NAVAL RESEARCH REVIEWS

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Portraits in Science

DR. ROBERT A. FROSCH, THE ASSISTANT SECRETARY OF THE NAVY FOR RESEARCH AND DEVELOPMENT, TOOK OFFICE IN 1966. HE IS ALSO CHAIRMAN OF THE COMMITTEE ON MARINE RESEARCH, EDUCATION AND FACILITIES.

PRIOR TO RECEIVING HIS PH. D. IN PHYSICS FROM COLUMBIA IN 1952, DR. FROSCH JOINED HUDSON LABORATORIES AS A SCIENTIST. IN 1956 HE BECAME ITS DIRECTOR. DURING HIS YEARS AT HUDSON, DR. FROSCH WAS INVOLVED IN JOINT RESEARCH EFFORTS WITH THE OFFICE OF NAVAL RESEARCH ON PROJECTS IN UNDERWATER SOUND AND VARIOUS ASPECTS OF UNDERSEA WARFARE. IN 1963 DR. FROSCH CAME TO WASHINGTON TO WORK FOR THE ADVANCED RESEARCH PROJECTS AGENCY, BECOMING ITS DEPUTY DIRECTOR IN 1965.

Navy Research and Development*

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I am not quite sure what the title of my talk really is. It started with a title like: "The Future of the Fleet," aimed more or less at the beginning of the 21st century. It might also be called: "What Does Make a Difference and What Does Not Make a Difference."

I can express one aspect of my central theme best in a statement that Vice Adm. Tommy Booth tells me was made by Sir John Carroll (then Chief Scientist to the British Admiralty) some time around 1963: "The ingenuity of your innovation nearly blinds me to its utter uselessness." I am afraid that this is an overwhelming point about a good deal of military research and development. I have tried to avoid this flaw in what follows. As you will hear, I find concepts more significant than their hardware realizations.

My question is: "How can we make predictions of what we are likely to need, in time to carry out the implications of those predictions in such a way that we can have the Navy that we require, at the time that it is required?"

The history of prediction of any kind is fairly dismal, and the longer ahead one has tried to make a prediction, the more dismal predictive history really is.

Inasmuch as the time it takes to develop and produce military systems has come to be long, compared with the time in which political and military change in the world is possible, we are now in an extraordinarily difficult situation.

I have tried to get at this problem by a process of extrapolation; that is, I have tried to look back over the past 30 years and ask myself, "What are the few things that I think have happened in technology in the past generation, the past 30 or 35 years, that have made a difference?" and then, looking at these, ask myself, "What are the things that are likely to happen between now and the year 2000 that are likely to make a difference?"

First I must say what I mean by a "difference." I am using the idea of difference at a rather extreme and high level. By difference, I mean things that make a radical change; things that change the character of warfare, particularly of naval warfare, in some qualitative way I am looking for changes that are as radical as the change from sail to steam.

I think one needs to be careful about what it is that changes. For example, there is frequently a temptation, particularly among people

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who have not really dealt with naval warfare problems, to think that the change from sail to steam was principally significant because of a change in speed, and, of course, that is not particularly true. I believe the time for a trans-Pacific crossing actually increased with the shift from sail to steam, certainly initially. The radical nature of the change had little to do with speed. It consisted almost entirely of the fact that one became relatively independent of the weather for the first time so that the necessity for following the winds was greatly decreased.

This attempt to look for qualitative, rather than merely quantitative, changes is a difficult one. It is sometimes difficult to distinguish between things that make major differences and things that just make small differences, since the superficialities of what one sees frequently overwhelm the important inner characteristics. However, I have made my choice. Such a choice is partly a matter of taste, and we could argue about these choices rather profitably, or perhaps they will at least be some food for thought.

I have tried to pick the things that are in the first category of what I would call "three categories of change." The first category contains the things that make qualitative differences; that change the world in some intrinsic way, so that warfare or human activity is somehow different in a major way from what it was before.

There is a second category of change in which the change is not in itself intrinsically important, unless it occurs asymmetrically, so that one side makes the change but not the other. Then there is an imbalance. All that happens when both sides change symmetrically is that warfare is just as it was before, except balanced on a new quantitative level.

Changes in speed are usually like that. For example, I would say that the supersonic aircraft has no intrinsic significance whatever in warfare. It has a significance only on imbalance. If one side has it and the other side does not have it, then it may have a significance; but, if both sides have it, all that happens is that you have air warfare that is twice the speed you had before. I assert that there is really no important qualitative change there.

The third category are changes where the imbalance does not mean anything whatever even if it is asymmetric. These are imbalances that are offset by other things. That is, a particular weapon may be of some special use to one side or another in a war for geographic reasons, but may quite naturally be offset by some totally different factor without leading to any basic change. For example, the use of silo-based ICBM's and Submarine Launched Ballistic Missiles in different mixes by two countries can be the result of geographic asymmetries and signify nothing as a strength asymmetry.

I will make one other comment which bears very strongly on the difficulty of making predictions at all. It is a statement about the nature of research and development. The best way I can make it is to make it by analogy, by making a comment which is mathematical in form: Theorems and the proof of theorems in mathematics are never found by systematic means; but after you have a completed collection of theorems and proofs, you always have a systematic arrangement of things. That is, the process of research and development, the process of getting ideas, particularly at the research end, is unsystematic; it is untidy; it is essentially unpredictable; and, in fact, in some ways, it is almost unmanageable. However, the process of taking things that have already been invented and turning them into specific engineering objects can be a very systematic kind of operation. We have two kinds of things, which are very different intellectually, going on inside the research and development community. At the research end, at the end of getting ideas, we have an untidy, difficult, ill-understood process in which what we do is try to get lots of people thinking and hope for the best. Once we have ideas and something that we want to go on and build, we then have a fairly systematic process even though there are many unsystematic and difficult things imbedded in the proce. s. There are always unanticipated difficulties that feed back into further research and applied research.

For the reason that the research end of things is so unpredictable, before I go on to making my predictions I will make a disclaiming statement: the most important technological developments for the next 30 years will turn out to be the fruit of things that have not yet been invented. It was that way if one made a prediction at the beginning of the last 30 years; I think it is that way now; it will always be that way. Thirty years is a long time for technological change. It is a human generation, but it is something between five and seven development generations; we could have technological changes several times in the course of the next human generation.

It is asserted from time to time that the time from the invention or discovery of an idea until its actual use in hardware is getting shorter and shorter. What is getting shorter and shorter is the time from the invention of an idea until somebody attempts to apply it. The time from the beginning of the attempt to apply the idea until it is actual hardware that can be used in the Fleet has stayed constant, perhaps gotten slightly longer, over the past couple of generations. The reason lies in the fact that the two processes are different. To get from the fundamental idea to the idea of an application—that is, to the beginning of development—one only needs communication and ideas, and the communication has been getting faster and better. To get from the beginning of the development to the end of the development takes a long sequence of detailed and specific steps. In particular, the beginning of development of the system is the point where one begins to have a complicated administrative problem, so that the process is governed by more than the availability of ideas and the availability of communications. If we get to a point in history such that the time from fundamental idea generation to the beginnings of application becomes zero, we will not necessarily continue to cut the time from the beginning of idea generation to actually having completed weapons and devices. I'll come back to this point a little later.

At the present time I think we are in the position that the time to go from development into initial production is shorter than the time it takes for the development, and that is an important point for the next 30 years.

Now I will give you my list, with some comments of the dozen or so things developed over the past 30 years that I think have really made major differences in warfare. I think I would not get a very different list if I tried to make a list of the dozen things that have probably made the major difference in all of technology over the past 30 years.

The first thing that I would list is, of course, nuclear explosives, not because of the properties of the hardware, but because of the mere existence of the hardware. What has happened is that the existence of nuclear capability has introduced the formal idea of deterrence, the capability of deterrence on a worldwide scale, and that has probably changed warfare more than anything else, because it has introduced a peculiar level of doubt and difficulty that previously did not exist. I will later come back to what I think that means for the future.

The second major event was the invention and development of radar and communications. I put these together as the general use of the electromagnetic spectrum, because this has made it possible to see at great distances, to see through the weather, to communicate at great distances, and to communicate without regard to weather or to distance. It is no longer necessary for a detached unit to be out of communications, or for a detached unit to be unable to see.

The third change is related to the use of the electromagnetic spectrum, at least conceptually, and that is the use of space because it means that we can look at the whole earth; we can look at the weather; we can do surveillance; and perhaps most important, it has forced us to think of the world as the world in a much more direct sense than we previously did. I think that there has been enforced a kind of psychological difference between looking at a globe and saying, "Oh, yes, the world is round, and at the present time around on the other side, it's nighttime," and looking at photographs from space. One sees it in a different way from the geography classroom than one observed it from photographs taken by astronauts from TV transmitted pictures of global weather, and so on. I think this concept of looking at the whole earth as the whole earth simultaneously has made a major difference.

In a direct naval warfare sense, I think the invention of nuclear power for submarines has made a qualitative difference because it has made the true submersible possible, and I think this has changed the nature of potential sea warfare greatly, even though we have not yet had to use it in warfare. It has changed the antisubmarine warfare problem profoundly, as well as making a special class of nuclear deterrent systems possible.

Nuclear power for surface ships I would class as a quantitative improvement, but not a qualitative improvement that changes everything completely as it does for submarines. That does not mean it is unimportant, but it does mean that I would not class it as one of the revolutionary and overriding changes.

The next thing I list is what I insist upon calling the revival of rocketry. The new rocketry, both tactically and strategically, has changed the world. The reason why rocketry could be revived is connected with one of my later points, which is probably of more importance.

Solid-state electronics, and its capability to pack a tremendous amount of information handling into a small space and weight, has of course been extremely important, and will continue to be so.

Perhaps as important, or more important, than the hardware capabilities that come with solid-state electronics, has been the philosophical change from analog thinking to digital thinking, from using continuous voltages and currents, as the computing elements themselves, to manipulating with numbers. This has meant an entire change in computing capability, in reliability, and, in fact, in whole new modes of thought about accuracy and about how to attack problems. This is making, and will make, a major change.

Another idea which is more important than its hardware, and is also connected in some ways to radar and communications, is the idea of the separation of the operator and the sensor; the idea that a man's eyes and ears, or what he uses for eyes and ears, do not have to be attached to him. There was always a rudimentary version of this in warfare in the sense of the forward scout who could go and look and come back and report, but we are in the beginnings of a revolution which is far beyond that, because we have begun to put the eyes and ears far away from the man who operates with the information. A man on the ground can now dig on the moon while he watches.

I would now like to mention four ideas which are more fundamental than any of the things I have already mentioned. They are ideas and not hardware. I think they are part of the really important intellectual inventions of the 20th century, and perhaps among the important intellectual technological inventions of all time. They are seldom or too infrequently mentioned.

The first is the idea of feedback: just the very idea that it is useful to take a portion of the output of a device and put it back into the input in order to change the operation of the system. This was invented originally as a technique for dealing with the stabilization of amplifiers in the early days of radio reception. It has become an idea which has a life of its own far beyond its use in hardware. It has changed the way in which computations are done; it has changed the way in which we look at physical, social, military, and economic processes entirely, and I think it has changed the way in which all warfare is done, at least because on the way it has changed hardware. It is the key idea that has made the revival of rocketry sensible, because it is the essential element in all modern guidance and control systems: take the output of the system and put it back in to correct the input so that the next output will be better.

The second idea that is extremely important, and I'm not sure these last four are in any particular order, is the idea of "system": the idea that lots of things working together are an entity that has to be thought of as an entity for a total purpose: it makes no sense to deal completely properly with each of the pieces unless you look at the overall entity and tie it together to be a total object to do a particular job.

