

**Proceedings of the Conference**  
**On Relation of the Environment**  
**To Hospital-Acquired**  
**STAPHYLOCOCCAL DISEASE**  
*(Atlanta : 1958)*

Atlanta, Georgia – December 1–2, 1958

*Sponsored by*  
*U. S. Public Health Service – Communicable Disease Center*  
*National Academy of Sciences – National Research Council*



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## FOREWORD

The increasing and universal concern with the problem of infections related to antibiotic-resistant strains of Staphylococcus precipitated the first National Conference on Hospital-Acquired Staphylococcal Disease held in September 1958, under the joint sponsorship of the Public Health Service and the National Research Council. The proceedings (1) of that conference indicated that the specific problem of hospital environmental sanitation merited further consideration. Since this problem involves the medical, engineering, architectural, biological, and chemical disciplines, the Public Health Service was encouraged to arrange a conference of interested representatives of those professions to examine the problem and to develop sound standards.

Thus, a Conference on the Relation of the Environment to Hospital-Acquired Staphylococcal Disease was held in Atlanta on December 1-2, 1958. The nature of the meeting and of the problem dictated that the conference be conducted in an informal discussion manner to provide maximum interchange of information among the professions represented. This informal philosophy is reflected in the publication of these proceedings which have been compiled from tape-recorded transcripts of the discussions which comprised the major portion of the conference.

It is believed that these published proceedings will help define the critical areas of hospital sanitation which need further investigation, will provide further orientation for workers in the field of staphylococcal infection, and will communicate to those workers a sense of concern which prevailed among those who participated in the conference.

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**SECTION I**

**INTRODUCTIONS AND DISCUSSIONS**

THE UNIVERSITY OF CHICAGO  
DIVISION OF THE PHYSICAL SCIENCES

PHYSICS DEPARTMENT

PHYSICS 309

PHYSICS 309 LABORATORY

## GENERAL INTRODUCTION

Robert J. Anderson, M. D.\*

I would like to review briefly some of the background for this meeting. Certainly, we are not meeting here to discuss a new problem, or even a newly recognized problem. It is an old problem. It is a problem that has plagued hospitals since the days of their inception. We are here today to talk about prevention of hospital infections, and particularly the staphylococcal infections which seem to have demonstrated pretty well that the Staphylococcus can adapt itself, or adapt its genus, to the environment in which antimicrobials are highly prevalent. In recent years, more and more information has come out on the subject. Starting with the New York Academy of Medicine meeting in 1956 on this topic, we have seen increasing interest in this subject and increasing concern by people interested in providing good medical care. A year ago, at the time and place of the meeting of the American Public Health Association, Dr. Stuart Mudd, for the American Medical Association, held a conference of interested persons in Cleveland on the subject of staphylococcal infections and their control. At the APHA meeting itself there was a scientific program session on the same subject. About the same time, the American Hospital Association established a Committee on Hospital Infections to make recommendations to the member hospitals of the AHA on the control of infections. A statement was issued, with which I am sure you are all familiar. It set forth, in general terms, the principles of control of staphylococcal, or other, infections within hospitals. This was distributed to all members of the AHA around the country. It gave expression to the great interest and concern on the part of the individuals within hospitals around the country on the specifics of the methods of control of staphylococcal infections. The offices of the AHA were soon receiving letters from hospital administrators, medical staffs, surgeons, about what the specifics of control should be -- what they should do about designing nurseries, what they should do about the air conditioning systems within hospitals, what they should do with regard to the scrubbing of floors or the sweeping of floors, what they should do with regard to handling of laundry, which chemical products were good, which ones met standards, and endless variations of these points of hospital hygiene and sanitation. The AHA sought audience with the Surgeon General of the Public Health Service last spring and reviewed their statement and the situation in hospitals. The meeting recommended to the Surgeon General that the Public Health Service sponsor a conference of all of the national professional bodies

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within the United States that had either an expressed interest or a related interest in this problem of the control of infections. This conference was held in September. There were 59 different national professional organizations that attended this conference with the representation of one or more delegates. The sessions were held over a period of two days. They were divided into three discussion groups and dealt with certain points. Among these were techniques of sterilization, disinfection, laundry, and ventilation. The conference, being composed principally of representatives of the medical care professions and the hospital administration groups, felt that they were not of themselves sufficiently familiar with all the research work that might have been done in the fields of hygiene and sanitation to come up with solid recommendations about these very pertinent and troublesome subjects that were bothering hospital administrators over the country. The conference therefore recommended that the Public Health Service should see if it could bring about some recommended standards which might be applicable to the field. I might say too that Dr. Solberg, an architect, in a meeting in Chicago, recited some of the experiences that engineers and architects have had with us doctors. He told us that the worst trouble with us was that all we knew we wanted was 13 changes of air an hour. We didn't care what kind of air we changed just as long as it got changed at that frequency. Obviously then, the answer to the problem that we are up against is one which is going to involve some exchange between most of the medical, engineering, architectural, and chemical groups. We are here today to review what is known with some degree of certainty about some of these areas of hospital operations as set forth in the agenda. First, consideration of the problems relating to hospital ventilation, or the movement of air within hospitals; second, the housekeeping procedures within hospitals; third, sterilization and decontamination; and fourth, a presentation on hospital design. We hope the discussion leaders will give us an over-all view of the problems to provide a springboard for discussion. You may develop this in any way that you choose.

May I say that we have been pleased to have the full-hearted cooperation of the National Research Council in this conference and in our earlier September conference. Without their excellent help, we could not have conducted the conference in the way that it was done.

## MODERATOR'S COMMENTS

S. W. Simmons, Ph. D.\*

I think Dr. Anderson has covered the subject very well. I do want to call your attention to the question sheets we have placed before you. Most of the questions are obvious, but we thought perhaps a list of these placed before you would serve as a starter to the discussions. Obviously, neither this group, nor any other group that could be brought together, can give positive answers to all of those questions. That is the reason we are having the meeting. However, the opinions that you express relative to those queries will certainly serve as a foundation for testing and research.

As Dr. Anderson mentioned, we plan to publish proceedings of this conference. These will consist of the remarks of the leaders of each discussion session plus group discussions that follow, which we presume will consume at least half of the time.

The first subject for discussion is hospital ventilation which is one of the very important aspects of the environment in a hospital, and it is certainly one that is subject to a great amount of manipulation either for good or for bad. To lead this discussion, we are fortunate in having Dr. Silverman who, as you know, is Professor of Industrial Hygiene at Harvard. He is an authority on particulate matter in air, and knows much about air in relation to our environment.

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# HOSPITAL VENTILATION

## Introduction

Leslie Silverman, Sc. D.\*

I think perhaps I was selected because I probably don't know much about hospital ventilation rather than for any other reason. Although I have had some contact with hospitals and their problems, it has been related to the questions of filtration of microorganisms, the proper design of respirators for surgeons, and the control of operating room atmospheres. As I look at the problem, I would like to compare it to what we know about industrial ventilation in general or control of radioactive materials by ventilation. When we talk about controlling an industrial environmental hazard, we try to substitute less toxic materials, if possible, but I don't believe anyone has been able to substitute something innocuous for Staphylococcus aureus, so that's out. We like to change the process if we can't change the materials. We try to switch from a dry to a wet process for example. Here again, I think we are thwarted by the nature of the hospital. We talk about local exhaust ventilation. This might apply in this instance only if we consider the operating room as one particular example where control is necessary to keep anesthetic concentration within limits. We are faced with general exhaust or dilution in hospitals as a form of control. If we can do nothing else, or can succeed only partially, we talk about the protection of personnel in a hospital. In contrast to industry or to industrial processes, this is a two-way street. The personnel who work in the hospital may be required to have protection from the patients, but it may also be true that the personnel are carriers and the patients should be protected from them. So when we think about personnel protection in industry we are thinking about a different thing. We normally conceive of cleaning the air for the individual by the use of a respiratory device - this is still important - but in industry the personnel are discharging exhaled air through a valve which does nothing in the way of attenuating the concentration of exhaled organisms.

Now, in terms of where we stand today, I've reviewed the Proceedings of the National Conference on Staphylococcal Disease and much to my regret I found that, while everybody said they thought airborne infection was important, they had very few facts to substantiate their thoughts. The net result is that, when we talk about

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ventilation, we are left with the concept "something should be done about it," but just what is left to the imagination. I thought it might be interesting to find something in the way of historical comment, so I looked up some statements from papers on hospital air conditioning prepared by Professor Yaglou and by Clarence Mills. They each prepared papers on hospital air conditioning. In 1936, which isn't so long ago in terms of progress in this field, it was stated that "complete air conditioning of the whole hospital involves a large capital investment, depreciation, and running expense, which are not justified by any evidence that we now have." Therefore, up until 1936, you can say that there were very few air conditioned hospitals, and there was very little justification for air conditioning. Operating rooms, premature baby wards, and nurseries were special cases where air conditioning proved of value. Now, the chief difference between this problem and any other which we have in regard to industrial ventilation or occupational disease exposures is that the sources in the industrial cases are far better defined than in this case. You see comments about corridor concentrations and room concentrations, but no real correlation between these and the incidence of disease. You also see statements that it isn't really air that's the problem - that it's a contact problem - that the air gap is quite short - that there's a fall-out problem between the host and the patient. So the real enigma, as far as I can see, is which is the source, the patients in the hospital or the staff? When considering air conditioning requirements in general, it is usually said that for general patient control (not premature infants) it is desirable to provide proper air conditions for the staff, not for the patients. The patients can be controlled individually by blankets or by hot water bottles, or by any number of procedures, whereas it is necessary to provide comfortable air conditions for the ambulatory staff personnel who are dressed with standard lightweight garments. The concept of body heat burden or thermal load has thus been directed more toward the staff than to the patient. It turns out, as some of you know, that the blankets, bedding, mattresses, and similar items are also involved in this problem. The methods of thermal control for the patient may involve different sources of contamination. We also have to watch out for some of the things that we do to clean the air. In particular, there has been much done about the use of ultraviolet and other types of sterilizing agents. The question arises, that even though this is air treatment, is it producing mutants or is there something here that has been disregarded? I'm not indicating that I have any such information, but it has been pointed out that ultraviolet may be capable of producing mutants. If these are harmful mutants, we should be worried about it. If you don't kill all the organisms, as we know we don't with antibiotics, do we produce any disease-resistant strains by so-called air or environmental treatment? My concept is to think first about what we know about control at the source and then go on from there to what I would consider an outline for discussion here this morning.

Initially, we want to talk about general environmental requirements - temperature, humidity, and air quantity, since these are the basic items we need for ventilation. These vary depending on whether for wards or for general large areas, whether for private rooms or semi-private rooms, whether for nurseries, whether for operating rooms, or for other special cases such as heat rooms, special humidity rooms, and so on. We are next concerned with air distribution requirements. I might say that my thinking on this problem is to approach it the way we do with laboratories in which radioactive materials are used. That is, to maintain flow from the cold to the warm to the hot areas. I speak of "hot" here in terms of activity. This can apply, and it does apply, at places like Ft. Detrick where you are trying to control agents that are pathogenic in fairly low concentration. You want to keep the air flowing from the corridors into the entrances of the laboratories and from the laboratories out of the building. There may also be intermediate steps. For example, the offices may be negative with respect to the corridor but still any laboratory adjacent to an office should also be negative with respect to the office itself. In other words, that laboratory should always be a source of in-leakage rather than any outward leakage.

In addition to air distribution requirements, we have the problem of air cleaning requirements. What acceptable methods are considered for intake air supply, what degree of cleaning should be required to rid outside air of dust, pollen, and microorganisms? We recognize that asthma patients have certain difficulties with outdoor air or under certain seasonal conditions, and therefore it's desirable to do some filtration for that purpose. Fortunately, this is not difficult. The question is, what is acceptable for intake air?

The next question is one that plagues all heating and air conditioning engineers and hospital designers. How much recirculation is permissible, if any? I ask "if any" because I believe that in some cases we have cleaning devices that can make the recirculated air much cleaner than the outdoor air we are now taking in for supply. I point this out because the cleaning device, if not properly maintained, becomes a secondary contamination source. Many of the hospital ventilation problems I noted recently and that were called to my attention had their basis in the fact that no one had ever bothered to change any filters after they had been put in. Soon that filter became a beautiful generating source for suspensions of microorganisms in air.

Lastly, I have indicated in my outline the consideration of structural materials and maintenance of equipment. I speak here of duct work and structural materials related to ventilation, not walls, windows and so on. If somebody decides that it is noisy and it's a good idea to put fiber insulation in the duct, what does this mean as a future generating source of contamination? Some of these fiberglass materials may be treated and some may not. If treated, the treatment may not have any reasonable life for killing organisms.

In the open discussion now, I would like to take up the question of general environmental requirements. I have already indicated that the question in recent years has been whether the requirements are based on the patient or the staff. I would like to know what your general reactions are toward indicating the desirable temperature, humidity and air quantity for general wards, private rooms, nurseries, operating rooms, and any other special cases. I don't know if anyone feels we should take up numbers of organisms per cubic foot as a basis, which seems to be general practice for occupied rooms, or whether we should talk about some other factor. The floor is now open to discuss temperature, humidity, and air quantity requirements. I think this is probably the easiest topic we have to discuss, because other factors in decontamination may dictate these values.

## HOSPITAL VENTILATION

### Discussion and Comments

Dr. Mudd: The doctors and the ventilating engineers have never adequately shared their insights, and in this particular problem, temperature, humidity, and air flow are conditions that are important to comfort. The specific question we are talking about is germ load. We are talking about microorganisms in the air, and you can't solve this question in terms of the comfort factors and disregard the factors that are immediately relevant, namely, the danger of the germ load under various conditions, in relation to source and in relation to the people who are going to consume that air.

Now, there are certain principles. I think that the medical situation might be clarified just for a little bit, so that we will have a little better focus in discussing some of these physical factors. It is perfectly clear from all the literature that of the three main sources of staphylococci, the patients with frank infections are the most important. The carrier personnel, who may be nurses, doctors, the chief of staff, the hospital administrator, or the lowliest scrub-woman or orderly, are the second in importance. The fomites, in third place, are certainly important, that is, the bed-clothing, mattresses, every object that comes in contact with an infected patient. Thus, you have three sources. Different conferences, different speakers, different investigators have emphasized one or the other as more important in their particular environment, but the aggregate picture is that all three are important.

It is also perfectly clear that there are certain special places where the people who are at risk have to be protected, particularly by an uncontaminated air supply. These are places where the physical condition of the inmates renders them particularly susceptible - first, the operating rooms, where a great many of these airborne infections occur when the open lesions are subject to fall-out or particularly to the nasal or finger contaminations of the operating room staff, and second, in dressing rooms where burns and wounds are open. This has been particularly brought out by the beautiful work of Colebrook et al. (2) at Manchester where it was found that by just simply providing positive pressure in the dressing rooms, with air brought in from the exterior, and using procedures of strict asepsis, the infections were reduced enormously. Because of the particular physiology of the inmates, the babies being particularly susceptible, newborn nurseries are important sources of contamination in the hospital, and produce reservoirs of infection which spread from the hospital into the community and infect the families, and from the families to the schools, etc. The principle should be clear, too, that we have to protect not only the occupants who are under particular susceptibility but also we have to protect

the sources from becoming means of spread of these specific germ loads into the air and into the whole hospital community.

Keep the patients with frank infections isolated. Find any carriers who may be responsible and whether they are top surgeons, or hospital nurses, or grayladies, and whoever they are, wherever they are, prevent those people from becoming dangerous sources of infection to other people who are particularly susceptible. Reduce environmental contamination to a minimum by intelligent application of aseptic and antiseptic practice. I think these principles are established and are rather basic.

Dr. Silverman: You have indicated that requirements vary considerably depending on the kind of patients and the kind of operations or activities that are conducted. Operating rooms have been recognized as a problem long before this recent concern of Staph. infections, namely because of explosions and controlled temperature and humidity for patients' welfare. We have to be alert to the fact that, as they develop suitable non-explosive anesthetics, they will want to reduce the air requirement on the room because these are refrigeration and ventilation loads in general. Any attempt to increase safety must be carried out, it's true, but at the same time you should not lower ventilation on the basis of explosibility, but maintain it at least for the purpose of controlling contamination.

Dr. Mudd's points are well taken. He has identified three sources. How well can we, from the standpoint of ventilation, do something about these sources? What can we do, for example, in terms of reducing germ load?

I would like to bring up one point here that I don't think we have the answer to. One of the problems in all of this is the degree of infectivity. Now, how effectively is this airborne contaminant infecting people? The question is, how many organisms does it take to be sure you are infecting a person, what are the control limits if you provide ventilation to dilute the number of organisms down in the room, or to remove all organisms? Is it necessary to remove all of them? What number of organisms per cubic foot of air can be tolerated? And the reverse of that is, how many does it take to cause an infection? This has been a riddle in terms of many, many agents.

Dr. Phillips: I don't know of any particular measurements that have ever been made on infectivity with Staph. aureus per se. In general however, one of the most interesting things about infectivity is the universal variance that you get in dose response. Talking in terms of aerosol studies and infection by the respiratory route, if you plot the number of organisms to which any experimental animal is exposed against the percentage of those that become infected, a dose response curve results which has an "S" shape. There is always a fantastic spread to these figures. For example, you take a given dose and infect 20 percent of the animals exposed - multiply that by tenfold,

say, and you still aren't infecting all. You will only have gone up to about 60 or 80 percent infections. The higher the dosage is, the higher the percentage of infection among the exposed, but you still have terrific ranges over which you will be getting sizeable percentages of infection. You can go to extremely high concentrations and get 100 percent infection. So, to give an exact figure, to say we should get below a certain number of organisms per cubic foot of air, is a very difficult thing to do.

Dr. Silverman: This makes it difficult for ventilation engineers. In our industrial hygiene practice in general, we have some yardstick to shoot for. If you give a "0" as the permissible germ load this means infinite air in some respects or air cleaned with 100 percent efficiency. This obviously is a limit which I don't think we have an answer to justify, and which could be achieved only by a hospital with a budget of national debt proportions. In other words, the number of organisms or the germ load that can be tolerated must have some finite value. If you say "0", then you can say that this is easy to do, it just means that you don't permit any organisms in the air at all and you sterilize all the air. However, filtration alone doesn't do this. There is no 100 percent filter. You would have to have filtration plus sterilization and then be sure that your sterilization was 100 percent effective.

Dr. Mudd: This is one very good reason why we need the insight of engineers and doctors and architects together. We need them to communicate these insights.

Now the beautiful work of Riley and Wells (3, 4) has shown that one tubercle bacillus in a large volume of air can infect one guinea pig with tuberculosis. This is one limit. The other limit is set by the ordinary airborne bacteria which make no difference at all. They aren't infectious and they are of no consequence. It is a specific germ load we are talking about, and in this case it is the staphylococcal germ load.

Dr. Langmuir: I would like to take issue with my very good friend, Charlie Phillips. The only rational approach to the dosage problem is to assume that for essentially all infectious agents the dose is one organism in the right place. Now then, there are all kinds of factors that prevent that organism from getting in the right place. Certainly Riley and Wells' beautiful work in TB has over and over again shown that one TB bug in the alveolus produces tuberculosis with a reproducible result. I think this is true in staphylococcal infection. There are very little data on it but Wysham (5), in his studies in Seattle using slit samplers that Larry Hall provided, believes that he had a nursery epidemic which was airborne. There is some argument about this. We don't know that he got every possible dangerous carrier, but he did get the bugs out of the air in moderate concentration. Then, taking the breathing rate of a baby, he showed that it was at the range of several hours to get one in the nose of

a baby. This is again, to me, coming pretty close to the level of a single organism in the right place, because the nose happens to be the focus of growth and in a baby it probably does pretty well. Now in adults, where you have immunities in a variety of specific organisms I agree, you have a whole raft of other barriers that come up. To me the logical approach is to think in terms of starting with one bug in the right place. Then going on, I'm afraid from the point of view of ventilation in nurseries, you are going to have to think in terms of keeping the specific "hot" bug out of the baby's nose. There isn't any other choice if you are going to approach it from the ventilation angle.

Dr. Silverman: This is the kind of question which is a good one to pose to our medical colleagues. It's the one I tried to identify at the beginning. What strength can we take in the philosophy that staphylococcal infections are airborne, and if they are airborne what percent can be handled by the ventilation system and what percent best handled by source control? If we are going to tackle the air problem, we still want to be certain that it is the mode for continuing contamination with which we are concerned.

Dr. Mudd: Dr. Langmuir and I could certainly cite many studies where airborne pathogens are responsible for infections. I refer particularly to the studies of Bourdillon (6) and Colebrook (2). I also refer to the particular studies of Overholt (7) in which he did thoracoplasties and found that the sepsis rate was remarkably reduced by ultraviolet irradiation in the operating room. I assure you that there is plenty of evidence for infection by specific pathogens either from the surgeon, the nurses, or the air from infected rooms. Any of these sources can infect wounds, and the air is only one of many sources.

Dr. Phillips: I think it has been so well established that we can set this as a philosophy: the Staph. is being generated largely within the hospital itself - certainly, as far as it gets in the air. It isn't an outside organism that is coming in with the outside air. It is in the places where there is the most activity. Around an operating room, in the nursery, wherever human activity is taking place, we have in essence an aerosol generator. In other words, generation is probably most apt to be right around your patient. It's almost as if you were setting an aerosol generator in the spot where you would least like to have the organism present. This, of course, disregards direct contact. If you consider, then, how to remove this aerosol from the air, you have a very simple mathematical problem of dilution. We have had our mathematics division do some simple calculations for us on the effects of dilution. For this we set up a mathematical model using ten changes of filtered air an hour and a constant rate of generation within the room. Unfortunately, no one has any good measurement of what that rate is. We picked four different air filtration efficiencies for the study - the first with 30 percent efficient filters, another with 60 percent, another with 90 and another with 100 percent - which is the same thing as saying we were blowing

in pure sterile air. Amazingly enough, you will quickly reach a more or less steady state within the room if you are assuming a constant generation in that space. While you get a fairly good difference between a 30 percent and a 60 percent efficient filter, there is very little significant difference in the results achieved by 90 and 100 percent efficient filters. You will never, of course, have sterile air in the places you are worried about no matter how much sterile air you pour in, if you're generating an aerosol within the room, as is always the case.

Dr. Bennett: Much of the information that has been discussed here in terms of slopes and so on is based on the establishment of infections by the deep respiratory route. However, the vast majority of staphylococcal infections at the present time are not respiratory. Respiratory infections are bad, but staphylococcal pneumonia is relatively unusual in contrast to subcutaneous abscesses, wound infections, multiple boils, etc. In the latter case we do not negate the premise that there may have been only one organism, because if the one organism falls into the right or wrong surgical incision, it may cause a very serious infection.

This group shouldn't be too disturbed over the fact that it has been impossible thus far to demonstrate that the airborne route is the only route of spread, whereas there have been studies such as that cited in which the infection rate remains constant despite considerable modification of bacterial count. There have been other instances where, by modifying the count in the air, the infection rate has been cut down considerably. This group should not have the feeling that the only approach to this problem is ventilation, because every attempt is certainly made to cut down on the dissemination of these organisms mechanically. It is possible to cite many, many instances in which transmission of infection takes place in the hospital where it obviously is not airborne. For instance, we recently had a patient with extensive burns, who was infected at the time of admission, and four of our house officers developed furuncles on or about the hands or wrists. These were the four who took care of this patient at the time that she was admitted. This obviously was not airborne - but was a matter of mechanical transmission. One of the difficulties of this problem is that it is obvious that there are a number of routes of transmission. However, the airborne route, in all probability, is important in certain instances.

Dr. Silverman: In other related work we always try to reduce the source, if possible, because if you use general ventilation to control, as an example, certain solvents, you may get into astronomical numbers for control and the costs are ridiculous - you just can't do it that way. You have to control the source and, obviously, this is the aim here.

Dr. Mudd: It is quite clear that the surface of the body is the commonest reservoir of Staphylococcus, but it also is true that if

you have conditions of especially lowered resistance, as in the case of Asiatic influenza or newborn infants, the contaminating organism in the nares or on the skin may reach the lungs. Most of the fatalities, in Australia at least, following Asiatic influenza, have been due to staphylococcal pneumonia and it turned out that they got the infection from skin reservoirs.

Dr. Silverman: We talk about general ventilation requirements and say they must be greater than for what we call normal thermal and comfort requirements. Any increase should be based on the need to diminish air concentration of organisms. On the other hand, if the volume remains the same, it places us into phases of air distribution, points of air introduction and removal, and air cleaning, rather than air quantity per se. This is the thing we want to find out: Are the existing quantities of extramural air, as supplied to air conditioning units of hospitals, universally lower than that of intramural air? I think we could probably agree that the answer is yes. The question then, is, are the air requirements for various occupied areas to be increased or are the present requirements satisfactory?

Mr. Snow: General ventilation practice assumes, for most efficient ventilation, that there should be a complete mixing of room air contents for comfort of room occupants. However, we recognize that the organisms we are dealing with are generated within the room and are generated from specific points in the room. Perhaps what we really are thinking of is local ventilation, not local in terms of the room itself, but locales within the room. If we can work from the patient and go out in terms of what ventilation is expected to do, perhaps then we will have a good starting point. Can we, in other words, ventilate the critical zones around and surrounding this patient; not in terms of what ventilation practice is as we know it today, but as what we could develop?

Dr. Silverman: We could easily make every operating table a down-draft grille but this gets to be a problem when you talk about every bed. If you have immediate fall-out in the area, it may become a secondary source of air contamination and may also be a problem. It may attach itself to dust - then if it's stirred up in the air again, even though it might have fallen out once, it doesn't stay up permanently, so there is a secondary source. The fact that one or two organisms may get out, float around in the air, and by the laws of probability and chance end up in somebody's naso-pharynx, is something that we should be concerned about. Dilution may help here, but how much more dilution than we're now getting is the question. Further, can we economically increase dilution if we are permitted to recirculate through a filter? This is effective cleaning, but is this generally desirable?

I would like to bring the second phase of air quantity into focus now and that is air distribution. When I speak of air distribution I mean bringing air into an area and taking it out. In some

areas this must be a one-way situation. You can't take it from the operating room out into the general corridor. It must leave the operating room and leave the environs of the hospital or at least be sterile if it leaves the operating room and goes any place else. This is the type of thing that can be controlled. The operating room I believe can be controlled, ventilation-wise. Now, as far as surgical procedures, control of the carriers who walk in and out of the room, the kind of barriers you set up, that comes secondary. But I do believe that ventilation for an operating room, or a nursery, or any special area can be best controlled by air distribution. By air distribution I mean isolation, essentially.

Can you do an effective job of keeping the contamination from leaving the patient area? The question then comes: Is this going to induce a thermal load, or an air conditioning load, that becomes exorbitant in cost to maintain, or even install in terms of capital expenditures? In terms of private rooms in new construction I don't think this is an exorbitant cost. In terms of wards, I think it could be almost impossible to do without cubicles.

Mr. Snow: We probably would be wise to consider drawing into the equation of cost the additional cost expended for patient care on resulting infections. This cost comment frequently creeps into our own considerations of new facilities and is one which compounds the confusion.

Dr. Silverman: The question is asked: Is any one method of air flow through a room better than another? I think this might be looked at in this light: Is it better to have a perforated ceiling and a down-draft exhaust which I would say would be the most positive flow? I would think an anemostat would be detrimental because it does a nice job of recirculating and accumulates a reservoir of organisms within itself. Yet, I have been in hospitals where anemostats have been installed. It is obvious that this can become a secondary source of airborne contamination and this would say to me that this type of mixing diffuser is bad. My answer to this question, "Is any one method of air flow through a room better than another?" would be yes, there is a better method than just anything that's used in general ventilation practice. Anemostats have many advantages in mixing air well and in getting high volumes of air into small spaces with a minimum of draft - but they would also succeed in causing maximum concentration of organisms under this application.

Mr. Gaulin: I would like your opinion of the so-called induction system which uses a room unit usually under the window to bring primary ventilating air into the room and, by the air movement through the unit, induces a circulation of room air. These units have filters but not what we call high quality filters. With this system, the corridor is supplied ventilating air which normally will move into the individual rooms to be exhausted along with the room air. We have thought of this in hospital design as an effective method of preventing air movement from room to room.

Dr. Silverman: If there are any surfaces for deposition, they also become surfaces for redispersion. In perimeter heating, we hope that those surfaces are heated and may in themselves be decontaminating. There's no certainty of that - they may circulate without heat through them. If there is a filter in the system and the filter is not properly maintained, then the next patient who comes into that room may get the benefit of the previous patient's filtered material if it is redispersed from the filter surface.

I would like to point out our own studies on redispersion from filters and fibers in which we want to know how particles are held by fibers and how long they are held. If the adhesive is poor, or if drying takes place, there can easily be redispersion from the filter. There is also the so-called chance collision of a larger particle with a smaller one, knocking it off. I have seen some of these filters simply loaded with organisms and yet the pressure drop across them isn't too bad. If the organisms partially dry out and then come off, that filter may turn out to be a nice focus for an infection.

Dr. Phillips: Still, in spite of this, do you not think it is safer to be collecting these things from the dust that is in the air, from the floor, etc. by continuous filtration? Isn't the contamination safer on the filter than it is, say, on the floor of the room?

Dr. Silverman: I wouldn't argue with that, but if you can afford it, it is safer to throw it outside.

