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**PANEL DISCUSSION
OPERATIONS RESEARCH**

Panel Members:

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GORDON D. SHELLARD

EDWARD A. LEW:

It is a great tribute to the business sense of our profession that so many of you have turned out to learn how operations research can aid us in the solution of managerial problems where the usual objectives are better service and lower expense. This panel would not be necessary if these objectives could be accomplished simply by using what we already know.

Operations research is no magic formula, but is merely one of several useful approaches to more effective management. This particular approach is grounded in mathematical analysis but is seasoned with a feeling for organization and common sense. It is timely that we should explore it. Other business enterprises are making increasingly greater use of more scientific tools in management, and it is for us to consider just how much of the new methodologies the actuary should include in his own professional domain.

We need to maintain a balanced view in answering this question. There are both opportunities and serious limitations in the application of operations research to life insurance. This panel will try to enlighten us about the potentialities of operations research in our business. The five panelists will not dwell on specific techniques but will endeavor to give you a better appreciation and some evaluation of the kind of thinking involved in operations research.

Besides our own three actuarial experts, the panel includes two distinguished practitioners of operations research—Professor Sandiford, of McGill University, and Mr. Martin Ernst, vice president in charge of operations research of Arthur D. Little, Inc.

In order to give the presentation greater coherence, we will discuss first some of the problems in the field of home office operations and the

way in which they might be tackled. Then, in the second part of our program, we will continue with applications of operations research to other types of problems.

I now call on Professor Sandiford to make the first presentation.

PETER J. SANDIFORD:

Usually one talks about operations research in one of two categories. He is either in the category that knows more about operations research than the audience does, or he is in the category that knows more about the subject under discussion than the audience does. Unfortunately, in this particular case, I am caught right in the middle, because the last that I learned about actuarial science was thirty years ago from the best lecturer I ever had in my life—M. A. Mackenzie, at the University of Toronto. "Life Contingencies" was his subject; perhaps some of you may remember him. On my right I have people whose writings I used to read in order to find out whether I should get into operations research or not. You can appreciate that it is a very difficult place to be. However, my part is to set the stage for their starring roles.

What I will try to do in this first few minutes is to set forth my idea of what operations research is, talk a little about the systems approach, with the idea of leading into the notion of the home office as a system, and put forward a few ideas about the way in which I think operations research should be conducted.

I am very distressed—and I guess most people who have been in this field for a while are distressed—about the mistake of identifying operations research with the techniques which are useful in operations research. The two things are two separate subjects, and somehow or other they continually get confused.

We also hear the question, How does operations research differ from X ? Now, in this case, X may be, and has been, and probably will continue to be, cost accounting, systems engineering, scientific management, management science, econometrics, common sense, systems and procedures, computer science, industrial engineering, applied mathematics, management consulting, work simplification—I am sure the list is inexhaustible. But today is the first time that I expect someone in the audience will want to ask, "How does O.R. differ from X , where X now equals actuarial science?"

Well, the answer is that that must be a foolish question because there can't really be anything which could be similar to so many other, different things. When I first got into this field, it bothered me because I liked to know what it was that I was doing. But, when I got into opera-

tions research, I did not know what I was doing and what to call it. My colleagues and I, on the team at the Ontario Hydro at that time, thought about this quite a bit and decided the reason that the definition is so difficult is that you probably are not trying to define a single thing. I think that this is true of operations research. We finally decided that operations research probably existed because it was a new blend of three old ingredients—personnel, techniques, and organization.

The personnel are applied to problems generally outside their active discipline. For example, one might find a physicist studying problems of naval warfare, or something of that type. Nevertheless, the personnel all had to be reasonably scientific in viewpoint, even though they might have numerous professional backgrounds. Then they applied various techniques. These were mostly the techniques of mathematics, but many other forms of scientific analysis were used. The key point, we felt, was the third component of the blend, the organization aspect.

I thought then, and I still think today, that the power of operations research lies principally in the organization for problem-solving that it provides. It is a strange thing—if you describe how operations research solves a problem, people always agree that it is a very intelligent way to solve a problem. You get together a group of people who, between them, know enough to be able to solve the problem. You give them full time on the project, access to data, and let them collect data. The manager, or the person for whom the problem is being solved, communicates fairly frequently with this group to let them know at first what it is that he wants solved and later how he thinks their solution fits his needs. Well, this certainly seems a very intelligent way to solve a problem. Yet how many times do people solve problems that way? If you want to solve a problem nowadays in most companies, you look at the organization chart for the department that ought to be concerned with this problem, you work your way down, and eventually you come to somebody who has enough free time to do the work.

I think that operations research has been so successful because it has insisted on organization by project, study by competent teams, full time on the project, and really concentrated effort on something that really matters.

This kind of organization encourages the formation of a team. It also permits the team, because of the more or less over-all view that they are taking of the problem, to adopt a systems approach, about which I will speak in a moment. It also enables them to have close liaison with the management.

So, to answer the question What is operations research with respect

to actuarial science? I would say that, if an actuary is on a team organized to tackle a problem from the whole or systems view, if another team member—not necessarily an actuary but perhaps an actuary—knows the O.R. literature, and if management is actively participating in defining objectives, then you are doing O.R. When it is viewed in this way, an actuary can do O.R. just as well as anybody else, in fact, probably better, because of the nature of his background.

I would now like to say a little about systems. The system idea is not something that soaks in too easily. It takes a little while before you see the interconnected components, interrelated activities, that go to make up a system.

I define a system as a set of interconnected components which perform interrelated activities, with each of these activities directed toward a goal, the goal being the production of goods, service, or information.

In studying a system, of course, one finds everything is connected to everything else and every activity is related to everything else in the world. "Send not for whom the bell tolls, It tolls for thee." We are tied together by our common humanity. In studying a system, you have to isolate some activities that are sufficiently closely related that they can be considered together. They, and the components they use, become the system. All the other activities and components outside become the environment. In this way you could look at a home office as a system with the rest of the universe as its environment. Then one would like to study the home office as a system, all its activities, all its components, and the interconnections between them.

There are tools for doing this. Queueing theory would appeal to any mathematician as being very useful. It is only when he goes to use it that he finds that, no matter how many thousand queueing models there are in the literature, the one that applies exactly to his problem has not yet been worked on. But he may find one, and, if he does, so much the better. If he does not, he is not stuck. He can use simulation with one of the new simulation languages, such as Simscript, or GPSS, the General Purpose System Simulator. These are computer "languages" for writing simulation programs rather rapidly.

Suppose that a person decides that he wants to study something like a home office as a system by operations research, how would he go about doing it? Well, I think the first thing that would have to happen is that the management of the organization would have to desire that this be done. Somebody would have to give them this desire by pointing out some of the advantages that might be gained. Next there would be the formation of a team. On this team there would have to be people with

all the necessary kinds of knowledge released from their normal duties for the duration of the project. The team would have to be put in the hands of a project manager, whose job is to set up the proper review dates at which the progress of the team is reported to an advisory committee—the next component of this operation. This advisory committee should consist of the decision-maker himself, the man who pulls the switch, and probably also the managers of the departments that are going to be most affected if any changes are going to be made, so that they know in advance what is coming. These managers can be very helpful in suggesting good ideas for the team to develop.

The team meets with this committee about once every four weeks or thereabout, depending on how the study is progressing; at each meeting they set the date for the next. At each meeting, if you do not like the way things are going, you stop studying that particular project, kill it off, and start another one. As long as it looks promising, you keep going with it.

The team would have to have a very good session with the management to decide what the objectives were for the study, what the objectives were for the organization that they were studying, what resources would be available for them as a team, what things they would be able to change in the operation, and what things they would have to consider as constraints.

If you are going to do this sort of thing often, you might want to have a unit somewhere in the company to house those who are continuously on operations research teams for successive projects. These might be the people who, because they are particularly familiar with the literature of operations research, might be wanted as a part of nearly every team and therefore you might wish to house them as a group. To that extent, you would have an operations research department. But I would really and sincerely hope that you would not do your operations research just with this little coterie of backroom boys, because I am sure that you would get the right solutions to the wrong problems this way. People from other departments must be full-time members of the team.

If you look at what I said about operations research and the systems approach, I think that you will see that the whole team of actuaries in a life insurance company is, in fact, an O.R. team. In over 300 years you have developed a fine model. It has been beautifully polished and developed to an extent that no other operations research model has ever been developed. You have excellent data. With all the computers you have, they are probably coming out of your ears.

However, I do not think that any of you believe that your model in-

cludes all the activities of a life insurance company. What the rest of the panel members will talk about today will show you that there are some areas in which the actuarial model has little to say or is only a component of the total. I am a gentle fellow. If somebody talks about analyzing how many megadeaths there will be in the next nuclear holocaust, I like to say, "Let somebody else analyze this. I will teach business at McGill." But I still feel that, gentle though I am, I must really give you people a blast, because I think that you have been too smug by far. Because you happen to be the best and largest collection of probabilistic thinkers in industry, you believe that you have done all the probabilistic thinking that needs to be done for your industry. Yet I think that if any other industry had had the phenomenal computer resources which you have; had had the mathematical talent that you have, which can easily be converted to operations research, as you can see by just looking at the people in your own industry who have been so converted at one time or another in their lives; and had had a service product that cries out for operations research, that industry would have been a leader in operations research development. Your talent is needed where all these models have to be developed; yet when I look around the insurance industry, with certain very remarkable exceptions, I see very little activity of this kind. I think you should do more.

EDWARD A. LEW:

We are indebted to Dr. Sandiford for his lucid presentation of several key issues in operations research and particularly for his emphasis on a team approach to problem-solving. We might now consider some examples of how this approach has actually been used. We are fortunate in having with us two actuaries who have been working at it for a long time, and I am going to call on the first of them, Gordon Shellard, to show us how this approach has been successfully used on a particular problem of a type alluded to by Professor Sandiford.

GORDON D. SHELLARD:

I can tell you about a study that I think nicely illustrates what a simple logical investigation and analysis can do. The study involves an example of balancing the benefits of improved service against the costs of providing the service. The solution is easy to follow and involves only trial and error on the simplest kind of arithmetic model.

Incidentally, I had absolutely nothing to do with this study. It was made some years ago in the *New York Life*, and the absolute numbers involved have no particular significance now.

The particular problem was one that many companies have faced—the apparently excessive time required for processing an application from its receipt in the home office until the issued policy is mailed out. There was an impression, based on individual cases, that this time was too long.

The first step was to learn more of the facts. What indeed was the average processing time from receipt of an application until the mailing-out of the corresponding policy? Follow-up of a sample of applications showed the average time in the home office to be four and one-half days. Was this too long?

