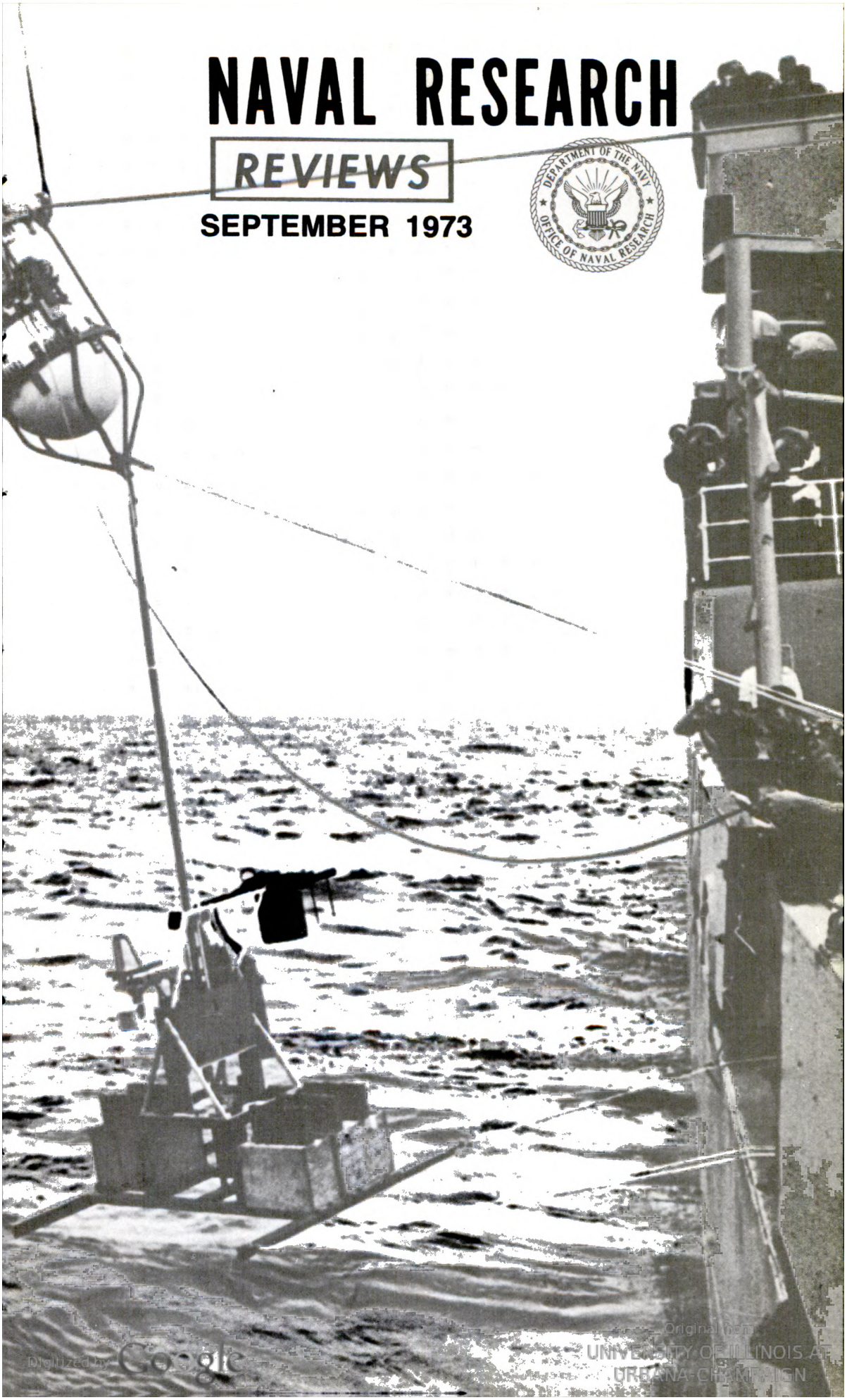
NAVAL RESEARCH

REVIEWS

SEPTEMBER 1973



PROFILES IN SCIENCE

Dr. Walter Munk

Dr. Walter Munk is Professor of Geophysics at the Scripps Institution of Oceanography and Director of the La Jolla Laboratories of the University of California's Institute of Geophysics and Plantary Physics. Dr. Munk, who was one of the first oceanographers supported by ONR, is a leading theoretical and experimental oceanographer whose main work has been on deep-ocean circulation and deep-ocean tides. His contributions in the last 20 years have touched on every field of oceanography as well as planetary sciences. His mathematical techniques and instruments have been successful in sea bed recordings and monitoring of minute fluctuations in sea environmental parameters.

Dr. Munk is a member of the National Academy of Sciences, the American Philosophical Society, and has served on several panels of the President's Scientific Advisory Committee.

A Study of Prisoners and Guards in a Simulated Prison

Craig Haney, Curtis Banks and Philip Zimbardo*
Stanford University

The research reported in this article is part of a larger project sponsored by the Office of Naval Research which is designed to develop a better understanding of the basic psychological mechanisms underlying human aggression. In this study, Dr. Zimbardo fabricated a simulation of the essential characteristics of a prison environment. From a highly selected group of college students, Dr. Zimbardo randomly assigned half as "guards" (with all attendant powers) and half as "prisoners" (under the complete subjugation of the "guards"). Essentially then, a group of intelligent, "normal" young men were put into a situation which demanded close contact over a period of several days. There was a well-defined authority/subordinate relationship between "guards" and "prisoners." The "prison" environment was further manipulated to promote anonymity, depersonalization, and dehumanization among the subjects. The study demonstrates how these variables combine to increase the incidence of aggressive behavior on the part of the "guards" and submissive and docile conformity on the part of the "prisoners."

Studies such as this one help to identify and isolate the various processes which motivate aggressive/submissive behavior within a "total institution" such as a prison. The Navy and Marine Corps have a direct interest in the conclusions drawn from this study in as much as parallels can be made between the forces which operated within Dr. Zimbardo's "prison" and those which spawn disruptive interpersonal conflict in Naval prisons. More importantly, however, this study identifies some of the conditions which are likely to promote unrest when men are placed in situations which demand close contact for protracted periods of time. Such research increases the Navy's capability to develop effective training designs to eliminate conditions which elicit counter-productive conflict.

INTRODUCTION

After he had spent four years in a Siberian prison the great Russian novelist Dostoevsky commented surprisingly that his time in prison had created in him a deep optimism about the ultimate future of mankind because, as he put it, if man could survive the horrors of prison life he

*Dr. Zimbardo is Professor of Psychology at Stanford. In the field of social psychology. Dr. Zimbardo has done important work in the areas of dehumanization, criminal behavior, and criminal justice systems. Mr. Haney and Mr. Banks are graduate assistants.

must surely be a "creature who could withstand anything." The cruel irony which Dostoevsky overlooked is that the reality of prison bears witness not only to the resiliency and adaptiveness of the men who tolerate life within its walls, but as well to the "ingenuity" and tenacity of those who devised and still maintain our correctional and reformatory systems.

Nevertheless, in the century which has passed since Dostoevsky's imprisonment, little has changed to render the main thrust of his statement less relevant. Although we have passed through periods of enlightened humanitarian reform, in which physical conditions within prisons have improved somewhat, and the rhetoric of rehabilitation has replaced the language of punitive incarceration, the social institution of prison has continued to fail. On purely pragmatic grounds, there is substantial evidence that prisons really neither "rehabilitate" nor act as a deterrent to future crime—in America, recidivism rates upwards of 75 percent speak quite decisively to these criteria. And, to perpetuate what is also an economic failure, American taxpayers alone must provide an expenditure for "corrections" of 1.5 billion dollars annually. On humanitarian grounds as well, prisons have failed: our mass media are increasingly filled with accounts of atrocities committed daily, man against man, in reaction to the penal system or in the name of it. The experience of prison creates undeniably, almost to the point of cliche, an intense hatred and disrespect in most inmates for the authority and the established order of society into which they will eventually return. And the toll it takes in the deterioration of human spirit for those who must administer it, as well as for those upon whom it is inflicted, is incalculable.

Attempts to provide an explanation of the deplorable condition of our penal system and its dehumanizing effects upon prisoners and guards, often focus upon what might be called the *dispositional hypothesis*. While this explanation is rarely expressed explicitly, it is central to a prevalent nonconscious ideology: that the state of the social institution of prison is due to the "nature" of the people who administrate it, or the "nature" of the people who populate it, or both. That is, a major contributing cause to despicable conditions, violence, brutality, dehumanization and degradation existing within any prison can be traced to some innate or acquired characteristic of the correctional and inmate population. Thus on the one hand, there is the contention that violence and brutality exist within prison because guards are sadistic, uneducated, and insensitive people. It is the "guard mentality," a unique syndrome of negative traits which they bring into the situation, that engenders the inhumane treatment of prisoners. On the other hand, there is the argument that prison violence and brutality are the logical and predictable results of the involuntary confinement of a collective of individuals whose life histories are, by definition, characterized by disregard for

law, order and social convention and a concurrent propensity for impulsivity and aggression. In seeming logic, it follows that these individuals, having proven themselves incapable of functioning satisfactorily within the "normal" structure of society, cannot do so either inside the structure provided by prisons. To control such men, the argument continues, whose basic orientation to any conflict situation is to react with physical power or deception, force must be met with force, and a certain number of violent encounters must be expected and tolerated by the public.

The dispositional hypothesis has been embraced by the proponents of the prison *status quo* (blaming conditions on the evil in the prisoners), as well as by its critics (attributing the evil to guards and staff with their evil motives and deficient personality structures). The appealing simplicity of this proposition localizes the source of prison riots, recidivism and corruption in these "bad seeds" and not in the conditions of the "prison soil." Such an analysis directs attention away from the complex matrix of social, economic and political forces that combine to make prisons what they are—and that would require complex, expensive, revolutionary actions to bring about any meaningful change. Instead, rioting prisoners are identified, punished, transferred to maximum security institutions or shot, outside agitators sought, and corrupt officials suspended—while the system itself goes on essentially unchanged, its basic structure unexamined and unchallenged.

