INFORMATION PROCESS ANALYSIS

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INFORMATION Process Analysis is a new charting technique developed by the General Electric Company to aid the introduction of electronic data processing systems in the office. Actually, it has applications considerably beyond this original purpose. However, the present discussion will deal primarily with its application to electronic data processing.

The introduction of electronic data processing equipment is forcing a greater awareness of the *systems* aspect of information processing than has, say the introduction of punched card techniques. Because of their speed, cost, and capabilities, these EDP systems are causing management to cut across existing functional lines in the development of new procedures. This is true not only of the different areas within the office but it is becoming equally true in the integration of office and factory.

How is this systems concept different from what has been done in the past? In a relatively few cases, procedural work has had a true systems approach. However, in the vast majority of cases, the emphasis has been on cost improvement projects designed to do a certain part of the business in a more efficient manner: for example, better methods for drilling a hole or for preparing factory paperwork: substituting a less expensive part which will perform the same function as the previous part, and so on. Most of these projects do not consider (or consider only briefly) the *inter-relationships* between the various activities of the business. The "bricks" are analyzed in great detail but the composition of the "mortar" is too often ignored.

There always seem to be numerous valid reasons for *not* studying these interrelationships. First, they are more difficult to analyze than are the activities themselves, and require a broader knowledge of the total business. The system interrelationships cut across existing functional and sub-functional lines so that no one is quite sure to whom they belong. Finally, their study takes longer and does not have the glory of an immediate reward.

Even in the face of these arguments, however, experience has shown that the "bits and pieces" approach by itself cannot produce the gains which can be realized from a study of the business as a whole—a systems study. Also, the advantages of electronic data processing lie, to a great extent, in tying together logically related activities. Maximum system speed and accuracy result from integration along lines of information flow, rather than within individual functions.

In a systems study, care must be taken to make the analysis much more comprehensive than the usual "procedures" analysis. Improving a particular process or activity is not the primary goal, but rather examining the necessity for having the process at all. This approach is not hardware-oriented; it is an effort to find out *why* things are done at all and then, after constructing a logical pattern for operating the process, to determine the real equipment needs.

The Information Process Analysis technique to be described was designed to meet the needs of such a systems study.

THE SYSTEMS APPROACH

In beginning an EDP systems study, we are more interested in *what* is going on in the business rather than in *how* it is being performed or *who* is performing it. For example, there are certain types of information which, though of interest in a conventional procedures study, are *not* of interest in a systems study:

1. We are not interested in the manual procedures that are used per se—e.g., how many clerks and typists work on a form during its preparation, or points along its route where the form is stored temporarily.
2. We are not interested in the fact that several people are involved in an operation, each doing part of the over-all job.
3. We are not interested in the layout of the clerical work area or the types of office equipment used.
4. We are not interested in the "exceptions" which arise due to internal clerical errors; however, we are interested in the types of information errors transmitted into the organization from outside over which the organization has no control.

Instead, since we are interested in learning *what* the mechanized system must be able to handle, we *are* interested in the following types of information:

1. The logically necessary alternative procedures which are needed in the business for handling main line flows as well as so-called "exception" cases.
2. The management control reports that are developed by the organization, and the purposes they serve.
3. The reports and other pieces of information that must be

transmitted outside of the organization, for legal or other reasons.

4. At first, a preliminary pin-pointing of all complex computation operations and decision areas. Later, we will need a more detailed understanding of these operations.

Conventional charting techniques usually involve symbols representing such clerical activities as transport, store, delay, inspect, and a general symbol representing all operations. These conventional techniques have been aimed at, and these symbols are useful for, one of two main objectives: a. to find out where human clerical time is being spent, so as to shorten the over-all process time, or reduce the man-hours to do a job, or b. to lay out a prescribed sequence of operations for a reasonably complex job, for the guidance of the clerks and operators—e.g., flow charts of punched card operations. Since our primary interest in a systems study is not in either of these objectives, it is not surprising that their associated charting techniques prove relatively ineffective in a systems study.

