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A STUDY OF MENTAL STRESS IN HOTEL ADMINISTRATIVE MANAGEMENT

A thesis submitted by Peter Wilfred Betts in fulfilment of requirements for the award of the degree of Ph.D. in the Department of Hotel, Catering and Tourism Management.

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SUMMARY

This study is concerned with the measurement of mental stress of administrative management in hotels. The aims were to assess the degree of correlation between certain specified managerial activities and associated variations in heart rate and to assess the degree of stress which occurred.

The final methodology was restricted to arrangements which were acceptable to the hotel managers on site. T.E.M. recording equipment was chosen in view of its compactness, light weight, recording capability, and portability. Questionnaires were used initially to determine the suitability of subjects and to record personal details.

A minute by minute log was recorded for the working day so that readings could be matched with activities and analysed. All physical activity was noted and timed. Personal details were noted and these included age, sex, marital status, experience in the job, general health, smoking habits, amount of stress experienced during the study, drinking habits, and other observations.

A device was designed and developed to cut recordings when any disturbing physical work occurred thus isolating mental work recordings.

The main conclusion was that the degree of mental stress in the working day is comparatively low and within accepted limits based upon heart rate as a dependent variable, and verified by published relevant studies. With the omission of one subject who was of a nervous disposition the group recordings conformed to a symmetrical frequency curve. No correlation was apparent between standard deviation and the independent variables of age, sex, drinking, or smoking.

A heart rate cycle is evident which persists regardless of the heart rate level within the range studied. The times are inconsistent between the troughs of the cycles. The range of the cycle reduces from 35 beats at 120 b.min to about 15 beats at 98 b.min therefore within the heart beat range quoted the cycle range decreases as heart beat falls.

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K cal/min.	= Kilo calories per minute
K cal/day	= Kilo calories per day
m.p.h.	= miles per hour
m.l.	= milli litres
l.m.	= litres per minute
C.O.$_2$	= carbon dioxide
O_2	= Oxygen
N_2	= Nitrogen
L/min. (STPD)	= Standard temperature, Pressure, and Dry
HR in b./min.	= Heart rate in beats per minute
VO_2 in l/min.	= Oxygen uptake in litres per minute
EEG	= Electroencephalogram
EMG	= Electromyography
FFF	= Flicker fusion frequency
A-V node	= Auriculo-ventricular node
S-A node	= Sino-auricular node
ECG	= Electrocardiogram
pO_2	= Concentration of oxygen
pCO_2	= Concentration of carbon dioxide
m.k.g.	= moving a kilogram through a metre
mkg/sec.	= moving a kilogram through a metre per second
U.V.	= Ultra violet
A.R.A.S.	= Ascending reticular activating system
A.N.S.	= Autonomic nervous system
c/s	= cycles per second
C.N.S.	= Central nervous system
CRF	= Corticotropin
ACTH	= Adrenal-cortico-trophic hormone
U.V. Beam Recorders	= Ultra violet beam recorders

1. INTRODUCTION

1.1 The Working Situation

The function and dynamics of the heart and circulation in individuals while working has become progressively more important considering the physical and increasing psychic stresses placed upon modern man living in the highly industrialised environment of today, according to Valetin and Woitowitz (1974).

The measurement of man at work, however, is not an area of knowledge where sudden insights and rapid advances are common. To approach even a moderate comprehension of the problem requires a level of cerebration to which even research workers rarely rise. Singleton et al (1969).

Robens (1970) summarised : "There are two aspects to the problem. On the one hand we are concerned with the efficiency of work, to compare the value or social benefit that a man can create working in one environment rather than in another. On the other hand we are concerned with the individual man - with the reaction of his working conditions on his bodily, emotional and social needs, and with the wear and tear of his daily task".

One example is the risk of coronary heart disease. According to French (1972) there are eight kinds of job stress which could induce this disease : not knowing what is expected on the job; conflicting demands from people with whom one works; having too much work to do in the time available; having work that requires more skills than one has; having poor relations with one's supervisor, subordinates, or other co-workers; being unable to participate in decisions that affect one's work; being required to deal frequently with people in other departments or who work for other employers; and being responsible for other people at work.

An indication of the possible pathological risks from causes such as excessive routine, incorrect diet, and harmful life style is given in Table I below compiled by the World Health Organisation (1976).

This table gives the increased or decreased risk in percentage terms of a man from each of five social classes dying from certain causes.

Cause of Death	Unskilled	Semi Skilled	Skilled	Managerial	Professional
ALL CAUSES	+ 43	+ 3	AVERAGE	- 19	- 24
Tuberculosis	+ 85	+ 8	- 4	- 46	- 60
Stomach Cancer	+ 63	+14	+ 1	- 37	- 51
Lung Cancer	+ 48	+ 4	+ 7	- 28	- 37
Coronary Disease	+ 12	- 4	+ 6	- 5	- 2
Bronchitis	+ 94	+16	- 3	- 50	- 72
Duodenal Ulcer	+ 73	+ 7	- 4	- 25	- 52

TABLE I : The class Distinctions of Disease

The aim of this study is to examine the hotel administrative manager in his working environment and to attempt to assess his mental stress levels because of the likely health hazards associated with high mental work loads.

1.2 The Mental Stress Concept

There seem to be two main views on stress according to Deese (1960). These are that stress may be conceived as a mediating variable, a state aroused in an individual by particular environmental stimuli and chronically present in some individuals; and that stress may be viewed as a collection of external stimulus events rather than an internal state of the individual. The latter view implies that stressful environments may have a quite different effect on different individuals because their susceptibility will vary.

According to Takakuwa (1971), however, stress can be construed as a failure in the co-ordination of organically related biological

functions both physical and mental.

A further view given by Singleton (1970) associates stress with arousal. He states that in the post-war period there has been a revival of interest in alertness levels as a variable affecting performance which was initiated by Magoun (1954) on the physiological side by studies of the reticular system and on the psychological side through studies of vigilance by Mackworth (1950). This work has been closely associated with the concept of stress as a descriptor of the load on the performer.

Singleton continues by pointing out that there has been a change of fashion in the optimistic belief that avoiding the terms fatigue and effort might avoid some of the disillusion following work in these fields and that some disillusion is evident now in relation to stress and arousal studies.

These difficulties arise, he states, though inconsistencies and ambiguities of meaning. A measure of stress is sometimes a description of the conditions causing the subject's reaction, e.g. a heat stress index, sometimes a description of some aspect of the reaction itself, e.g. change in alpha frequency in the EEG, and sometimes a performance change thought to result from the conditions and the reaction to the conditions, e.g. increase in errors on an inspection task.

Some clarification is possible by adopting the engineering convention of using stress in the sense of the stressor and strain for the reaction of the stresses. Parrot (1969) elaborated on this terminology and mentioned that in English engineering terminology stress refers more to the external force acting upon a system and strain refers more to the efforts this system has to provide and to the cost it has to pay in order to resist input stress forces. He thinks that strain in people appears particularly in some output variables such as an increase in internal temperature, heart rate, and sweating. A more dramatic example is heat collapse due to the breakdown of the thermoregulation or of water balance.

He summarises: stress as such is linked with strain; a

stimulus constitutes a stress for a particular system if a strain ensues within that system, in other words, under some threshold, a given factor may be stress only for those individuals in whom it results in strain.

The stimulus which causes a strain may be classified into two groups: physiological and psychological. Weybrew (1967) prepared a detailed scheme. Briefly, the physiological group included work divided into heavy work and immobilisation, and environment including atmospheric, vibration, noise, and temperature. The psychological group included environment in terms of danger and confinement, and work in terms of information overload and vigilance. Sleep loss in terms of the circadian effect was classified in both groups.

Thus mental stress in not necessarily observable and similarly mental work, according to Leplat and Pailhous (1969), is essentially non-observable which presents serious difficulties to the analyst who wishes to evaluate it.

They state that the notion of load is not very clear because there are two factors: the load, such as can be evaluated by objective physical measures intended for mental tasks and the load for the operator. The measures for the first factor are expressed by Fassina (1969) for instance, in terms of information quantity or index of complexity. In the second factor, for a given index of a physical load there corresponds at different moments of training, or for different operators, different loads of work. This load expresses the degree of mobilisation of the subject and the fraction of his working capacity which he spends on the task.

The phenomenon of stress, according to Burgoyne (1975) is easily recognised but difficult to describe. Few people could offer a definition of stress that would meet with even a modest degree of general agreement.

He makes the following comments:

(1) People asked about <u>their</u> stress describe two kinds; firstly experiences of mental discomfort and secondly physiological

manifestations of loss of appetite, sleeplessness, sweating, etc.

(2) The physical side of stress seems to be relatively well understood but it is not so clear what process sets off these physical reactions and how the psyochological aspects are to be explained. It seems likely they are closely related.

Other investigators have also commented on the imprecision of use of the term and definitional arguments have been made by Cofer and Appley (1964), Appley and Trumbull (1967), Weitz (1970), Kahn (1970), and McGrath (1970).

McGrath (1976) stated that there is a potential for stress when an environmental situation is perceived as presenting a demand which threatens to exceed the person's capabilities and resources for meeting it. These are under conditions where he expects a substantial differential in the rewards and costs from meeting the demand versus not meeting it.

1.3 Mental stress and the emotional theory

Friedman and Rosenman (1959) studied two groups; group A showed high competitiveness, quick thought and action, and consciousness over time and deadlines; group B was the reverse. It was found that group A suffered more than six times as many heart attacks.

1.3.1 Hormone Secretion

Another factor which caused the revival of the emotional theory was the discovery by Morris (1969) of how to measure emotion in terms of the hormones adrenaline and noradrenaline which are released under nervous stimulation.

The underlying cause of these reactions to emotional stress is apparently due to the fact that man has not changed significantly in either bodily or chemical form since the civilization process began according to Morris (1969). Primitive man was endowed with automatically aroused chemical alarm systems which prepared him for fighting or fleeing. Modern man, in many cases, is unable to respond in a similar fashion to primitive man, thus an imbalance tends to exist between his physical and mental activity.

The emotional theory is based upon the assumption that if an individual indulges in a high level of emotional activity and a low level of physical activity the body chemistry is deranged and this becomes a major cause of heart disease, according to Carruthers (1974).

This theory is supported by medical evidence but there are other factors according to Mitchell, at an interview (1976). A further effect of increased stress response is that the stomach is retarded and the blood flow is restricted in the stomach lining. Thus there is less resistance to high acidity, the stomach lining is irritated and an ulcer may develop.

Furthermore, he mentioned, the excess of cholesterol deposition also depends upon the existing level of cholesterol. For example, a high level at birth, in the region of three times the normal amount,

may cause death by the age of 30 years. Fat metabolism also is considered an important factor and there is conflicting evidence on arguments for and against involving diet. A typical case concerns the Danube Delta fishermen who exist on fatty fish, but apparently they do not suffer with coronary thrombosis.

A study involving the formation of ulcers in "executive" monkeys conflicts with the concept outlined by Mitchell. In this case, Brady (1971) proposed that ulcers are formed through an increase in the flow of the stomach's acid juices and a blood engorged stomach wall. This concept is supported by some studies on human beings conducted by Wolf S. and Wolf H. (1942) and Sawrey and Weisz (1956).

1.3.2 Current Thought

Current thought on the emotional theory seems to be moving away from some well-established aspects of biological phenomena and accepted effects of mental stress. Some groups of workers in this field do not agree entirely with many of the findings that are published, in particular, Raftery (1976) at an interview. The differences of opinion hinge on such factors as terminology, extrapolation of statistical evidence, the validity of samples, and biological interpretation of effects, as explained by Kirk and Hamley (1975) at an interview.

There are also opposing views on the validity of screening people for heart disease on a large scale. The main areas of controversy are associated with the setting of viable norms, individual differences, after-effects of the tests, the low percentage of positive results, and lack of definite proof that the disease will develop after a positive result, according to Pappworth and Wright (1976). In general Pappworth was for and Wright was against national screening.

The degree of mental stress felt and the actual mental stress occurring in the body at any particular time probably depends upon a complex number of integrated factors such as mental health, domestic problems, physical needs, work load, interaction with other people, previous experience, education and training, and degree of intelligence.

If any one or a combination of the factors is below a required level, a drop in performance and an increase in energy cost is likely to result. It is also possible that in sufficient adverse situations the manager could become pathological, according to Levine (1971).

1.4 Levels of Stress

Some of the main areas of stress levels that have received attention are:

(1) The effect of stress on mental performance including the ability to make choice reactions. This aspect was studied by Hick (1952)

(2) The presentation of stimuli at various rates to assess perceptual integration; studied by Edwards (1963)

(3) The degree of certainty in response time to information input. Hilgendorf (1966) conducted research on this aspect.

(4) EEG patterns associated with performance lapses in attention tasks; research was undertaken by Opton (1964).

(5) EEG criteria of fatigue after mental work, studied by Kiriakov (1964).

(6) The influence of massed and spaced practice on physiological adaptation to stress. Research conducted by Davis and Edwards (1965).

(7) Vigilance levels, studied by Gautier et al (1965).

(8) Distraction stress, reported by Kalsbeek and Ettema (1964).

(9) Mental task gradient in relation to cardio vascular change, reported by Gibson and Hall (1966).

(10) Arousal and task performance. Evidence submitted by McNulty and Noseworthy (1966).

Some examples of stressful situations involving car drivers, train drivers, and aircraft crew are now given.

An experiment was conducted by Rutley and Mace (1972) to determine what heart rate changes can be measured in stressful situations associated with driving cars such as what differences in average heart rate exist at different road junctions, whether instantaneous changes in a driver's heart rate can be correlated with events occurring in his visual scene, and what effects the physical work load in driving has on a driver's heart rate.

It was assumed from many previous studies that H.R. rises when a person experiences mental stress. Such experiments as assessing mental work load in airline pilots were conducted by Ruffell Smith (1967) and similar studies with police drivers by Hunt et al (1968) substantiated this assumption.

Figures I and II show the graphs drawn from beat by beat heart rate for subjects M and D. Subject M has an average heart rate of 70 -75 beats per minute with marked rapid fluctuations and Subject D has a high average heart rate of about 90 beats per minute and moderate fluctuations. Subject S (plots not shown) has a low average rate of some 60 beats per minute with smaller and usually less rapid fluctuations.

The effects of physical work involved in actually driving the car were accounted for by observing movements a driver makes whilst negotiating a motorway intersection and then repeating these on a test track during which time the loads were measured through variation of H.R. Figure III shows the H.R. rises with rate of working for Subjects M and S. Each point plotted represents one result but $\pm$10% error in the calculations is possible. There is a fair degree of correlation between the weight lifting points and the simulated driving points. One of the largest heart rate rises occurs at the on-ramp where only a small amount of physical work is done by the driver, but at this point decision-making is more difficult because a suitable gap for joining the motorway has to be chosen.

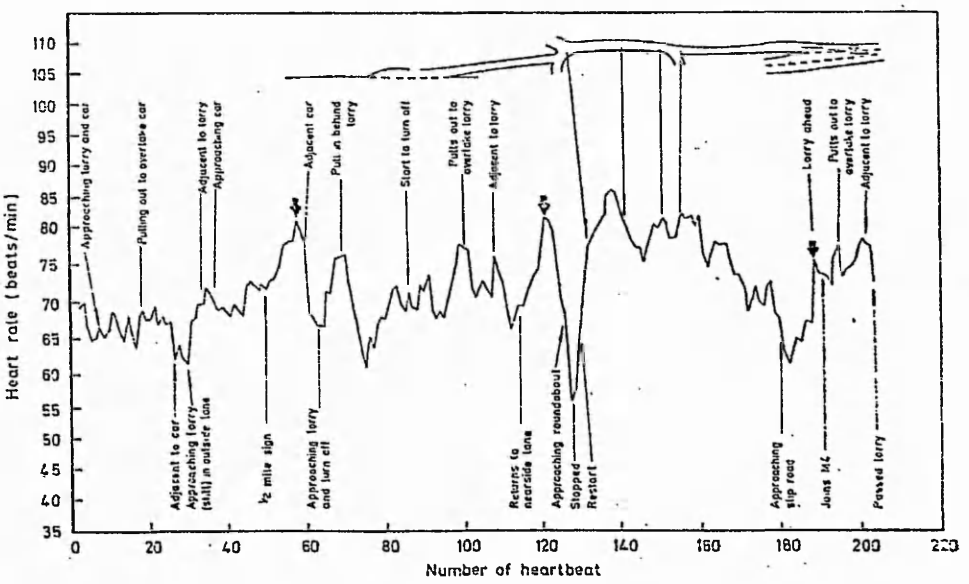


Figure I Langley Interchange - Subject M
(Rutley and Mace 1972)

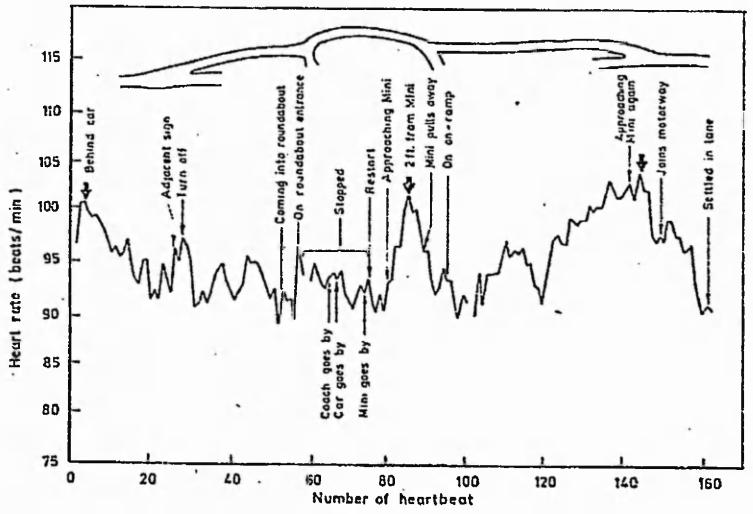


Figure II London Airport Interchange - Subject D
(Rutley and Mace 1972)

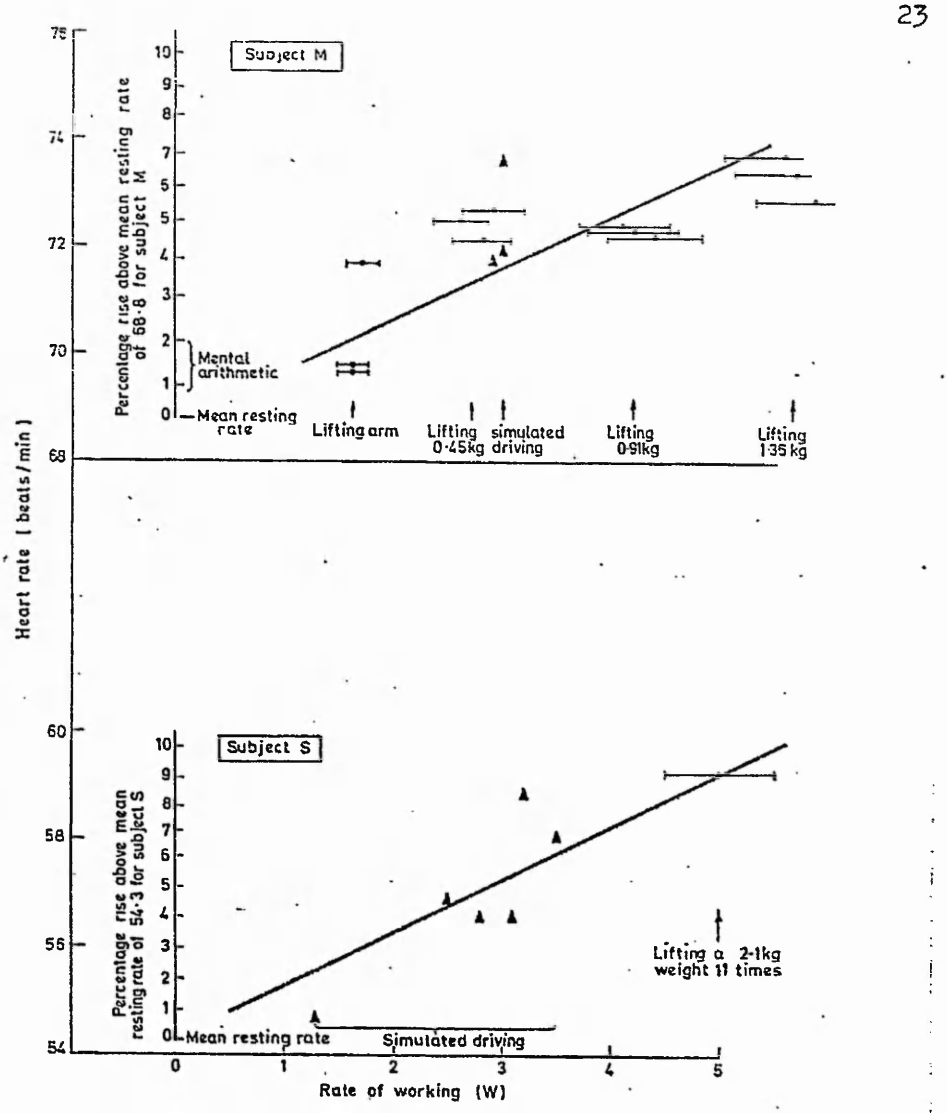


Figure III Effect of rate of working on heart rate for two subjects (Rutley and Mace 1972)

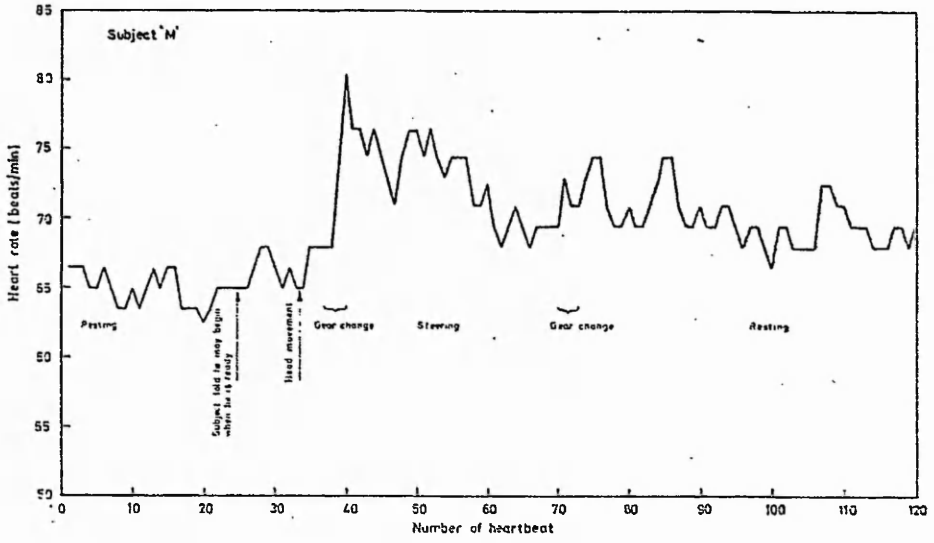


Figure IV Heart rate variations of the subject in a stationery vehicle as he goes through the motions of driving round a motorway intersection (Rutley and Mace 1972).

In Figure IV an example of the instantaneous H.R. changes for subject M is given during a simulated drive through a motorway intersection in a stationary car suitably modified to exert the various driving physical stresses.

The conclusions were that H.R. rises when drivers negotiate motorway interchanges through psychological stress as well as some physical driving stress. There is difficulty in distinguishing between these two components but it was thought that H.R. was worth pursuing as a measure of junction design.

Variation in the data suggests that results cannot be used to decide the correct number of runs required at the interchanges for this experiment. A sequential significance test conducted by Wetherill (1966) was thought to be an alternative.

There also seems to be a relationship between mean heart rate and periods of peak task loading. Typical studies which have verified this view have been conducted by Rowen (1961) during the X-15 research aircraft development programme, by Hashimoto (1964) during studies on train drivers, by Howitt et al (1965) who led a team to study Boeing 707 aircraft crew during civil flights, by Roman (1965) during flight research programmes on the X-15 and M-2 aircraft, and by Ruffell Smith (1967) during studies on civilian transport pilots.

These cases support the views that organic cost as a concept is measurable by physiological means, that a qualitative change occurs in physiological activity, and that there is a possibility that mental load changes may be indicated more rapidly by physiological measures compared with changes in system output.

Three reports in particular indicate the relevance of these views. Firstly, Rowen (1961) produced a report showing a definite relationship between heart rate response and peak task loading when the pilot is engaged on significant phases of launch, burn out, and landing the aircraft (Figure V).

Secondly, Howitt et al (1965) studied an aircraft captain's heart rate for sixteen scheduled transatlantic flights and the

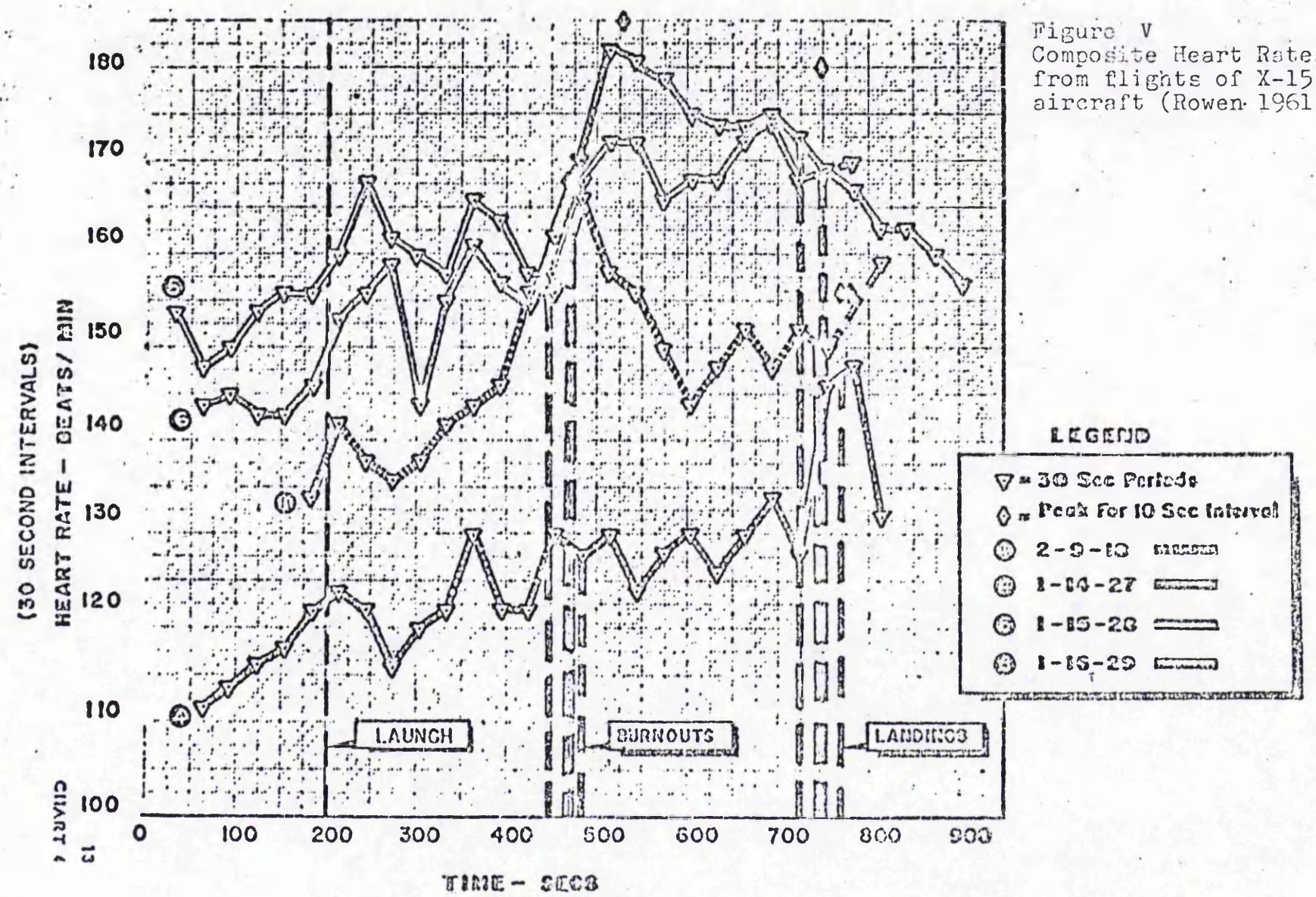


Figure V
Composite Heart Rates from flights of X-15 aircraft (Rowen 1961)

characteristic feature of the recordings was that higher rates occurred during take-off and on landing. The peak during landing usually exceeded the take-off values. An example is given in Figure VI.

Thirdly, Roman (1965) recorded heart rate during 37 flights in high performance aircraft. It appeared that physical risk or danger were not the primary causative factor in producing high heart rates, but that responsibility or responsibility coupled with risk were more potent factors. It was recognised, however, that responsibility is difficult to define clearly and that it encompasses many variables. The results for all pilots in control of the aircraft were 107.8 beats per minute as against their rates as passengers of 88.6 beats per minute. In all cases the heart rate as passenger was significantly lower than the heart rate for the same pilot while he was in control of the aircraft.

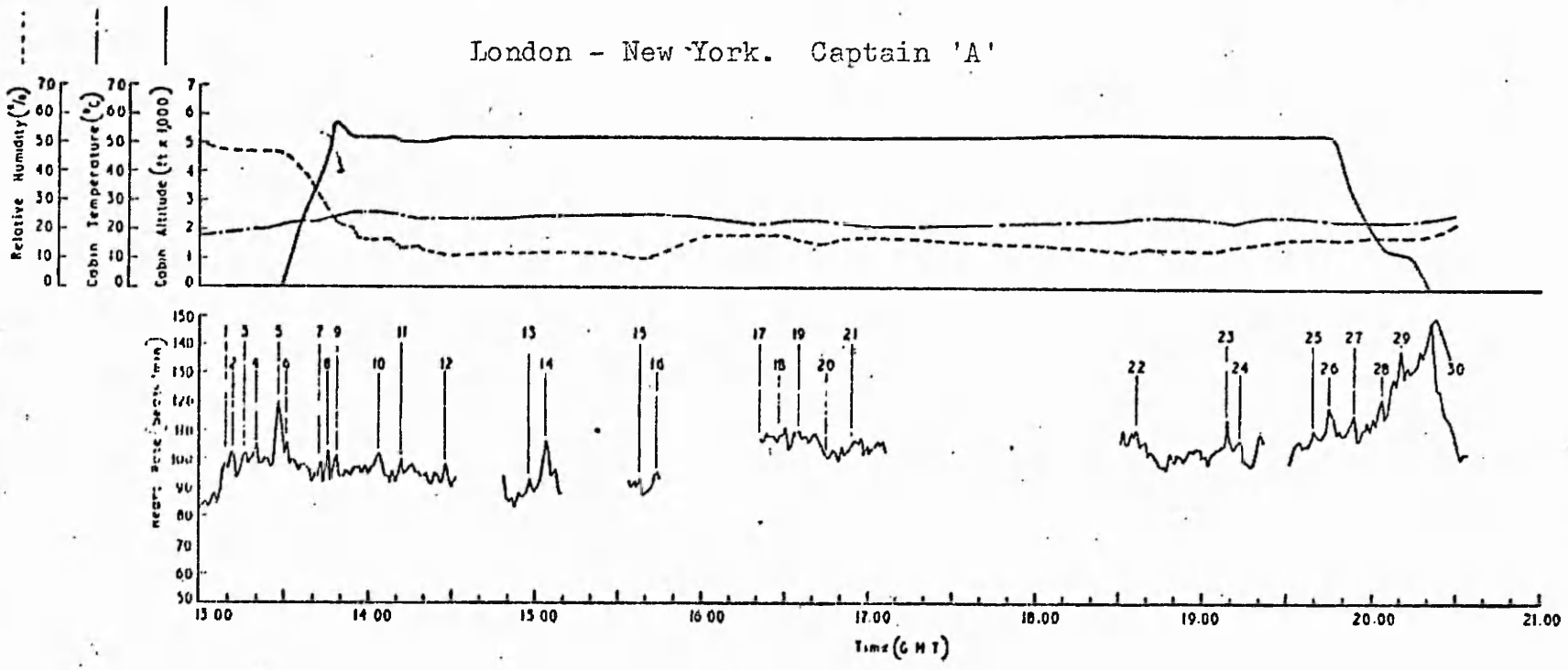
Another test employed by Rapp et al (1965) was conducted on a motor racing driver during trials on a racing circuit. Heart rate rose to 120-165 beats per minute and these rates were maintained for one to two hours. These readings were low compared with Carruthers (1974).

1.5 Managerial Stress

A further example of a stressful situation which was examined and measured by physiological means is given by Schäcke et al (1972). A group of 27 leading executives between the age of 37 to 64 years were examined from 0800 hours to 1700 hours by continuously monitoring their heart rate.

The results are given below:

(1) The profile of the heart rate showed a peak at the beginning and at the end of the 6 hour examination period. During the second to third work hour there was a plateau with a heart rate at 83/min. The amplitude of this cycle was about 10 heart revolutions per minute. It was independent of age, time of the last professional promotion or cardiocirculatory factors of risk.



1. Start engines
2. Push back.
3. Taxi
4. R/T clearance via Woodley.
5. Take-off
6. Noise abatement power reduction
7. Captain drinks tomato juice.
8. Speaks to passengers on P.A.
9. Tunes Strumble V.O.R.
10. Clearance from Shannon at flight level lower than requested.
11. Discussing assigned altitude and fuel consumption.
12. Levels out at 30,000 ft and reports to Shannon.
13. Hears R.A.F Britannia on R/T and discusses its chances in bad weather at Gander.
14. Captain reports to weather ship
15. Tries to raise Britannia on R/T.
16. No apparent event
17. R/T to weather ship.
18. Listening to aircraft ahead talking to Gander
19. Listening to weather report
20. First officer returns from lunch and Captain hands over R/T
21. Some turbulence and power adjustments.
22. Studying details of Kennedy approach
23. Speaks to passengers on P A
24. Breathes oxygen for 3 minutes
25. Speaks to passengers on P A
26. Top of descent
27. Level off at 22,000 ft
28. Captain on R/T.
29. Over Deer Park — autopilot out.
30. Land

Figure VI Heart rate recordings during a flight from London to New York (Howitt et al 1965).

(2) The distribution of the heart rate/5 min was nearly bell-shaped with a concentration between 80 and 90 beats/min and a variation from 60-130 beats per minute. The distribution of the mean values of the maximal and minimal heart rate/5 min showed a deviation of the concentration of 10 beats/min to the right respectively to the left.

(3) The dependence on the age was shown by the increase of the mean heart rate (10 beats/min) on the persons under the age of 50 years as opposed to those at the age of more than 50 years. The group of the younger managers showed a mean heart rate of 90 to 100/min during 75% of the working day. The older ones had a mean heart rate of 80/min during two thirds of the examination period. Maximal values of the heart rate ($\geq$120/min) were observed during 3.5% of the monitoring.

(4) The group of promoted managers showed a profile of the heart rate with a level of 3 ± 2 beats/min above the profile of the whole group. The persons with cardiovascular risks had the greatest deviation range per 5 min ($\bar{x} \pm s = 43.6 \pm 13.0$/min).

During an interview with Schäcke (1976) he stressed the importance of a trend line indicating heart rate increase in a slight upward curve in order to assess overload; the angle of the slope representing the degree of overload. He agreed that scale is one of the basic problems and that the effective use of statistical analysis utilising the histogram, minimum, maximum, median, and the regression line is helpful in analysing a stressful situation.

He also mentioned that there is a tendency to ignore allowances for physical activity, circadian rhythm, and other environmental conditions, and to concentrate on trends alone.

Another typical study on managers was conducted at the Goddard Space Flight Centre by McQuade (1972). The results showed that management jobs carried higher risks of coronary heart disease compared with the jobs of engineers and scientists. Whatever their assignment, the managers as a group had higher pulse rates and blood pressures, and smoked more than the engineers and scientists.

According to the medical records, managers suffered almost three times as many heart attacks as either the engineers or scientists, and the rise in serum cholesterol, blood sugar and blood pressure among ground managers was much greater during manned space flights than during flights of unmanned space satellites.

1.6 Stress in Hotel Management

A thorough investigation of current literature was carried out in order to ascertain any information about similar research projects involving stress in hotel management. Unfortunately nothing of particular relevance was discovered.

Physiological measurements of stressful situations within the field of hotel management seem to offer potential for further exploration.

1.7 The Measurement of Mental Stress

To reason about mental work Kalsbeek (1968) stated that it is necessary to be able to decide upon suitable units to express objective mental load, utilise an instrument capable of giving various doses of these units, and use physiological or psychological parameters of mental work load.

According to Fitts (1961) there are at least eight factors which usually have an adverse effect on the skilled performance of mental work.

Measurement of these factors has been undertaken by a number of investigators. For example Opton in 1964 examined EEG patterns as a function of subject age in an attention task and formed relationships which were reliable.

Many other measurements have been employed including heart rate, oxygen uptake, galvanic skin response, palmer skin inductance, blood pressure, myography, and critical flicker fusion. These have

been used by Benson et al (1965), Davis and Edwards (1965), Gautier et al (1965), Gibson and Hall (1966), Kiriakov (1964), and McNulty and Noseworthy (1966).

A brief survey of the suitability and use of various dependent variables is now given to determine the most suitable means.

Experiments with dynamic work by Kalsbeek (1968) showed a rise in the heart rate level and suppression of sinus arrhythmia, see Figure VII. The scoring method is shown in Figure VIII. Laboratory experiments according to Kalsbeek (1971) indicate that an increase in mental load is reflected by a decrease in the scored irregularity of heart rate pattern, and that suppression of S.A. is an objective measure of whether the person is only hearing or actually listening when subjected to certain tests.

Some experiments by Opmeer (1969) have shown that respiratory rates provide a better measure of mental load above a heart rate of 130 beats/min when compared with S.A. It was also found by Krol and Opmeer (1969) that emotional load is difficult to vary systematically, both S.A. and H.R. differentiating between levels of emotional stress. The suggested conclusion was that with emotional stress (information handling and physical load being at a minimum) as the independent variable, the differentiating power declines respectively with H.R., S.A., and respiratory rate.

The validity problem is difficult to solve when attempting to scale tasks with due regard for mental load. One aspect that emerged from experiments conducted by Kalsbeek (1971) was that significant scores on recording S.A. were not found during obviously different conditions of mental workload.

The energy requirements for certain jobs may be estimated by measuring food intake, oxygen uptake, body temperature, or pulse rate, according to Lundgren (1946).

He claims that of the four methods, heart rate is the easiest to measure and it does not inconvenience or distract the operator to any great extent. Another advantage is that oxygen uptake

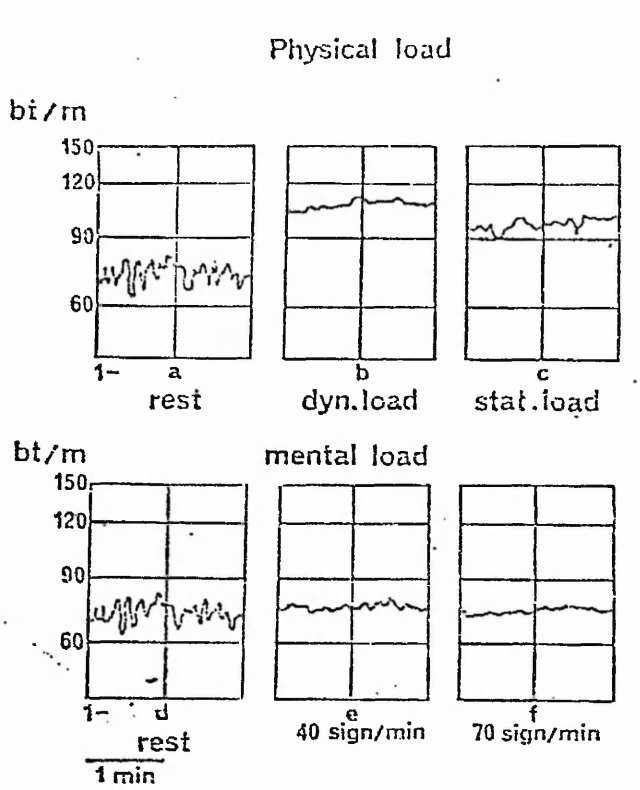


Figure VII Cardiotachogram of a subject "a" and "d": sitting in rest (s.a. score 13) "b": walking treadmill (6Km/hr.). "c": holding right arm outstretched (6th and 7th minute) "e": tone-task, 40 signals/minute (s.a. score 1.5) "f": tone-task, 70 signals/minute (s.a. score 0.5) (Kalsbeek 1968)

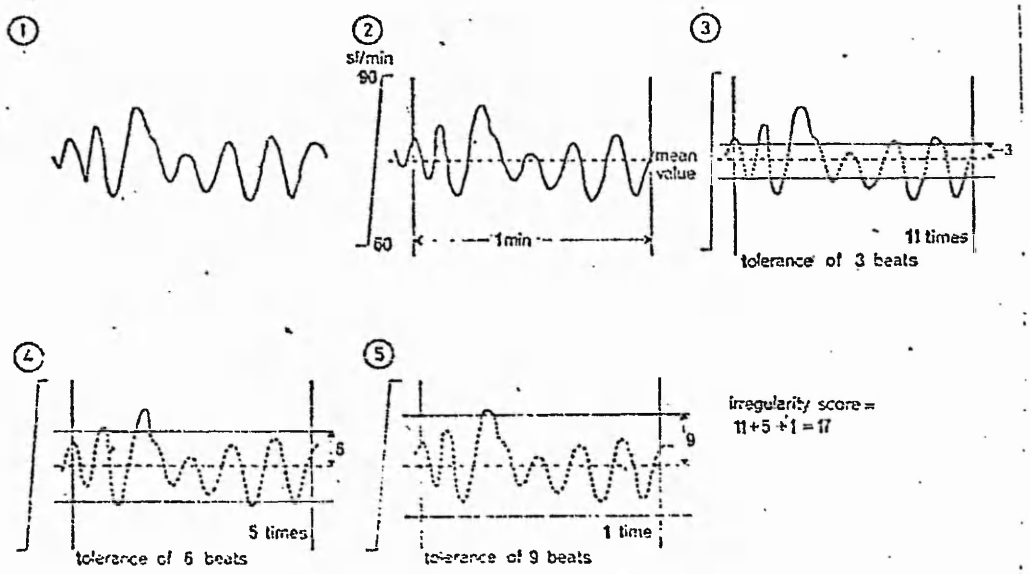


Figure VIII Method of scoring sinus arrhythmia (Kalsbeek 1968).

corresponding to a given heart rate can be easily calculated as there is, it is often claimed, a straight line correlation between the two measures in the steady state of work; thus all that is necessary is to measure the heart rate/oxygen relationship in the test subject before the experiment commences.

An experiment conducted on this basis was carried out by Poulsen and Asmussen (1962) to ascertain the energy requirements of operators on light work such as seated jobs: typewriting, sawing in steel, operating a punching machine and assembly work, and standing jobs: operating a turret lathe, a drilling machine, and planing wood.

The use of heart rate to predict energy cost has also been examined by Asmussen and Christensen (1939), Asmussen et al (1939), and Berggren and Christensen (1950).

Although they agreed that heart rate is a good predictor, certain reservations against its general use were mentioned. For example it was found that unless controlled conditions were applied the index is not strictly valid. Furthermore, some research undertaken by Malhotra et al (1963) has shown that the relationship between heart rate and energy consumption differs for each individual and that a critical point is reached with heart rate (95 beats/min) which directly affects regression analysis.

1.7.1 Pulmonary Ventilation

The three measurements of pulmonary ventilation are now discussed as an alternative to using heart rate.

It is claimed by Sharkey et al (1966) that ventilation rate is a more accurate predictor of oxygen consumption and hence energy expenditure when compared with heart rate as a predictor.

The exercise conducted for this purpose by Sharkey was very limited, however, and involved only four subjects. Considering the number of tests and the fact that the percentage error is positive in all cases the validity of the research findings is suspect.

Normally the errors occur each side of the regression line thus there should be a distribution of positive and negative figures.

Figure IX illustrates the regression equations and they certainly indicate that the percentage errors are less for ventilation rate compared with heart rate.

The second main measurement involves pulmonary ventilation related to tidal volume or depth of breathing. This method was proposed originally by Durnin and Edwards (1955). They calculated regressions between minute ventilation and energy expenditure and in the following years several other investigators established similar regressions: Sartorelli (1956), Ford and Hellerstein (1959), and Malhotra et al (1962).

Further research however, tended to apply limitations on these simple methods of calorimety, as evidenced by Ramanathan (1964) who mentions that unfortunately some error may appear in using the ventilatory minute volume as a yardstick for oxygen consumption. Such error could occur because the assumption is made that the extraction of oxygen from the blood by tissues is constant whereas in fact there is no guarantee of this. Furthermore the extraction of oxygen from the air should not vary and the stroke volume of the heart should be steady otherwise discrepancies in analysis will result.

The third measurement, Oxygen uptake, is probably most popular of the three when employed to discover the amount of energy expenditure involved in a workload because some of the latest techniques dispose of the Douglas bag (1911). Instead the gas is fed directly into a small metering device which analyses the oxygen content on a continuing basis. Typical devices which still utilise a collecting bag are the portable gasmeter developed by Kofranyi and Machaelis (1941) and the integrating motor pneumotachograph (IMP) designed by Heinz Wolff (1958).

A typical example utilising oxygen uptake was conducted on dustbin loaders by Bonjer (1969).

Various types of loading systems using different loading heights

Subject	Regression equation	Task	Rate	Predicted O_2 consumption	Actual O_2 consumption	Percentage error
PULSE RATE						
L.P.	$Y_O = 0{\cdot}023X - 0{\cdot}078$	T+S	150	2·772 l/min.	2·452	11·64
		C	143	2·611	2·396	8·23
		HC	137	2·473	1·754	29·07
B.B.	$Y_O = 0{\cdot}04x - 2{\cdot}611$	T+S	133	2·709	1·657	38·83
		C	134	2·749	2·576	6·29
		HC	150	3·389	2·156	36·38
R.S.	$Y_O = 0{\cdot}032X - 1{\cdot}46$	T+S	127	2·604	1·815	30·30
		C	120	2·380	1·677	29·54
		HC	113	2·156	1·694	21·43
J.L.	$Y_O = 0{\cdot}038X - 2{\cdot}366$	T+S	130	2·574	2·393	7·03
		C	132	2·650	2·139	19·28
		HC	135	2·764	1·876	32·13
VENTILATION RATE						
L.P.	$Y_O = 0{\cdot}007 + 0{\cdot}048X$	T+S	35·78	2·325 l/min.	2·452	5·46
		C	43·09	2·675	2·452	8·34
		HC	36·39	2·355	1·754	25·62
B.B.	$Y_O = 0{\cdot}07 + 0{\cdot}050X$	T+S	39·64	2·052	1·657	19·25
		C	45·02	2·306	2·476	8·88
		HC	50·61	2·601	2·156	17·11
R.S.	$Y_O = 0{\cdot}438 + 0{\cdot}043X$	T+S	41·82	2·250	1·815	19·65
		C	37·27	2·061	1·677	18·63
		HC	33·54	1·900	1·694	10·84
J.L.	$Y_O = 0{\cdot}325 + 0{\cdot}052X$	T+S	41·40	2·478	2·303	3·43
		C	41·77	2·407	2·139	14·34
		HC	39·00	2·358	1·876	20·44

Tasks: T+S = treadmill + static contraction; C = cycling ergometer; HC = hand-cranking.

Figure IX Regression equations, and predicted and actual oxygen consumption values (Sharkey et al 1966)

were examined using heart rate and oxygen uptake as measurements of energy expenditure. The relationship between the two measures and an indication of the optimum height for minimum energy expenditure is shown in Figure X.

1.7.2 Acceptable norms for Heart Rate

The definitions often used for the various aspects of heart rate or pulse rate were suggested by Karrasch and Müller (1951).

(1) Resting pulse rate: average pulse rate before work (60 pulse/min).

(2) Working pulse rate: average pulse rate during work.

(3) Work pulse: difference between the resting pulse and the working pulse rate.

(4) Total recovery pulse: total number of beats from the end of the work to the end of the recovery period.

(5) Total work pulse: total of pulse beats from the start of the work to the end of the recovery period.

Further criteria for the critical examination of work loads were suggested by Christensen (1964):

Physical Work Load	Heart Beats (beats/min)
Very low (resting)	60 - 70
Low	75 -100
Medium	100 -125
High	125 -150
Very High	150 -175
Extremely high (sport)	over 175

From the evidence submitted above on various measures of stress it was decided that the most suitable dependent variable for the study is heart rate. Sinus arrhythmia was considered unsuitable because of the validity problem in attempting to scale tasks with due mental load

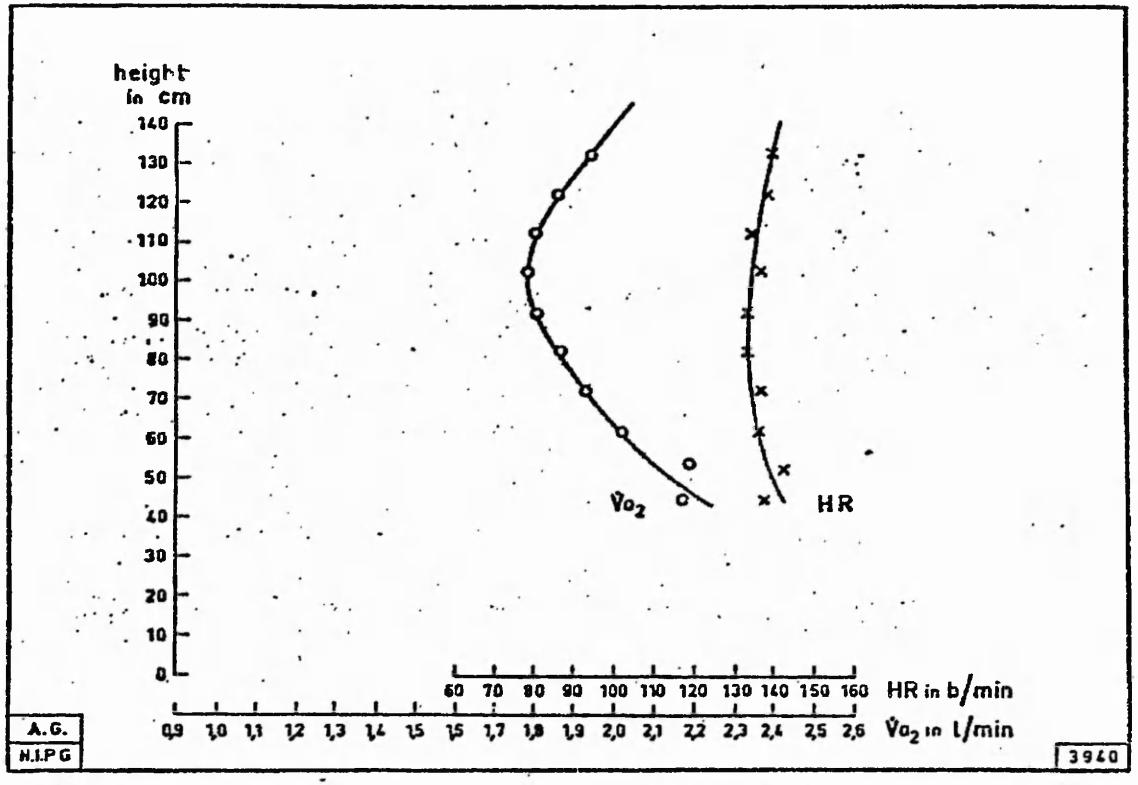


Figure X Oxygen uptake and heart rate as encountered in a standard task carried out at a standard rate, but at different heights. (Bonjer 1969)

(Krol and Opmeer 1969). From research undertaken by Lundgren (1946) it seemed that food intake measurements, oxygen uptake, and body temperature methods tend to inconvenience or distract the subject so these were also rejected.

1.8 Questionnaires

An additional assessment of stress was required to ascertain personal details of the subject and to determine any feelings of stress during the research.

The three basic methods of collecting data of this nature according to Ilersic (1952) are:

(1) The investigator conducts a personal interview. This technique was used by Professor Zweig (1948) who personally interviewed 400 people.

(2) The investigator delegates to selected agents the task of interviewing using a standardised questionnaire and providing explicit instructions as to the mode of completion and the information to be elicited.

(3) A questionnaire is designed and sent to individual informants chosen by the investigator.

The formulation of questions for an interview or questionnaire is an art according to Noelle Neumann (1970) and Payne (1951) who recommend that researchers must depend on rules of thumb and past experience more than empirical data.

It was decided to conduct personal interviews using a standardised questionnaire in accordance with the formulation and sequencing of questions recommended by Bouchard (1976). Some reservations must be borne in mind, however, according to Luczak (1977) who studied flight controllers at Frankfurt Airport in 1963. He felt that personal bias of the subject is likely to affect his answers, for example, if asked whether stress was experienced the

answer could be positive if an increase in salary is being demanded. He used the question-answer technique and stressed that the answers should be treated with care and not taken as definite proof.

1.9 Objectives

It was decided from the above evidence of managerial stress, the measurements of mental stress examined, and the lack of research into stress in hotel management, that the study should concentrate on hotel administrative managers.

The aim is to assess the degree of mental stress in hotel administrative management by using heart rate as a predictor and to record personal details of the subjects by completing a questionnaire at an interview. Further observations of the subject will be recorded during the study if it is considered necessary.

The results will be analysed to see if correlation exists between certain specified managerial activities and variations in heart rate. Further analysis is considered necessary to see if H.R. cycles or gradients may be located.

Three subjects in other occupations will be studied to compare results in addition to about twelve hotel managers. All will be selected from the local area telephone directory.

Before commencing the study a literature servey will be undertaken to assess other techniques and to determine other factors which should be taken into consideration during the discussion of the results and in the conclusions.

2. OTHER FACTORS AFFECTING HEART RATE

2.1 Introduction

There are some factors that could affect the heart rate recordings other than those due to mental loads occurring during the working day. These are now discussed and according to writers mentioned below they include the actile period, arousal, orientation reaction, circadian rhythms, age, and environment aspects.

2.2 The Actile Period

Even highly motivated people find that after a certain length of time they require a break from an activity. Some of the suggested reasons by Murrell (1962) for this phenomenon are:

(1) That there is a feeling suddenly that a build-up of resistance has occurred which demands a break;

(2) that concentration on the task becomes more difficult, and

(3) that a feeling of overall fatigue occurs.

The period between commencement of the task and the loss of concentration or whatever is sometimes called the actile period according to Murrell (1962). Recognition of the end of the period may occur in many ways such as a sudden deterioration in performance, loss of concentration, pauses in work, misinterpretation of instructions or indicators, and a fall in output. This change is often called fatigue or boredom in the industrial situation.

Evidence tends to show that if a break in the workload or a rest is arranged at appropriate times, the result should introduce a new period of optimum activity.

In the case of work which is continuous and repetitive there

are some famous studies in light exertion which requires a low perceptual demand. Considering the duration of the work Wyatt and Fraser, (1925), conducted experiments on folding handkerchiefs and an approximate duration was calculated to be seventy minutes, but there were considerable individual variations.

A further experiment conducted by Wyatt and Langdon (1938) on semi-paced machine feeding suggested a pause after seventy to eighty minutes of activity.

A pause itself does not necessarily mean a rest. It can take the form of a change in activity according to research by Miles and Skilbeck (1923) such as delivering completed parts to a nearby site, collecting materials from the stores, or recording data associated with the activity.

The duration of the break is debatable. Some research has shown considerable variation in suitable times that give satisfactory results. In one case the work period was divided into three parts of fifty minutes each with a five-minute spell between each part. The result was an increase of 10.1% when compared with a previous arrangement of one break of ten minutes which resulted in a 5.2% increase. These tests were carried out by Wyatt and Fraser (1925).

Similar findings of this nature were found by Murrell and Forsaith (1963), and Burnett, (1925).

Another experiment conducted by Jones (1919) involved the use of spontaneous rests. The findings were 16 pieces per hour during spontaneous rests, 18 pieces per hour when working for 25 minutes and resting for 5 minutes, 22 pieces when working for 17 minutes and resting for 3, and 25 pieces when working for 10 and resting for 3.

2.3 Arousal

The psychophysiological approach to arousal is associated with the concepts propounded by Cannon (1929) when bodily changes were observed during subjection to certain stresses such as fear, rage, pain, hunger, thirst, and various forms of emotional excitement;

and the research conducted on brain stem reticular formation and activation of the E.E.G. by Moruzzi and Magoun (1949).

It is often argued that all variations in behaviour may be attributed to variations in either the direction of behaviour or in the intensity of behaviour. This degree of intensity is normally referred to as arousal and according to Duffy (1957) is best indicated by the use of a combination of measures which include skin resistance, muscle tension, E.E.G., pulse rate, and respiration.

The degree of alertness (arousal) is often described as a continuum of central neural excitement ranging from a base point of low excitation which occurs during deep sleep and comatose states to high excitation in very alerted states. Duffy (1941) originally propounded this concept and she presented further evidence to support this contention in 1951 specifically for skin conductance, muscle tension, and E.E.G. Lindsley (1952) supported this concept as it applies to E.E.G.

2.3.1 Heart Rate and Arousal

A typical experiment involving arousal theory and heart rate was conducted by Belanger and Feldman (1962) to explain the observed effects of deprivation and external cues on behaviour using rats as subjects. A group of rats was trained in a Skinner box to depress a lever for water reward; they were then deprived of water for 24, 36, 48, and 72 hours and the rate of lever-depressions for water measured along with heart rate. Ill effects of deprivation were reduced by interspersing the deprivation periods with 4-7 day periods of complete drinking freedom. Figure XI shows the relationship between length of pre-trial water deprivation and lever-pressing and Figure XII shows the relationship between length of pre-trial water deprivation and heart rate during lever depressions. These findings indicate that arousal appears to depend upon internal determinants and external cues based upon learning in this experiment.

It was stated that the curvilinear relationship has an inverted "U" form as the lever pressing increases at first and then decreases.

Experiment on Rats by Belanger and Feldman 1962

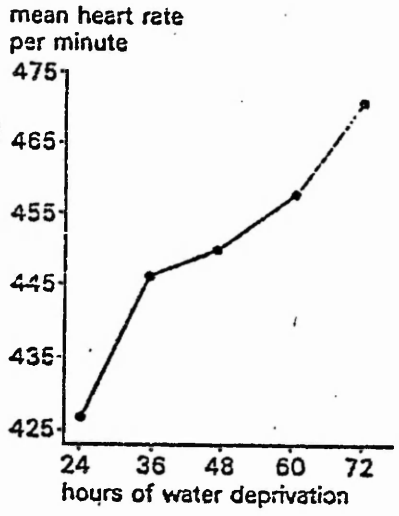


Figure XI. The relationship between water deprivation and heart rate.

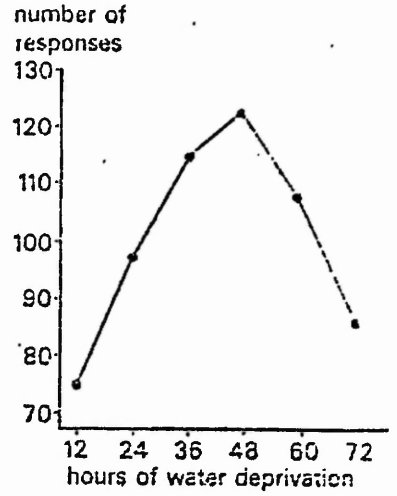


Figure XII The relationship between water deprivation and lever-pressing.

The author was not convinced and decided to run the plots through the computer to find the lines of best fit. The results are given in Figures XIII and XIV, thus indicating a power function with heart rate and a hyberbolic function in lever-pressing which would appear to show a high correlation in curvilinear relationship, according to the information available. It should be noted, however, that heart rate varied considerably during the experiment, going from 342 to 537 heart beats per minute in one group of rats. Also there were large individual differences.

A further experiment was conducted by Ducharme (1966) which was basically the same as that carried out by Belanger and Feldman. That part associated with the use of a Skinner box produced similar results. Arousal therefore seems to rely upon both internal determinants and external cues, which were acquired through learning in these two exercises.

2.4 Orientation Reaction

A new stimulus which involves a change in the surrounding environment immediately causes an "investigation" or "what is it?" reaction. This effect is often called orientation reaction, according to Lynn (1966). The reflex which causes immediate response produces a number of internal physiological changes:

(1) Heart rate slows. This phenomenon is the opposite to normal expectation. Generally heart rate increases when a task is performed according to experiments conducted by Lacey (1959) and Notterman (1953).

(2) Sense organs increase in sensitivity.

(3) Skeletal muscles change to direct the sense organs.

(4) Skeletal musculature changes include an increase in electromyographic muscular electrical activity.

(5) E.E.G. develops a faster and lower amplitude activity.

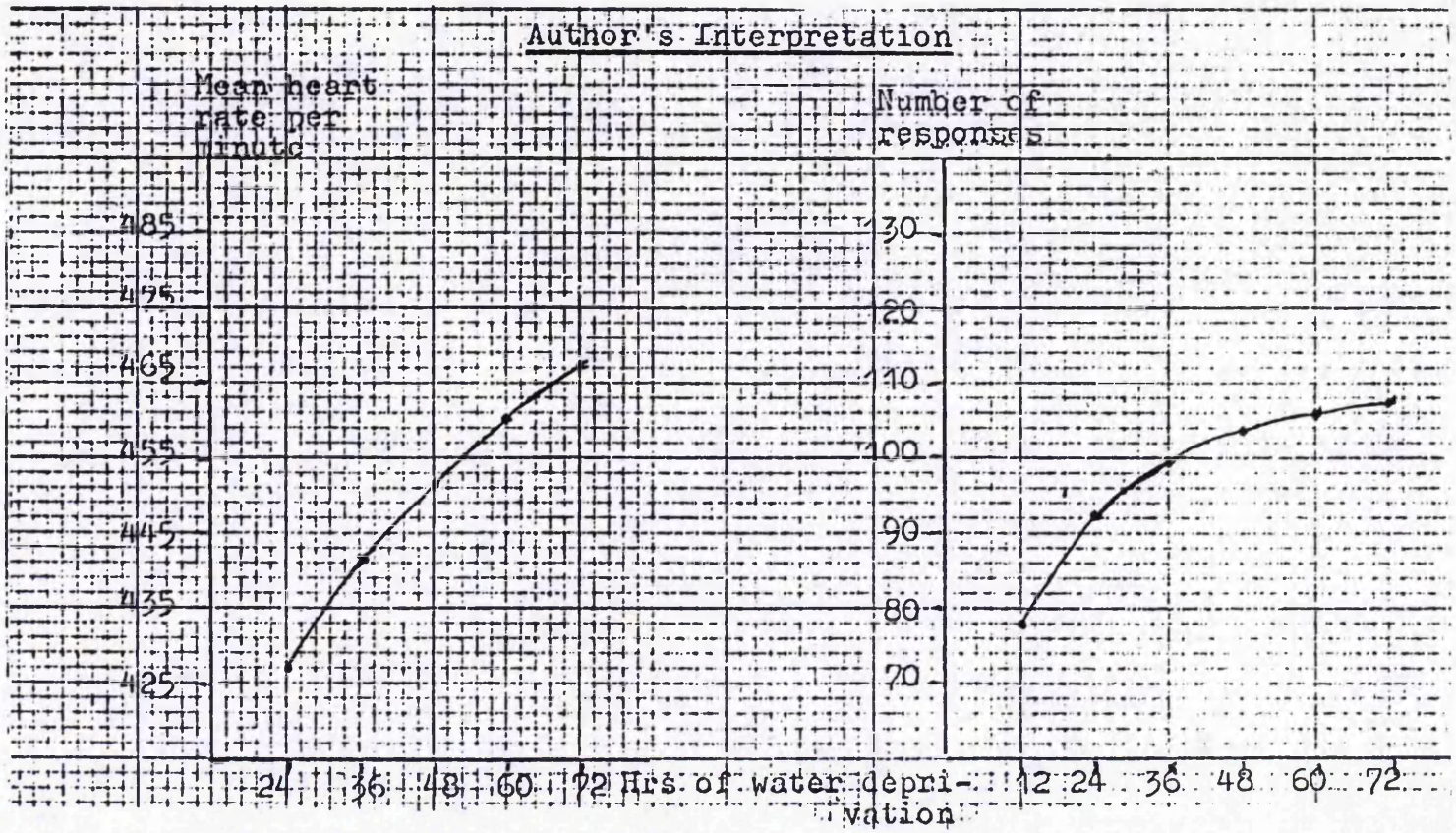


Figure XIII. The lines of best fit based upon data in Figure XI are a power function. The results of least-squares fit of its linear transform.
Formula: $Y = 328.339\ (X^{.0827})$

Figure XIV. The lines of best fit based upon data in Figure XII are a hyperbolic function. The results of least-squares fit of its linear transform.
Formula: $Y = \frac{X}{.05 + .0086X}$

(6) Galvanic skin reaction occurs.

(7) Respiration rate suffers a delay and then increases in amplitude and decreases in frequency according to research by Davis et al (1955).

2.4.1 Stimuli causing Orientation Reaction

Berlyne (1960) tabulated the characteristics of stimuli which cause orientation reaction as follows:

1.	Novelty	5.	Surprise
2.	Intensity	6.	Complexity
3.	Colour	7.	Conflict
4.	Conditioned stimuli		

2.5 Circadian Rhythms

Changes in the sleep/waking cycle dependent upon age were studied by Kleitman (1963) and the results are illustrated in Figure XV. The smaller waves in the traces show a basic rest/activity cycle which is noticeable throughout the 24 hours. The average length of the adult cycle is about 80-90 minutes.

The importance of Kleitman's work (1963) in the study of arousal states is often related to man's ability to adapt the phase of the circadian cycle to suit shift work. Studies of the cycle also indicate that arousal states conform to a pattern related to body temperature and performance according to Colquhoun et al (i) (1968). This experiment was based on two-point rating means and Figure XVI indicates the shape of the curve derived from 59 young men whose oral body temperatures were taken at two-hour intervals throughout 24 hours on two separate occasions. These recordings indicate a peak in the mid-evening but other recordings by Blake (1967) show that the peak may occur anywhere between noon and late evening dependent, it seems, partly upon the individual's personality and social habits.

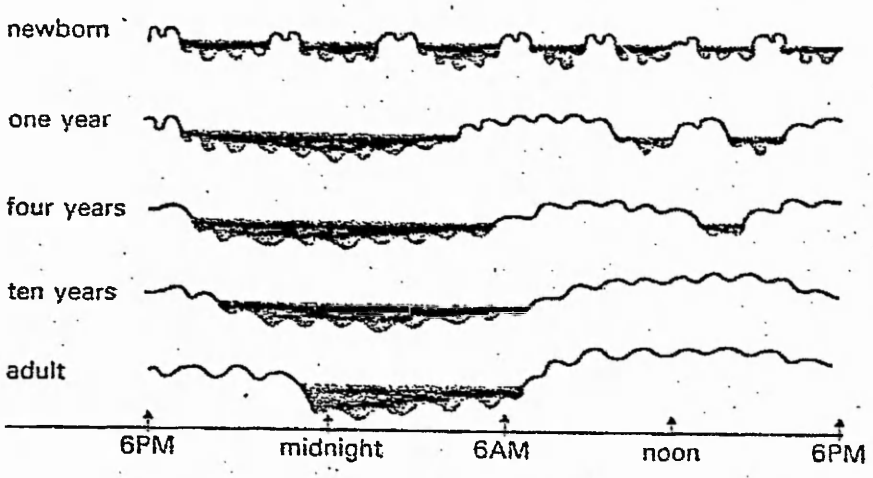


Figure XV Schematic representation of change in sleep/waking cycle. Shaded areas indicate sleep.