Dr. Phillips: By and large, I know of no measurements of the die-off rate of Staph. in particular on filters and floors, but such a place is a very unhappy environment for a vegetative organism - to be on a dry surface with a lot of dry air passing over it. They do die off on such things. We know from our difficulty in trying to use dry filter surfaces for air samplers - that is, to sample on dry surfaces. Organisms that are perfectly viable in the air get killed rather quickly when they are collected on such samplers.

Dr. Bennett: Dr. Shooter told me only last week that, on the basis of indirect evidence, they are about to come to the tentative conclusion that within 30 minutes after it is released in the air, a Staphylococcus is likely to be far less infectious than if the transmission is direct.

Mr. Kethley: There is a tremendous difference in the invasive ability and infectivity between organisms arising from carriers and those arising from frank infections.

Dr. Bennett: Individuals who have infections and also individuals who are supposed to be asymptomatic carriers vary a great deal in their ability to contaminate the environment and in these studies Williams and Shooter have drawn indirect conclusions from the occurrence of infection in individuals who were exposed either to frank

infections or to one of the so-called heavy carriers. They really are beginning to believe, and I must say that our own opinion coincides with this, that this difference between organisms from asymptomatic carriers and from individuals who have frank infections may be purely a numerical one, because there is a great difference among so-called asymptomatic carriers. There are some who literally scatter millions of staphylococci wherever they go, and there are others on whom you just simply can't find staphylococci unless you take a direct swab of the nose. It may be that this is all quantitative, but this included patients with frank infections. Again, their conclusions are certainly tentative. I simply raise this as a possibility that it may be possible to establish eventually that the Staphylococcus released into the air loses its infectivity without losing its viability - you can still culture it out on plates in a fashion similar to the Streptococcus.

Dr. Mudd: Considering expense, the first practicality of these programs, it seems to me that it is quite clear that there are certain areas in hospitals in which requirements are much more exacting than they are in others - that is, the operating rooms, the dressing room for burns and wounds, premature and newborn nurseries and isolation wards seem to have a very much higher need for clean air than the general hospital, so I don't think that we need necessarily get into astronomical expense if we limit ourselves to the places where clean air is most needed.

Dr. Silverman: In crystallizing the discussion, we want to try to arrive at a meeting of minds between the engineering and the medical groups assembled here. We want to be certain that what we feel is practical and can be attained engineering-wise is useful in terms of the medical needs. Economics, of course, is the foundation for all of this concern. Hospitals in general are non-profit institutions, but they can't be so far from realistic non-profit that operating people don't have some concern. We have talked about air requirements and air contamination and air distribution and we'll come back to it in summarizing.

I would like to talk now about air cleaning requirements, and I might begin by giving a little background. People have been worried about air cleaning since they thought about how to measure the contamination in air. In 1936 or perhaps later, about 1940, Prof. Yaglou made some measurements on air washers which were the standard type of cleaning equipment for hospitals. With clean water, he found they were about 66 percent efficient in removing Bacillus subtilis; and with dirty spray water, only 23 percent efficient. Now this isn't a very effective cleaner, although if you recirculate through such a filter you'd pull down to a certain level. Dust-stop or coarse fiberglass filters are the type that are used in many unit ventilators and air conditioners. In particular you've got to be certain that someone isn't talking about a half-inch filter as opposed to a two-inch, because our measurements of pollen removal with these are quite revealing

in that their efficiency practically follows log penetration. That is, a half-inch filter is 50 percent efficient on giant ragweed which is the smallest of all the pollen (about 20 microns), whereas a two-inch dust-stop is 95 percent efficient. Now, on bacteria, dust-stop type filters will be anywhere from 65 to 80 percent efficient. If you want to use a more effective filter, there is a type which is spun glass and which resembles insulation rather than filter material, if you want a crude illustration. This turns out to have an efficiency of 99 percent plus, and it's as good as an electrostatic precipitator. On phage, it may be less efficient, but I think the phage or viral measurements are highly suspect at this point, because of the sampling device. I would say we can't really give a good answer on removal of viral organisms and I would prefer to say that the problem is more associated with larger particles because the virus is not very apt to survive without some means of support. Thus we can obtain 99 percent removal at what I would consider reasonable pressure loss - a quarter of an inch of water at reasonable filtration velocities. A combination of a filter of the roughing type, plus one of 99 percent efficiency, would be efficient on all bacteria and certainly on the Staph. size to the extent of 99.5 to 99.9 percent removal.

We have tested some electrostatic precipitators for recirculating air in a room for pollen sufferers. Within a week, the efficiency will have dropped on pollen from 99 to 90 and at the end of two weeks it might be down to 80. This means simply that you build up deposits on the discharging wire and on the plates. A standard commercial unit placed in a central system doesn't get frequent maintenance. In fact, it is designed for 85 percent on a stain efficiency basis at 350 fpm velocity. Today they have increased performance to 90 percent. In most recent models, the manufacturers have increased velocity and decreased size and claim 90 to 95 percent efficiency but, again, unless the wires are cleaned and kept from being broken, the average efficiency is going to be far less than that of a dry filter of the high efficiency type.

I would feel that the precipitator is not a "fail-safe" device, whereas the filter is independent of power. If the power goes off on a precipitator, you don't have any cleaning. There is no problem such as this with a filter.

I think if you are starting from scratch in new and small hospitals, a dry filter has a lot of advantage. If you can use the type that is mechanically maintained, like the Rollomatic which is coming into use now, followed by some replaceable dry type you can achieve an efficiency of 99 percent plus, and you will have done a pretty good job with this on relatively low maintenance cost. Dr. Walter has found a lot of problems associated with airborne contamination due to inadequate maintenance. As I said earlier, the air filter, the air cleaner, and the spray washer, may become primary sources of contamination without maintenance. Further, in my opinion, it would be desirable to place filters ahead of the coils not only to maintain the

heat transfer characteristics of the coils but to prevent them from getting contaminated.

Dr. Hatch: I would like to suggest that, from all we know to date, the volume rate of ventilation, as it may be fixed by any present ventilation standards - thermal requirements, odor requirements, etc. - is definitely not enough, so we're talking now about some new criterion for volume rate of ventilation. I would like to suggest further the idea that the volume which will be necessary to provide effective removal of organisms from air, which is being shared by carrier and susceptible, is in fact greater than can be provided by any method of mechanical ventilation. If these statements are correct, then we have to look to some characteristic of ventilation within the room that will accomplish what we are after. There has to be some method of lowering the concentration of infectious particles. The possibility has been mentioned of utilizing a piston effect in moving air through a good ceiling diffuser in the room. I'm reasonably sure that, dollar for dollar, this would give you more effective ventilation than the usual method of putting air in and stirring it up within the room. I think this is a possibility that lends itself beautifully to systematic laboratory study, and I would recommend that this be done by somebody. I would suggest that we need to know more about other means of destroying organisms or removing them from this atmospheric environment.

Dr. Solberg: We have come to the conclusion that you cannot exceed about 15 air changes an hour on any kind of a practical basis, but that it would be practical, if the air is clean and sterilized, to recirculate about two-thirds of that air. So far as actually getting an area free of airborne microorganisms, there are a few examples of that being done around the country. We have found a couple of them in our investigations. Both of them happened to be in pharmaceutical plants where the contamination from airborne organisms would destroy the product. The way that it is done is to utilize just about every device that is available to carry on recirculation of air and bring in a certain amount of fresh air. Personnel are left in the rooms, four or five of them wearing sterile clothing and masks, but of course, making sure that the people are not carriers of undesirable organisms. We have gone in such places and gotten consistently zero counts in the air in various places around the room. This is the best we have ever seen. There are just two or three such places that we know of, and needless to say, it is expensive.

Dr. Phillips: We have had, of course, quite a bit of experience on air purification. We have tried all kinds of devices, but by far the simplest, most economical, and the most foolproof is just straight filtration. There are special filters that the Chemical Corps has developed and there are some on the market now I think that are not just 99 but 99.9999 percent efficient, which for all intents and purposes produce sterile air. These do not have as much of a fantastic additional pressure drop as you would imagine. The commercial ones which we largely rely on are approximately 90 percent efficient, are not high in cost and, if preceded by a roughing filter, may need replacement only once a year or so. If you protect a high efficiency filter with a roughing filter, you can add several lives to it.

Mr. Snow: I would submit that no fixed-in-place duct work system can be satisfactorily decontaminated once it has been installed, knowing full well some of the procedures used. For the average hospital, let us say economically, this is beyond the point of practical possibility. Therefore, I would think it would be more desirable, in the design of ventilation systems for hospitals or for certain areas within hospitals, that a fail-safe arrangement might well be planned for capturing whatever is sloughed off the fans or duct work systems - this device to be installed at the point where the air enters into the immediate area with which we are concerned. I think that if we are here to look at the practical measures, perhaps our objectives ought to be in that direction.

Dr. Silverman: Judging from the practical limitations, it almost looks like a cleaning element would have to be placed just before the register or the grille, and you can't do this very well. You could use a trunk duct precipitator, I suppose. I'm inclined to favor that type. If you use a filter at the supply register, it's going to have to be of fairly low efficiency, because the pressure drop is critical. I would not quite agree with you on the fact that you can't decontaminate ducts - I think you can - not with unreasonable requirements. In fact, if you simply seal the register and inject carboxide or materials of this type, and hold the system closed for a while, you will get a satisfactory kill on the kind of organisms we are worried about.

I don't think the duct problem is going to be serious if you clean the air well before it enters the duct. When you have recirculation in a duct without any cleaning in between, then the duct can be a reservoir.

Dr. Phillips: There is one other principle that hasn't been brought up. That is that the amount of pressurization needed to keep essentially 100 percent of any outside aerosol from filtering into a space is much less than a lot of people think. We've had spaces, for example, which are pressurized to only a tenth of an inch of water - as little as that - and which are essentially tight against any outside aerosol. So by maintaining the places you want to keep clean at a slightly higher pressure, you can do an awful lot in keeping any outside aerosol or dust from entering. I should, however, add that for entrances and exits to be made safely into such an area they would have to be made through air locks.

Dr. Bennett: Since it would be very difficult to set up a separate set of isolation rooms for individuals you are trying to protect from the rest of the hospital and another set for those from whom we are trying to protect the hospital, is there any practical and inexpensive way, in which, for a single room, the pressure gradient can be changed? In other words, could there be a switch on the wall, so that you could make this a positive pressure or a negative pressure room for isolation depending upon the type of individual you put in there?

Dr. Silverman: I think you could. But I just hate to think of somebody pushing the wrong button. You would simply have a motor-powered damper that reverses the fan inlet and outlet situation or have another fan which operates against the existing one - it is technically feasible - and to have both with cleaners, so that you could do it either way. But if the room is designed to be supplied from, and exhaust to, the outside it will be safe for either type of patient.

Mr. Hall: The air exhaust system in a large hospital is usually a complex setup. Is there any danger that's analogous to back-siphonage in a water system? If some of these systems fail to work, are we in danger of getting back-siphonage from the exhaust?

Mr. Snow: I can attempt to answer that from my own experience. Yes sir, there is a very great danger of that happening. We have the phenomenon at various places among our laboratory buildings, so I would suspect that the same is true elsewhere, depending upon the local weather conditions especially.

Dr. Anderson: Dr. Walter has released some figures as suggested standards. The floor counts in the operating room should be 0 to 5 bacteria per square centimeter. In the ward, the floor count should be 5 to 10 per sq. centimeter. The air count in the operating room should not exceed 5 to 10 per cubic foot. The air count in the ward should not exceed 10 to 20 per cubic foot. The bed rail can have 5 to 10 organisms per sq. centimeter. Soap ought to be sterile, bedside water ought to be sterile, bedding should have a 2 millimeter zone of inhibition. This is from a news release but it has quotes around these parts, so I presume it was taken from some paper that was given which is going to be published. What do you think about these?

Dr. Silverman: What do they mean? If these are all non-pathogens, what is the significance? If they are all pathogens, what is the significance? It's a relative index - something such as Escherichia coli in water is an index of other possibilities in the water; and maybe it's a good yardstick to begin with. You have to have some standard to work toward. However, they are a little higher than background for normal outdoor air. Ten to 20 per cu. ft. seems to my way of thinking a higher than normal background.

Dr. Phillips: The best data that I know of were collected for us by your Savannah Laboratory people. It was in Detroit which you would assume to be a quite dirty city. For almost a year Mr. Skaliy sampled several times a day in several locations. Whether Detroit is dirtier or cleaner than other places we don't know, because such a study has never been done anywhere else. But in downtown outdoor Detroit, they found levels of about 5 to 10 organisms per cubic foot of air.

Dr. Solberg: To tell you a little more about it, we discussed these figures with Dr. Walter, and actually these are practical limitations. They are just about as good as you can do with practical limitations. They are just about as good as you can do with present conditions. I think the conclusion we can come to here is that, if it were possible, all of these things ought to be zero.

Dr. Silverman: There is one thing that I just noticed on this release of Dr. Walter's. The filters must be policed and the coils must be flushed with a detergent germicide periodically. He's talking about the refrigerator coils and the air filter. These are ways in which he says you can attain these values in a room.

It has been asked if there is any epidemiological basis for Dr. Walter's figures or if they are just taken out of a hat. He does have some basis for them. He has some observations on the incidence of infections in several hospitals, including the Brigham. He is one of the few surgeons who really takes this sepsis problem with a great deal of concern.

The question has been asked, is any one method of air flow through a room better than another? I would say yes, but we have to qualify this. This is one area where we need investigations.

Dr. Hatch: With mechanical ventilation and air conditioning, there is a tendency to have higher air velocities. There would be a tendency toward greater dissemination of contamination in a room.

With mechanical ventilation, we have the capacity for controlling direction of flow. To utilize this intelligently or unintelligently is going to be a factor as to whether air conditioning is going to be more or less useful than natural ventilation. I would say that it works both ways. The utilization of mechanical ventilation with air conditioning may increase the magnitude of Staph. dissemination, but, on the other hand, the fact that it is a controlled system of ventilation against an uncontrolled, provides the possibility for a reduction of Staph. dissemination.

Dr. Langmuir: Shouldn't it be evident, or emphasized, that these remarks deal with particulates moving around a hospital and not with disease? I am unaware of a well-studied epidemic where the ventilating system is unequivocally incriminated as a mode of spread.

Dr. Wolman: I wanted to ask you whether your statement would be applicable to Dr. Riley's work in TB? Do you still consider that as not an authenticated demonstration?

Dr. Langmuir: You can put all kinds of people into chambers and infect them but it is different from the epidemiological situation, and we're talking about a hospital. We're concerned with people here, not animals, and I want to be sure that the transmission of a disease has not been implied.

Dr. Porter: I recall reading several years ago that the Russians had been quite successful in reducing the bacterial count in wards by recirculating air through ultraviolet sterilizers placed in the center of the wards. I don't know any more about it than that, but it would seem that we should know more about the effect of such techniques on the control of S. aureus.

Dr. Silverman: The Russians were only 10 or 15 years behind Wells and McCann, unless I am mistaken. The problem was studied at the Children's

Hospital in Boston in the 1930's. They proved you could do this, but the question was what it would do to cross-infections. It turned out to have very little influence on cross-infections.

Dr. Mudd: The Germantown Friends' School experiments were extremely successful as far as measles, mumps, and chickenpox were concerned - the common cold wasn't touched, because the children got that from their other outside contacts. The ultraviolet burners were removed from the Germantown school and the other schools, not because they weren't efficient, but because there was no useful purpose to be achieved in preventing the young children from getting these infections, which are much worse after puberty than before puberty. It wasn't because the air sterilization didn't work, but because there was no sense in doing it.

Dr. Hatch: It seems to me that there is a very real need for re-evaluation of these approaches to this particular problem. The Germantown school studies were effective with respect to those particular diseases, because the school room was the source of trouble, whereas, the common cold wasn't. It seems to me that this insight into destruction of organisms really has possibilities and it needs to be systematically evaluated. What may be the problems with regard to Staph. organisms we really don't know.

Dr. Bennett: There is information available about the use of recirculation employing ultraviolet in nurseries. Our British friends did, for a period of 6 months, use recirculation with ultraviolet exposure of the air in the nurseries and were able to quite effectively cut down on the count in the air. As I recall, they cut it down from an average of 10 colonies, per some unit, to about 1, of staphylococci. This in no way influences the rate in which the infants in that nursery were colonized by staphylococci.

I think the point here is that, in general, they could cut down on the number of staphylococci in the air by roughly 90 percent, but this had no effect on the rate of colonization of Staphylococcus.

Dr. Silverman: I believe the authorities on the explosion problem for safe hospital operation room practices have decided that degree of ventilation is a critical factor in preventing explosion hazards. Actually, I believe the air flow for maintaining aseptic conditions will be a lot higher than that necessary to dilute for purposes of explosion control.

Mr. Snow: Blower's experience in England with the piston effect of air through an operating room has been confined, as I gather from his letters, to an operating room in which heating constitutes the air conditioning applied. This is not true in this country where we have cooling as the most important problem over the majority of the year. I

would urge a bit of caution that we not interpret this as necessarily applying to heating and cooling practices in this country. We are not thinking in the same terms as England.

Dr. Bennett: I believe it has been perfectly obvious from these discussions that it is not possible to state at the present time just what role airborne infection plays in staphylococcal disease, and I think it would be very good if this group would emphasize the fact that there is need for some kind of a controlled study to see whether the incidence of infection is modified by these factors. I want to point out that most of the figures that have been quoted this morning, including those from the British Medical Journal, involve situations where not only was the air conditioning modified but also where many other things were modified. They tightened up surgical techniques, and did all sorts of things. I think that what is really needed is a clear-cut definition of the problem. At the present time, we just don't know the role of ventilation in the spread of infections.

This is exactly the point that this group needs to make and to throw back to the epidemiologists and the rest of the medical profession to point out that this is the crux of the matter. We have defined here fairly well what can be done, what is worth exploring further, but is it worth it?

Dr. Silverman: We have a parallel situation in air pollution today in which we say that we have all the causative factors and measurements for a disease which is not yet known. Now here you have a disease which is known but you haven't defined all the factors that go into producing it; but you've got an agent here which ought to help us some if you could only tell us the route that is most important.

Dr. Langmuir: Have you considered or contemplated the type, size, or scope of such a study in order to get such an answer? I'm very much in favor of the study, but it should be comprehensive. It is a major undertaking, not something you do in a small way.

Dr. Silverman: I would say that everyone I have talked to is well aware of the fact that you can't do this with a \$10,000 project.

Dr. Mudd: I maintain that the literature is sufficient to show that there are three major variables, three major factors in this. One is the human healthy carrier. There have been plenty of cases shown where one nurse or one surgeon has been the cause of a minor outbreak in a hospital. Then there is the infected patient, who is an unquestionable source of contamination. Then the fomites - any material or object, dust, blankets, mattresses, things by the bed, or the air - may be the agent. I don't quite see how you are ever going to get a general answer to the question of the relative importance of air when these other

major variables are to be controlled. We know that all these three major methods can be sources of communication of staphylococci from carriers to susceptible persons. I think it is not known that in these special areas there is a special danger; namely, the operating room, the dressing room, the contagious ward, and the nursery. It is certainly desirable to prevent spread through the air or any other fomites but I don't think this is going to be a complete answer to the problem. It all depends on conditions which are more important. They are all factors and we ought to do all we can to control them.

Dr. Anderson: I feel like Dr. Mudd on this, because I fear that behind all this talk about the relative importance really lies a strong conviction that this is a way that is not important at all, so that we shouldn't waste any time on it. I believe we ought to make up our minds at this time whether or not the floating of organisms in the air is important in hospital infections, not alone for Staph. but for other infections as well, and then go to work on it, rather than say this is more important than the puncture in the surgeon's glove or the other mechanisms.

Dr. Silverman: I would like to close with one statement here. In terms of my own thinking, anything you can do to ventilation in a way that permits recirculation through a proper cleaning device will lower the cost to the hospitals. That is something to be considered in this whole problem of heating and ventilating hospitals. This business of once through a building space and out into the atmosphere means quite a financial burden on the institutions in most cases. The difference between recirculating and not recirculating air is an important financial problem from both the standpoint of initial installation and operating costs.

# HOSPITAL HOUSEKEEPING PROCEDURES

## Introduction

Charles F. Kilpatrick\*

I am sure that all of us here today are quite familiar with the basic problem which is the cause of our meeting together. I am certain also that we are aware of the seriousness of hospital-acquired staphylococcal disease, and of the tremendous effort that is being made to combat, through every means available, the spread of hospital infection. Without doubt, every individual here has read the proceedings of the National Conference on Hospital-Acquired Staphylococcal Disease, and the summary report of the discussion groups from that conference.

Of interest to us in our discussion today is the recommendation that definite action on the part of hospitals and other community agencies is imperative. Since we are concerned with Section III, Hospital Environmental Sanitation Recommendations of the National Conference, our program has been divided into four sections, that of hospital design; hospital ventilation; sterilization and disinfection; and housekeeping procedures.

The National Conference has stated that there is growing evidence that poor housekeeping techniques contribute to the dissemination of hospital-acquired infections. It also is agreed that effective housekeeping demands constant vigilance on the part of both administrative and professional staff. This can be effectively accomplished only when all groups give due recognition to the housekeeping aspects of disease control. One of the recommendations of the National Conference was that a Hospital Infections Committee should be established and should consist of active, interested members of all major hospital departments including administrative, clerical, nursing, housekeeping, and laboratory personnel. This committee should utilize every facility of the hospital, leading to effective control of hospital infections.

If we are to improve housekeeping techniques as one of the steps in the control of hospital infections, we must first agree that the cleaning functions for hospital areas are the responsibility of one department or division, and that effective controls cannot be developed by dividing responsibilities for hospital environmental sanitation among several departments whose primary duties lie in other fields of

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hospital operations. If we agree on this concept, we must establish the housekeeping department on the same level as other departments or services and establish, through published hospital memoranda, the functions and areas of responsibility for this department. A staff must be provided, supervisory structure must be adequate, hospital housekeeping training must be given and, above all, a competent individual must head this important hospital operation.

Unfortunately, the reservoir of fully-qualified personnel to head this department is limited. While there are many individuals who are competent to serve in the capacity of foremen of laborers, there are few who have had the background of experience and training required to perform fully the staff functions of developing the organization, planning the program, setting standards, applying work simplification principles, handling the complete budget, advising management, and directing the interior decorating program. Further, the competent head of this program must have some knowledge of bacteriology and how to combat the spread of hospital infections, and have a knowledge of the chemistry of housekeeping supplies and materials. The department head must be an individual of many facets. He must be an organizer, planner, analyst, public relations expert, diplomat, salesman, teacher, and a strong supervisor. It is in his ability to convey his mission, his methods, and his understanding of the problems to his top management officials, to his supervisors and to his workmen, that his goals can be accomplished.

We must utilize specialized methods of sanitation in a hospital setting since usual methods of cleaning are not always effective. Thus, the hospital housekeeping head must have a specialized knowledge in cleaning techniques for contaminated areas and for handling contaminated materials which are not common to all sanitary maintenance programs. For training in aseptic techniques, the best qualified professionally-trained personnel - doctors, nurses, laboratory technicians - should be used as teachers in imparting to workers, a knowledge of contamination problems and the steps which must be taken to cope with them.

Controls must be established, not only for housekeeping but for the entire hospital staff and visitors who have any relationship with a patient while he is hospitalized, to assure that there is no break in the chain controlling hospital infections.

We must realize that hospital housekeeping IS a specialized type of housekeeping and, I repeat, that the department head MUST BE a highly qualified individual to direct the activities of this important hospital operation. There are too few qualified individuals, and there are too few sources for training in this field. To date, only a few colleges give training in hospital housekeeping, and most of the personnel occupying the departmental head position have only a background of hotel housekeeping experience or have had only on-the-job experience which, for the most part, has not provided the important management aspects of the job, as is necessary under the full department concept.

Since this field is making rapid growth and the supply of qualified personnel is limited, perhaps it would be expeditious to encourage colleges and universities to develop courses for training personnel in this very important field.

There appears to be a need for more adequate testing of materials, machines and products to determine that the methods and materials used actually achieve the sanitation level required in the hospital setting. Since rising labor cost is a problem, we should also investigate the man-hour savings which may be possible through improved methods, materials and machinery in order that we achieve not only improved production, but also raise the standards of hospital housekeeping. Perhaps, also, the emphasis in the past several years has been on production rather than in accomplishing the higher level of sanitation necessary to the hospital setting. I think we will agree that we cannot sacrifice sanitation in the hospital, and that the steps necessary to achieve sanitation are justified regardless of the labor costs, since we must first consider the well-being of the patient who is the only reason for the hospital being in existence. I believe, however, that we can achieve a high level of hospital sanitation with a reduction in the over-all housekeeping costs through the application of work simplification principles, better techniques of operation, and the use of modern housekeeping equipment and supplies.

Manufacturers and suppliers of materials and equipment have made great steps in recent years in providing better machinery and housekeeping supplies which will achieve sanitation at lower operating costs.

Many of the recent articles in connection with hospital infections have discussed the dangers of airborne infection. While we recognize the dangers from this source, few studies have been published as compared with studies of surface sources of infection. I believe that Dr. Phillips, who is in our group today, has made studies of airborne infections. His information in this connection should be very valuable to us in discussing the various housekeeping techniques, the problems they raise, and the possible recommendations which may emanate from this group.

In discussing housekeeping procedures, perhaps we should first center our thinking around the basic operations of dusting, sweeping, mopping, and waxing. A discussion of these operations will undoubtedly bring into the picture other phases of housekeeping operational techniques, such as use of germicidals and their value, isolation areas and special methods, operating suite cleaning methods, trash removal, machine methods of cleaning, and the handling of linen. We hope there will be sufficient time for a review of each of these subjects, an opportunity to outline the problems of each, and to develop recommendations from the group as to what can be done to solve the problems encountered.

Perhaps we should combine the subjects of dusting and sweeping, since sweeping is only a method of removing floor soil and is closely related to dusting as an operation. We should examine the various methods in use and evaluate these methods, utilizing the knowledge which those here today have of the infection possibilities of each. We still find, in some hospitals, the housekeeping personnel using sweeping compounds and hair brooms - and in some cases using a corn broom. In some areas their use may be justified, but as an over-all operational procedure I am sure that there must be better ways of cleaning floors in hospitals. Damp dusting and sweeping would appear to offer better control of dust to prevent spreading of infection into the air which may contaminate large areas if drawn into the ventilation system. Treated or damp dust mops and dust cloths, as well as disposable treated or damp cloths, offer possibilities for reducing airborne infection. Vacuum methods, either centralized systems or the conventional type, are also in use. Yet there is some question as to whether or not the conventional vacuum through its exhaust system tends to increase the number of airborne infectious bacteria. Water separator type of vacuum cleaners have been used in isolation areas in some hospitals, the theory being that bacteria are trapped in the water solution. Wet pick-up vacuum machines are in wide use today, the thinking being that bacteria are suspended in the scrubbing solution and are removed from the area by the wet pick-up vacuum method. Our discussion today will cover the various methods of dusting and sweeping just mentioned.

Mopping operations in hospitals today are becoming increasingly more important, especially since such wide publicity has been given to hospital infections, and particularly to Staphylococcus aureus. Hand methods, using the familiar cotton string mop and the mop pail, are still prevalent, especially in the congested areas, but increasing emphasis is being given to machine equipment for cleaning of open areas. With the latter method, production has been increased and there is also reason to believe that better sanitation is achieved through the use of combination scrubbing and wet pick-up vacuum equipment currently available. For congested areas, the detergent feed scrubber followed by the wet pick-up vacuum has, in part, taken the place of the mop and mop pail. Machine methods of wet mopping offer good possibilities in control of infectious bacteria, since the principle is that soil and bacteria are removed from the area in the dirty water solution. In hand mopping operations the mop becomes contaminated, and contamination may be spread unless germicidal additives are used in the cleaning solution to kill all bacteria before the rinsing operation is performed. I repeat, that recent developments in machine equipment, particularly the wet pick-up vacuum and the combination scrubbing and vacuum machines, offer improvement in mopping procedures over the hand mopping methods so widely associated with hospital cleaning.

There is also reason to believe that mopping and scrubbing operations will require a greater percentage of the hospital housekeeping department time and will replace, to a great extent, dry maintenance procedures now being used.

A discussion of cleaning methods, particularly those connected with damp dusting and wet mopping, will bring out further discussion of the use of germicides and detergents in hospital housekeeping procedures. Many germicides and germicidal detergents are currently available, with many claims of their ability to kill S. aureus and other pathogenic bacteria. The important question is - will these germicides perform under operating conditions as well as they did in the laboratory? Perhaps this question was the basis for the National Conference including in their recommendations the statement that "bacteriological services of a high caliber are essential to the diagnosis and therapy of staphylococcal disease and to the detection and control of hospital-acquired staphylococcal infections." Can test procedures be established to determine housekeeping department sanitation efficiency and, if so, how should samples for test be determined?

There is much to be done in the area of "How clean is clean?" There are many detergents on the market today, with various claims as to their cleaning ability. What are their advantages, if any, over soaps? And what are the disadvantages? The housekeeper is confronted with a barrage of claims, both for germicides and for detergents. Greater dependence on the laboratory by the housekeeping department will be necessary if the local problem of hospital infection is to be solved. The housekeeper will be an important individual in the study of environmental factors which contribute to the spread of infection in the local situation.

