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Naval Medical Research Institute
Bethesda, Maryland

15 February 1950

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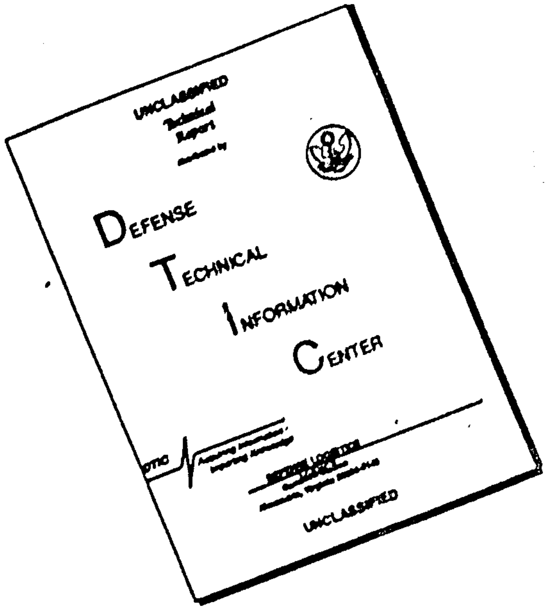

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Project NM 004 005.01.02
(formerly NM 004 003)

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VARIATIONS IN BODY TEMPERATURE AND IN PERFORMANCE UNDER DIFFERENT WATCH SCHEDULES*

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(formerly NM 004 003)

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*Reference may be made to this report noting authors, title, source, date, project and report numbers.

ABSTRACT

The two-fold purpose of the experiment was to determine the ease with which Navy recruits adapted themselves to various watch schedules, some now in use, others experimental, as judged by their diurnal body temperature curves, and to discover the existence, if any, of a correlation between body temperature and alertness, as indicated by performance in several tests and in other aspects of behavior.

Results obtained on 9 subjects indicated a variability in adjustment, the latter more complete the less the modified schedule of watches differed from the shore routine of activities. On the rotating (dogged) schedule of watches the pattern of the diurnal body temperature changes was the same as on a shore routine.

Color naming, and to a lesser extent reaction time and Link Trainer performance, showed a diurnal variation, particularly on the dogged watch routine, the only one which permitted testing around the clock. Although the results were not always clear-cut, in a general way, the higher the body temperature, the better was the performance.

Among other findings were the constancy of rank in performance, the existence of individual body temperature levels, variation in coffee consumption, and the interrelation among performance, body temperature, and coffee drinking.

INTRODUCTION

The operation of a warship under way involves a round-the-clock schedule of activities, necessitating the division of the personnel into several sections. There are usually three or four watch-standing sections, depending on the size of the crew and type of vessel. The average number of hours of duty varies from six to eight per day, in two watches, and the watch schedule is either fixed for the duration of the cruise or rotated among the several sections by being "dogged" at certain hours. Is one of these two watch routines more conducive to alertness at different hours of the day and night? Is it possible to devise other schedules that would be superior to those now followed?

The pertinence of these questions stems from observations on variations in alertness and performance of laboratory subjects tested over the successive hours of their usual daily routine of living. Contrary to popular opinion, one is not at his best, or most wide-awake, in the morning, after a "good night's sleep". Immediately upon getting up, one's efficiency of performance is, as a rule, about as low as it was the night before, prior to going to bed. During the day, however, there is a gradual improvement in alertness, with a plateau or distinct peak in the middle of the waking period, and this is followed by a decline in performance to a bed-time low. Furthermore, while a person kept awake for several days shows progressive deterioration, there is a daily waxing and waning in both alertness and performance. His performance is better, and it is much easier for him to stay awake, in the afternoon of the third day than it was in the middle of the second night of complete deprivation of sleep. These observations demonstrate the presence and persistance of a diurnal rhythm of alertness. It has been shown that this rhythm is associated with the establishment and maintenance of a fairly stable diurnal body temperature curve. When the body temperature reaches its daily peak, the individual is alert and his efficiency is high. Conversely, in the early hours of the morning, when the body temperature is at its lowest, it is almost impossible to remain awake, let alone perform efficiently. As would be expected, the diurnal body temperature rhythm is absent at birth and owes its development to the imposition (and later, free acceptance) of a daily schedule of hours, characteristic of the family and community pattern of living. This temperature rhythm can be shifted, inverted, shortened, or lengthened, by appropriately modifying one's routine of work, play, meals, and sleep (1).

A method is thus available for gaging diurnal variations in alertness and efficiency indirectly, by reading the body temperature at different hours of the day and night, rather than employing time-consuming performance tests which, in themselves, are likely to interfere with, or disrupt, the scheduled activities of the persons studied. In applying this method to the evaluation of existing or proposed watch schedules for a warship's personnel. it is necessary, *first*, to determine the presence of an association between watch routines and distinct diurnal body temperature patterns, and, *second*, to test the validity of the body temperature method as a measure of alertness and ability to perform under conditions, identical with, or closely resembling, those prevailing on board ship.

That characteristic diurnal body temperature patterns are established as a result of following particular watch routine was demonstrated in studies on submarine crews Of all fighting ships, the submarine offers the most favorable combination of factors conducive to the development of a maintained shift in the sleep-wakefulness cycle and therefore in the body temperature curve. Each of its three watch sections stands two 4-hour watches, separated by eight hours of free time, daily, and the watch schedule is usually fixed for the duration of the cruise. The men are permitted to sleep during either or both of the 8-hour breaks between watches, and, since practically all activities are carried on under artificial illumination, the differences between astronomical day and night are minimized, though not entirely absent. Thus, the meal hours on board a submarine are practically identical with those maintained in shore establishments, breakfast, for instance, being served in the morning, which coincides with the getting-up time of only one of the three watch sections.

Observations made on the personnel of the USS DOGFISH(SS 350) during a 16-day cruise revealed a highly skewed distribution of the hours of wakefulness (and sleep), meals and recreation activities (reading, writing, playing of games) in all three sections(2). The incidence of voluntary wakefulness was much greater in the afternoon and evening than during the night and morning hours. The diurnal body temperature curves of a representative sampling from each section were bimodal, with two uneven peaks, the higher of which was reached in the afternoon or evening. By contrast, members of the crew who were not required to stand watches exhibited typical unimodal diurnal body temperature curves, with lows during the conventional sleeping hours of the night.

As a result of this study, it was suggested that experiments be conducted with a new schedule of "close" watches. The schedule called for placing all the eight hours of duty within about one-half of the 24-hour period, allowing a long unbroken sleep of eight to ten hours' duration. It necessitated splitting the eight hours into three watches, instead of two, as with the "4-on, 8-off" schedule

It was also proposed that the meal hours be rearranged so as to furnish breakfast, dinner, and supper to each watch section in their customary relation to hours of duty.

A slightly modified form of the close watch schedule was tried out by Utterback and Ludwig (3) during a three-week submarine cruise. The "4-on, 8-off" schedule was followed concurrently on another submarine for comparison. Body temperature data from the personnel of the submarine that observed the experimental close watch routine revealed the rather prompt development of three distinct unimodal body temperature curves, with plateaus corresponding to the middle of the waking period of each watch section. There was also a pronounced diurnal body temperature swing, and, most important, the temperatures tende o rise before the beginning of the first watch of the "day". On the submarine where the present "4-on, 8-off" watch schedule was observed, the body temperature curves of the crew were bimodal, resembling those obtained in the previous study on the USS DOGFISH. It appeared, then, that, in spite of some short-comings in the close watch schedule, as actually tried, body temperature data, under this schedule, indicated a greater alertness during the hours of duty than under the "4-on, 8 off" system. There still remained, however, the question of the validity of the body temperature method itself.

The present investigation was undertaken with a twofold purpose. First, it was intended to have the same group of subjects, drawn from regular Navy recruits, successively follow several different watch schedules and use the distribution of hours of sleep and the shape of the diurnal body temperature curve as indices of the speed and completeness of their adjustment to each routine. Second, because the validity of the body temperature method has been established on civilians, usually students, undergoing relatively simple manipulative tests, it was considered imperative to reevaluate this method under conditions closely resembling the performance of regular duties by service personnel.

SUBJECTS, EXPERIMENTAL DESIGN, AND METHODS

Ten recruits, 17 to 25 years of age, all single, were assigned as subjects to this project. After a trial of two weeks, they were given an opportunity to ask for a transfer to other duties, and one man did so. In this manner a potential malcontent and possible disruptive influence was removed from the group and more complete cooperation of the remaining nine subjects assured. Evidence of the latter appeared at the end of the experiment, when each of the subjects, interviewed individually, expressed a willingness to submit to further testing, if the period of observation were extended

The men were housed in the Diving Building of the Institute. A large room on the first floor, equipped with reading matter, games, and radio, was available for lounging. Wash room, showers, and toilet facilities were located on the same floor. Immediately above were the sleeping quarters - a large, windowless, well-insulated simulated ship berthing compartment, with bunks arranged in tiers of three along two walls. As the subjects were expected to have to sleep at unusual hours, often in the middle of the day, while on certain watch routines, changes in duration and quality of their sleep might be the result of differences in the temperature of the sleeping compartment rather than modification of the routine. The compartment, therefore was air-conditioned, with the ambient temperature at 77-78 degrees F. dry bulb thermometer, 66-67 degrees wet bulb, and relative humidity varying from 50 to 60 per cent ("effective temperature" of 72 degrees).

The composition and schedule of meals were those customary to shore installations of the Navy. In addition, when certain watch schedules involved "long" sleeps through the morning or evening meal hours, the subjects could partake of midnight meals. While on liberty, the men often had extra snacks and occasionally consumed alcoholic beverages.

The subjects were instructed to take and record their own oral temperatures, by means of clinical thermometers and with suitable precautions against spurious readings, ten times per 24 hours. This was done at regular 2-hour intervals throughout the waking period and once in the middle of the "long" sleep, which was artificially interrupted for that purpose. Their oral temperatures were also taken while they were being tested, usually four times per day.

By a simple system of marks and code letters, each man was required to enter into a daily data sheet (see Appendix) a complete account of his activities, watch hours, onset and termination of "long" sleep and short naps, food and beverage intake, attendance at movies, etc. To insure prompt and accurate record keeping, as well as for general administrative and disciplinary purposes, the subjects were placed in charge of two petty officers, who shared their sleeping space and one of whom was always in attendance.

Performance testing was confined to five days per week, Monday through Friday, except where the watch schedule required uninterrupted daily sampling. Liberty was granted in the evening hours, after supper, if no watches were scheduled for those hours, and also during week-ends, usually to two men at a time. In general, a balance was kept between the requirements of the experiment and the social needs of the subjects, in order to insure compliance and cooperation. It was not considered feasible to make the living conditions a strict imitation of those prevailing on board ship, and that was one of the inevitable short-comings of the experimental set-up.

An entirely different kind of short-coming resulted from the use and possible abuse of coffee as a stimulant. For purposes of comparison, it may have been better either to prohibit the use of coffee, or to regulate its consumption so that the same number of cups would be drunk in relation to the hours of wakefulness of each of the several watch routines. However, because of the traditional availability of coffee to Navy personnel at all hours, it was decided that unrestricted consumption of coffee would be allowed, regardless of the watch schedule followed. Care was taken to keep an accurate time record of coffee drunk by each subject for possible clews concerning variations in alertness, expressed by an unequal consumption of coffee at different hours, during each of the several watch schedules.

Four watch routines were followed interchangeably in eight periods of observation, of two to four weeks each, with a total duration of five months (April through August 1949). As a general control, a shore ("office") routine, watch hours being 0800-1200 and 1300-1700, was kept for two test periods: I, of four weeks, 11 Apr to 6 May, when the outside temperature was lowest, and VI, of three weeks, 18 Jul to 7 Aug, at the height of the summer heat. A rotating watch schedule was used during Period II, 7 May to 27 May, involving daily changes in the hours of duty and continual testing during successive watches, without any week-end interruption. By this schedule, followed on large surface warships, each of the four watch sections puts in 24 hours of duty in 96 hours of elapsed time, or an average of six hours per calender day. The 1600-2000 watch is usually split, and thus the watch is "dogged" each day by a different section. The subjects of this experiment represented one watch section, and their hours of duty are shown graphically in figure 2. By the "4-on, 8-off" schedule of watches, at present in use on submarines and small surface vessels, the crew is divided into three watch sections, necessitating 8 hours of duty for each section, and the watch hours are fixed for the duration of the cruise, or, at the least, for one week. Two test periods, each of two weeks' duration, were given over to this routine with watch hours of 0000-0400 and 1200-1600 during Period III, 4 Jun to 18 Jun, and 0800-1200 and 2000-2400, during Period V, 5 Jul to 21 Jul. Three different close watch schedules, with watch hours between 0800 and 2000, 0000 and 1200, and 1200 to 2400, respectively; were followed during three two-week periods: IV, 19 Jun to 1 Jul; VII, 8 Aug to 21 Aug; and VIII, 22 Aug to 2 Sep.

To detect variations in alertness, as indicated by the speed and accuracy of performance, a 20-minute stint of "blind flying" on a Link Trainer was required daily of eight subjects (the ninth having joined the group too late to be properly indoctrinated in the operation of this device). Aside from imitating the operations of an airplane pilot and thus qualifying as a type of activity expected of service personnel in the performance of their military duties, the task of properly running a trainer demands continuous vigilance and simultaneous attention to many details. To keep within prescribed tolerances with respect to fluctuations in the readings of the indicator instruments, the subject must couple a sustained mental effort with finely coordinated muscular skills that can be acquired only by personal experience. It took all of a month, before the indoctrination of the subjects was considered adequate for scoring purposes, but further, although progressively slower, improvement in performance could be discerned until the very end of the experiment. The particular experimental Link Trainer used was equipped with five electric scoring timers. Four of these would be set in motion by the maintenance of the required standard of performance as regards air speed, pitch, bank, and rate of turn, respectively, while the fifth ("simultaneous") ran only when the four individual ones were activated at the same time. It was thus possible to run up high scores on the separate timers by alternately concentrating one's attention to the several dials, without much of a score on the simultaneous timer. The readings of the latter, accurate to within thousandths of a minute, were therefore used as indices of all-around performance. The scores, expressed in minutes run up on the silmulateneous timer in 20 minutes of "flying", varied from zero to a theoretical maximum of 20, higher scores indicating better performance. Ten subscores, obtained by making ten successive timer readings at 2-minute intervals, furnished additional information on the uniformity of trainer operation. It required about four hours, or a whole watch period, to put the eight subjects through their trainer runs.

Two subsidiary tests were employed as indices of short term attention and the ability to maintain neuromuscular activity for a few minutes. Neither test required dexterity or integrated synergy, and practice levels were reached after a few trials. They were essentially responses to visual signals previously shown to vary diurnally and with changes in body temperature (1). For one reaction time to a combination of lights, the subject was required, upon the appearance of red light "get ready" signal, to watch a panel with nine (three rows of three) unlit electric lamps, while resting his hands lightly on two keys placed, respectively, to the right and left of the panel. After two seconds, some of the lamps would light up in accordance with a series of random combinations followed by the observer in introducing or removing some of the lamps from the light circuit, and the subject had to press the key under his right hand if total number of lights (usually varying from five to eight) was even, and the one under his left hand when the number was odd. The reaction time apparatus available at the Institute (4) was modified to enable the observer to detect errors in the proper choice of the response key, as only when the correct key was depressed by the subject would an electric timer, started simultaneously with the turning on of the stimulus lights, be stopped. Reaction time was measured in hundredths of a second and, because of the delay introduced by the necessity of counting the lights, varied from less than one half of a second to more than a second and a half. With the time needed to reset the combination of lights, a run of fifteen reaction time trials required about five minutes, during which the subject took his oral temperature. All nine subjects were given this test twice during a 4-hour watch, or four times per calendar day.

The other minor test involved the rapid consecutive naming of the colors of one hundred half-inch squares (ten rows of ten), painted in ten different colors and in randomized arrangement on a large cardboard. The time taken for calling off the one hundred squares was determined by means of a stop-watch. Then the cardboard was turned 90 degrees, and a new arrangement of the colors was obtained. This was done repeatedly until a total of 600 colors was named. In a sense, the color-naming test was a verbal reaction time, but several successive stimuli could be perceived in advance. This test, run on each subject as soon as he was through with the reaction time to the lights, also required about five minutes per person.

RESULTS

Body temperature, consumption of coffee, and the distribution of hours of sleep and wakefulness.- The degree of adjustment of each individual, and the group, as a whole, to the several routines of living and schedules of watches can best be judged by simultaneously examining the data on these three variables for each of the eight periods of observation.

Period I, shore routine, hours of duty, 0800-1200 and 1300 1700 extended from 11 Apr to 6 May. It was a period of indoctrination for the operation of the Link Trainer, but provided, at the same time, a "normal" or control oral temperature pattern. Each subject and the entire group yielded mean diurnal body temperature curves (fig 1) typical of the shore routine of living: minima between 0200 and 0600, sharp rises on getting up in the morning, peaks in the afternoon, followed by moderate descents in the evening, and steep falls after bed time. The ranges of the diurnal temperature curves of the nine subjects varied from 1.82 to 2.36 degrees F., with a group mean of 2.00, not much larger than the range of mean diurnal curve of the group which was 1.94 (fig. 1). The individual mean curves for the period were thus practically superimposable on each other, coinciding a little better at their minima than maxima. Coffee consumption was low and except for breakfast time, confined to watch hours. The average duration of sleep was 8.11 hours per man-night, the hours falling largely between 2200 and 0600.