(Kleitman 1963)

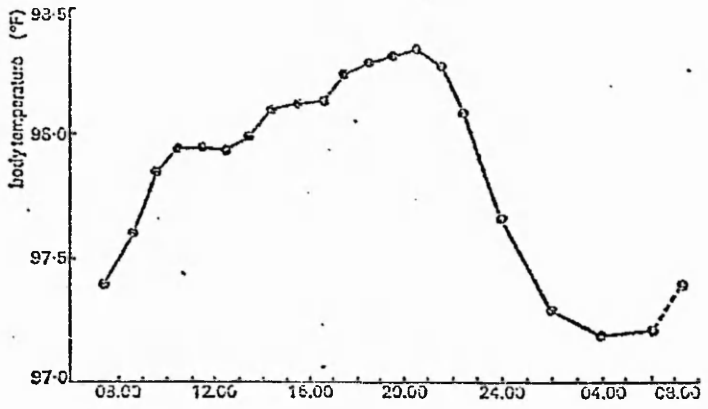


Figure XVI Oral body temperature of 59 subjects at twenty points of the 24 hour cycle.
(Colquhoun et al 1968)

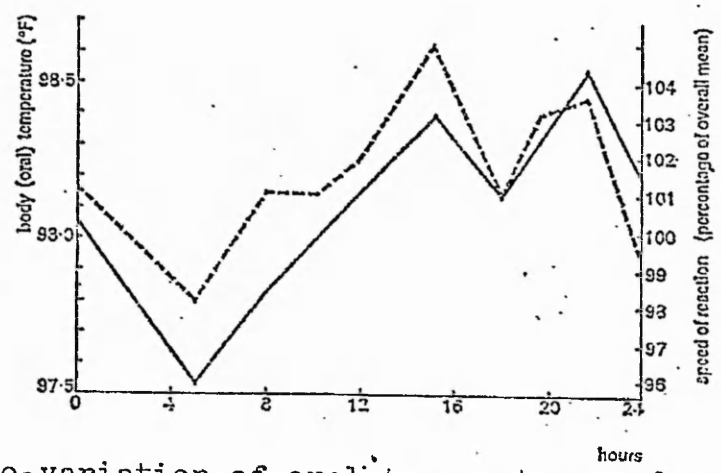


Figure XVII Co-variation of oral temperature and serial reaction time during the 24 hours. Speed of reaction is expressed as a percentage of the average over all subjects in all conditions. The continuous line is oral temperature; the dotted line is the reaction time score.
(Kleitman 1963)

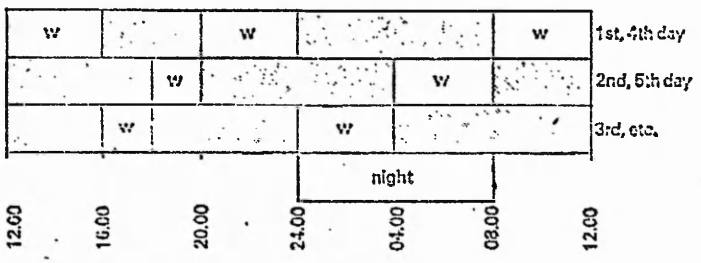


Figure XVIII Plan of work (W) and rest periods (hatched sections) in Naval rotating three watch system.
(Wilkinson and Edwards 1968)

Figure XVII illustrates a typical composite performance curve which was recorded by Kleitman (1963) showing the co-variation of oral temperature and serial reaction time during 24 hours, the correlation being +0.89. Other experiments of a similar nature have tended to coincide with these results, but studies where the effect of time of day was controlled by examining the temperature and performances correlation separately at each measurement point of the day or night, reduced the correlation to almost zero, according to Rutenfranz et al (1970). Thus it would appear that an unknown factor which varies in sympathy with the circadian cycle carries body temperature and some performance aspects along with it.

A well-known laboratory experiment of adaptation of the circadian rhythm of body temperature and performance involved the traditional British Naval System of rotating four-hour watches requiring three men per station with a proposed one in which two men worked stabilised five or seven hour shifts. This experiment was conducted by Wilkinson and Edwards (1968).

Figure XVIII illustrates the hours of work involved and Figure XIX shows the adaptation from first to fourth three-day period. Although a complete inversion of body temperature was not apparent, a flattening of the normal curve involving a definite raising of the level during the hours of night work was recorded.

Experiments involving the body temperature/performance relationships over 12 days to two four-hour shifts as people adapted, showed progressive but incomplete adaptation according to Colquhoun et al (ii) (1968). Figure XX illustrates the data recorded.

A similar situation occurs in time zone transition when people are transported rapidly from one part of the world to another involving a change of up to twelve hours out of phase. Such changes are ideal for conditions of adaptation and a typical experiment was conducted with twelve experienced pilots by Klein et al (1970). Figure XXI indicates the rapidity of adaptation and the studies qualify as a long duration exercise.

The general findings of studies indicate that within a week or even less people can cope with a phase shift in the circadian cycle

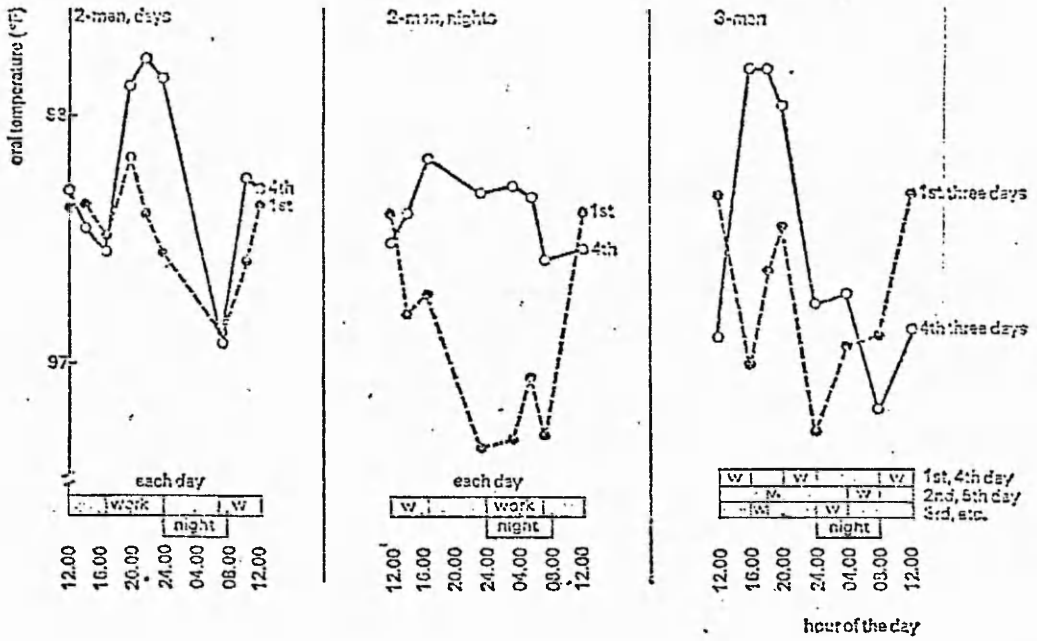


Figure XIX Adaptation of body temperature from first (dotted line) to fourth (continuous line) three day period in a 12 day programme of work on a stablised two-man Naval Watch system or a rotating three-man system.

(Wilkinson and Edwards 1968)

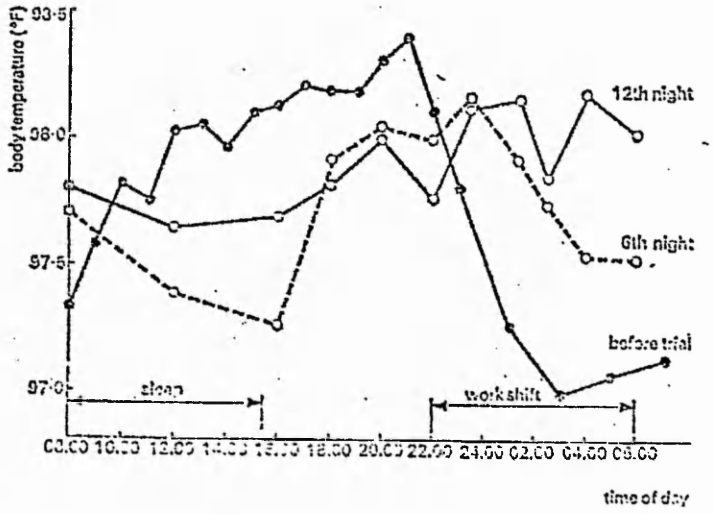
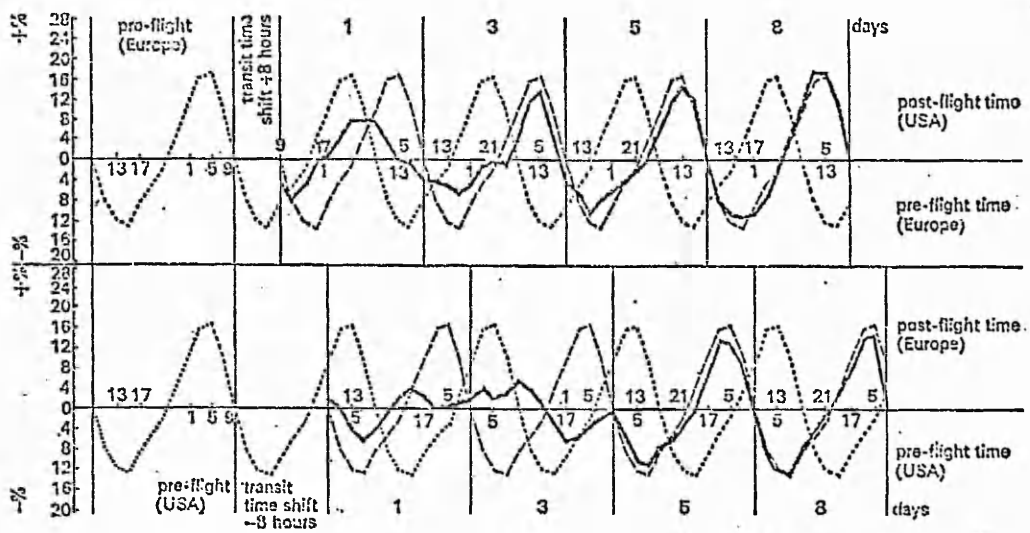


Figure XX Progressive but incomplete adaptation to night shift working: twelve days of working from 22.00 to 06.00 hours every day.

(Colquhoun et al (ii) 1968)



The effects of time displacement on the phase of the circadian rhythm of pilots' performance in a simulator

pre-flight rhythm (extrapolated into post-flight period) — performance rhythm as measured

post-flight (local) rhythm

Figure XXI — Adaptation of pilots' simulator performance to phase shift following a flight from Germany to U.S.A. (top half) and back (bottom half). The heavy continuous line represents time measurements, the dotted line shows where the normal (pre-flight) rhythm would have fallen had it continued during the post-flight days.

(Klein et al 1970)

and almost completely adapt themselves to the new situation if the external surroundings change in step. If the surroundings do not change, however, only partial adaptation occurs even over two weeks.

Such conclusions are particularly important when shift work is considered. Many of the systems in current use, it is often claimed, are bad for output and health especially when related to the amount of sleep lost. This is substantiated by Wilkinson (1965) and Wilkinson et al (1966).

The state of physical and mental health is also said to be lowered although there is some conflicting evidence given by Taylor (1967) and there is also evidence that motivation suffers through working during periods when social activities are usually occurring according to Wedderburn (1967).

So far the findings indicate that temperature rhythm can only be flattened slowly, thus a fixed night shift could be more beneficial to workers who would live permanently on an inverted sleep-waking routine, as suggested by Colquhoun (1970). It was recognised, however, that such an arrangement is not socially acceptable.

An experiment conducted by Adams and Chiles (1961) involved two teams of men (eleven in all) who were isolated in a special chamber simulating a kind of space vehicle for fifteen days. The men alternated four hours of work with two hours of rest throughout the period. The variation in heart rate is given in Figure XXII which indicates an average variation of heart rate on a daily basis of 4-5 beats per minute. Peak heart rate appears to be at around 15.00 hours.

2.6 Heart Rate Changes with Age

The relationship between physical work and heart rate with age is linear and comparatively large according to Borg and Linderholm (1967). Four age groups of lumber workers were studied and the mean pulse rates in relation to ratings of perceived exertion were plotted, see figure XXIII.

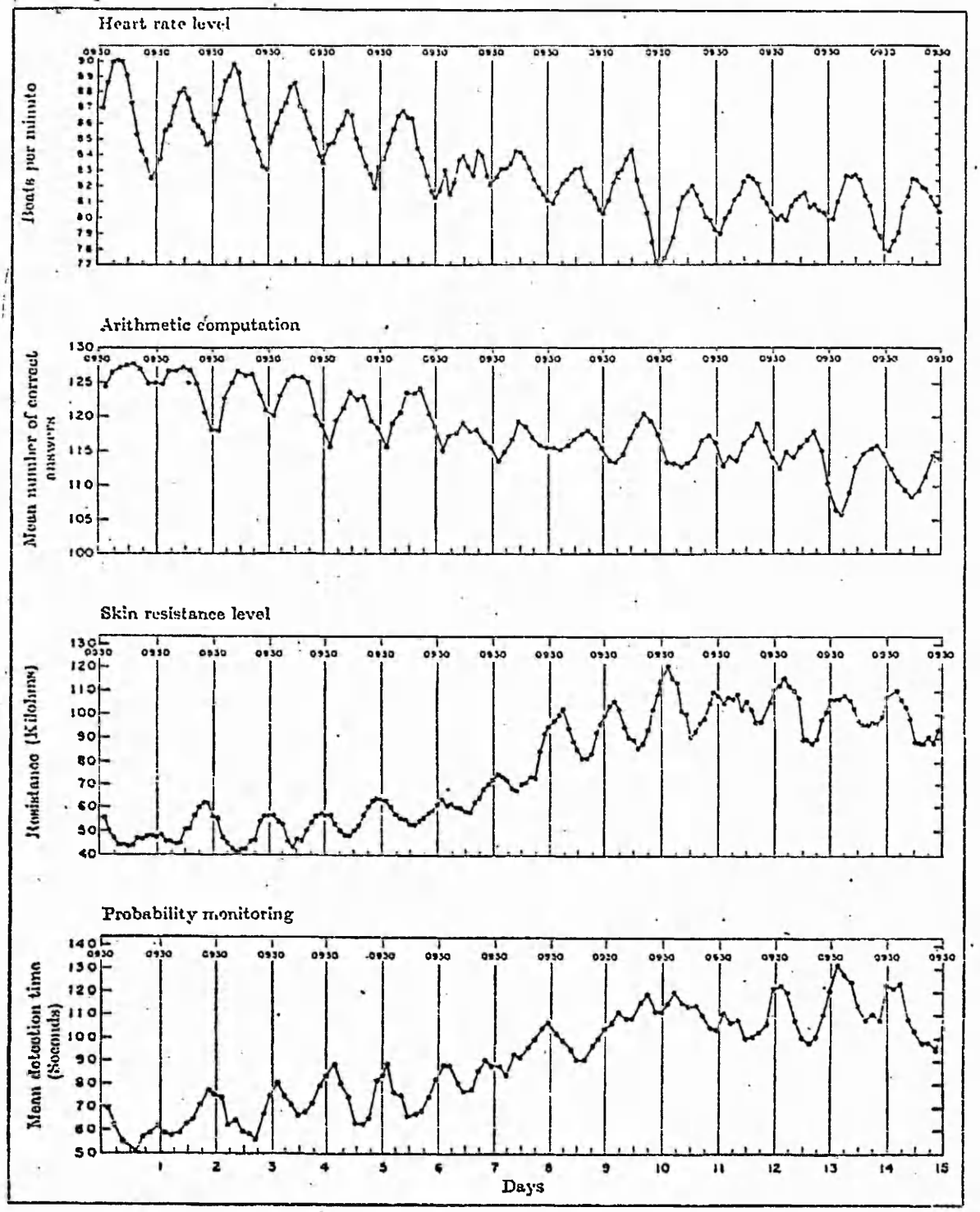


Figure XXII Average performance of eleven subjects during a fifteen-day confinement in a space vehicle simulation chamber.

(Adams and Chiles 1961)

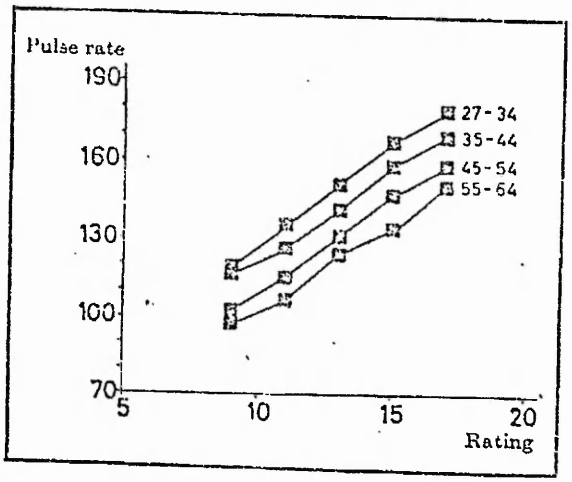


Figure XXIII Lumber workers' mean pulse rate in relation to ratings of perceived exertion, in four age groups.
(Borg and Linderholm 1967)

2.7 Environmental Aspects

It is suggested that high temperature can affect performance, for example, if the effective temperature passes beyond 27° to 30°C skill performance deteriorates sharply. Research in this field was undertaken by the Applied Psychology Research Unit at Cambridge according to Mackworth (1950) and by the R.N. Tropical Research Unit, Singapore mentioned by Pepler (1958).

Furthermore low temperature affects manual dexterity. A rapid fall off in performance occurs below 10°C, according to McFarland et al (1954) and tracking performance is impaired for long periods such as thirteen hours and short periods, half-an-hour, when an individual is subjected to an ambient temperature of 11.5°C, in tests conducted by Teichner and Wehrkamp (1954) and Teichner and Kobrich (1955).

Research by Vernon and Bedford, (1927), into coal mining conditions indicated that a slow but steady increase in the time taken to fill coal trucks occurred as the effective temperature increased from 19° to 28°C.

In the previous year Wyatt et al (1926) conducted research in a weaving factory and the findings showed that the average hourly output by pick-count on 44 looms dropped from 7,163 at 24°C to 6,832 at 27°C.

There is also information on studies undertaken in a bicycle chain factory where the time taken to complete a task increased by 12% when the temperature dropped from 17.5° to 10°C. These studies were undertaken by Bedford (1940).

Accident rates also seem to fluctuate with temperature changes. For example Osborne and Vernon (1922) demonstrated that there appears to be an optimum of 19° to 20.5°C and each side of these figures accidents increase. This effect was confirmed by Vernon and Bedford (1931) when it was related to the age of coal miners who, regardless of age group below a temperature of 21°C, showed little change in accident rate, but it was found that older men of various age groups were adversely affected by higher temperatures.

Christensen (1953) studied the effects of humidity. He mentions that in conditions of high humidity the body has greater difficulty in evaporating sweat, thus work becomes more difficult as the heat is mainly convected. Warm-moist processes occur in textile mills, dye factories, laundries, and many other different factories.

A body temperature rise in such circumstances above $1^{o}C$ may lead to severe distress and heat stroke. Symptoms include an increase in heart rate, a rise in skin temperature and an increase in blood flow to the surface of the skin. The individual feels very thirsty, and suffers with lassitude and faintness. In older men the increase in heart rate is very noticeable through an impairment of the cardio-vascular function.

Acclimatisation to such conditions in time allows individuals to withstand the change. Experiments associated with measurement of temperature and humidity effects have, in general, used heart rate and oxygen uptake. It was also claimed by Christensen (1953) that radiant heat does not affect the number of calories consumed to any extent during a particular physical task, therefore the use of oxygen uptake alone would not be viable. Heart rate does increase, however, which indicates the effect and substantiates the claim that in these circumstances the usual relationship between heart rate and oxygen uptake will not apply.

An increase of 15 beats per minute is sometimes quoted as being acceptable for the effect of heat load on a given task. The pulse recovery sum can also be used as an indicator according to Müller (1959-60), and the pulse recovery time taken during rest periods shows the duration of recovery time which also illustrates the effect as mentioned by Brouha (1960).

A more accurate method is the use of deep body temperature. Experiments have been conducted by Lind et al (1957) and Lind (1960) using a rectal thermometer. A radio pill which is swallowed and then transmits inner body temperature for a limited time period has also been successfully used. This pill was invented by Wolff (1961).

Attempts have been made to express in terms of a single index the parameters which contribute to heat stress. These parameters have included temperature, humidity, and radiation from surrounding areas during research undertaken by Houghten and Yagloglou (1923). Such an index is often called the effective temperature.

Similar studies on temperature were conducted by Bedford (1936) in various industries such as paper bag manufacturing, aircraft production and dressmaking. He claimed that most workers were satisfied and worked with high efficiency at 64° - 66°F. There was also a tendency for accidents to increase below the range 65°- 69°F.

All the above research work on environmental aspects indicates that although considerable variations in temperature and humidity affect skill performance, manual dexterity, output levels, accident rates, and physical discomfort, modest variations have little or no effect. This is substantiated by Mackworth (1950), McFarland et al (1954), Vernon and Bedford (1927), Wyatt et al (1926), Bedford (1940), Osborne and Vernon (1922) and Christensen (1953).

3. FURTHER FACTORS FOR CONSIDERATION

3.1 Introduction

Additional reading was undertaken to discover whether other areas of research would be of relevance to heart rate analysis in terms of control checks on accuracy and comparative data.

The main areas which proved to be useful were energy expenditure research, heart rate variations with work load, unrelated dependent variables, the value of negative results, probable effects of increased heart rate, and the emotional theory, according to the writers mentioned below in each section.

Although further interpretation was needed before comparisons were possible in the case of energy expenditure, the results did coincide with the previous research as mentioned in Chapter 8, section 8.1. Each factor is now discussed.

3.2 Energy Expenditure

Energy expenditure on particular jobs studied by Singleton (1972) is estimated to be:

1 Kcal/minute = complete rest
2 " " = office work
3 " " = driving
4 " " = machine tool operation
5 " " = average walking (limit for average man working eight hours a day continuously)
6 " " = shovelling earth
7 " " = hammer forging
8 " " = pulling rickshaw
9 " " = steel-works slag removal

Considerable research has been conducted on the question of how much energy should be allowed for an individual's diurnal activity and how much for his work load during the day. Studies have shown that there is a wide variance between individual needs; for example, army cadets were tested by Edholm et al (1955) and the results varied from 1,500 to 7,000 Kcal/day for food intake when they were performing similar duties. Energy expenditure for the same group varied from 2,000 to 5,000 Kcal/day in tests conducted by Edholm (1957).

Research in the USA by the Food and Agricultural Organisation of the United Nations (1949) provided for light work an average figure of 3,200 Kcal/day. Research in the UK by Garry et al (1955) revealed an average of 2,800 Kcal/day for clerks and in the same year an average of 3,600 Kcal/day for coal miners. Further research by Lehman (1958) and Edholm (1957) has indicated that an average expenditure of 2.8 Kcal/min for light work and 3.3 Kcal/min for heavier work is acceptable over a 24 hour period.

Estimates for the working day of eight hours are 4.17 Kcal/min plus 1 Kcal/min for basal metabolism according to Lehmann (1958) and a total of 5.21 Kcal/min according to Passmore (1956).

It is not always clear in some literature whether or not basal metabolism of about 1 Kcal/min has been included in the calculations. Furthermore, some research work has ignored the weight differential of various individuals undergoing tests. Although the error is not likely to be large in very light or static work it should be taken into account for heavier work. For example at a walking rate of 2 m.p.h. the energy expended is 1.9 Kcal/min for a body weight of 80lbs., 2.9 for 144 lbs., and 3.8 for 200 lbs; at 4 m.p.h. the expenditure is 3.5 Kcal/min for 80 lbs., 5.2 for 144, and 7.0 for 200. To allow for this error some results are given in terms of Kcal/Kilo body weight or in Kcal/metre of body surface area, as illustrated by Murrell (1971).

A conversion to interpret the heart rate range from 65 to 95 b.min on the nine point scale (1-9 Kcale/minute) of Singleton (1972) amounts to 14.5 b.min per Kcal/min on the basis of straight line correlation. This correlation also is applied in practise to oxygen

uptake with heart rate according to Lundgren (1946).

The expectation on this basis in the study will be:

Complete rest = 65-75 b.min
Clerical work = 76-90.5 b.min
Driving = 90.6-105.1 b.min

3.3 Heart Rate Variations with Work Load

Two rough checks on the results of the study are possible by applying the findings of the investigations given below:

According to Singleton, (1972) for normal work (presumably physical or mental work) the heart rate should not rise by more than about 40 pulses per minute above the resting rate and the body temperature should not rise by more than $1^{o}C$ above the resting temperature.

According to Müller (1961) the total recovery pulse indicates the recovery period but another view given by Grandjean (1958) is that it should represent individual physical stress only as the term "fatigue" is generally reserved for all subjective sensations of fatigue.

On the subject of the optimum upper limit of stress, taking into consideration pulse rate and the total recovery pulse, the definition proposed by Karrasch and Müller (1951) is: a work output in which the pulse rate does not continue to rise, which results in a return to the resting pulse rate within fifteen minutes at the end of the work period.

It follows therefore that during work output the energy consumption balances the energy supply and that the highest possible continuous output to complete these conditions is the optimum limit of performance for, say, an eight hour working day.

An acceptable optimum limit of performance apparently is

reached when the average pulse rate during work lies thirty beats/min above the resting pulse rate.

3.4 Unrelated Dependent Variables

Chapanis (1969) stated that there is a high probability that in choosing dependent variables for an experiment the results will indicate conclusively that they are unrelated.

The implications are that great care is needed in selecting dependent measures and that careful study of the exact dependent measures used in other experiments is essential before arriving at a conclusion.

3.5 The Value of Negative Results

In applied research it is sometimes important to know that some things do not make a difference according to Chapanis (1969), thus dependent variables may be chosen for their relevance to a practical problem rather than to establish significant positive results.

For example the effect of weightlessness in outer space was studied by Simons (1964) who experimented with psychomotor performance of operators in zero-g conditions. The negative results were proved to be correct later and helped considerably in the efficient design of space craft.

3.6 Probable Effects of Increased Heart Rate

Provided the heart is healthy its response to chemical changes induced by the pituitary and adrenal glands during periods of physical activity, physiological insult, and other similar stresses apparently is not harmful. However, its response to other kinds of stresses which are psychological in nature may be harmful. These stresses include conditions of fear, apprehension, anxiety, a loud noise, crowding, and exposure to a novel environment, according to Levine, S. (1971).

3.6.1 The Emotional Theory

A further effect is associated with the risk of heart disease. Since Ancient Egyptian times various famous writers have recorded heart attacks which have been attributed to anger. A typical example is Harvey (1628) who gave logical proof that blood circulated round the body from the arteries to the veins under the action of the heart and who published a case history of a strong man who was so overcome with hatred because he could not take revenge that he suffered from pain of the heart and breast, resulting eventually in death.

4. CRITIQUE

There is controversy over the true meaning of certain biological data and there is a tendency to use imprecise terms associated with stress. Thus the measurement and understanding of stress, although complex and widely studied, remains as an imprecise concept.

The problem of agreeing on a general framework for conceptualising stress which is aggravated by lack of comprehensive data remains, but some propositions are receiving more empirical support. Typical of these are the cognitive approach involving the individual's perception of the situation; the meaning of experience in terms of familiarity with the situation confronting the individual; the idea of reinforcement through past successes and failures; the inverted u-shaped relationship between the degree of stress and quality of performance; task differences related to stressor conditions; the effect of other people being present and influencing the situation; and the effect of the general environment.

Often the experimental criteria are chosen by the investigator who decides on the basis of cost, limitations imposed by the subjects, site difficulties, and the availability of suitable measuring equipment. These restrictions consequently produce evidence of limited use, such as the employment of one predictor. In addition there is often the difficulty of transposing considerable amounts of research in military and space programmes into useful comparisons in industry and commerce.

When two or more measures of stress are employed, however, a dilemma arises if they disagree. Should the differences imply that some measures are not suitable or are these different patterns of response? Furthermore it is accepted that different individuals react differently to similar situations and that one individual may react differently to two different situations, thus seeking general relationships between stressor conditions and observed reactions to them is exceptionally difficult.

It seems that considerably more data and experiments are needed before any form of cross-calibration of levels in various stressor

conditions can be attempted. At present it is not possible to compare one condition with another using any form of "yardstick", therefore it is difficult to interpret stress as being a broad concept or as highly situation - specific. Validation becomes questionable in these circumstances in view of the small sample size often employed, the unknown effects of phenomena outside the control of the investigator, the artificial situation created by the study itself, and biassed opinions expressed when interpreting data to suit fashionable theories.

The interpretation of evidence on stress considering the above mentioned comments becomes hazardous, extremely controversial, and often simply opinion based upon subjective instinctiveness.

5. METHODOLOGY

5.1 Pre-study Procedure

Hotels were chosen by random sample from the local Denham area Yellow Pages Classified Telephone Directory. Managers were telephoned, details of the study were explained, they were invited to participate, and any environmental or personal problems associated with the study were discussed. Appointments for interviews were arranged and accuracy checks on the equipment were conducted.

5.2 Study Procedure

The manager was interviewed and a standard questionnaire (Appendix X) was completed by employing the question-answer technique.

Heart rate was recorded on magnetic tape using skin electrodes. The electrodes used were V-Trace, Ag/Ag CI, EGG monitoring electrodes manufactured by NDM Corporation U.S.A. These were chosen because they were found to be most reliable over periods of eight hours. Others tended to become unstuck after a few hours.

The potential from the electrodes was recorded on magnetic tape in a miniature data-logging system which is described along with the circuitry in Appendix IX. This equipment was chosen because it is light weight and can be concealed easily on the body.

The electrodes were fixed to the chest and the H.R. recording apparatus secured to the waist. The apparatus was tested with pulse rate and stop watch, and resting pulse recorded for ten minutes.

The tape recorder was switched on, the time noted and entered in the activity diary, an example of which is given in Appendix XI. Observations were entered on a minute by minute activity analysis during the study period. Any personal details or relevant observations were also entered in the diary and the questionnaire as considered appropriate.

At the end of the study period the apparatus was checked with pulse rate and stopwatch, rest pulse recorded for ten minutes, and switched off. The electrodes and apparatus were removed and the manager thanked for his co-operation.

5.3 Post-Study Procedure

The tape recording was analysed and graphs produced from the analogue graphical output machine, details of which are in Appendix IX.

6. RESULTS OF THE STUDY

6.1 Procedure

All the main activities which were recorded in the diary for each study are transposed to the subject graphs. A copy of the activities diary used for this purpose is included in Appendix XI and the coding for each main activity is given in Item 5 (a) below. The main subject graphs are detailed in Appendix I and these include the variations in heart rate for the whole of the study period.

The results were analysed into a number of categories: histogram, line graph, moving average graph, the range, main activities, heart rate: rest pulses analysis, resting pulses, and perturbations analysis. Details for each category are given at the end of this section after the summary of results within the chapter.

The results for the main study subjects, A to K, include personal details, heart rate graphs, histograms, and activity analysis tables. These are augmented with a histogram for all the main study subjects and smoothed curves to determine any distinct patterns.

Three comparative subjects were chosen and studied. Similarities in standard deviation and histograms between these subjects and the main study subjects are given. Six further subjects were chosen at random for a public speaking exercise as a test of the effect of human presence and of mental stress; the results are tabulated and analysed. Finally the operational effectiveness of the equipment used during the study is examined.

Details for each category of the results for main study subjects are now given below.

(1) (a) Histogram

The frequency groupings to be arranged within the following limits:

61 - 70 beats per minute
71 - 80 " " "
81 - 90 " " "
91 - 100 " " "
101 - 110 " " "
111 - 120 " " "

(b) A summary table of histograms indicating a percentage for each frequency group.

(2) Line Graph

A minute by minute recording during the period of study. Coded activities to be included at appropriate intervals.

(3) Moving Average Graph

The moving average to be based upon the median of a 29 minute period at the start of the study.

(4) The Range

(5) (a) Main Activities

These activities will be grouped into the following headings and coded as follows for recording purposes:

1 Outgoing telephone calls
2 Incoming telephone calls
3 Personal telephone calls
4 Meetings with a group
5 Speaking with a peer
6 Speaking with a subordinate
7 Speaking with a superior
8 Speaking with a client
9 Dealing with clients' complaints
10 Reprimanding a subordinate
11 Dealing with domestic emergencies
12 Administrative duties

13 Dealing with cash

14 Meals and breaks

15 Driving

(b) A mean heart rate for each activity will be calculated.

(6) Heart Rates : Rest Pulses Analysis

The student - 't' distribution will be calculated to provide the degree of significance according to the value of 't'. This 't' test illustrates how much the activity is different from the mean resting pulse. Therefore it may be assumed that it is due to some factor which is most probably mental stress or mental activity.

The formulae used for 't' tests are modified to allow for small samples. The student - t distribution was chosen because the shape of this distribution is similar to the normal curve inasmuch that it is symmetrical with zero mean but there is a slightly higher probability for getting values into the two tails at the end of the curve.

(7) Resting Pulses

For the purpose of calculating the 't' distribution the mean resting pulse is based upon a number of recordings during the working day which occur when it is considered that the subject is relaxing and is not engaged in any recognisable physical or mental activity.

(8) Perturbations Analysis

The 't' value for the pertubations will be calculated based upon the difference between each mean heart rate per minute and its related resting pulse and the concept of null hypothesis. Thus the distribution will relate to the overbeats only and give an indication of their significance.

The concept of null hypothesis was used as the basis for these tests of significance because it postulates that any differences between the samples drawn from the population arise only from random sampling errors, thus the true difference is nil.

The use of this concept indicates the degree of validity of the results to such a point where it may be assumed that the difference has not occurred by chance. Figure XXIV illustrates the method of calculating each difference on a minute to minute basis to arrive at the number of overbeats.

6.2 Main Study Subjects

The results are given in Appendix I. Subjects are coded A to K and the analysis sequence for each one is divided into the following groups:

1. Personal details
2. Heart rate graphs
3. Moving average graph
4. Histogram
5. Activity analysis table

(abbreviations: H/S = highly significant, S = significant, and N/S = not significant)

The main features of the results in total, namely the histogram, the frequency table, ranked standard deviations, personal details summary, and interlace graphs, are now discussed.

6.2.1 Histogram of Heart Rate Distribution

A histogram of the heart rate distribution for all main study subjects is given in Figure XXV. The ordinate represents the total number of minutes recorded for all the main study subjects and the abscissa is grouped into class intervals of 10 b/min for heart rate.

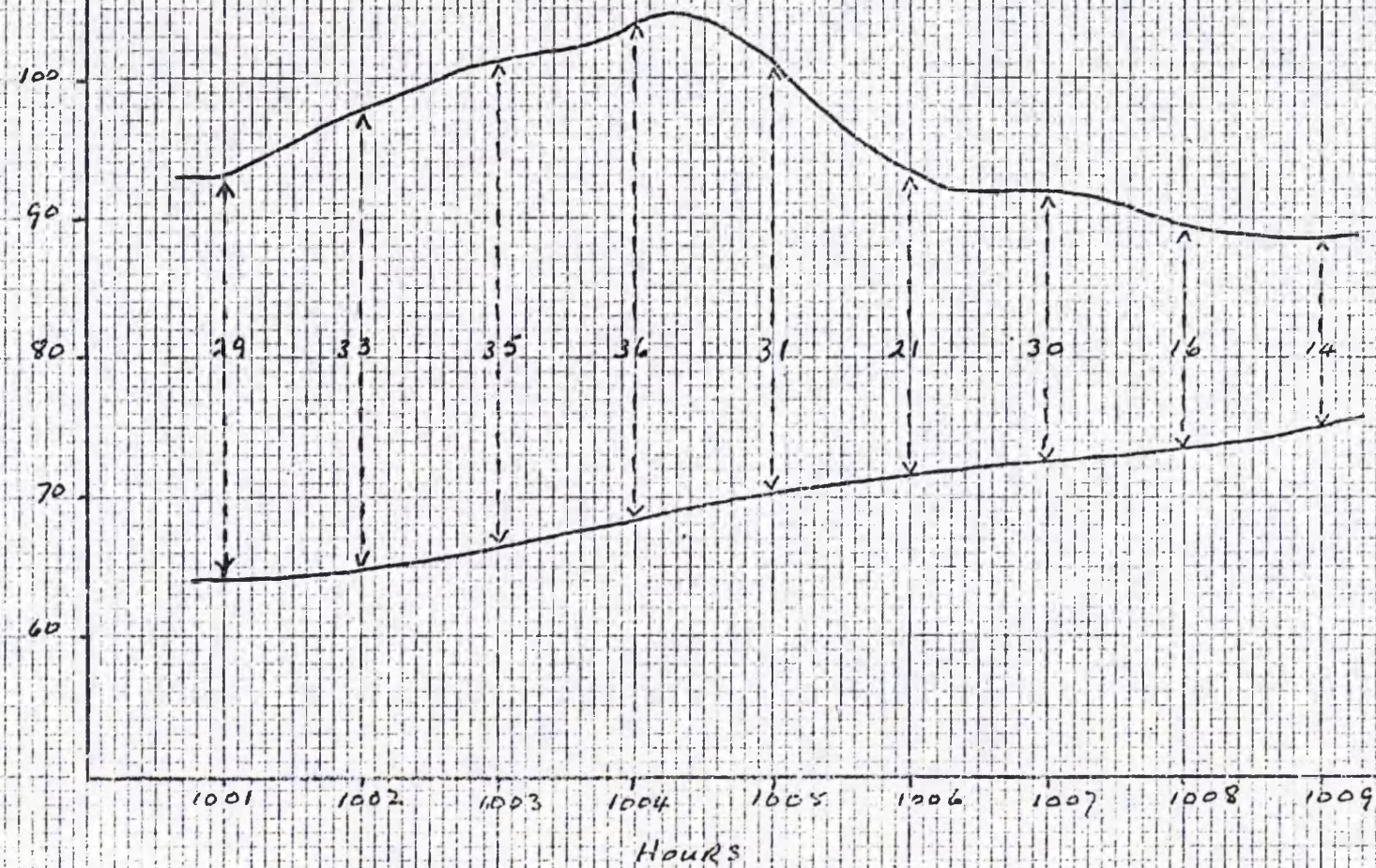


FIGURE XXIV : Perturbations Analysis: heart rate/resting pulse differences.

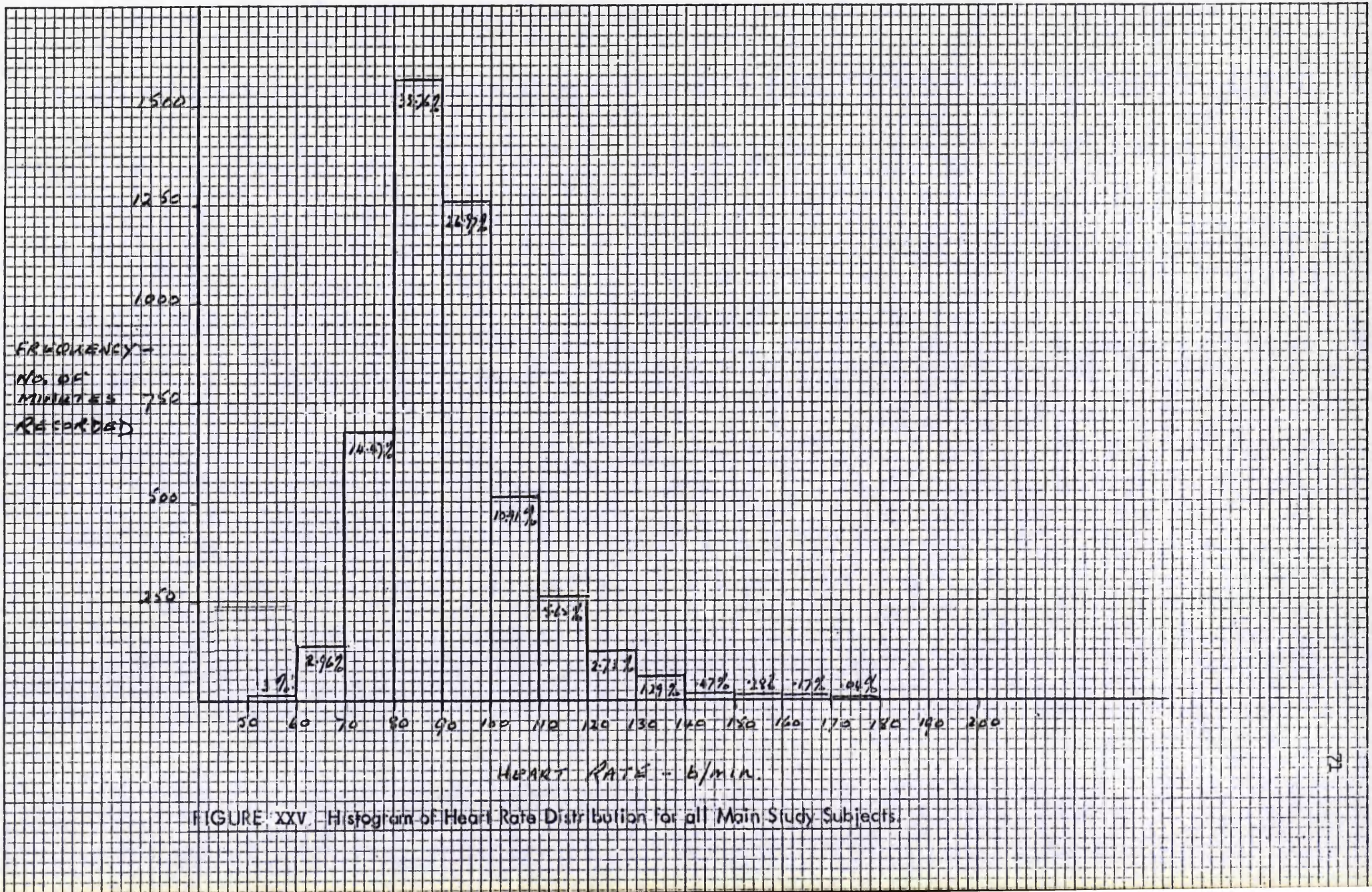


FIGURE XXV. Histogram of Heart Rate Distribution for all Main Study Subjects.

In summary Table II for all subjects the percentages for each heart rate group are recorded. The percentages indicate that heart rate group 81-90 forms the apex with 33.76% of the population and a standard deviation of 14.976.

The ranked standard deviation for each subject based upon the histogram is shown in Table III along with a summary of personal details. The only correlation worthy of note is the two high value standard deviations for subjects F and G who both felt some stress during the study. All the other subjects experienced no stress, their standard deviations ranging from 5.215 to 11.806; whereas the standard deviation for subject F was 18.152 and for subject G, 20.620.

The standard deviation for 'all subjects' except subjects F and G is 10.188.

6.2.2 Smoothed Curves - Moving Average Heart Rate

The lines on the Main Study Subject Graphs were smoothed and plotted on Interlace Graphs to determine if there were any distinct patterns.

Two patterns were apparent:

(1) Interlace Graph A (Figure XXVI)

This pattern shows an approximate range of 35 heart beats which occurs at intermittent intervals during the working day. A comparative subject - L- is included along with main study subjects G and I.

(2) Interlace Graph B (Figure XXVII)

This pattern indicates a narrower band of about 15 heart beats for six hours of the working day. Subjects A, B, C, D, E, F, H, J, and K are included.

SUBJECT / HEART RATE	PERCENTAGE OF TOTAL READINGS											
	A	B	C	D	E	F	G	H	I	J	K	ALL SUBJECTS
51 - 60										3.3		O.30
61 - 70	1.0	3.0				1.1	2.6	5.0		19.6		2.96
71 - 80	45.1	47.3		0.7	11.4	10.7	6.1	5.4	8.6	35.6		14.47
81 - 90	39.4	39.6	10.3	35.3	73.4	3.6	16.8	61.9	38.4	26.4	23.9	33.76
91 -100	13.7	9.1	51.0	49.2	14.7	6.7	23.4	23.8	36.2	9.4	59.0	26.97
101 -110	0.8	1.0	31.7	13.4	0.5	16.8	19.3	3.5	13.7	5.0	16.3	10.91
111 -120			5.8	1.4		30.0	15.5	0.4	2.7	0.7	0.8	5.65
121 -130			0.8			20.4	5.9		0.4			2.73
131 -140			0.4			8.5	3.9					1.29
141 -150						2.2	2.2					0.47
151 -160							2.4					0.28
161 -170							1.5					0.17
171 -180							0.4					0.04
TOTALS	100	100	100	100	100	100	100	100	100	100	100	100

TABLE II Frequency of Heart Rate Groups Expressed as a Percentage for all Main Study Subjects.

RANKED S.D.	Subject	Stress Felt		AGE				SMOKING		DRINKING		SEX	
		Some	None	20/25	26/30	31/35	36/40	Heavy	Light	Heavy	Light	Male	Female
5.215	B		x			x			x		x	x	
5.282	E		x		x			x			x	x	
6.565	K		x			x		x		x		x	
7.293	D		x			x			x		x		x
7.460	A		x				x	x			x	x	
8.024	H		x		x			x			x	x	
8.105	C		x				x	x		x			x
9.418	I		x					x			x	x	
11.806	J		x			x			x		x	x	
18.152	F	x		x				x			x		x
20.620	G	x			x				x		x	x	

TABLE III Ranked S.D.'s and Personal Details Summary for Main Study Subjects

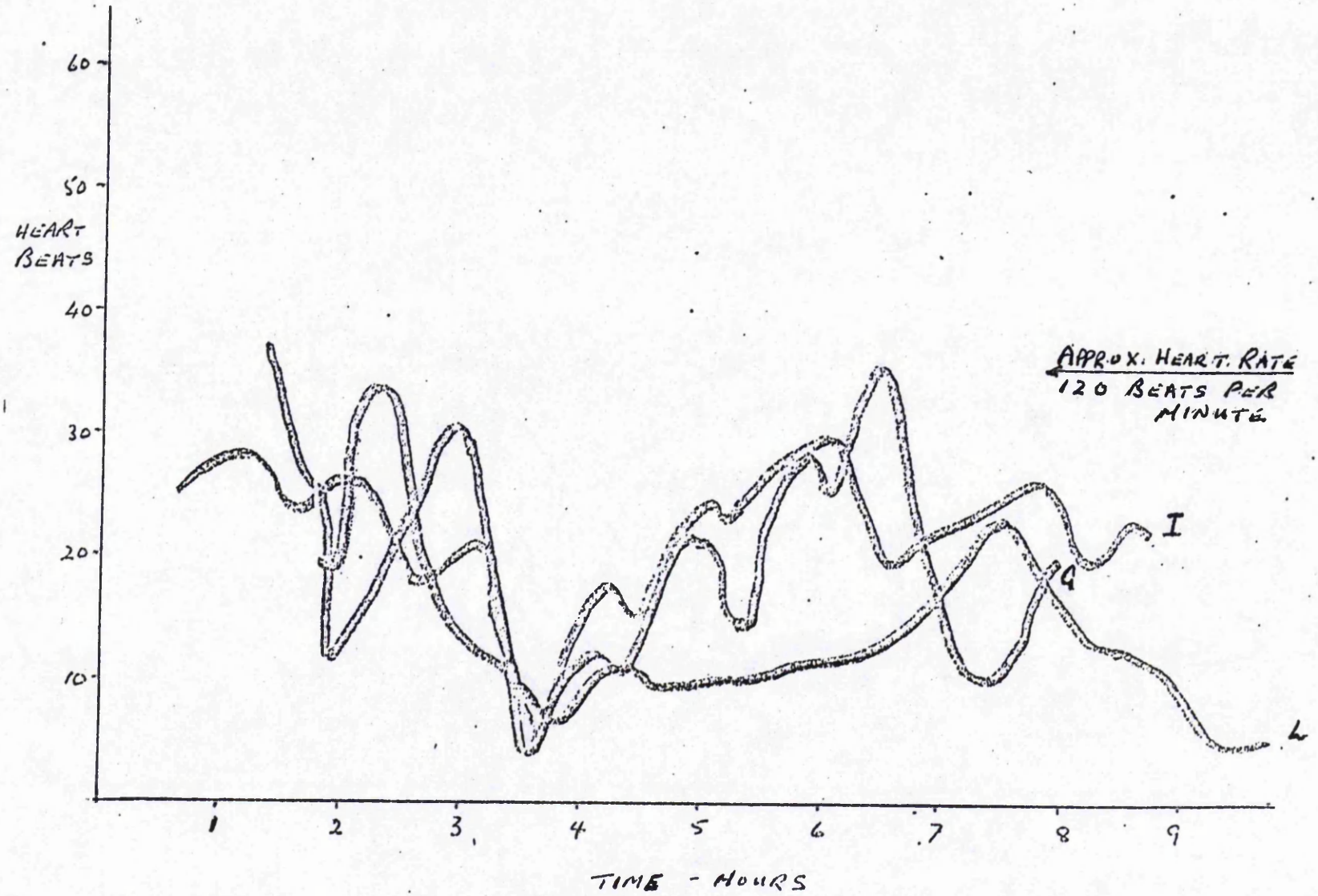


FIGURE XXVI Interlace Graph A, Subjects G, I and L

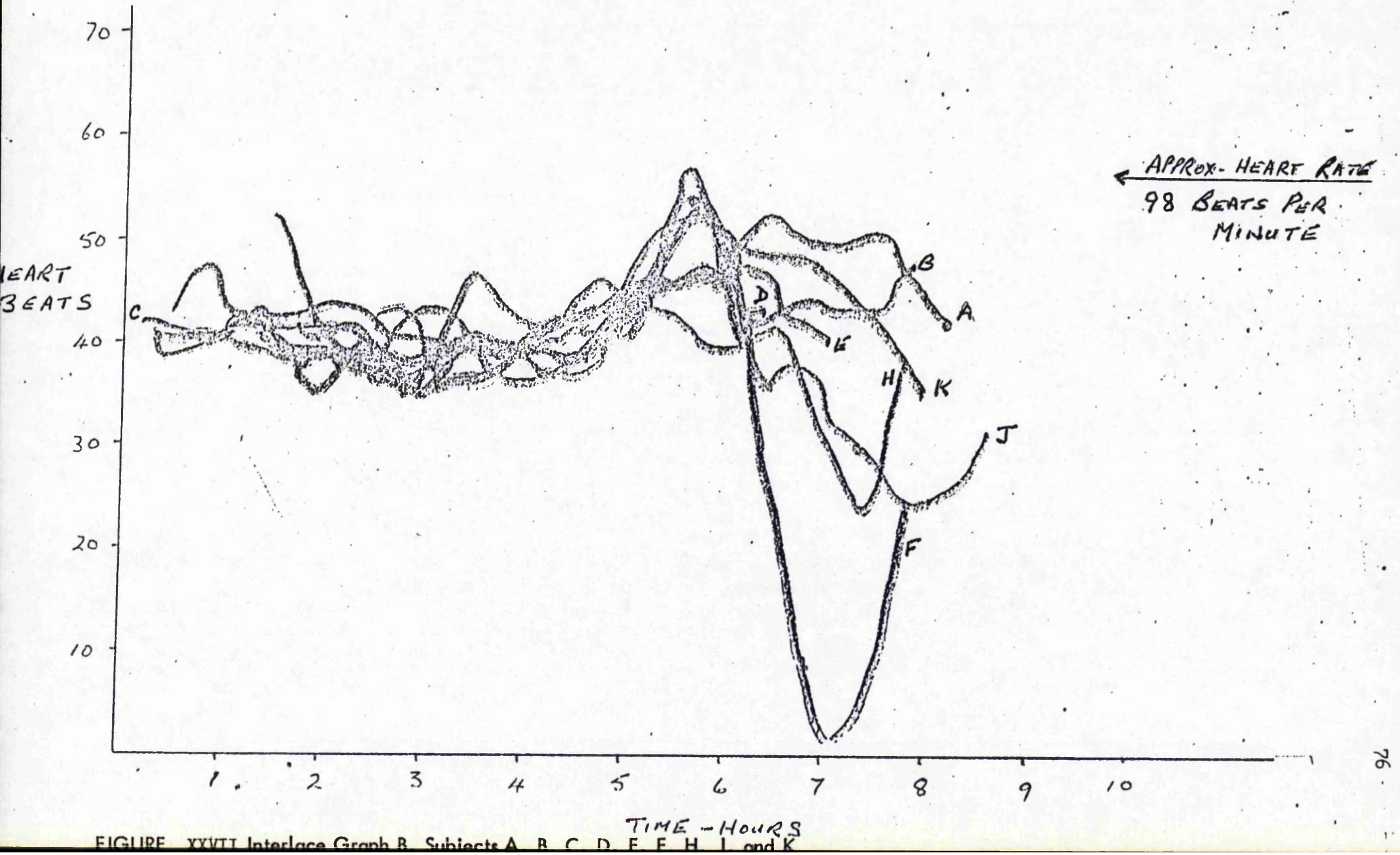


FIGURE XXVII Interlace Graph B. Subjects A, B, C, D, E, F, H, I, and K

6.3 Comparative Subjects

Three subjects were chosen from other occupations at random to provide a rough basis of comparison with the main subjects of the study. Their personal details, heart rate graphs, moving average graphs, and histograms are given in Appendix II.

Certain similarities are noticeable from the analysis and these are dicussed below.

6.3.1 Standard Deviation

The standard deviations of the comparative subjects are within the band of standard deviations for those main study subjects who felt no stress. The band ranges from 5.215 to 11.806 and for the comparative subjects from 4.538 to 11.340, they too feeling no stress. The standard deviation 10.188 representing all main study subjects feeling no stress compares with standard deviation 5.020 for the comparative subjects.

6.3.2 Histograms

A distinct similarity also exists for the heart rate group which forms the apex of the histograms. The group is 81-90 in both studies, the population represented being 33.76% for the main study and 36.84% for the comparative subjects. Table IV gives a summary of the histograms for the comparative subjects.

6.4 Public Speaking Exercise

Six subjects were chosen at random and each one lectured to a group of twenty five supervisors as a test of the effect of human presence and of mental stress.

Heart rate was recorded approximately ten minutes before the lecturette of about ten minutes duration and for ten minutes at the end of the end of lecturette.

SUBJECT / HEART RATE GROUPS	L		M		N		TOTALS	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
61 - 70	2	0.6	0	0	0	0	2	0.18
71 - 80	83	26.4	6	1.5	1	0.2	90	8.15
81 - 90	132	42.0	193	49.4	82	20.5	407	36.84
91 -100	58	18.5	132	33.9	215	53.7	405	36.65
101 -110	23	7.3	54	13.9	84	20.9	161	14.57
111 -120	11	3.6	5	1.3	14	3.5	30	2.71
121 -130	5	1.6	0	0	3	0.7	8	0.72
131 -140	0	0	0	0	2	0.5	2	0.18
TOTALS	314	100	390	100	401	100	1105	100

TABLE IV : Summary of Histograms for Comparative Subjects

Subject Z was the only experienced speaker and his maximum heart beats increase was 36 compared with the mean heart beats increase of 62.6 for the other subjects.

All subjects (except subject Z) claimed they experienced considerable mental stress, as it was their first attempt at public speaking. Their mean maximum heart rate was 138.4 b.min.

Their mental stress was experienced through feelings of "butterflies in the stomach", thumping heart beats, and flushed face symptoms. Table V indicates their main personal details and the various heart rate recordings including the means.

The rise in heart rate before the speech for all subjects, except subject Z, was a mean 16 b./min. below the mean during the speech, and for subject Z 3 b./min. below, compared with the higher drop after the speech of a mean 27 b./min. and 10 b./min. respectively.

6.5 Operational Effectiveness of the Equipment

The equipment failed to record on a number of occasions for the following reasons:

(1) A rapid deterioration of battery power during the study.

(2) A slipping belt drive on recording motor in the tape recorder.

(3) A break in the wiring of the transducer unit.

(4) The tape cassette jammed during two studies.

(5) The electrodes failed to remain completely adhered to the subject during very hot weather when temperatures were above 26°C.

(6) The press studs attached to the electrodes were easily detached during body movement.

SUBJECT	AGE	SEX	SMOKING HABITS	PHYSICAL HEALTH	EXPERIENCE IN PUB. SPEAKING	OCCUPATION	STRESS FELT
U	30	Male	Light	Fit	Nil	Supervisor	High
V	25	Male	Heavy	Fit	Nil	Supervisor	High
W	32	Male	Heavy	Fit	Nil	Supervisor	High
X	26	Male	Light	Fit	Nil	Supervisor	High
Y	28	Female	Light	Fit	Nil	Supervisor	High
Z	54	Male	Light	Fit	Experienced	Supervisor	Low

SUBJECT	REST PULSE	MEAN H.R. BEFORE SPEECH	MEAN H.R. DURING SPEECH	MEAN H.R. AFTER SPEECH	MAX. H.R. DURING SPEECH	MAX. BEATS INCREASE IN HR.
U	75	119	136	106	136	61
V	76	117	148	110	156	80
W	80	118	126	112	148	68
X	76	99	122	85	128	52
Y	72	103	104	88	124	52
Z	72	92	95	85	108	36
MEAN (EXCEPT Z)	75.8	111.2	127.2	100.2	138.4	62.6

TABLE . V Analysis of a Public Speaking Exercise

6.5.1 Remedies

The faults were overcome by adopting the following procedure:

(1) Batteries were charged after fifteen hours' usage.

(2) Checks and maintenance were carried out before each study.

(3) Extreme care was exercised when handling equipment.

(4) The tape was turned on by two revolutions to ensure freedom of movement in the cassette.

(5) Zinc oxide tape was strapped across the electrodes, press studs and wires at approximate places to reduce the risk of disconnections through perspiration and pulling movements.

6.5.2 Accuracy

Many tests were conducted during the studies and no discrepancy between the recorded and actual heart rate was discovered.

6.6 Practical Restrictions experienced during the Study

(1) Shift Work : Appointments needed checking to ensure that the arrival time coincided with commencement of the shift.

(2) Rest Periods : Some hotels allowed a two-hour rest period or stand-by duty in the afternoon to compensate for evening work.

(3) Varying Lunch Hours : Some establishments did not fix a definite lunch hour period.

(4) Study Restrictions : Managers were inclined to restrict the duration of the study because of other commitments.

(5) Co-operation : During initial negotiations with hotel managers it soon became obvious that their co-operation was only possible if they were convinced that there would be an absolute minimum of interference with their daily routine.

7. ANALYSIS OF RESULTS

7.1 Heart Rate Cycles Analysis

Only approximate measurements of the heart rate cycles in Interlace Graphs A and B are possible for the following reasons:

1) The angles subtending between troughs and peaks are difficult to measure with any degree of accuracy considering their shallowness and crude smoothing of the moving average curves.

2) The heart rate range suffers with similar problems therefore the actual minimum and maximum levels were extracted for analysis.

3) Due to the duration limitations of the studies some extrapolation was inevitable. Although it is recognised that extrapolation is generally not viable no other method was possible.

4) Because of the erratic nature of rises and falls in heart rate the trough to peak times do not necessarily coincide with half the trough to trough times. Actual times were used to avoid further extrapolation of data.

Table VI indicates for each main study subject the estimated times between troughs and troughs to peaks, the range of heart beats from troughs to peaks, and the average heart beat rise per minute which is calculated by dividing the range of heart beats by the estimated time between trough and peak. Also shown are the heart rate recordings divided into columns of minimum, maximum, and the range in b.min; and the heart rate moving average curve divided into columns for minimum, maximum, and range in b.min.

7.2 Analysis of Activities

SUBJECT	Estimated Time Between Troughs Hours : minutes	Estimated Time Between Trough and Peak Hours : minutes	Range of Heart Beats - Trough to Peak (Smoothed Curve)	Average Heart Beat Rise per minute	Heart Rate Recordings			Heart Rate - Moving Average Curve		
					min.	max.	Range	Min.	Max.	Range
A	4 : 30	2 : 10	18	0.138	68	105	37	74.8	93.6	18.8
B	4 : 20	2 : 10	16	0.123	68	106	38	76.0	91.4	15.4
C	4 : 50	2 : 30	11	0.073	86	136	50	88.6	00.0	11.4
D	4 : 40	2 : 20	17	0.121	82	114	32	88.6	05.4	16.8
E	4 : 40	2 : 20	10	0.071	72	104	32	83.6	94.0	10.4
F	6 : 00	3 : 00	50	.277	70	158	88	83.0	33.4	53.4
G	5 : 00	2 : 40	33	0.206	64	180	116	86.6	20.2	33.6
H	3 : 20	1 : 50	25	.227	68	120	52	69.3	94.5	25.2
I	4 : 30	2 : 40	27	0.168	70	130	60	72.8	00.8	28
J	4 : 50	2 : 40	33	0.206	58	112	54	63.7	97.6	33.9
K	4 : 10	2 : 25	12	0.082	82	108	26	88.8	01.4	12.6
TOTALS	50 : 50	26 : 45	252	1.692	788	1373	-	-	-	-
Mean - All Subjects	4 : 37	2 : 26	22.909	0.156	71.636	124.818	-	-	-	-

TABLE VI. : Analysis of Smoothed Curves from Moving Average Graphs

A summary of the activities shown in Table VII was used to determine the stress gradient by allocating a rank for each activity and positioning it in the range to allow for the total number of mean readings against the maximum number of mean readings. Thus the formula is:

$$\text{Total Ranking} \times \frac{\text{Maximum number of mean readings}}{\text{Total number of mean readings}}$$

An example is given below:

Activity 4 (5 readings out of a maximum 11)

1 reading at 1st place (min.)	= 11
1 reading at 5th place	= 5
2 readings at 7th place	= 14
1 reading at 10th place	= 10
	30

$$\text{Points} = 30 \times \frac{11}{5} = 66.00$$

The majority of heart rate recordings were highly significant. Those which were not significant (7 - H.R. and 5 Perturbations) are omitted from the calculations and indicated in Table VII by a star against the figure. The ranking is now given for heart rate/rest pulse analysis.

Points	Code	Activity
23.10 (min.)	14	Meals and breaks
24.44	12	Administrative duties
38.50	4	Meetings with a Group
55.00	5	Speaking with peers
60.50	6	Speaking with subordinates
66.00	1	Outgoing telephone calls
66.00	3	Personal telephone calls
66.00	15	Driving
80.00	2	Incoming telephone calls
82.00	8	Speaking with clients
99.00	11	Dealing with domestic emergencies
110.00	10	Reprimanding a subordinate
114.89	9	Dealing with complaints
123.75	7	Speaking with superior
136.00 (max.)	13	Dealing with cash

SUBJECT	MEAN HEART RATE			ACTIVITY GRADIENT - HEART RATE/REST PULSE														
	MIN.	MAX.	RANGE	Minimum rising to maximum (left to right)														
A	80.08	95.33	15.25	12*	14	9	6	5	1*	8	7	2	10	13				
B	79.74	95.60	15.86	12	3	14	2	1	5	9	11	8	6	7	13	10		
C	95.56	109.67	14.11	12	4	6	5	2	14	11	8	3	1	10	13	7		
D	90.55	99.48	8.93	14	12	3	5	11	1	4	2	6	10	13	9	7	8	
E	84.65	93.83	9.18	12	14	8	6	5	1	13	2	11	10	9				
F	106.95	137.00	30.05	6	3	14	12	1	2	11	7	8	13	10	9			
G	91.05	128.86	37.81	14	12	3	4	1	6	13	2	10	8	11	9			
H	83.87	98.33	14.46	14	15	12	8	5	1	6	2	3	13	7	10	11		
I	84.86	105.24	20.38	14	10	6	2	8	5	1	4	2	11	15	13	9	7	
J	71.00	99.80	28.80	1*	5*	12*	14*	6*	15	4	3	2	8	10	7	11	9	13
K	91.80	104.00	12.20	14	12	8	1	15	2	11	6	13	9	10	3			

SUBJECT	MEAN HEART BEATS			ACTIVITY GRADIENT - PERTURBATIONS														
	MIN.	MAX.	RANGE	Minimum rising to maximum (left to right)														
A	4.88	15.83	10.95	12	14	6	10	1	8	5	9	2	7	13				
B	4.78	21.50	16.72	14	12	9	3	2	1	8	10*	6	11	7	5	13		
C	8.22	21.67	13.45	4	12	6	5	2	14	11	8	3	10	1	13	7		
D	4.96	16.36	11.40	14	12	5	3	1	11	6	2	10	4	13	9	8	7	
E	5.83	15.08	9.25	14	12	5	6	11*	8	13	1	2	10	9				
F	17.30	45.33	28.03	14	12	6	3	11	1	7	2	9*	13	10	8			
G	13.62	44.12	30.50	14	3	12	6	4	13	10	2	1	8	9	11			
H	1.93	15.14	13.21	15	14	5	8	7	12	3*	1	6	13	2	11	10		
I	8.68	26.28	17.60	12	14	6	10*	8	5	4	1	15	2	11	13	7	9	
J	5.50	23.43	17.93	14	15	6	12	5	1	4	8	3	10	2	13	7	9	11
K	6.41	13.33	6.92	14	12	13	6	1	8	9	15	10	3	2	11			

TABLE VII: Activity Gradients (* = N/S)

A similar exercise was conducted for perturbations and the results are shown below:

Points	Code	Activity
19.00	14	Meals and breaks
27.00	12	Administrative duties
52.00	6	Speaking with subordinates
55.00	15	Driving
59.13	5	Speaking with peers
66.00	3	Personal telephone calls
66.00	4	Meetings with a group
77.00	1	Outgoing telephone calls
85.00	8	Speaking with clients
95.00	2	Incoming telephone calls
101.44	10	Reprimanding a subordinate
107.00	13	Dealing with cash
110.00	9	Dealing with complaints
110.00	11	Dealing with domestic emergencies
118.25	7	Speaking with a superior

7.3 Stress Gradients

A stress gradient based on the minimum and maximum points is given in Figure XXVIII. The angle for the heart rate/rest pulse gradient is 18° from the horizontal, and for the perturbations 16°.

Further analysis of the gradients is given in Figure XXIX. The base gradient is plotted from heart rate/rest pulse readings for each code on the points system. The perturbations are superimposed to illustrate the variation in the two methods.

7.4 Comparison of Mental Work with Physical Work

An analysis of mental work compared with physical work was undertaken and the results are plotted in Figure XXX.