Isolation areas present special problems in connection with housekeeping procedures. This is particularly true when individual patient rooms are designated as isolation areas, since equipment and materials used in sanitizing are potential carriers of infection if taken to non-contaminated areas without first being decontaminated. When wards are designated as isolation wards, the problem is less acute although aseptic techniques for both personnel and equipment should be carefully observed. It is becoming common practice to wash walls, floors, windows, blinds, beds, and all furniture items, clean draperies and completely sanitize such isolation units upon discharge of patients who had infectious diseases. Protective clothing and hand washing facilities are generally provided for personnel leaving such areas. Special items of supply are used and, in some cases, special cleaning teams are trained to perform this phase of housekeeping operations. In any event, personnel working in patient areas should have thorough training in aseptic techniques, for the protection of both patients and themselves. No break in the aseptic technique or in the specific cleaning procedures should be permitted since rigid controls are necessary if cross-infection is to be averted.

What has been said of isolation areas is also true of the operating suite cleaning procedures, except that there is the additional hazard of affecting the electrical conductivity of floors or equipment, with the resulting potential of operating room explosion possibilities. Special cleaning materials and equipment must be provided

for these areas and frequent tests, both as to electrical conductivity and infectious bacteria, must be made to determine the safety and sanitation of this area. Again, rigid control of all procedures, including housekeeping procedures, is essential in this area. A few conductive waxes, approved by Underwriters Laboratories, Inc. are available, but the specific danger lies in the "build-up" of wax, which destroys the conductivity of operating room floors, rather than the wax used. Many hospitals prohibit any wax being used on operating room floors.

Linen handling procedures are a potential source for spread of infections in hospitals. Not infrequently it is found that soiled linen is sorted in areas where clean linen is handled. Linen carts are used for both collection of soiled linen and the distribution of clean linen. Soiled linen is left in open containers in corridors for later pick-up and personnel handling both soiled and clean linen do not observe proper techniques. Where soiled-linen chutes and separate soiled-linen sorting rooms are provided in hospital construction, this problem becomes less acute--if aseptic techniques are observed in the handling of linen. Doctor Carl Walter of Peter Bent Brigham Hospital has made studies of airborne bacteria in patient areas over a 24-hour period, and has found that the bed-making activities and the housekeeping activities cause the highest rise in bacteria count. Contaminated linen should be bagged and handled separately to prevent spread of infectious diseases. Of interest will be the linen hamper liners now available commercially, which are designed to prevent contamination of the hamper when the hamper is used for both the collection of soiled linen and distribution of clean linen. The linen cart system for delivery of clean linen offers good possibility for more efficient linen handling. In any event, the least amount of handling of clean linen from the time it comes from the laundry to the time it is on the beds will reduce the possibility of cross-infection--provided that those who handle the linen observe aseptic techniques. Again, rigid control of linen distribution procedures and of the collection of soiled linen is essential if cross-infection is to be averted.

Every hospital accumulates a large amount of trash daily, and that from patient areas and certain other areas, if improperly handled, offers additional possibilities for spread of hospital infection. Trash from isolation areas particularly must be handled under specific procedures. Sterilization of trash containers presents a problem while attempts are being made to develop liners for trash cans. Also, desirable containers are now on the market. These developments show the need for better trash handling procedures, since recent developments in this field are the result of hospitals having problems which commercial concerns are helping to solve.

This discussion has not been an attempt to delineate specific housekeeping procedures, but only to present general information which may develop further discussion on the subject of the relationship of housekeeping procedures to hospital-acquired staphylococcal diseases. As a result of the discussion from those here in attendance, we plan to determine the problems in connection with housekeeping in a hospital situation and to develop recommendations which will lead to better control of hospital infections, and particularly S. aureus insofar as the housekeeping department may contribute to solving the over-all problem of hospital infections.

## HOSPITAL HOUSEKEEPING PROCEDURES

### Discussion and Comments

Mr. Hall: I want to ask if anyone here has really good information on the vacuum cleaning methods in a hospital. For instance, are the water separation vacuum system and the central vacuum system what they are reputed to be, or are they only setting up secondary aerosols?

Dr. Mudd: I had occasion to referee a paper in which very careful studies were made on various types of vacuum cleaners. One particular brand was found to be efficient. Some of the others were found to be extremely dangerous, particularly the ones that advertise that they walk on their own air. The exhaust air is brought out under the base which makes it easier to carry around - it stands up on its own aerosol.

Dr. Silverman: I could add a little information on the machine Dr. Mudd refers to as efficient. We tested it years ago, and as far as particle size is concerned, it doesn't collect much that's below a micron or really below 3 or 4 microns. Actually tobacco smoke goes through the machine and comes out as if it never even saw a cleaner. I think the size of tobacco smoke is around a half micron. I don't see how any wet vacuum cleaner could ever do very well. It isn't just the design of the chamber - it's a matter of principle. You would have to put such a high pressure in the receiver that the blower couldn't be made large enough and still be portable.

Dr. Hatch: I can add an experience of some years ago. We tested a whole series of various kinds of vacuum cleaners with particular reference to the decontamination of air in the space being cleaned. I put rugs in the corridors in a medical school according to a very carefully designed procedure. The medical students dutifully dirtied the rugs for me, and at regular intervals I moved the rugs into a dust-tight room to be cleaned with a fixed schedule of so many scrubs per minute. Included in the study were various types of dry and wet vacuum cleaners. I found that they all would let fine particles through. None of the filter types were unusually good filters. The wet type certainly let fine particles through also. I did find that the exposed bag type of vacuum cleaner, which was still popular in those days, was the worst contaminator of the air. This was not because it had a poorer filter. On the contrary, if anything, it was better because it was bigger - but it was the worst contaminator because it was exposed. Every time you hit your knee against it or banged it in any way, a cloud of dust came out. For this reason, vacuum cleaners with enclosed cleaning elements, whether they be water or filter, are superior. I would say that any type of portable vacuum cleaner that you would anticipate using would, of necessity, have to operate at such a low pressure drop, at the same time providing adequate storage capacity for the dust, that you never could expect to have filters of superior quality on such instruments.

I doubt very much that we could ever hope to have a portable vacuum cleaner that would deliver air that was remarkably superior to the air that was normally present in the room. I have in mind some of the claims that were made at the time, that using a particular vacuum cleaner would actually clean the air of the room. Even at 100 percent efficiency and 50 cu. ft. a minute in a 10,000 cu. ft. room, it would take a while to clean it.

Mr. Kilpatrick: I think the important point here is that vacuum cleaning removes the dust particles from the floor and deposits them in the bag. How much goes on through is the important point. Does it create an additional hazard by stirring up the dust in the room which is over and above what you would have if you didn't clean the floor by this method?

Dr. Silverman: There are some new ones called commercial-type industrial vacuum cleaners which are mounted on casters, have a good sized bag house and a 1-1/2 to 3-hp. blower which should do a pretty good job.

Mr. Kilpatrick: The Veterans Administration has standardized on a particular kind which has a 1-hp. motor that is very quiet. It can be used in the ward areas. It's the wet pick-up type in which the soil on the floor is mixed with a detergent solution and is carried away from the area. We hope that it is more advantageous than dry cleaning methods.

That brings this point for discussion - the centralized vacuum system which is more or less becoming common today where you have a large vacuum machine in a remote area of a building. Outlets on the wards and in various other parts of the hospital use a 35-foot hose connection. The dirt is pulled from the floor and deposited outside the building. The central vacuum system can be converted to a wet pick-up type so that in mopping operations the bacteria, being in the scrubbing solution, can be removed with it. In the use of either the wet pick-up type or the central vacuum system with the wet pick-up attachments, there is the additional advantage that, if the floor is scrubbed with a neutral solution, the floor is immediately dry and you don't have to go back and rinse it. This is an important labor-saving device.

Mr. Snow: I might offer an aside on the fixed-in-place or central vacuum cleaning systems. A good deal of imagination has to be used in the design of such systems. To witness a case in point, vacuum cleaning outlets were on the opposite side of the hall from the bedrooms to be cleaned. Obviously, there was a hose running across the corridor and this presented interference to cart traffic going up and down. The system fell into gradual disfavor and was abandoned for a period of time in favor of the tank cleaners. Even though one does have a central cleaning system, some of these problems have to be faced in its design.

Dr. Anderson: Why do you want to use a vacuum cleaner in a hospital - is this for the draperies, floors, rugs? Why don't they use wet mops?

Mr. Kilpatrick: Some of the offices have draperies, some of them have rugs. The vacuum systems are used to clean radiators, ducts, high areas, and in some cases, even to vacuum walls.

Dr. McKee: Do you find that staphylococci are particularly resistant to the various germicides or disinfecting agents that are used? Are they more resistant than other organisms that we work with in this respect? We've heard already that they are more resistant in connection with certain airborne operations. How are they in relation to germicides?

Dr. Phillips: I think it could be said that S. aureus is relatively resistant as far as the general run of vegetative organisms go. It is a little more difficult to kill than Escherichia coli or Serratia marsecens, to quote some of the common ones. It of course does not approach the quite resistant organisms such as the spore formers or the tubercle bacillus. It's sort of in mid-range in its resistance to chemical disinfectants.

Dr. Silverman: Dr. Walter has shown that the sweepers, with mops and the pails, are pretty potent sources of contamination. This leaves the question of whether these people aren't temporary carriers. Such carriers having frequent access to isolation areas are different from visitors who are permanent or semi-permanent carriers.

Mr. Kilpatrick: I lean toward the wet pick-up type of cleaning procedure rather than the mopping procedure because, if you have a mop with a double mop unit, one side of it is the detergent solution and the other is the rinse water. The dirty mop is placed in the detergent solution to scrub the floor, is then rung out, is dipped in the clean water solution, and placed back on the floor. I'm not sure that we have achieved sanitation, because the mop itself may be contaminated and the process is only contaminating the area again. With the wet pick-up method this is not true, because the tool picks up the water and the dirty solution. Also, the porous floors under a mop retain some of the moisture which evaporates sooner or later. The wet pick-up vacuum pulls this off the floor - it's dry and can be waxed in 10 or 20 minutes. So it's a labor-saving operation and perhaps a better sanitizing operation.

On the market today are what are called combination machines. They take a 20- to 26-inch cut. They are very valuable in corridor cleaning. An 8-foot corridor, for example, can be cleaned in two round trips with a 26-inch machine. This machine has a scrubber brush on it through which is fed a solution from a tank. The liquid and dirt are picked up immediately with a "squeegee" vacuum operation, are deposited in a separate tank, and the floor is dry. Currently, we are investigating the battery-operated type so that we won't waste time in plugging in and moving our equipment. We have one hospital alone that has

over 2 miles of straight corridor. So, with a battery-operated machine, which will run 6 to 7 hours, we hope to cut the machines loose from the cord. It's a matter of economics, as far as we're concerned, for the machine can do work equal to six men.

Mr. Hall: Do you have evidence with regard to whether an aerosol might be set up by the brushes of these machines?

Mr. Kilpatrick: We do not. This is a production method which has the advantage of lifting the liquid and dirt from the floor and afterwards it is dumped down the drain. We are not sure that all of these things are good from the standpoint of sanitation. We know that they are good from the standpoint of production, and we think they are better from the standpoint of sanitation.

Mr. Hall: There seems to be a gap in the actual testing of these devices for their lack of aerosol generation and for their actual biological efficiency. However, it would seem to be a fairly straightforward engineering process to correct any deficiencies which may exist. This would appear to be a rather fertile field for the improvement of the hospital environment.

Mr. Snow: The criterion for what constitutes a successful housekeeping program in the hospital is perhaps judged as much by the reflection on the floor as it is on any other single factor. What do we here as sanitarians propose to take the place of that glossy floor? Can we sell this to the public, which has been used to having a highly polished soft floor?

Dr. Simmons: Isn't there a great lack of any criteria for evaluating the effectiveness of present housekeeping procedures - haven't they just grown without evaluation, and what looks the best, may or may not be the best?

Dr. Wolman: May I ask a question which may seem a little aside but I hope it isn't? In our largest hospitals, do we have anything like a skeleton health department?

Almost everything we have talked about normally comes, to my mind, under the province of an individual who is concerned primarily with all these matters of epidemiology, of contact, environment, and the like, and I'm curious to know, is there anybody in any of our hospitals who makes that his primary job rather than the secondary one of some very busy other person?

Mr. Kilpatrick: I'm afraid not, but I think this is a problem with which everybody in that hospital needs to be concerned.

Dr. Wolman: Of course - but I look at it as a universe that is lacking in one kind of supervision.

Dr. Simmons: I believe you could definitely say, that from a bacteriological point of view, essentially none of the housekeeping operations have been evaluated. I do not know of a single one that has been evaluated to the extent that one could put a stamp of approval on it and say this is the best. I believe there is one striking conclusion here, and it is that there needs to be some sort of evaluation program for housekeeping procedures.

Mr. Kilpatrick: Is there any unanimity of thinking on dry maintenance versus the wet maintenance type of operation?

Mr. Hall: Isn't it pretty well agreed that dry maintenance is definitely taboo in most instances, but wet maintenance is still in question?

Dr. Phillips: I think one thing could be said from a bacteriological point of view. It is very difficult to kill dry microorganisms without getting them wet somewhere in the process. You not only need a liquid disinfectant, but we have found that just applying a liquid disinfectant, without a certain amount of mechanical agitation, is not always effective either. It is almost like trying to wash your automobile by just getting it wet with a hose. As soon as the sun comes out and dries it, you see that nice film of dust still there. Apparently it's the same thing with taking microorganisms mechanically off surfaces. They not only have to be wet but there has to be a certain amount of agitation or scrubbing.

We actually put hypochlorite with a detergent on a floor, which we had previously contaminated with spores, and let it sit for a half hour. Calcium hypochlorite kills spores in less than a minute at the concentrations we were using. We then used a swab, taking the precaution of having it wet with thiosulphate so it wouldn't be sterilized on the swab, and went through the hypochlorite to swab the floor surface. We then put the swab in another bottle of neutralizing thiosulphate and recovered spores by the dozens which had been sitting on the floor for a half hour under a film of calcium hypochlorite and a detergent. On the other hand, if you scrubbed that floor, they were gone. You just don't get the contact with liquid detergent sprayed or splattered onto dry surfaces if no mechanical action is present.

Dr. Mudd: I think everyone who goes to these different conferences and reads the literature must realize that routine housekeeping procedures are very, very uneven - that the ones used in some places are the result of studies by the staffs within those institutions, and in some cases have been published and are available in the literature. There are other cases in which housekeeping procedures are a matter of hunch and intuition.

It is clear that this problem is to be found in every medically advanced part of the world. It is desirable that anybody who can and is willing to evaluate it do so in a systematic manner.

Dr. Silverman: This raises a question which I ask knowing full well that you probably won't have an answer. When you make a change in technique, why do you make it? Is this on the basis of intuition that we heard about or on basis of previous experience or on the supposition that you think it is better?

Mr. Kilpatrick: We are confronted with the matter of man-hours available and production. I would have to answer you that probably the prime consideration is that we produce more.

Dr. Wolman: It is a fact that a hospital administrator has to make a great variety of decisions. One of them, the very one that you mentioned sometimes it's a dominant one - is the question of saving in labor and saving of equipment. I think the kind of answer you give is the kind that the hospital administrator gives almost every day. Your hope is that with that kind of equipment you get an additional value which may have pertinence to our particular problem. I don't think you need to be apologetic as to why you use labor-saving devices and at the same time have an intuition that they may have certain sanitary advantages.

Mr. Kilpatrick: I think we should go on to linen since this linen business is one that is of considerable concern to all of us. First of all, in any hospital operation, the linen is a costly item. Secondly, in the handling of the linen, we should avoid to every extent possible, any possibility of cross-contamination. I'm sure that all of us recognize that there is transportation of clean linen in the same carts in which soiled linens are carried. Handling soiled and clean linens in separate areas is a good step toward the prevention of cross-infection.

Dr. Phillips: I am aware of some of the work that is being done - it isn't just in the corridors where the clean and dirty linens cross. One of the main sources of crossing is in the laundries themselves. On one table there is sorting, shaking out, and separating of the linen and right beside it is the folding of the clean linen. There have been quite a few studies, in some of which we participated, on the effect of doing relatively simple things in the laundry such as adding a little higher concentration of chlorine to the rinse water. As the linens come out of the final rinse, the material is almost as sterile as the rinse water, that is, it is almost sterile. The laundry next goes into a hydroextractor in which it is centrifuged to throw out excess water. This is a beautiful device for sucking air into the laundry and the material is a nice filter, so as it comes out it is to a certain extent recontaminated. Then many of these organisms are lost as they are ironed. The total laundry procedure is quite effective as a disinfecting procedure, but organisms can get back on the linens from the time they leave the last laundering bath.

Mr. Gaulin: I have some of the figures that Dr. Phillips was talking about. Church and Loosli (13) at the University of Chicago found that before washing, the linen, as it came to the laundry, contained 38,000 organisms per sq. ft. After washing the linens, they found 350 organisms per sq. ft. After putting it through the extractor, the linens came out with 165,000 organisms per sq. ft. After ironing, the materials had 250 organisms per sq. ft. After the ironing process, the sheets and linens were folded in this contaminated atmosphere and ended up with 1140 organisms per sq. ft. as they were ready to go back to the floor.

Dr. Phillips: It's expensive to remodel laundries. I think it is one of the things that should be kept in mind in new hospital construction. The different sections in the laundry should be separated and they should be in as much of a line as possible, so that the dirty clothes, and the clean clothes won't cross. Quite a bit could be done on this problem in hospital design.

Mr. Kilpatrick: Many hospitals have set up a separate soiled linen sorting room and are utilizing laundry chutes which go to that central area. In the laundry planning, they are setting aside in the laundry a separate area to sort this soiled linen. The central service linen room for handling clean linen is in an entirely separate area. It goes through the laundry process and comes out at another point where the danger of cross-contamination is lessened.

Dr. Mudd: Is infected linen enclosed in an essentially airtight container before it goes in the chute? There have been studies published in which in these chutes, the laundry acts as a piston and forces contaminated dust out at each floor. To relieve this situation the laundry should be in essentially airtight containers.

Mr. Kilpatrick: Wet linen put in cart containers and soaked through can carry bacteria back to a cart, so there would be less danger of cross-contamination from the dry linen in the transportation process than there would be from the wet.

In our system, we have been using plastic mattress covers. We wash these covers. So far as blankets are concerned, we are presently discussing the possibility of providing blankets which can be washed without shrinkage and the possibility even of the disposable blanket for isolation areas as well as a disposable pillow. There are some very promising materials. Woolen blankets so frequently mat up in the washing process, the shrinkage is quite great, and they are expensive to start with. There are fabrics which will give warmth that are not wool. They are very lightweight, and are used in Arctic clothing to a great extent.

Mr. Hall: How much laundering of blankets is necessitated by pure removal of physical dirt and how much is a matter of sanitation? Is

some method of sterilizing available other than washing, which would serve in most instances, or does the blanket have to be washed after each patient to remove filth?

Mr. Kilpatrick: I doubt very much that in most hospitals the blanket is washed after each patient uses it.

Dr. Phillips: Dry cleaning can be used which is quite effective for vegetative organisms. It will not necessarily kill all spores, but this isn't what we are concerned with. One blanket and mattress sterilizer adapted to ethylene oxide treatment is now on the commercial market. It's relatively expensive, but perfectly satisfactory, and could be put into routine use on fomites from patients with certain diseases.

Mr. Kilpatrick: Trash is a problem in any hospital, particularly as TB patients are concerned. They have bags for sputum which are handled separately. In our hospitals the trash cans have been routinely sterilized in live steam. Recently we attempted to find a disposal type container, but the problem there was, in putting in broken bottles, etc., these containers would soak through. Another problem has been in getting one that would stand, could be closed up and efficiently carried out of the area. Another thing we attempted to work on was to find a suitable plastic liner for trash cans, but the broken bottle would cut through the liners, and the can was contaminated. We are still using the GI type of can and sterilizing it. We haven't arrived at any final solution. In some cases, the polyethylene bag type of liner is used. Again, in transporting trash, we have been confronted with a problem of air contamination in carrying it through the ward area. It would seem to me that it would be essential to have a closed container, whether it be a GI can or any other substitute for the GI can. This trash goes to a central location, and is put in the incinerator.

Mr. Snow: I could simply recite what we are doing at the clinical center. Hospital bedrooms are equipped with waste paper baskets which are daily provided with paper liners. These then in turn are placed in GI cans and the cans with the tops on are removed to the incinerator building following which they are washed the same as a dish. In certain areas, especially our infectious diseases floor, we take the additional precaution of using a polyethylene liner in the GI can itself. This liner is gathered, there being sufficient top material, and the can is then covered and transported to the main incinerator, so that there are combinations of cans, liners, and bags which give us, I presume, some additional measures of protection, if their use is religiously followed.

Dr. Simmons: Mr. Snow, has there been any evaluation of the house-keeping procedures at the Clinical Center?

Mr. Snow: No evaluation has been made bacteriologically.

Dr. Phillips: We have done some work on secondary aerosols which may be of interest. We first sprayed grass with a hardy spore, then we had a person walk across this. We had an aerosol sampler on a cart which followed him so that we could see how much of an aerosol he would kick up. Once sprayed and dried, clouds of spores were kicked up from the grass as someone walked across it. We wet the grass, and while it was wet, had someone walk across it again, and we got no measurable aerosol. When the grass dried again, the aerosol concentration was back to the same high concentration. We have done this on grass, on cement floors, and on a dirt road. Now, I think the same principle would apply that, while wet, it is very difficult to raise a secondary aerosol unless you happen to be splattering the liquid, which would of course raise fine droplets, and, if there were organisms in the liquid, we would raise an aerosol. But to disturb a wet surface makes very little measurable secondary aerosol.

Dr. Simmons: If you wet the surface with a mop and particularly if you put it back in the water and use it again, what you are doing is simply wetting the organisms that are there and painting them back on. It is true they are not going to be stirred up while it is wet, but all you are doing is delaying the inevitable. Aren't they going to dry again and come right back up? Are you destroying anything? Actually, of course, there are some times when wetting enhances the viability of an organism, in opposition to desiccation, so I don't think we know whether it is any better or not.

Dr. Phillips: I have gotten the impression from the discussion, and certainly from our own experience, that one of the activities which does most to raise aerosols is this cleaning activity. If it's wet while you are doing these things, you are safe during the procedure. In other words, if you are putting a broom over something and it's dry, you are going to raise an aerosol. If you put a wet mop over it, you will not raise an aerosol, but it would not mean that an aerosol can't be raised when it dries again.

Mr. Porter: Your mechanical device which wet scrubs and then removes the liquid suspension, theoretically, ought to be the best technique. We've already said that these things ought to be tested but, until they are tested, from what we know and from what Dr. Phillips has said, this would seem to be the method of choice if it satisfied your requirements for eliminating manpower.

Mr. Snow: Just to compound the confusion, however, how do we classify a central vacuum system which does not use a wet method? Are we in any sense condemning the central vacuum system using a dry pickup?

Dr. Silverman: As long as it doesn't discharge back into occupied spaces, there is no hazard.

Mr. Porter: On the other hand, from what Dr. Phillips said, the chances of getting a clean floor by dry methods is not very good.

Dr. Silverman: Certainly, central vacuum cleaning has much that could be recommended over dry sweeping and something has to be used to pick up the little pieces of paper and other litter on the floor.

Dr. Silverman: Loosli's studies during and after the war were dramatic on the effects of oiling in suppression of bacteria.

Dr. Phillips: I have the impression that oils only collect more microorganisms and hold them better. One of the best ways of preserving microorganisms is to put them in oil to keep them for long times. While you may not get as much of a secondary aerosol, I have always had the sneaking suspicion that the oiled blankets are much more heavily contaminated and pick up contamination more readily and hold it. This is just an impression. It has never been tested that I know of.

Dr. Simmons: I would like to know what has been done and what the potential is of utilizing a residual in the blankets you're talking about.

Dr. Phillips: Our group has been very interested in all these claims which come up. I recently heard another paper in New York on some kind of a marvelous chemical treatment that you put either on textiles or on surfaces and every microorganism which then rests on that surface immediately dies. The claims are fantastic and we have never been able to support one yet. We have found certain of these things do work if kept in relative humidities of around 85 percent or higher, which very seldom happens. As a matter of fact, you fight to get away from such relative humidities, but the test procedures by which the manufacturers make such fantastic claims are almost invariably done wet. You have a dry disinfectant on a dry surface - it isn't doing a thing until they start testing. Then they immediately put it in a solution or put it on moist agar and say, "See how it works." Well, the only time it works, as far as we've been able to find, is when it's being tested.

## STERILIZATION AND DECONTAMINATION

### Introduction

Charles Phillips, Ph. D.\*

Before we start the discussion on sterilization and decontamination, I would like to assume the Chairman's prerogative of going over briefly the material that I think we should consider, perhaps dropping in a few of my own prejudices on certain of the subjects.

It seemed to me that we might have our discussion centered around four major topics, the first perhaps being the methods we have at hand for measuring the amount of contamination in various areas within our hospitals, sampling techniques in other words. The second point of discussion I thought might center around the techniques which are available for sterilization and decontamination, and in this section I want to present first some newer procedures which our group has developed at Fort Detrick. Since they are only just now appearing in literature, many of you may be unfamiliar with these. The third topic for discussion could well be the subject of the advisability of extending our sterilization procedures to other areas and items of equipment not now routinely being sterilized. Last, but not least, I understand that our hosts today would like to have us consider areas in which our knowledge is incomplete and where we could profitably do more research.

The first of these topics, that of sampling, really does not logically fit in with the topic of Sterilization and Decontamination. When I discussed this earlier with Mr. Hall when he was arranging this program, I suggested that sampling should be a topic of some section of this conference, and since it did not seem to fit too well in any of the other major sessions, I thought it might as well be considered here. There have been many sampling studies in the literature in recent years, particularly sampling studies to determine where staphylococci occur in the hospital environment. These sampling studies fall into two general categories - those concerned with the prevalence of the organisms in the physical environment, and those concerned with the prevalence of the organisms in the bodies and on the persons of hospital staff. Many of these studies have been quite elaborate, differentiating between the various types of staphylococci found, carefully identifying the strains through phage typing and other techniques, and determining antibiotic resistance spectrum of the types isolated. I think the best general summary that could be made of these studies is that they have clearly brought out how ubiquitous this organism is. They have clearly demonstrated

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that it can be found in the most obnoxious forms practically everywhere where one has searched for it in hospital environments about the world.

One main personal objection which I have to many of these studies is that so many of them have been qualitative rather than quantitative. We have far more information on how often one finds this organism when one goes about looking for it than we have on how high its concentration is when found. We also have far more information on surface sampling or swab sampling than we do on air sampling. We need information which we get from swabbing various surfaces as to where this organism occurs whether these be human surfaces such as the mucous membrane of the nose, or inanimate surfaces such as on the floor in an operating room. However, we do not have enough information on how it leaves these surfaces and as to the route by which it is transferred to patients in the hospital who acquire the disease. Obviously, an organism in the throat of a nurse or the floor of a room can cause an infection in a surgical patient only when it is transferred from that area to the patient himself. This transfer mechanism cannot be thoroughly evaluated by swabs alone. We take extreme care to try and see that this is not done by direct contact. The air is another possible transfer route which has been all too poorly studied.

Perhaps there are good reasons for this. Aerobiology is a relatively new science. The groups working in this field have usually had to devise their own sampling equipment and today it is still almost impossible to pick up a laboratory supply catalog and order from it the quantitative air bacterial samplers. This is a situation we hope will be remedied soon. The swab on the other hand is ever present and so easy to use. Perhaps it is because almost all studies have centered about the swab as a sampling device that they have been largely confined to surface sampling and have been so largely qualitative only. I should like to stick one personal prejudice in here. It is quite simple to make the swab at least semi-quantitative. This is as simple as swabbing in a standard manner, using always the same number of strokes over the same area, and then breaking off the tip of the swab into a sterile water or saline blank. The blank is then shaken until it disintegrates and all the organisms are dislodged so that one can plate out aliquots or dilutions and counts made of the total organisms recovered. While this technique does not tell one exactly how many organisms are resting on a given surface area, it can, if carefully followed, tell whether one surface is 10 or 100 times as contaminated as another.

On the matter of quantitative air sampling our group at Fort Detrick, together with Mr. Hall's group with the Public Health

Service at Savannah, are preparing a monograph on the types of samplers which have been used in various research studies. We hope to get this published this spring. Meanwhile Mr. Hall's group has agreed to serve as a reference point to give out specific advice to anyone wanting samplers for a particular study. While there is still difficulty in purchasing samplers on the open market, there are at least three research groups currently conducting air studies in hospitals utilizing samplers which they have borrowed from us and there are other studies, I know, going on using Public Health Service equipment. To the extent to which our committee wishes to go into this, we can discuss the various types of samplers which have been developed and their advantages and disadvantages.

As mentioned earlier, I thought our second area of discussion should center about sterilization techniques. We should talk a little bit about what materials and equipment we have available and what kind of material and objects we can and cannot satisfactorily sterilize or decontaminate. Much of this was covered in Mr. Kilpatrick's session on Hospital Housekeeping. The question of air sterilization and purification was discussed in Dr. Silverman's session earlier. I would like, when we get into this area, to outline some of the newer techniques with which our group has worked, mainly gaseous techniques. Our work with ethylene oxide was first published over 10 years ago. Many other investigators have also reported on applications of this compound, and on the fact that it can be used to sterilize many objects which by nature of their heat or moisture sensitivity, could not previously be sterilized by more conventional means, such as autoclaving. Only recently, however, has the technique begun to have routine application in many hospitals, the reason for this probably being that only recently have the hospitals been able to procure on the open market commercial cabinets and chambers in which ethylene oxide could be used instead of having to improvise and make their own equipment.

