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ARMORED FORCE MEDICAL RESEARCH LABORATORY
Fort Knox, Kentucky

Project No. 2 (2-11, 2-12, 2-13, 2-17)
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Report On

STUDIES OF MEN IN SIMULATED DESERT HEAT

1. PROJECT: 2; 2-11, Influence of High Temperatures on the Efficiency of Personnel; 2-12, Study of Methods of Attaining and Maintaining Acclimatization to High Temperatures; 2-13 Effect of Training on the Efficiency of Performance at High Temperatures; and 2-17, Study of the Physiologic Effects of High Temperatures.

a. Authority - Letter, Commanding General, Headquarters Armored Force, Fort Knox, Kentucky, File 400.112/6 GNOHD, dated September 21, 1942.

b. Purpose - The purpose of these experiments was to study, under controlled conditions in the laboratory hot room, the behavior of men when exposed to high temperature, (as implied by the sub-project titles), and to enlarge upon the information obtained in previous studies in the California desert (Report on Desert Field Study, Project 2-8, File No. 724.3, October 20, 1942, and report on Water & Salt Requirement for Desert Operations, Project No. 2-6, File No. 333.34, November 12, 1942.).

2. DISCUSSION:

~~a. General.~~ Four acclimatization experiments, utilizing a total of fifty-six enlisted men, were carried out in the hot room ~~of the Armored~~ Force Medical Research Laboratory. The studies extended over a period of four months, some men being under study for a week; a great majority of the men for periods of from one to two months. Forty-eight men lived in the hot room continuously throughout the duration of the experiments, being permitted to leave for only two 5-minute periods daily.

~~b. Procedure:~~ Temperatures like those encountered during the hot months in the California desert were used; 120°F during the day (0300-1700 hours) and 90°F at night. The relative humidity ranged from 15% to 22% during the day. Detailed accounts of the test procedures and the results are given ~~in the Appendices.~~

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3. CONCLUSIONS:

a. Acclimatization.

(1) Soldiers exposed to desert heat become adapted to it by a process of acclimatization which enables them to carry out their duties more efficiently and with less risk of illness from heat than when first exposed.

(2) The condition of men in respect to their ability and fitness for their tasks in the heat can be estimated by a careful observer who knows what to look for. Using the information in Appendix I, line officers who know the work capacities of their men, can determine their degree of acclimatization and whether or not it is safe for them to continue activity.

(3) A man acclimatized to heat works in the heat with a lower body temperature, lower heart rate and a more stable blood pressure, than when not acclimatized. (Appendix II, Chart 1) Nevertheless, acclimatization to heat cannot be measured by these criteria alone. (Appendix II, Chart 2) Changes in pulse and temperature accompany acclimatization but do not necessarily correlate with the man's behavior and ability to work. The man as a whole must be considered and evaluated.

(4) Acclimatization begins with the first exposure. The process is rapid and a major proportion of the acclimatization is acquired by the third or fourth day. (Appendix II, Chart 3)

(5) Soldiers in good physical condition acclimatize more quickly and are capable of a greater work output in the heat than are men in poor physical condition. (Appendix II, Chart 4)

(6) Continued training in cool environments beyond that necessary to attain good physical fitness does not further increase the ability to work in the heat nor shorten the period of acclimatization. (Appendix II, Charts 5, 6)

(7) Resting for three or four days in the heat, with activity limited to that required for subsistence, results in definite, but only partial acclimatization. Some work in the heat is necessary for complete acclimatization. (Appendix II, Charts 5, 6)

(8) When work is begun with first exposure to the heat and progressively increased within the limits of tolerance of the man, full acclimatization (the ability to perform a maximum amount of strenuous work in the heat) is attained most quickly. (Appendix II, Charts 5, 6)

(9) Strenuous work on first exposure to the heat is not well tolerated and will often result in disability. Continuing such a degree of work for another day or two will incapacitate many men - the few who can continue their labors do so ineffectively and inefficiently. (Appendix II, Chart 7)

(10) Excessive work on first exposure, even leading to heat exhaustion, does not, however, retard the rate of acclimatization or lessen the degree which is finally attained, provided work is discontinued upon the appearance of symptoms; water and salt are given; and work when later resumed is in keeping with the tolerance of the soldier. (Appendix II, Charts 7, 8)

(11) Three or four exposures to heat of 3 or 4 hours duration with two one-hour work periods during each exposure, will produce a considerable degree of acclimatization. These exposures may be separated by intervals of two days in a cool environment. (Appendix II, Chart 9)

(12) So long as the work done is within the capacity of the man, the same pattern of acclimatization is produced by short severe exertion (for ten minutes of each hour, 4 or 5 times daily) as by moderate work of long duration (marching 12-1/2 miles with 20 pound pack at 2-1/2 miles per hour). (Appendix II, Chart 10)

(13) The well-acclimatized man deprived of adequate rest at night is incapable of producing his customary amount of work in the heat on the ensuing day or does so less efficiently. (Appendix II, Chart 11)

(14) Once acclimatized, the soldier will retain his adaptation for from one to two weeks after which it decreases at a variable rate. Most men lose the major portion of their acclimatization in one month - a few, however, are able to retain it for two months. (Appendix II, Chart 12) Men in good physical condition retain their acclimatization best, provided they remain in training after acclimatization. (Appendix II, Chart 12a) Repeated exposures to heat are required at intervals not exceeding one month, if a high degree of acclimatization is to be maintained for long periods of time. (Appendix II, Chart 13)

(15) Drinking of water in amounts equal to the weight (sweat) lost during work increases the amount of work which can be done on first exposure to heat. The rate and final degree of acclimatization attained, however, are not influenced by the water intake (forced, moderately restricted, or taken as desired) during the first two or three days of work in the heat, provided that after this initial period men are permitted as much water as desired. (Appendix II, Chart 14)

(16) Suddenly restricting the water intake of men working in the heat leads to a deterioration of morale and motivation, reduces greatly the efficiency with which work is performed, decreases the total work output, causes disabling symptoms in many men and renders others incapable of sustained purposeful action. This holds for even the well-acclimatized man. (Appendix II, Chart 15) Gradual reduction of water intake induces changes similar to sudden restriction, differing only in that they are produced more slowly.

(17) Acclimatization to hot dry (desert) environments increases markedly the ability of men to work efficiently and effectively in hot moist (jungle) environments. (Appendix II, Chart 16)

4. RECOMMENDATIONS:

a. Troops brought to a hot desert should when possible be given at least a four day period for acclimatization, during which time they should be supervised carefully by medical, line and non-commissioned officers.

b. Graded amounts of work should be done during acclimatization with regulated exposure to heat during the midday hours (Appendix I, Schedule 1).

c. Enough water should be drunk to satisfy thirst at all times. If more water is drunk during the first three days than is dictated by thirst alone, work will be accomplished more efficiently.

d. Unnecessary exposure to sun should be avoided. It increases the water requirement, adds to the danger of heatstroke and may cause serious sunburn.

e. All personnel should be familiarized with the signs and symptoms of heat exhaustion and should be instructed in methods of emergency treatment (Appendix I).

f. All officers should be made familiar with the water and salt needs of their men and be acquainted with the information given in the Appendices.

g. For one week before and after entry into a hot desert troops should be given adequate rest and alcohol should be prohibited. Men who have had recent illness should not be exposed to heat until they have completely recovered (and are back in good physical condition).

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#1 - Appendix I
#2 - Appendix II, with Charts (17)

APPENDIX I

GENERAL RECOMMENDATIONS FOR SUPERVISION OF TROOPS IN HOT DESERTS

1. Schedule of graded work during acclimatization

Gradually increasing amounts of work should be done during the acclimatization period, with limited exposure to heat during the midday hours. A schedule set up according to the following plan with alternating rest and work periods is safe for practically all men; it provides for work during the cooler morning hours and in the hot afternoon hours. Local and regional variations may call for slight modifications. During the midday period the men should rest and keep in the shade as much as possible.

Proposed Schedule of Work During Period of Acclimatization

	When Maximum Air Temp. is 90 to 105°F	When Maximum Air Temp. is 105°F and Over
	Hours of Work	
First Day	0700 - 0900 and 1500 - 1700	0800 - 1000 and 1500 - 1600
Second Day	0700 - 1000 and 1430 - 1630	0700 - 1000 and 1500 - 1600
Third Day	0700 - 1000 and 1400 - 1700	0700 - 1000 and 1400 - 1600
Fourth Day	0700 - 1100 and 1330 - 1750	0700 - 1000 and 1330 - 1630
Fifth Day	Regular Duty	0700 - 1100 and 1330 - 1630
Sixth Day	Regular Duty	Regular Duty

The working period should be divided so that a man works and rests in alternating half-hour periods. Two teams can be arranged to work in sequence. The work should equal that of marching with a 20 pound pack at the rate of 2.5 miles per hour. Lighter work may be carried out for longer, and heavier work, for shorter times.

2. Symptoms of Heat Exhaustion.

Symptoms of heat exhaustion should serve as a warning to cease work immediately and lie down - if possible in a shady place. Plenty of water should be drunk. These warning symptoms are: flushed face, headache, dizziness, irritability, shortness of breath, nausea, occasionally vomiting and sometimes abdominal cramps or cramps in the muscles. A man in danger of imminent collapse can often be recognized by his flushed face, weakness, incoordination or stumbling gait.

Incl #1

3. First-aid Treatment.

When a man has collapsed from the heat, first-aid treatment should be started at once by anyone at hand. The following should be done, in the order named:

a. Put the man in the shade.

b. Send for a medical officer and an ambulance.

c. Remove the man's clothing and sponge the body with water, fanning vigorously to help evaporation.

d. Give cool, salted water to drink, if it can be retained.

For a day or two before prostration a soldier may appear below par and have a poor appetite. Men showing these early effects of heat should be given plenty of water and adequate salt and be relieved of work until they have recovered.

4. Physical Characteristics in Relation to Heat Tolerance.

For protracted missions or when water is restricted, men with the following characteristics will do best:

a. Physical characteristics - men of below average to average stature, preferably of the lean, wiry type, having a low ratio of body mass to surface area. Large stocky and fat men perform at a much poorer level.

b. Age - between 20 and 30 years.

c. Physiologic characteristics - capable of working strenuously in natural or artificial hot environments without great rise in body temperature or pulse rate and without complaints.

d. Physical condition - maximum physical fitness is essential.

Incl #1

APPENDIX II .

A. EXPERIMENTAL CONDITIONS AND PROCEDURES

1. Environment - Air temperature during the day (0800 hours to 1700 hours) 120°F, during the night (1800 hours to 0630 hours) 90°F; relative humidity between 15% and 22% during the day. One hour was required to change from one temperature to the other. Wall and floor temperatures were in equilibrium with air temperatures. No additional radiant heat was supplied and the environment, therefore, was not as severe as that of a desert with identical temperature and humidity. Two sources of heat-gain present in the desert were lacking in this experiment; (a) the radiant heat of the sun, (b) the heat from the desert terrain which reaches 140°F to 160°F. A moderate degree of air movement was obtained by means of two 26-inch fans or four 10-inch fans. The rate of air movement was not measured.

Since the studies were carried out during five winter months, the experimental environment represented an extreme change in environment for the subjects.

2. Experimental subjects - 56 enlisted men; 48 lived continuously in the hot room, 8 lived in barracks, reporting to the Laboratory for exposure periods. The age limits of the men were 17 and 43 years, but the majority were between 20 and 28 years.

3. Clothing - Men wore what they chose; during the hot periods, only cotton shorts, shoes and socks; during the preliminary cool period, regulation fatigue clothing.

4. Preliminary training - Before being subjected to the hot environment all men worked in cool temperatures (70°F to 76°F) for one week. During this period their work was the same as that which they were to perform later in the heat. This procedure accustomed the men to the work and experimental procedures, and produced a more uniform state of physical fitness in all men.

5. Activity in the hot environment - For test purposes the men were divided into three groups according to activity:

Group I. Resting.

The men in the resting group were permitted to rest for 3 or four days in the heat before beginning work.

Incl #2

Group II. Riding bicycle.

The men in the bicycling group performed strenuous work for short periods; pedalling a stationary bicycle for ten minutes each hour, five times a day.

Group III. Walking.

The walking group was the largest of the three. These men performed work of moderate severity for long duration, namely, walking at a standard army pace while carrying a 20 pound pack. A walk of 2-1/2 miles in 47 to 50 minutes constituted a "work period". A rest of 10 to 13 minutes was given between successive work periods. Unless disabled, the men walked two successive periods in the morning and three in the afternoon, walking a total of 12-1/2 miles a day. The data and conclusions of this report are based for the most part on observations made upon men performing this type of work. Certain exceptions are mentioned in the text.

The eight men who lived in their barracks were subjected to the hot environment for 4 hours in the morning, returning to their quarters after each exposure. During each exposure to heat they walked for two work periods, separated by a rest period of one hour. All eight men had their initial exposures on the same day. They were then divided into pairs for re-exposure. At intervals of three days a new pair was re-exposed to the heat. Once a man had received his second exposure to the heat he returned to the hot room every third day until acclimatized.

6. Food - Regular army fare obtained from their regular mess. No record was made of the type or amount of food eaten.

7. Water - Salt was added to the drinking water (final concentration 0.1%). The water intake was measured and was administered according to one of three methods:

a. As much as desired, whenever wanted.
b. Intake regulated to equal the total weight lost.
c. Restricted to 4 litres, approximately one-half of the needed intake, and given in either of two schedules: (1) 270 ml every hour from 6:00 A.M. to 6:00 P.M., plus 750 ml from 6:00 P.M. to 6:00 A.M. (2) 750 ml at 6:00 A.M. 1250 ml with noon meal, 1250 ml with evening meal and 750 ml from 6:00 P.M. to 6:00 A.M.

8. Sleep - Eight to nine hours a night. A few men had difficulty sleeping on the first night of an experiment; most slept well throughout.

9. Observations made each morning on awakening - rectal temperature, pulse and respiratory rates, weight (± 1/4 pound), and measurement of the urine voided in preceding 24 hours.

Subj 2

10. Observations made during the work periods:

a. General appearance - noted continuously and records kept of vigor, flushing of the face, sweating, headache, and complaints of gastro-enteric or cardiovascular disturbances.

b. Body temperature - rectal temperatures were taken at the beginning and end of each work period.

c. Heart rate - at the beginning and end of each work period with the subject in both the supine and erect position (3 minutes in each) and at 15 minute intervals during the walking period (subject marking time). Ausculation over the precordium was necessary to determine the more rapid rates.

d. Blood pressure - at the beginning and end of each work period with the subject both supine and erect (3 minutes in each position). Change of posture was obtained by means of a tilt table and also by voluntary movement by the subject.

e. Weight - the weight within 5 grams was recorded at the beginning and end of the two morning and three afternoon work periods. Subjects were naked and the sweat dried off.

f. The water intake and urine output during each work period and during each 24-hour period.

11. Special observations made at intervals throughout the studies included:

a. Basal metabolic rate (Sanborn)
b. Electrocardiogram
c. Vital Capacity
d. Code aptitude tests
e. Attention tests

chl #2

B. COMPARISON OF ACCLIMATIZED AND UNACCLIMATIZED STATES

Work in hot environments is at first difficult or impossible for most men. By a process of acclimatization, however, man adapts himself to work in the heat. He then works without subjective complaints and with little or no disturbance of bodily functions. Acclimatization to heat appears to be a complex physiologic readjustment which cannot be adequately defined or completely determined by a few simple physiologic measurements. Nevertheless, this adaptation is accompanied by certain physiologic changes which serve as general indices of the whole process. In this report some of these physiologic changes are discussed and represented by a series of charts.

All charts are similarly plotted (see Chart 1). Along the ordinates heart rate, rectal temperature and blood pressure are charted in turn. The total height of the column indicating blood pressure represents the systolic pressure; the white portion of this column (limited by the transverse line) indicates the diastolic pressure; the solid or hatched portion of the column gives the pulse pressure. Along the abscissae are indicated the day of work, the environment in which the work was performed and the period of work at the end of which the plotted data were obtained. For example, in Chart 1 the first pair of columns represents the data obtained in the erect and supine positions at the end of the fifth work period on the 6th day in the cool environment; the next pair of columns, the data at the end of the second work period on the first day in the hot environment. Then, in turn, the data at the end of the third work period on the second day in the heat; at the end of the fourth work period on the third day in the heat and so on. A key with each chart interprets the hatching of the columns. The text associated with each chart indicates whether the data were obtained from single observations or averages.

1. Physiologic changes (Charts 1, 2)-

The acclimatized man works in the heat with a lower pulse rate, a lower body temperature and a more stable blood pressure after change in posture than when not acclimatized (Chart 1). Compare, for example, performance on the fifth and first days in the heat. In the unacclimatized state (first day in heat) change of posture causes marked alterations in cardiovascular dynamics, as indicated by pulse rate and blood pressure. In the erect posture the heart rate is markedly accentuated, the systolic blood pressure falls and the pulse pressure narrows. In Chart 1 compare the solid black (erect) and hatched (supine) columns. As a result of the lowered blood pressure the cerebral circulation at times becomes inadequate, symptoms of cerebral hypoxia arise and even syncope may ensue. Lying down promptly slows the heart rate, restores the blood pressure and dispels the symptoms of cerebral ischemia.

Chart #2

With continued exposure to heat, acclimatization progresses and the heart rate, rectal temperature and blood pressure return to levels approximating those obtained after similar work in cool environments. This is true with the subject erect or supine (Chart 1).