The groups of activities are plotted according to the ranges quoted by various investigators:

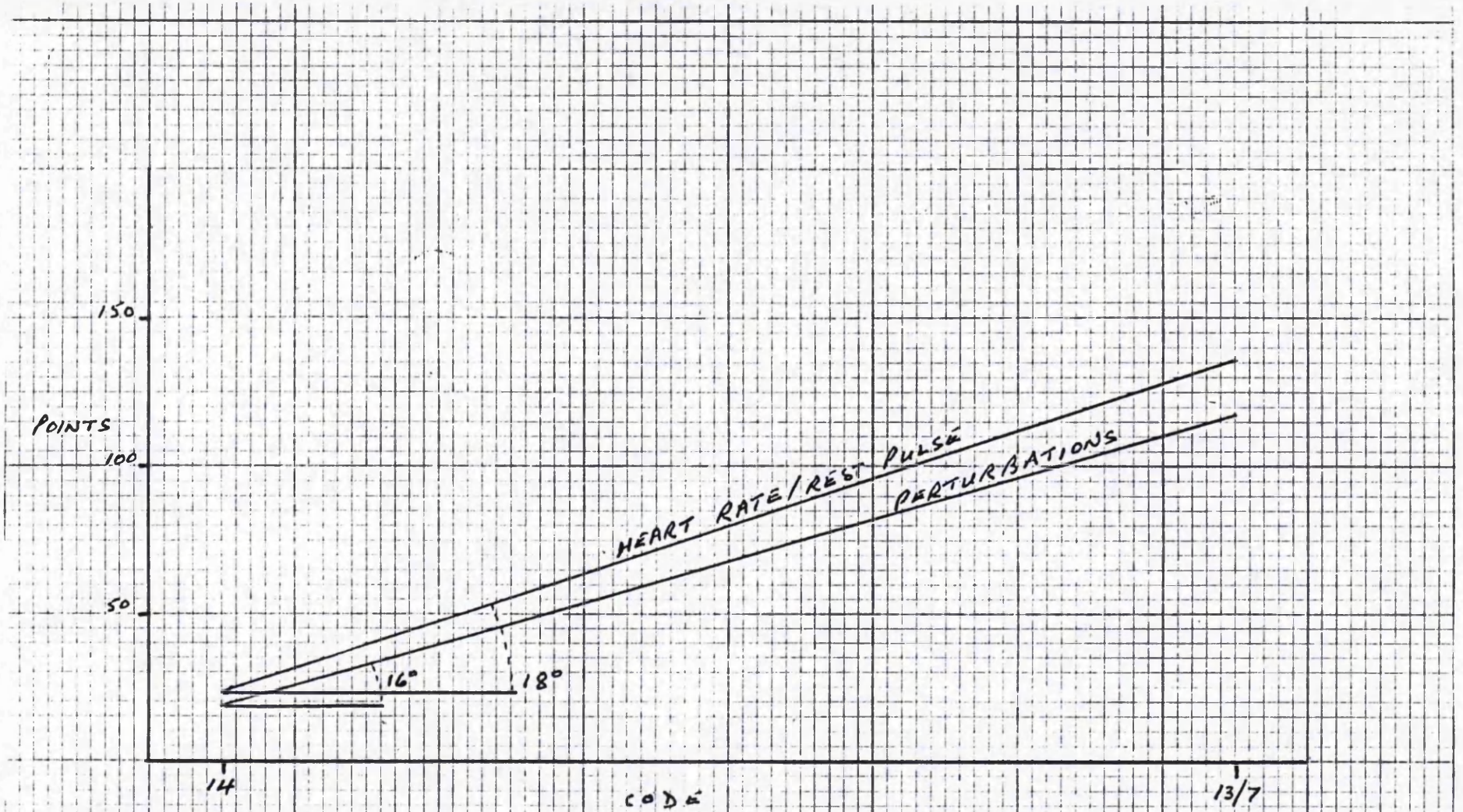


FIGURE XXVIII STRESS GRADIENTS – BASED ON MIN.-MAX. POINTS ANALYSIS.

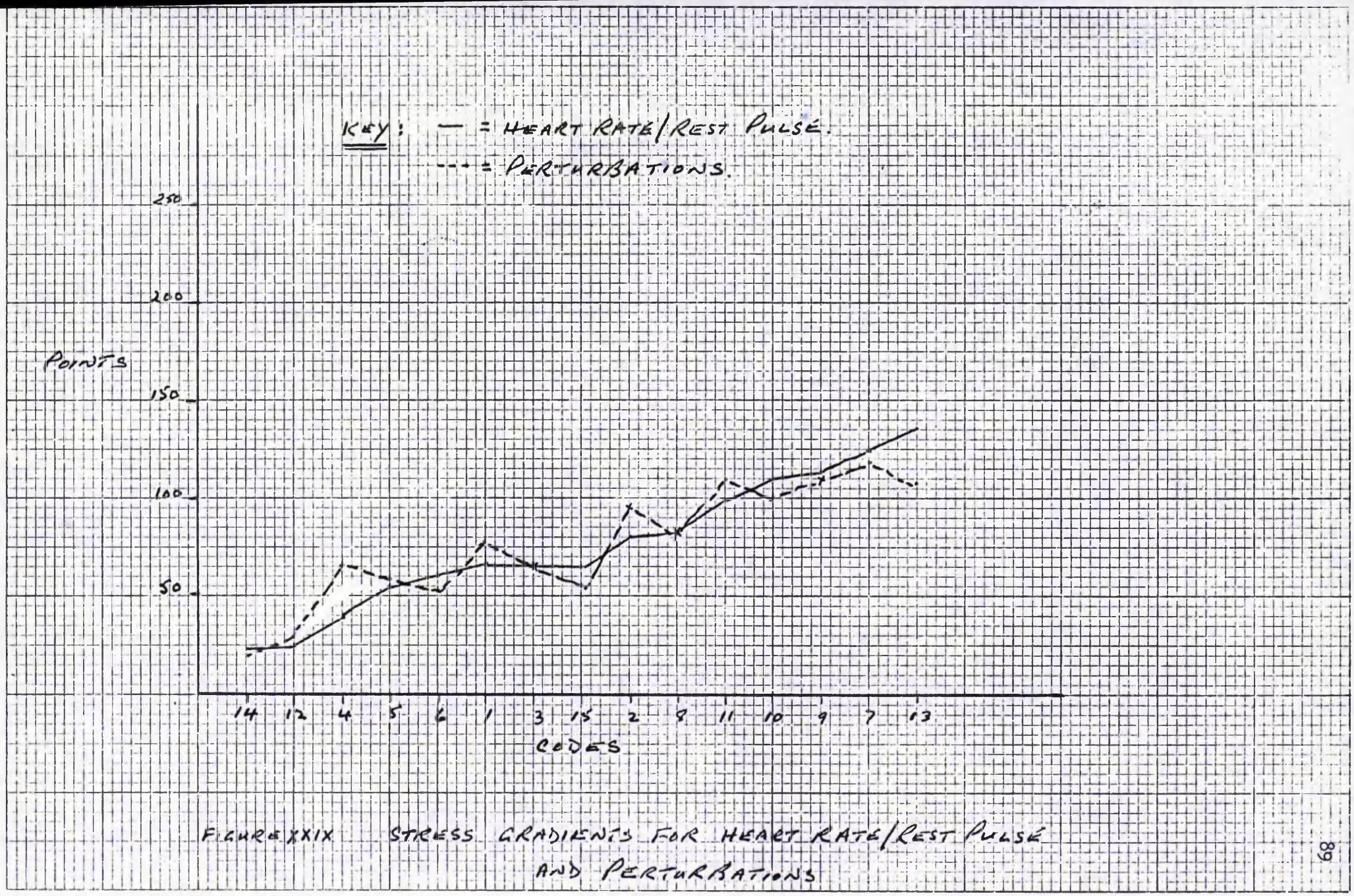


FIGURE XXIX STRESS GRADIENTS FOR HEART RATE/REST PULSE AND PERTURBATIONS

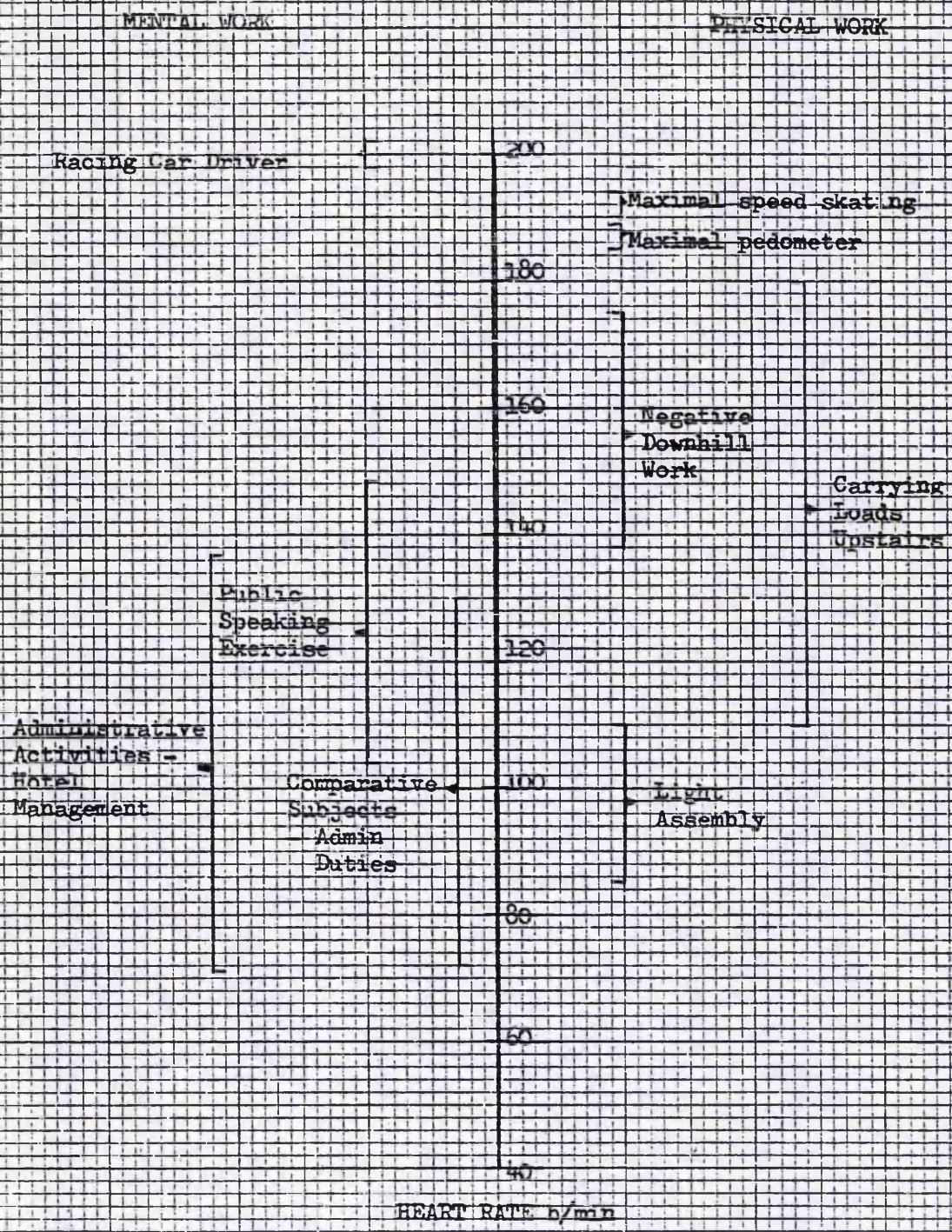


FIGURE XXX Comparison of Mental Work with Physical Work

Racing Car Driver	: Carruthers (1974)
Maximal Speed Skating	: Maksud et al (1970)
Maximal Pedometer	: Cotes (1969)
Negative Downhill Work	: Davies and Barnes (1972)
Carrying loads upstairs	: Datta and Ramanathan (1969)
Light Assembly	: Poulsen and Asmussen (1962)

8. DISCUSSION OF RESULTS

8.1 Histogram Analysis

The average mental stress seems to be inexcessive compared with the public speaking exercise and with other investigators' results. Assuming a rest pulse of 65 b.min the calculation by Singleton (1972) in Chapter 3 would imply that H.R. should not rise to more than 105 b.min and the calculation by Müller (1961) in Chapter 3 would be 100 b.min as an average pulse rate during work.

In the public speaking exercise the mean maximum rate was 138.4 b.min and during the speech the mean was 127.2 b.min.

The use of H.R. as a predictor seems to be valid although as Chaponis (1969) in Chapter 3 mentions, great care is needed in selecting dependent measures, and that negative results help considerably in later research.

Considering the upper limits of the histogram, the majority of the readings above 111 b.min are contributable to subjects F and G who both felt some stress during the study. A significant figure of 26.97% for the class interval 91-100 b.min could be included in the concentration calculation which would mean that 61.73% of the distribution is within a class interval of 81-100 b.min. This concentration is still inexcessive according to other investigators and approximately coincides with Schacke et al (1972) in Chapter 1 who recorded a concentration of 80-90 b.min for 27 leading executives and a variation of 60-130 b.min. His findings for managers under 50 years old averaged 90-100 b.min for 75% of the working day.

A further comparison shows a close similarity to energy expenditure findings given in Chapter 3 by Singleton (1972) for clerical (administrative) work and driving, based upon a straight line correlation conversion from Kcals to H.R. The range for clerical work is 76-90.5 b.min and for driving 90.6-105.1 b.min compared with the study findings: average 90.08 and 90.4 b.min respectively.

8.2 Analysis of Activities

A subjective assessment of the ranking for the activities recorded conforms to the perturbations gradient for the five codes: 10, 13, 9, 11, and 7. This judgement is based upon observations during the study, thus it would seem that the use of perturbations using a moving pulse rate base line is more accurate than heart rate/rest pulse analysis.

Below the top five code levels it was not possible to estimate the ranking order. The relatively low position of code number 4 - meetings with a group - is probably due to the minor importance of the meetings recorded.

There is a negligible difference in the angles of the stress gradients (16° and 18°).

8.3 Smoothed Curves - Moving average Heart Rate

The tendency for heart rate to decline towards the end of the working day could be because there is correlation between the breadth of the band of heart beats and the duration of higher mental activity. This assumption is supported by comparing the approximate heart rates shown on both graphs.

A heart rate rhythm is noticeable which persists regardless of the heart rate level within the range studied. The rhythm or cycle is inconsistent. The time between the troughs of the cycles varies from 4:20 hours to 6:0 hours, the mean value being 4:37 hours. The trough to peak times are erratic.

This phenomenon coincides with the findings in Chapter 2 of Murrell (1962) who uses the term "actile period" to describe the breaks from activity. These pauses sometimes are simply changes in activity, Miles and Skilbeck (1923).

Probably arousal also has an effect on this rhythm, Duffy (1957); the experiment on rats by Belanger and Feldman (1962) indicates that

internal determinants and external cues affect heart rate. Circadian rhythms, Kleitman (1963), and possibly biorhythms also contribute towards producing a heart rate cycle.

Another aspect of the smoothed curves analysis is the comparatively low mean heart beat rise, varying from 0.071 to 0.277 per minute and for all subjects, averaging 0.156. The upper limit of 0.277 for subject F is probably because her normal job, administration manager, was absorbed into her temporary post of general manager. She was not very experienced and felt some stress.

The small rise per minute is indicative of comparatively low stress during the study. The erratic nature of the smoothed curves in the sample is considered to be due to the effects of self-induced and externally induced activities, the latter being outside the control of the subject. Thus it may be assumed that the normal path of the cycle is not observable in the operational situation as it would be most unlikely that externally induced activities would not occur during the working day.

Finally the initial slowing from orientation reaction see chapter 2, Lynn (1966), was not indicated as at least twenty minutes passed before the electrodes were fixed. Interlace graph B, however, indicates comparatively high heart rates at the beginning which deteriorate later; this effect coincides with orientation reaction.

8.4 The Resting Pulse

It seems likely that a resting pulse is essentially a relative rate and is significant only within the time it is recorded. The resting pulse varies during the day, presumably in accordance with the diurnal cycle or circadian rhythm and in sympathy with the mental load applied at the time. An assessment of the degree of mental load affecting the so-called resting pulse is not possible as it is probably applying a load not only consciously but also sub-consciously and unconsciously.

The resting pulse also varies during sleep as presumably dreams

occur therefore the validity of using it as a base line for calculating the degree of stress is questionable. As no other base is available there is no choice, but thinking in terms of total load or total overbeats it means that the calculations are often minimal rather than maximal. It is apparent that often some mental load will be operating at any time the resting pulse is recorded.

The calculation of a resting pulse curve for correction purposes also presents serious statistical difficulties. It could be argued that the line should conform to the lowest readings throughout the period rather than conforming to a line of best fit as there is no justification for applying a smaller correction because the line happens to be above a rest pulse in terms of best fit only. On the other hand it is likely that some rest pulses will be excessively higher therefore a statistical compromise is probably acceptable and the curve of best fit was chosen in these circumstances.

8.5 The Mental Work/Rest Cycle

The true duration of this cycle is difficult to conceive in terms of time devoted to work and to rest. The time devoted to mental work is immediately apparent by observation and assessment of work load, but the true mental work load is obscure because it is doubtful whether it can be switched off immediately and in addition there is often apprehension or anxiety before mental work recommences. Therefore some allowance is necessary at both ends of the rest period.

A research case which highlights this effect is one associated with the "executive" monkey undertaken by Brady (1971). This research was described in Chapter 1 and briefly the "executive" monkey died after 23 days of continuous 6 hours' mental work and 6 hours' rest periods in sequence. The autopsy showed a large perforation in the wall of the duodenum which is a common site for ulcers in man.

An important point not mentioned in this case is that the rest period which coincided with the mental work period would, in all probability, contain periods of apprehension and anticipation at the thought of undergoing a further period of 6 hours' mental work of a very

stressful nature. Therefore the true ratio of the work/rest cycle which apparently caused death is not known.

In the heart rate moving average graphs of the main study subjects in hotel management it is noticeable that they all indicate a higher heart rate level at the start of the working day and a similar effect also can be seen for the comparative subjects. Thus it could be argued that anticipation or apprehension had built up the heart rate before commencement of duties therefore mental stress was occurring at that time.

The need to avoid a mental work/rest cycle which induces death as illustrated by the "executive" monkey is fundamental. As such practical research on people is obviously not possible, the lethal cycle is difficult to estimate but at least it may be thought very desirable to avoid routine work/rest cycles as much as possible and so minimise the possible coincidence with a lethal wave pattern.

8.6 Recognising Stressful Situations

With practice it may be possible for a manager to recognise the onset of mental stress symptoms. Judging from the interviews some of the symptoms are described below.

1) A feeling of tension building up inside the lower part of the body in the region of the stomach.

2) Sudden awareness of a thumping heart.

3) An odd feeling in the stomach which is difficult to describe.

4) A feeling of excitment.

5) Feelings of anger or frustration.

6) Wanting to reprimand but knowing it is imprudent.

7) Wanting to retreat from a situation.

8) Feeling depressed and unable to cope effectively.

9) Antagonistic feelings towards peers and superiors.

10) Feeling confused and unable to put a situation into perspective.

11) Feeling that there is a lack of achievement as the working day progresses.

12) Feeling impatient with people and trying to accelerate the working rate.

13) Feeling irritated unduly with minor details.

14) Endeavouring to do two things simultaneously.

Unfortunately many of these symptoms are not recognised as stressful but are just accepted as irritations associated with the normal working day.

8.6.1 The Range of Symptoms

Probably each individual feels a different symptom or group of symptoms which indicates mental stress. Every symptom may depend upon the pecularities of the person based upon a variety of factors associated with his background, thus it becomes very difficult to assess.

Nevertheless when an individual is questioned about stress it seems that the symptoms are recognisable and accepted although there is a wide variation. In this connection the following section on human presence is very relevant.

8.6.2 The Effect of Human Presence

Although there may not necessarily be any physical change measurable by heart rate it is probable that a number of chemical changes and electro-magnetic changes occur in the body when it is subjected to the presence of other people in certain situations.

Typical examples are:

1) An increase in emotional feelings if the person contacting another is disliked.

2) An increased tendency to make mistakes when a superior is present.

3) Feelings of nervousness, blushing, and other responses when confronted with a large group or with persons associated with emotional involvement.

4) Embarrassment by an athlete if he does not win.

5) Anxiety before an event such as a race or on stage.

These emotional stresses also may affect performance in the majority of cases. For example, often people may remark after a meeting that they did not think of the answer or opposing view during the meeting presumably because of the tension involved at the time. However, brain storming when people are in harmony with each other can be very successful.

The presence of people can be upsetting therefore the exercise of some skills such as decision making and problem solving could be improved in isolation if stress is felt, and then presented for further discussion and approval.

In hotel management an essential part of the job often includes direct contact with clients and staff. Such contact cannot and obviously should not be avoided but it may help to improve performance and avoid harmful stress if decisions requiring some thought are made after contact rather than at the time.

8.7 Avoiding Excessive Mental Stress

There appears to be a strong, natural tendency within people to arrange work loads in a fluctuating cycle of activity intensity.

This natural work load variation presumably conforms in principle to rise and fall patterns of intensity noticeable in other body systems. However, the sequence of wave form varies - according to the research findings.

Certain working arrangements could be programmed to encourage the operation of natural work load wave forms. Typical programmes would include a new concept of rest periods, new working patterns, increased control of self-induced activities, and carefully balancing the effects of externally induced activities.

Presumably a fully developed work load wave form of this nature would minimise the risk of overloading the body system thus avoiding pathological disturbances, see CH I, World Health Organisation (1976). This natural work cycle tendency is generally indicated to the individual in various ways. Examples are: the urge to stop work, thirst, hunger, distractions in the fringe areas of concentration, loss of concentration, a sudden increase in mistakes, speech errors, illogical thought, and an urge to move away from the work area.

In nature the tendency for animals is to hunt or eat food when hungry, sleep when tired, and exercise when inclined; thus no routine in terms of a strict time schedule is in operation. In civilised communities, however, a strong routine or rigid programme often applies which is outside the control of the individual. Only the fortunate few are able to regulate their own work load and life style.

8.8 Stress Factor Rating Scale

The varying rates of resting pulse make comparisons between subjects more difficult. The use of a stress factor rating scale would indicate a closer comparison between subjects as an allowance may be calculated easily for varying mean resting pulses and for determining a corrected stress factor.

A typical example of scale design is given in Figure XXXI and one simple method of calculating the stress factor is given in the two examples below:

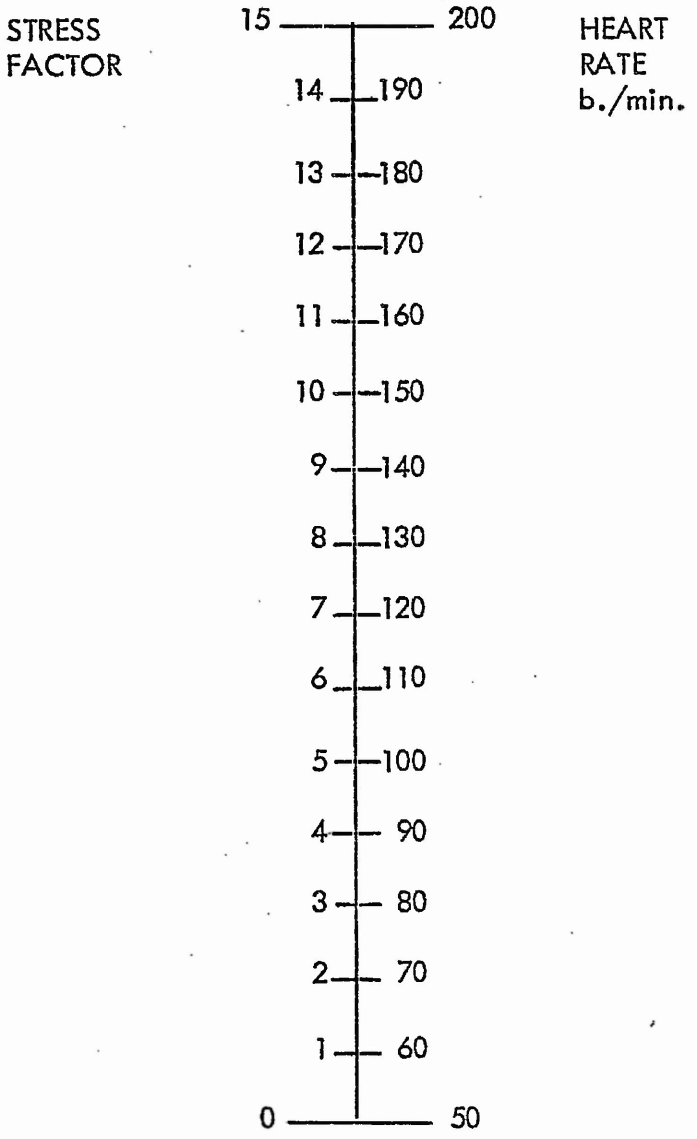


FIGURE XXXI Stress Factor Rating Scale

Example: Subject X

Peak heart rate group = 131 - 140 b./min. = S.F. 8
Mean resting pulse = 68 b./min. = S.F.-1
Corrected Stress factor = 7

Example: Subject Y

Peak heart rate group = 141 - 150 b./min. = S.F. 9
Mean resting pulse = 78 b./min. = S.F.-2
Corrected stress factor = 7

8.9 Separating Physical Movements

Careful recording of physical movements was needed to separate mental work only. Although mental work was naturally often continuing during physical movement it was decided to omit heart rate completely during those periods as no accurate method of separating the two was thought to be feasible in the circumstances, see Chapter 1, Schacke (1976).

8.9.1 Physical Movement Separation Device

Towards the end of the studies it was decided to construct a device which would automatically cut out recordings on tape during any physical movement.

A sensitive vibration detector was built along similar lines to the car thief alarm equipment which is marketed by several manufacturers. A one day study with the equipment indicated that separation is possible and FiguresXXXII and XXXIII illustrate the results.

The subject complained that the device was too bulky. A very small model was designed on the pendulum principle which can be easily strapped to the lower thigh. The dimensions are 4½ cms. x 7½ cms. x 2 cms. and FigureXXXIV illustrates the device in the closed and open

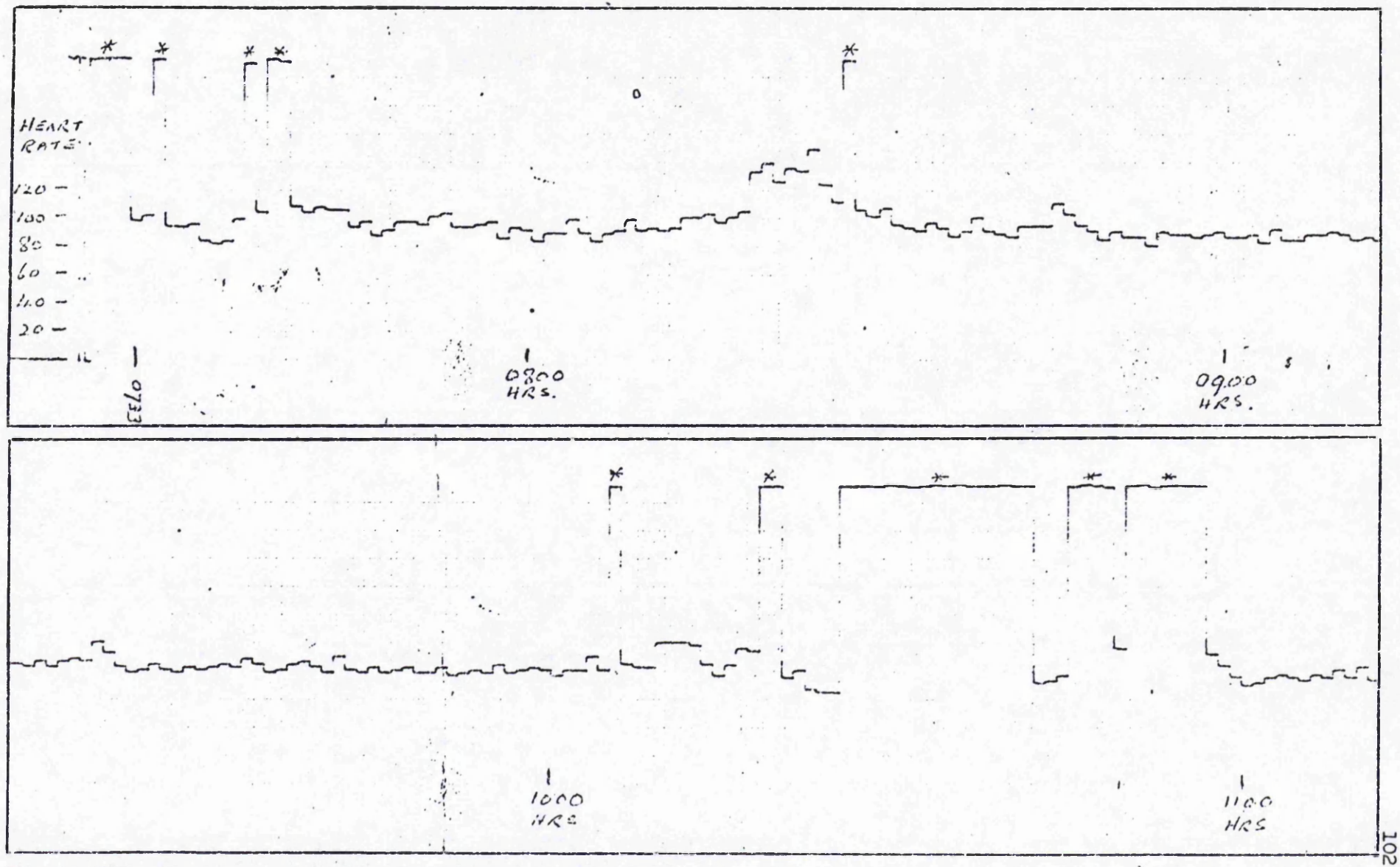


Figure XXXII : A graph recording of subject x during an experimental study of heart rate using a physical movement separation device (* indicates physical movements)

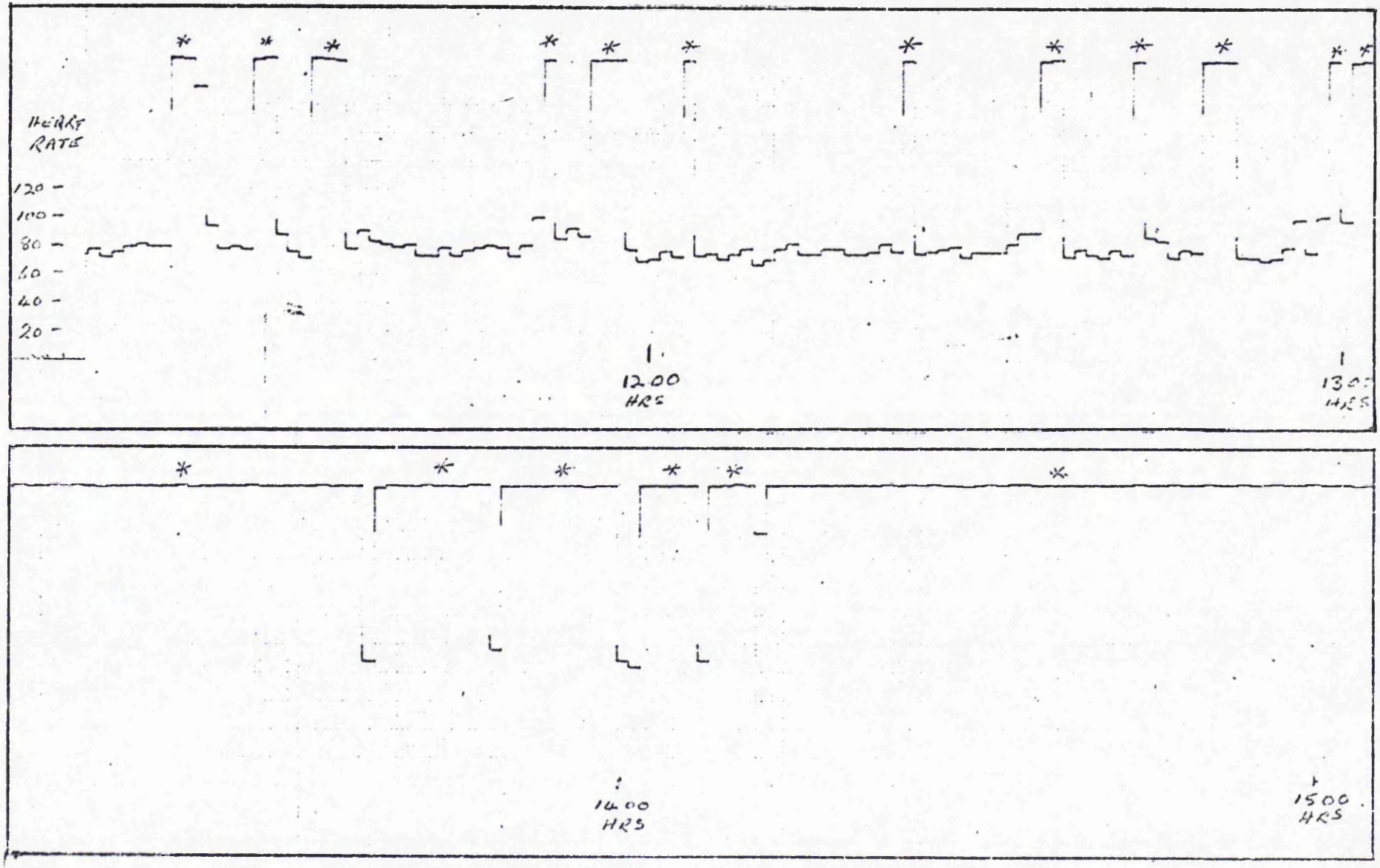
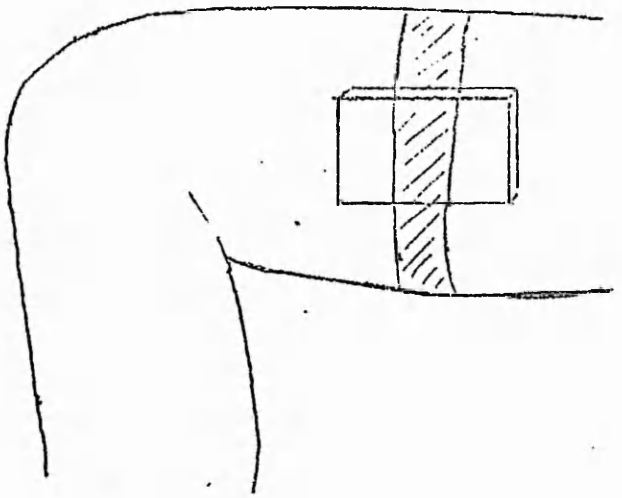
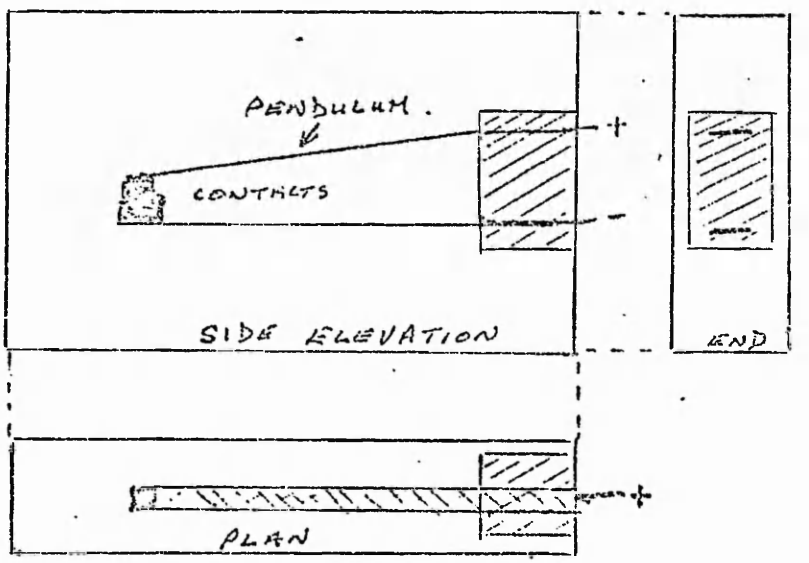


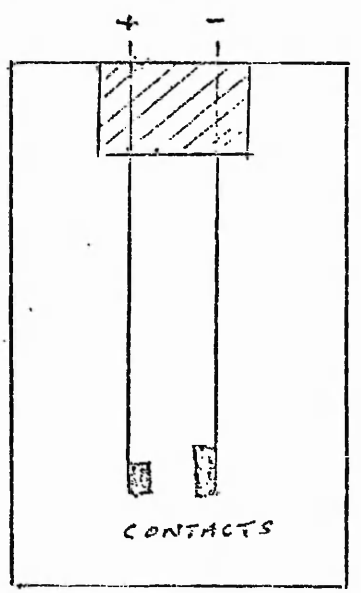
Figure XXXIII Continuation of graph recording from Figure XXXII



Location of device on thigh



Closed position - seated



Open position - standing or moving

Figure XXXIV Physical Movement Separation Device

positions along with its location on the thigh.

This device may be useful to a future researcher for analysis purposes.

8.10 Stress Reducing Programmes

During the interviews it was apparent that managers could be suffering from mental stress without realising it.

One of the factors mentioned by Levine (1971) in Chapter 1, which could alleviate mental stress is education and training schemes specifically designed for this purpose.

Overall concepts of management development programmes tend to be based upon improving managerial efficiency and effectiveness by technical and behavioural means. Whether undue emphasis on certain aspects of these means is self-defeating becomes a debatable point if the effect is to produce a manager who does not realise when he is over-stressed. So often a manager will take action which causes reaction from staff who in turn cause a reaction from the manager. Thus, self-induced stress of a recurring and continuous nature is often not recognised by him and his performance suffers.

To avoid such imbalance it is essential that programmes should be built into schemes so that the manager is capable of realising why and when he is under stress, who causes it, where it occurs, and what he can do about it. In this way he should be able to optimise his effect on the concern over a much longer period.

Certain fundamental questions need to be answered before a concise programme could be arranged.

1) Should each programme be tailored to the individual manager's requirements?

2) How is the possibility of inducing a degree of neurosis in the manager to be avoided?

3) Is sufficient knowledge of stress available for this purpose at present?

4) Who should decide to submit the manager to such a programme?

The importance of these questions is more acceptable perhaps when the various aspects associated with imbalance are outlined. For example, the manager needs to understand why the stress occurs; this involves self-analysis of a high order. He needs to recognise who causes the stress, such as senior executives, peers, subordinates, clients, Government Officials, Local Authorities, and others. He may wonder whether he suffers more or less than other managers which raises such questions as his suitability for the job and the effectiveness of selection procedures. There may be drastic effects when he examines all the areas where stress may occur such as in the office, at home, when travelling, in clubs, with friends, and with relatives.

8.10.1 The Main Topics

Finally there is the programme content to consider. From previous discussion it seems that the important topics which should be related to stress reduction are as follows:

1) Behavioural sciences
2) Communication
3) Life style
4) Organisation
5) Self-analysis
6) Routines and scheduling
7) Managerial skills
8) Ergonomic Disciplines
9) Personnel Policy

A list of typical questions on stress which are associated with the above topics is given below.

1) Behavioural Sciences

Why do people behave in certain ways?
How does a manager develop high sensitivity towards his staff and others?
How can the manager reduce any apprehension or hostility towards himself and work?
What can he do to reduce stress among his staff?
How can he gain a high degree of confidence from his staff?
What are the effects of interaction with staff and clients?
Are stress symptoms recognised by managers?

2) Communication

How can communication be used to improve relationships which, if neglected, could cause stress?
What can be done to avoid communication problems which induce stress?
How can a managerial policy of stress reduction leading to higher effectiveness be successfully transmitted to staff?
How can modern information technology be used to maximise efficiency and thus reduce stress?
How can misconceptions of injustice be avoided?

3) Life Style

Which life style minimises stress?
How can life style be changed if it does not coincide with minimising stress?
How can life style be recognised?
Is it possible to encourage less agitation and a more relaxed attitude?

4) Organisation

Which type of organisation is most suitable for minimum stress effect?
How can the organisation be arranged to ensure undue stress does not occur?
How can administrative expertise be achieved by managers so that systems and procedures are efficient, thus reducing stress among staff?

5) Self-Analysis

How much training is required for a manager to successfully carry out self-analysis?
What are the risks involved in self-analysis?
Who will be able to check the accuracy of self-analysis?
How can the manager assess his effect on staff?
Does the manager expect to see everyone very busy or does he equate a quiet atmosphere with efficiency?

6) Routines and Scheduling

How can work loads be measured in terms of stress?
Which work/rest cycle should be chosen?
How should the various durations associated with working hours, rest periods, and so on, be chosen?
What degree of flexibility is possible for staff?
What new working patterns can be introduced?

7) Managerial Skills

How are managerial skills learned and developed with a bias towards stress problems?
What training in managerial skills is needed to translate incoming information into more effective administrative activities?
Is there a skills technique which effectively reduces stress?

8) Ergonomic Disciplines

What can be done to improve the knowledge of ergonomics within the concern?
How can ergonomics be applied in hotels?
Where are the main areas in the establishment that will benefit by the application of ergonomics?

9) Personnel Policy

What changes are needed to ensure that staff develop high effectiveness which leads to less stress on themselves and on the managers?
Are the salaries adequate?

Are the personnel procedures working properly?
Is the personnel policy sincerely applied?

These questions are indicative of the essential broad approach to administrative expertise in hotel management, the aims being to introduce a stress reducing philosophy which should lead to a much better atmosphere and increased effectiveness in the hotel.

9. CONCLUSIONS

9.1 Histograms

The degree of mental stress in the working day is comparatively low and within accepted limits based upon heart rate as a dependent variable and published relevant studies.

With the ommission of subject G who felt stress and was very nervous the frequency curve is symmetrical. Skewness towards the upper limits exist if subject G is included.

9.2 Personal Details Summary

No correlation occurs between standard deviation and the independent variables of age, sex, drinking, or smoking.

Where the subject thought he was suffering stress, however, there is correlation as signified by subjects F and G only.

9.3 Analysis of Activities

A stress gradient may be determined by utilising either heart rate/rest pulse analysis or perturbations. There is only a small difference in the gradient angle, namely 18° and 16° (from horizontal) respectively when employing the points formula described in the analysis.

Although a subjective analysis of the rank for each activity indicates that the perturbation gradient is more accurate in determining the ranking, the data were insufficient to prove this conclusively.

9.4 Smoothed Curves

A heart rate cycle is evident which persists regardless of the heart rate level within the range studied.

There is no consistent period of time between the troughs of the cycles, the value varying from four hours twenty minutes to six hours.

The heart rate cycle seems to be erratic as verified by the fluctuating trough to peak cycle times.

The heart rate cycle range is reduced from about 35 beats at 120 b. min to about 15 beats at 98 b. min during the working day therefore within the heart beat range quoted the cycle range decreases as heart beat, falls.

9.5 Comparative Subjects

The results of standard deviation and histogram analysis for the comparative subjects coincide with those for the main study subjects.

Although the sample of three activities is small which includes a day nursery matron, a chartered secretary, and an office supervisor on a course, and data are insufficient to prove conclusively, there is an indication that similar results will be obtainable by using heart rate as a dependent variable in attempting to determine mental stress in occupations of this nature.

9.6 Stress Factor Rating Scale

A closer comparison between subjects' heart rate variances is possible by applying an allowance to determine a corrected stress factor based upon the mean resting pulse. This method is described in Chapter 8, Discussion of results.

APPENDIX I

Analysis of Main Study Subjects: A, B, C, D, E, F, G, H, I, J, and K

Analysis sequence for each subject:

1) Personal details
2) Heart rate graphs
3) Resting Pulse Curve of best fit
4) Moving average graph
5) Histogram
6) Activity analysis table

Abbreviations : HS = highly significant
S = significant
NS = not significant

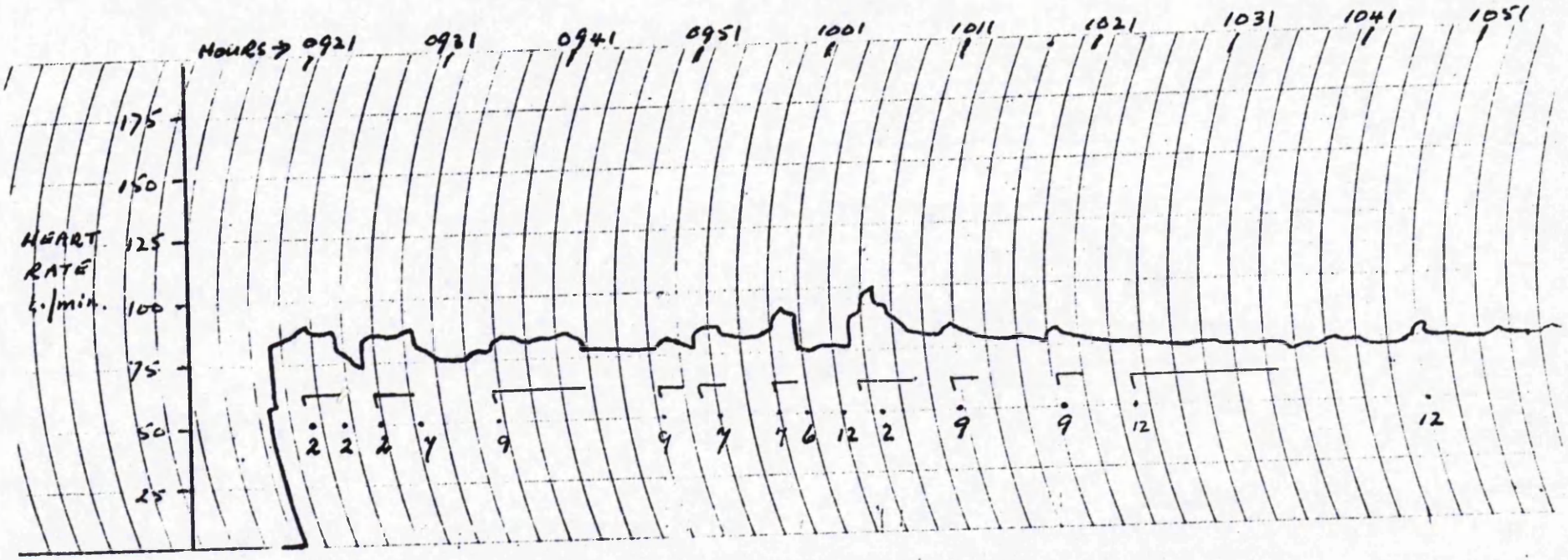
Analysis for each activity:

1) Outgoing telephone calls
2) Incoming telephone calls
3) Personal telephone calls
4) Meetings with a group
5) Speaking with a peer
6) Speaking with a subordinate
7) Speaking with a superior;
8) Speaking with a client
9) Dealing with clients' complaints
10) Reprimanding a subordinate
11) Dealing with domestic emergencies
12) Administrative duties
13) Dealing with cash
14) Meals and breaks
15) Driving

SUBJECT A

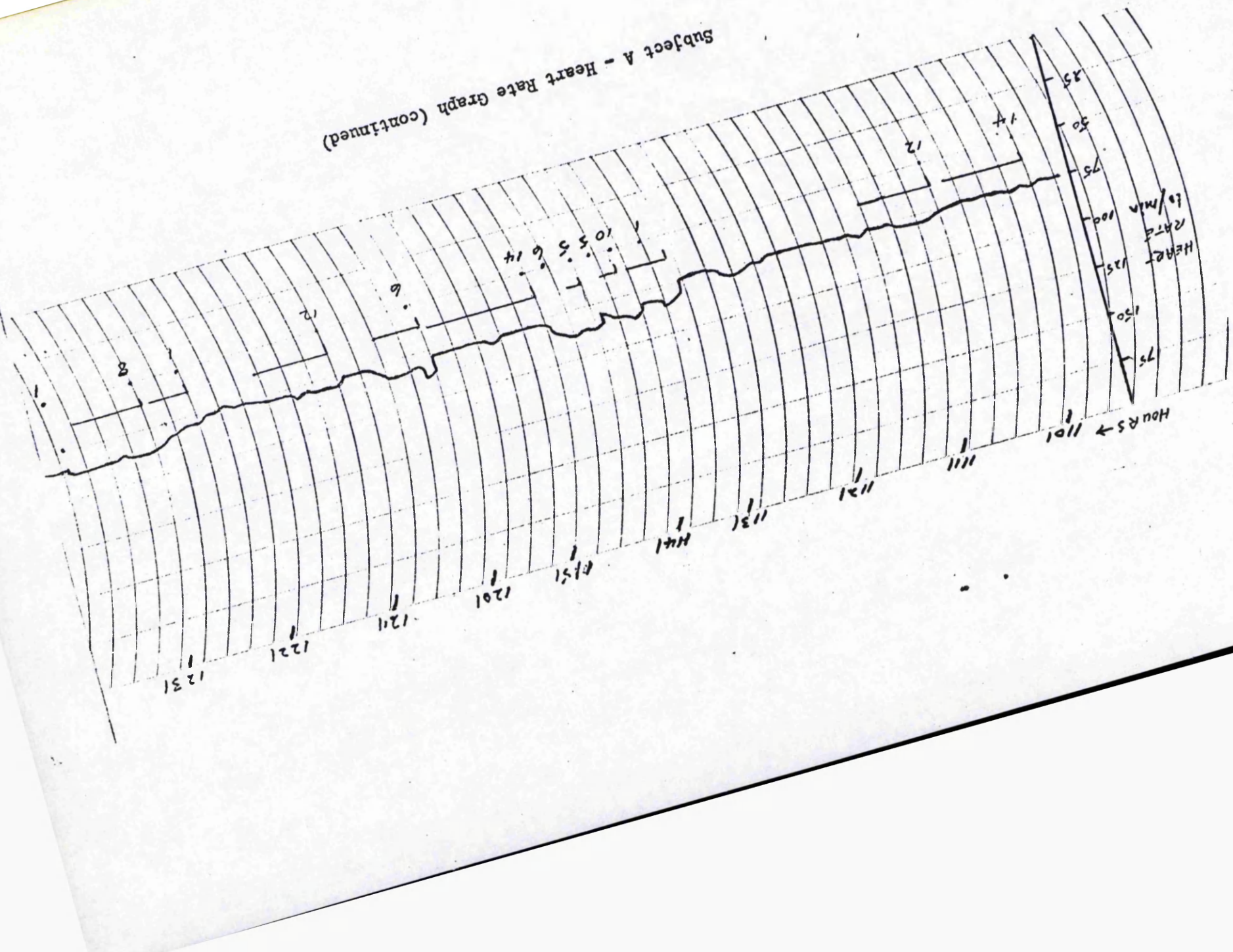
Personal Details

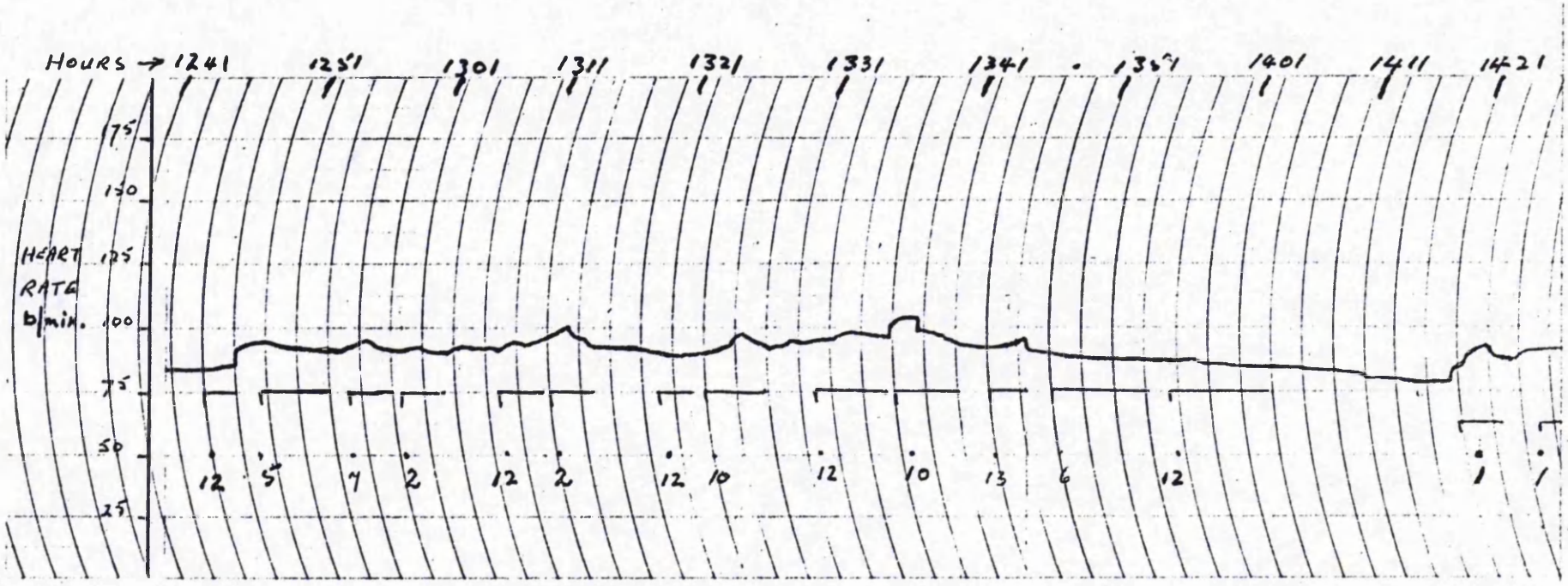
1)	Sex	Male
2)	Age	38
3)	General physical health	excellent
4)	Marital status	single
5)	Smoking habits	40 cigarettes a day
6)	Drinking habits	½-pint lager a day
7)	Hotel experience	21 years
8)	Occupation	Deputy General Manager
9)	Size of hotel	Large
10)	Stress experienced during study	No stress felt, normal day
11)	General impression	Casual, not bothered very much, competent.



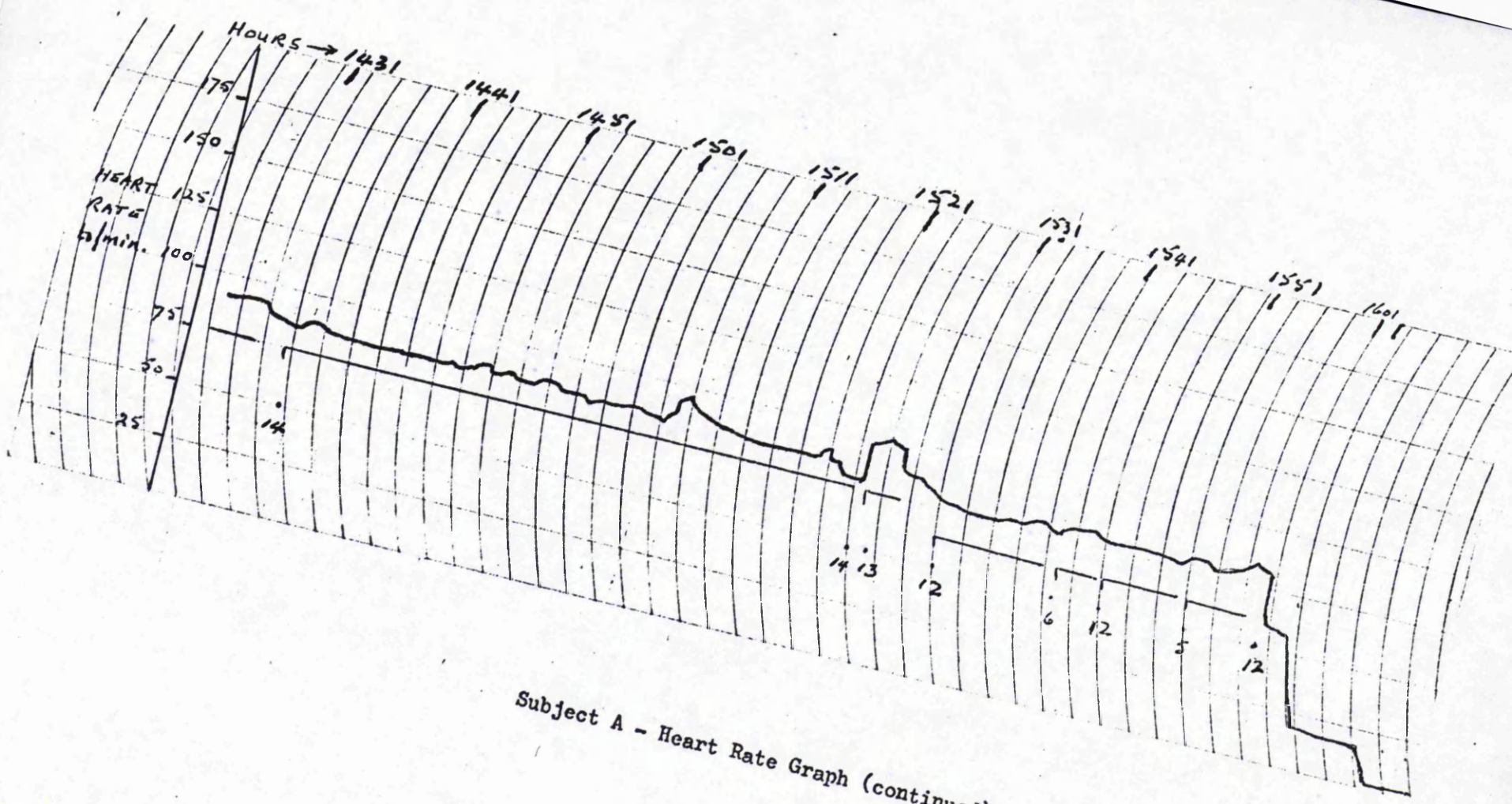
Subject A - Heart Rate Graph

Subject A - Heart Rate Graph (continued)



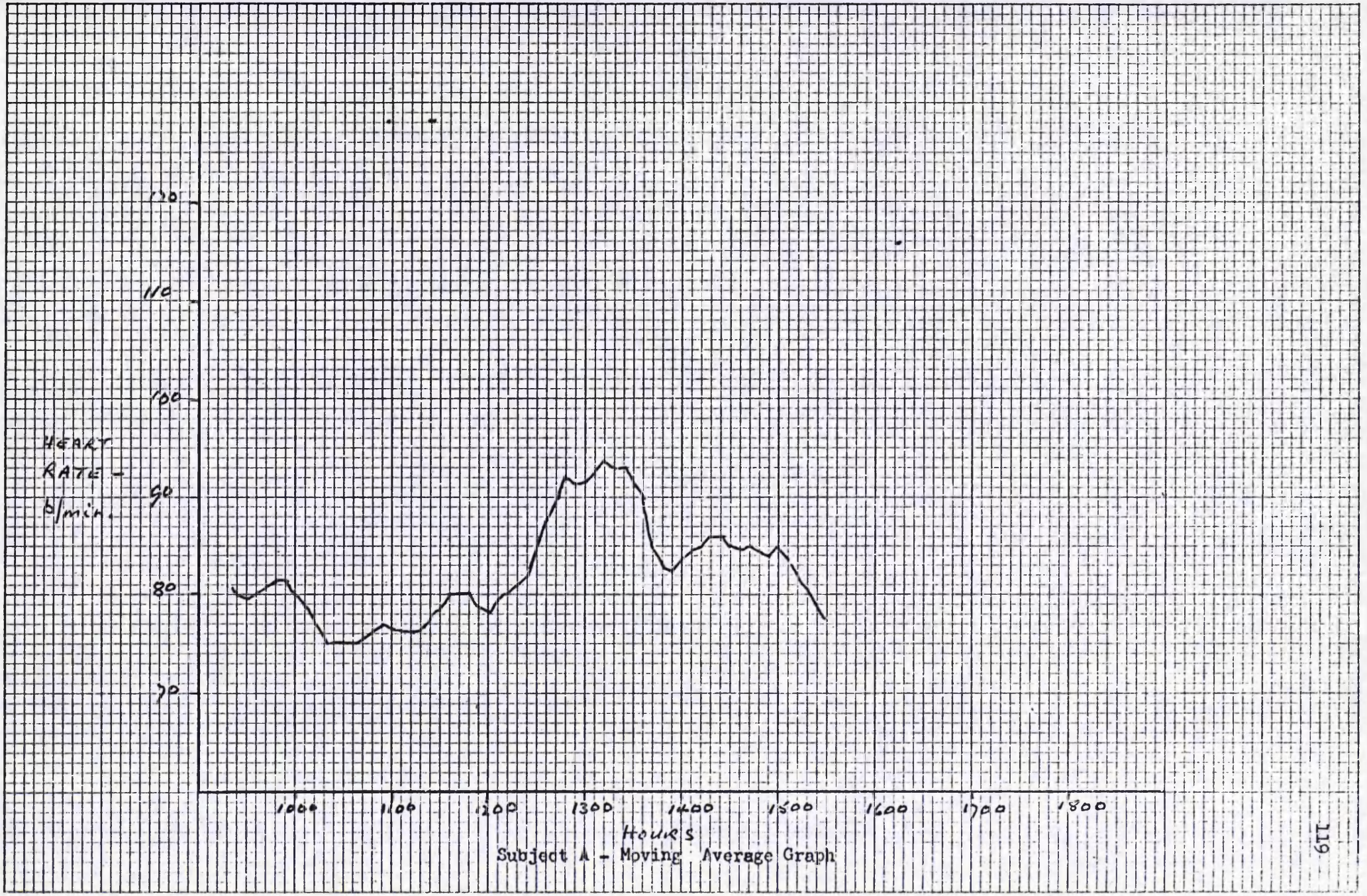


Subject A - Heart Rate Graph (continued)

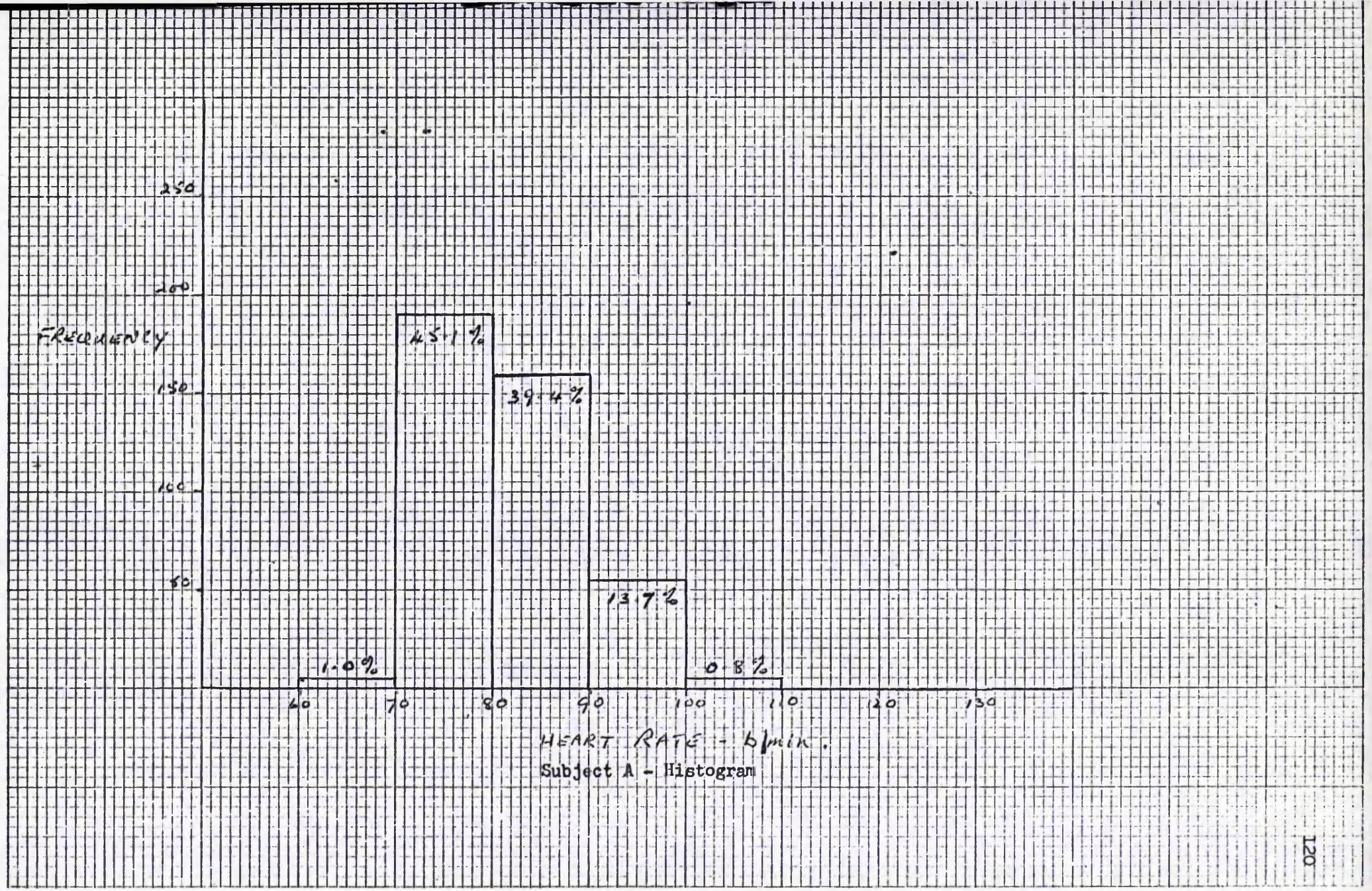


Subject A - Heart Rate Graph (continued)

Subject A - Resting Pulse Curve of best fit



Subject A - Moving Average Graph



Subject A - Histogram

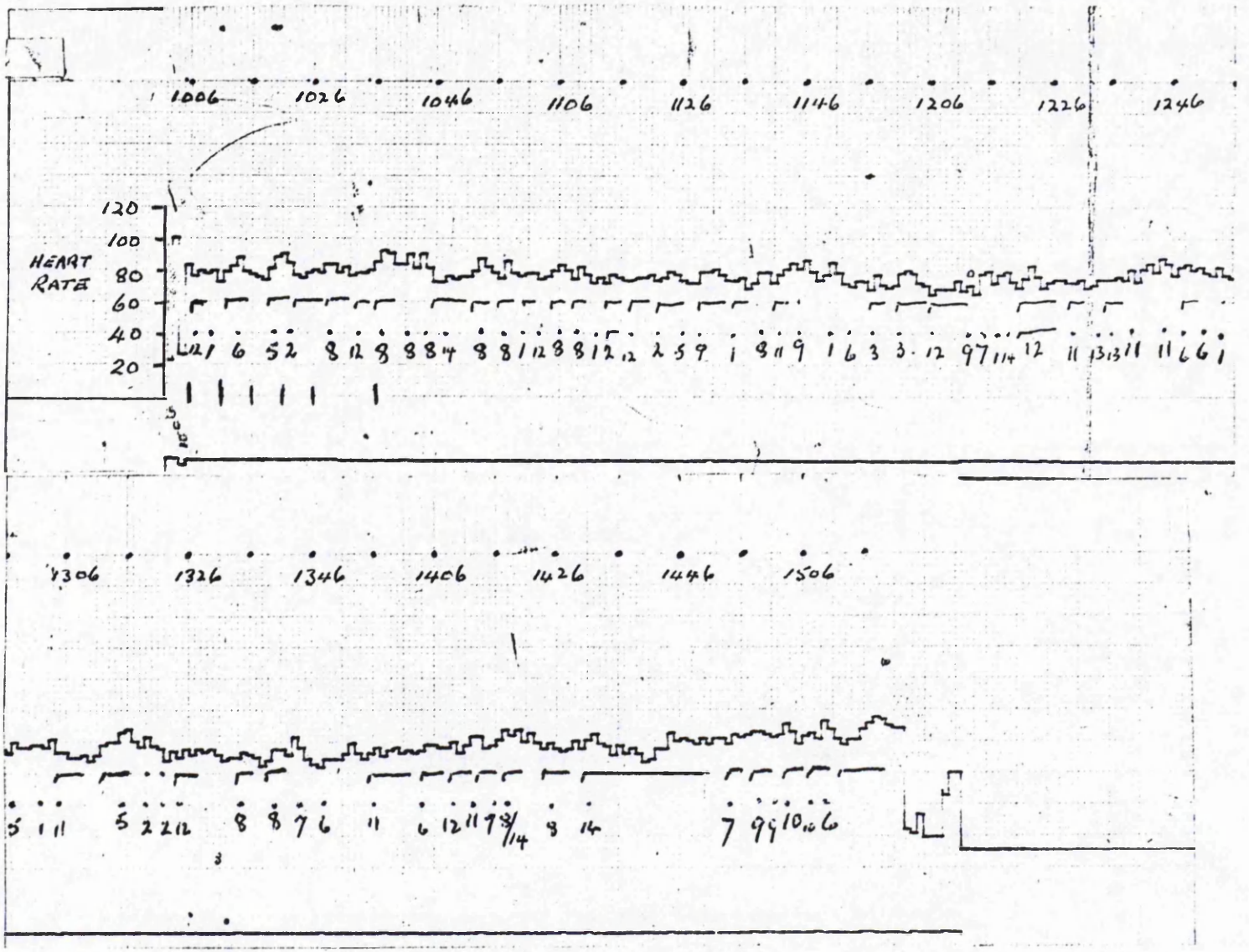
DESCRIPTION	ACTIVITY														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Heart Rates: Rest Pulses															
Sample Size	19	19	-	-	12	16	9	7	13	12	-	72	6	66	-
Mean	86.84	90.84			86.50	84.13	90.44	86.86	82.15	93.17		80.08	95.33	81.97	
Standard deviation(corrected)	5.13	5.78			6.87	3.22	3.97	1.57	3.21	7.50		7.33	3.50	4.67	
S.E. of difference	5.99	2.531			2.678	2.227	2.430	2.278	2.274	2.738		2.702	2.466	2.252	
Degree of freedom	30	30			23	27	20	18	24	23		83	17	77	
't' value	1.923	6.137			4.179	3.959	6.229	5.070	3.010	6.523		1.767	6.120	2.958	
significance	N/S	H/S			H/S	H/S	H/S	H/S	H/S	H/S		N/S	H/S	H/S	
PERTURBATIONS															
Sample Size	19	19	-	-	12	16	9	7	13	12	-	72	6	66	-
Mean	10.84	14.21			11.25	7.75	14.67	11.14	11.85	10.08		4.68	15.83	7.15	
S.D. (corrected)	3.79	6.28			5.91	5.19	4.92	1.87	3.10	5.58		3.30	7.62	3.11	
S.E. of difference	0.893	1.481			1.781	1.340	1.740	0.762	0.895	1.682		0.391	3.400	0.386	
Degree of freedom	18	18			11	15	8	6	12	11		71	5	65	
't' value	12.141	9.594			6.316	5.783	8.428	14.622	13.235	5.994		12.468	4.644	18.525	
significance	H/S	H/S			H/S	H/S	H/S	H/S	H/S	H/S		H/S	H/S	H/S	

Subject A : Activity Analysis Table

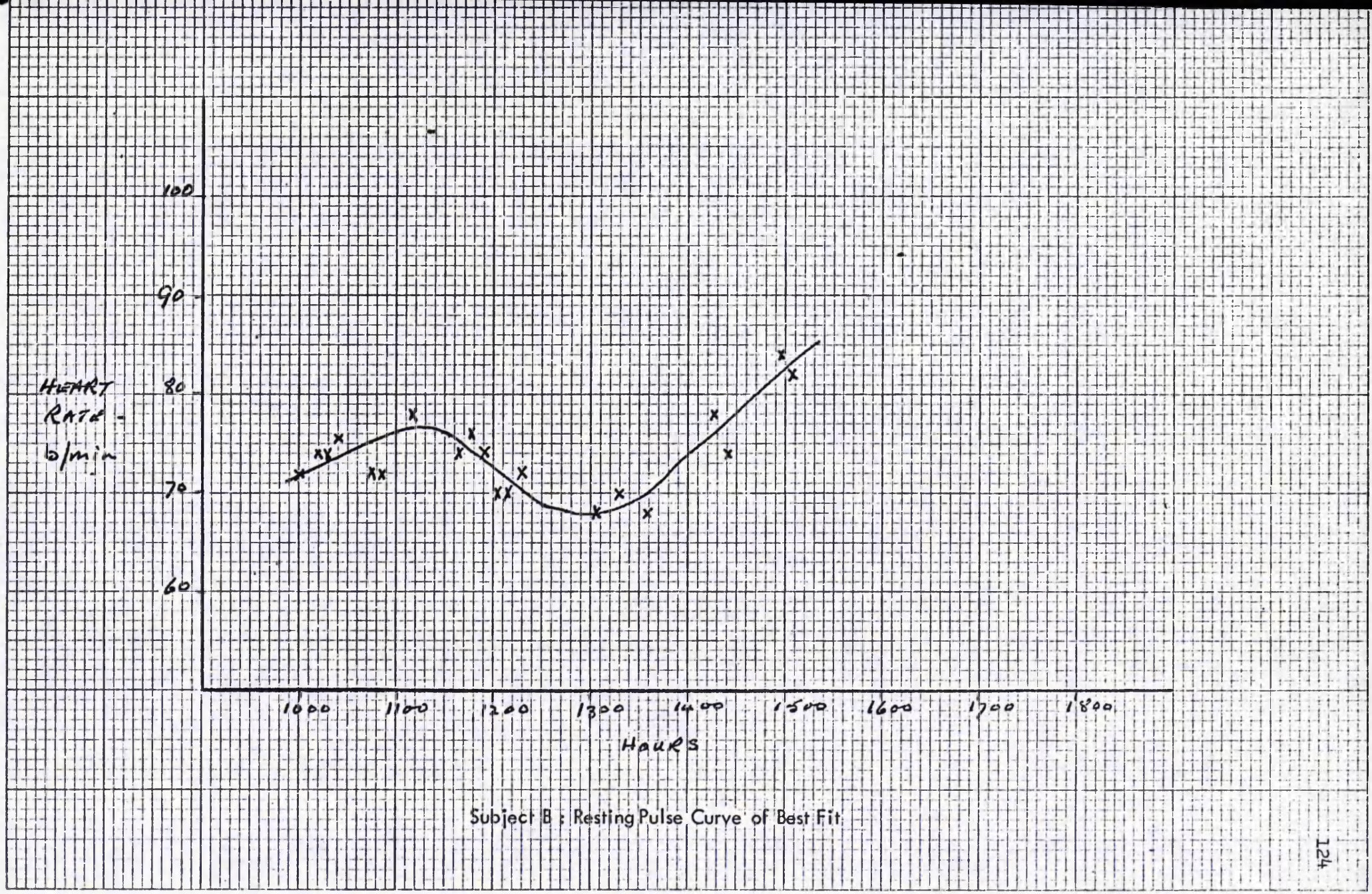
SUBJECT B

Personal Details

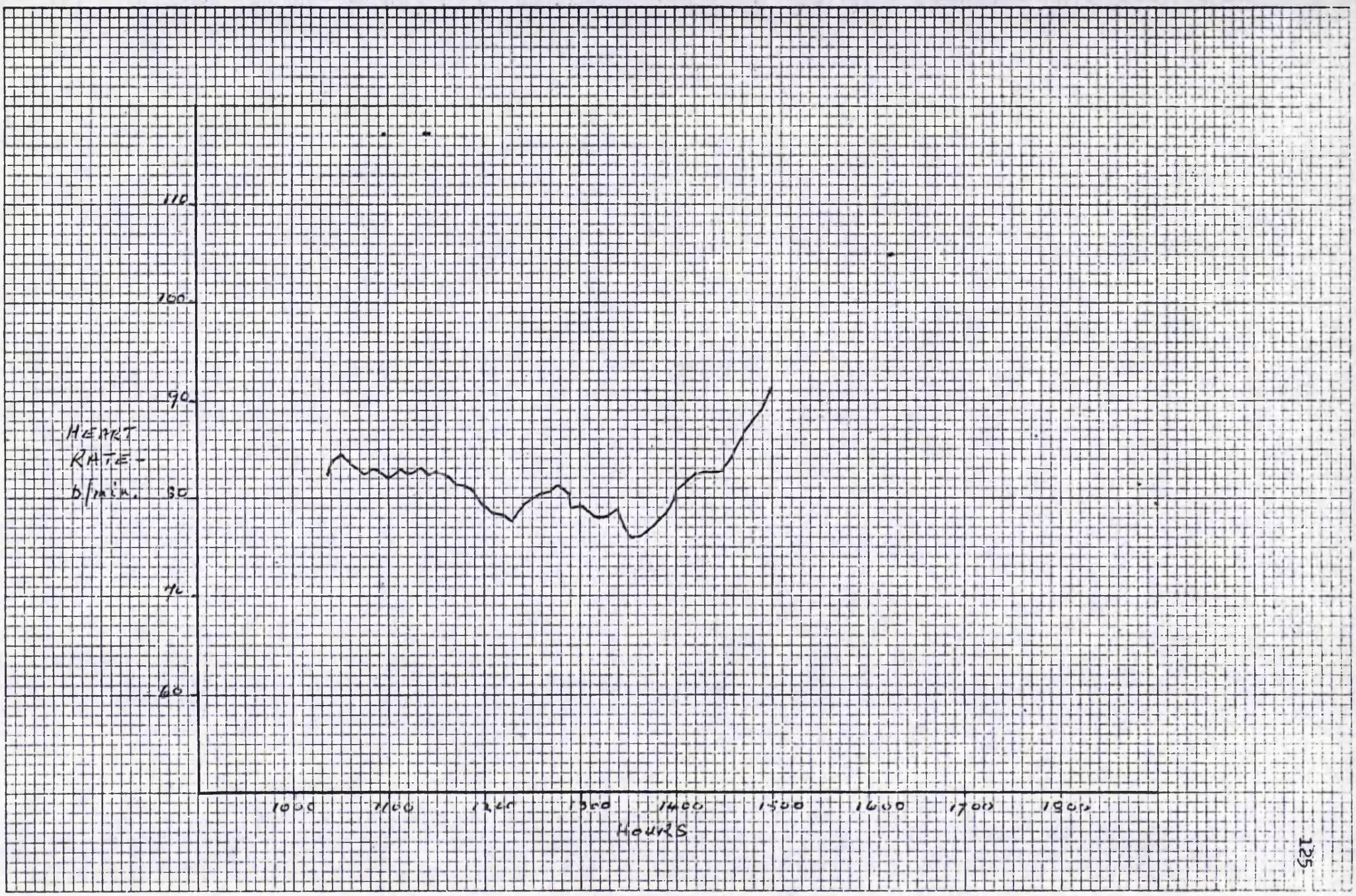
1)	Sex	Male
2)	Age	32
3)	General physical health	Very good
4)	Marital status	single
5)	Smoking habits	2 cigars a day
6)	Drinking habits	2 aperitifs a day
7)	Hotel experience	10 years
8)	Occupation	Food and Banqueting Manager
9)	Size of hotel	Large
10)	Stress experienced during study	No stress felt
11)	General impression	Very active, seems to be very efficient, smart.