Period II, dogged watch routine, hours of duty rotating around the clock (fig. 2) and a complete cycle of 24 hours of watches in 96 hours of elapsed time, ran from 9 May to 27 May. Only during this period was it possible to plot separate diurnal curves for on-duty and off-duty hours (fig. 3), although the apparent continuity of the curves is somewhat misleading, as adjacent parts of the several watches were necessarily based on data obtained 24 hours apart. However, such as they are, the patterns of the two mean group diurnal body temperature curves do not differ from that of the control period, except for the distinct minima at 0400 (no temperatures taken at that hour during Period I) and plateaus, rather than peaks, during the afternoon and evening hours. As the off-duty temperature curve is based on figures obtained during sleep as well as wakefulness, its night-time minimum is much lower than that of the on-duty curve. It also may be seen that only at 1800 was the mean group on-duty oral temperature lower than the off-duty one. This was probably due to the fact that no Link Trainer exercises were scheduled during the two 2-hour watches, 1600-1800 and 1800-2000, and during these hours the subjects were often more active when off-duty. When not split up into on- and off-duty figures, the mean diurnal body temperature ranges of the subjects varied between 0.91 and 1.36 degrees, with a group mean range of 1.19 degrees, which bore the same ratio to the range of the mean group diurnal body temperature curve, 1.13 degrees (not shown in fig. 3), as did the corresponding values for Period I. In other words, the nine subjects behaved alike during the two periods. The sharp decrease in the range of the diurnal body temperature curve, from 1.94 degrees in Period I to 1.13 in Period II, was probably caused largely be the seasonal rise in the external temperature. When plotted separately for successive complete four-day cycles, the ranges of the mean diurnal body temperature curves can be seen to decrease, the minima climbing more steeply than the maxima (fig. 4). As will be shown in succeeding body temperature curves, the seasonal influence on body temperature was manifested during the remainder of the summer.

Much more coffee was consumed during the hours of duty than in the other hours of the day and night. The marked decrease in on-duty coffee drinking between 1600 and 2000 corresponds to the 1800 notch in the body temperature curve and is likewise probably due to the fact that the men were away from the Link Trainer quarters during those hours. Allowing for the hours of sleep, which must be subtracted from the off-duty fraction of the day, over four times as much coffee was consumed during on-duty hours as during off-duty hours, with the greatest consumption during the 0000-0400 watch.

The sleep pattern is markedly different from normal. The line at the 25 per cent level (fig. 3) represents compulsory wakefulness imposed by the demands of the round-the-clock watches, thus allowing a maximum of 75 per cent in the distribution of the voluntary sleep and wakefulness hours. That percentage of occurrence of sleep was almost reached between midnight and 0600. In other words during the conventional sleep-time, the subjects were nearly always asleep if off duty, whereas in the afternoon and evening very few cared to sleep. This, as already alluded to, is reflected in the separation during the night, and the superimposition in the afternoon and evening, of the mean on-duty and off-duty body temperature curves. The mean duration of sleep per man per 24 hours was 8.66 hours, over one-half of an hour greater than the control figure.

Period III, "4-on, 8-off" routine, hours of duty, 0000-0400 and 1200-1600, covered two weeks, 4 Jun to 18 Jun. The ranges of the individual mean diurnal body temperature curves varied from 0.93 to 1.64 degrees, and the mean range, 1.25 degrees, bore a slightly higher ratio to the range of the group mean diurnal curve, 1.16 degrees, indicating a lesser consistency among the individual curve than during Periods I and II. The shape of the diurnal curve (fig. 5), however, does not reveal any bimodality such as was previously found in the curves of submarines' crews operating on the same watch routine (2,3). The minimum temperature is shifted to 0800, for the group as for each subject, and coincides with the middle of the prevalent sleep period. The maximum of the mean group body temperature curve is at 1800, with individual maxima extending from 1400 to 2000. As regards the group body temperature during watch hours, it is low (just above 98.00 degrees) and *falling* between midnight and 0400, definitely higher and *rising* between noon and 1600. Next to the dogged watch routine, this schedule led to the biggest difference between the group body temperatures for the two watch periods

Consumption of coffee was highest during this than during any other routine, with 76 cups per week drunk while on duty. Of these, 54 were consumed between 0000 and 0400, and only 22, from 1200 to 1600, a ratio of 2.4 for the two watches.

In the distribution of sleep and wakefulness, a fairly solid sleep area can be discerned between 0400 and 1200, and a much lighter one, between 1600 and 2400. The inequality in the incidence of sleep during the two off-duty periods is probably responsible for the lack of bimodality in the diurnal body temperature curve. The mean duration of sleep per man per 24 hours was 8.48 hours, about 20 minutes greater than during period I.

Period IV, close watch routine, hours of duty, 0800-1100, 1300-1600, and 1800-2000, extended from 19 Jun to 1 Jul. The ranges of the mean individual diurnal body temperature curves varied from 1.09 to 1.66 degrees, and the mean range was 1.33 degrees. The range of the mean group curve (fig 6) was 1 25 degrees, and the pattern of the curve resembled the control one, except that its range was smaller and the peak occurred later While the body temperature continued to rise during the first watch of the day, it was fairly constant during the other two

Less coffee was drunk during this period than during any other, Periods III and IV representing extremes, in this respect Out of 43 cups drunk during Period IV, however, 28 were consumed before 1000, when the body temperature was still low

The distribution of hours of sleep and wakefulness was about the same as under the shore routine, but the mean duration was distinctly smaller, 7 5 hours per man per 24 hours, as compared with 8.1. Perhaps the extension of duty to 2000 was responsible for the tendency to go to bed later than usual during these two weeks.

Period V, second "4 on 8-off" routine, hours of duty, 0800-1200 and 2000-2400, ran for two weeks, from 5 Jul to 17 Jul. The ranges of the individual mean diurnal body temperature curves varied from 0.98 to 1 47 degrees and the ratio of the mean range, 1.29 degrees, to the range of the mean group curve, 1.19 degrees, was exactly the same as in Period III, when the same routine was followed. Again, as in Period III, there was no bimodality in the group diurnal body temperature curve (fig 7), and the cause here, too, can probably be found in the unequal incidence of sleep during the two off-duty periods. The minimum temperatures occurred at 0400, in the middle of the solid sleep area, with the maxima somewhat scattered, and the usual drop in body temperature between 2000 and 2400 largely absent Otherwise, the diurnal temperature pattern during these two weeks was "normal", this timing of the "4 on 8 off" schedule of watches falling essentially within the usual waking hours of the shore routine of living.

Coffee consumption as in the first "4 on, 8-off" routine, was largely confined (except for the breakfast hours) to the two daily watch periods Again, the greater number of cups was drunk during the night watch, although the disparity between the amount taken during the two watches was less marked than in Period III The fine holding up of the body temperature between 2000 and 2400 may have had some connection with the coffee intake

The distribution of the hours of sleep and wakefulness was about as unequal as in Period III However the sleep area at night was a little more solid, and the afternoon naps were somewhat symmetrical about 1500 1600, whereas during Period III with sleep possible between 1600 and 2400, its incidence was greatest late in the evening The mean duration of sleep per man per 24 hours was 8 55 hours, a full hour over that of the preceding two weeks, but not much different from the 8 48 hours of Period III

Period VI, a repetition of the shore routine, hours of duty, 0800-1200 and 1300-1700, lasted three weeks, from 18 Jul to 7 Aug. The main reason for instituting the shore routine once more was to determine whether the marked decrease in the diurnal body temperature range, first noticed in Period II and persisting in all the subsequent periods, was related to deviations from the "normal" characterizing the several routines, or was a seasonal effect of higher environmental temperatures. A glance at the mean group diurnal body temperature curve for Period VI (fig. 8) at once reveals that the latter explanation is the correct one. With a mean external temperature, from 18 Jul to 7 Aug. of 82.6 degrees, the ranges of the individual mean diurnal body temperature curves varied from 1.06 to 1.60 degrees. This is to be compared with a variation in range of from 1.82 to 2.36 degrees in Period I, when the mean external temperature, from 11 Apr to 6 May, was 61.5 degrees. The ratio of the mean of the individual body temperature ranges for Period VI, 1.30 degrees, to the range of the group curve for the same period, 1.20 degrees, was also more like those obtained in Periods III, IV, and V, than that of Period I. The pattern of the group mean diurnal body temperature curve for Period VI, while resembling that of Period I during the night hours, shows a shift in the incidence of maximum temperature toward 1800, which is another characteristic of the temperature curves following Period I. The general effect of the rise of over 20 degrees in environmental temperature becomes very clear when one superimposes the diurnal body temperature curve for Period I upon that for Period VI (fig. 9). The mean difference in the group body temperatures for all ten daily readings is 0.35 degree F., and its "t" value of 4.48, using Fisher's method (5), makes it statistically highly significant, with a probability of less than 1 in 100 of its being due to chance ($P < 0.01$). Comparing separately the daytime (1000-1800) and night body temperatures, one gets mean differences of 0.17 degree ("t" value of 3.68) and 0.53 degree ("t" value of 5.72), respectively, each, like the 24-hour mean difference, statistically significant ($P < 0.01$). The predominately night-time seasonal elevation of body temperature appears all the more striking when one recalls that the subjects' sleeping compartment was air-conditioned and maintained at exactly the same temperature during the two periods in question.

The consumption of coffee was greater during these three weeks than in Period I, and there was a disparity between the morning and afternoon watches, with more coffee drunk in the former.

The distribution of the hours of sleep and wakefulness is almost identical with that of Period I, as is the mean duration of sleep per man-night - 8.05 hours, compared with 8.11 hours for Period I.

Period VII, second close watch routine, hours of duty, 0000-0200, 0400-0700 and 0900-1200, ran from 8 Aug to 21 Aug. This was the only routine that called for an almost complete inversion of the normal diurnal body temperature curve as the time available for sleep was from noon to midnight. Although the lowest diurnal temperature was reached at the unusual hour of 1600 (fig. 10), in the middle of the sleep period, there was no inversion of the curve as a whole, as the highest temperatures, instead of occurring in the middle of the prescribed waking period, were reached only toward its end, at noon. In fact, a distinct inflection can be seen in the mean group curve at 0600, the usual getting-up time. The sudden rise in body temperature between 0600 and 0800 was found in every subject's mean diurnal curve, and was statistically significant for the group. It undoubtedly represents a persistance of the well-established morning temperature upswing, added to the unusually high temperature resulting from being awake and active from midnight on. Another indication of the absence of an adequate adjustment to this routine was the small diurnal temperature range. The individual ranges in body temperature varied from 0.59 to 1.15 degrees, with a mean of 0.89, while the range of the group diurnal body temperature curve was 0.84 degree.

The rate of consumption of coffee during this period varied almost inversely with the body temperature, being highest between 0000 and 0400 and decreasing stepwise in the two succeeding 4-hour intervals.

The distribution of sleep between noon and midnight is somewhat bimodal, with one maximum at 1500-1600 and another, smaller one, at 2200-2300. However, there is no solid area of sleep at any time, and the mean duration of sleep per man per day was 8.4 hours, not much higher than the control figure.

Period VIII, third close watch routine, hours of duty, 1200-1500, 1700-2000, and 2200-2400, extended for two weeks, 22 Aug to 2 Sep, and was complementary to the routine of Period VII. This routine required less of a shift in the usual hours of sleep, and the adjustment of the diurnal body temperature pattern was much better than during the preceding two weeks. The ranges of the individual mean diurnal body temperature curves were larger, varying from 1.08 to 1.43 degrees, with a mean range of 1.26 degrees. The range of the mean curve of the whole group was 1.20 degrees, showing a fairly good consistency among the individual curves. The body temperature peaks were grouped about 1800, a feature common to other warm-weather curves. The temperatures were low and rising during the first watch, high and stable during the other two, resembling the first close watch routine, Period IV, in this respect (fig. 11).

Consumption of coffee did not quite follow the pattern established in other periods, but the large number of cups drunk between 2000 and 2400 may have been instrumental in checking the usual downturn of the body temperature curve during the pre-midnight hours.

The distribution of the hours of sleep, which was, as in Period VII confined to the 12 off-duty hours, this time from midnight to noon, shows a more solid area of sleep than any preceding period. There being no competition between need for sleep and the timing of social and recreational activities, as was the case in Period VII, those who were willing to forego breakfast slept through the entire morning. The mean duration of sleep per man-night was 10 1 hours, the highest of any period and exceeding the control value by two hours.

Performance on the Link Trainer. Involving as it did a combination of native muscular dexterity, an ability to acquire skill by experience, and a capacity for sustained effort and attention, performance on the Link Trainer varied greatly from one subject to another (table 1). Period I, as already mentioned, was devoted to indoctrination, and during Periods VII and VIII some of the subjects operated the trainer for a different type of test. Performance scores, the time run up on the "simultaneous" timer in 20 minutes of operating the Trainer, available for analysis, were therefore limited to Periods II to VI, inclusive. The first striking feature of the performance during the several periods was the fixity of the rank held by each subject. Indeed, the rank order correlation coefficient of the subjects from one period to the next was never less than 0.929. A second feature was the improvement of performance with practice. This was very marked, when one compares the group and individual scores for Period III with those for Period II, but the increment during Period IV was almost negligible. Because some subjects' mean scores were getting rather close to the theoretical maximum of 20, the tolerances were narrowed, and this led to a severe drop in the mean scores during Period V, followed by a slight increase in Period VI, without, however, interfering with the ranking positions of the subjects. A third feature was the association between the mean interperiod scores of the subjects and the coefficients of variation of these scores. The correlation coefficient between these two sets of figures was -0.8721, statistically highly significant ($P < 0.01$). It is interesting to note that the correlation coefficient between the same interperiod mean scores and the reciprocals of their coefficients of variation, now positive, was even higher, 0.9484. In any case the higher a subject's mean interperiod score, the less his several period scores varied. This association between the magnitude of a mean score and the variability of the individual scores can be detected all the way down the line: it applies to the mean period scores and intertest variation, and also to the individual test scores and the intratest variation of the ten 2 minute subscores. Such an association is, of course, inevitable when the scores, individual or mean, are close to the maximal theoretical values. A subject who runs up 19 minutes on the simultaneous timer while operating the Link Trainer for 20 minutes cannot possibly vary much from the mean subscore of 1.9 in successive 2-minute intervals, whereas another subject, with a test score of 3 and a mean subscore of 0.3 can easily show several subscores of zero and one or two of 1. In the performance of these subjects, however, the inverse relationship between performance and variability held for *all* scoring levels, from highest to lowest. Uniformity or steadiness of performance on the Link Trainer thus went with excellence and should serve as an index of achievement, when the scores, because of the considerable intersubject variation, do not lend themselves easily to group treatment.

To overcome the disparity among the scores of the several subjects, each person's mean score for the period was designated as 100 per cent and all his individual test scores for that period were expressed as percentages of the mean score. By averaging the percentage scores of all eight subjects during a given watch, a group score for the particular watch was obtained. It was thus possible to compare Link Trainer performance as it varied from one watch to another even though one subject's test score was 5, and that of another was 15. In addition, uniformity of performance, as indicated by the coefficients of variation of the mean subscores for the ten 2-minute intervals of the 20 minute test, could also be used on a percentage basis. Irrespective of the absolute value of the test score, the mean subscore was always 10 per cent, and individual subscores slightly or considerably higher or lower than 10 per cent. Thus mean group subscores for successive 2-minute intervals could be obtained by averaging corresponding individual percentage subscores, for a single test, for all the tests of a period, or even for all periods put together. Employing this double method of evaluating Link Trainer performance, one finds the percentage subscore variation from one watch to another a little more clear-cut than the percentage complete score variation.

Period II, dogged watch routine, was the only one in which performance scores for five different 4-hour watches are available, although - it should be emphasized once more - no two watches were actually contiguous. Performance was best during the 1200-1600 watch when the body temperature was highest, the group percentage mean score being 110 and the subscore coefficient of variation, 31.0 per cent (fig. 12). Next best Link Trainer performance was not, however, during the 2000-2400 watch, as could be expected from the diurnal body temperature curve (fig. 3). The score during this watch was 99 and the subscore coefficient of variation 49.9 per cent, while next to the best performance occurred during the 0000-0400 watch, when the body temperature was much lower (a percentage mean group score of 107 and a subscore coefficient of variation of 41.6 per cent). On the other hand, the score for the 0400-0800 watch was 95, and the subscore coefficient of variation 47.1 per cent. Least fitting was the score during the 0800-1200 watch - only 88, and the highest subscore coefficient of variation - 52.6 per cent. In other words, Link Trainer performance scores during the dogged watch routine did not vary with the body temperature of the subjects. However, the greatest intrawatch variations in performance were observed during the two night watches. With the body temperature falling, performance was much worse from 0200 to 0400 than from 0000 to 0200, while during the next watch, when the body temperature was rising, performance was better between 0600 and 0800 than between 0400 and 0600. The only thoroughly consistent variation during Period II was in the subscore coefficients of variation, which were smaller the higher the group mean score.

Somewhat better agreement with body temperature prevailed in the other four periods. In Period III (fig. 5), performance scores were decreasing during the 0000-0400 watch when the body temperature was falling and improving during the 1200-1600 watch when the body temperature was rising. With the rise in the absolute group mean performance score (from 7.26 in Period II to 13.02 in Period III), there was also a tremendous increase in the uniformity of the subscores, as shown by the decrease in their coefficients of variation. There is also a marked dissociation between the subscore coefficients of variation for the two watches - 15.7 per cent and 5.55 per cent - in favor of the afternoon watch.

In Period IV (fig. 6), the group absolute mean score rose only slightly over that for Period III and was now 13.50 minutes. The close watch routine followed during this period did not permit the testing of all the subjects during a single watch, but for the first Link Trainer run, between 0800 and 1400, when the body temperature was rising from a morning low, the subscore coefficient of variation was 10.4 per cent, while for the second run, between 1400 and 2000, with the body temperature high and steady, the subscore coefficient of variation was down to 5.68 per cent, practically the same as for the 1200-1600 tests of Period III.