Although observations were made with the subjects both erect and supine, in this report acclimatization was evaluated for the subjects chiefly in the erect posture and all charts (unless otherwise indicated) refer to such measurements. Three facts led to this decision; (a) the findings in the erect posture paralleled those in the supine, (b) the erect posture places an added strain on the physiologic functions of man, revealing disturbances not apparent in the supine position, (c) a useful man is a working man; work usually requires the upright posture.

Although a low heart rate, a low rectal temperature and a stable blood pressure generally accompany acclimatization, one cannot define the process nor detect differences in the degree of acclimatization between individuals by such simple measurements alone. This is illustrated by the data for four subjects plotted in Chart 2. On the fourth day of exposure to heat all four men successfully completed five work periods at which time subject Bel. had the most rapid heart rate and the highest rectal temperature. This might be taken as an indication of incomplete acclimatization and evidence that Bel. was not as capable of work in the heat as the other three men. His general appearance and behavior, however, indicated that he was more fit than Ham. or Gee., both of whom had lower heart rates and body temperatures. On the following (5th) day, the men worked under more severe conditions. Subject Ham. became weak, nauseated and vomited after the second work period and could not continue. Subject Gee. was forced to stop at the end of the third work period because of exhaustion. Subject Bel. with a heart rate and rectal temperature which were always higher than those of Ham. or Gee., continued energetically for another work period and on finishing appeared almost as fit as Lan. Thus, prediction of performance on the basis of heart rate and rectal temperature alone did not agree with the actual performance of these men.

Undoubtedly a man, doing a given amount of work, is less efficient and more prone to disability when his rectal temperature and pulse rate are high, than when they are low. Individual performance is influenced by many variables which are not evaluated by such simple measurements. It is necessary to consider and evaluate each man as a whole and to avoid focussing attention on the rectal temperature or heart rate. The man's subjective symptoms, his objective appearance, his behavior and his actual performance must receive at least equally careful consideration in any evaluation of his capacity to work in the heat.

Incl #2

2. Symptoms and signs -

The acclimatized man is alert, performs his work energetically and without symptoms. Usually his heart rate and rectal temperature are low, at least not markedly elevated. On the other hand the unacclimatized man working in the heat becomes dull and apathetic, performs his work poorly, has a rapid heart rate and a high rectal temperature and may manifest to varying degrees and either singly or in combinations, the symptoms and signs of heat exhaustion. In the present experiments these symptoms and signs appeared in the following order of frequency: Symptoms (1) fatigue (2) headache (3) dizziness, especially when erect (4) shortness of breath (5) loss of appetite (6) nausea (7) vomiting (8) abdominal cramps; Signs (1) flushing of face and neck (2) rapid pulse rate (140 - 200/min) (3) lack of coordinated effort (clumsy, stumbling) (4) staring glazed eyes (5) mental disturbances (apathy, poor judgment, irritability) (6) fever over 102°F (7) collapse.

Of interest is the marked flushing of the face, neck and upper chest which occurs in most men when they first work in the heat and which disappears as acclimatization develops.

Incl #2

C. FACTORS IN ATTAINING AND MAINTAINING ACCLIMATIZATION TO HEAT

As pointed out above, when different individuals are compared, the heart rate, rectal temperature and blood pressure are not in themselves completely reliable determinants of acclimatization to heat. Nevertheless, they may be utilized as indices of acclimatization when they are consistent with the other above-discussed evidences of acclimatization. It was with these limitations in mind that the heart rate, rectal temperature and blood pressures were used as indices in this study. The factors involved in attaining and maintaining acclimatization to heat are presented in a series of charts and it is to be understood that the plotted changes in rectal temperature, pulse rate and blood pressure were consistent with the picture of the man as a whole. When they were not, specific mention of the differences are made.

1. Course of acclimatization (Charts 1, 3) -

The process of acclimatization appears to be initiated by the first exposure to heat. This is indicated by Chart 1, in which are plotted the observations made on one man at the close of the last work period of each charted day. Considerable improvement in heart rate, rectal temperature and blood pressure (in the erect posture) is apparent on the second day in the heat, that is, after one day of previous exposure.

At the close of the last (second) work period on the first day in the heat this man was very tired, giddy and unable to stand erect. On the second day he finished three work periods feeling much better than on the previous day, had no difficulty in standing and maintained a normal blood pressure in the erect posture.

In most men, a major portion of the acclimatization to heat is attained by the fourth or fifth day of work in a continuously hot environment. This is illustrated in Chart 3 which shows the progressive changes recorded in two groups of men exposed to heat at different times. Each column represents the average of the data obtained on four men at the end of the last work period of the day indicated. During the first three to four days there is a progressive and rapid improvement in heart rate and rectal temperature, which thereafter levels off at values somewhat higher than those obtained under similar circumstances in the cool environment.

2. Physical condition (Chart 4) -

Although exceptions are not unusual in individuals, men in good physical condition generally acclimatize to heat more rapidly than men in poor condition. Moreover, the more fit men are capable of a greater work-output in the heat with less symptoms and less disturbance of their heart rates, rectal temperatures and blood pressures than are the less fit men. In this study the determination of physical fitness was based on the work performance of the men while in a cool environment. In evaluating physical fitness all of the factors previously discussed (the appearance and behavior of the man as well as the results of physiologic measurements) were taken into consideration. Those men were considered most fit who performed the prescribed work easily and energetically, without symptoms and with least disturbance of their heart rate, blood pressure and rectal temperature.

The three men whose records are compared were from a group of eight men whose physical fitness was assessed before they entered the hot environment. Three different observers gave independent ratings. All three observers placed subject Sch. first. Two observers placed subject Kit. seventh, one observer sixth. Two observers placed subject Lup. fifth, one observer second. Of the three men, Sch. was considered most fit, Kit. least fit, and Lup. intermediate between the two.

Observations on each of these three men were obtained at the end of the last work period of each of six days in the hot environment and, for comparison, the same measurements taken on the last day in the cool environment are also shown in Chart 4. The more rapid improvement in the pulse rate and rectal temperature of subject Sch. is readily apparent. An equally rapid improvement was also apparent in the general appearance and behavior of this subject. By the second day he was walking easily and with vigor. Note also the maintenance of blood pressure when erect. In contrast to Sch., the pulse rates, rectal temperatures and blood pressures of subjects Kit. and Lup. returned more slowly toward control levels. This was confirmed by the appearance of the men, especially Kit., who always seemed to be working with difficulty. Even after acclimatization had been attained by all three men the performance of Sch. was superior to that of the other two men (see 9th day in hot environment). On the fifth hot day subject Kit. was prevented from walking by blisters on the feet.

Chart #2

3. Activity prior to and during acclimatization (Charts 5, 6) -

Continuing the preliminary training period in a cool environment beyond that required to develop a satisfactory state of physical fitness does not increase the subject's tolerance to heat on first exposure. Resting in the heat for the first three days produces a definite tolerance to work in heat but the acclimatization thereby induced is only partial. Acclimatization is developed most rapidly by the daily performance of work in heat from the outset, the amount of work being progressively increased within the tolerance of the individual.

The relative effect of these three factors upon the process of acclimatization was determined, using twelve subjects divided into three equal groups. After the same preliminary training for all men, one group (A) continued to work in the temperate environment. The other two groups were taken into the hot environment and of these, Group B rested while the other (C) immediately undertook graded work which was progressively increased. When Group C was acclimatized (4th day) all three groups were subjected to the regular work schedule in the hot environment.

The comparative behavior of the three groups is striking. The subjects in Group C (with graded work in heat during the previous 3 days) had returned substantially to the normal physical state with only slight elevation of heart rate and temperature over the control levels. In contrast, the subjects in Group A, working in heat for the first time after extended preliminary training, gave no evidence of acclimatization, as shown by the high heart rate and body temperature. Only two of the four men completed the prescribed work and the condition of these two was considerably below that of the other men in the other groups.

The performance of the four men in Group B (resting in heat during the previous 3 days) fell between the other two groups. All four men completed the five work periods and, although the heart rate and body temperature were higher as compared with their control state, and also in comparison with Group C, the performance of these men was consistently better than that of the men in Group A. Thus, a partial state of acclimatization had been induced.

Chart #2

4. · Strenuous work from first exposure to heat (Chart 7) -

Strenuous work on first exposure to heat is not well tolerated. Twelve (12) unacclimatized men were asked to perform the full five work periods (12.5 miles) on their first day in the hot environment. Four men became exhausted (after the third or fourth period) and were unable to complete the task. The eight who completed the work did so with difficulty, finishing in poor shape and with high heart rates and rectal temperatures. The ability to complete strenuous work in the first exposure to heat does not necessarily indicate acclimatization nor the ability to continue to work in the heat. Maintaining work at a strenuous rate leads to progressive deterioriation of performance. After two or three days many men become disabled and those who continue to work do so ineffectively and inefficiently. This is in contrast to the progressive improvement of men subjected to a schedule of gradually increasing work in heat. The performance of one of the subjects (Sub. Geo.) illustrates this point.

The data were obtained at the end of each work period of the last day in the cool environment and of each day in the heat. During the first day in the heat this man completed five work periods without much difficulty. On the second day in the heat, however, he completed only three work periods. On the third day he was forced to stop in the middle of the first period. It is of interest to note the low blood pressure on this day despite the more nearly normal rectal temperature and heart rate as compared with the fifth period on the first day in the heat at which time he was still in fair shape. After dropping out in the first period of the third day, this man rested the remainder of that day and drank plenty of water. On the next (4th) day he finished five work periods in good condition and with a heart rate and rectal temperature approximating those recorded after similar work in the cool environment. Despite the exhaustion resulting from too strenuous work during the first three days in the heat, this man had attained a large degree of acclimatization by the fourth day.

Sheet #2

5. Intolerance to heat and heat exhaustion (Charts 7, 8) -

Development of symptoms of intolerance to heat and even heat exhaustion during the early days of exposure to heat do not retard the rate nor decrease the degree of acclimatization finally attained, provided that when such disability occurs work is discontinued, rest is permitted and water and salt are given. When work is resumed it should be within the capacity of the individual.

Chart 7, which illustrates this, has already been discussed. Chart 8 represents a similar, but more severe, situation in another subject. The data obtained at the end of each work period of each day in the heat are plotted and compared with the observations on the last day in the cool environment. On the first day in the heat this man could complete but four work periods when fatigue forced him to discontinue. On the second day he finished only two work periods; on the third day only one. Note the high heart rates and rectal temperatures reached on these days and the progressively decreasing blood pressure (Chart 8). The appearance and behavior of the subject indicated a parallel deterioration. On the third day this subject was quite ill; exhaustion, abdominal cramps, nausea, vomiting and marked apathy indicating heat exhaustion. After a litre of physiologic salt solution was administered intravenously, the nausea, vomiting and abdominal cramps ceased. He rested for the remainder of that day and drank salted (0.1%) water copiously. On the next (4th) day and the days thereafter he completed five work periods without difficulty, always finishing strongly and appearing to be acclimatized. This improvement was accompanied by a reduction of the heart rate to values equalling those obtained in the cool environment but the rectal temperature continued to rise to high levels (102°F.).

Sub #2

6. Single exposures to heat at intervals of three days (Chart 9) -

The following conclusions are based on data derived from eight subjects who performed two periods of work during a four hour exposure to heat every third day and who spent the intervening time in a cool environment: (1) A single relatively short period of work in the heat induces a little or no acclimatization, (2) a number of such exposures separated by two days in the cool environment results in acclimatization, (3) the major portion of the acclimatization for the above work requirements is produced by three or four such exposures to heat.

Representative observations on subject Mel., taken at the end of each work period during the four-hour exposures to heat are shown in Chart 9. During each exposure two periods of work were performed, separated by one hour of rest. The first exposure to heat was badly tolerated and caused weakness, nausea, vomiting and syncope when in the erect posture. The second exposure produced similar but less severe symptoms and vomiting was absent. Thereafter work in the heat was accomplished without difficulty and with increasing ease. The associated changes induced in the heart rate, rectal temperature and blood pressure and their regression paralleled the findings already described for subjects continuously exposed to the hot environment. (Compare Chart 9 with Charts 1 and 3) In this subject there was a particularly striking postural hypotension during the first three exposures to heat with a return of the blood pressure to normal as acclimatization developed.

Sml #2

7. Short periods of severe exertion (Chart 10) -

The behavior of subjects performing severe work of short duration in the heat follows a pattern of change and readjustment similar to that for less severe work of long duration (marching). The severe exertion consisted of pedalling a stationary bicycle for ten minutes each hour. The plotted observations are for one subject taken at the end of the first "ride" of each day.

The high rectal temperatures and pulse rates produced by this exertion become successively less marked as work in the heat is continued. Levelling off is attained by the fourth or fifth day. In one respect the readjustment differs from that observed for the more moderate work of marching. The resting level, rather than the increase cause by work, determines the final level of the pulse rate and body temperature. Most subjects found these short bouts of severe exertion less fatiguing than the prolonged but moderate work of marching.

Chart #2

8. Rest at night (Chart 11) -

Adequate rest at night is essential for good work performance in the heat, even in acclimatized men. Deprived of it, men work inefficiently the next day.

The data obtained on subject Mel. after the last (second) work period of each day are given. This subject belonged to that group which performed two periods of work during a four hour exposure to heat every third day. The night before his fifth exposure he failed to obtain adequate rest. His performance during the next day was almost as poor as that on the first exposure to heat and he completed the work with difficulty. Here again the true state of the subject is not indicated by the heart rate and rectal temperature. During the fifth exposure they are higher than during the first and second, yet the subject was in a better condition. There was no headache, nausea, vomiting or syncope in the erect posture, occurrences which had rendered him totally incapable of further effort on the first day in the heat.

The poor performance during the fifth exposure to heat did not retard further improvement. Note the much improved performance during the sixth exposure.

Sind #2

9. Duration of acclimatization (Chart 12) -

Acclimatization to desert heat after removal from the hot environment is well retained for at least one week and probably for two weeks. Thereafter, a variable but more rapid loss ensues so that after one month the major portion of the acclimatization is lost by most men. Some men, however, retained a considerable degree of acclimatization for two months after leaving the hot environment.

The plotted data were obtained on seven men at the close of the last work period on their first re-exposure to heat (solid column). These are compared with the observations made at the end of the last work period, on the last day in the cool environment (diagonal-lined column), with the first day in the hot environment (cross hatched column), and when fully acclimatized (open-block column). The observations for each individual are grouped together and separated by long vertical lines. "Interval" indicates the time between leaving the hot environment and first re-exposure to it.

The sharp loss in acclimatization after th. e weeks was indicated not only by the high heart rates and rectal temperatures (Sko., Foe., Ben.) but also by the failure to complete as many work periods and by the poor appearance of the subject. The vigorous and alert appearance of subjects Lup., Min., and Kus., and the ease with which they completed their prescribed work indicated a high degree of acclimatization despite their higher heart rates and rectal temperatures. Subject Sch. worked as well in the heat after a lapse of three weeks as when fully acclimatized.

Sheet #2

10. Maintenance of acclimatization (Charts 12A, 13) -

There are two requisites for the maintenance of a high degree of acclimatization to heat over a long period of time: a., the maintenance of good physical fitness and b., repeated exposures to heat, preferably with work, at intervals of one month or less.

Of the three subjects considered in Chart 12A, subject S was never in good physical condition, subject M remained moderately fit and subject W only fairly so. The strikingly poor performance of subject S when he walked in the heat after a lapse of 37 days indicated that he had not only lost all of his acclimatization but was in far worse condition than at any previous time. This was attributed to loss of fitness as well as of acclimatization in the interval.

The more fit subject (M) had a much better work performance than the less fit subject (W) when re-exposed to heat after a lapse of 16 days and 37 days. This was indicated not only by the lower heart rate and rectal temperature of subject M but also by the fact that of the three men re-exposed to heat after a lapse of 37 days he was the only one able to complete the full five work periods.

The need for re-exposure to heat in order to maintain acclimatization is indicated in Chart 13. Here are plotted the observations made on one subject at the close of each work period on the last (5th) day in the cool environment, on the first four days in the hot environment, and on re-exposure to heat 44 and again 47 days after leaving the hot environment. Initial acclimatization to heat was rapid and by the third day, five work periods were performed without difficulty and with heart rate, rectal temperature and blood pressure approximating those for the cool environment. On the first re-exposure to heat 44 days after leaving the hot environment, the subject was unable to continue after the fourth work period. At that time he was almost exhausted, the heart rate was more rapid than at any other time and the rectal temperature was high. But this exposure re-induced a great deal of acclimatization. During another exposure to heat three days later he was able to work as long and almost as efficiently as he had done when well acclimatized to heat 47 days previously.

Chart #2

11. Increased water intake (Chart 14) -

Thirst is an inadequate guide to the fluid required for work in the heat. No man drank enough water voluntarily to replace that lost in the sweat while working and all developed water deficits. Increasing the water intake during work to an amount (1200 ml per hour) equal to the water lost by sweating increased the amount of work which was accomplished on the first exposure to heat.

Twelve men were asked to work the full five periods during their first day in the hot room. Nine men received water in amounts sufficient to quench their thirst (600 ml per hour), 3 received water in amounts (1200 ml per hour) equal to the weight (sweat) lost. These three men all finished the five work periods without great difficulty. In contrast, four of the other nine men became exhausted after three or four work periods and could not continue. Those who did finish were in poorer condition than the men whose water intake was intentionally increased.

