AUTOMATION OF DATA-PROCESSING IN LIFE INSURANCE

by

Professor Dr. J. ENGELFRIET,
Municipal University of Amsterdam

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I. INTRODUCTION

1. Analysis and automation of data-processing systems mean teamwork. The general concept of the integrated data-processing system to be discussed in this paper may be seen as basically the author's. But different parts have been or are worked out by members of the staff of his company. The names of E. B. H. Van den Schoot, F. J. Schmidt, M. J. den Broeder in the first place and then of Mrs. J. H. Brinkman and B. J. Klünnen, M. P. Van den Logt, H. F. M. Van Rossum and A. J. E. Rövekamp may be mentioned in this respect. The author feels in debt most of all to E. William Phillips, whose paper "Binary Calculation", published in 1936 (J.I.A. 67, p. 187), gave him the first idea of what might be possible. Acknowledgment is also made to Messrs. G. C. Philip and G. D. Gwilt for a number of useful suggestions.

2. The main subject of this paper is the analysis of the automation of data-processing in the ordinary branch. What is done in the author's company with respect to group pension business under supervision of his colleague A. W. Dek will only be indicated briefly.

3. The concept of an automatic data-processing system has undergone many adaptations from new ideas produced by a growing understanding of the possibilities offered by a modern computer.

4. The first concept was a limited one based on the capacity of a small computer of which characteristics are given in Appendix 1.

The automation in this system is restricted to a series of activities which have to follow the manual punching of all data given in an application form for a new policy or in a similar internally prepared document with regard to an alteration, conversion or exit of an existing policy.
These activities (to be performed automatically) are:

(a) production of (new) policy record punched cards serving for printing a policy (if necessary) and to be filed for future use;

(b) production of punched cards for renewals;

(c) production of punched cards for payment of agency commission;

(d) production of punched cards containing constants for valuation purposes;

(e) updating valuation totals and totals of the accounts for surplus analysis as well as statistical totals.

All data in the cards (e.g. agency commission, Altenburger constants) are to be calculated from first principles.

This concept has been realised and the activities mentioned are performed daily in the author's company.

5. The second concept was an extension of the first one. It was the first concept based on the possibilities of a new computer of medium size. The computer was still under construction and the insight into its possibilities incomplete, when this concept was born.

The main characteristics of the new computer are given in Appendix 2.

The activities under paragraph 4 may be indicated as a whole by the expression "completion of a transaction".

The second concept included also the automatic performance of the calculation work connected with the preparation of a transaction.

A more detailed description of this concept has been given in the author's paper for the Fifteenth International Congress of Actuaries in New York in 1956 and in his paper in the *Blätter der Deutschen Gesellschaft für Versicherungsmathematik.*

The system as given under paragraph 4 still involves the maintenance of about six files of which three are of the order of magnitude of the number of policies in force.

In the second concept as described in the Congress paper a certain consolidation of files was indicated. In the paper for the *Blätter der Deutschen Gesellschaft für Versicherungsmathematik* it was indicated how a more compact storing of data on punched cards could be realised, thanks to the ability of the new computer to interpret information from a punched card in any code one might want to make use of. The compact storing of information and the possibility of recalculating data from first principles at any time would facilitate the consolidation of files.

6. A further analysis of the system under paragraph 5 has led to the conclusion that its realisation would necessitate a search through the original documents of the existing "in force" for data not yet available in the existing punched card files. This conclusion gave birth to the idea that it might be useful to include at the same time such data as might be used in a more comprehensive electronic data-processing system. The question which could be the most comprehensive E.D.P. system with the now available electronic installation was then put forward once again.

The new analysis of the limitation and realisation of an E.D.P. system extended as far as possible with the new installation has not been finished in all details, but the general outline has been drawn. As long as the new system has not been fully prepared those parts of the concept mentioned under paragraph 5 which can be realised without a search for new data to be made "machinable" are programmed in the orthodox way. These are the calculation of surrender values and a certain group of policy conversions.

In the following the analysis mentioned above will be described.

II. GENERAL STRUCTURE OF DATA-PROCESSING IN LIFE INSURANCE

1. The logical structure of data-processing in life insurance is to a certain extent (but not fully) independent of the tools, whether they are human brains, hands, eyes or electronic computers with input and output equipment. It is useful to analyse this structure at least roughly disregarding automation. The organisation, including human beings performing as a whole the task of data-processing for the ordinary branch, may be called the "data-processing unit".

The "internally stored information" will be seen as a separate element. It will contain, for example, the available data of the "in force", the general documentation, the written instructions, the unwritten ones in the heads of the staff.

By "external data-processor" is indicated any person or institution providing in any form "new information" for the data-processing unit. By external is meant outside the processing unit, not outside the company. New information may be a request for certain data (e.g. a surrender value), an announcement (e.g. the death of a certain person), but also, for example, a communication about a change in certain public regulations, etc.

For the sake of uniformity it will be assumed that for periodical
data-processing (e.g. the work in connection with renewals) the "announcement" that the process has to be started and some necessary data (e.g. next calendar-month) will be produced by an external data-processor. It is possible then to define all data-processing of the unit and in connection with it of the external data-processor as a complex of cyclic processes (daily or monthly) of the following structure:

<table>
<thead>
<tr>
<th>Part I</th>
<th>Part II</th>
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<tbody>
<tr>
<td>(i). Data-processing, creating of new informa-</td>
<td>(i). Interpreting of new information from external data-processor.</td>
</tr>
<tr>
<td>(ii). Communicating of new information to</td>
<td>(iii). Processing of joint information, producing of new information</td>
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<td>data-processing unit.</td>
<td>(a) to add to internally stored information;</td>
</tr>
<tr>
<td></td>
<td>(b) to communicate to external data-processor.</td>
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<td></td>
<td>(iv). Storing of newly produced information.</td>
</tr>
<tr>
<td></td>
<td>(v). Communicating of produced information to external data-processor.</td>
</tr>
</tbody>
</table>

Figure 1.

2. The data-processing of a simple case may consist of a number of cycles. When, for example, an announcement of death is received, Part II of the first cycle may consist of:

(i) finding any policy on which the death has a bearing,
(ii) selecting the record involved,
(iii) (a) finding out what are the consequences of the death, what formalities eventually have to be fulfilled and what additional information is wanted,
(b) calculating as far as possible the data wanted,
(iv) storing data produced, and
(v) sending a letter or a questionnaire to the external data-processor.

When the answer has come in, it may be possible to finish in the next cycle; it may also be possible that the new information causes a new letter to be written.

3. From the example under paragraph 2 it is seen that the author supposes the organisational form of the office to be such that practically all data-processing work is centralised at the head office. In such a situation it is perhaps easier to get an idea about the eventual advantages and disadvantages of automation of a certain complex of data-processing than in a decentralised organisation. As has been mentioned, in the author's office the data-processing connected with the completion of a transaction has been mechanised. For service to policyholders and the preparatory work in connection with alterations, surrenders, deaths, etc., there is employed at the author's office a staff of about 50 employees. If it were possible to mechanise not only the arithmetical part of the job but also the type of data-processing indicated in the example under paragraph 2 (iii) (a), it would not, of course, be possible to do without any staff at all for this work, but considerable reduction of the quantity of human labour might be possible.

From experience with the part of automation realised up to now, it can be estimated that not more than one hour of computer time will be needed for this service and preparatory work. Taking into account that for the permanently needed adaptation of the whole set of programmes to the changing circumstances a part of the available computer time will be used, one hour actual data-processing work may mean one-fifth of the total computer time available for actual work. One-fifth of the yearly cost of the new installation would mean about £3,000 a year. If we add £5,000 a year (which is a very high estimate) for amortisation of cost of first programming and analysing as well as for cost of maintenance of the installation and programmes, the break-even point would be under ten employees.

The basic assumption of five computer hours a day for actual data-processing does not seem unreal since the computer is used also for the work connected with completion of a transaction and is partly used, and will be more and more used, for group pension, investment and general accounting work.

Of the work described in the example under paragraph 2, the part (iii) (a) is so much interwoven with (iii) (b) that the effect of mechanising both together will be much greater than could be expected when the quantity of work for (iii) (a) only is taken into account.
III. HOW FAR AUTOMATION?

1. The new information coming from an external data-processor cannot be transformed into automatically readable form without any prior checking (e.g. the name of a deceased mentioned in a letter may not be spelled correctly, which makes it more difficult to make sure who might be meant). A rough preliminary comparison with existing internally stored information cannot be mechanised. It is preferable to have comparison made with ordinary readable data on alphabetically stored cards, produced and reproduced automatically from automatically readable information, each card giving in condensed form the actual data of a policy. Comparison with a dossier containing original documents will follow only in case of emergency.

Comparison would have to be restricted to verifying as far as possible and would have to be followed immediately by translating the information forwarded by the external data-processor.

Translating will mean:

(a) preliminary transformation (using, for example, code numbers) into the language understandable by the computer; which means filling in a communication form to be discussed later, and

(b) punching into tape or card or transferring directly to magnetic tape.

A good system will be to complete the communication form by a typewriter producing at the same time a punched tape.

In many cases the data-processing cycle will have to be gone through several times and each time additional information from the external data-processor will have to be typed on to the form and punched into tape.

All data-processing can then be done by handling internally stored automatically readable information in combination with the information on punched tape.

2. The preparation (at the end of the data-processing) of the communication of information to the external data-processor can be done automatically in the same way as the production of the cards of the alphabetic file mentioned above, for example, by using a printer controlled by the computer. In the pre-automation phase there has been in the author’s company—as no doubt in other companies—a growing tendency towards standardisation of information documents or documentation. For example, in his office a standard form is completed and sent to a policyholder who requests information about a policy loan or surrender value, a standard form
for expiries and so on. With the combination of a printer and a
computer with sufficient internal storage capacity it will not be
difficult to:

(a) store all sentences or parts of sentences covering nearly all
sentences occurring in correspondence with external data-
processors, and

(b) establish a programme for text-composition.
The possibility of printing practically any text at any given moment
will lead to a simplification of the range of pre-printed forms, since
a number of forms with a big pre-printed text and a small variable
one can be replaced by a letter with standard framework.

There will remain no doubt different forms (policy, letter, premium
notice) and it will be often necessary to produce forms of different
kind in random order during the daily cycle of the data-processing
unit. The possibility of producing forms of different kind "on line"
cannot easily be realised with a mechanical printer. It is conceivable
to produce punched cards with the text wanted and printed “off
line”. This involves the sorting of the cards to get them into
different groups, each group corresponding to one of the type of
chain forms to be used. A better solution is the use of a photo-
graphic or xerographic printer. The method to be applied is to
superimpose the framework wanted on the variable text. For the
installation in the author's company a high-speed printer is being
developed which projects the variable text and simultaneously a
chosen framework out of nine possibilities on to microfilm. The
definite forms will be produced off line in a continuous enlarging
process.

