.0	150.8	152.6	154.4	156.
70	158.0	159.8	161.6	163.4	165.2	167.0	168.8	170.6	172.4	174.
80	176.0	177.8	179.6	181.4	183.2	185.0	186.8	188.6	190.4	192.
90	194.0	195.8	197.6	199.4	201.2	203.0	204.8	206.6	208.4	210.
100	212.0	213.8	215.6	217.4	219.2	221.0	222.8	224.6	226.4	228.
110	230.0	231.8	233.6	235.4	237.2	239.0	240.8	242.6	244.4	246.
120	248.0	249.8	251.6	253.4	255.2	257.0	258.8	260.6	262.4	264.
130	266.0	267.8	269.6	271.4	273.2	275.0	276.8	278.6	280.4	282.
140	284.0	285.8	287.6	289.4	291.2	293.0	294.8	296.6	298.4	300.
150	302.0	303.8	305.6	307.4	309.2	311.0	312.8	314.6	316.4	318.
160	320.0	321.8	323.6	325.4	327.2	329.0	330.8	332.6	334.4	336.
170	338.0	339.8	341.6	343.4	345.2	347.0	348.8	350.6	352.4	354.
180	356.0	357.8	359.6	361.4	363.2	365.0	366.8	368.6	370.4	372.
190	374.0	375.8	377.6	379.4	381.2	383.0	384.8	386.6	388.4	390.

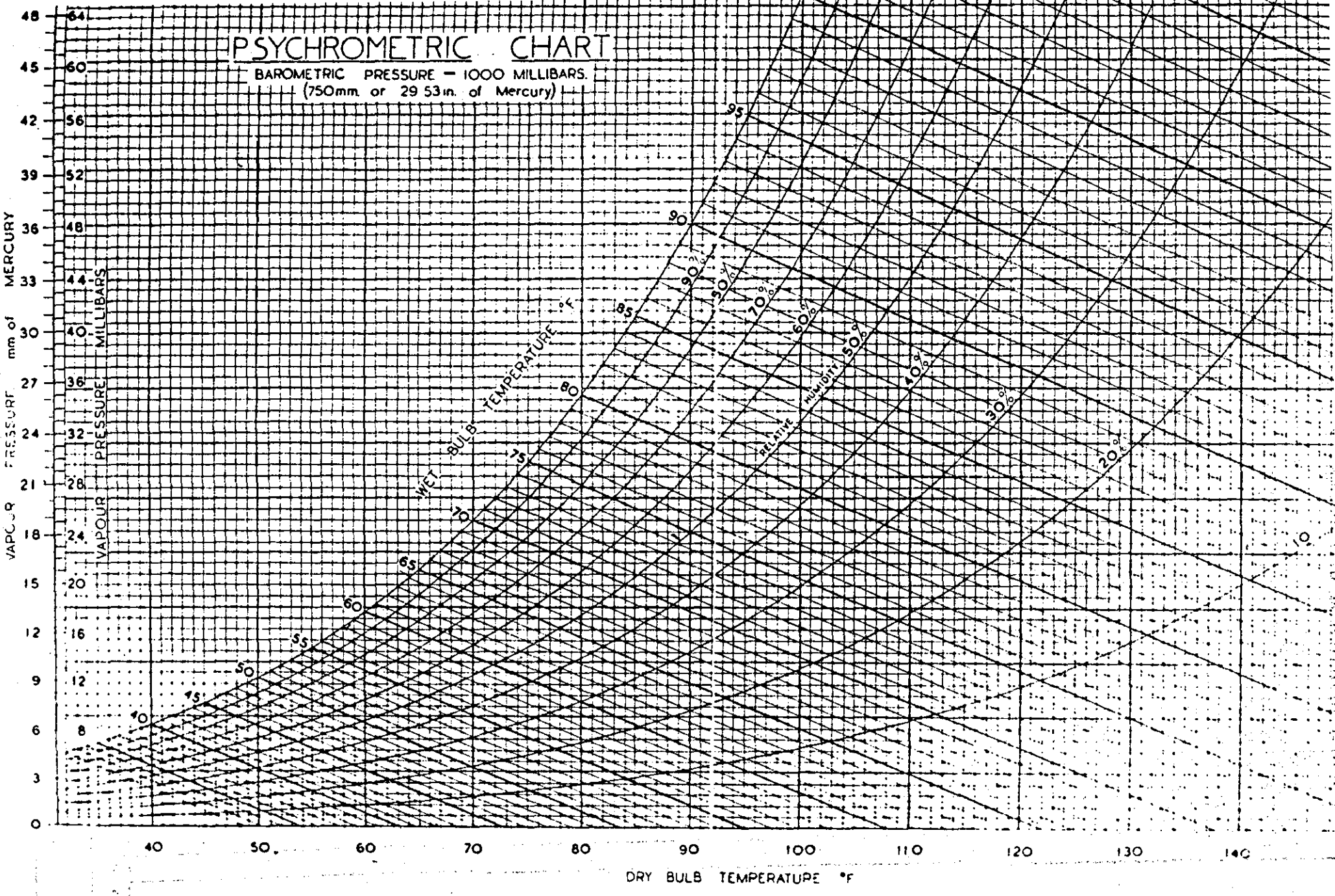
100 to 990°C (10°C intervals)