In chart 14 one may compare the effects of slight water restriction (6 litres per day), and of full water replacement (9 litres per day), on two groups of three men each, in their first and fourth days in the hot environment. Each column represents the averaged data for the group. Observations were made at the close of each of the five work periods for the last day in the cool environment and the first day in the hot environment. Observations are also recorded for the fourth day of heat exposure when both groups were permitted to drink as much water as they chose. Men who did not complete five full periods have been excluded.

Although the group in which water was forced to full replacement showed smaller disturbances of vigor, behavior, pulse rate and rectal temperature during their first day in the heat, the degree of acclimatization attained by both groups on the fourth day was the same.

Sheet # 2.

12. Water restriction (Chart 15) -

Sudden restriction of the water intake of well-acclimatized men at work to one-half of the optimal requirement induces changes similar to those which appeared in the men on first exposure to heat when they were unacclimatized.

In Chart 15 are plotted observations made on each of four well-acclimatized men. Their performance at the close of each work period on the day (9th) when water was restricted to 4 litres per day is compared with that following the fifth work period on a day (4th) when they received as much water as they desired. Subject Nor. was incapable of continuing after the third period and the other men finished five periods with difficulty. Note the higher pulse rates and rectal temperatures and the low blood pressures.

Important changes which the chart does not show is the condition of the men, their low morale and lack of vigor, their glassy eyes, their apathetic, torpid appearance, their "don't-give-a-damn-for-anything" attitude, their uncoordinated stumbling, shuffling gait. Some were incapable of sustained purposeful action and were not fit for work, let alone battle. All they wanted to do was rest and drink.

Progressive restriction of water was tolerated better than sudden restriction. For sudden restriction the intake was reduced on 1 day to 4 litres. Progressive restriction was carried out by limiting the intake from the optimum level of 8 L/day to 6 L for the first day, 5 L for the second and third day and to 4 L for the fourth day. The gradual restriction of water intake resulted in physiologic disturbances similar but less severe than those observed from sudden water restriction. Men were incapable of performing as much work as when water intake was adequate.

Chart #2

13. Cross acclimatization to jungle heat (Chart 16) -

Acclimatization to dry (desert) heat increases markedly the ability of men to work efficiently and effectively in hot moist (jungle) environment.

Three men were fully acclimatized to desert heat and six men were trained to work in a cool environment. All nine men then worked in a simulated jungle environment; dry bulb 90°F to 91°F, wet bulb 88°F to 89°F, relative humidity 90% to 96%. The averages of the data obtained on each group of men at the close of the last work period in the cool environment, and at the end of each work period of the first day in the hot moist (jungle) environment are compared. The performance in desert heat, (as expressed by average data for the desert group) is plotted between the heavy vertical lines. The first column represents observations made at the close of the fifth work period of the first day in the heat, the second column, the data from the fifth work period of the third day, when acclimatized.

On the first day in hot moist (jungle) heat five work periods were completed by each of the desert-acclimatized men; two men finishing strongly and easily and the third with some difficulty. Of the six men not previously exposed to a hot environment, four were able to complete only two periods of work, the first and third, while the other two completed three, the first, third, and fourth. Not only were the desert-acclimatized men capable of a greater work output but the work was performed more efficiently than was the smaller amount of work done by the other men.

The performance of the desert-acclimatized men, however, was poorer than it had been in the cool and desert environments.

Encl # 2

14. Results of special tests -

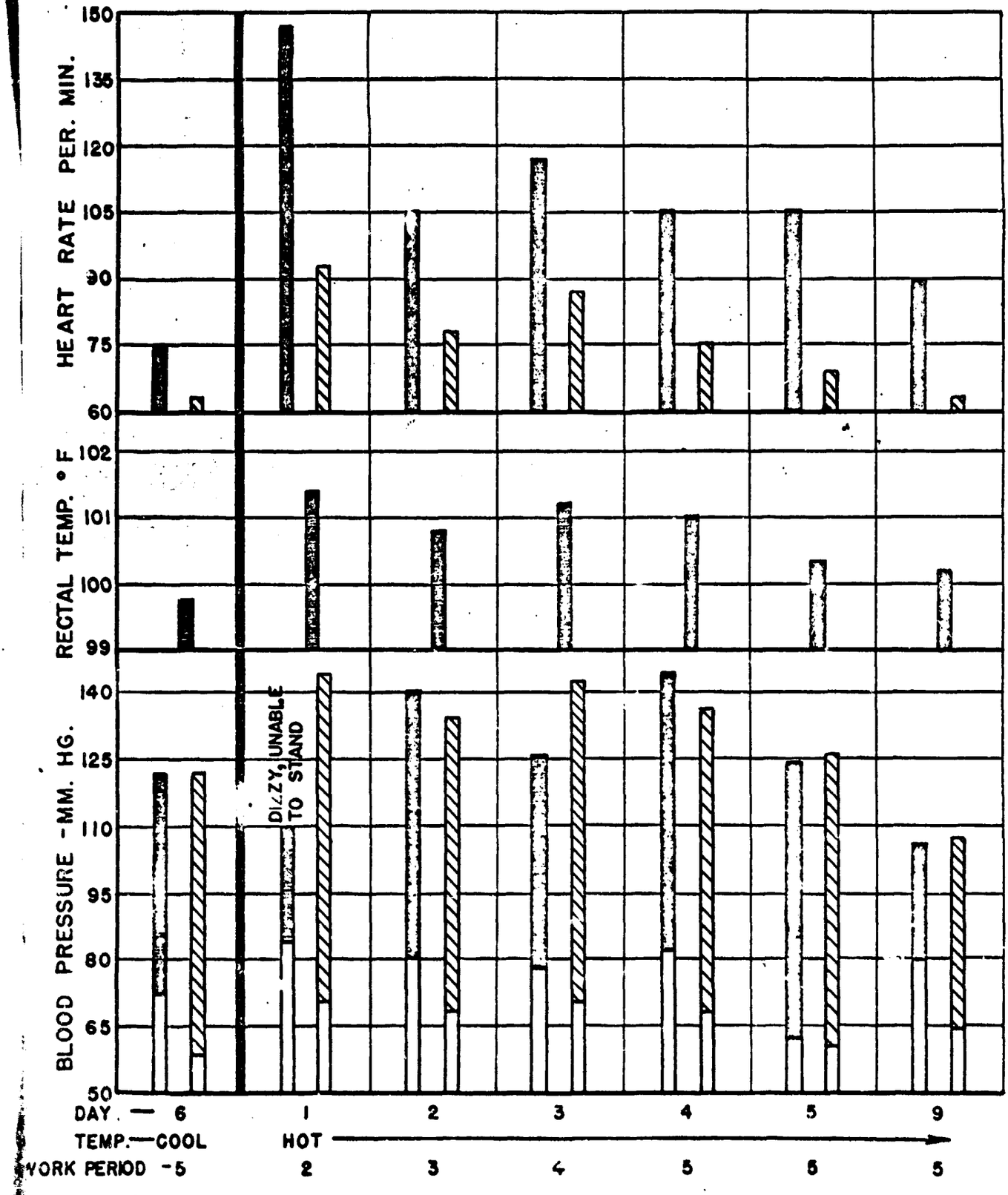
a. Basal metabolic rates did not change significantly during the process of acclimatization.

b. Electrocardiographic changes associated with work and change in position were the same with the subjects in the heat as they were when the subjects were in normal temperatures.

c. Vital capacity was not affected by acclimatization.

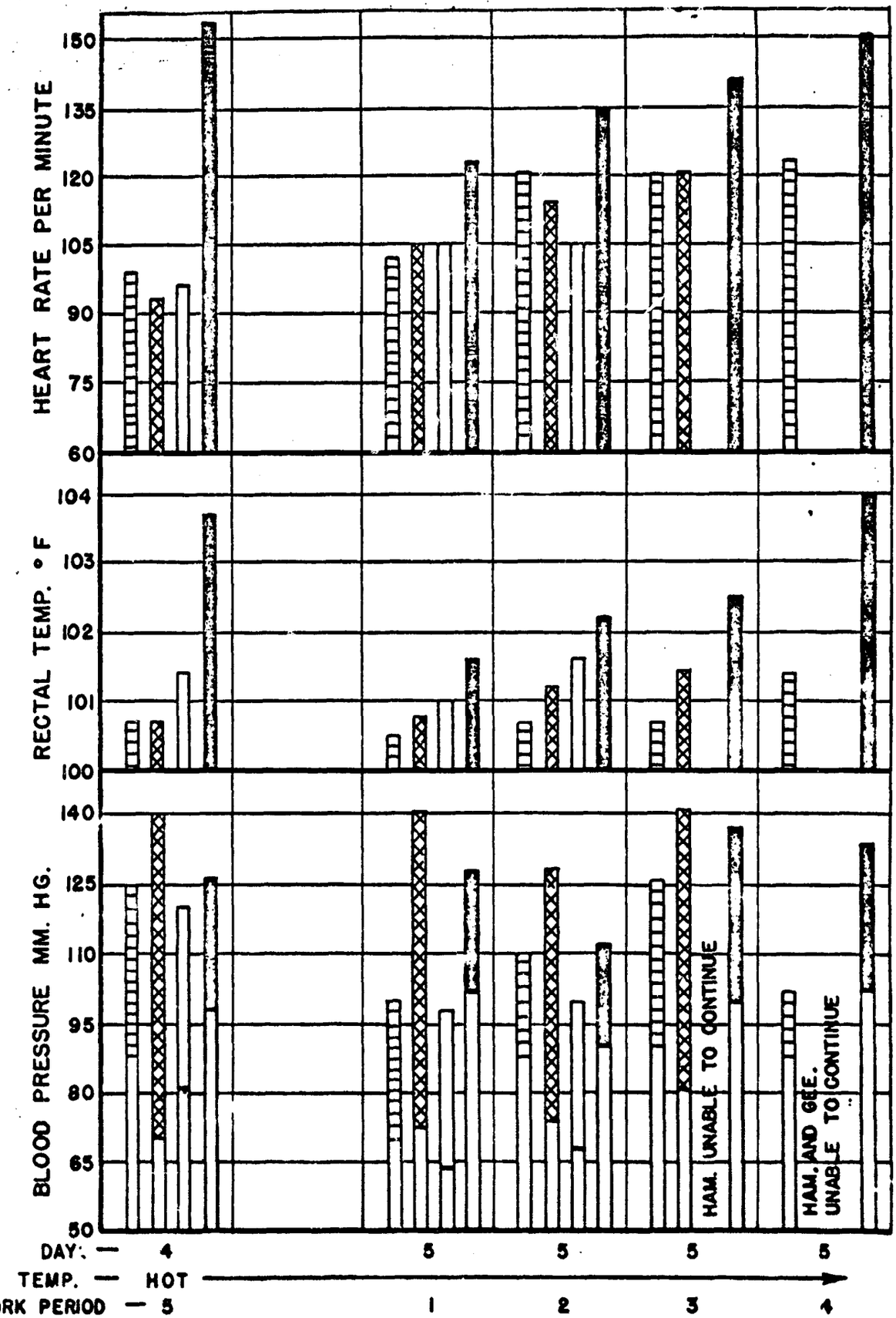
d. Code aptitude tests and attention tests showed a decrease in scores on the first day in the heat, and a gradual return to the control levels during the next three days. The initial decreases amounted to about 15%. All men were affected by an obvious depression in the heat for the first day and some instances for three days.

