A MATERIAL EXPEDITING SYSTEM FOR USE IN THE CONSTRUCTION INDUSTRY

PROJECT REPORT

GRAHAM E. FRAMPTON

A MATERIAL EXPEDITING SYSTEM
FOR USE IN THE
CONSTRUCTION INDUSTRY

PROJECT REPORT

Presented to the Graduate Studies Committee of the Faculty of Engineering and Applied Science of Memorial University of Newfoundland in partial fulfillment of the requirements for the degree of

MASTER OF ENGINEERING

by


GRAHAM E. FRAMPTON

MEMORIAL UNIVERSITY OF NEWFOUNDLAND

AUGUST 1972

TABLE OF CONTENTS

TABLES AND FIGURES

ACKNOWLEDGEMENTS

I wish to Acknowledge the valued guidance, and assistance provided by Professor Hira N. Ahuja; the assistance provided by Robert Verge and Peter Martin,under graduate students,on the computer portion of the report; and lastly the understanding and patience of my wife and family on my spending many evenings away from home working on this report.

Graham E. Frampton

ABSTRACT

The process of ordering, expediting and delivery of materials is a very important aspect in the successful management of a Construction Project. In regions not near the industrial areas, such as the Island of Newfoundland, the time of delivery of materials from supplier to project can be lengthy and uncertain.

Present systems for handling the material procurement process do not always systematically include or provide for all the procedures and their corresponding lengths of time that are necessary in procuring materials such as:

Preparation of Shop Drawings

Approval of Shop Drawings

Fabrication

Shipping

etc.

Consequently, often the procurement of the materials is the single most important thing which determines the progress of construction.

The Material Expediting System presented in this report covers the material procurement process from the date of award of contract up to the time the materials are delivered to the site. It relates to the Construction Schedule, the General Stores (if any), and produces a delivery schedule for each material to co-ordinate with the rate at which they are scheduled for incorporation into the work. The system is adoptable for use by the various forms of construction organizations such as General Contractor, Project Management etc.

A manually worked example of the system is contained in the report. A Computer program has also been written and a computer produced example is also included.

CHAPTER I - PROBLEM DEFINITION

1. INTRODUCTION:

The process of ordering and delivery of materials is a very important aspect in the successful management of a construction company.

In areas not near the heavy industrial centres and in remote areas having limited or heavily taxed transportation facilities, the time of delivery of materials from their source to the job site can be lengthy and uncertain. This is the case in the island of Newfoundland.

This process can not be successfully managed in the absence of properly prepared schedules, which must be frequently updated. The present methods of expediting often create panic situations which demand management time.

The lack of such a system or method could prove to be the most important factor in a project not being completed within the scheduled time.

2. ENVIRONMENT

2.1 GENERAL:

Areas which are remote and areas which have transportation difficulties all have the common problem of getting materials to the job-site as rapidly as possible and within the scheduled time for delivery.

In the Island of Newfoundland, the problem of delivery

is quite serious. Being an island off the east coast of Canada, it is removed from the heavily populated and industrial centres of Canada. The population is approximately one-half million with nearly forty per cent concentrated on the Avalon Peninsula, on the east coast of the island. The primary industries are: fishing, paper making and mining. There is little heavy industry and manufacturing carried on. Consequently, practically all construction materials with the exception of concrete products and miscellaneous fabricated iron products have to be imported to the island, mostly from Central Canada. Even wood products, lumber and wood framing have to be imported to Newfoundland.

Very little "off the shelf" buying is done in the construction industry; consequently, most materials are ordered on a per-job basis, and from the mainland.

2.2 TRANSPORTATION OF MATERIALS TO THE ISLAND OF NEWFOUNDLAND:

The two largest carriers of freight from mainland Canada to Newfoundland are the Canadian National Railways and Clarke Traffic Services Limited. Other carriers are unscheduled chartered ships operating mainly to the south coast of Newfoundland. Truck transportation also operate to and from the mainland. They cross from Port aux Basques to Sydney by CNR, but as yet are on a small scale and are not a proven established mode of transportation for freight.

The CNR's operations directs all freight destined for Newfoundland to Sydney by rail, and from there it is sent to Port aux Basques

by cargo vessel. From Port aux Basques, it is dispersed by rail across the island to the end of the line - St. John's freight destined to the south coast of Newfoundland is transferred to CNR vessels at Port aux Basques, for routing by marine cargo. Large or bulky orders destined for the south or west coasts are sometimes taken direct by cargo ship from Sydney.

This is a year round service; however, difficulties and delays are experienced during the spring of year, as frequently the harbour of Sydney becomes blocked with ice which halts navigation and causes freight to be diverted to an alternate shipping port. During the peak volume of freight movement, which occurs in the summer-time, Sydney literally becomes a bottleneck. It has not been uncommon for as many as 700 rail-cars of freight to be at Sydney waiting for shipment to Newfoundland.

Clarke Traffic Services Limited operate a cargo service from Montreal to St. John's, with a ship arriving at St. John's on Mondays and Thursdays of each week during the period from March to December. During the winter period, the arrivals are not so frequent and they claim the schedule is two arrivals every ten days. They also operate a service from Montreal to Corner Brook with one arrival every eight days. At one time they also operated a cargo ship service from Montreal to Botwood during the summer months. This is now discontinued. If there is sufficient demand, they will also deliver freight to Bav D'Espoir and Marystown on the south coast; however, this is not a scheduled run. They provide or arrange for the transportation of freight from Toronto, Hamilton and Kitchener to Montreal to connect with the Newfoundland service.

The time of delivery of materials from destination to job-site in the island of Newfoundland could vary from two to six weeks. This is because of:

(a) The remoteness from the main source of supply of construction materials;

(b) The fact that it is an island, which limits the methods by which materials can be transported;

(c) There is a very wide seasonal range in the volume of freight traffic, with the peak occurring during July and August, which the carriers are never geared to handle with maximum efficiency; and

(d) Because of the number of times freight has to be handled in the loading and unloading, breakage and damage is not uncommon.

2.3 PRESENT MATERIAL ORDERING PROCEDURES:

2.3.1 GENERAL

Generally speaking, construction projects in Newfoundland, as in other parts of Canada, are required to be started within a specified time after the award of the contract (usually two weeks). This is not sufficient time to place orders for all materials and obtain estimates of their delivery dates prior to the start of the job. Consequently, this is usually going on simultaneously with the construction of the project. Quite often during the construction of a project, delays are experienced because of the late arrival of materials. It is not advocated that the start of a project should not be made until all materials are ordered and their delivery dates determined. It does, however, point out the fact that the ordering and the planning of the pro-

curement of the materials is a very important aspect of the running of a successful construction project, particularly in areas such as Newfoundland. Normally, the procedure that is followed in the ordering of materials is that all materials are ordered as early as possible and a promised shipping date is obtained. Each construction company may have its own system for keeping up-to-date information of the progress of the delivery of the materials. Usually materials of the same kind are not asked to be shipped in lots less than the total job order, to co-ordinate with the rate at which they are incorporated into the job, but rather the whole job order is asked to be shipped as soon as possible. This procedure is followed for the procurement of all the materials. The rule of thumb is: order everything as early as possible. One can only feel safe when the materials are on the job-site; even if they are lying there for months before being incorporated into the work; which however, is rarely the case.

There is a disadvantage to the owner in having materials on site too long if he has agreed to pay for them, in that he is losing interest on his money.

In most General Conditions of contracts, provision is made for payments to be made to the contractor for materials delivered and stored on site, but not incorporated into the work. On a job of any consequence, if no scheduling of the arrival of materials was followed but rather done in a haphazard fashion, it would be possible to have some materials on the site for lengthy periods of time prior to incorporation into the work. This could work to the disadvantage of the contractor in having to find large outside storage areas as well as covered storage areas with heat and light. The possibility of damage and losses due to pilferage,

deterioration and re-handling is also much higher when materials are on site too long. Excessive costs will also be involved in controlling and managing a big material storage yard. Materials arriving at the job too soon or in too large a quantity results in much re-handling and interference with other work.

The ideal time for materials to arrive on the job, is immediately prior to, or at the time that they are to be used or installed in the job. In view of what has been previously said; that is, practically all materials have to travel from mainland Canada, this situation rarely occurs in Newfoundland.

2.3.2 SCHEDULING:

The importance and necessity of preparing schedules for the construction activities is readily acknowledged. Most all construction organizations use construction schedules whether they are of the simplist type or vary in complexity up to the most rigourous, i.e., CPM, PERT of PRECEDENCE. "The use of CPM Scheduling in all Construction projects of a value of $100,000.00 and greater is highly recommended." [16] What is often omitted from these schedules is their relationship with the materials ordering process and the times necessary for this procedure. Often the case is that the material ordering process is the most influencial in determining the construction schedule not only initially but at every up-date.

2.3.3 CONSTRUCTION ORGANIZATIONS:

In today's construction industry there are a number of different

forms of organizations by which construction projects may be carried out, such as: (a) Project Management

(b) Construction Management

(c) General Contractor

(d) In - house Work

(e) Separate Contracts Controlled by the owner.

Within these basic forms of organizations there are many variations. The same firm at different times and on different projects may operate under different types of organization. Generally speaking however, organizations will specialize under one type of organization.

Within these organizations there are many divisions or positions responsible for different functions such as management, engineering, purchasing, expediting, scheduling, site superintendent and field staff, and accounting. Quite often the total organization does not perform with maximum efficiency because of: lack of communication; not knowing what should be communicated; to whom, and at what frequency. This confusion and lack of communication, in part, can be attributed to the absence of a standardization for describing various parts of a project, the project itself, and all the various materials and equipment that go into a project.

2.3.4 PURCHASING:

On smaller jobs which do not maintain separate job offices, purchasing is done from the Head Office. In small one-man organizations the purchasing function is centralized in the Contractor, himself, except for occasional small items bought on the job as needed. As jobs

spread out over more territory and as they become larger the function of purchasing is moved to the site office.

When purchasing materials, consideration has to be given to such things as prices, price trends, time to buy, quantities to buy, dealers or manufacturers, transportation, deliveries, amounts to be kept on hand, checking, testing, insurance and follow-up. Consideration must be given to the method of transportaiton, such as rail, boat or truck transportation, expense of transportation; the time required, including delays; and the reliability of the transportation company. When planning on deliveries, some thought is given to the total amount of each material: the amount of each material to be kept on the job such as a few days supply, a week's supply, or the entire supply: the time or date the materials will be needed and the rate at which each material will be used. On most jobs, it is advisable to contract for the total materials required for the project as to price, quality, quantity, delivery, etc.. When practical, allowance must be made for variations in quality, quantity and delivery because the job conditions and needs vary after work starts.

Frequently, the actual shipping date is much later than the date promised at the time the order was placed, which may have been overly optimistic in an effort to obtain the order.

Orders placed with an Ontario supplier for example, may often be moved down their production schedule in favour of a nearer, larger customer. The uncertainty of the shipping date and the lengthy period of shipment coupled with the time required for other procedures such as:

(a) The placing of orders;

(b) Preparation of shop drawings;

(c) Approval of shop drawings;

(d) Manufacturing time;

adds up to a lengthy period.

This period of time in the first instance is often not accurately predicted and it is not taken into full consideration in the scheduling of the construction of projects. Often the initial prediction will change, usually for the worse, which necessitates expediting each individual phase of the material procurement procedure and updating the schedule frequently.

2.3.5 EXPEDITING:

Expediting is the job of following up the purchase to see that the items ordered (Not substitutes) are delivered and that delivery is made at the place and time required by the contractor's operations.

Almost everything a construction company purchases must fit somewhere into a production schedule. It is the job of the expeditor to see that the things bought, arrive on the job as nearly as possible to the exact time they are needed. The expeditor must know exactly what has been purchased;when it is due to arrive on the job; and what will happen if it is not there on time. He needs to have day to day knowledge of progress on all jobs, and of shipments and production schedules. If materials are to be fabricated, if he deems it advisable, he must be able to go into the supplier's factory and identify the items on their way through production.

The basis for the expeditors function are the job schedules and

they should be placed in his hands as soon as they are processed. This is particularly important as schedules are revised; for revisions may make it necessary to get in touch with manufacturers or suppliers, and in some cases may result in cancellation of purchase orders and sub-contracts.

If an orderly and planned system is not followed and authority is not delegated within the company's organization, it may be the case that management will find themselves having to deal with routine day to day problems or may find themselves dealing with crisis after crisis, such as suddenly finding out from the site superintendent that progress is held up or stopped because of a non-arrival of materials or equipment.

It is very difficult even for the most skillful expeditor to keep track of all the modifications to a schedule and to determine their effects on the numerous expediting duties that he is required to perform for materials that require attention. The expeditor has to spend a great deal of time, keeping up to date, handling the correspondence passed to him from Engineering, Purchasing, Site Superintendent, and Management, to extract the information actually needed by him, such as; where is a certain material at present? When is it needed? Will it arrive at the site in time?

In addition to the duties and responsibilities previously mentioned, it may be necessary to actually manage the delivery of the materials from their source to their destination. This would involve: determining the most economical and expeditous routing; pooling different orders and consolidating less than car load orders; preparing bills of lading;

tracing shipments; auditing freight bills; handling transportation insurance and in some cases arrange for the transit storage areas.

Thus his real job which is expediting the materials and not processing information suffers and consequently progress on the job is affected.

While it is necessary and important that the expeditor be kept up to date on the construction schedule, it is equally important that the Site Superintendent, Management, the Scheduler, etc., be kept informed on the Progress of the delivery of the materials. Often under the present arrangement there is no established pattern for issuing this type of information. Panic situations such as "hold-ups" in construction because of late arrivals of materials are handled as they occur, rather than preventing them from occurring by supplying information regularly.

2.4 GENERAL STORES

Some contractors maintain a continuous supply of some types of materials on hand at all times in a General Stores. All contractors, invariably, have excess usuable materials on hand at times, left over from previous jobs, which they are unable to return to the suppliers or consider it more feasible to keep these left over materials for use on some future project.

The type of materials that would be expected to be held in a General Stores would be those which are in constant demand by the Contractor; are not a job order type, i.e. those materials which are not likely to vary in any way from job to job; and those materials which may be required on a very short notice. The Contractor feels

that by maintaining these materials in his own General Stores they may be more readily available and that he would have a greater control over the furnishing of them to their place of requirement.

It is often the case that materials are found in General Stores which are obsolete; which have been ordered for a previous project but were not used because of modifications or were ordered in too large a quantity initially. These materials have little cash value and are occupying valuable space. Also materials are often ordered from a supplier for delivery to a project, without checking the quantities which are available in the General Stores. This contributes to a needless tie up of capital and if perpetuated may eventually render valuable material obsolete or useless as a result of deterioration or from damage while handling other materials in the same vicinity.

Inventory control systems are in use by some organizations with minimum and maximum stock limits specified. Often, however, there is no procedure for expediting the ordering and delivery of materials for restocking the General Stores.

3. PROBLEM STATEMENT

The material procurement process of obtaining materials from the time that a contract is awarded and the Estimator prepares bills of materials,up to the time that they arrive on the site for incorporation into the job,has been shown to be a lengthy, involved and demanding procedure. It involves office and on site personnel within the same organization; (Engineering, purchasing, expediting, checking and storing).