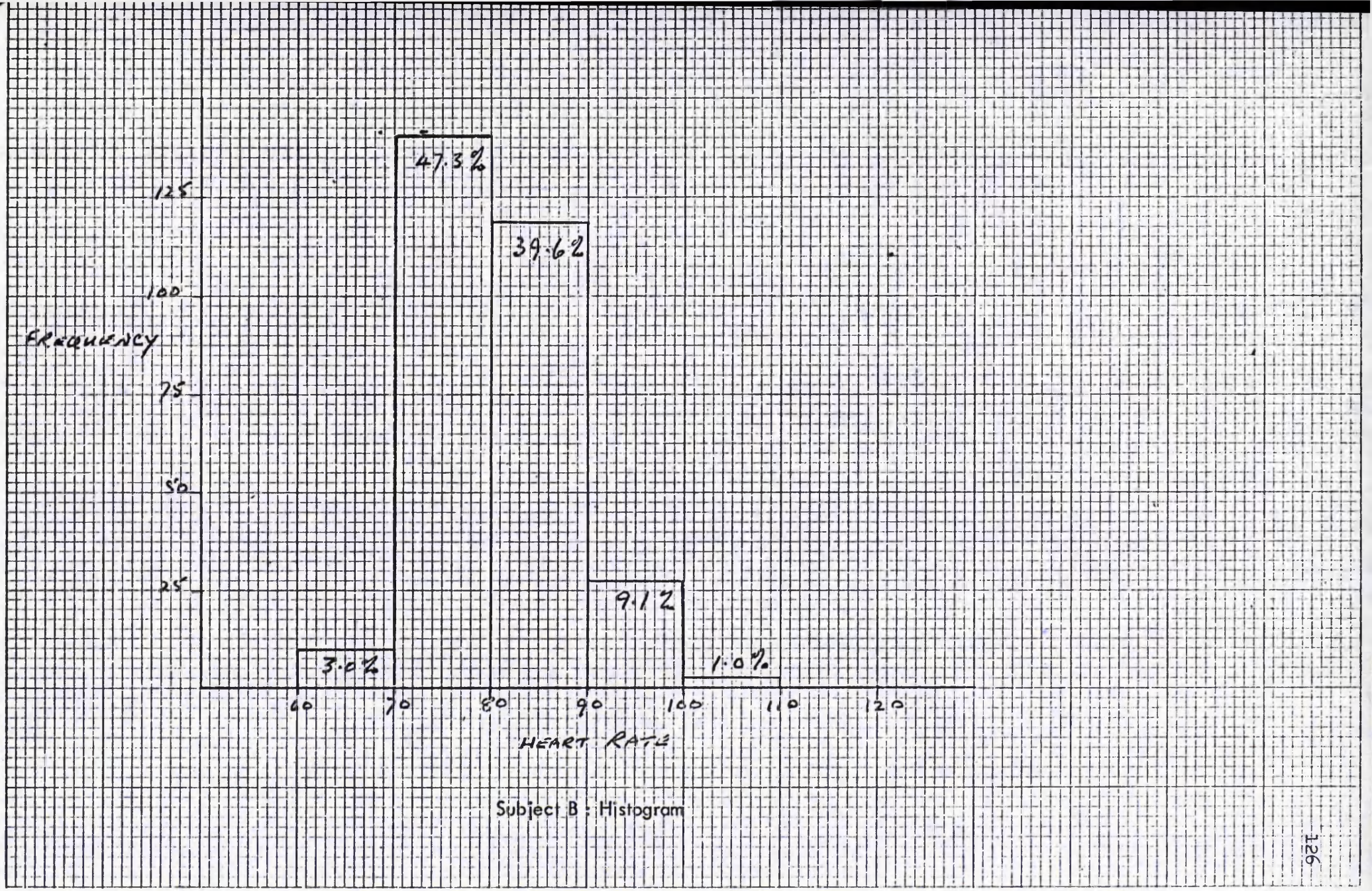
Subject B : Heart Rate Graph



Subject B : Resting Pulse Curve of Best Fit



Subject B : Moving Average Graph



Subject B : Histogram

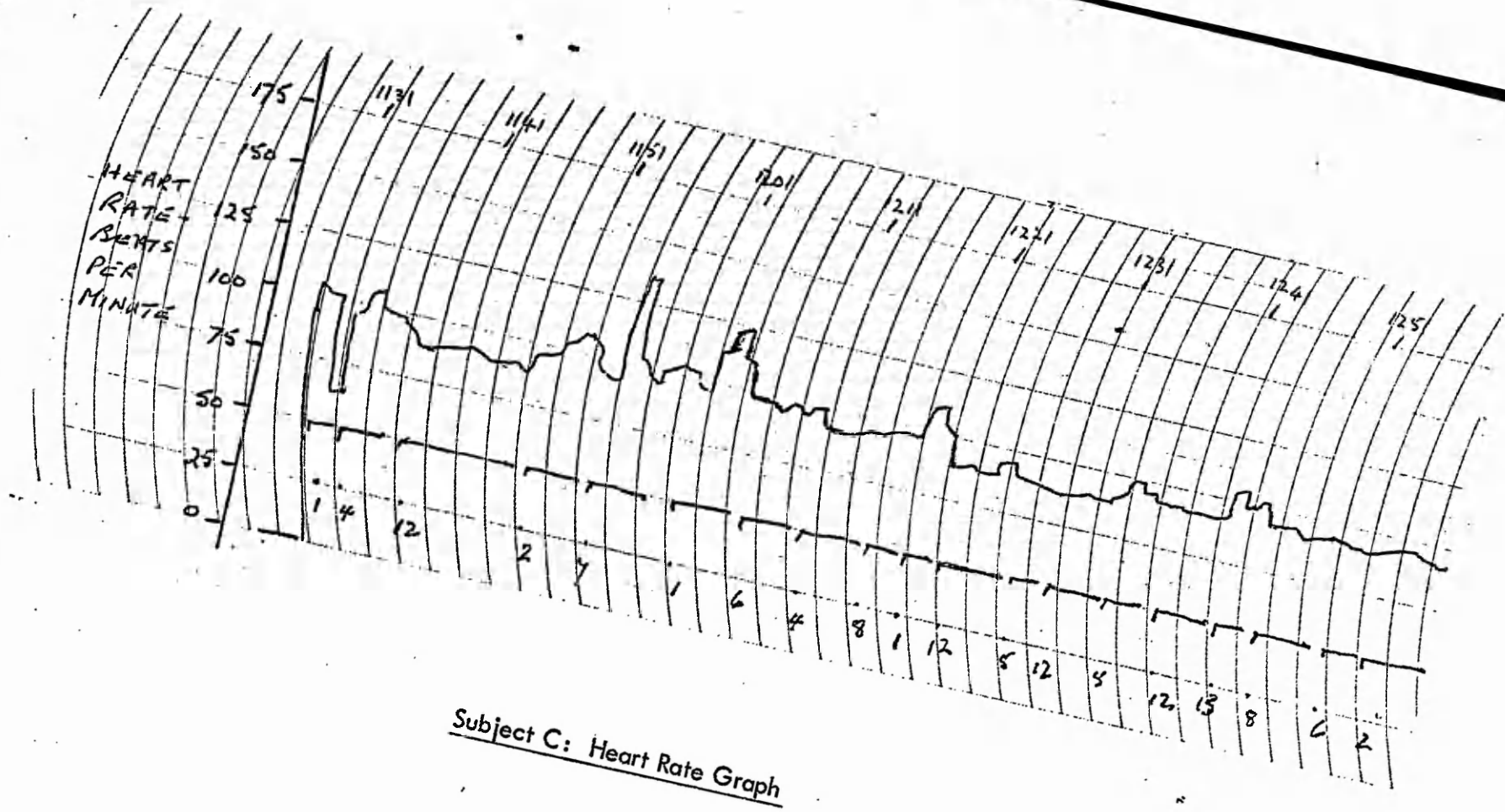
DESCRIPTION	ACTIVITY														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Heart Rates: Rest Pulses															
Sample Size	11	14	6	-	11	18	6	32	12	5	20	27	4	18	-
Mean	82.18	82.14	80.33		85.09	87.11	89.00	85.63	85.33	95.60	85.60	79.74	89.50	81.17	
Standard deviation(corrected)	2.63	2.57	6.98		7.24	8.12	6.54	4.86	5.07	9.21	5.21	3.08	3.46	6.05	
S.E. of difference	1.978	1.940	2.295		2.379	2.531	2.271	2.190	2.201	2.383	2.229	1.929	2.113	2.318	
Degree of freedom	29	32	24		29	36	24	50	30	23	38	45	22	36	
't' value	4.186	4.248	2.803		4.703	5.219	6.649	5.353	5.194	9.106	5.248	3.027	7.382	3.135	
significance	H/S	H/S	H/S		H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	
PERTURBATIONS															
Sample Size	11	14	6	-	11	18	6	32	12	5	20	27	4	18	-
Mean	8.73	7.71	7.67		14.36	12.67	14.33	10.50	7.00	12.60	14.30	6.63	21.50	4.78	
S.D. (corrected)	4.29	3.43	6.62		6.76	4.51	3.78	5.82	4.83	9.21	6.06	2.65	3.41	4.16	
S.E. of difference	1.356	0.950	2.961		2.137	1.093	1.689	1.045	1.456	4.604	1.389	0.519	1.970	1.009	
Degree of freedom	10	13	5		10	17	5	31	11	4	19	26	3	17	
't' value	6.435	8.120	2.588		6.721	11.588	8.486	5.563	4.807	2.736	10.295	12.772	10.911	34.734	
significance	H/S	H/S	S		H/S	H/S	H/S	H/S	H/S	N/S	H/S	H/S	H/S	H/S	

Subject B : Activity Analysis Table

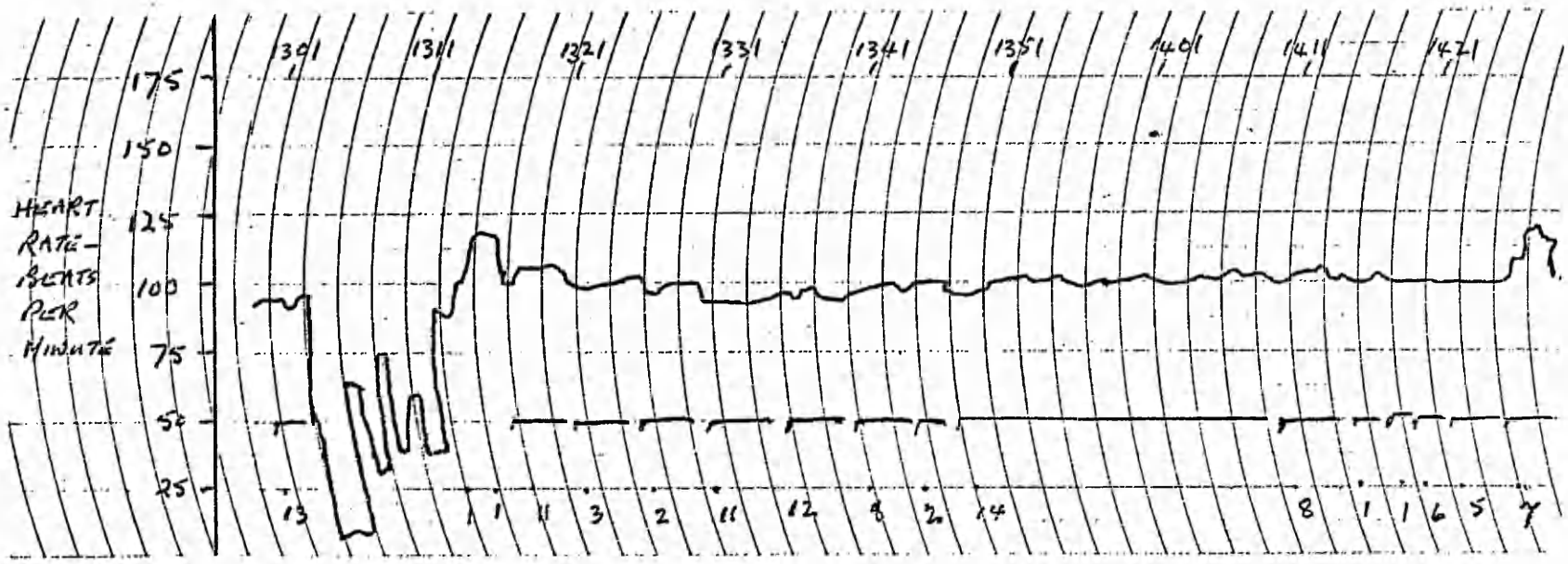
SUBJECT C

Personal Details

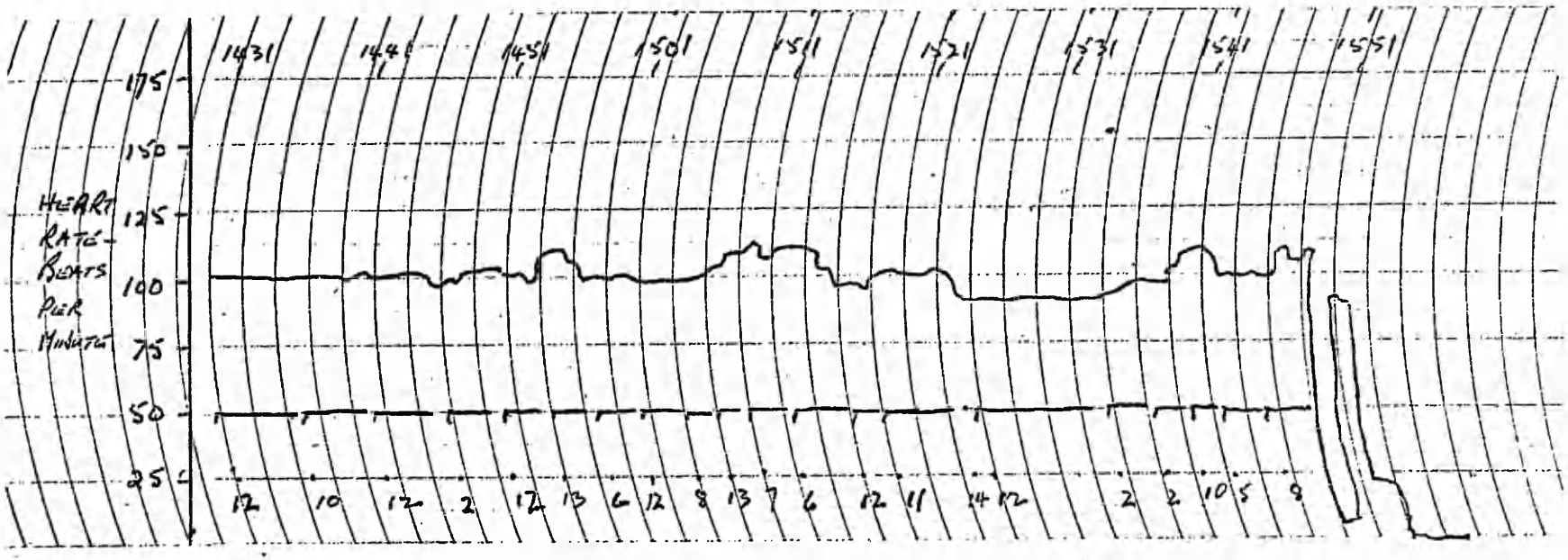
1)	Sex	Female
2)	Age	36
3)	General physical health	Good
4)	Marital status	Married
5)	Smoking habits	25 cigarettes a day
6)	Drinking habits	Heavy drinker
7)	Hotel experience	5 years
8)	Occupation	Conference Manager/Deputy General Manager
9)	Size of hotel	Medium
10)	Stress experienced during study	No stress experienced
11)	General impression	Nervous disposition, seems keyed up, efficient.



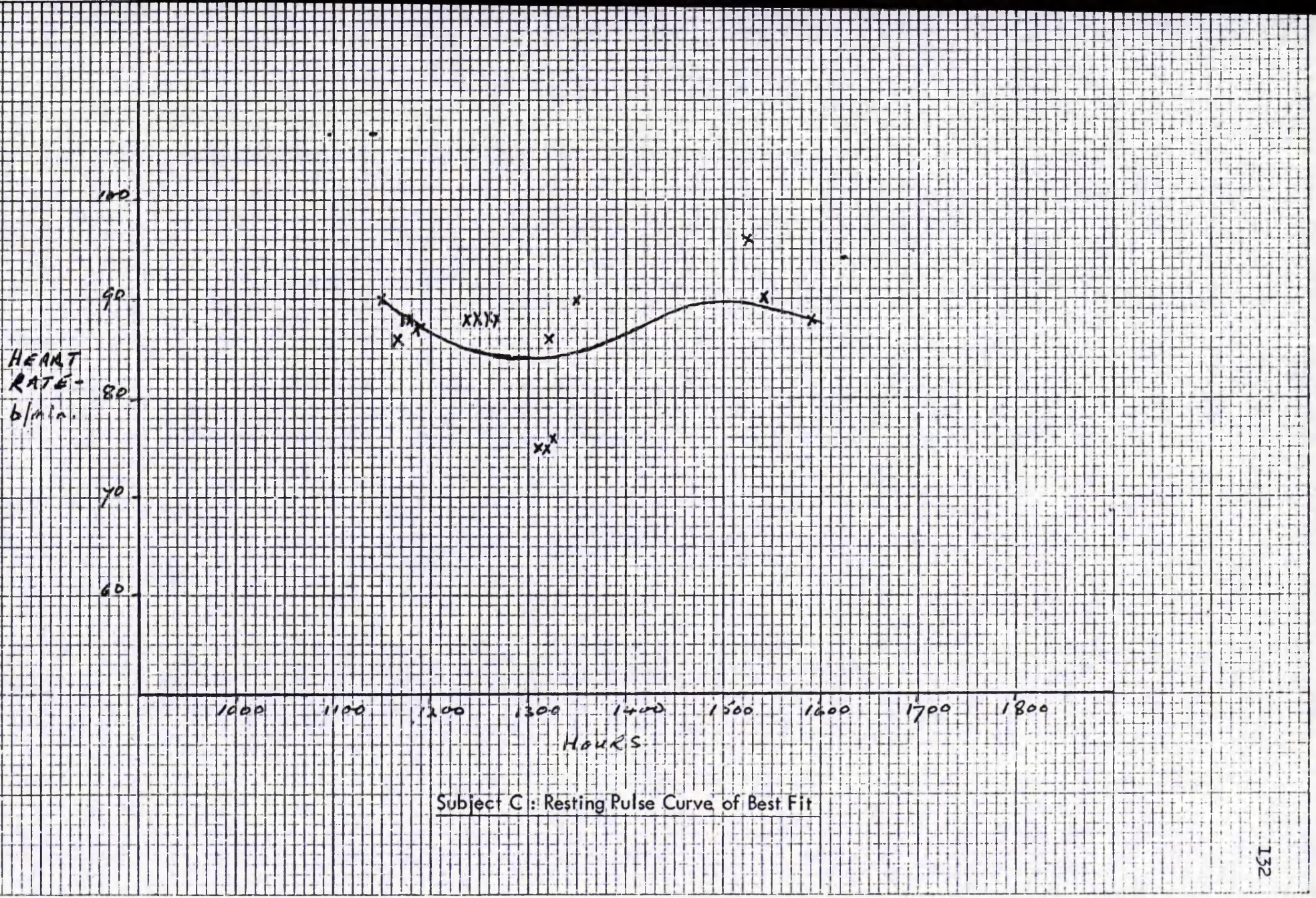
Subject C: Heart Rate Graph



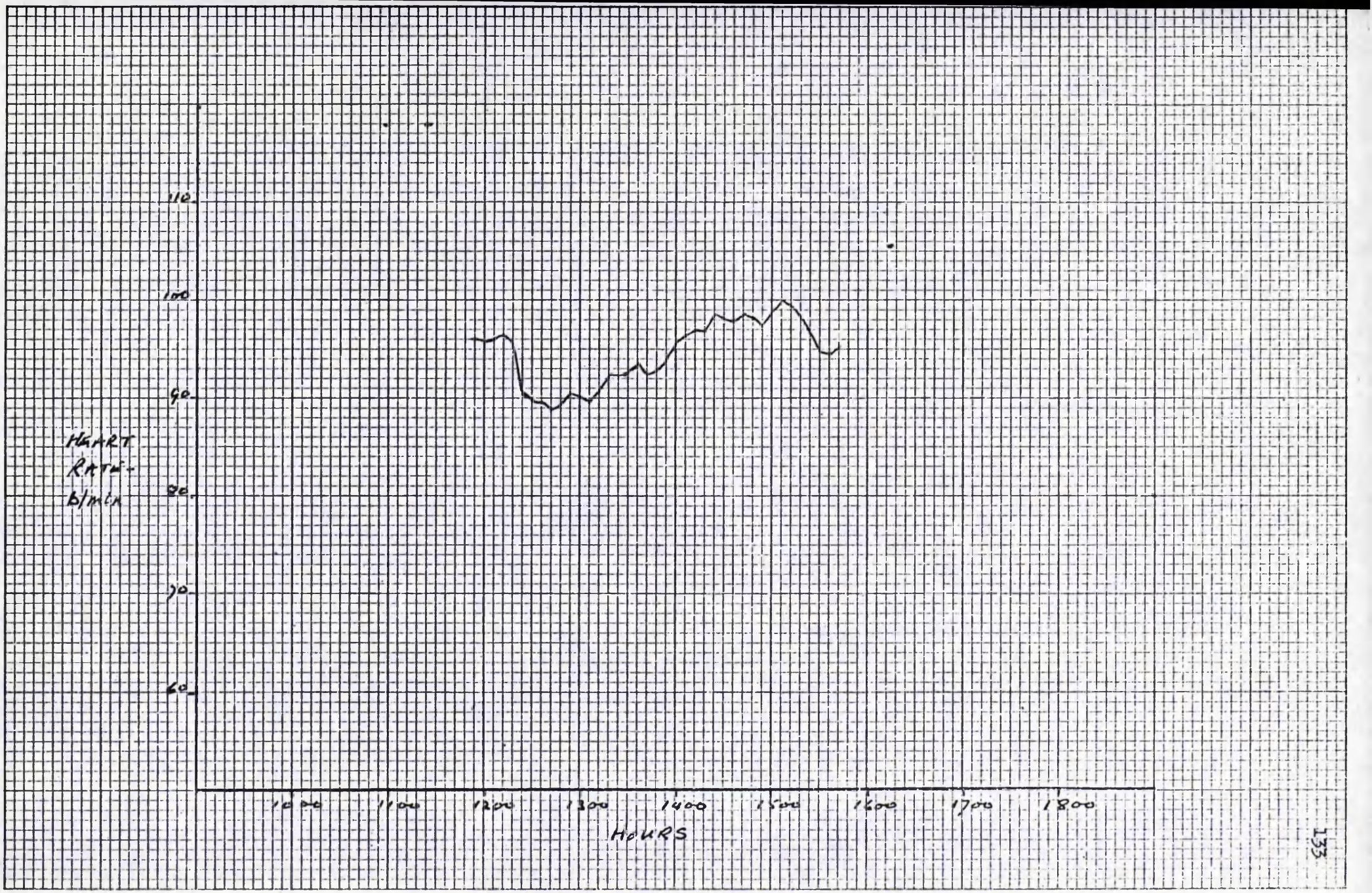
Subject C : Heart Rate Graph (contd.)



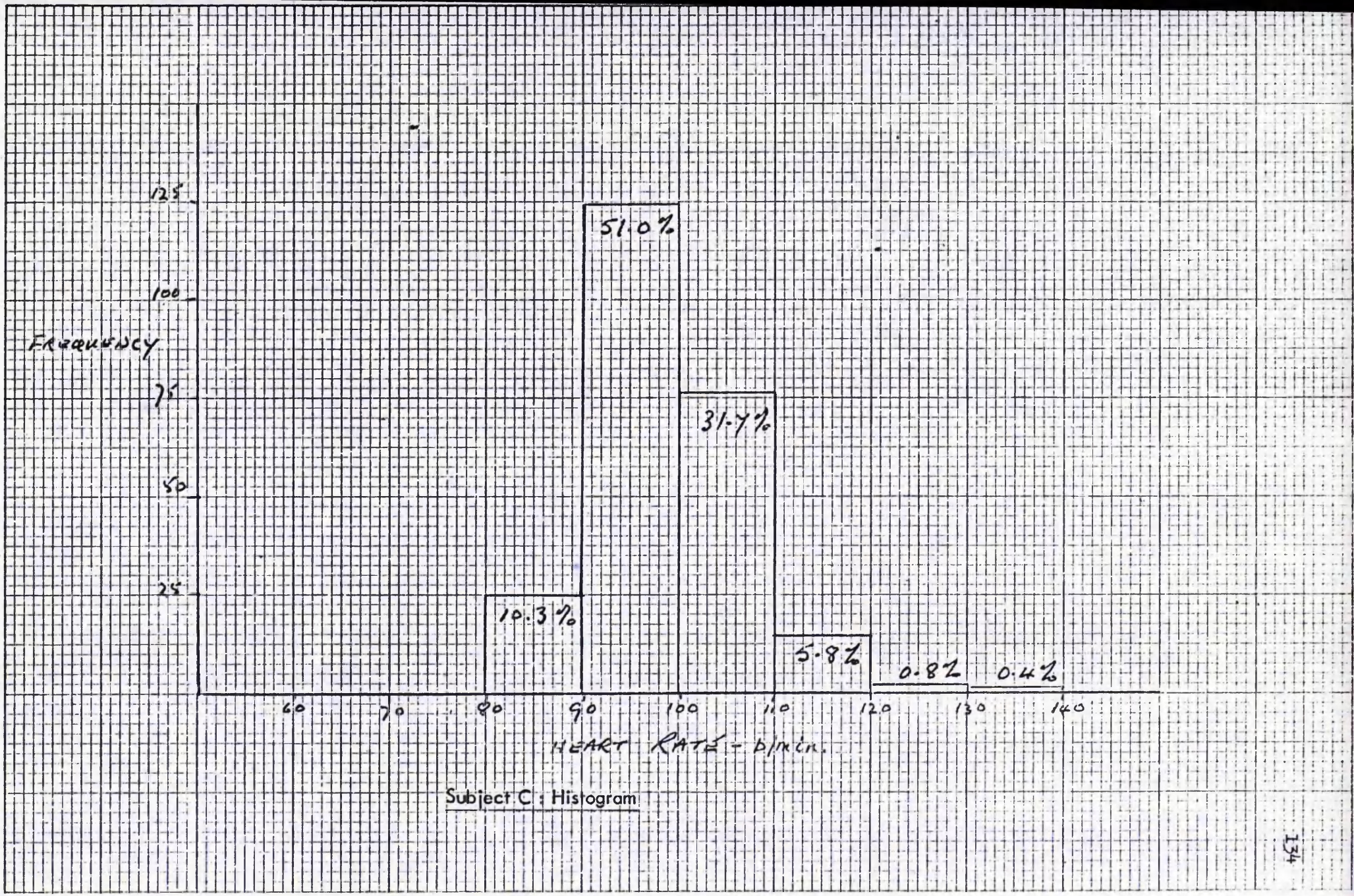
Subject C : Heart Rate Graph (contd.)



Subject C : Resting Pulse Curve of Best Fit



Subject C : Moving Average Graph



Subject C : Histogram

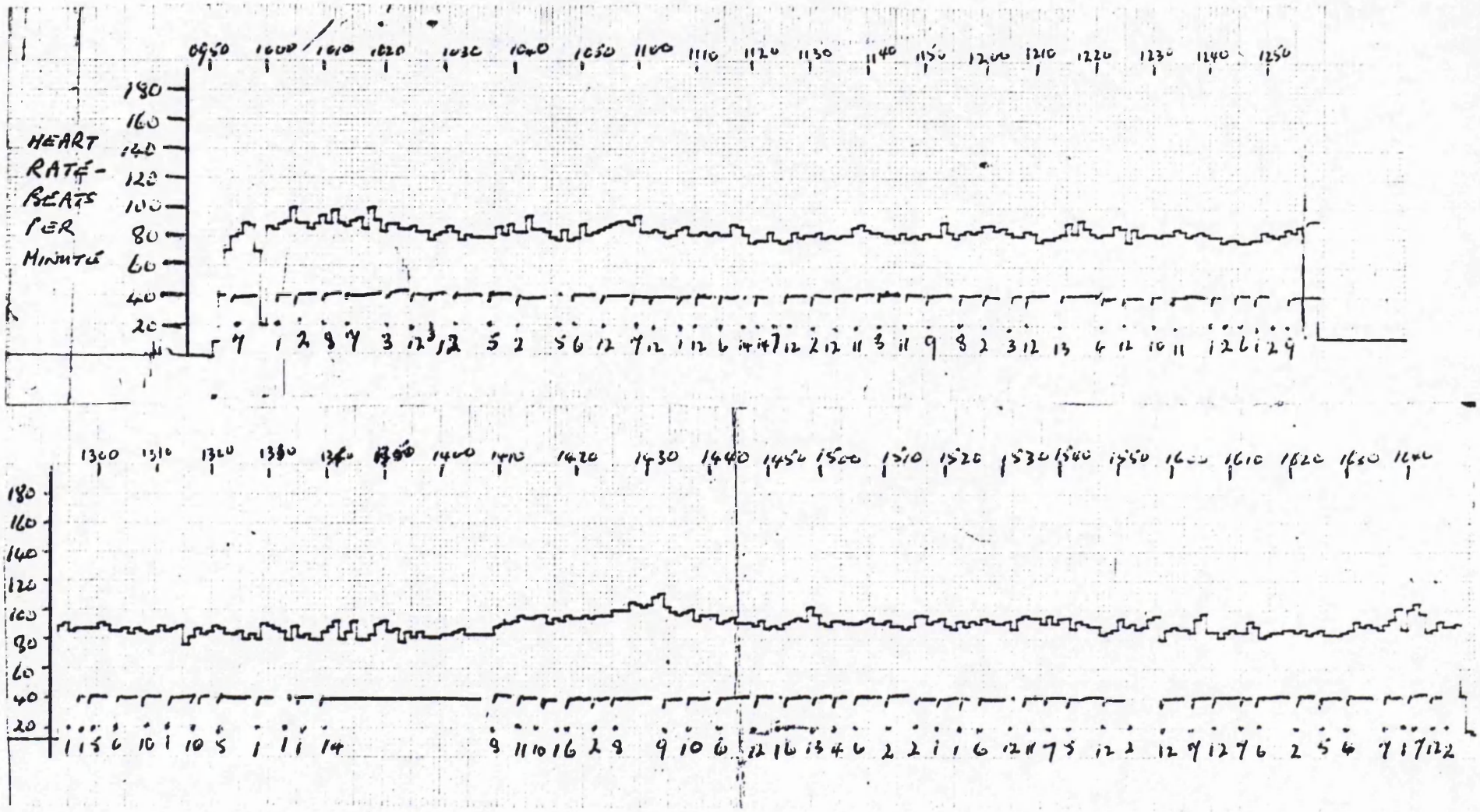
DESCRIPTION	ACTIVITY														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Heart Rates: Rest Pulses															
Sample Size	13	26	5	9	15	16	12	24	-	7	17	50	10	24	-
Mean	105.08	99.92	100.80	95.78	99.20	97.38	109.67	100.50		105.14	100.35	95.56	105.60	100.17	
Standard deviation(corrected)	9.18	4.54	3.32	6.04	3.69	4.36	12.64	5.87		4.74	5.06	4.41	6.85	3.68	
S.E. of difference	2.809	2.299	2.392	2.536	2.266	2.334	3.071	2.484		2.457	2.407	2.215	2.599	2.187	
Degree of freedom	27	40	19	23	29	30	26	38		21	31	64	24	38	
't' value	6.746	6.001	6.135	3.805	5.770	4.820	7.665	5.787		7.739	5.911	4.259	7.493	6.426	
significance	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S		H/S	H/S	H/S	H/S	H/S	
PERTURBATIONS															
Sample Size	13	26	5	9	15	16	12	24	-	7	17	50	10	24	-
Mean	18.31	13.69	16.80	8.22	12.67	10.12	21.67	14.75		17.14	14.70	8.64	18.60	14.08	
S.D. (corrected)	9.90	4.03	3.03	5.43	2.99	3.14	12.319	4.63		4.74	4.90	3.64	4.99	3.94	
S.E. of difference	2.856	0.805	1.516	1.919	0.800	0.810	3.713	0.966		1.936	1.225	0.529	1.664	0.829	
Degree of freedom	12	25	4	8	14	15	11	23		6	16	49	9	23	
't' value	6.410	17.008	11.801	4.284	15.832	12.498	6.531	15.269		8.854	12.003	16.615	11.177	17.173	
significance	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S		H/S	H/S	H/S	H/S	H/S	

Subject C : Activity Analysis Table

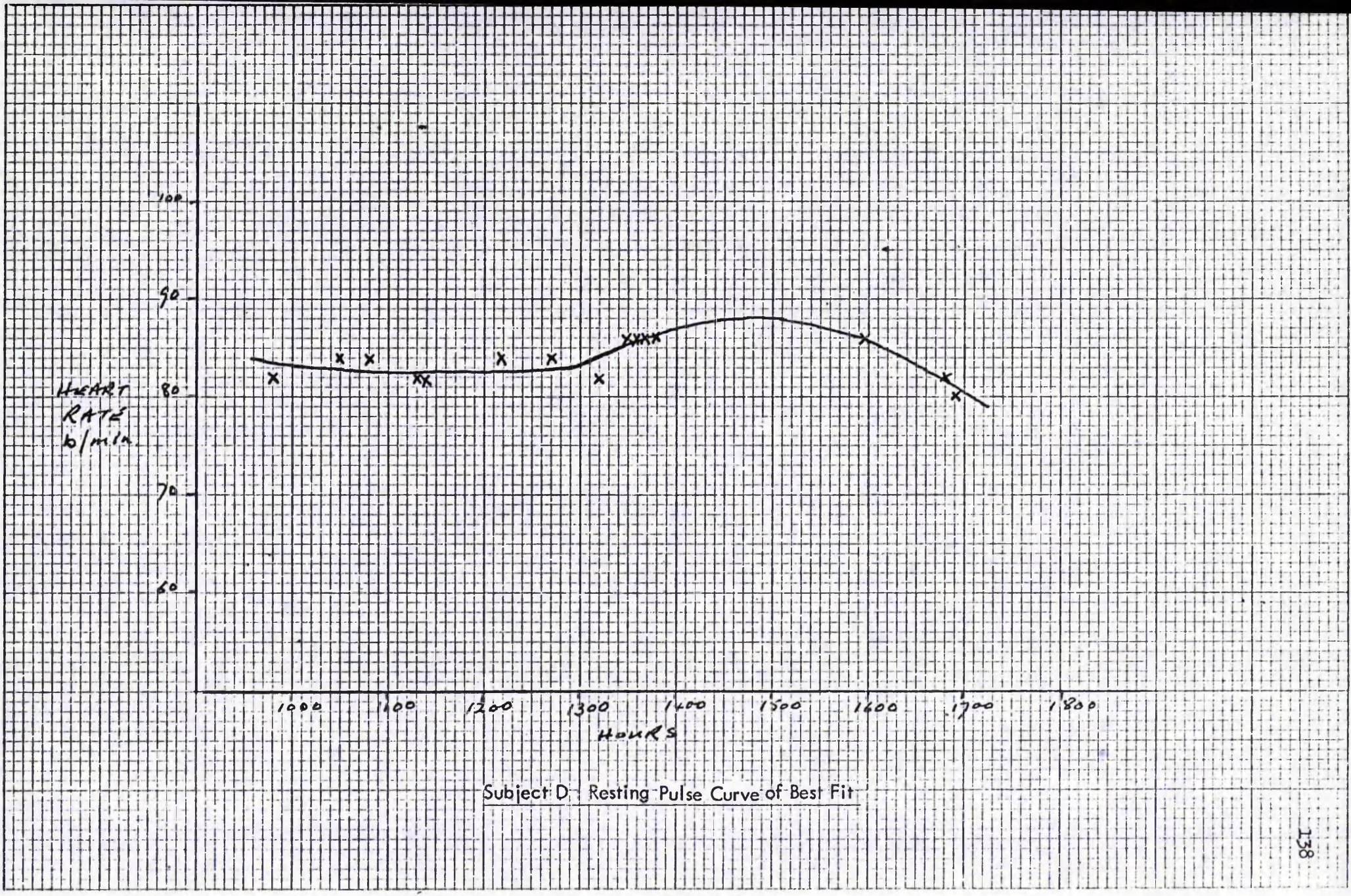
SUBJECT D

Personal Details

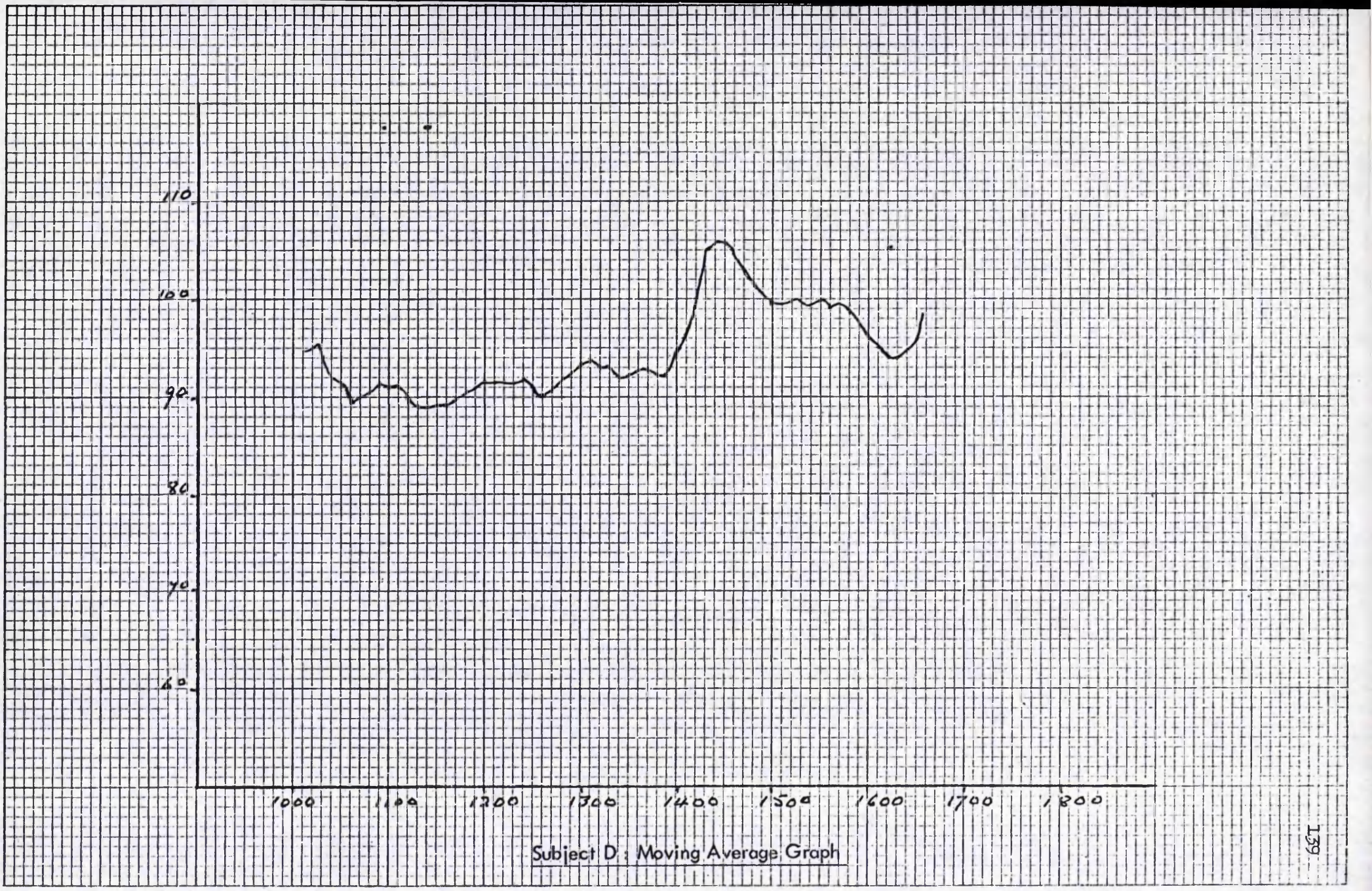
1)	Sex	Female
2)	Age	31
3)	General physical health	Good
4)	Marital status	Single
5)	Smoking habits	Non-smoker, gave up August 1975
6)	Drinking habits	2 or 3 gins a day
7)	Hotel experience	4 years
8)	Occupation	Banqueting Manager
9)	Size of hotel	Large
10)	Stress experienced during study	No stress experienced
11)	General impression	Smart, competent



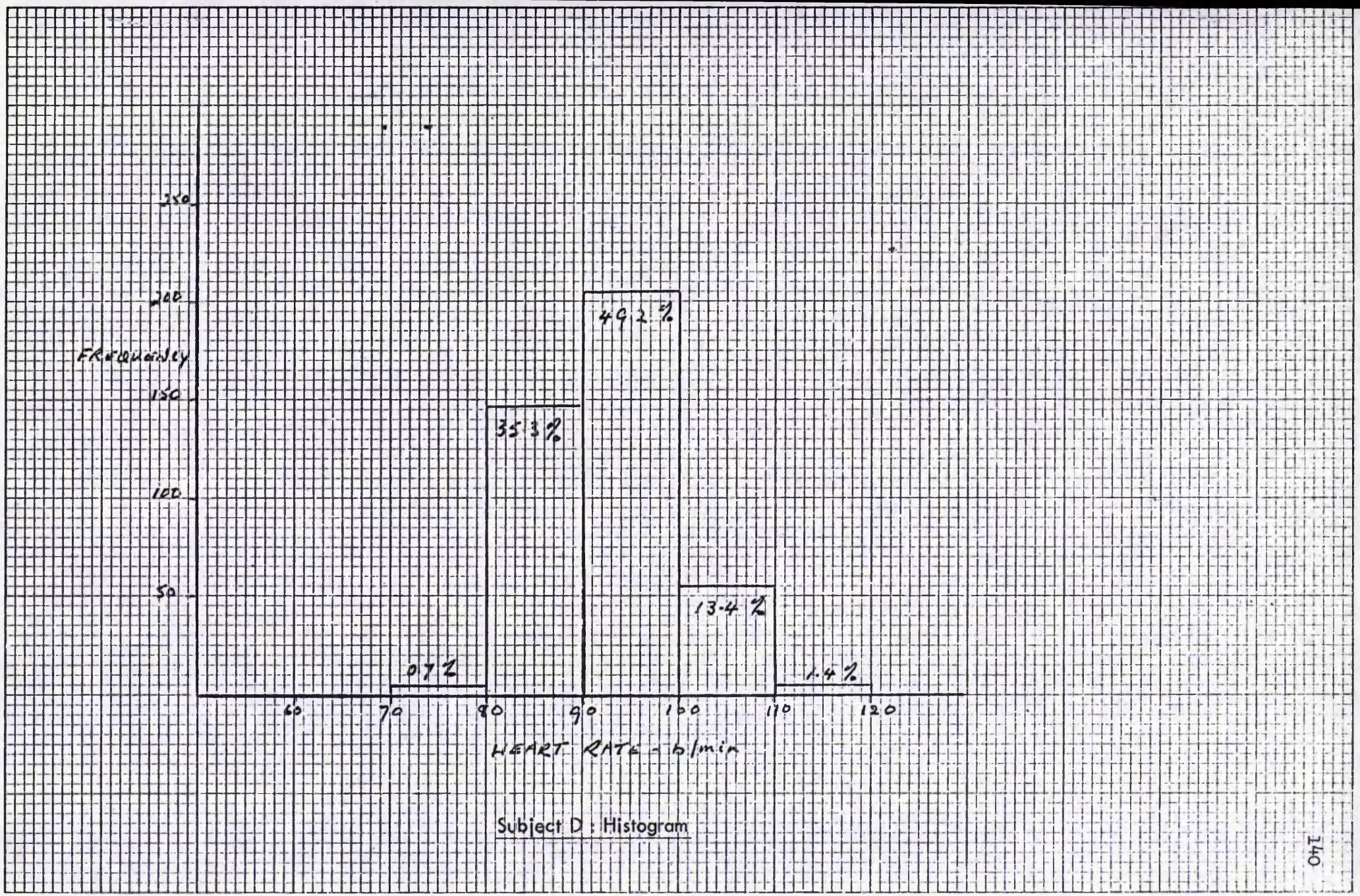
Subject D : Heart Rate Graph



Subject D Resting Pulse Curve of Best Fit



Subject D : Moving Average Graph



Subject D : Histogram

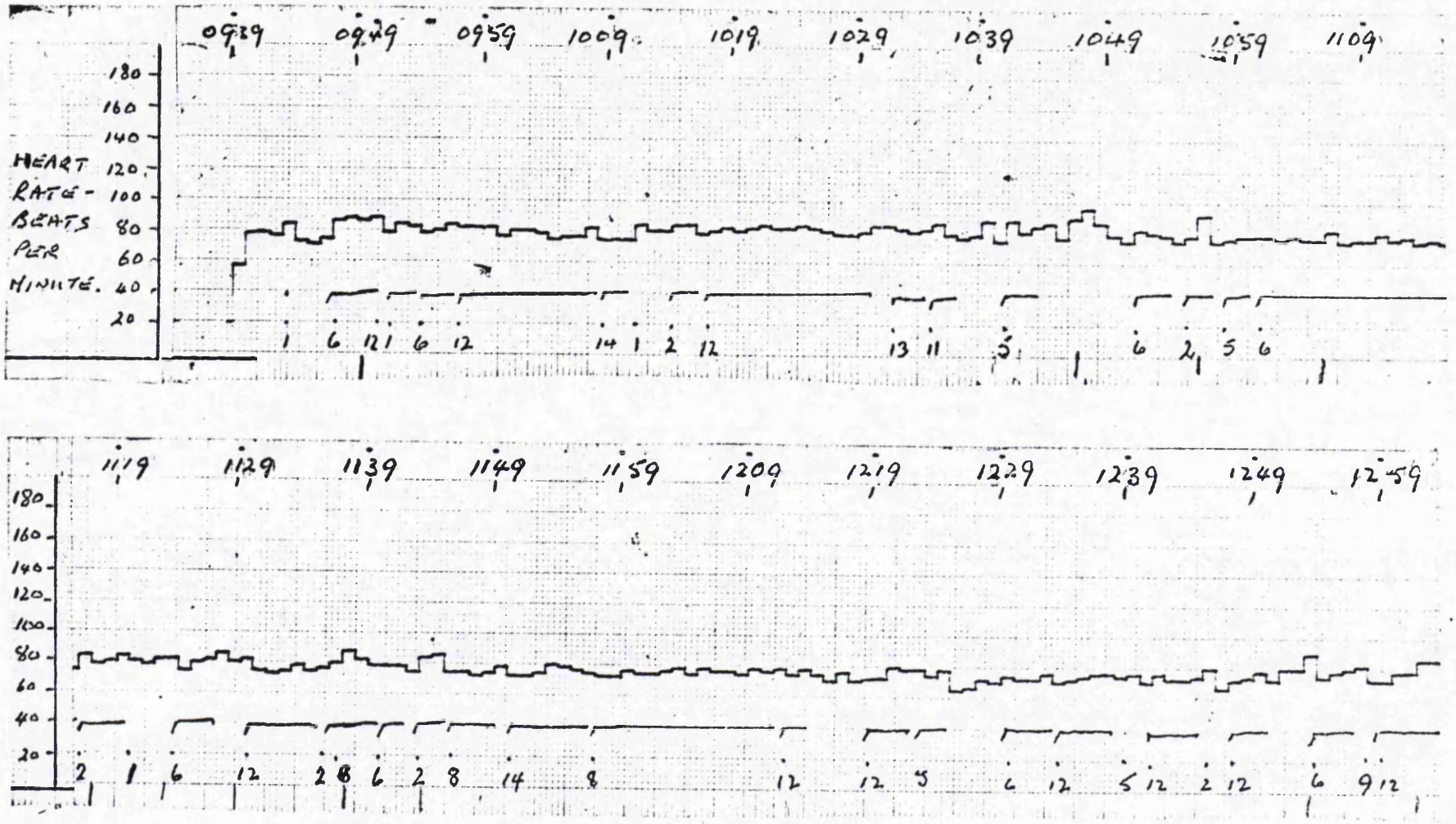
DESCRIPTION	ACTIVITY														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Heart Rates: Rest Pulses															
Sample Size	34	38	8	17	26	46	28	23	9	15	24	67	9	29	-
Mean	94.53	95.42	92.00	95.18	93.08	95.83	99.36	99.48	99.33	96.93	93.75	91.04	98.22	90.55	
Standard deviation(corrected)	4.50	5.54	3.02	4.18	3.76	5.41	6.73	9.03	7.62	6.32	6.19	4.05	6.44	4.07	
S.E. of difference	1.976	2.174	1.614	1.841	1.814	2.176	2.312	2.572	2.115	2.115	2.200	1.943	2.006	1.889	
Degree of freedom	47	51	21	30	39	59	41	36	22	28	37	80	22	42	
't' value	5.463	5.376	5.122	6.216	5.151	5.557	6.758	6.122	7.386	6.241	4.553	3.763	7.223	3.627	
significance	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	
PERTURBATIONS															
Sample Size	34	38	8	17	26	46	28	23	9	15	24	67	9	29	-
Mean	10.29	11.47	10.00	11.76	9.54	10.48	16.36	14.87	14.67	11.73	10.42	7.82	13.55	4.96	
S.D. (corrected)	3.79	4.76	3.02	3.80	3.68	4.00	6.80	6.90	5.00	4.95	4.45	3.15	4.78	3.69	
S.E. of difference	0.659	0.782	1.141	0.949	0.735	0.596	1.308	1.470	1.769	1.323	0.928	0.387	1.689	0.697	
Degree of freedom	33	37	7	16	25	45	27	22	8	14	23	66	8	28	
't' value	15.620	14.670	8.764	12.396	12.976	17.580	12.504	10.114	8.299	8.867	11.224	20.206	8.024	7.12	
significance	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	

Subject D : Activity Analysis Table

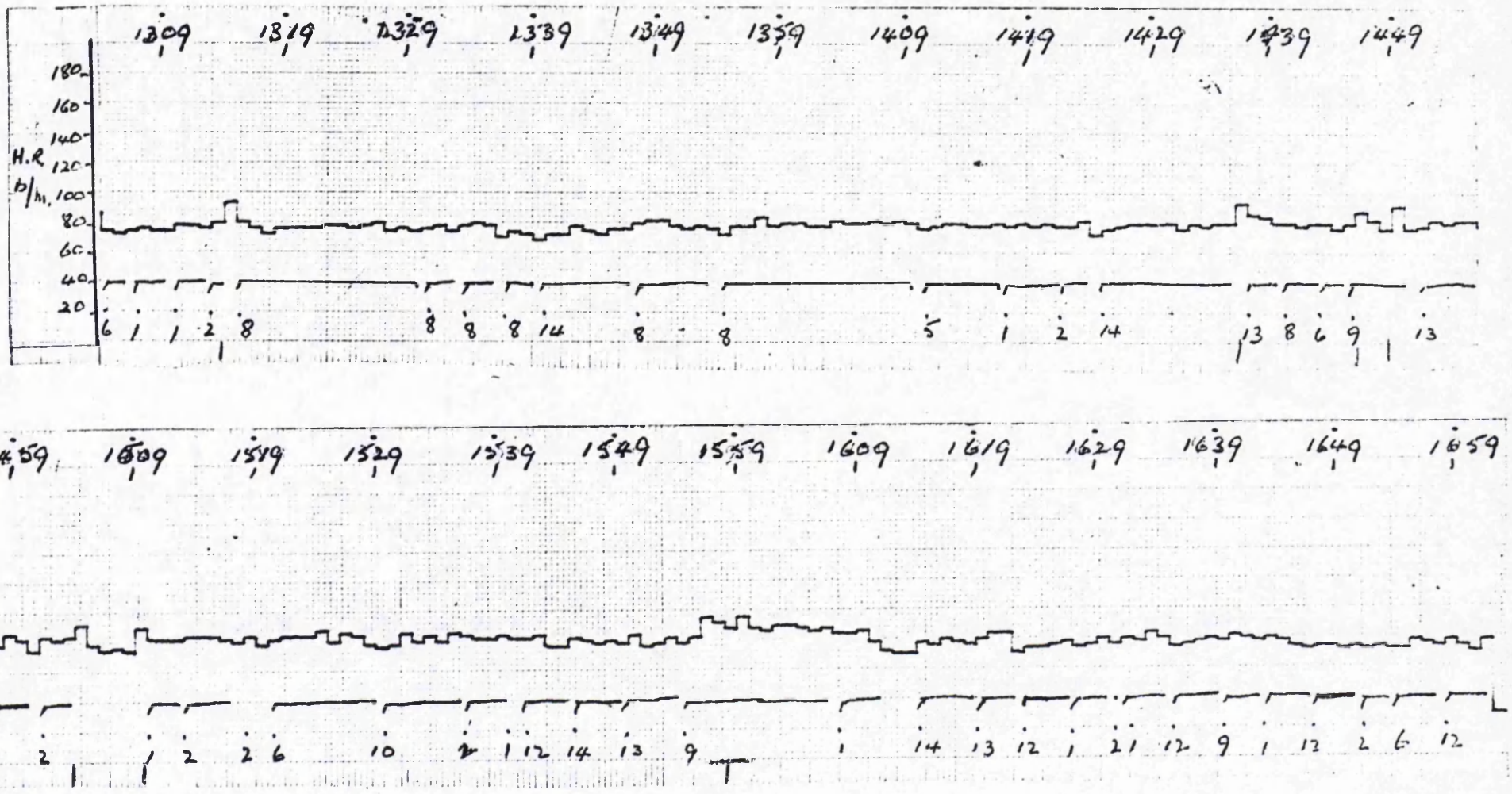
SUBJECT E

Personal Details

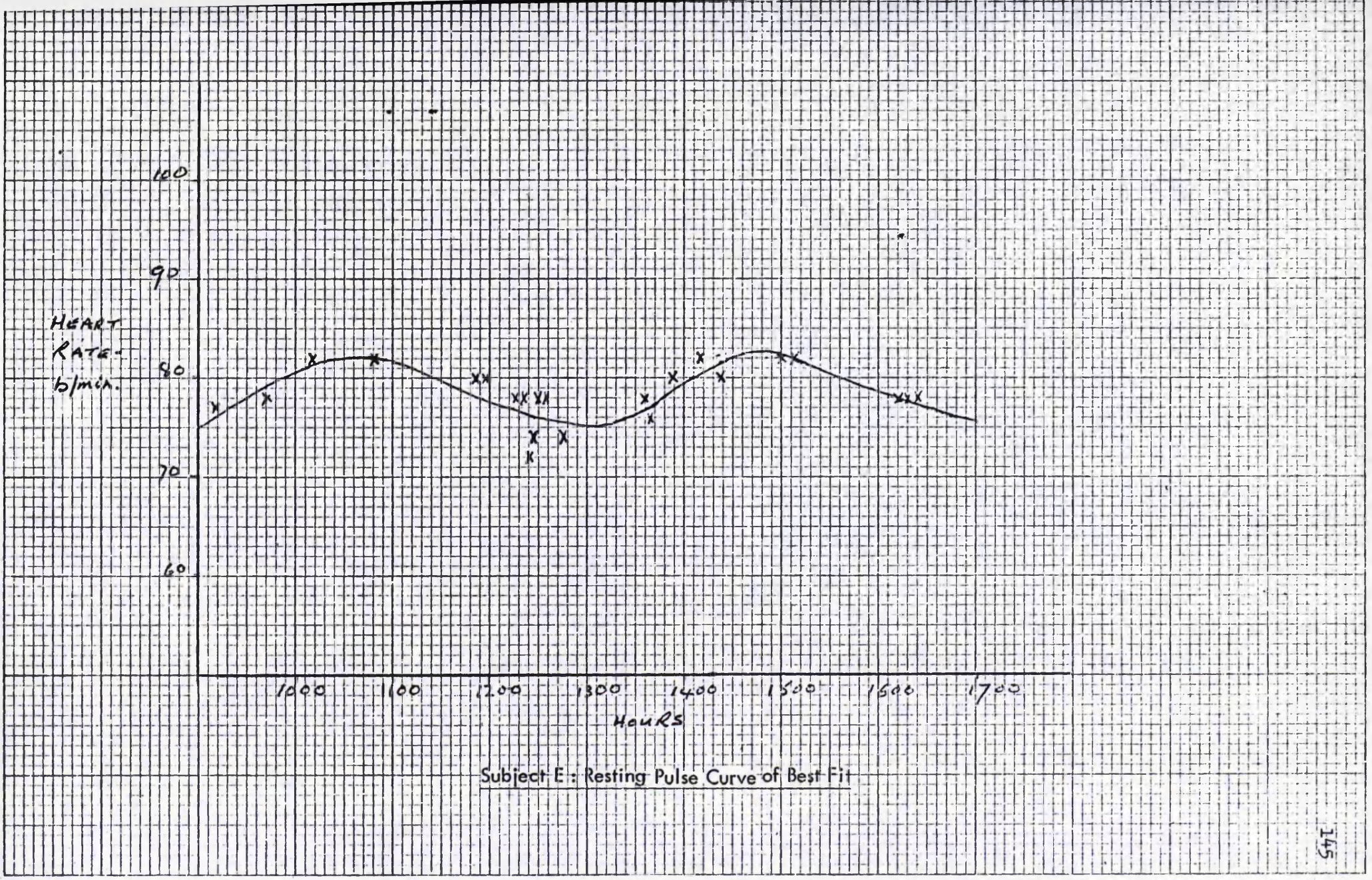
1)	Sex	Male
2)	Age	30
3)	General physical health	Very good
4)	Marital status	Single
5)	Smoking habits	30 cigarettes a day
6)	Drinking habits	Very little
7)	Hotel experience	$5\frac{1}{2}$ years
8)	Occupation	General Manager
9)	Size of hotel	Medium
10)	Stress experienced during study	Very little stress experienced
11)	General impression	Seems to be efficient, gets on well with staff.