Chart 2



Incl # 2

CHART - 1



Incl #2

CHART—2

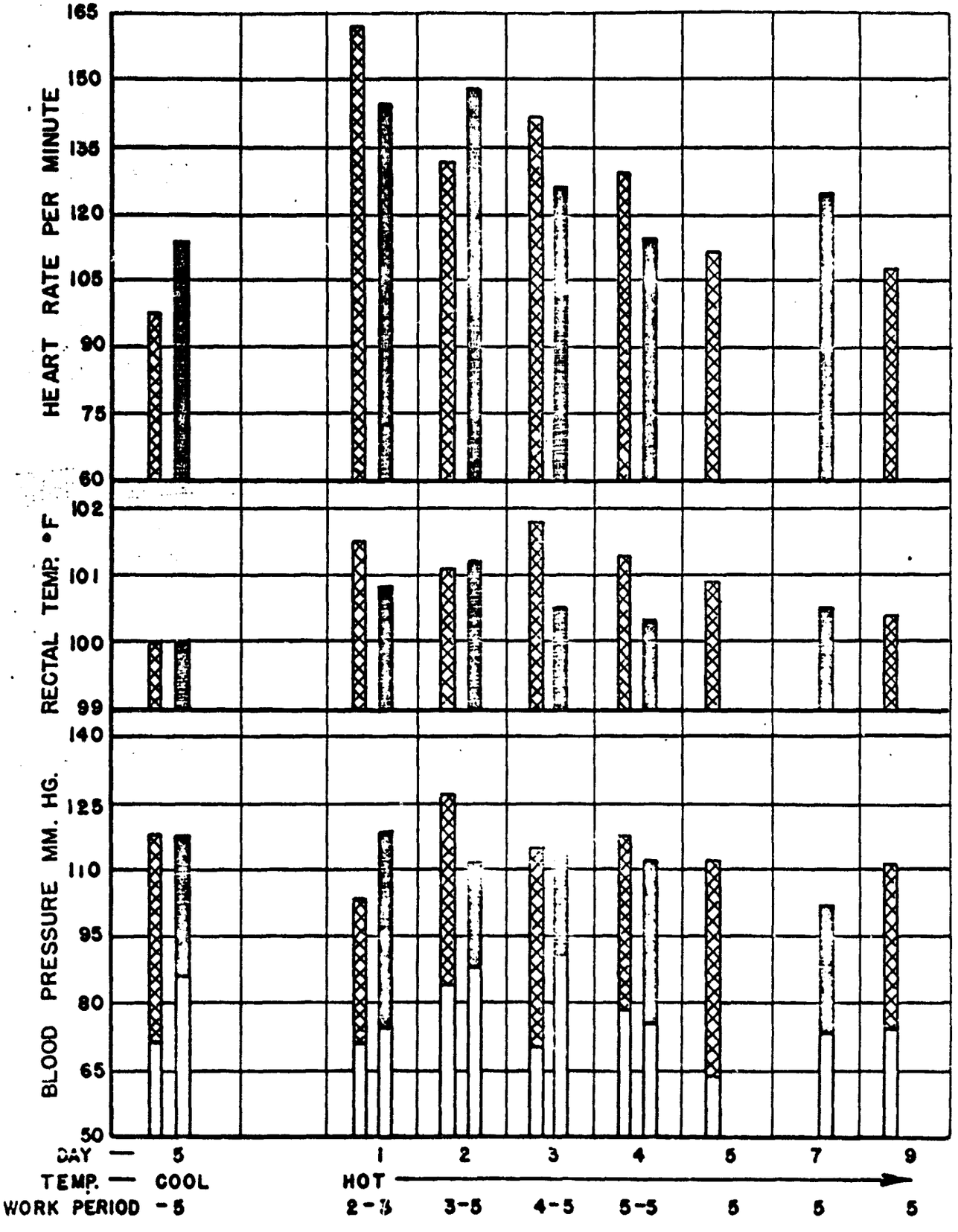


CHART — 3

Subj #2

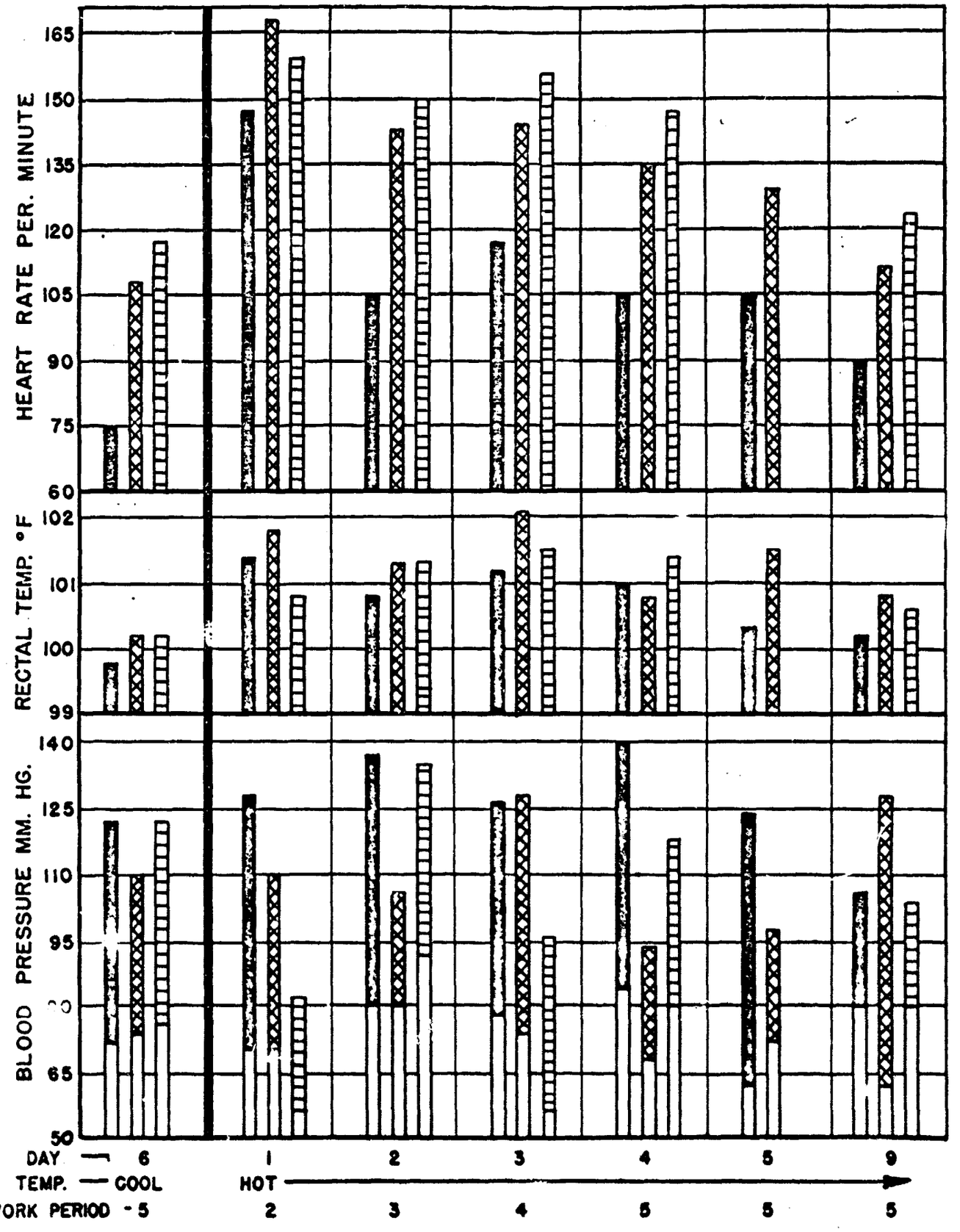
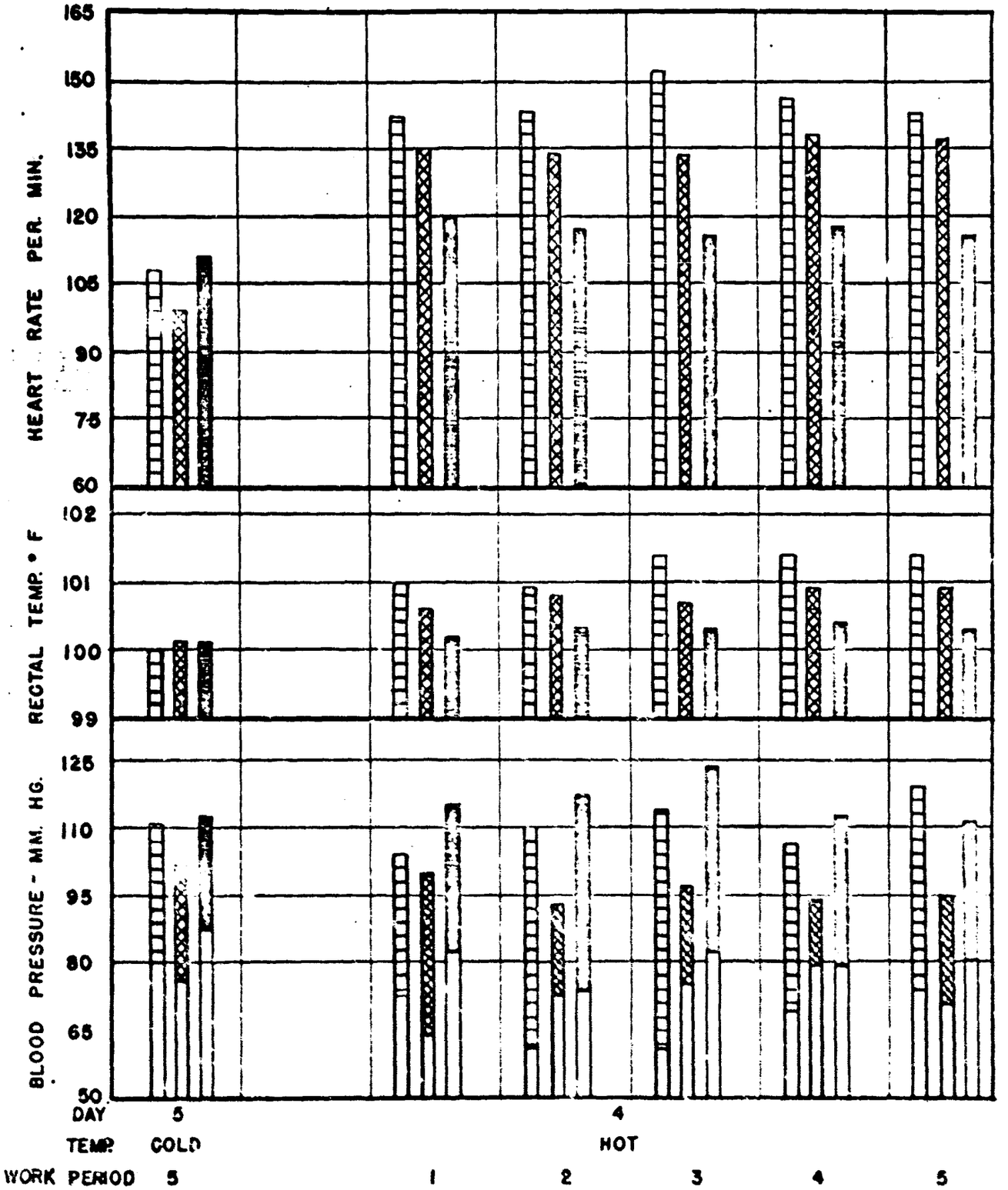

HEART RATE PER. MINUTE
165
150
135
120
105
90
75
60
RECTAL TEMP. °F
102
101
100
99
BLOOD PRESSURE MM. HG.
140
125
110
95
80
65
50
DAY — 6 1 2 3 4 5 9
TEMP. — COOL HOT
WORK PERIOD - 5 2 3 4 5 5 5
— SUBJECT SCH.
— SUBJECT LUP.
— SUBJECT KIT.

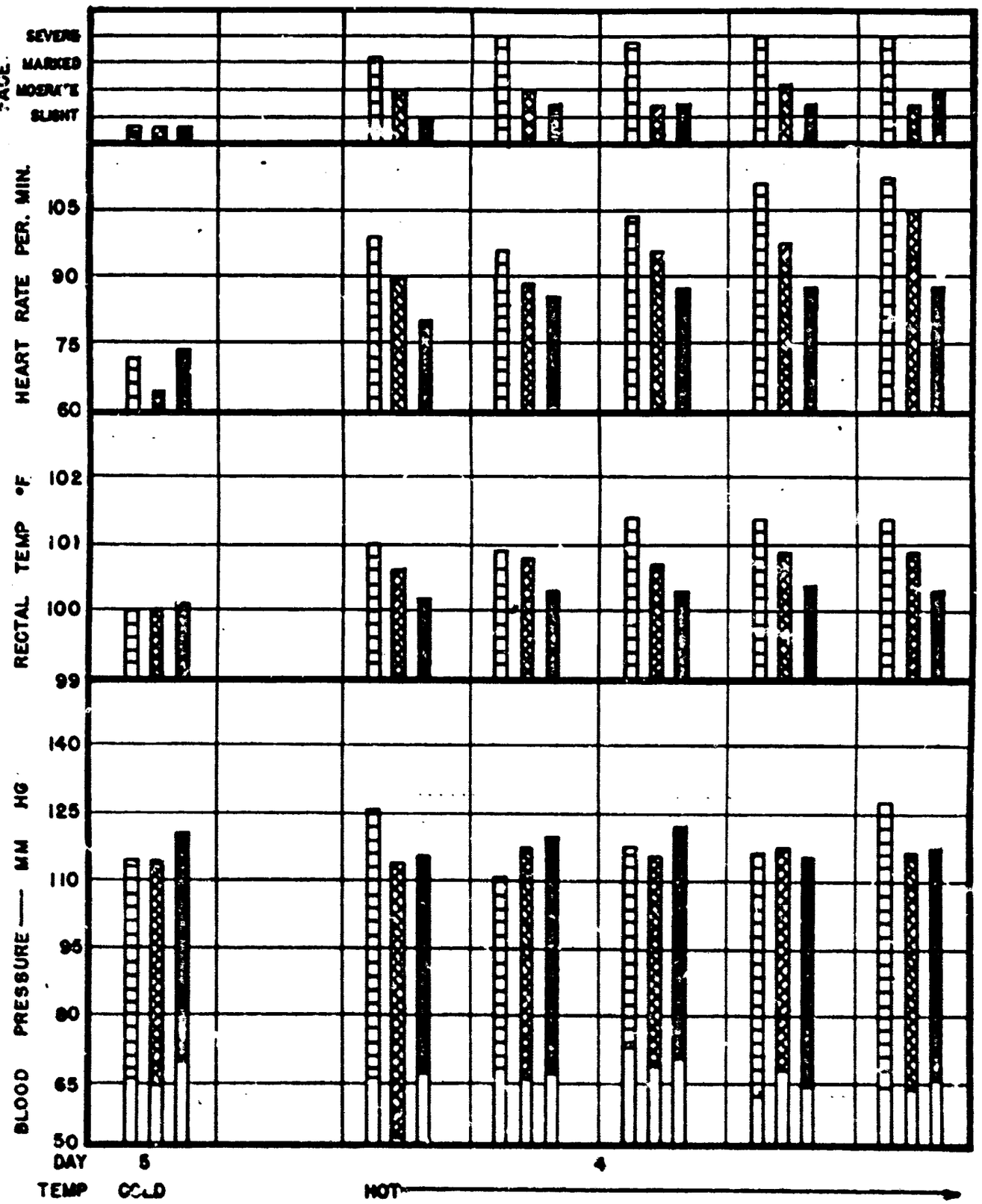
CHART – 4



Encl #2

CHART—5

DO NOT CUT HERE



AVERAGES OF 4 MEN, EACH GROUP — ▦ WORK IN COLD ▨ REST IN HEAT ▩ WORK IN HEAT

(SUBJECTS LYING) Suda 2 CHART-6

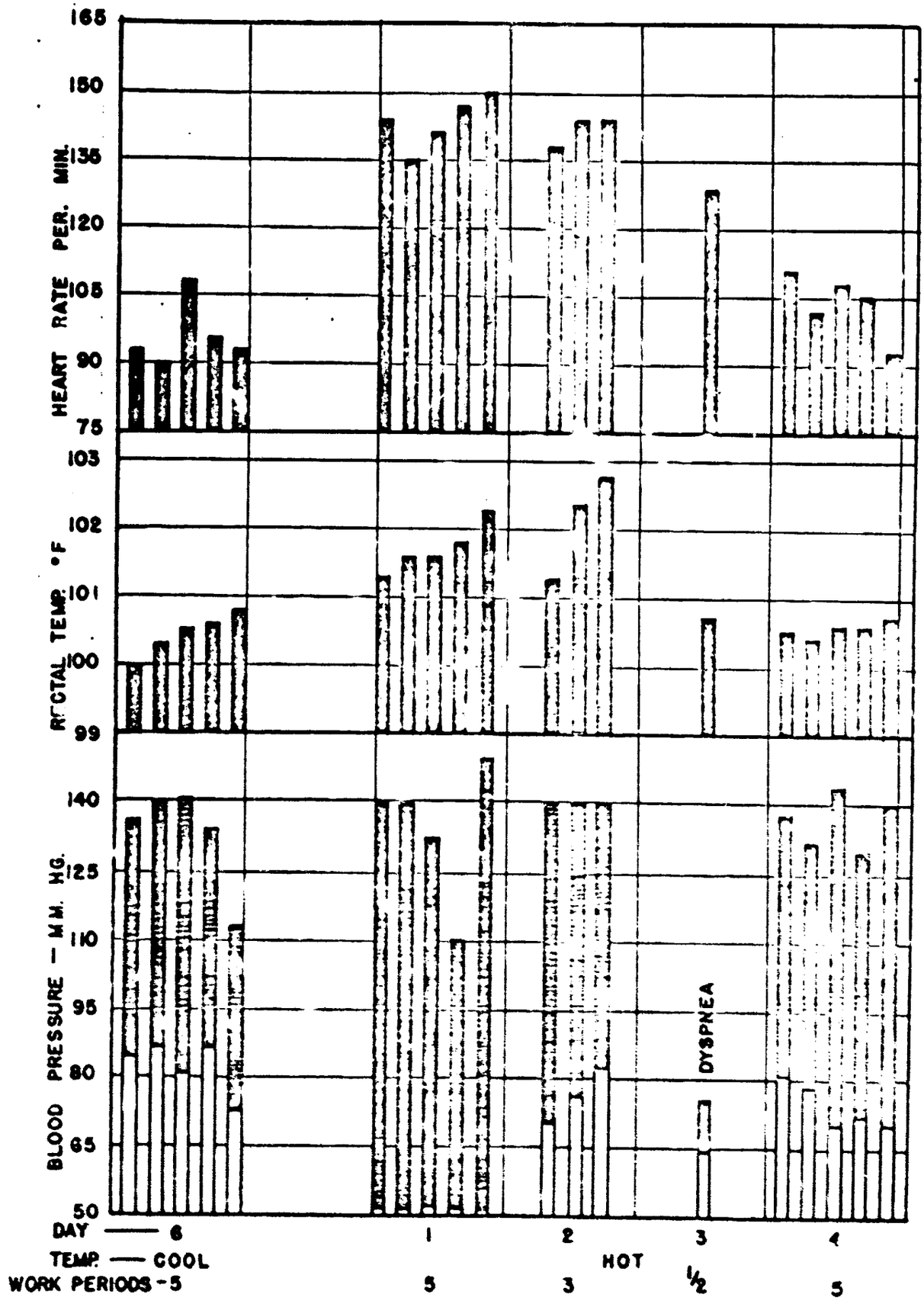
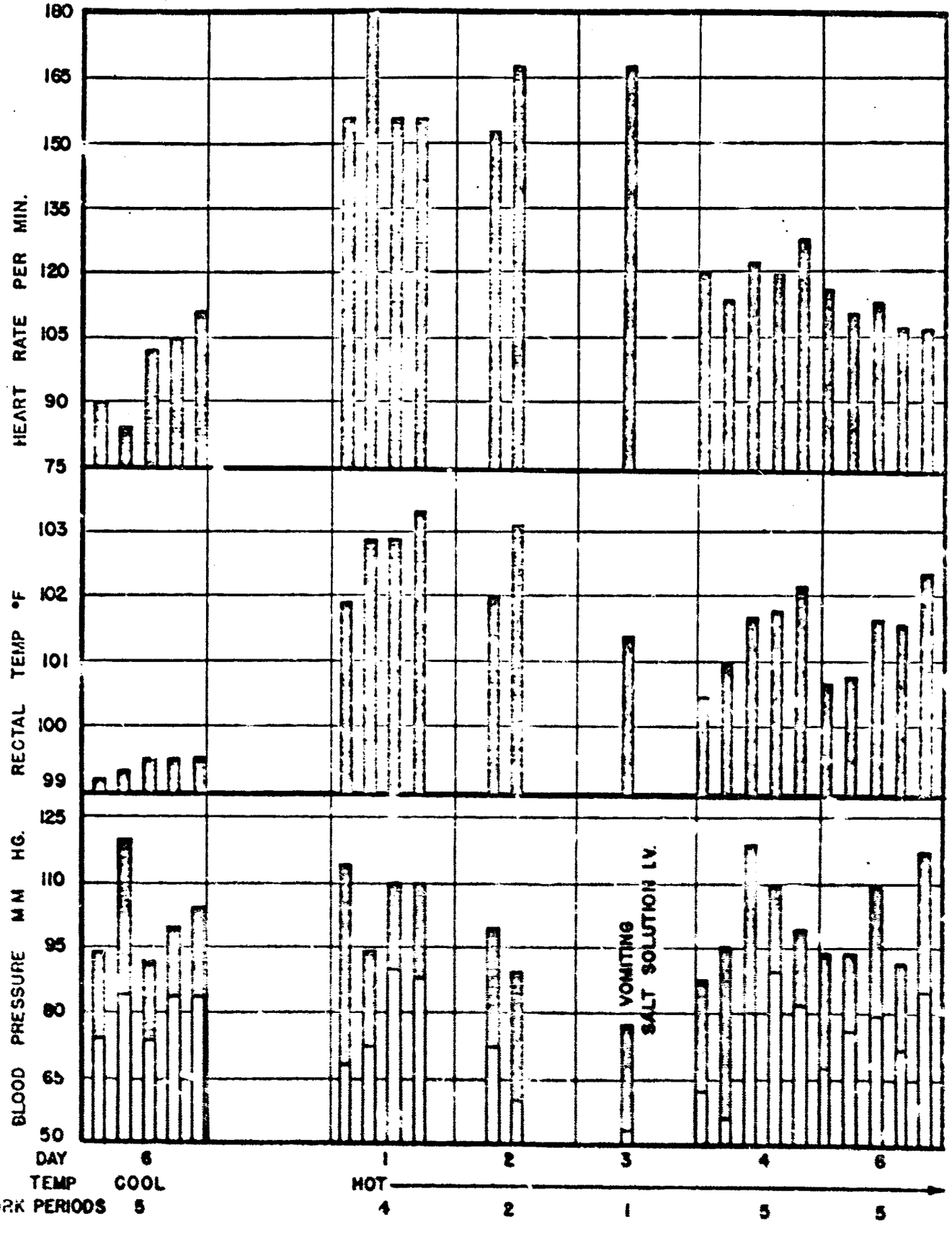
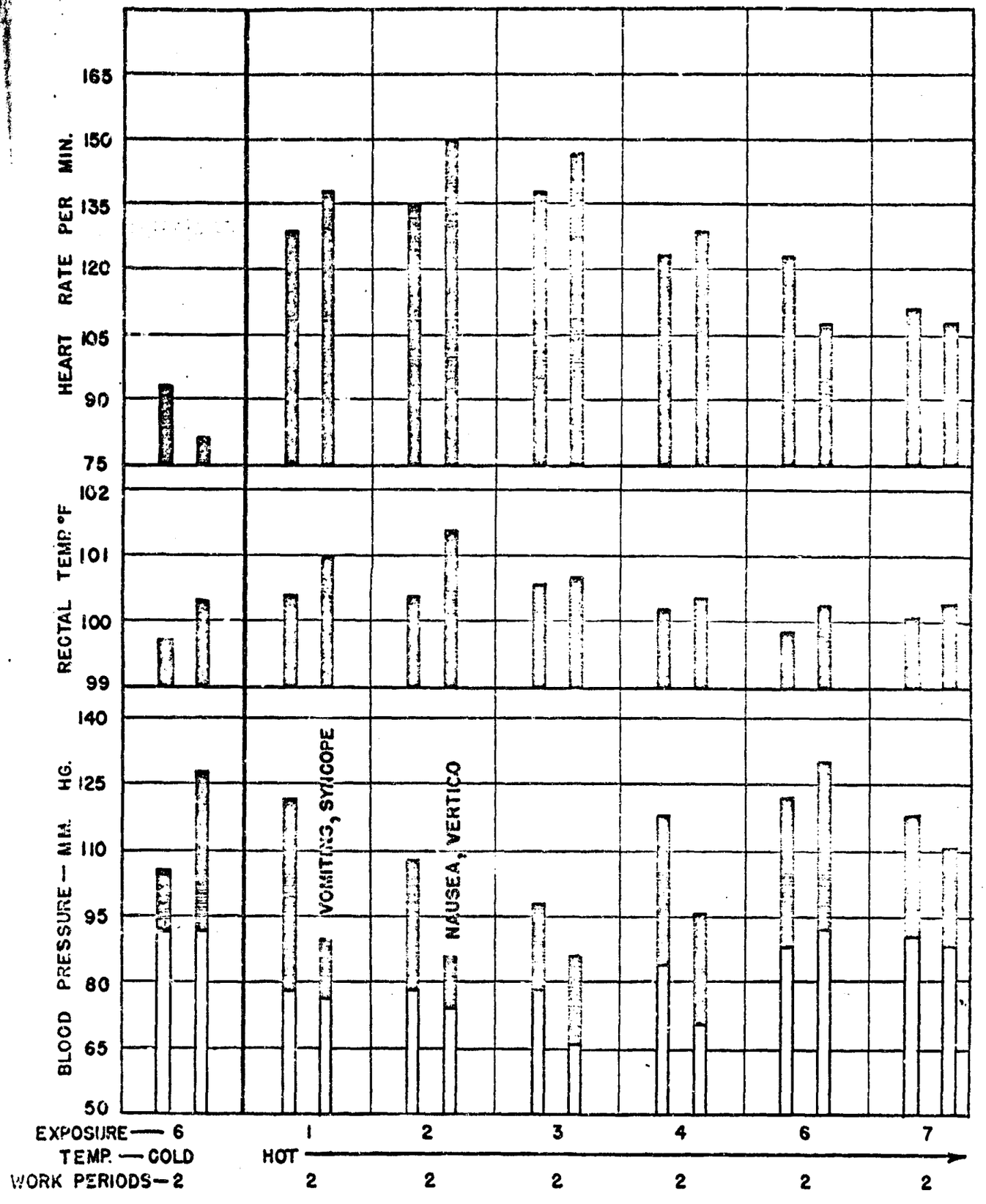