The beta-propiolactone investigations on the other hand are quite recent, and it was only a little over a month ago that the first paper on the use of this compound as a vapor-size disinfectant appeared. So far we have done studies with this compound sterilizing both individual rooms and wards at Walter Reed Hospital and, in one case, the entire hospital facility at Fort Detrick. Reports of these practical applications are yet to be published, and any recommendations as to the advisability of utilizing such procedures routinely can be only extremely tentative until more work is done. We can discuss the matter in more detail if the participants of this conference so desire.

This leads us to the third general section I had on our agenda, that of the advisability of extending sterilization or disinfection procedures. It is technically possible now to have

a sterile air supply brought into certain rooms, to close off rooms or groups of rooms and sterilize chemically all the surfaces therein, to revise the practice of terminal disinfection, and to use simpler and less time-consuming techniques to sterilize such materials as bedding, mattresses and the like, if we think all this is worth doing. The question of "how to" is sometimes considerably more simple to answer than the question "should we". It is around the latter point that I hope we can raise considerable discussion.

Last but not least, before we finish this morning we would like to see if we can arrive at some conclusions as to where we stand on this matter of sterilization and disinfection, and have some agreement not only on what we know, but on what we do not know, so that we can make specific recommendations to the sponsors of this meeting for research projects to obtain needed information. In this connection I was particularly impressed with the statements made by Dr. Dowling in his summary of the Proceedings of the Conference on Staphylococcal Disease held here in Atlanta last September in which he said "we don't know the most frequent pathways of spread, whether carriers or environmental sources are the most important, nor what makes the epidemics start." I am wondering if we at this meeting who are most concerned with the environment cannot recommend some studies which might help us determine whether the environment or the carriers are the major culprits in our epidemics, or whether it is a complicated mixture of both.

Along these lines I think also that we should at the end of our discussions be willing to make specific recommendations as to whether we should proceed with work and studies to eliminate the environment as much as possible as a reservoir for infection, or whether we should continue to place reliance on newer and still more antibiotics, hoping thus to eliminate the carriers and to treat patients as infections occur.

## STERILIZATION AND DECONTAMINATION

### Discussion and Comments

Dr. Phillips: The first item I would like to discuss is not on the agenda. It is the question of surgical masks. Here is an oronasal mask (Appendix B) developed by the Chemical Corps. It was originally developed as an accessory for leakage testing of gas masks. Its nature, however, suggests its use as a very efficient surgical mask. It consists of an efficient filter paper reinforced by vertical cloth strips. An adhesive strip around the edge clings tightly to the skin. The mask glues down tightly over the entire nose and mouth. It is quite simple and disposable - use it once and throw it away. It has about 97-percent efficiency as tested with clean, washed spores of about 0.9 by 1.1 micron dimensions. We have similarly tested a lot of hospital masks and found them to be in the 30-to 40-percent efficiency range.

We have always tested masks with the purpose of seeing what the wearer would inhale. I frankly don't know of a good technique of testing to see what protection the mask affords with regard to exhaled air. In most surgical masks, exhaled air goes out around the edges. However, since this Chemical Corps mask has a tight fit around the edges, the same percentage should apply both ways because all air, whether inhaled or exhaled, must go through the filter, and this filter is 97 percent efficient. It is not particularly difficult to breathe through. It interferes a little with speech, but not too badly. The pleating is to give more area and cut down on the resistance. We have been making them by hand, but I think it is the type of thing that could be machine made rather simply. They shouldn't cost much more than 10 or 15 cents and you could use them once and throw them away.

Dr. Mudd: If this were used by a surgeon, would you feel he ought to wear an ordinary hospital mask outside of it, or is this sufficient?

Dr. Phillips: This is far more efficient than the ordinary hospital mask. It will give a completely airtight seal all the way around.

Dr. Silverman: The only concern I would have with that would be the standard problem with breathing through any mask, and that is that moisture condensation builds up and pretty soon it would break the seal.

Dr. Phillips: We wore this quite a bit in testing it. Before we could use it, we had to determine its efficiency, and it worked. The boys didn't complain - that's about all I can say. It's been used in our test trials where it's not kept on more than a half hour, and then they take it off and put on another one and repeat the test.

Dr. Silverman: Some surgeons keep them on 4 to 8 hours, and that 15 cents that you talked about, if you talk to hospital people about these disposable masks, they say the present gauze masks just go back to the laundry, where it costs about 1/4 cent every time they are laundered.

Dr. Anderson: If these things build up moisture, do they become aerosol producers?

Dr. Phillips: We have not so found. Of course, it would be a very simple thing to change if the operation were a long one - someone could put it on for the surgeon.

Dr. Anderson: This gets away from one disadvantage of the present surgical mask, that is the leakage. It doesn't get away from the standpoint that most masks are worn beyond the point of usefulness. They get condensation - moisture. I imagine organisms get trapped both going in and coming out and then are released as sprays. I think the present masks do it and I'm not sure but that this one would.

Dr. Phillips: It's rather simple to expose a person to an aerosol of known concentration and measure how much of the aerosol gets through the mask. Man is such an uncertain aerosol producer, as he's talking, that putting a sampler out in front of him and seeing how many organisms penetrate a mask is not a quantitative procedure. You don't know how many organisms he would put out if he didn't have the mask. Also, he produces so irregularly that we've never been able to devise a way to give a good figure on how effective a mask is in stopping the production of aerosols. All we do know is how much it stops the inhalation of aerosols, and this figure shows it is about 95 - 97 percent effective.

Dr. Silverman: Actually, as long ago as 20 years, we did some testing in our lab on the surgical mask, and could easily show the surgeons then that their mask was of the order of efficiency which you indicated - perhaps even worse when it gets wet. They could wear an ordinary dust respirator which includes a greater than 1-micron aerosol filter and get 99 percent efficiency, but they just wouldn't want to wear a mask that looked like that.

Dr. Phillips: Along this line, much to our amazement, we found that just holding a folded handkerchief closely over the nose, gave about 90 percent inhalation protection, and the next best thing is soft toilet tissue. Turkish towels came next, and petticoat fabrics were way down at the bottom of the list. The one really outstanding scientific discovery was that it does not help at all to wet an object. It increases the resistance so it makes breathing very difficult, and it does not increase the protection. The thing should be used dry, holding several layers of fabric over the nose rather tightly to obtain a good amount of protection.

I have another subject which also isn't on the agenda. This is sampling. Without making any comments on the first group which met here, I would like to see if a few people at this meeting don't think there is some method of sampling besides opening a petri dish or picking up a swab. I would like to make a plea for quantitative sampling, rather than the qualitative type recommended in the appendix of the Proceedings of the National Conference. I make no pretense of reading carefully all the literature on the Staphylococcus problem, but when I come across an article, I read it; so I can say I have read haphazardly quite a few of the articles. But, almost invariably, the authors say something like, "We took 20 swab samples and 10 out of the 20 were positive." There is no statement on how positive they were or whether they found 1 or whether they found 1,000 organisms on the swab. Aside from the work of Larry Hall's group which Dr. Anderson described yesterday, there is little quantitative information given on the amount of contamination in the air. I think there are some very good reasons for this. Dr. Silverman said yesterday that there are as many samplers as there are people who have done sampling studies. This is actually by necessity and shows how little we know about sampling. It is almost impossible to get a scientific catalog, open it and pick out the sampler you will use. Most people have had to make their own. We're trying to get more types of samplers - this is one of the things we have been interested in. As a matter of fact after the last meeting, Dr. Wedum, who was the Detrick representative, and your Savannah Technical Development Laboratories got together to see if they could not set up an information service for interested investigators in this field. I think Dr. Wedum plans to drop a note to the editor of the JAMA to say that, very generously, the Public Health Service will serve as a referee or give advice to any competent investigator, who has trouble getting the proper samplers and finding instructions on operating them.

'Also, our two groups found out, quite by accident, that we were both writing a monograph on air sampling so we joined

forces, and the joint monograph on this subject now is in the final typing stage.

There has been great difficulty in getting concise information on quantitative sampling. It's not entirely the lack of samplers, but there is lack of ready information and ready availability of the instruments themselves. A petri dish is so simple. Everybody has a petri dish and everybody has a swab, but I do think, that until we get a little more quantitative information, we are in a bad way. We need to know more than that Staph. is there or it isn't and that it is strain 80/81 or VA4. But then, Prof. Hatch, I heard you say some good things for the open petri dish which I am condemning in these statements.

Dr. Hatch: What I said was that the open petri dish, together with quantitative sampling of the suspended materials, will give in itself a useful piece of information. The ratio between the two is the measure of the settling rate of the particles. This is an important characteristic of airborne material, and a relatively simple one.

Dr. Phillips: Our main objection to the open petri dish is that you take the top off, you get some organisms there, you count them, but then you can't figure out exactly what the counts mean in terms of aerosol concentration.

Dr. Hatch: The count indicates organisms per unit of area, per unit of time. If it were done by count per volume of air, taken from the same group, it would give a measure of the settling loss of the particles.

Dr. Phillips: Of course, your main interest is then for the larger particles which do rapidly settle out.

Dr. Silverman: I would like to put in a plea here for getting time sequence, because in any of these operations there are periods when you get variations in magnitude of an order of 10.

Dr. Phillips: We have been trying to develop continuous slit samplers. There was one that came out about 3 years ago which runs either 1 or 2 hours with a clock mechanism in which the slit was like the hand of a clock, so that it gives the sequence for a short period of time. I understand that a commercial firm is thinking of manufacturing this. We also have one that runs for 8 hours on a long tray, which can be read both for total colonies and for the time of day when they were collected. It has the advantage that you only have to attend it about once a day. We had it arranged to run under a slit for 8 hours and

then go into another chamber for incubation, so you come in once a day and pull out your incubated plates, put in a new plate, and set it again. We've had a little trouble with the incubator of this sampler, but the slit works well.

Mr. Hall: There is one important disadvantage about this type of sampler. None of them that I know of are explosion-proof. This presents a problem when they're being used in surgeries. The hospitals are rightly very touchy about this point. The samplers have only an electric clock mechanism which is presumably safe, but the connections to it could conceivably produce a spark. However, they can be operated at and above the five-foot level with complete safety. If necessary most can be equipped with a spring driven motor.

Mr. Kethley: What about the Andersen sampler? It's a decked affair, having six plates, each similar to the sieve sampler which is nothing but a plate punched with holes with a petri dish underneath. In the Andersen sampler, you start out with relatively big holes and as you go down they get smaller. Roughly speaking, you get rocks at the top and come on down to your smaller stuff.

Dr. Phillips: We have found the Andersen sampler quite a useful device, and one giving particle-size information as well as total count. It gives total counts, however, and gives no indication as to variation of aerosol concentration with time. It is another type of quantitative sampler. My earlier point was that we've run petri dishes side by side a lot of times with quantitative samplers, and sometimes we collect far less, sometimes far more with them than on the open petri dish. We have never been able to get a correlation between the exposed petri dish and the quantitative samplers.

Dr. Silverman: Well, there are a lot of phenomena such as charges, diffusion and convection currents that you can't eliminate. I would like to put in one point here and that is the population density of the Staph. in all these cases is so low that the sample must be large in volume in order to get a significant measure.

Mr. Hall: Even then, we are very unlikely to get enough Staph. to permit an attempt to size the particles. Sizing with any accuracy requires quite large numbers.

Dr. Silverman: One thing I would like to get some information on - how many Staph. are viable and how many are not? This business of trying to measure the dead ones would have some bearing if you could be sure they are Staph. because it would

give you some idea of what the decay situation is.

Dr. Phillips: As far as I know, there is only one technique for identifying a dead microorganism. Has anyone developed a fluorescent antibody for Staph.?

Dr. Kokko: Yes.

Mr. Hall: Is this well worked out as a feasible practical technique?

Dr. Kokko: It depends on the semantics - it works quite well for staining purposes, but it is not specific to any particular strain - it stains all Staph. aureus.

Dr. Phillips: To leave the exposed petri dish and return to the other techniques so often used, we have found that the swab can be a semi-quantitative instrument if you are interested in, say, this table top. It is probably the only available semi-quantitative method unless you are willing to cut a square centimeter out of the table top and transfer this to a water blank and really wash everything off. You don't have too good a method which preserves the table and gets bacteria off, except with the swab. What we do is carefully hold the swab and do a designated number of strokes. People can stroke about the same way each time, take the swab and break the tip into the water blank, shake it very well, wash off everything and then plate out either aliquots or dilutions. You can actually do a semi-quantitative count of the total number of organisms picked up by the swab. This does not tell you how many per unit area you have on the surface, but it tells you how many you washed off, and the relative values are pretty effective. If you have twice as many on the surface you get about twice as many per swab.

Dr. Kokko: I feel that I have to say a word. This Committee was fully aware of the sampler that was used and some of them have been using the samplers themselves. I think the recommendations in the Proceedings were written specifically for an average hospital and not for the university hospital or for the CDC.

Mr. Snow: Angelotti and Porter (13a) have published on the surface sampling techniques. Their interest centered on stainless steel and chinaware surfaces. It would seem to me that, if there is not already, there should be an extension of their work to surfaces commonly found in hospitals. By this, I am referring to textured or semi-porous surfaces to ascertain whether some of their observations on the relatively smooth surface would apply to some degree there. They found, as I recall, that the APHA cotton swab method, which is a variation of the single swab test and the agar syringe, was an extremely

worthwhile test. You imprint on an exposed plug of fresh agar whatever is on the surface that you are interested in. This method, while not gaining relatively high total counts, was remarkably consistent and had one of the least variations of the 6 or 7 methods tested. It occurred to me that this was a simple method which could be used by hospitals and similar institutions for vertical as well as horizontal surfaces. I would simply like to assert that I feel more studies should be done along the Angelotti and Porter line, but with surfaces that we are interested in.

Dr. Silverman: It's a good suggestion that better samplers be used, but I would ask if we can interpret what the better samplers give us now in terms of this problem? If you are going to talk about general bacterial contamination, I heartily endorse your suggestion. If you are talking about Staph., I would like to know a little more about the problem itself in situations where we can use good samplers. I don't think the problem at the moment is the samplers.

Dr. Phillips: The main subject on the agenda for this afternoon is sterilization, and I would like to channel the conversation into the techniques we do have for accomplishing this. Sterilization, of course, is as old as bacteriology. We have many standard techniques for this in the hospitals. For example, we have long had autoclaves. Most of the things used in the hospitals have been adapted more or less to be compatible with autoclaves. Incidentally, after all this time people can still misuse the autoclave. It is quite possible to put something in one, twiddle two or three valves, and take the article out of the autoclave and have it not sterile. However, it has not been until fairly recent times that we are beginning to get all types of things that people feel they absolutely have to use and subsequently sterilize, but which don't autoclave very well. Particularly some of the newer surgical devices - these things that you look in one end through a half dozen lenses and tubes down at the bottom of a lung or up in someone's bladder - that you can hardly autoclave by conventional methods.

Mr. Hall: Is this a problem in all Staph. transmission in hospitals today?

Dr. Mudd: It is said to be. Infants' thermometers and all the bedside objects in the nursery are supposed to be sources of spread. They are probably less important than open carriers, however.

Dr. Phillips: Our own experience had led us at Detrick to look for other techniques. We have had to treat all kinds of queer things that don't autoclave very well, such as analytical balances contaminated in laboratory use. Then, soldiers use wool uniforms

which can't be autoclaved as can your hospital linens. We have even talked about such things as the possibility of sterilizing a 6 x 6 truck. We've never done this, but we did once sterilize the interior of a commercial airplane in which someone shipped live polio virus poorly packed, so that the container cracked and leaked in the cabin.

The first thing we came out with was ethylene oxide - some 12 years ago. In our first test, we used up the entire stock of ethylene oxide on the post - 100 milliliters of it. It took time to reorder, and I got curious as to why no one had found out before how effective this was. While waiting for the new shipment of ethylene oxide, I went to the library and found about 2 dozen more or less obscure references on its bactericidal activity, none of which had ever gotten into such a thing as a review article or textbook on sterilization. We found ethylene oxide to be a very useful thing. You can sterilize cold and, by cold, I mean room temperature. We would also like it to work at 20° below but it doesn't. It does work very nicely at 20° C. Also, you can sterilize dry. These are its main advantages. You can now sterilize things which are heat and moisture sensitive although more time is required. It is an easy thing to modify autoclaves with a tee in the steam line so that either steam, or ethylene oxide mixtures can be used. Special commercial equipment in which it can be used has become available recently.

Incidentally, ethylene oxide is as flammable as ether, but it was soon discovered that this flammability can be suppressed by mixing with carbon dioxide. This mixture is sold commercially as carboxide. The bad thing about this is that you have to use 9 times as much carbon dioxide as you use ethylene oxide, and you pay as much for the inert carbon dioxide as for the ethylene oxide in the mixture. The Department of Agriculture has worked out for us an even more expensive way to dilute ethylene oxide and make it flame-proof. This is done with the fluorinated hydrocarbons, such as Freon. This mixture has, however, two advantages. Freon has a much lower vapor pressure than does carbon dioxide, so this mixture can be packaged in the beer-can type of containers instead of the heavy steel cylinders used with carboxide. Therefore, what you lose on the cost of the mix, you catch up with on cheaper packaging. Secondly, on a volume basis, you're getting about twice as much ethylene oxide vapor with the Freon mixture as you are with carbon dioxide.

The simplest sterilizing chamber that we have found to date happens to be a nice bag of polyethylene film in 6-foot lengths, appropriately broad, and a little thicker than usual. These sell commercially for 70 cents each as liners for chemical drums. We put in the bag anything you want to sterilize along with a can of ethylene oxide and Freon, and twist the top of the bag around once or twice and tie it with a string, which makes a pretty adequate seal. Then open the can - it has a tip that breaks off, and you

can work it easily from the outside through the polyethylene, which has the advantage of being transparent. So you have about a 70-cent chamber and a dollar can inside, which will do the sterilization - the same thing you can do with a quite expensive piece of apparatus. However, I have been so very happy to see these specialized pieces of apparatus for use with ethylene oxide appear on the market. If you are going to be doing large volumes of routine work and hope to save labor costs instead of initial investment, it's always advantageous to spend a little bit of money in getting nice foolproof machines, with all the gadgets on them that anybody can work, and not have to improvise your equipment. The only point I wanted to bring out was that there are quite simple ways of sterilizing with ethylene oxide, and there are very nice pieces of more or less foolproof apparatus available. You can sterilize safely with ethylene oxide many objects not ordinarily considered possible to so treat without ruining them. One paper that I love to quote mentioned something like 25 different objects safely treated, including leather pocketbooks and oil paintings. These happened to be objects made by tubercular patients in an occupational therapy ward.

Dr. McKee: You have been telling us mostly about the use of ethylene oxide for sterilizing in a vessel similar to an autoclave. Could you tell us a little bit about using it in a large space like this room? Would it be feasible to saturate this room with ethylene oxide, similar to fumigation?

Dr. Phillips: We can't do it for the reason that ethylene oxide has marvelous penetrating qualities. In some early experiments we took small cloth patches, soaked them in spores, and put them inside little paper coin envelopes so they could be easily handled. The envelopes were not sealed. These were put in pockets of clothing. We piled it all up just as you pile up things in an autoclave. Then we sterilized through the piles with complete penetration. For the same reason, ethylene oxide leaks out of any kind of a cabinet you put it in. We have found, for example, that we never noticed any leaks when we put steam in these converted autoclaves - but with ethylene oxide, it would run right through the gasket, and you had to put a fresh gasket on. This means that you could never make a room tight enough.

Dr. Silverman: Did I understand you correctly about this patch test that you could sterilize through all things effectively?

Dr. Phillips: Yes.

Dr. Silverman: What's the time relationship?

Dr. Phillips: It's a little difficult to say - something like 6

hours and, if you have a diffusion problem, you stretch it out to 7 or 8. It's a little hard sometimes to figure out, just as it is difficult to determine how many extra minutes you should autoclave to let the heat go through.

Dr. Dunn: I understood from some of the manufacturers that a certain degree of moisture was necessary for effectiveness. If so, how do you humidify your polyethylene bag?

Dr. Phillips: The moisture aspect is a rather tricky and peculiar one. We investigated the relative humidity curve at about 6 different spots, from 95 percent relative humidity down to 28 percent relative humidity. Twenty-eight percent relative humidity and below is a little difficult to maintain in our moist Maryland countryside, so we didn't go between it and the bottom where we got more or less lyophilized material. Materials sterilized better at 28 percent relative humidity than they did at 95 percent, and it is a rather straight line, going downhill from 95 percent to 28. Then between 28 percent and 0 to 1 percent is a vast unknown territory. But, somewhere before the 0 to 1 percent range, the resistance to sterilization again becomes very high. There is requirement for some moisture.

Now we have found that invariably, in every paper that's ever been published, the people who say they must have moisture evacuated before they added the ethylene oxide. They did this either to get around the flammability hazard or to get a larger concentration of ethylene oxide in their chambers. When they evacuated, they got down to quite a desiccated atmosphere, and then had to put some water back in before they could sterilize. This is my explanation of the phenomenon. Incidentally, there is quite a hysteretic effect on a highly desiccated organism. Just moving him out of that atmosphere and putting him in 50 percent relative humidity probably takes him up to a day to realize that he's there and to pick up the right amount of moisture. Don't pull the moisture out and you never have a problem. If you do pull it out, you have to rehumidify, and it is much easier to take moisture out of a live organism than it is to put it back in.

Some precautions should be observed if the materials being treated are not damaged. We found that with certain plastics you can get a certain amount of crazing like crackle on pottery. If unevaporated liquid ethylene oxide is sprayed on many materials, it can badly damage them. The liquid incidentally is one of the best solvents I've ever seen. The vapor itself can dissolve in solid materials and cause difficulties. For example, it will dissolve in rubber and then slowly redissolve back out. Ethylene oxide burns resulted with rubber safety shoes. Somebody took them right out of the chamber and put them on, laced up tightly, and thus kept the gas held around his feet. That person spent about a week in the hospital, not walking on anything. However, it doesn't seem to hurt the rubber

once it has redissolved from it. The same effect can occur with certain plastics.

Dr. Kokko: What about optical instruments? Can you put a good microscope in it?

Dr. Phillips: We have safely treated microscopes.

Dr. McKee: What about its toxicity toward humans?

Dr. Phillips: From a Chemical Corps point of view it's not toxic at all, but of course it is. It has an acute toxicity about the same as that of ammonia.

Dr. Kokko: What about temperature factors - how important are they?

Dr. Phillips: It's about two or three times more rapid for each 10° elevation, as are most chemical reactions. Most chemical disinfectants do work better warm, but you can sterilize at ordinary room temperature. Some of the equipment is designed to run the temperature up to about 130°F. to get a little faster effect. We are a little disappointed that it works so slowly at 20° below zero, but hospitals never seem to have that problem - they are always so nice and warm.

Mr. Wolf: The shoes that you mentioned, how long would they have to be aired out before you could use them?

Dr. Phillips: Dr. Wedum, our safety director, says the next day. Twenty-four hours.

Mr. Hall: Getting back to the Staphylococcus problem, it is suspected that mattresses are one of the greatest sources of contamination. Is ethylene oxide, in your opinion, the method of choice for sterilization?

Dr. Phillips: It is just about the only thing we found that we could recommend for wool, although dry cleaning can be done, of course. Just recently I saw the first commercial mattress and blanket sterilizer. It has room for about 4 mattresses and the blankets and pillows that go along with them. It is on the market.

Dr. Silverman: This brings up a point. Military hospitals have never been able to sterilize mattresses properly and decided to abandon sterilizing mattresses.

Dr. Phillips: Actually, the bare mattress hardly ever touches the patient. Not only do they have sheets, but they have rubberized

or other things separating them from the mattresses.

Dr. Mudd: They put plastic coverings over them, don't they?

Dr. Silverman: This was before the plastic coverings that they decided to abandon the practice of sterilizing mattresses.

Dr. Kokko: Ethylene oxide is still quite expensive - is there any hope that it will get less expensive in the near future?

Dr. Phillips: It's expensive when you compare it with steam. However, the compound is down in the price range of ethyl alcohol. The treatment is more expensive than autoclaving, but ethylene oxide is actually a cheap chemical. It's made in tank car lots - huge amounts. There are about six or eight people making it. Most of your detergents and almost all your anti-freeze compounds are made from ethylene oxide. These are the main uses and these are huge. Sales amount to millions of pounds per year. It is very much an industrial chemical, which is down to a fraction of a profit on the manufacturing cost. I don't see any possibility of it coming down in price.

Dr. Mudd: A word of caution about forgetting mattresses. Dr. Colbeck of Vancouver (14, 15) has pointed out that if you neglect them, they do become a reservoir of bacteria of very considerable magnitude. At the Walter Reed Hospital last spring they were using, on the basis of their own observations, plastic covers.

Dr. Phillips: There may be doubts as to whether it is necessary. I think we know lots more about how to sterilize objects than we do about whether we should or should not sterilize. However, if you have a patient with open staphylococcal lesions, I would hope and pray that someone sterilizes his blanket and mattress before they put it on my bed when I come in as a surgical patient.

Dr. Kokko: You have talked about penetration in general - but what about special stuff like dried pus - does it penetrate material such as that very well?

Dr. Phillips: You can of course run into difficulty sometimes in penetration through dried materials. In general I would recommend that articles be washed and clean, if possible, before sterilization, but when necessary ethylene oxide will penetrate almost anything if sufficient time is allowed.

We made a great discovery on catheters. Sometimes they worked fine, and sometimes they took much longer to sterilize. We found that, if you rinse them and just let them drain, you are apt to get just one little droplet that's still in the capillary, and then there is a long empty space and another little droplet.

Ethylene oxide then had to dissolve through the water blocks and then redissolve out. It sure slowed down the process, which you could speed up by blowing the water out of the catheters.

Dr. Bennett: I can tell you something about how it will penetrate pus. We took test tubes, with regular cotton plugs, which contained 10 cc. of pus from staphylococcal lesions. They were put in an autoclave which had been converted in the way that Dr. Phillips has mentioned. After the six-hour period that we ordinarily use, with two atmospheres of pressure, we were unable to culture staphylococci.

Dr. Kokko: But that was fresh pus?

Dr. Bennett: Yes - but it was 10 cc. in a test tube.

Mr. Wolf: Did you try culturing the organisms at least 6 hours after the exposure period?

Dr. Bennett: Tests were made to culture these over a period of almost a week to make sure that the organisms weren't just stunned.

Dr. Phillips: Ethylene oxide will diffuse through air much faster than it will diffuse through a liquid. Through considerable depths of liquid it does diffuse slowly. It penetrates rapidly, of course, if you shake it. In 6 hours we diffused only about 2 centimeters down in still test liquids. When you are trying to diffuse through some things there are limits, of course.

The next thing I would like to bring up, which is much newer, is beta-propiolactone, with which we have much less experience. Our first announcement about beta-propiolactone was made at the Society of American Bacteriologists last May, and the paper has just come out in the Journal of Applied Microbiology. We were interested in sterilizing large enclosed spaces. In the search for a satisfactory agent, we came across beta-propiolactone, which had been used by one of our contractors in liquid form for blood sterilization. It does work as a vapor. Quite small amounts sterilize enclosed areas in about 2 hours. Unlike ethylene oxide it does not penetrate well, which means you can use it in a room and not have it leak out. This poor penetration also means that if you put a patch on top of a rug, the patch will be sterile after treatment, but if you put in under the rug, it will not. Beta-propiolactone will not go through the rug, but it does sterilize spores and all other organisms on exposed surfaces. It has several advantages over formaldehyde. It works better at cooler temperatures, and it ventilates much more rapidly because it doesn't polymerize. It is toxic but it is also lacrimatory at much lower concentrations, so nobody is going to hang around it any more than they're going to hang around formaldehyde and get themselves poisoned.

This compound was used at Walter Reed Army Hospital where they were interested in studying the Staph. problem on their dermatology ward - nice and easy to work with because most of the patients were ambulatory. They had a day room furnished with curtains, a rug, a TV set, and other furniture. For this, - they decided to try beta-propiolactone. Our group did this for them using a couple of little generating units, and sealing the door with masking tape so it wouldn't leak out too badly into the hall where the patients were. After treatment the room was undamaged, the TV set still worked, even though some of the things got a little moist, and one of the pictures that was hanging on the wall looked a little wrinkled. Out of 35 places sampled for Staph. before the treatment, 25 were found to be positive with staphylococci 80/81 strain. We did the treatment on the 3rd of February, after which the surfaces were essentially sterile. Then the Staph. started coming back. On the next day, after the men were back, there were 7 positive places. By February 12, the contamination had gotten back up to about 24 positives and up to 31 in April. The interesting thing was that what came back first was plain old Staph. - much faster than the coagulase-positive hospital strain, which was in there before. We were then asked to repeat the treatment. I haven't seen the data yet, but this time the study is going to include quantitative counts as well as typing.

