Again, caution should be exercised in determining the numbers of commands necessary to perform these operations so that a generalization of the procedure will not entail too extensive housekeeping.

The first of these logical problems may be solved by a number of different approaches. However, the second problem, the interpretation of the keyword for unpacking, requires an instruction which examines the word digit by digit and controls the storing of the significant components in their proper position in the vector, suggesting a type of conditional jump command. The zero suppression multiply may be accomplished by forming the logical product of the keywords of two vectors, forming a new keyword which would control the multiply sequence exactly as the unpacking procedure. To illustrate the advantage of this operation, let it be supposed there is the vector,

\[ y = (2, 1, 0, 4, 0, 0) \]  

with the binary keyword,

\[ 110100 \]  

and suppose forming the scalar product of \( y \) and the vector \( x \) given by equation (1) is desired. This would be accomplished by forming the logical product of the keywords (2) and (5)

\[
\begin{align*}
(2) & \quad 101001 \\
(5) & \quad 110100 \\
\end{align*}
\]

indicating that the only corresponding significant components of the two vectors are the first, and the scalar product would then involve only a single multiplication rather than six multiplications and five additions.

It is estimated that a computer designed with all of the aforementioned qualities would reduce the running time of present procedures by as much as a factor of ten. Since most of the requirements of this problem are compatible with many other types of problems, and furthermore, since many of these features may be found on existing machines, such as the Univac Scientific, it is the contention in this paper that all of these requirements should be fully investigated so that they may be incorporated in the future machines of this industry.

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**Considerations in Making a Data-Gathering System Compatible**

**B. L. WADDELL**

The paper discusses the design problems facing the data systems engineers who are required to produce a data-collection system that will be able to enter a computer easily. Some empirical formulas are presented with a discussion of how to use these formulas.

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The many recording tools and their application to data systems which are being prepared for entry into computers are described with a discussion of the place of each recording device. The section of the paper is a critical analysis of four data recording or gathering systems designed to go directly to a digital computer.

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**Using a Variable-Word-Length Computer for Scientific Calculation**

**FRED GRUENBERGER**

In discussing the use of a variable-word-length computer, this paper will be restricted entirely to past history; that is, ideas and practices that are actually in operation. This implies, of course, that only the 701 will be talked about and the implied comparison to fixed-word-length machines is to a machine like the 701.

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At Hanford, Wash., the 702 has been used for scientific computing, with what is regarded as considerable success, since its installation in June 1955. The percentage of available machine time devoted to numerical analysis has steadily increased, standing currently at about 20 per cent. This is not to say that mathematics is taking time away from commercial work, but rather reflects the increase in efficiency on commercial problems and a general increase in mathematical problems as time goes by. Scientific computing has covered a wide gamut of problems, including linear programming, numerical integration, differential equations, and many complicated formula evaluations, as well as work on reactor data and weather data which might be called scientific data processing.

This work demands one large machine to serve for both commercial and scientific problems. This is a common situation, and perhaps any machine would suffice; it has been pointed out that through an automatic programming system, any machine can be made to appear like any other. Indeed, most programming is done with reference to the automatic programming system rather than the particular machine. The main contention here is that a variable-word-length
machine makes the over-all job easier and, in particular, it is felt that the variable-word-length machine offers some distinct advantages for scientific computing.

First, since the word length is arbitrary, floating decimal or fixed decimal calculations can be carried to any degree of precision with equal efficiency and equal ease of programming. At present, the floating routines use a 10-digit mantissa with a 2-digit exponent, which is treated as a single 12-character word; the exponent has a range of 200. Should greater (or less) precision be needed, no great effort would have to be expended to alter the routines for any other word length; in fact, the word length can be made a parameter. The appearance of the machine to the programmer is the same in all cases, and programs written for one word length will function properly in all cases, both on paper and in machine code. Moreover, the variable-word-length machine makes it attractive to carry through many calculations completely in fixed point which would certainly call for floating point on a fixed-word-length machine. It is awkward to do multiple-word arithmetic on a fixed-word-length machine, but easy to do the equivalently precise work on a variable-word-length machine. A fixed-word-length machine working in its own word length is obviously at an advantage; it is when the work calls for an odd word length that the variable-word-length machine excels.

Generally speaking, for an installation doing only scientific work, it would be natural to think of a pure computer, such as the 701, 650, or Datautron. However, even in this situation, the variable-word-length machine offers an advantage, if the data to be handled are intrinsically of an odd length. In data reduction, for example, large volumes of 2- or 3-digit numbers tend to waste either memory space or machine time or both, in a fixed-word-length machine.