The answer depends, at least in part, on how much work must be done on an individual case and on how much time this work takes. An estimate of the working time needed to process a case can be made by analysis of the operations involved and estimates of the time for each, but perhaps a better estimate can be made directly from the records of cases processed. Dividing the total number of clerk days worked on the cases during a year by the total number of cases processed during the year gives the average actual processing time per case. This method may be biased toward the high side, but for this study it gave an estimate of actual processing time of about half a day. Thus about 90 per cent of the time spent in the home office by such cases was waiting time, and only about 10 per cent was actual processing time.

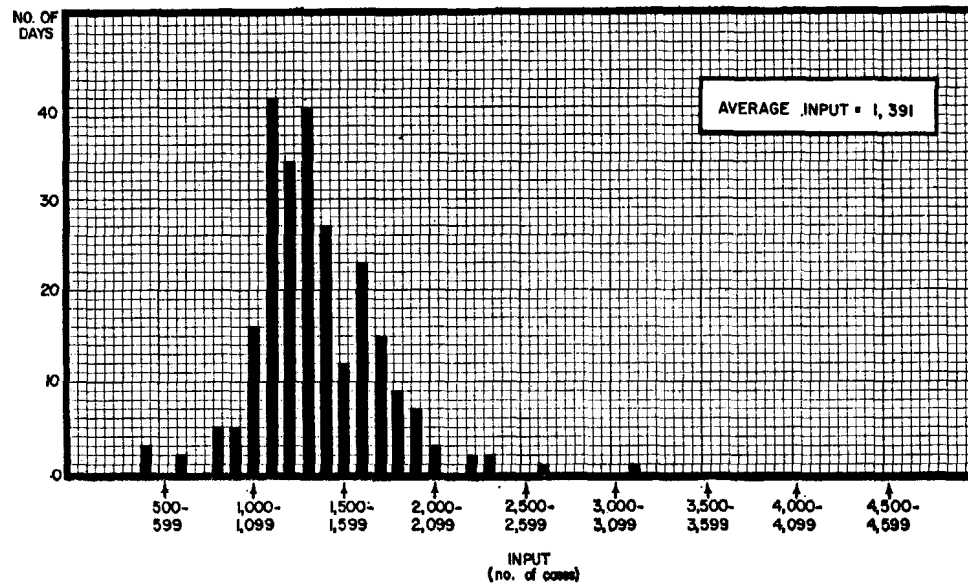
Why was there so much waiting time? Part of the answer was found in the fact that applications were received in large batches and part in the fact that the number of applications received fluctuated widely from day to day.

Chart I indicates the fluctuation in daily input over a whole year. Thus, while the average daily input of applications was a bit under 1,400, on only forty days during the year was the daily input between 1,300 and 1,400. You will note that the daily input ranged all the way from one day on which it was over 3,200 down to three days on which it was less than 400.

Such wide fluctuation in input, with a relatively constant capacity for processing the cases, is bound to lead to backlog at least part of the time. Actual backlog over a year varied considerably—from under 700 cases at one time to over 4,700 another—but averaged a bit under 2,800 cases.

This was not the backlog of all applications in the home office but only that of applications awaiting the fairly routine processing through which all applications must pass. It was the routine processing operations only that were the subject of further study. You will note that the average backlog of 2,800 cases was about twice the average daily input, or,

CHART I
DISTRIBUTION OF INPUT



since processing capacity was just about equal to average input, the average backlog was about twice the processing capacity. This means that, on the average, the staff would have had to work two full days just to process cases in the backlog, before processing a single new incoming case. Clearly the backlog is key to most of the waiting time and is worthy of more study.

First, output was studied as a function of backlog by analysis of a year's records. This showed that for small or moderate backlogs there was a slight increase of output with increased backlog but that for larger backlogs the output was constant except for overtime. With one exception, overtime was employed only if the backlog exceeded 2,000 cases, which was more than 140 per cent of an average day's output.

The backlog and factors affecting it can be expressed in a simple formula or mathematical model:

$$\text{Backlog } (t) = \text{Backlog } (0) + \Sigma_0^t \text{Input} - \Sigma_0^t \text{Output} ,$$

where a day's output can be expressed as

$$\text{Output} = \text{Minimum of } [(\text{Backlog} + \text{Input}), (\text{Capacity})] .$$

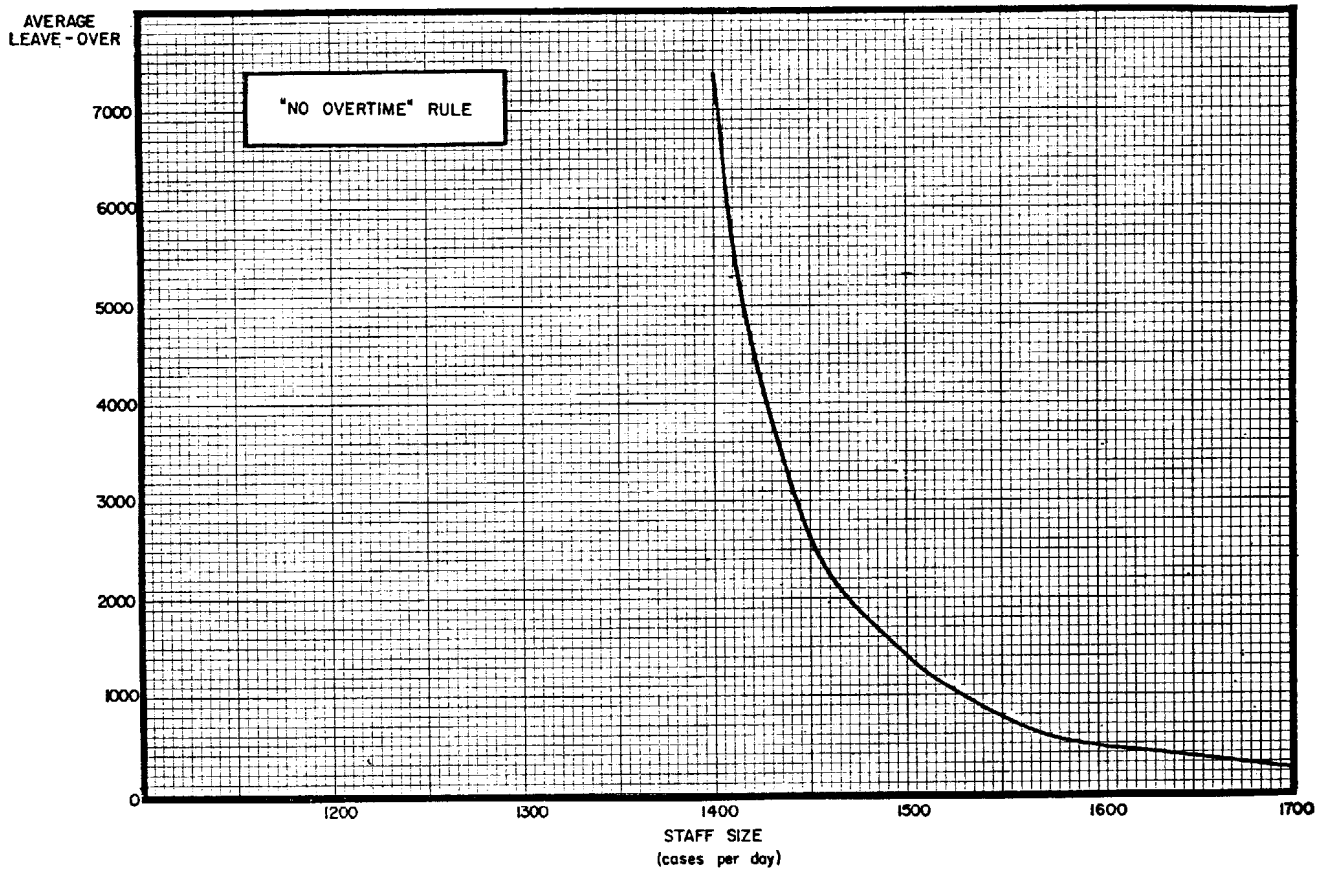
Capacity is a function of the number of clerks working, the number of hours per day worked, and the processing rate per clerk per hour.

Since the average waiting time for a case that comes in at a particular moment is equal to the backlog divided by the capacity, the only ways of reducing waiting time are by reducing backlog or by increasing capacity. From the expression above, we see that the only way of reducing backlog is by increasing output, so that the only way of decreasing waiting time is by increasing capacity. Capacity can be increased only by increasing staff, increasing overtime, or by increasing the work rate. Any of these is likely to increase expense and may possibly lead at times to situations in which there are no cases on hand to be processed. Increased expense and idle time are undesirable of themselves and are of the same order of interest to management as are large backlogs and lengthy processing time.

At this point it was decided to explore by the mathematical model the results that might be expected from different sizes of staff and different overtime rules. The various calculations were done by machine, using the formulae shown above, and the actual historical day-to-day input of cases found during a year of operation.

Chart II shows the relation of backlog to staff size if no overtime is allowed. Naturally, as the staff is reduced toward a capacity equal to

CHART II
AVERAGE LEAVE-OVER V. STAFF SIZE



the average input, the average backlog increases sharply. Of course, staff size can be translated into cost and backlog into average processing time.

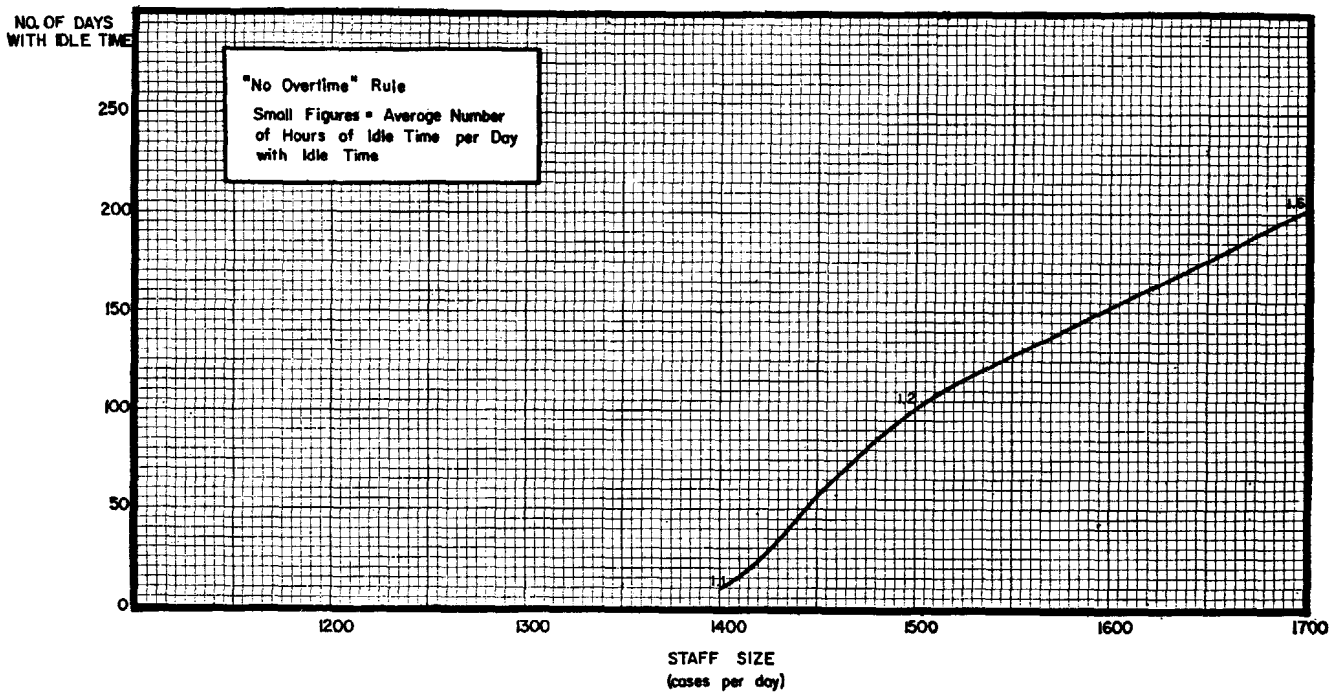
A larger staff means greater capacity, which occasionally works the backlog down to 0. When that happens the staff must be idle for some time. Chart III shows how frequently that would have occurred, together with the average amount of idle time per clerk on days when such idle time occurred.