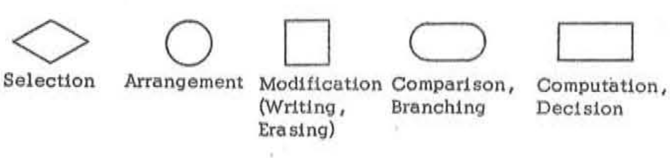
Instead, we are interested in learning of the flow of information throughout the business, for directing manufacturing and other activities, and for feedback and control. *All* uses of the information must be accounted for, so we soon find the scope of the systems study spreading throughout the entire organization. The Information Process Analysis technique designed to meet this objective is based on: a. reasonably precise definitions of basic data processing operations, represented in the form of symbols, and b. a charting procedure to make sure that the necessary descriptive information accompanies each symbol.

In other words, conventional charting techniques treat information systems as though they were material handling systems, where the material is paper. Since this new technique deals with the information itself, not the paper, we are able to concentrate on the different data processing operations.

INFORMATION PROCESS CHARTING TECHNIQUE

Fundamentally, there are only seven symbols used, five of them representing operations (where someone does something), and two representing conjunctive, or connective devices. These basic symbols are shown below:

OPERATIONS

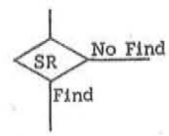


CONNECTIONS

In practice, there are variations for some of these symbols, so that a total of 11 different terms are used. Each of these 11 terms and symbols is described briefly.

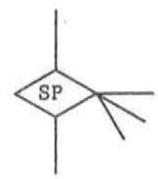
The Charting Symbols

1. Select, Search (SR)



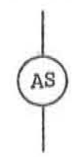
Search means to extract a particular record from a file of similar records which are sequenced by the field on which the search is being conducted. Illustration: Search the Planning File for the Planning Card covering part number 374255-1.

2. Select, Separate (SP)



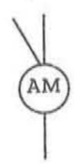
Separate means to select one or more records from a group or file, according to a key field. Sequencing by the key is not necessary. Illustration: Separate the copies of the Purchase Order by destination.

3. Arrange, Sequence (AS)



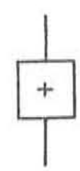
Sequence means to arrange (sort) a group of records into ascending or descending order according to a key field. Illustration: Sequence time cards by employee pay number.

4. Arrange, Merge (AM)



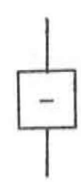
Merge means to combine two or more groups of records which are already in sequence by one or more key fields into a single sequence on the same keys, or to place a record in a file. Illustrations: Merge new Parts Lists with the Parts Lists File by Parts List number; merge the employee time cards with the employee job cards by employee pay number.

5. Modify, Insert (+)



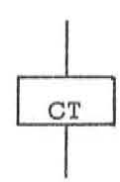
Insert means to create a new record or to add one or more fields of information to an existing record. Illustrations: Prepare a new Purchase Order; sign a Freight Bill.

6. Modify, Delete (—)



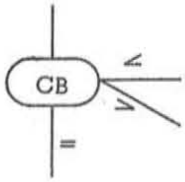
Delete means to remove one or more fields of information from an existing record. Illustration: Delete a terminated employee's pay number from the active employee ledger.

7. Compute (CT)



Compute refers to an arithmetic formula incorporating basic arithmetic operations: Add, subtract, multiply, divide, exponentiation, trigonometric functions, etc. It does not contain any comparison or choice operations. If the result of a computation is used in a comparison, this should be indicated separately. Illustrations: Total week-

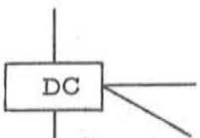
8. Compare and Branch (CB)



ly pay equals hourly rate times number of hours worked; stock on hand at end of period equals initial stock plus receipts minus disbursements.