As previously stated, the Link Trainer tolerances were narrowed at this juncture, and the consequences of this step can be seen not only in decreased absolute mean group scores, but also in the simultaneous increase in the subscore coefficients of variation, during Periods V and VI. In Period V (fig. 7), for the 0800-1200 watches, when the body temperature was low, the subscore coefficient of variation was 18.8 per cent, but it dropped to 12.3 per cent for the 2000-2400 watches, when the body temperature was high. In Period VI shore routine (fig 8), an improvement in performance (mean group absolute score rising from 8 51 to 10 87 minutes) is reflected in lowered subscore coefficients of variation, but here, too, the subscore coefficient of variation for the 0800-1200 watches was greater than that for the 1300-1700 watches

The correlation between Link Trainer performance and body temperature was never very distinct for the group as a whole and is manifested only a little better in the subscore coefficients of variation than in the absolute, or even percentage, group mean scores for the different watches of the successive periods. A more direct relationship between body temperature and Link Trainer performance will be discussed later in connection with body temperature levels of the several subjects.

Reaction time to combination of lights. - This test required no manual skill, involving only an ability to count, in the shortest possible time, the number of lighted lamps and then to make a choice as to which of two keys to press Alertness had been maintained for two seconds, the interval between the "get-ready" signal and the turning-on of the lights In between the 15 successive presentations of the different combinations of lights, the subjects could and did relax

The mean scores of the nine subjects are given in table 2. The reaction time of the fastest-responding subject was just under one-half of a second, with the slowest man requiring, on the average, a full second for the same task. After Period IV, a new, more varied and longer series of light combinations (not completely exhausted during a single test) was introduced, as the subjects seemed to be able to foretell some of the successions of light patterns. This led to a sharp increase in group mean reaction time during Period V, followed by a renewed drop in Period VI. It is perhaps significant that in Period VII, when the daily routine was practically inverted and the group body temperature adjustment was least satisfactory, there was no practice decrease in reaction time.

It will be seen from table 2 that the rank order of the subjects with respect to speed of response was fairly well maintained through the successive periods of changing routines. Subject 6, whose scores for Link Trainer performance were lowest, also holds last place in this series. However, subject 3, ranking sixth in the Link Trainer scores was fastest in responding to the light signals (being second only to subject 10 who did not participate in the Link Trainer tests). Thus, it appears that entirely different personality factors are needed for good performance in the two tests. This will be further substantiated when the color naming scores are presently examined

Concerning diurnal variation in reaction time, it was found to be just as erratic during the night hours of Period II, dogged watch routine, as were the variations in Link Trainer performance. However, during the usual waking span of the diurnal period, from 0800 to 2000, there was, as can be seen from figure 13, a very close association between the height of body temperature and the quickness of response. To equate the differences in individual reaction times, each subject's scores were converted into percentages of his own mean score, and the correlation coefficient between the group mean body temperatures at different hours of the day and the mean group percentage reaction time scores at corresponding hours was found to be -0.9472, statistically highly significant ($P < 0.01$). Alertness, expressed as a reciprocal of the reaction time score, can then be said to have varied directly with the body temperature during the hours of 0800 to 2000.

For Period III, "4-on, 8-off" routine, the two equally-spaced watches, 0000-0400 and 1200-1600, offered the greatest diurnal body temperature contrast. As the subjects were tested twice during each of the two watches, every individual furnished four daily mean body temperature readings and corresponding four mean reaction time scores, 36 pairs of figures in all. The deviations of each of the four mean body temperatures from their own global mean, in one-hundreds of a degree F., and the percentage deviations of the concurrent mean reaction time scores of that individual from their own mean, expressed as 100 per cent, are shown in figure 14 as 36 dots distributed unequally in the four quadrants, but predominately in the upper left and lower right ones. The correlation coefficient between these two groups of 36 variates is -0.4723, rather low, but statistically highly significant ($P < 0.01$), in view of the large number of pairs involved. That means that higher body temperatures were associated with lower reaction times, or faster responses.

Another comparison between the scores for the two watches of Period III was made by plotting the mean group scores for the successive 15 trials of each test (fig. 15). The two sets of 15 mean trial scores arrange themselves into rather irregular, but closely parallel, graphs. The irregularities suggest a tendency to slower responses during the first half of the test, followed by recovery later, but all the 15 mean trial reaction time scores for the 1200-1600 watch, when the group body temperature was higher and rising, were smaller than their counterparts for the 0000-0400 watch, when the body temperature was lower and falling. The mean difference between the two sets of 15 scores was 54 milliseconds, and its "t" value of 5.93 made it highly significant statistically ($P < 0.001$).

In Period IV, first close watch routine, the patterns of graphs representing the two sets of 15 mean trial scores for the two fractions of duty hours, 0800-1400 and 1400-2000, differed somewhat from those of Period III (fig. 15), and they crisscrossed in several places. The mean difference between the two sets of scores was tiny and without statistical significance. In Period VI, shore routine, the

15 scores of the 1300 1700 watch, when the group body temperature was high and steady, were, on the average, slightly but significantly smaller (by 11 milliseconds, with a "t" value of 4.17 and $P < 0.001$) than were those for the 0800-1200 watch, when the group body temperature was lower (fig. 15). There are thus two indications, one direct and the other indirect, that higher body temperatures are associated with greater alertness.

Color Naming - Unlike the other two tests, the color-naming test required neither manual skill nor extreme momentary concentration of attention. The colors were loudly named as they presented themselves to the continuously scanning eyes of the subject, and there was plenty of opportunity to "peek" at neighboring squares, soon to be named by their proper colors. Verbal ability, entirely without influence on performance in the other two tests, seemed important in color naming. Memory for certain successions of colors also undoubtedly affected the scores. After Period IV, a new and more difficult set of colors was adopted, with the result that the time required to name them was markedly increased, and these higher scores prevailed for the subsequent periods. Indeed, during Period VII, close watch routine with compulsory wakefulness between midnight and noon, was actually increased (though not by a statistically significant amount), instead of merely being left unchanged, as with the reaction time score - another indication of lack of adjustment to the inverted routine of this period.

The range of the mean scores of the nine subjects was smaller than that for the reaction time scores. The need for certain personality factors in the performance of the color naming task was demonstrated by the fairly consistent ranking order of the subjects in successive periods of observation (table 3). Of the eight subjects who participated in all three tests, subject 6 ranked highest (smallest mean score) in the speed with which he called off the different colors; but he was the poorest performer in both the Link Trainer and reaction time. On the other hand, subject 7, whose performance in the Link Trainer was highest, and who was only slightly less than the best in reaction time was next to the last in color naming. Perhaps he was adversely affected by the apparent lack of challenge to his capacities in color naming, while other subjects may have found great satisfaction in being able to call off the colors at a high speed. It should be mentioned at this point that no attempt was made to prevent the subjects from learning their scores in any of the tests, although no information was routinely given out and no subject was praised or scolded. Some, however, showed a marked interest not only in their own scores, but also in those of others, and occasionally expressed gratification when their performance was superior and concern when it was not.

Peculiarly, it was only during Period II, dogged watch routine, that the mean group color naming scores revealed a good association with body temperature figures, and this held for tests all around the 24 hours, instead of only during the waking fraction, as with reaction time scores. In figure 16 are the graphs of 12 successive mean group body temperatures and the corresponding mean group color naming scores. The correlation coefficient between these two sets of variates is -0.8874, statistically highly significant ($P < 0.01$). During the other periods the intersubject variations were too great to yield distinct watch differences for the group as a whole.

Body temperature levels.- Body temperature levels may be defined as the mean body temperatures of individuals or groups, for a day or a longer time interval. From the figures available, the daily body temperature level of each subject was obtained by averaging the ten temperature readings, and, thus determined, the level was a little too high, as fewer readings were made at night, when body temperatures are low, than in the daytime. It was considered undesirable to interrupt the night's "long" sleep more than once for the purpose of obtaining body temperatures.

There was a gradual rise in individual and group body temperature levels durings Periods I to IV (table 4), from 97.99 degrees in the beginning of April to 98.27 degrees at the end of June, as the mean external temperature increased from a mean of 61.5 to one of 79.3 degrees for Periods I and IV, respectively, confirming previous observations on seasonal variations in body temperature (6). In July and August, the group body temperature level varied only from 0.02 to 0.06 degrees during Periods V to VIII. Individual subjects seemed to maintain their ranking order, with only minor deviations, through the successive periods. Thus, subject 7, with the highest mean body temperature level, was in first place in 5 periods, second in 2, and tied for second place in one, while subject 10, with the lowest mean level, was in ninth (last) place in 5 periods, eighth in one, and seventh in two. The subjects differed from each other also in the seasonal stability of their body temperature levels, those with higher spring temperatures tending to vary less. In this respect it was possible to divide the group into two sections, the first section, subjects 2,7,1,4 and 8, having, in general, higher and less variable body temperature levels than the second section, subjects 3,5,6 and 10 (fig. 17). The body temperature level differences of the two sections, though gradually decreasing during Periods I through IV, persisted in all eight periods of observation, the mean difference amounting to 0.11 degree F. and, with a "t" value of 3.67, statistically highly significant ($P < 0.01$). As can be seen from table 4, the mean interperiod body temperature level fluctuation was 0.075 degree for the first section, and 0.114 degree for the second. Neither the mean diurnal period maxima, nor the minima, of the two sections varied as consistently as did the levels, the mean differences for all the periods being without statistical significance. However, the section differences in body temperature levels, when pronounced, are more definitely associated with marked differences in section temperature maxima than in minima (fig. 17). In other words, the section body temperature differences manifested themselves more distinctly during the waking hours than during sleep.

It is possible further to subdivide the two sections as regards body temperature. In the first section, the successive period body temperature levels of subjects 2 and 7 were higher than those of 1, 4 and 8, the mean difference for the eight periods being 0.16 degree F. ("t" value of 7.02, $P < 0.001$). In the second section, the mean body temperature levels of subjects 3 and 5 were likewise consistently higher than those of subjects 6 and 10, with a mean difference that was also 0.16 degree ("t" value of 4.75, $P < 0.001$).

Variation in the consumption of coffee was quite marked for the group as a whole from one period to the next, but even more so among the several subjects. From table 5, it can be seen that subjects 2, 7,1,4 and 8, with higher body temperature levels, were, by and large, heavier coffee drinkers (946 cups) than subjects 3,5,6 and 10 (204 cups). In addition, there were considerable differences between the number of cups of coffee consumed "on-duty" and "off-duty", although the daily 16-hour waking period was about equally split into these two fractions. More coffee was consumed during the watch hours, but the disparity was much greater for the second section (ratio of "on" to "off" being nearly 5:1) than for the first section (ratio of 3:2). Individual subjects showed distinct preferences in the incidence of coffee drinking. Thus, subject 1 drink twice as much coffee when not on watch (209 cups to 97), while for subject 2, an even heavier consumer of coffee, the ratio was about the same, but in favor of the watch hours (249 cups to 115). For the other subjects of the first section, 4, 8, and 7, the relative preponderance of "on-duty" coffee drinking was even greater than for subject 2, the ratios being over 3,4, and 5, respectively. Among the second section subjects, individual preferences were even more extreme. Subject 3 drank more coffee while off duty (ratio of 3:1), the coffee consumption of subject 6 was negligible at all hours, whereas subjects 5 and 10 drank almost all their coffee during watch hours. Indeed, subject 10, with the lowest body temperature level, would qualify as a heavy coffee drinker, his total of 103 cups consumed on duty accounted for three-fifths of the coffee taken by the second section during watch hours.

DISCUSSION

The results obtained on the Navy recruits constituting the subjects of this study were in general agreement with findings on civilians observed under laboratory conditions. Body temperature, within the normal limits set by the hypothalamic regulating centers, is continuously affected by endogenous and exogenous influences. Among the former, muscular activity, tonic (postural) and phasic (overt), varying with the pattern of living, particularly the alternation of sleep and wakefulness, leads to the establishment of a regular diurnal body temperature curve, with a range of one to two degrees F., rhythmic in character and resisting modification, displacement, or inversion. An obvious exogenous influence is the changing ambient temperature which leads to seasonal fluctuations in body temperature, with highs during the summer. Aside from these regular and irregular modifying influences, there are individual differences in body temperature level, with respect to both magnitude and stability. Such differences, reported previously (6), were substantiated by the fairly clear separation of the subjects of this study into two sections, of which one had a higher and more stable body temperature level than the other.

Concerning the diurnal variation in body temperature, the subjects, individually and collectively, while on a shore or "office" schedule of watches (0800-1200 and 1300-1700), yielded typical curves, with ranges of about 2 degrees F. (fig. 1). With the rotating routine of "dogged" watches, followed for nearly three weeks, the usual diurnal body temperature curves were left intact, save for a slight shift in the incidence of the daily maxima, probably related to the advent of warmer weather. The latter was also mainly responsible for the decrease in the range of the diurnal body temperature variation, as the smaller range persisted throughout the summer, irrespective of the watch schedules. However, on the rotating watch schedule, the 0400 mean body temperature of the subjects, awake and on duty, was 0.8 degree *higher* than when this schedule permitted them to sleep through the night, and this difference can be ascribed to the body temperature elevating effect of wakefulness and activity. Yet the same 0400 mean body temperature of the group, awake and on duty, was 0.7 degree *lower* than the 1600 temperature, under conditions requiring an equal degree of alertness, and this difference can be explained by the persistence of the diurnal body temperature rhythm, aided, to be sure, by the unchanged schedule of meals, the skewed distribution of the hours of sleep, evening recreational activities, etc. The conditions, with respect to the above-mentioned influences, were not much at variance with those prevailing on surface warships, and the preservation of the usual diurnal body temperature pattern could be, and was predicted, but here it was demonstrated as an actual occurrence for the first time.

In any case, under service conditions requiring an equal if not greater alertness at 0400 than at 1600, there was a marked disparity in the mean group body temperatures at these two hours. Was there a difference in performance? An examination of the Link Trainer scores for this period showed that during the 1200-1600 watch the scores were highest and the subscores least variable. The latter feature is hard to evaluate in the light of present information, but it will be recalled, that uniformity of Link Trainer operation during the ten successive 2-minute intervals, obligatory though it was for very high scores, held true for all levels of performance, for all subjects, for all periods, higher scores always being associated with lesser subscore variability. Performance during the 1200-1600 watch was thus best, by these two criteria. It was disconcerting, however, to find that scores obtained during the 0000-0400 watch were not as low as could be expected. Perhaps it was a group effort to excel, aided by a higher consumption of coffee during that watch, that served to compensate for and to overcome the inefficiency associated with low body temperatures. What might happen under humdrum conditions of every-day watch standing, was shown by the performance of the group in reaction time and color naming. For the former, demanding only momentary spurts of attention, performance varied directly with body temperature during the customary waking hours, but not at night, while color naming, which comes closest to being a routine and uninteresting task, correlated with body temperature at all hours of the day and night. It may be said, then, that, although the results were far from consistent, variations in performance during the dogged watch period confirmed the validity of the temperature method of gaging alertness.

Further evidence in this direction may be found in the body temperature curves and performance scores of Period III (fig. 5), when the group was on a "4-on, 8-off" watch schedule. Link Trainer performance was getting poorer during the 0000-0400 watch, when the body temperature was falling, and improving during the 1200-1600 watch, when the body temperature was rising. The uniformity of operating the Link Trainer was much greater in the afternoon than after midnight (fig. 12). On the other hand, much more coffee was consumed between midnight and 0400 than between noon and 1600. The extra coffee intake may have minimized the difference between the performance scores in the two watches and is, at any rate, an indirect indication of a lower alertness during the night watch. Reaction time to lights was also better in the afternoon (fig. 15), and here, too, it is impossible to say how much greater the difference might have been if coffee consumption had been prohibited or equalized in the two watches.

The validity of the temperature method was also supported by the hitherto unexplored data on individual characteristic temperature levels. If body temperature is to serve as index of efficiency, those with higher temperature levels should show better performance. In separating the group into two sections with respect to body temperature levels (fig. 17), it was quite unexpectedly found that the section, where temperature level was higher and less variable, performed much better on the Link Trainer than did the other section, and, of the tests employed, the operation of the Trainer came closest to the requirements of military duties. The difference in Trainer performance was especially striking when one compared the scores of subjects 7 and 6 The former, with the highest body temperature level of the entire group, ranked first in Link Trainer operation, both as regards the magnitude of scores and the uniformity of the subscores, whereas subject 6, with the lowest body temperature level (except for subject 10 who did not run the Trainer) ranked last.

The fact that the relationship between the height and stability of the body temperature level and excellence and uniformity of performance held for the Link Trainer operation and not for the two subsidiary tests has a two-fold significance. First, it suggests that an activity which requires memory, muscular coordination, an ability to attend to several indices simultaneously, as well as a prolonged maintenance of effort, is the type of activity where a high body temperature level shows its influence best. Second, it brings out the bearing which the type of test may have on the ranking of the subjects If only one or two of the tests had been used to rank the subjects, the results might be quite different than they were. By the color naming test, subject 6 would rank highest in the group, and subject 7, next to the last (table 3). On the other hand, subject 6 ranked last not only in Link Trainer performance (table 1), but also in reaction time (table 2). Thus, it cannot be concluded that a man who ranked highest in a certain test was the best man in the group. It appears rather, that there were several "best" men, each having talents that permitted him to excel in one type of activity. One man may qualify best for a job requiring sporadic bursts of attention (reaction time), another may do best at monotonous repetitious plodding (color naming), while a third is particularly fitted for complex many-sided tasks, exemplified by Link Trainer operation. A square peg should not be pushed into a round hold

Another difference between the two sections was in the respective consumption of coffee (table 5) The members of the first section drank, on the average, nearly three times as much coffee, during watch hours, as did those of the second section For the off-duty hours, the disparity between the two sections was even greater, the ratio rising to 8:1. That the situation was far from simple, however, can be seen from the scores of subject 10, who ranked highest in performance in both reaction time and color naming, while his mean body temperature level was the lowest of the entire group. Although this combination is not in contradiction with the findings on the other subjects (where the relationship between body temperature level and performance was found to apply to the Link Trainer operation from which subject 10 was excluded), it should be pointed out that this unusual performer was the only heavy coffee drinker in the low level body temperature section. Did the coffee help him? Or, in general, was greater coffee consumption, in part, the cause of the higher body temperature levels of the first section, or did the men of that section discover, by trial and error, that coffee contributed to their alertness and improved their performance?