It may be concluded therefore that the limitations of automation
of this part of data-processing do not seem to be very important.

3. A special group of documents to be printed is formed by the
policy and its clauses. The programming of text-composition of
clauses requires an analysis of the general structure of those clauses.
The same analysis is needed for establishing a coding system for
internally storing on punched cards or other media the information
contained in policy and clauses in such a way that testing of a given
situation for a certain insurance contract against its rules and specific
regulations can be programmed.

More will have to be said about this problem in another paragraph.
The analysis as far as it has gone now shows that a very wide field
of cases can be covered by standardised and generalised clauses.
This confirms the possibility of automatically handling those cases.
The exception has only to be made for the relatively rare case where
such specific knowledge is wanted that it cannot be incorporated
in the programme.

The problem of programming this comparison of actual situation
with rules and conditions touches the whole complex of that part of
data-processing to be performed between the typing of the communi-
cation form and the printing of documents for the external data-
processor, which part is to be reduced to logical and arithmetical
operations. The only limitation that could exist here might be the
length of the programme to be used in relation to the storage capacity
available. For daily work it will be advisable to pass all cases in
random order through the computer. This means storing in the
computer a very extended programme covering all jobs conceivable
in daily work. If necessary the total job can be split up into several
runs through the computer without the necessity of preliminary or
intermediate sorting as will be explained later. This might mean
more cost but no important limitation.

4. With regard to what has been said under paragraph 2, it may
be remarked that the external data-processor may be an automatic
data-processing unit itself. It is possible then, as is known, to
communicate mutually by aid of punched tape or punched cards.
Such a system will be realised in the not too distant future in the
author's company for collecting premiums via central postal accounts
and paying annuities with postal cheques. A similar relation exists
already with a commercial bank. Extension to individual external
data-processors does not seem very easy since the public up to now
is not enthusiastic for mark-sensing or similar techniques.

5. The last aspect to be analysed with regard to limitations is
that of the medium for internally storing information. In the
present stage of technical development this means comparison of
magnetic tape with punched cards or with a mixed system. A good
comparison will be possible only when each system has been worked
out a bit more in detail.

(a) Punched cards. As has been mentioned, the computer func-
tioning at the author's office can interpret information stored on a
punched card in any code. This allows compact coding especially
in such a way that a card will have no blank spaces except for any
unused portion still free for use. Some details will be given below.
From an analysis of a great number of existing policies it may be
estimated that, on the average, two and a half cards per policy will
be needed for storage of all data.

All data means not only the data in the policy and its special
clauses but also data for collecting premiums, with respect to policy
loans, unpaid premiums and finally also historical data, for example for a converted policy—data with respect to the period before conversion; or, as another example, the name of a previous policyholder. Because of this relatively small number of cards and because of the facility to feed along one reading channel 42,000 cards an hour into the computer, it is possible for a company of the size of the author's company to realise a fully consolidated functions system. Besides the above-mentioned alphabetic file there will be only one file, the file of punched cards. (The number of insurances in force in the ordinary branch is about 100,000.)

For the daily processing cycle Part II of Figure 1 can now be written as follows:

1. Interpreting of information from external data-processor.
   2a. Selecting of card from alphabetic file.
   2b. Checking of already known information contained in information received.
   2c. Typing new communication form or additional part on existing one, producing punched tape.
   2d. Selecting cards from punched card file.
   3a. Feeding cards and tape into computer.
   3b. Processing of data in computer.
   3c. Producing updated or completely new punched cards.
   3d. Printing documents.
   4. Re-filing updated or new cards.
   5. Sending documents to external data-processor.

Figure 2.

About periodical work and its impact on the daily cycle a little more is to be said. There is no special point as regards the producing of premium notices, postal account authorisations, postal cheques, etc. The cards can be fed into the computer along the high-speed reading channel. The speed of punching cards to be sent to the above-mentioned central postal account administration and the commercial bank will be decisive for the tempo of the process. About 30,000 premiums are to be collected each month, of which about 15,000 will cause a punched card to be produced. This does not seem likely to cause difficulties.

The control of premium payments will involve some daily case handling. If control consists of registering unpaid premiums, the monthly number of cases will be on the average relatively small. If direct registering of paid premiums is necessary this means selecting
and refiling a substantial number of cards, etc. (about 10,000 a month).

When the selecting of cards, etc., is done with a speed of 500 an hour and the filing with a speed of 300 an hour, this means that for this work and for the work connected with the 200 cases of daily service and transactions about one employee will be needed.

(b) Magnetic tape. A daily cycle can only be performed when the selection of information needed from tape does not take too much time. The equivalent of two and a half punched cards might be 400 lines of six bits on tape. About 250,000 punched cards would correspond with 40,000,000 characters. A reading speed of 30,000 characters a second will have to be reduced with regard to start and stop times as well as to data-processing to say 10,000 a second. This would mean a total time of about an hour when the programme for the whole daily cycle can be stored in the memory of the computer.

The additional cost of tape equipment may be about equal to that of the computer with punched card equipment. Programming cost need not be added. The break-even point would then be at perhaps four employees. But this holds only when direct registration of premiums paid can be done by aid of punched cards produced by the external institution which collects those premiums. Otherwise manual punching of this data would be needed. Since direct registering in the author's company is done only for postal account payments this will be possible in the future.

The use of magnetic tape will not be of advantage for this part of the data-processing. For a bigger company of the same structure it might be the same since all cost elements could be multiplied by the same factor.

IV. CODING SYSTEMS

In the following we shall restrict ourselves to storing coded information on punched cards. Coding on tape will be very similar.

1. As has been said, the computer as described in Appendix 2 can "read" any code. This is due to the fact that the 960 positions of a punched card can be represented by 960 bits of the memory of the computer. Transfer of the content of a punched card to those bits means making a bit = 1 for a hole and = 0 for the alternative.

In case a code is punched as "normal" for ordinary punched-card machinery it is possible to make the input organ convert directly a decimal punched in a column into a binarily coded decimal in the memory and the decimal number thus coded into a binary number.
The same holds for the output. If wanted, the card can be interpreted partly as a "normally" coded card and partly as a set of bits to be used for any convenient code. If in such a code numbers are coded binarily, there is no need for conversion. If a decimal-binary code is used (perforated tape input) some conversion will be needed.

In "normal" code the position on the punched card defines the variable ("column 17 contains the character indicating term and months of payment of the premium"). In a compact code, where no blank spaces are allowed for variables not occurring in the specific insurance, one has to provide for not being able to identify by position.

2. There is a strong interdependence between the programming system and the coding system. With "normally" coded cards one can assume that certain variables like the premium will be found invariably in the same address of the memory. This will not hold for a code where no blank spaces are allowed. There are different ways to overcome this difficulty.

(a) The programme is written with instructions containing addresses corresponding to a hypothetical generalised insurance in which every variable playing a rôle in any insurance occurs. There is a second programme, which adapts every instruction (by address modification) to the actual situation before it is carried through.

(b) During the input of a punched card, information contained in it is by aid of a special programme transferred to the addresses corresponding to the hypothetical insurance. Blank spaces omitted on the punched card will be created in the memory of the computer.

(c) The programme is not written in the ordinary instruction code of the computer. It is written in a code adapted to the code for storing information. This would mean, for example, that a variable is not indicated by an address but by the index by which it is indicated in the information code. There is a second programme needed (an interpretative programme) which analyses the main programme as well as the information. In that case the content of the card will be found in 960 bits corresponding to the 960 positions of the card. The last system has the advantage that for the programme less storage capacity is needed. The data-processing time will be no doubt longer. It can be applied when the computer is fast and either

(i) the number of cases is small (daily cycle), or
The number of operations is small (monthly cycle).

The system indicated under (c) will be described now in its main aspects.

3. The coding system for the information in a policy which will be described in the following has been based on the rules and general concepts of legislation in the Netherlands. It is hoped that nevertheless the ideas given in the following may be of some use to those who are living under other conditions.

(a) General structure of the information. The order in which the information is stored will be:

(i) list of “persons” with their predicates (personal data),
(ii) list of amounts insured with their coded definitions and specifications,
(iii) survey of nomination of beneficiaries,
(iv) survey of specifications, limitations of rights of policy-holder as far as not contained in (i), (ii) and (iii), and
(v) particulars about (inter alia) renewals, payment of commission.

A “person” as mentioned above may be every entity (natural person, legal body, group, estate) having anything to do with the policy (exercising rights, having obligations, functioning as collecting address for the premium). A “person” may be as well an entity, which will be clearly defined only after the occurrence of an uncertain event (heirs of X, widow of X).

“Persons” will be given a number in the coding system. Reference to a person will be made in (ii) up to (v) by quoting the number. Some numbers may be reserved for “persons” having a basic function in the policy (policyholder, insured, beneficiaries). The numbers above the maximum of the fixed numbers may be freely chosen. It will be assumed that the number of persons related to a policy will not exceed 64, which means coding of the number by a hexad.

(b) Coding. A number of symbols such as a symbol for person, amount to be paid will be coded by numbers up to 63, which means in the form of hexads. It would be easy if the string of 0/1 positions forming the total information could be split up into hexads. This would mean a loss of space, since for defining the information there are many code numbers to be used of a length in bits which is not a multiple of six. Therefore a group of the above-mentioned symbols will have more or less the character of directives, defining the lengths of the code numbers which follow them. This makes an unequivocal subdivision of the information possible.

Finding some data somewhere in the “mass” of information
relating to a policy would be, even with a very fast computer, a
time-consuming job since the directives would have to be analysed
one after another. Therefore a division in main parts with an
indication of the length at the beginning of each "block" is advis-
able. The length could be given in hexads and the block "rounded"
up to a multiple of hexads without much loss of space.

The symbols to be used would be:

(i) decimals (only for policy number, street numbers, in general:
numbers not to be processed, other numbers being coded
binarily since the cards are \textit{always} produced by the computer
and not by hand),

(ii) small alphabetical characters for all letter-combinations
occurring in the information,

(iii) the capitals : L, P, T, S, G, O, A, B, C, F, I, V for the directives
mentioned above,

(iv) arithmetical and logical operators (+, –, ×, : and \Lambda, V,
\Leftrightarrow as well as \rightarrow, =), and

(v) a few separators : space, |, ()

The number of symbols is less than 64. Some new symbols may be
introduced in the further development.