However, the dispositional hypothesis cannot be critically evaluated directly through observation in existing prison settings, because such naturalistic observation necessarily confounds the acute effects of the environment with the chronic characteristics of the inmate and guard populations. To separate the effects of the prison environment *per se* from those attributable to *a priori* dispositions of its inhabitants requires a research strategy in which a "new" prison is constructed, comparable in its fundamental social-psychological milieu to existing prison systems, but entirely populated by individuals who are undifferentiated in all essential dimensions from the rest of society.

Such was the approach taken in the present empirical study, namely, to create a prison-like situation in which the guards and inmates were initially comparable and characterized as being "normal-average," and then to observe the patterns of behavior which resulted, as well as the cognitive, emotional and attitudinal reactions which emerged. Thus, we began our experiment with a sample of individuals who were in the normal range of the general population on a variety of dimensions we were able to measure. Half were randomly assigned to the role of "prisoner," the others to that of "guard," neither group having any history of crime, emotional disability, physical handicap or even intellectual or social disadvantage.

The environment created was that of a "mock" prison which physically constrained the prisoners in barred cells and psychologically conveyed the sense of imprisonment to all participants. Our intention was not to created a *literal* simulation of an American prison, but rather a functional representation of one. For ethical, moral and pragmatic reasons we could not detain our subjects for extended or indefinite periods of time, we could not exercise the threat and promise of severe physical punishment, we could not allow homosexual or racist practices to flourish, nor could we duplicate certain other specific aspects of prison life. Nevertheless, we believed that we could create a situation with sufficient mundane realism to allow the role-playing participants to go beyond the superficial demands of their assignment into the deep structure of the characters they represented. To do so, we established functional equivalents for the activities and experiences of actual prison life which were expected to produce qualitatively similar psychological reactions in our subjects—feelings of power and powerlessness, of control and oppression, of satisfaction and frustration, of arbitrary rule and resistance to authority, of status and anonymity, of machismo and emasculation. In the conventional terminology of experimental social psychology, we first identified a number of relevant conceptual variables through analysis of existing prison situations, then designed a setting in which these variables were operationalized. No specific hypotheses were advanced other than the general one that assignment to the treatment of "guard" or "prisoner" would result in significantly different reactions on behavioral measures of interaction, emotional measures of mood state and pathology, attitudes toward self, as well as other indices of coping and adaptation to this novel situation. What follows is a discussion of how we created and peopled our prison, what we observed, what our subjects reported, and finally, what we can conclude about the nature of the prison environment and the psychology of imprisonment which can account for the failure of our prisons.

METHOD

Overview

The effects of playing the role of "guard" or "prisoner" were studied in the context of an experimental simulation of a prison environment. The research design was a relatively simple one, involving as it did only a single treatment variable, the random assignment to either a "guard" or "prisoner" condition. These roles were enacted over an extended period of time (nearly one week) within an environment that was physically constructed to resemble a prison. Central to the methodology of creating and maintaining a psychological state of imprisonment was the functional simulation of significant properties of "real

prison life" (established through information from former inmates, correctional personnel and texts).

The "guards" were free within certain limits to implement the procedures of induction into the prison setting and maintenance of custodial retention of the "prisoners." These inmates, having voluntarily submitted to the conditions of this total institution in which they now lived, coped in various ways with its stresses and its challenges. The behavior of both groups of subjects was observed, recorded, and analyzed. The dependent measures were of two general types: (1) transactions between and within each group of subjects, recorded on video and audio tape as well as directly observed; (2) individual reactions on questionnaires, mood inventories, personality tests, daily guard shift reports, and post experimental interviews.

Subjects

The 22 subjects who participated in the experiment were selected from an initial pool of 75 respondents, who answered a newspaper ad asking for male volunteers to participate in a psychological study of "prison life" in return for payment of $15 per day. Each respondent completed an extensive questionnaire concerning his family background, physical and mental health history, prior experience and attitudinal propensities with respect to sources of psychopathology (including their involvements in crime). Each respondent also was interviewed by one of two experimenters. Finally, the 24 subjects who were judged to be most stable (physically and mentally), most mature, and least involved in anti-social behaviors were selected to participate in the study. On a random basis, half of the subjects were assigned the role of "guard," half were assigned to the role of "prisoner."

The subjects were normal, healthy, male college students who were in the Stanford area during the summer. They were largely of middle class socio-economic status and Caucasians (with the exception of one Oriental subject). Initially they were strangers to each other, a selection precaution taken to avoid the disruption of any pre-existing friendship patterns and to mitigate against any transfer into the experimental situation of previously established relationships or patterns of behavior.

This final sample of subjects was administered a battery of psychological tests on the day prior to the start of the simulation, but to avoid any selective bias on the part of the experimenter-observers, scores were not tabulated until the study was completed.

Two subjects who were assigned to be a "stand-by" in case an additional "prisoner" was needed were not called, and one assigned to be a "stand-by" guard decided against participating just before the simulation phase began—thus, our data analysis is based upon ten prisoners and eleven guards in our experimental conditions.

PROCEDURE

Physical Aspects of the Prison

The prison was built in a 35-foot section of a basement corridor in the psychology building at Stanford University. It was partitioned by two fabricated walls; one was fitted with the only entrance door to the cell block and the other contained a small observation screen. Three small cells (6 × 9 ft.) were made from converted laboratory rooms by replacing the usual doors with steel barred, black painted ones, and removing all furniture.

A cot (with mattress, sheet and pillow) for each prisoner was the only furniture in the cells. A small closet across from the cells served as a solitary confinement facility; its dimensions were extremely small (2 × 2 × 7 ft.), and it was unlighted.

In addition, several rooms in an adjacent wing of the building were used as guard's quarters (to change in and out of uniform or for rest and relaxation), a bedroom for the "warden" and "superintendent," and an interview-testing room. Behind the observation screen at one end of the "yard" (small enclosed room representing the fenced prison grounds) was video recording equipment and sufficient space for several observers.

Operational Details

The "prisoner" subjects remained in the mock-prison 24 hours per day for the duration of the study. Three were arbitrarily assigned to each of the three cells; the others were on stand-by call at their homes. The "guard" subjects worked on three-man, eight-hour shifts; remaining in the prison environment only during their work shift and going about their usual lives at other times.

Role Instructions

All subjects had been told that they would be assigned either the guard or the prisoner role on a completely random basis and all had voluntarily agreed to play either role for $15.00 per day for up to two weeks. They signed a contract guaranteeing a minimally adequate diet, clothing, housing and medical care as well as the financial remuneration in return for their stated "intention" of serving in the assigned role for the duration of the study.

It was made explicit in the contract that those assigned to be prisoners should expect to be under surveillance (have little or no privacy) and to

have some of their basic civil rights suspended during their imprisonment, excluding physical abuse. They were given no other information about what to expect nor instructions about behavior appropriate for a prisoner role. Those actually assigned to this treatment were informed by phone to be available at their place of residence on a given Sunday when we would start the experiment.

The subjects assigned to be guards attended an orientation meeting on the day prior to the induction of the prisoners. At this time they were introduced to the principal investigators, the "Superintendent" of the prison (the author) and an undergraduate research assistant who assumed the administrative role of "Warden." They were told that we wanted to try to simulate a prison environment within the limits imposed by pragmatic and ethical considerations. Their assigned task was to "maintain the reasonable degree of order within the prison necessary for its effective functioning," although the specifics of how this duty might be implemented were not explicitly detailed. They were made aware of the fact that, while many of the contingencies with which they might be confronted were essentially unpredictable (e.g., prisoner escape attempts), part of their task was to be prepared for such eventualities and to be able to deal appropriately with the variety of situations that might arise. The "Warden" instructed the guards in the administrative details, including: the work-shifts, the mandatory daily completion of shift reports concerning the activity of guards and prisoners, the completion of "critical incident" reports which detailed unusual occurrences, and the administration of meals, work and recreation programs for the prisoners. In order to begin to involve these subjects in their roles even before the first prisoner was incarcerated, the guards assisted in the final phases of completing the prison complex—putting the cots in the cells, signs on the walls, setting up the guards' quarters, moving furniture, water coolers, refrigerators, etc.

The guards generally believed that we were primarily interested in studying the behavior of the prisones. Of course, we were as interested in the effects which enacting the role of guard in this environment would have on their behavior and subjective states.

To optimize the extent to which their behavior would reflect their genuine reactions to the experimental prison situation and not simply their ability to follow instructions, they were intentionally given only minimal guidelines for what it meant to be a guard. An explicit and categorical prohibition against the use of physical punishment or physical aggression was, however, emphasized by the experimenters. Thus, with this single notable exception, their roles were relatively unstructured initially, requiring each "guard" to carry out activities necessary for interacting with a group of "prisoners" as well as with other "guards" and the "correctional staff."

Uniforms

In order to promote feelings of anonymity in the subjects each group was issued identical uniforms. For the guards, the uniform consisted of: plain khaki shirts and trousers, a whistle, a police night stick (wooden batons), and reflecting sunglasses which made eye contact impossible. The prisoners' uniform consisted of a loose fitting muslin smock with an identification number on front and back, no underclothes, a light chain and lock around one ankle, rubber sandals and a cap made from a nylon stocking. Each prisoner also was issued a toothbrush, soap, soapdish, towel and bed linen. No personal belongings were allowed in the cells.