The third is the systematic treatment of signals and noise, and signals in noise, along with the systematic ideas that flow from the signal-to-noise concept: the ideas of detection, detection rate, missed detection, and, most important the idea of the false-alarm rate. This last is the idea that the ability to detect is intrinsically tied to the number of false detections—detections of targets that are not there. Previous to having this concept we went questing after impossible systems—for example, systems with perfect detection probabilities—because we did not understand the connection between our ability to detect things and the fact that we would automatically be fooled by detections of what is not there. This is a very general idea that goes beyond specific sensor equipment systems. It is an important general idea in thinking about how we deal with the world.

Finally, the idea of systematic economic choice—which is the real idea of systems analysis—has had an obvious impact on warfare and technology. This has had a very direct effect which has been obvious to all of use. To some extent many people feel it has had a directly deleterious effect. I think that problem is the result only of the birth-pangs of the idea and its use. In the long run, when we get better methodology and a better understanding of law to use study results in context, it will prove to be one of our most intellectual tools.

All of these things that have happened contain the seeds of what will happen, so that the things I will now talk about are built directly on those events.

I come to the things that will make a difference. Perhaps I should call them things that would make a difference, in the sense that they require work; we must work on these problems if they are really to make a difference.

The first is one to which I have already referred. The change that might make the greatest difference in future warfare, and in fact in future technology, would be to shorten the time it takes to develop something new. It now takes anywhere from 5 to 10 years to take a development from the idea to production and into the Fleet. Whether you think it's 5 years or 10 years depends in part on when you define the process as starting and ending; there is quite a lot of variance from development to development.

This change would make a difference because it would make it possible for us to respond more rapidly to change in the world. The time that we have to take to predict, develop and produce a Navy is now so long that we have a concern that we may, at the end of the process, have the wrong Navy and the wrong weapons for the true technological and political-military circumstances in being by the time we actually have that Navy and those weapons. This is frequently expressed by saying that everything is obsolete by the time it is produced, and is a natural consequence of the time it takes to develop. Any piece of electronics that goes into the Fleet uses technology which is at least 5 years old the day it goes into the Fleet. If we try to update that technology in the course of the development, we never complete the development, and/or we have terrible logistics problems with the weapons system. If we could make a radical decrease in the time it takes to do development, say, from 5 to 10 years down to 2 years, then we would be much more responsive and much more able to change the Navy to track the way in which the world changes. This could have the consequence that, at any given time we would actually need to have a smaller inventory of actual hardware without the smaller inventory being a danger to us, should we have to use it. I mean this in the following sense: currently we have to maintain a collection of navies aimed at a collection of possible wars and possible circumstances, and at possible technologies that a potential enemy might develop. If we actually were more responsive, we could diminish the necessity to keep in being some things—the trouble is we do not know which things—that we will never use or which, because circumstances have changed, would be useless if we had to use them. We would have to build fewer interim systems; systems we know are not right, but had better build, or patch together, because we might need them before we can get around to developing what we really ought to have. We do a large number of developments on an accelerated, makeshift, 2-year scale, because what we really want takes 5 to 10 years but we cannot wait. With a valid 2-year schedule, for example, we would be able to adjust our weapons better to the precise circumstances for which they would be required.

The second area which will grow in importance—it has already begun to do so—is the methodology for doing analyses of hypothetical situations, for analyzing warfare situations, and for understanding what they mean in terms of hardware which we should develop and tactics which we should use. We are just really at the beginning of the methodology for looking at war and at various scenarios for war. Better analytical methodology will make an important difference.

The third problem has very much more general application than warfare, and that is the development of the ability to think about nonlinear situations. Almost all of our analysis, almost all of our thinking about warfare, economics, hardware situations, and tactical situations is linear. We look at a large problem, and we are appalled at the size of the problem; we rapidly cut it up into pieces, each of which we can solve independently; and we then make the blithe assumption, because we must, that having put the problem into subproblems we can put the subproblems back together again, add up all the solutions, and thus have the correct solution to the overall grand problem.

This assumption is true for almost no real-world problems. One of the most important problems we are on the verge of solving, that will make a major difference in warfare, will be the ability to think about large nonlinear problems. If we are able to do this, then we will be able to measurably reduce development time by improving our capability to predict the results of large nonlinear situations. Improvement in analytical methodology and in nonlinear techniques together might change the whole time scale of our ability to change the Navy and to make predictions about how the Navy should be changed. If we can lengthen the time into the future for which we can make a good prediction and shorten the time it takes to respond to that prediction by changing the Navy, we would be in a much better position for future warfare.

The next area which is most important—and more important than any of the hardware—is a change in how we can learn about using people. By this I am referring to the vast expansion of solid knowledge in physiology, psychology, and in behavioral and social sciences in general. We are just at the very beginning, on the shadowy edges of knowing how to fit people and machines together; how to build the machines so that the people can really use them; and we have scarcely begun to work on how to fit people together, in a systematic, scientific technological way.

People have been tackling these problems more or less by intuition for a long time. We usually encapsulate existing knowledge in this field under the name of leadership, and we do fairly well without knowing anything technologically and systematically sensible about it. A systematic understanding in this area could help us in the detailed matching of people together, in groups, to their jobs and to the machinery they use to do those jobs.

I mentioned the idea of deterrence earlier and will now return to that subject to say what I think is happening to the idea of deterrence, what it has done to warfare, and what it is likely to mean in the future. The first thing the idea did was to lead to the invention of the escalation ladder, a systematic recognition of the fact that two boys in a schoolyard start by yelling at each other and end up pummelling each other by a simple, straightforward series of steps. Once nuclear deterrence actually came into being it had an effect which was not originally anticipated—that is, it decapitated the escalation ladder. Instead of having and escalation ladder that goes all the way up to an ultimate conflagration in smooth stages, what has now happened is that we have an escalation ladder truncated somewhere about the middle. It is a little fuzzy there. Everybody starts getting frightened that instead of going up the next couple of steps smoothly, there will be a sudden jump up the ladder to a global war. This has meant that it gets harder and harder, and there is more and more reluctance to engage in warfare above a certain level. Without arguing the question of whether this is a good or a bad thing, I think it is psychologically real, and something with which we will have to go on dealing. I think there is a research problem here which could change the whole nature of the problem.

We understand almost nothing systematically about the psychology and social forces that operate in deterrence. We really do not know why deterrence works, except in the general sense that people are afraid of what might happen and therefore they stop. We simple have no quantitative understanding of the problem. I am not sure it is possible to have one, but I think it is very important to look for one. For example, when we work out force levels for strategic war, we start out with assumptions that always read something like: "To deter an enemy nuclear weapons attack, we must have a force that is surely capable of destroying one-third of the enemy population and 50 percent of their industrial technology." These numbers are quite literally pulled out of the air, and nobody has the faintest idea of whether one-third is 10 times the necessary deterrence level or one-tenth the necessary deterrence level.

For example, how much deterrence must the Soviet Union provide to deter the United States? From the way they seem to have gone about it, they seem to think they need 90 percent destruction. I assert that we must consider—I am perfectly willing to treat this merely as a hypothesis for discussion—that the suitable level for destruction by the Soviets on the United States, to provide quite complete political deterrence, might be as low as 1 to 10 percent. That is, the absolute capability to destroy one reasonably major U.S. city may be perfectly good political deterrence against the United States, because in our present political state and frame of mind, one which I think will continue, it may be that no President could be other than deterred by such a threat. In fact, since we have not planned and are not likely to plan an attack on the Soviet Union under forseeable circumstances, the required level of Soviet deterrence force is really zero, but they do not believe this.

I don't think we fully understand the situation; I think it is most important to try to understand it better, and I think that such understanding might change many aspects of future foreign policy in general, as well as future warfare.

The problem of political restraint on tactics and doctrine is also related to deterrence in relationship to the decapitated escalation ladder. I mean the kind of political restraint we have witnessed in Southeast Asia and which many of you, I imagine, have experienced in actual tactical operations there. There is a tendency to regard this as an imposed irrelevance, an error, as something that we just simply should not be doing to ourselves. I do not agree with this view. I regard these restrictions as intrinsic to the situation, as restrictions and doctrine that are not going to vanish. These changes are going to change the nature of naval warfare. I think this because there is a reason to believe that a large portion of naval warfare in the next 30 or 40 years is likely to be relatively small action—small action in the sense that it will not be global, it will not involve all the maritime powers, and, in fact, it need not even involve all the countries in a local area.

Just consider fighting a naval war in the Mediterranean in which the Soviet Union, for example, was not an overt participant; although some of her satellites, or even countries that nobody was quite comfortable about calling satellites of the Soviet Union, were involved with Soviet assistance. We are not fighting hand-to-hand or within sight, we are fighting with radar; we are fighting with long distance systems, with systems that don't always identify targets perfectly; we are fighting in situations where we never have known absolutely which submarine fired the torpedo; we have no way of knowing which submarine will fire the torpedo or who owns it. We cannot even be sure who owns the airplanes which fire at us, even though we may identify them as *Badgers*, because countries have *Badgers*. In fact, we have come to a state of confusion whereby we cannot even be sure if an F-4 fires on us, who it may be. We are in a state in which we may not know precisely the politico-military scenario; where naval battles are likely to be fought in a situation in which there are neutrals who want to be regarded as neutrals, but become involved in a naval battle, as they have been occasionally in Vietnam; in which some of the adjacent countries are participants, some are not; where we want to restrict our actions because we do not want these countries to become participants; where we do not want to kill the innocent, and yet we do not want to take action to keep the innocent out by force, because this might adversely change the character of the war. I think this is intrinsic to this type of situation.

Furthermore, in peacetime maneuvers with navies we are doing what amounts to inadvertent combined exercises with the Soviets and with other navies, so that we do not even have the freedom to manipulate a naval force in absence of other naval forces and to hold completely independent operations. These difficulties are intrinsic and will perhaps have the greatest effect on what we can or what we must do with technology.

Partly for this reason I think we must and will move in the direction of a completely integrated Navy-wide and national global command control and communication system in which there will exist a complete surveillance system. In order to make any sense out of the kind of political-military situation outlined above, the fleet commander or the unit commander has to have full knowledge of his political and operational environment. He must know where all the other forces are, and not only the purposeful forces, but the inadvertent actors, the merchant ships and fishermen. He must know where they are and who they are. His actions must either be directed by central authority, based on information available globally to the central authority, or, possibly more sensibly, he must at least have available to him, on the local scene, the information which can only be available through central authority because it comes in from global information sources. The commander on the scene really needs to know the world-wide political and military situation before he can decide whether he wants to take the risk of firing at the unidentified submarine, because there may be information elsewhere in the world that would help him with the identification of that submarine. Not only is 'hard' sensor generated information, like surveillance information, important, but also 'soft' information, such as political intelligence that says that Party C, who is not involved in the battle between Parties A and B, probably sent a submarine there to keep track of what was going on, and the last thing in the world we want to do now is to involve Party C; therefore, prudence is required. The world has gotten complicated militarily in a way which we are just beginning to comprehend. This requires massive changes in technological requirements.

One obvious increasingly important technological requirement is IFF—the ability to identify at least your friends completely, unambiguously, and continuously. IFF has always been a hard problem; it has not gotten any easier with time. I think we are beginning to have some handles on it, at least for aircraft, possibly for ships.

That brings me to the question of the use of the electromagnetic environment, which I mentioned earlier as one of the great things that has happened in the past 30 years—the ability to see and to talk continuously. I calculate that we are now in the third era of the use of the electromagnetic environment; the future holds the fourth era. I count the zero era as being the time in which we had no radar and no electromagnetic communications. Then there was a period in which there was a massive qualitative change. There was radar and we could talk on the radio, but there were no artificial countermeasures. The second stage was the halting invention of countermeasures. The third stage has been the halting invention of counter-countermeasures—the things that will make you immune to what the other guys do. I think that what will have to happen next amounts to complete management of what happens electromagnetically, at least locally and possibly more than locally. We can no longer distinguish between the measures, the countermeasures, and the counter-countermeasures. We will have to be able to play the whole electromagnetic environment continuously as a single systematic operation.