Compare and Branch is the basic choice operation which involves a defined or fully prescribed decision. Illustrations: If the product model number is incomplete, then pass the order to Engineering; if an employee's accumulated salary year-to-date is greater than $4200, do not deduct social security.

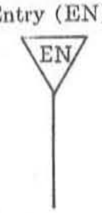
9. Decision-Making (DC)



alternate courses of action

Decision-Making is a higher level than Compare and Branch. It is used when a choice is not based on a clear cut set of rules; in other words, judgment is involved in a decision-making process. It is possible in a decision-making operation to indicate what factors are considered and often even the relative importance of these factors. To the extent that exact "weights" can be determined and all alternate paths noted the operation reduces to a series of Compare and Branch operations. Illustrations: Determine the quantity of Model XYZ that will be sold within the next 12 month period; decide whether a job applicant is suitable for a particular task.

10. Connection, Entry (EN)



An *Entry* serves to start a routine or to bring additional information into it. It may come from another part of the same chart or from a different activity entirely. Illustrations: The customer order entering the order service routine; a pay voucher coming to Cost Accounting from Payroll.

11. Connection, Exit (EX)

An *Exit* is the means by which an activity is terminated. It may go to another part of the same chart, it may go to another activity, or it may be the end of the routine. Illustrations: All requisitions requiring special engineering review go to Engineering; a pay check is given to an employee for his previous week's work.

The foregoing descriptions are necessarily brief; more complete definitions for each operation symbol may be obtained from (1). A summary of their use on the charting form is shown in Figure 1.

EXAMPLES OF PROCESS CHARTS

To give an idea of the technique in action, we have included two examples, one trivial and one from an actual systems study. Figure 2 indicates some of the "data processing" operations which might be followed by a young man in search of a date.

The steps on the chart are relatively self-explanatory. Alphabetic entries and exits provide connections to and from other charts while numeric entries and exits refer to different parts of the same chart. Line 3 shows a routine decision step, involving a Compare and Branch operation, while Line 15 shows a difficult decision involving judgment. Line 8 shows the procedure for entering a new record into a file (merging). In general, it will be seen that the technique brings out clearly the various alternative circumstances that can arise. Also, space is provided for a brief explanation of each step in the process. Thus, charts drawn by one person may be easily read by others.

Figure 3 is a reproduction of one part of a chart on tooling activities in a manufacturing organization. The particular operation being charted is the receipt of raw material at the tool crib, where the material is destined to be made into a tool. Line 4 shows a searching for a copy of the purchase order after the material is received; the charter may or may not chart the "no find" situation depending upon how significant it is. Line 6 indicates that the tool crib attendant checks to see who the material is for; the "not equal" branch indicates that it is for someone else, and Exit 3 connects to the charting of that condition. Line 7 here refers to the fact that "someone else" to whom the material is to go wishes it to be stored temporarily in the tool crib; after it has been suitably marked in the other operation, the information again enters the main line being charted. The remaining operations

INFORMATION PROCESS CHART

Entries	Main Line Flow	Exits	Second-ary Flow		Records		Record or Field		Fields	Remarks
	AM 1				Name of Record or File	By	Key	with	Name of File	
	AS 2				Name of Records Being Sequenced	By	Key			
	+ 3			on	Record onto which data is being inserted		Field(s) being inserted	from	Record from which data is obtained	
	– 4			from	Record from which data is deleted	Delete	Field(s) being deleted			
	CT 5				Field(s) being computed	from	Field(s) supplying information	on	Records from which field(s) were obtained	Formula, if easily obtained
	DC 6				Brief name of decision					List of major factors
	CB ≠ = 7			using	Record involved	compare	Field	with	Field	
					Record	and	Record	by	Field(s)	
	SR 8				Name of file being searched	by	Key	from	Record from which key was obtained	Do not search a record for a field
	SP 9				Name Records or file being Separated	by	Key			
		8 9				(Description of Exit 8) (Description of Exit 9)				

FIG. 1

shown here indicate the steps taken to determine where to store the material in the tool crib. The original chart continues beyond line 10 for this one function, and in fact, eleven of these 18-line charts were used in charting the tooling activities.