We've had one other hospital experience. This was at Detrick itself following a case of an infectious illness in our station hospital. In the room treated, there were various types of medical apparatus, including 4 stethoscopes and an oxygen tent, all the bedding, mattresses, towels, etc., as well as the usual furniture. We treated that room by merely sealing the door with masking tape after a generator had been placed in there which could be operated outside from the light switch. The patients' personal effects and some of the things we thought might present difficulty because of poor penetration were sterilized separately in a bag with ethylene oxide. Afterward, it was decided that it would be very interesting to see if the entire ward could be decontaminated, so the patients were moved to another ward leaving everything in the one ward wing of this old hospital which was really a complete small hospital, since only this one ward is now used. The entire place was treated for 2 hours, including kitchen, operating room, linen supplies, etc. After several hours of ventilation, the patients were moved back about 24 hours later. Since then, following another case of an infectious disease, another room has been treated similarly with beta-propiolactone, without disturbing the rest of the hospital wing or the patients in nearby rooms.

Thus, we have a new technique for disinfecting hospital rooms or wards, even though it has been tried only a few times. With ethylene oxide and beta-propiolactone, we have a method for treating things we don't ordinarily try to disinfect or sterilize, such as

entire rooms, groups of rooms and all their contents, down to the blankets and mattresses. If you give us an operating room for a half day, we can make sure that the operating room is sterile. Similarly, nurseries can be treated, or you can move things like bassinets, cribs, and incubators into another room for treatment between patients - if you buy another few bassinets so that you are willing to give each one up for 24 hours before you put another baby into it. This is the type of thing that can be done, but is seldom done now.

There are several things I would like to have discussion around. Dr. Mudd brought up several times yesterday that we have three potential sources of cases in the hospital: (1) the patients themselves who have open wounds and lesions; (2) the carriers, asymptomatic, and (3) the environment. We don't know epidemiologically whether the environment is more important or whether the carriers are the main source of new infections, but are we in any position now to say we should be sterilizing more things than we are sterilizing now? With some of these newer techniques in the hands of a good investigator we might be able to do quite a bit towards eliminating the environment as a possible reservoir, and see epidemiologically whether this cuts down the number of cases. In other words, if we take the Staphylococcus out of the environment, but leave the carriers and the active patients, are we going to do any good. I think this is capable of experimental study and should be looked into in an effort to find out whether the carrier or environment is the major source of infection. Perhaps cleaning up the environment may even tend to lessen the number of carriers.

Dr. Langmuir: The three points Dr. Mudd made are very clear. Without question, we want to have a pretty nearly sterile environment in the operating room. However, in a general medical service the patients should not be put into strict isolation. In the nurseries, we've got babies going through a process from birth, which is essentially sterile, to normal living in a home which is anything but sterile.

Dr. Mudd: Possibly I have been a little too active in talking about the environment. I think the thing to remember is that the source of staphylococci, the place that they multiply and from which they are disseminated, is the human being, whether it's a skin infection or a persistent sinus, or whatever. The human being is the source and the place they multiply. Environment is the passive reservoir. However, I do think it is also important to remember that we must not neglect the passive reservoir. As Dr. Colbeck said in one of his addresses: "patients come and patients go, but the mattresses go on forever." I think if you have a reservoir, you can infect the patients, you can infect the nurses. You can infect the personnel from the reservoir.

Dr. Langmuir: But this has not been demonstrated.

Dr. Phillips: Should we plan some key investigations of the environment? As Dr. Mudd says, the carriers are the important thing, but perhaps the environment is what is creating the carriers.

Dr. Silverman: Isn't this the proper way to begin this experiment - take a new institution and follow it as it develops? There are certainly new hospitals being put into service every month.

Dr. Mudd: Well, it has been done. There have been reports on this. In one new hospital they got so many infections they finally had to close it down and found that there was one nurse who was infecting people. They got her out of the operating room and it was all right again. I certainly don't think that we should recommend as a practical measure that the environmental factors should be attended to with neglect to the other factors. I thoroughly agree with Dr. Bennett that the environmental factors are secondary to the human spreader. One year at the University of Pennsylvania Veterinary School they had an infection rate in the first 3 classes of from 1 to 8 percent. In the Senior class the rate of Staph. infections was about 65 percent. The Dean said in a public meeting that apparently there was one animal clinic there that was so grossly contaminated that the boys who went through it acquired the infection, and this was more than half the Senior class. I think this is a pretty fair demonstration that something in the environment can be a source of infection, human beings being the continuing source of contamination.

Dr. Silverman: How well do you think you can make the reservoir sterile on the basis of everything you have told us?

Dr. Phillips: You can't sterilize the people, but this can be done to the environment if you are willing to take certain sections out of use for 12 hours or maybe a little more. It's quite easy to make sure that the air coming into these places is almost sterile. There are several techniques for this, of which filtration is a beautifully effective one. However the environment isn't going to stay sterile. This is a continuing thing that we'll have to do repetitively. What if you have a patient with open staphylococcal lesions? Should you treat his room when he leaves and treat all the bedding in it before you bring a new patient in?

Dr. Langmuir: There have been some awfully peculiar examples of a patient going into a room where there has been a staphylococcal disease acquiring the same type. There just isn't the epidemiological evidence that I know of to support the need for this kind of heroics in a disease that's as common as staphylococcal disease.

Dr. Farrer: I would just like to make a statement to support one of Dr. Langmuir's statements. At Pennsylvania, we had two isolation

wards from which we had innumerable cultures of Staphylococcus aureus, type 80/81 and other types. We abandoned these two isolation wards two months ago and moved into a new unit. These two old units did not receive any special treatment other than airing out and washing down with Wescodyne, soap, and water. We haven't had a single case of clinical staphylococcal infection since that time in any of the patients that are now housed in these two old units, although infections in other areas of the hospital have continued to occur.

Dr. Hatch: What about the new area?

Dr. Farrer: We moved patients into a new area, but the old areas have been turned into semi-private areas, and we haven't had any cases of hospital-acquired infections in these two old areas.

Dr. Silverman: This would indicate that sterilization is quite simple to accomplish by aeration.

Dr. Bennett: If you remove the source - which is what they did.

Dr. Anderson: Did they change the staff - the nurses, the orderlies, etc., too? How many days was the ward closed?

Dr. Farrer: About 5 days.

Dr. Bennett: Was this an isolation ward for patients who had this infection?

Dr. Farrer: This was an isolation ward for staphylococcal infections. We closed it and turned it into a semi-private surgical area, and we haven't had a single wound infection in that area since.

Dr. Anderson: Same blankets, same beds - they weren't washed or anything?

Dr. Farrer: The beds were washed with Wescodyne, soap, and water. Blankets were washed and mattresses were destroyed.

Dr. Solberg: Did anyone ever acquire staphylococcal disease in that area?

Dr. Farrer: Yes, two nurses who worked in the isolation unit.

Dr. Mudd: Dr. Bennett and Dr. Langmuir have been consistently talking in favor of common sense and good judgment based on all the factors involved, and I couldn't be more enthusiastic in support of what they are saying. Hospitals are mostly operating in the red, they are understaffed with nurses, and they are overcrowded. It would be a terrible mistake to let people believe that, by buying fancy new gadgets, they can rid themselves of the tiresome, tedious, meticulous attention to nursing procedures and de-

tails because they think that gadgets and antibiotics will do it all. Antibiotics aren't doing it for us. I still think that one of the things that this meeting has accomplished, if nothing else, is to let all the people who are interested and technically competent know that there is more to the air conditioning problem than humidity, temperature and air movement. You have to bear in mind the possibility that a specific disease agent, borne in dust, borne in the air, can be disseminated through the environment. It is less important than the human source, but it is something that I'm personally thankful that they have had a chance to think about. It is important that we have the wit and good sense to reduce this reservoir of infection, without necessarily adding a lot of expense to the hospital cost.

Dr. Phillips: I think that it is the consensus that we are not prepared at this time to make a recommendation that hospitals put in a lot of extra procedures as a routine operation. I don't think we have all the answers, but the answer to that is the same as to the Chairman of the Patent Commission who said in 1820 that we should abolish the patent office since there was nothing left to be invented.

If I can sum this up, our recommendation is that more careful, quantitative, definitive studies of the environment are the first thing we should aim at.

Dr. Anderson: Such studies will have to be related to sources. A study of the environment without relation to sources of contamination is going to mean nothing.

Dr. Hatch: Is there any procedure for determining the virulence of the organism once it has been recovered?

Dr. Langmuir: This is a very nice point. Allan McDonald in Ohio, who has a new hospital, set up a study in the nursery. He had a very nice epidemic of nothing but the carrier state of the 80/81 strain. It went right through the nursery, but there was no disease, so we have real troubles in the identification of what we mean by virulent strains. It may be a dosage factor or it may be some other adjuvant factor.

Dr. Mudd: In connection with Dr. Hatch's remark, there is a whole large area of immunology of Staphylococcus on which workers dropped their tools in the "thirties" and "forties" when antibiotics came along and everybody jumped into antibiotics. Now we have to go back and pick up these tools and do meticulous, painstaking work for the next 15 or 20 years in immunology.

Dr. Hatch: I think there is a very real danger in embarking on an elaborate sampling program if you don't know what it is you are try-

ing to do. The mere collection of data becomes in itself very impressive, but does not necessarily give us the right results. Is there any evidence that the resuspension of this organism from environmental surfaces followed by reabsorption by the skin or respiratory tract is, in fact, a practical avenue of spread? You can't prove this is so; so I would question the value of embarking on elaborate studies of the environment. It would be misleading.

Dr. Langmuir: Such studies are necessary to get the answer to your question.

Dr. Hatch: Yes, but there would still be a need for careful research. Would it be possible, say in an experimental nursery, to maintain such control over the nurses or other personnel to be sure that you had control of the carrier state? Would it be practical to check on the nurses at frequent intervals to make certain that they were not carriers?

Dr. Langmuir: You can't possibly do it if you use the Staphylococcus. If you use the Staphylococcus of a certain phage type, you can to a degree, but you've got how long between the culture of the nose and the phage typing? It's a week or longer unless you have an awfully well-run show. Then you have to have it on all of the shifts through the 24 hours. Who is going to be collecting samples? This means that somebody competent has got to be watching every moment, and there can be no vacations.

Dr. Hatch: But it can be done?

Dr. Langmuir: Oh, sure.

Dr. Silverman: Can you control the carriers by proper masking, assuming that what we were told can be carried out? Can you control these people by this technique? That is what I called "personnel protection" yesterday - can you muzzle them all and monitor the muzzling?

Dr. Bennett: It's not always direct dissemination from the noze. If one undertook to see if one could introduce a known carrier into the environment and clothe him in such a way that he wouldn't disseminate the organisms, an environmental study might indeed be meaningful.

Dr. Mudd: Dr. Williams, in his excellent report in the proceedings of the National Conference, has mentioned the use of multiple anti-biotic ointments in the nose. Dr. Colbeck at that conference mentioned the use of neomycin spray which he has found rather effective. I don't think that these measures are 100 percent effective, but they do certainly reduce the number of carriers significantly, and this is easier than going around in space suits.

Dr. McKee: With respect to residual bactericides, is there anything we can paint on surfaces that will provide some residual effect? Can we coat the floor with something, such that any Staphylococcus that settled on the floor would be killed?

Dr. Phillips: We have been looking for such a thing but haven't found it. A bactericidal surface or a coating is one of the things that I think everybody would love. If everybody found one that they agreed worked, we would start using it immediately and we'd treat every floor and every wall with it. There are claims for such things, but in our laboratories they have not stood up.

# HOSPITAL DESIGN

## Introduction

August F. Hoenack\*

The increasing problem of hospital infections has been one of concern to the architects and engineers who design hospitals, as well as to the individuals of the medical and nursing professions who have the responsibility for caring for the patients in the hospitals. Architects and engineers are familiar with many shortcomings in existing hospitals and they are very anxious to determine how, through the improvement of hospital design, they may create a better and safer environment for doctors and nurses to provide patient care.

While the successful hospital is the result of good programming, good design and construction, and good administration, I hope to bring out in the course of this discussion the contribution architects and engineers can make to the hospital construction field in alleviating the problem of infection and, perhaps, what is more important, some of the kinds of authoritative data which they need in order to do a better job. The conflicting opinions on the part of the medical and nursing professions and hospital administrators as to how certain critical areas of the hospital should function present a very confusing picture.

The designer's part in the hospital-care picture might be demonstrated by considering the operating hospital complex as three broad elements: first, the hospital techniques and procedures; second, the physical facility; and third, the skill and quality of personnel. These must be in balance and one element cannot change without affecting, to some extent, the others. Should one break down, or in some way become deficient, the others are affected. For example, an inadequate plant could require more vigorous nursing or housekeeping procedures to maintain the desired standards. On the other hand, in these times of rapid medical advances, many heretofore adequate hospital plants are currently found wanting.

Of the three elements, the one representing hospital techniques and procedures is undoubtedly the most significant. The ability to provide the patient with accurate diagnostic services, effective treatment, and proper nursing care is the essence of the hospital's existence.

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Gross shortcomings here cannot be compensated for by excellence of physical plant or even by skill of personnel if it is misdirected.

The general procedure in designing a hospital is to develop a program first. At this point, major decisions are made regarding services to be provided, the extent of the services, and how they will be organized and operated. This is the responsibility of the sponsor of the hospital, and he should see to it that only the best thinking is obtained at this critical phase of the planning.

At this time the proposed operational procedures must be scrutinized for possible opportunities for cross-infection to occur. However, a hospital board might well ask, "What are the procedures to be followed so that we can be assured that the best medical and nursing practices will be possible in our hospital?" Here is where they will meet their first serious obstacle, and let us hope they will recognize it as such. While the American Hospital Association, the American Academy of Pediatrics, and the Joint Committee on Accreditation of Hospitals, and others, have made excellent strides in this direction, there is still much to be done to provide hospital planning groups with authoritative guides for adequate programming of these areas.

Here, I believe, is where a firm step can be taken toward achieving some rationale to this phase of hospital planning. The functional requirements of critical hospital services should be analyzed in terms of human circulation, work flow, space, and total environment. This information would be a welcome point of reference from which hospital programs can be developed.

Only after the programming has been completed should the architects and engineers proceed with the design for the complex envelope that will house these activities. These designers bring to the program their experience in building construction, the use of materials, finishes and equipment, and what is most important, their knowledge of the interior circulation of staff, materials, and supplies. They are responsible for designing a building which will permit the hospital to function as programmed, yet be structurally sound, safe in all respects, and a credit to the community.

Certainly it is logical to assume that after the hospital has been completed, the procedures as programmed for each of the departments and services will be carried out and that the personnel will be adequate, by background and training, for the tasks.

I believe it is important that we understand also, besides satisfying the all-important program requirements, that architects and engineers must design within budgetary limitations and they must utilize in their designs materials and equipment as available and as manufactured. To depart from standard components is usually quite

costly and it is pointless for designers to do so unless it is essential for the safety and welfare of the patient.

We must keep in mind that while scientists search for answers to some of the hospital architects' and engineers' problems, hospital construction is proceeding at a high rate. For the current fiscal year, the Hill-Burton program has \$185,000,000 in grant funds which, when matched with local funds, will represent about \$400,000,000 worth of hospital construction. This represents approximately one-third of the total hospital construction in the country.

Some means of continuously evaluating medical development in terms of their impact on hospital procedures should be established and recommendations made which can be accepted by designers in the hospital field. This task probably can best be undertaken by an authoritative agency with competence in the medical and hospital fields and which could bring together appropriate disciplines to carry out various phases of this function. Certainly this would eliminate much of the trial and error planning which too many designers resort to.

This evaluation must be a continuous function and not merely related to the current staphylococcal problem. The hospital always had infection problems which probably will reoccur from time to time in the future.

It is important to understand that the hospital may not always be able to keep initial unknown infection from developing, but once it is known, the combination of personnel, procedures, and plant design should keep it under control. This combination should always be on duty--not allowed to relax until the next infection problem becomes firmly entrenched.

Hospital boards and their architects and engineers, I am sure, are willing to do what is necessary to make the hospital a safe place for sick people, and as a result their planning may too often be simply treating the symptoms. This may be the best that can be done today, but it unfortunately can involve the expenditure of scarce hospital construction dollars unnecessarily.

To further demonstrate where study or perhaps research would be fruitful in improved programming, design, and operation of hospitals, I believe it might be helpful to consider a number of designs (Appendix B) which actually have been built. All are the results of mature thinking on the part of the sponsors, their consultants, and architects; yet, these plans differ in some important respects and indicate that there is a need for much study to determine just what procedures are necessary to carry out the functions in surgery, nursing units, and maternity departments, as well as in other areas.

The first plan is that of a small surgical suite typical of many which have been built. The objective is to separate clean and sterile materials, and the other activities related to setting up the operating room for surgery; from the contaminated materials and activities related to cleaning up. The cleanup room is convenient for receiving and cleaning contaminated utensils and other items before they are sent to Central Supply. The cleanup room is not to be used for storage of clean materials or sterile packs. The Central Supply furnishes sterile materials to surgery on requisition, which are then stored in cabinets in the operating room.

Instruments, after being cleaned in the cleanup room, may be sent to Central Supply and sterilized in packs, or may be sterilized in the sub-sterilizer room and stored in the operating room. They are then reesterilized prior to being used again.

Surgeons' scrub-up sinks are located close to the operating room entrance, with a convenient view window to observe progress of preparations.

Plan No. 2 is a larger surgical department. Here the arrangement of the sub-sterilizing and scrub-up area is somewhat different. A clinical sink is a part of this space for immediate disposal of contaminated fluids and to be available for cleaning up the surgery. The interconnection of the clean utility room and the instrument room with the soiled utility area is somewhat questionable, as it would more readily permit accidental breaches of technique.

Plan No. 3 separates the circulation of the surgeons and nurses from that of the patients, which is desirable in a large and busy surgical department. However, carrying out the sub-sterilizing, storing of sterile and clean supplies, and scrub-up functions associated with the cleanup activities would require very strict supervision to avoid possible cross-contamination. From the standpoint of convenience to the nurses, the arrangement is good.

Plan No. 4 shows a type of isolation room which, for a number of years, has been recommended by the Public Health Service. The sub-utility room provides space for carrying out appropriate procedures for various types of contagious illnesses. The rooms may be shut off from each other and from the corridor, with access only through the sub-utility room. Since many typical patient rooms in new hospitals have individual toilets, it is possible to improvise isolation facilities in any single or double room, in which case the sub-utility room is not essential.

Plan No. 5 is the typical patient's bedroom found in most new general hospitals. While this plan shows a toilet for two rooms, usually a toilet for each room is preferred. Here, economy and good

technique conflict. The lavatory in the room is principally for the use of the nurses and the doctors. The lavatory in the toilet room is for the patient's use. Where a connecting toilet is provided, as in this plan, lavatories should be provided in the patient's room and in the toilet. However, if a toilet room is provided for each patient's room, installing a lavatory both in the room and in the toilet room adds to expenses, so one is usually placed in the toilet room only. This is probably the best compromise, but let us hope that the necessity for good technique is impressed upon and adhered to by the nurses and doctors.

Plan No. 6 is a newborn nursery design developed by the Public Health Service and the Children's Bureau. The principles upon which this design was developed are: 1) to reduce the number of infants in each nursery to eight; 2) to carry out individual techniques in caring for the infants; 3) to separate the infants from the workroom and examination room; and 4) to keep the bassinets separated from each other by cubicles. Many nurseries were built following these principles, although frequently the cubicles were omitted. This of course was of no consequence as long as the bassinets were kept apart. However, too often the bassinets were found crowded together on one side of the nursery to permit more bassinets to be moved in, and in some instances tables or counters for washing babies were brought into the nursery. This of course defeats the principles upon which the design was based.

Plan No. 7 is the same nursery design, as above, with a circular or individual type of washstand. This arrangement makes the washing facility more convenient to the nurse. Here again, the omission of cubicles can reduce the effectiveness of the design if the administration of this department is not strict.

Plan No. 8 shows an arrangement which is permitted by the Commonwealth of Massachusetts. Access to the nursery from the corridor can be only through an anteroom which can be used for examination. However, the workspace and the treatment space can be within the nursery. I assume that individual technique must be carried out in caring for the infants. Here, while one may question the work activity being carried out in the nursery, at least is a self-contained unit. The other plans would permit a common workspace and examination space between two 8-bassinet nurseries. One can expect that these principles when carried out to their limits would mean a unit of mother, infant, and nurse. This is probably, from an economical standpoint, beyond the means of many hospitals. What compromise is ultimately decided upon will depend on future research and study, which we hope will be forthcoming.

Plan No. 9 is a floor plan of a laundry for a 100-bed hospital. This is typical of laundry design and is planned with emphasis on work flow in the processing procedures. Linens from the floor are brought

by hamper or bag to the soiled linen room where it is sorted and placed in the bins according to the washload to be processed. Its path is first to the washers, then to the extractors and ironers, and finally to the central linen room for return to the floors.

The studies of Drs. Church and Loosli, as mentioned previously in this meeting, have indicated that the sorting of linens in the laundry proper results in a high degree of air contamination of the laundry air. The extracting process prior to ironing and the folding process after ironing, according to these studies, recontaminate the linen.

Where this type of plan is used in laundries, we strongly recommend that the sorting area be separated from the laundry proper. The room used for sorting should be ventilated with a minimum of eight air changes per hour, with supply air and exhaust discharged to the outside. This room should be maintained at a negative pressure.

## HOSPITAL DESIGN

### Discussion and Comments

Mr. Gaulin: I am particularly concerned about the soiled linen sorting areas being located in the laundry proper and the ventilation of these areas. Laundries are usually ventilated, but we are still faced with the fact that we dump soiled linens into the laundry proper which contaminates the air and the clean materials. One thing I would like to correct in a previous statement of mine. Dr. Loosli, while concerned with the organism count of the linens as they went back to the floor from the laundry, was especially concerned about the nursery linens and the possible effects of this contamination upon the babies and the newborn.

Dr. Silverman: I wonder if you could say anything about the effect redesigning these nurseries has had on acute diarrhea problems. Is there any way to decide whether this has been an improvement or whether the natural course of the disease was as much responsible as anything else?

Mr. Hoenack: I don't believe I could answer your question completely. I could say that the problem was reduced considerably, but we have had very few reports and did not make a study. I don't know whether the Children's Bureau completed a study or not, but they do have the feeling that this type of planning could nip epidemics in the early stages. For instance, a large hospital instead of having 30 or 40 babies in one nursery, which was not uncommon, may now have only 8 to 10. If they have an infection in one nursery, they can control it. It doesn't sweep through the whole department.

Some hospitals went to greater extremes. For instance, George Washington University Hospital in Washington developed a number of very small units - single, two-bassinet, and four-bassinet nurseries. Rooming-in has been advocated by some as the procedure for reducing any such infection. Complete rooming-in has not been found very practical in most hospitals, although many practice it to some extent.

Mr. Gaulin: The Children's Hospital of Pittsburgh built all-glass cubicles which were individual small glass rooms within the nursery proper so that each baby had an individual space.

Mr. Snow: There was a variation of that built and described some years ago at the Cradle in Evanston. I don't know the results of the work there, but it was carried out by Prof. Wells and Prof. Reyniers. Reyniers' proposal was an interesting one in that they pressurized the cubicle within which the bassinet was contained. The nurses' sink and table were within a room immediate to the cubicle so there was

always a flow of air away from the baby. Of course there was contamination from the nurse, but the assumption was made that by a gloving technique this could be appreciably reduced. It would seem that some additional studies, or a follow-up on this, would be well worth someone's time. The point that I would like to make is that it might be better to delay the process of building up biological flora on the baby's skin until after the baby has left the hospital and thus minimize the possibility of contamination with hospital strains.

Dr. Anderson: Why is it that all plans that I've ever seen of hospitals look just about like this? You see the physical layout of the plumbing, you see where the lavatories are, you see where the doors are, where the walls are, and the spatial relationships, but never once have I seen a plan showing which way air is moving. Yet in each hospital today ventilating systems are included. The movement of air is a standard feature. Now, is it in recognition of Dr. Langmuir's point that air is unimportant to the transmission of disease that the architectural plans purposely leave off the ventilating systems and concentrate on the direct contact effects of disease, or is this just an oversight? Personally, I would like to see them begin to show the entrance and exit of air and what the pressure relationships might be. Doctors look for what they want in hospitals. They look at things like space arrangement and the architectural design. It isn't until the architect comes around with the ventilating and heating layout that they suddenly realize that here is another thing they have to think about. I speak of a little experience here in connection with the new building that we are constructing for CDC. All of a sudden they tell me that there is one complete set of layouts showing just where the heating and ventilating system pipes go, and which way the air is moving and under what pressures. This comes along months after they begin laying out the sterile, clean, and contaminated areas.

Mr. Hoenack: In a hospital, the ventilation as well as the heating, plumbing, and electrical design should be considered during the very early planning stages. Unfortunately, too often the architectural plans develop long before the engineering aspects of the project are considered. Sponsors of projects can help correct this situation by emphasizing the ventilation requirements in their programs. Many sponsors do not wish to bother with a program for their projects and consequently too little consideration may be given to many things too late.

Dr. Mudd: May I revert for a moment to the Cradle situation? Actually they had 3 units - one with ordinary air conditioning, one with Reynier features, and one was the Wells design. The ordinary air conditioning was a source of a great many infections, but the Reynier and Wells cubicles had no infections to speak of. The Reynier children were completely cut off from their environment and they were retarded in their mental development, because they had no stimuli, no contact with the outside world. After about 3 or 4 years, when the results were

completed, the experimenters felt they were no longer justified in maintaining the ordinary air conditioned cubicles as a control because they had so many infections.

Drs. Bourdillon and Colebrook (6) did an outstanding piece of work on the burns unit in England. By a very simple local air conditioning arrangement, positive pressures, and strict asepsis, they were able to dress burns with a minimum of infection; whereas, with ordinary burn treatment, they got a lot of infection. They showed that the saving in time to the hospital, patient days in the hospital and disability to the patient were enormously significant. It's a very simple matter of having local air conditioning in dressing rooms which is the fourth area of critical importance with regard to cross-infection.

Dr. Silverman: This certainly emphasizes the need for model air flow studies and various shape quarters, and what effect the equipment has on some of these air flow patterns. There is certainly a point here to recommend studies of air distribution. All these changes made in spatial arrangements for convenience or even for partial isolation may have a definite effect on air flow patterns and contamination.

Dr. Langmuir: I would like to agree with Dr. Mudd on the Colebrook work. The Bourdillon sampler shows momentary changes of the concentrations of organisms in the air. He set one up beside an infected burn and showed that, as he gently lifted the bandage off the infected burn, juicy fresh pathogens from the discharging wound went off into the air. Now then, if you have a patient in the next bed with a loose dressing or an open wound, and a few minutes later bring another patient into this room, you are meeting all of the conditions that we recognize as a potentially dangerous situation. By setting up a separate burn room, by having controlled air currents and the requirement of a 5-minute wait - relatively simple devices - danger could be avoided.

Dr. Bennett: I would like to ask a question about programming. At the time that a group is asked to program a hospital, I presume they are given several mimeographed pages explaining how to write up the program. At least this is the way that the programs I have been asked to write have been begun. I wonder if in the instruction programming, the point is made that, when one is dealing with a given area, one should answer the question: Are there any special requirements about ventilation in this area? The question is always asked: How many people will work in this area?, and some determination is made as to what the heat load will be. Isn't there some way in which the individual might be asked to think in a routine fashion about the ventilation in a given area from the point of view of cross-infection? I was just thinking of a program that I drew up one time for a laboratory floor in a building that was connected with the hospital. There were a lot of questions asked about ventilation, but none of them had anything to do with cross-infection. It was about a draft on the back of someone's neck or whether it was going to be too cold or too hot in this room.

Dr. Wolman: How much consideration does the Hospital Facilities Division of the Public Health Service give to ventilation with particular reference to cross-infection?

Mr. Hoenack: In our regulations, we require ventilation in certain areas - surgery and delivery rooms - and in these we require that the makeup air be 100-percent fresh filtered air.

Dr. Wolman: Are they comfort standards or are they standards relating to cross-infection?

Mr. Hoenack: They relate to cross-infection. Our regulations involve only matters of minimum functional areas, structural safety, fire safety, and ventilation, which I have mentioned.

Mr. Gaulin: We have published guide material on air conditioning for hospitals, based on the recommendations which we make. These are not mandatory but are for the guidance of architects and engineers who are not acquainted with the problems in hospitals.

Dr. Langmuir: Of course, comfort standards are not too bad for one major problem of surgery and that is perspiration. The dripping of perspiration or just the soaking up around the edge of the glove is a problem, unless you have very careful observation and very careful mopping of the brow. In a tough operation I don't think you can prevent the sweating which is a pretty good source of skin contamination. I'm sure that, compared to the old days, operating rooms must be much improved from that standpoint.

Mr. Gaulin: We're finding in our investigations now that surgeries are going down to 70° and, in a few instances, below this. The surgeons asked for these lower limits. Generally, the average is about 74° where we used to go up to 80°. Apparently this doesn't have too much effect on the patient for he can be protected.

Dr. Langmuir: Why is there so much talk about the costs of installation and maintenance of operating and nursery air conditioned rooms? Why can't these rooms be one of the main inlets of the conditioned air and then let the outlet be under the door and out into the corridor to be dragged away from the operating room, thus not requiring anything more than just air conditioning that room? Why does it require special facilities and special controls? The operating room is a fairly safe place from which to draw air.

Dr. Silverman: I don't agree with Dr. Langmuir's suggestions because there may be a lot of contamination in the operating room and if you take air out of that into an adjoining room, it's going to carry that contamination.