I think we will have to move into an era where ships and aircraft do not just radiate when convenient or as they please, but they will radiate only as part of a symphony of radiation which is thought out and operated in a sensible and coherent manner.

This is more than just the ability to turn everything off. There are lots of situation in which (a) you cannot turn everything off and in which (b) you don't want to turn everything off; and you really want to use the electromagnetic spectrum. We may get into an era where, instead of being quiet except when you want to talk, you are always noisy, except sometimes you are noisy in a significant way, and sometimes you are noisy in a way which is not significant. We may also need to go to an era in which those who are noisy are not always in the same place, in which the use of electromagnetic radiation jumps around the task group, around the fleet, in a way which is confusing. We may have to fake, to make sure there are plenty of things that are radiating and look perfectly sensible, that have nothing to do with the fleet or are even someplace else. This is going to be complicated.

I want to comment a little more on the system idea. I think we have come into an era in which the system idea, which I earlier classified as one of the great inventions, has now gone mad in the sense that we have optimized and systematized and tied everything together so well that if the system is not quite right for the operational situation, we are faced with serious trouble. We cannot change it because it is all tied together so well we cannot pull one piece out without disrupting the whole thing. I said this to a group of technologists the other day, and they said, "Well, that's just bad system design," to which my reaction is that we have not designed any other kind.

The difficulty is that we are not designing systems to include the time dimension. We are designing a system to solve a problem at a particular time, whereas we should be designing a system with the idea of change with time built into it intrinsically. We should not be physically building the avionics into the airplanes, wiring it in and riveting it in, so that we must take the aircraft to a rework facility in order to change anything in the airplane. We should be able to change the avionics of the aircraft just as we change the weapon loading of the aircraft to suit the next day's tactics, and just about as easily. If the airframe is made for it, we should be able to change it from fighter-configured avionics and weapons, to attack-configured avionics and weapons. We should be able to change to any attack avionics system that the airframe can carry just as easily as we can hang the weapons on it. One of the significances of solid-state electronics and digital techniques is that they will permit us to do this.

I am afraid, however, that we will not do this. I am afraid that what we will do is take advantage of the space and weight improvements of solid-state electronics by packing in more electronics rather than making it interchangeable. We will again fill the airplanes with systems that will be so well tied together that we cannot change them. However, building avionics that can be changed easily could mean flexibility, the ability to make modular changes in tactics and weapons. The use of more unified solid-state components to accomplish this could mean a major improvement in reliability—up several orders of magnitude. The electronics can get to the point where, from the point of view of the people who have to operate with it, it is effectively as inert as the metal in the airframe. We would then have to maintain the electonics not at 35 flight hours, but on whatever cycle we use to worry about wing spars.

There is an important additional point about weapons—the air-to-ground weapons business, particularly, is now splitting. It used to be that all weapons were dropped using sensors in the airplane. They were all what I call "area weapons," that is, you can hit a football field with them. We have continued improving that accuracy, and we are still improving it, and I think that is a waste of time. We can go down that line for another decade, and, instead of being able to hit a football field we will be able to hit half a football field, and the cost will have gone up fantastically. Fortunately we have split, and we have now gone to putting the brains into some of the weapons using the idea of extensors; that is separating the sensor from the operator so that the eyes or the ears or the radar are in the weapon. The weapon tells the operator where it is and what it is doing, and the operator controls it so that the weapon is worked by the man all the way into the target. By this means one can get terminal accuracy to split the goalposts instead of just hitting the football field.

This changes air attack, and it changes it particularly for situations like insurgencies. This was best expressed to me by a colleague when he said, "The ideal for air attack in a counterinsurgency situation is to be able to kill the mortar operator in the schoolyard without breaking the windows in the school," and I think we may be on the edge of doing this. It would make a great difference between just crushing at random and being able to destroy selectively.

I would like to make one last point which I think is of general importance—that being the idea of mobile basing on a vastly larger scale. It has become clear that the politics and economics of overseas bases are beginning to be very difficult. Their expenses are politically difficult, even if we count just the direct costs. When we count the indirect costs, such as the related economic and military assistances program aid, then overseas bases become even more expensive. There is further evidence that the mere establishment of a base in an area for the purpose of being responsible to an insurgency has had the effect of increasing the probability of the insurgency for which the base was established to cope with. That is the kind of self-defeating result that we can only control by lessening the use of foreign land bases. There are implications here worth noting. First is the ability to move forces rapidly from the United States. Since we cannot do the total logistics for that by air, it further suggests the development of major mobile sea bases. I think that is another important step that will change the Navy in a very profound way in the next 30 years.

I am sure that the lists I have discussed have somewhat the sound of a random selection, but I think they are all tied together, in my mind at least, by the idea of integration and coordination. We have moved into an era of warfare situations where, whether we like it or not, everything affects everything else. The only way in which we can cope with that development effectively is to join it and to integrate our response so that our abilities to fight as a Navy are integrated in the same sense that our problems seem to have integrated themselves.

New Uses for Bioluminescence

The investigator on this project has been working on the bioluminescence produced by marine bacteria and flagellates under ONR support, first at the University of Illinois, where he discovered the so-called "scintillon," and currently at Harvard. The Scintillon is a crystalline organelle in luminous bacteria; it can be isolated in pure form and can be made to flash by mechanical or chemical stimulation. Currently, however, his interest is in the reactants produced by other light-generating organisms. Used in highly purified form, the luciferin and luciferase, substrate and enzyme involved in light producing reactions, may be mixed in the test tube, and will produce light if the proper additional substances are provided. The specific need for analysis of traces of certain elements makes this reaction of particular interest to the biochemist, since the light produced is easily measured and quantified. By the use of such reagents very delicate analyses of calcium ion and other substances can be made, making it possible to improve the studies on the transfer of such material into and within cells. The investigation which began through an interest in the phenomenon of luminescent wakes may well end up providing the tools needed for understanding of the action of nerves and the effects of various drugs and poisons on human tissues.

Navy Symposium Calendar

Symposium on Optimization Methodology and Applications to be held at Texas A&M University, College Station, Texas, 12-14 May. Additional information may be obtained from Professor H. O. Hartley, Texas A&M University, College Station, Texas 77843. Phone: Area Code 713, 845-3141. Sponsored by the Office of Naval Research.

Tri-Service Radar Symposium to be held at the Naval Postgraduate School, Monterey, California, 17-19 June. Additional information may be obtained from Mr. W. N. Shaddix (Code 5305, Naval Research Laboratory, Washington, D.C. 20390. Phone: Area Code 202, 767-3647, IDS 197-3647, Autovon 297-3647. Co-sponsored by the Army, Navy and Air Force.

Antishark Measures

CAPT H. David Baldridge, U.S. Navy
Naval Aerospace Medical Center, Pensacola

C. Scott Johnson, Ph.D.
Naval Undersea Warfare Center, San Diego

Interest in the development of effective means for protecting men from sharks has gained significant momentum in this country since the early days of World War II. The United States Navy, through its Office of Naval Research, established a Shark Research Panel in 1958 under the auspices of the American Institute of Biological Sciences. Research conducted by members of this panel and by similarly concerned scientists over the last decade has greatly improved man's position in this inherently uneven contest.

Approaches to the control of aggressive shark behavior fall into two general categories: area protection for a number of people, and the devices and procedures proposed for use by endangered individuals.

Methods of Collective Protection

Early concepts for collective protection at swimming beaches were straightforward, in that attempts were made to completely enclose large areas within rigid metal fences. Maintenance costs associated with corrosion and the shifting of bottom sand made fences impractical for extensive stretches of beach; nevertheless, today fences are still used at some Australian resorts for the protection of limited bathing areas. At one time it was believed that a barrier could be provided inexpensively by encircling a swimming area with a curtain of air bubbles streaming up from a perforated, pressurized line on the sea floor. Field tests, however, revealed that certain dangerous sharks quickly adapted to the bubbles and moved through them freely.

The most satisfactory collective protection for bathers is the "meshing" of beach areas. Meshing is a technique of intensive localized shark fishing, in which gill nets are placed in staggered discontinuous patterns beyond the breaker line offshore. No attempt is made to enclose the protected area completely or to prevent sharks from moving through the loose maze of nets. In fact, many of the entrapped sharks are caught while moving seaward away from the beach. The incidence of shark attacks has been drastically lessened in recent years through the meshing of resort beaches in South Africa and Australia, where this approach originated. According to Dr. David Davies, who was director of the Oceanographic Research Institute at Durban, the number of sharks caught in the sea-nets there decreased from a total of 552 caught in 1952 to only 117 taken in 1960.

Bathers at a beach in Australia cope with the hazard of shark attack by restricting their activities to an area completely separated from the sea by a shark-proof barrier

The sharks discussed here are the species that frequent relatively shallow water. There is some doubt that meshing or fishing techniques would be effective against the wide-ranging pelagic sharks, such as the blue shark, that are known to migrate over great distances.

Off South Africa, a form of electrical barrier is currently being evaluated in terms of power requirements and maintenance problems. Electrode arrays shallowly buried in the sand bottom are energized to inflict intolerable conditions on sharks attempting to transit the water above. Findings to date indicate that this method, although highly effective, may not be practical because of the expense of providing adequate current and maintaining the electrode array. Future developments may reduce costs and make this method practical; it may now be practical for certain naval operations.

Protection of Individuals

The problem of providing effective protection for individual swimmers is much more difficult than the problem of collective protection. Furthermore, the degree of difficulty increases rapidly with the level of the shark's excitation. Underwater swimmers on the move pose yet

Commercial shark fishing operations such as this one at Mezatlan, Mexico draw heavily upon local shark populations, thus helping to minimize the threat of sharks to swimmers and divers

another problem as compared with the immobile, perhaps bleeding, survivor of an air or sea disaster floating on the surface.

It is logical that the first protection aim should be not to advertise the presence of a man in shark-infested water. Once a shark is alerted and begins, out of natural curiosity, to investigate the presence of man, a maximum effort must be made to avoid stimulating the shark to agressive behavior. If the shark becomes sufficiently excited to attack, the odds are highly in its favor. This is particularly true if the presence of the shark was unnoticed and the man cannot employ the antishark devices and techniques available to him.

One sure way for a man to attract a shark's attention is to thrash around on the surface with the irregular, splashing movements of distress. A shark thus attracted would find the sight of arms and legs moving in very "unfishlike" fashion most interesting. An additional hazard is the possibility of olfactory stimulation by the presence of blood or other chemicals that might pass into the water from the body of a human under severe stress. With these aspects of the problem in mind, the Naval Undersea Warfare Center has developed the shark screen, which appears to hold great promise for men awaiting rescue in shark-infested waters. The shark screen is a water-filled plastic sack suspended from the surface by means of flotation rings. It is big enough so that a man can roll into it and float loosely within its diameter without bulging the sides or resting on the sack's bottom. The bright-colored flotation rings above the surface aid in detection by search aircraft, while the dark submerged part appears to sharks as an uninteresting gross shape with no dangling appendages. Olfactory stimulation is eliminated because blood and other chemicals are retained within the sack. The man should float quietly in the shark screen, with a minimum of movement while he awaits rescue. The shark screen can also be used as a poncho, stretcher, pup tent, sleeping bag, or water collector and container in other survival situations. Not a repellent in the true sense, the shark screen is best described as a camouflage device and, to some degree (because of its large, dark underwater shape), a passive visual deterrent.