The outfitting of both prisoners and guards in this manner served to enhance group identify and reduce individual uniqueness within the two groups. The khaki uniforms were intended to convey a military attitude, while the whistle and night-stick were carried as symbols of control and power. The prisoners' uniforms were designed not only to deindividuate the prisoners but to be humiliating and serve as symbols of their dependence and subservience. The ankle chain was a constant reminder (even during their sleep when it hit the other ankle) of the oppressiveness of the environment. The stocking cap removed any distinctiveness associated with hair length, color or style (as does shaving of heads in some "real" prisons and the military). The ill-fitting uniforms made the prisoners feel awkward in their movements; since these "dresses" were worn without undergarments, the uniforms forced them to assume unfamiliar postures, more like those of a woman than a man—another part of the emasculating process of becoming a prisoner.

Induction Procedure

With the cooperation of the Palo Alto City Police Department all of the subjects assigned to the prisoner treatment were unexpectedly "arrested" at their residences. A police officer charged them with suspicion of burglary or armed robbery, advised them of their legal rights, handcuffed them, thoroughly searched them (often as curious neighbors looked on) and carried them off to the police station in the rear of the police car. At the station they went through the standard routines of being fingerprinted, having an identification file prepared and then being placed in a detention cell. Each prisoner was blindfolded and subsequently driven by one of the experimenters and a subject-guard to our mock prison. Throughout the entire arrest procedure, the police officers involved maintained a formal, serious attitude, avoiding answering any questions of clarification as to the relation of this "arrest" to the mock prison study.

Upon arrival at our experimental prison, each prisoner was stripped, sprayed with a delousing preparation (a deodorant spray) and made to stand alone naked for a while in the cell yard. After being given the uniform described previously and having an I.D. picture taken ("mug shot"), the prisoner was put in his cell and ordered to remain silent.

Administrative Routine

When all the cells were occupied, the warden greeted the prisoners and read them the rules of the institution (developed by the guards and the warden). They were to be memorized and to be followed. Prisoners were to be referred to only by the number on their uniforms, also in an effort to depersonalize them.

The prisoners were to be served three bland meals per day, were allowed three supervised toilet visits, and given two hours daily for the privilege of reading or letterwriting. Work assignments were issued for which the prisoners were to receive an hourly wage to constitute their $15 daily payment. Two visiting periods per week were scheduled, as were movie rights and exercise periods. Three times a day all prisoners were lined up for a "count" (one on each guard work-shift). The initial purpose of the "count" was to ascertain that all prisoners were present, and to test them on their knowledge of the rules and their I.D. numbers. The first perfunctory counts lasted only about ten minutes, but on each successive day (or night) they were spontaneously increased in duration until some lasted several hours. Many of the pre-established features of administrative routine were modified or abandoned by the guards, and some privileges were forgotten by the staff over the course of study.

RESULTS

Overview

Although it is difficult to anticipate exactly what the influence of incarceration will be upon the individuals who are subjected to it and those charged with its maintenance, especially in a simulated reproduction, the results of the present experiment support many commonly held conceptions of prison life and validate anecdotal evidence supplied by articulate ex-convicts. The environment of arbitrary custody had great impact upon the affective states of both guards and prisoners as well as upon the interpersonal processes taking place between and within those role-groups.

In general, guards and prisoners showed a marked tendency toward increased negativity of affect, and their overall outlook became increasingly negative. As the experiment progressed, prisoners expressed intentions to do harm to others more frequently. For both prisoners

522-389 O - 73 - 2

and guards, self-evaluations were more deprecating as the experience of the prison environment became internalized.

Overt behavior was generally consistent with the subjective self-reports and affective expressions of the subjects. Despite the fact that guards and prisoners were essentially free to engage in any form of interaction (positive or negative, supportive or affrontive, etc.), the characteristic nature of their encounters tended to be negative, hostile, affrontive and dehumanizing. Prisoners immediately adopted a generally passive response mode while guards assumed a very active initiative role in all interactions. Throughout the experiment, commands were the most frequent form of verbal behavior and, generally, verbal exchanges were strikingly impersonal, with few references to individual identity. Although it was clear to all subjects that the experimenters would not permit physical violence to take place, varieties of less direct aggressive behavior were observed frequently (especially on the part of guards). In lieu of physical violence, verbal affronts were used as one of the most frequent forms of interpersonal contact between guards and prisoners.

The most dramatic evidence of the impact of this situation upon the participants was seen in the gross reactions of five prisoners who had to be released because of extreme emotional depression, crying, rage and acute anxiety. The pattern of symptoms was quite similar in four of the subjects and began as early as the second day of imprisonment. The fifth subject was released after being treated for a psychosomatic rash which covered portions of his body. Of the remaining prisoners, only two said they were not willing to forfeit the money they had earned in return for being "paroled." When the experiment was terminated prematurely after only six days, all the remaining prisoners were delighted by their unexpected good fortune. In contrast, most of the guards seemed to be distressed by the decision to stop the experiment and it appeared to us that they had become sufficiently involved in their roles that they now enjoyed the extreme control and power which they exercised and were reluctant to give it up. One guard did report being personally upset at the suffering of the prisoners, and claimed to have considered asking to change his role to become one of them—but never did so. None of the guards ever failed to come to work on time for their shift, and indeed, on several occasions guards remained on duty voluntarily and uncomplaining for extra hours—without additional pay.

The extremely pathological reactions which emerged in both groups of subjects testify to the power of the social forces operating, but still there were individual differences seen in styles of coping with this novel experience and in degrees of successful adaptation to it. Half the prisoners did endure the oppressive atmosphere, and not all the guards resorted to hostility. Some guards were tough but fair ("played by the

rules"), some went far beyond their roles to engage in creative cruelty and harassment, while a few were passive and rarely instigated any coercive control over the prisoners.

REALITY OF THE SIMULATION

At this point it seems necessary to confront the critical question of "reality" in the simulated prison environment: were the behaviors observed more than the mere acting out assigned roles convincingly? To be sure, ethical, legal and practical considerations set limits upon the degree to which this situation could approach the conditions existing in actual prisons and penitentiaries. Necessarily absent were some of the most salient aspects of prison life reported by criminologists and documented in the writing of prisoners. There was no involuntary homosexuality, no racism, no physical beatings, no threat to life by prisoners against each other or the guards. Moreover, the maximum anticipated "sentence" was only two weeks and, unlike some prison systems, could not be extended indefinitely for infractions of the internal operating rules of the prison.

In one sense, the profound psychological effects we observed under the relatively minimal prison-like conditions which existed in our mock prison made the results even more significant, and force us to wonder about the devastating impact of chronic incarceration in real prisons. Nevertheless, we must contend with the criticism that our conditions were too minimal to provide a meaningful analogue to existing prisons. It is necessary to demonstrate that the participants in this experiment transcended the conscious limits of their preconceived stereotyped roles and their awareness of the artificiality and limited duration of imprisonment. We feel there is abundant evidence that virtually all of the subjects at one time or another experienced reactions which went well beyond the surface demands of role-playing and penetrated the deep structure of the psychology of imprisonment.

Although instructions about how to behave in the roles of guard or prisoner were not explicitly defined, demand characteristics in the experiment obviously exerted some directing influence. Therefore, it is enlightening to look to circumstances where role demands were minimal, where the subjects believed they were not being observed, or where they should not have been behaving under the constraints imposed by their roles (as in "private" situations), in order to assess whether the role behaviors reflected anything more than public conformity or good acting.

When the private conversations of the prisoners were monitored, we learned that almost all (a full 90 per cent) of what they talked about was directly related to immediate prison conditions, that is, food, privileges, punishment, guard harassment, *etc.* Only one-tenth of the time did

their conversations deal with their life outside the prison. Consequently, although they had lived together under such intense conditions, the prisoners knew surprisingly little about each other's past history or future plans. This excessive concentration on the vicissitudes of their current situation helped to make the prison experience more oppressive for the prisoners because, instead of escaping from it when they had a chance to do so in the privacy of their cells, the prisoners continued to allow it to dominate their thoughts and social relations. The guards too, rarely exchanged personal information during their relaxation breaks. They either talked about "problem prisoners," other prison topics, or did not talk at all. There were few instances of any personal communication across the two role groups. Moreover, when prisoners referred to other prisoners during interviews, they typically deprecated each other, seemingly adopting the guards' negative attitude.

From post experimental data, we discovered that when individual guards were alone with solitary prisoners and out of range of any recording equipment, as on the way to or in the toilet, harassment often was greater than it was on the "Yard." Similarly, video-taped analyses of total guard aggression showed a daily escalation even after most prisoners had ceased resisting and prisoner deterioration had become visibly obvious to them. Thus, guard aggression was no longer elicited as it was initially in response to perceived threats, but was emitted simply as a "natural" consequence of being in the uniform of a "guard" and asserting the power inherent in that role. In specific instances we noted cases of a guard (who did not know he was being observed) in the early morning hours pacing the Yard as the prisoners slept—vigorously pounding his night stick into his hand while he "kept watch" over his captives. Or another guard who detained an "incorrigible" prisoner in solitary confinement beyond the duration set by the guards' own rules, and then he conspired to keep him in the hole all night while attempting to conceal this information from the experimenters who were thought to be too soft on the prisoners.

In passing we may note an additional point about the nature of role-playing and the extent to which actual behavior is "explained away" by reference to it. It will be recalled that many guards continued to intensify their harassment and aggressive behavior even after the second day of the study, when prisoner deterioration became marked and visible and emotional breakdowns began to occur (in the presence of the guards). When questioned after the study about their persistent affrontive and harassing behavior in the face of prisoner emotional trauma, most guards replied that they were "just playing the role" of a tough guard, although none ever doubted the magnitude or validity of the prisoners' emotional response. The reader may wish to consider to what extremes an individual may go, how great must be the consequences of his behavior

for others, before he can no longer rightfully attribute his actions to "playing a role" and thereby abdicate responsibility.

When introduced to a Catholic priest, many of the role-playing prisoners referred to themselves by their prison number rather than their Christian names. Some even asked him to get a lawyer to help them get out. When a public defender was summoned to interview those prisoners who had not yet been released, almost all of them strenuously demanded that he "bail" them out immediately.