HEART RATE PER. MIN.
165
150
135
120
105
90
75
RECTAL TEMP. °F
103
102
101
100
99
BLOOD PRESSURE — M.M. HG.
140
125
110
95
80
65
50
DYSPNEA
DAY — 6 1 2 3 4
TEMP. — COOL HOT
WORK PERIODS - 5 5 3 ½ 5
SUBJECT GEE

CHART-7



☐ SUBJECT SML

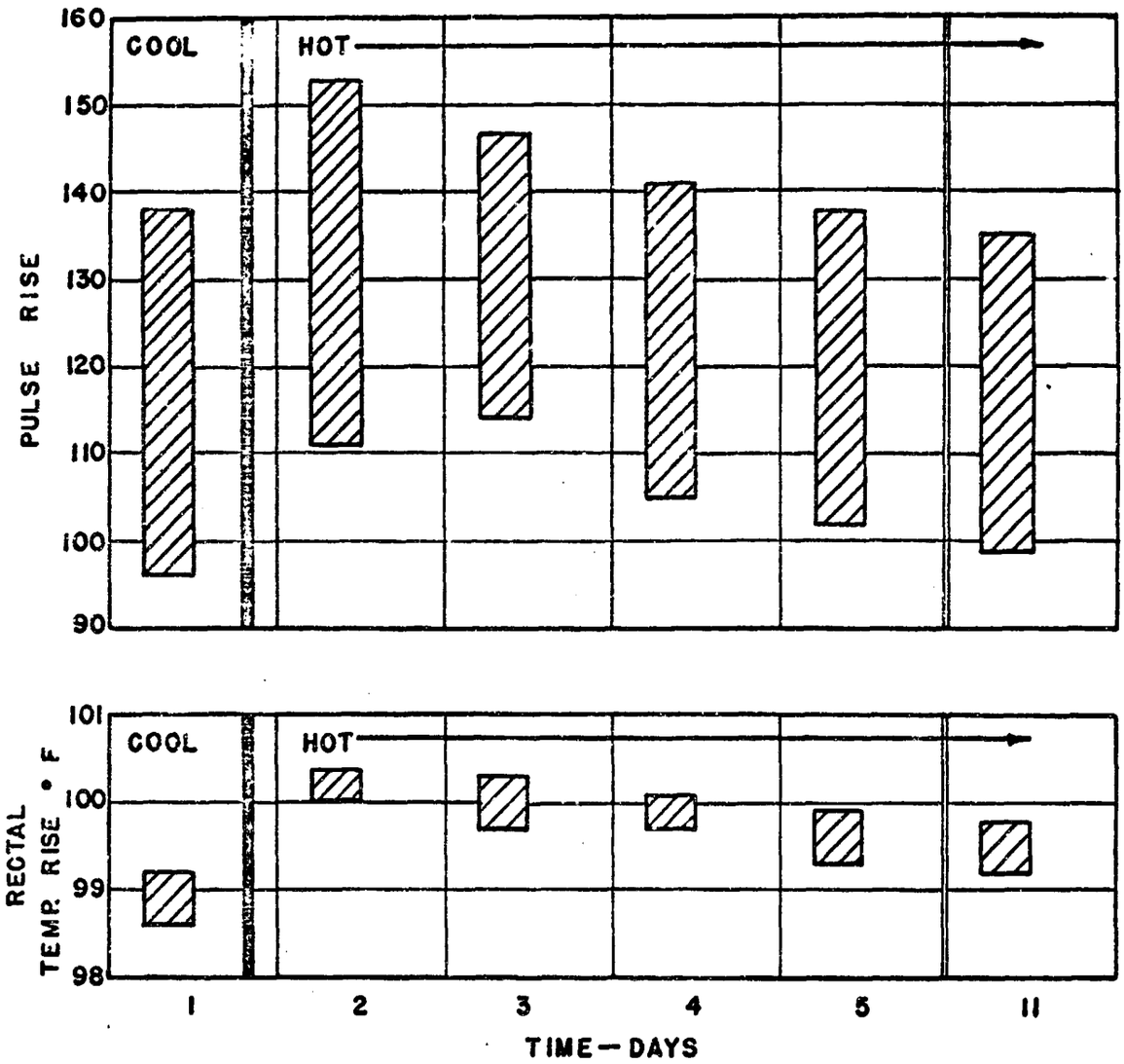
CHART— 8



☐ SUBJECT MEL

Incl #2

CHART—9

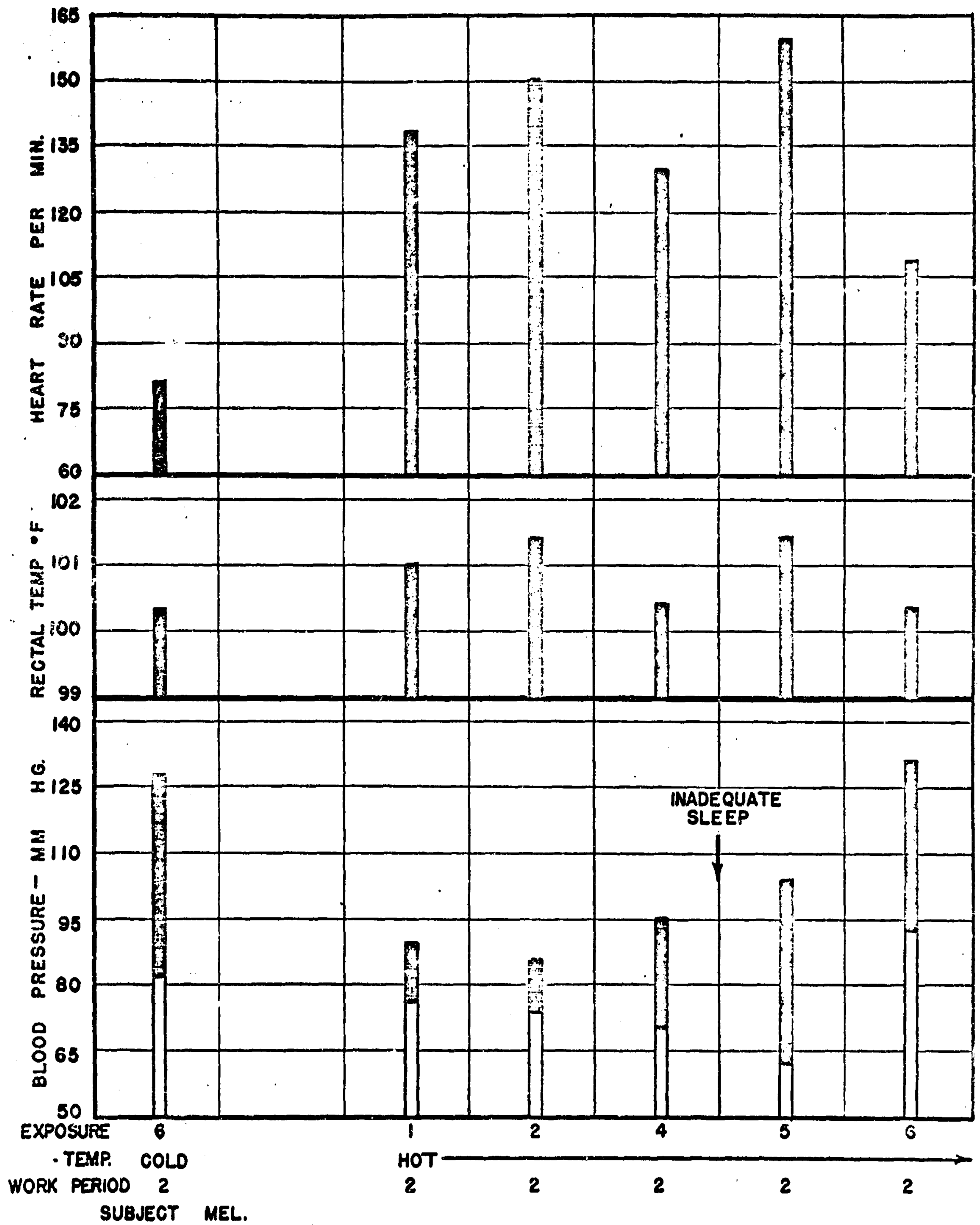


EFFECT OF TEN MINUTES OF BICYCLING IN A TRAINED SUBJECT

Incl #2

CHART—10

DO NOT CUT HERE



Incl #2

CHART—II