The dense black coloration produced in sea water by the dye component of the shark chaser chemical repellent provides a form of visual deterrence similar to the shark screen. Some species of dangerous sharks appear to be very reluctant to enter a region of water deeply stained by such a dye. It is possible that the deeply colored region may even appear to the shark as a solid and impenetrable barrier. A disquieting effect on the shark may also be produced by movements at the boundary of the developing cloud of dye as it expands in response to diffusion and water currents.

The problem of attracting attention by visual stimulation would also seem to dictate the judicious selection of colors for beach clothing and diving equipment. The eye of a shark, while not equipped for detailed sight, is well developed for discerning movement, as well as distinguishing contrasts in brightness and form, against a dim background. The bright patterns guaranteed by designers of swimwear to attract attention on the beach may do exactly the same thing underwater. The use of bright international orange for sea survival equipment would appear to be inviting trouble. However, this color does diminish a hazard far greater than the possibility of shark attack, failure to be spotted by search and rescue aircraft.

Pharmacological and Electrical Methods

A positive advance in deterrence would be a chemical or drug that could be deployed in the sea to produce an intolerable level of discomfort or an incapacitating physiological response in an onrushing shark. Unfortunately, many years of research have produced no chemical that could be used in reasonable concentrations. Even extremely toxic materials, such as strychnine, cyanide, and nicotine, are required in such concentrations that rapid incapacitation of a large, charging shark would be impractical. The quantity of such substances that would have to be carried as an item of individual survival equipment would be too large.

Hope remains that a drug will eventually be found that will reliably produce significant behavioral changes in aggressive sharks at low concentrations. Such effects would be best achieved in sharks that have not yet become excited to the level of aggressive behavior. However, even the ideal chemical repellent could only act for as long as it takes to dissolve the supply on hand. The present shark chaser packet is exhausted in about 3-1/2 hours when allowed to dissolve without interruption.

If an electric field were set up around a shark, the animal would experience a shock whose intensity would be determined by the strength of the field and by the orientation of the shark with respect to the potential gradient. The use of a pulsed field would lower the energy requirement and prolong the life of the battery power supply. The general theory appears sound, and approaches to the development of practical repellers in terms of size, weight, and effectiveness are matters of considerable attention at present. Electrical repellers tested thus far have not proven totally satisfactory because they apparently have not been able to provide voltages great enough to repel and still be safe to the user. This area, however, does show promise and it may be possible someday to design a device with the right combination of field intensity and wave form to repel the shark and not endanger the user.

Lethal Devices

For those adventuresome skindivers who find themselves in the position of directly engaging an overly attentive shark, there are several effective weapons available. The most basic is the shark billy, a short club used primarily to fend off sharks at close range. For more offensive use, there is the bang-stick, or power head. This device consists of a cartridge-firing chamber on the end of a probe several feet in length, that can be discharged by backward movement onto a fixed firing pin as the muzzle end of the bang-stick is driven smartly against the top of the shark's head. The force of the discharge, when applied to the region of the brain, is sufficient to produce instantaneous immobilization and rapid death. However, the user should be aware that the explosive discharge of the weapon can attract other sharks to the area, and that an inaccurate shot can produce a very unhappy shark in an extremely excited state.

A more sophisticated approach is the syringe-type pharmacological weapon proposed a few years ago by a group of Australian divers. A barbed hypodermic needle is rammed home by means of a spear or lance, and an incapacitating dose of drug is delivered to the shark's body by means of a spring-driven syringe. Current research is concerned primarily with the development of drug loads suitable over wide ranges of temperature and for sharks that differ greatly in size. This method also has its drawbacks, since the drugs so far tested require up to several minutes to cause death; in the first several seconds after application, the shark may become highly agitated.

The dangers inherent in handling lethal antishark devices cannot be overemphasized. The hazard posed by any shark-attack deterrent must always be weighed against the actual likelihood of attack. In general, the deterrent must always be readily available and dependable to be of value, which means that it must be capable of enduring long periods of safe storage with minimal maintenance and still be available on very short notice for use.

Difficulties in Research

When evaluating antishark devices, it is always important to test them against several members of a multitude of species. Otherwise, the conclusions reached may not be reliable. A good example is the previously mentioned bubble curtain. The device was tested against twelve tiger sharks. Eleven of the sharks swam back and forth through

The Mote Marine Laboratory (MML) shark facility near Sarasota, Florida offers conditions varying from heated, filtered sea water in tanks of various designs and sizes to natural pools. Live sharks, caught by long line offshore, are returned to MML in the sheltered water of a retriever, which is shown on the deck under the platform in the photograph. The shark is first placed in the handling flume between the main tanks and then into the 50-foot diameter holding tank. The 80-foot diameter circular "race-track" in the foreground was designed for use in studies on shark hydrodynamics.

This shark is about to bite a baited meter designed to measure the force exerted by its closing jaws as part of a Navy study on the ability of sharks to inflict damage on cables and other hydrographic equipment.

the curtain at will, but the twelfth refused to do so. Had only that twelfth shark been used in the tests, completely erroneous results would have been obtained.

Adequate holding facilities are expensive to construct and maintain. At present there are only about a half-dozen laboratories in the world that provide enclosed facilities for the study of large sharks. In the United States there are only three: The Mote Marine Laboratory, Sarasota, Fla.; the University of Hawaii, Oahu; and the Institute of Marine Sciences at the University of Miami. The Lerner Marine Laboratory in Bimini, The Bahamas, has excellent facilities and is operated by the American Museum of Natural History in New York.

It is difficult and expensive to test any shark-deterrent device adequately. One liability is the small number of dangerous species that can be kept alive in captivity long enough to be used for reliable testing. In fact, none of the large pelagic sharks (*e.g.*, the great white and mako) has been kept alive for more than a few days in captivity. While sharks are difficult to kill quickly, they are easy to injure during capture and may die within a few days or weeks. As a consequence, healthy captive sharks are very valuable, and the larger ones may be priced by a laboratory at from $200 to $500. Feeding and maintenance costs are also high. Under these circumstances, the testing of devices (chemical or otherwise) designed to kill or severely injure could become quite expensive.

In addition to experiments in captivity, tests must also be made on sharks in the wild if conclusions on the effectiveness of the deterrent are to be proven valid. The main problem in this regard is the maintenance of adequate facilities for long-time observation, with due regard for human safety, in areas where numerous sharks are present.

Shark Sense

For the hapless person who finds himself in waters where shark attack is likely, and to whom no deterrent devices are available, the best defense is use of good shark sense. In general, this means the making of as little commotion as possible in the total sense of the word. Olfactory, visual, and auditory attraction or stimulation should be avoided, if at all possible. At no time should a shark ever be provoked. Even the relatively docile nurse shark has inflicted serious injury on adventurous divers who have pulled their tails or tried to ride them.

There are some antishark actions that can only be considered as last-resort efforts. People under attack have sometimes been successful in driving away the shark or sharks by shouting underwater; kicking the animal in the nose, eyes or gills; or moving toward it in an aggressive manner. Some have escaped by simply playing dead. The effectiveness of such actions is highly questionable, but as the term implies, last-resort efforts must rely on even the slightest possibility of success.

Without doubt, our most valuable weapon against shark attack is our rapidly growing store of knowledge about this highly unpredictable animal. Out of intensive programs of basic research into its biology, physiology, and pharmacology will surely come indication of some vulnerable point that may be exploited to its disfavor. It is only through a clear understanding of the true nature of this problem that we may continue to move towards a satisfactory solution at a rate consistent with man's zeal for returning to the sea.

New Use for Laser Light

An important first was achieved in experimental mechanics with the successful measurement of strain rates of the order of 3000 in./in./sec on a free flight projectile impacting an anvil specimen at a velocity of 2000 ft/sec. Laser light sources were used in conjunction with extra precise defraction ratings. These measurements are significantly better than those made to date by other techniques.

Dental Mechanics

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Research Division, Rocketdyne,
Division of North American Rockwell Corporation

E. W. Collard and J. P. Standlee
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The demands of space travel have resulted in great advances in structural analysis and design. The authors believe that the experimental and analytical techniques which have been perfected and employed for aerospace structures could profitably be used in other areas, such as dentistry and medicine. This article describes the application of a commonly used technique of experimental stress analysis, photoelasticity, to two basic problems of dental research: elastic impression materials, and retentive and reinforcing pins. This research work was jointly supported by the Structural Mechanics and Medicine and Dentistry Programs of the Office of Naval Research. Photoelastic techniques have previously been employed in certain areas of dentistry such as cavity preparation and partial denture and crown design.

Photoelasticity is the main experimental technique being used in these investigations. This technique is based on the stress-optical properties of certain transparent materials, usually plastics. When a stressed plate of this type of material is observed by means of polarized white light, a vivid pattern of colors is seen. It is possible to relate these patterns to the state of stress in the plate. The photoelastic technique therefore consists basically of:

- Modeling the item of interest with a photoelastic material.
- Loading the model.
- Observing the resulting fringe patterns by means of polarized light.
- Determining the stress distribution from the stress-optic relations of the model material.

This technique is especially useful for the stress analysis of objects with complicated shapes or boundary conditions. The method has the additional advantage of providing a visual means of observing overall stress characteristics by means of either still or motion photography. Photoelasticity is employed mostly in the study of objects subjected to two-dimensional stress states. However, advanced experimental techniques can be used to study three dimensional stress fields in bodies.

Elastic Impression Materials

Many times in the construction of dental restorations such as inlays, bridges, or dentures, it is necessary to prepare a working model which is an exact duplication of the mouth area into which the restoration will be placed. In order to prepare the working model, it is necessary first to take an impression of the specific area with some suitable material. These materials should obtain complete, accurate and detailed impressions, or negative reproductions of either the hard or soft tissue in the area. At the present time, four types of elastic impression materials are being used in dentistry, (1) agar base hydrocolloids, (2) alginate base hydrocolloids, (3) mercaptan (polysulfide) rubber base, and (4) silicone rubber base. The rubber base material is generally used because less equipment is required than with the agar base hydrocolloid technique and the critical time-element is not so precise from the moment the impression is removed from the mouth until the die or cast is poured. Mercaptan rubber, the first rubber base impression material used, has greater dimensional stability than the hydrocolloids, and for this reason was chosen to begin the study of elastic impression materials.

As an impression is removed from the mouth, it is subjected to considerable deformation as it is drawn away from undercut areas. In addition, other variables such as sharp line angles, bulk of material, nature of the tray used to carry, confine, and control the material influence the deformation of the impression material. None of these variables should infringe upon the elastic limit of the material or permanent deformation will result. Some investigators are of the opinion that this material should be removed with a quick "snap" while others believe that greater elasticity and toughness of rubber-base materials allows a steadier, slower manner of removing the impression. All investigators seem to agree that the undercuts and geometric designs of the cavity and teeth affect the elastic recovery of the material, and the resulting accuracy to the final die. We are unable to locate any published investigation which attempts to correlate the time necessary for different sections of the impression material, stressed towards different portions of their elastic limit, to recover after being stressed on removal over various geometric designs.

It is generally agreed that the amount of distortion varies directly with the bulk of impression material and is generally attributed to polymerization shrinkage. A shrinking material, owing to the fact the material is tightly bonded to the impression tray, will invariably produce an oversize die in direct proportion to the amount of shrinkage which has occurred. Any variable which would tend to produce an uneven curing of the material or a stress pattern would increase the danger of distortion. A basic problem to be answered is what amount of contraction may be due to stress relaxation. Research on rubber-base impression materials to date has not answered this question and generally accounts for the contraction as polymerization shrinkage.

The first phase of this investigation was designed to evaluate the mechanical performance of elastic impression material as influenced by type of retaining tray, bulk impression material and removal techniques. The main concern is the magnitude and nature of the stresses induced in the impression as a function of the above mentioned parameters. The approach taken involves replacement of the polysulfide Class II impression material with a birefringent material having comparable properties. A series of two dimensional dies, which represent various degrees of tooth undercut, were prepared for impression removal studies. Simulated retaining trays were fabricated to confine the birefringent impression material around the dies. Impression removal testing is being performed in a tensile test machine. Still and high speed motion pictures are taken of the stress patterns which develop as the impression is removed from the die.

