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ACTUARIAL ASPECTS OF A CONSOLIDATED FUNCTIONS ELECTRONIC SYSTEM

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INTRODUCTION

WE ARE all aware of the ever increasing importance of electronic computers in the work of the actuary. As bigger and better computers have been developed for commercial applications, more and more companies have gone into electronic data processing on a large scale. In most insurance companies actuaries have had an active role in computer planning, installation, and successful operation.

While those actuaries who became actively engaged in electronics soon acquired an intimate knowledge of the area, many others have not had this opportunity. Yet, since electronic data processing affects practically every area of insurance operations, the principles and problems involved in successful computer planning and operation are subjects of interest to all actuaries.

The purpose of this paper is twofold: (1) to describe some of the actuarial aspects of one company's electronic system (this should be of general interest to those engaged in computer work) and (2) to discuss the underlying analyses and comparison of alternatives that led to the selection of particular electronic procedures to solve certain actuarial problems (it is hoped that this will serve to impart a better understanding of what is involved in adapting large-scale computers to insurance operations).

The selection of the proper electronic procedure is conditioned by many factors which naturally vary from one company to another. What is far and away an ideal electronic system for one company may be completely unsuitable to another. While individual solutions will vary, the types of analyses used in the selection are substantially the same. For this reason the primary purpose of this paper is not to describe the end results but to portray the steps along the way.

At Mutual of New York, we selected the consolidated functions approach to electronics. As a result, we now have operational a fully inte-

grated electronic system that is exceptionally broad in its scope. Requiring over 300,000 program steps so far, including those necessary for the initial conversion, the system is now able, or soon will be, to handle practically all routine Ordinary insurance operational functions. These include premium billing, accounting, loans, surrenders, lapses, maturities, expiries, and many others. In fact, all told the system handles some 260 individually distinct transactions, and the list is growing steadily.

A key feature of the operation is the fact that each day the entire tape master file, consisting of 1,600,000 comprehensive basic policy records, is passed through the computer and tested for possible activity. The appropriate records then undergo further processing. This series of computer runs, commonly referred to as the "daily cycle," is the heart of our electronic system.

A major advantage of the daily-cycle approach is that it allows one-day service on the vast majority of computer-processed transactions. Policyholder requests are received during the day, are coded immediately for processing, and enter the computer at night. Early the next morning the results are available, and the appropriate action is taken. The whole process is dependent, however, on keeping the daily computer running time to a maximum of twelve or possibly fourteen hours. Otherwise, there would not be enough time left to allow the necessary processing of the previous night's computer output. Minimizing computer running time is thus an especially important goal in the design of all aspects of our daily-cycle system.

CASH VALUES AND DIVIDENDS

The remainder of this paper discusses some problems faced in the design of our electronic system. The examples were chosen from the cash value, dividend, and valuation areas, since these are of most general interest to actuaries. Although these problems arose within the context of a consolidated functions system, they illustrate techniques of system design that are equally applicable in other situations as well.

Obtaining factors in the daily cycle.—The basic problem faced in the dividend and cash-value areas was how best to provide these values in the daily cycle when needed. There were two major alternatives—calculating them whenever needed from basic principles or storing current factors in each policy record, with periodic updating. Of course, there were all sorts of possible variations and compromises, but the basic choice boiled down simply to calculating versus storing.

Under the calculating approach, dividends and cash values are not contained in the basic record but are computed during the daily cycle at any time needed. Since every item added to the policy record adds to the

daily tape-passing time of the master file, there is a definite advantage to keeping unnecessary items out of this record. However, the time thus saved is offset in part by the extra time it takes to calculate cash values and dividends on those policies where they are required for that day's processing.

The storing approach involves a calculation also, but this occurs just once a year, in December, with the results of the calculation being carried in the individual tape records until needed. Factors per thousand are stored and multiplied by the face before actual use. Although the storing method has much in its favor, there is one important limitation. This is the fact that the policy status as of December must necessarily be used in determining which factors to insert. If subsequently there is a lapse to reduced paid-up or extended term or a change of plan, new factors must be substituted manually. This contrasts with the calculating method, where naturally the most up-to-date status is used in the computation.

On the other hand, and of far greater importance, the storing method has the very significant advantage of keeping the ultravaluable daily-cycle program steps to a minimum. This is vitally important, since the daily programs in a consolidated functions system tend to become packed full as more and more functions are added. Any program steps added for one purpose necessarily are at the expense of another.

A further advantage of the storing approach is flexibility. Since the bulk of the calculation is confined to an annual updating run, the system has complete freedom and can easily absorb changes in dividend or cash-value formulas no matter how complex they become. Complexities merely add to the machine time of a once-a-year run; the daily programs, which use only the stored results, are not affected. There is a concomitant practical programming advantage, too. All actuarial formula programming is concentrated in an annual run which can be assigned to one or two actuarial trainees. The large-scale daily-cycle programming effort, necessarily staffed by nontechnical personnel, is freed of this added burden.

Consequently, assuming that the total annual running time required would be reasonable, the storing approach appeared the better method. The next step, therefore, was to estimate what the actual running time would be under each of the two approaches.

Under the storing approach additional running time arises in two ways. First, the carrying of cash value and dividend factors, rather than calculating them when needed, increases the over-all length of the basic record and thus the daily tape-passing time as well. Second, the storing method requires whatever once-a-year running time is necessary for the December updating run. It was therefore necessary for us to determine total time

resulting from both of these factors and then compare this sum with the additional daily calculation time which would result from the alternative method.

Before proceeding with this comparison, however, we first had to determine a tentative machine procedure for the December updating run so that we would have at least a rough idea of what the time requirements would be. This was done, and then the over-all comparison of time required under each method was made. When the differential between the two turned out to be inconsequential, we selected the storing method for the reasons previously mentioned.

However, for dividends a compromise solution was thought best. Here a problem is caused by the fact that the total dividend payable is made up of a number of separate elements. In addition to that on the base policy, there may be a dividend on term riders, prior dividend additions, substandard extras, benefits such as accidental death or waiver of premium, etc. If the dividend is inserted in December for use on anniversaries in the following year, then it would have to be serviced for changes in any of these elements. To reduce servicing requirements, we decided to insert only the base policy dividend in the basic record. The remaining elements would be calculated during the daily runs for those policies then having anniversaries. Since the formulas for the ancillary components of the total dividend tend to be very simple, this procedure does not place any real burden on the daily cycle.

Annual insertion of new factors.—As stated earlier, the storing method requires a run each December to supply new cash-value and base-policy-dividend factors. The problems faced in selection of the best method to do this updating are of some interest. Here, again, we were faced with two basic choices. Either we could pass the master file in our regular sequence (agency–policy number) through a program to calculate values from basic principles, or we could sort the file, match against a precalculated tape file of actuarial factors, and then resort into the regular sequence. The tape factor file would contain current dividend and cash-value factors for each in-force combination of rate basis, year of issue, plan, and age and would itself be updated annually by a computer program.

The advantage of the regular-sequence approach is that it avoids not only sorting but also the creation and maintenance of the factor file. On the other hand, the sorting approach involves far fewer "basic principle" calculations, since it is necessary to calculate factors for each valuation cell rather than for each policy. As a matter of fact, this reduction in calculations more than offsets the time needed to sort and resort the master file.

Both methods require a basic principles program—either to service the master file directly or to service a factor file which later services the master file. However, under the regular-sequence approach, all formulas and commutation functions must be in memory at the same time. In contrast, presorting into valuation sequence conserves memory. New sets of formulas and commutation functions can be brought in when necessary, replacing those no longer needed.

A further advantage of the sorting method lies in the furnishing of gross annual premium factors, which are needed in the basic dividend calculation under our three-factor formula. Under the regular-sequence approach this calculation is made policy by policy, and consequently gross premium factors, either stored or computed, have to be available policy by policy. However, because of a multiplicity of loading formulas used over the years, the storage of gross premium factors in the individual policy records is the only practical means, in our case, of accomplishing this. In contrast, the sorting method allows storage of gross premiums in the factor file itself. There they are readily available for the preliminary factor file servicing run, where the basic dividend factors, under the sorting method, are calculated for later insertion in the master file. Since storage of gross premium factors is much cheaper in an infrequently used factor file than it is in the actively used master file, this is a clear-cut advantage for the sorting, factor-file approach.