Increasing staff size is a rather uneconomical way of combating backlog. Backlog results from fluctuating input. This can be most efficiently handled by a flexible capacity, achieved by appropriate overtime, as shown in Chart IV. In this study an n -night rule means that overtime is worked on a night only if the backlog is large enough to provide n full nights of overtime (and n days of regular time) for the entire staff. You will note that the smallest backlogs are achieved by the 1-night overtime rule. These results also may be expressed in terms of cost rather than of staff size. It appears that considerable improvement in operations may be obtained by change of the overtime rule.

Larger staffs or readier overtime do cut down backlog, but also result in more situations when there are no cases to be processed. Chart V shows the frequency of days with idle time, and the average amount of idle time on such days, for various overtime rules and staff sizes. This chart, together with the previous one, shows that the most desirable staff size from a cost versus performance point of view requires both overtime and idle time. It appears that substantial reductions in backlog and processing time could have been achieved at the expense of only a slight increase in cost and overtime.

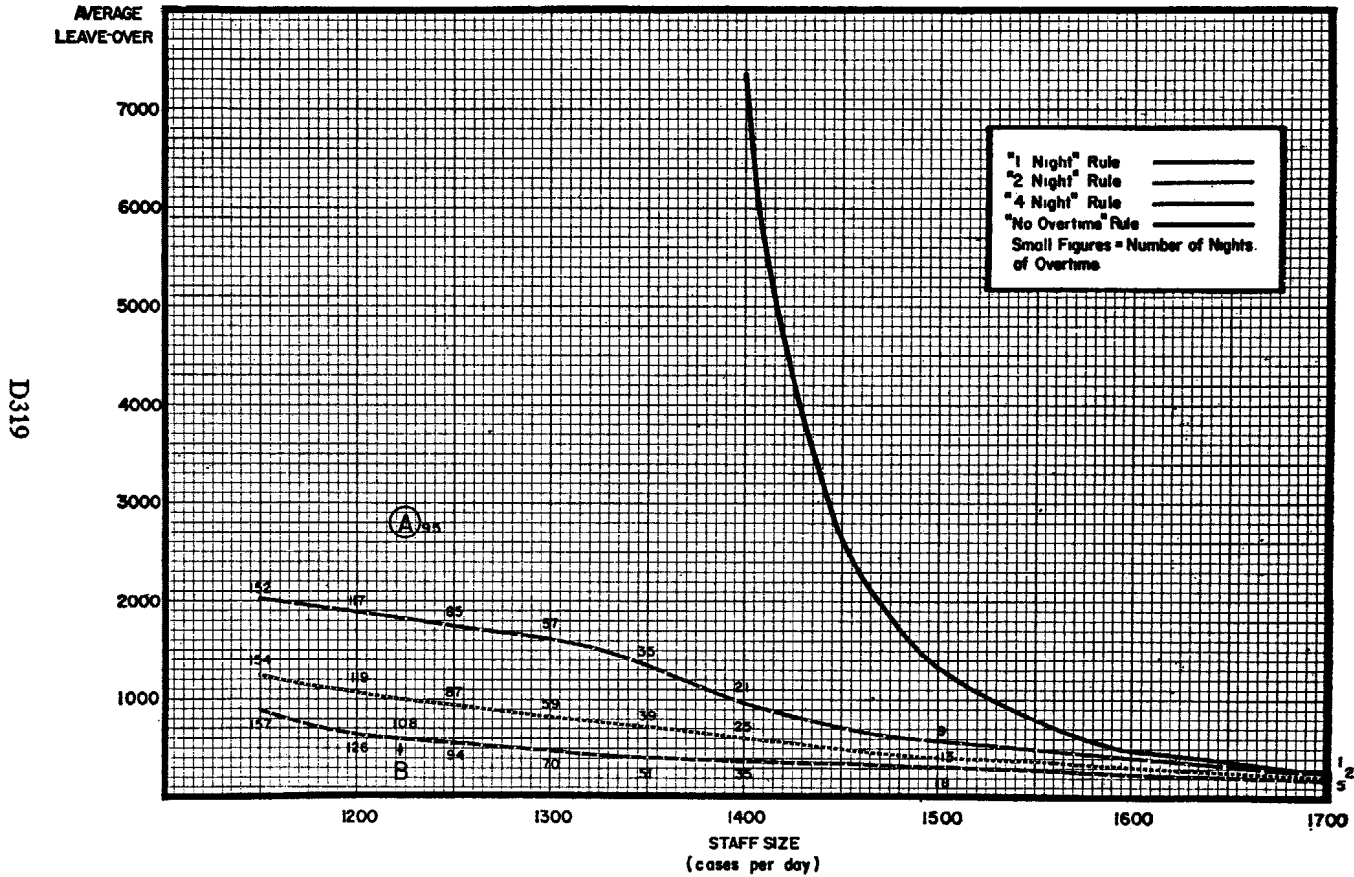
These charts do not show explicitly which staff-size and overtime policy is best, but they do show the pertinent implications of each policy, from which management can select what it considers the best combination of staff and overtime policy. This is characteristic of problems in which there are several different measures of effectiveness of the results of action. If more had been known about the effect of overtime and idle time on the company's ultimate objectives, and of the interrelations between objectives, it might have been possible to recommend a particular staff-size and overtime policy to best meet the company's objectives. As it happened, this was not possible; but the study did indicate an area of staff and overtime policy that was feasible and that appeared to offer a considerable reduction in over-all processing time. Such a policy was implemented, with generally satisfactory results.

CHART III
IDLE TIME V. STAFF SIZE



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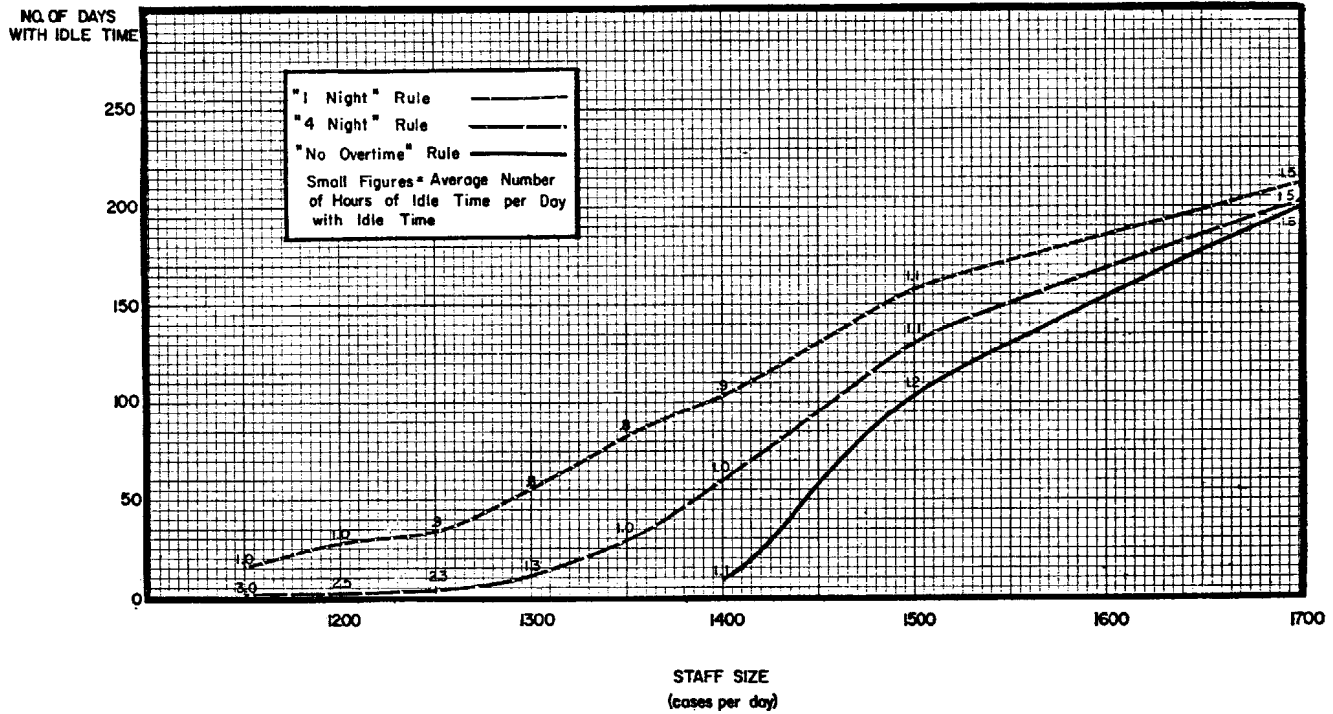
CHART IV
AVERAGE LEAVE-OVER V. STAFF SIZE



NOTE A: approximate location of present operation

NOTE B: desirable rule with present staff size

CHART V
 IDLE TIME V. STAFF SIZE



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EDWARD A. LEW:

Another one of our members who is highly conversant with operations research is Nate Jones. He has a very interesting problem in scheduling to present to you.

NATHAN F. JONES:

This is a good example of a problem to which an operations research type of approach has been very useful, although no advanced mathematical techniques have been employed. In that way it is quite like Gordon's problem.

The Prudential's Newark office now has nine IBM 1401's with varying configurations. At present there are about a thousand jobs a week, exclusive of 1401 testing. The scheduling method which is now employed is a simulation which could be done manually if it could be done fast enough. It is much more convenient to use about ten minutes of 705 time to produce a week's 1401 schedules.