While the group failed to flatten its diurnal body temperature curve on the dogged watch schedule, its adjustment to other schedules, as judged by the diurnal body temperature curves, was better, the less of a shift they involved from the usual shore routine. It must be admitted that the community pattern of living (meals, recreation, etc.) made adjustment to the several watch schedules harder than it would be on board ship, particularly a submarine. Thus, as could be expected, least satisfactory adjustment occurred during Period VII, when the watches were distributed between midnight and noon. It will be recalled that during this period the maximum body temperatures were attained at 1200, the hour of going to bed, instead of in the middle of the daily waking hours, as on other routines (fig. 10). The persistance of the normal diurnal body temperature curve during this period was also revealed in the matutinal upswing of the body temperature shown by each subject at 0600. Another evidence of maladjustment was the lack of practice improvement in reaction time, and even some regression in color naming, that occurred during this period.

The mean daily duration of sleep seemed to be related to the incidence of the hours of duty on the different watch schedules. The control or "normal" value for Periods I and VI, shore routine, was 8.1 hours. There was an increase, respectively, to 8.48 and 8.55 hours, during Periods III and V, when the subjects followed a "4-on, 8-off" schedule of watches. The dogged watch routine, with the hours of sleep changing daily, led to a somewhat greater increase in the duration of sleep, to 8.66 hours, while after-duty recreational activities in Period IV, caused a postponement of the hour of retiring, the duration of sleep being shortened to 7.5 hours. None of these deviations from the normal amounted to much more than half an hour, either way, but in Period VIII, when the men were free to sleep between midnight and noon, the mean duration of sleep was 10.1 hours, or just two hours longer than usual. This is a good indication of how much more sleep men will indulge in when there is nothing else to do, i.e., when the off-duty hours do not coincide with the recreational hours of the community.

There certainly was nothing about the required activities, during Period VIII, that might have tired the subjects more than in other periods and thus result in a greater need of sleep and rest. Escape from boredom is probably the best explanation of the additional two hours of sleep.

Another unexpected finding was the failure of the body temperature to reach the same mid-sleep minimum, on a shore routine of living, in July, as it did in April, in spite of the fact that the temperature and humidity of the air in the sleeping compartment were the same during these two months. The relatively cooler evenings in April brought the mean group body temperature down to 98.03 degrees at 2200, while the warm evenings in July kept the temperature at 98.48 degrees at the same hour. But four hours later, the midsleep temperatures were, respectively, 96.68 and 97.45 degrees, a difference of 0.77 degree, instead of 0.45. This greater difference was also in evidence at 0600, the hour of getting up. No explanation of this accentuated temperature drop during sleep can be offered at present.

In conclusion, it should be pointed out that the validity of the temperature method was tested only with respect to performance and behavior. No attempt was made to have the men give a subjective evaluation of their changing states of alertness or fatigue, as it was held that they would be swayed in their judgment by a positive or negative emotional attitude toward one or another schedule of watches.

SUMMARY

1. The diurnal body temperature curves of nine Navy recruits were modified, in a few days, to conform to a variety of experimental watch routines. The adjustment was better, the less the deviation from the usual watch schedule. There was no adjustment to the dogged watch routine which is followed on large surface warships.

2. Color naming, and to a lesser extent reaction time and Link Trainer performance, showed a diurnal variation, particularly on the dogged watch routine, the only one which permitted testing around the clock. Though the results were not always clear-cut, in a general way, the higher the body temperature, the better was the performance.

3. In operating the Link Trainer for 20 minutes, the higher the total performance scores, the more uniform were the 10 subscores for successive two minutes of testing.

4. During the entire experiment there was a remarkable maintenance of rank by each subject in the scores of the three tests, but high ranking in one test was sometimes associated with poor placing in another. No subject excelled in all three tests.

5. The group could be divided into two sections, with respect to their body temperature levels: one section had higher and less variable daily mean body temperatures than did the other.

6. The section with the higher body temperature level also had higher performance scores on the Link Trainer, suggesting a new type of temperature index of efficiency.

7. Consumption of coffee was very uneven, varying with (a) hours of the day, (b) watch routines, and (c) individual subjects. Relatively more coffee was consumed during watches in which the body temperature was low and falling. The high body temperature level section drank over three times as much coffee as did the other section.

8. During sleep, the body temperature did not fall as low in the summer as it did in the spring, in spite of the fact that the temperature and humidity of the air in the sleeping compartment were identical at all times.

9. The duration of sleep, under various watch schedules, did not deviate by more than half an hour, one way or the other, from the control value of 8 hours; except that in one period, when the leisure hours were mainly in the forenoon, the mean duration of sleep was over 10 hours.

ACKNOWLEDGMENTS

We are greatly indebted to the staff of the Institute for material assistance and numerous helpful suggestions in the course of this study, expecially to Albert R. Behnke, Captain, MC, USN, for suggesting the investigation, and to Dr. John P. Flynn, head of the Psychology and Statistics Facility, for constructive criticism of the manuscript. Particular thanks are due to Miss Adel L. Fochtmann and Miss Lucille C. Lay who conducted the Link Trainer tests, often at odd hours and considerable inconvenience to themselves, to the petty officers who helped with the reaction time and color naming tests and supervised the subjects around the clock, A. J. Goepfert, HMI, USN, C. H. Pichon, HMI, USN, and R. S. Rector, HMI, USN; and to Wave G. C. Supino, SA, USN, who spent countless hours in tabulating the data and calculating statistical values. Last, but not least, should be mentioned and acknowledged the fine spirit of cooperation shown by the subjects of the experiment: W. A. Buckley, SN, USN, F. J. Hepner, SN, USN; H. E. Jones, SN, USN; W. R. Kelly, SN, USN; A. L. Keltz, SA, USN, J. Kurnyta, SN, USN; W. McBurney, SN, USN, D. M. Mero, SA, USN; and J. H. Waddey, SN, USN.

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Table 1.- Mean scores (in minutes out of 20) for Link Trainer performance and ranking order of subjects

Period	Subject numbers																Period Means
	2		7		1		4		8		3		5		6		
	Scr.	Rnk.	Scr.	Rnk.	Scr.	Rnk.	Scr.	Rnk.	Scr.	Rnk.	Scr.	Rnk.	Scr.	Rnk.	Scr.	Rnk.	
II	8.1	4	11.8	1	9.9	3	11.4	2	6.9	5	3.8	6	3.0	8	3.1	7	7.3
III	12.5	5	17.9	1	17.1	2	17.1	3	14.0	4	9.2	6	8.9	7	7.5	8	13.0
IV	12.9	5	18.9	1	17.1	3	17.9	2	15.2	4	8.9	7	10.3	6	6.8	8	13.5
V	5.8	6	16.5	1	11.5	2	11.1	3	8.4	4	5.0	7	5.8	5	3.8	8	8.5
VI	10.9	5	17.5	1	15.1	2	14.7	3	11.1	4	8.4	6	6.3	7	3.0	8	10.9
Subject means	10.0	5	16.5	1	14.1	3	14.4	2	11.1	4	7.1	6	6.9	7	4.8	8	

Scr = Score (in minutes out of 20)

Rnk = Rank

Table 2 . Mean scores (in 0.01") for reaction times to light combinations and ranking order of subjects

Period	Subject numbers																		Period Means
	2		7		1		4		8		3		5		6		10		
	Scr.	Rnk.	Scr.	Rnk.	Scr.	Rnk.	Scr.	Rnk.	Scr.	Rnk.	Scr.	Rnk.	Scr.	Rnk.	Scr.	Rnk	Scr.	Rnk.	
II	78	4	67	2	110	8	109	7	96	5	58	1	98	6	144	9	76	3	93
III	67	6	54	3	80	8	66	5	61	4	50	1	68	7	103	9	50	2	67
IV	55	5	49	3	74	8	59	7	54	4	46	2	58	6	84	9	34	1	57
V	77	6	61	3	85	8	84	7	66	4	61	2	71	5	101	9	53	1	73
VI	67	6	54	3	83	8	74	7	60	4	50	2	63	5	83	9	44	1	64
VII	59	4	54	3	81	8	68	7	62	6	49	2	62	5	95	9	45	1	64
VIII	55	4	50	3	78	8	69	7	60	6	49	2	62	5	92	9	43	1	62
Subject means	65	4	56	3	84	8	76	7	66	5	52	2	69	6	100	9	49	1	

Scr = Score (in 0.1")

Rnk = Rank

Table 3   Mean scores (in seconds/100 colors) for color naming test and ranking order of subjects

Period	Subject numbers																		Period Means
	2		7		1		4		8		3		5		6		10		
	Scr	Rnk	Scr	Rnk	Scr	Rnk	Scr	Rnk	Scr	Rnk	Scr	Rnk	Scr	Rnk	Scr	Rnk	Scr	Rnk	
II	56	6	57	8	49	3	55	5	56	7	51	4	59	9	41	1 2	41	1 2	52
III	51	9	47	8	46	4	48	7	47	6	42	3	46	5	35	2	33	1	44
IV	48	9	46	7	44	5 6	46	8	43	4	38	3	44	5 6	32	2	32	1	42
V	46	8	44	6	46	9	45	7	40	4	35	3	43	5	32	1 2	32	1 2	40
VI	64	5	72	9	65	6	63	4	63	3	67	7	71	8	54	2	49	1	63
VII	66	4	72	7	70	6	67	5	74	8	63	3	82	9	62	2	46	1	67
VIII	65	6	64	5	62	4	66	7	66	8	61	3	69	9	54	2	45	1	61
Subject means	57	7	57	8	55	4	56	6	56	5	51	3	59	9	44	2	40	1	

Scr = Score (in second/100 colors)

Rnk = Rank

Table 4. - Mean oral temperature levels (Degrees F.) and ranking order of subjects   All periods, 11 Apr to 2 Sep 1949

Period	Subject numbers																		Period Means	Mean external temp °F
	2		7		1		4		8		3		5		6		10			
	Temp	Rnk	Temp	Rnk	Temp	Rnk	Temp	Rnk	Temp	Rnk	Temp	Rnk	Temp	Rnk	Temp	Rnk	Temp	Rnk		
I	98.13	2	98.17	1	98.04	4	98.11	3	98.02	5	97.72	9	97.99	6	97.89	7	97.80	8	97.99	61.5
II	98.21	3 4	98.23	2	98.21	3 4	98.08	6	98.14	5	97.95	7-8	98.24	1	97.95	7-8	97.76	9	98.09	65.1
III	98.34	2	98.35	1	98.14	6	98.15	5	98.31	3	98.02	8	98.22	4	97.89	9	98.10	7	98.17	74.5
IV	98.35	4	98.39	2-3	98.20	6	98.18	7	98.42	1	98.26	5	98.39	2 3	98.14	8	98.13	9	98.27	79.3
V	98.43	3	98.53	1	98.24	8	98.32	5	98.31	6	98.38	4	98.46	2	98.25	7	98.18	9	98.34	79.4
VI	98.41	2	98.49	1	98.28	6	98.23	7	98.33	5	98.34	4	98.39	3	98.22	8	98.17	9	98.32	82.6
VII	98.35	3	98.50	2	98.20	7	98.09	8	98.33	4	98.29	5	98.53	1	98.22	6	97.97	9	98.28	77.6
VIII	98.48	2	98.52	1	98.18	8	98.16	9	98.42	3	98.32	5-6	98.40	4	98.32	5-6	98.26	7	98.34	76.3
Subject means	98.34	2	98.40	1	98.19	5	98.17	6	98.29	4	98.16	7	98.33	3	98.11	8	98.05	9	98.23	
	Section mean 98.28										Section mean 98.16									
Mean inter-period fluctuation	.073		.061		.069		.081		.089		.111		.121		.087		.137		.067	
	Section mean .075										Section mean .114									

Temp = Temperature levels (Degrees F.)

Rnk = Rank

Table 5.- Cups of coffee consumed by each subject, on and off duty, during successive periods

Periods	Subject numbers																					
	2		7		1		4		8		3		5		6		10		2,7,1,4,8		3,5,6,10	
	on	off	on	off	on	off	on	off	on	off	on	off	on	off	on	off	on	off	on	off	on	off
I	25	9	0	2	16	52	3	1	2	0	1	1	6	0	3	0	0	0	46	64	10	1
II	31	6	20	3	7	30	12	2	5	2	2	4	11	0	3	0	40	2	75	43	56	6
III	24	0	23	1	16	24	15	1	12	0	1	12	19	0	0	9	43	1	90	26	63	22
IV	7	1	2	0	2	13	5	2	2	0	2	0	0	0	0	0	7	0	18	16	9	0
V	31	11	18	2	2	23	14	1	14	0	0	0	4	0	0	0	13	0	79	37	17	0
VI	70	19	29	4	18	27	15	3	8	0	0	1	0	0	0	0	0	0	140	53	0	1
VII	32	35	2	4	19	26	4	7	6	4	0	1	9	1	0	0	0	0	63	76	9	2
VIII	29	34	5	3	17	14	5	5	1	6	1	2	4	1	0	0	0	0	58	62	5	3
Subject means	249	115	100	19	97	209	73	22	50	12	7	21	53	2	6	9	103	3	569	377	169	35

on = on-duty hours

off = off-duty hours

Figure 1 "SHORE" ROUTINE OF WATCHES, with hours of duty *(indicated in thick line)* 0800-1200 and 1300-1700, for PERIOD I, 11 April to 6 May, 1949

TOP Mean diurnal oral temperature (°F) curve of group of nine (9) subjects

MIDDLE Total number of cups of coffee consumed by group in successive two-(2-) hour intervals during the entire period.

BOTTOM Percentage distribution of incidence of sleep (shaded area) and wakefulness (light area), respectively, for successive hours of night and day, based on 4656 man-hours.

Mean hours of sleep per man per twenty-four (24) hours--8.11.

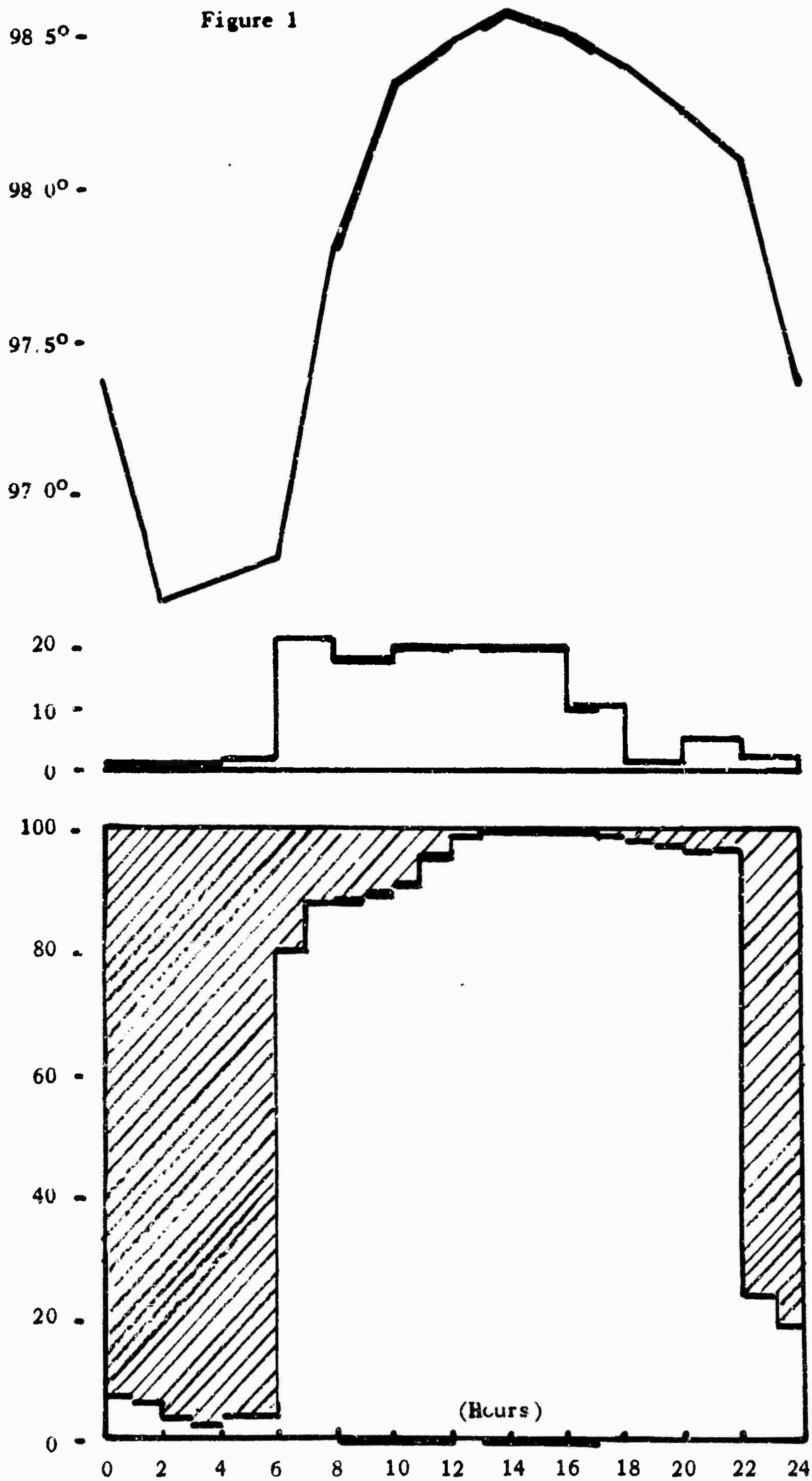


Figure 1
98 5°
98 0°
97.5°
97 0°
20
10
0
100
80
60
40
20
0
(Hours)
0 2 4 6 8 10 12 14 16 18 20 22 24