It involves manufacturing (the supplier and his personnel). It could involve all the different modes of transportation (ship, rail, truck, air). It takes away the action time of the expeditor which he has to spend in information absorption and processing, to assure co-ordination between the delivery of materials and the project schedule.

3.1 DESIGN CRITERIA

A need is therefore apparent for some overall planned system to control this procedure;

It is necessary that the system operate by the "Management by Exception" concept;

That it relate to the different divisions or functions within the company structure, i.e. Management, Engineering, Purchasing, Expediting, Accounting, Field Staff;

That it be tied to a Construction schedule;

That one person, the Expeditor, is able to produce instant up-to-date information on the status of all materials at any time;

That it relieve the Expeditor of the tiresome task of keeping track of the changes in the construction schedule ;

That it be compatible with existing procedures or systems; and lastly,

As it is the case for most systems and procedures, in order that it be most successful, it must be simple and easily understood, easy to adopt for use and economical.

CHAPTER II - DEVELOPMENT OF THE SOLUTION

1. GENERAL

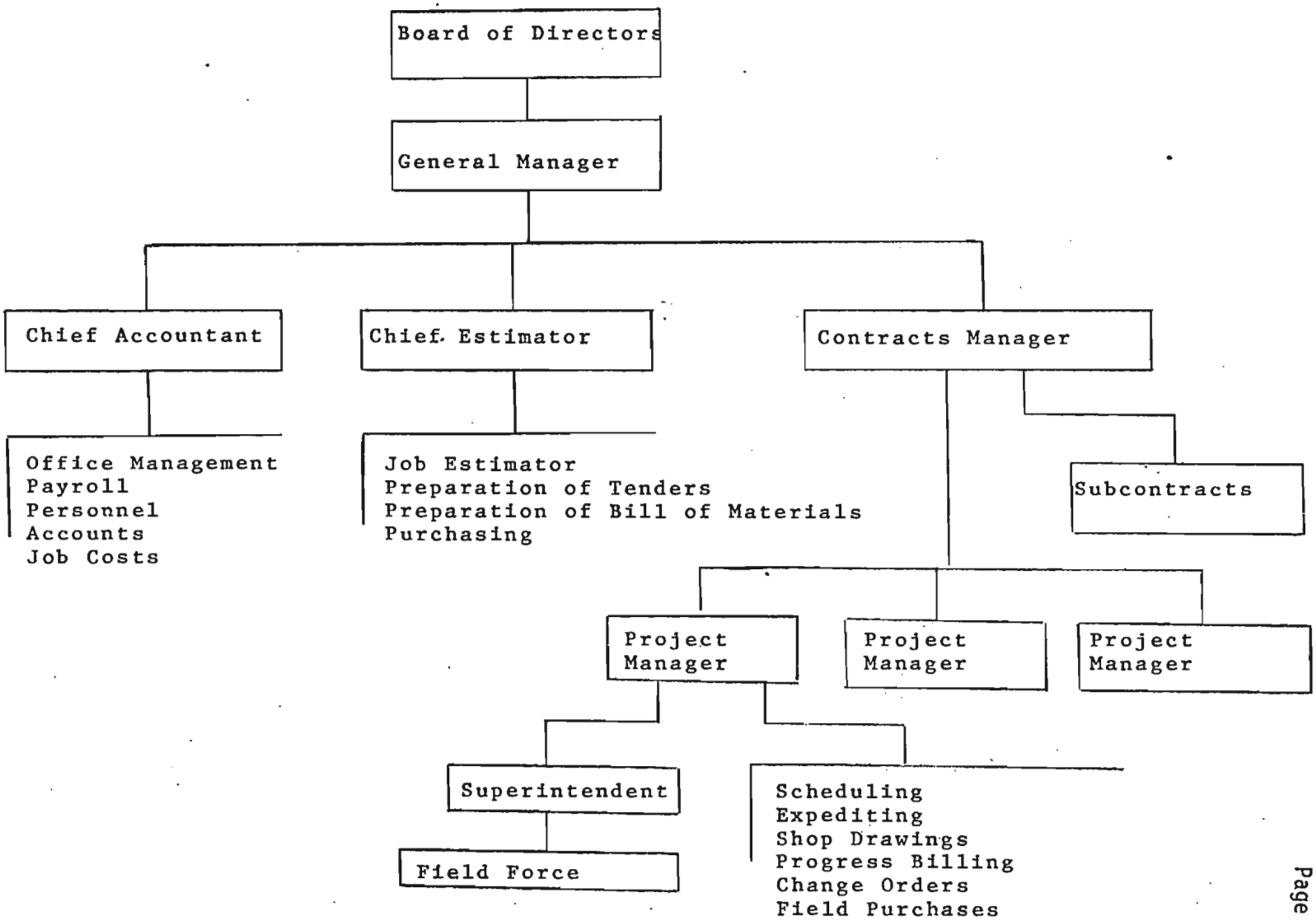
In chapter I, the whole process of ordering and delivery of materials for construction projects was reviewed with special emphasis on the construction industry of the Island of Newfoundland.

The object of this report is not to recommend how materials should be shipped or to criticize or suggest improvements to the existing methods of transportation, but rather how to effectively "keep your thumb" on the process of getting materials to the job-site from the time that the orders are placed, until they arrive at the job-site. The procurement and the expediting of the materials to the job-site must be treated in the same manner and with the same importance as each activity or work item making up the whole project. There is little point in scheduling the start date of an activity when it is not known whether the materials will be on the job or not. It should never be the case that "when a certain material or item arrives, it will be installed". The delivery of all materials should be known as much in advance as possible.

2. CONSTRUCTION ORGANIZATIONS

To illustrate the relationship between the function of purchasing and expediting an organizational chart of medium-sized General Construction Organization * is shown in figure 1. This is a representative chart of this type of organization and it will be seen that the function of purchasing is under the Estimating section

* having an annual volume of 5 - 10 million dollars.



Organizational Chart Medium-Size Construction Company

FIG. I

and the function of Expediting is placed under each Project Manager or more closely related to the field operations. Although charts for other forms of organizations, as mentioned in Chapter 1, will differ, the relationship between the function of Purchasing and Expediting will be similiar.

3. INFORMATION REQUIRED FOR ORDERING MATERIALS

3.1 GENERAL

For the processing of procuring materials for Construction Projects it is necessary that the following information or procedures be used and it is observed that many General Contractors and Project Management Organizations actually use them:

a) Coding System for materials.

b) Bill of Materials Form which would include the material description and the quantity.

c) Job Scheduling.

If a system is developed to meet the design criteria as given in Chapter 1 the following additional information will be required:

d) A relationship between the scheduling of the work items and the delivery dates of the materials.

e) Information on each material such as:

   i) Are shop drawings required?

   ii) Estimated time for the preparation of shop drawings and/or samples or submission.

   iii) The estimated or allotted time to review the shop drawings and/or samples.

iv) The estimated or allotted time for architect's approval of shop drawings or samples.

v) The estimated or allotted time to prepare and resubmit shop drawings or samples in the event that the first submission was not approved.

vi) The fabrication time.

vii) The lead time, that is, the amount of time that the material should be on the job before it is scheduled for installation into the work.

If an Organization maintains a General Stores, it would be expected to find that the following information on each material kept in stock is recorded.

.I Quantity in stock.

.II Whether the material is to be restocked.

.III The minimum quantity to be held in stock (the order point).

.IV The maximum quantity to be held in stock.

.V The quantity on order and it's estimated delivery date.

The proposed material procurement system, in addition to the above listed information must also receive another input. It is:

.VI The quantity of each material in stock which is available for use in the current project at hand.

3.2 CODING

Coding is the important key to tying together materials, equipment, labour etc. and all the various functions making up the total project.

Coding is used extensively in keeping inventory records and in

costing for all types of operations and is used universally in the Construction Industry.

In a major project the number of people who contribute data to the capital cost cycle and receive information from it can be numbered in the hundreds and even thousands. These people have different backgrounds and training; they are accountants, estimators, design engineers, purchasing agents, time clerks, labour foremen, construction superintendents, etc.

They may come from various parts of a corporate structure, each with its own area of emphasis and established way of thinking. They may be from more than one organization. In this day of specialization, these groups also tend to develop their own words and their own special meanings for words. These people with varying backgrounds and responsibilities, need a common language when dealing with the various elements of the project. A code provides this common language. It is also a means by which the vast volume of capital cost detail can be organized, manipulated, and made useful.

A system for the procurement and expediting of materials will have to deal with all such people. Therefore it is necessary to have a suitable coding system.

A code may also be used as a basis for:

i. Identification of materials in a bill of materials.

ii. Requisition and purchase order numbering system.

iii. The drawings numbering system.

iv. Data filing.

v It should be suitable for use with a computerized system to reduce

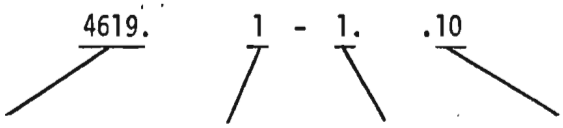
the cost of collecting, analysing, summarizing and distributing the information required.

vi. It may also be used for cost accounting.

It should be as simple as possible consistent with the number of items to be classified and purposes to be served.

A number of coding systems are in use. Different firms may develop their own coding system consistent with their requirements. The code system presented here is a modification of the Building Construction Index dated February 1966 (Appendix No. I) and the Uniform System for the Construction Cost Accounting (Appendix No. II)

A sample of the code for a filing index is as follows:



Project Number — Job Number — Section — Division

4619 - Project Number

4 - Company division, i.e., Project Management division.

6 - Geographic location of project, i.e. Nfld.

19 - Serial number of project undertaken at this particular location.

1 - Job Number within project, i.e. boiler house.

1 - Planning (from Building Construction Index - February 1966).

.10 - Correspondence with Owner (from Building Construction Index - February 1966).

An example of the code for use with materials is as follows:

4619. 1 - 5. .0820

4619 - Project Number, as in previous example.

1 - Job Number - as in previous example.

5 - Specifications Format and Filing Index (Construction)

0820 - Wood Doors (from Uniform System for Construction Cost Accounting Guide).

The specifications Format and Filing Index (Construction) while being fairly detailed in it's present from does not account for every item of material; for instance the number 0820 simply represents Wood Doors, which for normal requirements may be sufficient. There are however numerous types and sizes of Wood Doors. The Code could be expanded to allow for all different types of materials represented by the single number in the Specifications Format and Filing Index (Construction). This could be accomplished by placing a dash after the material number and allowing a two digit number for all the different materials under the one material number.

4619.1 - 5.0820.01

4619.1 - 5.0820 as in previous Example.

.01 - 2' - 8" x 7' - 0" x 1 3/4" Solid Core Slab, Mahogany

To use this Code for Cost Accounting of the materials installed, it can be further expanded by adding a decimal and a two digit number representing the various cost items that may be necessary to identify. These may be as follows:

.01 Material, Field Purchase

.02 Material, Home Office Purchase

.03 Labour, Hourly Payroll

.04 Salaries, Supervisory

.05 Travelling and Living Expenses for Personnel

.06 Rentals

.07 Freight

.08 Taxes

An example of the Code for use in cost accounting would be as follows:

4619.1 - 5.0820.01 - 02

4619.1 - 5.0828.01 as in previous example.

02 - Material home office purchase (i.e. the cost of this type of Wood Doors for this job).

4. WORK PACKAGES

The only remaining information required to complete the material ordering information is a method of determining the Sizes of shipments of materials to relate to the rate at which they are installed into the work. This is particularly important in large projects. This can be accomplished by breaking the whole project down into it's individual definable parts or work packages.

This is not by any means arduous or a time consuming task and does not add any additional time to the material procurement process as it can be done simultaneously with the other requirements.

By breaking a project down into Work Packages, in addition to serving the purpose of determining the size of material shipments, it also makes the whole project more clear and more easily understood.

The benefit of cost control and analysis may also be derived from a Work Package breakdown of project.

A definition of Work Package[12] is as follows:

"The lowest level end item, or work package, becomes manageable unit for effective planning and control. The work packages must be logical manageable units in terms of time, cost and organizational responsibility.

The D.O.D. - NASA PERT/COST manual set - forth as a guide or goal that the lowest level work package should represent a value of "no more than $100,000.00 in cost and no more than three months in elapsed time".

In applying this criteria, it must be recognized that the overall objective is that a work package be logical and manageable rather than that it conform arbitrarily to the dollar and time criteria. To be logical and manageable, a work package is defined as a task that has a recognizable beginning and end. That is, first level supervisors and the people who will be charging time or ordering materials against a specific work package, must be able to recognize the task. The work package must, therefore, be definable with recognizable boundaries that will differentiate it from other similar types of work packages. The work packages must be manageable and still not extend beyond the organizational authority of the manager or supervisor having prime responsibility for carrying it out. Therefore, it is possible that many work packages may exceed the three-month period simply because the activities underway require more than 90 days before a recognizable end event occurs and, as a result, it may exceed the $100,000.00 value."

In determining work packages for use with the Material Expediting System presented in this report, it is necessary that each work package not extend over a pre-determined selected maximum length of time (the previous mentioned definition states 90 days), otherwise materials may be on the site much longer than desired. For example, if a maximum length was not imposed, it would be possible for a work package having an item of work requiring similar material at the beginning of the project as well as at the end. In this case, the like materials required for the work items at the end of the project would be ordered and delivered at the same time as the materials were ordered and delivered for the items of work carried out at the beginning of the project. This could result in materials being on the site longer than desirable.

An example of breaking a project down into work packages, as applied to a two-storey rectangular shaped office building measuring 50 feet by 100 feet in plan, might be as follows:

No.	Work Package
1.	Concrete Foundation,
2.	Structural Steel Frame,
3.	Concrete floors, first and second,
4.	Masonry,
5.	Built-up Roofing,
6.	First floor, all trades and finishes,
7.	Second floor, all trades and finishes,
8.	Exterior services and site development.

5. SUMMARY

In this Chapter all the required inputs for a system which would meet the design criteria discussed in Chapter I were defined. To show this more clearly separate listings of inputs are shown in figure 2; one which comes from information already being used by construction organizations and the other, information that is proposed to be collected for a Material Expediting System. The outputs to meet the design criteria are also listed in Figure 2.

INPUT

INFORMATION PRESENTLY AVAILABLE

1. Bill of Materials.
2. Coding System.
3. Job Schedule.
4. General Stores Inventory

ADDITIONAL INFORMATION REQUIRED

1.
1. Relationship between job schedule & material delivery schedule.
2. Work Breakdown Structure (Work Packages).
3. More Elaborate Coding System.
4. Information on each material as follows:
   1. Are shop drawings required?
   2. Time required for preparation of shop drawings?
   3. Time for review of shop drawings.
   4. Time for Architect's Review and Approval of shop drawings
   5. Allowance for Resubmission of shop drawings.
   6. Fabrication time.
   7. Shipping time, for Supplier and General Stores.
   8. Lead time
5. The Quantity of each material in General Stores which is available for use in the Project in question.