	0	10	20	30	40	50	60	70	80	90
100	212	230	248	266	284	302	320	338	356	37
200	392	410	428	446	464	482	500	518	536	55
300	572	590	608	626	644	662	680	698	716	73
400	752	770	788	806	824	842	860	878	896	91
500	932	950	968	986	1004	1022	1040	1058	1076	109
600	1112	1130	1148	1166	1184	1202	1220	1238	1256	127
700	1292	1310	1328	1346	1364	1382	1400	1418	1436	145
800	1472	1490	1508	1526	1544	1562	1580	1598	1616	163
900	1652	1670	1688	1706	1724	1742	1760	1778	1796	181

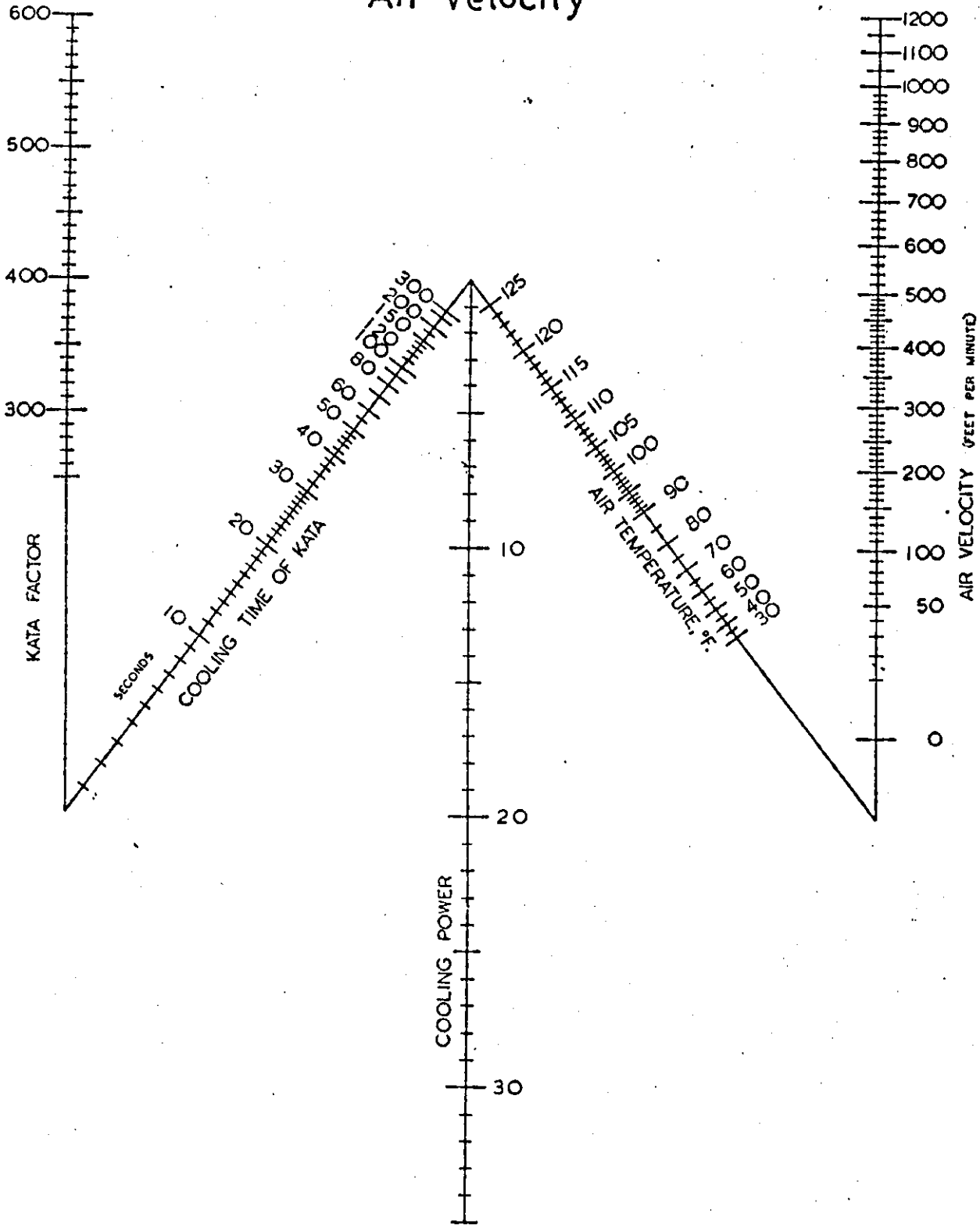
TABLE OF RELATIVE HUMIDITY

(For use with sling or Assmann type hygrometers)