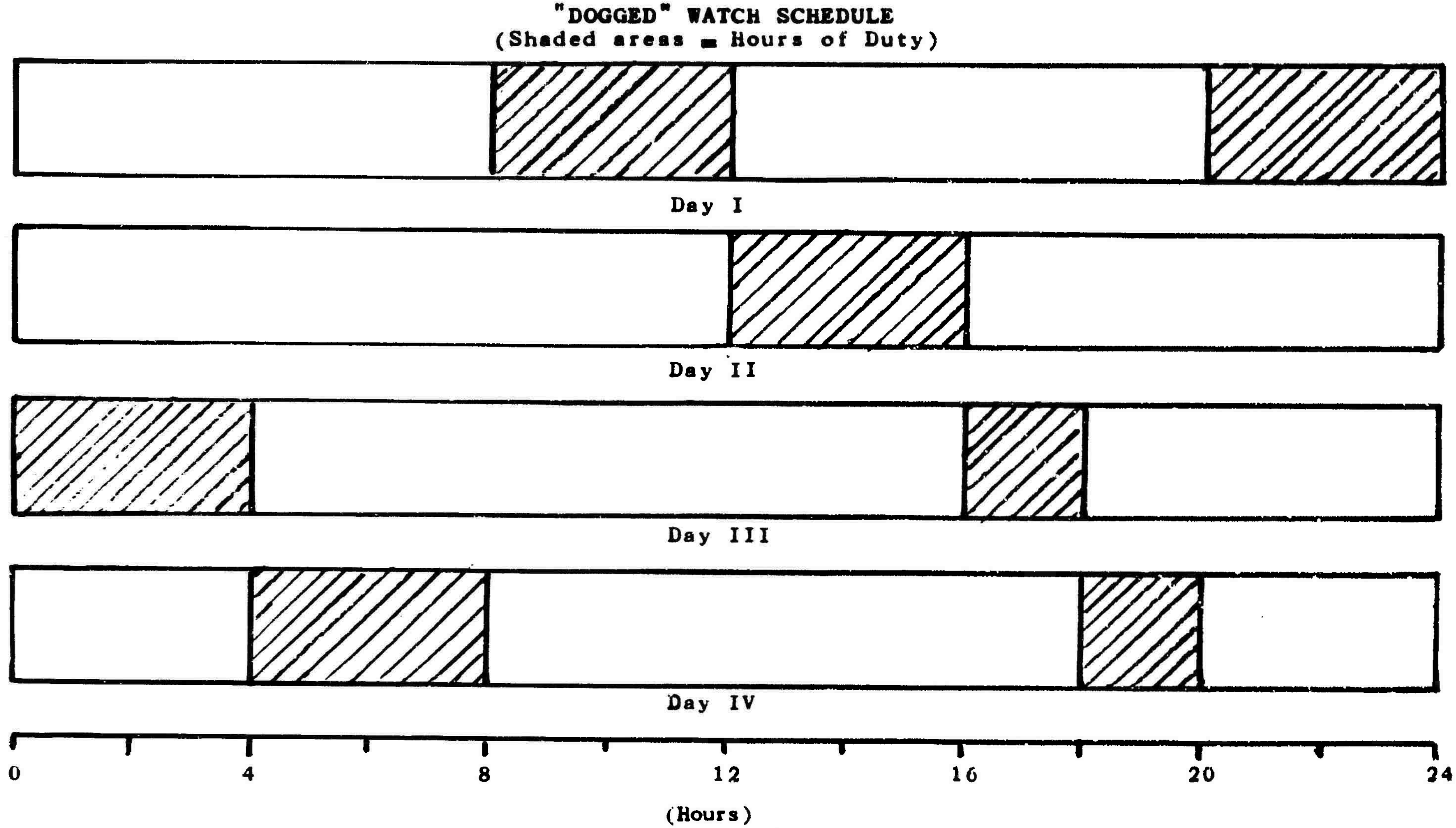

"DOGGED" WATCH SCHEDULE
(Shaded areas = Hours of Duty)
Day I
Day II
Day III
Day IV
0
4
8
12
16
20
24
(Hours)

Figure 2

Figure 3 - **"DOGGED" ROUTINE OF WATCHES**, with hours of duty rotated around the clock, four (4) or two (2) hours at a time, and a total of twenty-four (24) hours of duty in ninety-six (96) hours of elapsed time (i e four days) for **PERIOD II**, 9 May, 1949

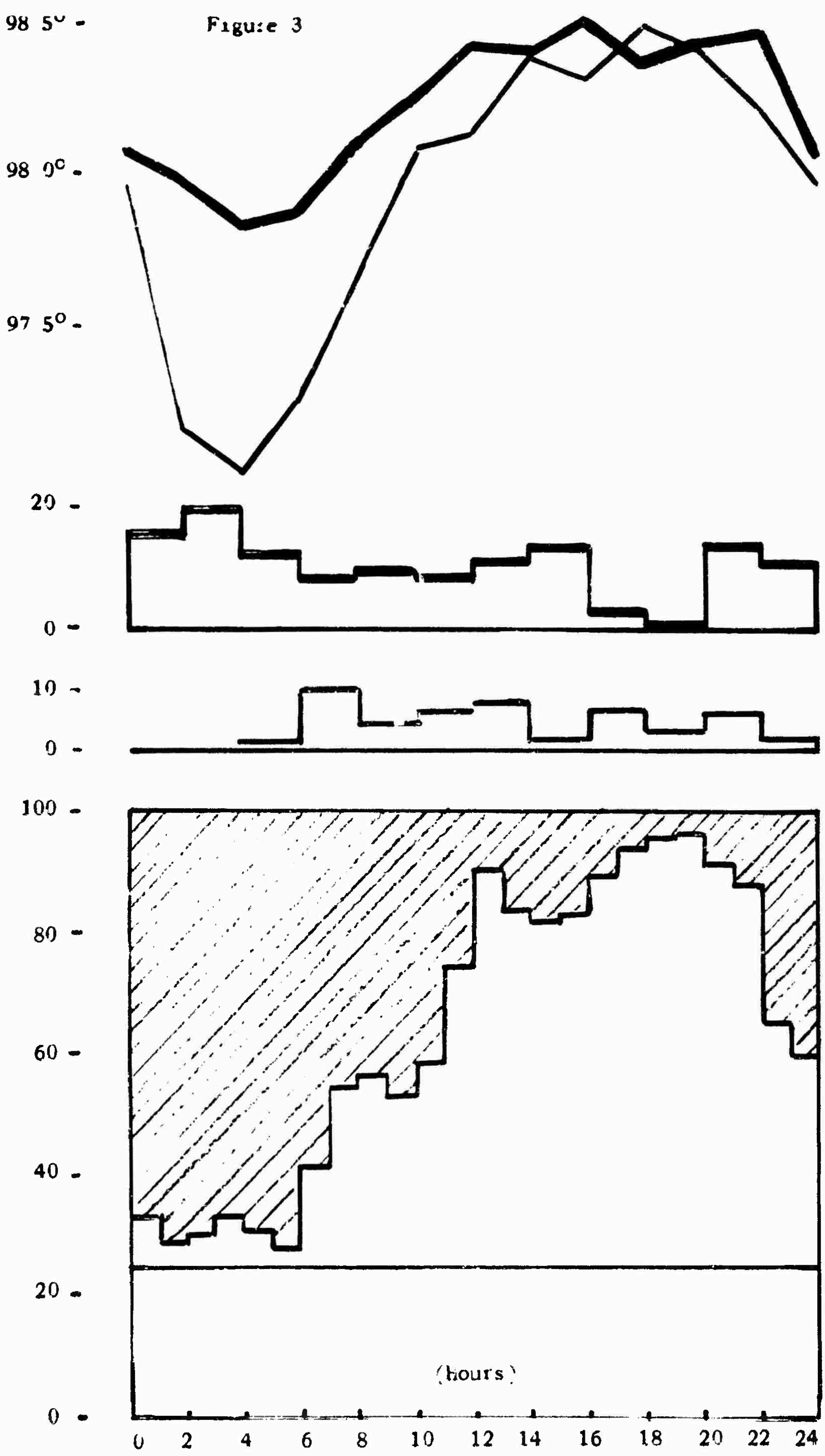
TOP: Superimposed mean diurnal temperature ($^{\circ}$F) curves of group of same subjects as in figure 1, with temperatures during *ON* duty hours in thick line, and those during *OFF* duty hours, including sleep, in thin line

MIDDLE Total number of cups of coffee consumed by entire group in successive two-(2) hour intervals, *ON* duty (upper portion) and *OFF* duty (lower portion)

BOTTOM Percentage distribution of incidence of sleep (shaded area) and wakefulness (light area), respectively, for successive hours of night and day; based on 3456 man-hours A twenty-five (25) per cent minimal wakefulness (shown by line), was imposed by the requirements of the "DOGGED" routine of watches

Mean hours of sleep per man per twenty four (24) hours--8 66

Figure 3


98 5°
98 0°
97 5°
20
0
10
0
100
80
60
40
20
0
(hours)
0
2
4
6
8
10
12
14
16
18
20
22
24

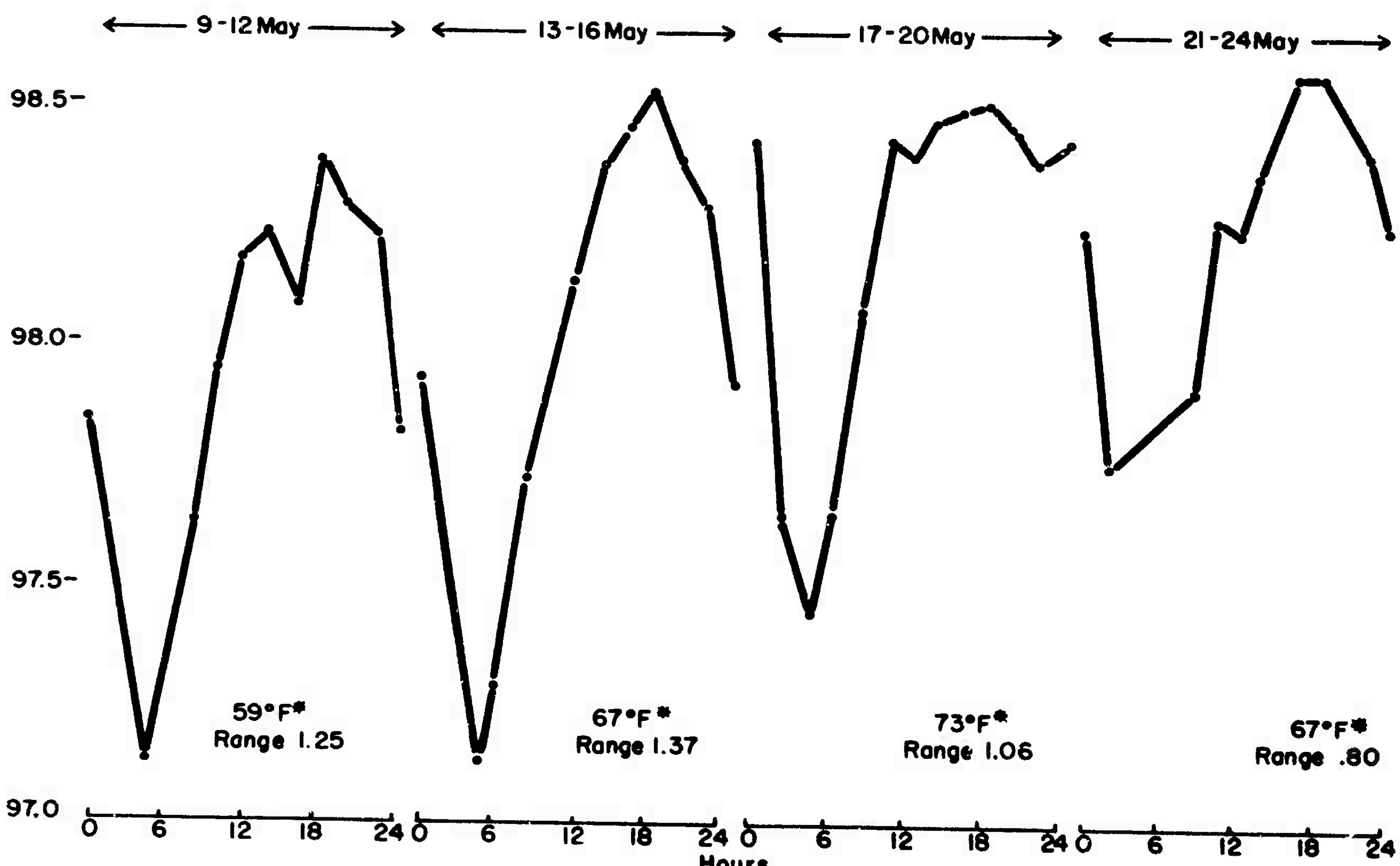


Figure 4.-Mean diurnal oral temperature (°F) curves of group in four (4) successive four (4-) day periods of the "DOGGED" routine of watches.

* Mean external temperature of each four-day period.

Figure 5.- "4-ON, 8-OFF" ROUTINE OF WATCHES, with hours of duty 0000-0400 and 1200-1600, for PERIOD III, 4 June to 18 June, 1949.

TOP: Same as in figure 1.

MIDDLE: Same as in figure 1.

BOTTOM: Same as in figure 1.

Based on 3048 man hours.

Mean hours of sleep per man per twenty-four (24) hours--8.48.

Figure 5

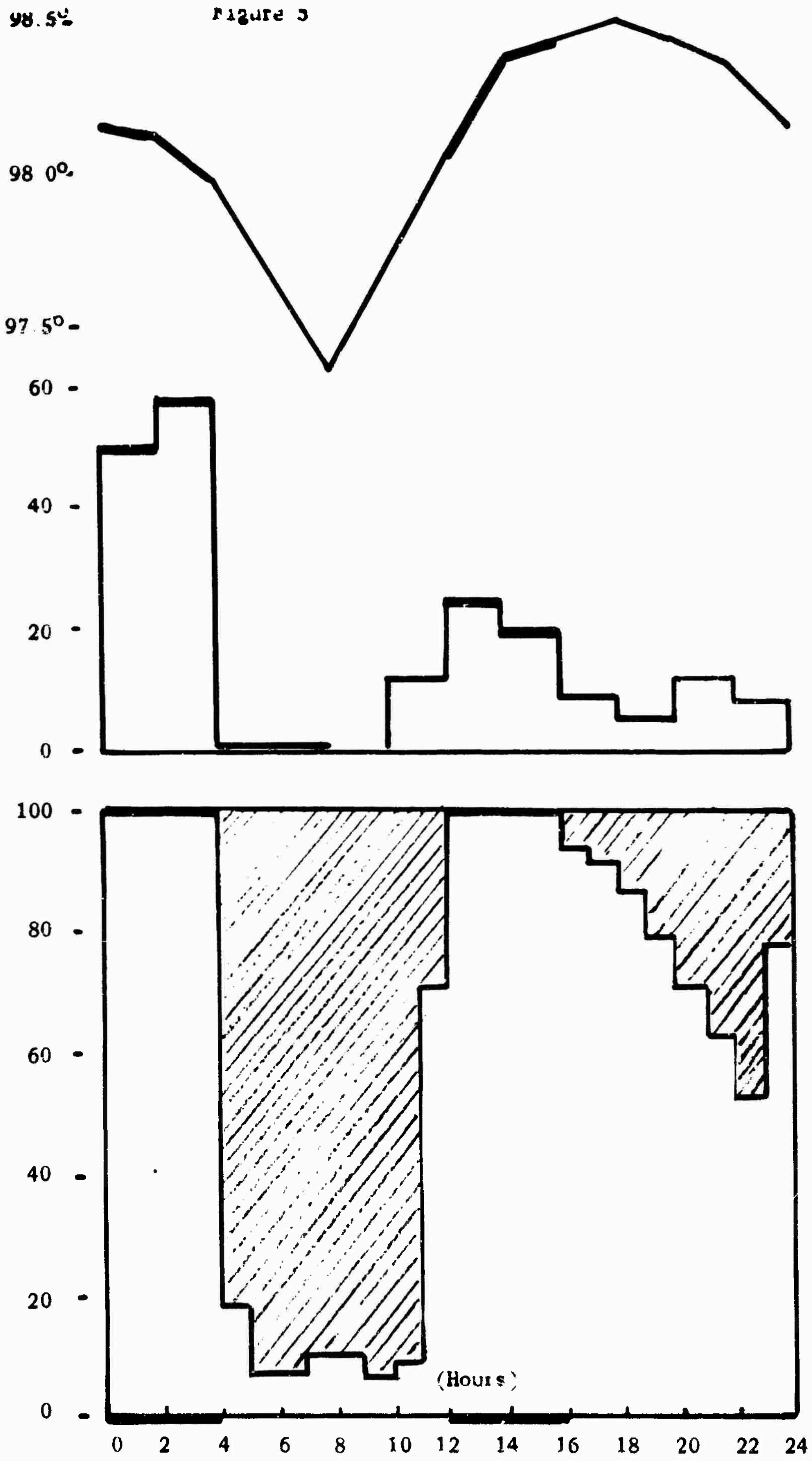

98.5°
98.0°
97.5°
60
40
20
0
100
80
60
40
20
0
(Hours)
0 2 4 6 8 10 12 14 16 18 20 22 24

Figure 6.- "CLOSE" ROUTINE OF WATCHES, with hours of duty 0800-1100, 1300-1600, and 1800-2000, for PERIOD IV, 19 June to 1 July, 1949.

TOP: Same as in figure 1.

MIDDLE: Same as in figure 1.