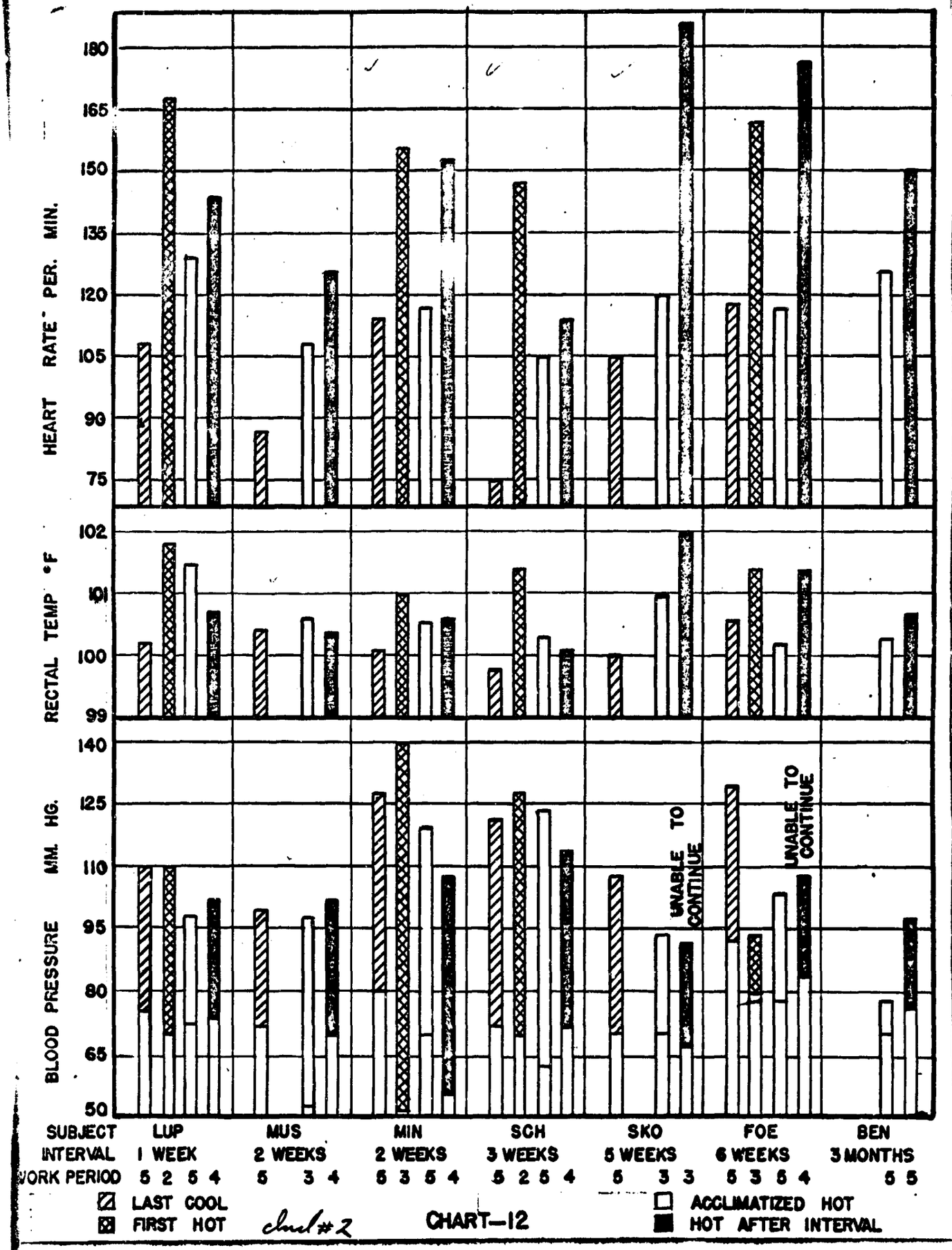


Chart #2

CHART—12

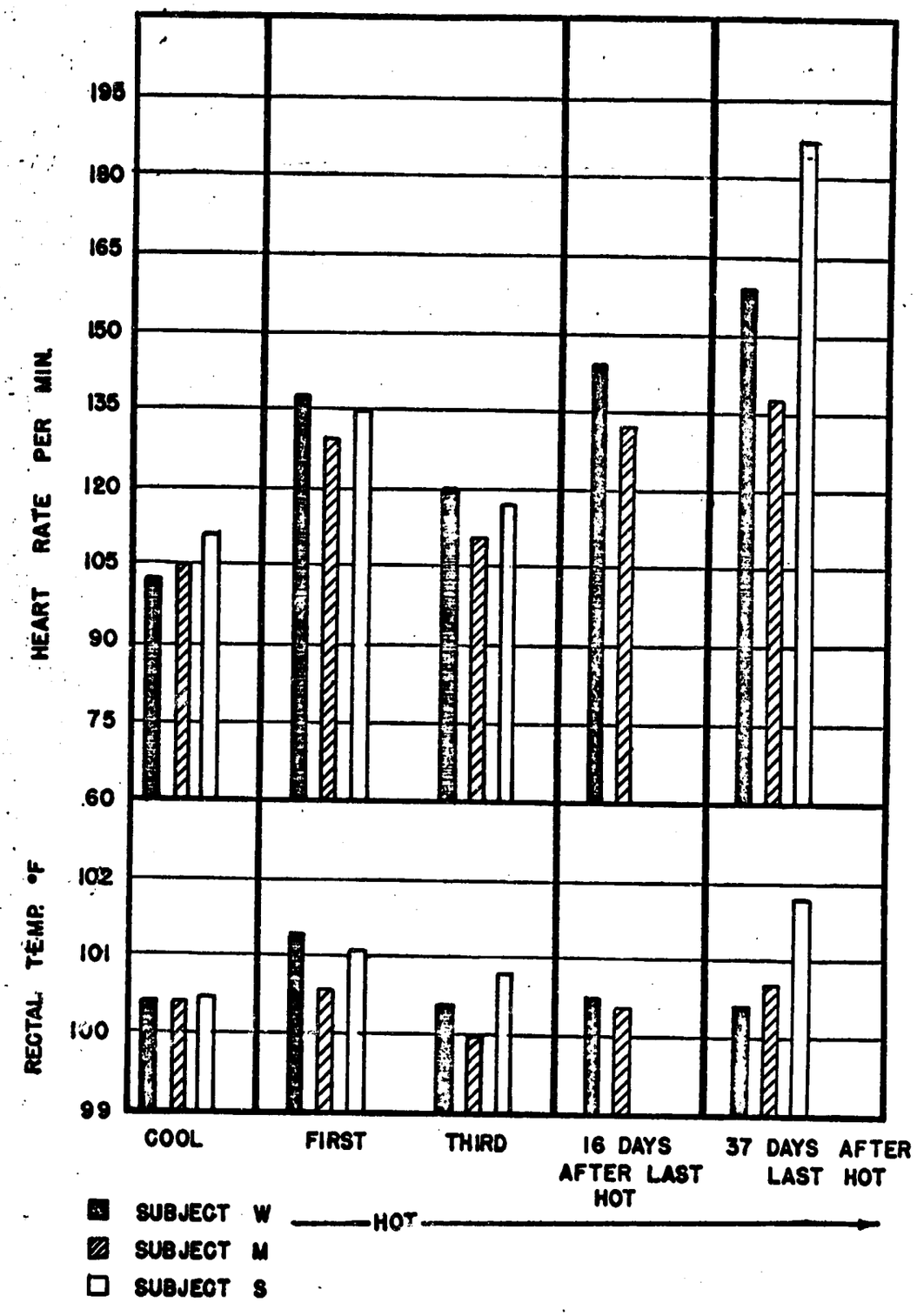
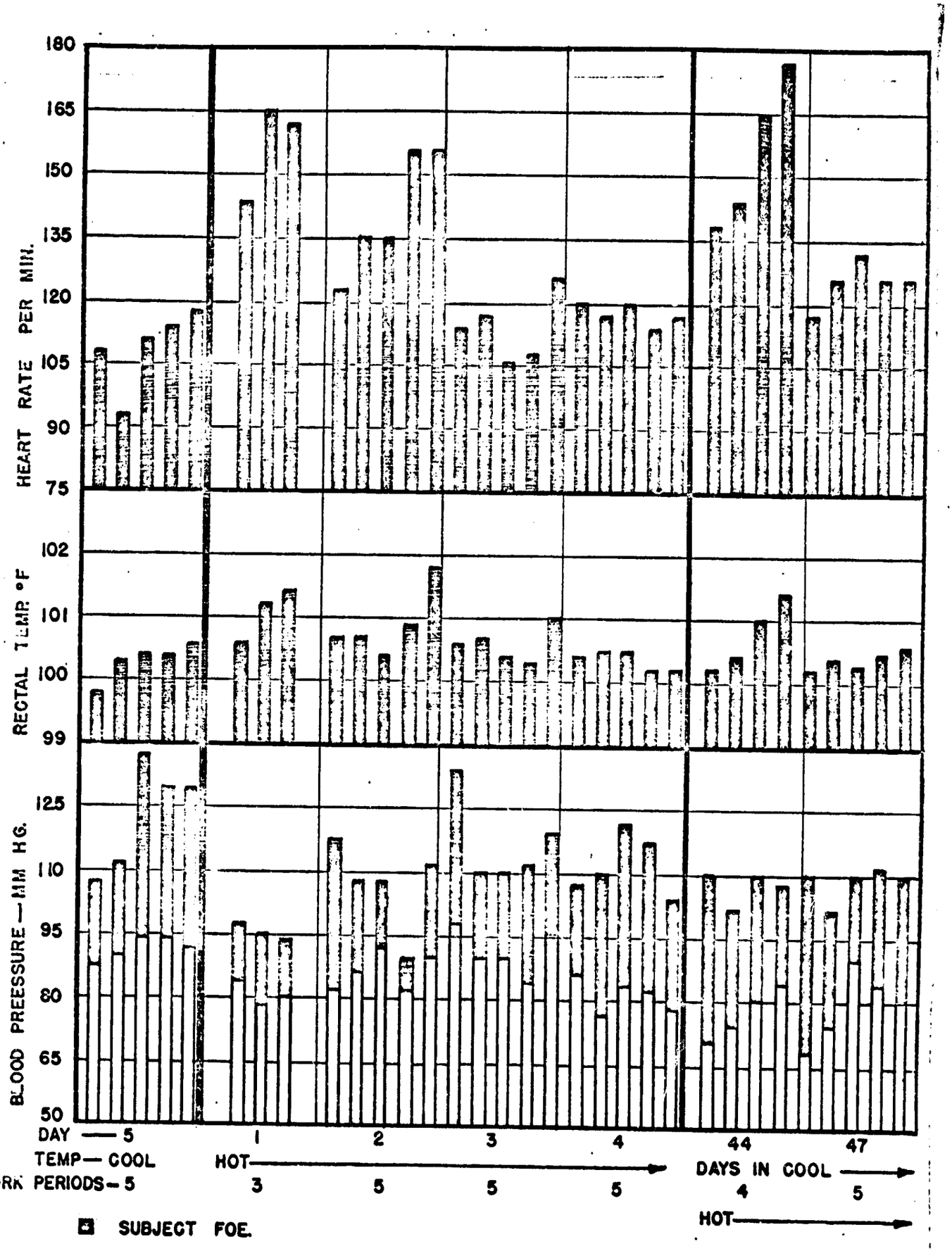


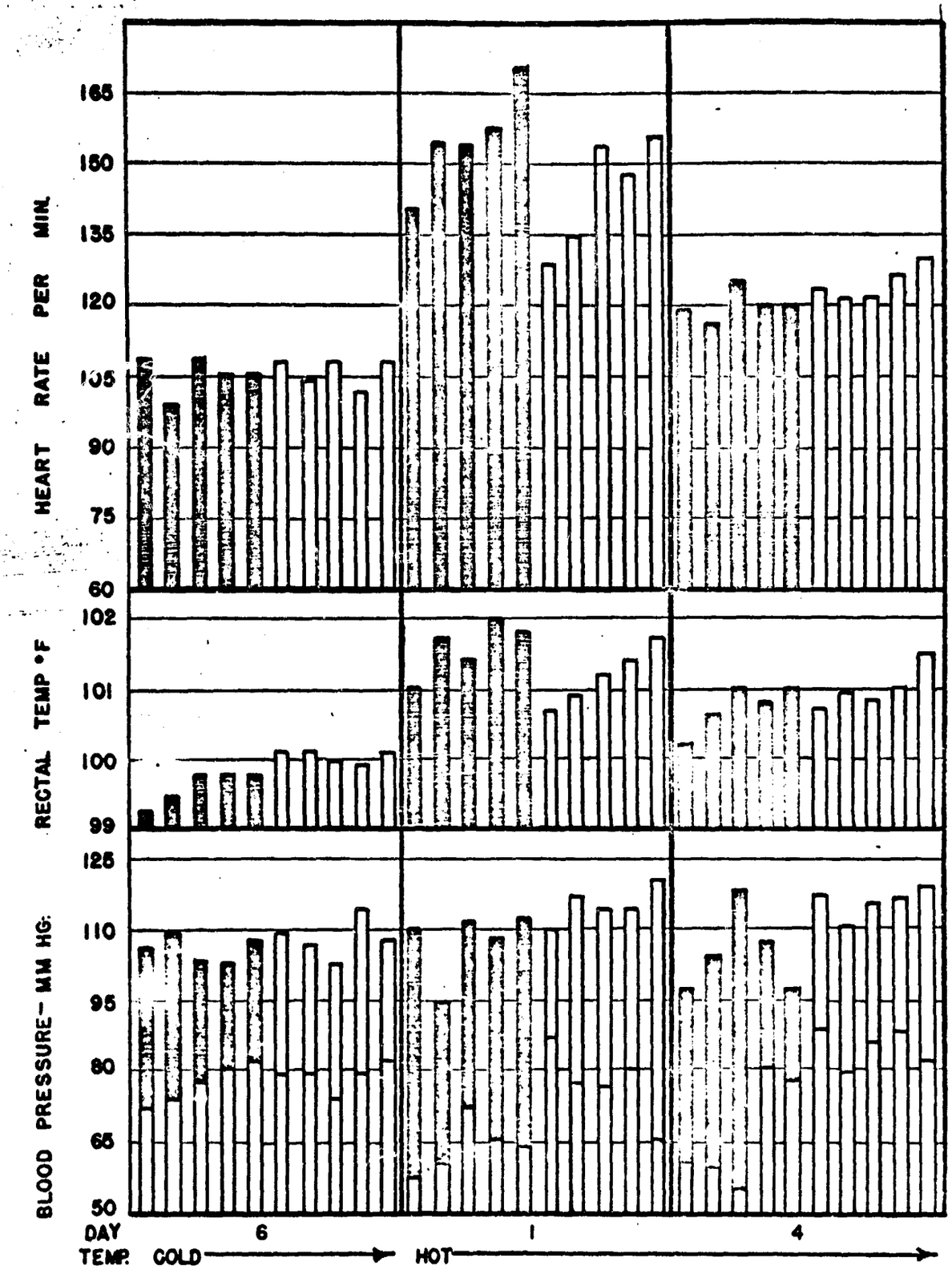
Chart #2

CHART— 12A



Subj # 2

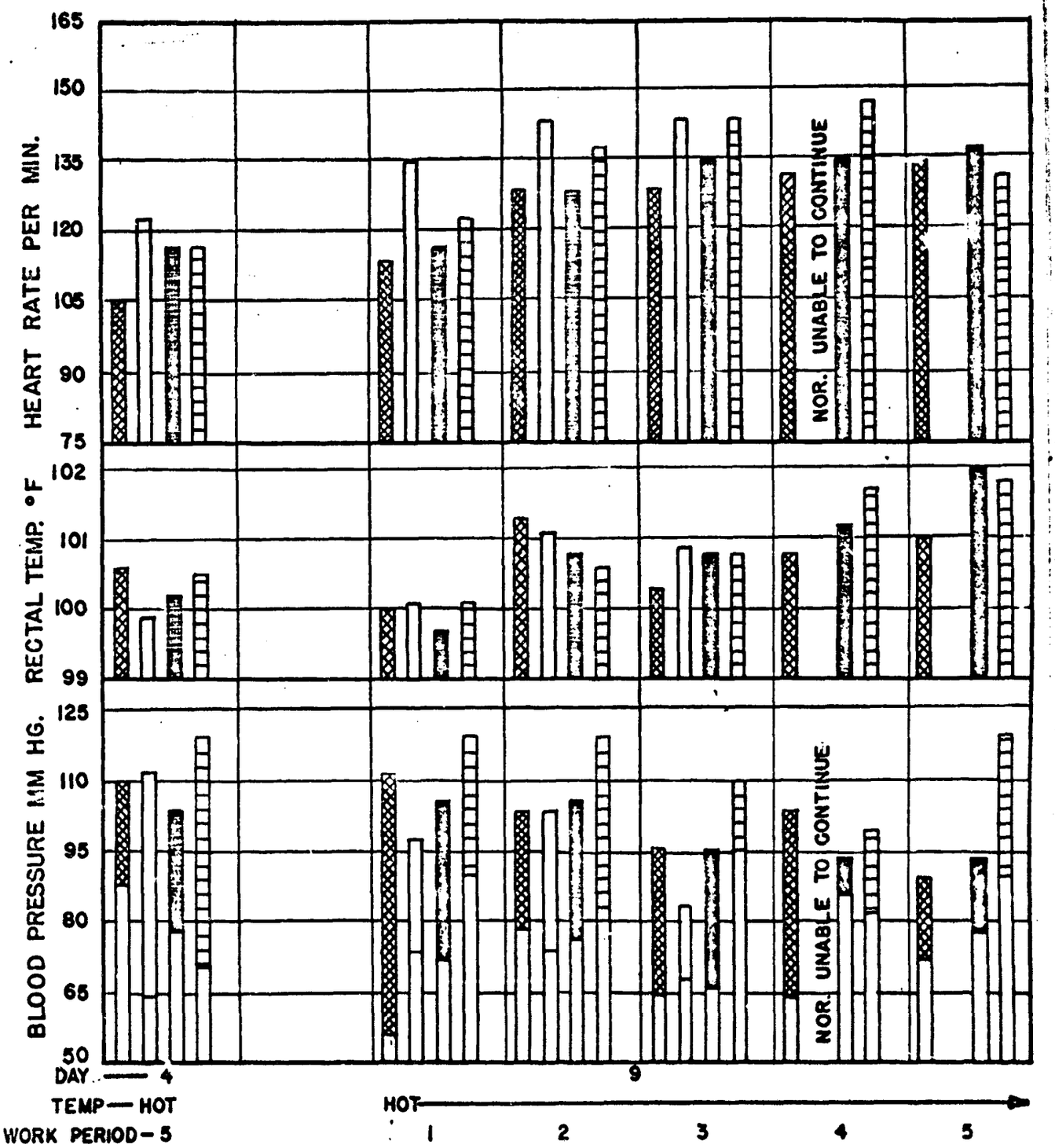
CHART — 13



Incl #2

CHART—14

DO NOT CUT HERE



WATER RESTRICTED 4L/DAY

Chart #2

CHART — 15

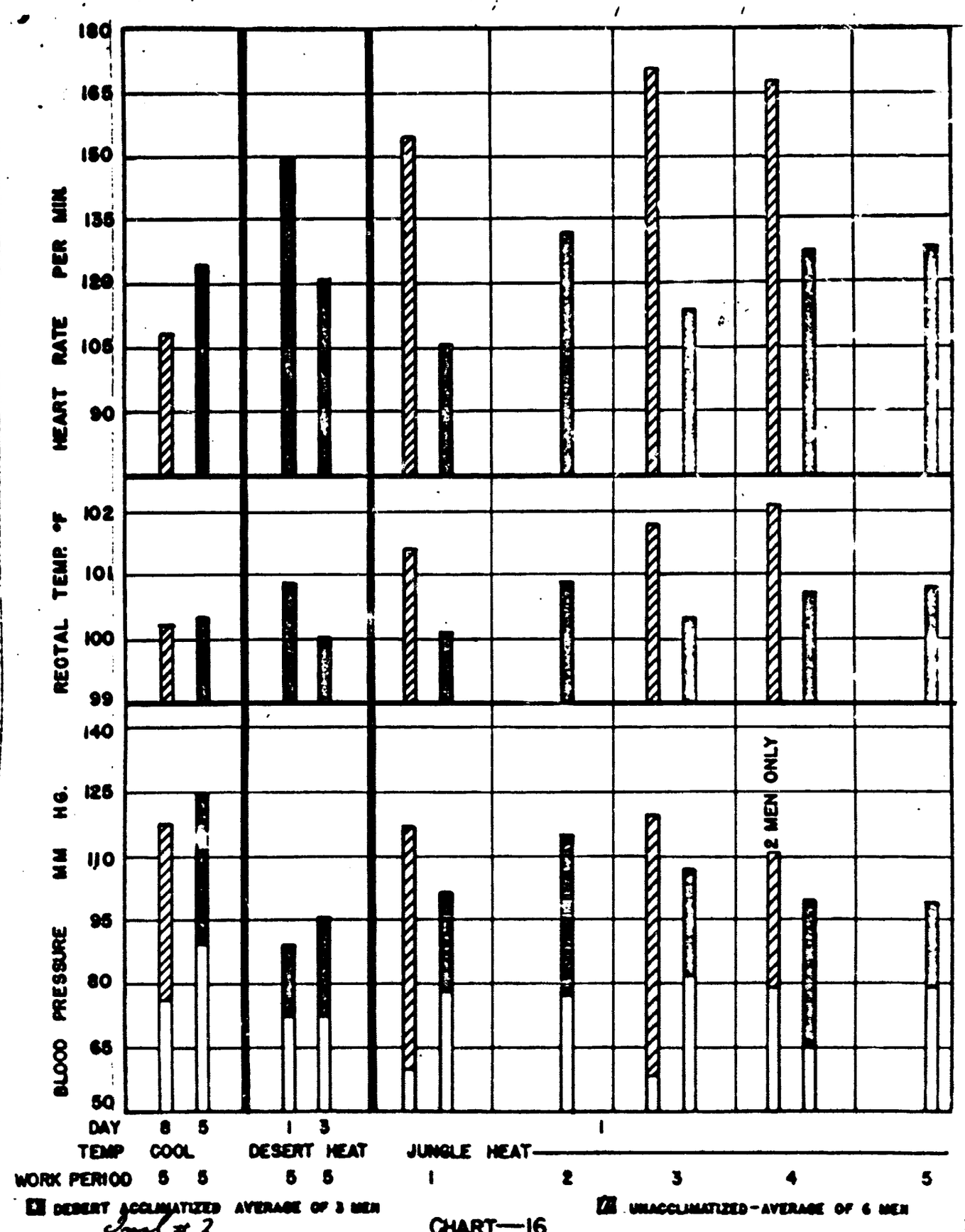


Chart # 2

CHART—16

Table 1 a. Single values at 50° room temperature without work.