Removal of an impression confined in a methyl methacrylate tray is shown in Figure 1. In this picture the large portion of the die has just entered the constricted portion of the impression. Very high stress concentrations can be seen where the die contacts the impression. Deformation of the retaining tray has caused bending stresses to develop in the top region of the impression. Upon complete removal of the impression, no residual stresses were present.

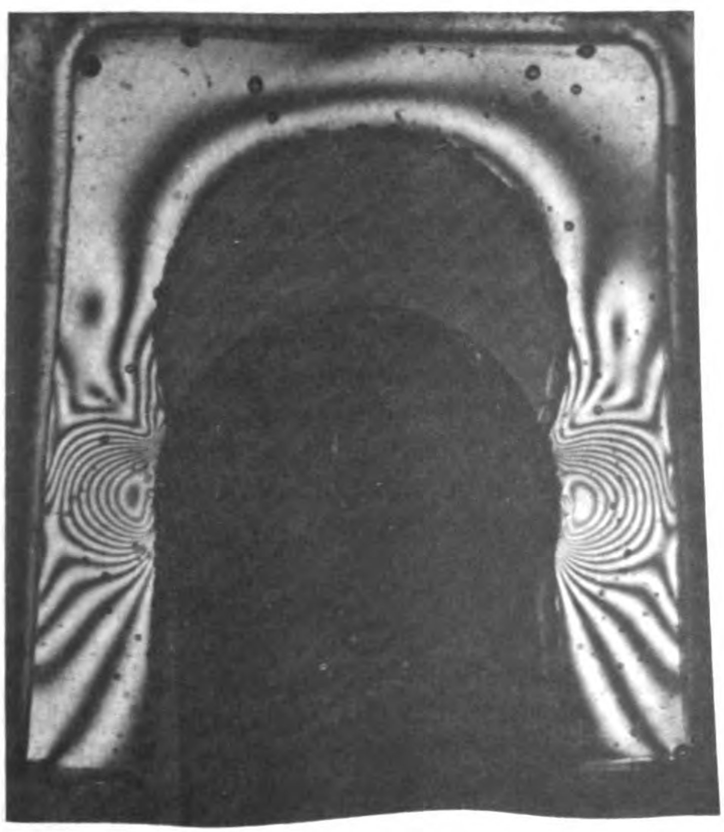

Figure 1 - Stress pattern formed in simulated impression material during impression removal (4X)

Other tests are planned which will consider such variables as (1) shape and rigidity of retaining tray, (2) bulk of impression material, and (3) direction and speed of impression removal. The effects of sharp shapes on impression materials, such as those usually employed in tooth preparations, will also be studied.

Retentive and Reinforcing Pins

When the crowns of teeth are severely decayed or fractured, leaving normal root structure and pulpal tissue but inadequate dentin, conventional preparations, grooves, undercuts, and parallel walls, often will not retain a restoration. Until recently such problems were solved by extraction. Also, when decay is minimal and cast restorations are still required, conventional preparations require excessive destruction of a sound, healthy tooth.

During the last ten years, techniques utilizing multiple miniature retentive and reinforcing pins have become popular. Generally steel or platinum-iridium pins are embedded in dentin. Pins provide excellent retention of restorations and are indispensable for conservation of tooth structure. Pins are also used to secure porcelain facings to their supporting castings, allowing a minimum display of metal. The basic technique involves drilling channels in the dentin, followed by placing pins in the channels. The pins are retained in the channels by cement, by screwing them into the channel, or by forcing them to a friction lock (a pin of larger diameter is forced into the channel). Restorations are secured to the tooth by means of the firmly attached pins which protrude from the tooth into the restorative material.

After reviewing the dental literature, it is apparent that much of the theory for these techniques is based on limited case reports. There seems to be a lack of design based on sound architectural or engineering principles. There is no general agreement concerning pin size, number and spacing of pins, depth of pin embedment in dentin, and the nature of installation stresses. Obviously, conflicts of this type cannot, and should not, be resolved by instinct or clinical evaluation alone. Ideal pin designs would result from a knowledge of the stresses induced in teeth by pins. These studies would involve modeling dentin with a photoelastic plastic and installing actual dental pins.

During the processes of establishing standard model configurations, we became aware of the need for certain standardization techniques within the dental profession. Variations of pin dimensions and lack of precision in pin installation procedures resulted in non-uniform installation stresses. Laboratory solutions to these problems have been found, but means towards clinical solutions require more thought and research. Figures 2 and 3 show uniform installation stress interactions for two types of pins.

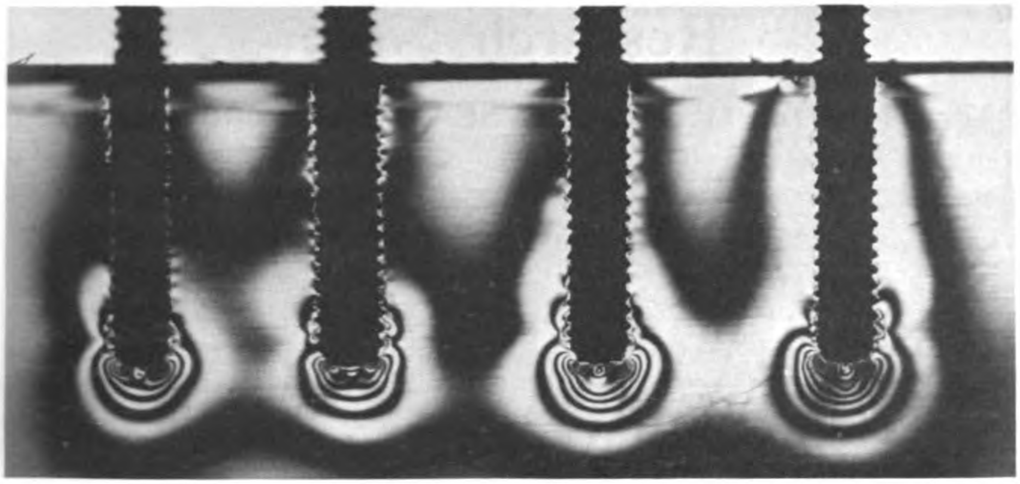

Figure 2 - Uniform interaction of multiple self-threading pins (13X)

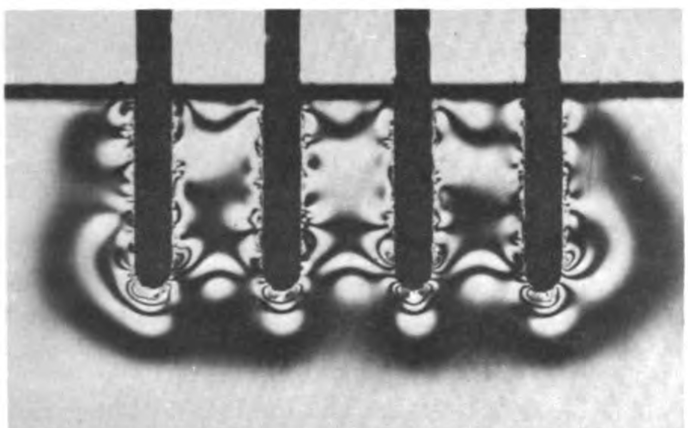

Figure 3 - Uniform interaction of multiple friction lock pins (10X)

The next phase of these pin studies involves installation of self-threading, friction lock, and cemented pins into photoelastic blocks. Pins will be installed at various spacings, depths and directions. Simulated restorations will be cast over the installed pins and loads (tensile, compressive and shear) will be applied to the restorations. Stress distributions developed in the modeled dentin will be observed and analyzed; and principles of pin design and installation will be evaluated.

Professor N. M. Newmark, a charter principal investigator in ONR's Structural Mechanics Research Program (Head of the Civil Engineering Department at the University of Illinois, Urbana) has been named by President Johnson as one of the twelve winners of the 1968 National Medal of Science for his contribution to the development of "Powerful Methods for Analyzing Complex Structural Components Under a Variety of Conditions of Loading."

Research Note

Agreement for Operation of SEA CLIFF and TURTLE

RADM T. B. Owen, Chief of Naval Research (left), and RADM E. J. Fahy, Commander, Naval Ship Systems Command (right), have signed an agreement for joint operation of SEA CLIFF and TURTLE, two deep sea submersibles, which are being built by Electric Boat Division of General Dynamics Corporation. In a twin launching ceremony, Mrs. Owen and Mrs. Fahy christened the vehicles.

SEA CLIFF will be operated by Woods Hole Oceanographic Institute under contract to the Office of Naval Research. TURTLE will be operated by the Atlantic Undersea Test and Evaluation Center, a field activity of the Naval Ship Systems Command. This agreement provides for joint use of the surface support, ship, LULU, which is operated by Woods Hole Oceanographic Institute. LULU served as the support ship for ALVIN and is undergoing modification to enable her to support either of the two new heavier submersibles. Training and operator qualification will be conducted in New England waters after delivery of SEA CLIFF and TURTLE in July 1969. In the fall of 1969, the system will move to West Palm Beach, Florida for operations in the Tongue of the Ocean.

Symposium on Parallel Processor Systems, Technologies and Applications to be held at the Naval Postgraduate School, Monterey, California, 25, 26 & 27 June. Additional information may be obtained from Mr. Joel Trimble, Office of Naval Research (Code 437), Washington, D.C. 20360. Phone: Area Code 202, 696-5038. Co-sponsored by the Naval Weapons Center, Naval Postgraduate School, Hobbs Associates, Inc., and the Office of Naval Research.

Symposium on Mathematical Problems in the Geophysical Sciences to be held at Rensselaer Polytechnic Institute, Troy, New York, 7 July - 1 August. Additional information may be obtained from Dr. Leila D. Bram, Office of Naval Research (Code 432), Washington, D.C. 20360. Phone: Area Code 202, 696-4644. Co-sponsored by the American Mathematical Society, Providence, R.I., Society for Industrial and Applied Mathematics, Philadelphia, Pa., and the Office of Naval Research.

TEKTITE habitat on the way down, Greater Lameshur Bay in the background

The four aquanauts dropping into the Bay where they will live and work 60 days from the TEKTITE habitat 50 feet below the surface

One of the television monitors at the surface control station which keeps constant watch on the aquanauts while in the habitat

On the Naval Research Reserve

NRRC 8-3 Receives Award

Texas Governor John Connally presents an Excellence Award to LCDR Ron Darby (right) of College Station, Tex. LCDR Darby is executive officer of Naval Reserve Research Company 8-3 in College Station. The award was made by Gov. Connally at a ceremony at the Texas Capitol in Austin. It is sponsored by the Director of the Chicago Branch Office, Office of Naval Research (ONR) and was awarded to the College Station Reserve company as the outstanding Naval Reserve research company in the Eighth Naval District. This is the first year the award has been made. CDR Joseph W. Tilford, an assistant to the director of the Chicago Branch Office, ONR, looks on.

NRRC 9-2, Urbana, Illinois gets a Computer Orientation

In addition to sessions on Department of Defense-sponsored research NRRC 9-2 in Urbana, Illinois has each year chosen a single topic area which the members have endeavored to study in depth. Last year the topic was communications. It featured speakers from the English and Speech Departments and from the college of Communications at the University of Illinois.

Some members who attended the Research Reserve Seminar on Computers at College Station, Texas encouraged the unit to make computer applications this year's topic of study. The program began with a screening of the Navy series of films on computers. Since then the unit has visited the Coordinated Sciences Laboratory on the University of Illinois campus to see some new developments in computer application. Dr. Dale Compton, the Lab's director, introduced to the unit some new work in urban planning and development, data retrieval, and three-dimensional structural manipulation, all using computers.