(c) \textit{Changes, alterations}. Not all data has historical value (address
of policyholder). So far as the old information is no longer required
it can be replaced by the new information at the same place in the
logical structure. Otherwise the new information can be inserted
immediately after the old. In both cases the punched cards will
have to be reproduced, but for programming purposes it is of great
advantage to keep the structure of the information unaltered.

(d) \textit{Predicates of \textquoteleft persons\textquoteright}. The predicates which can be predi-
cates of a person may be arranged in groups of mutually exclusive
predicates as indicated in Appendix 3—exclusive not in the logical
sense, but in this way that they will for the most part not be used
at the same time.

The symbol for personal predicates may be P, the symbol for the
group predicates i. (The predicate P15 is a predicate of a predicate,
not of a person.)

The symbol i as well as P may be coded by a value \leq 63. This
means that the symbol Pi always has a fixed length. The predicate
indicated by Pi may have a fixed length (in bits) for a given i, e.g.
when as in P13 the predicate is a code number itself, the length of
the predicate being defined by the maximum value of the code
number. For predicates with fixed length for a certain i the length
may vary with i. The predicate P4, however, which is not a general
predicate assignable to any person, but an individual one identifying an actual person, will be of variable length. For the predicates \( P_i \) with fixed length a list of the values of length as a function of \( i \) may be stored in the memory of the computer to be used as an aid to subdividing into its elementary parts the string of 0/1 positions. For predicates like \( P_4 \) we do not need a special aid to indicate the end of the predicate since as has been said the characters forming the name (including space between parts of the name) are given values of hexads always different from the value of \( P \).

Strings of predicates will be written e.g.

\[ P_0 \ldots P_2 \ldots P_4 \ldots P_8 \ldots P_0 \ldots \text{ etc.} \]

If \( P_i \) be void, the symbols \( P_i \) will be omitted. If a certain predicate (e.g. of the type \( P_{14} \)) has been "active" for a certain period and is active again since a certain date, this situation may be coded e.g.:

\[ P_{14} \ldots P_{15} \ldots F \ldots P_{14} \ldots P_{15} \ldots I \ldots \]

The repetition may be used in every situation where registration of "history" is wanted. The directive \( F \) indicates the final date and \( I \) the initial date.

It may be remarked that the code number \( P_{13} \), if it defines the concept of widow, may refer to an actual person if \( P_4 \) is not void, but otherwise to a potential person.

(e) *Non-personal predicates* may be coded as follows:

\( T \) = symbol for predicate of Time. The predicate may be:

1 being a date, 2 being any date out of an infinite series of equidistant dates, 3 being any date out of a finite series of equidistant dates, 4 being any date in an infinite period, 5 being any date in a finite period.

The predicate \( T_3 \) may be coded by the first date followed by the number of months of the period and the final date. Mention of the first date will not be necessary if it coincides with the date of entry of the policy.

\( S \) = symbol for public state

\((1=\text{peace}, 2=\text{war}, 3=\text{revolution}, \text{etc.})\).

\( G \) = symbol for geographic location

(any list for code numbers wanted may be added).

\( V \) = symbol for various predicates not belonging to the classes defined above.

(f) *Predicates of the direct rights and obligations* embodied in the policy.

The symbol \( A \) may define the concept of the obligation for the insurer to pay amounts insured.

The symbol \( A_n \) refers to a specific amount insured to be specified
by information to follow in the string. It is of advantage as with persons to use a group of values of the number \( n \) for standard types of amounts insured like pure endowment, term, etc.

The free numbers can be chosen in each policy according to need in order to indicate less frequent variations.

The specification for a standard \( A_n \) can be much simpler than for a free value of \( n \). In the latter case the chain of information will be, in general:

\[
\text{An, amount, Time predicate, other non-personal predicates if wanted, personal predicates, or}
\]

\[
\ldots \text{An} \ldots \text{T} \ldots \text{S} \ldots \text{G} \ldots \text{P}0 \ldots \text{Pi}_1 \ldots \text{Pi}_2 \ldots \text{Pi}_k
\]

\[
\ldots \text{An}.
\]

If the code number \( \text{P14} \) defines: deceased, then \( \text{A3} \ldots \text{T}5\text{F} \ldots \text{P0}3 \text{P14} \ldots \) defines a term insurance.

The meaning is as follows: the obligation to pay the amount following \( \text{An} \), \( \text{A3} \) respectively exists if and as soon as the application of each predicate given in the definition to its object gives as a result a true proposition.

The insurance defined with the string \( \text{A3} \) and following information being a standard form can be written \( \text{A3} \ldots \text{T}5\text{F} \ldots \) with omission of the condition \( \text{P0}3 \) deceased.

In the definition the predicates could have been separated by the logical symbol \( \land \). This was not necessary for understanding.

In the following example:

\[
\text{A16} \ldots \text{T}1 \ldots (\text{P0}3 \text{P14} \ldots \text{VP}04 \text{P14} \ldots)
\]

if \( \text{P14} \) defines the predicate “alive” the amount will be paid at the given date if at least one of the persons \( \text{P0}3 \) and \( \text{P0}4 \) is alive.

It may be useful to reserve the symbol \( \text{A1} \) for the general concept of “capital” and \( \text{A2} \) for “annuity”. There may be a symbol \( \text{An} \) for a bonus.

Assuming now that every \( \text{An} \) occurring in the policy has been defined, we can quote \( \text{An} \) without the information following.

\( \text{B} \) may be the symbol for the general concept of the rights of the beneficiaries.

It may be specified by information immediately following.

\[
\ldots \text{BA1} \text{P0} \ldots \text{P0} \ldots \text{P0} \ldots \text{will mean that the persons P0} \ldots \text{P0} \ldots \text{P0 are beneficiaries in succession for the capitals to be paid ex the insurance.}
\]

\[
\ldots \text{BA7 P0} \ldots \text{indicates the beneficiary for the amount insured A7.}
\]
C may indicate the general concept of the obligation of the policyholder to pay premiums.

Specification as in the following example:

\[ C_n \ldots T \ldots P_0 \ldots P_{14} \ldots \]

\[(g)\] The symbols for operations to be carried out on the direct rights and obligations and on indirect rights. According to legislation and customs in the Netherlands the rights of the policyholder are indirect and consist of the possibility of effecting operations (inter alia) on the direct rights of beneficiaries and on his own obligations (with the consent of the insurer) as well as on his indirect rights.

The capital \( O \) may be the symbol for the general concept of the right to operate of the policyholder.

(A) Specifications of some operations on direct rights or obligations.

\( O_1 \) may be the symbol for the operation: replacement by.

As has been said, new information will be inserted after or in the place of the information which it will replace. Only the first case calls for comment. The symbol \( O_1 \) will be inserted immediately after the old information and be followed by the date of operation (which may be equal to date of entry) and the new operation.

The symbol | is placed just before the old information.

Examples:

\[ | A_n \ldots O_1 \ldots A_n \ldots T \ldots P_0 \ldots P_{14} : \text{replacement of an amount insured by a different amount without changing the form of insurance.} \]

\[ | A_n \ldots T \ldots P_0 \ldots P_{14} \ldots O_1 \ldots A'_n \ldots T' \ldots P_0 \ldots P_{14} \ldots \]

(where the second predicate \( P_{14} \) may be different from the first) : replacement of a part of the insurance by another part. Any conversion can be indicated in this way. Also changes in the schedule for payment of premiums.

In a content:

\[ \ldots B_A I \mid P_0 \ldots O_1 \ldots P_0 \ldots P_0 \ldots P_0 \ldots \]

\( O_1 \) has the function of replacing one of the beneficiaries by another. \( A_0 1 \ldots \) followed by a string of \( A \) symbols with their specification may indicate a conversion into a completely different plan.

A special form of replacement is the obligation to replace a capital insured by an annuity payable from the moment on which the capital would be due. Coding as follows:

\[ | A_n \ldots O_1 \ldots (A'_n \ldots T' \ldots P'0 \ldots P'_{14} \ldots ) \ldots T \ldots P_0 \ldots P_{14} \ldots \]

The symbol \( T' \) between brackets will be different from the following symbol \( T \). The symbols \( P_{14} \) and \( P'_{14} \) will be different too (e.g. capital to be paid on death, annuity during lifetime of widow).
The amount An' may be given (annuity guaranteed). If not: the highest amount according to the number of bits between An' and T' could be used to indicate e.g. "to be calculated on the date the capital falls due according to the then existing rules". The general interpretation of the expression given above might be that the replacement will not take place when the condition T (not T') P'O P'14 will not be fulfilled.

There may be different replacements under different conditions, e.g. an annuity on two lives, when two given persons are both alive at date of replacement, an annuity on one life in each of the other cases. The expression between brackets may be replaced then by three expressions separated by the logical operator V.

A number of operations may be revoked. Therefore Oi can better be followed by nothing or I date, or I date F date, or F date.

O2 will mean "making and end to ".

Therefore AO2 will be the symbol for surrender and CO2 the symbol for conversion into a paid up policy.

O3 may be the symbol for the operation "giving an option" for conversion into another form. The coding will be practically the same as for O1. If the option can only be realised under certain conditions these conditions can be placed (in the same code) between O3 and its date(s) on one side and the coded optional plan on the other side.

O4 the symbol for the operation "excluding", may be used as indicated in the following example (where the first symbol P0 may indicate "heirs of a given person" and the second symbol P0 one of the possible heirs).

\[ B | P0 \ldots O4 \ldots (P0 \ldots) \]

This means that beneficiaries will be the heirs of X with the exception of Y.

O5 may be used as a symbol for limitation, e.g. :

\[ BAn \ldots | P0 \ldots O5 \ldots A \ldots P0 \ldots P0 \ldots \]

which means that the rights of the first beneficiary will be limited to the amount given immediately after O5. This amount might be "the then existing debt" which can be indicated by using the highest value the amount following O5 can have.

A symbol (O6) will have to be used for coding stipulations about the destination of the amount insured (say: a monument to be erected to the deceased). The operation symbol will have to be followed by the alphabetical text (binarily coded) to be used in correspondence. The frequency of that type of stipulation is very low.

2F
(B) Operations on indirect rights. The first symbol to be discussed is that of the acceptance of the assignment as a beneficiary by the assignee.

O7 is in this way a symbol for an operation on direct rights but under Dutch Law it affects indirect rights of the policyholder (in the first place the right to replace the beneficiary by another one) which cannot be exercised after this without consent of the beneficiary under discussion.

Example:

... BA1 | P0 ... O7 ... P0 ... P0 ...

We can now enumerate a series of symbols for (legal) operations, which have a direct or deferred effect on the total or a part of the policyholder's operational possibilities. They will therefore have the general symbol O as their object. This means that the coding will be of the form OOi if i is the index of one of the operations to be mentioned.