time	Experiment person.	Blood-pressure mm Hg.	Pulse.	Body Temp.	Room Temp.	Details.
00	2	126/85	82	37,4	27	
	2	117/80	80	36,7	23	
	4	117/75	68	36,9	25	
	5	122/75	82	36,9	25	
	6	120/80	66	37,15	22	
	7	120/60	70	37,4	23	
	8	145/85	71	36,8	23	
15	2	128/90		37,3	45	
	2	119/75	82	37,1	44	
	4	115/76	71	37,0	43	
	5	119/72	86	37,1	43	
	6	120/84	70	36,95	38	
	7	140/65	74	37,4	45	
	8	130/85	72	36,8	41	
30	2	131/90	69	37,6	50	
	2	116/78	80	37,4	49	
	4	120/76	77	37,1	44	
	5	115/80	94	37,3	50	
	6	115/65	72	37,1	46	
	7	120/80	81	37,45	50	
	8	115/80	74	37,1	46	
45.	2	135/95	99	37,8	49	Pulse consid-erably higher
	2	120/75	77	37,5	50	
	4	123/76	81	37,2	47	
	5	125/80	102	37,6	53	
	6	125/80	75	37,15	49	
	7	127/85	94	37,45	50	
	8	125/85	77	37,2	50	
			Depart. Pulse			
60.	2	150/90	37,9	129	50	Headache.
	2	130/78	38,0	135	51	
	4	123/78	37,5	83	47	stop due to
	5	135/80	38,2	112	52	sickness.
	6	125/80	36,3	81	51	
	7	127/75	37,9	110	49	
	8	125/85	37,9	120	43	stop due to
			Pulse	Body	50	sickness.
	2	115/75	110	38,0	51	
65	2	125/75	125	38,3	51	
70	5	110/85	116	38,4	51	
75	6	122/75	96	37,55	50	
80	7	115/80	121	38,7	50	
85	7	135/85	110	38,3	49	
90		110/85		38,6		

Table 1 b. Single values at 5o and work.

time.	Experiment person.	Bloodpressure mm Hg.	Pulse.	Body T. Degree.	Room T.	remarks.
00	9	122/80	65	36,6	27	
	10	125/70	74	36,7	26	
	11	110/70	76	37,1	26	
	12	120/65	54	37,05		
15.	9	105/70	65	36,9	42	
	10	105/60	76	37,2	45	
	11	118/75	76	37,2	46	
	12	105/60	66	37,3	42	
30.	9	115/65	73	37,1	5[illegible]	
	10	110/66	88	37,3	4[illegible]	
	11	116/66	80	37,25		
	12	120/65	70	37,5	48	
45	12	118/61	75	37,6		
	9	115/65	80	37,3	50	
	10	120/65	98	37,7	52	
	11	115/60	82	37,5	51	
60	9	116/65	90	37,6	50	
	10	120/65	112	38,3	50	
	11	116/80	88	37,6	51	
	12	116/61	84	37,7		
70	9	120/65	94	38,3	51	
	10	112/60	114	38,5	50	attack of weakness,
	11	116/75	92	37,7	51	
	12	120/65	92	38,2	50	
80	9	145/65	102	38,6	50	unrest
	10	130/70	118	38,9	50	
	11	116/65	93	37,8	50	
	12	120/61	96	38,4		
90.	9	130/65	107	38,9	50	
	11	113/56	109	38,2		
	12	128/60	114	38,7		
180.	9	1285/55	111	39,3	50	collapse at rising
	12	138/ 50	108	39,0	50	
110	12	140/52	116	39,2		slight headache.

Recovery values after the end of the experiment.

after 10 Min.	11		88	38,2	
20 Min.			84	37,5	
10 Min.	12	125/50		38,9	

Table 2. Single values at 55° and work.

time.	Experiment person.	Blood-pressure.	Pulse.	Body T.	Room T.	remarks.
00	13	135/85	80	37,1	25	
	14	135/85	72	36,9	26	
	15	130/85	68	37,2	21	
	16	147/80	70	37,1	26	
	17	120/80	78	36,7	21	
	18	150/85	84	36,9	43	
	19	155/80	64	36,4	23	
	21	115/85	72	36,4	26	
05	13	123/85	80	37,1	40	
	14	130/80	76	36,9	33	
	15	130/80	67	37,2	33	
	16	147/85	74	37,1	30	
	17	110/80	80	36,7	21	
	18	150/85	80	37,1	33	
	19	114/80	68	36,5	30	
	21	120/85	74	36,5	35	
15	13	135/80	87	37,1	44	
	14	147/80	75	37,1	44	
	15	122/75	69	36,3	44	
	16	134/70	80	37,1	44	
	17	110/85	82	36,9		
	18	147/90	77	37,3		
	19	105/70	72	36,8	43	
	21	106/64	80	36,8	50	
30.	13	125/70	75	37,7	55	
	14	125/65	84	37,3	55	
	15	130/84	80	37,5	55	
	16	130/70	88	37,1	55	
	17	120/80	80	37,1	55	
	18	150/90	116	37,5	55	
	19	110/66	94	37,0	55	
	21	112/80	90	37,1	55	
45.	13	135/85	100	37,3	55	
	14	130/80	92	37,7	55	
	15	140/70	110	37,8	55	
	16	134/72	105	37,7	55	
	17	120/55	102	37,3	55	
	18	140/72	135	37,1	55	
	19	122/65	124	37,6	55	
	21	124/80	92	37,1	55	
60.	13		135	38,3	55	
	14	150/90	105	38,5	55	
	15	144/64	135	38,4	55	
	16	150/80	130	38,5	55	
	17	136/70	111	37,7	55	
	18	130/80	155	38,5	55	
	21	150/75	114	38,1	55	
		136/64	110	38,3	54	
		128/55				

Continuation of table No. 2. Single values at 55° and work.

time.	Experiment person.	Bloodpressure mm Hg.	Pulse	body T.	room T.	remarks.
65	14	144/66	113	38,9	55	pressure in the
	15	155/70	150	38,8	55	stomac
70	16	144/70	150	38,7	55	
	17	138/65	130	38,3	55	
70	18	140/80	168	39,0	56	
	19	145/60	120	38,5	55	
	21	140/55	130	38,6	55	
80	14	150/65	120	39,2	55	Collapse
	16	140/60	150	39,2	55	little sweat
	17	140/70	126	38,7	55	pressure on stomac
	19	145/60	127	38,5	55	
90	14	154/70	128	39,8	55	swollen feet

values of recovery after the end of the experiment.

after					
10	21	122/60	108		
20		125/65	82	37,1	
15	19	115/50	116	37,6	
20	18	120/65	102	36,8	
10	17	135/75	88	38,1	
10	16	125/70	100		
20		115/70	82	37,4	
10	25	150/70	100	37,2	
15		130/80	76	38,1	
10	14	120/80	106	37,2	
20		130/80	108		
40	13	14[illegible]/65	80	36,8	

Table 3. Single values at 55° work and blowing upon the face.

Min.	experiment person.	Blood press. in Hg.	Pulse.	Body temp. degree.	Room temp.
00	2	130/45	63	36,6	26
	13	125/85	74	37,2	24
	20	125/75	56	36,6	24
	21	118/70	74	37,0	25
	22	115/70	60	36,8	24
	23	130/70	63	37,3	25
05	2	125/80	64	36,6	38
	13	112/65	75	37,2	36
	20	122/75	57	36,6	34
	21	130/73	76	37,0	35
	22	112/70	52	36,3	60
	23	120/70	70	37,3	40
15.	2	125/80	75	37,0	49
	13	112/85	76	37,3	45
	20	122/75	63	36,7	43
	21	120/73	85	37,0	42
	22	118/75	70	36,8	42
	23	114/75	76	37,4	48
30	2	126/77	90	37,3	54
	13	121/87	83	37,5	50
	20	135/60	72	36,9	56
	21	118/75	91	37,1	50
	22	115/70	70	37,0	43
	23	122/84	68	37,4	54
45.	2	130/70	93	37,3	55
	13	120/85	90	37,7	60
	20	137/85	73	37,2	52
	21	116/70	96	37,5	54
	22	117/74	65	37,2	52
	23	124/55	100	37,9	58
60	2	134/70	110	38,2	55
	13	125/85	78	37,9	56
	20	140/80	84	37,4	55
	21	111/65	103	37,6	55
	22	123/80	92	37,4	55
	23	140/80	104	38,6	58
70	2	127/[illegible]	117	38,4	55
	13	123/80	104	38,0	55
	20	130/85	88	37,5	55
	21	125/82	112	37,9	55
	22	120/77	98	37,6	55
	23	127/80	109	38,7	55

continuation of table No. 1.

time.	exp. person.	blood Press. mm Hg.	Pulse.	Bodytemperature.	Room temp.	remarks.
80	2	138/60	124	38,6	55	
	13	130/80	108	38,1	55	
	20	132/55	96	37,7	55	
	21	134/60	120	38,1	55	
85	22	123/80		37,6	51	headaches.
	23	140/80	113	39,0	55	
90	13	134/90	114	38,2	60	good condition
95	21	130/65	140	38,5	54	strong sweat
90	23	148/55	120	39,2	55	condition good.
recovery values after						
10 minutes	2	130/55	100	37,3		
30 minutes		120/80	94	37,3		
10	13	122/[illegible]	84	37,5		
20		125/80	84	37,2		
10	21	140/65	100	37,5		
20		110/80	92	36,9		
30		115/75	86	36,9		
40		110/75	78	36,7		
10	23	135/55	100	36,9		
20		130/50	100	36,3		
30		125/70	80	38,0		

Table No. 4.

Experiment No.	person.	Loss of Kg.	time Exp.	Erythrocytes in Mill. before	after 0 Min.	after 15 Min.	after 30 Min.	HT.	remarks.
9		1,3	100	4,7	5,3		5,7	50	1/2 Collapse
10		1,4	80	6,2		5,5		60	do. do.
12		1	90	4,1	4,8			50	
13		1,1	55	4,7	5,4			55	tired
13		1,2	90	4,7	5,3		4,88	55	
14		1,5	85	4,4			4,1	55	
15		1,2	65	5,2	5,2	5,3	5,1	55	1/3 collapse
16		1,7	85	4,4	4,8	4,9	4,8	55	full collapse
17			85	4,8	5,3	5,5		55	
18		1,2	70	5		6		55	blowing upon
19		2	80	5,1	5,3			55	
20		1,3	80	5,1	4,6			55	
21		1,7	70	4,7	5	5,6		55	
21		1,4	95	4,7	5,1		5,1	55	
22			85	4,7	4,7	4,6		55	
23		1,6	90	4,5	5,2	4,8		55	

LIMITS OF ADJUSTMENT OF HEAT REGULATION DURING EXPOSURE TO HIGH TEMPERATURES.

by Professor Dr. Hinrich Kluge.
assistant physician of the physiological Institution
of the physicians military academy in the German army.
(Received January 25,1940)
Translated from the German by Alfred A Salamon, Private US Army)

SUMMARY of this Report.

23 persons were exposed in 30 experiments at slight physical and mental work to temperatures of 50° and 55° .

The bloodpressure showed systolic a drop up to 15 minutes whilst diastolic it remained constant or even rose a little bit. In the further course the systolic bloodpressure rose on figures of 140-160 mm Hg, in order to fall only shortly before the collapse.

The diastolic pressure dropped constantly. Each diminuation of the bloodpressureamplitude has to be considered as a sign of a near collapse.

The pulse in all cases rose straight up ,in some cases at the experiment quicker to 140 pulsations pro minute.

The body temperature at first started after 15 minutes slowly,after the 45th minute faster and only in two cases reached heights over 39,5° C in 90 minutes.

The bloodthickening or increase of washing away of Erythrocytes could also be observed.

Psychotechnical tests and experiments of the reaction resulted no restriction of mental qualities even before the collapse.

The recovery took place very fast. The bloodpressure became normal after 20 minutes whilst pulse and temperature required a longer time.

The rise of the temperature worked out surprisingly strong. On the other side by the blowing upon the face with 25-27° warm air, at the same roomtemperature, an enormous improvement of the condition was resulted.

Instead of collapsing after 50/70 minutes, the experiment persons submit. felt good after 80/140 minutes although only the head was hit.

Also the slight consumption of alcohol restricted the capacity of the heat regulation.

Each overstrain of the heatregulators required some days of rest.

LIMITS OF ADJUSTMENT OF HEAT REGULATION DURING EXPOSURE TO HIGH TEMPERATURES

BY PROFESSOR DR. HEINRICH KRUEGER
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(received January 25,1940)
(Translated from the German by Alfred A.Salomon, Private,US Army)

Technic and Industry,also in our moderate climates,force a man often to work under entirely changed conditions,which correspond to tropical climates.

The occurring of heatstrokes as well as a decrease of performing work requires a very correct scientific investigation of all the causes.

Dr. Bazett in his book"Response to heat " in 1927 very correctly included all experiments concerning the influence in the change of temperatures.

According to this book, especially Lehman & Szakall broke into this very interesting scientific territory, by separating in addition to the usual observations of blood circulations,therapeutically important questions like change of liquidity and assimilation of chlorine by digestion.

Already before this time Professor Herzheimer examined the consumption of O_2 and the decrease of performing work. Results in the different places of experiments showed the well known results of Professor van Hasses researches concerning climate and production of work in mines and the experiments of Professor Dr. von Uglowconcerning acclimitization of heat at shipheaters,whilst Dr. Adolph investigated the exchange of heat in the desert with his own objects of scientific experiments.

The roomtemperatures at the different authors fluctuate between 30 and 45°.

It so happened, that sometimes even within one line of experiments, that have not been constant. The conditions of experiments in other respects also changed, like moisture in the air, circulation of the air,the performing of work,clothing etc or they did not find any consideration at all.

It was hard consequently to draw any clear conclusions out of these observations as it was hard to compare them with eachother.

Since 1936 also in other territories of the investigation of collapses, through the books of Dr. von Ranke and Dr. Besserer ,there were general curves for the controlling of the pulsefrequency and the bloodpressure by the rising and falling in the Compressionchamber just as this was fixed by Dr. Ruff in 1938 for the effect of centrifugal forces.

Similar estimated observations should be gained now also for the effect of heat,here naturally in order to reach the problem of the collapse very closely by the control of the first stage of the disease.

It was necessary therefore to make series of experiments which

1. under always similar conditions of experiments exposed a greater number of persons to a constant temperature by excluding all influences from the outside.
2. included the important temperatures over 50° and
3. discovered the development of changes by regular measurements.

Methods.

These experiments were tried out on 23,2nd Lieutenants and Cornets Juniors (In the sanitary corps) in May and June 1938.

They took well trained and specially strong men in the age of 19/24 years who with the greatest understanding and persistance put themselves, mostly voluntarily under these experiments.

With the exception of these regular Experiment persons , 6 soldiers were not accustomed to the heat, as Climatochamber a small timber with a roomcontents of about 2 cbm was taken.

Experiments were tried out in a sitting position.

Electrical heating equipments took care of the rise in the temperature. The rise of the heat could not hit the experiments soldiers, as the heating equipment was directed towards the outer wall.

The experiments were mostly made in noontime after Lunch.

The roomtemperatures was measured with a Quicksilverthermometer in the height of a head. At the bottom the temperature was about 1° lower .

The body temperature was measured sublingually, as any change of the body temperature could be demonstrated at once due to the small capacity and good bloodcirculation of the cavity of the mouth.

The temperatures indeed are a little bit lower than in the Aorta and in the Rectum,but on account of practical considerations no other measurements were accepted.

Any influence by respiration etc. was avoided as far as possible.The measurements took place every 10 or 15 minutes. The counting of the Pulse was effected by the experiment soldiers themselves,however often it was also controlled by some physicians. The measurement of the bloodpressure caused difficulties sometimes,as the experiment soldiers had to put on a so called hearingfunnel,(a kind of stetoscope) and a pipostotoscope.

It was very hard to find the diastolic bloodpressure. At experiment soldiers No.9 and 23,blood out of the flaps of the ears had to be taken before the end of the experiment,at the end of the experiment and also 15 and 30 minutes after the end of the experiment and the number of the Erythrocytes according to Zeiss Thoma were also counted. This could be done however only on account of temporal reasons in a kind of Preresearches and the results have to be estimated accordingly.

In order to find a slackening of the physical performance of work, the experiment boys had to cancel the letters D,I, and R out of a text given to them.

The number of lines, frequency of the letters and percentage of mistakes was measured. Besides the times of reactions were considered and marked down. Their measurements were taken in such a manner,that the experiment soldiers heard a buzzsound in the headtunnel(pipe) of constant length and strength, in different intervals.

Through some kind of a morsekey equipment the tone and the optical registration had to be interrupted (According to a procedure not yet published by Professor Dr. Henke)

The experiment soldier had to react every 15 minutes,in 75 seconds 25 times on the buzzsound.