Pretend that we graybeards on the panel are dance-hall hostesses and you all are patrons—perhaps that is asking too much of your imaginations. Scheduling is matching patrons to hostesses, jobs to equipment. Some will dance only with favorite hostesses, others with the first available. A few hostesses are able to dance with two patrons at once, when the patrons are small enough to be held off the floor, one in each arm—rather a striking image of "simultaneous operations."

There is a master clock which, in the Prudential, runs either backward, as some of you have often suspected, or forward, depending on whether the jobs are sorted in order of required completion time (backward) or in order of availability for processing (forward).

Equipment descriptions used are sufficient to enable any patron to determine whether his specifications—brunette, tall, strapless gown, ability to Watusi, etc.—are met. Deletions from the hostess queue are by job assignment (to the dance floor) or for scheduled maintenance, either mechanical (to the little girls' room) or personal (typically for lunch). First priority is to those big, strong hostesses who can carry the two patrons. If they do not meet specifications or are not available, the simplest configuration acceptable is selected. The program can be altered so as to give particular favored hostesses a maximum number of dances.

Patrons—jobs—must know their times of availability (entry to the dance hall), required completion (time the last train leaves for home), job time requirements (the earlier of satiation of body and exhaustion of wallet), and equipment requirements (blonde, short, bouffant dress, apparent willingness to waltz). We do not assume that a patron ever

becomes tired of waiting for a hostess who meets his specifications and goes home to his wife.

First patron priority is the so-called golden or supervening VIP type—friends of the management. Other jobs are assigned in order of time remaining before the job must be started in order to be completed in time. Finally, the shortest job first.

The clock starts, the first patron available advances and selects his favorite hostess. Away they whirl in the waltz (or Watusi)! May each hostess be so memorable that her personality and the master-clock time that he started to dance with her impress themselves indelibly upon the patron—indelibly enough, at least, to produce an appropriate output record for schedule preparation. The resulting records can be used to prepare printed schedules or tickets in any reasonable form. In practice, certain manual adjustments are made.

The program does a lot of other incidental things, which I will not go into now. One of the things it does *not* do is schedule with an eye to patrons who are still on their way to the dance hall; that is, it cannot produce a schedule optimized for the whole list of jobs which will become available during the schedule period. At the present stage, this might not be worth while in terms of the extra 705 time. Scheduling might well extend further in both directions (getting the patrons out of their offices on the way to the dance hall and pouring them from the dance hall onto their trains). We are hoping to schedule jobs through both the 1401 and the 705. This would be practice for the 360, which will prepare its own schedules. The program is easily used to estimate the effect on schedules of changes in equipment availability, and it can also be used to estimate the effect of changes in job loads.

Now, I have a description of a job in a field which our industry has not tackled much, which is a little related to Gordon's queueing problem and also to the schedule problem that I have just described. Agents often have sales-to-call ratios one in ten or fifteen, or even worse. A mere change to one in eight would be a major breakthrough for the insurer. We are not talking about that now because that is a marketing problem, but, in attempting to improve home office operation, it is hard to find an opportunity for improvement which is major in that sense. The only area, besides automation, where I think major improvement is at all likely is research in the utilization of personnel. Improvement in the utilization of home office personnel is like a great gold-bearing lode under tons of overburden; we may never reach it, but that does not decrease the richness of the treasure. Dramatic examples are the cases that all

of us know of persons who perform clerical or low-level technical assignments so well that two or three or even four persons of average ability might be required to replace them. Even more important for present purposes, most of us know people on our home office staff who, if we think about it, would be likely to do very poorly on any assignment not specially structured for them but who obviously have found their niches in the company, whether by luck, by unusually perceptive supervision, or, *mirabile dictu*, by sound personnel planning. If we could merely double the first class, efficiency might increase very sharply. If we could double the second, we might greatly reduce the difficulties of adequate clerical staffing from the available labor pool.

As an illustration of personnel-utilization research, take two relatively simple repetitive transactions. The first averages 2,000 a week. A fully trained clerk should be able to do about 80 in a working day. The second averages 500 a week, and a fully trained clerk of the same salary level should be able to do about 70 per day. For the first stage of the model, I shall note that most actuaries have a predilection for assuming that any given distribution is completely concentrated at its mean. On this basis, five clerks are needed for the total volume of 2,000 per week. For the second transaction, we shall reluctantly have to employ two clerks, owing to the difficulty of fractionating clerks. Under this formulation, work flow is absolutely uniform and service could not be a problem and therefore not a criterion. The cost criterion is clearly the only important one. Cross-training is obviously of no value. It costs more, since trainer and trainee will to some extent be unproductive during the training period, and it contributes nothing. In this initial stage, perfect health and an absence of jury duty, grandmothers' funerals, and so forth, are assumed. Presumably agents, policyholders, and clerks all take exactly the same vacations at the same time.

The second stage is less unrealistic. An actual historical distribution of the arriving work is used—heavy on Mondays; light at the end of the week; light in the summer; heavy, perhaps, at year-end. Holidays, staff vacations, and absence for other reasons are recognized. Overtime appears as an alternative to more staff, with its costs and conventions, for example, advance notice, no Friday nights.

Now we have a situation for a queueing model. The distribution of backlog and service times can be estimated. Service as well as cost becomes a factor. This is about the stage of most of the clerical queueing work that I have seen. So far as I know, models at this stage still assume that all clerks and all cases are alike and that variations in staffing and

scheduling do not affect the rate or quality of work. I have to qualify that a little. You saw Gordon's chart, which showed the slight variation in output at the low end. There was a little evidence of pacing.

Maybe, however, more realistic assumptions are not worth while. At this stage, consider cross-training. The effect statistically will be roughly to substitute a distribution of the sum of the two variances for the sum of the separate distributions. If the two are heavily positively correlated, like preparing and checking the same transaction, there is little possibility of gain. If the arrivals are independent, the sum distribution will have a lower coefficient of variation. This may permit a decrease in staff or of overtime sufficient to outweigh the costs of cross-training. If you have negative correlation, of course, you are even better off.

In the third stage, we introduce a distribution of inherent case times and of clerical skills. Some variation in skills with time may also be assumed, particularly in lower-level jobs affected by periodic hiring. Statistically, we should expect all these to increase variability and hence increase staffing and costs as well. Perhaps, however, we should also introduce the well-known tendency for clerks to pace themselves to the work load and the schedule, which I mentioned a little earlier, in particular, to adjust to continued overtime by lowered productivity in both regular and overtime.

The "cross-training" issue becomes much more complex here. The greater variability in work flow will tend to indicate cross-training. Properly, however, we should consider here the longer case time of the clerk performing two functions.

Set-up time is an additional factor. It is this that makes field office clerical jobs with their multiplicity of functions so hard to evaluate by the simple industrial engineering approach.

For still later stages and for executive decision, we have to consider whether job enlargement will increase job satisfaction enough to produce significantly lower termination rates and higher job performance. Will it do this for everybody or primarily by a greater retention of more able employees, which is often suggested? If it does produce these results, is this desirable? We all think we want the most able employees possible, but we also want neither a CORE picket line nor an organized boycott nor an organization full in later years of higher-talent people who feel that they were promised advancement beyond what now seems likely. Will a pattern of job enlargement soon require different home office administrative organization? If there are not enough jobs in the department which are candidates for enlargement, maybe departmental lines

should be transcended permanently. Computerization has made us aware of this problem.

This is only an example of the ways in which I hope O.R. might help us to take advantage of the personnel resources we have, or could have.

EDWARD A. LEW:

We might next pursue our subject beyond the limits just sketched into areas involving more complex problems. For this more ambitious exploration, we are fortunate in having Mr. Ernst of Arthur D. Little, Inc.

MARTIN L. ERNST:

My role at this point is to comment briefly on the examples which were discussed here today and to examine the possibilities of extending this type of work into other areas of your industry. Let me say at once that I know relatively little about the operations of insurance companies; accordingly, my remarks will be based on experience with the application of operations research in many other businesses. However, some guidance may be available because of the longer history in the use of these techniques which some of these businesses have had.

The first example, given by Gordon Shellard, is to my mind a very nice, straightforward piece of work, of a kind that is seldom presented at any operations research meeting because it is not sufficiently esoteric. I think that there is a very wide range of opportunities in any home office for the type of work Gordon described. The limits will probably be set by the policies of your companies, by legal requirements and similar constraints, but the opportunities certainly exist. I think that it is worth while to point out why these opportunities exist, because the reasons provide a clue as to where to look for potential areas of work.

It is my impression that almost every competent business organization does an extremely good job of running its operations under conditions where the objectives are well known, the incentives reasonably established, and the environment relatively stable. Opportunities for improvement most often arise because the environment has changed and management has not yet caught up with the fact. Let me take Gordon's example and illustrate this point: I suspect that ten or fifteen years before this study was made, the conditions he described existed but were relatively unimportant. The lengths of servicing times may have been less important simply because communications and correspondence moved more slowly in those days. Or it may have been possible to provide somewhat better service because clerical costs were lower relative

to many of the other costs, so that staff levels were higher. In other words, for a past environment the manning of this office probably represented a very good balance between the service required and the costs involved; but, as time passed and the pattern of insurance operations altered, the demand for service by customers also changed. Similarly, the relative costs of clerical and other operations changed, so that a business pattern which was successful and quite appropriate lost a degree of balance.

The example that we had today was not a bad example of imbalance. There are plenty of examples of companies where individual components are working quite successfully, but, because the manner in which they are mated to other parts is based on policies set during an earlier period of history, the over-all effect at the interface leads to very poor co-ordination for common objectives.

Organizations generally do an extremely efficient job when they have an opportunity for trial and error over a period of time. For example, there are few jobs that are much more complicated than, say, scheduling a very large fleet of oil tankers. Yet every time that we have examined this subject for normal operating periods, we find that the scheduling is very well done. However, let a major change arise in the environment—as, for example, during the Suez crises—and all this scheduling quickly becomes far less efficient, because there is no experience and no opportunity as yet to gain skill by trial and error.

So, one place to look for real potential gains is the interfaces, where different components of a company can most easily get out of adjustment and where the effects of changes in the environment—whether in terms of service demand or costs—are most likely to have gone unnoticed.

Let me now turn to another area that I think will become increasingly important and one which ties together with Nate Jones's paper as well as Gordon's. This is the area of use of large electronic equipment. EDP equipment, I believe, will represent perhaps the major investment in plant which many insurance companies will make. The details of scheduling these computers are going to become more and more complicated. Nate made a remark that the 360 series will do its own scheduling. This may be so, but I believe that, if you look into the details, you will find that it does not do so very efficiently without some help from the outside. As we get multiprocessing and time-sharing equipment, there are great opportunities for analysis of mechanisms to load these machines better, to get more efficient utilization of their capacity by matching jobs with different characteristics for simultaneous processing. The net effect of such studies is to allow a company to get along with less equipment for

an extended period of time and to stall off the day when new equipment purchases of considerable magnitude will be necessary.