The unit also heard from MAJ David Smith USMC-R who heads a unit that does personnel-information and other data-processing for The Marine Corps Reserve. There is planned a drill on the operation and uses of the computer teaching system, PLATO, developed at the University of Illinois, primarily with the assistance of ONR. A visit is also scheduled to the laboratory where Illiak IV is being developed. This is a computer with unmatched speed and memory capacity, again primarily being done with Department of Defense assistance. NRRC 9-2 is cooperating with Army Research and Development Unit 5000 in presenting these programs.

NRR 9-10, Evanston, Illinois

Officers of Naval Reserve Research Company 9-10, Evanston, Illinois posed with RADM H. A. Renken, Commandant, Ninth Naval District at a recent seminar conducted by this company at Great Lakes, Illinois. Reading from left to right: LCDR E. L. Deam, LT J. Dumelle, CDR W. Bohan, LT D. Knott, RADM H. A. Renken, LCDR E. Blum, CDR B. Jaskoski, LCDR G. Pickett, LCDR H. Levin, CDR J. Martin, and LT (JG) A. Pock.

Members of NRRC 9-10 with the cooperation of the Office of Naval Research, Chicago, conducted their third weekend seminar on 17-19

January 1969 at Great Lakes, Illinois. The theme of the seminar was "New Sources of Power and Fuels." Previous seminars in past years had been on "Engineering the Environment" and "Recruiting for the Research Reserve."

The seminar opened with a dinner on 17 January attended by Rear Admiral Henry Renken, USN, Commandant, Ninth Naval District and other dignitaries. Some 40 officers and wives were in attendance. The speaker of the evening was Dr. Wilbur A. Affens of the Naval Research Laboratory, Washington, D.C. who spoke on "Fuels, Flammability and Fire."

On Saturday, January 18, the Director of the Institute of Gas Technology of the Illinois Institute of Technology, Dr. Henry R. Linden spoke on "The Gas Industry Plans for the Future." Dr. Linden's talk dealt with gas reserves, costs of converting coal to gas, fuel cells, and the increasing use of liquified natural gas (LNG) by the Navy.

The second speaker, Mr. John F. Bracken, Advanced Concepts Engineer, Commonwealth Edison Co., Chicago, spoke on "The Many Methods of Power Generation" with emphasis on magentohydrodynamics and electrogasdynamics. He mentioned that a large MHD plant is now under construction.

The third speaker was Mr. Eugene C. Bailey, Administrative Engineer for the Commonwealth Edison Co. In Chicago spoke on "Nuclear Power Today" and described his company's nuclear program which will make it "most nuclear" of any major U.S. utility.

On the final day two Atomic Energy Commission films were shown and a short talk given by seminar coordinator LT Jacob D. Dumelle, CEC, USNR-R on "The Electric Auto" with emphasis on photochemical smog constituents and the reasons for renewed interest in non-polluting vechicles. A critique followed with all of the 36 officers from 9 separate Reserve units participating. CDR Benedict J. Jaskoski, USNR-R, Commanding Officer of NRRC 9-10, termed it an excellent seminar and thanked everyone for participating, especially the Office of Naval Research, Branch Office Chicago and CDR J. W. Tilford.

NRRC 9-14, Madison, Wisconsin Schedules Field Trip Program

The Naval Research Reserve Company 9-14, which meets on the campus of the University of Wisconsin in Madison, has scheduled an interesting and informative series of field trips to supplement the company's regular program. The extensive resources and facilities of the University and surrounding community provide NRRC 9-14 ample opportunity for such trips.

In recent months, for example, the Madison Reservists have toured the production and quality control facilities of a major manufacturer of hospital equipment, the Cybernetics Laboratory at the University and the University Computing Center. Scheduled for the month of February is a conducted tour of the facilities of the University of Wisconsin Nuclear Research Reactor.

The Cybernetics Lab proved to be of special interest to the Reservists since topics and research techniques were discussed and demonstrated which revealed the impact of this relatively new field upon the development of the neural sciences. An impressive demonstration was given of computer techniques utilized in conducting neurophysiological studies.

The officers of NRRC 9-14 consider field trips to be a vital part of the company's overall program, especially in terms of keeping abreast of current research developments.

NRRC 9-19 Iowa City, Iowa Establishes "CO's Info Letter"

NRRC 9-19 has instituted some unique ideas in recent months that have benefited our members.

One of these is the new "CO's Information Letter" which covers a wide range of information from uniform requirements to ACDUTRA opportunities. Passing the word in this written form has proven to be more effective than voice announcements and provides a ready reference for future use.

The units's latest recruiting innovation is a Naval Research Reserve Corps Information Booth set up during University of Iowa registration to attract the increasing number of veterans returning to our campus.

The weekly programs of the unit have taken on a new dimension of interest by conducting field trips. These trips have provided a firsthand look at the wide variety of research being done on campus. Recent trips have been to the Department of Nuclear Medicine and the Institute of Hydraulic Research.

NRRC 9-25 Indianapolis, Indiana

A rather unique relationship exists between two Ninth Naval District Naval Research Reserve Companies. Naval Research Reserve Company 9-25 is located in Indianapolis, Indiana and its members are mostly influenced by industry and governmental research endeavors. While in Lafayette, Indiana, the members of Naval Research Reserve Company 9-7 find themselves very closely associated with university research work. A mix of these environments has been accomplished by the two companies drilling jointly at least twice a year. The success of these joint drills may be measured by the very high attendance percentage on these particular drill nights.

In February, NRRC 9-7 visited Indianapolis to learn about the uses of the Walleye Weapon, a Navy Research & Development program. In March, NRRC 9-25 visited Layfayette to learn about Purdue University's program on Aerial Photography utilizing satellite concepts.

NRRC 9-28 Columbia, Missouri

Columbia, Missouri's MRRC 9-28 features a wide cross-section of programs. Lectures, tours and discussion program in recent months have ranged from biology to nuclear physics to criminal law.

A lecture-discussion and guided tour of the University of Missouri's nuclear reactor was one of the highlights of the company's weekly programs in the past few months. The 21-officer unit toured the big reactor plant listening to detailed explanations of its many uses in research. The reactor currently has a licensed capacity of some five megawatts and is reportedly the largest university-affiliated facility of its type in the country.

Most of the unit's programs concern active research projects, usually being directed by faculty members of graduate students at the University of Missouri in Columbia. Recent topics have included: detinning of canned food products, gun registration, factorial theory of human ability, industrial development, intensive coronary units, criteria of water quality, advances in cancer treatment, and the biology of white blood cells.

Equally as diversified is the membership of NRRC 9-28. Among the company's active members are: Dr. John S. Spratt, Jr., (CDR), Director of Columbia's state-owned Cancer Research Hospital; Dr. William C. Allen (CDR), Assistant Medical Director and Professor of Community Health at the University of Missouri Medical Center; and Dr. B. Cope (CAPT), Director of the U.S. Fish Pesticide Research Laboratory in Columbia.

Dr. Donald H. Hazelwood (LCDR), Associate Professor of Zoology at the University of Missouri, is Commanding Officer of the unit.

Other professions represented in the company include: university professors of psychology, horticulture, biochemistry, physics, chemical engineering, law, banking, university administration, and computer science.

Some twenty-five per cent of the company's members are listed in this year's edition of Who's Who in America.

NRRC 9-6 Receives Award

Minnesota Governor Harold LeVander presents an Excellence Award to LCDR T. E. Molitor of St. Paul, Minnesota. LCDR Molitor is Commanding Officer of Naval Research Reserve Comapny 9-6, Twin Cities. The award was made by Governor LeVander at a ceremony at the Capital in St. Paul, Minnesota. It is sponsored by the Director of Naval Research, Branch Office Chicago, and was awarded to the Twin Cities Research Reserve Company as the outstanding unit in the Ninth Naval District during the past year. This is the first year that the award has been made. CDR Tilford, Assistant to the Director for Research Reserve, looks on.

Selected Contract Research Reports

The contract research reports listed below have been extracted from U.S. Government Research and Development Report 68, No. 24 of 25 December 1968, 69, No. 1 of 10 January 1969 and No. 2 of 25 January 1969. Government agencies and their contractors who are registered with the Defense Documentation Center of the Defense Supply Agency may obtain copies from the Center at Cameron Station, Alexandria, Virginia 22314. Abstracts of the reports are found in USGRDR 68, No. 24 and 69 No. 1 and 2.

For non-DDC users, most reports may be purchased from the Clearinghouse for Federal Scientific and Technical Information, Department of Commerce, Springfield, Virginia 21151.

AERONAUTICS

On the Feasibility of Replacing a Helicopter Tail Rotor; Cornell Aeronautical Lab., Inc.; Sowyrda; AD-677 642

Human Engineering Recommendations for the Instructor's Station of the F4H-1 Weapons System Trainer; Psychological Research Associates, Inc.; Price and Older; AD-678 370

Human Engineering Recommendations for the Instructor's Station of the A3J-1 Weapon System Trainer; Psychological Research Associates, Inc.; Price and Older; AD-678 371

ASTRONOMY AND ASTROPHYSICS

Two Prominence Eruptions and the Problem of Emission; Palomar Observatory; Zirin; AD-678 342

Discussion of Paper by C. Y. Fan, M. Pick, R. Pyle, J. A. Simpson, and D. R. Smith, 'Protons Associated with Centers of Solar Activity and Their Propagation in Interplanetary Magnetic Field Regions Corotating with the Sun', Calif. U.; Wilcox and Schatten; AD-676 759

Prediction of the Coronal Structure for the Solar Eclipse of September 22, 1968; Calif. U.; Schatten; AD-676 898

ATMOSPHERIC SCIENCES

Photometric Observations in South America and Their Relation to Trapped Radiation; Rice U.; Eather and O'Brien; AD-676 257

Wind Measurements from Buoys: A Sampling Scheme; Woods Hole; Millard, Jr.; AD-676 767

The Very Heavy Nuclei in the Primary Cosmic Radiation. Observations on the Energy Spectrum; Minn. U.; Freier and Waddington; AD-677 282

The Very Heavy Nuclei in the Primary Cosmic Radiation. Interpretation of the Energy Spectra; Minn. U.; Waddington and Freier; AD-677 283

An Exploration of the Origin and Persistance of the Beaufort Wind Force Scale; Johns Hopkins U.; Kinsman; AD-677 044

An Experimental Study to Determine the Utility of Standard Commercial Hot-Wire and Coated Wedge-Shaped Hot-Film Probes for Measurement of Turbulence in Water-Contaminated Air Flows; Johns Hopkins U.; Merceret, Jr.; AD-677 048

Morphology of VLF Emissions Observed with the Injun 3 Satellite; Iowa U.; Taylor and Gurnett; AD-677 868

Acoustic Output of a Long Spark; Arizona U.; Dawson *et al;* AD-677 954

Accuracy of Finite-Difference Methods Applied to the Advection Equation; Arizona U.; Molenkamp; AD-677 867

BEHAVIORAL AND SOCIAL SCIENCES

Retrieval of Answer-Providing Documents; Lehigh U.; O'Conner; AD-677 860

Shipboard Manpower, 1965: A Statistical Study of Men in the Privately Operated U.S.-Flag Merchant Marine; NAS-NRC; AD-678 420

Simple Stochastic Networks; Some Problems and Procedures; Carnegie-Mellon U.; Gaver, Jr. and Burt, Jr.; AD-676 891

Multivariate Transvariation Theory Among Several Distributions and Its Economic Applications; Princeton U.; Dagum; AD-676 907

Structural Change and Postwar Economic Stability: An Econometric Test; Princeton; Howrey; AD-676 908

Studies of the Elastic Surface Transformation Process; Human Factors Research Inc.; Hall *et al;* AD-676 631