OUTPUT

1. Total Quantity of Each Material Required for the whole project and also the total per work package.
2. Quantity of Each Material available from General Stores
3. Quantity of Each Material to be ordered from Supplier.
4. Delivery Schedule for each material.
5. For each material the following:
   1. Order Date
   2. Date of Receive Shop Drawings and/or Samples
   3. Date to submit shop drawings for approval
   4. Date shop drawings are to be received back from Architect.
   5. Shipping Date
   6. Delivery Date
6. Information similiar to that listed above for materials ordered for delivery General Stores, to replenish depleted stock.
7. A requisition for each material either ordered from supplier for project or General Stores or from General Stores to Project and containing the following:
   1. Order Date
   2. Whether shop drawings are required and if so the date they are required
   3. Description of material and quantity
   4. Delivery Schedule for Material.

INPUT-OUTPUT CHART
MATERIAL EXPEDITING SYSTEM
FIG. 2

CHAPTER III - THE MATERIAL EXPEDITING SYSTEM

1. GENERAL

In Chapter I the existing situation was described and the problem defined with regard to the expediting and delivery of materials to a project.

In Chapter II existing procedures and methods in use were described which can assist in the problem solution and which can be incorporated in the proposed system.

In this chapter the complete proposed Material Expediting System will be described.

2. SUMMARY FLOW DIAGRAM

A summary flow diagram of the proposed system is illustrated in Figure 5. As can be seen from this figure, immediately after the award of contract four procedures can commence;

a) Prepare Work Breakdown Structure (form 1)

b) Prepare CPM Schedule

c) Update Materials Information Sheet (form 2)

d) Update General Stores Materials list (form 3)

e) Prepare Bill of Materials (form 4)

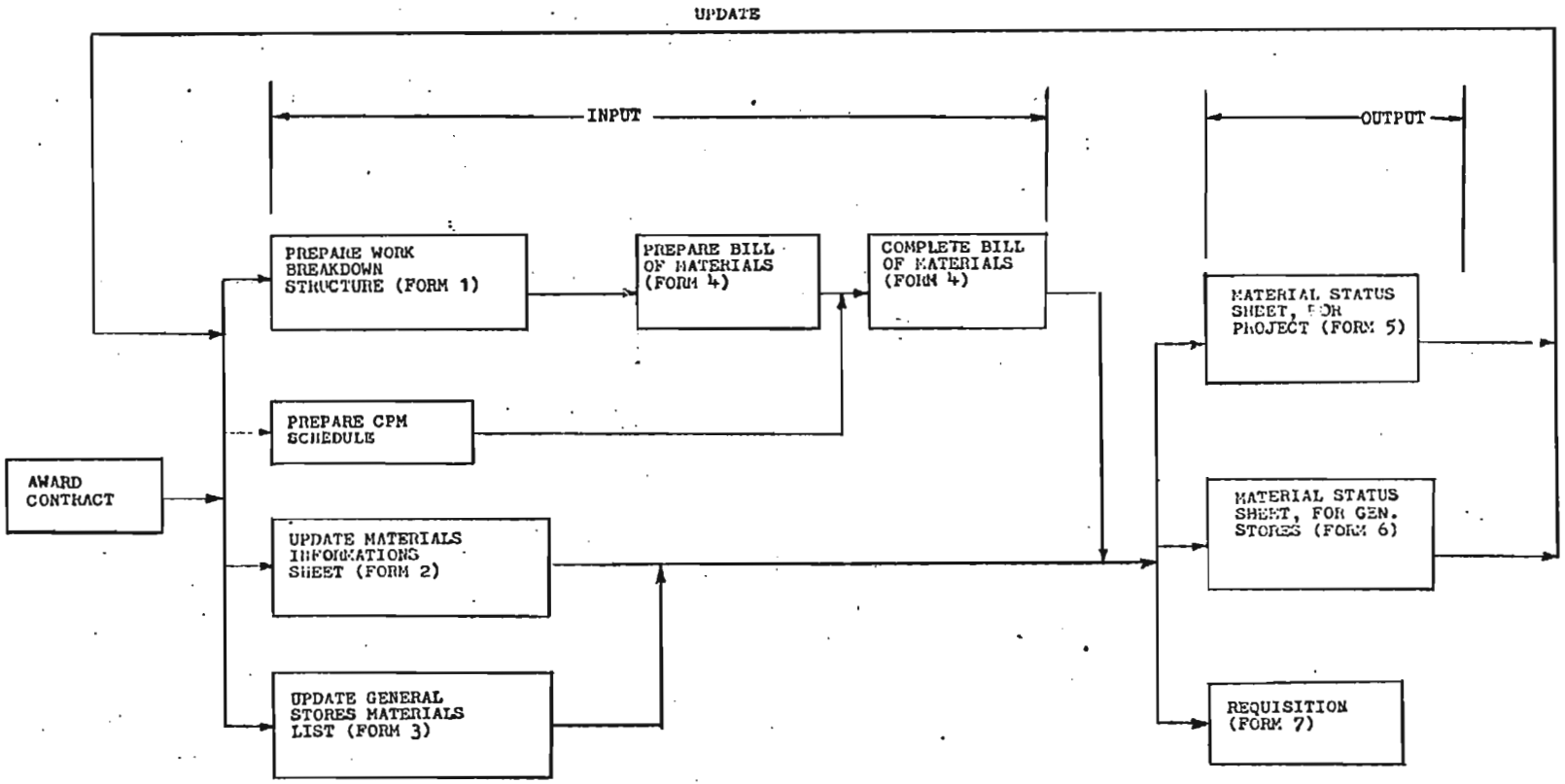
After processing, the outputs are produced which are:

f) Material Status Sheet for project (form 5)

g) Material Status Sheet for General Stores (form 6)

h) Requisition (form 7)

The whole process of ordering and expediting materials for a



SUMMARY FLOW DIAGRAM

MATERIAL PROCUREMENT SYSTEM

FIG. 3

project are tied to the Schedule for the Construction of that project.

All materials are not shipped at once, but are shipped in smaller quantities to coincide with the rate at which they are scheduled for use. The Work Packages (which are limited in duration eg. 90 days - see Chapter II) determine the size of the material shipments and the delivery is determined from the start date of the first activity in each Work Package requiring the material.

The systems provided for updating. Updated information or data can be fed into the system at regular intervals such as bi-weekly or monthly or at any time thought necessary and corresponding new reports will be provided.

In Following Sections of this Chapter the forms will be illustrated and described in detail.

3. INPUTS

3.1 WORK BREAKDOWN STRUCTURE - FORM 1

This in one of the first forms to be completed and can be done fairly rapidly. The job is broken down into Work Packages, concisely described, and listed as accurately as possible in the order in which they are likely to be carried out and numerically identified in ascending order i.e., 1, 2, 3, etc.

A sample of this is illustrated in Figure 4.

3.2 MATERIALS INFORMATION SHEET (FORM 2)

This form gives the estimated lengths of time that are required for various procedures for each type of material. It may be necessary to

only initially prepare this form once, usable with an update for each project. A description of each column is as follows:

Column 1 - Material Code

In this column will be listed the material code number for each type of material in question.

Column 2 - Material

Here will be listed the name of the material as it is described in the coding system.

Column 3 - Unit of Measure

Here will be indicated the units in which the materials are measured. The abbreviated form will always be used:
i.e. pounds - lbs; feet board measure-fbm; each - ea; sheets - shts; cubic years - c.y., etc.

Column 4 - Are Shop Drawings and/or samples Required

This column will require a simple yes or no answer. Practically all items in a building require shop drawings and/or samples, with the exception of national standards and basic items such as lumber, sheets of plywood, gyprock, etc. If the word "no" is inserted in this column for any particular material, Columns 5, 6, 7 and 8 will be blank or zero.

Column 5 - Time for Preparation of Shop Drawings (T1).

Here insert the time that is expected that the supplier will require to prepare and forward shop drawings and/or samples, from the date that he receives the order to supply the material.

Column 6 - Time for Review (T2)

Here insert the time that would be required by the Contractor to

review the shop drawings and/or samples to insure they conform with the order requirements and the plans and specifications, and to submit them for the required approval.

Column 7 - Time for Architect's Review and Approval (T3)

Here insert the estimated time that would be required by the Architect to review and hopefully approve, and return the shop drawings or advise on the acceptance of the sample.

Column 8 - Time for Resubmission (T4)

In the event that the shop drawings and/or samples submitted do not meet with the Architect's approval and are returned stamped "Not Approved - Resubmit", a period of time must be provided for the preparation and re-submission, which would be inserted in this column.

Column 9 - Time for Fabrication (T5)

This column is for inserting the fabrication time, if any, for the material in question.

Columns 10 and 11 - Time for Shipping; from Stores (T6)
or from Supplier (T7)

Here the estimated time for shipping is inserted in one column or the other whether it is shipped from the Contractor's stores or from a Supplier to the job-site.

Column 12 - Lead Time (T8)

Lead time is the arbitrarily selected period of time that the user would like the material on the job-site, prior to it being scheduled for incorporation into the work.

A sample copy of this Material Information Sheet is illustrated in Figure 5.

3.3 GENERAL STORES MATERIALS LIST (FORM 3)

This form provides up-to-date information on materials which the Contractor carries in the General Stores, if there is one. A column by column description is as follows:

Column 1 - Material Code Number and Column 2 - Material

These are as previously described for Form 2 . Materials Information Sheet.

Column 3 - Material Description

This column provides for a further sub-division of the materials within the Material Code No. and Material. An example of this would be as follows:

Material Code No. 0320 is for the material Concrete Reinforcement. Within this material there are many various sizes and types, such as 3/8 inch diameter rebar; 1/2 inch diameter rebar; 5/8 inch diameter rebar. This is also described in Chapter II under Coding.

Column 4 - Unit of Measurement

As previously described for Form 2, Materials Information Sheet.

Column 5 - Quantity in Stock, available for the Project

This is self-explanatory.

Column 6 - Will this Material be Re-stocked

A simple yes or no will be inserted in this column for each material description. If "no" is inserted here, Columns 7, 8, 9 and 10 will not apply.

Column 7 - Minimum Quantity to be Held in Stock

The quantity inserted here is the "order point". When the quantity in stock plus the quantity on order falls below the minimum

quantity to be held in stock and Column 6 is in the affirmative, an order of the quantity equal to the maximum quantity to be held in stock minus the quantity in stock and the quantity on order will be generated.

Column 8 - Maximum Quantity to be Held in Stock

This is the maximum quantity, that should ever be held in stock at any time. It is the quantity used as the upper limit for determining sizes of re-stocking orders as described above.

Column 9 - Quantity on Order

This quantity is calculated as previously described and is the quantity listed in Column 3 - Quantity, on Form 6 - Material Status Sheet for General Stores, which will be described later.

Column 10 - Delivery Date

This is the estimated delivery date for the quantity on order and is obtained from Column 9 - Material Status Sheet for General Stores.

A sample of the General Stores Materials List - form 3, is illustrated in figure 6.

3.4 BILL OF MATERIALS (FORM 4)

This form when complete provides a complete list of all materials required for the whole project, described in detail and assembled together by work package. A column description of the form is as follows:

Column 1 - Work Package Number

This is now self-explanatory, as it has been previously described for Form 1 -

Column 2 - Material Code Number

This column is also now self-explanatory as it has been previously described for Form 2 - Materials Information Sheet.

Column 3 - Material Description

This column was also described previously for Form 3 - General Stores Materials List. It is a sub-division of the materials within the Material Code Number and Material.

Column 4 - Quantity

In this column is listed the quantity of each Material Description.

Column 5 - Unit of Measure

This column is self-explanatory.

Column 6 - Start Date of First Activity Requiring this Material

To obtain the date required for this column, it is necessary that the CPM Schedule first be prepared. By reference to the schedule, the start date of the first activity within the work package in question which requires the item as listed under Material Description will be found. This data establishes the link between the Material Expediting System and the Construction Schedule. A date is necessary for each individual item listed under Material Description

A sample of the Bill of Materials Form 4 is illustrated in Figure 7.

4. OUTPUTS

4.1 MATERIAL STATUS SHEET (FOR PROJECT) - FORM 5

This is the first output form of the Material Procurement System and is probably the most powerful form of the whole system. It gives complete information on the materials and the status of the materials at any point in time as it is progressing through the procurement pro-

cess. A column description is as follows:

Columns 1 to 3 are now self-explanatory.

Column 4 - Total Job Quantity

This is the total quantity of each material , and by Code Number, required for the whole project on the assumption that all material will be ordered from the same supplier or source. No destinction is made between them,and their quantities are summed together under each material.

Column 5 - Total Quantity from Stores

This is the total quantity of the material by Code Number which can be obtained from the General Stores.

In all cases materials will be first taken from the General Stores , if these materials are available in General Stores. The balance of materials not available from General Stores will be ordered from a supplier and will be listed in Column 6 - TOTAL QUANTITY FROM SUPPLIER.

Columns 7, 8 and 9

Provides for a breakdown of the quantities from stores and from supplier on a work package basis.

Column 10 - Order/Expedite Date

This is the latest date that the material can be ordered or expedited so that it will arrive on the job in sufficient time for incorporation into the work when required, according to the CPM Schedule.

It is arrived at by substracting $T_1 + T_2 + T_3 + T_4 + T_5 + T_7 + T_8$

(from form 2 - Materials Information Sheet) from start date of the first activity requiring the material (Column 6 - Form 4) - Bill of Materials.

Column 11 - Receive Shop Drawings and/or Samples

This is the date that shop drawings for each material are scheduled to be received at the office of the Contractor, whether the materials are to be supplied by a supplier or are to be supplied from General Stores. It is arrived at by adding the time (T1) - Time for Preparation of Shop Drawings and/or Samples, taken from Material Information Sheet, Form 2, to the Order/Expedite Date, Column 10.

Column 12 - Submit for Approval

This is the date that shop drawings and/or samples are to be submitted to the Architect or Owner for approval. It is determined by adding the time (T2) - Time for Review, taken from Material Information Sheet, Form 2, to the Receive Shop Drawings and/or Samples Date.

Column 13 - Receive Back From Architect

This is the date that shop drawings and/or samples are due back from the Architect. It is determined by adding the Time (T3) - Time for Architects Review and Approval, taken from Materials Information Sheet, Form 2, to the Submit for Approval date.

If the shop drawings and/or samples were not approved by the Architect, it is necessary that new shop drawings and/or samples be prepared and re-submitted to the Architect. To provide for this eventuality, (T4) - Time for Resubmission, has been included in the Materials Information Sheet, Form 2. This time allows for the repeat of the process of preparation and approval.

Column 14 - Shipping Date from Stores

This is the scheduled date for the shipping of the material from General Stores. It is best arrived at by subtracting the summation of (T6) - Time for Shipping from Stores and (T8) - Lead Time, taken from Materials Information Sheet, Form 2, from Start Date of First Activity requiring this Material, Bill of Materials, Form 4.

Column 15 - Shipping Date from Supplier

This is the scheduled date for the shipping of the materials from the supplier. It is determined similar to Column 14, except, of course, that Time for Shipping from Supplier (T7) is substituted for Time for Shipping from Stores (T6).