BOTTOM: Same as in figure 1.

Based on 2616 man-hours

Mean hours of sleep per man per twenty-four (24) hours--7.5.

Figure 6

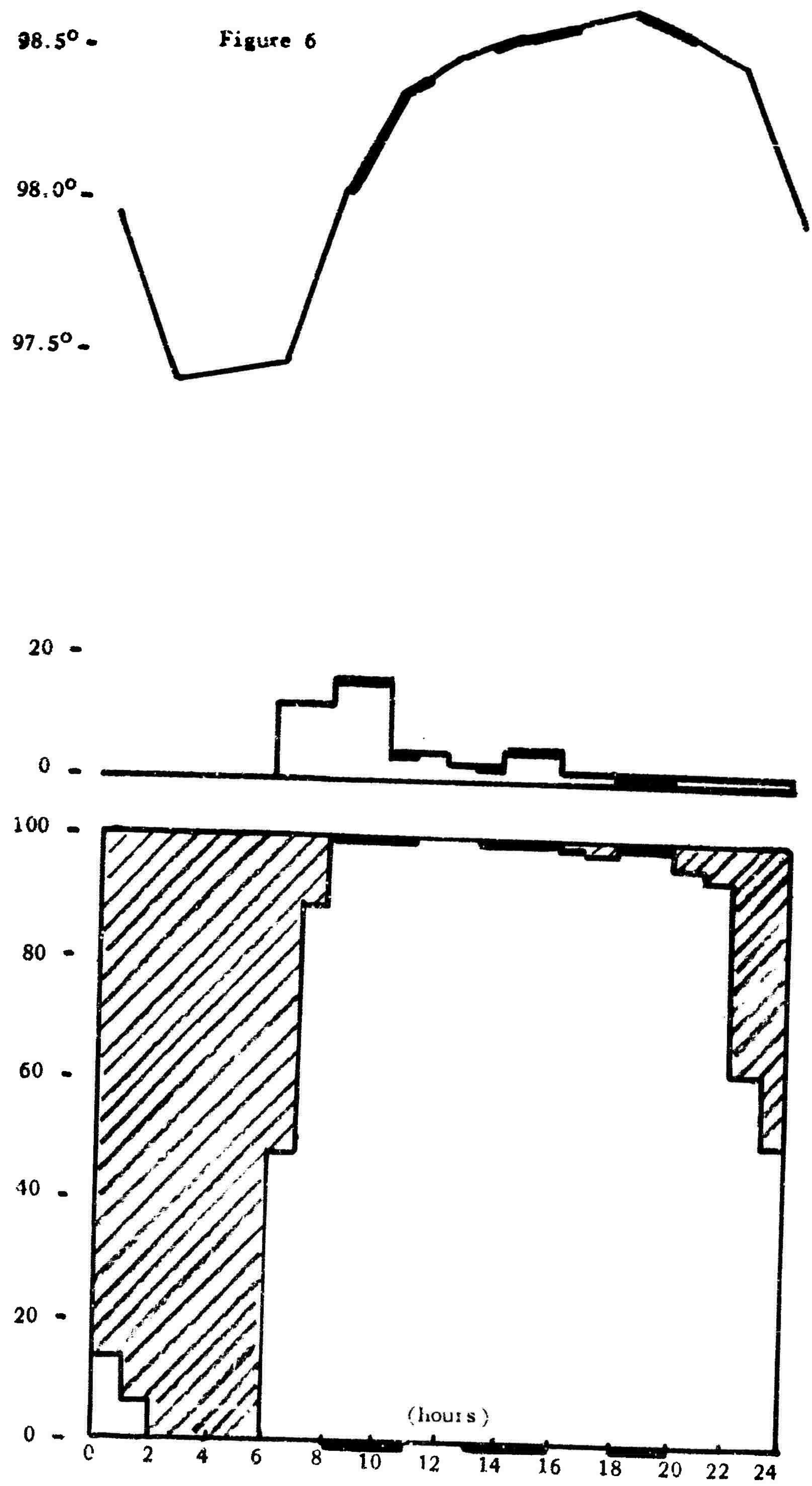

98.5°
98.0°
97.5°
20
0
100
80
60
40
20
0
0 2 4 6 8 10 12 14 16 18 20 22 24
(hours)

Figure 7 - "4-ON, 8-OFF" **ROUTINE OF WATCHES**, with hours of duty 0800-1200 and 2000-2400, for **PERIOD** V, 5 July to 17 July, 1949.

TOP: Same as in figure 1.

MIDDLE: Same as in figure 1.

BOTTOM: Same as in figure 1.

Based on 2640 man-hours.

Mean hours of sleep per man per twenty-four (24) hours--8.55.

Figure 7

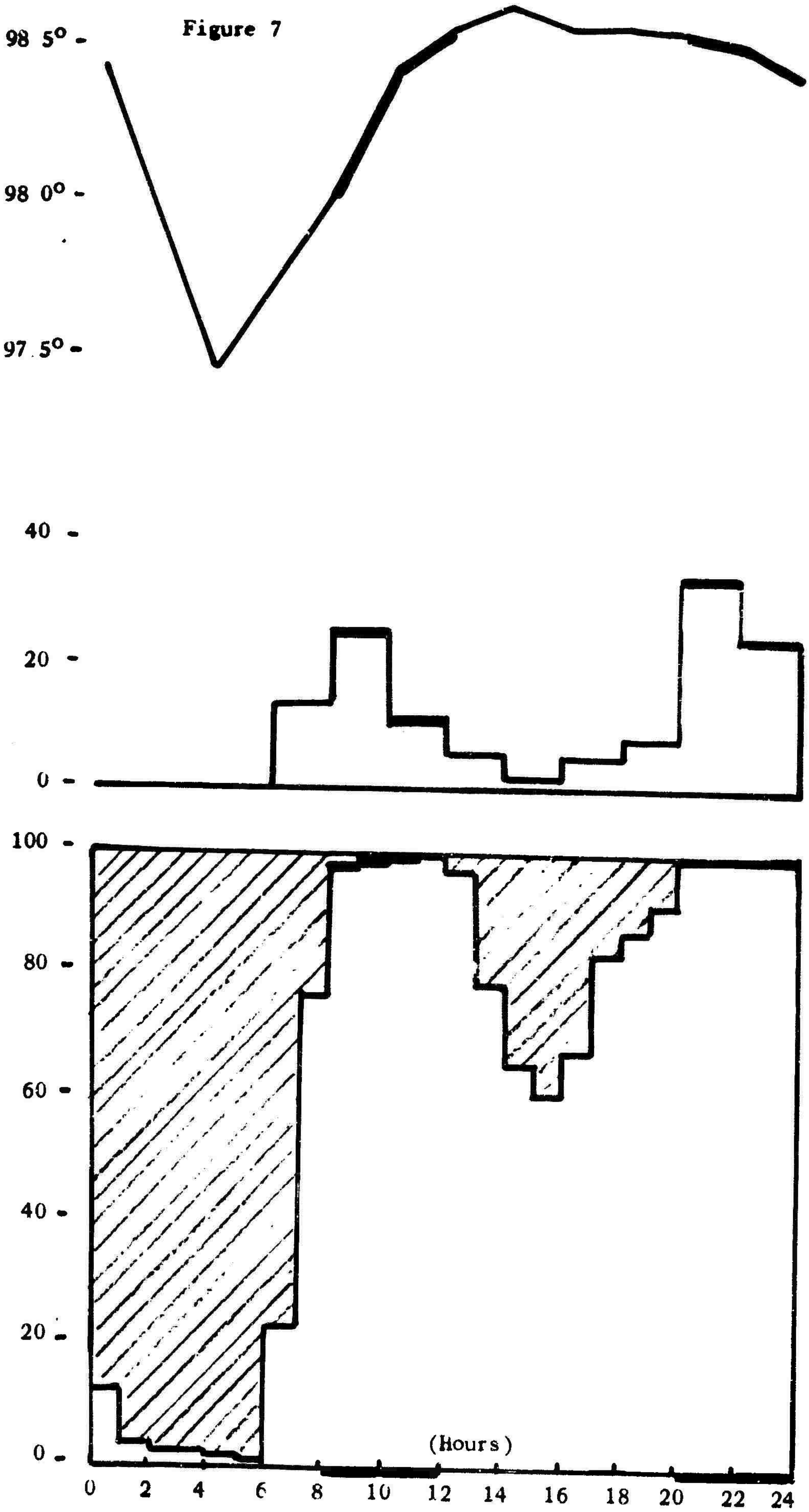

98 5°
98 0°
97.5°
40
20
0
100
80
60
40
20
0
(Hours)
0 2 4 6 8 10 12 14 16 18 20 22 24

Figure 8. "SHORE" ROUTINE OF WATCHES, with hours of duty 0800-1200 and 1300-1700, for PERIOD VI, 18 July to 7 August, 1949.

TOP: Same as in figure 1.

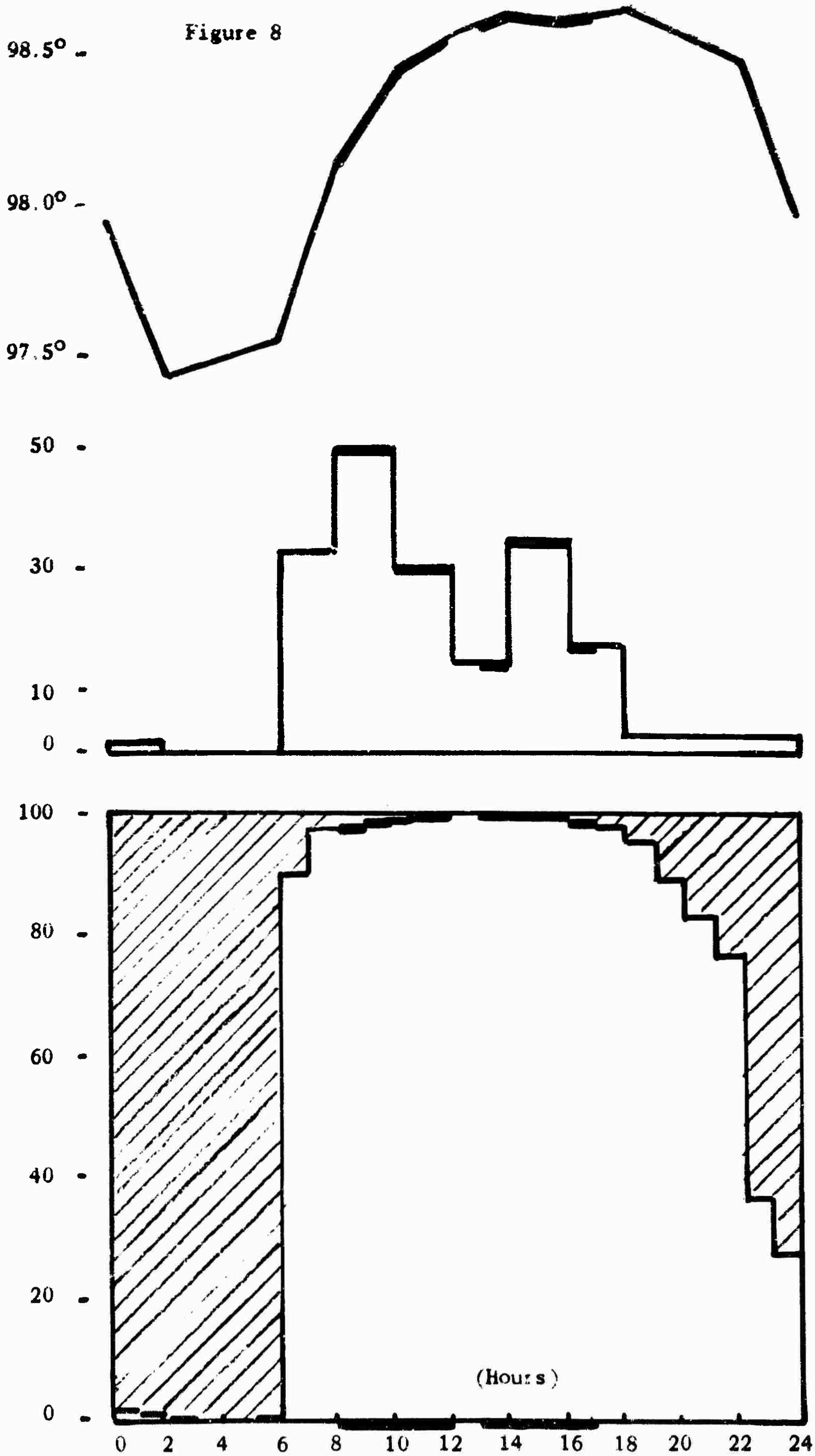
MIDDLE: Same as in figure 1.

BOTTOM: Same as in figure 1.

Based on 4224 man-hours.

Mean hours of sleep per man per twenty-four (24) hours--8.05.

Figure 8



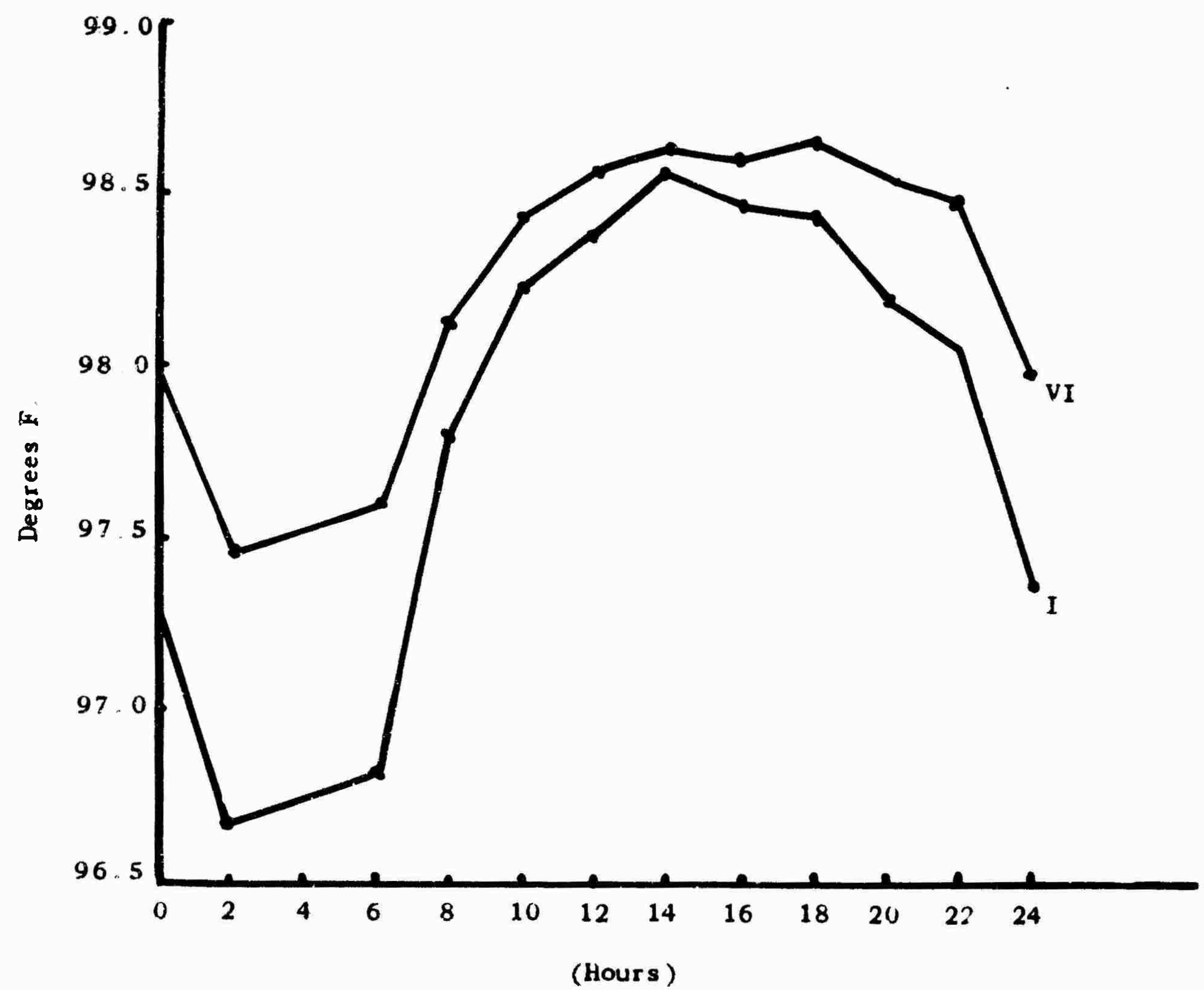
98.5°
98.0°
97.5°
50
30
10
0
100
80
60
40
20
0
(Hours)
0
2
4
6
8
10
12
14
16
18
20
22
24

Figure 9.- Comparison between mean diurnal temperature curves of group during two (2) periods of "SHORE" routine of watches.

UPPER CURVE: Taken from figure 8, showing a range of 1.20°F., is for Period VI of 18 July to 7 August, 1949; when the mean EXTERNAL air temperature was 82.6°F.

LOWER CURVE: Taken from figure 1, showing a range of 1.88°F., is for Period I of 11 April to 6 May, 1949; when the mean EXTERNAL air temperature was 61.5°F.

The mean difference between the two (2) sets of temperature curves was 0.35°F., statistically highly significant ($P < 0.01$).



99.0
98.5
98.0
97.5
97.0
96.5
Degrees F
0
2
4
6
8
10
12
14
16
18
20
22
24
(Hours)
VI
I

Figure 9

Figure 10.-- "CLOSE" ROUTINE OF WATCHES, with hours of duty 0000-0200, 0400-0700, and 0900-1200, for PERIOD VII, 8 August to 21 August, 1949.