They are

O8 "blocking" by a person,
O9 cession to a person,
O10 pledging to a person,
O11 arrest by garnishment by a person,
O12 seizure under a writ of execution.

In Appendix 3 the predicate P16 will be used to indicate a personal status leading to the assignment as representative of a person. The person will have to be mentioned after the predicate. In case the representation is not general and has not a bearing on all the rights of the one who is represented, one might use a symbol O13 for representation followed by specifications.

(h) General remarks. The coding of mode of payments (renewals, etc.) may be left out of discussion, since no new fundamental problems will arise.

As has been said, the total string of 0/1 positions may be subdivided into blocks and sub-blocks.

The blocks may successively contain the total information "ruled" by all P-directives, the next one the information "ruled" by the A-directives, etc.

It is advisable to indicate the beginning of those blocks by directives L1 (P-information) L2 (A-information), etc. Each directive Li now to be followed by the number giving the length in hexads of the block. The same can be done with the sub-blocks. The numbers indicating length being written mL mP, etc., we get the following string:
The operations $O_8$ up to $O_{12}$ will have to be followed by the name of the “blocker”, the assignee, etc.

From the above detailed description of the coding system it seems that practically every policy-text, however complicated it may be, can be stored in a very compact form on punched cards or magnetic tape. A very careful and detailed analysis of a problem like this is necessary since very often a system (e.g. coding system) which is based on an apparently sound and logical principle fails because of difficulties hidden in the details.

4. Consequences for the programming system. The following description of the programming methods connected with the coding system as given in paragraph 3 will have to be far less detailed than the description of the coding system itself: in the first place because a detailed description would take too much space and secondly because the system has not yet been worked out at the author’s company. Some general aspects may, however, be discussed.

(a) Symbols. As has been said before, use of the normal instruction code will be pointless since the “address part” could not be filled. For this reason it is preferable to write down the programme just like a formula is written down and to store the “formula” in the memory by coding the symbols used in the formula. The arithmetical operators have been mentioned as well as a number of logical symbols. Some more complex ones will have to be added, since questions will have to be answered of the type: has the policy been pledged? Or: is there a symbol $O_{10}$ to be found? As far as possible such type of operations (search in the information after a given symbol) can be indicated directly by a hexad or indirectly by a hexad indicating the general concept of function, followed by a number.

The operands will be mainly predicates, numbers, etc., given in the policy information. Some additional symbols may be necessary (e.g. for constants to be used in the calculation). Say a part of the programme reads (calculate:) date of expiry—date of birth of the insured. Date of expiry may be the date following a symbol $T_1$ in connection with e.g. $A_4$ and date of birth the date of birth of the person following $A_4$. We would get $A_4 T_1—P_0 P_7$.

In the programme interpreting this part of the “formula”, first the symbol $A$ will be “recognised”. Then, as soon as the beginning of the $A$-information has been found out (by jumping from the beginning of a block to the next one) the $A_4$ will have to be located by jumping from sub-block to sub-block and finally $T_1$. The date
can then be stored in a given address to function as an operand. The same holds for P0 P7. As soon as both operands are placed in fixed addresses (one of them being a register) the symbol "-" has to be analysed. The operation can be carried through immediately.

The language in which the programme will be written will of course have much likeness with the Algol language which has been developed to serve as a general language for programmes. It will be less extensive than Algol, since it can be wholly adapted to our specific subject.

(b) General organisation of the programme. The daily case work to be handled will consist of:

(i) answering questions for general information or about possible alterations not yet decided upon, and

(ii) completion of a transaction decided upon.

Data produced for the answer to (i) might be used when (ii) has to be carried through. It is easier (and safer, since a long time may have elapsed since the production of (i) before the decision is taken) to recalculate data at the date of completion.

In the communication form an indication which makes distinction between (i) and (ii) possible, and, therefore, allows for different handling, will have to be made.

In the communication form the questions to be answered and the transactions to be performed have to be coded as much as possible with the aid of the symbols defined under Section IV, paragraph 3. Simplification is possible. The type of information may be partly defined by its location on the form. The programme as a whole may be subdivided as follows:

A. comparison of the actual situation and intended operation with the rules embodied in the policy and its clauses as it is stored in coded form. Determination of

(i) data to be produced, and

(ii) sentences to be printed

B. calculation of data, and

C. production of sentences.

The best system seems to be to establish a list of calculations each of which will have or will not have to be performed according to a complex of conditions being satisfied or not—the same for sentences to be printed. The first part of the programme will consist then of the assembling of a set of numbers indicating the calculations (sentences) to be performed (printed). The second and third parts
can be performed (if necessary) in a separate run. The numbers of
calculations to be performed and sentences to be printed will have
to be punched then on intermediate punched cards.

The total number of "elementary" calculations can be reduced by
generalisation.

Generalisation of calculations. One generalisation consists of the
generalising of the insurance scheme. This means that calculations
(e.g. of a surrender value) are done as if the insurance contains every
type of amount insured conceivable, or a list of symbols $A_n$ is
established covering practically all elementary insurances known in
practice and each amount $A_n$ is first assumed to be given in the
information. If the programme is written in compact form, during
its performance in the interpreting programme the general rule will
have to be followed that every failing amount $A_n$ is replaced by
the amount zero to be processed normally.

This might be called zero operation. The same holds, for example,
for all cases where a loan and/or unpaid premiums may play a rôle.
No loan and no unpaid premiums will mean a loan and a total of
unpaid premiums each equal to zero.

The programme for a conversion will be a programme for a con-
version of a generalised insurance into a generalised one.

The change caused by the death of the insured may be handled
as a conversion; the same with expected alterations and surrender.

Generalisation of sentences. In case of cession, for example, or
acceptance by assignment, pledging, etc., an intended transaction
cannot be performed without the co-operation of the cessionary,
beneficiary, etc.

One sentence of the following content: "Please return the
enclosed copy of this letter with a subscription signed by ...........
in which approval is given to the above-mentioned transaction"
might cover all these cases.

The system adopted here is quite similar to methods used in
simplifying standard letters.

If the number of calculations is relatively small, the calculations to
be performed in a specific case can be indicated by the aid of a binary
word in such a way that each bit corresponds to an "elementary"
calculation. The value 1 of a bit will mean: performance of the
calculation. This method of binary "key-words" has advantages
which can only be indicated here.

The construction of the binary word required is a simpler process
to be programmed than the assembling of numbers of "elementary"
calculations to be performed. The same holds for text-composition.
V. CLOSING REMARKS

1. In the system first developed, emphasis was laid on combining as much as possible of the preparatory work for monthly and yearly work with the daily cycle. This involved, for example, the application of interpolation methods for valuation purposes and the daily updating of totals of interpolation constants. The daily processing of surplus analysis forms a logical component of the whole system.

The new possibility of processing monthly all the “in force” cards might lead to another system in which, for example, the above-mentioned part of the data-processing would be done monthly.

Experience has shown that the definite control with immediate correction of errors which is a consequence of the daily system has many advantages. For this reason it does not seem likely that the system will be changed in this respect.

The interpolation constants (and Altenburger constants) are now stored in punched cards for each policy. This will no longer be necessary since recalculation at any time they are needed will not take time worth mentioning. The automatic preparation of expected alterations will be, of course, a monthly job.

2. The development of a reasonable coding system for all information connected with a policy took a lot of time. It was necessary to get some idea of the different specific regulations occurring in policies issued in the past. It was also necessary to classify the different legal relations embodied in a policy.

Attempts were made to analyse in detail the logical structure of the data-processing involved with daily case work before the coding system had been worked out. This proved to be impossible, the logical structure of data-processing is dependent on the coding system chosen.

The coding system which has been discussed in this paper might be adapted to other types of information.

3. In group pension data-processing a coding system will probably not require to be extended so far as in the ordinary branch. The automation which has been started successfully will lead to a situation in which will be automatically processed:
   (a) calculation of increase of benefits on increase of salaries,
   (b) calculation of premiums,
   (c) updating of the current account with the pension fund, and
   (d) updating of valuation totals, totals of internal accounts as has been indicated for the ordinary branch.

It is conceivable that the text-composition of a group pension contract can be programmed.
APPENDIX 1

CHARACTERISTICS OF THE COMPUTER GAMMA 3M


Store: delay lines. Capacity: working memory 4 up to 31 words. Instruction memory: 64 instructions and card programming (48 complete instructions per card). Access time: 170 microsec./word.

Input/output: (maximum equipment): 1 Bull-reproducer (120 cards/minute in and out) or 1 Bull-tabulator (150 cards per minute in and 150 lines of 92 characters per minute out).

Operation speeds: addition and subtraction minimum 1 millisec. Multiplication/division: average 11 millisec.

Power consumption 3 KVA. Floor accommodation required: circa 50 square metres.

APPENDIX 2

CHARACTERISTICS OF THE COMPUTER X1


Store: magnetic cores. Capacity: units of up to 8 blocks of 512 words (minimum capacity 512 words). A passive store, used for input routines, fixed subroutines and so on, is added in blocks of 64 words (minimum capacity 512 words). Total maximum capacity of active and passive store together: 32,768 words. Access time: 16 microsec. The connection of magnetic tape units is under study.

Input/output (maximum equipment): 1 5-hole punched tape reader (Ferranti: 150 char. per sec.), 1 punched card sorter (Bull: 700 cards per min.), 1 or more reproducers (Bull: 120 cards per min. in and out), 1 or more tabulators (Bull: 150 cards per min. in and 150 lines of 102 char. per min. out), 1 5-hole tape punch (Creed: 25 char. per sec.) and 1 electric typewriter (IBM: 10 char. per sec.). The punched card equipment handles 80-column cards. All units operate simultaneously and computing may proceed in the meantime.

Operation speeds (access time included): from 0.032 to 0.084 ms. for addition and subtraction, about 0.500 ms. for multiplication and division. Power consumption: 2-3 KW. Floor accommodation required: according to volume of installation 20-50 square metres.

