

C

# REPORT

## INFORMATION PROCESS CHARTING AND PHYSICAL OPERATION FLOW CHARTING

DECEMBER 31, 1959

R59MS307

MANUFACTURING SERVICES

GENERAL  ELECTRIC

NEW YORK, N. Y.





## TECHNICAL INFORMATION SERIES

Title Page

AUTHOR B. Grad RG Canning RH DeRubbo WC O'Neal	SUBJECT CLASSIFICATION  SYSTEMS ANALYSIS	NO. R59MS307 <hr/> DATE Dec. 31, 1959
<b>TITLE</b> Information Process Charting and Physical Operation Flow Charting		
<b>ABSTRACT</b> Information Process Charting is a data gathering technique developed on the Integrated Systems Project to aid in clearly stating the WHAT of present systems in a business.  Physical Operation Flow Charting is a technique derived from Information Process Charting to describe the flow of materials and products in a shop.		
G.E. CLASS 1	REPRODUCIBLE COPY FILED AT Production Control Service 570 Lexington Ave., NYC	NO. PAGES 30
<b>CONCLUSIONS</b> The information charting technique has since been used in two systems studies and seems to offer certain advantages in attempting to describe a complex business process. The physical charting concepts needs further exploration and testing. This approach seems to provide insights into the development of a more general systems charting technique which could be used for manual, punched card or computer procedures.		

INFORMATION PREPARED FOR \_\_\_\_\_

TESTS MADE BY Integrated Systems Project

AUTHOR B. Grad, R. G. Canning, R. H. DeRubbo, W. C. O'Neal

COUNTERSIGNED H. F. Dickie, Manager - Production Control Service

SECTION Materials Service LOCATION 570 Lexington Ave., New York 22, NY



GENERAL ELECTRIC COMPANY  
TECHNICAL INFORMATION SERIES  
CONTENTS PAGE

CONTENTS OF REPORT R59MS307

NO. PAGES TEXT 30

NO. CHARTS

DRAWING NOS.

PHOTO NOS.

---

DISTRIBUTION

Integrated Systems Project

T. F. Kavanagh, Materials Service

D. F. Langenwalter, Engineering Administrative Consulting  
Service

S. A. MacMullen, Cost Accounting Service

H. W. Nidenberg, Advanced Equipment Development Service

T. E. Schultz, Manufacturing Operations and Quality  
Control Service

Internal Automation Operation

John Ryan (5)

Technical Distribution (50)



INFORMATION PROCESS CHARTING

Burton Grad  
Manufacturing Services  
General Electric Company

Richard G. Canning  
Consultant  
Vista, California

Ralph H. DeRubbo  
Specialty Motor Department  
General Electric Company

March 15, 1957

Manufacturing Services  
General Electric Company  
570 Lexington Avenue  
New York 22, New York





## INTRODUCTION

The information process charting which is discussed in this write-up is aimed at helping to analyze the so-called "office automation" aspect of the project. It is a technique to be used during the data gathering phase of the project, when we are trying to find out as much about the present business as time will allow. It should be emphasized, however, that this process charting technique is only part of the overall data gathering phase. In addition to this charting, we must also obtain a considerable amount of statistical data about such things as the flow of information and the size of the files. Similar types of studies must be made of the factory operations, too.

The sequence of presentation in this Information Process Charting write-up will be:

- I Description of the charting symbols used, together with a brief discussion of some of the less obvious points.
- II Description of the charting form used.
- III Discussion of the overall charting technique.
- IV Definitions of terms, to aid in understanding the discussion.

## I. PROCESS CHARTING - GENERAL

We are interested in learning what the mechanized system must be able to handle. For the "office automation" aspect of the Project, then, we are interested in the following types of information:

1. The logically necessary alternative procedures which are needed in the business, for handling the main flow as well as the so-called "exception" cases.
2. The management control reports that are developed by the organization, and method of use.
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.

Conversely, there are certain types of information in which we are not interested:

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 overall 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 errors in information transmitted into the organization from outside, over which the organization has no control).