Dr. Bennett: This all depends on what kind of case is in the operating room.

Mr. Gaulin: Dr. Langmuir, one of the difficulties with the idea that you have in mind would be the regulation of the air flow. We would have the possibility of short circuiting, and a number of other factors. Open doors and closed doors and such would be very hard to control.

Mr. Porter: It seems to me that once you've conditioned the air, it wouldn't add too much expense to put bacterial filters on each of these areas in both the incoming and outgoing air passages. This would filter relatively all the air through bacterial filters, and allow the central system to do the conditioning. This can be done by balancing the pressures, depending on whether you want positive or negative pressure. The high cost of bacterial filtration would be restricted to these primary areas with which we are concerned.

Dr. Silverman: But there is another problem. If you discharge an operating room exhaust into general areas you get odor problems not only from the wound, but also from the anesthetic.

Mr. Porter: What I'm trying to point out is that we are talking very glibly about air conditioning when bacterial filtration is the specific problem.

Mr. Gaulin: I see another difficulty Mr. Porter. If we get a good bacterial filter, we have a relatively high resistance.

Dr. Silverman: A quarter to one-half inch of water drop is all that occurs in a filter of about 99-percent efficiency.

Mr. Gaulin: I'm thinking of the leaks around the doors and other openings. Air would go out through these areas of least resistance rather than going out through a filter with even that resistance.

Dr. Silverman: That is one of the reasons why I would be against the general idea of letting the air from the operating room drift out into any place else.

Dr. Phillips: There is a system where you can stop air flow very easily. It is the same old storm door principle with the little vestibule. Very seldom do you have both doors wide open at once, and this keeps the dust in an operating room.

Mr. Gaulin: The architects would tell us we are adding cost to the building, that we're taking up cubage.

Dr. Phillips: I have read about the number of people who wander in and out, something like 100 or more entrances and exits during an operation. It's very difficult to see how you can maintain any air isolation and still have a door constantly swinging, even just one door.

Mr. Hoenack: I think this is where administration and techniques come back into the picture. How can all this process be organized so we can cut down that traffic?

Mr. Gaulin: I recall one study in which monitors were stationed outside the operating room to see what these people did. The results showed that 3/4 of the trips were unnecessary. They just wanted a change of atmosphere.

Dr. Langmuir: I would like to see studies made to see just how dangerous the operating room is as a source of infections for other areas in the hospital.

Mr. Gaulin: In a clean operation, would this be particularly dangerous?

Dr. Langmuir: Even in a dirty operation, I would question that it is too serious a source compared to making the patients bed in the ward.

Mr. Gaulin: Isn't there a great deal of wound dressing done right in the wards today? Isn't this a practice we should discourage and go back to the treatment room?

Dr. Bennett: Wounds are dressed in open wards in some places, but in our own hospital there is an attempt to have it done in the dressing room. Actually we have separate dressing rooms for various services. I must say it isn't too well organized. The waiting period is sometimes enforced by the nurse and sometimes not. This gets to be a problem if one private surgeon has several patients on the ward, and he's changing dressings. He would have to sit and twiddle his thumbs for 5 minutes before he works on his next patient; therefore, we are trying to have a least two such units so that they can alternate.

Mr. Gaulin: There is one point on operating room ventilation I would like to make. There is a condition that we have found very often where there are awinging louvered doors placed between the sub-sterilizing room and the operating rooms. The general exhaust ventilation from the operating rooms is taken out through the sub-sterilizing room with the idea that equal amounts of air will flow into it from both operating rooms. Often we find one door propped open and the other one closed. Now, there is sufficient resistance through these louvers so that the closed room is pressurized and most of the exhaust ventilation is going out of the open room. This produces a dangerous negative pressure in the open room. There are many problems of that kind that have to be watched.

**SECTION II**

**SUMMARIES AND RECOMMENDATIONS**

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## SUMMARY OF THE CONFERENCE

Abel Wolman, Dr. Eng.\*

Dr. Simmons, members of the conference, this has been for me an exciting, but horrifying, two days. Horrifying in the sense that this has been a period dominantly of diagnosis of areas of ignorance, with, however, exciting aspects. In defining areas of experience and areas of ignorance, a number of things have been disclosed which perhaps might point the way toward the next significant steps. This was the primary purpose in calling a conference such as this. It perhaps is gratifying to a person such as myself to find that these areas of ignorance cover all the disciplines, if there is any gratification in having a multidisciplined company of representatives who are looking for answers and, at the same time, are not able to supply them as completely and as definitively as we would all like. These areas of ignorance cover the epidemiological, biological, physical, chemical, and financial territories, and the psychiatric deficiencies. I added the last because Mr. Hoenack, in opening his comments, referred to his dilemma, which is the dilemma of the conference on a small scale and the dilemma of the hospital designer, constructor, and operator, on a large scale. That dilemma he very well phrased in simple terms. When he asks his client to tell him what he wants to be translated into the physical, mechanical, biological environment in which the client is to work, the client and his associated advisors and participants are apparently not in a position to supply these answers as adequately as the designer would like.

My second reaction, which is more or less a preamble to what I hope is a kind of helpful summary, has been that I was sitting at a kind of posthumous conference in which the participants were of 50 and 75 years ago, without dignifying the individuals around the table. These might be the Pettenkofers of that day, the Chapins, the Semmelweisses, even the Dr. Billings, the designer of our own hospital in Baltimore. All of these posed to each other and to themselves questions which have been raised here the last two days. Again it is gratifying to note that they did not come out with answers that were positive and convincing to all people concerned. Historically, logic loosely defined is not too good a guide for many of the people who are in this room. Perhaps under the generalship of Alex Langmuir, logic and intuition may be correct in their directives, but they may also be incorrect and even wasteful. Now, to return to the summary, I had to make certain choices. The first was to detail for you once

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more all of the technical and scientific data, hopes, and contradictions which have been presented to you during the last two days. That, to my mind, was neither necessary nor helpful. If the members of this conference cannot remember what was said yesterday morning, it is doubtful whether they would remember what was said this afternoon. I shall not, therefore, rehearse those details and dilemmas. Certain underlying principles seem to be threaded through most of the discussions. Certain basic premises as to hospital-induced staphylococcal disease apparently are rather generally agreed upon. I restate them purely to give us the framework in which some of our conclusions may fall. The first is that this particular disease is epidemic at times in hospitals. I restate this because we can eliminate a good deal of debate as to where we are going, once that is a rather generally accepted reality. This reality carries with it the problem of the frank disease case, the carrier, and the total environment as we have described it.

The second basic premise I quote from Dr. Williams: "The probability that the routes of infection are numerous and perhaps on occasion devious." The routes of infection are numerous. In other words, it is not a simple interruption of route with which we are confronted. His other corollary, which I listed as third is the probability that the precautions therefore needed for the prevention and control are likely to be many in number, and perhaps even complex in character. There is a fourth which I have added because it is desirable to relate and recognize as distinct from the epidemic character of this disease when it occurs. It is a fair premise that there is a high possibility of endemic staphylococcal infection in hospitals. Those are the four premises upon which the conference rests.

I move then to a very rapid review of the environment or the possible routes of cross-infection. Here, of course, we enter the realm of those possible routes, of which there are four on the program. I have added a fifth which had very little discussion. All those possible routes of cross-infection have the characteristic of being frustrating in their nature. I shall comment on each with my own impression as to where we stand with respect to each.

The first, in order of the sequence you used here, not necessarily in the order of priority of their importance, was via the air. The conclusions from the discussion on air indicate that we need a primary shift from the orthodox criteria for air, loosely defined as the comfort criteria, to those which emphasize increasingly, both in measurement and in assessment, the criteria of biological content and bacteriological impact, and the like.

Secondly, we have a distinct problem, which in a way simplifies the problem of air control. We are not confronted with an air conditioning problem from the cross-infection standpoint for street blocks of hospitals, but of isolated areas, whether surgery, nursery,

wound dressing areas, or the like. I emphasize this, as it has been emphasized by many of the speakers, because it seems to give us at least a way of diagnosing the significance of the control of those much smaller areas which lend themselves to less heroic ventilation and bacteriological control. We lack in air, as we shall discover later on in almost all the other categories, any true assessment of our present knowledge of its behavior or of the methods of control. There are rich resources in experience which need to be corraled, assembled, and placed before people who have something to do with this problem. The research needs follow the orthodox patterns, the desire for improved precision of sampling. I am not overly excited with improved precision in the stage in which we are assessing the problem, because gross sampling may have merits which precise sampling may not have. These are strictly personal views - they are not reflections necessarily of the participants. We search always in this area, as in every other environmental area, for quantitative criteria with respect to air and, in turn, we search as we've always done in environmental areas of much simpler issue, for standards - not incidentally standards of perfection, but standards of feasibility - which have a reasonable biological counterpart.

The second major item discussed was housekeeping procedures. My own appraisal of housekeeping procedures and their relationship to this particular spread of disease, is that our areas of ignorance are great. It is a matter of interest that, in housekeeping procedures, we have developed over the years so few criteria for either equipment, practice, or materials. It is a disheartening situation. It is one which, if subjected to supervision and intensive exploration could show a better picture at the end of the next five years than over the previous quarter of a century. It is not surprising, however, that housekeeping practice shows these deficiencies. This incidentally is characteristic not only of hospitals. If we were to sit here tomorrow and review hotel practice, railroad practice, or any practice that deals with community systems, and therefore entails a responsibility for total cleanliness, we would find a chaotic situation in equipment, materials, and operation.

Our third discussion centered on sterilization and decontamination, with the disclosure of a variety of very helpful solutions. The presentation of new materials or old materials resuscitated for a new purpose certainly gives us some cues as to how those might be extended for our purposes, and whether they ought to be or need to be. The fruitful values coming out of the sterilization and decontamination discussions certainly give us a basis for further appraisal, research, standardization, and comparison. It offers a very fruitful area in fact.

Hospital design, my fourth area listed here over the few days, is close to what Mr. Hoenack has said, except again to emphasize that we are working and striving for answers in the midst of a rate

of execution of hospital design which is unprecedented in our history, or perhaps in the history of any country. It is a staggering fact that \$400,000,000 worth of hospitals are under design and construction, while we sit in debate as he requests: "What is it you want me to do?" No public, no society will sit still while we hold up our hands and say: "There's a red light for the next 5 years; now please wait, don't construct until we can arrive at some of the answers which are hinted at here," even if we could guarantee that we would have those answers. I have only one issue to take with Mr. Hoenack, and I don't take it with him personally. I take it with him professionally. I have had the pleasure of a peripheral relationship to the design and construction of our new medical center in Baltimore, which is a \$20,000,000 development. The issue which I would pose for him, because it is again part of our hopes for the future, is that I find the architect a little less than patient with professional interests outside of his field. He asks for operational memoranda, but I almost get the feeling that he asks for them in a perfunctory way. I get the impression that he listens with one ear, but has a fairly effective filter between that ear and the other one, which will not dissuade him from his original intent. There isn't the wholehearted communication, the wholehearted infection of the architect by the necessities of the professional worker in the hospital, be these the surgeon, the X-ray man, the nurse, as I am sure that Mr. Hoenack provides within his particular sphere. I hope he can get out of his sphere and extend that infection. This is a case where I want to disperse the infection rather than to contain it.

The fifth area appears only incidentally in our discussions. Not too much emphasis has been placed upon this particular environmental feature, because it's the closest one. That is the person to person contact - protection of the hospital against the patient and protection of the patient against the hospital and staff. I find in the two-day conference here no great amount of discussion on this aspect, except as to a new type of mask, or the like. The reason I included it as a fifth item not to be forgotten is that one of the great disappointments in the public health field is that personal hygiene has not made any tremendous progress. That is applicable not only to Staph. - it's applicable to polio, it's applicable to the common cold perhaps - to any number of diseases. This lack was dramatized for me some many years ago in the 1930's in the experience with amoebic dysentery in the hotels in Chicago. No one in Chicago management and down the line to the cooks and the bus boys had ever read any of the late Prof. Winslow's papers. They had never read any of the documents that we now get out. I stress personal hygiene here because we still have that job to do.

Many significant things we can do. These have all appeared in your comments. When I rephrase them, I take the responsibility perhaps for rephrasing them inaccurately or badly, but they stem from the two days of this conference. I write off the millennium as impossible -

as a matter of fact, horrifying - mainly the millennium where you have a sterile patient, a sterile surgeon, and a sterile nurse in a sterile hospital for reasons scientific. We aim at something in between and on a selective basis where hazard is perhaps greatest. In our programming for the future, we center on the determination of significance of environmental control in all its elements, the epidemiological approach as balanced against the practicability in all of its essence of accomplishing that control. Two fundamental necessities confront us for the future. Some four or five routes need to be travelled before we will get even partially definitive answers. Some we might get fairly promptly. The first route, obviously, is the one which I think stemmed originally from Dr. Bennett. It has been reinforced by many others, and we have run the risk of having it completely defined as a research opportunity. I have never known of a protocol for research that can be developed by a Sanhedrin, even as expert as Sanhedrin as this group. Detailed definition of protocol for research has been deferred to a more matured and perhaps smaller group. A controlled study of the routes of transmission under the impact of various environmental factors is an early desideratum. A practical way of getting this information pretty fast is by comparing hospital experience and practice with different single factor environmental changes. Certainly in the number of hospitals we have, we ought to be able to get certain controlled comparisons. It would be worth reviewing and rehearsing in the literature all of the experience such as Dr. Mudd mentioned a moment ago. Individual pieces of this information are in the record if we could summon them up and assess their accuracy by going back and checking up this particular missing link. This is a much simpler job than the total one. High emphasis should be placed on that first opportunity. It is long delayed, incidentally, whether it be Staph. or something else. We have referred today, for example, to the earlier history of diarrheal diseases in the nurseries. What became of that record and the lessons which we should have learned from it? Which of those lessons are applicable to this particular problem? I rather suspect that some of them are. Those were records of person to person as well as environmental collapses, perhaps collapses of the simplest type. At any rate, let's find out again in some detail. There is always a great advantage, as Dr. Phillips pointed out, in going back in the history to rediscover what we perhaps forgot. Their ethylene oxide is an example of an earlier discovery, now applicable to a modern problem.

The second route again in the area of research, emphasizes the fact that an evaluation of the past should be coupled with a field approach to the future. The two together have significance. The second is a quantitative bacterial study of the different special areas, surgeries, nurseries, and the like, in selected hospitals. What, in fact, is the situation in those selected areas if we do not do anything, if we do not change anything? This is the base for some exploration. What is the biological situation in the environment at Cornell, at Hopkins, Pennsylvania, Chicago, and elsewhere? Not at all

of them, but at a half a dozen of them - what do they show under the schemes of control which they already have? I wish that had been done before the patterns of control have become more self-conscious even over the last year, but let's do it as well as we can.

Route number three is an evaluation of the ventilation mechanisms for special areas. How does one do what one intuitively or logically thinks would be worth doing, measured against the bacterial result, if we do it in small controlled areas? This does pose a tremendous financial problem, a tremendous personnel problem, but is within the framework of a reasonably successful experimental approach.

Number four is an evaluation of housekeeping procedures - again, with selection and in an attempt to try to answer Mr. Kilpatrick's question with respect to bacterial density. What happens to his new device, the combined wet and vacuum procedure? It may lead to a procedure which is easily correctible in the machine that does your bacterial job successfully, or it may not. At any rate, there are certain primary things that could be studied on a selective basis, with particular reference to the movement of bacteria.

I put the next route fifth almost because it may not have quite the priority that the epidemiological diagnosis may disclose. It is an evaluation of housekeeping materials. Such an evaluation with respect to bacterial problems is urgent, simply because we spend in our country large amounts of money on housekeeping materials. With this in mind, for example, it is an interesting thing that the fabrics in use in hospitals for all purposes are largely the same orthodox fabrics of a hundred years ago. I raise the question as to whether under the conditions that we may set up, under the criteria or specifications that we may establish in the future, are those fabrics best adapted to our purposes? This is not a purely hypothetical question. In our studies of the laundry at Los Alamos and at Oak Ridge, handling highly radioactive materials, one of the first things that confronted us in the initial studies was the fact that ordinary soap and water often did as good a job as most of the proprietary compounds. Secondly, it soon became apparent that there were significant differences in materials as to the capacity to wash them adequately and to remove radioactive materials. In similar fashion we might well ask in hospital practice why the woolen blanket, why the particular white gown of a certain fabric - is it the best for purposes other than history? In other words, if you compare the evolution of fabric design in hospital or laboratory practice, with the design for man and his suit and the wool in his fabric, for washing, for holding, for life purposes, the latter are designed with specifications of a synthetic nature. I can find no counterpart in hospital practice insofar as materials for hospital use are concerned. We are often the victims of the material of the orthodox and of history. This is a good time to look at that again. Maybe we can simplify the mattress, linen and blanket problems.

When one visits the hospitals, say in England and France, he observes that they have the heritage of heavy linen covers for hospital beds. These linens weigh a ton, and are beautiful in fabric. They are also very difficult to wash and one wonders why they cling to them. Probably, it is because they had them and they never wear out. We can be in a position where we may, as our fabrics wear out, provide new kinds.

These proposals for investigation, research, for a reinventory of the past, coupled with field opportunities for research, will all fail unless we have some kind of continuity of clearing house. You might very well say, what's the matter with the American Hospital Association, the APHA, the hospital, and the medical society? The difficulty is that these institutions are not geared to pursue the subject for some years and on many fronts. A second difficulty, unless you consciously set out to correct it, is that the interdisciplinary meeting of minds at regular intervals, and persistent and repeated effort are not provided. I therefore propose, without having done more than discuss it tentatively with a few of you, that the conference propose that some machinery be provided for the continuity of action, for the extension of research, literally from the farming out of such research, for the appraisal of the findings of such research, for developing criteria, and for assessing the priorities for control of environment which stem from this continuous inquiry. It is suggested that the National Research Council be requested either to set up anew such a committee or to assign this particular obligation to an existing committee, expanded in whatever directions appear to be necessary. Such a function the Research Council can determine for itself, once we have placed before them the necessity of continuity of action in this particular area. This is exactly a mechanism which has been used in other fields with the Research Council, and with great success. It will provide a clearing house for all the functions discussed. It provides for recognizing the problem and then hunting around and finding the groups of people who are willing to tackle it on the various fronts. The successes are high. It would provide the multidiscipline forum which this conference illustrates, but which has a tendency to disappear at the end of each conference. Conferences have a habit of preparing excellent documentation. Participants then go home on the assumption that, having printed something, something has been accomplished. Such need not be the case. I offer, Dr. Anderson, to the group a device for continuity of approach to the series of issues posed here, to the research opportunities gleaned from it, and to the opportunity for multiprofessional interchange of points of view.

## GROUP SUMMARY

### Discussion and Comments

Dr. Anderson: Do any of you have things you would like to say regarding what Dr. Wolman has stimulated here? Do you wish to discuss his recommendation? Would you please restate it Dr. Wolman?

Dr. Wolman: That the National Research Council be requested to set up either a new committee, or assign the problem to an existing committee, amplifying that committee's membership if necessary, and make its responsibility a continuous review of the problems proposed at this conference, as well as the September conference, but primarily this one which deals with the environmental issues.

Dr. Anderson: I would like to point out, in connection with this resolution, that we have the National Research Council here as a co-sponsor of this meeting, as we did at the September meeting, and we have here Mr. Whittaker, the representative of the NRC. Possibly he should talk about his views on such a resolution.

Mr. Whittaker: I do not know that I can add anything material to what Dr. Wolman has said except possibly to explain that the Division of Medical Science of the NRC as set up administratively, is designed to take various types of problems for review and recommendations. Whether this is a problem that the Division would be willing to accept is something that would have to be determined. Dr. Wolman is Chairman of the Committee on Sanitary Engineering and Environment which would probably be more concerned with such environmental problems than any of the other committees in the Division. No doubt if the proposal were accepted that would be one of the logical committees to be considered, but that does not mean that other committees could not be set up for the purpose.

Dr. Wolman: The only thing that I left open was where it would turn up in the particular structure of the Division of Medical Science. I can conceive that there could be an ad hoc committee created by the Division, could be an offshoot of our own committee, or an ad hoc group in that committee. I think much depends on the views of groups such as this and the view of Dr. Cannan, particularly, within the Research Council.

Dr. Langmuir: Would this be for staphylococcal disease or all hospital-acquired infections?

Dr. Wolman: Well, I'm more of a gradualist as you probably detect. To embrace the entire field of hospital infections might be structurally possible and then break it down into the individual groups. I don't think this is wholly because I am geared to environmental practice, but I think it is a more manageable first attack for diagnosis.

Dr. Langmuir: It is very apparent that the other committees, both the AMA and AHA, have not given due attention to the environmental side of the problem, and this is needed.

Dr. Wolman: There is perhaps a greater emphasis on the medical and biological side, perhaps even a greater recognition, and therefore I hemmed it in the environment because it is the one that gets least attention. It is also the one that is most difficult to appraise.

Dr. Langmuir: I recognize a very real need for this committee as compared to the AMA or the AHA, which were considering professional problems that they saw. They were defining existing knowledge and focusing attention on problems. But this has real research potential - a long term coordination of new things to be brought to bear and very careful evaluations that have to be forged out over a good many years. I do feel, though, that this group has not been adequately represented in the sense that we have no pediatricians or surgeons in the group here. We've done an awful lot of talking for these people without giving them an adequate hearing. I see many reasons for the environmentalists having sufficient identity to carry through. If they don't, you might have the surgeons, the pediatricians, and the medical epidemiologists run wild around the human source only, and environment may suffer a second rating.

Dr. Wolman: You're going to have the opportunity to determine whether that's true and it may turn out to be true.

Dr. Anderson: I'd like to ask a question here. I wonder if your resolution or your recommendation takes cognizance of the fact that this particular meeting grew out of a conference sponsored by the NRC and the PHS on the problem of hospital-acquired staphylococcal infections, at which time it was recognized that we really needed information on the environmental aspects. I wonder also if it recognizes the fact that monies have been appropriated for research - better than a million dollars to the Institutes of Health for studies on staphylococcal infections of all sorts, and that the Study Sections have been reviewing what is known and what should be done. I believe the NRC is invited to those though I'm not certain of that. With regard to some of the operational aspects, our own staff here is already at work and the question that I am coming to is, do we throw all this overboard now and back completely out of the field or what?

Dr. Wolman: No, Dr. Anderson. You are describing with great accuracy the underpinning of the kind of machinery that I was describing. Our NRC committees in a sense are not only dependent upon all the forces you are describing but, in fact, make maximum use of those resources. For example, if we have a problem in the environment which requires rather detailed study, no Research Council committee does the research. It says the Navy, for example, has the opportunity to do this with great wisdom and facilities and the money. We therefore most successfully ask the Navy if they would undertake this for the reasons that may be useful

in the environment. We have an awareness that the Public Health Service, through many of its routes and devices, is already doing a number of these things. The committee's primary function would be to detect the areas that are not being covered, if there are any; secondly, to corral the results and appraise them; and, third, hopefully, to lead ultimately to applications.

Dr. Mudd: It seems that this would provide a multi-disciplinary continuous oversight in a field that has been neglected, in which there have been faulty communication and wide differences of opinion. I don't think at all, Dr. Anderson, that this would in any way make supplying this from other programs unnecessary.

Dr. Wolman: It is absolutely dependent on a maximum of work by existing public and private agencies.

Dr. Mudd: It is my personal conviction that the whole question of immunology, the whole relationship of staphylococcal disease is enormously in need of renewed interest and focus of attention.

Dr. Wolman: The most the committee might have done if it existed would have been to point out the significance of that necessity.

Dr. Mudd: Dr. Anderson, I think this should be in a sense a collaboration. Nobody wants CDC to abdicate its leadership in this field.

Dr. Anderson: Suddenly I'm confused, because we've been going along, the NRC and the PHS, on a joint endeavor. Now, I'm not certain if it's being suggested that the PHS back off and the NRC and its committee mechanism tell us what to do and tell the Navy and the Army what to do. You see, I'm in the part of the Public Health Service that doesn't give away money. We have direct operating commitments to carry out, and one of the things that we are committed to Congress on is progress in the field of control of hospital staphylococcal infections. To wit, we had a conference of a certain group to start off in September. It led to a meeting of this group and we don't think this is the last meeting that we should hold with regard to staphylococcal infections. I'm just sorry that the conference didn't result in more specific information that we could go on and say: "This will produce some effect on the staphylococcal infections in the hospital." We didn't expect, though, really that we would produce an awful lot, but this is the direction in which we hope to go here in the Communicable Disease Center. So this is my point, Dr. Mudd. I'm not certain whether NRC and the PHS still have relationships here of the sort that have been built up over the past 9 months on this problem, or do we fracture those off?

Dr. Mudd: May I just state what I think I was moving in terms of Dr. Wolman's resolution. I think I was moving, and I certainly want to move, that there be a special implementing interdisciplinary organi-

zation within the NRC to cooperate with the splendid leadership which you have already exercised and which I hope you will keep on exercising. That's what I'm trying to say. Not that you be excluded, but that you be given a little interdisciplinary continuity which will help you.

Dr. Wolman: I certainly drifted unsuspectingly into a failure to recognize, or to make clear, that all that we're proposing is a device that will not lose the values that come out of these conferences of which you may call a dozen in the next year, and which I hope you will. I cannot overemphasize that fact - that you might call them - you might multiply them - you might report on findings and the like. The sole purpose of the NRC committee, if one were created, would be to entice similar activity that would parallel yours or would be covering an area that isn't already covered. This may extend to the Navy, the Army, the Cleveland hospital, or the Hopkins hospital and the like.

Dr. Simmons: Isn't this recommendation made on the premise that there is a need for a more or less permanent organization?

Dr. Wolman: Permanent to this extent, none of the committees of the Research Council are permanent and that's a good thing, because when the answers to what we are after have emerged, whether it's 1, 2, or 3 years, depending on our optimism, the ad hoc committee disappears. We have an example. We created a committee in NRC in the mosquito field during the war period. We were anxious to drive people into a study in the physiology of mosquitoes. You might say, why in the world did they need driving. The reality indicated that they didn't. They needed driving because most people working in the mosquito field were not doing fundamental physiological research. It was our judgment, which we believe has now been fairly well ratified, that that was what we were waiting for, and all the effort went through NIH grants, through Army grants, Navy grants, to get people of competence in the physiological field to devote themselves to that. Now, that committee has been, not abandoned, but put up on the rack in disuse until we have another reason for reviving it.

Dr. Simmons: I think the non-departmental status of the NRC is a very desirable feature for a committee of this sort. If there were to be another meeting held and that was the end of it, then I don't think it would be worth while to set one up, but, if it is foreseen that it will be needed over the next number of years, then I think NRC is the appropriate organization for a committee of this type. It should draw its membership from the various governmental and non-governmental people who are working in this field, to give it proper impetus, direction, and prestige.

Dr. Wolman: It makes known to the Surgeon General of the Army, the Navy, the Air Force and the Public Health Service that this is an area which is empty. I might indicate, just by way of interest, that the

Public Health Service has on more than one occasion asked our Committee of the Research Council to carry forward a joint operation, not of research, but a joint discussion for a very interesting reason. They could get out the same group of invitations, but they felt that in going into multiple agencies, private and public, NRC had a better opportunity, perhaps, of getting them all in to sit and discuss the problem. The Public Health Service then returns to its base and picks out the things that its people can do best. I was a little afraid, in summarizing this, that if we summarized a set of frustrations and then coupled it with a set of prospective hopes in investigation, we might leave you with no machinery by which to keep up a broad appraisal of it as time goes on, either through your device or through additional ones.

Dr. Simmons: I have an idea that a new committee, if one is needed, would be better than to detail it to an existing agency because you have so many people interested in this problem who are not connected with existing committees.