Technical data: 250 kc/s P.S.R., transistors, printed circuits on plug-in boards, magnetic core matrices.
APPENDIX 3

PREDICATES OF PERSONS (Pi)
(I = initial date, F = final date)

Pi
0 number of persons or potential person or representation
1 titles, degrees (as part of name)
2 Christian name(s)
3 initials
4 family name (also name of legal body or expressions like "The heirs of X")
5 residence
6 street and number
7 date of birth (3 binary numbers of 5, 4 and 8 bits respectively)
8 place of birth
   Code number for: (eventually followed by number of person, initial and/or final date)
9 nature of person (natural person, firm, estate, participant in estate, etc.)
10 sex
11 marital state
12 marital relation
13 family relation and relation by inheritance or by will (of person or potential person)
14 personal condition in terms of policy regulations (alive, active, totally permanently invalid, totally temporarily invalid, etc.)
15 cause of change in condition as coded in P14
16 personal situation involving legal disqualification or representation [under age, under guardianship not for bankruptcy, bankrupt, in state of impending bankruptcy, represented by proxy by assignment, etc.]
17 residing or non-residing
18 profession
19 in military service of a foreign country

Examples of P13

<table>
<thead>
<tr>
<th>Number</th>
<th>Family Relationship</th>
<th>Number</th>
<th>Family Relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>son (daughter)</td>
<td>20</td>
<td>heirs</td>
</tr>
<tr>
<td>2</td>
<td>child</td>
<td>21</td>
<td>successors in title</td>
</tr>
<tr>
<td>3</td>
<td>children</td>
<td>22</td>
<td>representation by universal</td>
</tr>
<tr>
<td>4</td>
<td>step son (daughter)</td>
<td>23</td>
<td>appointed by will</td>
</tr>
<tr>
<td>5</td>
<td>step child</td>
<td>24</td>
<td>estate</td>
</tr>
<tr>
<td>6</td>
<td>step children</td>
<td>25</td>
<td>participant in estate</td>
</tr>
<tr>
<td>7</td>
<td>legal children</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>natural children</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SYNOPSIS

1. The E.D.P. system which has been developed in the author's company a few years ago was based on the use of a small wired computer with a storage capacity of 30 words of 12 decimals each for data to be processed and (intermediary) results and with a practically unlimited capacity as regards the length of a programme because of the possibility of card-programming (48 instructions on each card). The system which in the meantime has been fully realised includes: manually punching of all data given in an application form for a new policy or in a similar internally prepared document with regard to an alteration, conversion or exit of an existing policy and automatically (a) producing of (new) policy record punched cards serving for printing a policy (if necessary) and to be filed for future use, (b) producing of punched cards for renewals, (c) idem for payment of agency commission and (d) of cards containing constants for valuation purposes, (e) updating valuation totals and totals of the accounts for surplus analysis as well as statistical totals. All data in the cards i.e. agency commission, Altenburger constants to be calculated from first principles.

2. Since a computer is available with much higher capacity (operation speed ± 64 microsec. for short operations, 500 microsec. for multiplication and division, storage capacity for data and programmes up to more than 30,000 words of 27 bits each, possibility of connecting the computer with a group of punched card machines and with a high speed photoprinter, if needed magnetic tape equipment) a new system has been developed which is based on the following assumptions:

(a) it is possible not only to do all calculations by aid of an electronic computer, but also the part of the daily work, which consists of the interpretation (in daily case work as it is centralised at the head office of the author's company) of the rules contained in a policy and its clauses;

(b) it is possible to store information contained in or connected with a policy (including historical data) with the aid of a compact coding system on about two and a half punched cards;

(c) it is possible to use the cards mentioned under (b) for monthly renewals, because of the given speed of the connected reading unit. This leads to the following general structure of data-processing:

(a) interpreting of the content of incoming letters and copying with the aid of a typewriter-tape punch this content on a form in a code adapted to the automatic data handling of the computer, producing simultaneously punched tape, (b) selecting the punched cards of the policy involved from the only existing consolidated file, (c) data-processing in the computer and producing automatically all documents needed.

3. The system of compact coding has been based on the possibility in the computer to interpret any combination of binary units. Since in this type of storing information data have no fixed localisation the normal programming system where operands are supposed to be found in a known address has to be adapted.
The President (Mr. A. R. Reid).—It gives me very great pleasure and pride to introduce to you to-night Professor Engelfriet from Holland. Professor Engelfriet, of course, is no stranger to many of us. Many have met him and his charming wife at International Congresses, and in 1956 on the occasion of the Faculty Centenary both Professor and Mrs. Engelfriet were in Edinburgh.

As the Professor is such an acknowledged expert on a subject which is of such great importance these days, the Faculty Council, not without, I may say, a certain trepidation, decided to ask the Professor whether he would come to Edinburgh and give us a lecture on electronic machines, and we were most grateful and very delighted to receive an acceptance to that invitation. The old Latin proverb, *bis dat qui cito dat*, has a great deal of truth in it and I would like to assure the Professor that the readiness with which he accepted the invitation has really doubled our pleasure in having him with us at this time. It is no easy matter to face the rigours of the month of January in Edinburgh, and that should make us all the more grateful to the Professor for coming, although of course it has been recently brought home to us by the sad news of the flooding that in Holland also winter has its rigours, and I would like to take this opportunity of assuring the Professor of the deep sympathy we all have with those of his fellow-countrymen who are in such dire distress at the present time.

The subject on which the Professor is going to speak to us is necessarily only sketchily known to very many of us and the meeting to-night will not therefore take the usual form of a paper and a discussion. At the conclusion of the Professor's lecture, however, there will be an opportunity for questions and I hope that as many as possible will take the chance of picking the Professor's brains. In this invitation I include two very welcome visitors from the Institute, Mr. Usherwood and Mr. Allaway, whom we are delighted to have with us.

I now have much pleasure in asking Professor Engelfriet to address us.

Professor Engelfriet.—Mr. President, Gentlemen: If I were a Scottish Actuary, I think the best way to introduce a paper would be to follow the example of an Actuary who once closed a discussion by rising from his seat and saying "this discussion is now closed". That would mean that in this case I would simply say "the paper is now introduced", and sit down again. Being a guest, and considering the nature of the subject, as you have already explained, I am given rather more time. I appreciate this for, in the first place it gives me an opportunity of thanking you very heartily for the kind words which you addressed to me. I feel very honoured by the invitation you extended to me and I feel still more honoured by the way in which you have introduced me to-day to the audience. My colleagues in Holland have also appreciated this gesture and regarded it as an honour for the Nederlandsch Actuarieel Genootschap. They have asked me to convey to the Faculty of Actuaries their best wishes. I thank you also very much for the kind words you have spoken about the flooding in Holland. We hope that the reparations will be done in a reasonably short time.

Coming now to the paper, I thought it was very appropriate to mention, at the start of the paper, the name of Mr. E. William Phillips, for it was from the paper read by him to the Institute of Actuaries in 1936 that I first got the idea of what might be possible. I have mentioned in my
paper also the names of Mr. G. D. Gwilt and Mr. G. C. Philip. Their papers arrived too late for me to make extensive reference to them, but I have since read as much as possible of their papers; I am very glad to see that they approach the problem more or less in the same way although there are, of course, differences arising from differences in the nature of the companies concerned. I think there is much similarity between our two approaches; there is a wider difference between the European approach and the American approach because of the great disparity in the size of companies.

I would like now to say a few things about the background to our problems and the situation in which we work so that it may be easier for you to understand what I have said in the paper. My Company is a Company transacting ordinary branch and group pension business; there are about 100,000 policies in force in the ordinary branch, with an average sum assured of about £1,000. The average sum assured under new business is between £1,400 and £1,500. Companies in Holland compete with each other in the ordinary branch by offering various combinations of insurance benefits. There is a large variety of plans; there is no fixed maturity age and the prospect may choose the maturity age which best suits his requirements; we have sometimes to combine in one policy, if required, say five family incomes of different durations with a capital sum payable immediately on death and another capital sum payable on survivance to a certain date; and perhaps still a third capital sum payable at the same date or some other date if the life assured is not then alive; there may also be various other combinations required for individuals who are able to assess accurately their future financial situation. Such a situation sometimes leads to two or three combinations of benefits. We have sometimes to tell our staff to avoid too many combinations but we still have a very big variety.

The first analysis we made was about the possibility of doing valuation work, and we had immediately to face these many variations; we had to ask ourselves whether we should be content with covering only 90% of all the policies for valuation work or whether we should endeavour to include more. At first we thought we should be content if we covered only 90%, but we soon became convinced that the use of a computer required new methods. For example, it was realised that it would be necessary in certain cases to calculate age at maturity in months instead of years and that, with a computer, it is as easy to calculate all ages in months as to programme a mixture of years and months. We accordingly came to the conclusion that, when using a computer, the whole system would be completely different from the existing manual system. It was therefore less attractive to leave 10% of all policies outwith the new system; we tried to cover more and more policies and arrived at the end in building up a system—a formula system—which covered nearly every policy; we had to make an exception for, on the average, only one in three hundred policies. The queer thing was that at first, everyone thought "why such perfectionism" but as soon as the system worked, those who had been most incredulous about the possibilities were, after that, most pressing for the programmers to include all those remaining exceptions in the system and they could not believe that there might even be a limit to the possibility of generalisation.

I shall give some more details about the type of generalisation we have followed. We knew, however, when beginning with the valuation side
that we would not stop there and that we would try to combine that work with a number of other jobs previously done manually. That made us analyse again the whole system which we were trying to build up and we came to the conclusion that we would start building up a system which can be defined as doing the work connected with the completion of a transaction by aid of a computer. Completion of a transaction means that, *as soon as* a policy has been sold, the proposal form has come in and the medical form has been seen by the doctor and has been accepted, *then* you start with the first punching of all the data in the proposal form into preliminary punched cards; from that moment onwards, you do all the work connected with the printing of the policy, calculating valuation constants, agents' initial commission, agents' renewal commission and so on by means of the computer. We considered for a long time whether we should do the printing of policies with the aid of punched cards or not. There are other systems available, such as, first typing the policy by aid of a Flexowriter and then producing at the same time on punched tape all the data typed in the policy and feeding the data on tape into the computer; in our plan, however, the typing of a policy requires some preliminary data-processing—not so very much—calculating a few dates, for instance, so that in the end we thought it better to start the other way round and begin by punching the data given in the application forms into punched cards in the order in which the data appear in the form. The complete processing involves also the calculation of a net valuation premium and of, for instance, the other Altenburger constants from first principles. We have also created a system by which we could make the analysis of surplus daily by aid of totals which are kept up to date, and also calculate the agency commission from first principles. That means that we had to overcome a lot of difficulties for the computer only contained 30 memory units, each unit containing 12 decimals. This memory could be used for the data to be processed. While part of the programme could be punched into punched cards, part of it had to be written. Each punched card contained 48 instructions and that meant that the programme would be as long as desired—although there is a certain limit to that as we afterwards discovered. The plan was then to feed the preliminary punched card for each new policy (or for each policy after conversion) into one of the channels of the punched card machine connected to the computer and to pass along another channel of the punched card machine, the programme cards for every set of policy cards, a set of programme cards containing again and again the same programme because the programme had been established in such a way that it covered any type of insurance contained in a set of policy cards. In this way the instructions contained in the programme cards are carried out on the information contained in the set of policy cards and the results required punched into cards.