Column 16 - Delivery Date

This is the scheduled date for the arrival of the materials to the site. It is determined by subtracting Lead Time (T8) taken from Materials Information Sheet, Form 2, from Start Date of First Activity Requiring this Material, Bill of Mateirals, Form 4.

4.2 MATERIAL STATUS SHEET FOR GENERAL STORES (FORM 6)

This Material Status Sheet gives readily up-to-date information on the status of materials ordered for delivery to General Stores. It is very similar in make-up to Material Status Sheet for Project (Form 5). A column by column description is as follows:

Columns 1 and 2

Need no further explanation.

Column 3 - Quantity

This is the total quantity of material placed on order to replenish

the General Stores Stock. It is calculated by first comparing the "Quantity" in Column 4 of Form 4 - Bill of Materials with the "Quantity in Stock" - Column 5 of Form 3 - General Stores Material List. If it is greater, the "Quantity to Order" will equal the "Maximum Quantity to be held in Stock" Column 8 of General Stores Material List. If it is less it is to be subtracted from the "Quantity in Stock" and the resulting figure compared to the "Minimum Quantity to be held in Stock", Columns of Form 3 - General Stores Materials List. If it is less, the "Quantity to order" equals "Maximum Quantity to be held in Stock" minus the "Quantity in Stock" after "Quantity" from Column 4 of Bill of Materials then been subtracted.

Column 4 - Unit

- as explained previously

Column 5 - Order/Expedite Date

This is the date upon which the replenishing order is to be placed and is the same date as the "Shipping Date" of the material from the General Stores.

Column 6 - Receive Shop Drawings

This is calculated by adding "Time for Preparation of Shop Drawings" (T1) (Column 5, Form 2 - Materials Information Sheet) to "Receive Shop Drawings" day.

Column 8 - Shipping Date

This is calculated by adding "Time for Fabrication" (T5) (Column 9, Form 2 - Materials Information Sheet) to "the Return Shop Drawings Date".

Column 9 - Delivery Date

This is calculated by adding "Time for Shipping from Supplier" (T7), (Column 11, Form 2 - Materials Information Sheet) to "Shipping Date".

A sample is illustrated in Figure 9.

4.3 REQUISITION - FORM 7

This is the last form produced by the system and contains all necessary information, except the prices, to enable the preparation and issuing of company purchase orders.

A separate requisition will be produced for:

a) Each Material Code for material designated to project from Supplier

b) Each Material Code for material designated to project from General Stores; as well as for,

c) Each material to General Stores from Supplier.

Although the form is fairly self-explanatory and straight forward, a brief detailed description is as follows:

Material Code No. - Insert the Material Code No.

Material - Insert the name of the material.

Order Date - Taken from Column 10 - Form 5 - Material Status Sheet for Project or Column 5, Form 6 - Material Status Sheet for General Stores.

Source of Supply - Insert Supplier or General Stores.

Shop Drawings and/or Sampled Required By - Here insert the date which will be taken from Column 11 - Material Status Sheet (For Project), Form 5 or Column 6 - Materials Status Sheet

WORK BREAKDOWN STRUCTURE

FORM 1

1 WORK PACKAGE	2 WORK PACKAGE NO.

FIGURE 4

MATERIALS INFORMATION SHEET

FORM 2

1 MATERIAL CODE	2 MATERIAL	3 UNIT OF MEASURE	4 ARE SHOP DRAWINGS AND/OR SAMPLES REQ'D YES/NO	5 TIME FOR PREPARATION OF SHOP DRAWINGS ETC T1	6 TIME FOR REVIEW T2	7 TIME FOR ARCHITECT'S REVIEW AND APPROVAL T3	8 TIME FOR RESUBMISSION T4	9 TIME FOR FABRICATION T5	TIME FOR SHIPPING 10 FROM STORES T6	11 FROM SUPPLIER T7	12 LEAD TIME

FIGURE 5

FORM 3

GENERAL STORES MATERIALS LIST

MATERIAL CODE NO.	MATERIAL	MATERIAL DESCRIPTION	UNIT OF MEASURE	QUANTITY IN STOCK	WILL THIS MATERIAL BE RESTOCKED	MINIMUM QUANTITY TO BE HELD IN STOCK	MAXIMUM QUANTITY TO BE HELD IN STOCK	QUANTITY ON ORDER	DELIVERY DATE

FIGURE 6

FIGURE 7

BILL OF MATERIALS

FORM 4

WORK PACKAGE NO. 1	MATERIAL CODE NO. 2	MATERIAL DESCRIPTION 3	QUANTITY 4	UNIT OF MEASURE 5	START DATE OF FIRST ACTIVITY REQUIRING THIS MATERIAL 6

FORM 5

MATERIAL STATUS SHEET FOR PROJECT

1 MATERIAL CODE NO.	2 MATERIAL	3 UNIT OF MEASURE	4 TOTAL JOB QUANTITY	5 TOTAL QUANTITY FROM STORES	6 TOTAL QUANTITY FROM SUPPLIER	QUANTITY PER WORK PACKAGE			10 ORDER / EXPEDITE DATE	11 RECEIVE SHOP DRAWINGS AND/OR SAMPLES	12 SUBMIT FOR APPROVAL	13 RECEIVE BACK FROM ARCHITECT	SHIPPING DATE		16 DELIVERY DATE
						7 WORK PACKAGE NO.	8 QUANTITY FROM STORES	9 QUANTITY FROM SUPPLIER					14 FROM STORES	15 FROM SUPPLIER	

FIGURE 8

MATERIAL STATUS SHEET
FOR GENERAL STORES

FORM 6

MATERIAL CODE NO.	MATERIAL	QUANTITY	UNIT OF MEASURE	ORDER/EXPEDITE DATE	RECEIVE SHOP DRAWINGS ETC.	RETURN SHOP DRAWINGS ETC.	SHIPPING DATE	DELIVERY DATE

FIGURE 9

Form 7

REQUISITION

MATERIAL CODE NO. _____ MATERIAL _____ ORDER DATE _____

SOURCE OF SUPPLY: _____

SHOP DRAWINGS REQUIRED BY: _____ SHOP DRAWINGS WILL BE RETURNED BY: _____

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	UNIT PRICE	TOTAL

DELIVERY SCHEDULE

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	REQUIRED SHIPPING DATE	REQUIRED DELIVERY DATE

FIGURE 10

(For General Stores), Form 6. If shop drawings are not required, N. A. (not applicable) will be inserted.

Shop Drawings and/or Samplex Will Be Returned By - Here insert the date that the shop drawings and/or samples will be returned to the supplier, which will be the date found in Column 13 - Form 5 of Column 7 - Form 6. If shop drawings are not required, N.A. (not applicable) will be inserted.

Under Material Description the description of each sub-item of material will be listed. Under Quantity the total quantity of each sub-item of material will be listed. Under Unit of Measurement the unit of measurement for each sub-item of material will be inserted.

The Unit Price and Total columns will not be filled in by the computer. These must be filled in manually after the requisition forms have been produced and after prices have been obtained.

In the Delivery Schedule block, the sub-item of material will be inserted under Material Description. Under the Quantity column, the quantities of the sub-items which are required for each work package will be inserted. The dates to be inserted in Required Shipping Date column and Required Delivery Date column are dates obtained from Column 14 or 15 and Column 16 of Form 5, or Column 8 and 9 of Form 6.

A sample is illustrated in Figure 10.

5. DETAILED FLOW CHART

A detailed flow chart for the system has been prepared and is presented in the following pages.

A list of abbreviations of arrays and variables used in the

flow chart is as follows:

FORM 4

WPNA (I)	-	Work Package No.
MATCOA (I)	-	Material Code No.
MATDESA (I)	-	Material Description
QA (I)	-	Quantity
UNITA (I)	-	Unit of Measurement
SDAA (I)	-	Start date of 1st. activity using the material
NOBM	-	No. of "Form 4" cards

FORM 3

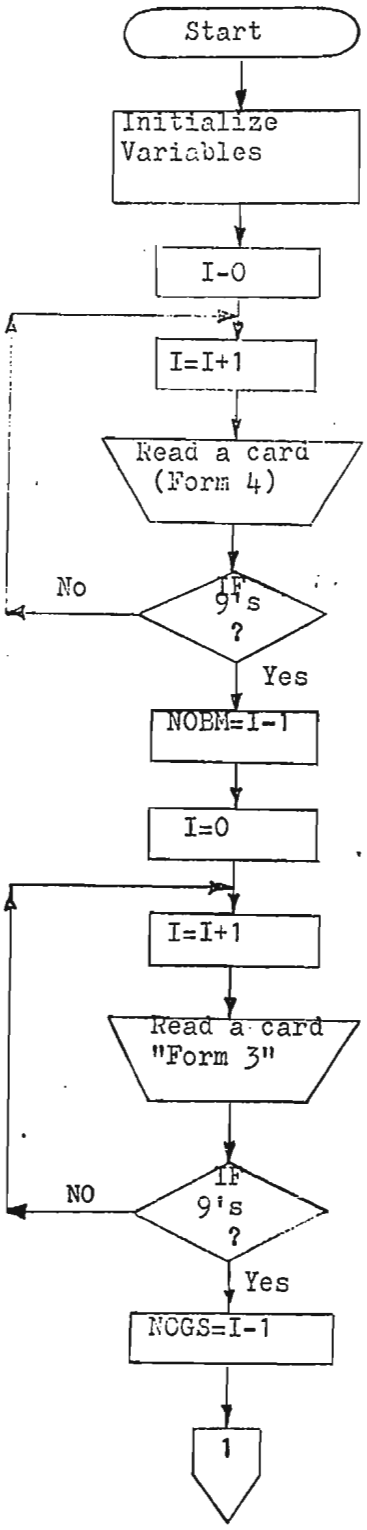
MATCOB (I)	-	Mat. code No.
MATB (I)	-	Material type
MATDESB (I)	-	Material description
UNITB (I)	-	Unit of measurement
QISB (I)	-	Quantity in stock available for this project
WMRB (I)	-	Will material be restocked
MINQB (I)	-	Min. quantity to be held
MAXQB (I)	-	Max. quantity to be held
QOOB (I)	-	Quantity on order
DDB (I)	-	Delivery date
NOGS	-	No. of "Form 3" cards

FORM 2

MATCOC (I)	-	Material code No.
MATC (I)	-	Material type
UNITC (I)	-	Unit of measurement

ASRC (I)	-	Are shop drawings and/or samples required
TIC (I)	-	Time for preparation of shop drawings and/or samples
T2C (I)	-	Time for review
T3C (I)	-	Time for architects approval
T4C (I)	-	Time for resubmission
T5C (I)	-	Time for fabrication
T6C (I)	-	Shipping time (from stores)
T7C (I)	-	Shipping time (from supplier)
T8C (I)	-	Lead time
NOMS	-	No. of "Form 2" cards
TQ (I)	-	Total quantity per material
MAT (I)	-	Material name
QFST (I)	-	Total quantity from stores
QFSU (I)	-	Total quantity from supplier
QWPST (I)	-	Quantity per work package form stores
QWPSU (I)	-	Quantity per work package from supplier
OEXD (I)	-	Order expedite date
RSDD (I)	-	Receive shop drawings and/or samples date
SFA (I)	-	Submit for approval date
RFA (I)	-	Receive from architect
SDST (I)	-	Shipping date from stores
SDSU (I)	-	Shipping date from supplier
DD (I)	-	Delivery date
RD (I)	-	Return shop drawings and/or samples date
SD (I)	-	Shipping date (Form 6)
DDT (I)	-	Delivery date (Form 6)

SOURCE (I)	-	Source of supply
SDRB (I)	-	Date on which shop drawings and/or samples required
SDR (I)	-	Date on which shop drawings and/or samples will be returned



- Initialize Variables

Step I

This procedure reads the 1st card file (Form 4 Records) and stores it in memory, each record contains:

WPNA (I), MATCOA)I), MATDESA (I), QA (I), UNITA (I), SDAA (I)

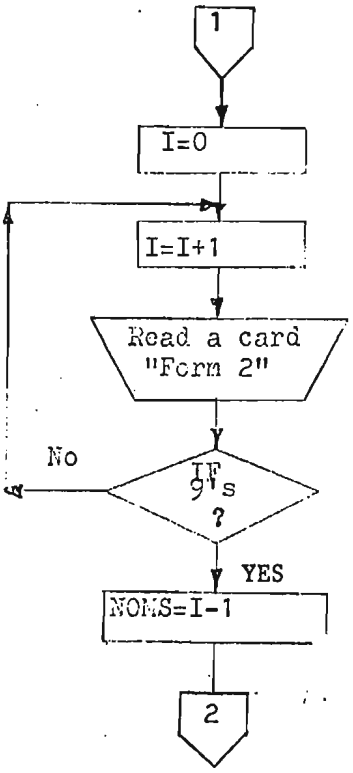
When a 9's card is encountered the program branches to set NOBM equal to the No. of records read.

Step 2

This procedure reads the 2nd card file (Form 3 Records) containing the following information:

MATCOB (I), MATB (I), MATDESB (I), UNITB (I), QISB (I), WNRB (I), MINQB (I), MAXQB (I), QOOB (I), DDB (I)

NOGS is set equal to the No. of records in the 2nd file.