EVALUATION AND SPECIAL PROBLEMS

The speed with which Information Process Charts can be prepared seems to bear a close relation to the speed of programming a problem for a large scale digital computer. Interviewing, charting, rechecking and summarizing result in about 2 steps per hour, although this improves with experience. Remember though that these steps are more powerful than the normal computer operation codes since each symbol may represent an entire subroutine like "Sequence," "Merge," etc.

As in any new technique there is a significant learning curve effect. As experience is developed, speed and accuracy improve considerably. It is also apparent that different types of problems require somewhat different viewpoints and charting "tricks."

In first applying the technique the procedure was described with brief examples to a group of trainees and first line supervisors and specialists. The initial charting accuracy was substantially less than expected, probably because the training techniques were at fault. It is our conclusion that the best teaching method would be a practical example (like receiving of purchased parts) performed individually by each member of the team and then discussed and analyzed as a group.

In choosing the particular format and charting arrangement much consideration was given to the location of the symbols. In contrast to the usual computer charting which uses a "large" sheet of paper and writes in each block a description of the operation, we felt that the in-line page type arrangement was more easily traced and understood by the non-charter, yet this produces its own problems in excessive numbers of sheets and a lack of "Gestalt" or total grasp.

Since grasp and insight are among the main reasons for choosing process charting in the first place, it would have been most unfortunate if they had been lost because of difficulties of paper representation. Two approaches were used to help solve this problem. First, the original process charting forms were modified to allow the parallel indication of a secondary flow beside the main line. This permits a visual continuity and apparently saves many exits and entries. The second solution was the introduction of summary charts which served to review the over-all pattern of a particular business activity. These gave a sort of index to the detail charts and helped significantly in grasping and absorbing the major implications of the activity.

It is also evident that this summary process is vital to the desired insight into the ramification of the whole business. In other words, there needs to be a hierarchy of summarization eventually leading to a "Master Diagram" of the key processes in the business.