Let me turn for a minute to the examples given by Nate Jones. On the first example, I must admit that I am a little confused; I have just a wee suspicion that this simile was selected more for entertainment than for clarification! At any rate, after listening to it, I gathered that we were considering a simulation of sorts; but he has done a very clever job of leaving out enough of the details so that I cannot really evaluate whether it was a representative simulation.

I will, however, make a general remark about simulation. Simulation has gotten to be a jazz word these days—even more than operations research! One result has been that a number of companies are going all out (in the industrial field, that is; I wouldn't accuse any insurance company of this) to apply this tool in a major way. There are companies, for example, that have decided they want to simulate their whole company, or their whole industry. I have a very simple piece of advice to give you here; don't—at least, not for a while! Simulation is a wonderful tool when applied at about the level that Nate Jones was talking about—to relatively simple tasks where, when you get the results, you will be able to evaluate them to see if they also make common sense. The most satisfactory simulation I have ever worked on was one which simply extended the region in which we could get answers beyond that which was possible with analytical techniques. We obtained the happy result that the curves for the analytical range and those for the simulation range faired neatly together; and that was a simulation where I had full faith in the results.

On the other hand, I have seen some very massive simulations, and all too often I do not really believe their outputs. They are too complex to fully understand, and one must accept too many assumptions and too much input data without full understanding.

My final comment—on the cross-training job-enlargement area—is that this, as was Gordon's first example, is a very fruitful area for further exploration. I think it is a very nice example in several respects. It shows very clearly the interplay that one must have between the quantitative aspects of a problem, where I believe operations research or actuarial science has a legitimate role to play, and the policy elements where operations research would normally admit it has little to contribute. The example illustrates the necessity in most important problems of distinguishing between that region where we can use numbers and analysis and the region where we cannot. The use of numbers can often help us reach a better decision, but there are large elements in the

decision concerned with problems beyond the capabilities of quantitative analytical techniques.

EDWARD A. LEW:

For an over-all view of what might be accomplished with operations research, we will now turn to a distinguished past-president of the Society, Bill Anderson, for an appreciation of operations research from the executive floor.

WILLIAM M. ANDERSON:

I had the temerity to make some remarks about operations research in my presidential address nine years ago. I could repeat them now, but I think that it would be a more useful conservation of your time to refer you to that address.

One question that is uppermost in the mind of almost anyone who looks at operations research—a process which, according to my definition, is an organized method of solving problems under conditions of complexity and/or uncertainty—is “Just how do you go about making operations research part of the state and condition of activities in an organization?” Sandiford has warned us that you do not just establish an operations research department and say, “Now, you go to work and do operations research.” You do not do it that way at all.

As you go through the operations research literature, it is interesting to observe that most of the problems discussed are of such a character that they involve solutions that result in a maximum or minimum or, alternatively, in optimal results. As a general rule, a good many of the problems use the profit criterion as the objective that is sought, that is, the problem is one of maximizing profit or minimizing cost.

This is a difficult kind of criterion for a life insurance company, particularly a mutual life insurance company, the reason being that maximization of profit as such for a mutual life company is not by any means a well-understood or well-accepted criterion. This is primarily because the concept of mutuality involves the question of a changing body of owners, and profit in the orthodox sense is not the aggregate profit of the organism but rather the unit profit that relates to the particular policyholder. In this sense the mutual company differs materially from normal organizations, because it has the problem of unit profit rather than aggregate profit, together with the collateral problem of equitable treatment as between policyholders at any one time and as between the successive generations of policyholders. Accordingly, it is a little difficult

to get a jumping-off point in a mutual company in order to rationalize and organize the problem-solving process.

When you start to study this difficulty, it becomes obvious that you are going to be in a good position if you can arrive at a criterion which will give you a similar kind of objective to that of other types of business. In our company, without formally saying so, we arrived at the criterion of growth. In other words, our company seems to operate on a basis where it is our general objective to maximize growth, subject to a number of very important constraints in relation to adequacy—that is, we feel that we have to have adequate strength, adequate net cost, adequate persistency, adequate service to policyholders, adequate remuneration, both to agents and to employees—but, subject to those constraints, the end objective seems to be a question of finding as much money as we can in order to grow.

We discovered that if growth is a prime criterion, you then face the same kind of problems which you find in other organizations because, quite obviously, once you have rationalized the idea of making a profit in the aggregate sense, then you put yourself in the same position as other businesses and learn how they try to solve some of their problems. In our case, a very important point that arose as a consequence of using the criterion of growth was that we led ourselves into very complete budgeting of the whole of the company's operations, both in the physical and financial sense, budgeting that is done from the ground up by the agencies and departments, all pulled together into the end result of the budget. Each year, as it is prepared, there is some money left over—sometimes not very much but occasionally quite a bit—and this is the juncture at which the company consciously acts to allocate the money left over to different types of new projects, such as expanding agencies or varying products which will contribute to the end result of maximizing growth.

It has been interesting to observe that this pattern within the company has tended to create what you might call total involvement, in the sense that almost everyone with responsibility in the company is participating initially in the budget-making process and is seeing the end results of the budgets. In consequence, there seems to be a recognition at the operating levels of the value of achieving greater efficiency in order to contribute more money to the total which is subjected to allocation by decision. The interest throughout the company is such that the actual decision-making regarding the residual expenditure has often been arrived at through the preparation of different types of projects which may or

may not be approved, not on the grounds of whether they are good or not but on the grounds that you can only do the things which you judge to be best, or which have priority, within a limited budget.

So I suggest that in the course of the years, in my observation, we have developed quite a few people who have been doing many of the kinds of things that can be described under the heading of operations research without using that label. The process as it has been followed has tended to produce a considerable amount of interaction between different divisions of the company and, in some instances, what may be called feedback, in the sense that solutions that might be found in isolation become different under conditions where there is full knowledge of the effect of those solutions on other parts of the company's operations.

The only other point that I want to mention at this stage is that it is not by any means necessary or perhaps even desirable to become more active in operations research within your own company as a first step. I suggest that many actuaries may find themselves in the position where some of the opportunities that might open up to them in this field are outside their companies. They can arise in relation to work in community affairs and elsewhere, and, as a consequence of having engaged in important problem-solving in areas beyond their own familiar occupations, actuaries can find that their problem-solving abilities within their companies will be strengthened.

Additionally, and as I mentioned nine years ago, if actuaries take a broader interest in activities beyond the realm of the life insurance business, this can lead to a spreading of the use of the actuarial profession in wider areas of economic activity and, in turn, to a more satisfactory solution of the rather acute recruiting problems which our profession has faced over the years.

EDWARD A. LEW:

We will now proceed to applications of operations research to problems in areas which Bill Anderson characterized as involving both complexity and uncertainty. The specific areas that we want to touch on are marketing and investments. I am going to ask Professor Sandiford to give us the benefit of his comments on the possibilities of operations research in these fields.

PETER J. SANDIFORD:

Well, if an O.R. man is asked what one can do in the area of marketing, the first thing he does is to review past volumes of *International Abstracts in Operations Research* (published by the Operations Research Society

of America for the International Federation of Operational Research Societies, in order to provide world-wide coverage of operations research literature). These are available in the library. I refer you in particular to Volume 4, No. 5 (December 1964). The reason that I mention this volume is that it has a cumulative index for the first four volumes, going back to 1961. This will give you, on any subject you care to worry about, a number of abstracts on that subject, whether the paper has been published in the United States, Canada, Russia, Romania, Italy, Japan, or elsewhere. If anybody has done any work that can be helpful to you in the area of the problem you care to study, I suggest that you are apt to find a good start on it by looking in that volume.

By following that process and looking up marketing, I find about 75 abstracts on marketing. If you look up some of these, you see what the people in O.R. have been doing about marketing. They have been studying Markov processes, particularly with respect to whether people will switch from one brand to another or from one supplier to another. There is an article on a double exponential model for the penetration into the market of a new product; there is the development of marketing games by which you train people to market better; there is reference to a book by F. M. Bass, *Mathematical Models in Marketing*; there are a number of articles on decision theory, on game theory with respect to new products; several papers on media selection for advertising; a statistical paper on the early prediction of a new product's success as it hits the market by the use of a two-state Markov chain; a number of papers on Bayesian statistics, and so forth. So, if you wanted to follow the suggestion of my first remarks and do a little operations research and one of the things you wanted to do was study the marketing of your company, I think that the thing to do would be to get a study project set up and make a team that consisted of the right sort of people (if you do not have them in your company, hire outsiders), and go ahead and take a crack at the problem and see where you get. There are many prior examples to suggest fruitful ways that you might tackle the problem, as in any other research.

The second thing that I think you might be interested in—and you probably know quite a bit about this—is that there exists a very interesting theory on the subject of investment portfolio selection. There is a monograph written by Harry Markowitz, who invented a theory of portfolio selection. Gordon Shellard has some comments to make on this, but let us look at the situation here.

Here we have a theory based on the expected return from the investment, with the taxes, and so on, taken into account, and the variance

of the return and the covariance of various securities one with the other. This theory requires a fantastic amount of input, and various methods have been put forward, by Sharpe particularly, to cut down on the amount of input by relating the different securities to indices of one kind or another.

So we have a theory, and the theory has been examined rather critically by a lot of people and seems reasonably acceptable. It has not been worked on very hard yet, so nobody knows quite what is wrong with it, but it looks like a good start.

Furthermore, we have a method for doing this, a computer algorithm, and this has been enshrined in a computer program which is available through SHARE, a portfolio selection program that is available for a 7090, for a 7040, and for a 7070 computer. It is a very large program, very complicated. It has built-in regression programs and quadratic programming programs and linear programming programs and input editors and output editors, and the write-up for it is about an inch thick; but it does exist, and it has been tested and is known to work—the programming has all been done.

Now we have some test evidence of performance. Some people say that it does not work worth a darn. But other people have been a little more careful in how they used it. I know of one group—unfortunately, I am not able to say who it is, but it happens to be an industry you might be quite interested in—that has done an examination and found that, without in any way reducing the risk, they were able to produce a portfolio whose average return, including appreciation of stock prices, increased from 6 per cent for the portfolio they were using to 10 per cent for the new portfolio. This isn't to be sneezed at. It represents a large chunk of money. So, let us suppose that the probability of getting this large chunk of money is fairly small. You, as actuaries, should surely be able to figure out what the premium ought to be in the way of investment in research to get into this thing to see whether you can become beneficiaries without dying in the process.

The question that I would like to raise, then, is, Why isn't it used more? It has been around quite a while now, and I would have thought that organizations such as yours that are involved in huge investments would find this something well worth looking into.