Now, we had only 30 memory units at our disposal for storing the data contained in the policy cards, for processing the data, for storing the constants and functions needed for the calculations so that, for instance, we could not even store the function $N_x$. We had to store some constants which enabled us to calculate the function $N_x$ by aid of a polynomial of the fifth degree. We could, however, cover a range for $x$ from about age 20 to age 95 by using two sets of constants for those 5th degree polynomials. So even $N_x$ during the time in which the cards passed through the computer had to be calculated by aid of a 5th degree function and
from it we could derive other functions in the same way as has been given in the paper by Mr. Philip—for instance we could derive $D_x$ and the other values which we needed from the values of $N_x$. We required also to have values for $v^x$ and these were calculated in the same way by aid of a polynomial. The storing of these functions took 12 of the 30 memory units. Now we were anxious to generalise the type of insurances covered by the programme as much as possible and in analysing all the types of insurance issued by our company we devised a system in which we supposed every insurance to have a certain number of periods.

In practice there were many policies, of course, which had only one period, for instance an endowment assurance or a term assurance; a deferred annuity was assumed to have two periods between the date of entry (or alteration) and the date of death. In this case I think your practice might have been the same. You might also have a deferred annuity or temporary annuity with differing periods of premium payment, for example a low premium during the first three years. You might also have endowment assurances with family income benefits for differing durations and amounts. To cover all such types of insurance we have simply regarded every insurance as consisting of an appropriate number of periods; say $n$ periods with the corresponding ages $x_0, x_1, \ldots, x_n$ where $x_n$ may be the final age of the mortality table. We have supposed that for every period we could have a different amount say $O$, to be paid on death, or an amount say $L$ payable on being alive at some age, or an amount, say $V_r$, payable in case of not being alive at some date. During such a period we might have a family income benefit, for which our symbol is $E$. We also could have an annuity different for each period, which we call $r$. We might have a premium which might be different for each period—so you may get the impression that we went wholly crazy doing it that way, but that system was introduced so as to cover any unusual combination that might arise. Our system made it possible to split up the calculation work into calculations for each period separately. It made it possible to calculate, for instance, the value at the beginning of each period of all the amounts payable by recasting the formulae; the recast formulae being constructed in such a way that they could deal with any combination in any period. The system was dictated in this case by the fact that we could not store all the data relating to an insurance in general in the memory of the computer, we could only store simultaneously the data relating to one period, calculate the intermediate result and then carry on to the next card coming through.

Since we had decided to calculate the net premiums and other constants required for valuation purposes on such a generalised system, we came to the conclusion that we might as well use the same system in our policies. That is the reason why we devised a policy form for our existing system in tabular form rather than in narrative form. We introduced the system into our policy forms by presenting the whole policy in numbered columnar form and preprinting the definition of the reference numbers given in the columns. For instance, in one place we show the capital sum payable immediately on death if it occurred in the period defined; in another place we show the capital sum payable if the insured is alive at the end of the stated period—or in another case, for example, if he should not be alive. In the policy, of course, we did not use symbols but definitions and words and we wrote down for instance in the first line of the first column "the period 1 January 1960 to 1 January 1980" and showed
against this entry in the same line of the next column the amount payable on death within the period. For endowment assurances we required a further column for the sum payable on survivance. This may seem queer to you, but in our practice the amounts payable, especially in the past, on death and survivance frequently differed. We produced a policy form which could cover similar variations in the case of deferred annuities and other classes; thus we created as general an insurance as we could cover with our formulae. We dealt similarly with agency commission, and to enable the whole system to be readily operated we also drew up an application form in a similar way. We were rather nervous when we started that system in 1955, introducing an application form with similar columns and definitions on top, and asking our agents to fill up such forms. We thought it might be too difficult for them, but the result has been quite satisfactory. Even policyholders expressed satisfaction in that they now had a policy which they could understand in a few minutes instead of having to read a long narrative as they used to have to do. We also received, I must confess, from time to time a letter from some person asking us whether we had gone mad, or something like that, but you know from your own experience, I think, that, in the long run, you become immunised against such attacks. The theme of the whole system has been generalisation, generalisation and, I emphasise, generalisation. The system has been operated so that application forms and policy forms were as similar as possible, but this could not be wholly realised because of the technical features of the available tabulator. Some data had to be added to the application forms coming in, for example the number of the agent, the number of the inspector and so on. Thereafter everything is, you might say, blindly punched into cards and run through the computer several times. It was a small computer. On the first run we had to split up the cards and do some intermediate sorting from time to time, not because we have to sort according to type of insurance, but only because in one programme it was easier to start with cards for the last period of our records, while in another programme it was easier to start with cards for the first period, and thereafter proceed in the opposite way. We called the first run the transformation run, and that run had the function of feeding the preliminary punched cards into the computer. Then the computer, by aid of the automatic punch connected to it, produced the cards for the other functions to be performed afterwards. These cards are, for example, those intended to enable the policy to be printed; they are also filed as policy record cards. The second type of card is that for valuation purposes containing not only Altenburger constants but also constants for enabling a second-degree interpolation formula to be used to calculate the policy reserve for the business as a whole by the aid of totals, but I will not go into that in detail. The third type of card is the renewal card; and some other cards are used for the calculation of agency commission, the latter being filed with the renewal cards. We were not so much in need of a full consolidation of files. We started with three main files. Firstly the file of policy register cards which we wanted to use also for calculating from first principles the conversions of policies that may be different in your country as we do a lot of work involving the conversion of existing policies into new ones. The three main files are the policy record cards, the policy valuation cards and the policy renewal cards. We combined the first two files since it was easier to have the valuation cards and the record cards filed together. You will appreciate that for such a generalised type of insurance we have, as a rule, quite a number
of cards per policy. On the average there are 8 cards per policy and we have not had any difficulties with such a large number. On the contrary, the system has worked quite well. We have employed the system for new policies, for alterations and conversions after the preliminary work and calculations have been done, embodying in the course of such changes, the printing of the new policy, the change in the valuation constants and so on. This system did not require the whole file to be passed through the computer every day. We have done this by selecting only the cards required and filing them again after they have been serviced daily. In my view it is not the most important part of automation to avoid such selecting and filing of cards. In my view it is much more important to do all the data-processing, involving logical and arithmetical operations, by aid of the computer; I have tried to give in this paper an idea of how, in a more consolidated system, the selecting and filing could be done on the average by one employee in our office. I must say that we plan to go much further and to do also the daily servicing with the aid of the computer—and we are preparing for that. We could not do that with a small computer because the storage capacity was not sufficient. That was the reason why we have constructed a new computer with a storage capacity which is, at the moment, 4,000 words each of about 7 or 8 decimals instead of 30 words of 12 decimals, but of which the storage capacity can be extended up to more than 30,000 words so that it is, for our purposes, practically unlimited. We cannot with the small computer calculate conversions which take a lot of time. We cannot with a small computer do the data-processing work for the group pensions department which involves old age as well as widows' pensions. So we needed a bigger computer, but, having that bigger computer, we want to go much further; we want to do not only the preliminary calculations required when a transaction is prepared but also that type of data-processing which consists of analysing the legal situation of any transaction planned. Here our practices and methods are perhaps more different from yours. I think such type of work as preparing surrenders or conversions will often be done in your Branch Offices. Our Branch Offices are only centres where the acquisition of business and the negotiations with prospects are organised, and nothing else. There are also some files of prospects pending; there are no files about existing policies. If someone wants to surrender, or if someone wants to ask questions, he has to apply to the main office, and that makes it possible to do also that type of work which consists of looking to see what type of special regulations are in a policy; for example, if there are regulations that the capital shall not be paid immediately but shall be obligatorily transformed into an annuity; or looking after the legal position as to whether the policy has been pledged or if there is a cession or something like that. Now with us an important part of the system relates to assignments of benefits. In the Netherlands it is generally the custom to name, in the policy of the ordinary branch, all the beneficiaries of the policy monies in succession. In 1955 we introduced a system of fixing the beneficiaries by relationship; that means by the definition of the widow, for example, at the moment of decease, or of the children at the moment of decease. That made it possible to simplify that type of work. It may not be a problem at all to you, but we had to face it when we wished to mechanise the processing which consists of analysing the legal situation at the moment a transaction has taken place. Our plan had to cover not only the more or less simplified ways of determining beneficiaries but also the complicated ones. That has been the
reason why we have tried to build up a coding system which makes it possible to lay down in a very compact form all information relating to a policy, not only the arithmetical data but everything pertaining to the legal situation and to the historical data. That coding system has been devised in the same way as we conceived in the beginning the most generalised insurance capable of being dealt with on the small computer. We have also made the coding system as general as possible so as to cope with any new developments. The type of generalisation followed is such that some regulations, which occur infrequently, may be dealt with as often as may be required in the future. We can combine by aid of our coding system any arrangement of conditions and special regulations that may occur. We have developed that from our experience during the last 5 or 6 years. I would very much like to go into the details of that but I think that my time is now up, Mr. President, and I will leave it to some of the actuaries present perhaps to put some questions forward. Thank you very much.

The President.—Thank you very much indeed, Professor Engelfriet, for that most interesting running commentary, shall we say, on the more technical sides of the paper. I am sure all found it very interesting and the stray comments on the differences between and the similarities with business in your country and ours were of particular interest.

If now some of the more acknowledged experts would like to ask Professor Engelfriet any questions I am sure he would be very pleased to answer them.

Mr. T. M. Springbett.—First of all, sir, I would like to say what a great privilege it is to have heard this lecture by Professor Engelfriet and to have had the very great benefit of his wide experience in this field. We, of course, are rather novices compared with him and we have still a great deal to learn. I expect most of us have questions about one aspect or another of this automation question, and I am sure Professor Engelfriet will forgive us if some of our questions seem perhaps rather elementary.

The part of the Professor’s paper in which I was particularly interested was where he compared the merits of magnetic tape and punched cards. I have particularly in mind the situation which will arise when he has his bigger and faster computer fully in operation and his new coding system working. It seems to me that if an Office is going to be ambitious and install a large computer with a view to full automation it should strive to eliminate as far as possible the human element—it should be possible to start with the data at one end, feed it into the machine and get the answers out at the other end. So far as I understand the new system there will be cards punched in quite a complicated code and there may be 2, 3 or even 4 punched cards for a given policy, and it is the intention that when any kind of transaction takes place an operator should go to the file and should extract by hand the punched cards for that particular policy. All the cards for the transactions of that particular day having been collected, they would be fed into the machine. The answers would come out of the machine and the punched cards in so far as they were still relevant would be refilled in the punched card file by an operator. It seems to me that the human operations will introduce quite a large degree of error—there will not be the same number of cards for each policy and sometimes mistakes will be made in taking out the cards and in refiling them. Also the state
of the cards in the file will suffer to some extent because the file will have to be looked through each day in order to extract cards and some may become distorted. I wonder whether in due course this may not lead to mechanical trouble in feeding the cards, especially at the high speeds of card feeding which Professor Engelfriet envisages with his new machine.