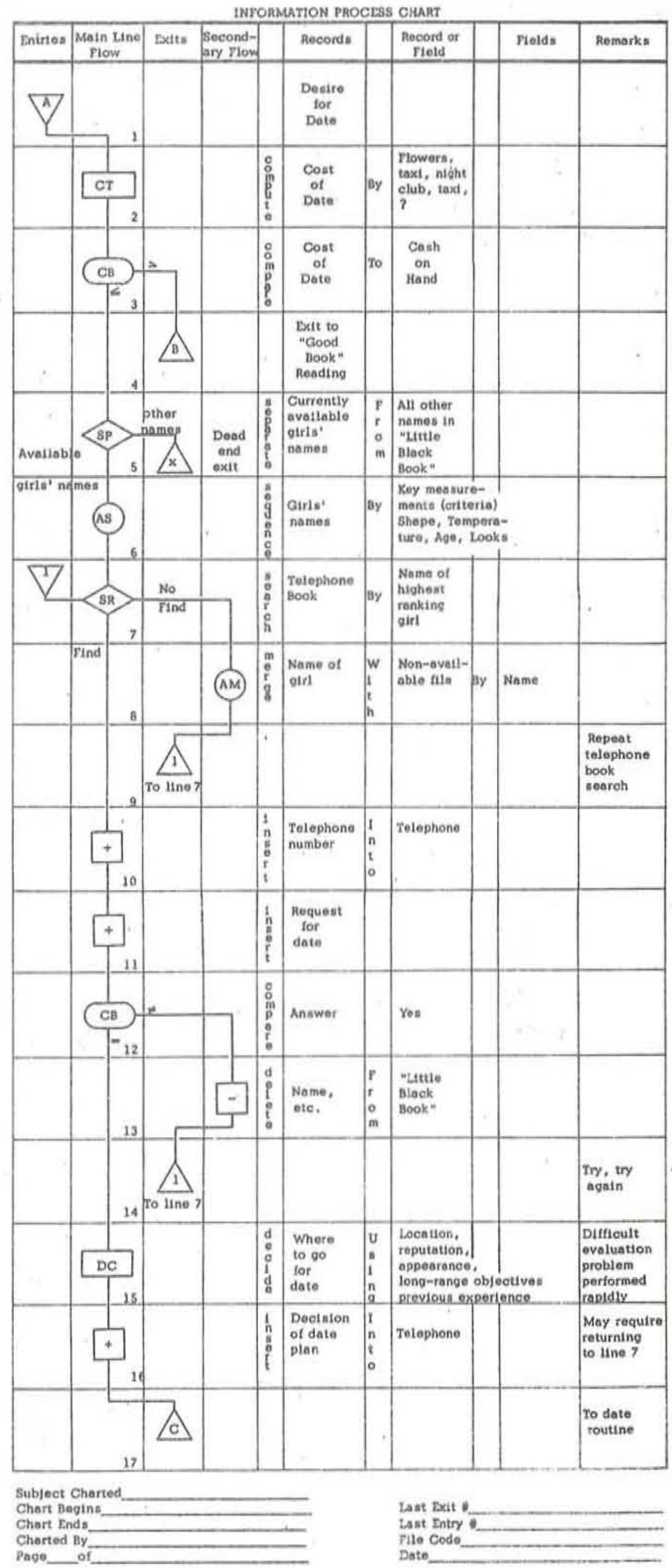


FIG. 2

To elaborate on the charting, reference is made to the column headings shown in Figures 1, 2 and 3. The mean-

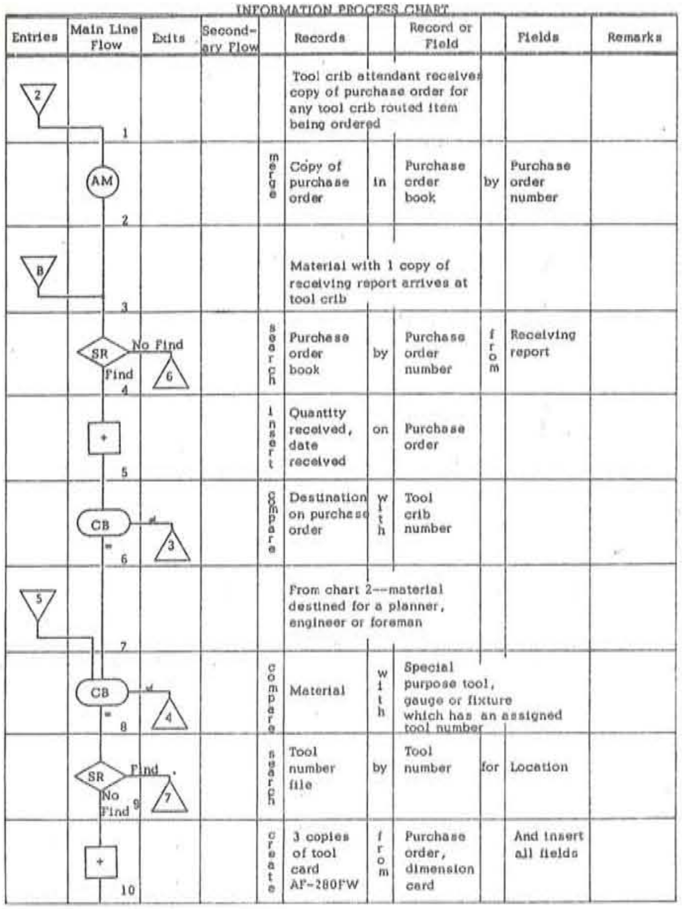


Fig. 3

ings are reasonably self explanatory. The following definitions of terms are quoted from (1):

File A collection of data, generally applying to one aspect of a business. A file consists of a group of "records" (to be defined), usually each of which contains the same type of information. The records are arranged (in most cases) in a specific logical sequence. Example: personnel file, inventory file, model list file, etc. (Note that the word "file" is used as a noun, not a verb.)