This transaction was adopted before,during and after the burden of heat.

These three divisions were made seating and did not cause any difficulties, as the clothing of the research persons always consisted of Underwear and socks.

The boys were stripped and they were weighed before and after these experiments.

Ia. In a first line of experiments without any work the room was heated at 50°. The starting and the examination of the reactions and measurements always took about 15 to 20 minutes ,so that the experiment boys during this time really could acclimatizise and get accustomed to the conditions. Only after this the entrances to the chamber were closed, the heating equipment opened and then the experiments startod.

The temporal conditions are to find in the tables and indexes.

The different tests were not felt as a burden. At the beginning the pulse reacted with an immediate rise at all experiment soldiers, at first slowly, but after 20 minutes continuoulsy faster.

After 70 minutes there were 30 more pulsations each minute than at the beginning. The exat values are to be found in table No. 1.

The temperature at the beginning remained constant and went up slowly (0,5°) each hour) after 45 minutes however faster,2° pro hour.

In two cases (Experiment soldier NO 6 and 16) at the beginning ,even a fall of temperature was found 37,1° C -36,9° C, 37,2 -37 C. The absorption of the heat at these soldiers evidently by the acceleration of the pulse and the vasodiladation was so much risen,that not only the rising of the body temperatures was prevented,but even a dropping was observed,as it is known in experiments with animals(See Professor Barott from Obernior Bavaria)

It is remarkable,that experiment soldier No. 6 and No 16 already before showed a high temperature and at soldier No. 6. it was remarkable,since he was born in a tropical country and was always sensible against heat.

This can be found also in the Table No. 1.

The bloodpressure is exposed to individually different fluctuations. At all these experiments ,the amplitude became smaller at the beginning, in order to become greater after 40 minutes mainly through the rising of the systolic pressure.

The systolic pressure dropped during the first 5 minutes,remained low for a while and started to rise very often from 30 minutes and up very considerably (145 mm Hg)

Only two experiment soldiers (No. 4 and 6) who could stand the heat very well,showed smaller fluctuations without any rising over the starting point.

The single curves are much more organized, as at the addition of the curves all individual sharpness dropped. The loss of weight showed an average of 1300 Gramm.

Subjecttively the rise of the roomtemperature from 22 to 35° was felt as very disagreeable (at a higher temperature the heat was not very much to feel) as the body gradually got accustomed to the high temperature.

After the 45/60 minute the strength of defense gradually dropped, A Terrible unrest, headaches and a strong beating of the heart did not make a longer burden advisable.

Ib. In a second line of experiments (experiment boys 9/12) at an equal temperature of 50° a work was to perform of about 5000 m kg every hour,with an automile bremse lever,which had to be pulled with the right arm as far as 20 cm before the breast.

The execution of this work corresponded approximately to a normal drivers work. The different individual values are to be found in Table No. 1.

The result showed no rise of the values for the frequency of the pulse, Blood pressure and body temperature.

As most of these men were trained by military training and also sport, the results in some cases were even lower. The systolic blood pressure was much better controlled now during the first minutes by more frequent measurements and showed exactly the same starting of the dropping, although by this work an immediate rising of the systolic blood pressure had to be expected. (See Professor Dr. Siebel) On the other hand, Dr. Rakujoff at his work during the first minute, found a falling and during the third minute already a rising of the systolic pressure at a slight diastolic fall.

The initial drop of the systolic blood pressure are shown in Professor Dr. von Bessorers Curves at the rise on greater heights in the Underpressurechamber and also in Dr. von Huffs explanations at the effect of centrifugal forces of the men.

It is hard to decide, how far a nervousness and an excitment before such an experiment can cause a high blood pressure.

In any case the same picture could be seen at old trained experiment persons thouroughly acquainted with this work.

II.

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In a third line of experiments, 7 experiment soldiers were examined at 55° Roomtemperature and light work. At this experiment the rise of temperature represents only an increase of 5° namely from 50 to 55, apparently an important difficulty in the conditions of these experiments. The blood pressure rose at all the experiment persons (after a slight fall at the beginning) from 5-10 mm Hg and up and reached 140 mm after 60 minutes.

This astonishing rise has to be considered as a pure effect of the heat, as the rise took place the very latest after ten minutes work. (See Lehmann III)

The diastolic blood pressure usually dropped after 35/40 minutes and really should even be lower in the curves, as the boundary had to be estimated too high sometimes on account of technical difficulties.

In exceptions some values of 20-30 mm Hg. were not marked down, as they appeared to be too low and not quite possible.

The rise of the Pulsefrequency for over 8-9 pulsations pro 1° bodytemperature shows, that it was not only the influence of the heart by the rise of Body temperature but really a more performance of work of the blood circulation due to transfer of heat.

Nevertheless, the pulsefrequency rose at the two observed body temperatures It has to be taken for granted, that the pulse does not get his acceleration in such cases by the body temperature.

At ships and other heaters Professor Dr. Below shows after 3 or 4 years service at 4 hours work under a temperature of 45/50° a rise of temperature of only 0,2-0,3, instead of 2,4 to 2,8 body temperature. At our experiment persons, the body temperature usually came up to 39°, sometimes even to 39,6 ° C so that experiments had to be interrupted even at a relatively good physical condition, as heat strokes were observed very often at 39° C (See Professor Hirsch fields explanations)

The body temperature is only typical for untrained men and shows, that the organism was not able to keep up its natural conditions.

At the resting men, also the body temperature was rising, if the abcobtion of the outbreaking heat, arisen from the normal living conditions is prevented (See Cournier)

This formation of heat in the body is risen by activity of the Muscles and quicker chemical transplantation and a pressing of the heat from the outside into the blood has also to be considered.(Leyton, Sherrington)

At temperatures higher then 36,6°,increased formation of heat, stoping of heat, absorbtion of the heat from the outside has to be added.

Although all retinas (Skin vasculare) were strongly extended & the pulse went faster and stronger and the body in every case strengthened the absorbtion of heat by increased evaporation, he did not succeed in retaining the normal bodytemperature .

On the other hand and in certain cases the subjective condition of the experiment boys compelled the entire breakup of the experiment. Sometimes the respiration became breathing and the secretion of the perspiration dropped.

A bad feeling, the feeling of a disagreeable pressure on the head (They cried "I Loose my head ") and stomachtrouble were observed in a greater degree.

Whether this feeling corresponds to a real increase of pressure in the head ,as Professor Schuermann requires it for the acute brain system at heartstrokes, is very hard to decide here.

In any case at a look of those experiment soldiers, the face was slightly inflammated and slightly cyanotic. The Conjunctiva and Sklera very often were strongly injected, the temporalis was very clear to see.

The loss of weight in the average was amounting to 1600 G in 70 minutes. The experiment soldiers who were generally in goodod condition even did not loose more weight in 85 minutes.

An increased outbreak of perspiration always started at the psychotechnical tests. A feeling of thirst was not to observe. A leading up with water at such high temperatures would have had the effect of a high burden of the blood circulation. (Lehman & Smalall).

After 40 to 60 minutes the secretion dropped a little bit.

This also perspiring is advisable, as each falling drop will never be consumed for the cooling. A definite exhaustion of the perspiration glands was never to fear, as also not trained persons can loose up to 2500 Gramm sweat,trained men naturally much more.

At the end of the experiments at least in most of the cases, the limit of the utmost was really done. Also from the objective standpoint the condition was dangerous, although it is hard to see this from the curves without any difficulty.

180 pulse and 14,5 mm Hg bloodpressure dont mean a collapse.

The disturbance has to be found centrally,so that the measurables changes only appear as the consequences and symptoms of this interior damage.

By all kinds of changes in the evolution of Hydrogen,the body tries to acclimatisize to the changed conditions of living.

If the body is not successfull,a collapse must enter.

At experiment person No.13 this occured immediately after the end of the experiment on account of a sudden indisposition. Although the taking of blood out of the carotope usually occured immediately after the stroppe, Experiment person No. 13 immediately stepped out with great unrest,and a feeling of pressure in his stomac.

He at once tried to rest,but then run to the waterfountain on account of very heavy stomachtrouble, where he collapsed. The face, which was up to then cyanotic,became entirely white. By lying down, this experiment person soon recovered. The pulse all the time was very regular and well filled,the tones of the heart quite normal.

The result of this personal investigation of this man showed : 7 or 8 glasses of beer the evening before and going to bed at only 2 Clock at night.

Two other experiment persons (No.10 and 11) could not stand the heat either.

They took a lot of alcohol the day before, however they only had a slight collapse, as they were exposed to only 50° roomtemperature and insisted upon the stopping of the experiment already at a less dangerous condition.

At experiment person No. 15 however ,bloodpressure and pulse were not normal before the beginning of the experiment. The bloodcirculation in this case made tremendous efforts to stop the rapidly rising temperature ,but after 35 minutes was not able to continue this.

At experiment person No. 10 and no. 15 the bloodpressureamplitude became smaller shortly before the collapse, especially by sinking of the systolic bloodpressure. Experiment person No. 7. as the only one failed completely, at the reaction time (45% faults) and was already very nervous before, at a time,where the bloodpressureamplitude with really small.

The meeting of high bloodpressure at the beginning, the sinking at experiments in the underpressurechamber after a small rise and collapse was found by Professor Bauereer, just as at a certain acceleration the experiment persons lost the consciousness if the bloodpressure was falling.

III. In order to ascertain, how an air cooling affects on the single measuresizes ,the experiment persons were blown full of air at a roomtemperature of 25° by a kind of a thermal machine. The current of air constantly hit the face and the throat from the right side with a velocity of 8,5 m/Sek.at the exit of the pipe (40 cm before the head)

At the head, the current air was only 2,2 m /sek.

In a single minute, more than 50 liter of fresh air came into the room, which naturally had to be heated much stronger accordingly.

1. The airmovement had a pure coolingeffect by the low temperature. Even if as before the room temperature of 35° was measured in the height of the head,the temperature of the air at the targetspot in the face was certainly another few degrees lower.

The cooling effect of the perspiration was considerably increased ,as it could evaporate much better and the freshly heated air was able to accept the highest amount of watervapor.

In the literature however the positive effect of the moved air at temperatures of 34,6° is very much doubted (See A linke , Hecht, through yagoglou -Miller)

According to these authors the exposure & airmovement in such cases is unfavorable, as the hot air has a better effect on the body and no coolingmovement is formed.

Although the temperatures were partly higher than in the experiment without aircooling, no collapse entered and even after 60 minutes the condition was bearable.

The systolic bloodpressure actually drops and then gradually rises,but never over 140 mm Hg. The diastolic bloodpressure remains constant or at the beginning rises a little bit, in order to fall then gradually to 45 mm, so that the amplitude always becomes greater.

This has to be considered as a very unfavorable mark, as at the previous experiments really each diminution of the amplitude was preceded by a strong deterioration of the general condition, especially it was a drop of the systolic bloodpressure.

The same experience was made by Professor Dr. Rauhe with an experiment on himself at the underpressurechamber at 405 mm Hg. airpressure.

He found, that in the underpressure the drop of the systolic bloodpressure almost alone reduces the amplitude,whilst the diastolic pressure especially at persons with a great power of resistance showed a tendency to rise.

The pulse first of all rose just the same,however much slower after 30 minutes in order to become more frequent after 55 minutes.

110 pulsations a minute after 80 minutes were absolutely bearable. There were never any troubles from the side of the heart however. The rise of temperature was small up to 60 minutes ,but then stronger, so that from this side accurate figures could have been fixed. The numbers of the temperature and pulse never stood in a proportion at once and the same person.

F. I. Experiment person 21 in different experiments had a body temperature of 110° and 140 pulse at 38,5° (in person no. 22 at 38°3 had a body temperature of 105 and a pulse of 116. Only the descending angles of both curves showed a great resemblance.

In the average calculations the values equal more already.

At an equal bodytemperature the frequency of the pulse is higher at a greater effort of the heart.

If the increased heat production (Lehman II Irving Fisher) has to be considered, it can be imagined which enormous work a heart has to perform.

For the researches with aircooling (Table III) the values of the Pulse are relatively high, as only after a considerably longer time a bodytemperature of 38° can be obtained.

Loss of weight was always considerable. A part of this loss is due to the face , that a tremendous loss by sweat has to be considered.

After 20/30 minutes the sweat dropped down in big drops from the face, the same from breast and arms, whilst on the other parts of the body a smaller well distributed evaporation without any formation on drops took place.

It can be taken for granted from the increased respiration,that also the great surface of lungs was influenced for the cooling.

An increased consumption of O_2 can be the reason for this,as according to Lehman & Hasselt and also Bardhaver the consumption of O_2 in the heat is only slightly smaller, but rises never more than 10%.

Also Professor Adolph never found an overrespiration although he does box the breathe as gasping.

Only an evaporation of water has been succeeded at which the hot and dry air is changed into cold and watefilled air. Therefore blood as well as air were cooled in the lung.

The rise of the outer evaporation is absolutely necessary as at such increased temperatures the absorption of heat by transfer and radiation does not take place,which are usually interested in the falling of bodytemperatures from 36° plus 45 - 55° . The possibilities of evaporation in the chamber were usually sufficient. The humidity of the air in the room and at the beginning of the experiments in the chamber with the hairhygrometer ,relatively measured,amounted to 40% at 21°.

At the experiment at 50° ~25%, at 55° ~10%, at 60° ~12%.

At the beginning therefore 10,4 Gram of water pro Kubikmeter were calculated and at the end 23 Gram pro Kubikmeter air, so that a great possibility of evaporation was available in the room.

The loss of weight liability at Division I amounts to 1,2 Kilogram in 60 minutes at R II 1,6 Kilogram in 70 minutes, and R III 1,4 Kilogram in 87 minutes .

The result therefore was : Pro 1° rise of temperature a loss of sweat of 33 g per hour at 50° which should correspond to a coolforce of 22,2 Kal. or at 55° bodytemperature an increase of 555 calories.

40 Gram per hour at 55° - 404 calories, altogether

32 Gram per hour at 55° and bleeding in ~19 calories-570 Cal altogether

These figures are considerably under the values of 62 Gram pro 1°

and hour in the Desert climate as Professor von Adolph found it.

At the countening of the Red bloodcorpuscles some difficulties occured, as due to the lack of time the counting could not always be added immediately to the taking of blood ;

However the corresponding values at experiment person 13 and 21 speak for a certain exactitude (Correctness) .At the considerable loss of water the blood evidently is thickened. The clearer the loss of sweat,the stronger the thickening (Experiment person 13 and 21) as the liquidity can pour only slowly from the cells into the veins. I fisher already after 15 minutes found a pouring of cell liziquidity. At the end of the experiment with the ceasing of the sweat loss, the blood has to come back to a normal concentration.

This occurs very fast at the single experiment persons,as there are no figures to make for the degree of thickening. 15/30 minutes,after the breakup.

The erythrocytical figures approach again to the normal. At Bazett without additional liquidity from the outer side, the bloodconcentration is again normal after a heavy H2O loss.

It is conspicious, that at people in a bad condition,the thickening takes a much longer time. Whether the increase of the Erythrocydical figures proves a thickening of the blood,is not admitted by some authors. Bazett also makes a pouring of Erythrocytes out of the spleen and bone marrow responsible whilst Dr. Hiller has the standpoint, that a thickening of the bloc is not possible at all.

The world wide famous Professors Dr. Lehman -Nzakall, Schuermann and Dr. Mass and Dr. Bazett are entirely for the thickening of the blood.

The exchange of water will be made possible by an increased capillarwal Meability, which Mr. Schuerman counts as a great harm to the Capillarwall under serious infections(See Professor Epplinger)

The times of the reaction and the psychotechnical tests did not show any valuable results. At the reading and cancelling of the letters the exercise always excelled the damage caused by heat which possibly entered.

At the time of the reaction,only experiment soldier No. 9. already sometimes before the end of the experiment showed a lack of concentration capacity and a lack of a quick reaction, whilst at all the others Experiment persons the times of the reaction were normal also shortly before the collapse entered.

The recovery always succeeded quick and good. The normal bloodpressure after 20 minutes was recovered again.

If at the beginning the values were over the normal figures, they dropped after the experiment on the usual height. The dropping usually occured very straight up, in the first 5 minutes however sometimes delayed.

The Pulse retarded during the first 10 minutes very quickly, about 30/40pulsations,but then much slower, so that after 20 minutes there were still 20 pulsations more pro minute than at the beginning.

Also after the showering the heart in most of the cases still bate quicker.

Kalayeffs observation , that the pulse recovers much quicker as the bloodpressure only proves right for the first minutes of the recovery time.

Although the room temperature still was higher (30/35 $^{\circ}$) the body

temperature dropped 0,6° each 10 minutes. After 20/30 minutes the old condition was notyet recovered again. In 4 cases with higher starting temperature 37-37,4° the body acclimatisized after the experiment to a lower stand.

Although the room temperature and the subjective condition was not always satisfactorily,headaches and slight outbreaks of sweat and a general weakness kept on for at least the same day from these hard and tiring experiments.

If the experiment was stopped at the experiment person on account of indisposition or even a collapse, so the next days showed a greater sensibility against heat and an almost depressive fear before each kind of heat burden. At experiment person No. 13, this condition kept on for another 7 days accompanied by really disagreeable pains in the backhead.

At the slightest physical and mental reasons a sudden breakout of sweat entered,conditions ,as they were observed by Dr. Hirschfield after strokes at shipheaters.

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