One of the most remarkable incidents of the study occurred during a parole board hearing when each of five prisoners eligible for parole was asked by the senior author whether he would be willing to forfeit all the money earned as a prisoner if he were to be paroled (released from the study). Three of the five prisoners said, "yes," they would be willing to do this. Notice that the original incentive for participating in the study had been the promise of money, and they were, after only four days, prepared to give this up completely. And, more surprisingly, when told that this possibility would have to be discussed with the members of the staff before a decision could be made, each prisoner got up quietly and was escorted by a guard back to his cell. If they regarded themselves simply as "subjects" participating in an experiment for money, there was no longer any incentive to remain in the study and they could have easily escaped this situation which had so clearly become aversive for them by quitting. Yet, so powerful was the control which the situation had come to have over them, so much a reality had this simulated environment become, that they were unable to see that their original and singular motive for remaining no longer obtained, and they returned to their cells to await a "parole" decision by their captors.

The reality of the prison was also attested to by our prison consultant who had spent over 16 years in prison, as well as the priest who had been a prison chaplain and the public defender, all of whom were brought into direct contact with our simulated prison environment. Further, the depressed affect of the prisoners, the guards' willingness to work overtime for no additional pay, the spontaneous use of prison titles and ID numbers in non role-related situations all point to a level of reality as real as any other in the lives of all those who shared this experience.

To understand how an illusion of imprisonment could have become so real, we need now to consider the uses of power by the guards as well as the effects of such power in shaping the prisoner mentality.

PATHOLOGY OF POWER

Being a guard carried with it social status within the prison, a group identity (when wearing the uniform), and above all, the freedom to exercise an unprecedented degree of control over the lives of other

human beings. This control was invariably expressed in terms of sanctions, punishment, demands, and with the threat of manifest physical power. There was no need for the guards to rationally justify a request as they did their ordinary life, and merely to make a demand was sufficient to have it carried out. Many of the guards showed in their behavior and revealed in post-experimental statements that this sense of power was exhilarating.

The use of power was self-aggrandizing and self-perpetuating. The guard power, derived initially from an arbitrary and randomly assigned label, was intensified whenever there was any perceived threat by the prisoners and this new level subsequently became the baseline from which further hostility and harassment would begin. The most hostile guards on each shift moved spontaneously into the leadership roles of giving orders and deciding on punishments. They became role models whose behavior was emulated by other members of the shift. Despite minimal contact between the three separate guard shifts and nearly 16 hours a day spent away from the prison, the absolute level of aggression, as well as more subtle and "creative" forms of aggression manifested, increased in a spiralling function. Not to be tough and arrogant was to be seen as a sign of weakness by the guards, and even those "good" guards who did not get as drawn into the power syndrome as the others respected the implicit norm of *never* contradicting or even interferring with an action of a more hostile guard on their shift.

After the first day of the study, practially all prisoner rights (even such things as the time and conditions of sleeping and eating) came to be redefined by the guards as "privileges" which were to be earned by obedient behavior. Constructive activities such as watching movies or reading (previously planned and suggested by the experimenters) were arbitrarily cancelled until further notice by the guards—and were subsequently never allowed. "Reward," then became granting approval for prisoners to eat, sleep, go to the toilet, talk, smoke a cigarette, wear eyeglasses, or the temporary dimunition of harassment. One wonders about the conceptual nature of "positive" reinforcement when subjects are in such conditions of deprivation, and the extent to which even minimally acceptable conditions become rewarding when experienced in the context of such an impoverished environment.

We might also question whether there are meaningful non-violent alternatives as models for behavior modification in real prisons. In a world where men are either powerful or powerless, everyone learns to despise the lack of power in others and in oneself. It seems to us, that prisoners learn to admire power for its own sake—power becoming the ultimate reward. Real prisoners soon learn the means to gain power whether through ingratiation, informing, sexual control of other prisoners or development of powerful cliques. When they are released from

prison, it is likely they will never want to feel so powerless again and will take action to establish and assert a sense of power.

THE PATHOLOGICAL PRISONER SYNDROME

Various coping strategies were employed by our prisoners as they began to react to their perceived loss of personal identity and the arbitrary control of their lives. At first they exhibited disbelief at the total invasion of their privacy, constant surveillance, and atmosphere of oppression in which they were living. Their next response was rebellion, first by the use of direct force, and later with subtle divisive tactics designed to foster distrust among the prisoners. They then tried to work within the system by setting up an elected grievance committee. When that collective action failed to produce meaningful changes in their existence, individual self-interests emerged. The breakdown in prisoner cohesion was the start of social disintegration which gave rise not only to feelings of isolation, but deprecation of other prisoners as well. As noted before, half the prisoners coped with the prison situation by becoming "sick"—extremely disturbed emotionally—as a passive way of demanding attention and help. Others became excessively obedient in trying to be "good" prisoners. They sided with the guards against a solitary fellow prisoner who coped with his situation by refusing to eat. Instead of supporting this final and major act of rebellion, the prisoners treated him as a trouble-maker who deserved to be punished for his disobedience. It is likely that the negative self-regard among the prisoners noted by the end of the study was the product of their coming to believe that the continued hostility toward all of them was justified because they "deserved it" (following Walster, 1966). As the days wore on, the model prisoner reaction was one of passivity, dependence, and flattened affect.

Let us briefly consider some of the relevant processes involved in bringing about these reactions.

Loss of personal identity. For most people identity is conferred by social recognition of one's uniqueness, and established through one's name, dress, appearance, behavior style and history. Living among strangers who do not know your name or history (who refer to you only by number), dressed in a uniform exactly like all other prisoners, not wanting to call attention to one's self because of the unpredictable consequencies it might provoke—all led to a weakening of self identity among the prisoners. As they began to lose initiative and emotional responsivity, while acting ever more compliantly, indeed, the prisoners became deindividuated not only to the guards and the observers, but also to themselves.

Arbitrary control. On post-experimental questionnaires, the most frequently mentioned aversive aspect of the prison experience was that

of being subjugated to the patently arbitrary, capricious decisions and rules of the guards. A question by a prisoner as often elicited derogation and aggression as it did a rational answer. Smiling at a joke could be punished in the same way that failing to smile might be. An individual acting in defiance of the rules could bring punishment to innocent cell partners (who became, in effect, "mutually yoked controls"), to himself, or to all.

As the environment became more unpredictable, and previously learned assumptions about a just and orderly world were no longer functional, prisoners ceased to initiate any action. They moved about on orders and when in their cells rarely engaged in any purposeful activity. Their zombie-like reaction was the functional equivalent of the learned helplessness phenomenon reported by Seligman & Grove (1970). Since their behavior did not seem to have any contingent relationship to environmental consequences, the prisoners essentially gave up and stopped behaving. Thus the subjective magnitude of aversiveness was manipulated by the guards not in terms of physical punishment but rather by controlling the psychological dimension of environmental predictability (Singer & Glass, 1972).

Dependency and emasculation. The network of dependency relations established by the guards not only promoted helplessness in the prisoners but served to emasculate them as well. The arbitrary control by the guards put the prisoners at their mercy for even the daily, commonplace functions like going to the toilet. To do so, required publicly obtained permission (not always granted) and then a personal escort to the toilet while blindfolded and handcuffed. The same was true for many other activities ordinarily practiced spontaneously without thought, such as lighting a cigarette, reading a novel, writing a letter, drinking a glass of water, or brushing one's teeth. These were all privileged activities requiring permission and necessitating a prior show of good behavior. These low level dependencies engendered a regressive orientation in the prisoners. Their dependency was defined in terms of the extent of the domain of control over all aspects of their lives which they allowed other individuals (the guards and prison staff) to exercise.

As in real prisons, the assertive, independent, aggressive nature of male prisoners posed a threat which was overcome by a variety of tactics. The prisoner uniforms resembled smocks or dresses, which made them look silly and enabled the guards to refer to them as "sissies" or "girls." Wearing these uniforms without any underclothes forced the prisoners to move and sit in unfamiliar, feminine postures. Any sign of individual rebellion was labelled as indicative of "incorrigibility" and resulted in loss of privileges, solitary confinement, humiliation or punishment of cell mates. Physically smaller guards were able to induce stronger prisoners to act foolishly and obediently. Prisoners were

encouraged to belittle each other publicly during the counts. These and other tactics all served to engender in the prisoners a lessened sense of their masculinity (as defined by their external culture). It followed then, that although the prisoners usually outnumbered the guards during line-ups and counts (nine vs. three) there never was an attempt to directly overpower them. (Interestingly, after the study was terminated, the prisoners expressed the belief that the basis for assignment to guard and prisoner groups was physical size. They perceived the guards were "bigger," when, in fact, there was no difference in average height or weight between these randomly determined groups.)

In conclusion, we believe this demonstration reveals new dimensions in the social psychology of imprisonment worth pursuing in future research. In addition, this research provides a paradigm and information base for studying alternatives to existing guard training, as well as for questioning the basic operating principles on which penal institutions rest. If our mock prison could generate the extent of pathology it did in such a short time, then the punishment of being imprisoned in a real prison does not "fit the crime" for most prisoners—indeed, it far exceeds it! Moreover, since both prisoners and guards are locked into a dynamic, symbiotic relationship which is destructive to their human nature, guards are also society's prisoners.

REFERENCES

Adorno, T. W., Frenkel-Brunswik, E., Levinson, D. J., and Sanford, R. N., *The Authoritarian Personality,* New York: Harper, 1950.

Charriere, H., *Papillion,* Robert Laffont, 1969.

Christie, R. and Geis, F. L. (Eds.), *Studies in Machiavellianism,* New York: Academic Press, 1970.

Comrey, A. L., *Comrey Personality Scales,* San Diego: Educational and Industrial Testing Service, 1970.