The alternative would, as the Professor says in his paper, be to have magnetic tape. I agree that a magnetic-tape installation would be about twice as expensive as a punched-card one, but on the other hand on his estimates it would be possible to search through the tape each day, just taking an hour a day to do so, and to my mind it might still be worth while to go the whole way and get the full benefits of automation by using magnetic tape, thus eliminating any possibility of human errors coming in through the extraction of cards by operators. I would be very glad if Professor Engelfriet could elaborate to some extent what his feeling is about the relative merits of magnetic tape and punched cards. My own instinctive feeling is that if one is going to do automation, one should go the whole way and use magnetic tape.

Professor Engelfriet.—Well, I cannot say that I am absolutely against magnetic tape, but I would say that I am quite glad to learn that Mr. Springbett has fully understood the ideas in my paper. Indeed, it is the idea to have two files including a visual file produced by aid of the computer from the punched-card file and that visual file stored in alphabetical order. The other file is the only punched-card file. And now your question—“Would there not be a source of error when you have to select the cards from the file for all alterations?” I must say that we have that system of random access to the main files. We need those files for doing some calculations for each alteration. The only differences will be that we shall need in our new system also cards for the preliminary calculations and preliminary repetitive data-processing of transactions that may not be completed afterwards because the policyholder does not take a decision. Our experience has so far been satisfactory. A month ago, we made a check of the main file consisting of the policy record cards and the valuation cards (brought together into one file); we ran the cards through the big computer at the speed of 42,000 cards an hour and checked firstly as to whether the cards were indeed filed in policy number order and whether in each set the cards were filed also in the order in which they ought to be filed. We found a number of errors, but no error had any effect on what we had been doing. In some cases the cards within a set were not in the right order. In the new system we have files which will be much more compact. We have now a file of 6 or 7 cards per policy as well as the file for renewals which contains only one card per policy and, with a file of 2 or 3 cards per policy (under the new system), I am not so much afraid of difficulties. On completion of a transaction, new cards for the most part are produced so there is little danger or difficulty for the punched-card machine through cards becoming rough. If necessary, one might even in preparatory work reproduce the cards from time to time. Nevertheless, it is not wholly impossible that, in the end, we might employ magnetic tape with our computer—not so much for this part of the work but more for the group pension part because there there is the problem of altering the cards each year to meet increases or decreases in salary and so on and the well-known yearly run through the computer. And there we have the big advantage of being able to run it on a still higher tempo.
than by aid of the card-reading device which reads 42,000 cards an hour. Anyway, we have started the new system without using magnetic tape.

Mr. W. M. Morrison.—I want to refer to the ultimate system which Professor Engelfriet proposes to use on his new machine. It seems to me that three characteristics of this machine are fundamental. First of all its very large storage capacity, secondly its extremely short time of random access to the storage locations, and thirdly its ability to deal with the very compact coding system which the Professor proposes to use. In fact, I have probably stated these in inverse order of importance. The compactness of this coding system enables him to put not only current but also historical information on his policy record cards. So apparently the Professor has one consolidated file in numerical order of policy and, as Mr. Springbett says, he proposes to update this file daily for all the transactions from new business, premium payments, conversions, alterations, claims and surrenders and even to go as far as dealing with requests for loans and requests for surrender value quotations and so forth. It seems to me that he is proposing to extract those cards required for monthly renewals each month as the occasion arises and so my question to him is, “Are you proposing to run the whole file through your computer only once per year on the occasion of the valuation or are you proposing to use some system of extracting information periodically by means of summary cards?”

I was going to go on, sir, to ask a much less serious question, but I think the Professor has dealt with it already this evening. I was much struck when I had the privilege of visiting Professor Engelfriet’s Company in The Hague last Easter with the type of form he was using—his proposal form, and his policy form and these other questionnaires which seem to be required in Holland. The layout of these forms was such that I felt the public might well think the Company to be, if not mad, at least a little peculiar in its approach.

Professor Engelfriet.—I think I agree with Mr. Morrison in this respect that one of the best advantages of the computer in my opinion is the ability of the computer to deal with any code using the binary scale. I would not know how to create such a system in any other way. I would like to come back, for a moment, to a remark that Mr. Springbett made. It is not at all impossible when you have a compact code to interpret the cards with an interpreter connected to the computer so that you may have along the top of the cards always the information in visible form—which may prevent errors. Now Mr. Morrison has asked me whether we intend to pass the whole file only once a year through the computer for valuation work and whether it would not be better to do that also at other times, when for instance we have to produce the punched cards for the renewal work. It is indeed the case that we have not decided on that yet, but we feel we should pass the whole file through the computer once a month, not only in order to produce the renewal cards (punched in the normal code), but also in order to use them for printing notices and so on, or to produce debit cards (or something like that), or to prepare the expected alterations of the next month. That is the best we can do and for that purpose we need the whole file. When using the cards only for renewal purposes, we could arrange them according to the method of premium collection in policy number order—or we could arrange them preferably in order of the month in which a premium falls due and the frequency of
a premium. We have 22 different groups of months and frequency of premiums and we could file the cards according to those 22 groups and simply select for a certain month, when feeding through the computer, the cards for which premiums will fall due—we will probably not do that because we can use the same cards for preparing the expected alterations for the next month. We do not need to feed the whole file through the computer for valuation work. We calculate all the valuation results (besides the Altenburger constants which are only intermediary results) at three fixed dates, say 1st January 1955, 1960 and 1965 for each insurance. That does not make so much work and already with the small computer it is done daily—involving a daily processing of the transactions, and when we have the figures for these three interpolation dates we can build up totals for the whole stock—so enabling us to calculate at any moment the premium reserve for the whole business, thus avoiding the necessity of passing the whole file through the computer. We do that it is only done as a check; we can make that check at any moment we like—we do not need to do it at the end of the year. The formula employed is Newton’s Interpolation Formula but it may be expressed in the following way. For each policy the premium reserve is calculated by the formula

\[ A + Bt + Ct^2, \]

where \( t \) is the time elapsed since a fixed date so that we can keep up-to-date the totals of \( A, B \) and \( C \). Knowing \( 2A, 2B \) and \( 2C \), the total premium reserve can always be calculated from the formula

\[ 2A + \ell_2B + \ell_2^2C. \]

So just as other totals are kept up-to-date in the daily work, so also we can calculate at any moment the total reserves, and that is what we are actually doing. So at the end of the year for the ordinary branch, as soon as the last transaction has been processed—generally a few days after the 1st of January—we have practically at that same moment the valuation reserves. We also make the surplus analysis by way of that formula—and we can do that analysis monthly. You can easily see that, for instance, you can calculate the saving part of a premium per annum by using the formula

\[ (vV_{t+1} - V_t) \]

and by the well-known equality, net premium = saving part of premium plus the death strain, you can indirectly calculate the death strain, i.e.

\[ P = vQ(S - V_{t+1}) + (vV_{t+1} - V_t). \]

You can also calculate the total death strain monthly if you like by using the constants referred to for the whole business. We calculate daily for each transaction the valuation reserve of the policy involved, e.g. the valuation reserve before exit, or on conversion or alteration of a policy the reserve before and after the change; we can thus build up the records for surplus analysis in such a way that they provide internal controls in order to avoid errors. We use the complete run only occasionally so as to check that the totals arrived at after deductions and additions will be the same.

Mr. G. C. Philip.—When the meeting started I had a large number of questions ready to ask Professor Engelfriet, but I found as the meeting progressed that he was answering all the questions and resolving all my doubts. It just remains to ask him perhaps one question about renewals,
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in particular as regards premium accounting. You mentioned I think, sir, that various external organisations were willing to assist by preparing punched cards for premiums paid. I was wondering whether you could amplify that by telling us just how your premiums are collected, whether they are payable direct or through agencies or through banks and perhaps a little more about how you propose in the future to account for premiums paid or unpaid.

Professor Engelfriet.—I understand you wish me to give some idea of our methods of collection and accounting of premiums and the way we produce debit punched cards and so on. I have noted from your Faculty papers that you have methods in Scotland which may be partly centralised and partly through your Branch Offices. I will begin by saying that we used to have a system of collecting premiums through Branch Offices, but we no longer do so. We have several mediums; we have collecting agents and collecting banks (not Bankers' Orders). We send receipts in punched card form to a Bank and they send these receipts to their own Branch Offices—they have about 200 small offices throughout the country—and these Branch Offices send out their collecting men (not only collecting for us!)—collectors you might call them—to the addresses of the various policyholders. The receipts in the form of punched cards carry a pre-printed text of the receipt produced by aid of the tabulator and contain the name and address and the amount of premium as well as (punched by us) the code number of the Branch Office of the Bank. The receipts are issued in policy number order and sorted at the Head Office of the Bank according to their Branch Office to which they are then despatched for collection. We also send the Bank duplicates of the punched cards used to produce these receipts and the Bank uses the duplicates to control the Branch collections. At the end of each month the Bank returns to us the receipts of unpaid premiums and the due cards of those receipts, and by aid of these cards we simply make the postings in our accounts, listing them where necessary. That is one system.

There is another system which we call the remittance system. Under this, policyholders simply remit the premiums through their postal accounts system which everyone can have in the Netherlands. The office looking after these accounts is part of the general post and telegraph service system. These policyholders do not wish to give a general regular transfer authorisation every month or three months; they complete a transfer form themselves each time. We prepare the transfer forms for these people by aid of the tabulator using the renewal punched cards and issue them some time before the due dates—the policyholders concerned simply affix their signature and send the transfer forms to the postal office. The postal office transfers the amount authorised and sends us lists of such amounts paid by policyholders along with the number of the policy and the name. In addition to preparing the transfer forms, we can by the use of the paid lists and the duplicate punched cards similarly prepared and separately filed separate the paid and the unpaid and record the latter separately (including interest to be added) on the transfer form of the next month.

The third system employed involves a general authorisation to the central postal office. In this case we produce transfer forms for the central office direct and they also send us lists of transfers in that way—these policyholders cover about 20% of our business. The central postal office is now starting a mechanised system by which they will send us punched cards (instead of lists) so that we can ourselves process the premiums paid
direct by using the punched cards. We can, for instance, collate them with our own duplicate cards and so avoid selection by hand. In this case, in future we shall not produce transfer forms in visual form but we shall produce ourselves the punched cards for the central office where they will be processed automatically and in due course returned to us.