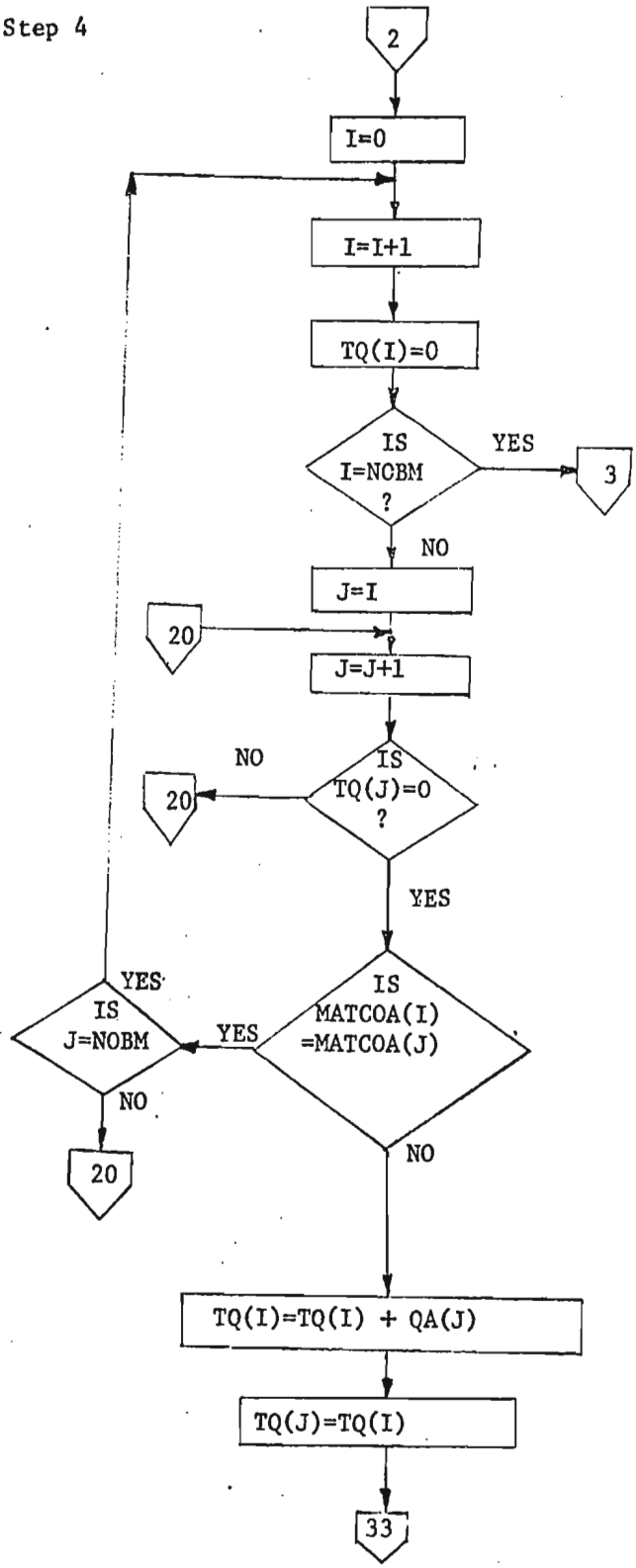


Step 3

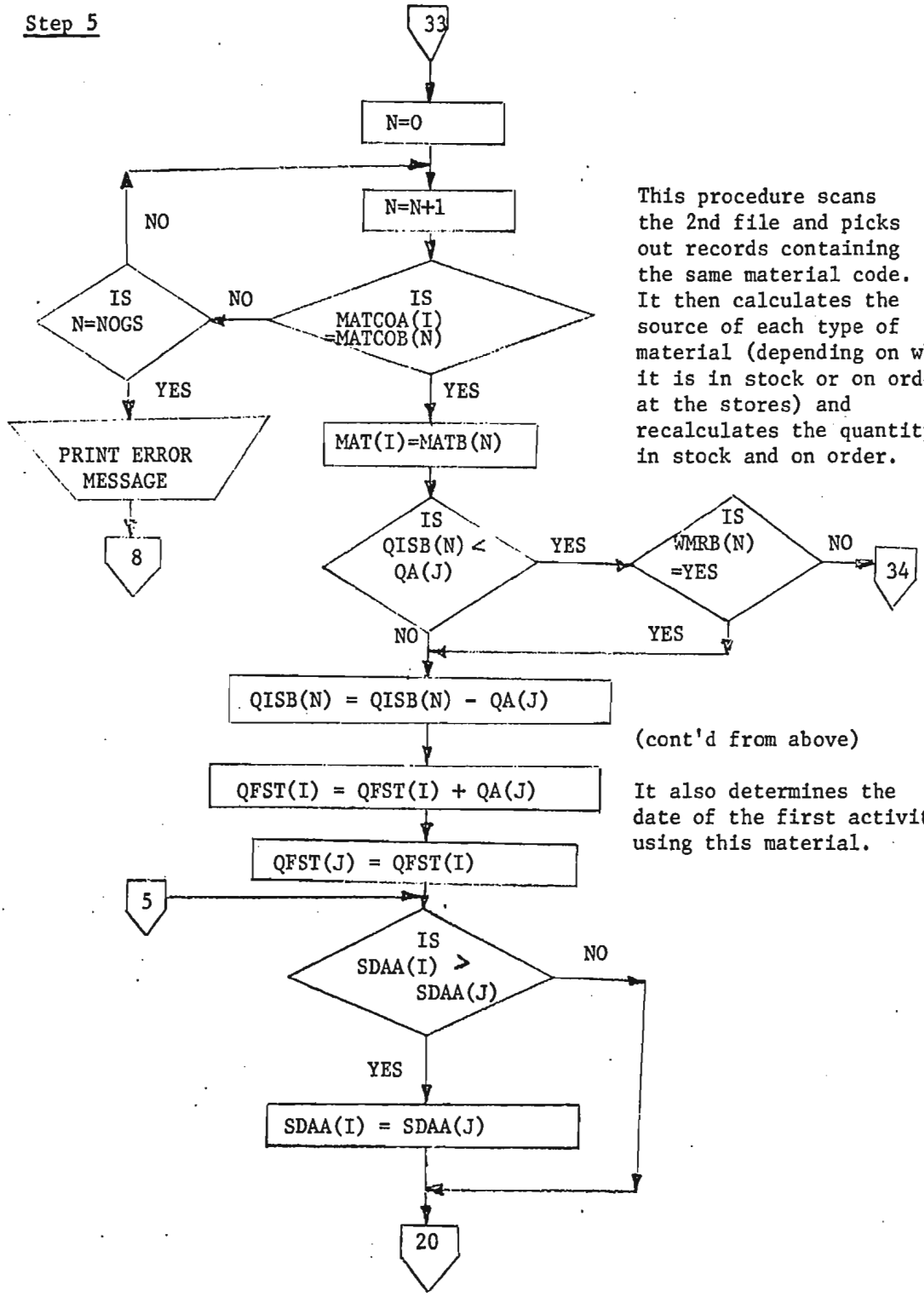
Reads 3rd card file (Form 2 Records) containing:

MATCOC (I), MATC (I), UNITC (I), ASRC (I), TIC (I), T2C (I), T3C (I), T4C (I), T5C (I), T6C (I), T7C (I), T8C (I)

Sets NOMS equal to the No. of records in file 3.



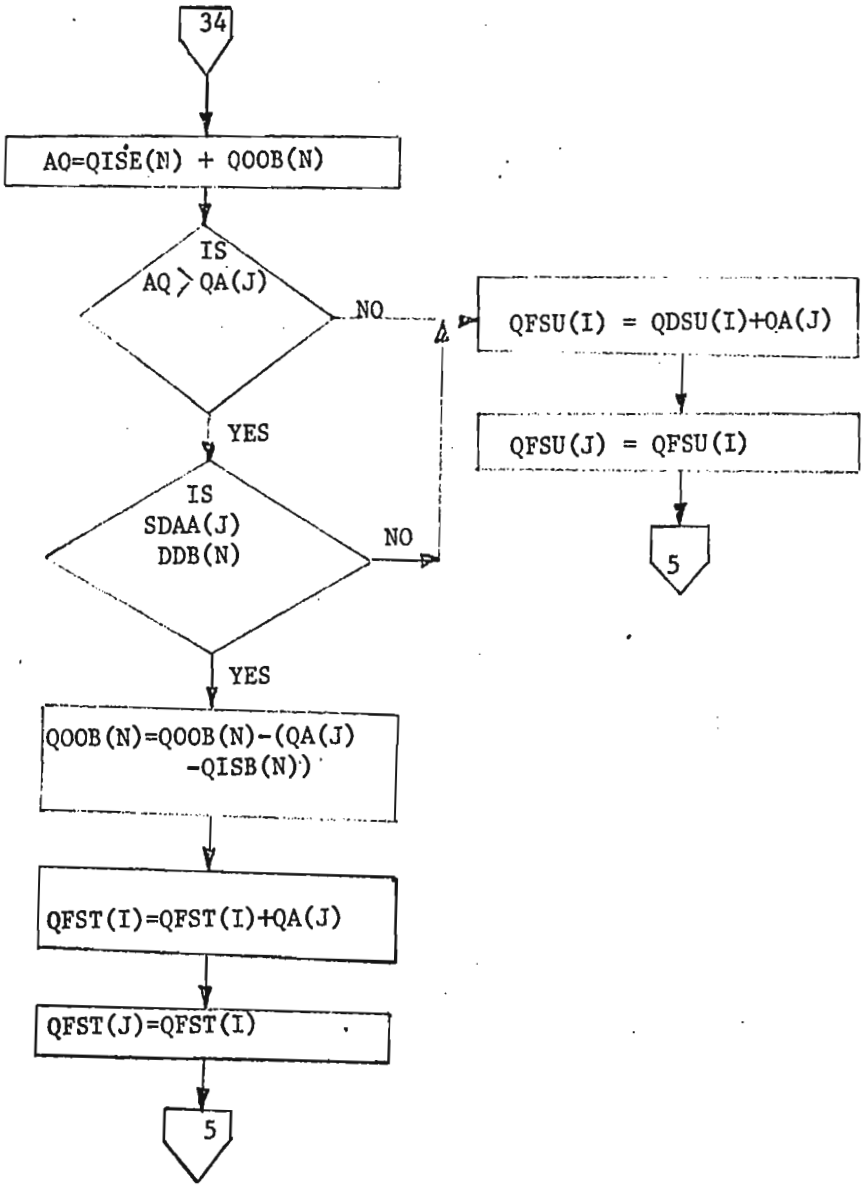
This procedure scans the 1st file and adds the "quantity required" on records with the same "material code" to get the total quantity required for each material, for each Work Package.



This procedure scans the 2nd file and picks out records containing the same material code. It then calculates the source of each type of material (depending on whether it is in stock or on order at the stores) and recalculates the quantity in stock and on order.

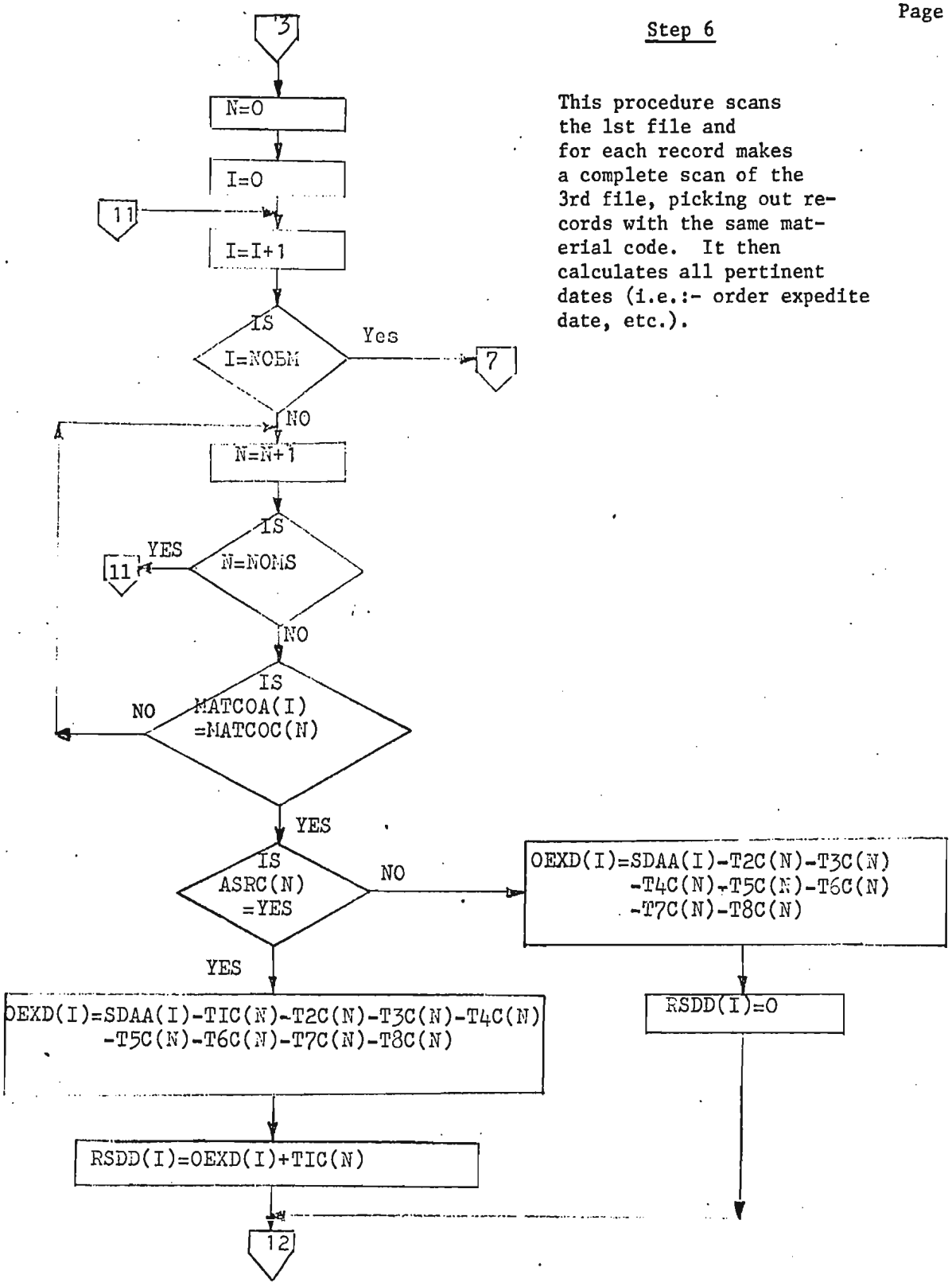
(cont'd from above)

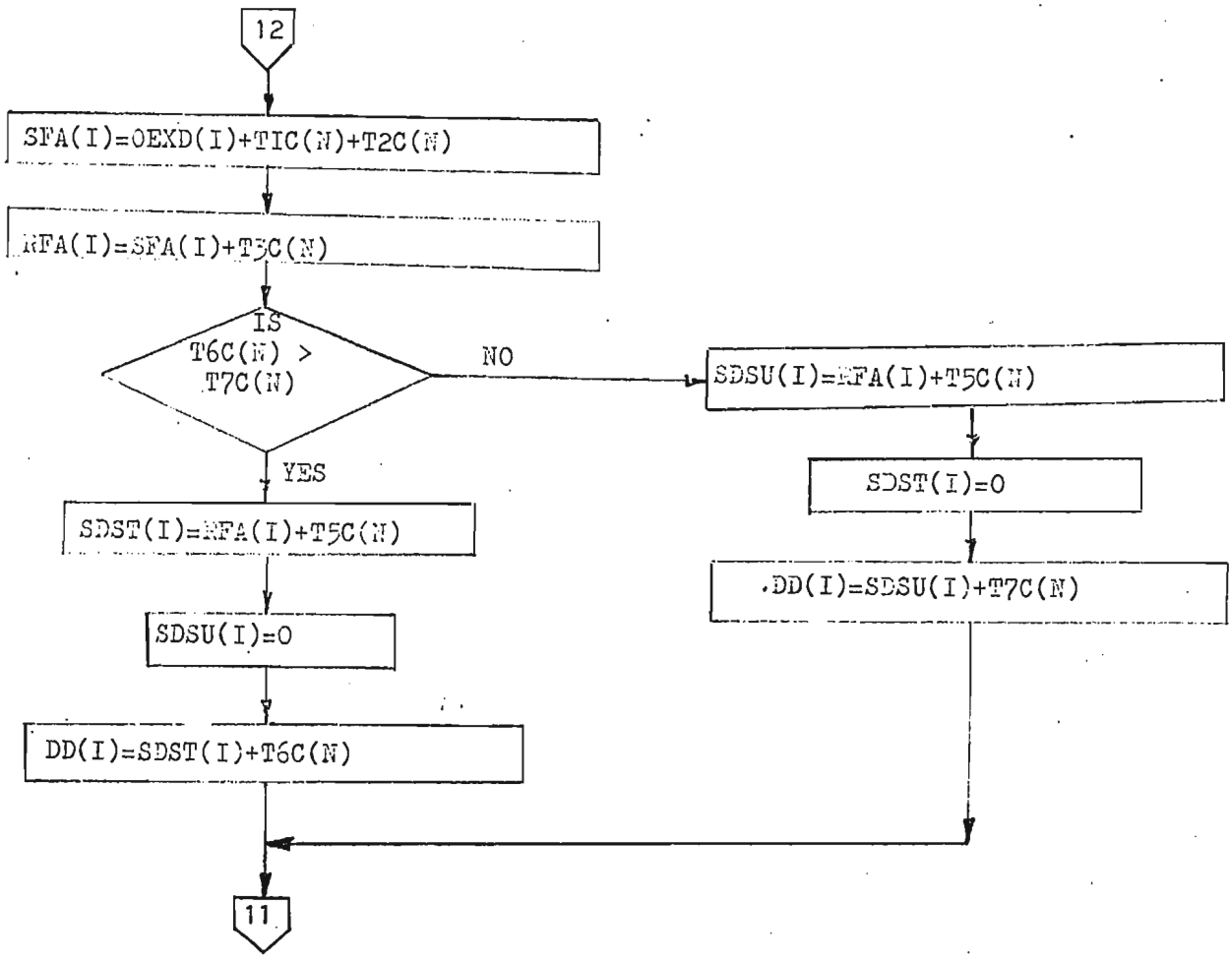
It also determines the date of the first activity using this material.