Glass, D. C. and Singer, J. E., "Behavioral after Effects of Unpredictable and Uncontrollable Aversive Events," *American Scientist,* **6** (4), 457-465, 1972.

Jackson, G., *Soledad Brother: the Prison Letters of George Jackson,* New York: Banatm Books, 1970.

Milgram, S., "Some Conditions of Obedience and Disobedience to Authority," *Human Relations,* **18** (1), 57-76, 1965.

Mischel, W., *Personality and Assessment,* New York: Wiley, 1968.

Schein, E., *Coercive Persuasion,* New York: Norton, 1961.

Seligman, M. E. and Groves, D. P., "Nontransient Learned Helplessness," *Psychonomic Science,* **19** (3), 191-192, 1970.

Walster, E., "Assignment of Responsibility for an Accident," *Journal of Personality and Social Psychology,* **3** (1), 73-79, 1966.

Oceanography from the Bottom Up

Walter H. Munk, Frank Snodgrass, and Bernard Zetler*
Scripps Institution of Oceanography

INTRODUCTION

Much of the interesting physical oceanography takes place at low frequencies. The work preliminary to Mid Ocean Dynamic Experiment (MODE) has shown that four months are required, at the very minimum to document fluctuations in the ocean circulation. Large patches of sea surface temperature anomalies, which are the subject of the North Pacific Experiment (NORPAX), have characteristic times of a fraction of a year. Thus it is vital to obtain continuing oceanographic data over time periods sufficiently long to adequately resolve some of the problems.†

The desired time scale just about rules out oceanographic vessels as platforms for the data series. The relatively small ELLEN B. SCRIPPS (95 feet long, with a complement of five men), which we have used for most of our work, costs more than a thousand dollars a day. Even if we could afford her, it would be hard to find a captain who would voluntarily stay on one spot for so long.

The solution is automatically recording buoys. While surface buoys have been successfully moored for many months, withstanding the most severe storms, we decided to develop buoys to be dropped onto the deep sea floor where the benthic ocean provides a benign environment for observations.

The effects of sea and swell are eliminated; furthermore the sea bottom has a root mean square (rms) acceleration of only 10^{-7} gravity (g) rather than the 10^{-1} g typical of the sea surface environment. Moreover, there are no electronic technicians to fiddle with dials. By now we have had over 60 deep-sea drops with support from the Office of Naval Research; and our enthusiasm for doing oceanography from the bottom up is undiminished. This work is part of NORPAX program.

THE DEEP-SEA CAPSULES

The capsules developed by Frank Snodgrass (1) consist of aluminum spheres capable of withstanding pressures down to 18,000-ft. Data

*Dr. Munk's scientific achievements are described on the inside front cover. Mr. Snodgrass is a research engineer at the University of California's Institute of Geophysics and Plantary Physics. His field is oceanographic instrumentation. Mr. Zetler is a research oceanographer at the Institute specializing in tidal analyses.

†For a description of MODE see *Naval Research Reviews*, May 1973. NORPAX will explain large scale oceanic and atmospheric fluctuations over long periods in the North Pacific Ocean.

are recorded in computer-compatible format on magnetic tape (soon to be replaced by core storage). The aluminum spheres provide 220 pounds of buoyancy; when the capsule package is put overboard, the total weight exceeds the buoyancy by 250 pounds, and the capsule drops freely at a rate of about 3 ft/sec. Recovery is achieved by acoustic command from a surface vessel; this separates a 290 pound ballast (a pack of automobile storage batteries that also provides the principal power source) and the capsule becomes buoyant and rises to the surface where it is located with the help of radio signals and flashing lights.

As this is being written, three capsules intended for four month stays are being dropped in the MODE area to monitor sea-floor pressure fluctuations. Development of a one-year capsule is underway to permit certain types of seasonal experiments, such as monitoring the formation of Antarctic bottom water beneath the ice cover. One could make a drop near the ice border during one summer, then recover during the next summer.

Frank Snodgrass is working on several extensions of the present capsules. At this time acoustic communication with the capsule is mainly to inquire about its state of health and ultimately for recovery. One obvious extension is to have certain data transmitted. Another is a self-contained decision-making circuit which will vary the sampling rate in accordance with the "interest" (*e.g.* the frequency content of the signal). Thus, once-per-two-hour pressure sampling (adequate for tidal studies) would switch to once-per-minute sampling if a tsunami should occur.

THE BENTHIC BOUNDARY LAYER

Soon after the first capsules were completed, we attempted to ascertain the basic character of the boundary layer on the deep-sea floor (2). There had been various reports of stongly "superadiabatic" temperature gradients over the bottom (thus implying heavy over light water, an unstable situation). Our measurements indicated that this was not so, and that observed gradients in the bottom few meters did not differ significantly from the adiabatic. We also were interested in determining how high above the sea floor one needs to go to measure currents reasonably representative of the water column. For tidal currents, at least, the answer seems to be about ten meters. The results have been pretty much in accord with what one would expect from classical turbulence theory, and in this sense, they are disappointing.

TIDES IN THE NORTHEAST PACIFIC

The principal application of our buoy systems so far has been the measurement of deep-sea tides (3). In principle, this is simple; we

record the pressure fluctuations on the sea floor. Bottom pressure at high tide exceeds that at low tide by just the weight of the incremental water column. Although there are many thousands of gauges at the entrances of harbors, their data are not really useful in studying open tides, because they are significantly affected by local conditions. What we want are measurements away from shore and in critical locations.

As a result of several expeditions conducted by Scripps, the tides in the northeast Pacific are now quite well-defined. The most interesting result is a lunar amphidrome (a point at which there is no tide) between San Diego and Hawaii (Figure 1). This was determined from measurements in 1970, which predicted that the tides 600 miles to the northwest of the 1970 stations should be in opposite phase. We subsequently went into the northwest area (4) (Josie II in Figure 1) and found that the phase was in fact reversed.

Having once described the tidal pattern in the northeast Pacific, it became possible to correct gravimeter measurements on land for ocean loading, an effect which is remarkably large and represents the principal source of uncertainty in the land observations (5).

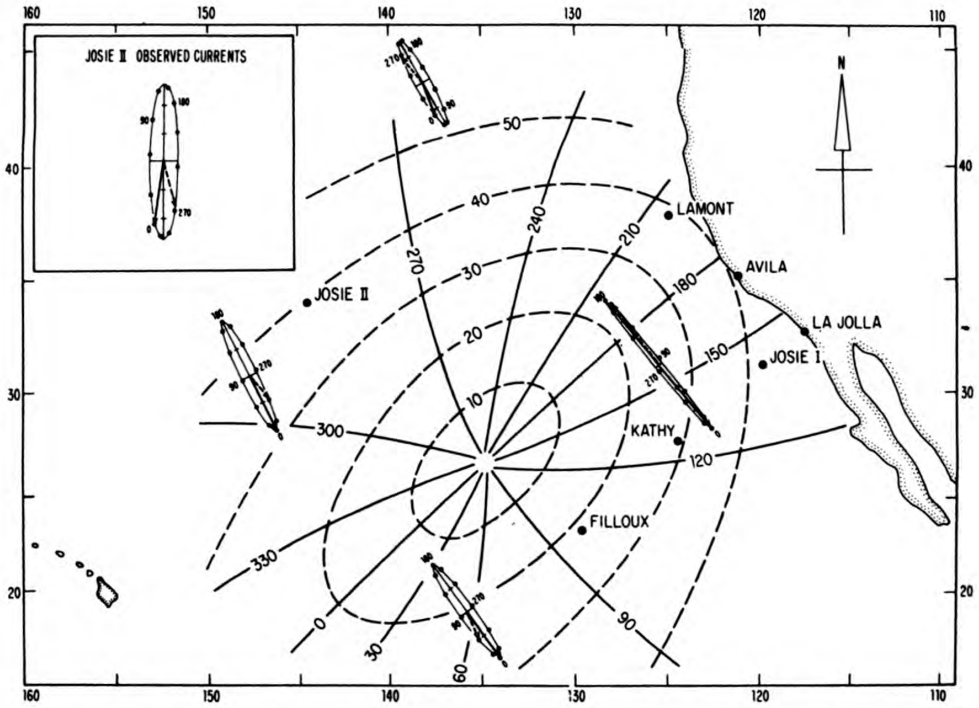


Figure 1 — M^2 cotidal chart from Munk, Snodgrass and Wimbush (1970). Lines of equal amplitude H cm and of equal Greenwich epoch G° are shown by the dashed and solid curves. Ellipses refer to the computed tidal currents at the ellipse center. The heavy arrow toward G = 0 is the tidal current when the Moon is over the Greenwich meridian. The dots indicated for 30°, 60°, ..., give the end point of the current vector for other Greenwich epochs. The dashed arrow is the current vector at the time of
The inset shows the observed currents at JOSIE. Tick marks on the major axis of the ellipses correspond to current speeds at intervals of 1 cm/sec.

ANTARCTIC

The Antarctic Ocean, which circles the Earth at high Southern latitudes has tidal dynamics which are as different from the California situation as one can find. Since ancient times there have been reports that enormous tides could be expected at about 60° latitude, this being the only place where a free wave traveling at $\sqrt{gh}$ (h is bottom depth) would be in keeping with the motion of the moon. Although any reasonable dynamic consideration would suggest that this is nonsense, still it seemed of some interest to subject this ancient claim to an experimental test. This was the principal motivation for the Antarctic expedition in February 1970. Our tide capsules were placed aboard the USNS ELTANIN in Adelaide, Australia; heading south, capsules were dropped at 37°, 50° and 60° latitudes. Although there was some malfunction of equipment, we recovered all capsules (the last under gale conditions) and have useful records at all three stations for the better part of a month.