Another advantage of the sorting method is that it conveniently lends itself to a sequential listing of dividends and cash values for checking and reference purposes. Under the regular-sequence approach (as well as the daily calculation, non-sorting approach discussed earlier), this is not at all convenient.

Taking all these factors into consideration, we had no difficulty in deciding to use the sorting, factor-file method for handling our annual updating requirements. It is superior, for our problem, on practically all counts.

VALUATION

Once the consolidated functions daily cycle was planned, programmed, and became operational, we turned next to the area of valuation, which had not been included in the initial effort, largely to shorten the programming period. However, the basic tape record had been designed to include all the information necessary to determine policy reserves and therefore could readily replace a separate punched-card file being used for that purpose. Not only would we then achieve the advantages of a comprehensive electronic valuation system but we also would eliminate the considerable manual and punched-card operations required in the servicing of the separate file.

The advantages of a tape valuation system being readily apparent, the next step was to select the most efficient and satisfactory method. We had first to determine the best over-all approach and then, within that framework, make the proper choices for each of various secondary problems that presented themselves.

Group versus seriatim.—Mutual of New York has traditionally used a group method of valuation, but, in view of the fact that the tape master file is in agency–policy number sequence, we wanted to explore the possibility of a seriatim method which would obviate the need for sorting. Computers had the reputation of being extremely fast calculators but relatively slow sorters. So, naturally, everyone felt that a seriatim method would be quickest and cheapest, even though in our case this meant 1,600,000 reserve calculations from basic principles. Seemingly, the only real question was whether the limited number of totals produced under a seriatim method would be acceptable.

Much to our surprise, however, further exploration revealed that the seriatim method from basic principles is neither quicker nor cheaper and, in fact, is inferior to the group method on practically all counts. This conclusion would not necessarily hold true for all size companies, for all computers, and for all valuation problems, but it certainly seems true in most instances for major reserve calculations by any medium or large company with the present generation of computers.

The reason for this is quite simple. Sorting has turned out to be much faster than expected and calculations, on the other hand, much slower. The net result is that the group method is better on tape for the very same reasons that led to its original adoption years ago. It is quicker to sort and take totals, applying calculated reserve factors to the totals, than it is to make separate calculations from basic principles for each policy. This does not rule out a seriatim valuation entirely, however, since it still may be the most convenient method for some secondary reserve items valued through separate, relatively small files. But, for our main valuation, once the facts became clear, the seriatim method was quickly eliminated from consideration.

The group method.—Once we decided to retain a group method, the next step was to determine exactly what kind of group system would be best. Again, there were two basic choices. One was the group method at its simplest—passing the year-end master file, sorting, summarizing, and applying reserve factors to the totals. The other version, used on punched cards by many companies, involved keeping a more or less separate group summary file from year to year. The summaries would be updated annually by sorting and summarizing just the year's transactions, not the entire

tape master file. Updating summaries through the use of transactions is, of course, a much faster operation, and, under this approach, it would be necessary to deal with the supporting master file only on relatively infrequent occasions as part of a cyclical checking operation on the accuracy of the summary totals.

As applied to our particular electronic system, either method involves tape summaries at year-end. However, one requires keeping the summaries perpetually as a semi-independent file, while the other means discarding last year's summaries and starting afresh.

The choice was a difficult one to make, since the decision was not clear-cut. Both methods fit well into the over-all electronic system, and either one can provide highly satisfactory valuation results. Timewise, there is little to choose. While sorting and summarizing transactions are obviously quicker than sorting and summarizing the entire file, this is offset by the machine time required each year to do a cyclical check on a portion of the file. The only difference is that the cyclical check, needed only under the perpetual-summary approach, can be scheduled at the most convenient time, whereas the extra time under the start-over approach comes during the critical January period when computer time is at a premium.

Nevertheless, we chose the start-over method. There were a number of reasons, none of which would have been convincing taken alone but, when added together, provided enough evidence to decide the issue.

Essentially, the only significant advantage of the perpetual-summary procedure, under our particular set of conditions, is the transferal of machine time (about nine hours) from January to another time of year. Weighed against this is a series of minor factors favoring the other method.

In the first place, the perpetual-summary system requires somewhat more complicated programs. Updating previous summaries is a slightly more difficult operation than creating a new set. Moreover, the perpetual-summary method requires a larger number of programs as well. It is necessary to have programs to get the summaries started, to update each year, and to do cyclical checks. It is true that a certain amount of generalized programming might consolidate two or even all three of these functions into the same runs, but this would further increase program complexities.

In addition to being simpler, the start-over approach is more flexible. Changes in summary total requirements require no more than a program change; they do not invalidate previous summary records. Under the perpetual-summary approach, however, changes could easily require a resummarization into different or new breakdowns and, in that event, would

probably require an immediate comparison of the old summaries against the new. In effect, this would be a cyclical check not of a portion of the file at a time but of the entire file at one time. Naturally, an operation of this nature would serve to deter changes.

The start-over approach, adequately controlled, not only avoids the computer time for cyclical reconciliations of summaries against details but also avoids difficulties involved in tracking down any discrepancies that may be found. While there is no doubt that electronic systems are inherently more accurate than manual or punched-card methods, it would be foolhardy to expect them to be error-free. Until we reach that millennium, it seems well to avoid, if possible, methods which may allow discrepancies to creep in and hence require extensive checking operations.

Consequently, after adding up all these miscellaneous considerations, we decided that the transfer of nine hours of machine time from January just was not worth it. At electronic speeds there should be no problem with doing an entire Ordinary valuation from scratch in January and still be well ahead of present time schedules.

The policy exhibit.—At this point a few words about the policy exhibit appear in order. Policy exhibit totals, like valuation, had not been included in the initial effort, also for practical reasons. However, we have always intended to use the electronic system to provide these totals, since they are a logical by-product of the operations which service the master file for changes. Accordingly, the design of the best system of providing these totals was included as a part of the comprehensive valuation study that we were making.

The method eventually arrived at for the policy exhibit is actually very simple. Each day, when any pertinent transaction occurs, the computer writes an appropriate record or records on an accumulated monthly transaction tape. For new issues and terminations what is written out is simply a copy of a portion of the regular policy record. For changes copies of both the old and the new statuses are furnished. In all cases, a small amount of information describing the transaction is included as well. Then once a month a special computer run examines the accumulated tape and prepares the appropriate policy exhibit totals. Since most of the work is done by the monthly run, the method is far superior to a daily analysis and accumulation, which would have eaten up a substantial number of daily-cycle program steps.

Interim reserve calculations.—Another requirement of our valuation system is in the area of reserve released totals. These are desirable during the year for surplus estimates and are needed in any event by year-end for the Gain and Loss Exhibit. Hence it is necessary to have an additional

valuation program to make this calculation, using the monthly policy exhibit accumulated transaction tapes as a basis.

Thus our requirements involve two valuation programs—one to operate on the master file summaries at year-end and one to operate on transaction tapes at interim points during the year. This dual need for both year-end and interim valuation programs and procedures raised an interesting question: Why not keep a running account of reserve progress during the year? If we changed the year-end programs to make an additional calculation, a preliminary valuation for the year-end following, we could then, in addition, easily modify the reserve released program to update the preliminary totals, reflecting the changes that have occurred since. Only broad groupings of totals would be needed to provide a running control on the progress of reserves. If any of the results appear out of line, action can be taken immediately to track down the source of error. At year-end, then, we would have a very accurate control on the expected results. In addition, surplus estimates under this procedure would tend to be more accurate.

This running-account procedure does not involve any new runs but only modifications of runs otherwise required. Hence little extra cost was anticipated, and, as a result, we included it in our system.

A factor file for valuation.—The next step in systems design was to devise a means of calculating or otherwise obtaining the actual reserve factors at year-end. We were again faced with a choice between a factor file or basic principles method. In this case, however, we were constrained toward the particular solution by a problem faced in a related area. Nevertheless, the method arrived at has much in its favor and would probably have been the best choice for our system in any event.

The constraining situation is in the area of gross premiums. Our company's premium accounting system involves booking the total premium collected, with no split of accidental death or disability premiums. For Annual Statement purposes an inventory of total premiums in-force for each line of insurance is used to provide the necessary split of the accounting totals. We had no choice but to continue this procedure, since the individual premium elements were never available in the previous manual policy record and therefore could not practicably be included in the conversion to the new tape record.