I am quite sure that the average investment analyst is not able to do this on his own. I think that he is going to need a lot of technical help because of the complexity of the mathematics of the model and so forth. I think that this would be an ideal sort of thing for an operations research team to get to work on. It needs a lot of different kinds of

talent—it needs investment talent and it needs managerial know-how, as well as computer technology and mathematics. And, if the model is found to be unsatisfactory, the team should have the talent to make one that is.

I would just like to close by saying that I think both of these areas, both marketing and investment, would be very good areas for operations research activity in the life insurance business because the problems there are so difficult. If you people are good at developing models and refining models, this is a wonderful field to put some work into. I think that you might find great rewards working in these areas—both would be highly interesting. We are dealing with the future, with uncertainty; we have to cope with probabilistic ideas, with subjective probability, and so on. I think that these are very fine fields, and I would like to see more work done. I hope some of you will do it.

EDWARD A. LEW:

Gordon Shellard will now tell us something about an actuary's view of the Markowitz model.

GORDON D. SHELLARD:

The position of life insurance companies with respect to the Markowitz model is somewhat different from that of many other investors. Legal restrictions quite sharply limit our investment in stocks. Most other investors are not limited in this way, and, while the Markowitz model is applicable to any kind of investment, I believe that most discussion of its use has been in connection with stocks.

Any attempt to apply the Markowitz model in the usual way, to detailed selection of investments, would require a great quantity of input data. Assuming that in some way the data could be supplied, the continuous activity of the market and the sensitivity of the model probably would call for such ceaseless switching of investments as to be impracticable. Perhaps a cost of switching could be built into the model, to make it less sensitive.

But application of the Markowitz model to detailed selection of investments is not its only possible use. If classes of investments are treated rather than individual securities, both the input-data problem and market activity seem quite manageable. In this way the Markowitz model could suggest an ideal portfolio composition that could be used as a guide in practical operations.

Less known except to actuaries, perhaps particularly except to Canadian actuaries, are some papers on the immunization of funds that

have appeared in the last few years in the *Journal of the Institute of Actuaries* and in the *Transactions* of the Faculty of Actuaries. These papers describe methods designed to maximize yield subject to conditions limiting loss to specific amounts in the event of adverse turns of the market. One of these papers uses game theory, while another employs linear programming.

EDWARD D. LEW:

At various times Nate Jones has forcefully presented a number of interesting ideas on the subject of marketing. He will comment on his views of marketing problems in relation to operations research.

NATHAN F. JONES:

I am not really going to talk about O.R. at all. I am going to talk about the marketing problem of our industry—I realize that this is a professional society, but we seem to be talking about it as a trade association of life insurers this afternoon—as I would start framing it up for operations research consideration, and put this up to Dr. Ernst to see what he can do with it from there. Like our industry, operations research has, in my opinion, been doing a relatively poor job in marketing; but I shall leave this to Dr. Ernst also.

In important ways the life insurance business is a simple business. None of its products can be patented, so that we can all copy each other without further raising the going price for actuaries. These products require minimal capital investment and cost very little to manufacture. Inventory, purchasing, and traffic problems in the usual sense are almost nonexistent. So, anyone can be in it, and we sometimes think everyone is. More than even other financial businesses, it provides its own financing. We require an investment operation, but this is typically performed by methods, skills, and persons who are fairly freely transferable in and out of the job, so that we do not have to grow our own.

The insurance business has many fascinating technical aspects, primarily because it is based on contingencies and because it is very heavily regulated by law. These make underwriting and legislative and supervisory relations—lobbying of one sort or another—the most important technical problems. But *life* insurers, as opposed to property and casualty insurers, have limited rate regulation, and the secular trend of their most important contingency (mortality rates) has long been running heavily in their favor, since annuity business is less important than the insurance business and planning for contingencies which come slowly is much easier anyway. Annuities are not, anyway, underwritten in the usual

sense of the word, and to protect the insurer against antiselection would be like advocating sin.

A & H does have real underwriting problems, and we squeal about them like stuck pigs until we happen to notice results in the property and casualty fields.

So, apart from legislative relations, the technical problems are not those toward whose solution chief executives of life insurance companies are panting to spend more money, and those are the only kinds of problems worthy of an O.R. man's professional attention. From this point of view, life insurance is primarily a marketing business.

While the product sold is far from the whole of marketing, it is a good starting point. From my point of view—this afternoon, anyway—our product is not a piece of paper or a service contract of adhesion or even a set of benefits, options, conditions, exceptions, and exclusions, with a graduated price structure. From the point of view of most consumers, our product might be described as an enforceable agreement through which the buyer hopes to secure such goods as financial security for himself and those dependent on him or whom he loves, a feeling of having done his duty, savings, assurance of continuity of family ownership in a home or business, and so forth.

I know that there are a lot of sales in our business not from this point of view, but I think that an overwhelming proportion of at least all *life* insurance bought is on this basis. More importantly, while the dollar potential for additional sales in the other subsidiary purposes is very great, it is as nothing compared to the potential for additional sales under the definition above.

Most of what follows relates primarily to individual insurance sales, because they probably have the greatest potential and because the marketing problems for commercial lines are different.

A product like this is, of course, a luxury product. Salesmen naturally and properly try to obscure this by, "You can't afford to be without it." Many of us probably are deeply convinced of this. Nevertheless, in terms of pressures for expenditure actually operating on most prospective purchasers, life insurance cannot rank with food, clothing, and shelter, even well beyond the theoretical minimum level, and a host of things under the general heading of "keeping up with the Smiths"—I personally never say "the Joneses"—health care, education, transportation, recreation, and so forth. Intangible luxury products are easy to take orders for but hard to sell, as we all know. Other savings institutions in general only advertise and then take orders over the counter. A luxury product has advantages, however: the market is far from saturated and there is high

potential sales leverage with the further growth of an economy of abundance in our two countries. On the other hand, products designed to further human security but which are hard to sell on an individual basis are a natural for government pre-emption.

What is the matter? We have a very expensive distribution system. When my parents were young adults, there were two competing telephone systems in my native city. If you wanted to be able to receive all calls, you had to have both. Nowadays, we are reconciled to the concept of regulated monopoly where duplication of distribution facilities for a necessity would be unreasonably expensive. But, if one of you fine young prospects in the audience were to let it be known that you were in the market for more life insurance, dozens of salesmen would be clamoring to spend their afternoons and evenings with you. True, only one would be paid—except, perhaps, for the majority who are subsidized—only one would be paid *for that sale*, but our incentive compensation system must reimburse even moderately successful salesmen for their total working time at rates comparable to what they could earn in other occupations. It is no wonder that the *really* successful salesman can tell the president where to go—for the Agency Conference.

We compound this. Pricing in any business must be designed to yield, in the aggregate, the marginal costs of production and distribution, the overhead costs of the business, and the margin for contingencies and profit. Most of us believe that, to a substantial extent, the law fairly strongly requires, or if called upon would require, that the provision for overhead and for contingencies and profits be spread “equitably” over our pricing structure. This means theoretically that we cannot get the money where it can be had or meet bona fide price competition—two important pricing phrases elsewhere. Gestures in these directions are nevertheless sometimes made, particularly in the group branches, due to the relentless pressures of economics from the front office.

Beyond this, we have, for individual insurance, a pricing structure based generally on age, plan, year of issue, and mode of premium payment, with, nowadays, some concession to size of sale. Other pricing differentiations based on cost are generally directly considered only in group insurance, although they sometimes creep in indirectly, as size used to do before it was overtly recognized. The result is that our pricing is generally at average cost levels for all other factors, offering sharpshooters the obvious possibilities for skimming the cream. Because of very real difficulties, they have not done much about it yet—or am I forgetting the growth of group, association group and pseudo-group, to coin a phrase? When something *is* done about it, we can expect that it is at distribution cost that aim will be taken first, where we have an

almost rigid, traditional sales compensation structure, pitched, not at the average cost level, but at the highest cost level at which insurance can be sold at all. The effects of the direct writers on the so-called American Agency System carriers of private passenger automobile insurance bear eloquent testimony to this. Incidentally, this rigid compensation structure often provides salesmen incentives which clash with those we provide our sales managers, and both clash with executive goals.

Finally, we have inherited not merely government regulation but the heavy taxation to which it inevitably gives rise and which it supposedly justifies. Since other savings media do not take for the government a few cents off the top of every dollar deposited, it is no wonder that we did, until recently, find ourselves priced out of the sale of employee pensions.

Of course, purchasers of lower-cost products get only the service that they are willing to pay for, while we will in theory give service to an individual insured far beyond the value of his premium. That is one of the troubles. However, many of our better agents have outstanding incomes while providing such service that their clients would no more think of comparing prices elsewhere than they would for medical, dental, or legal service. But be honest. This applies to no more than a small proportion of the insurance your company or mine sells and to an even smaller proportion of the salesmen, due to the hunger for sales which has resulted almost everywhere in the world in the acceptance in this business of the minimally qualified marginal producer. What are we going to do about it? Probably very little. It is too hard. And, to sum up, as I was recently quoted as quoting from someone else: "We're not hurting"—not *really*; not yet.

EDWARD A. LEW:

Nate Jones has made it abundantly clear that marketing is a very promising area for the application of operations research. Martin Ernst will now give us the outside expert's viewpoint on this subject.

MARTIN L. ERNST:

I hope that no one expects that I am going to analyze your entire distribution system and instantly recommend a complete reformation. If I could do so successfully, I would be a lot richer than I am now! In fact, if I could come anywhere near doing it, I probably would not tell you, because the union of consultants would pick on me for cutting prices. So my long-term future rests on being a bit of a failure in solving this problem.

Let me comment first on one of Nate's remarks, to the effect that he

feels that O.R. has been doing a poor job in the marketing area. I agree with the comment that a poor job is being done in applying quantitative techniques in marketing, but I do not know whether the fault is in the O.R. workers or in the marketers. I believe that there are two sources of difficulty in this area, and I suspect both of them apply in life insurance as well as in other industries. One of these is the temperament of marketers, and the other is lack of investment in acquisition of marketing data.

Let us examine the first of these, the temperament of marketers. For a long time, executives responsible for marketing—especially of consumer items that are sold by agents or by salesmen—have recognized that the personality, the character, the skills of individual salesmen dominate most factors in the marketing system, other than the product itself. They have, therefore, oriented all their attention toward dealing with sales personnel rather than dealing with numbers and analyses. The people who have been most successful at dealing with sales forces have been the ones who have advanced in management, and these are not necessarily men who will easily acquire, recognize, or appreciate skills in quantitative analysis. In fact, they are apt to be just the opposite. They are worried about these kinds of techniques, they do not understand them, and they probably—with varying degrees of justification—suspect somebody is going to use these techniques to their disadvantage. I see no easy means for curing this condition, which is fairly prevalent, other than waiting. It is going to take us the better part of what I call a “business generation” before marketing people really accept quantitative techniques. By a business generation I simply mean the time until some of the young marketers, who are beginning to get these skills while in the educational system, reach a position in industry where they begin to make the important decisions.