The results of the Antarctic test were disappointing with respect to diurnal (once daily) tides in the sense that everything behaved pretty much as one might have expected. Plots of amplitude and phase (Figure 2) showed smooth variations from the south coast of Australia through our three observation points to the site of a turn-of-the-century tide station (6). The semidiurnal (twice daily) tides along this part of the south coast of Australia are anomalous in that the solar tide equals or exceeds the lunar tide, and the phase age (lag of spring tide behind new and full moon) is negative. It is not immediately apparent whether the local bathymetry is sufficiently selective to favor the solar over the lunar semidiurnal tide or whether the anomaly is due to meteorological tides caused by barometric winds.

MODE

The three capsules now being placed in the MODE area, between Florida and Bermuda, have very sensitive temperature and pressure transducers sitting on the sea bottom. An electric cable extends upward to the capsule, 1 km above the sea floor, and has four additional temperature recorders situated along its length. The experiment has two purposes. The first is to furnish sea-bottom pressure data (in conjunction with similar work by James Baker and NOAA) from which currents can be geostrophically deduced. This is in every way analogous to using barometers on land (*e.g.*, at the bottom of the atmosphere) to deduce surface winds. A large number of current measurements near the sea floor are being taken as part of the MODE experiment, and it will be possible, for the first time, to compare the observed currents with those deduced from the geostrophic relation. The sea-floor experiment is more difficult

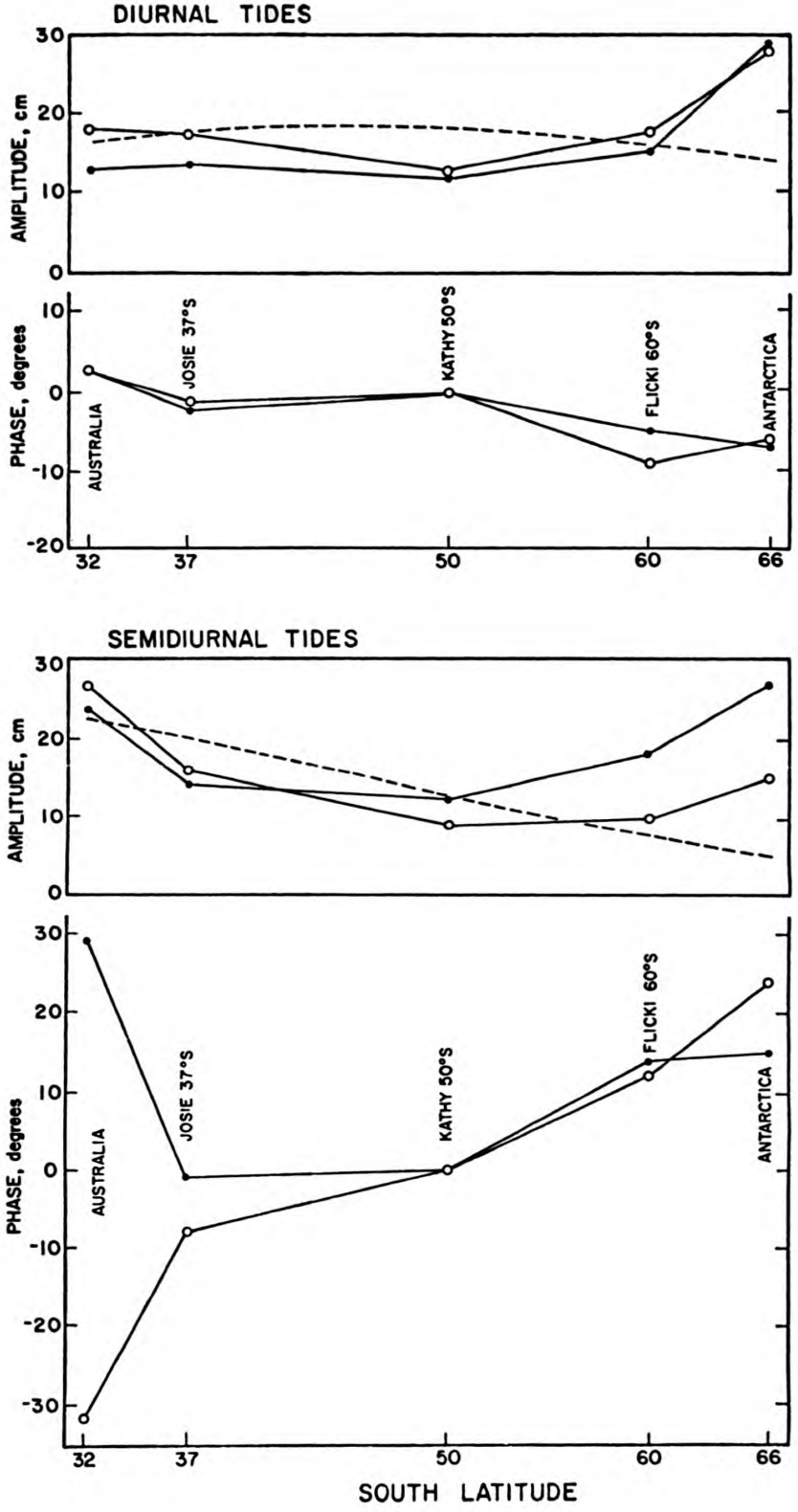


Figure 2 — The amplitude and phase of the tides on a section from Australia to Antarctica. The equilibrium tide are indicated by the broken line. Open circles refer to solar tides and solid circles to lunar tides.

than its analogue on land for two reasons: (1) the relative pressure fluctuations are only about one part of 5×10^5, as compared to one part in 10^2 on land; and (2) the period of the pressure fluctuations appears to be of the order of months rather than days which means the measurements are more subject to error introduced by instrument drift. The second objective is to obtain thermal information. Four temperature sensors positioned between 800 and 1000 meters above the sea floor, have been so spaced as to give definitive information concerning the vertical modal structure of internal waves. The horizontal coherence of temperatures over distances (about/km) between the capsules will also be obtained in this experiment.

FREE-FLOAT CAPSULES

In recent months, Gordon Williams and James Cairns of the Scripps Institution have adapted the Snodgrass capsule to a neutrally-buoyant mode. Further, by attaching a variable buoyancy cannister to the capsule, this can be made to oscillate up and down about to its mean depth. So far, the work has been conducted at about one-kilometer depth. The purposes are as follow:

A. To obtain time histories of the temperature microstructure in the sea. The microstructure goes down to scales of centimeters, and these smallest scales must be destroyed by diffusion processes in just a few hours. We want to learn something about the processes by which the structure is being continuously renewed. At this time, intermittent internal wave breaking seems to be the most likely source.
B. To study the vertical mode structure of the internal waves, this time in the upper parts of the oceans.
C. To make Lagrangian observations (following the water drift) which appear to be appropriate to some NORPAX objectives but have been largely neglected in oceanography because frequent observations have been expensive and/or impractical. There are very limited benefits to be gained just from launch and recovery data, as with drift bottles so we propose to use SOFAR (Sound Channel at mid-depth having largest velocity of sound in a water column) to track our free-floating instrumented submerged buoys and possibly to transmit data as well; consideration will be given to programming the buoys to "yo-yo." We expect to learn about ocean processes and circulation more effectively than by Eulerian measurements (at a fixed position).

One of the fundamental questions of NORPAX is whether anomalous regions in the ocean drift with the mean current or whether they are

wave-like disturbances propagating at wave velocity. Drift measurements could be decisive on this point and we propose to use acoustic means to obtain such data by tracking the capsule for relatively long periods. The methods to be used are yet to be worked out.

DISCUSSION

Observations of sound transmission between fixed source and receiver have shown that fluctuations occur in the relative phase, the bearing of the acoustic wave front, and the acoustic intensity. These scintillations are generally believed to result from variations in sound velocity associated with internal wave activity, at least in the frequency range from cycles per hour to cycles per day. We hope that the experiments described here will help to establish a connection between underwater acoustics and dynamic oceanography, two important oceanographic disciplines that have interacted rather weakly to date. Some preliminary quantitative comparisons are encouraging.

We hope that this work may proceed in two directions: one aimed at interpreting and predicting the acoustic scintillations on the basis of the many internal wave observations (7,8), and the other focussed on the inverse problem of studying internal wave activity by means of acoustic transmission experiments. The latter method is a special case of remote sensing by forward scattering.

REFERENCES

1. Snodgrass, F. E., "Deep Sea Instrument Capsule," *Science,* 162, 78, (1968).
2. Wimbush, M. and W. H. Munk, "The Benthic Boundary Layer," *The Sea,* 4, Pt. 1, Chap. 19, *Interscience,* 731 (1971).
3. Munk, W., F. Snodgrass, and M. Wimbush, "Tides off-shore: Transition from California Coastal to Deep-Sea Waters," *Geophys. Fl. Dynam.,* 1, No. 1, 161 (1970).
4. Irish, J. D., W. H. Munk and F. E. Snodgrass, "M_2 Amphidrome in the Northeast Pacific," *Geophys. Fl. Dynam.,* 2, 355 (1971).
5. Farrell, W. E., "Deformation of the Earth by Surface Loads," *Rev. of Geophysics and Space Physics,* 10, No. 3, 761 (1972).
6. Irish, J. D. and F. E. Snodgrass, "Australian-Antarctic Tides," *Antarctic Oceanology II: The Australian-New Zealand Sector,* Antarctic Research Series, Vol. 19, 101 (1972).
7. Garrett, C. J. R. and W. H. Munk, "Space-Time Scales of Internal Waves," *Geophys. Fl. Dynam.,* 2, 225 (1972).
8. Munk, W. H. and C. J. R. Garrett, "Internal Waves and Microstructure (The Chicken and the Egg)," *Proc. of 1972 IUCRUM Colloq.,* La Jolla, Ca. (in press).

On the Naval Research Reserve

Officially Activated Research Reserve Companies

The Research Reserve program is composed of 59 companies throughout the United States. The Naval Reserve Officers are qualified in the conduct and/or administration of scientific research, or in patent, trademark, and copyright matters. These officers are available in the event of national emergency to meet the needs of the Office of Naval Research and the Naval Establishment. Through the year the companies report on their activities and training programs.