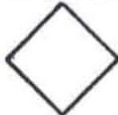
The more conventional charting techniques have not proved themselves adequate for uncovering the types of information in which we are interested. Such conventional techniques have generally been aimed at one of two objectives: (a) trying to find out where human clerical time is being spent, so as to shorten the overall process time, or reduce the man-hours to do a job, or (b) lay out a prescribed sequence of operations in a reasonably complex job, for the guidance of the clerks and operators--e.g. flow charts of punched card operations. We are not yet interested in either of these objectives, in this study, so it is not surprising that their associated charting techniques turn out to be relatively ineffective for our present purposes.

Rather, to obtain the understanding we require, we must learn the flow of information throughout the business, for directing manufacturing and the other activities, and for feedback and control. All uses of the information must be accounted for, so we soon find the scope of the project spreading throughout the entire organization.

To accomplish this objective, we have designed and tested a new technique which we call Information Process Charting. This technique 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.

PROCESS CHARTING - SYMBOLS

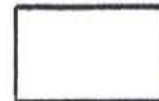
Fundamentally, there are only seven symbols in this technique, five of them representing "operations" (where someone does something), and two representing conjunctive, or connective devices. These basic symbols are shown below:

**OPERATIONS**

Selection



Arrangement

Writing,  
ErasingComparison,  
BranchingComputation,  
Decision**CONNECTIONS**

Entry

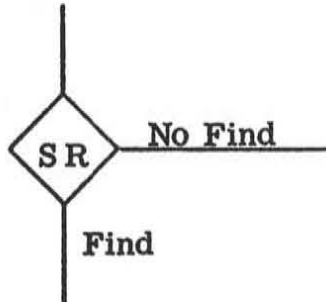


Exit

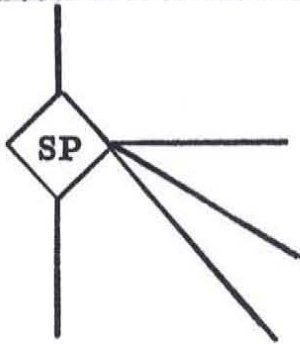
As will be seen shortly, there are different variations for some of these symbols, so that in practice 11 different symbols are used. Each of these 11 symbols is defined on the following pages.



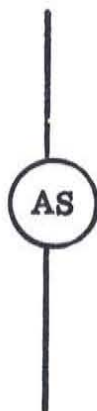
## SELECT, SEARCH (SR)



1. Search always means to look for a specific record in a file, and not to look for a field of information on a record.
2. In searching, the file is always assumed to be present and available.
3. Indicate which file is being searched, the field(s) of information by which the search is made (the key), and which record the search key was obtained from.
4. Search implies that the file is sequenced by the key being used; otherwise, a Separate operation should be used.
5. Always indicate both the Find and the No Find cases; even though the latter may be impossible, unlikely, or trivial.
6. We are interested in analyzing those cases of No Find that are logically important - e.g. there has not yet been time for the record to reach the file, the record has not been created, etc.
7. Both the input records and the selected file record are available at the output.
8. If the record is a separate unit record (e.g. a separate form), it is assumed to be removed from the file by the search operation, and must be merged back with the file if that is its disposition. If the record is simply an entry on a line, such as an entry in a log book, then it stays in the file but is, of course, available at the output also.

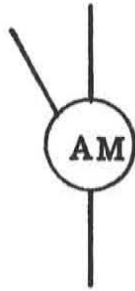
SELECT, SEPARATE (SP)

1. Separate means to select one or more records from a group or file according to some "key"--e.g. separating copies of a form according to the distribution field, or separating a batch of incoming mail by type of document.
2. Name what is being separated - e.g. multiple copies of a specified record, records of a specified file, etc.
3. Indicate the key by which the separation is being made. It is generally sufficient just to name the type of document, without giving details about the key.
4. A separate operation may have numerous outputs, one of which usually is the "main line" being charted. Use exits for all the other outputs, and use a separate line on the chart for each such exit, so as to be able to describe it properly.
5. If some outputs go to a simple filing operation, use the "file, then stop" exit described under Exits.
6. If multiple copies of a form are being separated, the disposition of all copies must be shown.

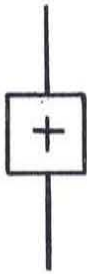
ARRANGE, SEQUENCE (AS)

1. Sequence means to arrange a group of records into ascending or descending order. It does not mean "sort into different groups", which is the Separate operation.
2. Name the records being sequenced, and indicate the key on which the sort is being made. If more than one field, indicate their order.
3. There is only one input and only one output to a sequencing operation.