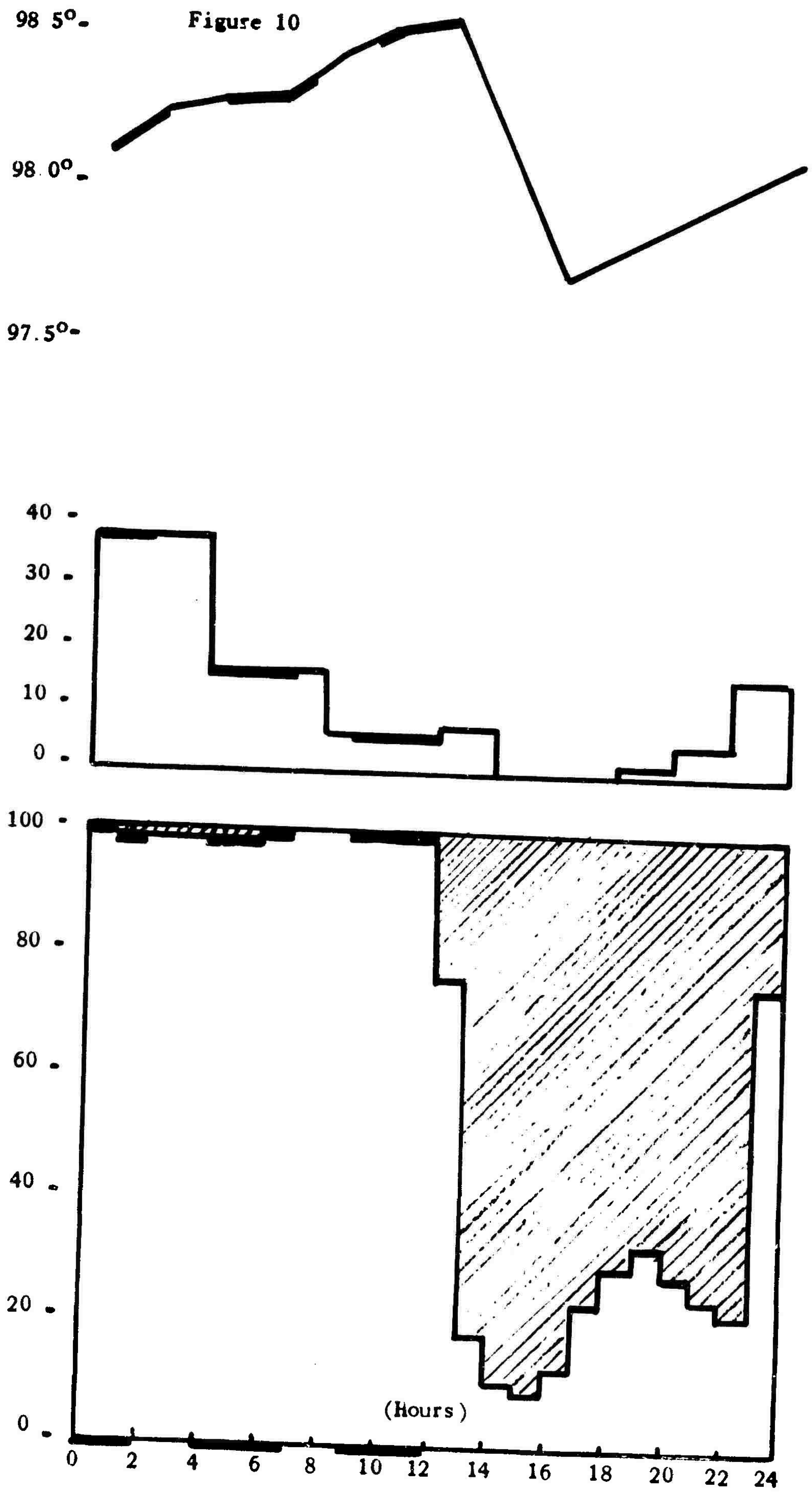
TOP: Same as in figure 1.

MIDDLE: Same as in figure 1.

BOTTOM: Same as in figure 1.

Based on 2784 man-hours.

Mean hours of sleep per man per twenty-four (24) hours--8.4.



98 5°
Figure 10
98.0°
97.5°
40
30
20
10
0
100
80
60
40
20
0
(Hours)
0
2
4
6
8
10
12
14
16
18
20
22
24

Figure 11.- "CLOSE" ROUTINE OF WATCHES, with hours of duty 1200-1500, 1700-2000, and 2200-2400, for PERIOD VIII, 22 August to 2 September, 1949.

TOP: Same as in figure 1.

MIDDLE: Same as in figure 1.

BOTTOM: Same as in figure 1.

Based on 2592 man-hours.

Mean hours of sleep per man per twenty-four (24) hours--10.1.

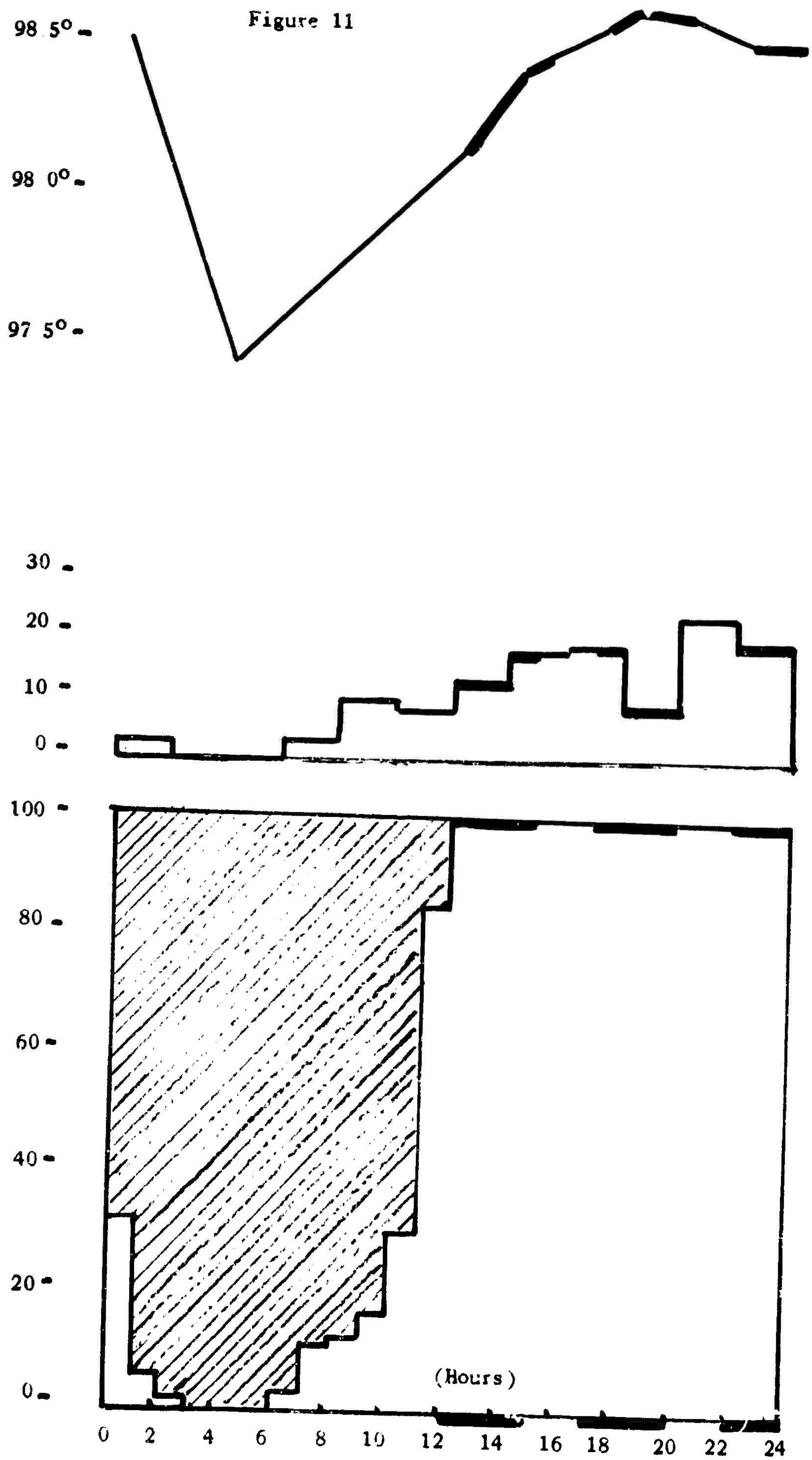


Figure 11
98 5°
98 0°
97 5°
30
20
10
0
100
80
60
40
20
0
(Hours)
0
2
4
6
8
10
12
14
16
18
20
22
24

Figure 12.- Variations in the group mean percentage subscores for ten successive 2-minute intervals of the 20-minute tests of Link Trainer performance, for Periods II to VI, inclusive. The actual absolute mean group scores, in minutes, are given next to the period number, the mean group subscores being 0.1 or 10 per cent of actual scores. The mean percentage subscores, always ten per cent irrespective of the absolute score values, are represented by horizontal broken lines running through the 13 graphs. The numerical values placed above the graphs are the coefficients of variation (in per cent) of the mean group percentage subscores for the watch periods indicated under the graphs.

The more variable the ten percentage subscores, the higher the coefficients of variation. Note that the highest subscores were always attained during the first 2-minute fraction of the 20-minute test and was usually followed by a sharp decrement. The subsequent fluctuations are, in part, due to the characteristics of the pattern the subjects were required to follow in operating the Link Trainer during a particular period.

Note the difference in scale between the graphs for Period II and those for all subsequent periods.

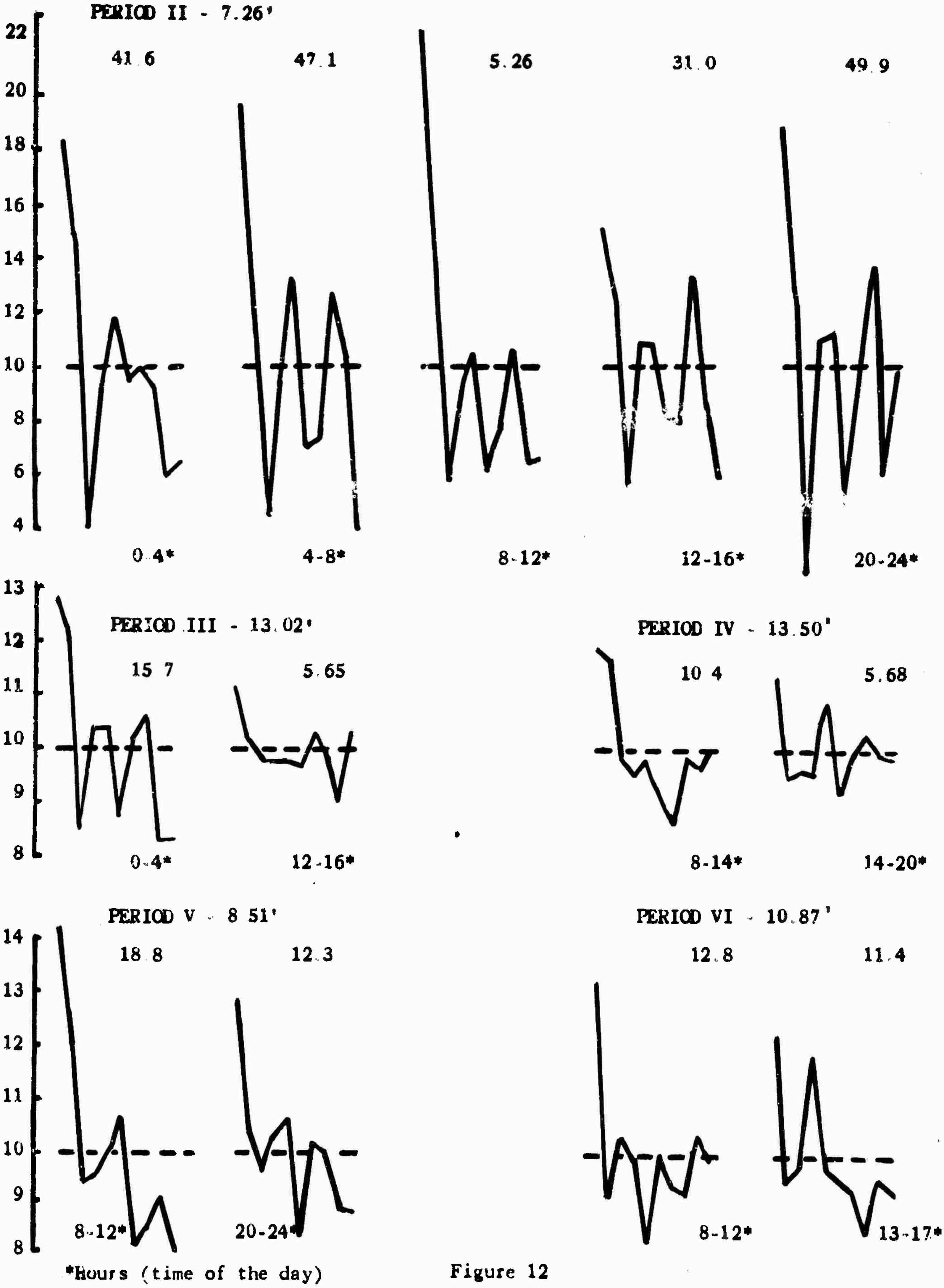
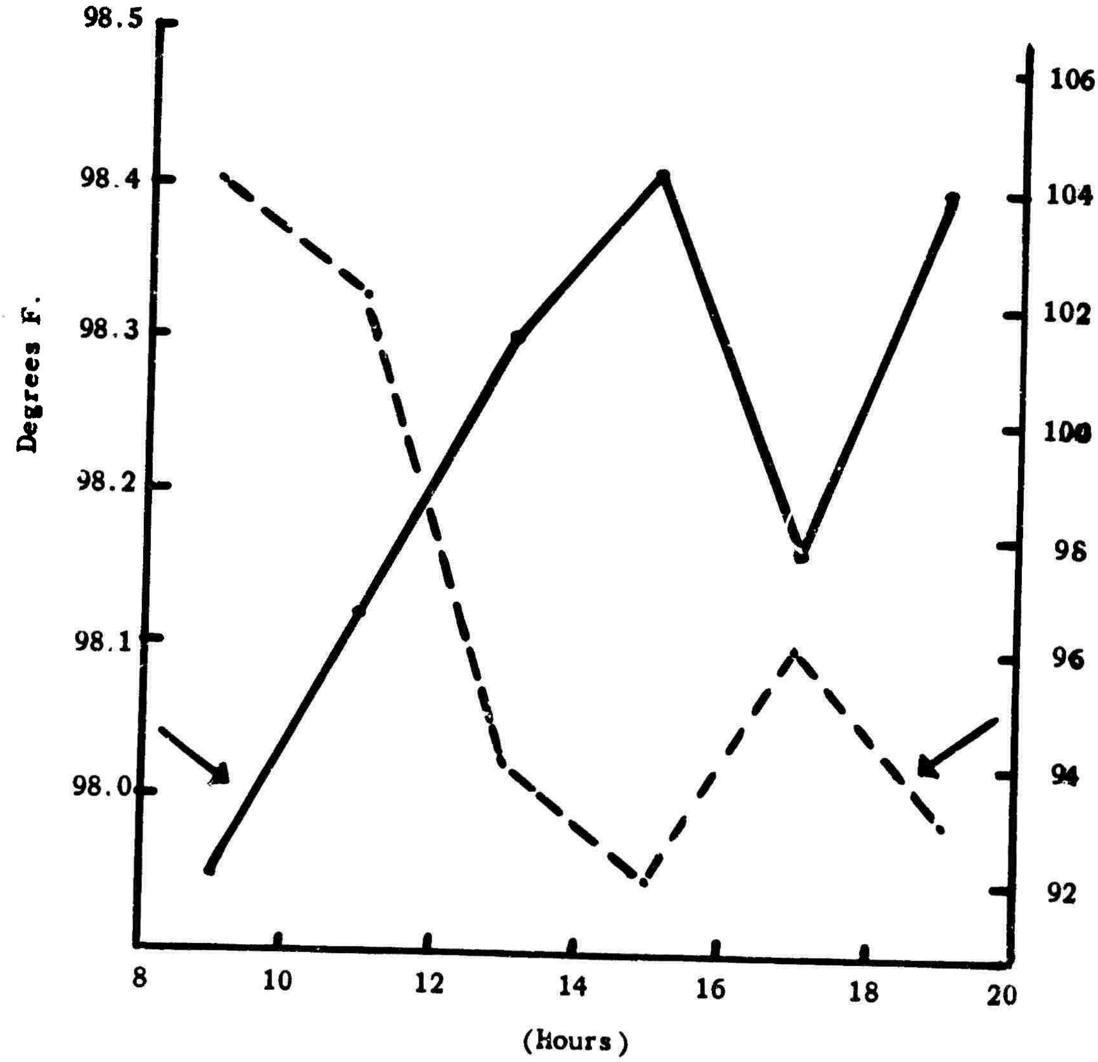

PERIOD II - 7.26'
41.6
47.1
5.26
31.0
49.9
0-4*
4-8*
8-12*
12-16*
20-24*
PERIOD III - 13.02'
15.7
5.65
0-4*
12-16*
PERIOD IV - 13.50'
10.4
5.68
8-14*
14-20*
PERIOD V - 8.51'
18.8
12.3
8-12*
20-24*
PERIOD VI - 10.87'
12.8
11.4
8-12*
13-17*
*Hours (time of the day)
Figure 12

Figure 13.- Variations in group mean oral temperature (solid line), taken at the time of test administration during Period II, "dogged" watch routine, and concomitant variations in group mean reaction time to different combinations of lights, expressed as percentage of total group mean (broken line). The correlation coefficient between these two variates was -0.9472 ($P<0.01$).

(It will be noted that the correlation shown applied only to tests made during the usual waking hours, from 0800 to 2000.)