Consequently, a necessary requirement of our valuation system is that it be able to furnish total gross premiums by line of insurance. This, in turn, necessitates access to individual gross annual premium factors for each valuation cell. As previously mentioned, because of a rather extensive variety of loading formulas, it is not practical for us to attempt to

generate gross premium factors through programming. Instead a simple transference from present punched-card files to permanent tape storage is highly preferable. Hence, as in the cash value and dividend area, we again found ourselves faced with the need for a tape factor file of some sort. There is, of course, no reason why the same factor file cannot be used for both functions, particularly in view of the fact that gross premiums are needed for both dividend and valuation purposes.

In practice, such a use of the factor file means that at valuation time, while calculating reserve totals for a valuation cell, we would at the same time be matching the in-force summary totals against the factor file containing gross plain and benefit premiums. The next step in the development was obvious: Why not include precalculated reserve factors in the factor file as well? Instead of a calculation of factors from basic principles for each cell as needed, we simply look them up in what amounts to a giant, sequential table.

The basic principles calculation is not avoided; it is simply moved to an earlier point in time and used to supply factors in advance to a tape table. This saves time during the critical January period and, in addition, allows ample time for a listing and spot-checking of factors before they are used. Even more important, the factor file can be used for the interim valuation runs also, thus tremendously simplifying programming requirements.

Controls.—Before concluding the subject of valuation, it is well to dwell a moment on the subject of controls. In an electronic valuation system controls are necessary to insure that policies do not somehow get "lost" from one computer run to another and that each policy passes through all appropriate runs. A tight set of internal checks is especially vital, since the total amount of insurance at year-end, determined in our system from the master file, must balance out with the previous year's in-force, adjusted by the net changes for the year, as calculated in monthly policy exhibit runs. Controls, properly conceived, can detect discrepancies at the time they arise and allow correction to be made at the earliest possible moment.

Accordingly, we have included a strong set of in-force controls in our electronic system. The cornerstone of this control mechanism is a *daily* balancing between the master file itself and what is being sent over to the policy exhibit runs via the accumulated transaction tapes.

The first step in this balancing process is a summation of face amounts and number of policies for all those policy records that are extracted for processing on a given day. The summation is done twice—once before processing has taken place and once afterward. Since only those particular

policies extracted for processing can possibly be changed, the difference between the "before" and "after" inventories gives the precise total change in insurance in-force in all policy records that has occurred as a result of the day's processing.

The next step is to insure that the accumulated transaction tape, and hence the policy exhibit, reflects each and every change. The computer will, of course, be programmed to record every single change on the tape, but that in itself is not quite enough. Control total checking is needed to give complete assurance. This is done easily by adding up the face amounts and number of policies for all the "plus" and "minus" records as they are being written on the accumulated transaction tape. Then, after the last transaction has been processed for the day, it is a simple matter to check that the net of the "plusses" over the "minuses" is the same as the net change in the master file that day, as determined by the two inventories.

The final aspect of the control system is to insure that policies do not get "lost" from run to run and that each policy passes through every appropriate computer run. This is accomplished by the computer "telling" all subsequent runs what the total in-force is, plus and minus separately, on the records that are being sent over. The Policy Exhibit Run, for example, can then balance out by totaling the policy exhibit entries themselves, transaction by transaction, and comparing the result with the controls sent over.

The over-all effect of the entire procedure, once the control mechanism has been fully "debugged," is to make it impossible for in-force discrepancies among the master file, the policy exhibit, and each of the interrelated computer runs to arise without our immediately becoming aware of it at the time it is actually happening. If an imbalance occurs, immediate action can be taken to track down the source of error and correct it. Although this by no means prevents all possible errors, it does provide an electronic valuation system that we can be sure is internally consistent and remains in balance with itself.

Summary.—A brief step-by-step summary of the entire valuation process appears below:

1. Once a year, at year-end, an extract from each basic policy record is selected and sorted into valuation sequence, and appropriate in-force totals are obtained. The computer then obtains reserve factors from a factor file and applies them to the group totals of insurance and benefits in force.

2. At the same time, other Annual Statement calculations are made. These include total gross and net premiums by line of insurance, deferred

and uncollected premiums, the dividend liability, policy exhibit in-force totals, etc.

3. The year-end runs also perform a preliminary valuation for the following December 31. This is for management and control purposes, and therefore a relatively few broad groupings of reserve totals are all that is necessary.

4. During the year, as a by-product of the daily-cycle runs, a record of all transactions affecting either valuation or the policy exhibit is kept on a special tape. This tape is then the basis of a monthly policy exhibit run.

5. At interim periods during the year a small-scale valuation of the accumulated transactions that have occurred in the previous period is made for the purpose of calculating reserves released by death and by other terminations. At the same time, as a by-product, the preliminary valuation made at the beginning of the year is updated.

6. At year-end the final valuation of the transactions is made, and the results are used as a control on the main valuation which is about to occur.

7. Extracts from the master file for sorting, the in-force totals thereof, and the accumulated monthly transactions tapes are expected eventually to form the basis of a great many additional jobs now being done on punched cards. These include mortality studies, lapse studies, issue statistics, and other similar jobs.

THE ACTUARIAL FACTOR FILE

It is worthwhile to take a concluding look at the entire dividend, cash value, and valuation picture from a different point of view—from the point of view of the factor file. The net result of all our thinking in these three areas has been to make this giant tape table the heart of the actuarial portion of the electronic system.

First of all, the factor file is used in December, after prior updating, to supply cash values and dividends to the master file. Second, it is used at year-end, also after prior updating, to supply reserve factors to be multiplied by valuation summary totals. Third, it is used all during the year for reserve released and other interim valuation calculations. Fourth, containing gross premiums and reserves, the factor file is the basis of dividend experimentation, testing, and final calculation under our three-factor formula. Fifth, it is the basis of the calculation of total premiums by line of insurance. Finally, the factor file is the source of printouts of all actuarial values for checking and reference purposes.

All these applications stem from the creation and maintenance of a

single-factor file, justified for each separate use in its own right, but even more desirable from an over-all point of view because creation and maintenance costs are spread over so many different functions. Furthermore, all the complexities being in the servicing of the factor file, not in its use, the few maintenance programs are concentrated in the hands of a small, skilled, specialized group of actuarially trained personnel, thus substantially reducing the number of programs requiring such skills.

But the most important fact that this all points up is the tremendous desirability of developing an integrated electronic system where all the pieces fit together. Only with such a system can we expect real savings to materialize.

DISCUSSION OF PRECEDING PAPER

CHARLES F. PESTAL:

As pointed out by the author, many actuaries are involved directly or indirectly with the data-processing application of electronic computers. Mr. Becker is the first to write a paper on this subject and is to be commended for his contribution.

There are many ways to accomplish the actuarial aspects involved in data processing. At Northwestern National Life Insurance Company we have a consolidated daily cycle, and I would like to point out our approach to nonforfeiture values and dividends, which differs from the author's approach.

We do not include the next dividend or the cash values in our policy master file, nor do we calculate these values during the daily cycle from basic principles. We take advantage of the high sorting speed of our computer and daily sort the external and internal transactions requiring values into plan and age order, herein called the daily sort method. The sorted transactions are then run against a rate tape from which we pick up N_x values, dividend per thousand and cash values per thousand.

The dividend per thousand is used for the current dividend on the anniversary, and the cash values per thousand are used to obtain three cash values for status requests and for policies requiring loans or a nonforfeiture calculation. The N_x values are used to calculate cash values on paid-up insurance and for the calculation of paid-up dividend additions and paid-up extended insurance at lapse time.

The reasons for adopting the daily sort method are as follows: (1) A formula approach to cash values creates problems when there is a discontinuity in the formula. (2) Annual updating increases an already heavy load at year end time. (3) The annual updating method unnecessarily calculates values on many policies where the values will not be needed. (4) If the cash values are included in the policy master file and all possibilities for automatic premium loan and nonforfeiture calculation are provided for, it is necessary to have four values in the file. These values would add to the size of the policy master record, which not only increases the time for the daily cycle but also increases the time for any statistical runs using the policy master file. (5) The daily sort method eliminates the necessity of inserting policy values into the policy master file in case of policy changes during the year. (6) The daily sort method

makes it easy to change the dividend scale and to add new policies during the year. It is only necessary to update the rate tape.

The programing and maintenance of programs for the daily cycle is done in our planning department with the exception of the daily rate run, which is the responsibility of the actuarial department. We have felt that it was necessary for an actuarial student to be responsible for this portion of the daily cycle, but this creates a minor communication problem. We now feel that the rate run should be transferred to the planning department and help secured from the actuarial department if necessary.