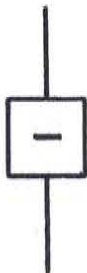
ARRANGE, MERGE (AM)



1. Merge means to combine two or more sequences of records into one sequence.
2. Merging assumes that all records and/or files are already sequenced by the key.
3. Merge also covers the operation of placing a record into a file in proper sequence. In this operation, the file is assumed to be present and available.
4. Name the records and/or files being merged and fields by which the merge is made.
5. There are always at least two inputs to a merge operation, and always just one output.
6. In a "file, then stop" operation (described under Exits) use a merge and a dead-end exit, both in the exit column.

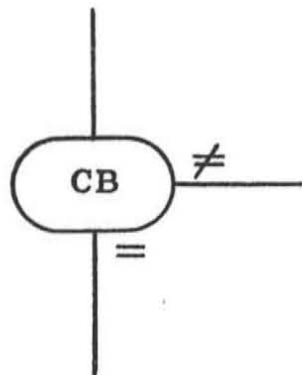
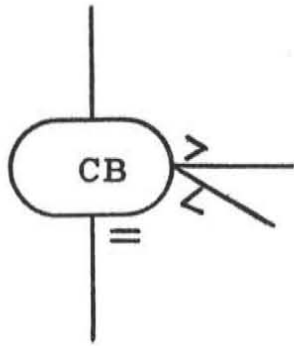
MODIFY, INSERT (+)

1. Modify insert means
  - (a) To create a new record, e. g. a new Purchase order;
  - (b) To add one or more fields of information to an existing record; e. g. signing a freight bill.
2. Indicate the record from which data is taken, the record into which it is inserted and the field(s) being inserted.
3. If a new document is created, show the disposition of both old and new documents.
4. It is usually not necessary to chart out the insertion of each field in a report (as discussed under Compute). Use one Insert for the whole report, or at least that amount which is done as one job.
5. As discussed under Search, a record should not be Searched to obtain a field of information prior to an insert. It is assumed that the entire record is read "at a glance" and all fields in that record are available. If there is a logical likelihood that a certain field will blank, use a Comparr and Branch, comparing the contents of that field with "blank".

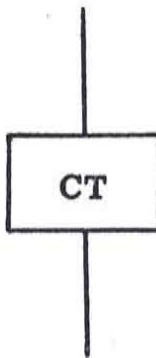
MODIFY, DELETE (-)

1. Modify delete means to delete one or more fields from an existing record.
2. Indicate record and field deleted.
3. Complete records are destroyed by means of a dead end exit, and not by means of a Delete operation.

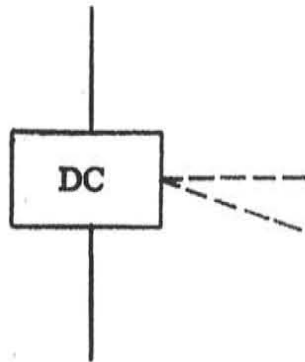


COMPARE AND BRANCH (CB)

1. Compare and branch is a basic choice operation involving a defined or prescribed decision; e.g. if x is greater than y, take one course of action, etc.
2. Compare and branch is one of the operations to be used for showing how alternative processing paths are selected - for locating the "exceptions". (Other operations which do similar but not identical functions in this regard are Separate, Search, and Decision-Making).
3. If at all possible, the two things that are being compared, x and y, should be expressed as numbers. For instance, "compare the number of copies with 1" to determine if there are zero, one, or more copies. Or "compare the contents of a certain field with blank" to determine if anything is written in that field.
4. Always indicate the record (s) and fields (s) involved.
5. Y should always be the standard, if there is one.
6. There are two varieties of outputs from this symbol: (a) = and  $\neq$ , to indicate "equal" and "not equal" when this expresses the situation adequately; (b) >, <, and =, when each of these three alternatives must be taken into account. ">" means "greater than", and "<" means "less than".
7. If one of the outputs is impossible, so mark it.
8. If the same action results from two outputs, the two signs may be shown together on one output line.
9. All outputs must always be accounted for.