There is much to be gained from having two groups of people working around one machine within one organization. The diverse backgrounds and experience of commercial and scientific people blend into a powerful team when the common problem, outwitting a machine, is approached. Programming insights and triumphs of either group become helpful to the other. For example, the floating point arithmetic subroutines, developed for the numerical analysts, have been used on commercial problems, where a given variable, such as stock quantity, may have low precision but a wide range. Similarly, a routine of particular value to the commercial people for producing tabular reports has proved to be just the thing for processing meteorological data and preparing tabular reports. A generalized sorting routine has become widely used by both groups, since internal sorting is common to all sorts of problems. Characteristically, commercial people have a background which is strong on procedures and flow-charting; mathematicians have an ingrained love of precise definition and compact symbolism. The two groups thus tend to complement each other.

It seems to be intrinsic to a data-processing machine like the 702 that it become surrounded by a greater quantity of more flexible peripheral equipment than does a pure scientific machine. This is no drawback to doing scientific computing on such a machine. For example, there was an initial feeling at Hanford that problems from the numerical analysis unit involving only a small amount of the peripheral equipment could be sandwiched in between commercial problems which tend to use every gadget available. This has not come about. The mathematical programmers have used the devices available to the fullest, with a corresponding speed and efficiency increase.

It is reasonable to assume that, regardless of the nominal capacity of main memory for a given machine, one pays for memory in direct proportion to the number of characters one can store at one time. Here the variable-word-length machine pays off again; it is parsimonious with main memory and tape memory, and hence of tape-read time. Main memory is always packed solid, regardless of the amount of the peripheral equipment. This is evidenced in both scientific- and commercial-type problems in two ways: (1) The simple structure of the machine makes it possible to define an abstract or "automatic coding" system without rather than from within. That is, the machine is sufficiently simple and yet sufficiently flexible so that any automatic coding technique or philosophy can be described from the point of view of the problems to be solved and the demands for particular manipulations inherent in those problems, rather than starting from a set of machine restrictions and doing the best one can or going to great length to overcome inherent difficulties. (2) The machine is extremely easy to code in its own language, if necessary (indeed, where the number of different jobs is small, this is the only method used at some installations). This feature gives one tremendous power in two operationally vital areas. First, in processing a job, when machine failure, operator error in judgement or accident, or erroneous or unanticipated data cause one to "fall flat on his face," it is not necessary to
Unusual Problems and Their Solutions by Digital Computer Techniques

L. ROSENFELD

Ten years ago the primary role of an electronic computer was to develop mathematical tables and to solve the scientific problems which arose during the research and development work being done at that time for the military and other government agencies. Since then, and particularly of late, the emergence of business and industrial corporations in assisting them to carry out their normal business operations has been witnessed. These would include such standard operations as payroll accounting, inventory control, production scheduling, invoicing, billing, and cost accounting.

It is natural that company management should now seek other fruitful areas where the computer might be utilized for profitable advantage. By and large, with the possible exception of those companies which are large enough to afford to have on their staff a group similar to an operations research group, the places where management will seek additional

areas of work for its computing facility will be chiefly limited to those areas which are normally under the cognizance of the comptroller or finance officer. Usually, management will not think in terms of using the computer as a device which could possibly aid in improving a company system or subsystem which is part of the way by which part or all of the business of the company is carried out. For example, management of a large trucking company probably would not use the computer to help determine the most economical time to replace worn-out vehicles though it might use it to bill its customers; similarly an automobile manufacturer probably would not use the computer to predict what his spare parts inventory should be for the next 10 or 20 years although he would use it to maintain his inventory.

This paper is essentially a brief description of three case histories of what would generally be defined as operations research improvements in the next automatic programming system.

The dual-purpose installation has only one serious drawback, which comes about from the diametrically opposite nature of the work of the two groups when they are sharing one machine. By and large, commercial problems tend toward the routine, "chiseled-in-granite," repeating problems; numerical analysis problems tend to be on-demand one-time (or few-time) affairs. This can lead to questions of priority; fortunately for this thesis, there are questions of priority with any kind or kinds of work on any type of machine.

On the whole, however, it is felt that the advantages far outweigh these somewhat tenuous disadvantages. Attention should be focused on the possibility of adding numerical analysis work to a commercial installation and/or the attractiveness of a dual-purpose installation. In any installation involving commercial problems, the record-keeping (which is the essence of present-day commercial work) gets done; there may then be an opportunity to work on commercial problem solving. When that situation evolves, it may be quite a help to have a scientific group at hand. Under a common leader, the two groups become compatible and ideas cross-fertilize each other.