34
AQ=QISE(N) + QOOB(N)
IS
AQ > QA(J)
NO
YES
IS
SDAA(J)
DDB(N)
NO
YES
QOOB(N)=QOOB(N)-(QA(J)
-QISB(N))
QFST(I)=QFST(I)+QA(J)
QFST(J)=QFST(I)
5
QFSU(I) = QDSU(I)+QA(J)
QFSU(J) = QFSU(I)
5

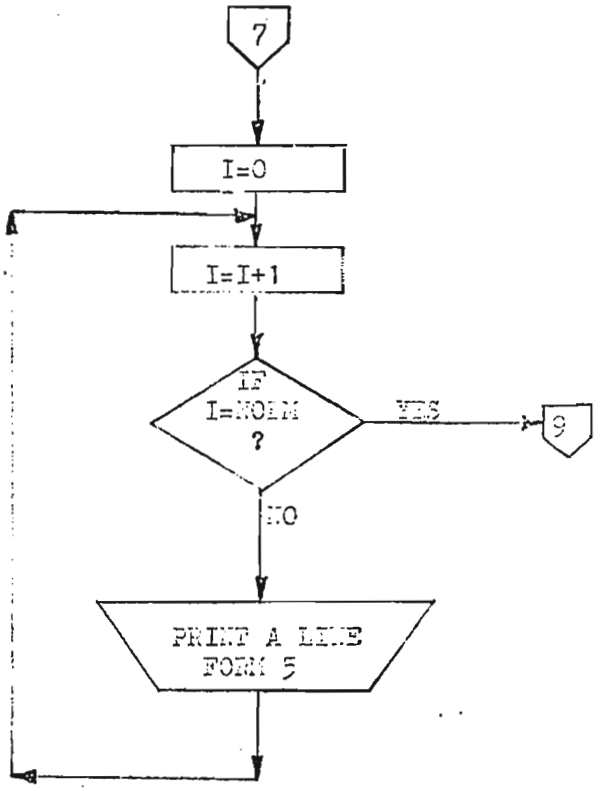
Step 6

This procedure scans the 1st file and for each record makes a complete scan of the 3rd file, picking out records with the same material code. It then calculates all pertinent dates (i.e.:- order expedite date, etc.).





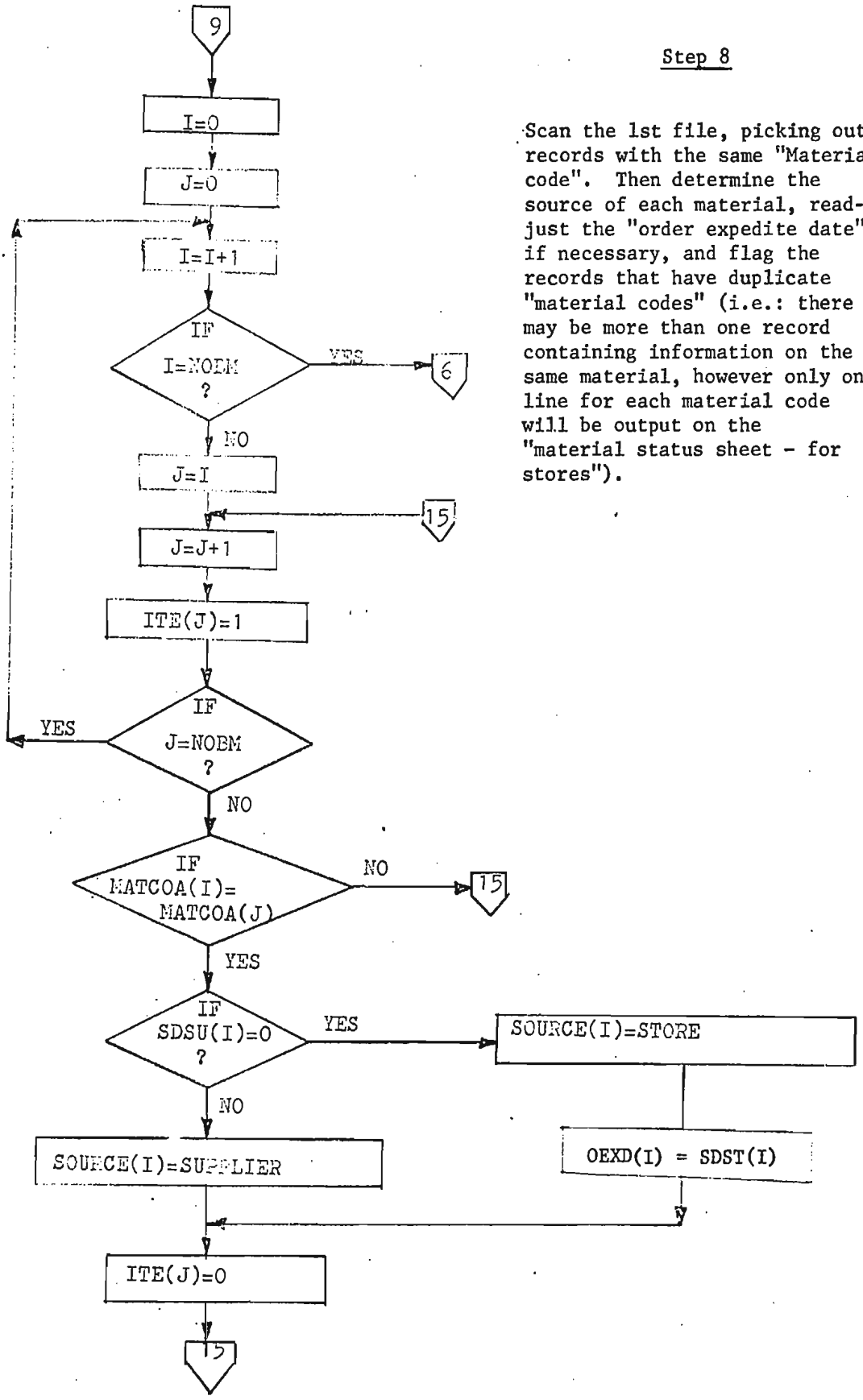
(Explanation on preceding page)



Step 7

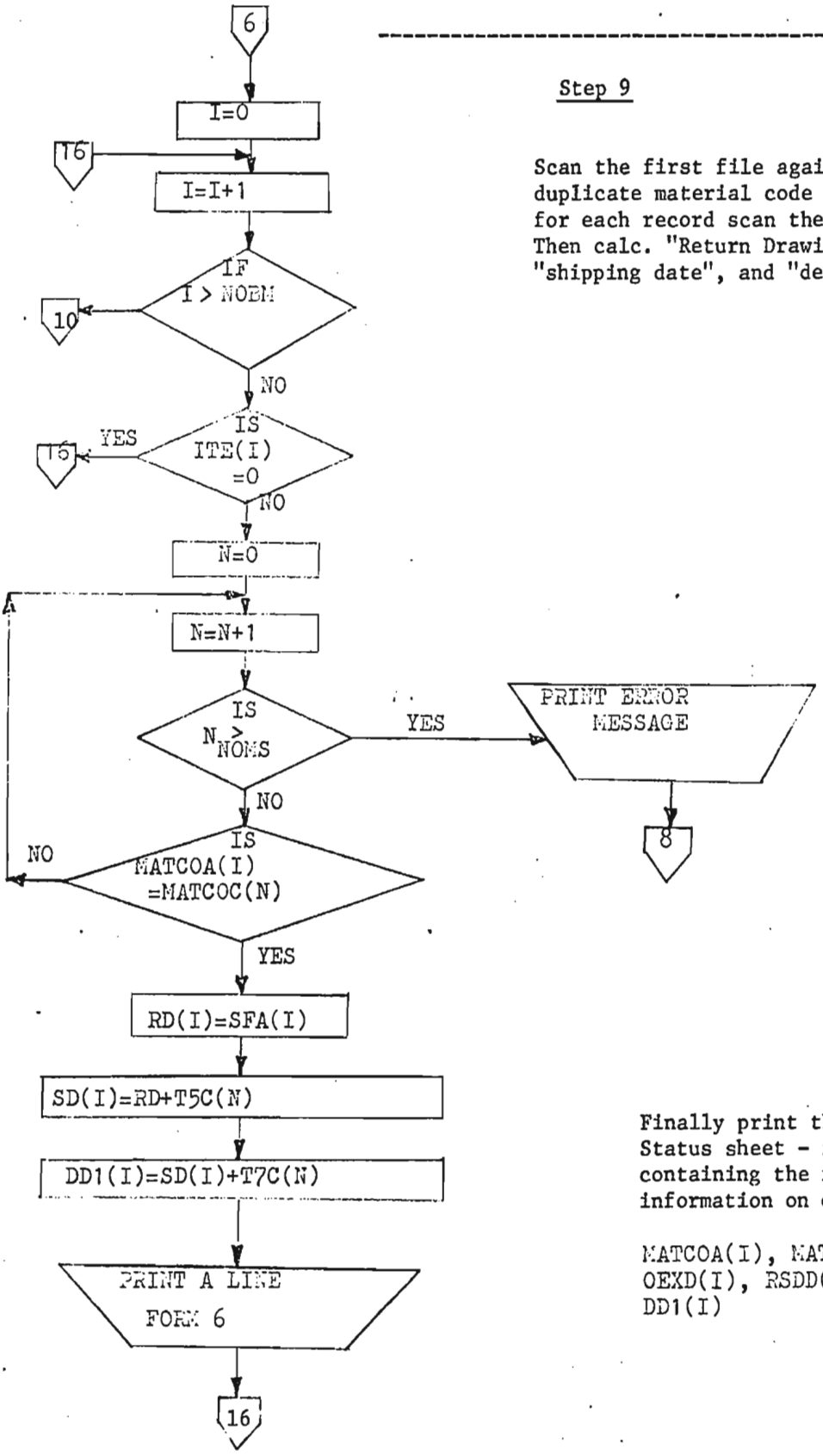
This procedure prints out the "Material Status Sheet - for project" putting the following information on each line:

MATCOA(I),MAT(I),UNITA(I),TQ(I), QFST(I),QFSU(I),WPNA(I),QWPST(I), QWPSU(I),OEXD(I),RSDD(I),SFA(I), RFA(I),SDST(I),SDSU(I),DD(I)



Step 8

Scan the 1st file, picking out records with the same "Material code". Then determine the source of each material, readjust the "order expedite date", if necessary, and flag the records that have duplicate "material codes" (i.e.: there may be more than one record containing information on the same material, however only one line for each material code will be output on the "material status sheet - for stores").

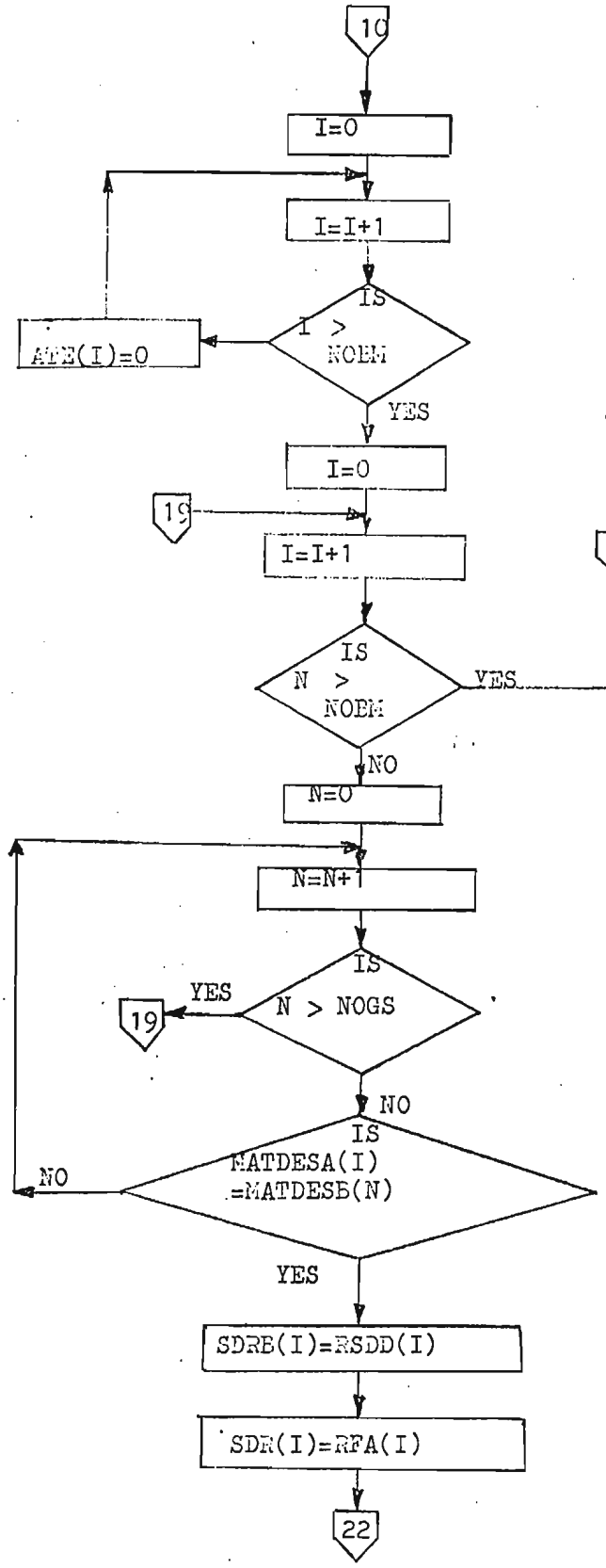


Step 9

Scan the first file again, ignoring duplicate material code records, and for each record scan the 3rd file. Then calc. "Return Drawings date", "shipping date", and "delivery date".