FIRST NAVAL DISTRICT

TIME AND PLACE OF MEETING	COMMANDING OFFICER & MAIL ADDRESS
NRRC 1-1 1930, 1st & 3rd Mondays Room 4-270, M.I.T. 77 Massachusetts Avenue Cambridge, Massachusetts 02138	LCDR Alan G. CAMERON, USNR 324 School Street Carlisle, Massachusetts 01741
NRRC 1-2 1930, 1st & 3rd Wednesdays Room 114, Naval & Marine Corps Reserve Center, Fields Point Providence, Rhode Island 02905	LT Richard C. WILKINSON, USNR 62 Griffin Drive Warwick, Rhode Island 02886

THIRD NAVAL DISTRICT

NRRC 3-1 1915, 1st & 3rd Thursdays Naval Reserve Center Hudson & Essex Streets Jersey City, New Jersey 07302	LCDR John J. FERRARA, USNR 68 Broadman Parkway Jersey City, New Jersey 07305
NRRC 3-2 1930, 2nd & 4th Mondays Merchant Marine Academy Kings Point, New York 11024	CDR Ronald A. WEINRESS, USNR 99 Huntington Road Port Washington, New York 11050
NRRC 3-4 1930, 2nd & 4th Mondays Naval Reserve Center Monroe at Clinton Avenue, S. Rochester, New York 14607	LCDR John S. SETCHELL, Jr., USNR 376 English Road Rochester, New York 14616

NRRC 3-5
2000, 1st & 3rd Thursdays
Naval & Marine Corps Reserve Center
Reserve Road
Hartford, Connecticut 06114

CDR Benny A. ANDERSON, USNR
11 Lakeview Street
E. Hampton, Connecticut 06424

NRRC 3-7
1930, 2nd & 4th Thursdays
Naval Reserve Center
Scotia, New York 12302

LT C. R. BRADER, USNR
68 Swaggerton Road
Scotia, New York 12302

NRRC 3-8
1900, 2nd & 4th Tuesdays
Young & Rubican, Inc.
6th Floor, 285 Madison Avenue
New York, New York 10017

CDR Arthur J. MORR, USNR
267 Lakeview Avenue
Rockville Centre, New York 11570

NRRC 3-9
1930, 2nd & 3rd Wednesdays
Naval & Marine Corps Reserve Center
One New York Avenue
Huntington, New York 11743

LCDR William J. SCHNEIDER, USNR
Box 374
Setauket, New York 11785

NRRC 3-18
1945, Mondays
Naval Reserve Center
Onondaga Lake Parkway
Liverpool, New York 13088

LCDR James E. KUNEMAN, USNR
309 Juanita Drive
Liverpool, New York 13088

FOURTH NAVAL DISTRICT

NRRC 4-1
2000, 1st & 3rd Wednesdays
FMC Research Center
US No. 1
Princeton, New Jersey 08540

CDR Earl K. SNEDEKER, Jr., USNR
160 Carter Road
Princeton, New Jersey 08540

NRRC 4-3
2000, 2nd & 4th Thursdays
Naval & Marine Corps Reserve Center
4902 Forbes Avenue
Pittsburgh, Pennsylvania 15213

LCDR Robert S. HOWARD, USNR
3831 Logans Ferry Road
Pittsburgh, Pennsylvania 15239

NRRC 4-4
1930, Mondays
316 Wagner Building
Pennsylvania State University
University Park, Pennsylvania 16801

LCDR Carl R. AMICK, USNR
125 S. Osmond Street
State College, Pennsylvania 16801

NRRC 4-5
2000, Alternate Mondays
Naval & Marine Corps Reserve Center
3920 Kirkwood Highway
Wilmington, Delaware 19808

CDR Herbert W. LARSON, USNR
8 Hollingsworth Drive
Wilmington, Delaware 19807

NRRC 4-7
1930, Alternate Thursdays
Battelle Memorial Institute
505 King Avenue
Columbus, Ohio 43201

LCDR Raymond E. MESLOH, USNR
6640 Guyer Street
Worthington, Ohio 43085

NRRC 4-8
1800, 2nd & 4th Wednesdays
Naval & Marine Corps Reserve Center
1089 East Ninth Street
Cleveland, Ohio 44114

LCDR David B. SNOW, USNR
18 Richmond Square
Cleveland, Ohio 44143

NRRC 4-11
1900, 1st, 2nd & 3rd Tuesdays
GE Technical Training Center
Interstate 75
Cincinnati, Ohio 45215

CAPT(Sel.) Harold A. BALO, USNR
3783 Moorhill Drive
Cincinnati, Ohio 45241

FIFTH NAVAL DISTRICT

NRRC 5-4
1945, 1st & 3rd Thursdays
Marine Corps Armory
Hamlet & Chesley Avenues
Baltimore, Maryland 21230

CDR Lawrence J. VANDEKIEFT, USNR
RD 1, Box 616
Churchville, Maryland 21028

NRRC 5-8
2000, 2nd & 4th Thursdays
National Academy of Sciences
2102 Constitution Avenue, N.W.
Washington, D.C.

LCDR Thomas W. DENNISON, USNR
3408 Memphis Lane
Bowie, Maryland 20715

NRRC 5-9
1630, 1st & 3rd Fridays
(Except during First Quarter; meetings are alternate Wednesdays)
Naval Research Laboratory
4555 Overlook Avenue
Washington, D.C. 20375

LCDR Donald J. HANRAHAN, USNR
3288 Annandale Road
Falls Church, Virginia 22042

NRRC 5-10
2000, 2nd & 4th Tuesdays
Naval Medical Research Institute
National Naval Medical Center
Bethesda, Maryland 20014

LCDR C. Richard VANNIEL, USNR
11104 Powder Horn Drive
Potomac, Maryland 20854

NRRC 5-11
2000, 1st & 3rd Tuesdays
Michelson Hall, Rm 316
Naval Academy
Annapolis, Maryland 21402

CDR William J. THOMPSON, USNR
500 Old Pasture Land
Severna Park, Maryland 21146

NRRC 5-12
1630, 2nd & 4th Mondays
Bldg. 1200, Rm A135
Naval Weapons Laboratory
Dahlgren, Virginia 22448

LCDR Victor A. MEYER, USNR
3 Laurel Court
Fredericksburg, Virginia 22401

SIXTH NAVAL DISTRICT

NRRC 6-1
1930, 1st, 2nd & 3rd Thursdays
Naval & Marine Corps Reserve Center
274 Fifth Street, N.W.
Atlanta, Georgia 30318

LCDR Charlotte M. DIENHART, USNR
1943 N. Decatur Rd., N.E.
Atlanta, Georgia 30307

NRRC 6-3
1930, 2nd & 4th Wednesdays
Army Reserve Training Center
Oak Ridge, Tennessee

LT Philip S. REICHLE, USNR
212 W. Vanderbilt Drive
Oak Ridge, Tennessee 37830

NRRC 6-6
1830, Mondays
NROTC Bldg., Univ. of N.C.
Chapel Hill, North Carolina

LCDR Jerry L. HARRIS, USNR
922 Green Street
Durham, North Carolina 27701

NRRC 6-8
1930, 1st, 3rd & 5th Mondays
Naval Reserve Center
Livingston & Parramore Streets
Orlando, Florida

LCDR Robert L. WALSH, USNR
169 Plumosus Drive
Altamonte Springs, Florida 32701

NRRC 6-9
1900, 1st, 3rd & 4th Mondays
Soil Test Laboratory
2400 College Station Road
Athens, Georgia

LCDR Clifton W. PANNELL, USNR
860 Ivywood Drive
Athens, Georgia 30601

NRRC 6-17
1900, Mondays
Naval Reserve Center
203 Leeman Ferry Road, S.W.
Huntsville, Alabama

LCDR Bruce L. SPENCER, USNR
10019 Willow Park Drive, S.E.
Huntsville, Alabama 35803

NRRC 6-18
1930, 1st & 3rd Mondays
School of Engineering
Vanderbilt University
Nashville, Tennessee

LCDR Raymond D. WHITE, USNR
116 Harding Place, Apt. D-6
Nashville, Tennessee 37205

NRRC 6-19
1930, 1st, 2nd & 3rd Thursdays
Naval Reserve Center
12 Meadow Street
Chattanooga, Tennessee 37405

LCDR William R. CAUTHEN, USNR
1115 Tamarack Trail
East Ridge, Tennessee 37412

EIGHTH NAVAL DISTRICT

NRRC 8-1
1930, Tuesdays
Civil Engineering Bldg., Rm. 207
Tulane University
New Orleans, Louisiana

CDR Stanley P. KOLTUN, USNR
5601 Avron Boulevard
Metairie, Louisiana 70003

NRRC 8-3
1930, Mondays
Petroleum Engineering Bldg., Rm. 209
Texas A&M University
College Station, Texas 77843

LCDR Robert G. MERRIFIELD, USNR
1403 Glade
College Station, Texas 77840

NRRC 8-4
1930, 1st & 3rd Tuesdays
Naval Reserve Center
Houston, Texas 77025

CDR Marion JOHNSON, USNR
194 N. Burnette Drive
Baytown, Texas 77520

NRRC 8-9
1930, Alternate Tuesdays
Naval Reserve Center
Albuquerque, New Mexico

LCDR James J. THOMPSON, USNR
6628 Lafving, N. E.
Albuquerque, New Mexico 87109

NRRC 8-12
1930, 1st & 3rd Tuesdays
Naval & Marine Corps Reserve Center
Dallas, Texas 75202

CDR Robert McCURLEY, Jr., USNR
2600 Brookview
Plano, Texas 75074

NRRC 8-13
1930, 2nd, 3rd, & 4th Mondays
Oklahoma State Univ., PS 453
Pot Office Building
Bartlesville, Oklahoma