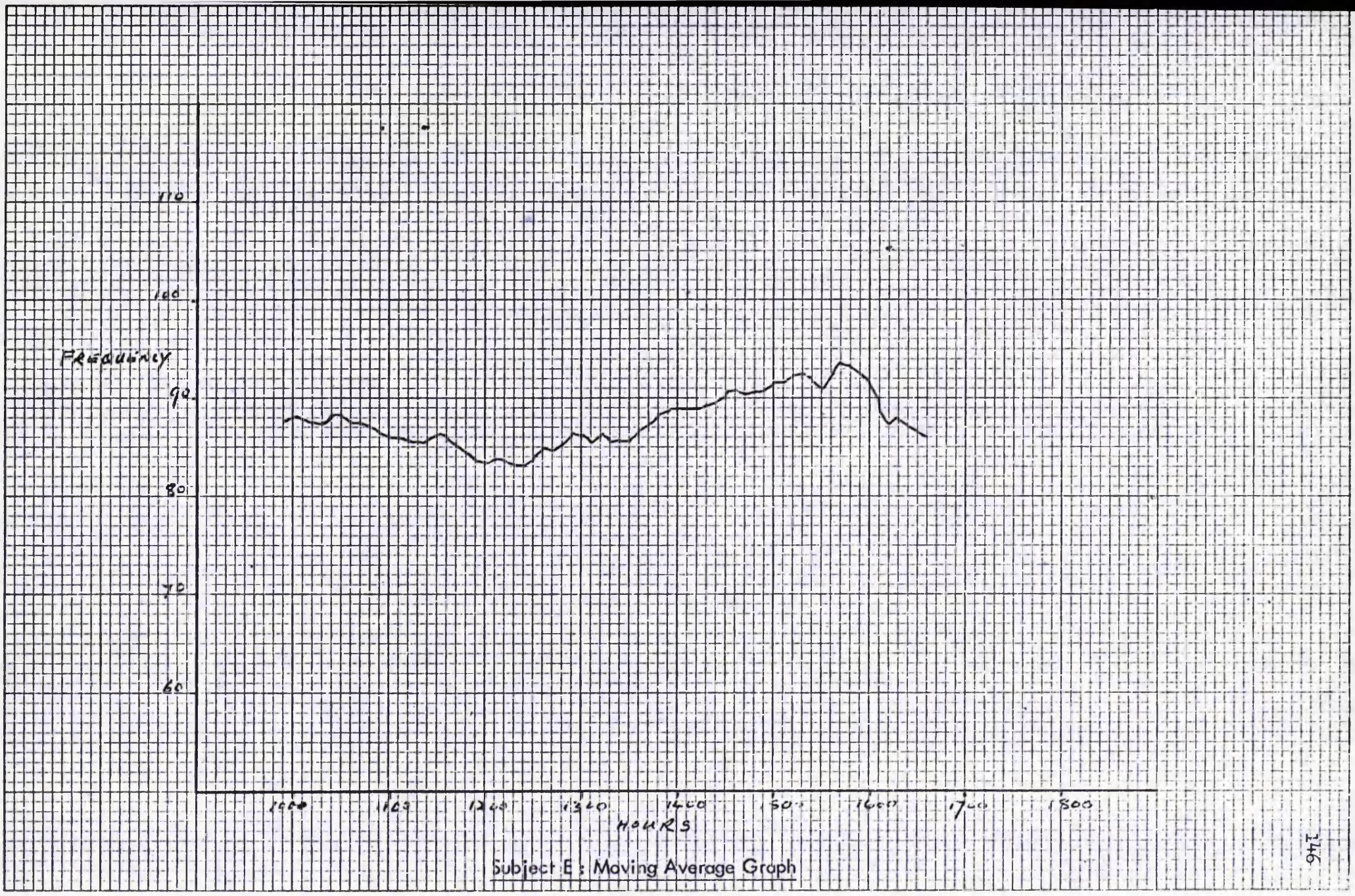
Subject E : Heart Rate Graph



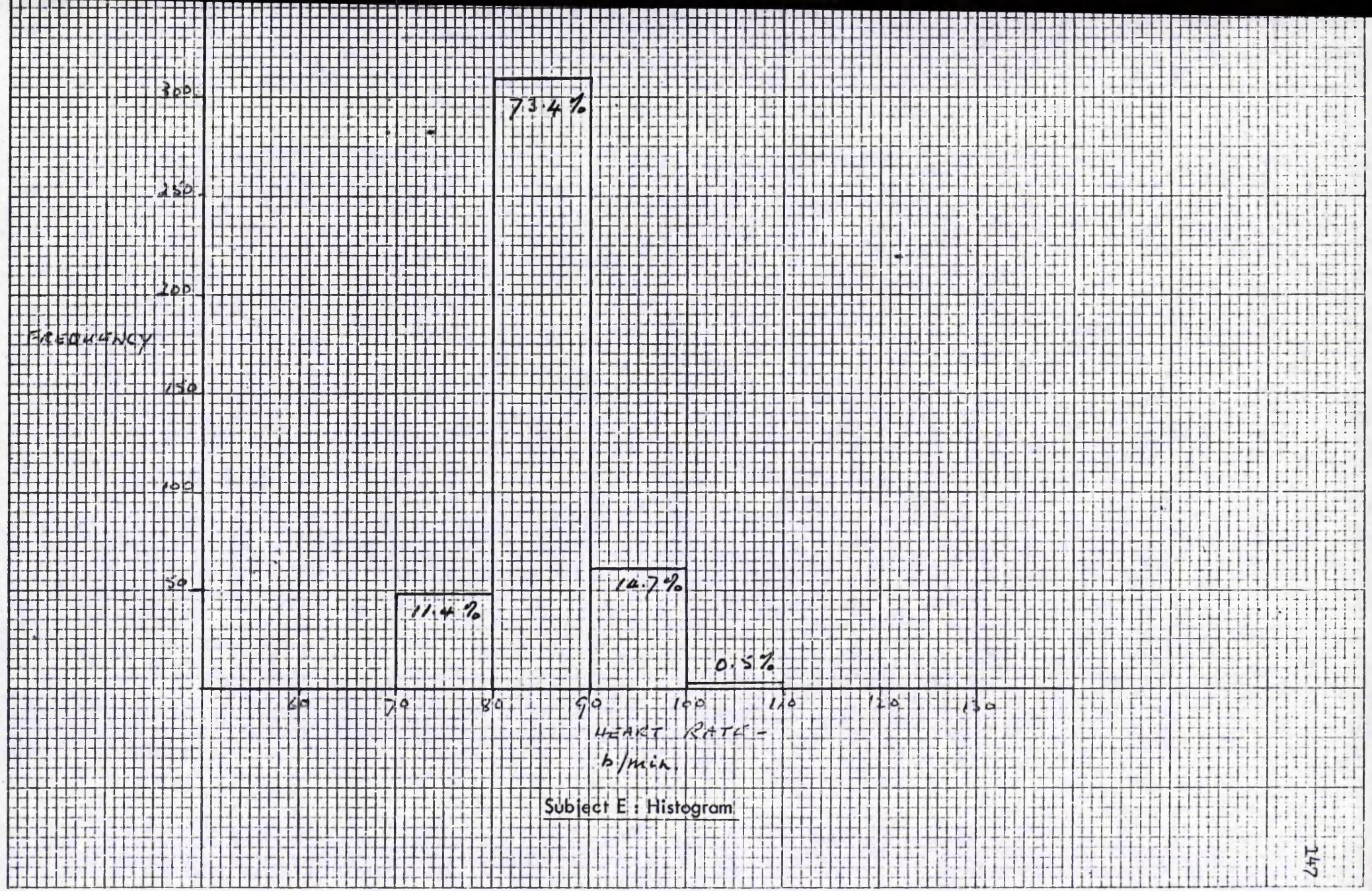
Subject E : Heart Rate Graph (contd.)



Subject E: Resting Pulse Curve of Best Fit



Subject E : Moving Average Graph



Subject E : Histogram

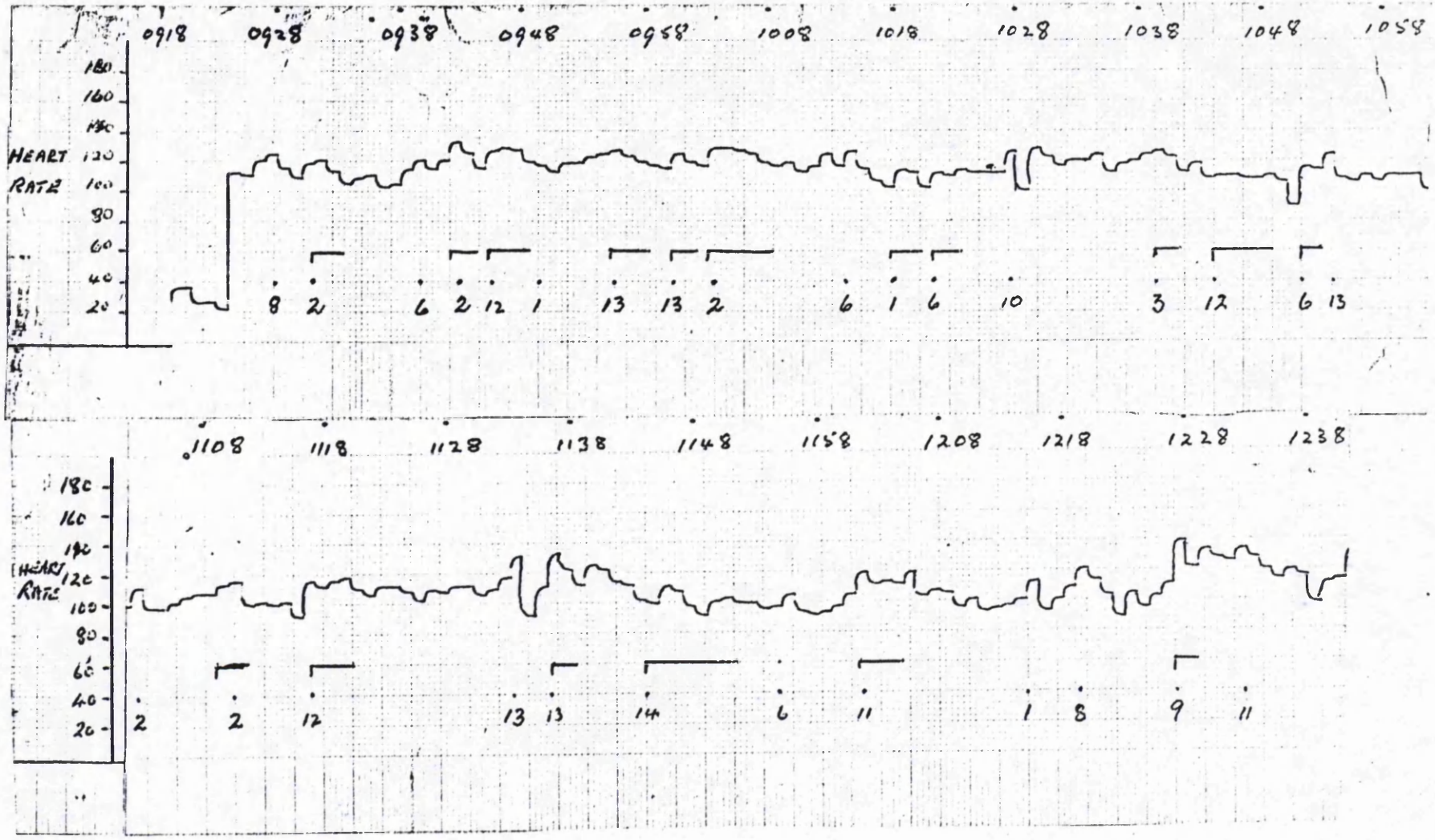
DESCRIPTION	ACTIVITY														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Heart Rates: Rest Pulses															
Sample Size	33	33	-	-	14	59	-	65	24	8	2	71	18	36	
Mean	87.21	89.64			87.14	86.88		85.54	93.83	90.50	90.00	84.65	89.33	84.72	
Standard deviation(corrected)	3.60	3.95			3.48	4.19		3.06	5.40	2.97	5.66	3.59	2.66	2.87	
S.E. of difference	2.333	2.378			2.529	2.297		2.084	2.165	2.619	2.847	2.162	2.391	2.211	
Degree of freedom	54	54			35	80		86	65	29	23	92	39	57	
't' value	4.451	5.386			4.079	4.377		4.183	7.855	5.221	4.627	3.617	5.230	3.571	
significance	H/S	H/S			H/S	H/S		H/S	H/S	H/S	H/S	H/S	H/S	H/S	
PERTURBATIONS															
Sample Size	33	33	-	-	14	59	-	65	24	8	2	71	18	36	
Mean	9.70	10.24			7.28	7.62		8.18	15.08	11.50	8.00	7.01	8.89	5.83	
S.D. (corrected)	3.13	3.49			2.90	4.01		2.80	6.01	3.34	5.66	2.79	3.23	2.55	
S.E. of difference	0.551	0.614			0.803	0.526		0.349	1.253	1.261	5.656	0.332	0.784	0.430	
Degree of freedom	32	32			13	58		64	23	7	1	70	17	35	
't' value	17.597	16.686			9.070	14.498		23.449	12.036	9.119	1.414	21.126	11.336	13.562	
significance	H/S	H/S			H/S	H/S		H/S	H/S	H/S	N/S	H/S	H/S	H/S	

Subject E : Activity Analysis Table

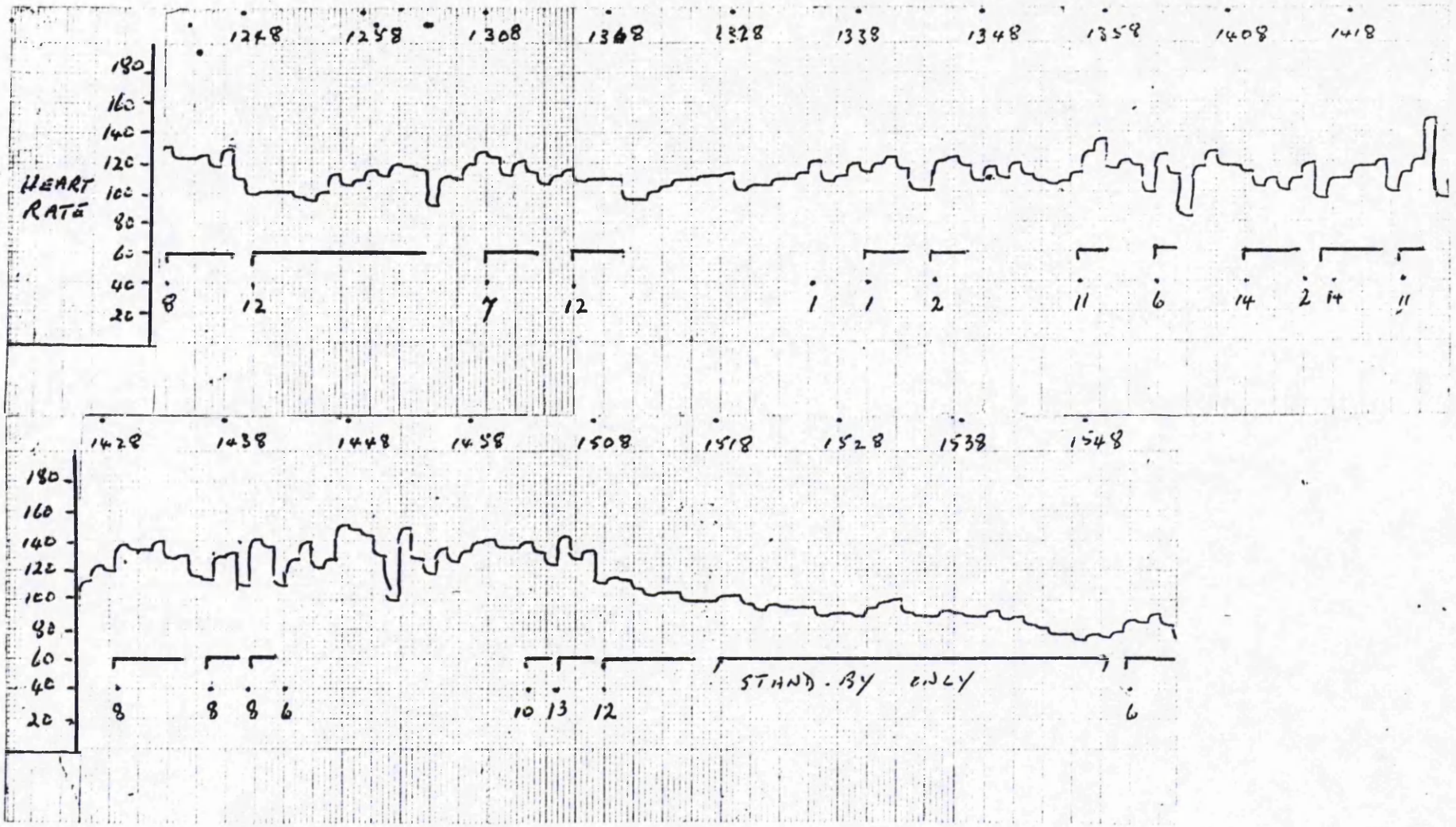
SUBJECT F

Personal Details

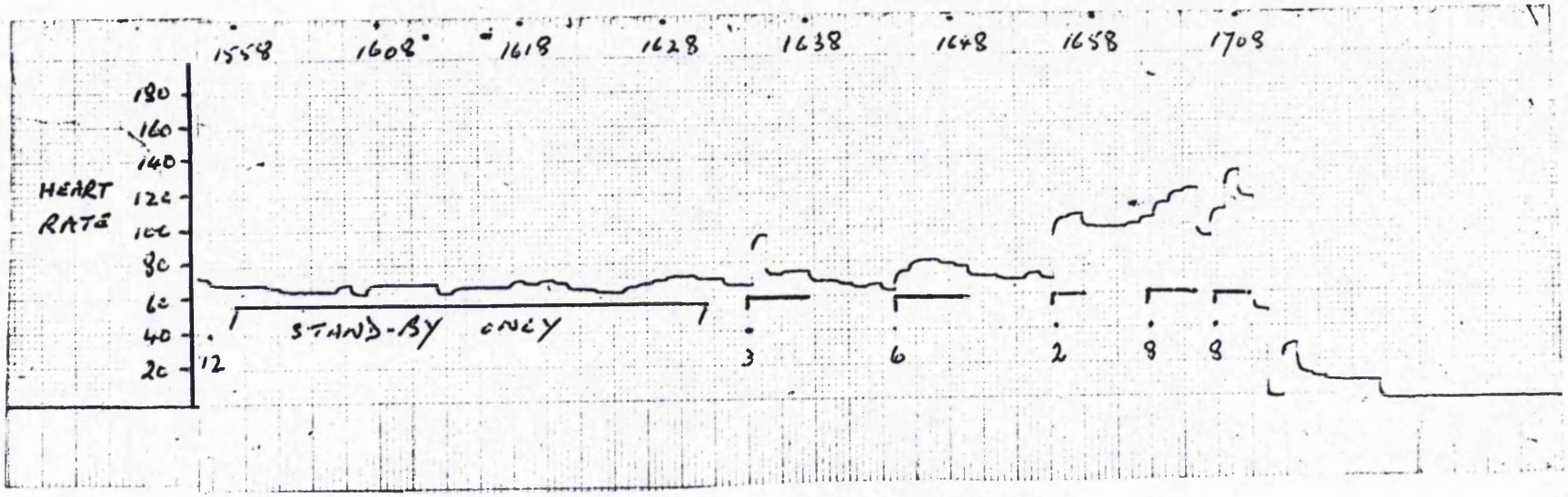
1)	Sex	Female
2)	Age	23
3)	General Physical Health	Good
4)	Marital status	Single
5)	Smoking habits	20 cigarettes a day
6)	Drinking habits	2 drinks only
7)	Hotel experience	2 years
8)	Occupation	General Manager (temporary)
9)	Size of hotel	Small
10)	Stress experienced during study	Felt some stress during the study
11)	General impression	Normal job: Administration Manager, not very experienced but seems to be efficient.



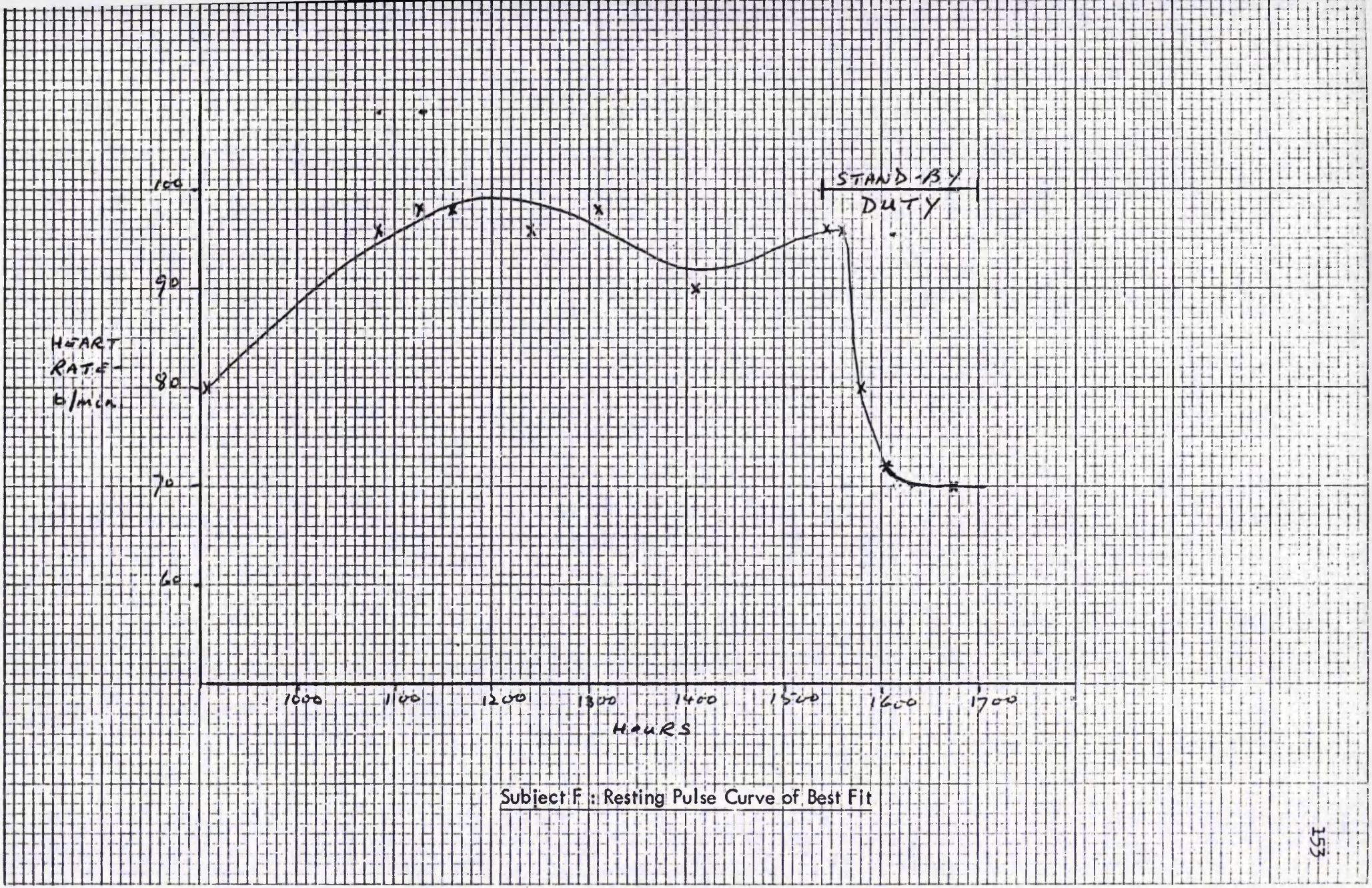
Subject F : Heart Rate Graph



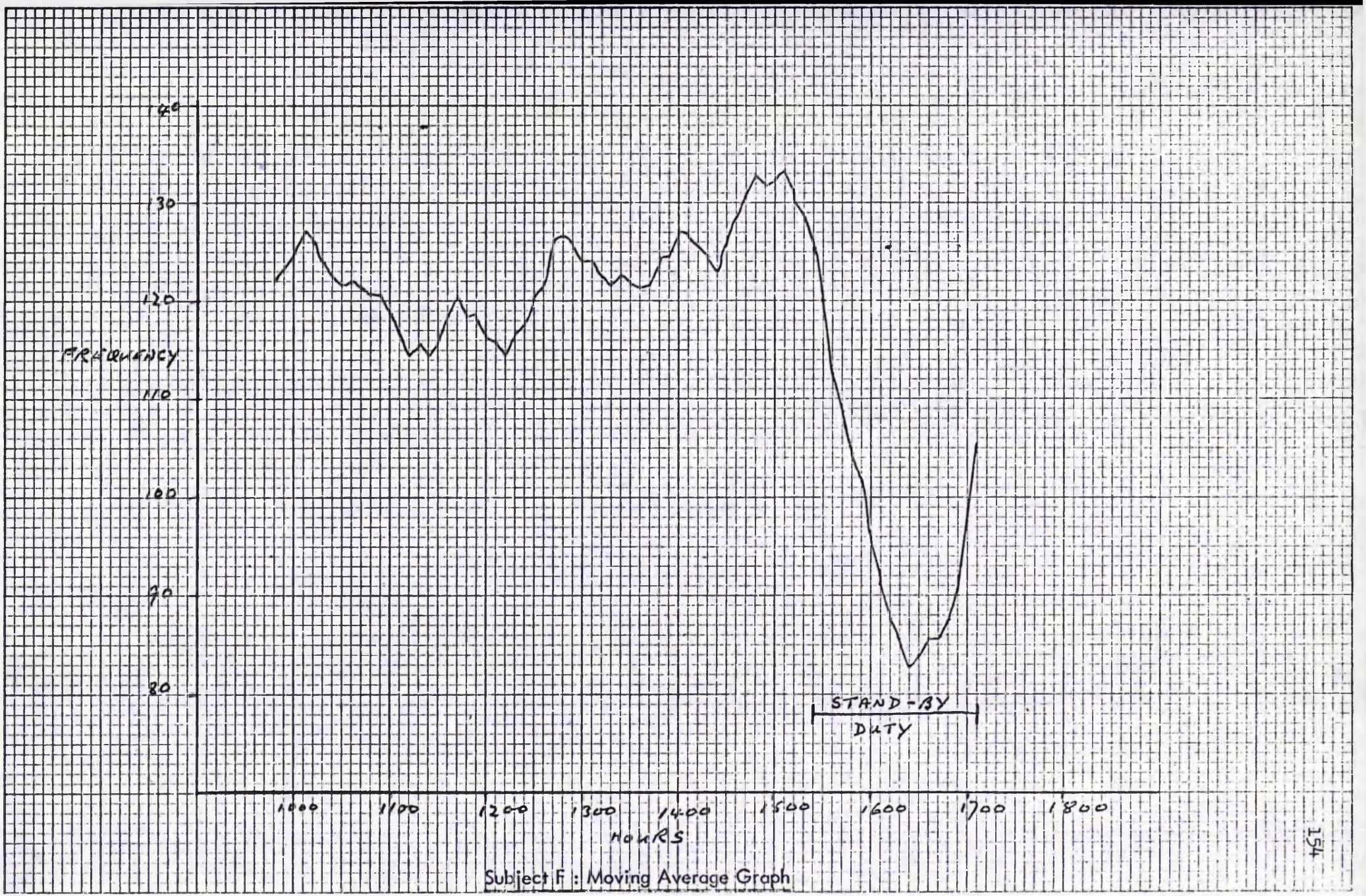
Subject F : Heart RateGraph (contd.)



Subject F : Heart Rate Graph (contd.)



Subject F : Resting Pulse Curve of Best Fit



Subject F : Moving Average Graph

Subject F : Histogram

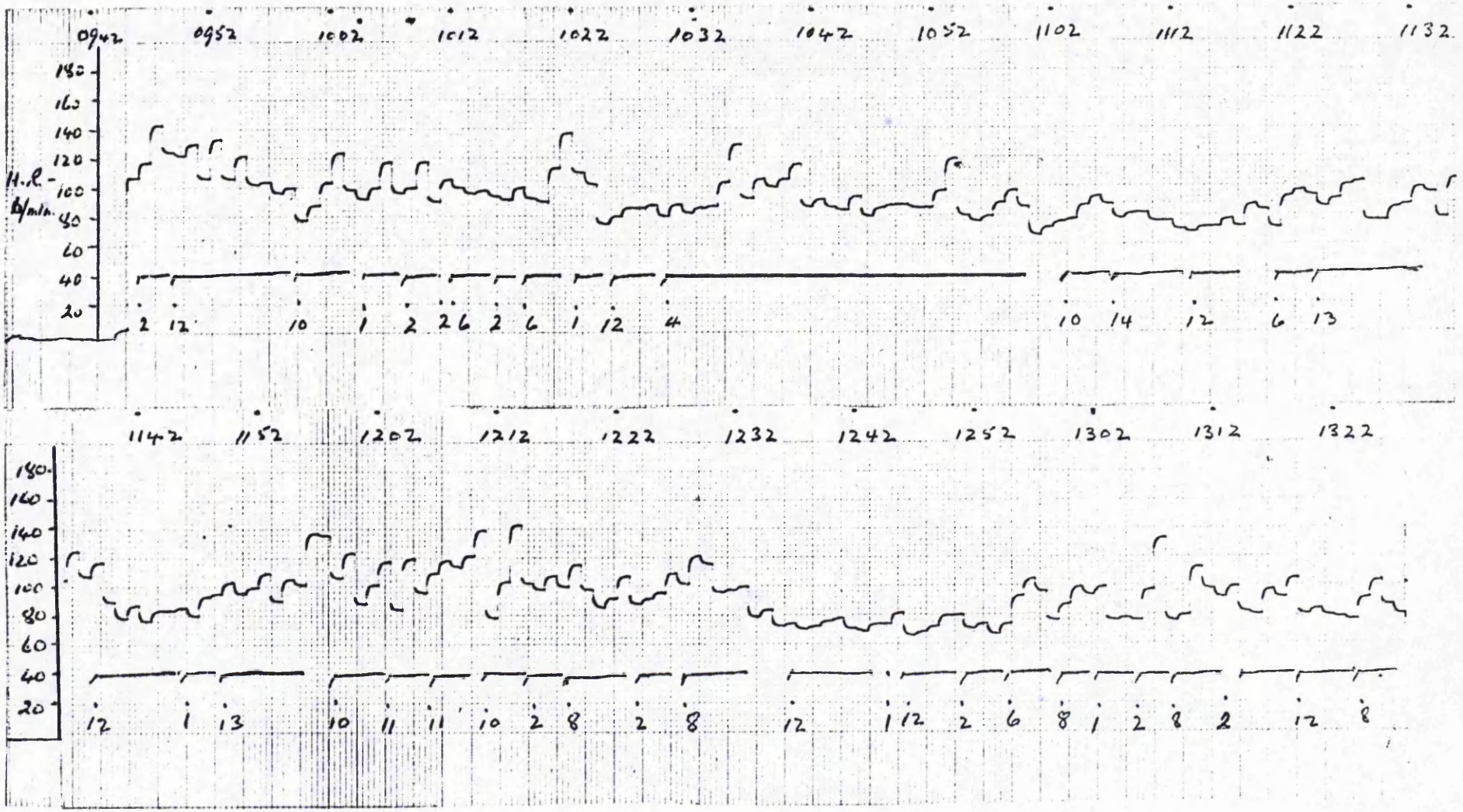
DESCRIPTION	ACTIVITY														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Heart Rates: Rest Pulses															
Sample Size	10	19	9	-	-	19	4	24	2	4	9	39	12	20	-
Mean	123.20	125.47	108.89			106.95	127.50	133.42	137.00	136.75	126.67	115.74	134.00	112.40	
Standard deviation(corrected)	4.02	7.02	22.25			18.50	6.81	8.29	12.73	7.27	8.54	9.43	7.58	7.55	
S.E. of difference	2.895	2.998	4.153			4.063	3.284	3.098	3.569	3.343	2.916	3.178	3.150	3.046	
Degree of freedom	20	29	19			29	14	34	12	14	19	49	22	30	
't' value	11.756	12.110	4.748			4.376	11.672	14.324	13.402	14.233	12.860	8.363	14.233	7.627	
significance	H/S	H/S	H/S			H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	
PERTURBATIONS															
Sample Size	10	19	9	-	-	19	4	24	2	4	9	39	12	20	-
Mean	31.50	37.89	25.56			24.05	32.00	45.33	39.00	42.50	30.89	20.90	40.92	17.30	
S.D. (corrected)	12.41	7.77	11.38			10.01	6.376	6.87	12.73	7.32	10.87	9.55	5.54	9.85	
S.E. of difference	4.136	1.830	4.025			2.359	3.681	1.433	12.727	4.228	3.624	1.548	1.669	2.260	
Degree of freedom	9	18	8			18	3	23	1	3	8	38	11	19	
't' value	7.616	20.707	6.349			10.196	8.693	31.635	3.064	10.052	8.523	13.499	24.515	7.654	
significance	H/S	H/S	H/S			H/S	H/S	H/S	N/S	H/S	H/S	H/S	H/S	H/S	

Subject F : Activity Analysis Table

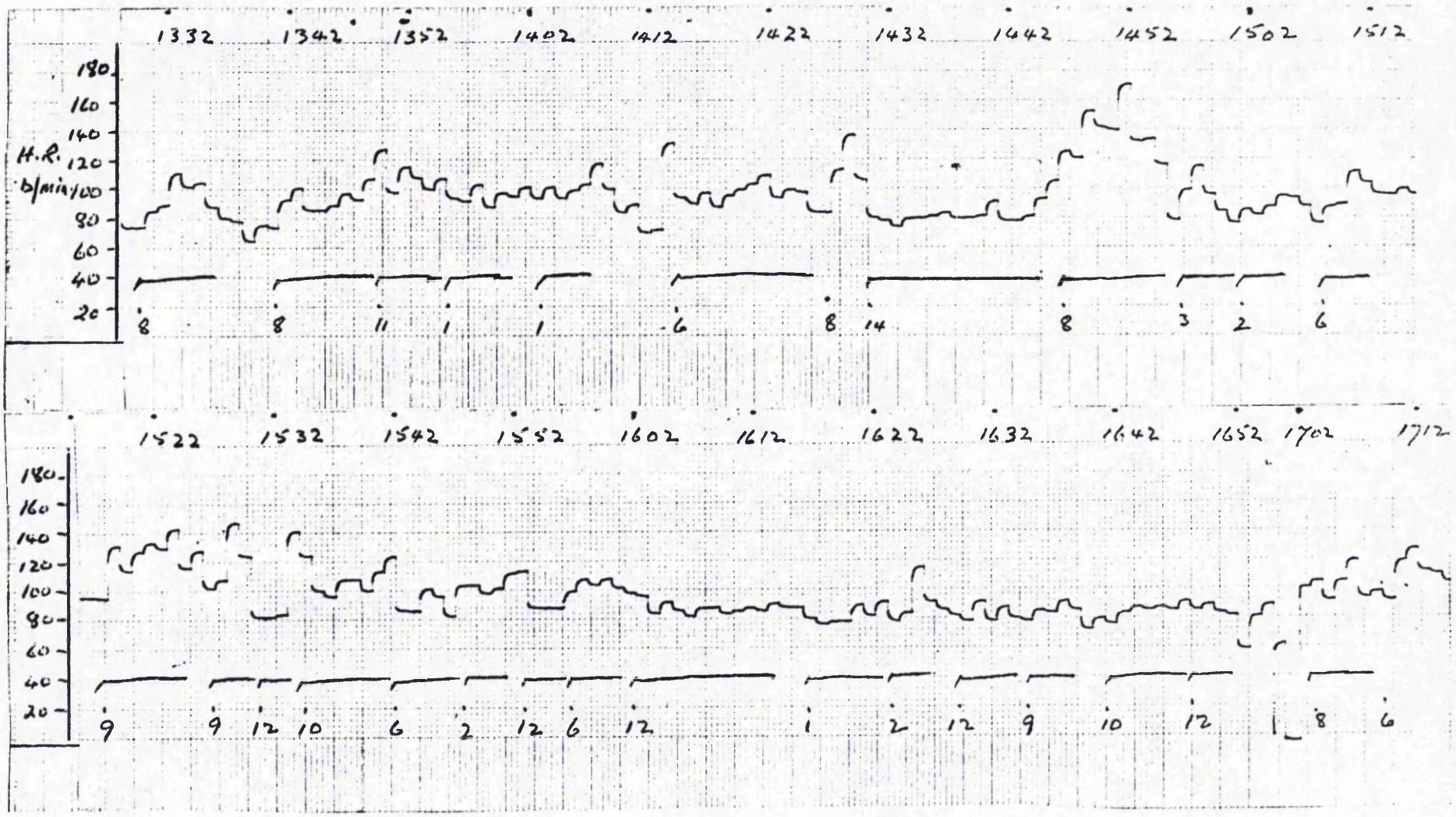
SUBJECT G

Personal Details

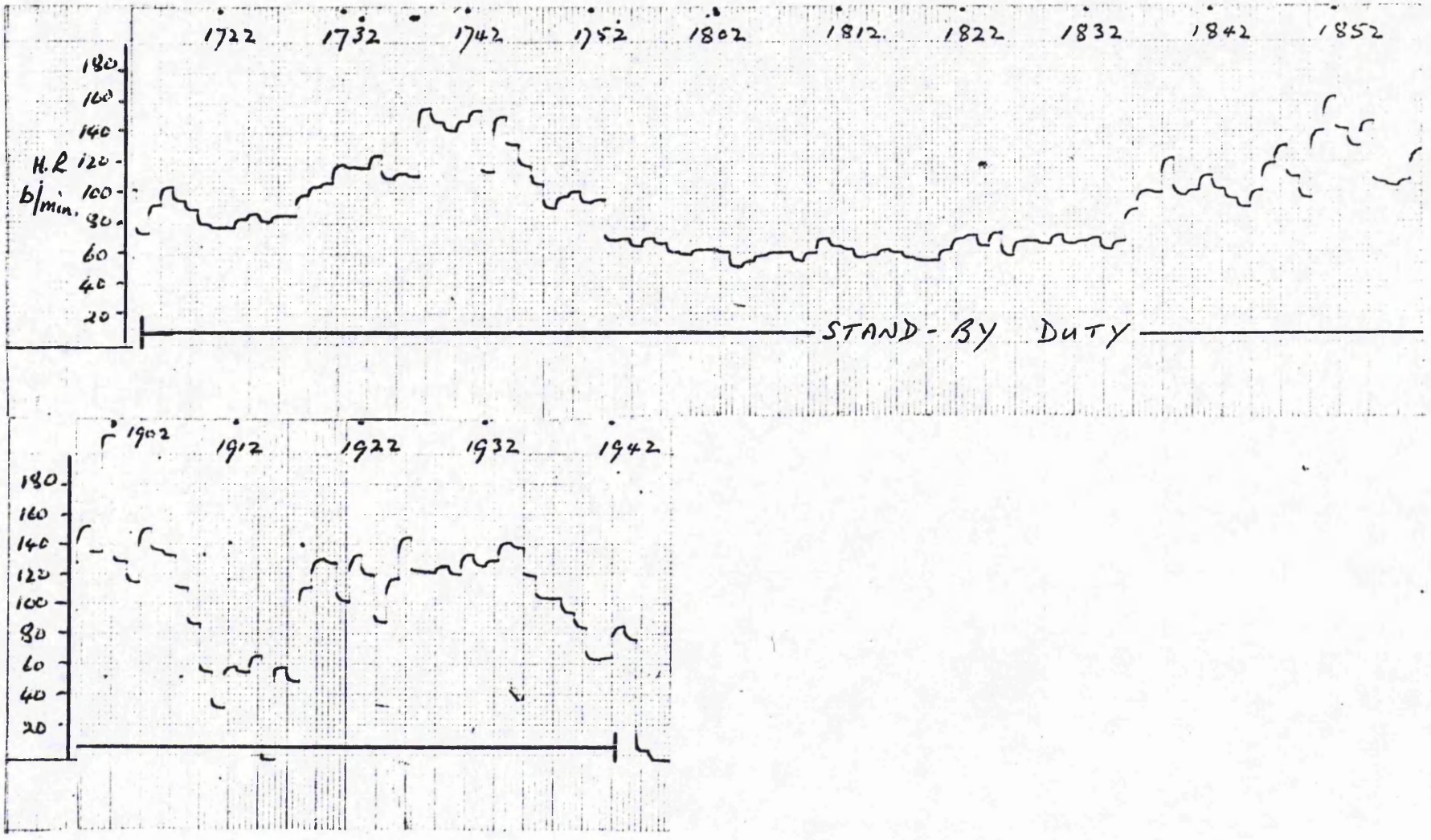
1)	Sex	Male
2)	Age	30
3)	General physical health	Good
4)	Marital status	Married
5)	Smoking habits	4 cigars a day
6)	Drinking habits	2 half-pints beer at lunch
7)	Hotel experience	6 years
8)	Occupation	General Manager
9)	Size of hotel	Medium
10)	Stress experienced during study	Felt some stress
11)	General impression	Very interested in the study, seemed nervous.



Subject G : Heart Rate Graph

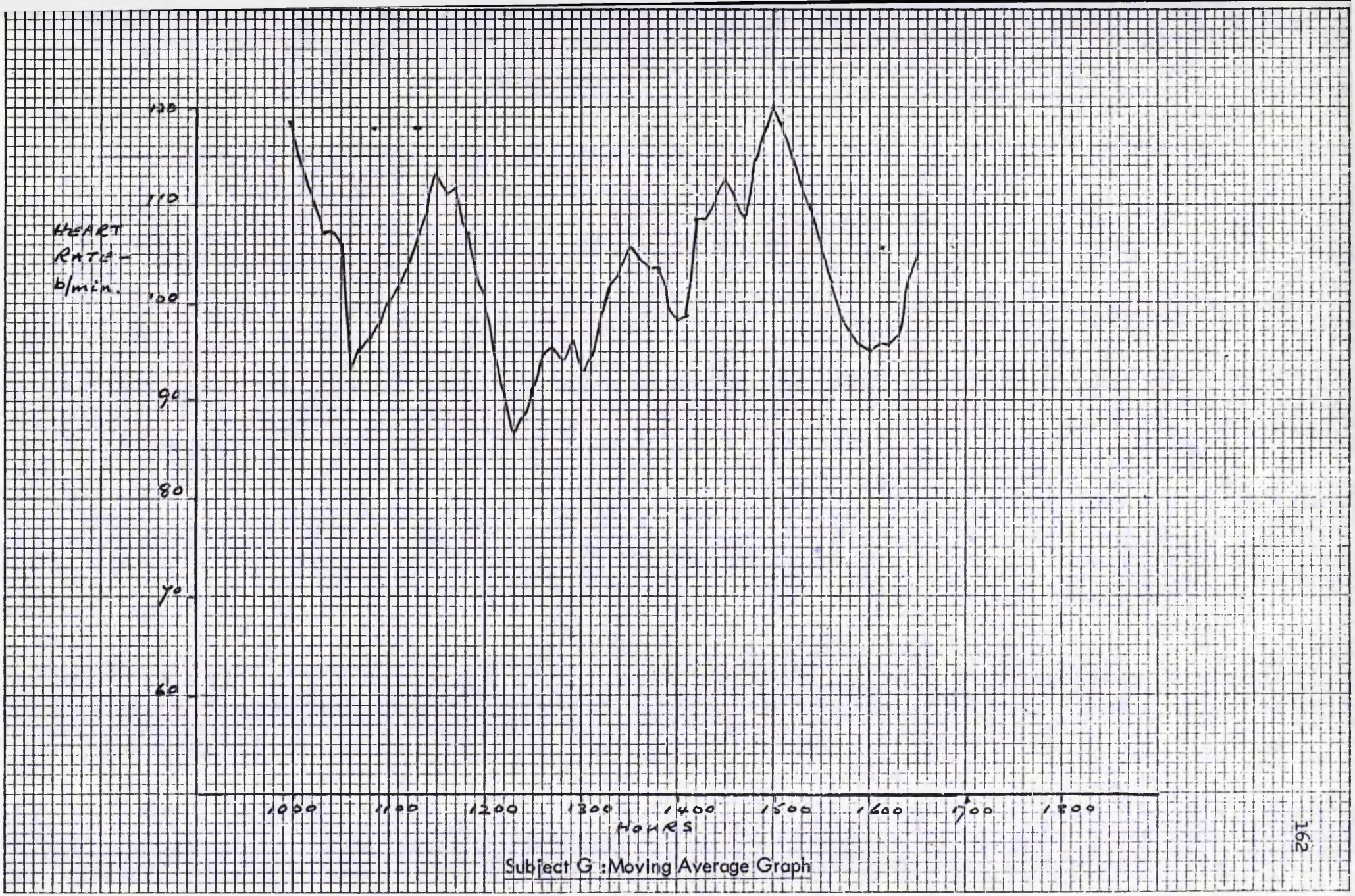


Subject G : Heart Rate Graph (contd.)

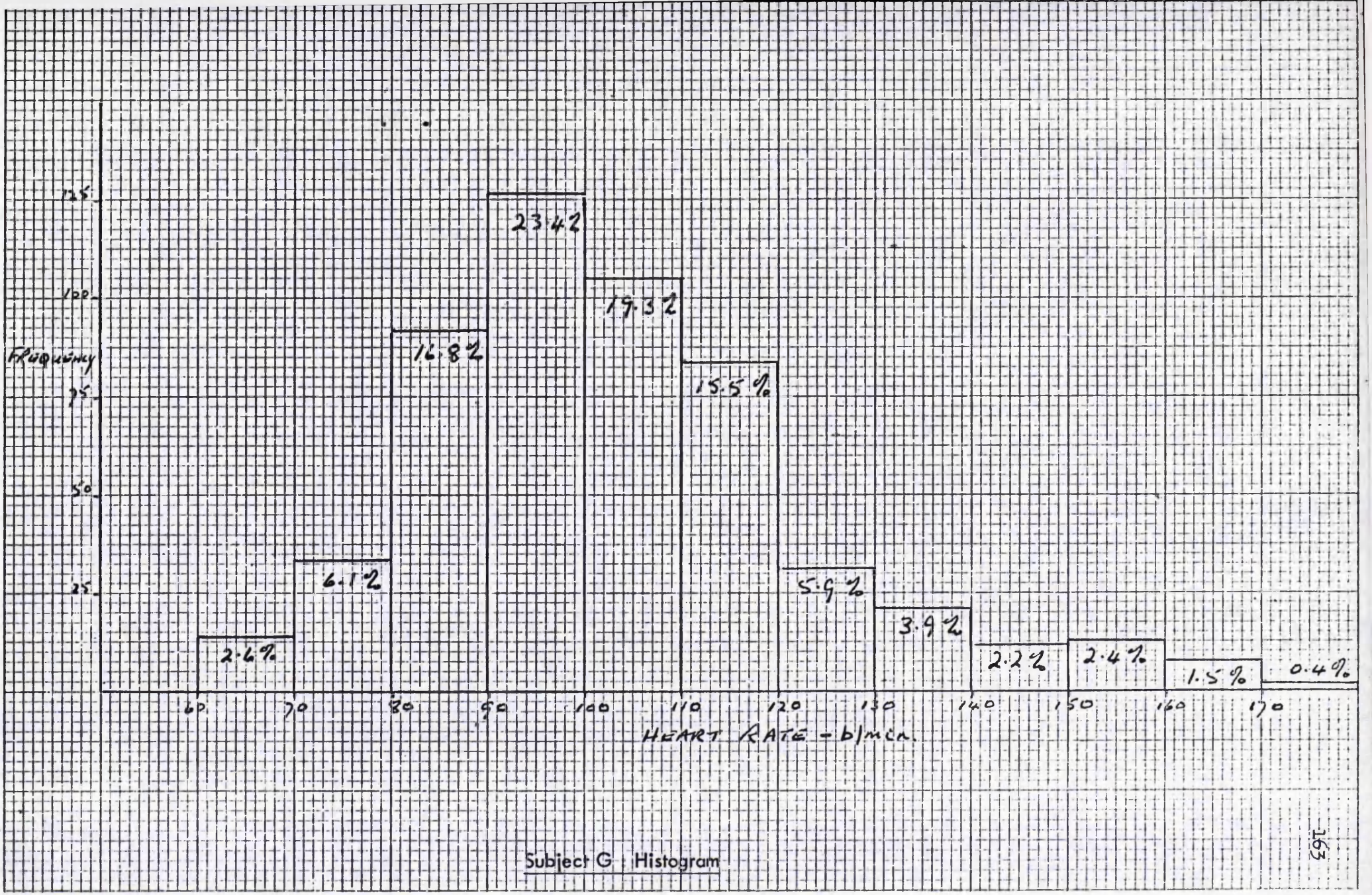


Subject G : Heart Rate Graph (contd.)

Subject G : Resting Pulse Curve of Best Fit



Subject G : Moving Average Graph



Subject G Histogram

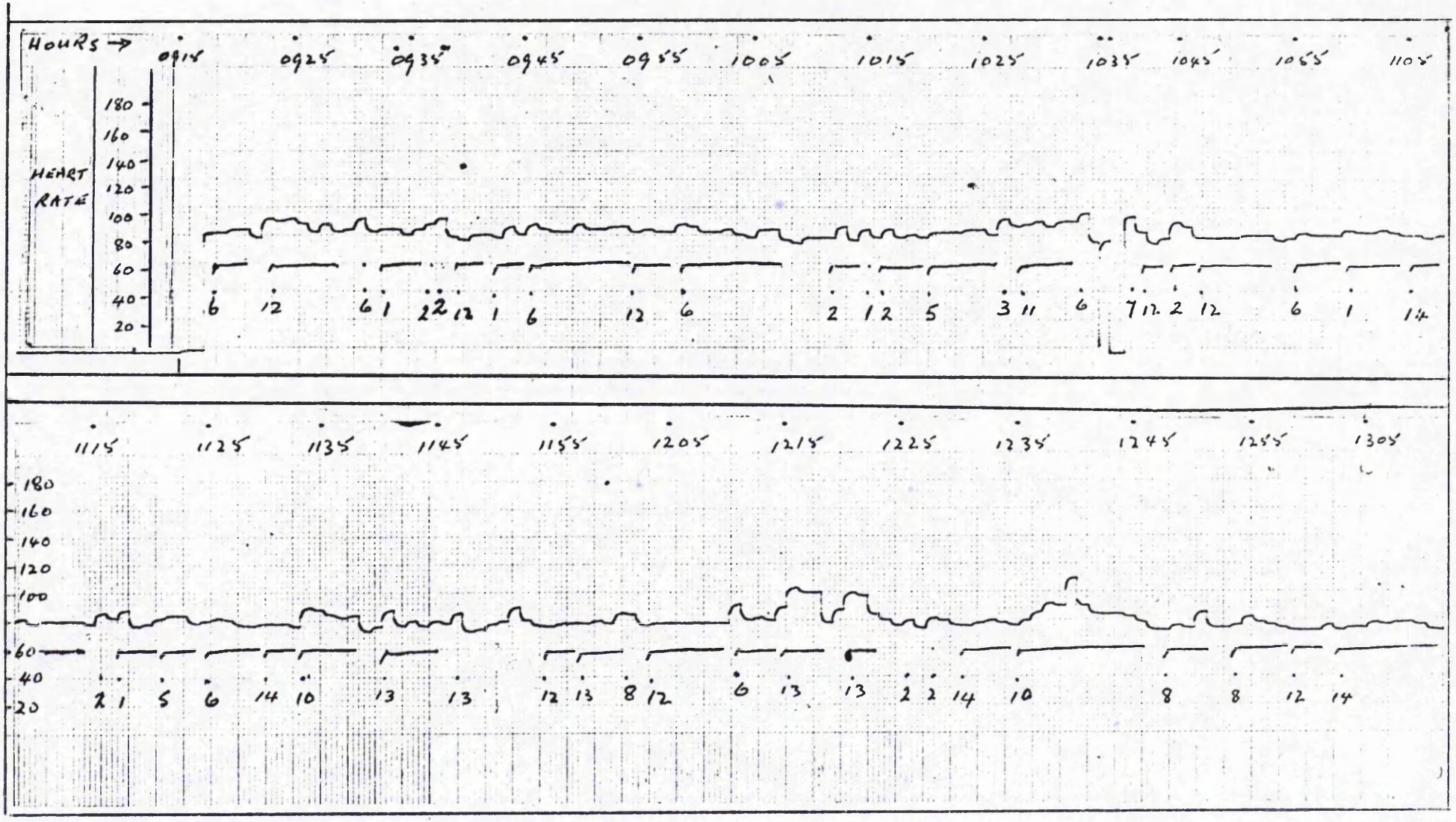
DESCRIPTION	ACTIVITY														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Heart Rates: Rest Pulses															
Sample Size	35	39	7	30	-	43	-	47	14	32	16	72	20	21	-
Mean	104.63	109.85	102.00	103.40		104.79		113.32	128.86	111.94	117.12	97.97	106.30	91.05	
Standard deviation(corrected)	10.81	16.31	11.99	12.61		10.89		20.49	20.35	16.55	9.04	14.17	9.50	7.00	
S.E. of difference	3.206	3.847	3.144	3.407		3.229		4.303	3.951	3.837	2.959	3.676	3.018	2.715	
Degree of freedom	44	48	16	39		52		56	23	41	25	81	29	30	
't' value	7.795	7.852	7.113	6.975		7.790		7.827	12.457	8.418	12.669	4.988	8.834	4.202	
significance	H/S	H/S	H/S	H/S		H/S		H/S	H/S	H/S	H/S	H/S	H/S	H/S	
PERTURBATIONS															
Sample Size	35	39	7	30	-	43	-	47	14	32	16	72	20	21	-
Mean	30.86	30.61	15.14	27.40		25.53		39.11	41.71	29.87	44.12	18.39	27.40	13.63	
S.D. (corrected)	13.42	17.84	12.80	12.62		10.77		16.83	18.94	16.49	8.048	14.80	9.04	7.37	
S.E. of difference	2.301	2.894	5.225	2.342		1.662		2.481	5.252	2.962	2.077	1.756	2.073	1.647	
Degree of freedom	34	38	6	29		42		46	13	31	15	71	19	20	
't' value	13.409	10.578	2.897	11.699		15.363		15.762	7.942	10.085	21.244	10.471	13.217	8.268	
significance	H/S	H/S	S	H/S		H/S		H/S	H/S	H/S	H/S	H/S	H/S	H/S	

Subject G : Activity Analysis Table

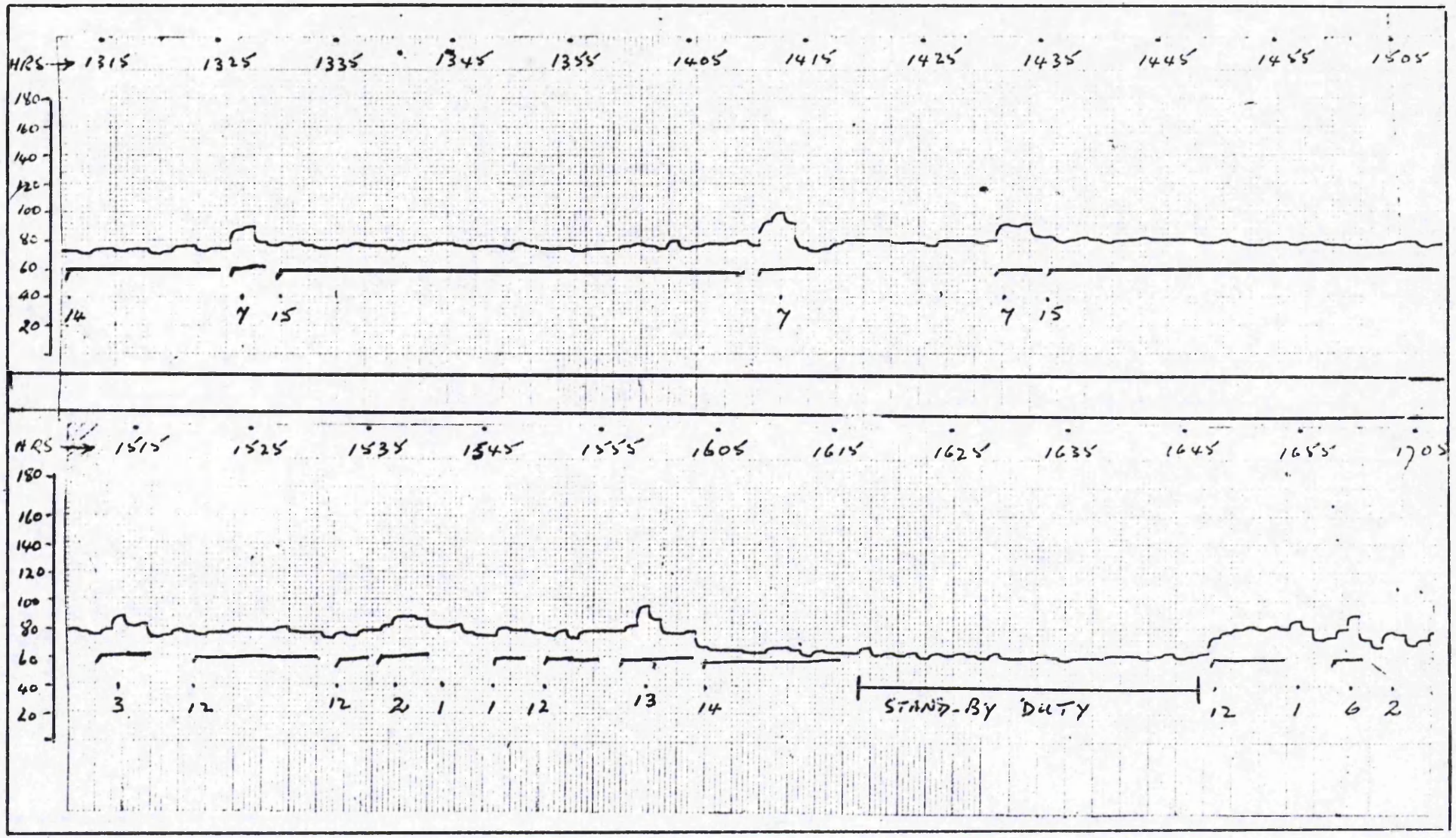
SUBJECT H

Personal Details

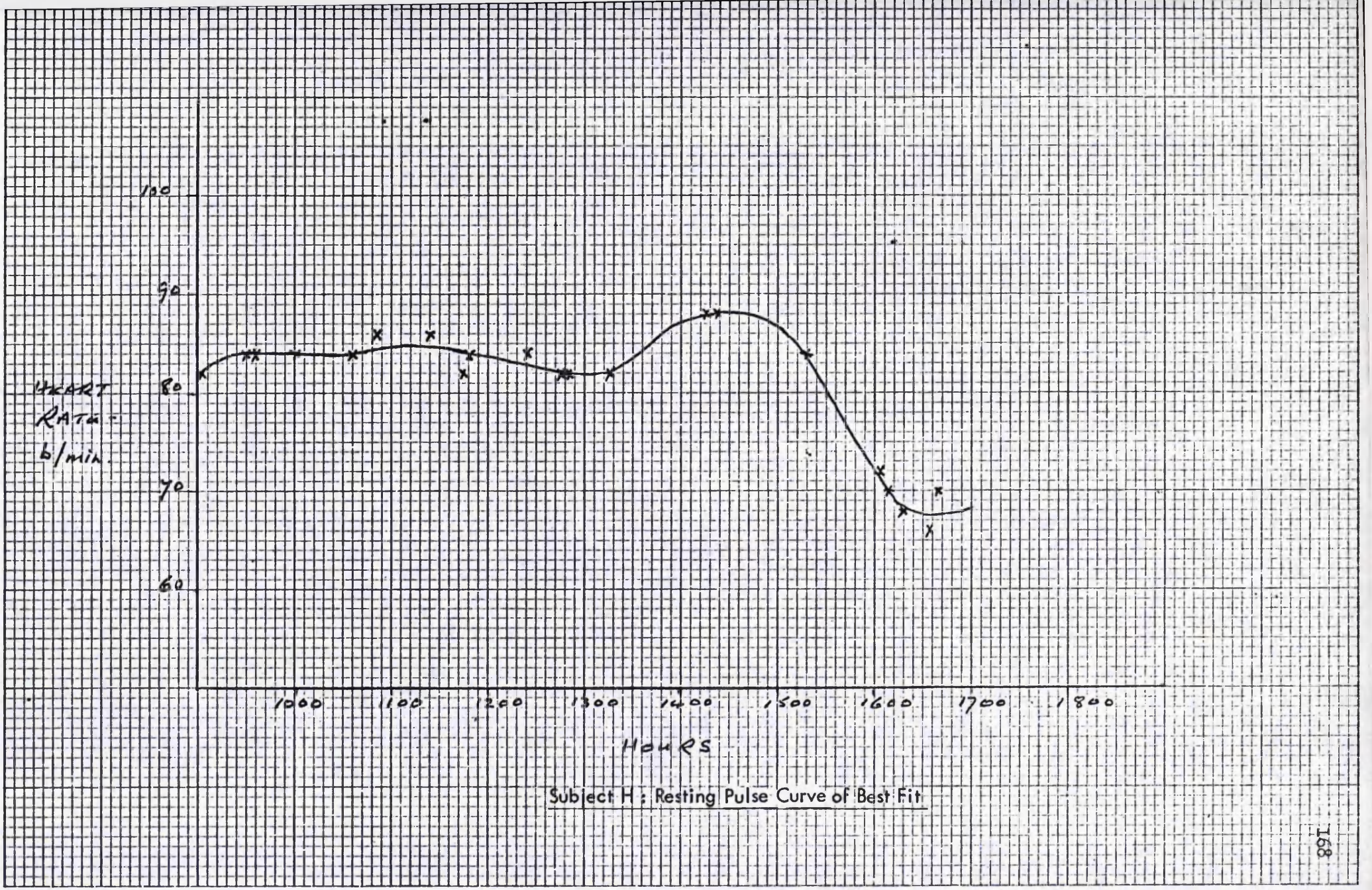
1)	Sex	Male
2)	Age	27
3)	General Physical Health	Fit
4)	Marital status	Single
5)	Smoking habits	30 cigarettes a day
6)	Drinking habits	No drinking at work, ½-pint lager at home
7)	Hotel experience	11½ years
8)	Occupation	Deputy General Manager
9)	Size of hotel	Large
10)	Stress experienced during study	No stress experienced
11)	General impression	Competent, smart.



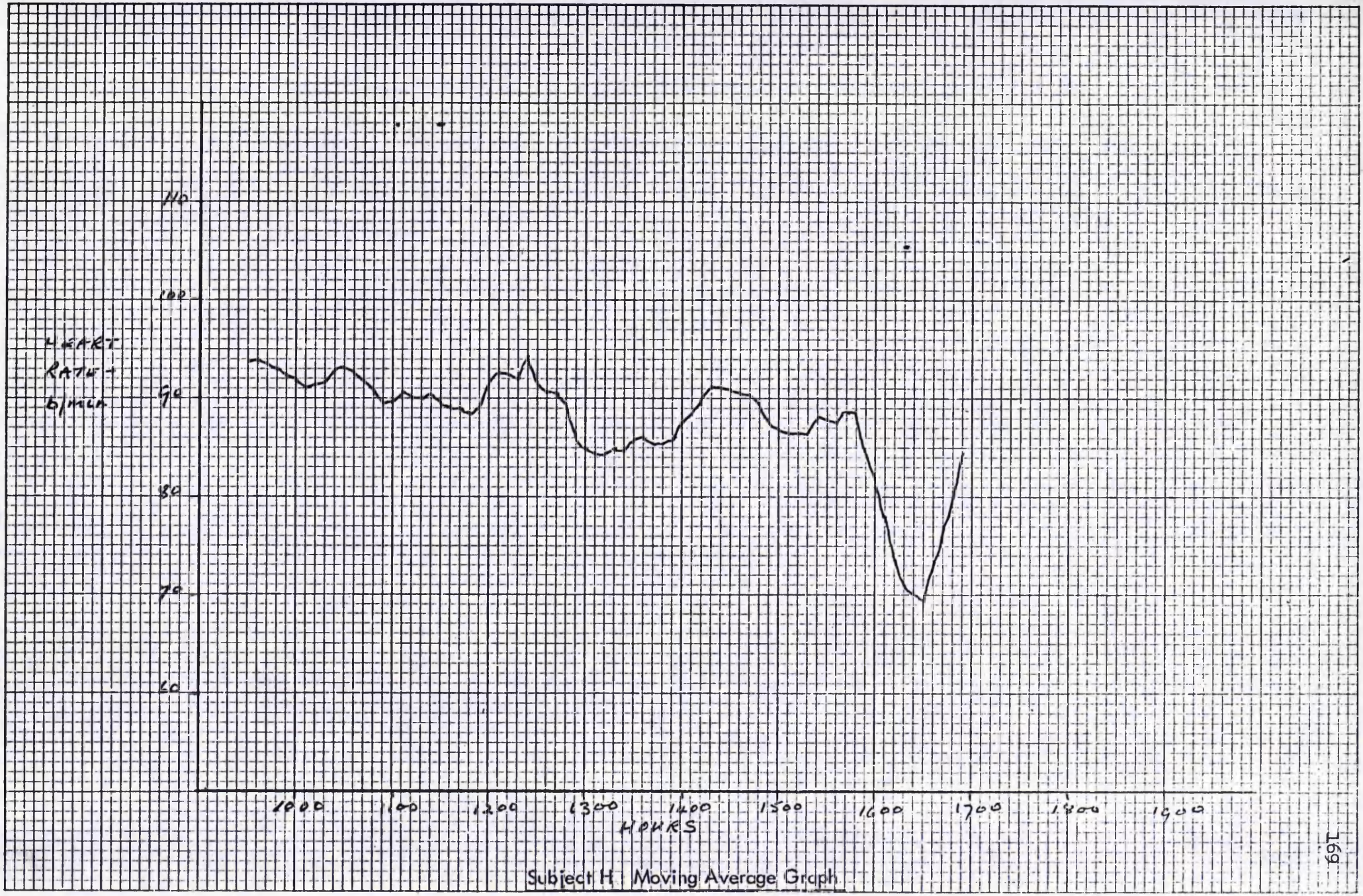
Subject H : Heart Rate Graph



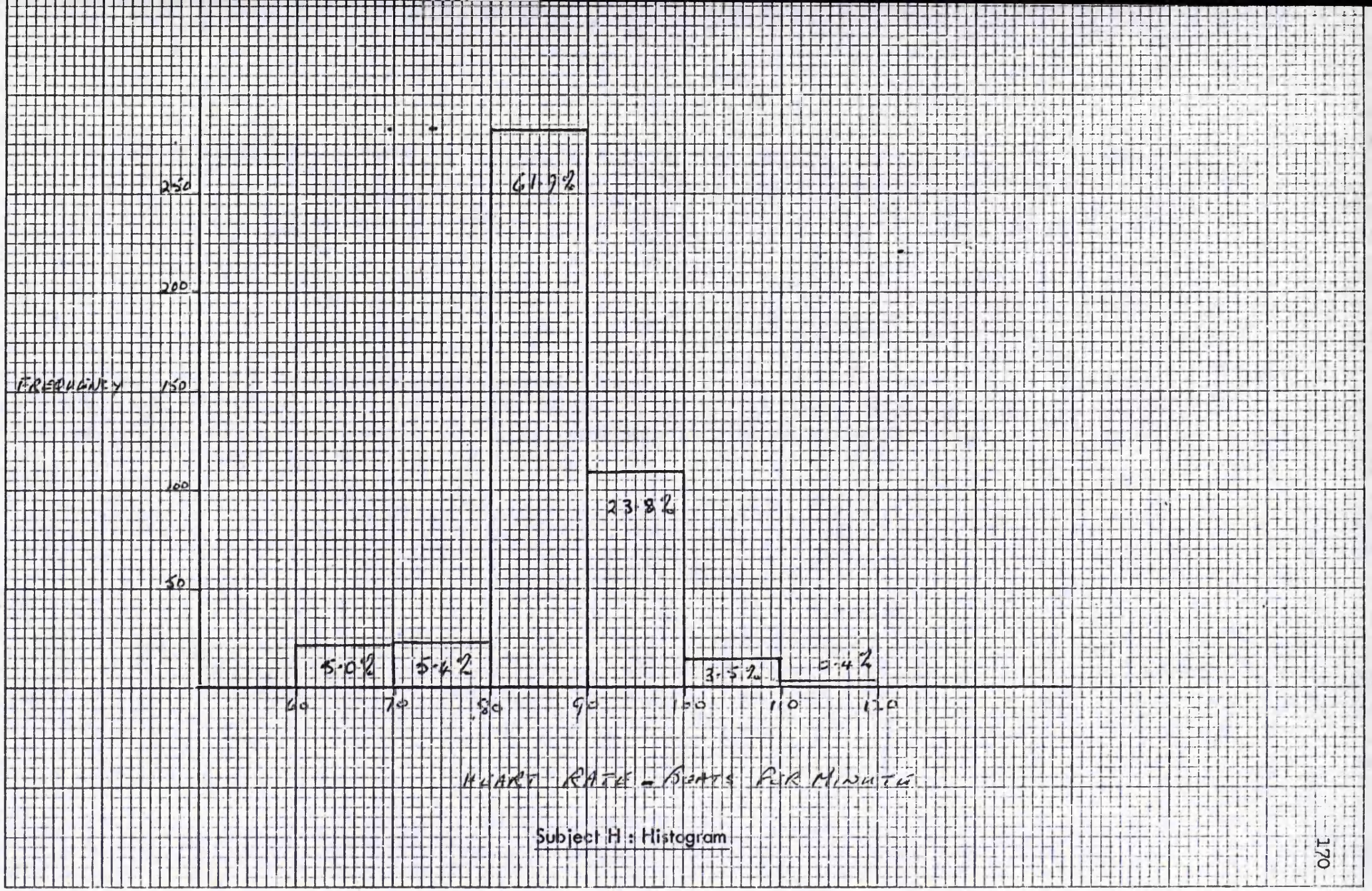
Subject H : Heart Rate Graph (contd.)