At the end of the year a record is extracted from the policy master file for each basic policy and each rider. The extracted tape is used by the actuarial department to produce ratios of net to gross premiums, due and deferred premiums, accrued interest items, a ratio of disability and accident premiums to total premiums, and the reserve items. The reserve items are calculated from the same file which we use for billing, and therefore, we have eliminated need for an audit between the valuation and premium billing.

Once the policy master file and the related files required for a daily data-processing operation are set up, there is a wealth of information available on magnetic tape which can be used for statistical studies and reports to management. In the future, programing in this area holds great promise, and actuaries will certainly be instrumental in the planning involved.

JACK O. PARSONAGE:

At the beginning of his paper Mr. Becker states that the selection of the proper electronics system is conditioned by many factors which naturally vary from one company to another. I am in complete agreement with this. Therefore, my remarks relate to the approach taken to the actuarial aspects of a consolidated functions system by the Great-West Life—a company with 450,000 ordinary insurance policies in force as compared to 1,600,000 in Mr. Becker's company.

The Great-West Life has a consolidated functions system involving a master file of 450,000 ordinary policy records in policy number order which is passed through the computer each day. I think perhaps the outstanding feature of our system, as it affected our approach to the actuarial aspects, is the extent to which we attempt to complete the processing of all activity, including the creation of a newly updated master file in the main file maintenance pass. Except for policy changes which affect actuarial values, *e.g.*, a plan change, all activity is reflected in the newly created master file on the day that it first enters the system.

This approach, of course, taxes the core storage capacity of our computer, since we require space in our file maintenance program for the instructions to update the master file and produce results for virtually every conceivable type of transaction. Once having adopted this general approach, we were more or less forced to adopt the factor method rather than the formula method as far as actuarial items are concerned. Even without the many program steps and storage of actuarial tables in our file maintenance program, we are forced to make extensive use of program tape. Had we attempted to incorporate the programing of actuarial values into this program as well, we would have been forced into even more extensive use of the program tape with adverse affects on our running time.

In our system the concept of actuarial values stored in valuation cell order on a factor tape file is used extensively. Included on the factor tape file on a per unit basis are terminal reserves, cash values, dividends, net annual premiums, gross annual premiums, gross extra premiums by substandard class, net single premiums for calculation of paid-up additions, medial annuity values for calculation of deficiency reserves, and monthly annuity values per $1,000 of policy proceeds. These values, as applicable, are contained not only for basic policies but also for insurance riders and additional benefits such as disability and accidental death.

Our approach to the use of the factor tape file is quite different from that described by Mr. Becker. As I understand the system he describes for cash values and dividends, a special run is done at the end of each calendar year, at which time the values applicable in the ensuing calendar year are placed in the record for each policy on the master file on the basis of the status which then exists. Hence changes in the status of a policy such as a change in plan during the ensuing year requires that new factors be substituted manually.

In our system new cash values and dividends are applied to each individual policy on the master record on its anniversary. This is accomplished by anticipating anniversary hit dates in advance and creating search arguments for the various types of actuarial values in the daily cycle preceding the one in which the anniversary updating actually takes place. These search arguments, comprised of identification such as rate basis, plan, age at issue, duration, etc., for each policy involved, are held until the following cycle. At that time they are combined with search arguments for new business and for policies on which there has been a policy change which affects actuarial values. The combined search arguments are then sorted into factor file order, the required factors obtained from the factor tape file, the results sorted into master file order and made available to the file maintenance run. Using this approach, we have been

able to overcome the one important limitation of the factor approach mentioned by Mr. Becker, *i.e.*, obtaining actuarial values for current status of the policy during the calendar year. No manually coded actuarial values are contained on our master file at any time, and the values that are contained are always on the basis of the current status of the policy.

Our approach to valuation is also quite different in that the various reserve factors are stored in each individual policy record on the master file. These reserve factors are looked up from the factor tape file in the same way and at the same time as the cash values and dividends are looked up. Coming out of each file maintenance run are messages which flow to a valuation summary updating run. At the end of each day's cycle, a valuation ledger is available containing summaries of all reserve items in the breakdowns required for statement purposes. The number of policies, amounts of insurance, and reserves contained in the valuation ledger reflect directly the detailed individual policies contained on the master file. The messages coming out of the file maintenance run are also accumulated on a movement tape file, and this is used to produce all policy exhibit data.

To a large extent, our approach to valuation was dictated by our long-range plans of being in a position to produce a revenue statement each month reflecting the surplus earnings of the company for the year to date.

The foregoing indicates what seems to be practical for a company in our size range. However, if we had 1,600,000 ordinary policies in force instead of 450,000, we would have probably arrived at quite a different answer to the handling of the actuarial aspects of a consolidated functions electronic system.

JOSEPH R. PICKERING:

This excellent paper has a twofold interest to me. First, a couple of years ago, I was a bit involved in the thinking leading up to the decisions summarized in the paper. Let me hasten to add that the credit for reaching these apparently well-reasoned decisions, however, goes to Mr. Becker. The second reason for my interest in the paper is that I am very closely involved in similar considerations for Investors Syndicate Life.

My discussion contains three points. First comes a bit of speculation about why there have been so few papers in the actuarial literature about electronics. Next, I offer what seems to be a third alternative to obtaining cash value factors in a tape master file. Last comes a brief discussion of Interim Reserve Calculations.

Actuarial Literature about Electronics

For some time I have wondered why there have been so few papers about electronics in the actuarial literature. Mr. Becker has titled his

paper "Actuarial Aspects of a Consolidated Functions System." It seems to me that there are two separate, but not opposed, kinds of actuarial aspects. First, as business managers, we actuaries are interested in any tool which will produce required information more economically. Second, as actuaries and business managers, we are interested in what information is required. Mr. Becker, in an extremely lucid manner, discusses the first of these two aspects, namely, an analysis of how to produce certain required information. I personally prefer to call this aspect "electronic aspects of actuarial functions."

I think we would all agree that it takes an actuary to decide what actuarial information is required from a system. It also seems clear that the actuarial aspects of any system lie first in what actuarial-type information should be produced by any system. After this comes the method of producing that information. Many of us, however, seem to have left to others the decisions on how to produce that information. Perhaps this gives a clue to why there is so little data-processing information in the actuarial literature. We, as actuaries, seem to be spending most of our time on deciding what information is needed rather than on how to produce it.

It seems to me that we are missing the point to some extent. The information that is required depends greatly upon the cost and method of obtaining that information. Consequently, I was glad to see Mr. Becker's paper accepted for publication in our *Transactions*. He has done quite well in explaining the considerations.

Obtaining Factors in the Daily Cycle

The second part of my discussion concerns the method of obtaining cash value factors in the daily cycle. As the paper states, each company is different and may reach different solutions although the method of analysis is similar.

As background, therefore, my company currently has about 90,000 individual policies in force. The current amount at risk is somewhat over $900,000,000. All but about 300 policies have been placed in force since January 1, 1959. It can be questioned what a company of this size can possibly do with large computers. Our parent company, which is in the same building, owns a 7074 electronic data processor and makes it available to Investors Syndicate Life on a service-fee basis. Because of our very rapid growth, we are converting to a magnetic tape consolidated functions system early.

The paper states that two major alternatives were considered in obtaining cash value factors in the daily cycle—calculating from basic principles as needed or storing the factors in each record. A possible third

alternative would seem to be to use a factor tape daily or as required. (The daily transactions requiring the cash value would need to be sorted into the same order as the factor tape, and after calculating, re-sorted back into master-file order.) This method seems to have most of the advantages of both the storing and calculating approaches described by Mr. Becker. In addition, the method gets around most of the disadvantages. That is, factors do not clutter up the master file, up-to-date status is used, the method is quite flexible, and the programing for actuarial functions is concentrated in the actuarial file system. We have not eliminated the other two alternatives from consideration, but at the moment it appears we can become operational sooner by aiming for the use of a factor tape daily.

Interim Reserve Calculations

It is not clear to me whether Mr. Becker means by an interim reserve that he is making a monthly adjusted estimate of the year-end reserve or an estimate of what the reserve should be at the month-end. At Investors Syndicate Life, we are committed to producing a monthly earnings statement. This requires an estimate of the reserve liability as of the month-end. Consequently, our system will be somewhat different from a company which does not produce such an earnings statement.