98.5
98.4
98.3
98.2
98.1
98.0
Degrees F.
106
104
102
100
98
96
94
92
Per cent
8
10
12
14
16
18
20
(Hours)

Figure 13

Figure 14.- Dots represent deviations of mean individual oral temperatures taken at the time of test administration from the total mean testing time temperature of each subject (in one-hundredths of a degree F.) and concomitant percentage deviations of the mean individual score for reaction time to different combinations of lights from the total mean reaction time score of that subject, during Period III, "4-on, 8-off" routine, hours of duty, 0000-0400 and 1200-1600. Each subject furnished four combinations of temperature and reaction time deviations, making 36 in all.

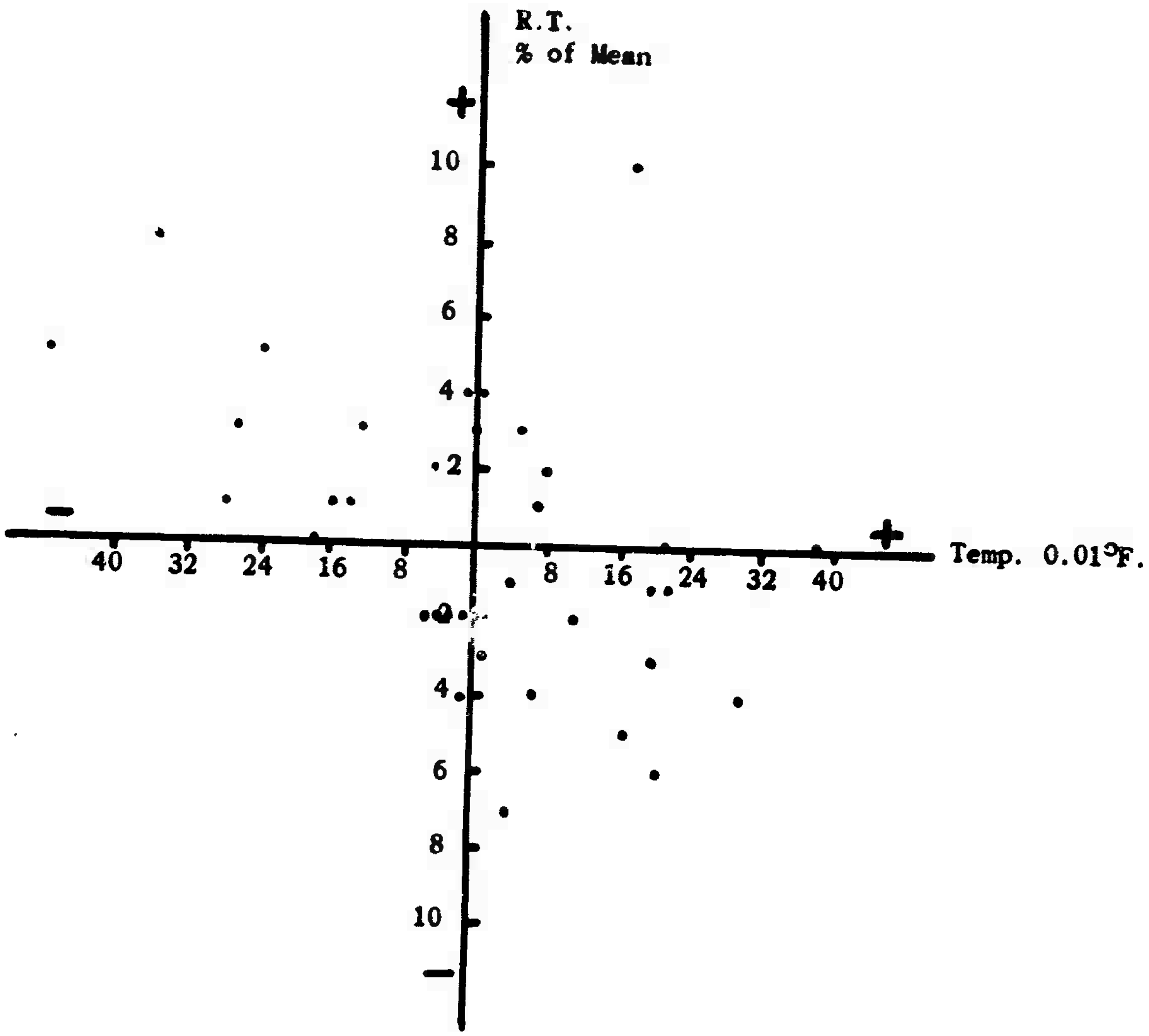
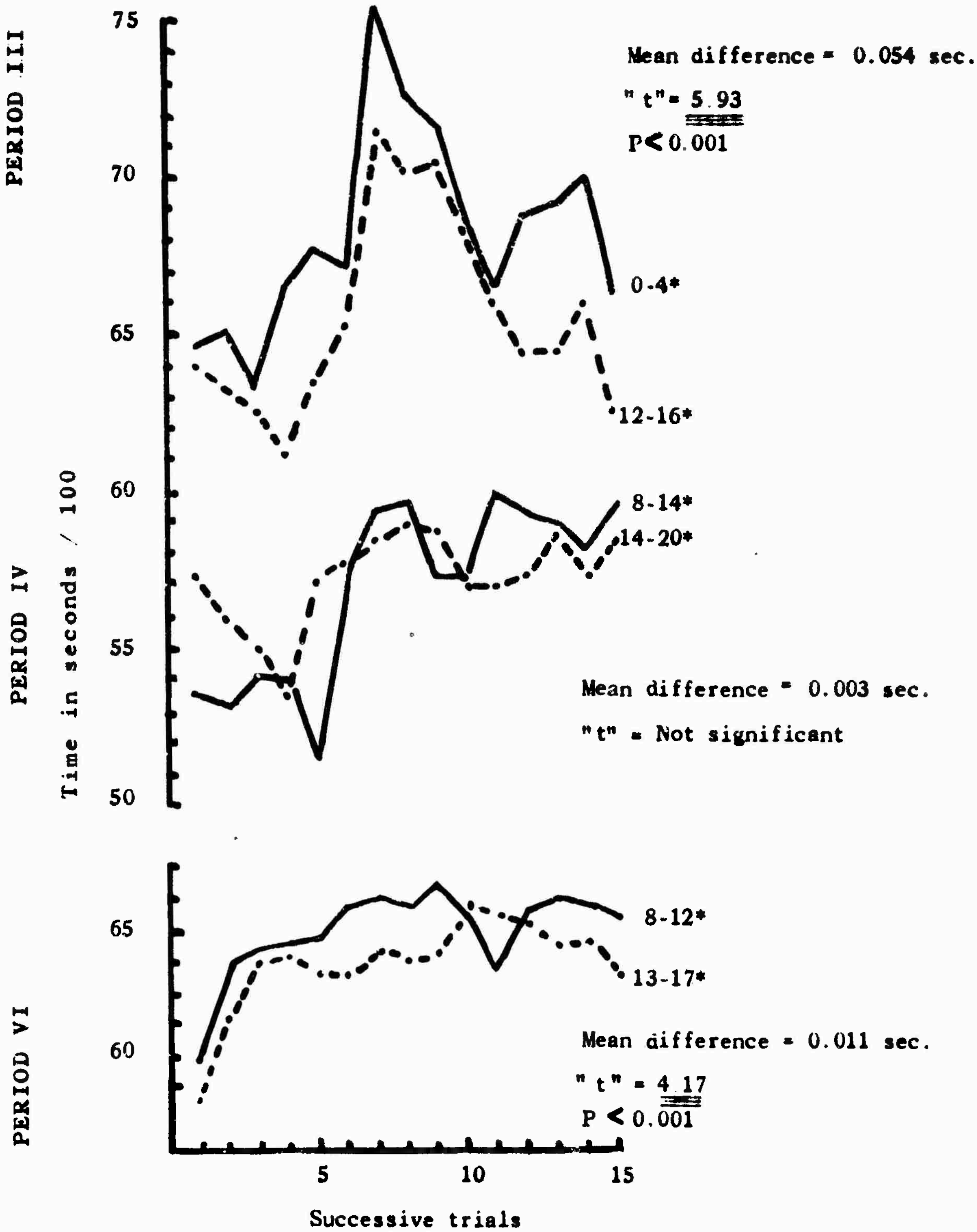


Figure 14

Figure 15.- Group mean scores (in one-hundredths of a second) for reaction time to different combinations of lights, for the 15 consecutive trials of this test, during Periods III, IV, and VI. Solid and broken lines correspond to series of trial scores obtained during the different watches of each period.



*Hours (time of the day)

Figure 15

Figure 16.- Variations in group mean oral temperature (solid line), taken at the time of test administration during Period II, "dogged" watch routine, and concomitant variations in mean time required to name 600 colors, the latter expressed as percentage of total group mean score (broken line). The correlation coefficient between these two variates was -0.8874 ($P < 0.01$).

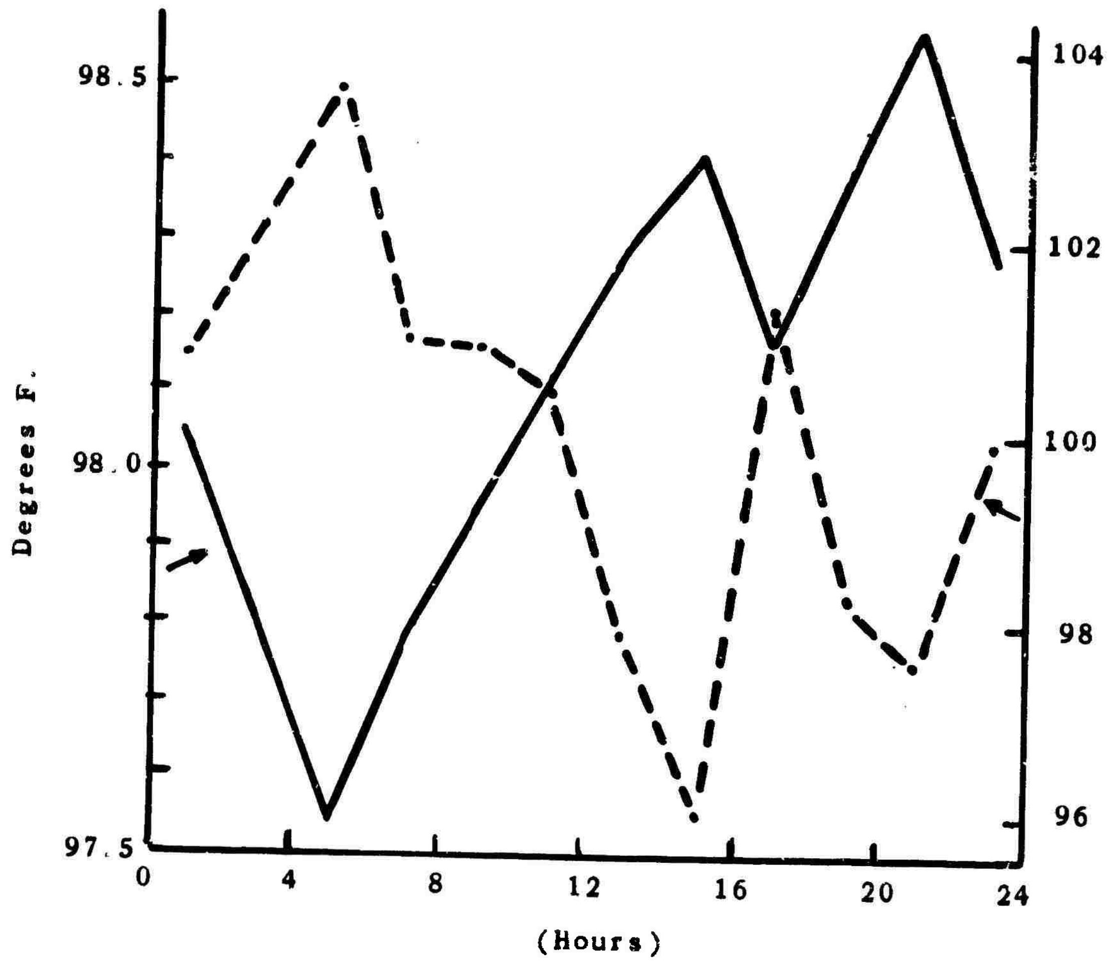
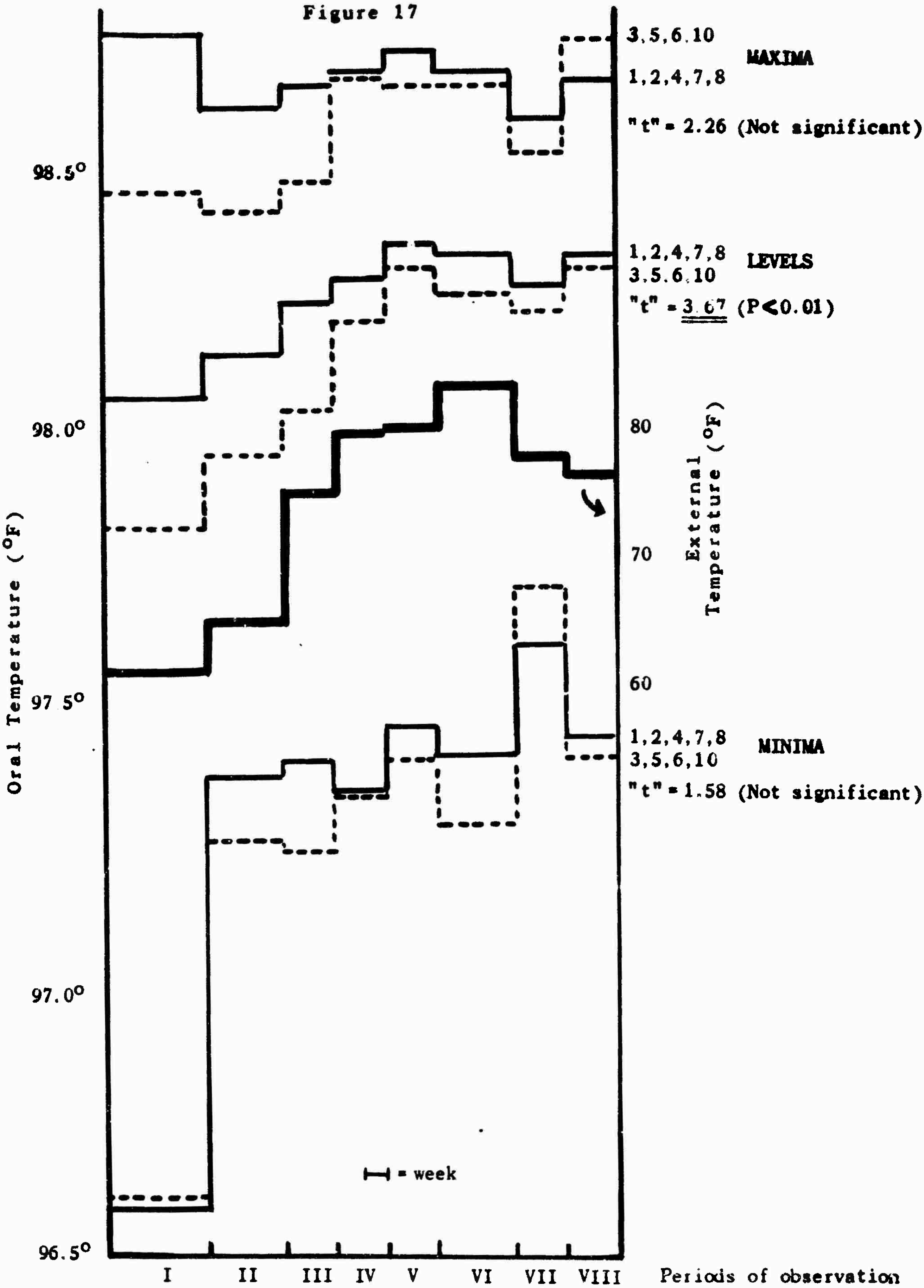

98.5
98.0
97.5
Degrees F.
104
102
100
98
96
Per cent
0
4
8
12
16
20
24
(Hours)

Figure 16

Figure 17.- Comparison between the mean oral temperatures of two (2) sections of the group for successive periods of DIFFERENT watch routines. Temperatures of subjects #1,2,4,7, and 8 are shown in solid lines; and temperatures of subjects #3,5,6, and 10 are shown in broken lines.

TOP, MIDDLE, and BOTTOM are, respectively, histograms of mean diurnal temperature (scale on the left) maxima, levels, and minima of the two (2) sections. Thick line graph in the middle portion indicates variations in the mean external temperature (scale on the right) during the successive periods of observation.

Figure 17


3,5,6,10
MAXIMA
1,2,4,7,8
"t" = 2.26 (Not significant)
98.5°
1,2,4,7,8
LEVELS
3,5,6,10
"t" = 3.67 (P<0.01)
98.0°
80
70
External Temperature (°F)
60
97.5°
Oral Temperature (°F)
1,2,4,7,8
MINIMA
3,5,6,10
"t" = 1.58 (Not significant)
97.0°
= week
96.5°
I
II
III
IV
V
VI
VII
VIII
Periods of observation

APPENDIX

SAMPLE OF RECORD SHEET THAT WAS FILLED IN DAILY BY EACH OF THE SUBJECTS

Name: ______________________________

Date. ______________________________

	0000		0200		0400		0600		0800		1000		1200
Activity													
Temp.													

	1200		1400		1600		1800		2000		2200		2400
Activity													
Temp.													

Remarks:

Code:

▭ .... Sleep

↑↑ (big meals) ..... Eating

↑ (small meals)/snacks .... Eating

D .... Duties (non recreational)

R .... Reading

W .... Writing

B .... Ball games or similar activity

⟷ .... Liberty

├──┤ .... Link Trainer

L .... Lounging (not asleep)

G .... Cards or games

t .... Tea

c .... Coffee or coke

a .... Liquor or beer