Subject H : Resting Pulse Curve of Best Fit



Subject H Moving Average Graph



Subject H : Histogram

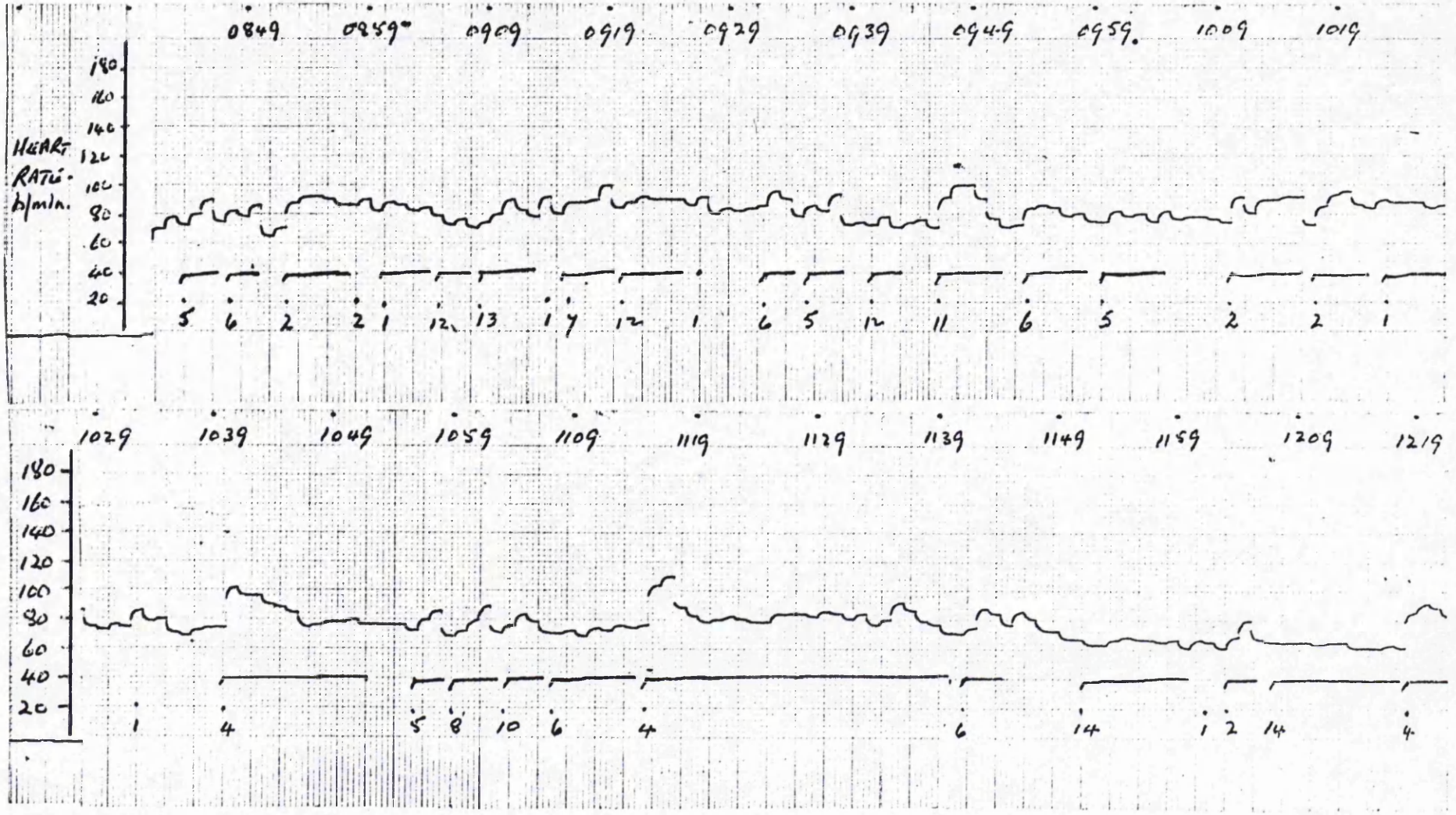
DESCRIPTION	ACTIVITY														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Heart Rates: Rest Pulses															
Sample Size	20	22	5	-	10	42	13	7	-	14	6	68	22	46	83
Mean	91.60	92.73	92.80		91.40	92.05	94.61	89.71		97.86	98.33	88.97	94.18	83.87	87.52
Standard deviation(corrected)	2.39	4.94	7.69		1.90	5.59	8.64	4.96		7.18	2.05	4.24	8.70	5.87	3.286
S.E. of difference	2.215	2.481	2.754		2.367	2.490	2.827	2.613		2.719	2.496	2.227	2.858	2.522	2.020
Degree of freedom	39	41	24		29	61	32	26		33	25	37	41	65	02
't' value	4.979	4.899	4.440		4.575	4.608	4.967	4.217		6.357	7.116	3.771	4.762	1.307	3.439
significance	H/S	H/S	H/S		H/S	H/S	H/S	H/S		H/S	H/S	H/S	H/S	H/S	H/S
PERTURBATIONS															
Sample Size	20	22	5		10	42	13	7		14	6	68	22	46	83
Mean	9.80	10.73	9.20		7.40	9.90	8.77	7.43		15.14	14.33	9.09	10.18	3.87	1.93
S.D. (corrected)	2.75	6.31	7.05		1.90	4.76	8.93	4.58		7.47	1.97	7.10	6.08	3.22	2.73
S.E. of difference	0.629	1.376	3.507		0.632	0.742	2.577	1.868		2.070	0.884	0.867	1.325	0.480	0.301
Degree of freedom	19	21	4		9	41	12	6		13	5	67	21	45	82
't' value	15.589	7.795	2.623		11.708	13.347	3.402	3.976		7.314	16.212	10.482	7.683	8.058	6.398
significance	H/S	H/S	N/S		H/S	H/S	H/S	H/S		H/S	H/S	H/S	H/S	H/S	H/S

Subject H : Activity Analysis Table

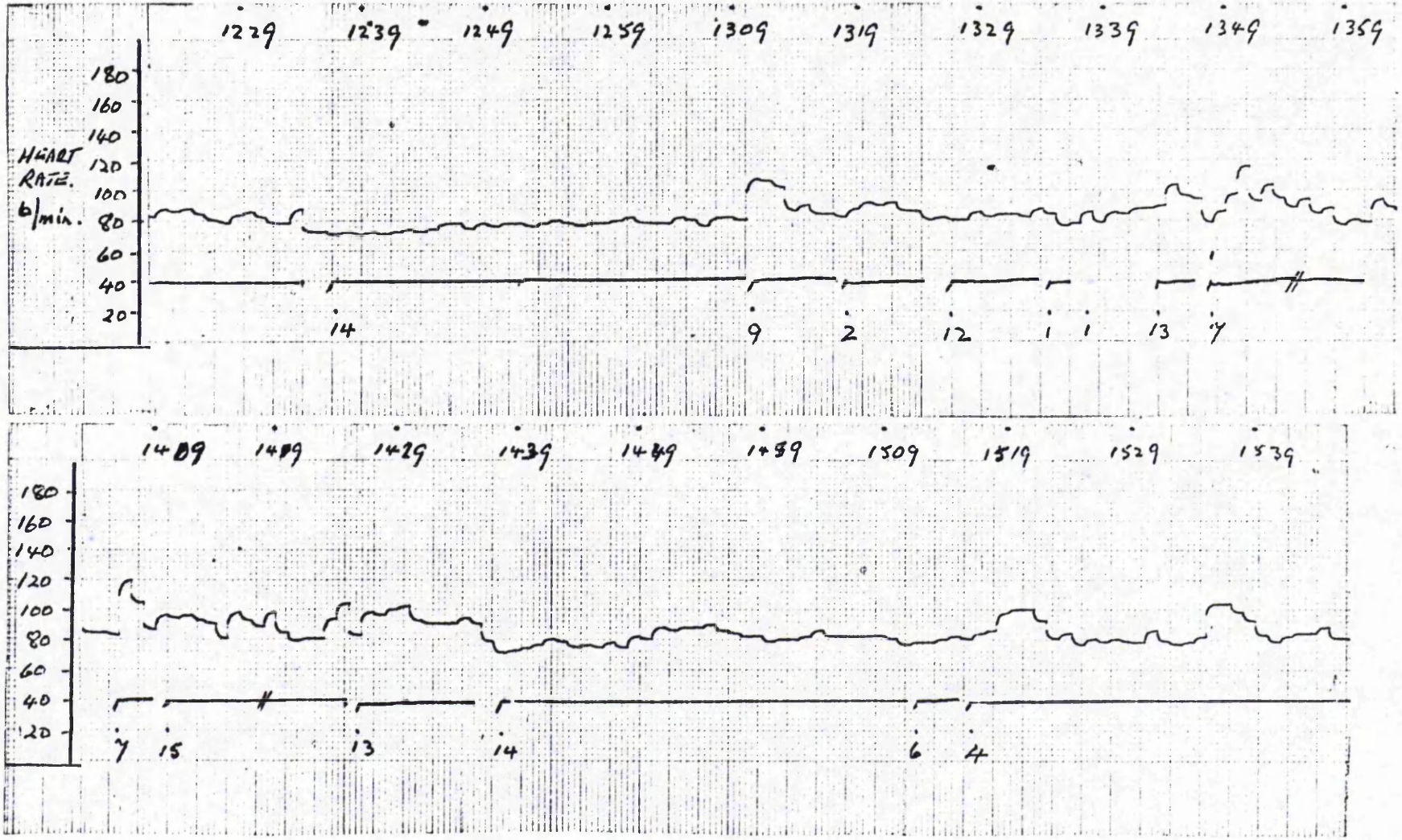
SUBJECT I

Personal Details

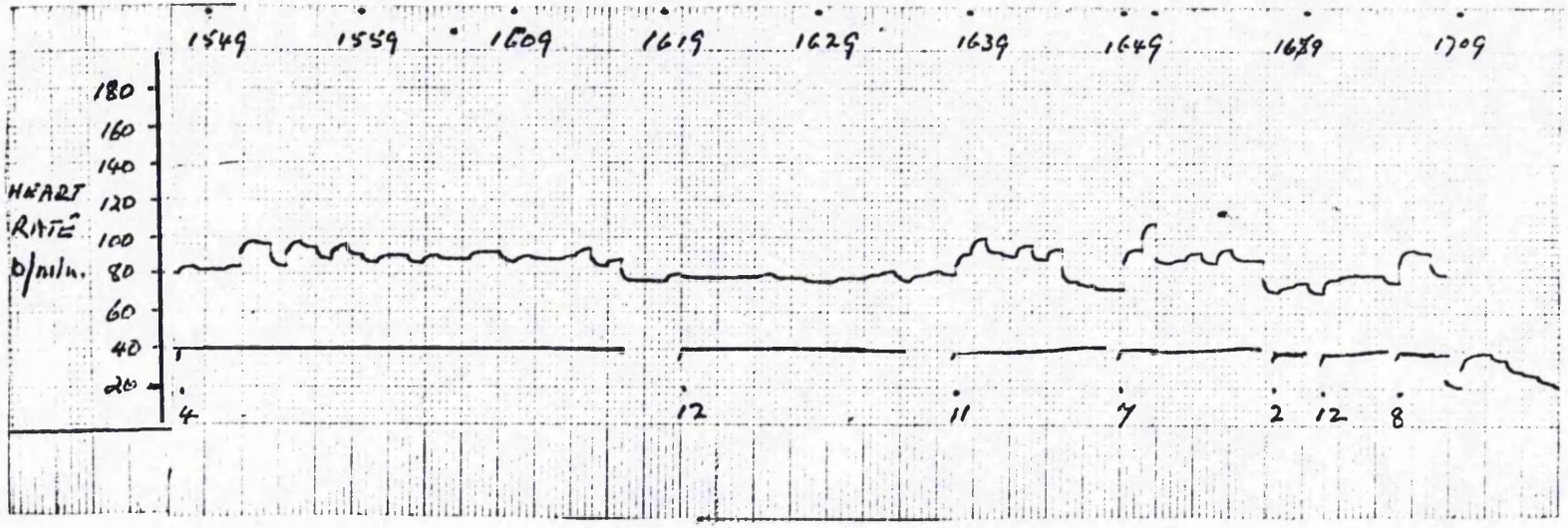
1)	Sex	Male
2)	Age	33
3)	General Physical Health	Good
4)	Marital Status	Married
5)	Smoking Habits	20 cigarettes a day, occasional cigar
6)	Drinking habits	3 glasses of wine
7)	Hotel experience	12 years
8)	Occupation	General Manager
9)	Size of hotel	Large
10)	Stress experienced during study	No stress felt
11)	General impression	Competent, good personality, confident



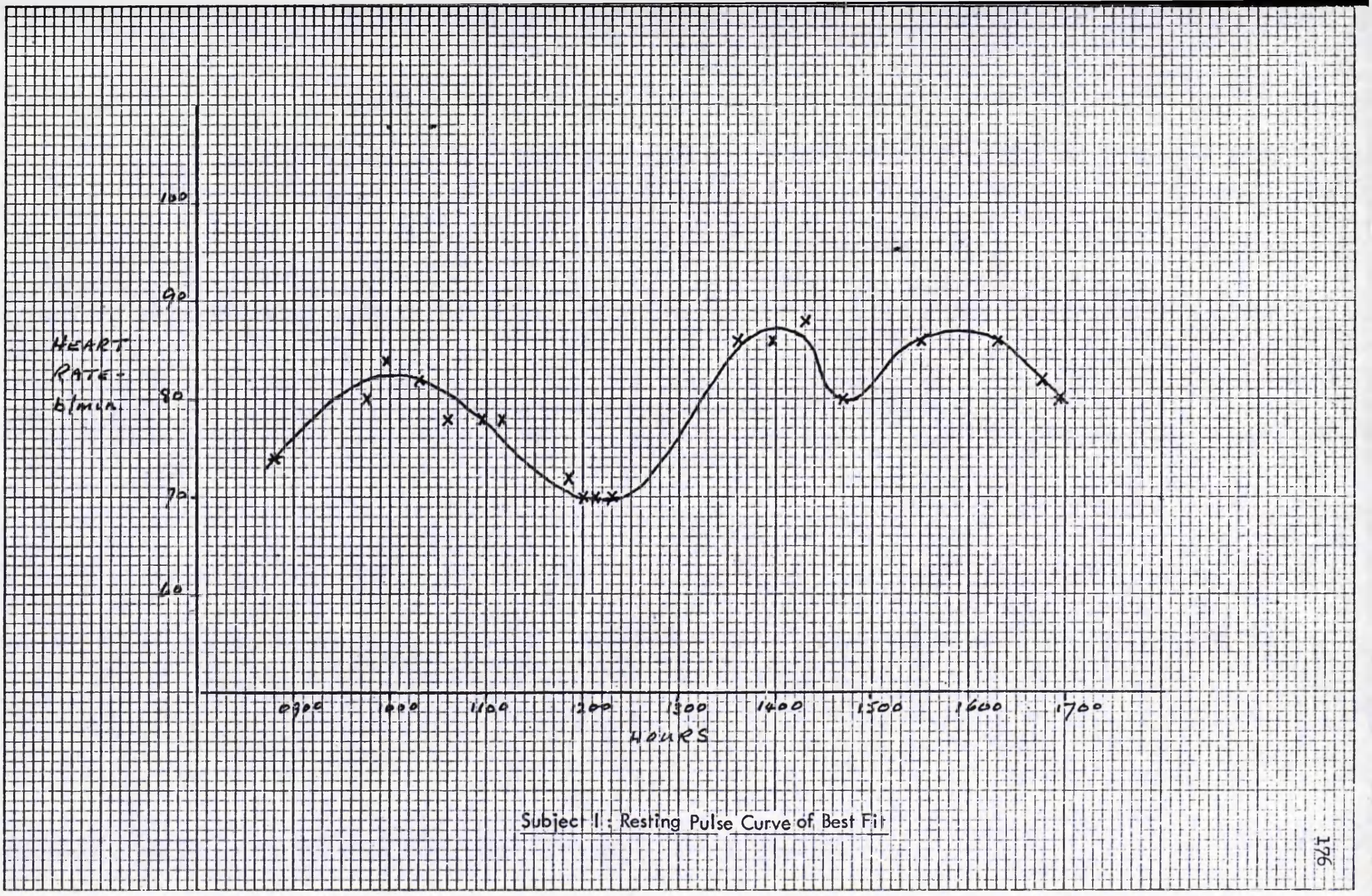
Subject I : Heart Rate Graph



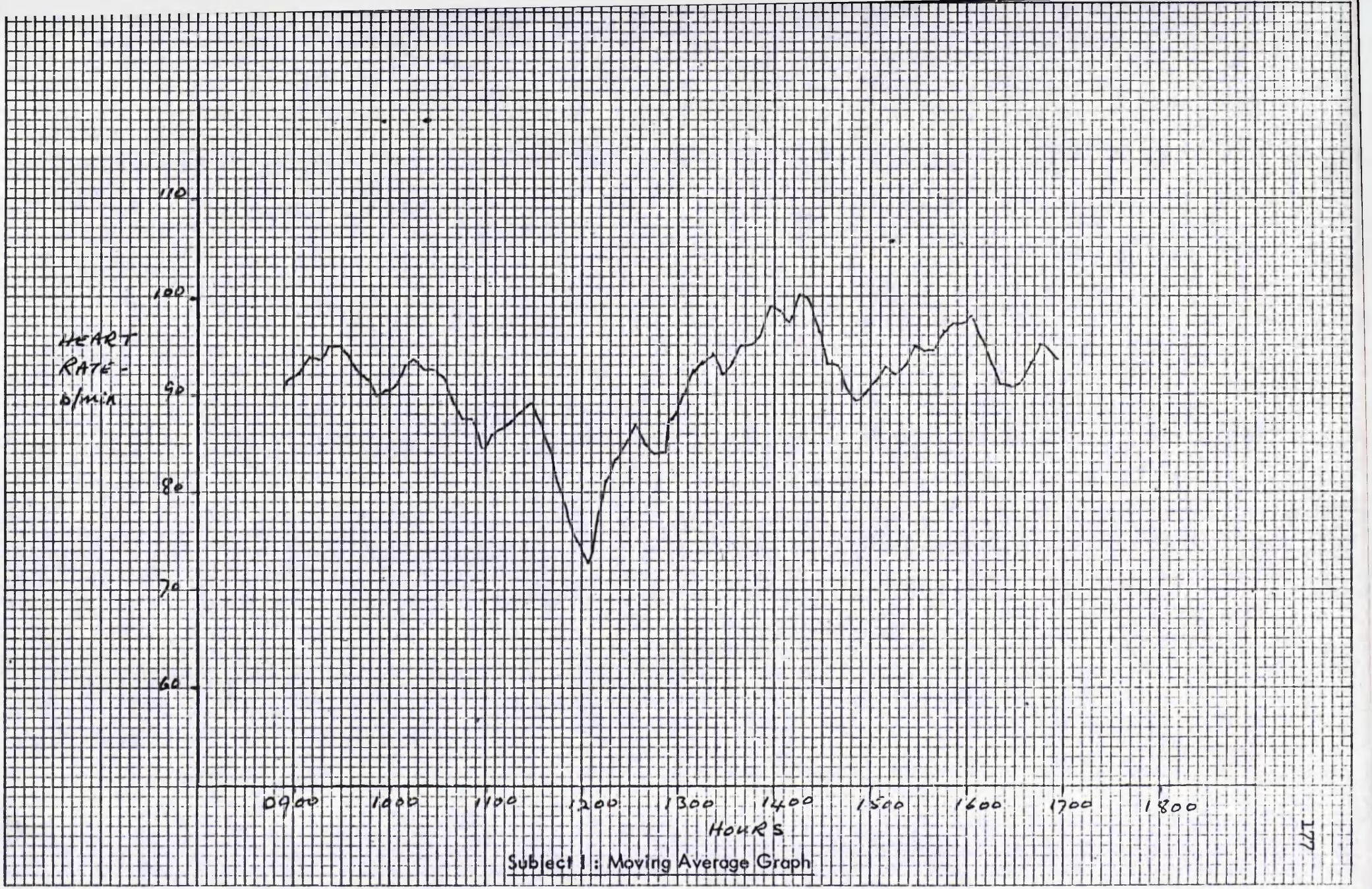
Subject I : Heart Rate Graph (contd.)



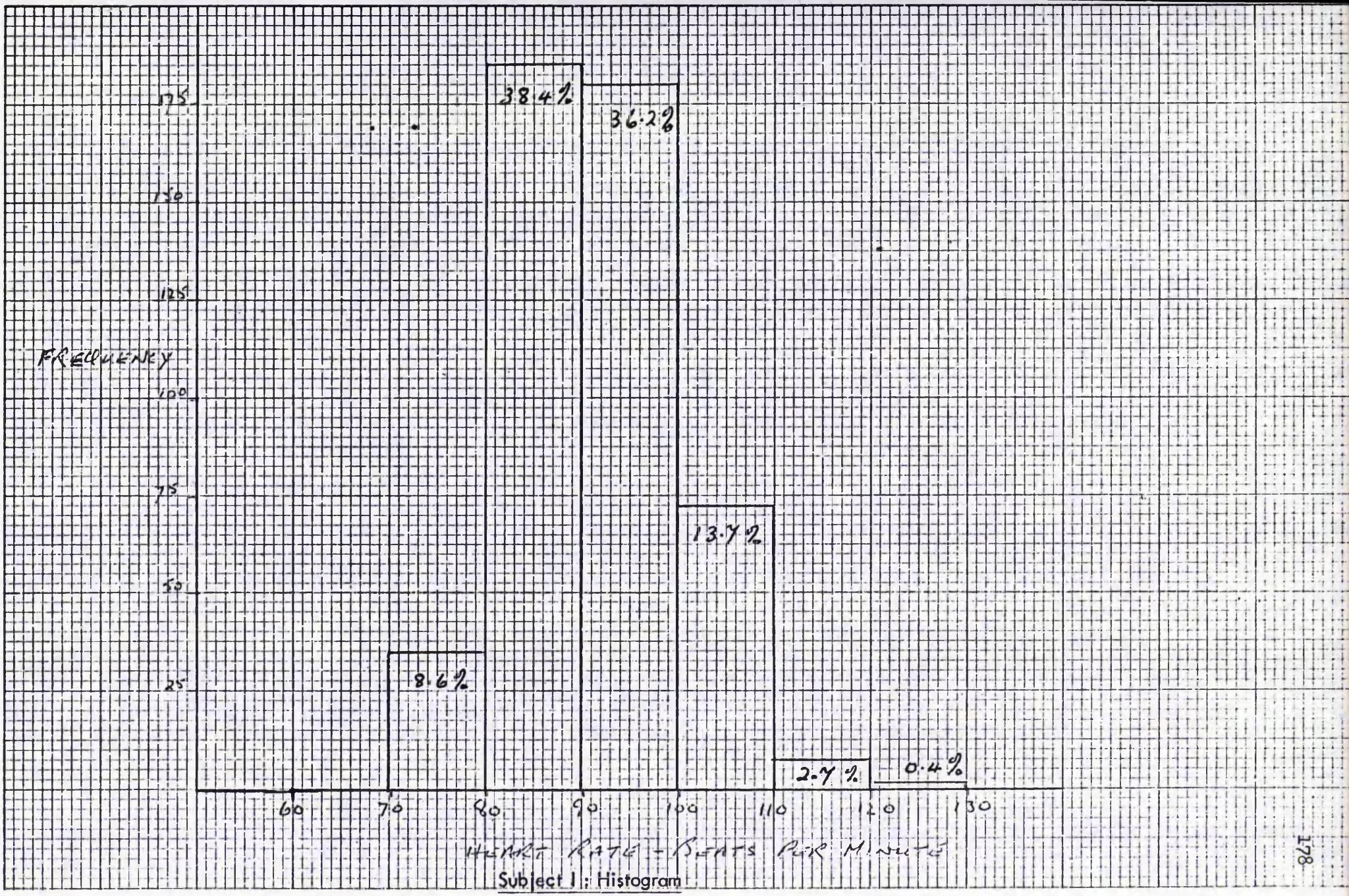
Subject I : Heart Rate Graph (contd.)



Subject I: Resting Pulse Curve of Best Fit



Subject 1 : Moving Average Graph



Subject 1 : Histogram

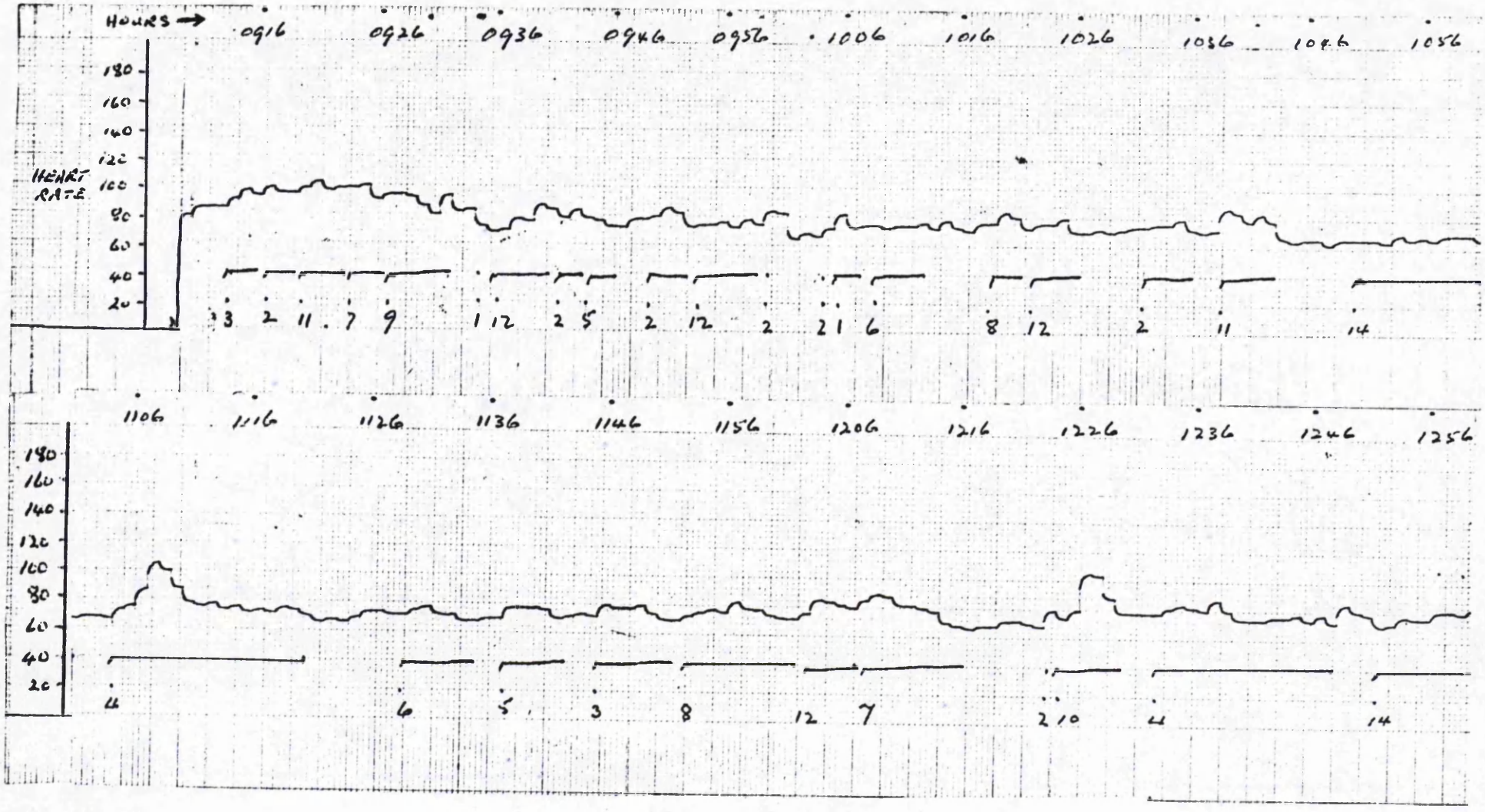
DESCRIPTION	ACTIVITY														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Heart Rates: Rest Pulses															
Sample Size	16	28	-	108	12	28	21	8	7	3	13	38	18	86	14
Mean	95.37	97.07		95.94	92.83	89.57	105.24	91.75	103.71	89.33	101.08	90.21	101.78	84.86	101.57
Standard deviation(corrected)	6.32	6.45		7.42	5.45	6.65	10.09	9.22	15.88	4.21	8.20	5.26	7.59	11.74	7.38
S.E. of difference	2.549	2.555		2.705	2.481	2.579	2.926	2.736	3.058	2.509	2.707	2.387	2.672	3.302	2.644
Degree of freedom	33	45		125	29	45	38	25	24	20	30	55	35	103	31
't' value	6.238	6.887		6.089	5.384	3.915	8.805	4.487	7.927	3.929	7.980	4.498	8.346	1.631	8.357
significance	H/S	H/S		H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S
PERTURBATIONS															
Sample Size	16	28	-	108	12	28	21	8	7	3	13	38	18	86	14
Mean	15.87	18.36		15.72	13.67	11.28	22.09	12.75	26.28	12.67	19.08	8.68	20.33	9.46	16.00
S.D. (corrected)	4.98	6.37		9.38	7.47	6.98	9.61	8.81	10.67	5.04	8.19	5.90	5.71	4.91	7.48
S.E. of difference	1.285	1.226		0.906	2.252	1.342	2.148	3.330	4.355	3.561	2.362	0.970	1.384	0.532	2.073
Degree of freedom	15	27		107	11	27	20	7	6	2	12	37	17	85	13
't' value	12.353	14.972		17.353	6.068	8.408	10.285	3.828	6.035	3.556	8.076	8.592	14.690	17.789	7.718
significance	H/S	H/S		H/S	H/S	H/S	H/S	HES	HES	N/S	H/S	H/S	H/S	H/S	H/S

Subject 1 : Activity Analysis Table

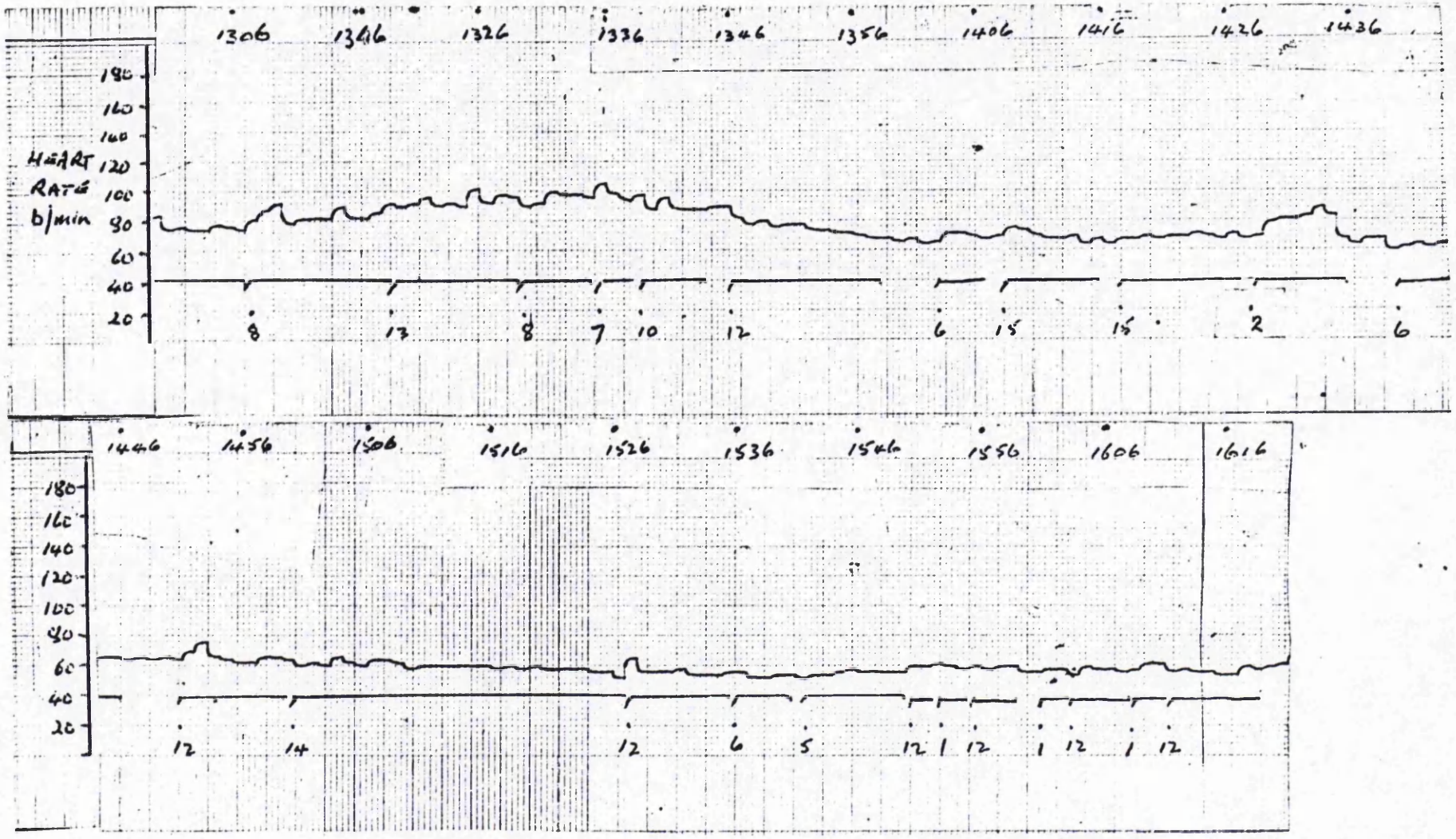
SUBJECT J

Personal Details

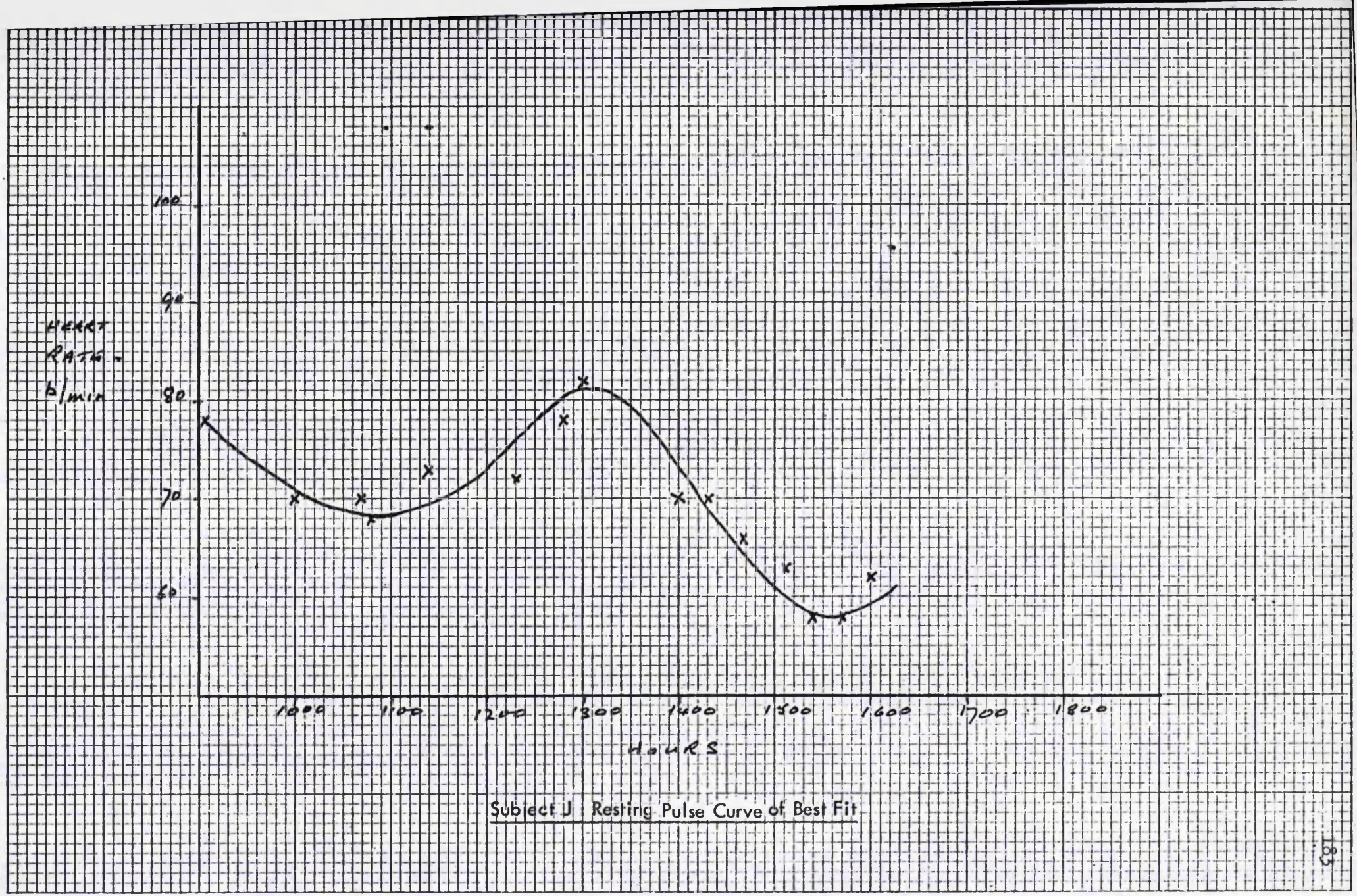
1)	Sex	Male
2)	Age	31
3)	General Physical Health	Very good
4)	Marital Status	Single
5)	Smoking Habits	Non-smoker
6)	Drinking Habits	½-pint beer
7)	Hotel Experience	7 years
8)	Occupation	Deputy Manager
9)	Size of Hotel	Large
10)	Stress experienced during study	No stress felt
11)	General Impression	Smart, efficient



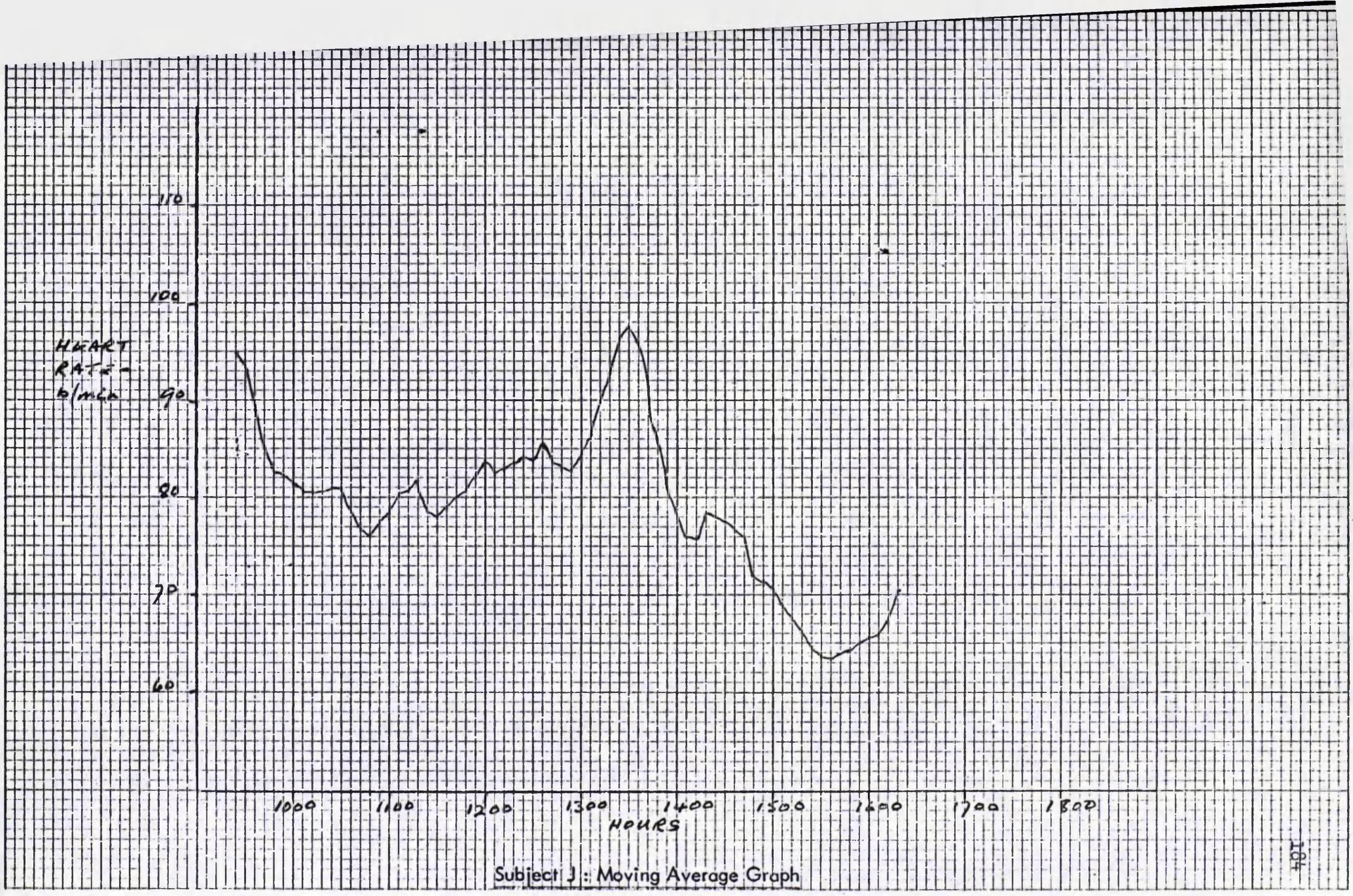
Subject J : Heart Rate Graph



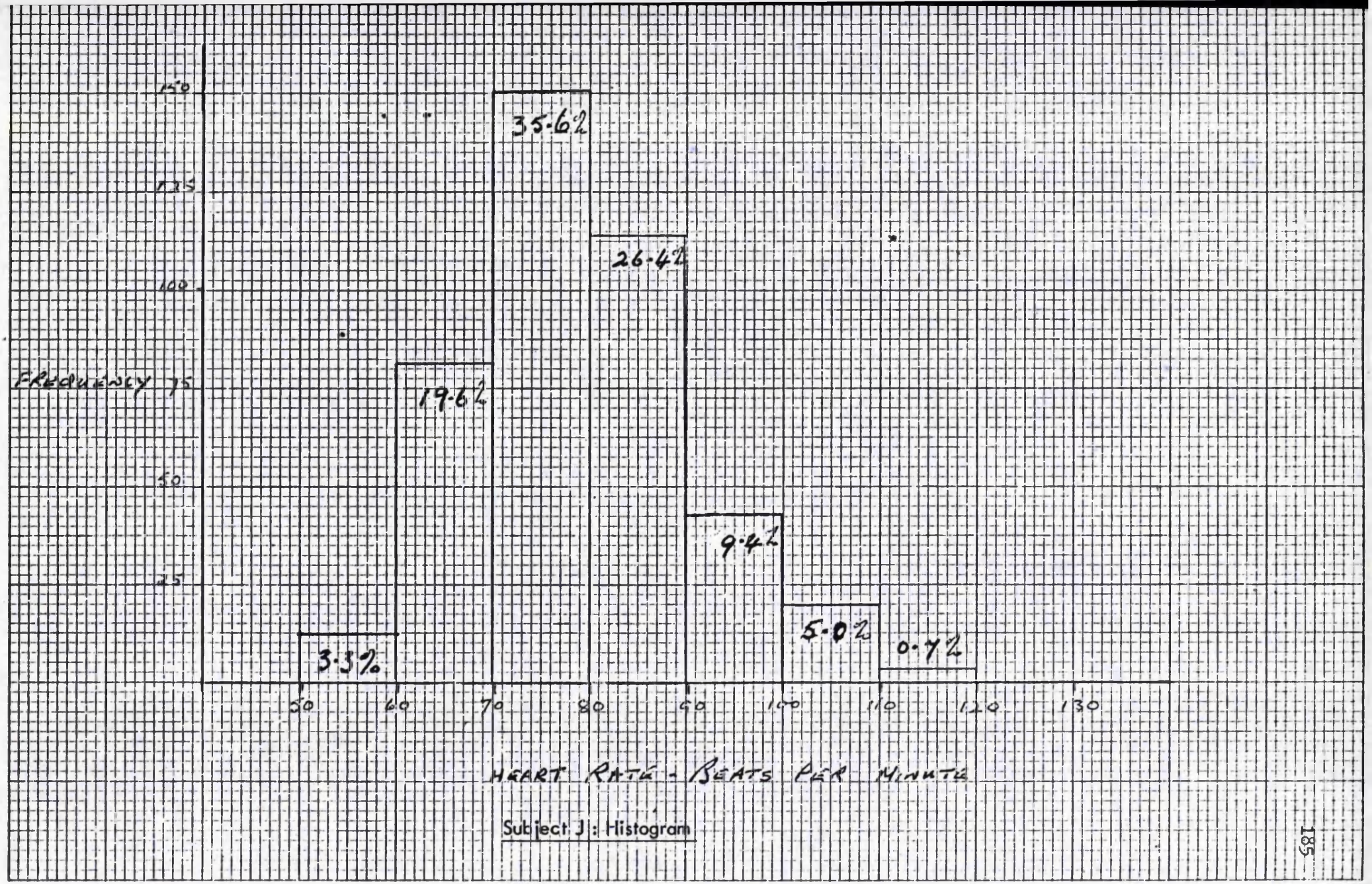
Subject J : Heart Rate Graph (contd.)



Subject J Resting Pulse Curve of Best Fit



Subject J : Moving Average Graph



Subject J : Histogram

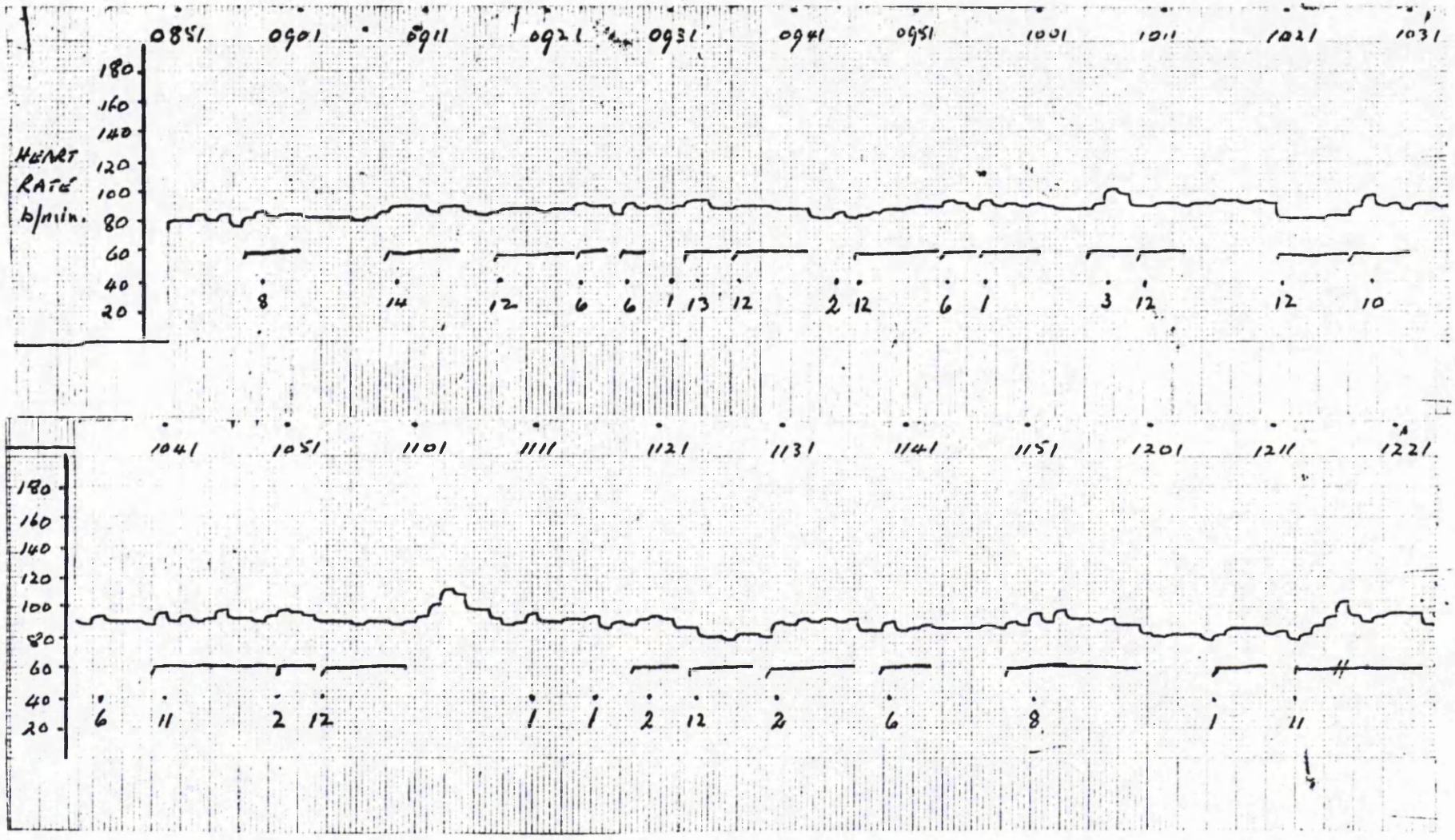
DESCRIPTION	ACTIVITY														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Heart Rates: Rest Pulses															
Sample Size	10	20	8	29	15	24	17	27	5	11	7	69	10	56	18
Mean	71.00	89.60	88.50	86.14	72.40	73.25	95.41	90.89	97.20	94.91	96.00	72.58	99.80	72.75	75.77
Standard deviation(corrected)	11.72	6.44	7.23	7.93	11.93	8.08	8.79	7.76	3.35	9.08	9.86	9.09	4.05	8.27	2.70
S.E. of difference	3.104	2.659	2.779	2.821	3.181	2.839	2.909	2.802	2.594	2.917	2.945	2.987	2.509	2.868	2.221
Degree of freedom	23	33	21	42	28	37	30	40	18	24	20	82	23	69	31
't' value	0.579	7.672	6.944	6.003	1.005	1.426	9.009	7.740	10.794	8.813	9.100	1.130	12.196	1.237	2.960
significance	N/S	H/S	H/S	H/S	N/S	N/S	H/S	H/S	H/S	H/S	H/S	N/S	H/S	N/S	H/S
PERTURBATIONS															
Sample Size	10	20	8	29	15	24	17	27	5	11	7	69	10	56	18
Mean	9.80	19.30	16.25	12.83	8.40	6.75	20.82	14.52	22.00	18.91	23.42	7.216	20.00	5.50	6.55
S.D. (corrected)	5.99	5.59	4.83	9.99	5.41	4.03	7.01	6.60	2.83	9.98	5.97	4.12	4.22	3.06	2.55
S.E. of difference	1.998	1.282	1.826	1.887	1.445	0.840	1.752	1.294	1.414	3.155	2.437	0.499	1.405	0.412	0.619
Degree of freedom	9	19	7	28	14	23	16	26	4	10	6	68	9	55	17
't' value	4.904	15.054	8.899	6.797	5.813	8.035	11.884	11.219	15.558	5.993	9.613	14.460	14.234	13.349	10.588
significance	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S

Subject J: Activity Analysis Table

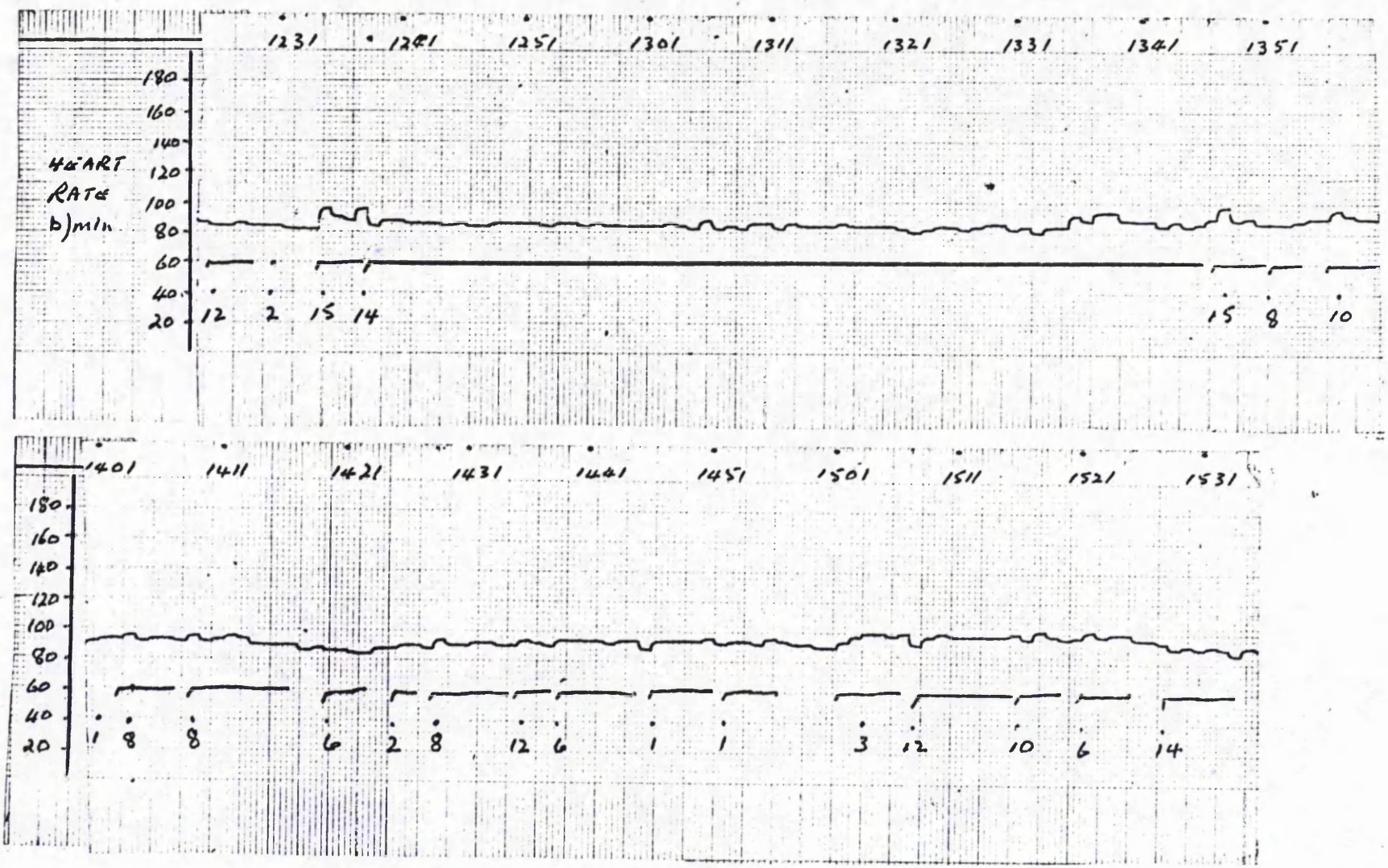
SUBJECT K

Personal Details

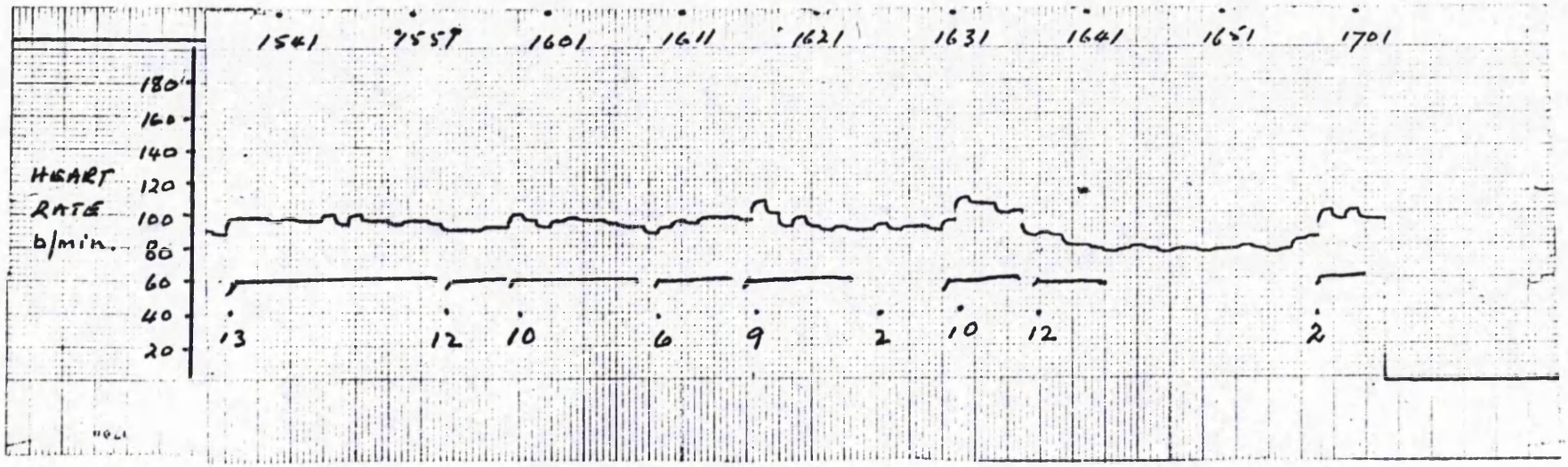
1)	Sex	Male
2)	Age	33
3)	General Physical Health	Very Good
4)	Marital Status	Single
5)	Smoking Habits	60 cigarettes a day
6)	Drinking Habits	6 pints lager/5 vodkas on average
7)	Hotel Experience	2 years
8)	Occupation	Proprietor/General Manager
9)	Size of Hotel	Small
10)	Stress experienced during study	No stress experienced
11)	General Impression	Casual, not very efficient, liked by staff and clients



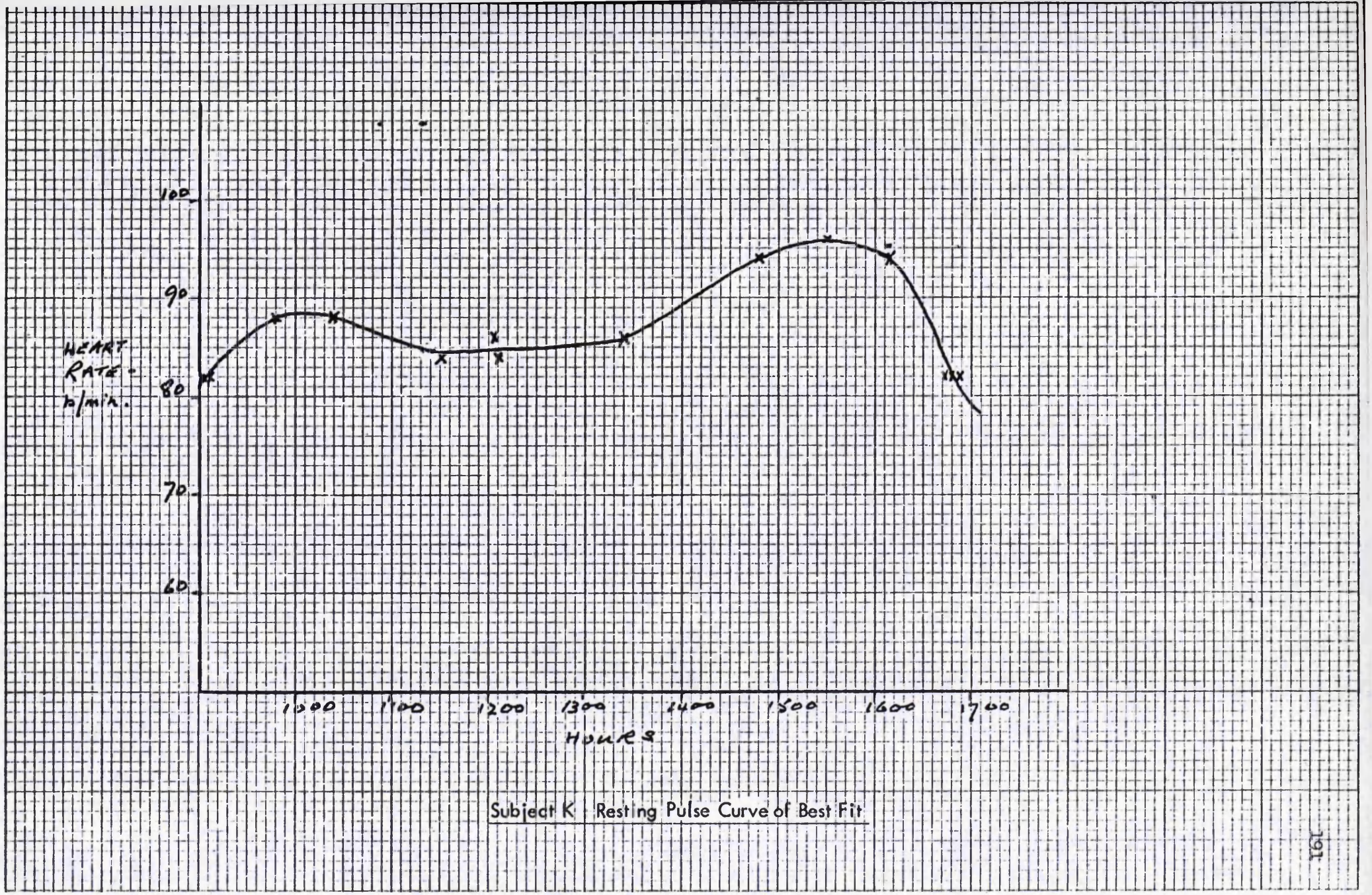
Subject K : Heart Rate Graph



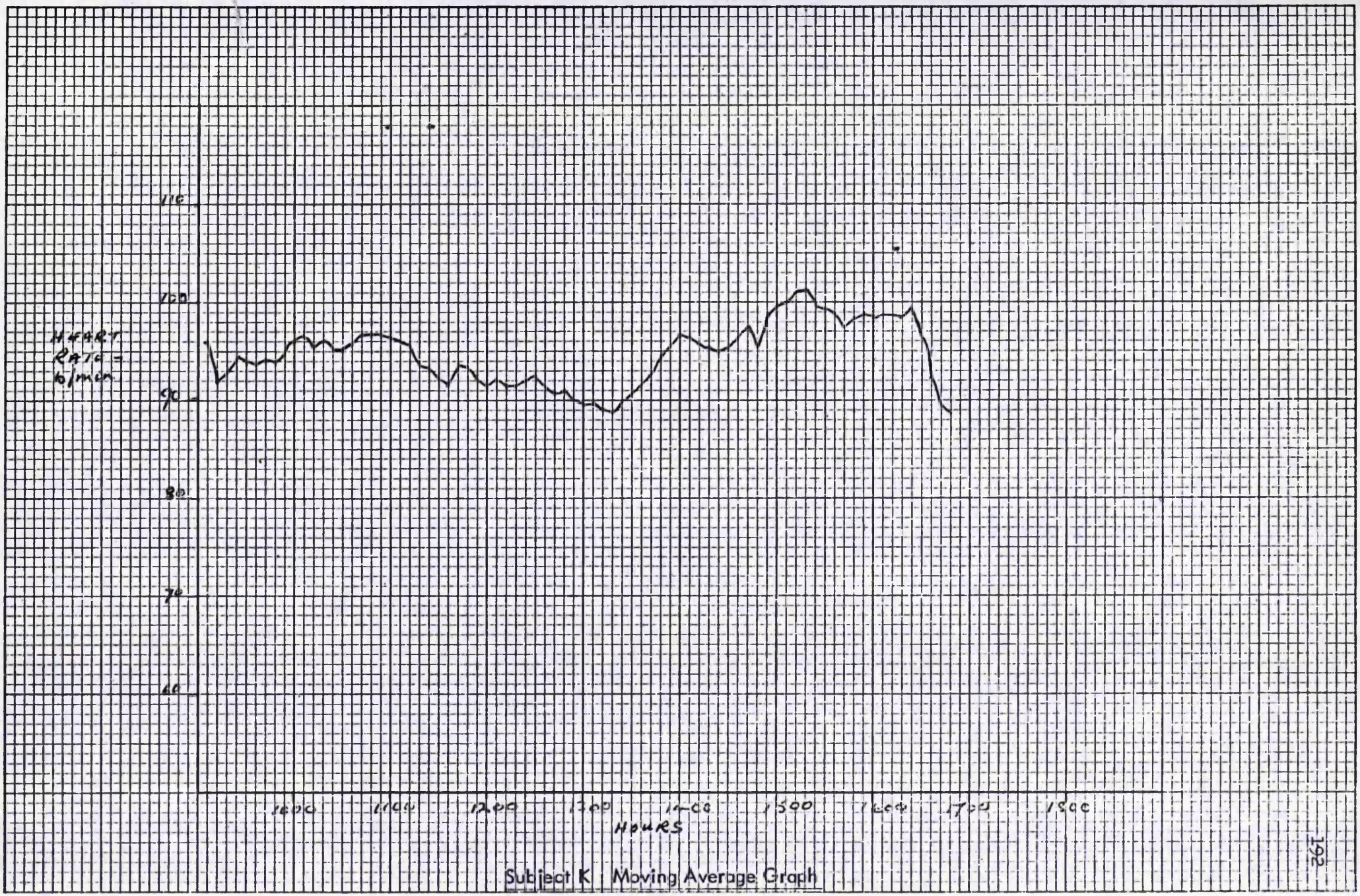
Subject K : Heart Rate Graph (contd.)