There seem to be two criteria to satisfy in getting a monthly reserve to be used in determining monthly earnings. The less important is that the monthly reserve should grade smoothly into the year-end reserve. The more important criterion is that the method used should not distort monthly earnings.

These two criteria have led us into using a "gain-and-loss" type of formula in determining the monthly reserve for life insurance. At the year-end, the gain-and-loss page of the annual statement is in balance because the tabular cost is forced. During the year, we estimate net premiums received, monthly tabular interest, and monthly tabular cost so that the reserve at the month-end is the balancing item. This, of course, means that we need a good estimate of the net premiums and tabular costs. It might be noted that this method produces reserves net of deferred and uncollected premiums.

For the past few years we have been using this method on a manual basis. This is, gross premium income has been reduced to net premium income by ratios determined at various times during the year. Although the method has not been completely out of line on the manual basis, the use of the 7074 should improve net premium income figures considerably and in addition give us better tabular cost. At the year-end, net deferred and uncollected premiums will also be produced from the 7074.

The net premium items will be calculated by the use of the factor tape at each month-end. During the month all premium income transactions will be accumulated on a special tape along with policy exhibit transactions. This special tape is prepared similarly to the policy exhibit tape described in the paper except that premium income items will be included. At the month-end, the special tape will be sorted into the same order as the factor tape and net premium income calculated.

Monthly tabular cost factors per $1,000 will be determined for various categories at the beginning of the year and applied to the appropriate amount figures during the year. Reserves released by death and other terminations will be calculated in a manner similar to the method described in the paper. Tabular interest is easily calculated from the beginning-of-the-year reserves and the net premium figures.

With this method we expect to satisfy both criteria for monthly reserves mentioned above. The error at the year-end should be less than $\frac{1}{10}$ of 1 per cent.

JOHN O. PROUTY AND GEORGE E. WALLACE:

Mr. Becker's paper is a valuable contribution to the role of the actuary in converting the day-to-day operations of a large company to electronic systems. While actuaries can hardly avoid becoming involved in the details of these conversions, Mr. Becker's paper will, no doubt, bring out discussions which indicate that they have become involved in different ways in different companies. It is especially interesting to note that several large companies have now reached the point where they can talk about what they have done rather than what they propose to do.

The John Hancock has a consolidated functions electronic system, similar to the one described by Mr. Becker, in operation for 2,250,000 monthly debit ordinary insurance policies. The same daily-cycle approach is used and all routine insurance operations are processed automatically. One of the most interesting parts of the paper was Mr. Becker's excellent description of alternative systems that were considered and abandoned. The purpose of this discussion is to present the reasons why the John Hancock sometimes selected the alternative that was discarded by Mr. Becker.

Cash Values and Dividends

The paper describes two major alternatives for obtaining factors in the daily cycle—calculating them whenever needed from basic principles or storing current factors in each policy record, with periodic updating—and gives basically sound reasons for choosing the second of these alternatives.

The John Hancock uses a variation of the first alternative which avoids

the problems associated with calculation from basic principles. Whenever factors are needed for a given policy, a small item consisting of two key words is extracted from the master item during the daily file maintenance run. These items are sorted into factor-tape order and matched against the factor tape, from which a small package of factors applicable to this particular plan, age, duration, and premium status is extracted. In some cases where it is not efficient to store factors (*e.g.*, policies under extended insurance) the values are calculated by formula. The packages of factors are then sorted back into the order of the master file and matched back against the master items which were extracted from the master file at the same time as the keys were extracted. Calculations are then made on a policy basis and the results included in the daily production of hard copy. Master records are updated wherever required and reinserted into the master file during the next day's file maintenance run.

This system was adopted primarily because it automatically provides values for reinstatements and policy changes, or for paid-to-dates in the past or future. If factors are retained on the individual records, each of these transactions requires special handling.

VALUATION

Group versus Seriatim

The reasoning by which the Mutual of New York selected its start-over approach was extremely interesting to us because the John Hancock made much the same choice for much the same reasons. Whenever a valuation is required, a modification of the regular monthly tabulation prepares an actuarial valuation record for each policy and for each rider. These valuation records are sorted into group valuation order and by matching to a valuation factor tape the reserves are calculated and recorded on the individual records. A traditional group tabulation is prepared by summing these seriatim records. Accurate subdivisions of the reserves by states or by any other classification can be easily and accurately prepared by tabulating the individual records. In our opinion this system is far superior, both in accuracy and efficiency, to keeping a separate group valuation summary record either on tape or on punched cards.

The Policy Exhibit

The method adopted by the John Hancock for recording policy exhibit transactions differs from that adopted by Mutual of New York. Transactions involving actuarial fields are recorded on the master tape either in a special field in the basic record or by creating an additional record. This approach increases the length and processing time of our master file by approximately 2 per cent. The retention of the transactions on the master

file permits easy reference through normal cycles, eliminates the daily accumulation of a transaction file, and keeps the transactions under the same accuracy controls as the master record.

At the end of a calendar month a special three-hour tabulation of the master file produces a policy exhibit for the month, valuation and statistical totals, and a separate tape in actuarial valuation record format of the transactions for the month. The totals are designed to check all actuarial fields by proving that the in-force totals at the beginning of the month adjusted by the transactions for the month equal the tabulation of the in-force at the end of the month. Approximately four thousand totals are subject to this monthly control, proving that no changes in actuarial fields have occurred that are not accounted for by transactions.

Interim Reserve Calculations

The monthly-transaction tape is of the same format as the annual-valuation tape. Reserves released are computed and recorded on the individual policy records. The transaction tapes for the twelve months of the year are the source of issue and lapse statistics, eliminating the need for card files for these reports. The transaction tapes and the valuation tapes will be retained indefinitely and will be available to trace either in force or reserves from one year to the next for examination purposes and will be a very powerful tool to permit mortality or persistency studies for any class of business.

CONTROLS

We are in complete agreement with Mr. Becker (and probably with internal and external auditors and state insurance departments) that a comprehensive set of controls is necessary in an integrated system. Our master file has a complete set of controls for every block of 100,000 policy numbers, and all transactions are controlled with reference to these totals. It is very comforting to know that if a transaction has been lost or mishandled, a warning that something is amiss will appear at the next daily file-maintenance run. Our system of controls on transactions is sensitive enough that if a transaction is mishandled or incomplete, the policy number of the affected policy is recorded on an error list for subsequent investigation and corrective action. The effectiveness of this control has been demonstrated numerous times during the nine months that this file has been on a daily integrated system.

STATISTICAL DATA

The power of an integrated system can be demonstrated by describing the handling of a recent request from our actuarial department. The

request was for data on the number of policies with Monthly Debit Ordinary premiums greater than $20 per month. Within twenty-four hours of the receipt of this request a tabulation by plan and by attained age had been prepared and a worksheet for each policy had been delivered to the actuarial department. This service was provided for little more than the cost of printing the individual output records.

This ability of an integrated system to provide, rapidly and economically, specific and accurate data will simplify many of the actuary's problems. These semiautomatic by-products of a well-designed system not only materially aid management but are an important factor in evaluating the over-all cost of the system.

YUAN CHANG:

Many insurance companies have given serious consideration to the business application of electronic computers from the time these powerful tools first hit the market. Many have made considerable headway ever since. There perhaps have been at least twice as many actuaries involved in this field of endeavor as there are electronic computers, large or small, applied in the insurance industry. Yet there has been surprisingly little presented on this platform. To my knowledge there has been no formal paper on this subject contained in the pages of the *Transactions* of this Society. It is, therefore, with gratitude that this paper is being discussed. Mr. Becker is to be congratulated for his astute observations and organized comments, which I hope will serve as the beginning of a large number of papers to follow.

At the outset, data processing in the ordinary life at The Travelers was divided into three relatively independent subsystems: billing and accounting, valuation, and mortality. The latter two subsystems were primarily the design of actuaries. Although the primary input is prepared for the total system, the concept of separate in-force file maintenance was adopted. The need for co-ordination among all functions to be served by the total system was thereby considerably reduced, while the infrequent maintenance of the additional two files would not consume very much computer time. At the same time, each subsystem was designed with a large amount of freedom. Because of the relatively mechanized procedures already existing and the fact that separate in-force files were already in existence, this concept was easily facilitated. The valuation subsystem, which is expected to be in operation in less than a year from now, was designed not only to produce for the Annual Statement all the actuarial figures that Mr. Becker described, but also related statistics for research purposes. The so-called maintenance cycle is monthly for the valuation

subsystem. Therefore, there is practically no limitation on the computer time for each run as in the case of a daily cycle.