COMPUTE (CT)

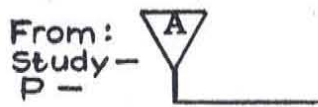
1. Compute refers to arithmetic operations; e. g. computing new shop load, delivery schedule, etc. using addition, subtraction, multiplication or division.
2. If the formula is easily expressed, note it down in the Remarks column of the charting form, or on a supplementary note sheet.
3. If the method of computation is at all complicated, do not spend the time to analyze it in detail, but simply group the whole computation into one compute operation. There is one exception to this rule: where significant branching occurs between portions of the computation, each of these portions should be shown as a compute operation, and the branching indicated by Compare and Branch operations. In either case, a detailed analysis of the computation will be made later.
4. Likewise, it is not necessary to indicate how each field in a statistical report is computed; just show one computation for the whole report, followed by an insert, for recording it.
5. If not too difficult, it would be desirable to have a two or three sentence write-up of the computation, indicating what is being done, for the more complex computations. This write-up can be on a supplementary note sheet.
6. Indicate the records involved and the fields being computed.

DECISION-MAKING (DC)

1. Decision making generally involves judgment; e. g. estimating what will be the volume of customer orders during the next three months.
2. These operations are usually quite difficult to analyze, (because of the large number of factors involved), so do not spend the time to analyze them. They will be analyzed at a later date.
3. However, it is desirable to chart the processing of information up to the point where the decision is made, and also after the decision is made. For instance, information is usually pulled together from a number of sources and often presented in report form before the decision-making operation takes place.
4. After the decision is made, indicate that the results are recorded, by an Insert operation.
5. In some cases, alternative processing steps will be taken, depending upon alternative results of the decision. In this case, several exits may be shown from one decision symbol.
6. List the major factors involved in making the decision, in the Remarks column or on a supplemental note sheet if necessary.
7. If there are well-defined intermediate steps or computations during portions of the decision process, these should be charted in the normal manner.
8. The decision symbol may also be used to represent non-routine activities of professional and semi-professional personnel which are difficult to chart. Examples might include data gathering and analysis prior to a decision, where methods of data gathering and analysis vary with the situation.



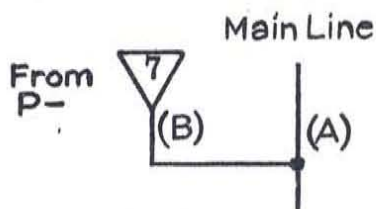
## ENTRY (EN)



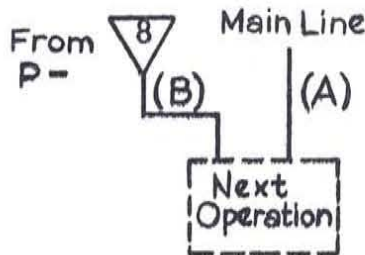
Inter Activity Entry



Intra Activity Entry

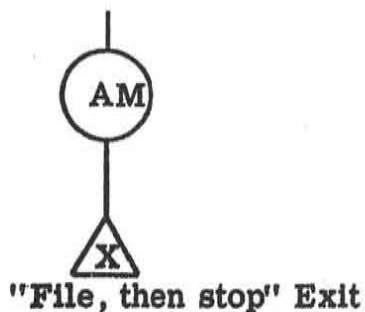
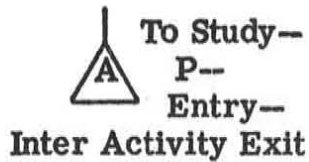


"And" Entry



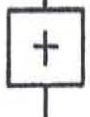
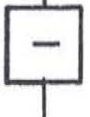
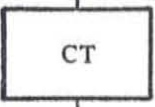
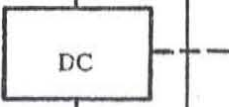
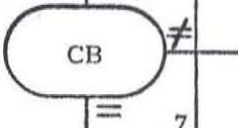
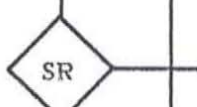
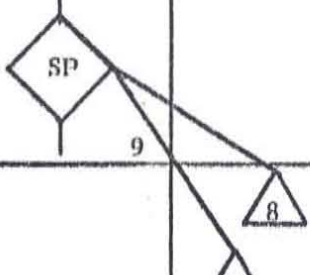