Development of Performance Evaluative Measures. Personal Psychophysics: Terminal Threshold and Signal Detection Theoretic Applications to Performance Assessments; Applied Psychological Services, Inc.; Siegel *et al;* AD-676 326

Organizational Climates and Administrative Performance; Educational Testing Service; Frederiksen *et al;* AD-676 697

Fear of Failure and the Zeigarnik Effect; Buckness U.; Moot and Teevan; AD-676 770

A Cross-Cultural Study of the Relationships Between Personal Values and Managerial Behavior; Rochester U.; Thiagarajan; AD-676 521

Design of a Computer-Assisted Coastal Information System; Matrix Corp.; Campbell and Sykes; AD-677 299

Requirement Specifications for a Design and Verification Unit; Technomics, Inc.; Pelton *et al;* AD-677 479

Geographic Orientation in Aircraft Pilots: A Field Validation of a Post-Flight Method of Reporting Navigation Performance; Human Factors Research, Inc.; Borden and McGrath; AD-677 055

Fitting a Multidimensional Component Model to Binary Data; Ill. U.; Koopmen, Jr.; AD-677 294

BIOLOGICAL AND MEDICAL SCIENCES

Collected Technical Papers; Cornell; Rosenblatt; AD-677 639

Adaptive Performance Measurement; Dunlap and Associates, Inc.; Kelley and Prosin; AD-677 049

Human Antibodies to Human IgA Globulins; Calif. U.; Fudenberg *et al;* AD-677 864

Studies on the Isolation and Characterization of the Proteolytic Enzymes of Rat Skin and Their Role in the Physiological and Pathological Aspects of Thermal Injury; Pittsburgh U.; Axelrod; AD-678 380

Hemolytic Plaque Formation by Mouse Spleen Cells Producing Antibodies to Ovalbumin; Ill U.; Segre and Segre; AD-677 865

Mycoplasma Inhibition of Phytohemagglutinin Stimulation of Lymphocytes; Calif. U.; Spitler *et al;* AD-677 866

Selective Absence of IgA: A Family Study; Calif. U.; Goldberg *et al;* AD-678 216

Transfusion of Cerebrospinal Fluid and Tissue Bound Chemical Factors Between the Brains of Conscious Monkeys: A New Neurobiological Assay; Purdue; Myers; AD-676 415

Analysis of Assemblies with Large Defect Concentrations with Special Applications to Theory of Denaturation of Copolymeric DNA; Rochester U.; Montroll and Yu; AD-676 416

Relaxation Kinetics of Denaturation of DNA; Rochester U.; Goel; AD-676 418

Studies with Hydroxyurea. The Deoxyribonucleic Acid of Hydroxyurea-Treated Cells; Columbia U.; Rosenkranz *et al;* AD-676 441

Denaturation and Renaturation of DNA. Possible Use of Synthetic Periodic Copolymers to Establish Model and Parameters; Rochester U.; Goel and Montroll; AD-676 445

Purification and Properties of the Luciferase and of a Protein Cofactor in the Bioluminescence System of Latia Neritoides; Princeton; Shimomura and Johnson; AD-676 474

The Enzyme Catalyzed Oxidation of Cypridina Luciferin; Princeton; Stone; AD-676 475

The Structure of Latia Luciferin; Princeton; Shimomura and Johnson; AD-676 476

On Nonlinear Processes Involving Population Growth and Diffusion; Rochester U.; Montroll; AD-676 439

Desmids of Arctic Alaska; Arctic Inst. of North America; Hirano and Kobayasi; AD-676 708

Anti-Gamma Globulin Antibodies After Open Heart Surgery; Calif. U.; Pretty *et al;* AD-676 450

Semi-Annual Research Summary (8th), January-June 1968; Purdue; AD-676 321

Temperature in the Monkey: Transmitter Factors Released From the Brain During Thermoregulation; Purdue; Myers and Sharpe; AD-676 412

Discussion of Serotonin, Nonrepinephrine, and Fever; Purdue; Myers; AD-676 414

Human Ecology in Space Flight; N.Y. Academy of Sciences; Calloway; AD-676 565

CHEMISTRY

The Variation of Carbon Dioxide Under the Snow in Arctic; Wash. U.; Kelley *et al;* AD-676 402

New Hypofluorites Containing Nitrogen; Idaho U.; Shreeve; AD-676 878

Some Developments of Faddeev's Theory for Reactive Scattering; Purdue; Eu and Ross; AD-676 554

The Variation of the Randomness of Correlations of Orientation of Crystals in Crystalline Polymers; Mass. U.; Chu and Stein; AD-676 692

The Dichroism and Birefringence of Polymer Containing Conjugated Polyene Sequences; Mass. U.; Stein and Shindo; AD-676 693

The Scattering of Light From Deformed Regions Surrounding Voids and Inclusions in High Polymers; Mass. U.; Stein and Wilkes; AD-676 694

Calculation of Oscillator Strength and Estimation of the Absorption Coefficients in Conjugated Linear Polymer Compounds; Mass. U.; Shindo and Stein; AD-676 695

The Scattering of Light From Assemblies of Oriented Rods; Mass. U.; Rhodes and Stein; AD-676 696

The Raman Spectrum of Crystalline Lithium Nitrate; Mich. St. U.; Miller *et al;* AD- 676 779

Effects of High Pressures on the Phosphorescence of Aromatic Hydrocarbons at 77K; Calif. U.; Offen and Hein; AD-676 741

Fluorescence Spectra in Frozen Heptane at High Pressures; Calif. U.; Hein and Offen; AD-677 475

Dynamic X-Ray Diffractometer for Measuring Rheo-Optical Behavior of Crystals in Polymer Solids; Mass. U.; Kawaguchi *et al;* AD-677 641

Comparative Studies of the Catalytic Fluorination of Carbon Monoxide with Elementary Fluorine; Wash. U.; Wechsberg and Cady; AD-677 930

Some Aspects of the Poly (Metal Phosphinates); Pennsalt Chemicals Corp.; Block; AD-678 324

The Formation of CB5B9 and its 1-Methyl Derivative From 1,7-C2B6H8; Calif. U.; Dunks and Hawthorne; AD-678 373

nmr Studies of Heptafluorobutyric Acid Micelle Formation; Wash. U.; Bailey and Cady; AD-678 200

Scattering Theory of Pressure Broadening of Rotational and Vibration-Rotation Transitions; Tufts U.; Illinger and Trindle; AD-677 857

Rotational and Vibration Rotation Line Shifts and Widths. Distorted-Wave Approximation; Tufts; Illinger and Trindle; AD-677 861

Preferred Orientation in Microstructures of Eutectics Between Compounds; Mich. U.; Moore and Van Vlack; AD-677 879

The Solubility of Certain Gaseous Fluorine Compounds in Water; Oxford U., (England); Ashton *et al;* AD-678 233

Electrical Conductivity Changes During Heterogeneous Catalysis: A Study of the Interfacial Polarization of a Powdered Zinc Oxide Catalyst by Audio Frequency Relaxation Measurements During the Catalytic Oxidation of Carbon Monoxide; Princeton; Connoy and Mark; AD-678 384

Structure of Liquids; M.I.T.; Kaplow and Averbach; AD-678 410

EARTH SCIENCES AND OCEANOGRAPHY

Modern Coccolithophoridae of the Atlantic Ocean-I, Placoliths and Cyrtoliths; Lamont; McIntyre and Be; AD-678 006

The Aboriginal Cultural Geography of the Llanos de Mojos of Bolivia; NAS-NRC; Denevan; AD-678 286

The Mining Industry of the Norte Chico, Chile; NAS-NRC; Pederson; AD-678 295

Heat Flow and Water Temperature Fluctuations in the Denmark Strait; Geological Survey; Lachenbruch and Marshall; AD-677 897

Marine Biology. Unresolved Problems in Marine Microbiology; Sperry Gyroscope Co.; Oppenheimer; AD-676 563

A Numerical Treatment of Steady, Frictional Boundary Currents in a Homogeneous Ocean Applied to a Two-Port Basin; Texas A & M U.; Jacobs and Nowlin, Jr.; AD-676 579

Currents in Long Strait, Arctic Ocean; Arctic Inst. of North America; Coachman and Rankin; AD-676 706

An Acoustical System for Remote Bottom Contact and Current Speed Determinations; Texas A & M U.; Gutierrez, Jr. and Pequegnat; AD-676 752

Effect of Boundary Conditions on the Onset of Convection; Yale U.; Foster; AD-676 951

Calcium Carbonate Interaction with Organic Compounds; Lehigh U.; Suess; AD-676 524

Fortran Computer Program for Simulation of Transgression and Regression with Continuous-Time Markov Models; Northwestern U.; Krumbein; AD-676 505

Computer Simulation of Transgressive and Regressive Deposits with a Discrete-State, Continuous-Time Markov Model; Northwestern U.; Krumbein; AD-676 506

The Dynamics of Penetrometers and Corers; Woods Hole; Korites; AD-676 545

Genesis and Evolution of Water Masses; Woods Hole; Worthington; AD-676 614

Measured and Performed Phosphate in the Gulf of Mexico Region; Texas A & M; Paskausky and Nowlin, Jr.; AD-676 751

Comments on a Paper by J. B. Shepherd and G. R. Robson: The Source of the T Phase Recorded in the Eastern Caribbean on October 24, 1965; Scripps; Shepherd and Robson; AD-676 926

VLF Emissions During Magnetic Storms and Their Association with 40 keV Electrons; Iowa U.; Cauffman and Gurnett; AD-676 887

Doppler-Shift Current Meter Signals and the Drop-Out Problem; Johns Hopkins U.; Wiseman, Jr.; AD-677 050

On-Field Experiments, With a Sketch of a Plan for a Wind Wave Generation Experiment to be Carried Out Off Aruba, N.A. Aboard the R/V Ridgely Warfield; Johns Hopkins U.; Kinsman; AD-677 051

On the Origin of Certain Breakers Off the Island of Aruba; Johns Hopkins U.; Wilson; AD-677 052

A Report on Geomagnetic Electrokinetograph Observations Off the Oregon Coast; Oregon St. U.; Curtin *et al;* AD-677 117

Studies in Marine Geophysics and Underwater Sound From Drifting Ice Stations; Columbia U.; Hunkins; AD-677 054

ELECTRONICS AND ELECTRICAL ENGINEERING

Asynchronous Computational Structures; M.I.T.; Luconi; AD-677 602

Adaptive Detection Receivers and Reproducing Densities; Mich. U.; Birdsall; AD-677 466

PAL — A Language Designed for Teaching Programming Linguistics; M.I.T.; Evans, Jr.; AD-677 862

Considerations for Computer Utility Pricing Policies; M.I.T.; Diamond and Selwyn; AD-677 863

Gyrator and State-Variable Results for Linear Integrated Circuits; Stanford; Newcomb and Anderson; AD-678 274

Periodic Decomposition of Sequential Machines; Calif. U.; Gill and Flexer; AD-676 398

MATERIALS

Exact and Approximate Theory for Linearly-Complaint Layer with Inflexible Adhesive Backing; Columbia U.; Elrod, Jr.; AD-470 721

X-Ray Study of Deformation in Metals and Alloys; Yale; Wagner; AD-677 293

Rheo-Optical Behavior of Polyacrylonitrile: Creep and Creep Recovery; Stevens Tech.; Andrews and Okuyama; AD-677 646

MATHEMATICAL SCIENCES

Summary of Recent Work on Variables Acceptance Sampling with Emphasis on Non-Normality; Southern Methodist U.; Owen; AD-677 045

Sample Sizes for Approximate Independence of Largest and Smallest Order Statistics; S. Methodist U.; Walsh; AD-677 047