While the problems of calculation versus storing, valuation order versus agency-policy number order, and perpetual-summary approach versus start-over approach are basic considerations in the design of any system performing actuarial work, the importance of these required decisions can be reduced by a somewhat different approach. While the length of each record has significant effect on the total annual tape-passing time in a daily-cycle system, it is much less important in the case of a monthly cycle. Mr. Becker pointed out there are many advantages to storing at least the current factors in each policy record. If the annual extra tape-passing time with an extra item stored is comparable to the annual calculation time for the same item in a daily cycle system, the circumstances are even more favorable toward storing in the case of a monthly-cycle system.

In the choice of a valuation method, I do not think that one should be confined to the four traditional methods—attained age, retrospective, group, and seriatim. It is clear that each method embodies (1) a definite file format, (2) a definite method in maintaining the file, (3) a definite valuation formula, (4) a definite order of calculation of the policy reserves, and (5) a definite procedure in producing aggregate reserves. These are elements of a valuation method. Each element may be satisfied in various ways. While the satisfaction of one is not completely independent of the satisfaction of another, the number of combinations of choices must nonetheless exceed four. In the use of any one of the traditional methods, there is no doubt that modifications of one or more elements have been made by different actuaries, more so since the advent of high-speed computers to valuation and the production of related statistics. As such, method by itself should no longer be an important concept. Each element must be considered in turn. A valuation method would automatically emerge, although the method so chosen may very well turn out to be identical to one of the traditional methods. It is interesting to note that the valuation method described by Mr. Becker consists of a summary file of the in-force records in valuation order, summarized every year so that it needs no updating, and a factor file presumably using whatever formula was appropriate for the calculation of these factors. The application of these factors to the summarized totals and the production of aggregate reserves are then executed in one computer program operation. Consistent with the nature of his system structure, of which valuation is a part, and the hardware to which the system is tied, I feel certain that Mr. Becker has described an optimum of choices.

It is clear, then, that if a different valuation method is arrived at by combining different choices with respect to these five elements, some of the problems described by Mr. Becker lose some of their significance. For those interested in an entirely different approach, The Travelers valuation system is briefly described below.

As mentioned above, this system has its own file in policy-number order maintained on a monthly cycle. We found out at an early stage that calculation of individual reserves would be time-consuming, while the computer time required to pass extra items on a policy record would be proportionately much less. We therefore decided not only to store the current terminal reserves, but also terminal reserves for all subsequent durations. This may sound like a startling proposition. But, considered in the light of the other procedures in the system, it can be said that both flexibility and efficiency are achieved. Monthly the maintenance program not only takes appropriate actions caused by external transactions, but also generates all contractual changes, including increases and reductions of coverages, changes in premiums, expiries, and maturities. All new issues and change issues will be prepared with the entire set of policy reserves attached mechanically. At each anniversary, one terminal reserve is deleted, constituting the entire updating of reserve factors necessary in any calendar year. A separate program initially calculates all per thousand reserve factors for each valuation basis, form, issue age, and duration combination, *i.e.*, the group valuation cell. After the calculation of net premiums, terminal reserve factors are calculated, using the Fackler Accumulation Formula for two reasons: (1) Each reserve factor, with certain exceptions, is the result of one multiplication and one subtraction, greatly reducing calculation time. Formula: ${}_tV = ({}_{t-1}V+P)u_x - k_x$. (2) Once the number of significant digits required for u_x and k_x are determined, the computer may automatically control the accuracy of the calculations. In short, the last terminal reserve for a term, level or decreasing, is 0; for endowment other than retirement income type, 1,000; and for retirement income, the prestored maturity value.

Once the reserve-per-thousand file is established, very little maintenance is required. All monthly issues are sorted to valuation order. They then "pick up" the reserves in a program operating monthly. This program also has the facility of calculating all reserve factors and will actually calculate reserve factors for odd forms not considered worthwhile to keep in the reserve-per-thousand file. This "pick-up" procedure is particularly suited to the ever-changing portfolio we have experienced and undoubtedly has been experienced by many other companies in that the precarious balance on which data-processing decisions are based may be preserved

by minor program adjustments easily accomplished. Reserve factors are multiplied by the amount on the record to obtain the set of terminal reserves applicable to the particular record. At the year-end, a simple program operates on the in-force file to obtain not only the aggregate reserves for the Annual Statement but also a completely flexible distribution of policy reserves such as reserves on pension insurance types for income tax purposes, reserves on policies owned by residents of a particular state, etc. One of the main advantages of such a distribution procedure is the fact that it is possible to obtain at will reserve status as of any valuation date on any group of policies by any combination of criteria desired, at the present or in the future. The same combination of criteria or any other combination, for that matter, may be used to extract a portion of the valuation in-force file for hard-copy print-out. If necessary, the entire in-force file may be printed. Such print-outs plus a demonstration of the compiling procedure should leave nothing more to be desired for the quadrennial examination of the company policy reserve liability by the insurance departments.

The new issue input records, external transaction records, internally generated transaction records, and successive in-force files together can furnish a large amount of statistics as required, whether status oriented, such as the policy exhibit in force totals or transaction oriented, such as the remainder of the policy exhibit. Thus complete procedural flexibility is achieved to satisfy not only requirements known at the present but also all future requirements that may arise. The single limitation in obtaining any desired output is an obvious one: the nature of the information in the input.

As pointed out by Mr. Becker, "What is far and away an ideal electronic system for one company may be completely unsuitable to another. While individual solutions will vary, the types of analyses used in the selection are substantially the same." I cannot agree more with this statement. To this I may add: The analyses for a data-processing system must include a set of objectives, a set of problems, and a set of solutions. For different companies at the same time or for the same company at different times, solutions vary more than the problems and problems vary more than the objectives because different objectives lead to different problems which in turn lead to different solutions. Not to be forgotten, however, is the fact that different solutions may in turn lead to different problems, although different problems do not lead to different objectives, we hope. One thing remains constant: the types of analyses are substantially the same.

Again Mr. Becker is to be congratulated for having undertaken a very

difficult task in organizing a thought-process that is basically fragmentary in nature. I hope that the active interest of actuaries in the data-processing field will be increasingly reflected in the literature, now that Mr. Becker has taken the lead.

One point, however, does not seem clear. Mr. Becker spoke of "an integrated electronic system where all the pieces fit together." What is meant by "an integrated electronic system"? If it means an electronic system where all the pieces fit together, I am hard put to find a system where this is not true. On the other hand, if it means a system based on the consolidated-functions approach, I am surprised that "only with such a system can we expect real savings to materialize."

RUPERT L. SUTTON:

This is indeed an excellent paper, and the author should be congratulated on having handled a complex subject with such ease. There is, however, one very important point which must be made initially; as the author points out very wisely, the selection of the proper electronic procedure is conditioned by many factors which naturally vary from one company to another. I believe that this should be stressed most emphatically, so that those entering this particular field should not be tempted to follow Mr. Becker's procedures too closely but should critically analyze what he did, bearing in mind what they intend to do, the size of their master file, and finally, what equipment is available to them.

In discussing the daily-cycle approach the author points out that a major advantage of this is that it allows one-day service on the vast majority of computer-processed transactions; while this, of course, is perfectly true, one must not neglect to decide first of all what standard of service one wishes to afford the operating departments and the branch offices. It is important not to put the cart before the horse; a decision on this question of the standard of service is an essential preliminary to any electronic data processing system—it is not limited merely to the question of daily cycles or not.

There is another point which the author very wisely mentions and which could well bear greater emphasis: he states that minimizing computer running time is an especially important goal in the design of a daily cycle system. In the early days of an electronic data processing system it is very tempting to continue to add to the system without really appreciating how much time one is really adding to the daily cycle. In addition, when working with a new machine and a new system it is almost inevitable that the early programs will not be the most efficient. In Confederation Life, for example, we installed a fully integrated system

using an IBM 705 at the end of 1958 with some 350,000 ordinary policies. Originally, the cycle which we had hoped to run daily took some twenty-six hours to process but now, after five years, we have so improved the design of our system and our operating programs that our daily cycle using the same equipment now takes only some ten hours to process with rather more ordinary policies, and we are achieving considerably more in our present ten hours than we originally achieved in twenty-six. We have, among other things, amalgamated our three original files into one integrated master file.