"Or" Entry

1. An entry indicates the beginning of a series of related operations (a routine). An entry may have inputs from more than one exit.
2. There are four types of entries:
  - a. Inter activity entry, (inputs from outside the system, or from another activity study within the system). Letter such entries beginning with "A".
  - b. Intra-activity entry (entries from exits from within this same study). Number these entries, beginning with "1".
  - c. "And" entry. If records A and B must go through a series of steps together, and record A has been charted as the main line, bring record B in with an "and" entry. This condition is represented by connecting the entry to the main line, as indicated.
  - d. "Or" entry. If record A or record B (but not both) can go through the same series of steps, and A has been charted as main entry. The entry symbol is connected to the next operation symbol, and not to the main line.
3. On lettered entries, indicate study, page, and exit supplying the record, if possible. On numbered entries, specify the page number of all exits which are inputs to the entry.
4. The analyst will have to decide whether the first entry is to be numbered or lettered. If the activity originates at point where the chart begins, use number "1". If the activity is supplied by forms or information from some other activity, or from outside the system, use letter "A".
5. Indicate all entering records (but not fields).
6. An entry may be initiated at any point on the chart, but must be made to the main line flow. A direct entry may not be made to a secondary flow.
7. An entry does not necessarily have to have an entering document or form. Also, an entering record may be in the form of direct measurements or observations.

EXIT (EX)

1. There are four types of exits:
  - a. Going out to some other study; letter sequentially, beginning with "A", indicate study and page number, if possible. All exits going to the same outside entry should use the same letter. It is desirable to name the exit on the chart in terms of the activity--e.g. copy to Accounts Payable.
  - b. Going to an entry within this same study (a "normal" exit); number the same as the entry to which it is going, and indicate page number of that entry.
  - c. A "dead end" exit, either destruction of a record or ceasing to process a record, indicate by an X in the exit symbol.
  - d. A "file, then stop" exit; use a "merge" operation, then a dead end exit, both in the exit column. Name the file and sequence "Key"
2. An exit should go to only one entry.
3. Do not use an exit at the end of a page just so as to refer to the next page; just stop the line at the bottom of the page and pick it up at top of next page. Be sure page numbers are correct to prevent confusion.
4. As discussed under the Separate operation, use exits for all the secondary outputs of Separate. Spread these exits vertically, not horizontally (to provide space for proper description) but take up as little space on the page as possible.

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



## PROCESS CHARTING - DISCUSSION

There are a few points of special interest that should be discussed briefly, about the use of the above 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 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 spend much time in detailing these operations. The process charting simply pin points the computations and decisions, and gives some understanding of what is involved. After the data gathering phase, many of these operations will be analyzed in detail.

Occasionally an analyst will come across a "loop" operation, where a series of steps is performed on a number of items, before going on with the processing. An example: 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 totalling or summary is performed afterward if there was more than one item on the list. Do not try to chart this out, using conditional transfers. Simply indicate the totalling 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 is desired 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 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 record employee numbers indicating Find and No Find.

The "and" and "or" concept 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 using an "and" entry, as shown on page 12, by connecting the entry to the main line.

Note that this "and" entry is somewhat different from a Merge or a Search operation. If record A is being charted on the main line and B is located in a file, then B is obtained by a Search operation.

Also, if two files are in a common sequence, they can be combined into one file of the same sequence by a Merge operation. Similarly, a record can be placed into its proper place (in sequence) in a file by the Merge operation.

The "And" entry implies no searching or no sequencing. There is no file; only records are involved. Two or more records are brought together, so as to be able to form a larger record.

For the "or" situation, record A or record B (but not both together) can go through the same sequence of steps. There are two permissible ways to chart this. (1) Use an "or" entry for record B; draw the line from the entry into the next operation box. Then, at the end of the sequence of steps, use a Separate operation to split the two types of documents apart. (A Compare and Branch operation is more correct logically, but the Separate operation is easier to use in the present case.) (2) Sometimes, however, it would be confusing to use the method described above, since records A and B are so dissimilar. When charting the processing of record B, then, the analyst (when he comes to the same sequence as he used in charting record A) can leave a blank line on his chart and insert the note "Use steps \_\_\_ through \_\_\_ from page \_\_\_."



## II CHART FORM

Below is a sample of the chart form used, showing the column headings:

Entries	Main line Flow	Exits	Secondary flow	Records	Record or field	Fields	Remarks

The meaning of the headings is reasonably self-explanatory. All entries will be shown in the first column, properly numbered or lettered and page numbers of pertinent 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; in the case of a "file, then stop" exit, both the merge symbol and the dead end exit may be shown in the exit column.