Finally print the "Material Status sheet - for stores", containing the following information on each line:

MATCOA(I), MAT(I), TQ(I), UNITA(I), OEXD(I), RSDD(I), RD(I), SD(I), DD1(I)



Step 10

Go thru the 1st file and set flag "ATE" for each record equal to 0

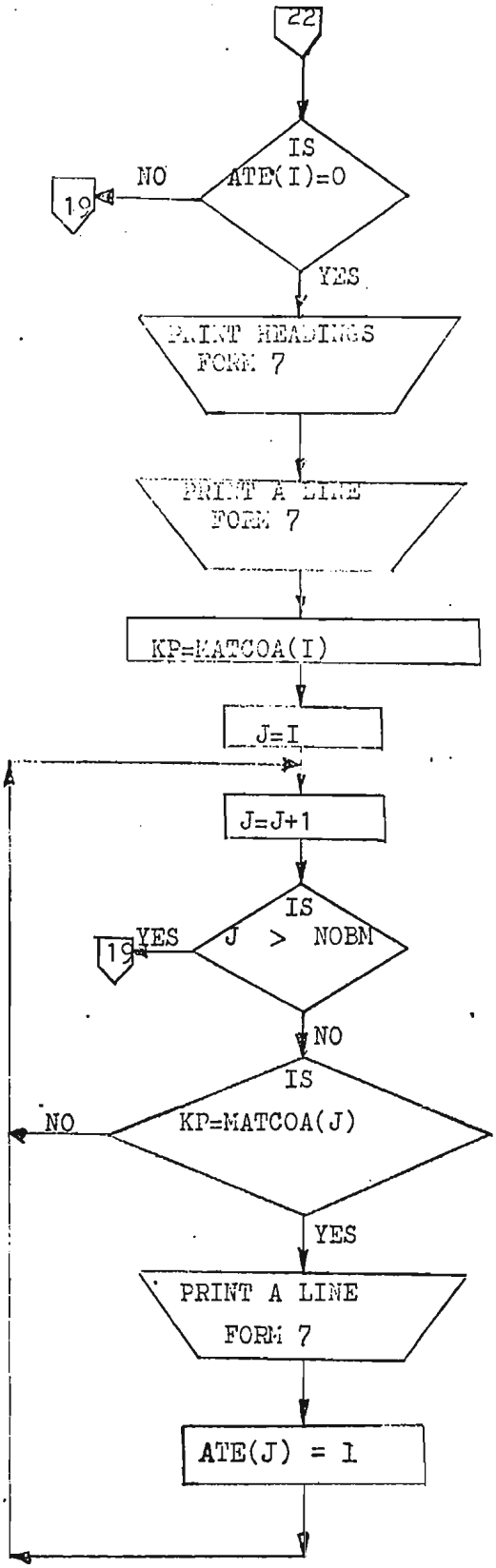
Step 11

Scan the 1st file one record at a time, stopping when the file is exhasted.

For each record scan the 2nd file picking out matching material codes and calculating shop drawing dates.

As each record is processed all records containing the same material code are flagged by setting ARE=1 and subsequently ignored.

(Cont'd)



For each material code a "Requisition and "Delivery Schedule" (Form 7")is printed. First, the headings are printed

(ie: MATCOA(I), MAT(I), OEXD(I), SOURCE(I), SDRD(I), SDR(I))

Then the first line is printed, containing the following information from record I:

MATDESA(I), QA(I), UNITA(I), MATDESA(I), QA(I), UNITA(I), SD(I), DD(I)

Finally the other records, containing this material code, are printed out.

ie: MATDESA(J), QA(J), UNITA(J), MATDESA(J), QA(J), UNITA(J), SD(J), DD(J)

CHAPTER 4 - EXAMPLE

1. GENERAL

In Chapter 3 the Material Expediting System and the forms were described in detail. In this Chapter the system and the forms will be further explained by the use of an example.

One material, WOOD DOORS, having Code Number 0820 in a hypothitical project titled "SMALL BUILDING" is worked through.

2. WORK BREAKDOWN STRUCTURE (FORM,1 FIG. 11).

As previously mentioned this one of the first forms completed and is done fairly rapidly.

In the example, the project has been divided into 8 work packages and are as listed on the form.

3. SCHEDULE

The next three figures are:

(a) CPM Arrow diagram - figure 12

(b) Table showing activities per work package, with early and late starts - figure 13

(c) Project Calender - figure 14

4. MATERIALS INFORMATION SHEET (FORM 2,FIGURE 15)

The times shown are working days. Where applicable the time required for mailing is included in the times shown. At the commencement of each project it may be necessary to review this data on this form and update the information where necessary for it to relate

accurately to the project in question.

5. GENERAL STORES MATERIALS LIST (FORM 3,FIGURE 16)

The information shown on the form in the example is representative of what might be found in a typical situation

6. BILL OF MATERIALS (FORM 4,FIGURE 17)

In the example there are three types or kinds of WOOD DOORS and all have the same code number 0820.

In this example NO distinction in the code number is given for the different kinds of the same material. This matter is described under CODING of Chapter 2.

7. MATERIAL STATUS SHEET FOR PROJECT (FORM 5,FIGURE 18)

In the example the total job quantity for WOOD DOORS is 20 (Column 4); the total quantity available from General Stores is 6, leaving the balance of 14 to purchase from a supplier. All the WOOD DOORS for the project appear in the same work packages (No. 8); and consequently the split in the quantity from General Stores and Supplier is the same for work package No. 8 as it is for the whole project.

Column 10 - Order/Expedite date is obtained by subtracting $T_1 + T_2 + T_3 + T_4 + T_5 + T_7 + T_8$ (from form 2 - Materials Information Sheet) from Start Date of first Activity requiring the material (Column 6 - form 4 - Bill of Materials).

i.e. 109 - (10 + 5 + 5 + 10 + 15 + 15 + 15) = 44

Column 11 - Receive Shop Drawings

This is arrived at by adding the time - T_1 (from form 2 - Materials Information Sheet) to the Order/Expedite Date,

i.e. 10 + 44 = 54

Column 12 - Submit for approval

It is determined by adding the time - T_2 - time for review, (Form 2 - Material Information Sheet) to the Receive Shop Drawings Date - Column 11 i.e. 5 + 54 = 59

Column 13 - Receive Back Architect

It is determined by adding T_3 (from form 2 - Materials Information Sheet) to submit for Approval date - Column 12

i.e. 5 + 59 = 64

Column 14 - Shipping Date from Stores

It is arrived at by subtracting $T_6 + T_8$ (Form 2 - Materials Information Sheet) form Start Date of first Activity Requiring this Material (From 4 - Bill of Materials)

i.e., 109 - 5 - 5 = 99

Column 15 - Shipping Date from Supplier

It is determined similarly to column 14, except of course T_7 - Shipping time from Supplier is substituted for T_6 - Shipping time from Stores i.e. 109 - 15 - 5 = 89

Column 16 - Delivery Date

It is determined by subtracting T_8 (Form 2 - Materials Information Sheet) from start date of first activity requiring this material (Form 4 - Bill of Materials)

i.e., 109 - 5 = 104

8. MATERIAL STATUS SHEET FOR GENERAL STORES (FORM 6,FIGURE 19)

Column 3 - Quantity

In the example all the quantity of the material in question in stock was committed to the Project, reducing the stock to zero and consequently an order is generated equal to the maximum quantity to be held in stock i.e. 10.

Column 5 - Order/Expedite Date

This is the same day that the materials are shipped from stores (Column 14 - form 5, Material Status Sheet for Project). i.e. 99.

Column 6 - Receive Shop Drawings

T_1 (form 2 - Materials Information Sheet) + Order/Expedite date - column 5 i.e. 10 + 99 = 109

Column 7 - Return Shop Drawings T_2 (form 2- Materials Information Sheet) + Receive Shop Drawings - Column 6

i.e. 5 + 109 = 114

Column 8 - Shipping Date

T_5 (form 2 - Materials Information Sheet) + Return Shop Drawings - Column 7 i.e.

15 + 114 = 129

Column 9 - Delivery Date

T_7 (Form 2 - Materials Information Sheet) + Shipping Date - Column 8 i.e.

15 + 129 = 144

9. REQUISITION - FORM 7 - FIGURES 20, 21, 22

The Requisition in the example is for ordering of the material from Supplier to Project.

The order date, the shop drawings required by date: and, the shop drawings will be returned by date; are all taken from the material status sheet for Project - form 5.

The next part of the Requisition lists the total quantity of materials required for the project less the quantities to be shipped from General Stores.

In the Second Part - Delivery Schedule, the quantities of each material required per work package are listed and opposite each is listed Required Shipping date and the Required Delivery Date (both taken from Material Status for Project - form 5).

In the example the materials in question are all found in the same work package and consequently the quantities are also the total job quantities ordered from supplier. *

The Second requisition example is for the material ordered from the General Stores to be delivered to the project.

The third requisition example is for the material ordered from Supplier to be delivered to General Stores to replenish the stock.

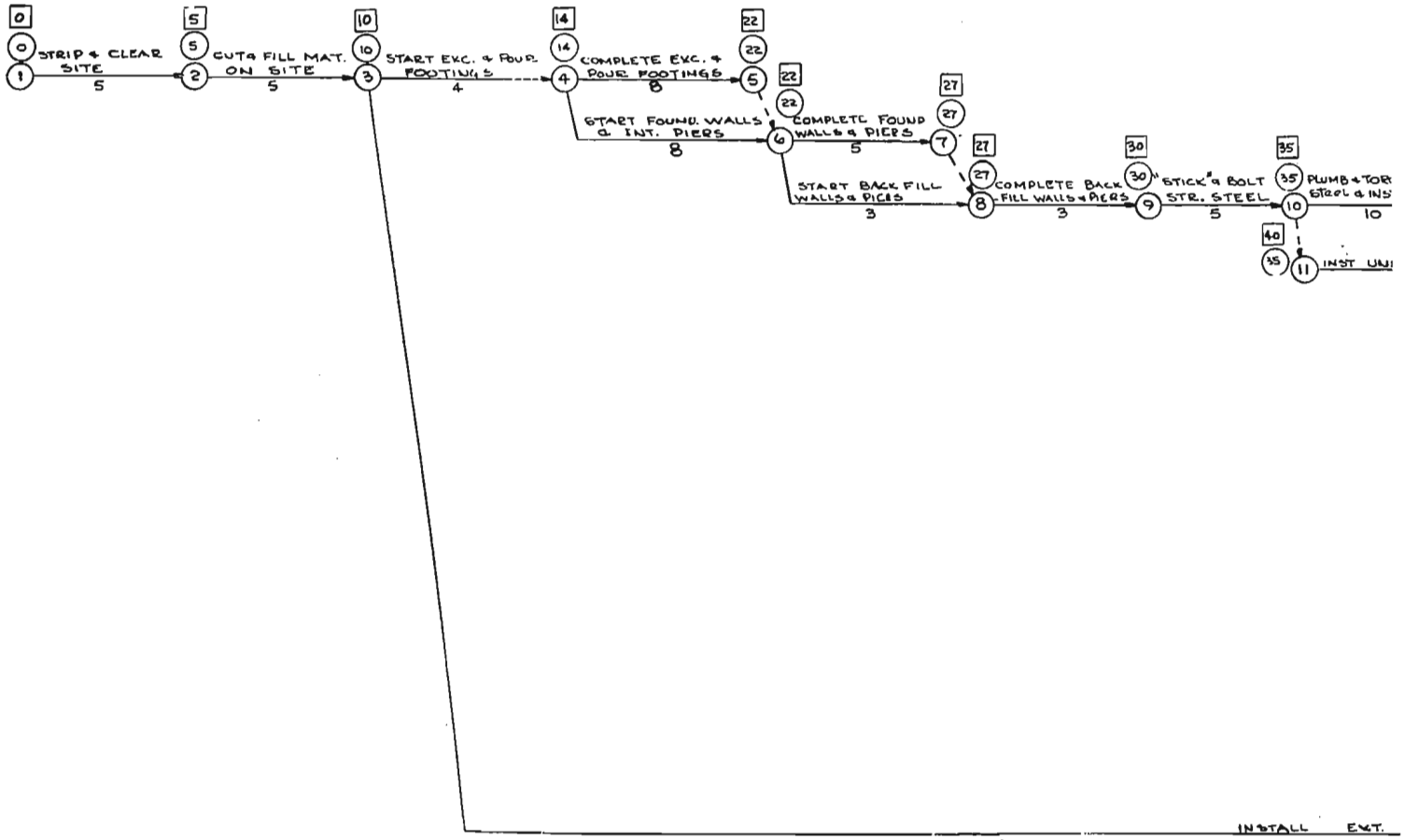
* In the computer program example in Appendix IV all aspects of the system are illustrated.