There is a lot of justification for this attitude by marketing executives. A senior executive always has to be able to evaluate intelligently the performance of the people who are working for him, and if these people are dealing with skills which he does not understand and cannot evaluate, he is quite correctly going to be very uncomfortable.

The lack of investment in marketing data could be cured more simply, so let me discuss this area in more detail. Time and time again certain types of problems come up in marketing. Should we issue this new product? Should we increase our efforts in a given area? In general, when the question arises, there is a complete lack of adequate data to make use of quantitative technique to resolve the matter. The cost of going out and acquiring this quantitative data is usually greater than is worth

while for the question at hand. Therefore, the decision is made: We will go with what we have, and we will not bother to collect more data. The fact that next month another related question is going to come up, that could use the same data, is ignored; and the fact that, when you add up all these decisions over a period of time, it might be very worth while collecting the data on a continuing basis has not yet been accepted in the marketing area. There are some companies that are beginning to do this, but they are few in number.

The most fundamental step to take in any marketing activity is to learn to understand your market properly and in great detail. This is important any time you are trying to develop a new product, any time you are trying to make estimates of what your sales will be, and any time you want to try to change your sales incentives and the techniques with which you handle employees, such as salesmen or agents.

A question which continually arises in your case is, Who buys what kind of insurance and under what circumstances? What you would like to have available, you and most other industries, would be what might be called a good, detailed customer profile—a profile that provides a discriminant function, which, with relatively high accuracy, can separate the population into various groupings which have appreciably different probabilities of being vulnerable to different types of sales effort.

I do not believe that at the present time you have this information, just as I do not believe that most industrial organizations have an adequate picture of their markets. You have enormous amounts of data—often very well analyzed—on people who *do* buy insurance, but you do not have equivalent data on the people who do not, particularly on why they do not. There are a variety of techniques for gaining this type of information; in many respects I think that insurance companies are better equipped to acquire it than most industries, but we all have a long way to go in this area.

The collection, the tabulation, and the interpretation of this data are basically forms of investment, and they have to be started and conducted on a continuing basis if any company is to properly understand the nature of its market. In the area of insurance, I think that you might even want to go further; it might be desirable to use the various customer profiles that you develop to build a model—and I will use that word since we are talking about operations research—a model of how customers with given characteristics spend their disposable income. Our environment is continuously changing. For example, the actions of the federal government in promotion of operations such as Medicare certainly will have an influence on how people view the spending of their

disposable income. The growth of pension plans, of group insurance, of group health plans, all of these must have important influences on very important market sectors. I believe that a suitable model of disposable income expenditures by various consumer profile groups offers you your best hope of understanding and preparing for the coming changes.

Knowing the market is not going to be enough. You still have to worry about this question of distribution. In a sense Nate Jones's cry—and I guess it is not really a cry in the wilderness—is essentially one of saying that your whole distribution system is archaic. This is a viewpoint with which I would agree. It may be the best distribution system you can have at the present time, and this may continue for a long time, but it nevertheless is an archaic system for the world of today. The effectiveness, the productivity per man, is not very great in an era when productivity in most other areas is increasing rapidly. I cannot make any forecast with regard to what is going to happen in the future here and whether there are any real possibilities for revision of the system. I just suspect that it is in a highly vulnerable position in case a feasible alternative comes along.

While I can offer no clear-cut answer or solution, I will make one suggestion based on the characteristics of modern marketing for industrial products. There has been growing recognition in recent years of the fact that even for a simple product you do not have a simple market; the market tends to be stratified in a wide variety of ways. There are always the big customers and the small customers, the customers who want to order frequently and the customers who order seldom. If the market can be stratified according to these and other characteristics, it often is possible to use different sales techniques for the different strata, or segments.

An obvious possibility here, though not one which is necessarily feasible, is recognition of the fact that in the area of life and associated insurance there are probably always going to be some big customers who merit individual personal attention by agents in rather large doses, who only buy under these conditions, but who, once sold by an agent, will continually go to him. Nate Jones made reference to this fact.

There are probably also a large number of people who will always be small customers, who may or may not be influenced by the nature and the personality of the agent, and who in a sense have relatively simple demands and do not require much service. Clearly there is a differentiation in the nature of the market here. Whether this can be utilized by differentiating the sales force is something I cannot answer, because I do not know enough about your industry.

These are fairly broad problems that I have been talking about. Naturally, there is a whole host of other problems where operations research can be, and in equivalent situations has been, applied. The evaluation of the performance of agents is certainly one, and I am sure that you already have measures of this. The question is, can these be improved and made more meaningful? The selection of agents is not an unimportant subject. Much as we would like to be able to develop a good customer profile, it would be nice to be able to develop a good prospective agent profile that would provide some degree of discrimination as to who would and who would not be successful.

Nate made mention of the fact that an individual company is likely to have a limited number of good agents. I do not know what per cent of the total business these good agents sell, but there certainly must be a cut-off point at which you are better off doing without additional agents than adding agents if they are only going to come at the lower end of the range of skills. These topics are in the area of tactical problems, where operations research in general has been fairly effective. The pattern of agent calls and a host of other matters have been subject to study in other industries. Again I do not know whether they can be usefully employed in a loosely knit distribution system, such as you have in life insurance, but there is a wide field for study in these areas.

EDWARD A. LEW:

I want to thank Martin Ernst for his penetrating comments on the potentialities of operations research in life insurance marketing. For a further perspective on this most important problem, as well as on operations research in the investment field, I am now turning to Bill Anderson.

WILLIAM M. ANDERSON:

At this stage we are discussing two areas where the problems are somewhat staggering and possible solutions are commonly bandied about but also where a great deal of the kind of approach to solutions that we have been talking about today is probably going to be required—not primarily at the level of individual companies but at the level of the life insurance business as a whole—if these problems are to be solved satisfactorily.

In the investment field two of the speakers have referred to Markowitz and his work on portfolio analysis. Peter Sandiford talked very learnedly about it, and then finally said he did not know too much about it. I will do it the other way round. I know very little about the mechanics of the Markowitz programming, but I must confess that, from the point

of view of our business, I am not very much impressed with its possibilities. The reason is that, if I am not misunderstanding the Markowitz method, it is designed for the theoretical individual investor who invests a known amount of money within a prescribed but finite time horizon. Under these conditions it is possible, given the premises of Markowitz' reasoning, to arrive at solutions which will maximize yield subject to given risk or minimize risk subject to given yield.

Unfortunately, the process assumes an unlimited market in the sense that the investor's action, according to the theory, is not going to have any effect on the conditions of the market. He is small, in a big capital market. Our business, of course, is in the position where in certain sections of the capital market our actions are dominant. The long-term corporate bond sector is the best example of this. Here is an area where, if a number of the big companies tried to practice Markowitz in selecting corporate bonds, they would very rapidly shatter the premises and find themselves in the position where the theory would not work because the premises would not stay still.

More importantly, the life insurance business has a much longer time horizon than the kind that Markowitz envisages. We are in the business of making very long-term commitments not only in respect to money that we have received but on money that we have undertaken to receive in the future. You have seen projected asset and liability positions of life insurance companies. They are dealt with extensively in the literature referred to by Shellard.

The kind of problem that the life company faces continually is one where, to a very large extent, the major risk is the risk of change in the general level of interest rates, the so-called riskless interest rate that people talk about. Using the long-term government bond rate for illustration, in both Canada and the United States it is about twice as high today as it was at the end of the war; this kind of movement is one of the things which can affect us long-term ever so much more than a process of endeavoring to maximize yield for given risk within a portfolio where the actual investments primarily differ by issuer rather than by length of term.

Some of the problems that we face here are ones where, as Shellard has suggested, we should do as much as we can to try to immunize ourselves against the risk of long-term change; and I think that the life insurance companies have done quite a bit of this. In particular, if you look over the record of the last hundred years or so, you will find that there has been a distinct tendency for the industry, during periods of low interest rates, to major on mortgage investment and, during periods

of high interest rates, to lean in the direction of long-term bond investment. This is obviously the way to handle the problem of length of term of investment. You shift from short to long when interest rates are high, and you shift from long to short, as best you can, when interest rates are low. This process has had a beneficial effect within our business because of the fact that mortgages, which are inherently short-term, bear higher interest rates than bonds do at any one time. Therefore, we have stabilized our internal yields to a much greater extent than has been the case for the riskless interest rate as represented by government bonds, so that, in the process of immunizing ourselves, we also have enjoyed an internal smoothness that this method has brought about.

One aspect that we have not paid as much attention to as we might is the proposition of the British writers that, under conditions where the net cash outflow on the insurance side of business will be maximum some years hence and, in fact, will be negative in the earlier years, the investment portfolio is much better designed if it tends to concentrate length of term in short investments that will mature before the outflow occurs together with long investments that will not mature until after the outflow occurs. They demonstrate that this pattern has the effect of insulating against changes in interest rates and, also, due to the second difference effect in the equations, it actually tends to produce profits by reason of either upward or downward movement in the general level of interest rates.

Another area where work is now being done is in the problem of cash management. Our business is of such a character that our short-term cash inflows are highly predictable. We have virtually no liquidity problem, and, when you look at the investment policies of most of the companies, there is no real investment reason that I can see for the kind of cash balances and short-term liquids that the life insurance companies keep in their portfolios.

Some companies have tried to correct this situation by the process of making free use of bank loans. This permits a company to be more fully invested, and it uses the movement of the overdraft rather than the movement of cash itself as the investment-balancing factor. This has the happy effect not only of keeping money more fully employed but also permitting much greater freedom in timing on new investments over short periods of weeks and months, which can be quite important whenever the securities markets fluctuate significantly.

Another process that is in use is in the single-premium immediate annuity market, where, thanks to the computers, it has been practical to change rates overnight. It is now feasible for the actuary to go to the

investment department and say, "We run our annuities on a split-interest assumption, and we have made up our minds that this is the rate beyond fifteen years hence. What do you think it should be for the first fifteen years? What are you content to borrow money at for investment?" The decision is not an actuarial decision; it is an investment department decision, which says, "You put out a rate basis which will bring in immediate annuity money at the kind of rates that we are willing to pay for short-term borrowing with the repayment pattern of the annuity fund, and we will turn around and put this money into long-term bonds." This seems to be a perfectly sensible process.

Another method that some of the big companies use is the warehousing method, where blocks of mortgages are made or taken up in the first instance by a bank and under agreement with the life company will be drawn down. If the draw down is to a large extent according to the life company's cash flow, the draw-down process on the warehoused mortgages can become the prime instrument for managing cash.