The secondary flow column has been provided to reduce the need for exiting and re-entry to handle minor variations in procedures. 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, and a re-entry provided.

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."

Recommended procedures for filling out the remaining columns are shown on page 10. The last column is for remarks; if the remarks exceed the space provided, refer to a supplementary note sheet, as "See Note 1."

Following is a sample of the identification block at the bottom of the chart form:

Subject Charted Procurement (Direct Mtls)	
Chart Begins Initiation of Purch. Ord.	Last Exit # 9
Chart Ends Preparation of Purch. Ord.	Last Entry # 4
Charted By A. Close	File Code
Page 1 of 9	Date 12/3/56

It is very desirable to have these blocks filled out completely, indicating the activity being studied, who is doing the charting, the date, and so on. The blanks for "Chart begins" and "Chart ends" are most helpful when searching through a group of charts to find a particular sequence. In these blanks, indicate roughly what part of the whole activity is being covered by this one chart.

In some cases, the entry "Miscellaneous Exceptions" is as close as the analyst will be able to come to describing the subject covered by the particular chart.

### III CHARTING TECHNIQUE

#### 1. General Procedures

- a. Draw all charts (even preliminary ones) on the 8 1/2 x 22 inch forms provided, using No. 2 (soft) pencil. Do not use any pencil as hard as No. 4, as this hardness will not reproduce well. When using a soft pencil, it will be necessary to be careful not to smudge the lines.
- b. It is suggested that both the senior analyst and the analyst draw charts of initial interviews. These charts should then be checked against each other for consistency of approach.
- c. The senior analyst should review all new process charts on a frequent basis.
- d. It is anticipated that project review meetings will be held weekly during the data gathering phase, to discuss the progress of the studies. Discussion of charting technique will be held at those meetings.

#### 2. Beginning a chart

In beginning the charting of an activity, do not lump all possible types of transactions together artificially. If all types of transactions come in from a common source, such as the mail room, then this fact should be shown, followed by a Separate operation to select out one type of transaction for analysis. But if the transactions come from different sources, just select the most common one and start charting it.

If the information originates at the beginning of the chart, the first entry should be numbered "1". If the activity is started by the receipt of a document from another part of the system, or from outside the system, then the first entry should be lettered with "A". It is hard to define this point too precisely, and it is somewhat arbitrary. For instance, the receipt of mail from outside the business can be considered as external to the system, so that the first entry should be lettered, not numbered.

The objective of the lettering is to quickly point out those entries (and exits) that tie in with other charts in the system. If the analyst knows that an entry is fed from some other chart, he should use a letter.



### 3. Ending a Chart

When the analyst comes to the bottom of a chart, and is simply going to continue charting on the next page, he should not use an exit and a re-entry on the next page. Simply draw the line to the bottom of the chart, and pick it up at the top of the next chart.

### 4. List of Open Exits

After charting has been completed, the analyst should prepare a list of the exits that refer to other studies. Each exit should be described briefly, so that it can be understood from just the list (without having to refer to the charts), and the other study to which it refers should be indicated.

### 5. Working from Other Charting Forms

It is sometimes possible to do much of the charting from flow charts and procedures charts prepared for other purposes. The big difficulty here is that these other charts usually concentrate on the main line flow only, and do not specify the conditions under which alternative paths of processing are selected. This branching will have to be uncovered by interviews.

Another example of charts that can be used is an IBM procedures chart. These charts have usually been developed for instructing machine operators as to the sequence of machines to be used on a job. As such, they very much reflect the particular limitations of the machines. If a process chart were to be drawn from these charts directly, there would be a considerable waste of effort. For instance, a half of a page of charting would be needed to show the insertion of an invoice number in a deck of billing cards, due to the way that this operation must be done on the machines. Actually, all that would be desired would be the one operation - "insert". Therefore, the person making process charts from IBM flow charts will have to do some abstracting before drawing the process charts.

### 6. Control Totals

The use of control totals is very common, both in manual and punched card operations. The purpose and technique of these control totals are quite well understood, therefore, the analyst should not go to any pains to chart out the method of preparing control totals, of segregating different types of control totals, or of specifying what is done when an error is detected. Simply indicate a Compute operation, an Insert operation and later a Compare and Branch operation. For the "Not Equal" output of this last, simply add the note, "Correct Clerical Error".