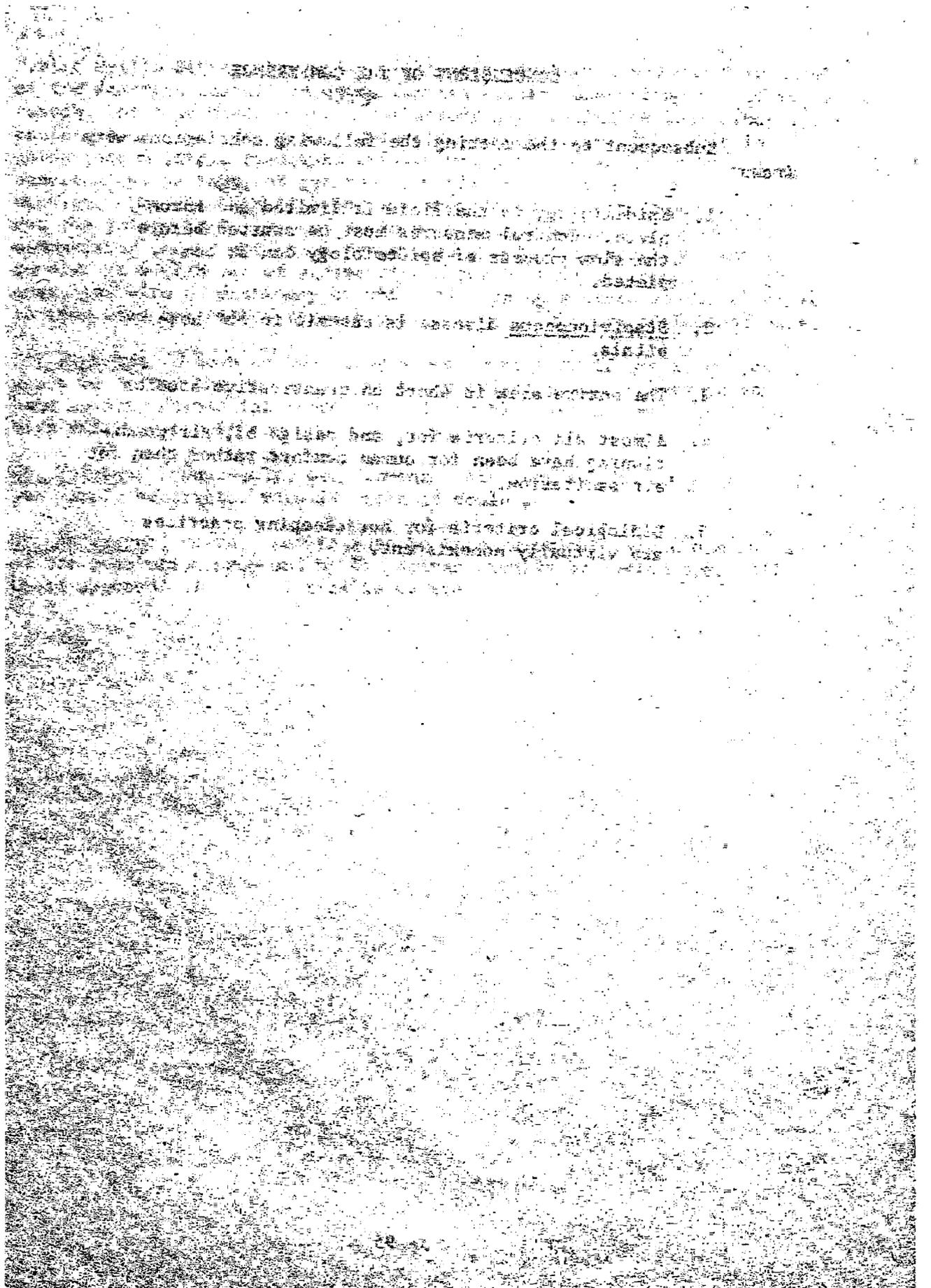
Dr. Wolman: I purposely, Dr. Simmons, left that to the conference. I was merely describing ways in which it could be done.

Dr. Anderson: Do you want to vote on this question? All those in favor of the resolution proposed by Dr. Wolman signify by saying aye. All those opposed? The resolution is carried.

## CONCLUSIONS OF THE CONFERENCE

Subsequent to the meeting the following conclusions were drawn:

1. Epidemiology in the field is limited and incomplete. Control measures must be started before the slow process of epidemiology can be completed.
2. Staphylococcus disease is endemic in our hospitals.
3. The entire area is short on quantitative studies.
4. Almost all criteria for, and design of, air conditioning have been for human comfort rather than for air sanitation.
5. Biological criteria for housekeeping practices are virtually nonexistent.



**APPENDIX A**  
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1950

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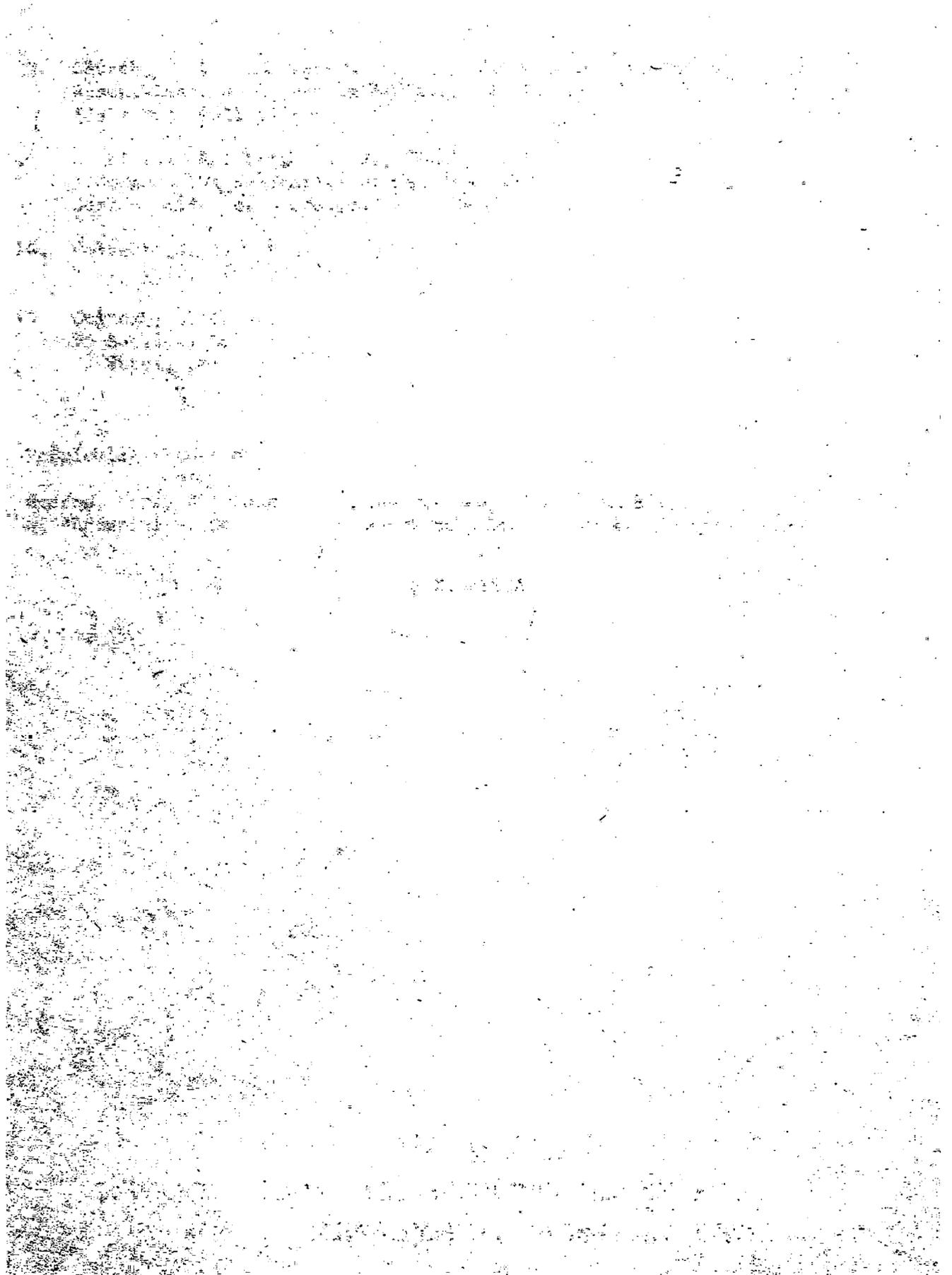
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Hudson, Perry B., Sanger, G., and Sproul, E. E.: An Effective System of Bactericidal Conditioning for Hospitals. J.A.M.A., in press (1959).

**APPENDIX B**

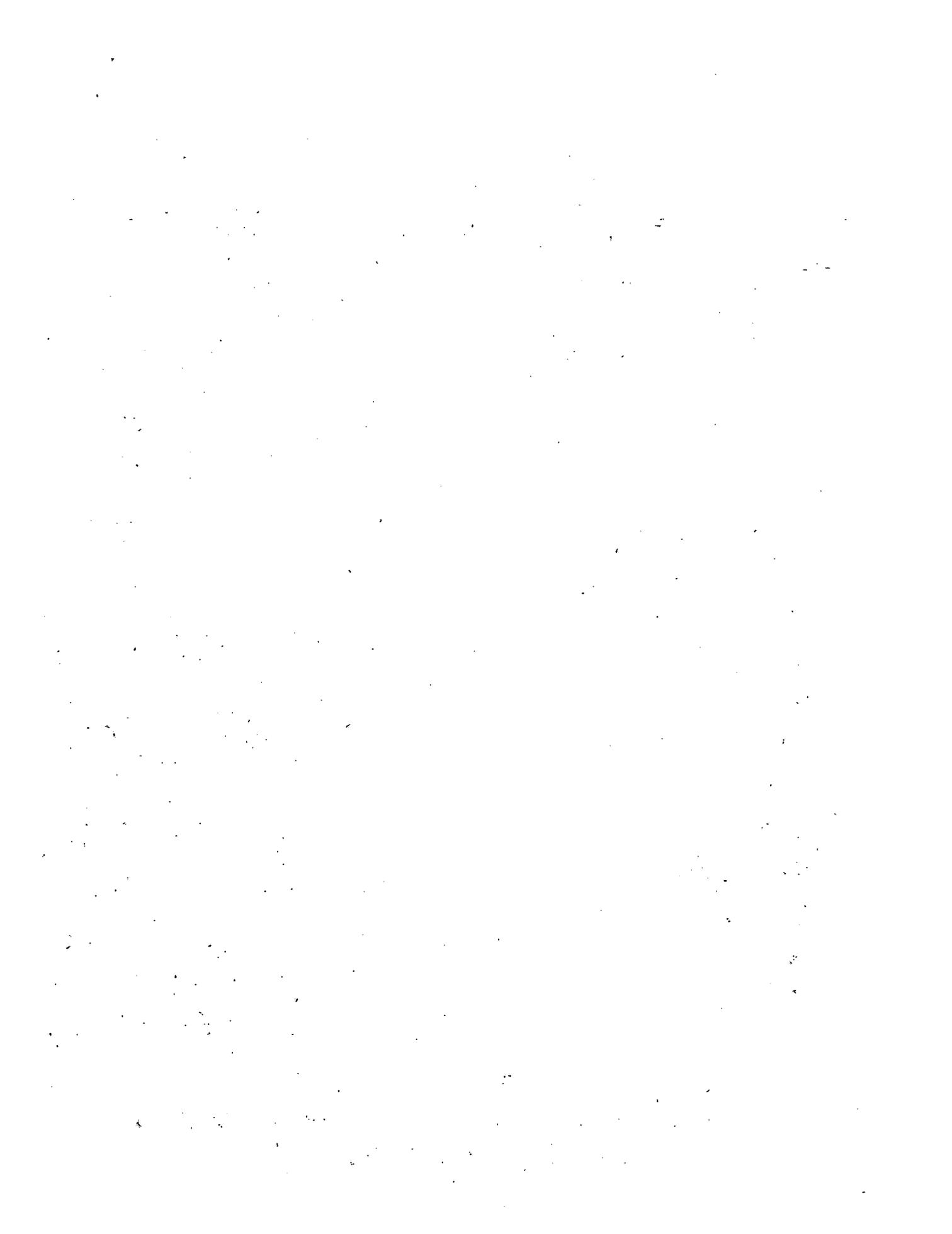
**Illustrations**

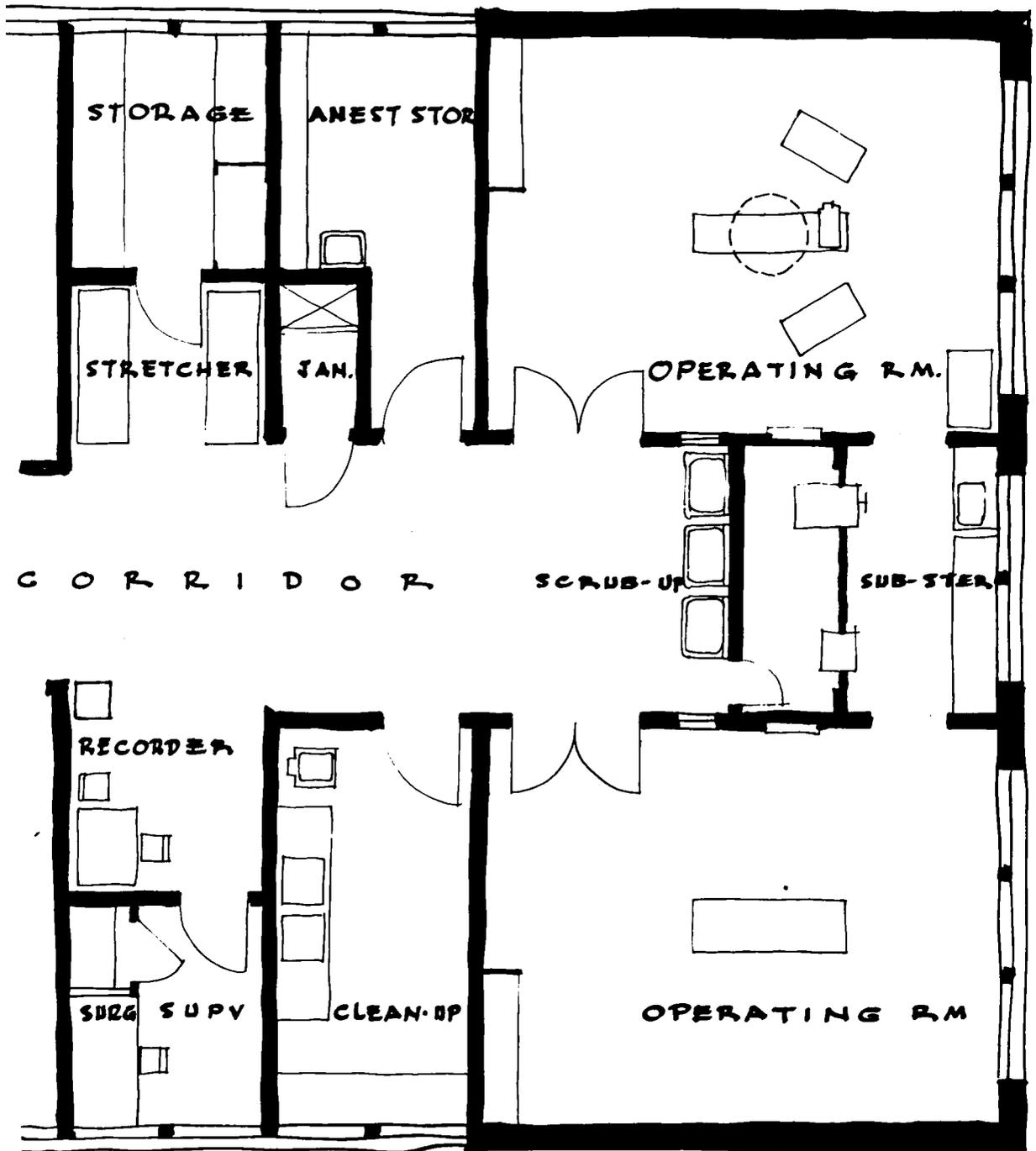




## ORO-NASAL MASK

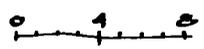
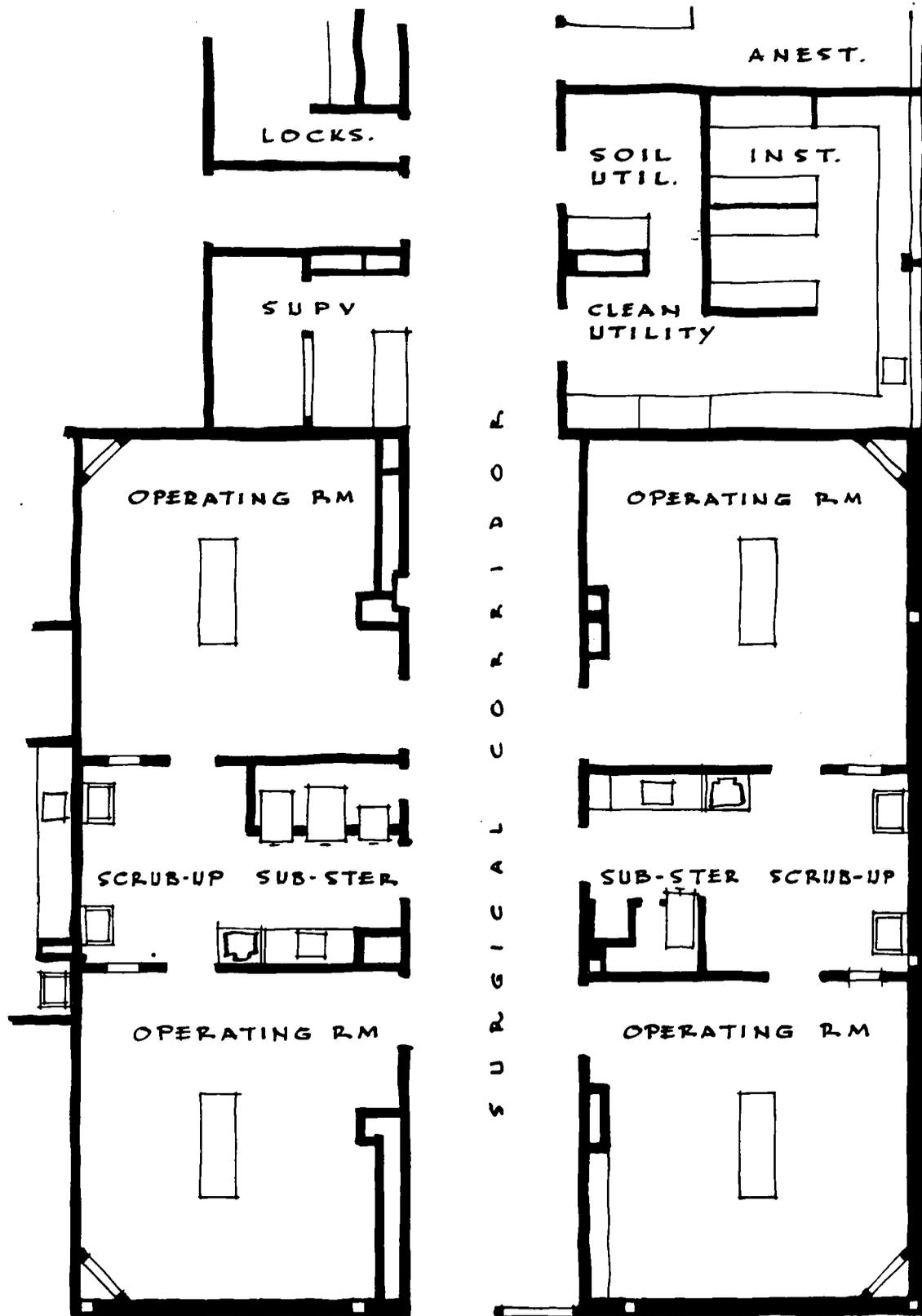
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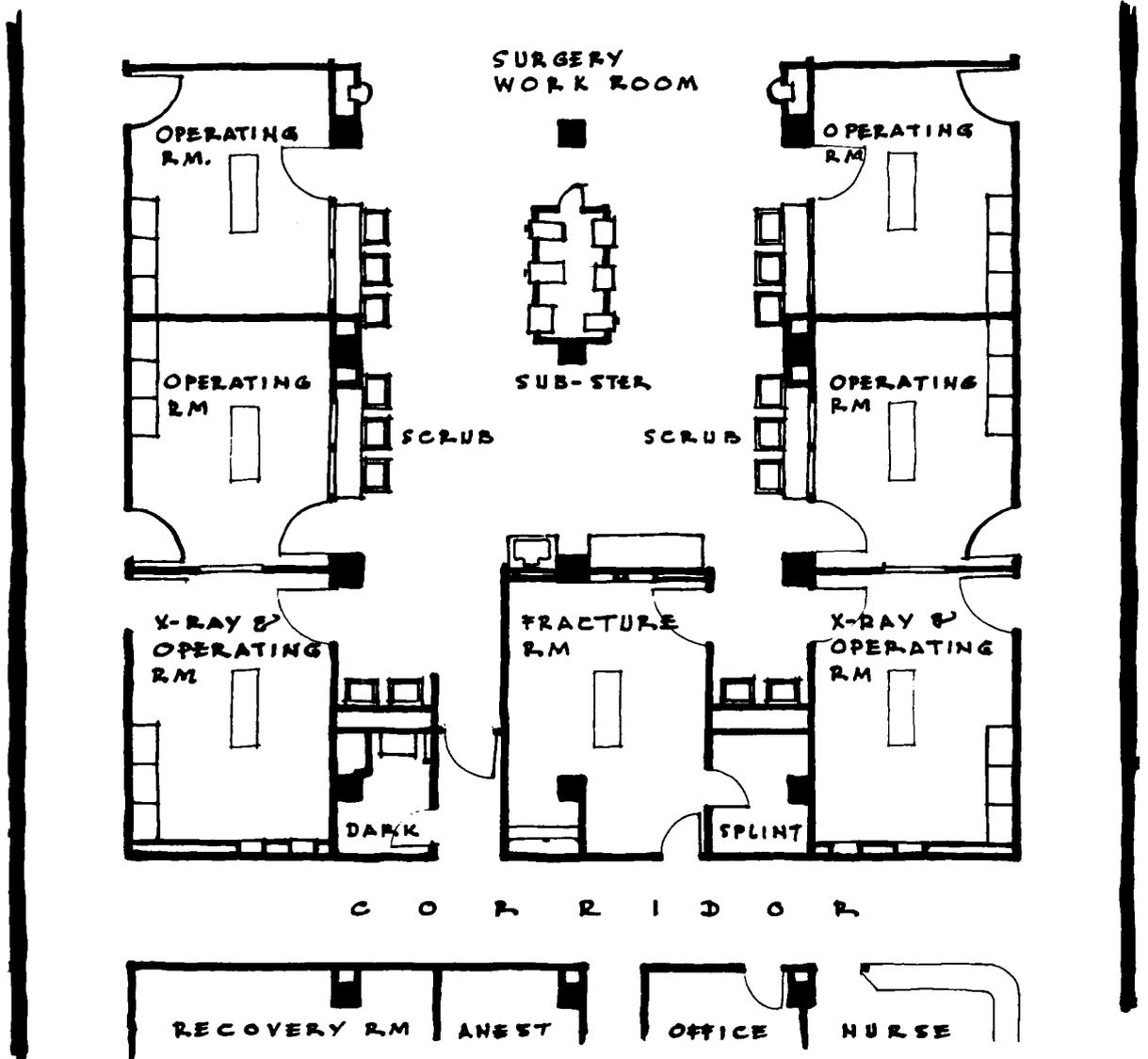


# HOSPITAL DESIGN

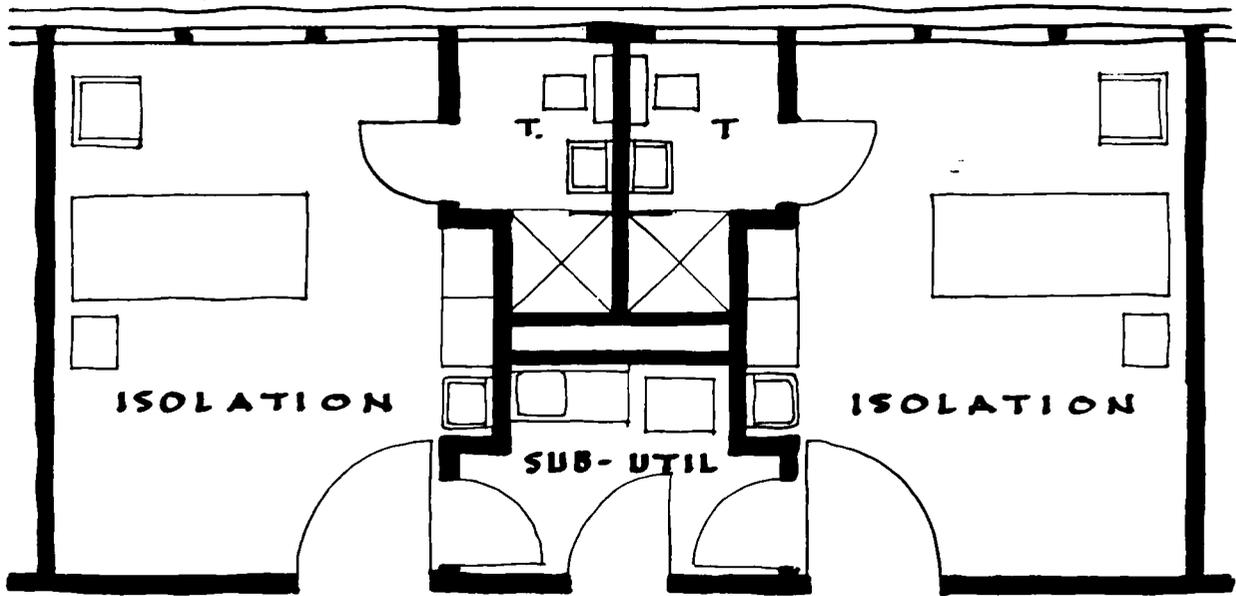
PLAN NO. I: SCRUB-UP AND SUB-STERILIZING AREAS BETWEEN OPERATING ROOMS



**HOSPITAL DESIGN**  
**PLAN NO. 2: SURGERY--COMBINED SCRUB-UP AND**  
**SUB-STERILIZING AREAS**



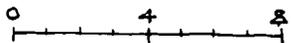
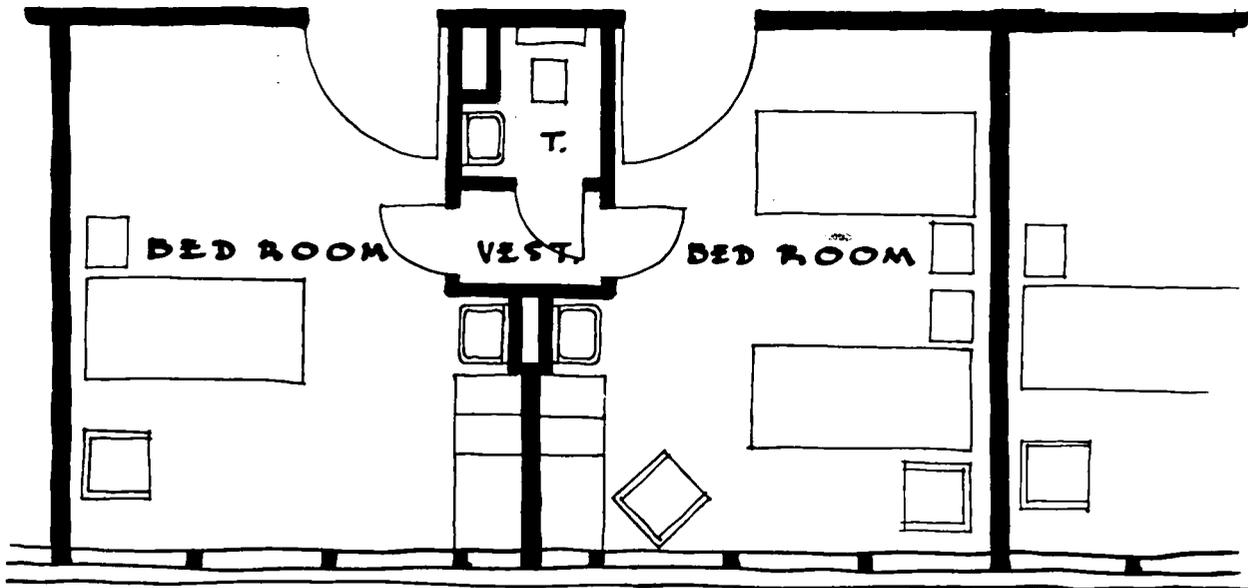
**HOSPITAL DESIGN**  
**PLAN NO. 3: SURGERY WITH CENTRAL WORK ROOM**



CORRIDOR

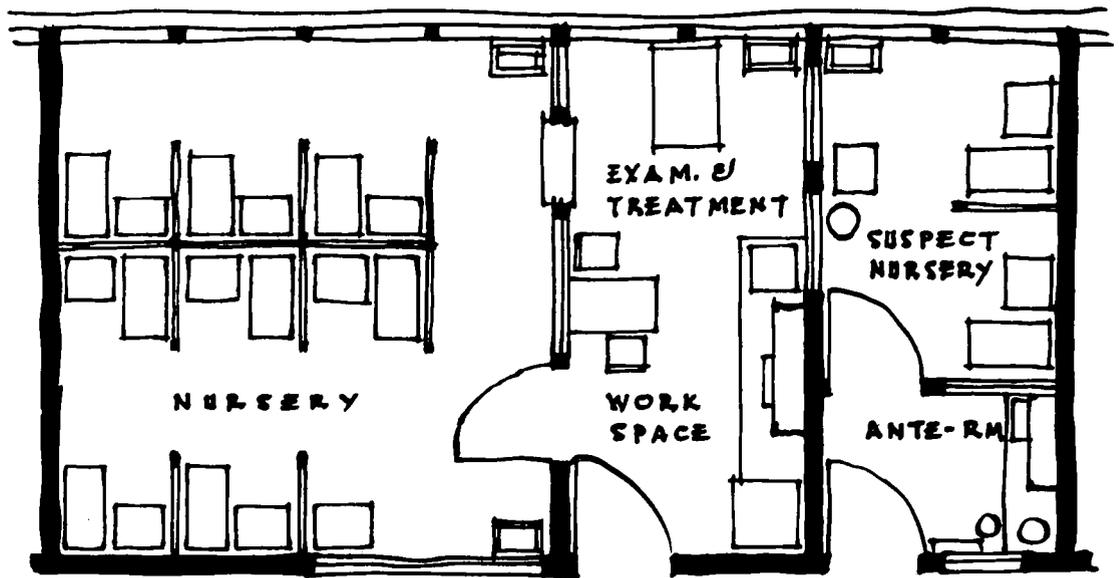
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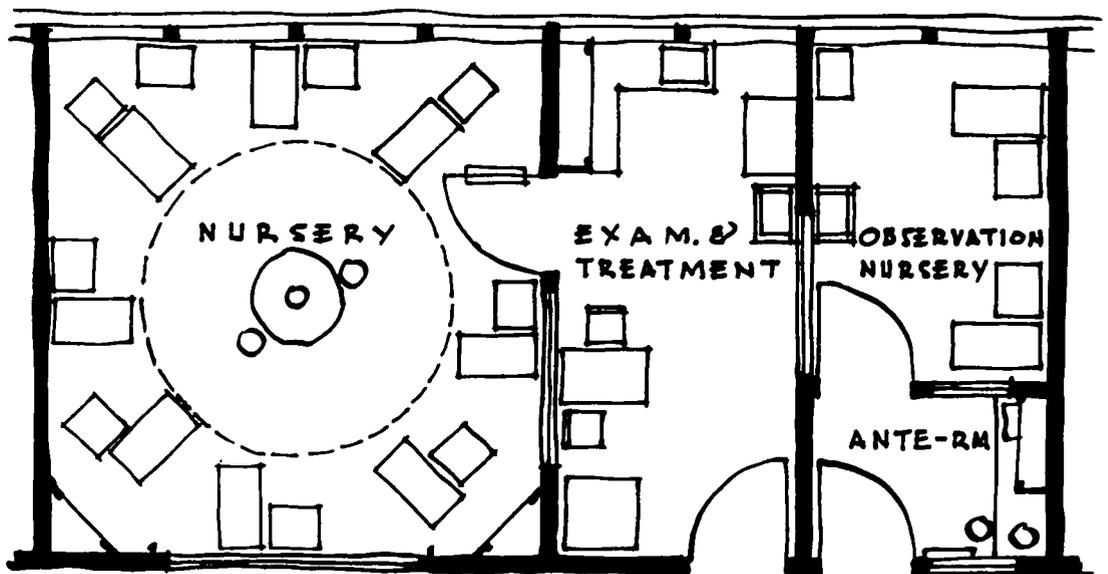