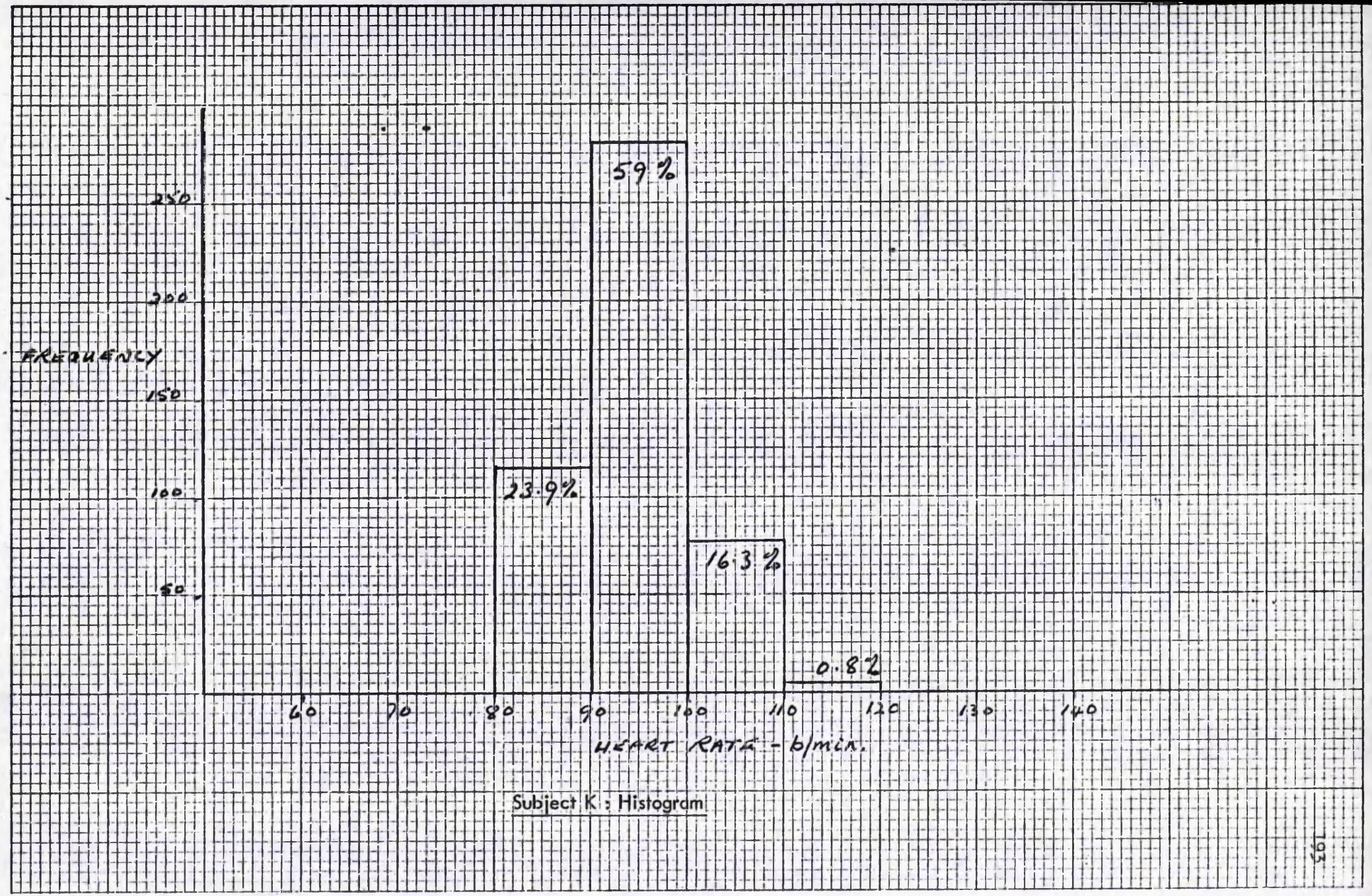
Subject K : Heart Rate Graph (contd.)



Subject K Resting Pulse Curve of Best Fit



Subject K : Moving Average Graph



Subject K : Histogram

DESCRIPTION	ACTIVITY														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Heart Rates: Rest Pulses															
Sample Size	19	25	9	-	-	31	-	39	7	25	18	64	20	82	7
Mean	96.84	98.32	104.00			98.64		96.61	102.00	102.88	98.44	94.41	101.50	91.80	96.86
Standard deviation(corrected)	4.44	4.19	3.16			4.96		3.93	6.43	5.38	3.80	4.94	3.17	3.02	4.48
S.E. of difference	2.226	2.171	2.162			2.279		2.091	2.457	2.359	2.146	2.253	2.040	1.837	2.307
Degree of freedom	31	37	21			43		51	19	37	30	76	32	94	19
't' value	4.678	5.477	8.127			5.360		4.871	6.416	7.000	5.599	3.541	7.388	2.926	4.520
significance	H/S	H/S	H/S			H/S		H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S
PERTURBATIONS															
Sample Size	19	25	9	-	-	31	-	39	7	25	18	64	20	82	7
Mean	9.37	12.08	12.00			8,84		9.38	10.00	11.36	13.33	6.72	8.30	6.41	10.57
S.D. (corrected)	3.89	6.49	4.00			3.53		3.84	6.43	6.26	3.82	3.44	2.45	3.48	5.13
S.E. of difference	0.916	1.324	1.414			0.644		0.623	2.624	1.277	0.927	0.433	0.562	0.386	2.094
Degree of freedom	18	24	8			30		38	6	24	17	63	19	81	6
't' value	10.227	9.123	8.486			13.723		15.062	3.810	8.895	14.381	15.515	14.768	16.616	5.047
significance	H/S	H/S	H/S			H/S		H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S

Subject K : Activity Analysis Table

Analysis of Each Activity - All Main Study Subjects

DESCRIPTION	SUBJECT										
	A	B	C	D	E	F	G	H	I	J	K
Heart Rates: Rest Pulses											
Sample Size	19	11	13	34	33	10	35	20	16	10	19
Mean	86.84	82.18	105.07	94.53	87.21	123.20	104.63	91.60	95.37	71.00	96.84
S.D. (corrected)	5.13	2.63	9.19	4.50	3.60	4.02	10.81	2.39	6.32	11.72	4.44
S.E. of difference	5.99	1.98	2.81	1.98	2.33	2.89	3.21	2.22	2.55	3.10	2.23
Degree of freedom	30	29	27	47	54	20	44	39	33	23	31
't' value	1.923	4.186	6.746	5.463	4.451	11.756	7.795	4.979	6.238	0.579	4.678
significance	N/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	N/S	H/S
PERTURBATIONS											
Sample Size	19	11	13	34	33	10	35	20	16	10	19
Mean	10.84	8.73	18.31	10.29	9.70	31.50	30.86	9.80	15.87	9.80	9.37
S.D. (corrected)	3.79	4.29	9.90	3.79	3.13	12.41	13.43	2.75	4.98	5.99	3.89
S.E. of difference	0.893	1.356	2.856	0.659	0.551	4.136	2.301	0.629	1.285	1.998	0.916
Degree of freedom	18	10	12	33	32	9	34	19	15	9	18
't' value	12.141	6.435	6.410	15.620	17.597	7.616	13.409	15.580	12.353	4.904	10.227
significance	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S

Analysis : Activity No. 1 - Outgoing Telephone Calls

DESCRIPTION	SUBJECT										
	A	B	C	D	E	F	G	H	I	J	K
Heart Rates: Rest Pulses											
Sample Size	19	14	26	38	33	19	39	22	28	20	25
Mean	90.84	82.14	99.92	95.42	89.64	125.47	109.85	92.73	97.07	89.60	98.32
S.D. (corrected)	5.78	2.56	4.54	5.54	3.95	7.09	16.31	4.94	6.45	6.44	4.19
S.E. of difference	2.531	1.940	2.299	2.174	2.378	2.998	3.847	2.481	2.555	2.659	2.171
Degree of freedom	30	32	40	51	54	29	48	41	45	33	37
't' value	6.137	4.248	6.001	5.376	5.386	12.110	7.852	4.899	6.887	7.672	5.477
significance	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S
PERTURBATIONS											
Sample Size	19	14	26	38	33	19	39	22	28	20	25
Mean	14.21	7.71	13.69	11.47	10.24	37.89	30.61	10.73	18.36	19.30	12.08
S.D. (corrected)	6.28	3.43	4.03	4.76	3.49	7.76	17.84	6.31	6.37	5.59	6.49
S.E. of difference	1.481	0.950	0.805	0.782	0.614	1.830	2.894	1.376	1.226	1.282	1.324
Degree of freedom	18	13	25	37	32	18	38	21	27	19	24
't' value	9.594	8.120	17.008	14.670	16.680	20.707	10.578	7.795	14.972	15.054	9.123
significance	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S

Analysis : Activity No. 2 - Incoming Telephone Calls

DESCRIPTION	SUBJECT										
	A	B	C	D	E	F	G	H	I	J	K
Heart Rates: Rest Pulses											
Sample Size	-	6	5	8	-	9	7	5	-	8	9
Mean		80.33	100.80	92.00		108.89	102.00	92.80		88.50	104.00
S.D. (corrected)		6.98	3.32	3.02		22.25	11.99	7.69		7.23	3.16
S.E. of difference		2.295	2.392	1.614		4.153	3.144	2.754		2.779	2.162
Degree of freedom		24	19	21		19	16	24		21	21
't' value		2.803	6.135	5.122		4.748	7.113	4.440		6.944	8.127
significance		H/S	H/S	H/S		H/S	H/S	H/S		H/S	H/S
PERTURBATIONS											
Sample Size	-	6	5	8	-	9	7	5	-	8	9
Mean		7.67	16.80	10.00		25.56	15.14	9.20		16.25	12.00
S.D. (corrected)		6.62	3.03	3.02		11.38	12.80	7.01		4.83	4.00
S.E. of difference		2.961	1.516	1.141		4.025	5.225	3.507		1.826	1.414
Degree of freedom		5	4	7		8	6	4		7	8
't' value		2.588	11.081	8.764		6.349	2.897	2.623		8.899	8.486
significance		S	H/S	H/S		H/S	N/S	N/S		H/S	H/S

Analysis : Activity No. 3 - Personal Telephone Calls

DESCRIPTION	SUBJECT										
	A	B	C	D	E	F	G	H	I	J	K
Heart Rates: Rest Pulses											
Sample Size	-	-	9	17	-	-	30	-	108	29	-
Mean			95.78	95.18			103.40		95.94	86.14	
S.D. (corrected)			6.04	4.18			12.61		7.42	7.93	
S.E. of difference			2.536	1.841			3.407		2.705	2.821	
Degree of freedom			23	30			39		125	42	
't' value			3.805	6.216			6.975		6.089	6.003	
significance			H/S	H/S			H/S		H/S	H/S	
PERTURBATIONS											
Sample Size	-	-	9	17	-	-	30	-	108	29	-
Mean			8.22	11.76			27.40		15.72	12.83	
S.D. (corrected)			5.43	3.80			12.62		9.38	9.99	
S.E. of difference			1.919	0.949			2.342		0.906	1.887	
Degree of freedom			8	16			29		107	28	
't' value			4.284	12.396			11.699		17.353	6.797	
significance			H/S	H/S			H/S		H/S	H/S	

Analysis : Activity No. 4 - Meetings with a Group

DESCRIPTION	SUBJECT										
	A	B	C	D	E	F	G	H	I	J	K
Heart Rates: Rest Pulses											
Sample Size	12	11	15	26	14	-	-	10	12	15	-
Mean	86.50	85.09	99.20	93.08	87.14			91.40	92.83	72.40	
S.D. (corrected)	6.87	7.24	3.69	3.76	3.48			1.90	5.45	11.93	
S.E. of difference	2.678	2.379	2.266	1.814	2.529			2.367	2.481	3.181	
Degree of freedom	23	29	29	39	35			29	29	28	
't' value	4.179	4.703	5.770	5.151	4.079			4.575	5.384	1.005	
significance	H/S	H/S	H/S	H/S	H/S			H/S	H/S	N/S	
PERTURBATIONS											
Sample Size	12	11	15	26	14	-	-	10	12	15	-
Mean	11.25	14.36	12.67	9.54	7.28			7.40	13.67	8.40	
S.D. (corrected)	5.91	6.76	2.99	3.68	2.90			1.90	7.47	5.41	
S.E. of difference	1.781	2.137	0.800	0.735	0.803			0.632	2.252	1.445	
Degree of freedom	11	10	14	25	13			9	11	14	
't' value	6.316	6.721	15.832	12.976	9.070			11.708	6.068	5.813	
significance	H/S	H/S	H/S	H/S	H/S			H/S	H/S	H/S	

Analysis : Activity No. 5 - Speaking with a Peer

DESCRIPTION	SUBJECT										
	A	B	C	D	E	F	G	H	I	J	K
Heart Rates: Rest Pulses											
Sample Size	16	18	16	46	59 -	19	43	42	28	24	31
Mean	84.13	87.11	97.38	95.83	86.88	106.95	104.79	92.05	89.57	73.25	98.64
S.D. (corrected)	3.22	8.12	4.36	5.41	4.19	18.50	10.89	5.59	6.65	8.08	4.96
S.E. of difference	2.227	2.531	2.334	2.176	2.297	4.063	3.229	2.490	2.579	2.839	2.279
Degree of freedom	27	36	30	59	80	29	52	61	45	37	43
't' value	3.959	5.219	4.820	5.557	4.377	4.376	7.790	4.608	3.915	1.426	5.360
significance	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	N/S	H/S
PERTURBATIONS											
Sample Size	16	18	16	46	59	19	43	42	28	24	31
Mean	7.75	12.67	10.12	10.48	7.62	24.05	25.53	9.90	11.28	6.75	8.84
S.D. (corrected)	5.19	4.51	3.14	4.00	4.01	10.01	10.77	4.76	6.98	4.03	3.53
S.E. of difference	1.340	1.093	0.810	0.596	0.526	2.359	1.662	0.742	1.342	0.840	0.644
Degree of freedom	15	17	15	45	58	18	42	41	27	23	30
't' value	5.783	11.588	12.498	17.580	14.498	10.196	15.363	13.347	8.408	8.035	13.723
significance	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S

Analysis : Activity No. 6 - Speaking with a Subordinate

DESCRIPTION	SUBJECT										
	A	B	C	D	E	F	G	H	I	J	K
Heart Rates: Rest Pulses											
Sample Size	9	6	12	28	-	4	-	13	21	17	-
Mean	90.44	89.00	109.67	99.36		127.50		94.61	105.24	95.41	
S. D. (corrected)	3.97	6.54	12.64	6.73		6.81		8.64	10.09	8.79	
S. E. of difference	2.430	2.271	3.071	2.312		3.284		2.827	2.926	2.909	
Degree of freedom	20	24	26	41		14		32	38	30	
't' value	6.229	6.649	7.665	6.758		11.672		4.967	8.805	9.009	
significance	H/S	H/S	H/S	H/S		H/S		H/S	H/S	H/S	
PERTURBATIONS											
Sample Size	9	6	12	28	-	4	-	13	21	17	-
Mean	14.67	14.33	21.67	16.36		32.00		8.77	22.09	20.82	
S. D. (corrected)	4.92	3.78	12.319	6.80		6.376		8.93	9.61	7.01	
S. E. of difference	1.740	1.689	3.713	1.308		3.681		2.577	2.148	1.752	
Degree of freedom	8	5	11	27		3		12	20	16	
't' value	8.428	8.486	6.531	12.504		8.693		3.402	10.285	11.884	
significance	H/S	H/S	H/S	H/S		H/S		H/S	H/S	H/S	

Analysis : Activity No. 7 - Speaking with a Superior

DESCRIPTION	SUBJECT										
	A	B	C	D	E	F	G	H	I	J	K
Heart Rates: Rest Pulses											
Sample Size	7	32	24	23	65	24	47	7	8	27	39
Mean	86.86	85.63	100.50	99.48	85.54	133.42	113.32	89.71	91.75	90.89	96.61
S.D. (corrected)	1.57	4.86	5.87	9.03	3.06	8.29	20.49	4.96	9.22	7.76	3.93
S.E. of difference	2.278	2.190	2.484	2.572	2.084	3.098	4.303	2.618	2.736	2.802	2.091
Degree of freedom	18	50	38	36	86	34	56	26	25	40	51
't' value	5.070	5.353	5.787	6.122	4.180	14.324	7.827	4.217	4.487	7.740	4.871
significance	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S
PERTURBATIONS											
Sample Size	7	32	24	23	65	24	47	7	8	27	39
Mean	11.14	10.50	14.75	14.87	8.18	45.33	39.11	7.43	12.75	14.52	9.38
S.D. (corrected)	1.87	5.82	4.63	6.90	2.80	6.87	16.83	4.58	8.81	6.60	3.84
S.E. of difference	0.762	1.045	0.966	1.470	0.349	1.433	2.481	1.868	3.330	1.294	0.623
Degree of freedom	6	31	23	22	64	23	46	6	7	26	38
't' value	14.622	x5.568	15.269	10.114	23.449	31.635	15.762	3.976	3.828	11.219	15.062
significance	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S

Analysis : Activity No. 8 - Speaking with a Client

DESCRIPTION	SUBJECT										
	A	B	C	D	E	F	G	H	I	J	K
Heart Rates: Rest Pulses											
Sample Size	13	12	-	9	24	2	14	-	7	5	7
Mean	82.15	85.33		99.33	93.83	137.00	128.86		103.71	97.20	102.00
S. D. (corrected)	3.21	5.07		7.62	5.40	12.73	20.35		15.88	3.35	6.43
S. E. of difference	2.274	2.201		2.112	2.165	3.569	3.951		3.058	2.594	2.457
Degree of freedom	24	30		22	65	12	23		24	18	19
't' value	3.010	5.194		7.386	7.855	13.402	12.457		7.929	10.794	6.416
significance	H/S	H/S		H/S	H/S	H/S	H/S		H/S	H/S	H/S
PERTURBATIONS											
Sample Size	13	12	-	9	24	2	14	-	7	5	7
Mean	11.85	7.00		14.67	15.08	39.00	41.71		26.28	22.00	10.00
S. D. (corrected)	3.10	4.83		5.00	6.01	12.73	18.94		10.67	2.83	6.43
S. E. of difference	0.895	1.456		1.769	1.253	12.727	5.252		4.355	1.414	2.624
Degree of freedom	12	11		8	23	1	13		6	4	6
't' value	13.235	4.807		8.290	12.036	3.064	7.942		6.035	15.558	3.810
significance	H/S	H/S		H/S	H/S	N/S	H/S		H/S	H/S	H/S

Analysis : Activity No. 9 - Dealing with Clients' Complaints

DESCRIPTION	SUBJECT										
	A	B	C	D	E	F	G	H	I	J	K
Heart Rates: Rest Pulses											
Sample Size	12	5	7	15	8	4	32	14	3	11	25
Mean	93.17	95.60	105.14	96.93	90.50	136.75	111.94	97.86	89.33	94.91	102.88
S.D. (corrected)	7.50	9.21	4.74	6.32	2.97	7.27	16.55	7.18	4.21	9.08	5.38
S.E. of difference	2.738	2.383	2.457	2.115	2.619	3.343	3.837	2.719	2.509	2.917	2.350
Degree of freedom	23	23	21	28	29	14	41	33	20	24	37
't' value	6.523	9.106	7.739	6.241	5.221	14.233	8.418	6.357	3.929	8.813	7.000
significance	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S
PERTURBATIONS											
Sample Size	12	5	7	15	8	4	32	14	3	11	25
Mean	10.08	12.60	17.14	11.73	11.50	42.50	29.87	15.14	12.67	18.91	11.36
S.D. (corrected)	5.58	9.21	4.74	4.95	3.34	7.32	16.49	7.47	5.04	9.98	6.26
S.E. of difference	1.682	4.604	1.936	1.323	1.261	4.228	2.962	2.070	3.561	3.155	1.277
Degree of freedom	11	4	6	14	7	3	31	13	2	10	24
't' value	5.994	2.736	8.854	8.867	9.119	10.052	10.085	7.314	3.556	5.993	8.895
significance	H/S	N/S	H/S	H/S	H/S	H/S	H/S	H/S	N/S	H/S	H/S

Analysis : Activity No. 10 - Reprimanding a Subordinate

DESCRIPTION	SUBJECT										
	A	B	C	D	E	F	G	H	I	J	K
Heart Rates: Rest Pulses											
Sample Size	-	20	17	24	2	9	16	6	13	7	18
Mean		85.60	100.35	93.75	90.00	126.67	117.12	98.33	101.08	96.00	98.44
S.D. (corrected)		5.21	5.06	6.19	5.66	8.54	9.04	2.05	8.20	9.86	3.80
S.E. of difference		2.229	2.407	2.200	2.847	2.916	2.959	2.496	2.707	2.945	2.146
Degree of freedom		38	31	37	23	19	25	25	30	20	30
't' value		5.248	5.911	4.553	4.627	12.860	12.669	7.116	7.980	9.100	5.599
significance		H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S
PERTURBATIONS											
Sample Size	-	20	17	24	2	9	16	6	13	7	18
Mean		14.30	14.70	10.42	8.00	30.89	44.12	14.33	19.08	23.43	13.33
S.D. (corrected)		6.06	4.90	4.45	5.66	10.87	8.048	1.97	8.19	5.97	3.82
S.E. of difference		1.389	1.225	0.928	5.656	3.624	2.077	0.884	2.362	2.437	0.927
Degree of freedom		19	16	23	1	8	15	5	12	6	17
't' value		10.295	16.615	11.224	1.414	8.523	21.244	16.212	8.076	9.613	14.381
significance		H/S	H/S	H/S	N/S	H/S	H/S	H/S	H/S	H/S	H/S

Analysis : Activity No. 11 - Dealing with Domestic Emergencies

DESCRIPTION	SUBJECT										
	A	B	C	D	E	F	G	H	I	J	K
Heart Rates: Rest Pulses											
Sample Size	72	27	50	67	71	39	72	68	38	69	64
Mean	80.08	79.74	95.56	91.04	84.65	115.74	97.97	88.97	90.21	72.58	94.41
S.D. (corrected)	7.33	3.08	4.41	4.05	3.59	9.43	14.17	4.24	5.26	9.09	4.94
S.E. of difference	2.702	1.929	2.215	1.943	2.162	3.178	3.676	2.227	2.387	2.987	2.253
Degree of freedom	83	45	64	80	92	49	81	87	55	82	76
't' value	1.767	3.027	4.259	3.763	3.617	8.363	4.988	3.771	4.498	1.130	3.541
significance	N/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	N/S	H/S
PERTURBATIONS											
Sample Size	72	27	50	67	71	39	72	68	38	69	64
Mean	4.88	6.63	8.64	7.82	7.01	20.90	18.39	9.09	8.68	7.216	6.72
S.D. (corrected)	3.30	2.65	3.64	3.15	2.79	9.55	14.80	7.10	5.90	4.12	3.44
S.E. of difference	0.391	0.519	0.520	0.387	0.332	1.548	1.756	0.867	0.970	0.499	0.433
Degree of freedom	71	26	49	66	70	38	71	67	37	68	63
't' value	12.468	12.772	16.615	20.206	21.126	13.499	10.471	10.482	8.952	14.460	15.515
significance	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S

Analysis : Activity No. 12 - Administrative Duties

DESCRIPTION	SUBJECT										
	A	B	C	D	E	F	G	H	I	J	K
Heart Rates: Rest Pulses											
Sample Size	6	4	10	9	18	12	20	22	18	10	20
Mean	95.33	89.50	105.60	98.22	89.33	134.00	106.30	94.18	101.78	99.80	101.50
S. D. (corrected)	3.50	3.46	6.85	6.44	2.66	7.58	9.50	8.70	7.59	4.05	3.17
S. E. of difference	2.466	2.113	2.599	2.006	2.391	3.150	3.018	2.858	2.672	2.509	2.040
Degree of freedom	17	22	24	22	39	22	29	41	35	23	32
't' value	8.120	7.382	7.493	7.223	5.230	14.233	8.834	4.762	8.346	12.196	7.388
significance	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S
PERTURBATIONS											
Sample Size	6	4	10	9	18	12	20	22	18	10	20
Mean	15.83	21.50	18.60	13.55	8.89	40.92	27.40	10.18	20.33	20.00	8.30
S. D. (corrected)	7.62	3.41	4.99	4.78	3.23	5.54	9.04	6.08	5.71	4.22	2.45
S. E. of difference	3.409	1.970	1.664	1.689	0.784	1.669	2.073	1.325	1.384	1.405	0.562
Degree of freedom	5	3	9	8	17	11	19	21	17	9	19
't' value	4.644	10.913	11.177	8.024	11.336	24.515	13.217	7.683	14.690	14.234	14.768
significance	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S

Analysis : Activity No. 13 - Dealing with Cash

DESCRIPTION	SUBJECT										
	A	B	C	D	E	F	G	H	I	J	K
Heart Rates: Rest Pulses											
Sample Size	66	18	24	29	36	20	21	46	86	56	82
Mean	81.97	81.17	100.17	90.55	84.72	112.40	91.05	83.87	84.86	72.75	91.80
S.D. (corrected)	4.67	6.05	3.68	4.07	2.87	7.55	7.00	5.87	11.74	8.27	3.02
S.E. of difference	2.252	2.318	2.187	1.880	2.211	3.046	2.715	2.522	3.302	2.268	1.837
Degree of freedom	77	36	38	42	57	30	30	65	103	69	94
't' value	2.958	3.135	6.420	3.627	3.571	7.627	4.202	1.307	1.631	1.237	2.926
significance	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	N/S	H/S
PERTURBATIONS											
Sample Size	66	18	24	29	36	20	21	46	86	56	82
Mean	7.15	4.78	14.08	4.96	5.83	17.30	13.62	3.87	9.46	5.50	6.41
S.D. (corrected)	3.11	4.16	3.94	3.69	2.55	9.85	7.37	3.22	4.91	3.06	3.48
S.E. of difference	0.386	1.009	0.820	0.697	0.430	2.260	1.647	0.480	0.532	0.412	0.386
Degree of freedom	65	17	23	28	35	19	20	45	85	55	81
't' value	18.525	4.734	17.173	7.121	13.562	7.654	8.268	8.058	17.789	13.349	16.616
significance	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S	H/S

Analysis : Activity No. 14 – Meals and Breaks

DESCRIPTION	SUBJECT										
	A	B	C	D	E	F	G	H	I	J	K
Heart Rates: Rest Pulses											
Sample Size	-	-	-	-	-	-	-	83	14	18	7
Mean								87.52	101.57	75.77	96.86
S.D. (corrected)								3.286	7.38	2.70	4.48
S.E. of difference								2.020	2.644	2.221	2.307
Degree of freedom								102	31	31	19
't' value								3.439	8.357	2.960	4.520
significance								H/S	H/S	H/S	H/S
PERTURBATIONS											
Sample Size	-	-	-	-	-	-	-	83	14	18	7
Mean								1.93	16.00	6.55	10.57
S.D. (corrected)								2.73	7.48	2.55	5.13
S.E. of difference								0.301	2.073	0.619	2.094
Degree of freedom								82	13	17	6
't' value								6.398	7.718	10.588	5.047
significance								H/S	H/S	H/S	H/S

Analysis : Activity No. 15 - Driving

APPENDIX II

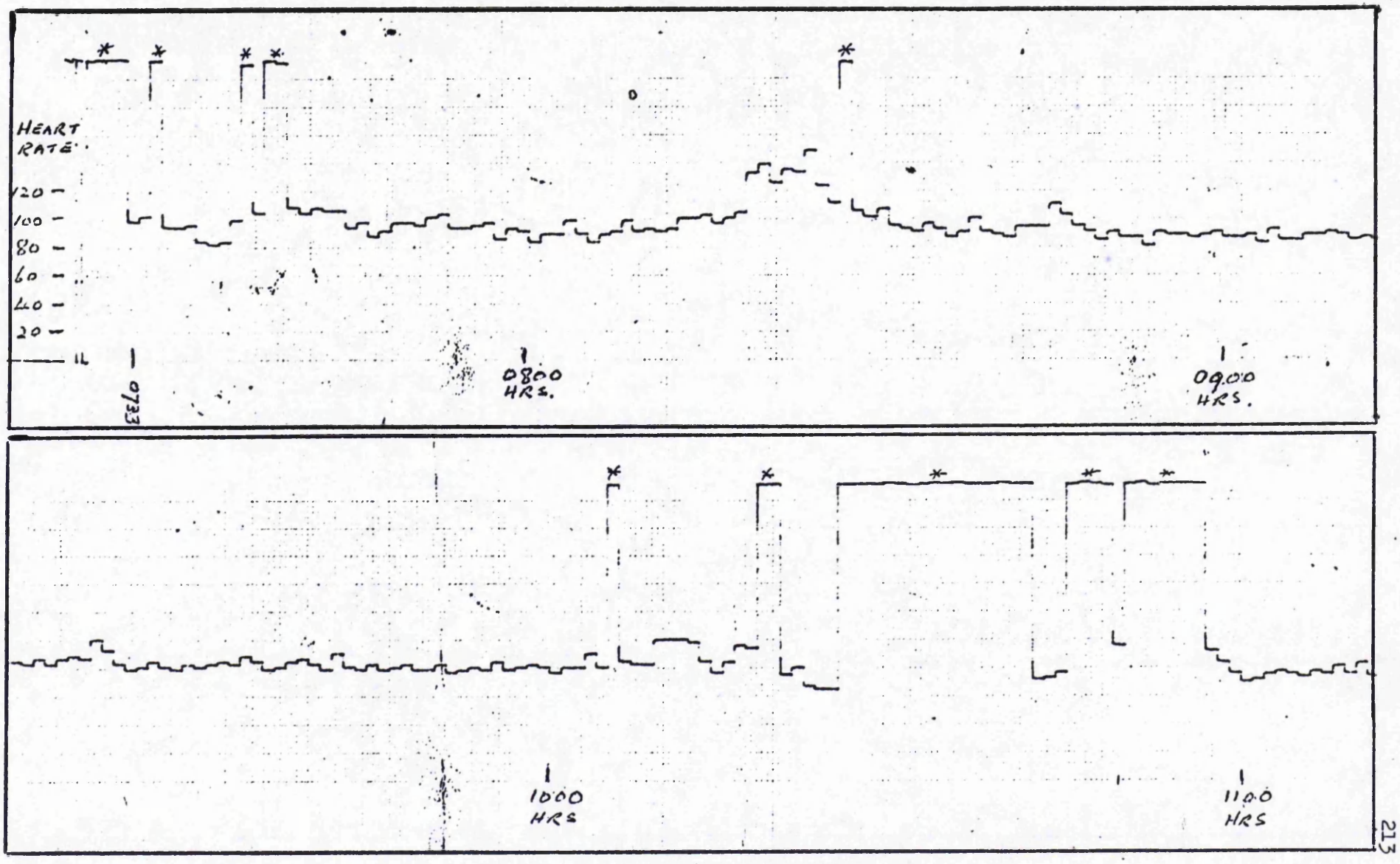
Analysis of Comparative Subjects L, M, and N

Analysis sequence for each subject:-

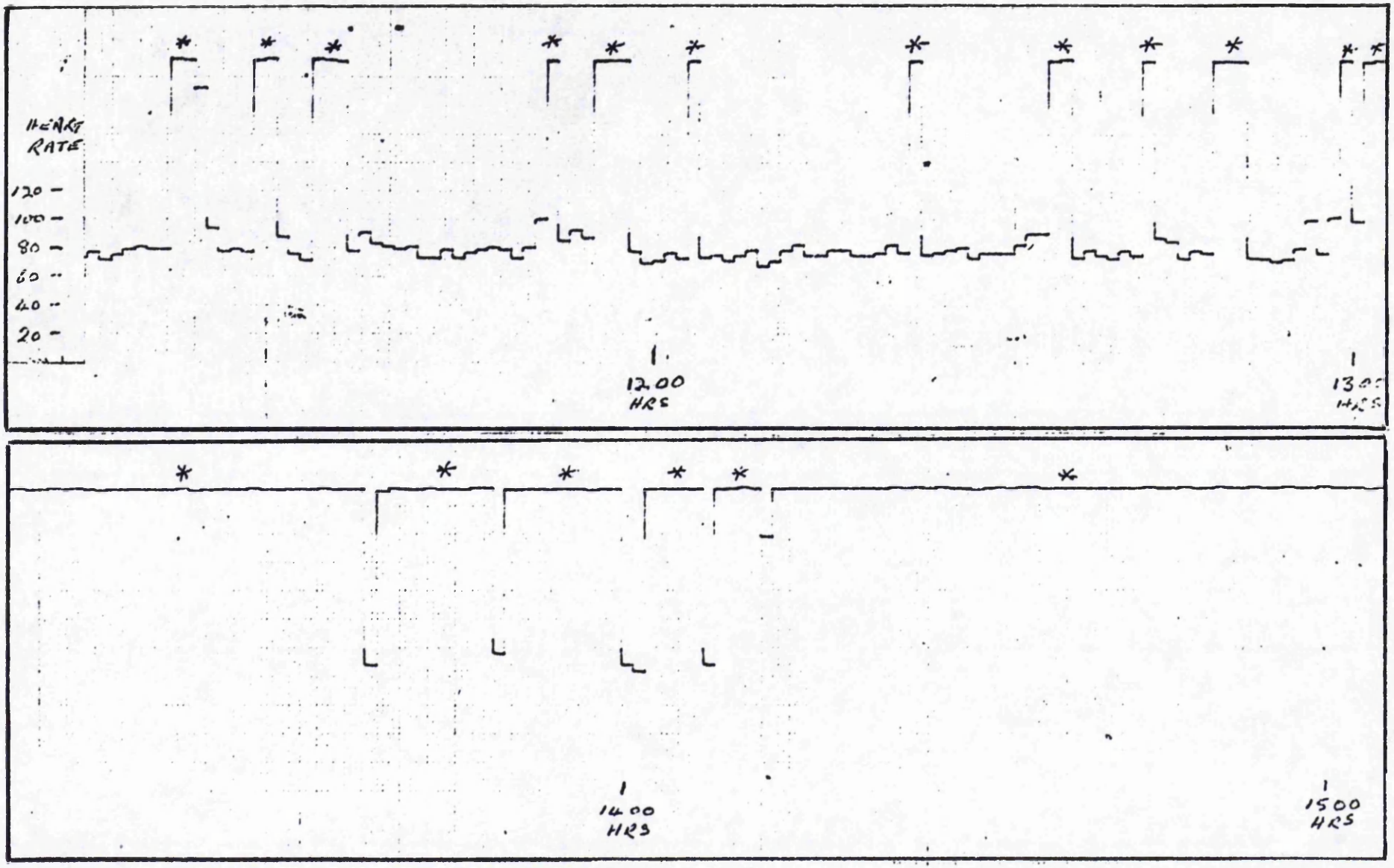
1) Personal Details
2) Heart Rate Graphs
3) Moving Average Graph
4) Histogram

PERSONAL DETAILS	SUBJECT		
	L	M	N
Sex	Female	Female	Male
Age	28 years	36 years	26 years
General Physical Health	Excellent	Very good	Very good
Marital Status	Married	Married	Single
Smoking Habits	Non-smoker	Non-smoker	Non-smoker
Drinking Habits	Occasional glass of wine	3 Whiskeys a day	Tee-total
Experience	8 years in commerce	16 years Local Government	8 years Administration
Occupation	Chartered Secretary	Matron, Day Nursery	Supervisor on Supervision Course
Stress experienced during	No stress felt	No stress felt	No stress felt
General impression study	Very intelligent, competent	Capable, efficient	High capability, excitable

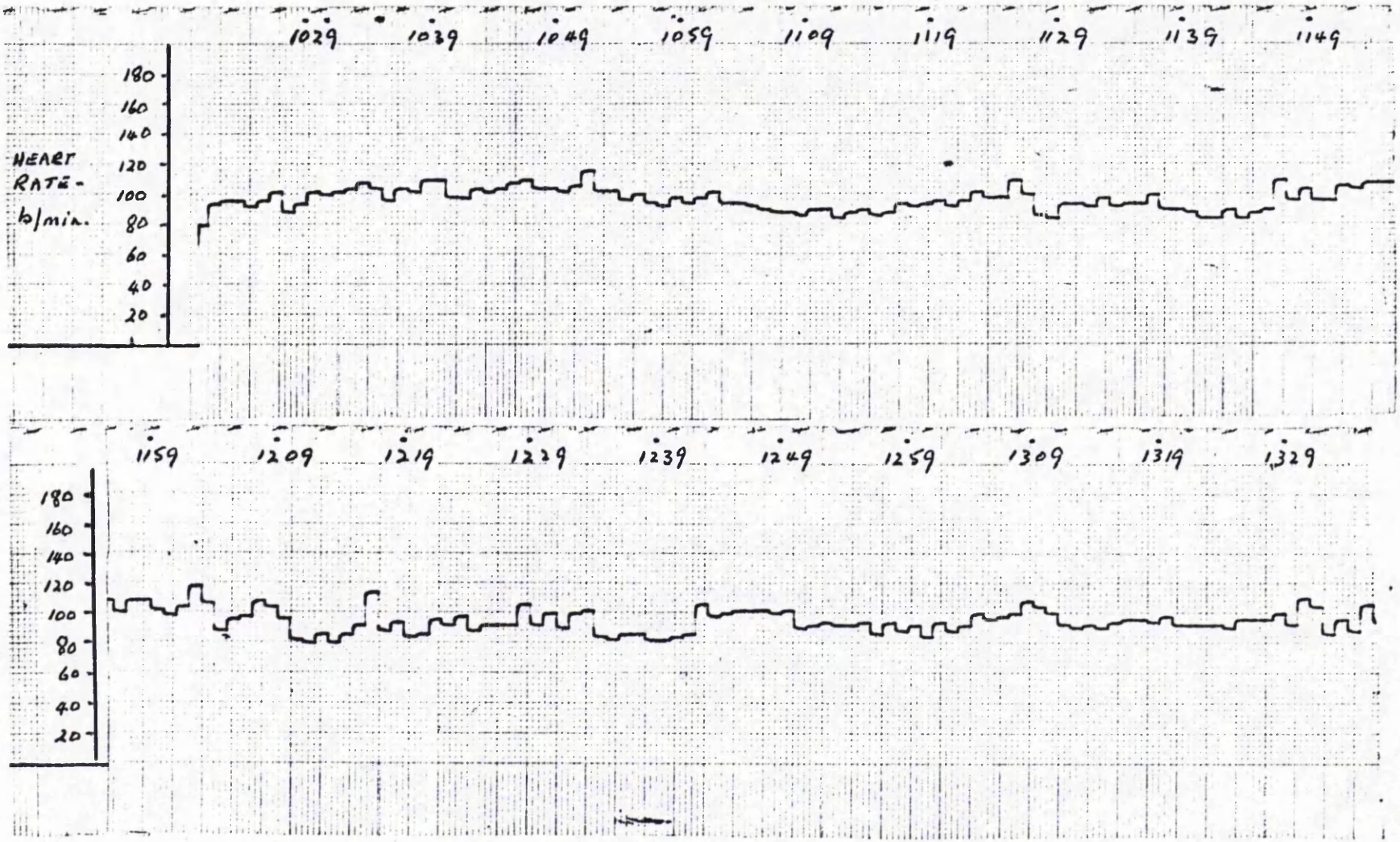
Subjects L, M, and N - Personal Details



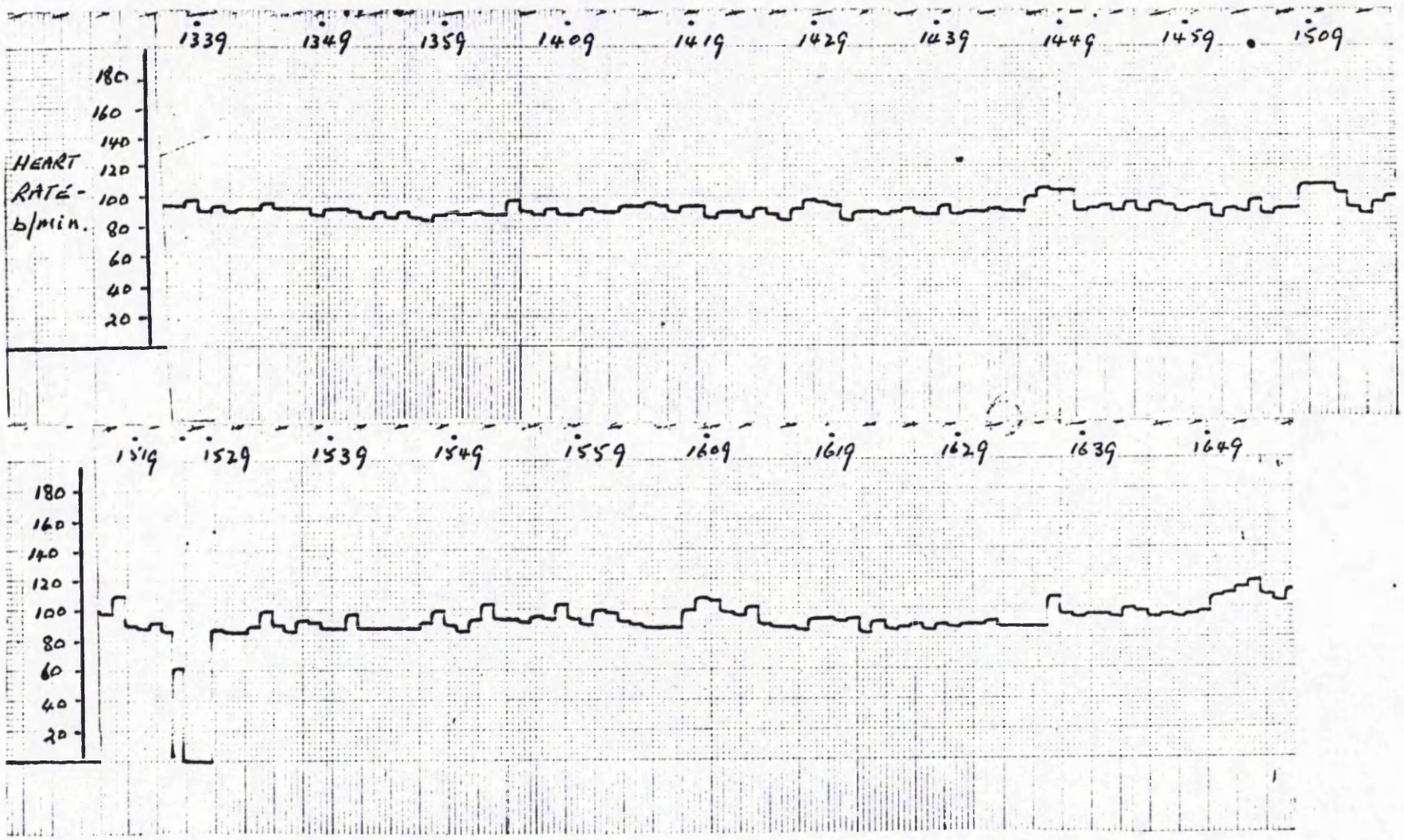
Subject L - Heart Rate Graph



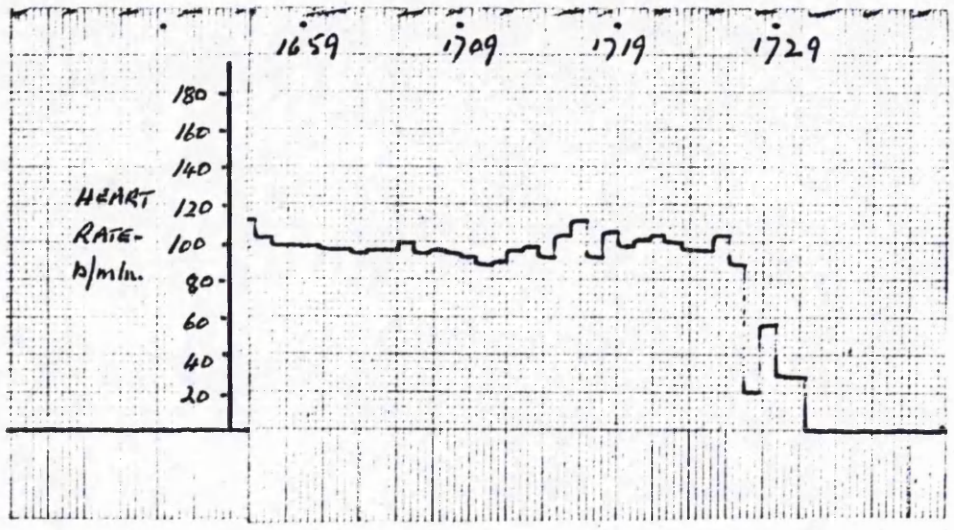
Subject L - Heart Rate Graph (continued)



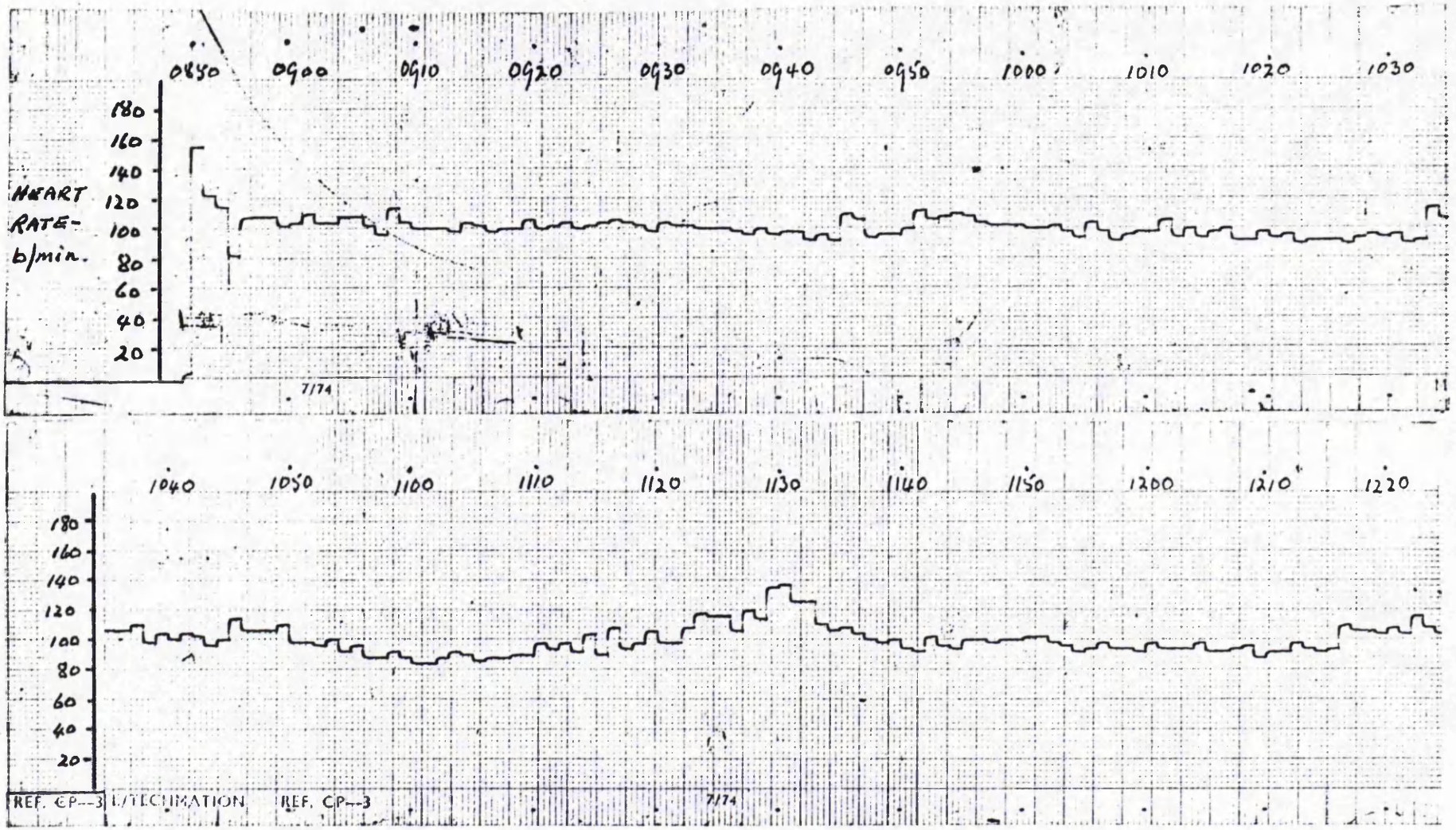
Subject M – Heart Rate Graph



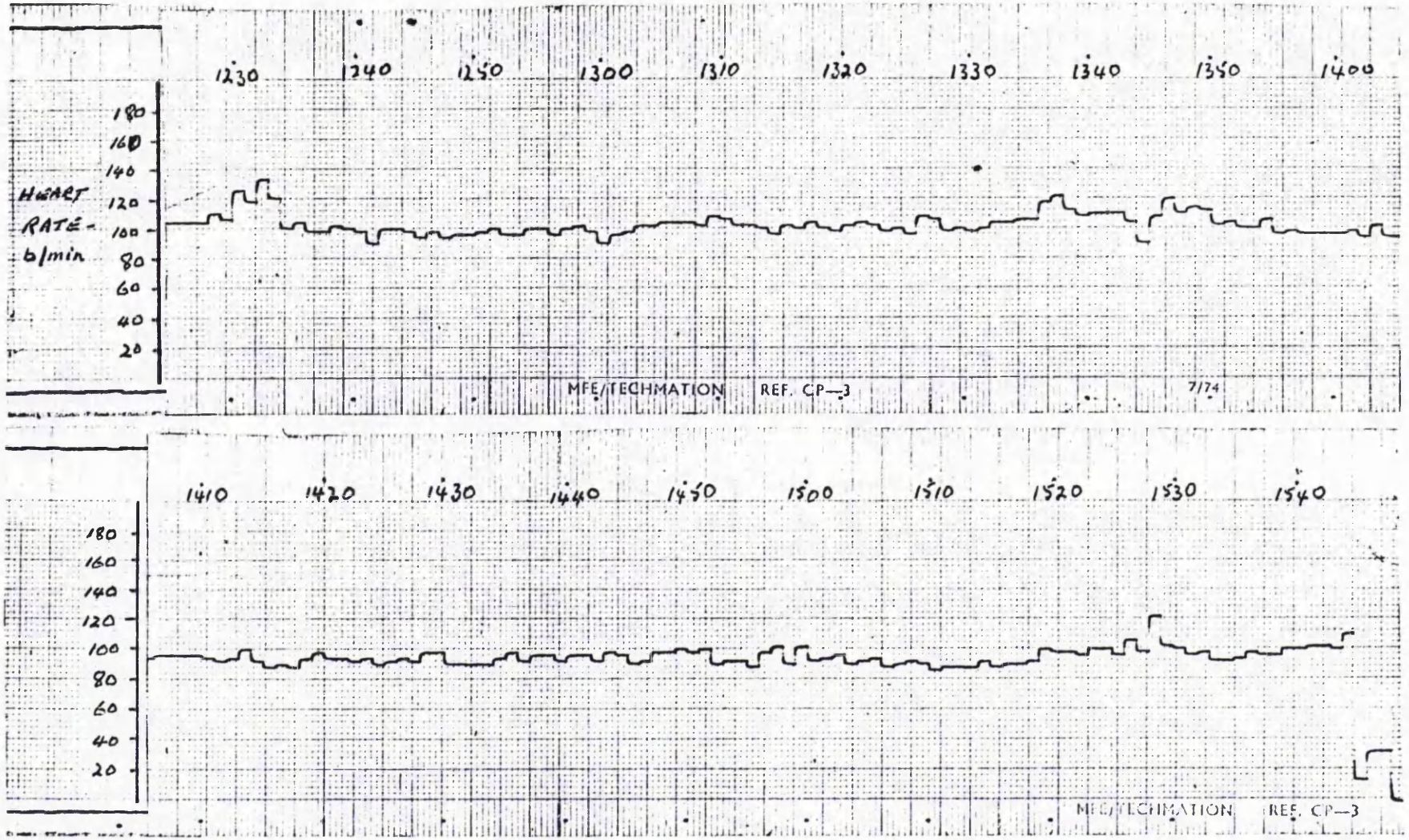
Subject M - Heart Rate Graph (continued)



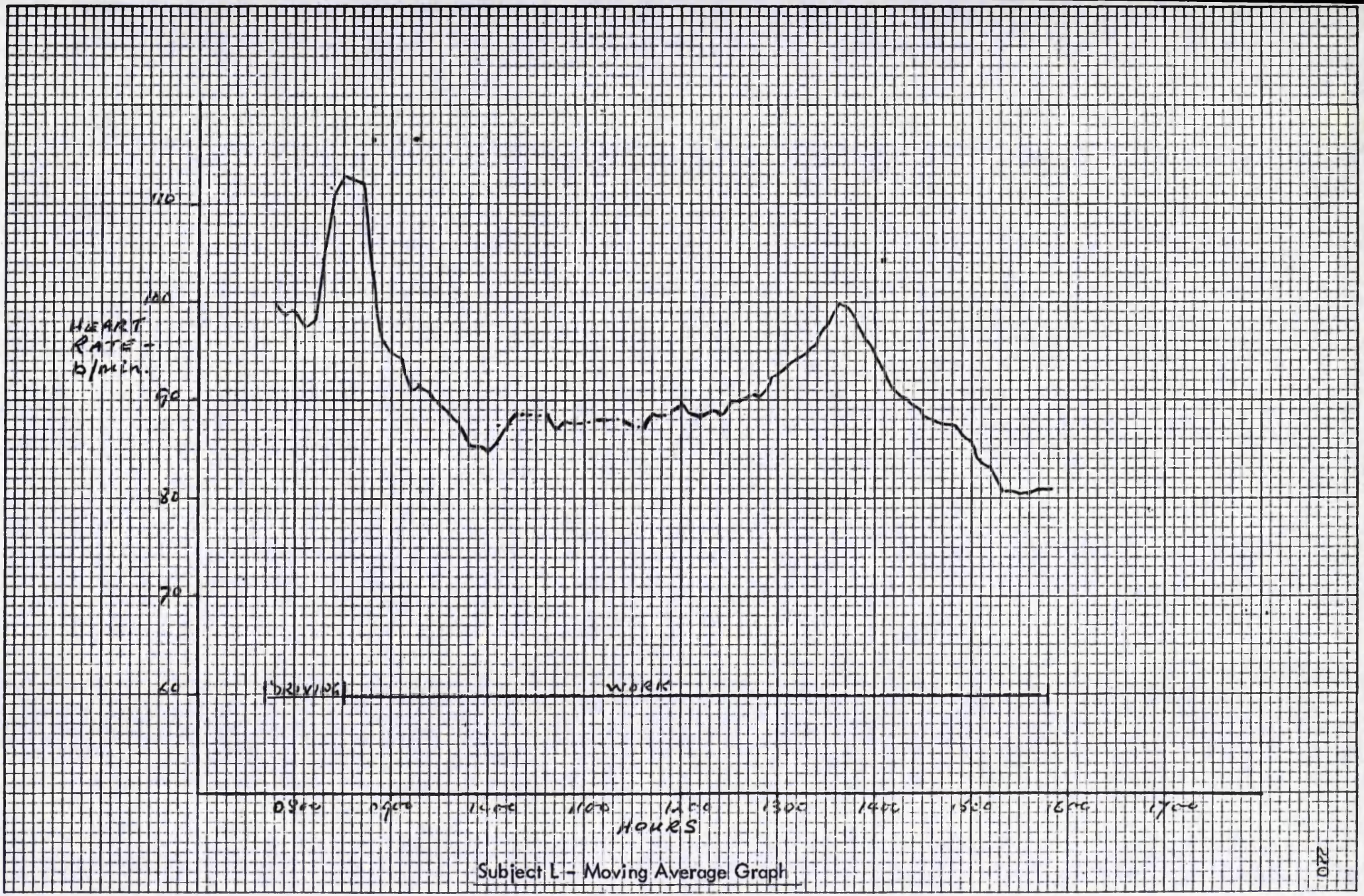
Subject M – Heart Rate Graph (continued)



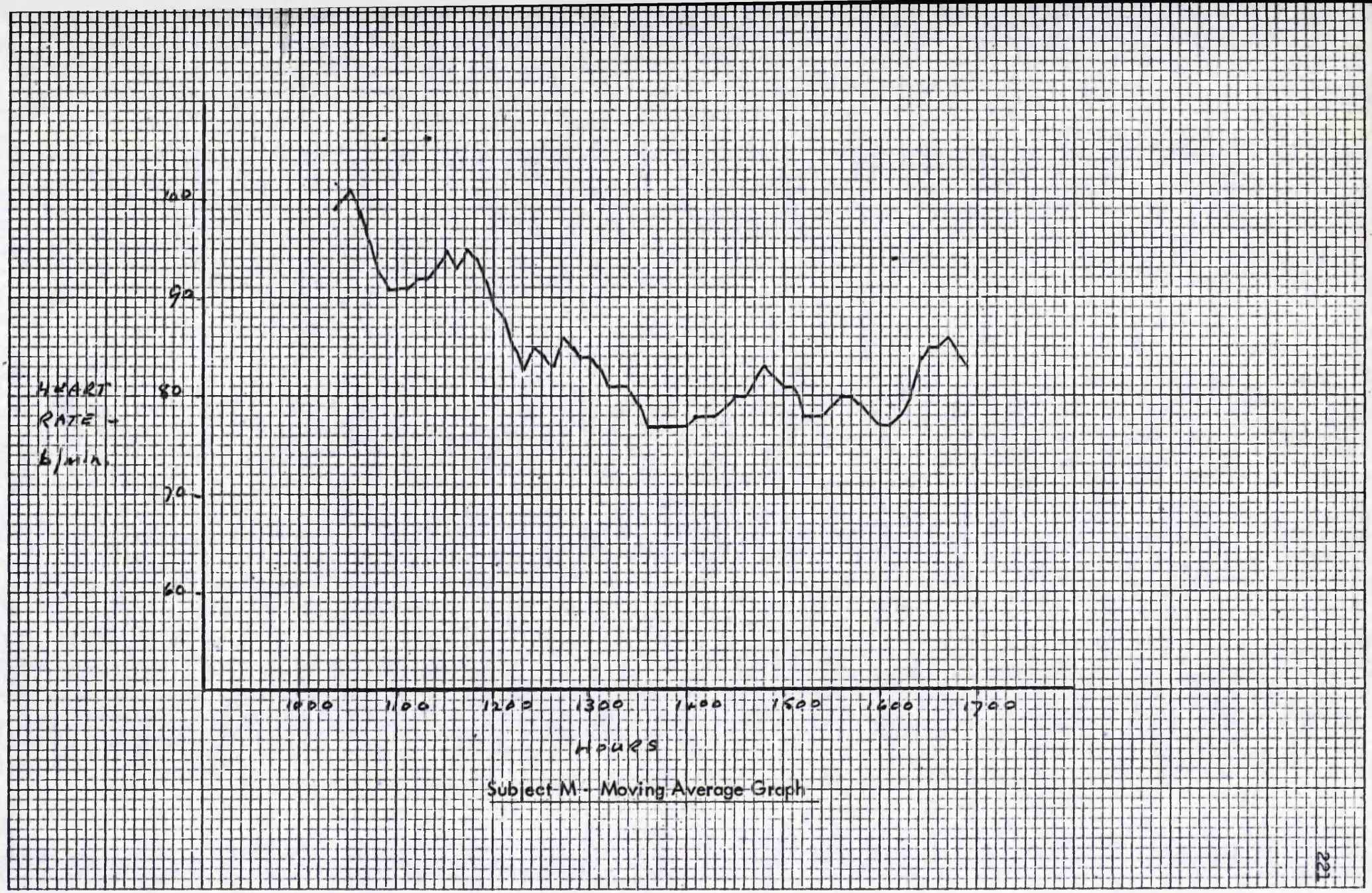
Subject N - Heart Rate Graph



Subject N – Heart Rate Graph (continued)

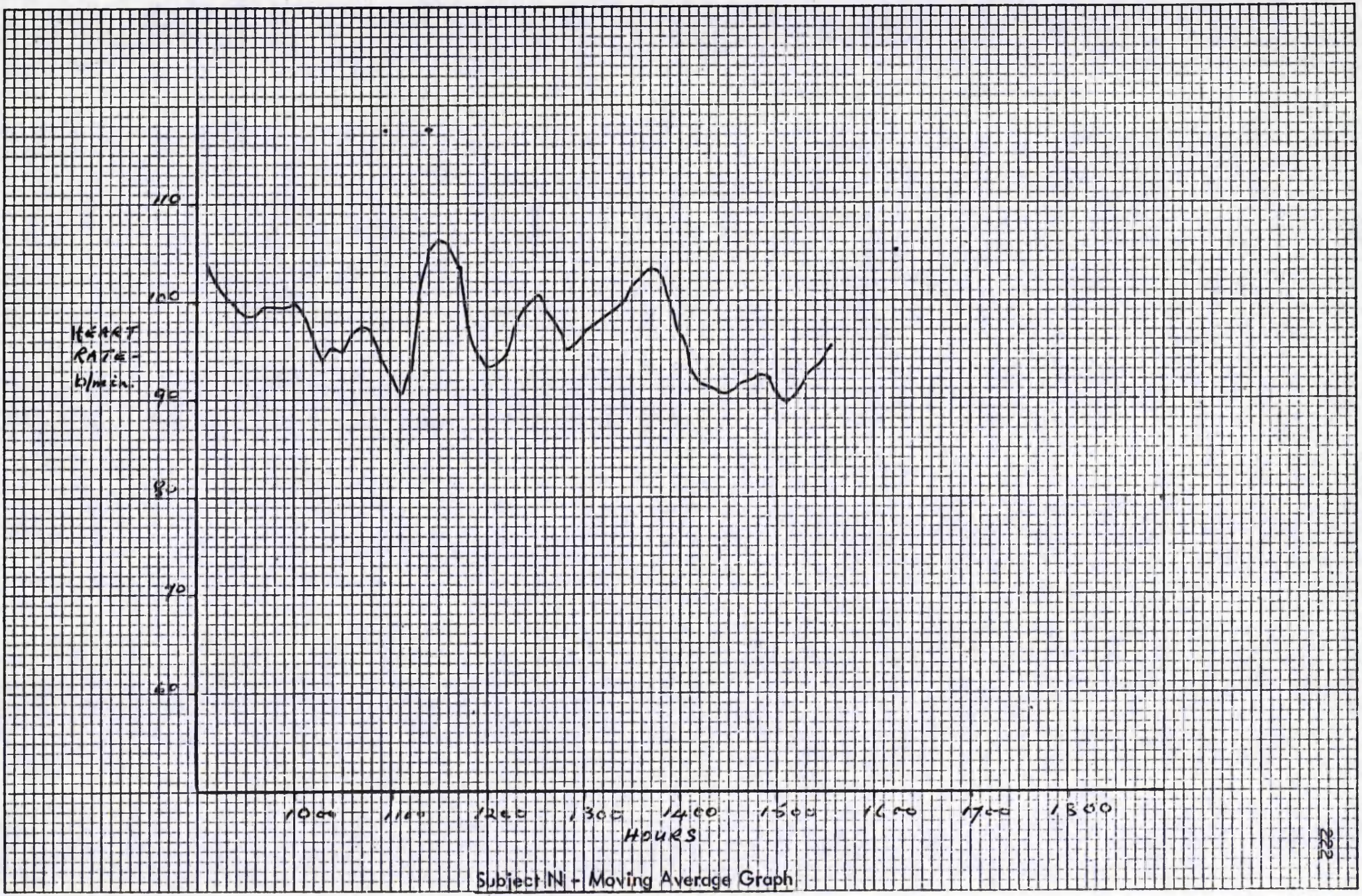


Subject L - Moving Average Graph

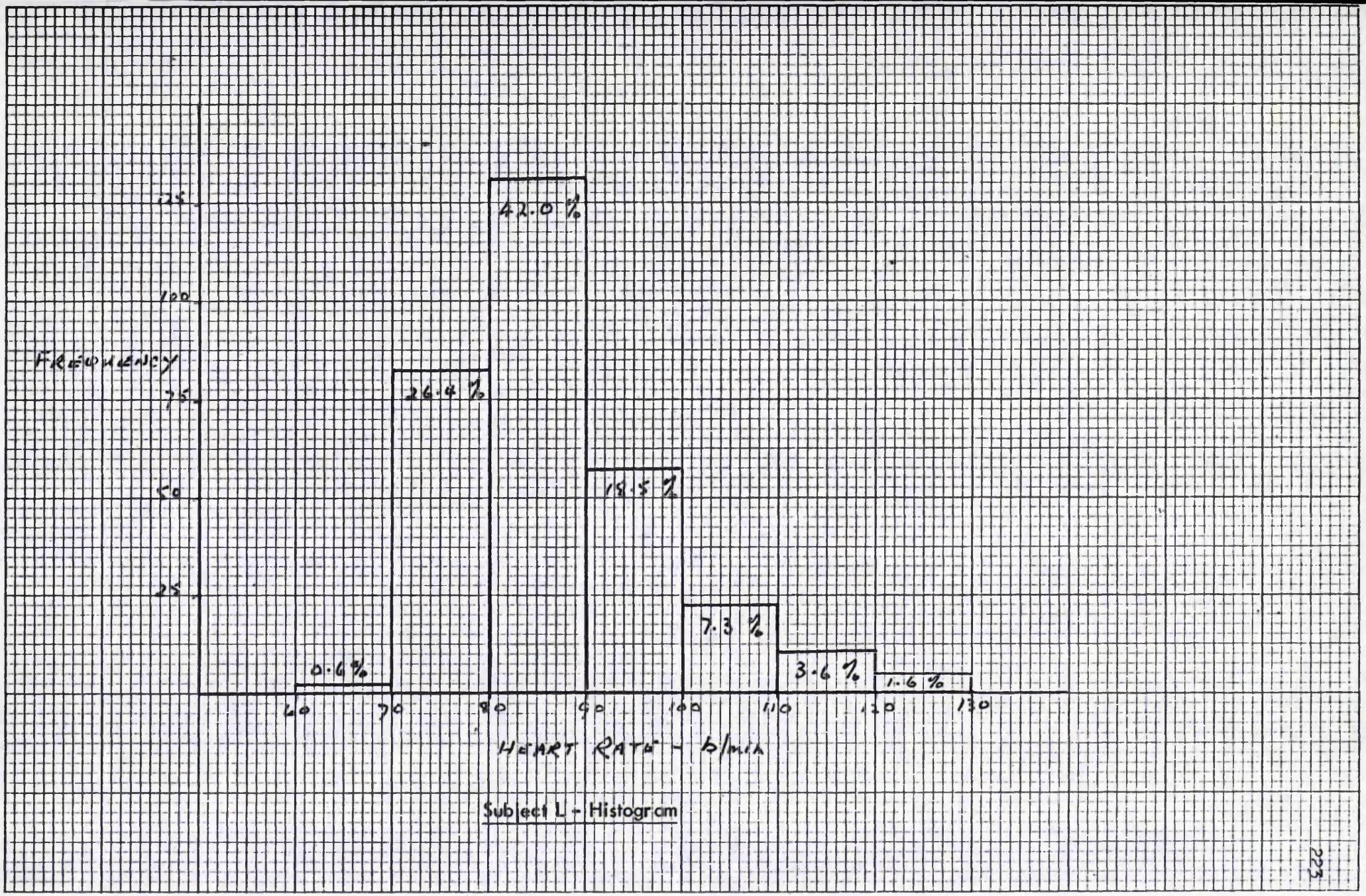


Subject M - Moving Average Graph

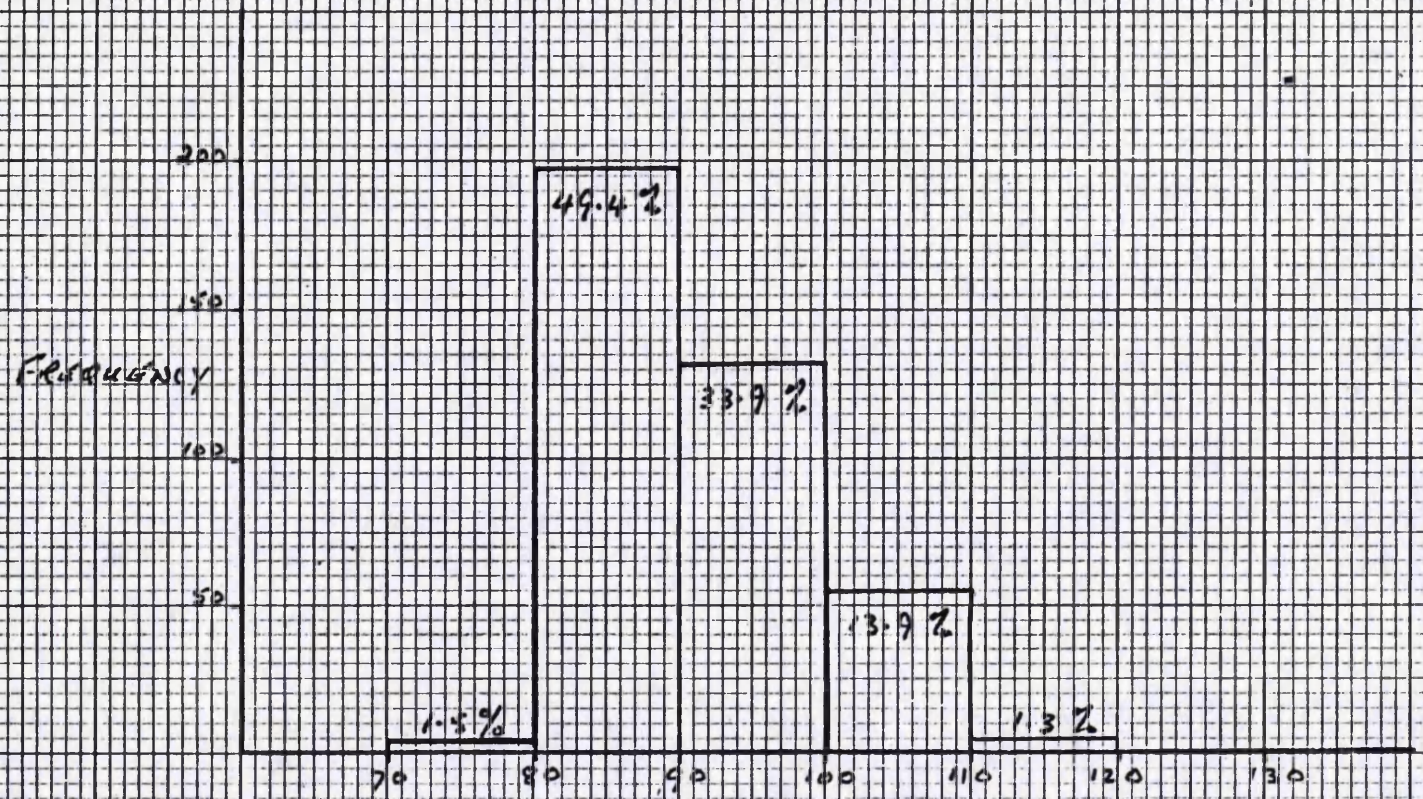
T22



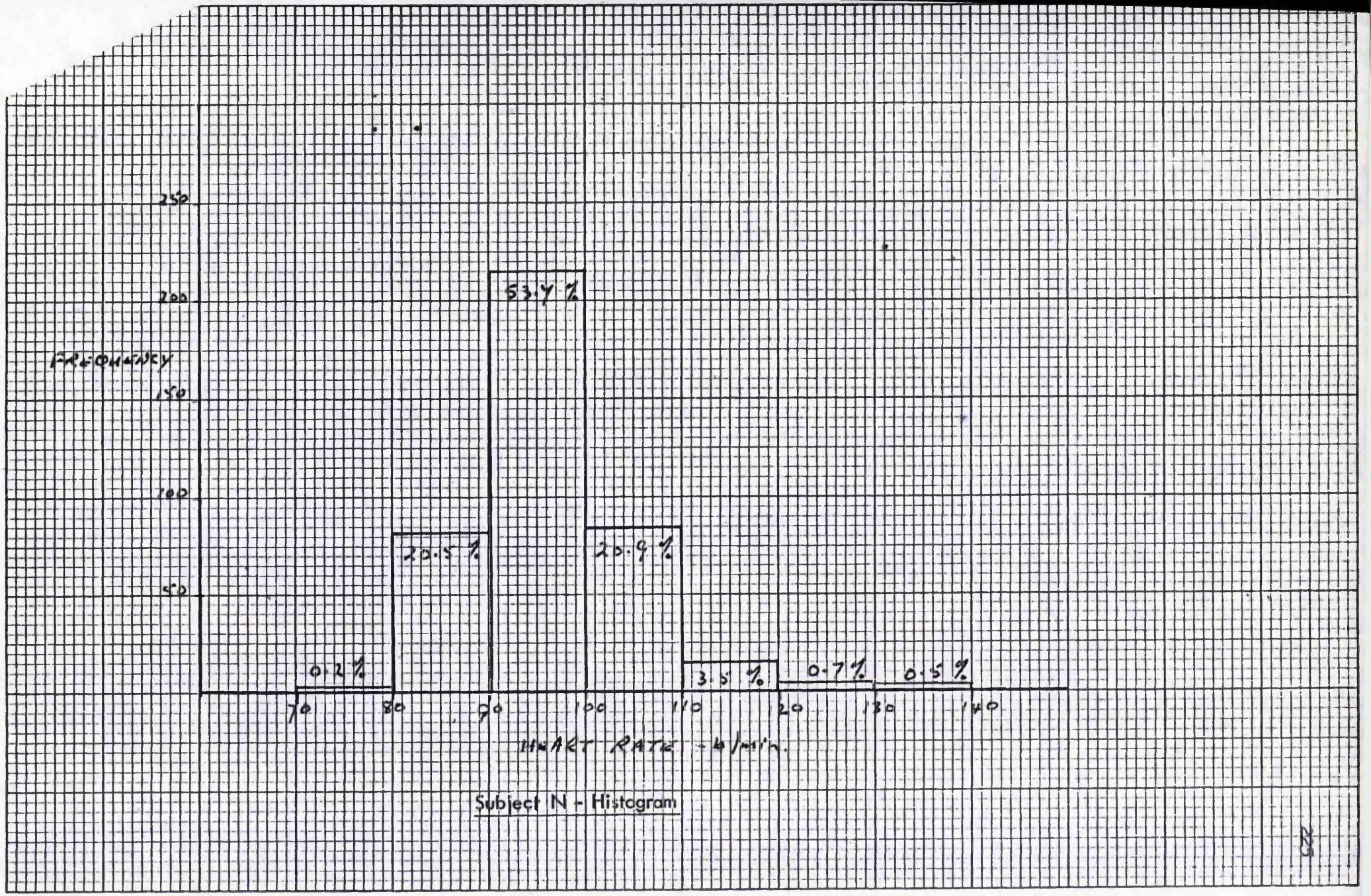
Subject N - Moving Average Graph



Subject L - Histogram



Subject M - Histogram



Subject N - Histogram

APPENDIX III

Radio Programme : "Stress - Your Life in Your Hands" - 29th April, 1976, 8.45 p.m., B.B.C., Radio 4

Source : Radio Times

Subject : A look at how much people have learned about stress at home and at work

Speakers : Dr. D. Bannister
Head of Psychology Unit, Bexley Hospital, Kent

Dr. Robin Sharpe
Director of "Stress"

Dr. Malcolm Carruthers
St. Mary's Hospital

Professor Ivor Mills

Peter Blythe

Main Points of Interest

Dr. Bannister : "Stress is the anxiety one feels faced with elements outside the range of one's construing. It is the internal response not the outside influence - the whispered unpleasantness hurts more than the roar of Concorde."