#### IV DEFINITIONS

**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 includes 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.



PHYSICAL OPERATION FLOW

An Analogy To Information Process Charting

Burton Grad  
Manufacturing Services

W. C. O'Neal  
Manufacturing Training Program

March 15, 1957

Manufacturing Services  
General Electric Company  
570 Lexington Avenue  
New York 22, New York





PHYSICAL INFORMATION - A CONCEPT

The concentrated study and research in fields of data processing machines and computers, during recent years, has led to methods of symbolizing and charting information processes from the "systems standpoint". That is, the pieces and flow of information which occur in a business or other operation are looked at as an orderly, dynamic whole rather than isolated, loosely related parts.

In an attempt to study manufacturing or making operations in such a way as to understand the system as a logical whole and at the same time encompass the inherent, indispensable information processes, we have discovered that there is a very close-coupled relationship between information and manufacturing.

In fact, it can be said that "making something" and "information" are identical. Webster's unabridged dictionary gives one definition of information as "the act or process of endowing with form". This is precisely what we do when we make a finished product from a raw material - a physical transformation. However, this is a little-used meaning of "information". What about the commonly used meaning of "information"?

An examination of an article such as a motor-shaft reveals many locked-in fields of information. There is the length, the several diameters, the finish, the chamfer dimensions, the keyway, and most hidden, the physical and chemical make-up of the metal. These are valuable pieces of information that originated somewhere, and serve a useful purpose somewhere else. They are pieces of information in physical form rather than the usual symbolic form, such as printed words. They are bits of transformation information; a very important type of physical information.

The concept of physical information allows us to graphically close the information loop of a manufacturing business system. Heretofore, charts of information processes showed information flowing in one end of the manufacturing area and out the other; a series of unconnected inputs and outputs. The charting of physical information joins and explains these unconnected inputs and outputs, and reveals feedback and control information flow within the manufacturing area.

To complete the analogy of information and transformation, it is necessary to examine how "symbolic information" is handled, and what can be done with it, and then compare these things with "physical information" to see if the analogy holds true. Primarily, symbolic information can be communicated.



An obvious example of communication of physical information is the inspection process. There the inspector measures the physical information on the finished part, converts it to symbolic information, records it, and sends the report to its destination. Another, but less obvious example, is the direct communication of physical information to an automatic inspection device. There the device reads the physical dimensional information and makes a decision based on the physical memory that is built into the device. It not only can accept or reject the part, it can also extract other physical information from its memory, and communicate it to the machine, instructing the machine to stop or adjust itself; thus, we see that physical information can be communicated.

There are many things a computer can do with information. It can sort by a key field of information and it can add information to information fed to it, either by a program or from its memory according to what primary information it receives. It can extract and print information, and it can accomplish mathematical computations.

Since physical information is tied up closely with factory machines, these machines must be able to do the above operations on physical information in order for the general analogy of symbolic and physical information to hold true. It is unusual to find a factory machine that can do all of these operations, but there are machines which do one or more of them.

An egg-grading machine sorts eggs by weight and other characteristics. Most factory machines add information to raw material from memory, by a program, such as length, diameter, finish and other dimensions, characteristics and properties. Part of the program is fixed, in that, for instance, a lathe normally can add only cylindrical dimensions, a milling machine can add only plane or flat dimensions. The variable part of the program is determined by the different set-ups made to accommodate product-mix. Inspection devices extract information from the part, and in some cases, print it. Some modern lathes and boring-mills make computations to change speeds and feeds according to the varying diameter of the piece they are machining, thus acting as analog computers. Process industries utilize automatic-batching scales which digitally count out weights of ingredients and number of ingredients to make up the final mix proportions. It is evident then, that factory machines can accomplish the same types of operations on physical information that computers can with symbolic information. Actually, however, computers generally handle physical information in the form of punched cards, punched tape, or magnetic tape. Somewhere in the system, people must translate symbolic information into physical information before computers or factory machines can do operations with information.

With the foregoing discussion in mind, it is now easy to chart factory operations by considering machines as computers or data-processing machines, and considering machining operations to be insertions of information on a partially complete record - the raw material.