In Confederation Life we have found this paper of absorbing interest to us because on so many occasions we chose to follow different paths from those chosen by Mr. Becker; for example, in the "calculating-versus-storing" decision we decided to calculate, and again, when considering the question of grouping policies for valuation or valuing them seriatim, we chose to value seriatim. We believe we chose correctly—we had a machine of an earlier generation, we had fewer policies to process, and we believe that our initial system was a little more comprehensive than that described by Mr. Becker. As he implies earlier in his paper, what is sauce for the goose is not necessarily sauce for the gander!

In considering the calculating-versus-storing argument, I believe that the author could have explained with some advantage rather more fully what it was that he was considering calculating, giving some illustrative formulas. In Confederation Life we have adopted an approach which approximates more nearly to the calculating than to the storing; we store net premiums and theta corrections and we value by the Karup attained-age method, carrying out our valuation seriatim. The advantages are that the net premium and the theta corrections need to be changed relatively rarely, and the Karup approach does provide us with a simple and uniform method of valuation, applicable to the vast majority of our ordinary policies. I would mention in passing that we handle cash surrender values in a similar way, though with different net premiums and theta corrections.

Discussing the calculating-versus-storing argument further, the author explains his system of an annual updating run, and theoretically his argument is attractive, but in practice I would feel a little hesitant about using a program only once a year without having previously carried out a particularly thorough "volume test" of the program. During the course of the year it is so easy to make a slight amendment to the system and overlook the possible effect that it might have on a run which is only used at the end of each year. Possibly Mr. Becker's office maintains a much tighter control over these matters than we do in Confederation Life,

but we must admit that we have had some problems of this nature in the past, and it might be helpful to others if we draw their attention at least to the possibility of such difficulties arising with programs which are only used once a year.

There is a kindred problem to that referred to in the preceding paragraph, in that we have found that any data which have been accumulated during the course of the year without any use being made of them or any special checks placed upon them are apt to be unreliable; in fact, this has always been one of our objections to an inventory type of valuation with calculations made once at a year-end. We have always felt very strongly, again speaking from experience, that work of this nature should be spread uniformly throughout the year and that there should be widespread and continuous checks on the methods, programs, and data in question. For this reason we in Confederation Life have adopted a valuation ledger in which we keep our reserves, both for the in-force and for movements, making individual entries from our daily cycle. Similarly, we keep an accounting ledger and an exhibit ledger.

By means of the valuation ledger we keep a figure for the total in-force reserve at all times, updating it by movements and by the change in the individual policy's reserve at each anniversary, making entries at that time to reserve increase, net premiums, tabular interest, and cost of insurance; in this way we obtain the gain and loss items directly. The ledger, of course, can be analyzed as required at any time.

The exhibit ledger is broken down by valuation basis so that the in-force amounts are available for the valuation summaries required in the Canadian Government Statement. At each policy anniversary the new reserve is calculated from the net premium and theta correction and is compared with one developed independently from last year's reserve via the gain-and-loss factors. Any discrepancies beyond a very small tolerance are highlighted and investigated. This gives us a valuable check on reserves. Also, since the total reserve is available throughout the year, month-by-month progression can be observed. In addition, the medial reserve is carried on each policy record, and this is added up on an inventory basis each month to insure that the total reserves from the tape files agree with the valuation ledger.

It should be noted in passing that with the introduction of a valuation ledger and an exhibit ledger a company can go to a complete double-entry bookkeeping system on a revenue basis without any difficulty and for a Canadian company this is the logical course to follow, as the Canadian Government Statement requires all items on a revenue basis without showing the development of the earned premiums, for example, from

premiums collected, adjusted by those due, in advance, etc. At the year-end only items such as accrued interest on loans, deposit accounts, etc., need special calculation.

When a premium is billed, the premiums-outstanding account is charged and the premium-income account is credited, automatically giving the outstanding premiums at the year-end. It is important to note, however, that any of the items which we accumulate on an inventory basis are obtained once a month, so that their progression can be observed also. The monthly program which does this is one in which every single policy record can be interrogated, and we have made great use of this particular program for special studies, checking specific errors on the file, etc.

In Confederation Life we feel that with a computer a complete double-entry bookkeeping system on a revenue basis is both practical and desirable. Of course, the United States Convention blank requirements raise problems in this respect, and in fact we prepare items for the Convention blank by working backwards from an incurred basis to a cash basis for our United States business.

A greater advantage of a ledger system is that the entries from a number of systems can be directed into each ledger; *e.g.*, entries from the ordinary system, the group life and health system, group pensions' system, etc. A further advantage that we have found from this ledger concept is that the ledger can be analyzed in ways which were not originally envisaged, whereas if a tape of reserve totals had been kept, any break-down not clearly determined in advance would not be available.

Many actuaries and actuarial students are involved in electronic data-processing, and Mr. Becker makes the point that in his system all actuarial formula programing is concentrated in an annual run which he assigns to one or two actuarial trainees. This may well suit Mr. Becker's circumstances, but one should point out that with adequate actuarial supervision it is quite possible for non-actuarial personnel to handle the programing of actuarial formulas perfectly satisfactorily. In Confederation Life we have operated in this way with great success.

We are all aware of the criticism that is heard from time to time that actuaries tend to cultivate and maintain an aura of mystery around their activities; I believe that those of us involved in electronic data-processing have many excellent opportunities of dispelling such ideas. In Confederation Life we believe that the introduction of the valuation ledger—to give just one example—has done much to make clear to many people exactly what a reserve is and why and how it changes. This is, I suggest, a general point which deserves careful consideration by all of us involved in "computing."

Mr. Becker does not mention the question of whether any discrepancies were found between the valuation card file and the tape master file when these two were compared; we suspect that he must have been quite exceptionally lucky if the discrepancies between these two files were merely trivial; we feel that a warning on the subject of discrepancies should most certainly be made.

I will conclude with a final speculation; one must admire the ingenuity of modern man when one considers a daily cycle involving 1,600,000 basic policy records being processed each day in some twelve or fourteen hours. Although Mr. Becker does not mention the actuarial methods he uses in calculating his reserves, cash surrender values, etc., I will hazard a guess that he is using commutation columns and classical actuarial methods mostly invented by the early nineteenth-century actuaries working with tables of logarithms to carry out their multiplications and divisions; while this says much for the classical methods, nevertheless, one may be permitted to wonder whether modern mathematics could not produce techniques to provide the same end results but by methods more suited to the potentialities of modern computers.

J. STANLEY HILL:

In his discussion of the choice of alternative methods, Mr. Becker has quite wisely pointed out that local conditions may alter the choice. I think this is well exemplified in our choice of a system for entering dividends.

We have a first-generation computer whose relatively slow speed makes sorting to any degree almost prohibitive. On the other hand, we have a rather capacious and addressable memory system, and we also have an unusually high degree of co-ordination between the people who develop our dividend scales and those who design our computer applications. This combination has produced, I believe, a unique method of entering dividends. We use the factor method, but the table look-up is done on a random basis as the factors are needed. The master record contains a so-called dictionary code or an address to which the computer may look for dividend factors if it needs them. The master record also contains sufficient information to calculate dividends until the next anniversary divisible by ten or until the next dividend scale change. Upon either of these occurrences, the computer looks in the factor table for the makings which will carry it to the next occurrence.

The factor table is highly concise, approximately 2 per cent the size which it would be if it contained dividends for all combinations of plan, age, and year of issue. This is accomplished by storing dividends only for tenth durations and for fifth ages at issue. The dividends for other ages

at issue are developed by either a first- or second-degree interpolation formula depending on the nature of the plan and the shape of the scale. The dividends for durations not divisible by 10 are developed by straight-line interpolation.

DANIEL BARRY:

Mr. Becker's paper serves a very valuable purpose. It enables companies contemplating for the first time the automation of actuarial procedures to receive the benefits of someone else's thinking. For companies that already have mechanized, it permits them to take a fresh look at the reasonability of their approach.

It may be of interest to contrast our approach to the problem of valuation procedures with that of the Mutual. Like them, the New York Life uses the group valuation method for insurance and its supplemental benefits, all of which are contained in summary records by year of issue, reserve basis, plan, and age. Unlike the Mutual, we adopted what Mr. Becker calls the perpetual-summary system.