Record One member of a file; a record usually contains all pertinent information on a single item. Examples: a personnel record for one employee, an inventory record for a raw material type, or an entry in a log book.

Field A sub-division of a record; one or more related characters of data referring to a single aspect of an item. Examples: date of birth of an employee, employee's name, etc.

Character A character of data may be a numerical digit (0 to 9), an alphabetic character (a to z) or a special character ($, blank, @, etc.)

Data Known facts; generally, recorded facts, as used herein. The term "data" is often used synonymously with "information" although data generally include redundancy and errors as well as information.

Information Communicated knowledge (more precise engineering definitions are available but will not be presented here). It is important to know that information can be measured in terms of "binary digits" (bits), where each bit is equivalent to one yes-no decision.

Form A printed form used in manual data processing; generally is covered by the definition of "records."

Transactions A record of an event, an action. Examples: a new customer order, a shipment to a customer, an employee clocking in at work, etc.

Key One or more fields of data within a record used for controlling the handling of the record—sequencing, merging, searching, and separating. Example: Employee name in sequencing personnel records in the personnel file.

Main Line The predominant flow of data in the specific area being charted. A sequence of operations which is a secondary branch and exit on one page of a chart will generally be the main line on another page where it is charted.

All entries will be shown in the first column, properly numbered or lettered and page numbers for pertinent reference exits shown. The next column is where the bulk of the charting will be done—the main line, or the sequence of steps being described. The exit column is similar to the entry column.

The secondary flow column has been provided to reduce the need for exiting and re-entry to handle minor variations in procedure. We believe that the use of this secondary flow column should be quite restricted. For one thing, no separate entries should be made to the secondary flow column; rather, it is limited to branches out of the main line via Compare and Branch, Search, Separate, or Decision operations. In addition, if the secondary flow involves over 6 operation symbols, an exit should be made to another page of the chart, where it is charted as a main line.

There should be only one operation symbol per line—either an entry, main line, secondary flow, or exit symbol—so that the proper notation can be made in the other columns of the chart.

The three narrow columns which have no headings are provided for inserting prepositions, conjunctions or verbs. For example, "Insert *on* Record A Field X *from* Record B."

PROCESS CHARTING—DISCUSSION

There are a few points of special interest that should be discussed briefly, about the use of the foregoing symbols.

First, the operation of "reading" is implied in all of the above symbols, and is not called out as an independent step. It is assumed that the person or machine doing the processing must first read the information from the documents.

Next, it should be re-emphasized that whenever Compute and Decision-Making operations are encountered, the analyst should not initially spend much time in detailing the routines. The process charting simply pin points these computations and decisions, and gives some understanding of what is involved. After the initial data gathering phase, many of these operations will need to be analyzed in greater detail.

Occasionally an analyst will come across a "loop" operation, where the same series of steps must be performed on a number of items, before continuing with the processing. An example of a loop might be computing the standard cost for each operation in making a part, before the standard cost of the finished part can be determined. Indicate such loops as simply as possible; e.g., "steps ——— through ——— repeated for each item on the record."

Also, in some possible loop operations (where there may be one or more items on the list), a totaling or summary is performed afterward if there were more than one item on the list. Do not try to chart this out, using conditional transfers. Simply indicate the totaling operation right after the last operation of the loop, and indicate in the Remarks column, that it is used if necessary.

Occasionally a matching operation will be encountered, such as a group of time cards being matched against a payroll file. It may be of interest to know if there are any time cards for which there are no payroll records, and if there are any payroll records for which there are no time cards, as well as matching the payroll records and time cards for computing gross pay. Such situations as this may be charted by two Search operations in sequence. In the case above, search the payroll file by the time cards' employee numbers indicating "Find" and "No Find." Then search the time card "file" by the payroll records' employee numbers indicating "Find" and "No Find."