PHYSICAL TRANSFORMATION\* OF MATERIALS,  
INCLUDING MATERIAL HANDLING AND STORAGE  
STUDY APPROACH

In flow charting the physical transformations of materials into components, sub-assemblies, and finished products, the following restrictions should be considered:

1. Physical movement of materials between factory points where physical transformations take place or where materials are stored will be explored as separate activities.
2. The entry point into this study occurs when a command is given or dispatched to factory personnel who either directly perform or control the physical transformations occurring on materials being processed.
3. The exit point occurs when completed products are delivered to the factory warehouse ready for shipment.
4. Methods for determining process facilities or equipment should not be included.

In flow charting the physical storage of materials\*\* between physical transformation and/or movements, the following restrictions should be considered:

1. Storage of material temporarily occurring within a physical transformation process or during time of physical movement will be thought of as being an inherent part of transformation or movement activity. (Example: Material moving on conveyor inside an annealing furnace is part of the furnace process activity.)
2. The entry points into this study occur with arrival of material from physical transformation point or from subsequent physical movement away from physical transformation point to storage point. (There can be either stationary or mobile storage points - examples: stockrooms, stockpiles, or "transport and store" type conveyors).
3. The exit points occur with arrival of material at physical transformation point or at physical movement point ahead of transformation point.

\*By "physical transformations" are meant the "making operations for converting materials into components, subassemblies, and finished products".

\*\* Raw materials, components, and subassemblies.

In flow charting the handling of materials between physical transformation and/or storage points, consideration should be given to the following:

Re: Physical Transformation:

1. Handling of scrap\* from generating areas to:
  - (a) Reclaiming area
  - (b) Salvage area
  - (c) Destruction or ultimate disposition
2. Entry point into the study. This will occur when scrap\* leaves the physical transformation activity and discharges into collecting station(s).
3. Exit point from the study. This will occur when scrap\* returns to:
  - (a) Physical Transformation study
  - (b) Purchaser of Classified Scrap
  - (c) Ultimate Disposition

Re: Physical Handling:

1. Investigation of Receivables\*\* to facilitate and simplify Receiving and Manufacturing activities with alternate handling systems to exit points.
2. Entry point into the study. This will occur with the suppliers to resolve the best solution of fulfilling handling requirements.
3. Exit point from the study. This will occur upon the delivery of receivables to the physical transformation process.
4. Secondary consideration should be given to the influence of Central Warehousing activity and the movement of finished products either direct to shipping or to warehouse-storage point.

Re: Physical Storage:

1. Confined to the Receiving, Shipping and Warehouse areas.
2. In process inventory to be resolved by Physical Transformation.

\*Scrap- supplier cartons (wood & paper), chips (metal & other) etc.

\*\*Receivables - all raw and finished material from suppliers.

## CHARTING OF MAKING OPERATIONS

Definitions of "information process charting" symbols with reference to "material and information process charting".

### MODIFY-INSERT

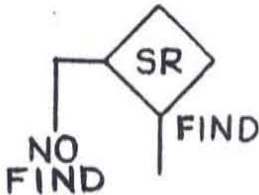


- Means to: (A) Insert information on a machine program. (To set-up the machine).  
 (B) Insert information on a part. (Machine the part).

The machine program and part are considered to be records which yield or accept fields of information.

The machine is thought of as a computer.

### SEARCH-SELECT



- Means to: Search in a stock area containing many stockpiles of similar parts with different drawing numbers.

A stock area, therefore, is a file containing groups of similar records.

### SEPARATE



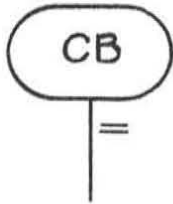
- Means to: Separate one part from a stockpile of identical parts. Therefore, a stockpile is a group of identical records.





### ARRANGE-MERGE

- Means to:
- (A) Combine a machined part with other identical machined parts. (I. E. into a Totopan). Thus, merge a record with other identical records.
  - (B) Combine a stockpile of identical parts with other similar stockpiles of parts in a stock area. Thus, file a group of identical records in a file, by Drawing No.
  - (C) Combine two or more different parts into one Assembly. This arrange and merge will always have two or more inputs.



### COMPARE AND BRANCH

Means to:

Compare certain characteristics of a part with the Blueprint or other Specification; thus, to inspect or test the part or assembly. The two outputs will be accept and reject: i. e., if greater or less or not equal to Spec, reject. If equal to Spec, accept.