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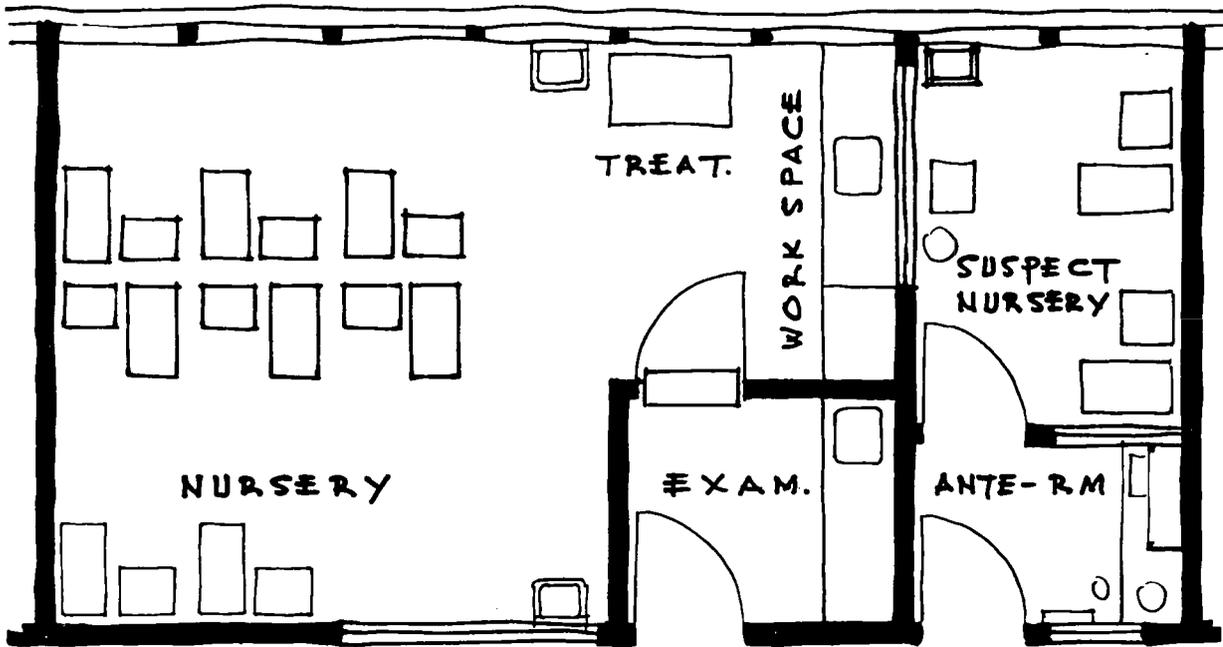
PLAN NO. 5: TYPICAL BEDROOMS



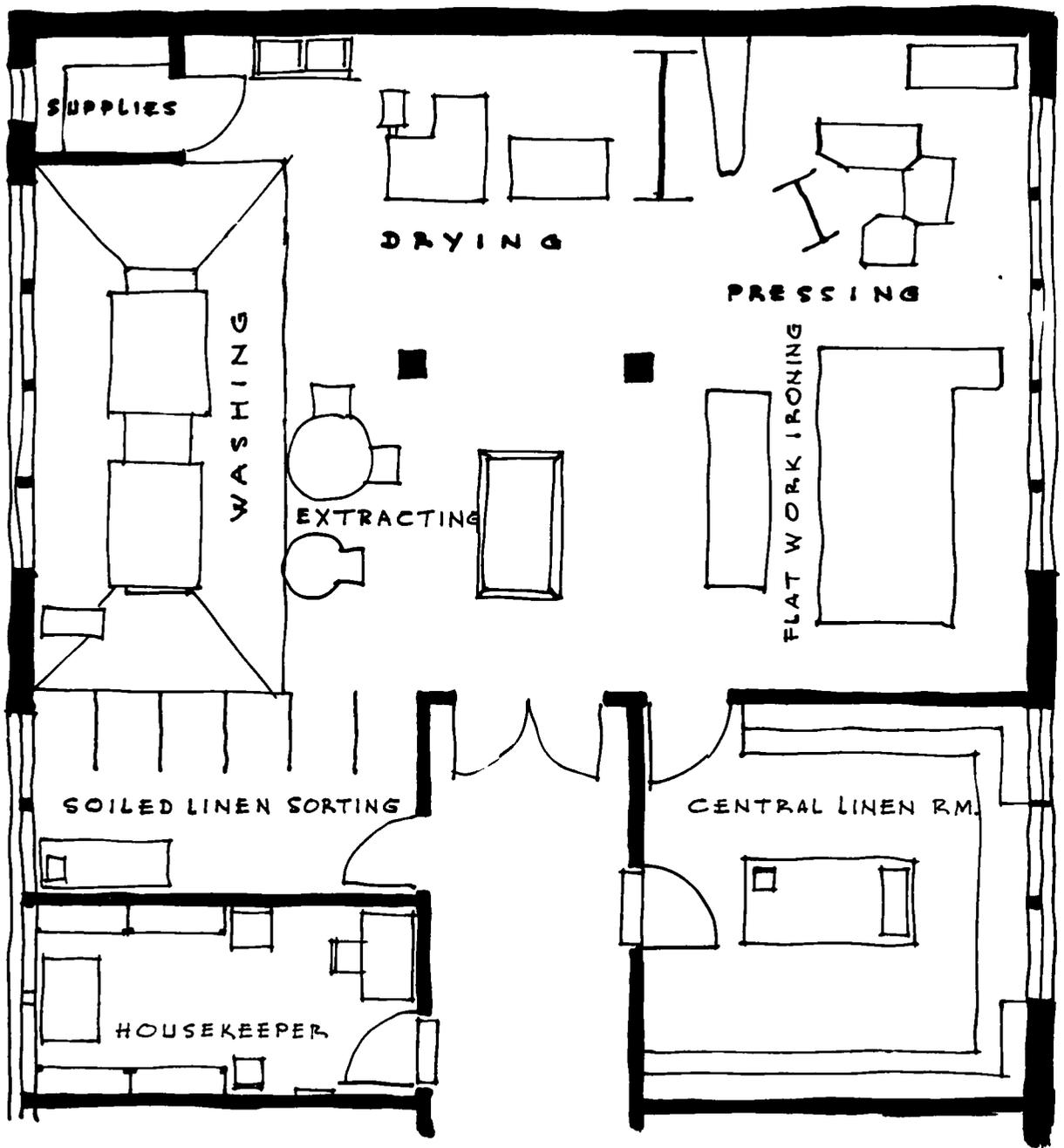
**HOSPITAL DESIGN**  
**PLAN NO. 6: CONVENTIONAL NURSERY**



**HOSPITAL DESIGN**  
**PLAN NO. 7: NURSERY WITH CIRCULAR WASHBASIN**  
**IN CENTER**

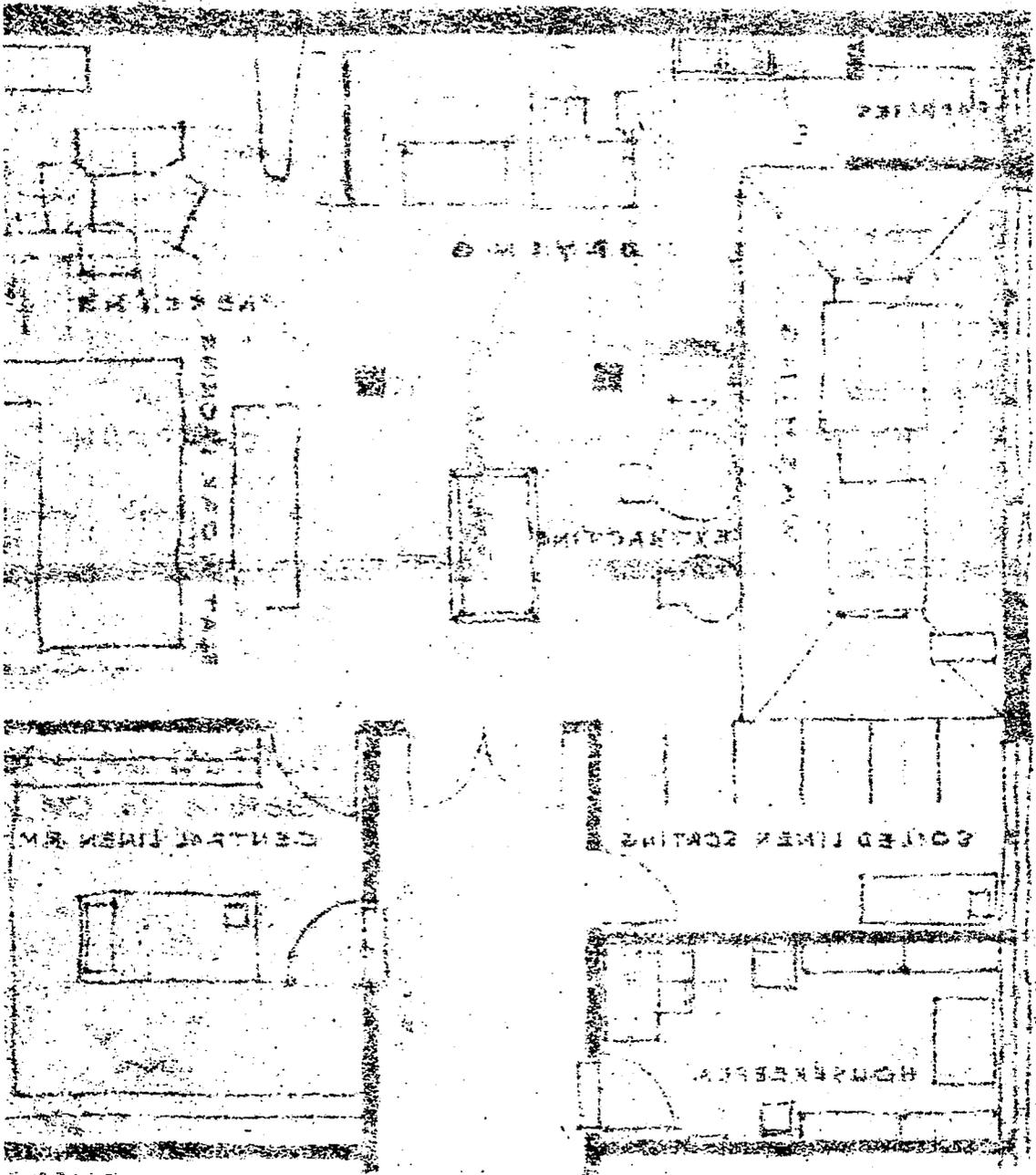


HOSPITAL DESIGN  
PLAN NO. 8: NURSERY



# HOSPITAL DESIGN

PLAN NO. 9: LAUNDRY--100-BED GENERAL HOSPITAL



PLAN NO. 91 LAUNDRY-100 BED GENERAL HOSPITAL  
 HOSPITAL DESIGN

**APPENDIX C**

**Hospital Design Features  
Affecting Maintenance of Asepsis**

11.

... and the ...  
... of ...

**HOSPITAL DESIGN FEATURES  
AFFECTING MAINTENANCE OF ASEPSIS**

**Department of Health, Education, and Welfare  
Public Health Service  
Bureau of Medical Services  
Division of Hospital and Medical Facilities  
Washington 25, D. C.**

**March 1959**

**HOSPITAL DESIGN FEATURES  
AFFECTING MAINTENANCE OF ASEPSIS**

The hospital represents a complex of areas and a complex of services rendered to the patient. In designing a hospital among the factors that must be considered is the problem of infection and its possible spread through the hospital. Good design practice must therefore place emphasis upon those functions performed in the hospital which may contribute to infection and the areas in which such functions are performed. Among the most critical areas are the following:

**I. Surgical Suite**

- A. Operating rooms
- B. Cleanup room
- C. Janitor's closet

**II. Obstetrical Suite**

- A. Delivery rooms
- B. Cleanup room
- C. Janitor's closet

**III. Nursery**

- A. Nursery proper
- B. Examination and treatment room
- C. Work space
- D. Suspect nursery
- E. Premature nursery

**IV. Nursing Unit**

- A. Treatment room
- B. Isolation suite
  - 1. Patient rooms
  - 2. Subutility room
  - 3. Toilets
- C. Utility room
  - 1. Dirty functions
  - 2. Clean functions
- D. Janitor's closet
- E. Pantry

F. Patient rooms

1. Toilet

V. Emergency Suite

VI. Central Sterilizing and Supply Room

VII. Kitchen

VIII. Laundry

IX. Morgue and Autopsy

Each of the above areas is discussed below as to equipment required for good aseptic practice. The items with no asterisks indicate mandatory regulations as administered under the Hospital and Medical Survey and Construction Program.

I. SURGICAL SUITE

and

II. OBSTETRICAL SUITE

These suites, because of the functions performed and the necessity for maintaining strict asepsis, are located to prevent traffic through them to any other part of the hospital and are completely separated from the emergency department. Within the hospital they are completely separated from each other, but are here discussed together because of the similarity of design.

A. Operating rooms

1. Major
2. Cystoscopic\*\*
3. Fracture\*\*

B. Delivery rooms

C. Auxiliary rooms (common to both areas)

1. Cleanup room

Provides facilities for immediate disposal of waste and cleanup of equipment

2. Substerilizing room

Eliminates travel to nonsterile areas for instruments or supplies if required

\*\* Recommended

3. Scrub-up area

Adjacent to operating rooms

4. Janitor's closet

Provides supervision of equipment and supplies and restricts use to this area

5. Doctors' locker room

Change of garments within this area

6. Nurses' locker room

Change of garments within this area

D. Appurtenances affecting aseptic control

1. Plumbing

a. General

- 1) Faucet spouts above rim of fixtures  
Prevent back siphonage and contamination
- 2) Elbow, knee or foot action valves  
Prevent contact contamination of hands
- 3) Sterilizers and stills require indirect waste connections and thermometers on steam return line.  
Prevent back siphonage and contamination and insure proper temperature in sterilizer
- 4) Floor drains should not be permitted in this area

b. Fixtures\*\*

- 1) Surgeons scrub sinks  
Adjacent to operating rooms
- 2) Clinical sink  
In cleanup room for waste disposal  
Sink trap should have a fresh water seal
- 3) Double compartment laundry trap with double drain-board\*\*  
For instrument cleaning

\*\* Recommended

- 4) Lavatories  
In doctors' and nurses' locker rooms
- 5) Water closets  
In doctors' and nurses' locker rooms
- 6) Shower baths\*\*  
In doctors' and nurses' locker rooms

## 2. Ventilation

- a. A minimum of eight air changes per hour of outdoor air
- b. Air filters installed to prevent leakage around frames\*\*
- c. Humidity control equipment
- d. Forced system of air exhaust
- e. Air exhausted near the floor to reduce turbulence and remove heavy gases\*\*
- f. Sterilizing equipment chambers ventilated by exhaust from rooms
- g. Operating and the delivery rooms pressurized relative to the outside and to adjoining corridors to prevent inflow of air to aseptic area\*\*
- h. Adjustable for recirculation of air when not in use\*\*

## 3. Interior finishes

The entire area to be finished with waterproof floors, walls, and ceilings to facilitate cleaning and disinfecting.

### III. NURSERY

This area is provided for the individual care of newborn infants who, because of their susceptibility to infection and lack of metabolic adjustment, must receive maximum care. The area must be designed for efficient service and must provide an aseptic environment.

#### A. Full Term Nursery

1. Not more than 12 bassinets per room  
Eight bassinets recommended\*\*
2. Not less than 24 square feet per bassinet  
Thirty square feet per bassinet\*\*
3. Physical barrier between bassinets to prevent overcrowding and as a reminder of technique\*\*

\*\* Recommended

4. Hook strip at each bassinett\*\*
5. Minimum of one examination and workroom between each two full term nurseries  
A workroom for each full term nursery\*\*
6. Entrance to nurseries through the workroom to restrict entrance to authorized personnel\*\*
7. Plumbing  
One lavatory with gooseneck spout and knee or elbow action valves for each nursery  
Two lavatories for each nursery\*\*
8. Piped oxygen system\*\*  
To eliminate need for nonsterile oxygen cylinders in the nursery areas
9. Ventilation\*\*  
Ventilated by using outdoor air at the rate of three changes per hour with recirculation within the area. No air from other areas of the hospital should be permitted in this area.

#### B. Suspect Nursery

This nursery provides temporary care and isolation for the newborn who develop unusual clinical symptoms. After diagnosis they are removed to the proper treatment area.

1. Completely separated from other nurseries; entered only through an anteroom
2. Not more than six bassinets per room
3. Not less than 40 square feet per bassinet
4. One workroom for each two nurseries
5. Plumbing
  - a. Sink in counter with gooseneck spout and knee action valve\*\*
  - b. Lavatory with gooseneck spout and knee action valve

\*\* Recommended

6. Equipment\*\*

- a. Hook strip for gowns
- b. Sanitary waste receptacle
- c. Linen hamper

7. Ventilation\*\*

Outdoor air should be used for ventilation with no recirculation

C. Premature Nursery

This area is provided for the premature infants who, because of their prematurity and lack of development, require intensive care and special environmental conditions in order to continue their development. The area is usually separated from other nurseries.

1. Not more than six bassinets per room

2. Not less than 30 square feet per bassinet

3. One workroom for each nursery

4. Plumbing\*\*

One lavatory with gooseneck spout and knee action valves

5. Equipment\*\*

- a. Hook strip for gowns
- b. Sanitary waste receptacle
- c. Linen hamper

6. Ventilation\*\*

Outdoor air should be used for ventilation with no recirculation

D. Examination and Treatment Room

This area is provided principally for the use of doctors to examine the infants. It eliminates the necessity for entrance to the nursery proper. A sliding window or dutch door is recommended for passing babies from the nursery to the examination room.

1. Equipment\*\*

- a. Sanitary waste receptacle
- b. Hook strip for gowns

\*\* Recommended

2. Plumbing\*\*

One lavatory with gooseneck spout and elbow or knee action valves

3. Ventilation\*\*

This area is ventilated the same as the full term nursery, but the pressure should be negative in relation to the nursery proper and positive in relation to the corridor.

E. Work Space

The space is primarily a work area for the nurse to perform necessary preparations for care of the infant. It serves as the entrance to the nursery and provides control of the entrance.

1. Plumbing

Sink in a counter with a gooseneck spout and knee or elbow action valves\*\*

2. Equipment\*\*

- a. Refrigerator for storage of formulas
- b. Instrument sterilizer
- c. Bottle warmer
- d. Hot plate

3. Ventilation\*\*

This area is ventilated the same as the examination and treatment room.

IV. NURSING UNIT

This area provides complete care for medical, surgical, obstetrical, and pediatric patients. In hospitals of 100 beds or more the obstetrical nursing unit shall be housed in a separate wing or floor.

A. Treatment Room\*\*

1. Plumbing\*\*

Combination instrument and scrub sink

If installed, gooseneck spout and spray and knee action valve

2. Equipment\*\*

- a. Kickbucket
- b. Waste paper receptacle
- c. Sanitary waste receptacle

\*\* Recommended

3. Ventilation\*\*

Supply air for ventilation may be taken from the general system with all exhaust air discharged to the outdoors.

A negative pressure relative to all adjoining areas should be maintained in this area.

B. Isolation Suite

This area is required unless contagious disease nursing unit is available in the hospital, and is usually designed as a pair of rooms with a subutility room between. A single room with private toilet is acceptable.

1. Patient rooms

- a. Lavatory with knee or elbow action valves
- b. Private toilet--water closet with bedpan lugs and bedpan flushing attachment

2. Subutility room\*\*

- a. Utensil sterilizer
- b. Sink and drainboard, knee action valve
- c. Linen hamper

3. Interior finish

Walls and floors must be waterproof to facilitate cleaning and disinfecting

4. Ventilation\*\*

- a. Supply air for ventilation may be taken from the general system with exhaust from the area to the outdoor. Air from this area may be recirculated when the area is not used for isolation purposes.
- b. A negative pressure relative to the corridor and adjoining areas should be maintained.

C. Utility Room

When this room is used for both clean and dirty functions, the procedures performed within the area should be strictly supervised. The area is usually divided by a low partition to separate the two

\*\* Recommended

functions. Because of the possibility of cross infection of materials and equipment being processed, the dirty and clean functions are sometimes completely separated.

1. Plumbing and equipment

a. Clean area

- 1) Sink in counter with gooseneck spout and knee or elbow action valve\*\*
- 2) Waste paper receptacle\*\*

b. Dirty area

- 1) Double compartment laundry tray with drainboards\*\*  
If installed, knee or elbow action valves
- 2) Clinical sink\*\*  
If installed, elbow action valves  
Sink trap should have a fresh water seal
- 3) Pressure sterilizer\*\*
- 4) Sanitary waste receptacle\*\*

2. Ventilation\*\*

Supply air for ventilation may be taken from the general system and recirculated if properly filtered. Air supply should be introduced into the clean area and flow toward the exhaust in the dirty area.

3. Interior finishes

Floor and walls shall be waterproof to facilitate cleaning and disinfecting

D. Janitor's Closet

This room serves an important function in maintaining the general cleanliness of the nursing unit.

1. Plumbing\*\*

Janitor's sink usually at floor level with curb

2. Ventilation\*\*

A ventilation exhaust outlet should be provided in the room, which will draw air from the corridor, thus maintaining a negative air pressure.

\*\* Recommended

3. Interior finishes

Waterproof floor and walls to facilitate cleaning and disinfecting

E. Pantry

This room is provided primarily for in-between meal feeding.

1. Plumbing

Sink in a counter\*\*

If installed, elbow action valves

2. Ventilation\*\*

The ventilation air supply may be taken from the general system if properly filtered. It is important that the supply and exhaust air quantities for the area be carefully balanced so that air is not introduced from the corridor and that odors do not escape into the corridor.

3. Interior finishes

Waterproof floor and walls are required to facilitate cleaning and disinfecting

F. Patient Rooms

These areas may accommodate one, two, or four patient beds. In order to properly care for patients and avoid overcrowding, which presents the possibility of cross infection, the following minimum areas are required:

One-bed room	-	100 square feet
Two-bed room	-	160 square feet
Four-bed room	-	320 square feet

1. Plumbing

- a. Each bedroom--lavatory with gooseneck spout and knee or elbow action valves
- b. Individual toilet room, including lavatory, water closet with lugs for bedpans, and spray attachment\*\*
- c. A lavatory in the bedroom, in addition to the lavatory in the toilet room, for four-bed rooms\*\*

2. Ventilation\*\*

- a. Supply air for ventilation may be taken from the general system with recirculation if properly filtered. However, it is desirable that recirculation be confined to the individual room.
- b. A ventilation rate of two air changes per hour.

\*\* Recommended

3. Interior finishes

Floors must be smooth and easily cleaned

V. EMERGENCY SUITE

The suite, composed of one operating room, vestibule, and toilet, is generally utilized for outpatient service of an emergency nature. Because of the type of service rendered, this area may be the most highly contaminated area in the hospital. It must therefore be separated from the operating and delivery suites and preferably from patient care areas.

A. Operating Room

1. Plumbing\*\*

- a. Clinical sink with fresh water trap and bedpan flushing attachment
- b. Combination instrument and scrub sink with gooseneck spout and knee action valve

2. Equipment\*\*

- a. Waste paper receptacle
- b. Kickbucket
- c. Pressure sterilizer

3. Ventilation

Same as operating room in surgical suite

4. Interior finishes

Same as operating room in surgical suite

VI . CENTRAL STERILIZING AND SUPPLY ROOM

This area contains facilities for the processing and assembling of instruments, packs, and equipment. Sterilizing, storage, and distribution for the entire hospital may be done in this area. The area is usually divided into four spaces, the first three of which may or may not be physically separated: 1) work area for receiving and cleaning unsterile and contaminated materials and for assembling packs prior to sterilization; 2) sterilizing area; 3) sterile supply area for storage and issuance of sterile supplies; 4) a separate area for storing unsterile new unused material.

A. Plumbing\*\*

Sink with drainboard

If installed, knee or elbow action valves

\*\* Recommended

B. Equipment\*\*

1. Dressing sterilizers
2. Water still
3. Hot air sterilizer

C. Interior Finishes

The walls and floors must be waterproof to facilitate cleaning and disinfecting

D. Ventilation\*\*

1. Ventilation air may be supplied to this area from the general system if properly filtered.
2. The flow of air should be from the clean area toward the exhaust in the dirty area

VII. LAUNDRY

A laundry is required unless commercial or other laundry facilities are available. If a laundry is provided, it must meet all codes and the requirements of the State Department of Health for sanitary facilities and operations. It will usually be composed of a processing area, a sorting area, clean linen and sewing room separate from the laundry. However, where no laundry is provided, a soiled linen room and a clean linen room are required.

A. Ventilation

1. A ventilation rate of ten air changes per hour for the laundry proper, with the exhaust air discharged above the roof of 50 feet from any window
2. The soiled linen sorting area should be a separate room with a ventilation rate of eight air changes per hour\*\*with no recirculation
3. A negative pressure should be maintained in this area\*\*

VIII. KITCHEN

This area must include the following services: main kitchen and bakery, dishwashing room, adequate refrigeration, can washing facilities, and a day storage room.

\*\* Recommended

A. Plumbing

1. Dishwashing water at 170°
2. Lavatories in main kitchen and dishwashing room for hand-washing\*\*  
If installed, knee or foot action valves
3. Garbage grinders\*\*
4. Refrigerator drains with supplementary water feed to traps\*\*
5. Floor drains for cleaning operations with supplementary water feed to traps\*\*
6. Steam and hot water connections to can washing equipment\*\*

B. Interior Finishes

1. Floors shall be waterproof, greaseproof, and smooth
2. Walls shall be waterproof, painted, or glazed to a point above splash or spray line; base shall be free from spaces which may harbor vermin

C. Ventilation

1. Ten air changes per hour
2. All exhaust air must be carried above the roof or 50 feet from any window
3. Hoods over ranges for cooking and over dishwashing equipment\*\*

D. Equipment

1. Adequate facilities for washing and for bactericidal treatment of utensils used for eating
2. Adequate cabinets for storage of food, drink, and utensils designed to protect them from contamination by insects, rodents, splash, dust, and overhead leakage

\*\* Recommended

## IX. MORGUE AND AUTOPSY

In hospitals under 50 beds, a morgue and autopsy area may not be required if other facilities are available. Where provided, a mortuary refrigerator is required in the morgue. Because of the functions performed in this area, this location must be considered as highly contaminated.

### A. Plumbing\*\*

1. Combination instrument and scrub sink with gooseneck spout and spray and knee action valve
2. Autopsy table with sink
3. Floor drain with supplementary water feed to trap
4. Shower room with lavatory, water closet, and shower bath

### B. Equipment\*\*

1. Sterilizer
2. Mortuary refrigerator
3. Kickbucket

### C. Interior Finishes

Walls, floors, and ceilings of a type that can be easily cleaned and disinfected

### D. Ventilation

1. Ten air changes per hour
2. Exhaust air discharged above the roof or 50 feet from any window
3. Negative pressure maintained to prevent any exfiltration of air from the area

## LAUNDRY CHUTES

Chutes for the transportation of laundry in multistory buildings are not recommended. They are difficult to maintain in a sanitary condition and may disseminate organisms to the various floors.

\*\* Recommended

**TRASH CHUTES**

Trash chutes for transporting waste are definitely discouraged. They are unsanitary, harbor vermin, and are entirely unsuitable for hospital use.

Discontinued

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