Dr. Sharpe : "Stress is an external stimulous that impinges on the organism and affects the performance. Things tend to spiral: the executive who rows with his wife at breakfast, gets caught in a traffic jam, and is finally carpeted at work suffers stress."

Dr. Carruthers : Advocates schools where the middle-aged can go to choose which killers to avoid.

Professor Mills : Suggests that the life tempo is too fast, people should slow down and accept a lower standard of living, rather than be driven by stress

into a lemming-like journey to destruction.

Peter Blythe : Suggests that some people - a particular group - like stress and become addicted to the excitement caused by the rise in noradreniline in the bloodstream which triggers off the pleasure centres.

APPENDIX IV

Radio Programme : "You and Yours" - 30th April, 1976, 12.02 p.m., B.B.C., Radio 4

Source : Radio Times

Title : Your Health and General Wellbeing

Producer : Miss Jessica Mayer

Presenter : Bill Brecken

Views presented by:

1) Dr. Berick Wright
BUPA Medical Centre

2) Dr. Maurice H. Pappworth
Registrar, Royal Infirmary, Liverpool

Subject : Screening on a large scale for heart disease, breast cancer and hernia

Case for presented by Dr. Pappworth

Case against by Dr. Wright

Main Problems

1) How to set viable norms
2) Every individual seems to be different and reacts in many different ways
3) The effect on the individual as a result of the tests
4) Possible development of hypertension if disclosure is positive
5) The percentage of positive results of screening is apparently very small
6) Difficulty of prognosis as there is no definite proof that disease will develop even after tests prove positive

APPENDIX V

Private interview with Dr. E. B. Raftery, Consultant Physician/Cardiologist, Northwick Park Hospital and Harley Street : 26th April, 1976.

Main Aspects

1) Prefers to avoid term "mental stress" as there is difficulty in defining it and he uses "mental activity" as the alternative.
2) There seems to be no way of measuring mental stress.
3) The case studies often quoted, such as rally car drivers, free-fall parachutists, and other groups of extremist-behaviourists, are biased samples and do not conform to the general type of person.
4) Heart rate increase may also be caused by a reduction in the dampening effect of the vagus nerve on the heart. Thus no adrenalin increase would have occurred.
5) Check on Selye, a Canadian, whose work is now discredited.
6) He agrees that there are unknown mechanisms that allow concentration to reduce and increase heart rate at will.
7) Contact M. Carruthers and speak with him.
8) Contact Lorimer at Glasgow on standardised stress reaction.
9) There seems to be no evidence to show that managerial jobs are highly stressful but he agreed that personal involvement in speaking to groups is stressful.
10) Modern thought tends to rule out the effects of the pituitary gland on the heart's behaviour.

APPENDIX VI

Private interview with Dr. F. Mitchell, Head of Clinical Chemistry Department, Clinical Research Unit, Northwick Park Hospital : 24th February, 1976.

Main Aspects

1) Worry, flight, or fight may evoke a stress response which eventually causes the adrenal gland to increase the amount of adrenalin flow into the blood stream. This increase causes, among other activities, an increase in heart rate, preparations in the body for fight or flight, and the stomach is retarded.
2) A stomach ulcer is caused by too high acidity irritating the stomach lining where blood-flow is restricted due to stress.
3) The vagus nerve also has an effect on heart rate. This effect should be discussed with E. B. Raftery.
4) Adrenalin flows to many areas of the body including all the organs.
5) Discussions on coronary thrombosis highlighted the following points:-
   i) The deposition of cholesterol is a critical feature
   ii) The cholesterol level is important. For example, a high level of, say, three times the usual amount at birth is sufficient to cause death by the age of 30 years
   iii) Fat metabolism also affects cholesterol build-up in the body
   iv) The effect of butter and margarine is still debatable. For example, the Danube delta fishermen eat practically nothing else but fatty fish but they do not contract coronary thrombosis
   v) Much of current theory is based upon the liberation of adrenalin

APPENDIX VII

Private interview with Professor N. S. Kirk and Dr. E. J. Hamley at Loughborough University of Technology on 11th February, 1975.

Main Topics

Question : Is heart rate a suitable dependent variable in the measurement of mental stresses?

Answer : Totally unsuitable.

Question : What are suitable measuring parameters for this purpose?

Answer : i) Measurements of work output
ii) Measurements of performance
iii) Visual observations of bodily changes that coincide with the managerial skill being exercised.

Question : Are the results of any use to the ergonomist?

Answer : Many results apparently are simply factual but do not add materially to the existing body of knowledge.

Question : Is information processing a unique problem?

Answer : Yes: the findings can only be interpolated (not extrapolated). There is a tendency to use psychological measures in view of the crudeness of other measures.

Question : Are there any known cases of measuring human presence in the exercise of managerial skills?

Answer : Not known, but some research associated with human vigilance was indicated in a textbook "Human Vigilance Performance" by Davis and Tune, Staples Press.

Question : Are there known research units who are interested in this particular field?

Answer : Possibly Bradford University. Contact Professor C. Higgins and

G. Randall.

Question : Are there any measurement methods that have been found useful in work of this nature?

Answer : i) Breathing rate assessed by observation was used in locating the best passenger position in underground trains

ii) The number of times a manager contacted subordinates was also mentioned as a measure of strain

iii) A textbook was mentioned which may be of use in deciding on appropriate psychological measures: "Systems Related Measures - Man/Machine System Experiments" by H. M. Parsons, John Hopkins Press

iv) A useful contact could be Colin McKay at Nottingham University

APPENDIX VIII

Private interviews with Dr. G. Schäcke held on 3rd and 4th March, 1976, at Institut Für Arbeits und Sozial Medizin, und Poliklinick Für Berufskrankheiten, Der Universitat Erlangen - Nurnberg, West Germany.

Main Topics

1) Problems of Observation. He considered it was very difficult to avoid bias during direct observation. For example, asking a subject immediately after an activity exactly what he was doing is sufficient to raise heart rate considerably.
2) Suitable Statistical Analysis of Observations. The trend line was considered to be very important; a slight upward trend over the day would indicate overload.
3) Scale in Mental Work. He considered that there was still no answer to this problem.
4) Statistical Analysis at the University. The main statistics utilised were histograms, minimum, maximum, median, and regression lines.
5) Physical activities and their effect. The tendency is to ignore all the physical activities and concentrate on trends. This also applies to circadian rhythm and environmental conditions.
6) Recording. Accurate, consistent, and unbiased recordings are still very difficult to achieve.

APPENDIX IX

Description of the Equipment

A miniature data-logging storage system was conceived and developed by the Medical Research Council at the Clinical Research Centre, Harrow, for the purpose of collecting long-term measurements of physiological and environmental variables on people. It is distributed by T. E. M. Engineering Ltd.

The apparatus consists of skin electrodes which pick up the ECG waveform and transfer it via twin cables to the transducer unit (8 cms. x 11.5 cms. x 2 cms.). The processed signals are then transferred to the tape recorder (11.5 cms. x 6.5 cms. x 2.5 cms.).

The storage medium is a miniature dictation cassette with a total running time of 24 hours. The replay machine is designed to produce an analogue graphical output. The photograph on the next page illustrates the three pieces of equipment.

The system may be adapted to record micro-environmental and skin temperatures at the same time as heart rate. Facilities are also available for producing punched paper tape and printed readings.

After some initial testing of various types the most suitable electrodes were found to be V-Trace, Ag/AgCl, ECG monitoring electrodes manufactured by NDM Corporation, U.S.A.

The Circuitry

The input signal is recorded on the magnetic tape in the form of pulses generated by a square-wave pulse generator. The number of pulses is proportional to the number of beats in one minute.

The recorder is separated into three main electrical circuits:

(i) acceptance and storage of the data

(ii) the timing mechanism

(iii) the digitizing of the data into pulses and recording of these on tape.

Analogue Graphical Output, Transducer, and Recorder.

The main aspects are given below:

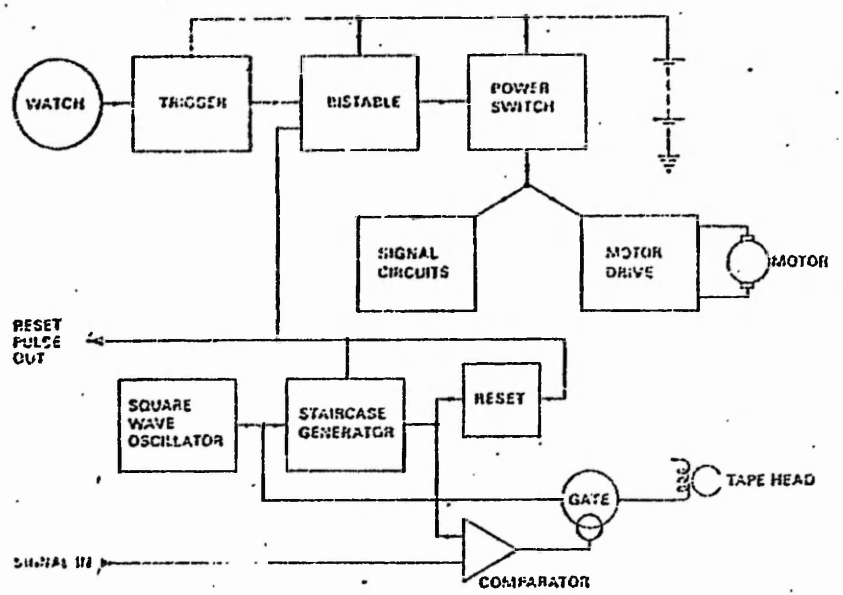
(1) The electrical cardiac impulses are picked up by the electrodes and fed to the amplifier which charges a storage capacitor. Each beat triggers the circuit passing a fixed charge to the capacitor which therefore sums the number of beats. The voltage across the capacitor is passed to the comparator (see block diagram on the next page).

(2) The watch movement operates at 1-min. intervals, triggering a bistable circuit. This causes a switch to close, thereby powering the main recorder circuits. The motor is accelerated and its speed is stabilized by a negative resistance circuit.

(3) The signal from the capacitor is fed into the comparator as a reference voltage. When the watch movement triggers the circuit, the square-wave oscillator drives a staircase generator, providing a train of pulses to the recording head. At the instant the staircase voltage reaches the reference voltage the gating circuit closes, allowing no more pulses to pass. Thus the number of pulses corresponding to the number of heart-beats is recorded on the tape.

(4) Three tracks are available on the tape, for recording three different parameters. The fourth track is used to reset the staircase generator, and other circuits. When the pulse count reaches 120 (i.e. the staircase reaches the "top") the oscillator switches off and the staircase disappears ready for the next count.

(5) On replay, the pulse trains from the tape, suitably amplified are fed to staircase Digital/Analogue converters for the analogue outputs and to Binary Coded Decimal counter chains for the digital outputs. Replay may take place continuously or intermittently as determined by the device that the replay machine drives - paper tape punch, etc.



Block Diagram of Recorder Circuit

APPENDIX X

QUESTIONNAIRE

(to be completed by interviewer)

GENERAL DETAILS	
(1) SURNAME:	(2) FORENAMES:
(3) TITLE	
(4) RESPONSIBLE TO:	
(5) RESPONSIBLE FOR:	
(6) HOTEL:	
(7) ADDRESS OF HOTEL:	
(8) TELEPHONE NO:	
PERSONAL DETAILS	
(9) SEX:	(10) AGE:
(11) GENERAL PHYSICAL HEALTH:	
(12) IF POOR HEALTH - MAIN AREAS:	
(13) MARITAL STATUS:	
(14) SMOKING HABITS:	
(15) DRINKING HABITS:	
(16) MANAGERIAL EXPERIENCE IN HOTELS:	
GENERAL IMPRESSIONS	
(17) DISPOSITION:	
(18) ATTITUDE TOWARDS STUDY:	
(19) CONFIDENCE:	
(20) AGGRESSIVENESS:	
(21) PERSONALITY:	
(22) OTHER COMMENTS:	

APPENDIX XI

ACTIVITIES DIARY

NAME:
HOTEL:
DATE:
TEL. NO:

STARTING TIME:
FINISHING TIME:
TOTAL MINUTES:

TIME	CODE	TIME	CODE	TIME	CODE	TIME	CODE	TIME	CODE	TIME	CODE	TIME	CODE	TIME	CODE
01		31		01		31		01		31		01		31	
02		32		02		32		02		32		02		32	
03		33		03		33		03		33		03		33	
04		34		04		34		04		34		04		34	
05		35		05		35		05		35		05		35	
06		36		06		36		06		36		06		36	
07		37		07		37		07		37		07		37	
08		38		08		38		08		38		08		38	
09		39		09		39		09		39		09		39	
10		40		10		40		10		40		10		40	
11		41		11		41		11		41		11		41	
12		42		12		42		12		42		12		42	
13		43		13		43		13		43		13		43	
14		44		14		44		14		44		14		44	
15		45		15		45		15		45		15		45	
16		46		16		46		16		46		16		46	
17		47		17		47		17		47		17		47	
18		48		18		48		18		48		18		48	
19		49		19		49		19		49		19		49	
20		50		20		50		20		50		20		50	
21		51		21		51		21		51		21		51	
22		52		22		52		22		52		22		52	
23		53		23		53		23		53		23		53	
24		54		24		54		24		54		24		54	
25		55		25		55		25		55		25		55	
26		56		26		56		26		56		26		56	
27		57		27		57		27		57		27		57	
28		58		28		58		28		58		28		58	
29		59		29		59		29		59		29		59	
30		60		30		60		30		60		30		60	

APPENDIX XII

Publications Consulted

Textbooks :

ALPERN, M., LAWRENCE, M & WOLSH, D. 1967 Sensory Processes. Prentice-Hall

APPLEY, M. & TRUMBELL, R. 1967 Psychological stress : issues for research. Appleton.

ANDREWS, R.B., 1967. Estimation of values of energy expenditure rate from observed values of heart rate. Human Factors No 9, p.p.581-586.

ANGELONE, A., COULTER, N. A., 1964. Respiratory sinus arrhythmia: a frequency dependent phenomenon. Journal of Applied Physiology 19, 479-482.

ASTRAND, P. O., 1952. Experimental studies of physical working capacity in relation to sex and age. Ejnar Munksgaard, Copenhagen.

ASTRAND, P. O., CUDDY, T. E., SALTEN, B., STENBERG, J., 1964. Cardiac output during submaximal and maximal work. Journal of Applied Physiology No 19, p.p. 268-274.

ASTRAND, P. O., RHYMING, 1., 1954. A nomogram for calculation of aerobic capacity (physical fitness) from pulse rate during submaximal work. Journal of Applied Physiology No. 7, p.218-221.

BANNISTER, D., SHARPE, R., 1976. Views expressed in "Stress - Your Life in Your Hands", B.B.C. Radio 4, 29th April, 1976. Radio Times, London. (See Appendix III).

BARCROFT, J., 1934. Features in the Architecture of Physiological Function. (London: Cambridge University Press).

BERLINER, C., ANGELL, D., SHEARER, J. W., 1964. Behaviours, measures and instruments for performance evaluation in simulated environments. Paper presented at the symposium and workshop on the qualification of human performance, Albuquerque, New Mexico.

BINDRA, D., 1969. The inter-related mechanisms of reinforcement and motivation and the nature of their influence on response in Nebraska Symposium on Motivation, University of Nebraska Press 1970

BLOHMKE, M., SCHAEFER, F., STELZER, O., KOSCHORRECK, B., und ALMANN, H.H., 1967. Vegetative Tonisierung des Herzens wahrend geistiger Belastung, gemessen am E.K.G. Int. Z. angew. Physiol. einschl. Arbeitsphysiol. No. 24 p.p. 181 - 193.

BOLLES, R.C., 1967 Theory of Motivation. Harper & Row, Harper International.

BORG, G., LINDERHOLM, H., 1969. Exercise performance and perceived exertion in patients with coronary insufficiency, arterial hypertension, and vaso-regulatory asthma. Acta Medica Scandinavia 474, 187, 17-26.

BORNEMANN, E., 1942. Untersuchungen uber den Grad der geistigen Beanspruchung. Arbeitsphysiologie, 12, p.142.

BRAZIER, M.A., (ed). The central nervous system and behaviour Josiah Macey Jr. Foundation 1960.

BRITISH PRODUCTIVITY COUNCIL. Ergonomics: fitting the job to the worker: a seminar by K. F. Murrell. British Productivity Council 1960.

BRITISH STANDARDS INSTITUTION ADVISORY COMMITTEE, 1958. "Anthropometric recommendations for dimensions of office machines, operators' charts and desks" No. BS.3044.

BROWN I.D. 1964. The measurement of perceptual load and reserve capacity. Transactions of the Association of Industrial Medical Officers 14, p.p. 14-49

BROWN, I.D., POULTON, E.C. 1961. Measuring the spare mental capacity of car drivers by a subsidiary task. Ergonomics 4, 35-40.

BURNS, W., Noise and man. Murray, 1968

CANNON, W.B., Bodily changes in pain, hunger, fear, rage Harper 1963.

CASPERSEN, P., LARSEN, S.E., NIELSEN, I., 1960. A remote pulse recording system. Comm. nr.8 Danish National Association for Infantile Paralysis.

CHAPANIS , A. Man-machine engineering. Tavistock Publications, 1965

CHAPANIS, A., 1967. The relevance of laboratory studies to practical situations. Ergonomics 10, 557-577.

CHAPANIS A., LINDENBAULM, L.E. 1949. A reaction time study of four control display linkages. Human Factors 1, 1-7.

CHILES, W.D., 1966. Assessment of the performance effects of the stresses of space flight. AMRL. TR66-192. Wright & Patterson Air Force Base, Ohio.

CHILES, W.D., 1969. "Complex performance: the development of research criteria applicable in the real world". Paper presented at symposium sponsored by International Ergonomics Association held in Amsterdam.

CHILES, W.D., ALLUISI, E.A., ADAMS, O.S., 1968. Work schedules and performance during confinement, Human Factors 10, 143-196.

CHRISTENSEN, E.H., 1952. Fysiologisk arbetsvarderning inom jarnverksindustrien. Uddeholmaren 1-2 (Karlstad).

CHRISTENSEN, J.M. MILLS, R.G., 1967. What does the operator do in complex systems. Human Factors 9, p.p. 329-340.

CLYNES, N., 1960 Respiratory sinus arrhythmia - laws derived from computer simulation. Journal of Applied Physiology 15,5, p.p. 863-874.

COMROE, J.H.,FORSTER, E.E., DUBOIS, A.B., BRISGOE, W.A., CARLSEN, E., 1964. The Lung. Year Book Medical.

CORNOG. D.Y., ROSE.F.C., 1967. Legibility of alphanumeric characters and other symbols: II A reference handbook (National Bureau of Standards Miscellaneous 262-2, Washington D.C.: U.S. Government Printing Office.)

COTES, J.E., 1969. Relationships to oxygen consumption, ventilation and cardiac frequency to body weight during submaximal exercise in normal subjects. Ergonomics, Volume 3, p.p. 415-427.

CRAIK, K.J.W., 1948. Theory of the human operator in control systems: II. Man as an element in a control system. British Journal of Psychology 36, 142-148.

DATTA, S.R., RAMANATHAN, N.L.,1969. Energy expenditure in work predicted from heart rate and pulmonary ventilation. Journal of Applied Physiology, Volume 26, p.p. 297-302.

DAVIES, C.T.M., 1967. Maximum oxygen uptake: prediction from cardiac frequency during submaximal exercise. Journal of Physiology (London) 14.1.67., p.p. 77-78.

DAVIES, C.T.M., BARNES, C., 1972. Negative (Eccentric) Work, 1. Effects of repeated exercise. Ergonomics Journal, Volume 15, 3-14.

DAVIES, C.T.M., TUXWORTH, W., YOUNG, J.M., 1970. Physiological effects of repeated exercise. Clinical Science 39, No. 2, 247-258.

DE GREENE, K.B., (Ed.). Systems psychology. McGraw-Hill 1970

DAVIS, P.R., Performance under sub-optimal conditions. Taylor & Francis, 1971.

DRURY, C.G., FOX, J.G., Human reliability in quality control. Taylor & Francis 1975.

DUFFY E., 1952. The relationship between muscular tension and quality of performance. American Journal of Psychology, No. 44. p.p. 535-546.

EKSTROM, P.J., 1962. Analysis of pilot work loads in flight control systems with different degrees of automation. Paper at I.R.E. International conference on human factors engineering.

ELLIOTT, R., 1964. Physiological activity and performance. A comparison of kindergarten children with young adults. Psychol. Manogr. 78 (whole no. 587, No. 10).

ELTON, P.M., 1920. A study of output in silk weaving. No. 17. Industrial Fatigue Research Board Publication.

ERNSTING, J. 1965. The effects of anoxia on the central nervous system. A textbook of aviation psychology (edited by J. A. Gillies, London: Pergamon Press).

ETTEMA, J.H., ZIELHUIS, R.L., 1971. Physiological Parameters of Mental Load. Methodology in Human Fatigue Assessment, edited by Hashimato, Kogi and Grandjean, p.p. 137-143. Taylor & Francis Ltd., London.

FARMER, E., CHAMBERS, E.G., 1936. Individual differences in accident rates No. 38. The Industrial Health Research Board (Great Britain).

FIRTH, P.A., 1973. Psychological factors influencing the relationship between cardiac arrhythmia and mental load. Ergonomics, Volume 16, No. 1, p.p. 5-15.

FITTS, P.M. & POSNER, M.I., Human performance. Prentice Hall 1967.

FITTS, P.M., Human engineering for an effective air navigation and traffic control system. National Research Council, 1951.

FLAHERTY, B.E., (ed). Psychophysiological aspects of space flight. Columbia University Press, 1961.

FLEISHMAN, E., 1967. Performance assessment based on an empirically derived task taxonomy. Human Factors 9, 349-366.

FLEISHMAN, E.A., HEMPEL JR., W.E., 1954. A factor analysis of dexterity tests. Personnel Psychology, volume 7, p.p. 15-32.

FOWLER, R.D., 1969. An overview of human factors in Europe; Human Factors II, 91-94.

FREEMAN, C.L., 1940. The relationship between performance level and bodily activity level. Journal of Experimental Psychology No. 26, p.p. 602-608.

FREEMAN, C.L. The energetics of human behaviour. Cornell University Press, 1948.

GALLOWAY, D.G., WOMARK, B.F., 1969. An application of spectral analysis and digital filtering to the study of respiratory sinus arrhythmia. Technical Report no. AD701731 (2), Bioengineering Research Laboratory, University of Texas at Austin.

GASTAUT, H. et Y., ROGER, A., CORRIOL, J., NAQUET, R., 1951. Etude electrographique du cycle d'excitabilite cortical E.E.G. Clinic of Neurophysiology No. 3., p.p. 401-428.

GRANDJEAN, E. Fitting the task to the man: ergonomic approach. Taylor & Francis, 1969.

GRANDJEAN, E. Sitting posture. Taylor & Francis, 1969.

GRANDJEAN, E.A., 1971. Fitting the task to the man, an ergonomic approach (Taylor & Francis, London).

GRANDJEAN, E. Ergonomics of the home. Taylor & Francis, 1973.

GREAT BRITAIN. Department of Scientific and Industrial Research Conference on ergonomics in industry. H.M.S.O., 1961.

GREAT BRITAIN. Ministry of Labour. Noise and the worker. H.M.S.O. 1963.

GREEN, I.D., 1965. The circulation in anoxia. In a textbook of aviation physiology (edited by J.A. Gillies, London: Pergamon Press).

GRODSKY, M.A., 1967. The use of full-scale mission simulation for the assessment of complex operator performance; Human Factors 9, 341-348.
GUDNASON, C.H. & CARLETT, E.N. (eds). Development of production systems. Taylor & Francis, 1974.
GUIGNARD, J.C., 1965. In a textbook of aviation physiology (edited by J. A. Gillies, London: Pergamon Press.)

HAIDER, M., 1962. Experimentelle Untersuchungen ober geistigen Beanspruchung durch Arbeitsleistungen. Int. Angew. Physiol. einsch. Arbeitsphysiologie 19, 241-251.
HASHIMOTO, V., & KOGI, K. Methodology in human fatigue assessment. Taylor & Francis, 1975.
HENRY, F., FARMER, D., 1938. Functional tests: II. The reliability of the pulse-ratio test. American Association for Health and Physical Education Research Quarterly, No. 9, p.p. 81-87.
HULL, C.L. 1943. Principles of Behaviour. Appleton, Century, Crofts.

JAQUES. E, Work, creativity and social justice. Heinemann 1970.
JONES, J.C., Design methods. Wiley, 1970.

KALSBEEK, J.W.H., 1964. On the measurement of deterioration in performance caused by distraction stress. Ergonomics 7, p.2.
KALSBEEK, J.W.H., 1965. Mesure objective de la surcharge mentale: nouvelles applications de la methode des doubles taches. Le Travail Humain 28, p.p. 121-132.
KALSBEEK, J.W.H., ETTEMA, J.H., 1963. Continuous recording of heart rate and the measurement of mental load. Ergonomics 6, p.p. 306-307.
KALSBEEK, J.W.H., ETTEMA, J.H. 1965. Sinus Arrhythmia and the measurement of mental load - Communication at the London Conference of the British Psychological Society. December.
KELLERMAN, F. (ed). Vademuum: ergonomics in industry. Phillips Technical Library, 1963.
KENNARD, M.A., WILNER, M.D., 1943. Correlation between electroencephalograms and deep reflexes in normal adults. Dis. Nervous System, No. 6 p.p. 337-347.

KRAFT, J.A. 1958. Industrial approaches to human engineering in America. Ergonomics 1, 301-306.
KROL, J.P., OPMEER, C.H.J.M., 1970. Psychological parameters during different phases of flight in a flight simulator. Laboratory of Ergonomic Psychology - T.N.O. Report.

LACEY, J.I., 1967. Somatic response patterning and stress: some revisions of activation theory. Paper from Department of Psychophysiology-Neurophysiology, Fels Research Institute, U.S.A.
LANSING, R.W., SCHWARTZ, E., LINDSLEY, D.B., 1956. Reaction time and E.E.G. activation. American Psychologist No. 11, p. 433.
LEES, F. & EDWARDS E. (eds). The human operator in process control Taylor & Francis, 1974.
LILLE, F., POTTIER, M., SCHERRER, J., 1968. Influence chez l'homme des nouveaux d'activite mentale sur les potentiels evoques. Rev. Neurd. 118, 476-480.
LYNN, R. Attention, arousal and the orientation reaction. Pergamon, 1966.
LYTHGOE, R.J. 1932. The Measurement of Visual Ascuity (Medical Research Council 1932).

MAKSUD, M.G., WILEY, R.K., HAMILTON, L.H., LOCKHART, B., 1970. Maximal Vo_2, ventilation and heart rate of Olympic speed skating candidates. Journal of Applied Physiology, Volume 29, p.p. 186-190.
MALMO, R.B., 1959. Activation - a neuropsychological dimension, "Psychological Review" 66, pages 367-386.
MALMO and SHAGASS, C., 1949. The variability of heart rate in relation to age, sex and stress. Journal of Applied Psychology 2, 181-184.
MARGARIA, R., 1966. Assessment of physical activity in oxidative and anaerobic maximal exercise. International Z. Angew Physiology No. 22, p.p. 115-124.
MARGARIA, R.P., AGHEMO, P., ROVELLI, E., 1965. Indirect determination of maximal O_2 consumption in man. Journal of Applied Psychology No. 20. p.p. 1070-1073.
MARGARIA, R., CERRETELLI, P., VEISTEINAS, A., 1970. Estimation of heart stroke, volume from blood, haemoglobin, and H.R. at submaximal exercises. Journal of Applied Physiology, Volume 29, No. 2, p.p. 204-207.

MARITZ, J.S., MORRISON, J.F., PETER, J., STRYDOM, P.B., 1961. A practical method of estimating an individual's maximal oxygen uptake. Ergonomics No.4, p.p. 97-122.

METZ, B.G., 1967. Paper to scientific group on health factors involved in working under conditions of heat stress. World Health Organization. In W.H.O. Report T.R. 412.

MICHON, J.A., 1966. Tapping regularity as a measure of perceptual motor load. Ergonomics 9, p.5.

MILLS, I., 1976. Views express in "Stress - Your Life in your Hands". B.B.C. Radio 4, 29th April, 1976, Radio Times, London. (See Appendix III).

MORGAN, C.I. et al (eds). Human engineering guide to equipment design. McGraw-Hill 1963.

MÜLLER, E.A., 1963. The physiological basis of rest pauses in heavy work. Quarterly Journal of Experimental Physiology No. 38. p.205.

MUNDY-CASTLE, A.C., McKIEVER, B.L. 1953. The Psychophysiological significance of the galvanic skin response. Journal of Experimental Psychology, No. 46, p.p. 15-24.

MÜNSTERBERG, H. 1913. Psychology and Industrial Efficiency. Publisher: Longman, New York.

MURRAY, H.A., 1938. Explorations in Personality. New York: Oxford University Press.

MURRELL, K. F. 1968. On the validity of ergonomic data, Occupational Psychology, 42, 71-76.

McCORMICK, E.J. Human factors engineering. McGraw-Hill 1970.

McCULLOUGH, W. Physical working conditions. Gower Press, 1969.

McFARLAND, R.A., 1938. The effects of oxygen deprivation (high altitude) on the human organism. Washington D.C., Civil Aeronautics Authority Technical Development Report No. 11.

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT. Fitting the job to the worker; a seminar on ergonomics for engineers. O.E.C.D. 1963.

PARKER, JR. J.R., 1967. The identification of performance dimensions through factor analysis. Human Factors 9, 367-374.

PLUTCHIK, R., 1959. The effects of high intensity intermittent sound on performance, feeling, and physiology. Psychological Bulletin 56, 133-151.

POULTON, E.C., 1958, Measuring the order of difficulty of visual motor tasks. Ergonomics 1, 234-239.

POULTON, E.C. Environment and human efficiency. Thomas 1970.

PROCEEDINGS OF THE SECOND INTERNATIONAL CONGRESS (DORTMUND), 1964. Taylor & Francis 1965.

RADFORD, JR. E.P. 1955. Ventilation standards for use in artificial respiration. Journal of Applied Physiology No. 7 p.p. 451-460.

ROLFE, J.M. 1971. The secondary task as a measure of mental load. In Measurement of Man at Work - An Appraisal of Physiological and Psychological Criteria in Man-Machine Systems. (Edited by W. T. Singleton, J. G. Fox and D. Whitfield). Taylor & Francis Limited.

SCHOLZ, H., 1963. Forschungsbericht Nr. 1185. D.E.S. Londes Nordrhein-Westfalen. West Deutscher Verlog Cologne.

SCHOUTEN, J.F., KALSBEEK, J.W.H., LEOPOLD, F.F. 1962. On the evaluation of perceptual and mental load. Ergonomics 5, p.251.

SENDROY, JR. J., CECCHINI, L.P., 1954. Determination of human body surface area from height and weight. Journal of Applied Physiology No. 7 p.1.

SINGLETON, W.T., 1971. Psychological aspects of man-machine systems. "Psychology at Work" edited by P. B. Warr. Penguin Books Ltd.

SINGLETON, W.T. (ed). The human operator in complex systems. Taylor & Francis, 1971.

SINGLETON, W.T. Introduction to ergonomics. World Health Organisation, 1972.

SINGLETON, W. T. (ed). Measurement of man at work: and appraisal of Physiological and psychological criteria in man and machine systems. Taylor & Francis, 1973.

SINGLETON, W.T., Man machine systems. Penguin 1974.

SINGLETON, W.T., & P., SPURGEON. Measurement of human resources. Taylor & Francis 1975.

SINGLETON, W.T., EASTERNLY, R.S., WHITFIELD, D., 1967. Preface, The human operator in complex systems (London, Taylor & Francis).
SNOOK, S.H., IRVINE, C.H., 1969. Psychophysical studies of physiological fatigue criteria. Human Factors 11, No. 3 p.p. 291-299.
STERNBACH, R.A., 1966. Principles of psychophysiology. Academic Press, London.
STREIMER, I., TURNER, D.P.W., VOLKMER, K., 1968. Task accomplishment times in underwater work. Journal of Marine Technology 2, 22-26.
STREIMER, I., TURNER, D.P.W., VOLKMER, K., 1969. Study of work producing characteristics of underwater operations. North American-Rockwell, Space Division Document 69-20, Office of Naval Research Cont. No. N00014-67-03636, Research Task P002, February, 41pp.
SZAFRAN, J., 1966. Limitations and reliability of human operators of control systems to process information. Aerospace Medicine, No. 37, p.p.239-246.

TUTTLE, W.W., DICKENSON, R.E. 1938. A simplification of the pulse ratio technique for rating physical efficiency and present condition. American Association for Health and Physical Educational Research Quarterly, No. 9, p.p. 73-80.

ULETT, G.A., GLESER, G., WINOKUR, G., LANSER, A., 1953. The E.E.G. and reaction to photic stimulation as an index of anxiety-proneness. No. 5 p.p. 23-32.

VASS, C.C.N., (editor), 1961. A synopsis of Physiology, p. 53-63, by J. R. Short, Wright, Bristol.
VERNON, H.M., 1921. Industrial Fatigue and Efficiency. Industrial Fatigue Research Board Publication.

WALLACE, S.R., 1965. Criteria for what? American Psychologist 20, 411-417.
WARTNA, G.F., DANEV, S.G., 1970. Sinus arrhythmia as a measure of mental load: a comparison of different scoring methods. Paper presented at the First Physiological Congress, Sofia, Bulgaria (from the Psychophysiological Laboratory, Netherlands Institute for Preventive Medicine - T.N.O. Leiden, The Netherlands.

WEINTRAUB, D.J., & WALKER, E.L. Perception. Prentice Hall 1967.

WEITZ, J., 1961. Criteria for criteria. American Psychologist 16 228-231.

WELFORD, A.T., 1959. Evidence of a single channel decision mechanism limiting performance in a serial reaction task. Quarterly Journal of Experimental Psychology No. 11, p. 193.

WELFORD, A.T., 1960. The measurement of sensory motor performance: survey and reappraisal of 12 years' progress. Ergonomics 3, 189-230.

WELFORD, A.T. (ed) Contemporary problems in perception. Taylor & Francis 1972.

WELFORD, A.T. (ed.) Man under stress Taylor & Francis 1974.

WIGERTZ. O., 1970. Dynamics of ventilation and heart rate in response to sinusoidal work load in man. Journal of Applied Physiology, Volume 29, p.p. 208-218.

WILLIAMS, A.C., JR., MacMILLAN, J.W., JENKINS, J.G. 1946. Preliminary experimental investigations of "tension" as a determinant of performance in flight training. Civil Aeronautics Administration Division of Research. Report No. 54. Washington. D.C.

WOODSON, W.E. & CONOVER, D.W. Human engineering guide for equipment designs. University of California Press, 1970.

WYATT, S., FRASER, J.A., 1929. Comparative effects of variety and uniformity in work No. 56. Industrial Health Research Board (Great Britain) Report.

PAMPHLETS:

Great Britain. Department of Scientific and Industrial Research. Ergonomics for industry. This is a series of six pamphlets designed as a guide to the industrial applications of ergonomics research:

1. Industrial use of ergonomics
2. Instruments and people
3. Design of work for the disabled
4. Inspection and human efficiency
5. Ergonomics versus accidents
6. Noise

K. Murrell. Data on human performance for engineering designers.

PERIODICALS:

Principal ones in the field:	Ergonomics
	Applied Ergonomics
	Human Factors
Others of Interest	Psychological Review
	Journal of Applied Psychology
	British Journal of Psychology
	Journal of Applied Physiology

APPENDIX XIII

Bibliography

ADAMS, O.S., CHILES, W.D., 1961. Human performance as a function of the work-rest ratio during prolonged confinement. U.S. Air Force, Wright-Patterson Air Force Base, Ohio, Aerospace Medical Laboratory. A.S.D. Technical Report 61-720.

APPLEY, M.H., TRUMBULL, R., 1967. Psychological stress. Appleton Century Crafts, New York.

ASMUSSEN, E., CHRISTENSEN, E.H., 1939. Einfluss der Blutbertellung auf der Kreislauf ber Korperlicher Arbeit. Skand. Arch. Physiol 82: p.p. 185-192.

ASMUSSEN, E., CHRISTENSEN, E.H., NIELSEN, M., 1939. Die Bedentung der Korperstellung fur die pulsefrequenz bel Arbeit. Skand. Arch. Physiol 81: p.p. 225-233.

BEDFORD, T., 1936. The warmth factor in comfort at work No. 78. Industrial Health Research Board (Great Britain) Report.

BEDFORD, T., 1940. Environmental warmth and its measurement M.R.C. War Memorandum no. 17. H.M.S.O. London.

BELANGER, D., FELDMAN, S.M., 1962. Effects of water deprivation upon heart rate and instrumental activity in the rat. J. Comp. Physiol. Psychol. 55, p.p. 220-225.

BENSON, A.J., HUDDLESTON, H.F., ROLFE, J.M., 1965. A psychophysiological study of compensatory tracking on a digital display. Human Factors No. 7, p. 457-472.

BERGGREN, G., CHRISTENSEN, E.H., 1950. Heart rate and body temperature as indices of metabolic rate during work. Arbeitsphysiologie 14: 255-260.

BERLYNE, D.E., 1960. Conflict, arousal and curiosity. New York: McGraw Hill. Nebraska. Symposium on Motivation, Univ. of Nebraska Press 1970.

BLAKE, M.J.F., 1967. Relationship between circadian rhythm of body temperature and intraversion and extraversion. Nature No. 215 p.p. 896-897.

BONJER, F.H., 1969. The contribution of work physiology to the evaluation of man-machine systems. Measurement of man at work. Taylor and Francis, London.

BORG, G., LINDERHOLM, H., 1967. Perceived exertion and pulse rate during graded exercise in various age groups. Acta Medica Scandinavia 472, 194-206.

BOUCHARD, T.J., JR. 1976. Field Research Methods in Handbook of Industrial and Organisational Psychology. Editor M. D. Dunnette, Rand McNally, Chicago.

BRADY, J.V., 1971. Ulcers in "executive" monkeys. "Scientific American". W. H. Freeman & Company, San Francisco, U.S.A. (Originally published in 1958).

BROUHA, L., 1960. Physiology in Industry, Pergamon Press, Oxford.

BURNETT, I., 1925. An experimental investigation into repetitive work. Industrial Fatigue Research Board Report No. 30. H.M.S.O. London.

BURGOYNE, J.G., 1975. Stress, Motivation and Learning. Contributor in textbook "Managerial Stress" Edited by D. Gowler and K. Legge Gower Press, Epping.

CANNON, W.B., 1929. Textbook "Bodily Changes in Pain, Hunger, Fear, and Rage", second edition. Harper Torchbooks, London.

CARRUTHERS, Malcolm, 1974. The Western Way of Death, Davis-Poynter, London, p.12.

CHAPANIS, A., 1969. The search for relevance in applied research introductory paper, symposium sponsored by International Ergonomics Association; held in Amsterdam.

CHRISTENSEN, E.H. 1953. Physiological valuation of work in Nykroppa Iron Works. In Symposium on Fatigue. Editors Floyd, W.F., and Welford, A.T. Publisher: H. K. Lewis, London.

CHRISTENSEN, E.H., 1964. L'homme au travail. Serie securite, Hygiene et Medecine du travail, No. 4. Bureau International de Travail, Geneva.

CHRISTENSEN, E.H., ASTRAND, P.O. 1953. Synpunkter pa Varmearbetets fysiologi, Socialmed. tidskrift nr. 3.

COFER C.N, APPLEY, M.H., 1964. Motivation Theory and Research Wiley, New York.

COLQUHOUN, W.P. 1970. Circadian Rhythms, Mental Efficiency and Shift Work. "Performance under sub-optimal Conditions", edited by P. R. Davis, Taylor & Francis, London.

COLQUHOUN, W.P. BLAKE, M.J.F., EDWARDS, R.S., 1968 (i). "Experimental Studies of Shift Work 1: a comparison of 'rotating' and 'stabilised' 4-hour shift systems", Ergonomics Volume II, p.p. 437-453.

COLQUHOUN, W.P., BLAKE, M.J.F., EDWARDS R.S., 1968. (ii). Experimental studies of shift work II: stabilised 8-hour shift systems. Ergonomics Volume II. p.p. 527-546.

DAVIS, G.R., EDWARDS, A.E., 1965. Physiological Adaptation to Stress: the influence of massed and spaced practice. Proceedings of the 73rd Annual Convention of the American Psychology Association p.p. 157-158.

DAVIS, R.C., BUCKWALD, A.M., FRANKMANN, R.W., 1955. Autonomic and muscular responses and their relation to simple stimuli Psychol. Monogr. No. 405.

DEESE, J., 1960. Skilled Performance and conditions of stress. Paper read at a symposium on training, University of Pittsburgh February, 1960.

DOUGLAS, C.G., 1911. A method for determining the total respiratory exchange in man. J. Physich 42, XVII.

DUCHARME, 1966. Effect of internal and external cues on the heart rate of the rat. Canadian J. Psychol. 20, p.p. 97-104.

DUFFY, E., 1941. The conceptual categories of psychology: a suggestion for revision. Psychological Review No. 48, p.p. 177-203

DUFFY, E., 1951. The concept of energy mobilization. Psychological Review No. 58, p.p. 30-40.

DUFFY, E., 1957. The Psychological significance of the concept of arousal or activation. Psychological Review, Volume 64, No. 5 p.p. 265-275.

DURNIN, J.V.G.A, EDWARDS, R.G., 1955. Pulmonary ventilation as an index of energy expenditure. Quarterly Journal of Experimental Physiology No. 40. p.p. 370-377.

EDHOLM, O.G., 1957. Energy Expenditure. Advanced Science No. 13 p.486.
EDHOLM, O.G., FLETCHER, J.G., WIDDOWSON, E.M., McCANCE, R.A., 1955. The energy expenditure and food intake of individual men. British Journal of Nutrition No. 9 p.286.
EDWARDS, E., 1963. The integration of spaced signals. Ergonomics No. 6., p.p. 143-152.

FASSINA, A., 1969. Un intermediaire dans le systeme homme-travail: le dessin technique. Lecture et ecriture des schemas explicatifs These, Paris-Sorbonne.
FITTS, P.M., 1961. Skill maintenance under adverse conditions. Psychophysiological aspects of space flight, p.p. 309-322 (edited by B. E. Flaherty). (Columbia: Columbia University Press).
FOOD AND AGRICULTURAL ORGANIZATION OF THE UNITED NATIONS, 1949. Dietary surveys. Their technique and interpretation. Nutritional Studies No. 4., U.N. Washington.
FORD, A.B., HELLERSTEIN, H.K., 1959. Estimation of energy expenditure from pulmonary ventilation. Journal of Applied Physiology No. 14. p.p. 891-893.
FRENCH, J., JR., 1972. "Statement by Dr. John French". Worker Alienation: Hearings before the sub-committee on Employment, Manpower, and Poverty. (Washington: 92nd Cong. 2nd sess., U.S. Senate Committee on Labour and Public Welfare. June 25 1972) Committee Print p.p. 36-41.
FRIEDMAN, M., ROSENMAN, R.H., 1959. Association of specific overt behaviour pattern with blood and cardiovascular findings Journal of the American Medical Association No. 169. 1268.

GARRY, R.C., PASSMORE, R., WARNOCK, G.M., DURNIN, J.V.G.A., 1955. Studies on expenditure of energy and consumption of food by miners and clerks, Fife, Scotland. Medical Research Council Special Report Series No. 289. H.M.S.O. London.
GAUTIER, H., HONOTEL, H., HUGELIN, A., 1965. Level of vigilance and type of respiratory movements in waking man. Journal of Physiology, Paris, No. 57 p.p. 1-246.

GIBSON, D., HALL, M.K., 1966. Cardiovascular change and mental task gradient. Psychonomic Science No. 6., p.p. 245-246.

GRANDJEAN, E.A., 1958. Fitting the job to the worker: a survey of American and European research into working conditions in industry. (Paris: O.E.E.C.) p.125.

HARVEY, William, 1628. The Circulation of the Blood, Everyman's Library (1907).

HASHIMOTO, K., 1964. The application of heart rate (electro-cardio-tachogram) into the "ergonomical research - estimation of the driver's workload of electric car operation on the new Tokaido line in Japan". Internal Report, Laboratory of Physiology, Institute for Railway Labour Science, Japanese National Railways.

HICK, W.E., 1952. On the rate ofgain of information. Quarterly Journal of Experimental Psychology, No. 4., p.p. 11-26.

HILGENDORF, L., 1966. Information input and response time. Ergonomics No. 9. p.p. 31-37.

HOUGHTEN, F.C. YAGLOGLOUR, C.P., 1923. Determining lines of equal comfort. Trans-American Society of Heating and Ventilating Engineers. No. 29, p.163.

HOWITT, J.S., BALKWILL, J.S., WHITESIDE, T.C.D., WHITTINGHAM, P.D.G.V., 1965. A preliminary study of flight deck workloads in civil air transport aircraft. Flying Personnel Research Committee Report No. 1240.

HUNT, T.J., DIX, B., MAY, P.I. 1968. A preliminary investigation into a physiological assessment of driving stress. Joint Medical Research Council/Metropolitan Police Report.

ILERSIC A.R., 1952. Statistics and their application to Commerce H.F.L. Publishers, London.

JONES, E.D., 1919. The administration of Industrial Enterprises Longman, New York.

KAHN, L., 1970. Some propositions towards a researchable conceptualization of stress. "Social and Psychological Factors of Stress". Holt, Rinehart & Winston, New York.

KALSBEEK, J.W.H., 1968. Measurement of mental work load and of acceptable load. International Journal of Production Research, Volume 7, p. 33-45.

KALSBEEK, J.W.H., 1971. Sinus arrhythmia and the dual task method of measuring mental load. In Measurement of Man at Work (edited by Singleton, Fox and Whitfield,) Taylor & Francis.
KALSBEEK, J.W.H., ETTEMA, J.H., 1964. Physiological and psychological evaluation of distraction stress. Proceedings of the Second International Congress on Ergonomics, p.p. 443-447.
KARRASCH, K., MÜLLER, E.A., 1951. Das Verhalten der Pulsfrequenz in der Ertholungs - periode nach Korperlicher Arbeit. Arbeitsphysiologie 14.
KIRIAKOV, K., 1964. Some E.E.G. criteria of fatigue after mental work. Aerospace Medical Abstracts No. 35., p.1258.
KIRK, N.S., HAMLEY, E.J. 1975. Private interview held on 11th February, 1975, with Professor N. S. Kirk and Dr. E. J. Hamley at Loughborough University of Technology. (See Appendix VII).
KLEIN, N.K.E., BRUNER, H., HOLTMANN, H. REHME, H., STOLZE, J., STEINHOFF, W.D., WEGMAN, H.M. 1970. Circadian rhythms of pilots' efficiency and effects of multiple time zone travel. Aerospace Medicine Volume 41, p.p. 125-132.
KLEITMAN, N., 1963. Sleep and Wakefulness. University of Chicago Press, second edition.
KOFRANYI, E., MICHAELIS, H.G., 1941. Ein tragbarer Apparat zur Bestimmung des Gasstofwechsels. Arbeitsphysiol II, p.p. 148-150.
KROL, J.P. OPMEER, C.H.J.M., 1969. Sinus Arrhythmia, heart rate and respiratory rate with parachute jumpers. Report T.N.O. - Laboratory of Ergonomic Psychology.

LACEY, J.I., 1959. Interpolated remark in Grastyon's "The Lippocampus and higher nervous activity." M. A. Brazier (ed) The Central Nervous System and Behaviour. New York J. Macy.
LEHMANN, G., 1958. Physiological Measurement as a basis of work organization in industry. Ergonomics No. 1., p.238.
LEPLAT, J., 1969. La Methode experimentale en ergonomic. Bulletin de Psychologie 22, 775-781.

LEPLAT, J., PAILHOUS, J. 1969. 'The analysis and evaluation of mental work'. Paper presented to a symposium in Amsterdam. Printed in textbook 'Measurement of man at work'. Edited by Singleton, Fox, Whitfield, Taylor and Francis, London.

LEVINE, SEYMOUR, 1971. Stress and Behaviour. "Scientific American". W. H. Freeman & Company, San Francisco, U.S.A.

LIND, A.R., 1960. The effect of heat on the industrial worker. Annual Occupational Hygiene. No. 2. p.190.

LIND, A.R., HELLON, R.F., WEINER, J.S., JONES R.H., AND FRASER, D.C., 1957. Reactions of mine-rescue personnel to work in hot environments. National Coal Board. Medical Research Memorandum No. 1.

LINDSLEY, D.B., 1952. Psychological phenomena and the electro-encephologram. E.E.G. Clinical Neurophysiology No. 4 p.p. 443-456.

LUCZAK, Dr. H., 1977 Personal interview at Darmstadt Institute of Biology and Dynamics.

LUNDGREN, N.P.V., 1946. Physiological effects of time schedule work on lumber workers. Acta physiol. Scandinavia 13, suppl. 41.

LYNN, Richard, 1966. Attention, arousal and orientation reaction, p.p. 162-175. Pergamon Press Ltd.

MAGOUN, H.W. 1954. The ascending reticular system and wakefulness in "Brain Mechanisms and Consciousness" Edited by J. F. Delafresnaye (Springfield ICC: C.C. Thomas).

MACKWORTH, N.H., 1950 Research on the measurement of human performance. M.R.C.Special Report Series No. 268. H.M.S.O. London.

MALHOTRA, M.S. RAMASWAMY, S.S., ROY, S.N., SHRIVASTAV, T.N. 1962 Minute ventilation as a measure of energy expenditure during exercise. Journal of Applied Physiology No. 17. p.p. 775-777

MALHOTRA, M.S., SENGUPTA, J., RAI, R.M. 1963. Pulse count as a measure of energy expenditure. Journal of Applied Physiology No. 18 p.p. 994-996.

MILES, G.H., SKILBECK, G., 1923. Experiments on change of work. Journal of National Institute of Industrial Psychology No. 1 p. 236.

MITCHELL, F., 1976. Private interview held on 24th February 1976 with Dr. F. Mitchell, Head of Clinical Chemistry Department, Clinical Research Centre, Northwick Park Hospital. (see Appendix VI).

MORRIS, D., 1969. The Human Zoo. Jonathan Cape, London pages 1-25.

MORUZZI, G., MAGOUN, H.W., 1949. Brain stem reticular formation and activation of the E.E.G. Ergonomics Volume I p.p 455-473.

MÜLLER, E.A. 1959-60 Muscular Fatigue. Annual volume of Physiology and Experimental Medical Science. India No. 3. p.67

MÜLLER, E.A. 1961. Wie physische Ermudung. Handbuch der gesamten Arbeitsmedizin, Volume 1, p. 405. Verlug Urban und Schwarzenberg, Berlin.

MURRELL, K.F.H., 1962. Operator variability and its industrial consequence. International Journal of Productivity Research No. 1 (3) p.39.

MURRELL, K.F.H. 1971. Ergonomics, Man in His Working Environment p.376 Chapman and Hall, London.

MURRELL, K.F.H., FORSAITH, B., 1963. Laboratory Studies of repetitive work II: results from two subjects. International Journal of Productivity Research No. 2(4). p.247.

McFARLAND, R.A., DAMON, A., STOUDT, H.W., MOSELEY, A.L., DUNLAP, J.W., and HALL, W.A., 1954. Human body size and capabilities in the design and operation of vehicular equipment. Harvard School of Public Health, Boston, U.S.A.

McGRATH, J.E., 1970. Settings, measures and themes: An integrative review of some research on social-psychological factors in stress In: McGrath (Editor) Social and psychological factors of stress. Holt, Rinehart & Winston, New York.

MCGRATH, J. E. 1976. Stress and Behaviour in Organisations. Contributor in Handbook of Industrial and Organizational Psychology Editor M. D. Dunnette. Rand McNally. Chicago.

McNULTY, J.A. NOSEWORTHY, W.S., 1966. Physiological response specificity, arousal and task performance. Perceptual and Motor Skills, No. 23. p.p. 987-996.

McQUADE, W., 1972. What Strss can do to you, Fortune, January 1972, p.134.

NOTTERMAN, J.M., 1953. Experimental anxiety and a conditioned heart rate response in human beings. Trans. N.Y. Acad. Sc. 16, p.p.24-33.

NOELLE-NEUMANN, E. 1970. Wanted: Rules for structuring questionnaires.Public Opinion Quarterly 1970, No. 34 p. 191-201

OPMEER, C.H.J.M. 1969. Sinusariturie als maat van mentale belasting bij verschillende niveau's van de hart-frekwentie Report Laboratory of Ergonomic Psychology - T.N.O.

OPTON, E.M., 1965. E.E.G. correlates of performance lapses on an attention task in young and old men. Duke U., L. C. Mic. 64-21, 736, 121, p.p.

OSBORNE, E.E., VERNON, H.M., 1922. Two contributions to the study of accident causation. I.F.R.B. Report No. 19 H.M.S.O. London.

PAPPWORTH, M, WRIGHT, B., 1976. Views expressed in "You and Yours" B.B.C. Radio 4, 30th April, 1976 Radio Times, London, (see Appendix IV).

PARROT, J., 1969. The measurement of stress and strain "Measurement of Man at Work", p.p. 27-33. Edited by Singleton, Fox and Whitfield, Taylor & Francis, London.

PASSMORE, R., 1956. Daily energy expenditure by man. Journal of Nutrition Society No 15, p.83.

PAYNE, S.L. 1951. The art of asking questions. Princeton: Princeton University Press.

PEPLER, R.D., 1958. Warmth and Performance: an investigation in the tropics. Ergonomics No. 2. p.63.

POULSEN, E., ASMUSSEN, E., 1962. Energy requirements of practical jobs from pulse increase and ergometer test. Ergonomics No. 5 p.p. 33-36.

RAFTERY, E.B., 1976. Private interview held on 26th April 1976 with Dr. E. B. Raftery, Consultant Physician/Cardiologist, Northwick Park Hospital and Harley Street. (See Appendix V).

RAPP, R.M., DIETLEIN, L.F., NUTTALL, J.C., 1965. Some physiological observations and monitoring techniques associated with auto racing (Abstract). Journal of Aerospace Medicine 36, p 159.

RAMANATHAN N.L., 1964. Reliability of estimation of metabolic levels from respiratory frequency. Journal of Applied Physiology No. 19, p.p. 497-502.

ROBENS, Lord of Woldingham, 1970. Opening address at a symposium Performance under sub-optimal conditions. Edited by P. R. Davis. Taylor & Francis London.

ROMAN, J., 1965. Risk and responsibility as factors affecting heart rate. Aerospace Medicine 36, p.p. 518-532.

ROWEN, B., 1961. Biomedical monitoring of the X-15 program. Armed Services Technical Information Service Report No. AFFTCTN-61-4.

RUFFELL SMITH, H.P., 1967. Heart rate of pilots flying aircraft on scheduled airline routes. Aerospace Medicine 38, 1117-9.

RUFFELL SMITH, H.P., 1967. The effects of stress on civilian transport pilots. In Reports of the 7th Conferrence on Aviation Psychology, Brussels. (Edited by F. J. Mirety Alsina). (Western European Association for Aviation Psychology.)

RUTENFRANZ, J., ASCHOFF, J., MANN, H., 1970. The influence of cumulative sleep deficit and length of preceding sleep period on multiple choice reaction time at different times of night, in W.P. Colquhoun (ed.) Proceedings of the NATO Symposium on the effects of Diurnal Rhythm and Loss of Sleep on Human Performance English University Press.

RUTLEY, K.S., MACE, D.G.W., 1972. Heart rate as a measure in road layout design. Ergonomics, Volume 15, No. 2., p.p. 165-173.

SARTORELLI, E., 1956. Relation between pulmonary ventilation and energy consumption during work Medical Lavoro No. 47 p.p. 350-355.

SAWREY, William L., WEISZ, John D., 1956. An experimental method of producing gastric ulcers. Journal of Comparative and Physiological Psychology., Volume 49, No. 3 pages 269-270

SCHÄCKE, G., 1976. Private interviews held on 3rd and 4th March 1976, with Dr. G. Schacke at Institut fur Arbeits und Sozial-Medizin und Poliklinik fur Berufskrönkheiten, Der Universitat Erlangen-Nurnberg, West Germany. (see Appendix VIII)

SCHÄCKE, G., WOITOWITZ, H.J., RIETSCHEL, E., HAVLA, R. 1972 Radiotelemetric long-term examinations of heart rate and electrocardiogram on leading persons of industry. Int. Arch. Arbeitsmed. No. 29 pages 142-158, by Springer-Verlag.

SHARKEY, B.J., McDONALD, J.F., LYNN, G. CORBRIDGE 1966. Pulse rate and pulmonary ventilation as predictors of human energy cost. Ergonomics, Volume 9, p.p. 223-227.

SIMONS, J.C., 1964. An introduction to surface-free behaviour. Ergonomics 7, 23-26.

SINGLETON, W.T., 1970. Preface, Measurement of man at work, (London, Taylor & Francis).

SINGLETON, W.T., 1972. Introduction to Ergonomics. World Health Organisation, Geneva.

SINGLETON, W.T., FOX, J.G. WHITFIELD, J. 1969. Measurement of man at work. Prologue P. 15. Taylor & Francis London.

TAKAKUWA, E. 1971. Maintaining concentration (TAF) as a measure of mental stress. Article p.156 in textbook 'Methodology in Human Fatigue Assessment' Edited by Khashimoto, Kkogi and E. Grandjean. Taylor & Francis, London.

TAYLOR, P. J. 1967 Shift and day work: a comparison of sickness absence, lateness and other absence behaviour at an oil refinery from 1962 to 1965. British Journal of Industrial Medicine 24, 93-102.

TEICHNER, W.H., WEHRKAMP, R.F. 1954. Visual-motor performance as a function of short duration ambient temperature. Journal of Experimental Psychology No. 47 p.447.

TEICHNER, W.H., KOBRICH, J.L. 1955 Effects of prolonged exposure to low temperature on visual motor performance. Journal of Experimental Psychology No. 49 p. 122.

VALENTIN H., WOITOWITZ, H.J., 1969. Zur Funktion und Dynamike von Herz und Kreislauf und Ihre Erfassung durch Funktionanalysen verh Deutsch Ges Arbeitsschutz 10. 255-261.

VERNON, H.M., BEDFORD, T., 1927. The relation of atmospheric conditions to the working capacity and the accident rate of coal miners. I.F.R.B., Report No. 39 H.M.S.O. London.

VERNON, H.M. BEDFORD, T., 1931. Two studies of absenteeism in coal mines. I.The absenteeism of miners in relation to short time and other conditions. I.H.R.B. Report No. 62 H.M.S.O. London

WEDDERBURN, A.A., 1967. Social factors in satisfaction with swiftly rotating shifts. Occupational Psychology 41. 85-107.

WEITZ, J. 1970. Psychological research need on the problems of human stress. In: Editor J. E. McGrath, Social and psychological factors in stress, Holt, Rinehart and Winston, New York.

WETHERILL, G.B., 1966. Sequential methods in statistics London Methuen.

WEYBREW, B.B. 1967. Psychophysiological response to military stress. In "Psychological Stress". Edited by M. H. Appleby and R. Trumbull, Appleton Century Crafts, New York.

WILKINSON, R.T., 1965. Sleep Deprivation. In the Physiology of Human Survival (edited by Edholm & Bacharach) New York: Academic Press, p.p. 399-430.

WILKINSON, R.T., EDWARDS, R.S., HAINES, E., 1966. Performance following a night of reduced sleep. Psychonomic Science 5, 471-472.

WILKINSON, R.T., EDWARDS, R.S., 1968. Stable hours and varied work as aids to efficiency. Psychonomic Science Volume 13, p.p. 205-206.

WOLF, Stewart, WOLFF, Harold, 1942. Evidence of the Genesis of Peptic Ulcer in Man. The Journal of the American Medical Association, Volume 120, No. 9. pages 670-675.

WOLFF, H.S., 1958. The integrating motor pneumotachograph; a new instrument for the measurement of energy expenditure by indirect calorimetry. Quarterly Journal of Experimental Physiology No. 43 p.p. 270-283.

WOLFF, H.S., 1961. The Radio Pill. New Scientist No. 12 p.419.

WOOD, C.C., 1958. Human factors engineering: an aircraft company chief engineers viewpoint. Ergonomics 1, 294-300.

WORLD HEALTH ORGANISATION, 1976. Registrar General, Office of Population Censuses and Surveys published in the Times Supplement, 26th September, 1976, article on The Art of Body Maintenance.

WYATT, S., FRASER, J.A., 1925. Studies in repetitive work with special reference to rest pauses. Industrial Fatigue Research Board report no. 37 H.M.S.O. London.

WYATT, S., FRASER, J.A., STOCK, F.G.L. 1926. Fan ventilation in a humid weaving shed. I.F.R.B., Report No. 37H.M.S.O. London.

WYATT, S. LANGDON, J.N., 1938. The machine and the worker. A study of machine feeding processes. Industrial Health Research Board Report No. 82. H.M.S.O. London.

ZWEIG, F., 1948. Labour, Life and Poverty.Penguin books, Harmondsworth.