Dry bulb temp. (°F.)	Vapour Pressure of Saturated Air mm.Hg.	Relative humidity when depression of wet-bulb (°F.) is																									
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	18	20	22	24	26	28	30	34	38	42	46	50
	6·30	92	84	76	68	60	52	45	37																				
5	6·54	92	84	76	69	61	54	46	39																				
	6·80	92	84	77	69	62	55	47	40	33																			
	7·07	92	85	77	70	63	56	49	42	35	28																		
	7·35	93	85	77	71	64	56	50	43	36	30	24																	
	7·64	93	86	78	71	64	58	51	44	38	31	25	19																
	7·93	93	86	79	72	65	58	52	45	39	32	27	20	15															
	8·24	93	86	79	72	66	59	53	47	41	34	28	22	16	11														
	8·55	93	86	80	73	66	60	54	48	42	36	30	24	18	12	7													
	8·87	93	87	80	74	67	61	55	49	43	37	31	26	20	14	9	4												
10	9·21	93	87	80	74	68	62	55	50	44	38	33	27	22	16	11	6												
	9·56	94	87	81	75	68	62	57	51	45	40	34	29	23	18	13	8												
	9·92	94	88	81	75	69	63	57	52	46	41	35	30	25	20	15	10												
	10·29	94	88	81	75	70	64	58	53	47	42	37	31	26	21	16	12	2											
	10·68	94	88	82	76	70	65	59	54	48	43	38	33	27	23	18	13	4											
	11·07	94	88	82	76	71	65	60	54	49	44	39	34	29	24	19	15	6											
	11·48	94	88	82	76	71	66	60	55	50	45	40	35	30	25	21	16	7											
	11·90	94	88	82	77	71	66	61	56	51	46	41	36	32	27	22	17	9											
	12·35	94	88	83	77	72	67	61	57	51	47	42	37	33	28	23	19	10	2										
15	12·79	94	89	83	78	72	67	62	57	52	48	43	38	34	29	25	20	12	4										
	13·26	94	89	84	78	73	68	63	58	53	49	44	40	35	30	26	22	14	6										
	13·73	94	89	84	79	73	69	63	59	54	50	45	40	36	32	28	23	15	7										
	14·24	94	89	84	79	74	69	64	59	55	50	46	41	37	33	29	24	16	9	1									
	14·75	95	89	84	79	74	69	64	60	56	51	47	42	38	34	30	26	18	10	3									
	15·27	95	90	84	80	75	70	65	60	56	52	48	43	39	35	31	27	19	12	5									
	15·81	95	90	85	80	75	70	66	61	57	52	48	44	40	36	32	28	20	13	6									
	16·37	95	90	85	80	75	71	66	62	58	53	49	45	41	37	33	29	22	15	8	1								
	16·95	95	90	85	80	76	71	66	62	58	54	50	46	42	38	34	30	23	16	9	2								
20	17·54	95	90	85	81	76	72	67	63	59	54	51	46	42	39	35	31	24	17	10	3								
	18·16	95	90	85	81	76	72	68	63	59	55	51	47	43	40	36	32	25	18	12	4								
	18·79	95	90	86	81	77	72	68	64	60	56	52	48	44	40	37	33	26	20	13	6	1							
	19·44	95	91	86	81	77	72	68	64	60	56	52	49	45	41	38	34	27	21	14	8	2							
	20·11	95	91	86	82	77	73	69	65	61	57	53	49	46	42	38	35	28	22	16	9	4							
	20·80	95	91	86	82	78	74	69	65	61	58	54	50	46	43	40	36	29	23	17	10	5							
	21·51	95	91	86	82	78	74	70	66	62	58	54	51	47	44	40	37	30	24	18	12	6	1						
	22·24	96	91	86	82	78	74	70	66	62	59	55	51	48	44	41	38	31	25	19	13	7	2						
	23·00	96	91	87	82	78	74	70	67	63	59	55	52	48	45	42	38	32	26	20	14	9	3						
25	23·76	96	91	87	83	79	75	71	67	63	60	56	52	49	46	42	39	33	27	21	15	10	5						
	24·57	96	91	87	83	79	75	71	67	64	60	56	53	50	46	43	40	34	28	22	16	11	6	1					
	25·39	96	91	87	83	79	75	71	68	64	60	57	54	50	47	44	41	34	29	23	17	12	7	2					