At the end of each month the accumulated transactions and paid issues for that month, all previously computer-prepared on a daily basis, are sorted in valuation order. Following the sort, the transactions are subjected to a computer run which produces, among other things, policy exhibit data in total and by state plus a net increase and decrease summary by valuation cell. The resulting increase and decrease summary records also contain fields for totals of certain types of transactions, such as deaths, lapses, surrenders, changes, etc. These special totals are useful in making future surplus estimates.

The basic data for either interim or year-end valuation needs are obtained by applying the net increase and decrease summaries against the prior year's in-force summaries. In a subsequent computer operation, a rate tape is applied against the updated summaries and also the net increase and decrease summaries to develop all required valuation results. The final results produced as part of our valuation procedure include, for all benefits, the reserve liabilities, the dividend-declared liability, premiums receivable both gross and net, tabular cost, reserves released, etc. A control check on the reserve liabilities is imposed by applying the typical gain-and-loss formula to the results of the current and prior year-end valuations and the data developed from the increase and decrease summaries.

The specific reserve rates and other factors required for the valuation procedures are generated from first principles by reference to the updated summaries which serve to indicate the rates and factors needed. For

reconciliation purposes, the magnetic file of detail records is summarized every three years, coincident with the state triennial examination, to compare against the updated summaries. Differences so far in the two sets of summaries have been minor. Our monthly operations on the transactions enable us to produce many valuable by-products, including those mentioned by Mr. Becker, namely, mortality studies, lapse studies and new issue statistics, as well as many other items.

WILLIAM R. LONES:

Mr. Becker's paper on a consolidated functions electronic system was most interesting and timely. We all recognize the importance of electronics to accuracy, speed of service, number of operations that can be performed, and its effect on expenses. Also, currently the consolidated-functions approach appears to be the ultimate in electronics application to the life insurance operation.

Such a system would appear to be available only to the large companies. It would not seem feasible for a medium-sized company to develop its own consolidated-functions electronic system. The manpower necessary to accomplish the project would not be available from within the company. Possibly, such manpower could be found in the market. However, even if the manpower were available, the question of cost of the project would have to be answered. Such anticipated cost would undoubtedly negate the project.

Fortunately, the medium-sized companies need not forego such a desirable project. It is no longer necessary for a company to develop its own system in total. IBM have developed a consolidated-functions package which they have titled the "62 CFO." It is available for use with their 1401 and 1410 computers. This program is very comprehensive. Also, it has been designed with considerable flexibility in order to meet the various needs of a variety of life insurance companies.

This is not to say that there is no programing to be done by the company. The form of input to the system for new records and the form of output are company programs. Also, the conversion program is a company program. We have spent about three man-years on programing to date and expect to spend approximately two man-years more. However, the cost of this programing is within the limits which a medium-sized company can incur.

Not being able to afford the luxury of a personalized system, such as Mr. Becker has described, it was very interesting to compare the approaches of the two systems for various operations. The ordinary insurance operational functions appeared to be the same: policy issue, premium

billing and collections, commission calculation and agents' accounting, general journal accounting, loans; nonforfeiture calculations; policy terminations, application of dividends, valuation of reserves, and policy exhibit.

The package program is based on the "daily-cycle" approach. All records are passed each day to merge the previous day's activity and to extract the current day's activity resulting from external requests and from machine-generated activity. The selected extracts are then processed through some twenty-two programs. Over 50 per cent of these programs require more than 11,000 positions of core storage. The information resulting from the processing of the current day's activity will be available the following morning.

The cash value and dividend approach is similar to that used by the Mutual of New York. The cash values and dividends per unit are stored in the master record for each policy. The cash values are updated annually. Dividends are updated monthly. The cash value and dividend factors per unit are stored for all possible durations which might be required between updatings. Cash value and dividend factors for both the basic policy and riders are stored.

A tape factor file containing the cash values and dividends per unit is used for updating. The master records to be updated are sorted into sequence and matched against the precalculated tape factor file for updating. The valuation method is the same. It is the group method, using the start-over approach of passing the year-end master file, sorting, summarizing, and applying the reserve factors to the totals. The approach used on the policy exhibit is the same.

No interim reserve calculations are made on the basis of running adjustments to reserve totals. Interim reserves are calculated by the start-over method. However, reserves released are calculated on the same basis as Mr. Becker has indicated.

The approach in respect to factor files is again the same. Precalculated factors are stored on reference tapes for gross premiums, net premiums, dividends, reserves, and cash values. Controls are somewhat similar and, of course, for the same purpose: to immediately bring to attention any balancing discrepancies in the master file, policy exhibit, and computer runs.

The extreme similarity of approaches in the two systems was most impressive. Also, most of the Mutual of New York's considerations given for the choice of approaches on the items discussed were equally applicable to the Pacific National.

WILLIAM H. PHILLIPS:

Mr. Becker is to be commended for his very lucid description of his company's consolidated functions use of electronics.

Our organization, Aid Association for Lutherans, completed conversion to a consolidated functions system very recently—March 20, 1963. Rather than attempt a complete description of our system or a point by point comparison with MONY, I will today just outline the important areas of difference between our approach and that of MONY:

1. Our master file of 820,000 basic policy records is completely in policy-number order, rather than in agency–policy-number order.

2. Rather than converting agency by agency and continuing the prior functional systems on the unconverted business, we performed a conversion of the entire file in a two-and-one-half–week period running twenty-four hours a day, except for a half-hour per day when new business was issued by the computer.

3. Our entire conversion and operation, including input/output control requirements, tables, and constants, requires 142,000 program steps. If duplications in conversion and operation are not counted, the total becomes 109,000.

4. Our system updates cash values, reserves, and dividends daily on the anniversary rather than annually late in December as the MONY system does. These are calculated from first principles.

5. New actuarial factors, required on changes and when transfer to a nonforfeiture option occurs, are computed from basic principles (C's, M's, D's, and N's) as a part of a daily processing run. We felt this approach was necessary to avoid the errors which a manual insertion method would be subject to.

We tied in the introduction of a number of actuarial refinements with the adoption of the consolidated functions system. These would not have been feasible under prior procedures. Examples of these refinements are:

1. We began to pay higher dividends on old policies with accidental death benefits and premium waiver disability supplementary benefits, equalizing the cost for these benefits with new issues which have much lower premiums for these benefits.

2. On participating paid-up additions we began to use a three-factor formula for obtaining the dividend on the paid-up additions. Our prior method was a simple approximation. With the current emphasis on paid-up additions this move has proved to be very timely.

3. In the past we had lumped a number of similar plans for dividend calculation purposes. Since each record now contains the necessary factors, the dividend can be calculated more accurately for individual plans.

(AUTHOR'S REVIEW OF DISCUSSION)

MURRAY L. BECKER:

First, I would like to thank all of those who participated in the discussion. It was very gratifying to me that the paper has stimulated such widespread interest. It is, of course, both interesting and beneficial for all of us in electronics to learn how other companies are solving similar problems. The discussions provide a wealth of material in this respect.

Messrs. Pestal, Parsonage, Pickering, and Prouty and Wallace described a method of supplying cash values and dividends which is commonly referred to as the "daily-sorting" method. As has been pointed out, the procedure has most of the advantages of both the storing and calculating approaches discussed in the paper. We, in fact, did consider this method along with the others, but discarded it when the time requirements for sorting, matching against the factor file, and re-sorting turned out to be too great. Of course, with different volume requirements or equipment this method might well have been the best approach for us too.

I completely agree with Mr. Chang that the advent of high-speed computers has made the traditional classification into four valuation methods to a large extent outmoded. No doubt we will see far more than four distinct types of valuation systems in the years to come.

Mr. Sutton brings up an interesting point when he questions the use of classical actuarial methods and commutation columns rather than mathematical techniques specifically designed for modern computers. Although we would certainly welcome improved methods, our experience has been that the classical techniques, with occasional modifications, are quite suitable to modern computers. We have always looked for better ways, but so far have not been able to improve on the nineteenth-century methods!

Mr. Hill's discussion offers a perfect illustration of how proper electronic system design takes into account and is constrained by the characteristics of the particular computer. A capacious memory but limited calculation speed has resulted in a unique system involving storage of factor tables and simple interpolation formulas. This seems an excellent and ingenious solution to the problem faced under the particular set of conditions.

I am indebted to Mr. Barry, Mr. Lones, and Mr. Phillips for their comparisons between the MONY system and those used by their respective companies.