Synthesis of Time-Optimal Control for Second-Order Nonlinear Systems; Purdue; Haas and Boettiger; AD-677 060

Norms and Inequalities for Condition Numbers; Boeing Scientific Research Labs; Marshall and Olkin; AD-677 107

Some Decision Problems Associated With Weighted, Directed Graphs; Calif. U.; Deuel and Gill; AD-677 139

On a Class of Selection and Ranking Procedures; Purdue; Gupta and Panchapakesan; AD-677 297

Admissible Designs for Polynomial Spline Regression; Purdue; Studden and VanArman; AD-677 298

On Selection Procedures Based on Ranks: Counter-Examples Concerning Least Favorable Configurations; Stanford; Rizvi and Woodworth; AD-677 313

A Decomposition Method for Interval Linear Programming; Northwestern U.; Robers and Ben-Israel; AD-677 101

Note on an Application of a Goal Programming Model for Media Planning; Northwestern U.; Charnes *et al;* AD-677 175

A Goal Programming Model for Media Planning; Northwestern U.; Charnes *et al;* AD-677 176

Some Results on the Upper-Bound Conjecture for Convex Polytopes; Wash. U.; Grunbaum; AD-678 317

Intersection Properties of Boxes in Rd; Wash. U.; Danzer and Grunbaum; AD-678 318

Grassman Angles of Convex Polytopes; Wash. U.; Grunbaum; AD-678 319

Imbeddings of Simplicicial Complexes; Wash. U.; Grunbaum; AD-678 320

Graphs, Complexes, and Polytopes; Wash. U.; Grunbaum; AD-678 321

Incidence Patterns of Graphs and Complexes; Wash. U.; Grunbaum; AD-678 322

Diffusion Approximations in Collective Risk Theory; Stanford; Iglehart; AD-678 413

Two Renorming Constructions Related to a Question of Anselone; Wash. U.; Klee; AD-676 513

On Decompositions of Matrix Spaces with Applications to Matrix Equations; Northwestern U.; Ben-Israel; AD-676 515

On KU — Symmetric and KU — p.d. Matrices with Applications to Hyperpower Methods of Generalized Inversion; Northwestern; Zlobec and Ben-Israel; AD-676 516

Nonparametric Confidence Regions for Some Multivariate Location Problems; N.Y.U.; Puri and Sen; AD-676 727

On the Estimation of Location Parameters in the Multivariate One Sample and Two Sample Problems; N.Y.U.; Puri and Sen; AD-676 728

On the Distribution of the Last Occurrence Time in an Interval for a Regenerative Phenomenon; N. Carolina U.; Heyde; AD-676 880

Stochastic Processes with Sample Path Functions of Bounded Variation; North Carolina U.; Shachtman; AD-676 881

A Discrete-Time Differential Dynamic Programming Algorithm with Application to Optimal Orbit Transfer; Harvard; Gershwin and Jacobson; AD-676 311

Economic Comparability of Information Systems; Calif. U.; Marschak and Miyasawa; AD-676 419

Results on a Transient Queue; N.Y.U.; Siegel; AD-676 455

On a Moving Server with Bounded Range; N.Y.U.; Siegel; AD-676 458

On Optimal Solutions of 2-Person 0-Sum Games; Northwestern; Ben-Israel; AD-676 472

On Some Nonstandard Semi-Infinite Programming Problems; Northwestern; Charnes *et al;* AD-676 514

On the Explicit Solution of a Special Class of Linear Economic Models; Northwestern; Ben-Israel *et al;* AD-676 517

Interval Programming: A New Approach to Linear Programming with Applications to Chemical Engineering Problems; Northwestern U.; Robers and Ben-Israel; AD-676 519

Minimizing the Number of Operations in Certain Discrete Variable Optimization Problems; Harvard; Brioschi and Even; AD-676 560

MECHANICAL, INDUSTRIAL, CIVIL, AND MARINE ENGINEERING

Anti-Fouling Research; Chesapeake Instrument Corp.; Schunemann; AD-676 905

The Application of Dynamic Relaxation to the Finite Element Method of Structural Analysis; Notree Dame U.; Lynch *et al;* AD-676 566

A Network-Topological Formulation of the Analysis and Design of Rigid-Plastic Framed Structures; Ill. U.; Gonzalez-Caro and Fenves; AD-676 738

A Theoretical and Experimental Study of the Dynamic Behavior of Foil Bearings; Columbia; Barnum and Elrod, Jr.; AD-677 326

An Electrochemical Carbon Dioxide Reduction-Oxygen Generation System Having Only Liquid Waste Products; Ionics, Inc.; Meller; AD-678 427

METHODS AND EQUIPMENT

Proceedings of the Symposium on Remote Sensing of Environment (5th), 16, 17, 18 April 1968; Mich. U.; AD-676 327

Scatter-Hole Cameras for X-Rays and Gamma Rays; Princeton; Dicke; AD-676 473

MILITARY SCIENCES

Optimal Policies Under the Shortage Probability Criterion for an Inventory Model with Unknown Dependent Demand; Decision Studies Group; Iglehart and Jaquette; AD-677 939

NAVIGATION, DETECTION, COMMUNICATIONS, AND COUNTERMEASURES

Speech Research; Haskins Labs; Cooper; AD-676 520

The Testing and Performance of a Wide-Band Underwater Liquid Communicator; Houston U.; Mitchell and Muster; AD-676 522

Target Acquisition Studies: Fixed Television Fields of View; Martin Marietta Corp.; Ozkaptan *et al;* AD-677 322

NUCLEAR SCIENCES AND TECHNOLOGY

Studies of the Action of Leucogenenol on the Myeloid and Lymphoid Tissues of the Sublethally Irradiated Mouse; American U.; Rice *et al;* AD-677 880

The Use of Ionization Calorimeters in High Energy Neutron Experiments at Particle Accelerators; Michigan U.; Jones AD-676 909

ORDNANCE

Submarine Topographic Echoes From Chase V; Scripps; Northrop; AD-676 929

Location and Enumeration of Underwater Explosions in the North Pacific; Scripps; Spiess *et al;* AD-676 937

Spectral Analysis of Hydroacoustic Signals Generated by the Chase V, Chase VII, NOL-VELA, and Arctic Explosions; Underwater Systems, Inc.; Young *et al;* AD-677 473

PHYSICS

Lattice and Continuum Theories of Simple Modes of Vibration in Cubic Crystal Plates and Bars; Columbia; Mindlin; AD-677 041

Crystal Lattice Theory of Torsion of a Rectangular Bar of Simple Cubic Structure; Columbia; Mindlin; AD-677 042

On the Distribution and Development of Mean-Flow and Turbulence Characteristics in Jet and Wake Flows; Iowa U.; Naudascher; AD-677 367

Effect of Wall Shear Stress on Drag Reduction of Viscoelastic Fluids; Western Co. of North America; Whitsitt *et al;* AD-677 467

On the Stability Against Shear Waves of Steady Flows of Non-Linear Viscoelastic Fluids; Carnegie-Mellon; Coleman and Gurtin; AD-677 664

Stokes Paradox in Kinetic Theory; Applicazioni E Ricerche Scientifiche, (Italy); Cercignani; AD-677 717

Some Remarks on the Symmetry Properties of Nonlinear Optical Susceptibilities; Harvard; Bloembergen; AD-677 037

Johnston Island Light Scattering and Transmission Data; Oregon St. U.; Beardsley, Jr. *et al;* AD-677 569

Muon Polarization in Neutral-Kaon (3) Decay; Mich. U.; Longo *et al;* AD-667 064

Negative-Pion-Proton Elastic Scattering at 180 Degrees From 1.6 to 5.3 GeV/c; Mich. U.; Kormanyos; AD-677 067

Investigation of Partially Reflected Echoes From the D-Region of the Ionosphere; Pa. St. U.; Cole; AD-677 328

Magnetically Induced Currents and Thermoelectric Effects in a Non-Uniform Plasma Stream; Calif. U.; Dove; AD-677 463

Research in the Application of Spinors and Other Representations of the Lorentz Group to General Relativity; Southwest Center for Advanced Studies; Cahen *et al;* AD-677 344

Micropolar Elastic Solids with Stretch; Princeton; Eringen; AD-677 324

Wave Motion in Solids With Lamellar Structuring; Northwestern; Achenbach and Herrmann; AD-677 325

On the Diffusion of an Axial Load From an Infinite Cylindrical Bar Embedded in an Elastic Medium; CalTech; Muki and Sternberg; AD-677 474

Optical Third Order Mixing in GaAs, Ge, Si, and InAs; Harvard; Wynne; AD-677 036

A Note on the Static Stability of an Elastico-Viscous Fluid; Saint Andrews U., (Scotland); Craik; AD-677 910

Comments on 'Evolution of a Density Discontinuity as Governed by the Boltzmann Collision Integral'; St. U. of N.Y.; Springer and Kovitz; AD-678 234

Viscous Effects on Impact Pressure Measurements in Low Density Flows at High Mach Numbers; Purdue; Chang and Fenn; AD-678 416

Formulation of Constitutive Equations for Turbulent Mixing; N.Y.U.; Kirwan, Jr.; AD-678 417

Direct Measurement of Picosecond Lifetimes; Cornell; Scarlet *et al;* AD-677 775

Research Investigation of Laser Line Profiles (Picosecond Laser Pulse); United Aircraft Corp.; DeMaria *et al;* AD-678 382

Research Investigation of Picosecond Optical Pulse Technology; United Aircraft Corp.; DeMaria and Glenn; AD-678 383

Uniform Asymptotic Theory of Diffraction by a Plane Screen; N.Y.U.; Ahluwalia *et al;* AD-678 226

High Intensity Laser Propagation in the Atmosphere. Far Wing Pressure Broadening; TRW Systems; Holstein; AD-678 422

Experimental Form Factor Compendium; Kaman Nuclear; Veigele; AD-677 948

Transport Coefficients of Degenerate Plasma; Calif. U.; Lampe; AD-677 787

Transverse Plasma Wave Echos; Calif. U.; Fried and Olson; AD-678 350

Time-Harmonic Waves in a Stratified Medium Propagating in the Direction of the Layering; Northwestern U.; Sun *et al;* AD-677 869

Infrared Emission from Free Carriers in Germanium; Pa. St. U.; Ulmer, Jr.; AD-678 315

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User-Oriented Program for Shock Analysis and Heavy Shipboard Design of Equipment

For a number of years the Navy has had a very accurate method of designing structures to resist shock. The method was developed at the Naval Research Laboratory and is called D-DAM. Navy specifications require that various heavy equipment components aboard ships be appropriately shock resistent in accordance with the D-DAM method. Unfortunately, it has not been possible to properly implement these important design specifications. The inherently complex dynamic analysis of critical machinery, equipment, and weapon systems is time-consuming and extremely expensive, requiring considerable computer use. In general, shipbuilding engineers are simply not conversant with sophisticated computer techniques. Also, Navy managers have no ready method of assessing whether the shipbuilders are complying with the required specifications.

The Structural Mechanics Branch or ONR has proposed the development of a time-shared user-oriented computer program that will enable the naval architect to solve directly and simply very complex shock design problems in accordance with the required specifications. Moreover, the Navy manager should also be able to use the program directly with no difficulty finding out whether or not a given design is acceptable or not.

The Ship Acquisitions Directorate realizes the benefits to the Navy of the proposed program and is supporting the project. The proposed program should be ready about the Spring of 1969. If successful, this computer program which is constantly reusable, should effect annual multi-million dollar savings to the Navy. Naval architects should be able to quickly perform parametric studies for the determination of optimum designs; naval administrators should be able to evaluate automatically submitted designs with increased speed, reliability, and economy.

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An undersea photograph of blue tang fish drifting by staghorn coral in Greater Lameshur Bay, Virgin Islands in the area of the TEKTITE site. See page 29.

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