	26·24	96	92	87	83	80	76	72	68	64	61	58	54	51	47	44	41	35	29	24	18	13	8	3					
	27·11	96	92	88	84	80	76	72	69	65	61	58	55	51	48	45	42	36	30	25	19	14	9	4					
	28·00	96	92	88	84	80	76	73	69	65	62	59	55	52	49	46	43	37	31	26	20	15	10	6					
	28·92	96	92	88	84	80	76	73	69	66	62	59	56	53	49	46	43	37	32	26	21	16	12	7					
	29·86	96	92	88	84	81	77	73	70	66	63	59	56	53	50	47	44	38	33	27	22	17	12	8					
	30·84	96	92	88	84	81	77	74	70	67	63	60	57	54	50	48	44	39	33	28	23	18	13	9					
30	31·83	96	92	88	84	81	77	74	70	67	64	60	57	54	51	48	45	39	34	29	24	19	14	10	4				
	32·88	96	92	88	85	81	77	74	71	67	64	61	58	55	51	49	46	40	35	30	25	20	15	11	5				
	33·93	96	92	88	85	81	78	74	71	68	64	61	58	55	52	49	46	41	35	30	25	21	16	12	5				
	35·03	96	92	88	85	81	78	74	71	68	65	62	58	55	53	50	47	41	36	31	26	22	17	13	5				
	36·13	96	92	89	85	81	78	75	71	68	65	62	59	56	53	50	47	42	37	32	27	22	18	14	6				
	37·35	96	92	89	85	81	78	75	72	68	65	62	59	56	53	51	48	42	37	32	28	23	19	14	7				
	38·46	96	93	89	85	82	78	75	72	69	65	62	60	57	54	51	48	43	38	33	28	24	20	15	8				
	39·75	96	93	89	85	82	78	75	72	69	66	63	60	57	54	51	49	43	38	34	29	24	20	16	9	1			
	40·92	96	93	89	86	82	79	75	72	69	66	63	60	57	55	52	49	44	39	34	30	25	21	17	9	2			
35	42·23	96	93	89	86	82	79	76	73	69	66	63	61	58	55	52	50	44	40	35	30	26	22	18	10	3			
	43·59	96	93	89	86	83	79	76	73	70	67	64	61	58	55	53	50	45	40	35	31	27	22	18	11	4			
	44·93	96	93	89	86	83	79	76	73	70	67	64	61	58	56	53	50	45	41	36	31	27	23	19	12	5			
	46·25	96	93	89	86	83	80	77	73	70	67	64	62	59	56	54	51	46	41	37	32	28	24	20	13	6			
	47·70	96	93	89	86	83	80	77	74	71	68	65	62	59	56	54	51	46	42	37	33	28	24	21	14	7	1		
	49·12	96	93	90	86	83	80	77	74	71	68	65	62	60	57	54	52	47	42	38	33	29	25	21	14	8	1		
	50·63	96	93	90	87	83	80	77	74	71	68	65	63	60	57	55	52	47	43	38	34	30	26	22	15	8	2		
	52·15	96	93	90	87	83	80	77	74	71	68	66	63	60	58	55	52	48	43	39	34	30	26	23	16	9	3		
	53·78	96	93	90	87	83	80	77	74	72	69	66	63	61	58	55	53	48	44	39	35	31	27	23	16	10	4		
40	55·34	97	93	90	87	84	81	78	75	72	69	66	63	61	58	55	53	48	44	40	35	31	28	24	17	10	5		
	57·08	97	93	90	87	84	81	78	75	72	69	66	64	61	59	56	54	49	44	40	36	32	28	24	18	11	5		
	58·73	97	93	90	87	84	81	78	75	72	69	67	64	62	59	57	54	49	45	40	36	32	29	25	18	12	6	1	
	60·53	97	93	90	87	84	81	78	75	72	70	67	64	62	59	57	54	50	45	41	37	33	29	26	19	13	7	2	
	62·26	97	93	90	87	84	81	78	75	73	70	67	65	62	60	57	55	50	46	41	37	33	30	26	19	13	8	2	
	64·13	97	93	90	87	84	81	78	75	73	70	67	65	62	60	57	55	50	46	42	38	34	30	27	20	14	8	3	
	66·01	97	93	90	87	84	81	79	76	73	70	68	65	63	60	58	55	51	46	42	38	34	31	27	21	14	9	3	


PSYCHROMETRIC CHART
BAROMETRIC PRESSURE — 1000 MILLIBARS.
(750mm. or 29 53in. of Mercury)
VAPOUR PRESSURE mm of MERCURY
VAPOUR PRESSURE MILLIBARS
WET BULB TEMPERATURE °F
RELATIVE HUMIDITY
DRY BULB TEMPERATURE °F
40
50
60
70
80
90
100
110
120
130
140

Air Velocity



Nomogram for Calculating the Body Surface Area of Adults[1]