I also wanted to mention another method which, to my knowledge, is fairly new and has not yet been used extensively. Several of the Canadian companies have decided that it is too much of a luxury under present conditions to hold a lot of short-term paper issued by nonfinancial corporations, finance companies, and governments. These companies are now moving into a position where they are issuing short-term paper, so that pretty soon you will be able to go to investment dealers and brokers and buy paper of a life company on terms of your selection. You will be able to buy notes that mature anywhere up to several years ahead, and, if this process is used extensively, it will provide probably the most efficient type of cash-management control that the life insurance business can develop.

Another point in the investment field that I want to mention is the fact that the over-all program of equity investment has become more important in recent years, not only because of competition with uninsured pension funds but also because of the increasing realization (*a*) that we are a type of instrument in the capital market that is a principal mobilizer of long-term savings, (*b*) that quite naturally large parts of long-term savings must find their way into equity investment if our capital structure as a whole is to work well, and (*c*) that an increasing proportion of equity investment will in fact be institutionalized and life insurance companies, in self-defense, must be prepared to move further and further into this field. Of course, the development in the last few years of segregated funds is an excellent illustration of the way in which the industry has started to move in this direction. I am of the view that

we will find ways of moving much further than we have, but I am not suggesting that these ways will necessarily, or even ordinarily, involve us in radically different forms of contractual arrangements with our policyholders.

In this same connection, we have tried to dispose of the problem of the large and irregular sums of money that come to us in the group business by using the so-called new-money approach. I have taken occasion to study some of the literature on this subject, and I must confess that I am not impressed with what is being done. It seems as if the actuaries have found a new toy with which to play. I suggest instead a very much simpler method of solving the whole problem—one that is less arbitrary as well as being less complex. Why not pretend, if you will, that the company itself is a segregated fund and that what you are really doing intrinsically is issuing units. You can carry this exercise through theoretically, and all that is required to put it into practice is a method of calculating market values of assets periodically. With this approach, you find that you can generate for every class of contract an asset share that is developed with investment return measured at market, the same kind of thing that a mutual fund does.

In effect, what you are doing is saying to all your existing policyholders, "Well, we have to take new money in on a new-money method, so we pretend that we sell all our investments at December 31, credit the proceeds properly to all of you, and then buy the investments back January 1. Now we will have all of you on a new-money method for this year, and therefore we can bring fresh money in, in parallel with what we are doing with existing money."

May I suggest that if you think this problem through in this fashion, you will conclude that it can provide you with the same answers as the new-money approach without being anything like as burdensome either on your own thinking or on the time of your computers.

May I now take a minute or two on the agency side. Here, of course, we have some problems that have existed for a long time, and, when you come to examine them, you can see how the problems developed and you should be able to see the direction in which the solutions lie. Obviously, the agency system developed because of the fact that we had to have missionaries, and agents were effective missionaries for the life insurance business. Up until the end of World War I, when life insurance was not as widespread as it has later become, that was their role, and they filled it very effectively. During that era the agency system was not an expensive process. In fact, it was probably the most economical way in which the missionary effort could be carried forward.

After the war, we moved into the era of programming and professional life underwriting as instruments for intensive development of the market. We were not then finding people that had never heard of life insurance and having to convince them that life insurance was a good thing. Instead, we were teaching people to realize the magnitude of their problems by offering them solutions that fitted those problems as visualized.

Now we have moved into another era, where the large-scale growth of the mass coverages, both private and public, together with large-scale accessibility to various methods of saving for retirement, has meant that the individual part of our business is not going to be the same in the future as it was in the past. It is not true that it is going to be constricted. As I estimate the potential for coverage in our two countries, I am convinced that the uncovered potential is of the order of magnitude of one and a half to twice the amount of life insurance that is now in force, and this is after allowing for the effect of social security programs and all forms of private saving. Individual life insurance faces not a problem of potential but rather the point that, as life insurance becomes more universally recognized, it is obvious that the costly process of individual selling must occupy a relatively lesser role. As a community, we cannot afford the luxury of wasting the talents of manpower that is as productive as many of our life underwriters are, in the expensive process of handling individual coverages; so I suggest that the individual business in the future is going to move in a direction where we find ways of manning our field forces with fewer and better agents.

I do not agree with the industry's current thinking to the effect that we should be planning ways of expanding the agency forces. I think that the solution lies in the direction of holding in on the size of the agency force and gradually retailoring the abilities and skills of the men, together with changes in our products, so that the agency system fits the kind of emerging individual market that seems to be developing so rapidly. The kind of things that will have to be done in the future will consist of providing large amounts of life insurance of a simple kind as building blocks in people's total programs, together with more intimate custom-tailored design of contracts which will fit much more closely along with the other coverages that people have in order to provide the kind of over-all satisfaction of the kind described by Jones a few minutes ago.

The problems that I have been discussing are big ones, and perhaps the first thing we should do, as Sandiford remarked, is to try to understand what our objectives are. Until we do this, we are likely to have an awful lot of thinking at cross purposes within our business, and this

seems to be not just true of the actuaries but of the agency men and of the top executives of the companies.

The only other problem that I want to refer to is one that ties product and marketing together with the investment problems in our business. It is the point that as an industry, we have moved very rapidly into the process of structuring our prices by size of policy. Literally all of us today are using a graded premium or policy fee system, and I am very worried about the kind of problem that is going to be on our doorsteps a few years hence. While we were monolithic, in the sense that we did not grade by size, we experienced the coincidence that the size of our policies in force tended to grow at about the same rate as the administrative cost per policy. We condensed these two factors and allocated our expenses on a per thousand basis for this class of expense. This process had the intrinsic merit that newer, larger policies were always being somewhat overcharged and older, smaller policies somewhat undercharged, but this was regarded as a good thing because a life insurance company has to find money to grow and most of the companies can only find money by borrowing, in effect, from policyholders. Nowadays, when we are into the fee system, we have changed this pattern. Under today's conditions we are selling our business, say, with a \$9 or \$10 policy fee, and in effect saying to ourselves, "This is what we expect the administrative expenses to be during the lifetime of this policy." But this is not the case; they are going to be higher. For a long time they have been moving up significantly year after year in spite of all the improvements that we have made in our administrative operations. They have been moving up, and no doubt they will continue to move up. We can no longer look at the policies we are selling on a basis where we say, "Well, of course, we'll have margins from interest and mortality in the future to look after this problem," because we seem to be heading into an era where the potentiality for further improvement in mortality on insurances is not very remarkable and certainly I do not think anybody is expecting that we are going to get marked further upward movement in our investment returns. Accordingly, we have not got those cushions to rely on, and sometime we are going to find a major problem on our hands and what will we do about it?

One suggestion is to develop a participating policy fee with cash values and death benefits and a built-in rising policy fee, paid for on a level basis, and this would give us what we predict we will need. Another suggestion is to recognize that the present value of future administrative expense is an explicit liability of the company and that, under today's conditions, we cannot just say, "Well, we ignore our loadings, and there-

fore ignore this," because the loadings are fixed dollars. The future administrative expense will be paid in tomorrow's dollars, but, if it is recognized as a separate liability, perhaps this would lead us much further in the direction of an appropriate investment policy to cover the liability. This might lead us in the direction of more substantial equity investment, both in stocks and in real estate, deliberately for the purpose of looking after the problem of rising future administrative expense on policies that we have already written.

A solution of this particular problem obtained through an operations research approach would present a very happy blend of thinking between the marketers, on the one hand, and the investment people on the other.

EDWARD A. LEW:

Before closing this session, we would like to hear from one of our Canadian members who has a great interest in operations research, Mr. Kenneth G. Murden, actuary for Canada of Holland Life Insurance Society, Ltd.

MR. KENNETH G. MURDEN:

I am making these remarks not in the position of an actuary doing operational research in an insurance company but as an actuary who has always been interested in operational research. I am a past president of the Toronto Section of the Canadian Operational Research Society where we have a few actuaries already involved in the section. There is some indication that the numbers are growing, judging from inquiries we have had. To some extent this has been encouraged by a recent meeting of the Younger Actuaries Club in Toronto, when the subject was operational research.

I would not, however, at the present time feel that there are many actuaries actually practicing operational research in the insurance companies. This is due partly to the newness of the subject, partly to the fact that the bigger companies are more capable of applying it and will probably reap the quickest benefits. Inside the big companies, I would guess that only a few select people are involved. From the point of view of my own company, which is a company small in Canada but large in Europe, we would more likely find more immediate value in applying it in our home office operation than in our Canadian operation, although we are paying close attention to the situation.

There are two main reasons why operational research is of importance to the actuarial profession. First, operational research techniques require mathematical knowledge of a high level, and the actuary by education and training is generally adequately equipped in this direction. Second,

the actuary is intimately involved in insurance management, either being an integral part of top management or with the ability to speak to top management. General experience with operational research has been that its success depends upon the ability of the practitioner to talk directly to top-level management, and it helps considerably if top management understands what he says. This is not always easy. It would be difficult to find another part of the insurance organization capable of dealing with this matter if the actuary does not become involved.

My own personal involvement with operational research dates primarily from the five years I spent working with London Transport in the United Kingdom, where, as a group of several actuaries following the original inspiration of Mr. Menzler, we became involved in applied statistics and related matters, all of which were on the fringe of operational research.

My discussion concerns three main points, all of which have probably been made elsewhere very frequently. The first is the interrelationship between scientific disciplines and the value that can be obtained by one discipline from understanding and applying, where possible, the techniques of other disciplines. This was brought to my attention quite clearly when, as a newly qualified Fellow, I became editor of the *Students Society Journal* for the Institute of Actuaries and one of the first papers that came before me to edit was one by Mr. Grossman on the subject of the Duhamel integral. The subject of this paper was the application of an equation well known in magnetism theory to a particular actuarial problem.

This brings me to my second point, which is that the relationship between operational research and the actuary should be a two-way process. We should be able to give to operational research as much as operational research gives to us. It may be necessary to bring operational research specialists into the head office of insurance companies either on a consulting or full time basis, but at the same time we must provide that within the insurance industry actuaries themselves play a big part in developing operational research applications. Inevitably, this will mean actuaries branching out into operational research generally.

My third point is that we should, as far as possible, keep our eye on the problem rather than the method. It is easy and often convenient to look at the different operational research techniques and then to look around for places to apply them. Rather, we should be looking at the problem and what is the best way to solve it. Certainly there are plenty of problem areas where this can be done. I will list them briefly.

1. Investment.
2. The model office method of financial forecasting.
3. The calculation of premium rates.
4. The development of an agency force.
5. The determination of maximum amounts of retention and issue.

These are but a few of the problems on which some work already has been done.

There is perhaps one final question. Where do we go from here? I think that there are two ways. First, I would recommend that actuaries join the local operational research societies. Second, I think that means should be developed for actuaries to discuss among themselves the specific problems of applying operational research to insurance.