CDR Franklyn D. WICKS, USNR
2300 Meadowbrook
Ponca City, Oklahoma 74601

NINTH NAVAL DISTRICT

NRRC 9-1
1900, 2nd & 4th Tuesdays
Naval Armory
Randolph at the Lake
Chicago, Illinois 60601

LCDR L. S. KAMBEROS, USNR
9151 West Forest Drive
Hickory Hills, Illinois 60457

NRRC 9-3
1930, Mondays
(Varied dates July, Aug. & Sept.)
NRC, Southfield & Bendix Corp.
Ann Arbor, Michigan

LT R. J. TAGGART, USNR
16046 13 Mile Road
Beverly Hills, Missouri 48009

NRRC 9-4
2000, 2nd & 4th Tuesdays
Naval & Marine Corps Reserve Center
Milwaukee, Wisconsin 53207

CDR Bruce E. SNYDER, USNR
12007 Elmhurst Parkway
Wawautosa, Wisconsin 53226

NRRC 9-5
1900, 1st, 2nd & 3rd Wednesdays
NROTC Building
Iowa State College
Ames, Iowa 50010

LT J. P. HIERONIMUS, USNR
302 E. Fourth Street
Ankeny, Iowa 50021

NRRC 9-6
1930, 2nd & 4th Mondays
Food Science Building
University of Minnesota
St. Paul, Minnesota

LCDR John W. BARBER, USNR
1919 Hunterlane
St. Paul, Minnesota 55118

NRRC 9-12
1930, Thursdays
Room E-326, Zoology Building
Colorado State University
Ft. Collins, Colorado

LCDR Willam M. HANTSBARGER, USNR
2712 Killdeer Drive
Ft. Collins, Colorado 80521

NRRC 9-16
1930, Tuesdays
221 Computing Center
Michigan State University
East Lansing, Michigan

LCDR Oscar TABOADA, USNR
1826 N. Hayford Avenue
Lansing, Michigan 48912

NRRC 9-21
1930, Thursdays
Denver Federal Center
Denver, Colorado 80225

LCDR Robert D. PRICE, USNR
370 Auburn Street
Boulder, Colorado 80303

NRRC 9-23
1930, Wednesdays & Thursdays
Argonne National Laboratory
Argonne, Illinois

LCDR Dale A. MASSEY, USNR
7818 W. 123rd Place
Palos Park, Illinois 60664

NRRC 9-28
1900, Wednesdays
Crowder Hall
University of Missouri
Columbia, Missouri

LCDR Donald A. WOLFSKILL, USNR
2009 Bald Hill Road
Jefferson City, Missouri 65101

ELEVENTH NAVAL DISTRICT

NRRC 11-2
2000, Mondays
Naval Reserve Center
2727 Paloma Street
Pasadena, California

CDR Forrest A. MILLER, USNR
17421 Alta Vista Circle
Huntington Beach, California 92647

NRRC 11-5
1930, Tuesdays
Naval Reserve Center
San Diego, California

LCDR Thomas J. DELACY, USNR
1427 Big Red Road
Alpine, California 92001

NRRC 11-11
1930, Mondays
Naval & Marine Corps Reserve Center
3400 Airport Avenue
Santa Monica, California

LT Gunter HAGEN, USNR
27357 Pacific Coast Highway
Malibu, California 90265

TWELFTH NAVAL DISTRICT

NRRC 12-2
1700, Mondays
Rm. 1188, Building 311
Lawrence Radiation Laboratory
Livermore, California

LCDR Colin C. MCANENY, USNR
178 Martin Avenue
Livermore, California 94550

NRRC 12-3
1930, Wednesdays
Lockheed Missiles & Space Co.
Building 181
Sunnyvale, California

LCDR George D. SCHMIEG, USNR
901 Oxford Drive
Los Altos, California 94022

NRRC 12-5
1930, Wednesdays
Naval & Marine Corps Reserve Center
Alameda, California

LCDR Neylan A. VEDROS, USNR
2625 San Jose Avenue
Alameda, California 94501

NRRC 12-6
1930, Thursdays
Briggs Hall, Rm. 197
University of California
Davis, California

CDR David R. STORM, USNR
58 College Park
Davis, California 95616

NRRC 12-8
2000, Wednesdays
Naval Postgraduate School, Rm. S-136
Monterey, California

CDR Roderick A. DRESSER, USNR
840 Dry Creek Road
Monterey, California 93940

THIRTEENTH NAVAL DISTRICT

NRRC 13-1
1930, Tuesdays
Naval Reserve Center
860 Terry Avenue, North
Seattle, Washington

LCDR Frederick P. CARLSON, USNR
12701 6th Avenue, N.W.
Seattle, Washington 98177

NRRC 13-4
2000, Tuesdays
Naval & Marine Corps Reserve Center
Swan Island
Portland, Oregon

LCDR Richard E. MEADE, USNR
7940 S. W. Cedar
Portland, Oregon 97225

NRRC 13-5
1930, Mondays
NROTC Armory
Oregon State University
Corvallis, Oregon

LCDR Paul A. VOHS, USNR
1646 N. W. Crest Place
Corvallis, Oregon 97330

Research Notes

Navy Develops "Synthetic" Skin to Treat Burn Wounds

A synthetic "skin" that can be used in place of human tissue to treat severe burn wounds has been developed by the Navy. The new material is inexpensive and can be readily produced in large quantities.

The artificial tissue is a thin, cellophane-like polyester film obtained by the polymerization of organic compounds. It is being developed by the Dynatech Company, Cambridge, Massachusetts, under a contract administered by the Office of Naval Research and funded by the Bureau of Medicine and Surgery.

The conventional treatment of serious burn wounds includes covering them with human skin from donors and specially prepared pigskin. This is necessary partly to prevent infection and the formation of scars but primarily to reduce excessive evaporation of body fluids through the open wound. The loss of body fluids seriously contributes to the debility of the patient, delays healing and increases the susceptibility to respiratory diseases, one of the major cause of death in burn victims.

Human skin and pigskin, however, are expensive and difficult to obtain, This material must also be changed every few days to prevent the immune rejection response from the patient. Consequently the use of these tissues requires the maintenance of tissue banks with the considerable problems of supply, handling and storage.

These drawbacks, along with the possibility that a large-scale disaster could result in a rapid depletion of human tissue in the Navy's own tissue bank, has led to the search for a compatible material that could be produced at low cost and in large quantity and thereby be quickly available in the event of large-scale mishaps.

The material under development by Dynatech is obtained from easily available lactic and glycolic acids. Lactic acid is found in the juice of sugar cane. By polymerization of these acids scientists have been able to produce films ranging down to one thousandth of an inch thick. Since both acids occur naturally in the human body, a burn covering made of these compounds can be absorbed and metabolized by the patient without developing symptoms of tissue rejection.

Tests of these films on laboratory animals has shown promising results in their ability to control the loss of body fluids. Work is now continuing to develop films of uniform thickness and desired flexibility and elasticity. Control of bacterial infection and scar formation will also be studied.

NRL Scientists Discover Mercury in Volcano Plume

Naval Research Laboratory scientists have measured heavy concentrations on toxic mercury in the atmosphere over the Helgajfell Volcano that erupted on Iceland's Heimaey Island in January causing more than 5,000 inhabitants to flee to the Iceland mainland. The measurements were made through the use

of special scientific instrumentation aboard the Laboratory's RP-3A Orion research aircraft. Flying 800 ft. above the volcanic crater, the aircraft flew through the plume (heaviest smoke concentration over volcano) in passes of about 13-minutes each, where both gas and aerosol samples were taken. It was the aerosol (particulates in the air) samples gathered in the one hour and ten minute scientific mission that proved to contain the mercury.

According to Dr. Peter E. Wilkniss and David J. Bressan of NRL's Ocean Sciences Division, principal investigators on the scientific mission, this is the first time that such data had been gathered from the air over a volcano. More important, the data prove that volcano eruptions are significant natural sources of mercury pollution. Studies of the data obtained from the Helgajfell Volcano site are continuing at NRL to determine, if possible, where such toxic effluents go after an eruption.

The scientific mission during which the air over the volcano was investigated, carried the NRL oceanologists almost-around-the-world using special aerosol-gathering and other instruments aboard the specially equipped aircraft to obtain scientific data. The NRL scientists also took random samples of air masses en route, especially in weather fronts, to check for radon, a radioactive gas which is emitted from decaying uranium in the earth. Concentrations of radon in the air tell the scientists about the mixing and movement of air masses: for example, heavy concentrations in frontal system at sea indicate that an air mass recently passed over land. Such information is important to the understanding and forecasting of weather.

NAVAL RESEARCH REVIEWS publishes highlights of research conducted by Navy laboratories and contractors and describes important Naval experimental facilities. Manuscripts submitted for publication, correspondence concerning prospective articles, and changes of address, should be directed to Code 109, Office of Naval Research, Arlington, Va. 22217. Requests for subscriptions should be directed to the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402. Subscription price: $3.00 per year in the U.S. and Canada; $3.75 per year, foreign; $0.35 per individual copy. The issuance of this periodical approved in accordance with Dept. of the Navy publications and printing regulations.

NAVSO P-510

IN THIS ISSUE

VOL. XXVI, NO, 9

Cover Caption

A deep-sea instrument capsule is launched in the Antarctic. The aluminum spheres that contain the recording and release electronics are tethered to the instrument frame by a multiconductor cable. The sensors are attached to an instrument frame that sits on the battery pack. *See page 18.*

DEPARTMENT OF THE NAVY
OFFICE OF NAVAL RESEARCH
ARLINGTON, VA. 22217

POSTAGE AND FEES PAID
DEPARTMENT OF THE NAVY
DoD-316

U.S.MAIL

OFFICIAL BUSINESS

PENALTY FOR PRIVATE USE, $300.