The "and" and "or" concepts should be mentioned briefly. Sometimes two records must be brought together, so as to go through a series of processing steps; record A and record B. If record A has been charted as the main line, then record B can be brought in by connecting an "and" entry to the main line with a solid circle. See Figure 4.

Note that the "and" entry implies no merging, search-

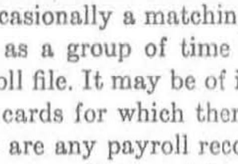


Fig. 4

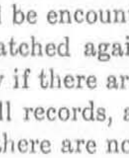


Fig. 5

ing or sequencing. There is no file; only individual records are involved. Two or more records may be brought together, so as to form a larger record. If record A is being chartered as the main line and B is located in a file, then B should first be obtained by a Search operation.

For the "or" situation, record A *or* record B (but not both together) can go through the same sequence of steps. If the two types of records are similar or are logically related, it is often desirable to show this by an "or" entry and a second input line to an operation box, such as Figure 5. Then, at the end of the common sequence of steps, a Separate operation may be used to split the two types of documents apart. (A Compare and Branch operation is more correct logically, but the Separate operation is often easier to use.)

Sometimes, however, records A and B are so dissimilar that it would be confusing to use this "or" method. When charting the processing of record B, the analyst (when he comes to the same sequence of steps as he used in charting record A) can leave a blank line on his chart and insert the note, "Use steps ——— through ——— from page ———."

FUTURE USAGE POSSIBILITIES

We have tried to look ahead and deduce the logical implications of the process analysis technique and have found that many ideas can be suggested.

One idea is concerned with the use of punched cards for analysis of individual operations and the preparation of summaries. For example, by defining the records and fields carefully we could use one punched card for each line on the process chart. This is similar to work reported through the American Management Association by two Lehigh professors (4). This might be a convenient procedure for reducing the clerical content required to draw the flow charts.

Another possibility would be the evolution and development of higher level symbols to represent recurrent data processing elements. Examples of this might include edit, translate, and verify. These should be particularly meaningful for summary charting and would also indicate computer sub-routines which should prove useful.

While much of our present charting seems record oriented, this is merely a space reduction convenience. The record stands for or represents the fields it contains. Since all operations are performed on the fields themselves, it might be possible, with appropriate identification and coding techniques, to define all functions in terms of the fields instead of the records. This would be advantageous in leading toward nonredundant systems. Reference (3) is an extremely thought provoking paper on one aspect of this subject.

Since Information Process Analysis can be used to describe any data processing operation, it might be interesting to investigate the application of this language to computer programming. Because these charts are at a somewhat higher level than the charts now used, a significant saving in time and effort could result.

Another unexpected area which was uncovered was the strong similarity between physical processing and data processing systems. This is described in (2). As an analogy, we can consider that the part corresponds to record, and each hole, groove or surface is a field inserted in the record. Parts may be associated together in a "file" (stock room) which can be searched for a particular part. Compare and Branch can be used to represent inspection operations, and merge would imply parts accumulation to precede assembly. While this simile can be overdrawn, there nevertheless appears to be a sound foundation for further study with the implication that physical processing systems are directly analagous to data processing systems.

Since the process charting technique is organized around a generalized set of rigorously defined symbols, it may help to solve another common problem: the present inability to communicate solutions to various business systems problems. The Department of Defense has initiated a commendable program for the development of a Common Business Language—a computer programming system that uses English sentences which can be compiled into running programs for most machine types. But this Common Business Language will most likely be at a more detailed level than the language described in this paper, and may not be as satisfactory for communications at a systems level. It seems to us that the progress of data processing as a science requires establishing such common problem-oriented languages so that we can more successfully communicate with our fellow systems designers.

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