**Mr. G. W. E. Allaway.**—There are two points of interest on which I would like to raise questions. First of all, is the actual setting up of the information on the cards in binary form in the first place? In your paper you say that the details for alteration will come through on, perhaps, a letter or form, and can conveniently be typed on to a preparation form at the same time producing punched paper tape. But that will not necessarily apply, sir, will it, to your proposal form for a new policy or to the setting up of your original consolidated file? If information is punched straight into binary form, do you have to process or interpret the information on your proposal so that the punch operator can put it in binary form on the card, and does the processing involve a lot of work?

One more short question if I may put it. I think our own experience with machinery is that perhaps the first question our Board of Directors ask if we suggest a machine is—"Who else has got it? How does it work, what faults are there and does it live up to specification?"

Your remarks about producing a machine which is more or less a prototype, particularly on the printing side, make me wonder how sure you can be in advance that the machine, when you have it, and the printer with your pre-prepared phrases will live up to its specification. Are you quite content on that point?

**Professor Engelfriet.**—It is impossible to introduce all data in the code in which the data will be filed. From the application forms we punch preliminary cards and feed them into the computer to have them transformed from one code into the other. We are not afraid of this conversion; at the moment we convert all data on the cards into the binary system—that is the system on which internal calculations are made. We have conversion programmes all ready and set up for that purpose; any user for the new computer will receive programmes to enable him to carry out the transformation—he could not work otherwise—the transformation programmes have been prepared by our staff. Even in the small computer we carried out transformations from the preliminary cards in order to produce renewal cards, etc. For example, we transform the code of the method of payment of premiums into the code required for renewal work. The reason why we are planning (for it has not yet been fully decided) to have the preparation form typed for all alterations and queries, etc., and for having punched tape produced immediately, is so that we can employ for that type of work a code which is not the defined code but one which will require less conversion than when we use decimally coded cards. For in a tape you can have already a semi-binary code because you use hexads, for instance, which are all combinations of six binary positions; the part of the code which is built up of hexads need not, therefore, be transformed again. That answers the first question.

The second question is the reliability of the equipment. We are the producers of the computers—I hope you will understand that I am not trying to sell any computer at the moment. But we have had the prototype of the X1 computer for more than a year in our Office. We did not
start doing any actual data-processing until about say three months ago, for we had a number of teething troubles to overcome. We had the same thing with the Gamma machine, of which we were one of the first users. In the meantime we did a number of jobs in the old way as well as in the new way until we were absolutely sure that everything was working correctly. We have also built in to the programmes a number of controls; for the past three months the results have been very satisfactory. We still await the Printer. The Printer employs quite a large system of lenses and other apparatus for projecting the characters correctly on to the microfilm and selecting the diapositives and projecting them also correctly. It has been developed by a Dutch institute doing mostly that type of optical research work; the necessary part will be delivered in a few weeks. There will then be experiments with the simpler electronic part of it to check that the mechanical and the optical part will work well together; then and only then will we start connecting the whole thing to the X1 and thereafter much experimenting will be required. We feel that as the difficulties of connecting punched-card machines to the computer have already been overcome, the experimenting period will be short. If there is delay, we would proceed with the new system in another way; we would use an interpreter to print the information from the punched cards by line printing on pre-printed cards—unfortunately we would not then be able to print the forms in random order. We would have to produce first punched cards with the text recorded; thereafter we would sort the cards according to the type of form to be used for recording and then print them; that will be the first stage and it will start as soon as possible; but I should say that the preparation of the programmes will take another year although we have been working on the new system for more than a year.

Mr. A. C. Baker.—Professor Engelfriet first built his systems on the small computer. He has now progressed on to a high-speed computer although without magnetic tapes; he has indeed developed this punched-card computer to what, I think we will all agree, is the ultimate stage within the Company. He has now in front of him a third choice, which is magnetic tape. Opinion in this country in the larger offices seems to be that high-speed magnetic tapes on a daily processing cycle offer the optimum advantages and I should be interested in the Professor’s views as to how best the small company can obtain the economies which the larger companies feel lie with magnetic tape. If we relate the magnetic tapes situation to a Company with 100,000 policies it is apparent that modern machines on offer can process the said 100,000 policies in half an hour and can store the whole data on two reels of magnetic tape; cost, however, would appear to be a disadvantage. With the small punched-card computer the Professor was able to do a small amount of work, with his next sized computer to justify the cost he has had to do some extremely complicated and detailed programming to make full use of the computer. I should like to know roughly how much this programming has cost because I feel it must have been very expensive. If he were offered the choice of moving on to a high-speed even more expensive machine, would he be prepared to economise, shall we say on programming, in order to justify the increased expenditure?

Professor Engelfriet.—I will start with the cost of programming the small computer. Originally we had only one programmer—the author of
the paper—but only for a very short time. In 1954 I selected one of my male staff a year before we got the computer—for this man it was a full day's job. For me it was just for fun! During the year before we got the computer we prepared the first programme—the valuation programme. In the meantime one more man was trained, so that in 1955 we had two programmers. We then extended to 6 programmers in 1956, 1957 and 1958—you might say 18 man years of programming. The total cost of programming at an average of say £1,200—£1,500 per programmer would be about £24,000. The small computer cost about the same amount. It is difficult to judge whether the resulting saving in costs came from the computer alone or from the introduction of the punched-card system generally. We can say that the cost of punched-card machines, the small computer and a large number of control panels was about £90,000 in all, and with £24,000 for the programmers, the total would be about £115,000. The total of employees in all departments affected by automation was 181 and the net reduction in staff about 70 employees. The large reduction of staff in those departments was offset by an increase of about 25 in technical department; we had, however, an increase between 1954 and now of about 10% in the number of new policies per annum—in sums assured it was 50%; and an increase of about 30% in the number of policies in force. If we had gone on with the old system, there would have been practically no programming left to do—one programmer would more than suffice; so I think the results have been not too bad. We might, therefore, say that, taking into account the increased work, we have saved about 50 employees. For employees on the average the average salary may be about £800 and that makes a totalling saving of £40,000 a year for 6 or 7 years—quite a satisfactory result.

Now the method of use of a computer in a small office will usually for various reasons be quite different from the way employed in a big office. At the start I mentioned the difference between the American approach and the methods used in Scotland and in Holland. For a very big company, the Dutch method may differ from the British method. The small company owning its own computer has to try to build up, as far as possible, an integrated system. In my view, however, the big attraction in using a computer is not so much in speeding up the mass of work to be done but just in integrating the whole system. Some persons consider that all costs apart from the cost of the programming are covered, but so far as we are concerned, I think that all costs including the costs of programming have been covered. The sooner you start the process of automation in the history of a policy the better are you able to save the endless copying of data. For me (and I think also for Mr. Baker after reading his paper) it is difficult to conceive a system in which you are doing only part of the work; it is necessary to examine and analyse the whole daily work of the whole office and to analyse and consider against that background the possible use of magnetic tape instead of punched cards. I think that we shall perhaps buy magnetic tape equipment also, but at the moment I am not convinced that it will be of much use to us. It is true that you can process all the daily work with a stock of 100,000 policies perhaps in half an hour—or perhaps an hour. I base that estimate on a speed of 30,000 hexads a second, but we must not forget the stopping times for inserting new tape and for processing. With the integrated system which we are trying to build up, involving the composition of letters from standard sentences, much data will have to be produced with the high speed printer; I think it will take an hour, but no one can tell exactly beforehand. Prac-
tical times are not usually quite so short as theoretical times. We are
doing the job of completing a transaction daily in our existing system
on a small computer in 1½ hours.

When I calculated the costs of using magnetic-tape equipment I came
to the conclusion that the additional costs as far as regards the ordinary
branch would be met when you could save 4 employees—but I do not see
at the moment how we could save 4 employees. I asked the head of our
Mechanical Department the times needed for selecting and re-filing cards
in connection with the payment of premiums and he considered that we
could do this with 1 employee a day on the average—some days you need
a few more—some days you do not need any. I think that answers
Mr. Baker's question.

It is planned to reserve on the punched cards a few columns and to
punch a hole in one column when a premium is paid, and in another
column when the premium has not been paid—or something like that—it
has not been fully worked out. I do not anticipate any difficulty even if
you have to select by hand every day the cards of paid premiums. With
only 1,000 cards to be selected and filed each day, I do not see how we
can reduce the cost of the operation by use of magnetic tape. If you have
magnetic tape and the lists of paid premiums (in the case of premiums
paid direct to the central postal offices), you have to prepare punched
cards to be fed into the computer for updating the tape. We can save
the labour of preparing punched cards if we do not use magnetic tape and
that is always a question of one or more employees.

For larger businesses or where there is a large number of changes the
position may be different. For example, for other types of institution
such as central post offices, where you have millions of accounts, and at
least 20% of them altered every day, then it becomes quite another
problem. Different types of companies may require different approaches.

The President.—Thank you very much, Professor. Well, Gentlemen,
we must not make this into an endurance test for Professor Engelfriet.
Like me, I am sure you admire the way in which he has virtually been on
his feet for two solid hours. Just before we close I should like if Mr. Ross,
as Convener of the Faculty Electronics Study Groups, would put in a
special word of thanks to the Professor for coming over.

Mr. A. F. Ross.—Well, Mr. President, sir, we have had a most inter-
esting evening. I had not expected to propose a vote of thanks to the
Professor but it is a great pleasure indeed to me to do so. The Professor
has given a rather unique performance as you pointed out, sir. We
usually have a writer of a paper who in a few words outlines the scope of
his paper. The Professor has given us a most stimulating lecture as well
as a most stimulating paper. I think by any standards we must just say
it is a magnificent performance. Professor, on behalf of all the people
here and on behalf of all the people who will read your paper our sincere
thanks to you for all the trouble you have taken on our behalf.

The President.—I am sure you will realise, Professor Engelfriet, from
the way in which Mr. Ross's motion was received how very grateful we
all feel to you, and I can only say again that we have appreciated the way
in which you have come over and spoken to us. You have got off rather
lightly on account of this marathon exhibition you have given. Most
people who give papers have questions put to them. They answer some on the spot, but they have to go home and write answers to the rest. So although you have spent a lot of time answering questions put to you here, I think that you will probably be able to leave Edinburgh with a clean sheet and feel that you have no "home work" to do after you have gone.

Once more, Gentlemen, I would ask you formally to give a very hearty vote of thanks to Professor Engelfriet.

Professor Engelfriet.—It has been very kind of you to study my paper and to put forward such interesting questions. I hope that I have answered your questions fully. Remembering the pleasant days of the Centenary of the Faculty in 1956, I had looked forward to taking part in an ordinary Sessional Meeting. Thank you very, very much.