WORK BREAKDOWN STRUCTURE

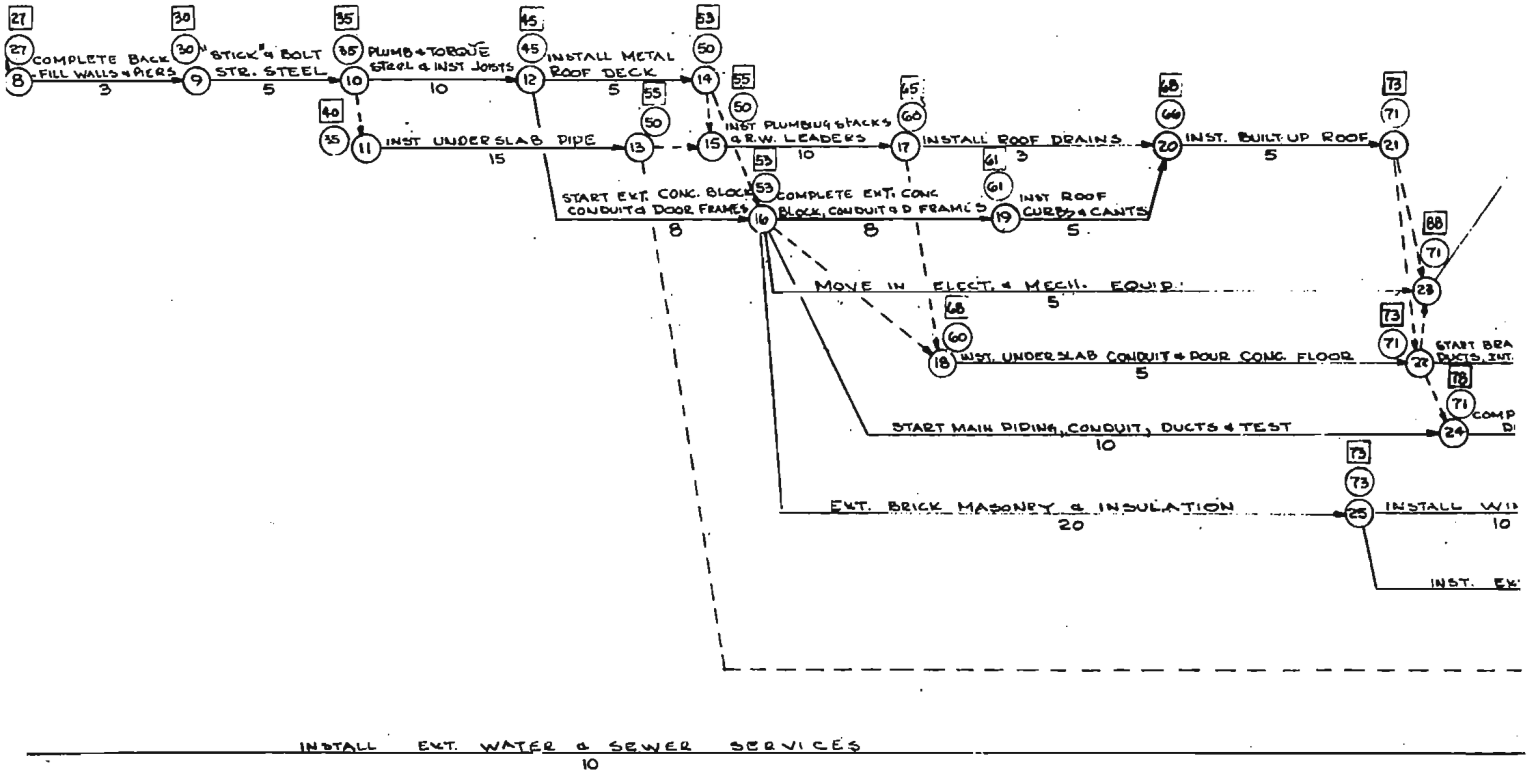
FORM 1

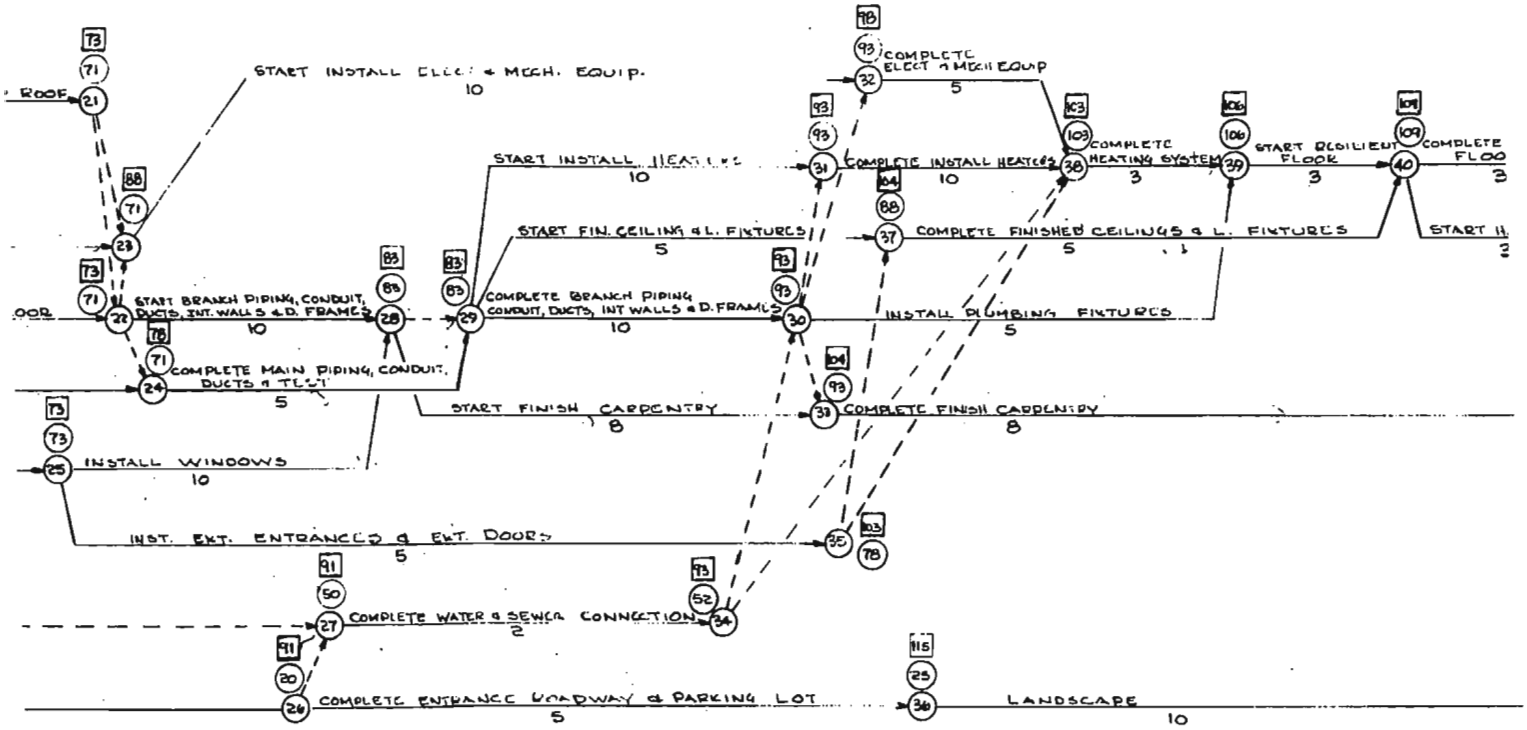
1 WORK PACKAGE	2 WORK PACKAGE NO.
SITE WORK AND EXTERIOR SERVICES	1
CONCRETE FOUNDATION, CONCRETE FLOOR AND UNDERSLAB PIPE	2
STRUCTURAL STEEL	3
MASONRY AND EXTERIOR WALL INSULATION	4
BUILD-UP ROOF, FLASHING AND ROOF INSULATION	5
ELECTRICAL WORK	6
MECHANICAL WORK	7
CARPENTRY, WINDOWS AND ALL FINISHES	8

FIGURE 12


0
0
1
STRIP & CLEAR SITE
5
5
5
2
CUT & FILL MAT. ON SITE
5
10
10
3
START EXC. & POUR FOOTINGS
4
14
14
4
COMPLETE EXC. & POUR FOOTINGS
8
22
22
5
22
22
START FOUND. WALLS & INT. PIERS
8
COMPLETE FOUND WALLS & PIERS
5
27
27
7
START BACK FILL WALLS & PIERS
3
27
27
8
COMPLETE BACK FILL WALLS & PIERS
3
30
30
9
"STICK" & BOLT STR. STEEL
5
35
35
10
PLUMB & TOR STEEL & INST
10
40
35
11
INST UNI
INSTALL EXT.

2 of 1

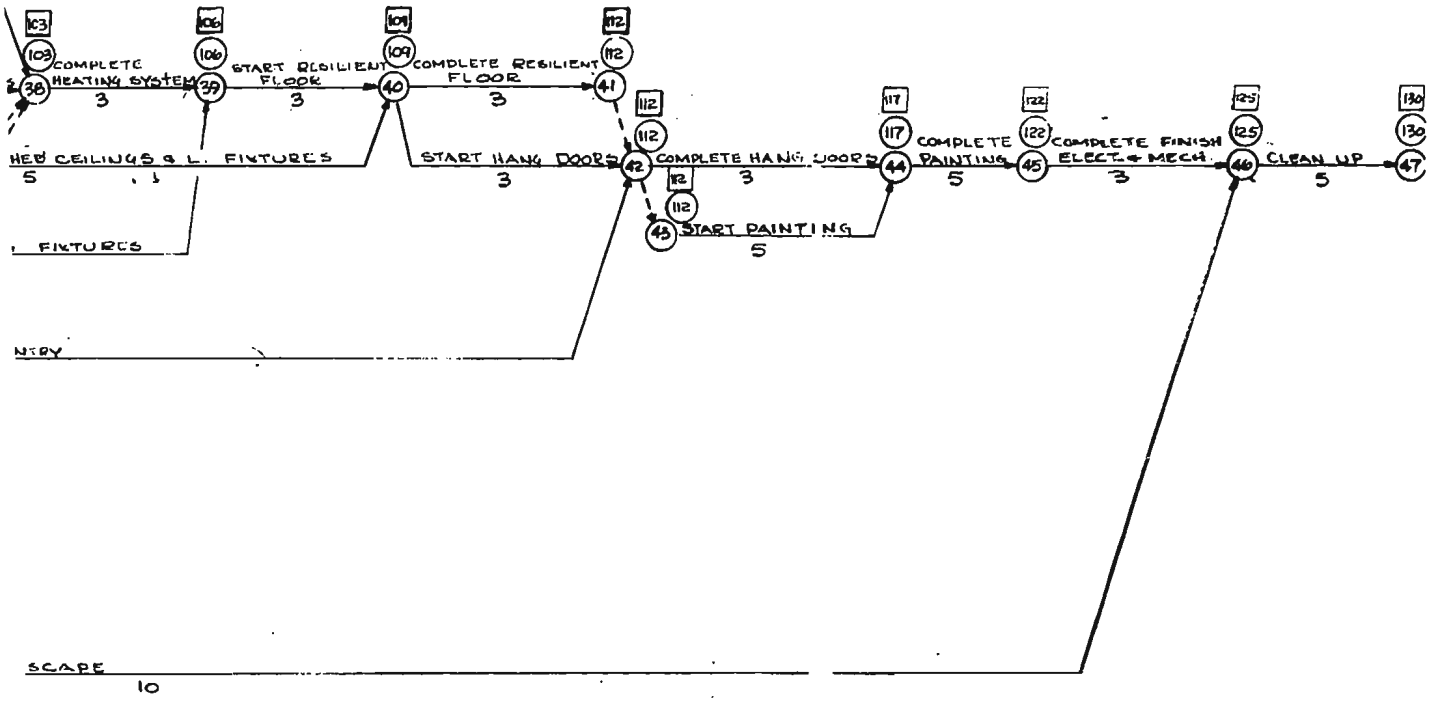

COMPLETE BACK FILL WALLS & PIERS
3
STICK & BOLT STR. STEEL
5
PLUMB & TORQUE STEEL & INST JOISTS
10
INSTALL METAL ROOF DECK
5
INST UNDERSLAB PIPE
15
INST PLUMBING STACKS & R.W. LEADERS
10
INSTALL ROOF DRAINS
3
INST. BUILT-UP ROOF
5
START EXT. CONC. BLOCK CONDUIT & DOOR FRAMES
8
COMPLETE EXT. CONC BLOCK, CONDUIT & FRAMES
8
INST ROOF CURBS & CANTS
5
MOVE IN ELECT. & MECH. EQUIP.
5
INST. UNDERSLAB CONDUIT & POUR CONC. FLOOR
5
START MAIN PIPING, CONDUIT, DUCTS & TEST
10
EXT. BRICK MASONRY & INSULATION
20
INSTALL EXT. WATER & SEWER SERVICES
10



CPM DIAGRAM
FOR
SMALL BUILDING

MARCH 15/72 G. FRAMPTON

FIG. 12



CPM DIAGRAM
FOR
SMALL BUILDING

MARCH 15/72 G.FRAMPTON

FIG. 12

ACTIVITIES PER WORK PACKAGE

i j	ACTIVITY DESCRIPTION	E.S.	L.S.
	Work Package No. 1-Site Work & Ext. Services		
1-2	Strip & Clear Site	0	0
2-3	Cut & Fill Material on Site	5	5
3-26	Install Ext. Water & Sewer Services	10	10
26-36	Complete Entrance Roadway & Parking Lot	20	91
36-46	Landscape	25	115
27-34	Complete Water & Sewer Connection	50	91
	Work Package No. 2 Concrete Foundation Concrete Floor and Underslab Pipe		
3-4	Start Exc. & Pour Footings	10	10
4-5	Complete Exc. & Pour Footings	14	14
4-6	Start Found. Walls & Int. Piers	14	14
6-7	Complete Found. Walls and Piers	22	22
6-8	Start Backfill Walls and Piers	22	22
8-9	Complete Backfill Walls and Piers	27	27
18-22	Inst. Underslab Conduit & Pour Conc. Floor	60	68
	Work Package No. 3 Structural Steel		
9-10	Stick & Bolt Structural Steel	30	30
10-12	Plumb & Torgue Steel and Inst. Joists	35	35
12-14	Install Metal Roof Deck	45	45
	Work Package No. 4 Masonry and Exterior Wall Insulation		
12-16	Start Ext. Conc. Block, Conduit & Door Frames	45	45
16-19	Complete Ext. Conc. Block, Conduit & D. Frames	53	53
16-25	Ext. Brick Masonry & Insulation	53	53

FIGURE 13

ACTIVITIES PER WORK PACKAGE

i j	ACTIVITY DESCRIPTION	E.S.	L.S.
	Work Package No. 5 Built-up Roof, Flashing and Roof Insulation		
20-21	Inst. Built-up Roof	66	68
	Work Package No. 6 Electrical Work		
12-16	Start Ext. Conc. Block Conduit & Door Frames	45	45
16-19	Complete Ext. Conc. Block, Conduit & D. Frames	53	53
16-23	Move in Elect. & Mech. Equip.	53	53
16-24	Start Main Piping Conduit, Ducts & Test	53	53
18-22	Inst. Underslab conduit & Pour Conc. Floor	60	68
22-28	Start Branch Piping, conduit, Ducts, Int. walls & D. Frames	71	73
24-29	Complete Main Piping conduit, Ducts & Test	71	78
23-32	Start Install Elect. & Mech. Equip.	71	88
29-31	Start Install Heaters	83	83
29-37	Start Fin. Ceiling & L. Fixtures	83	83
29-30	Complete Branch Piping Conduit, Ducts int. walls & D. Frames	83	83
32-38	Complete Elect. & Mech. Equip.	93	98
31-38	Complete Install Heaters	93	93
37-40	Complete Fin. Ceilings & L. Fixtures	88	104
38-39	Complete Heating System	103	103
45-46	Complete Finish Elect. & Mech.	122	122
	Work Package No. 7 Mechanical Work		
11-13	Inst. Underslab Pipe	35	40
15-17	Inst. Plumbing Stacks	50	55
16-23	Move in Elect. & Mich Equip.	53	53

FIGURE 13 (CONT'D)

ACTIVITIES PER WORK PACKAGE

i j	ACTIVITY DESCRIPTION	E.S.	L.S.
16-24	Start main piping, conduit Ducts & Test	53	53
17-20	Inst. Roof Drains	60	65
23-32	Start Install Elect. & Mech. Equip.	71	88
22-28	Start Branch Piping, conduit, ducts int. walls and D. Frames	71	73
24-29	Complete Main Piping Conduit Ducts and Test	71	78
29-30	Complete Branch piping, conduit Ducts int. walls & D. Frames	83	83
32-38	Complete Elect. & Mech. Equip.	93	98
30-39	Install plumbing fixtures	93	93
45-46	Complete Finish Elect. & Mech.	122	122
	Work Package No. 8 Carpentry, Windows & All Finishes		
12-16	Start Ext. Conc. Block Conduit & Door Frames	45	45
16-19	Complete Ext. Conc. Block, Conduit & D. Frames	53	53

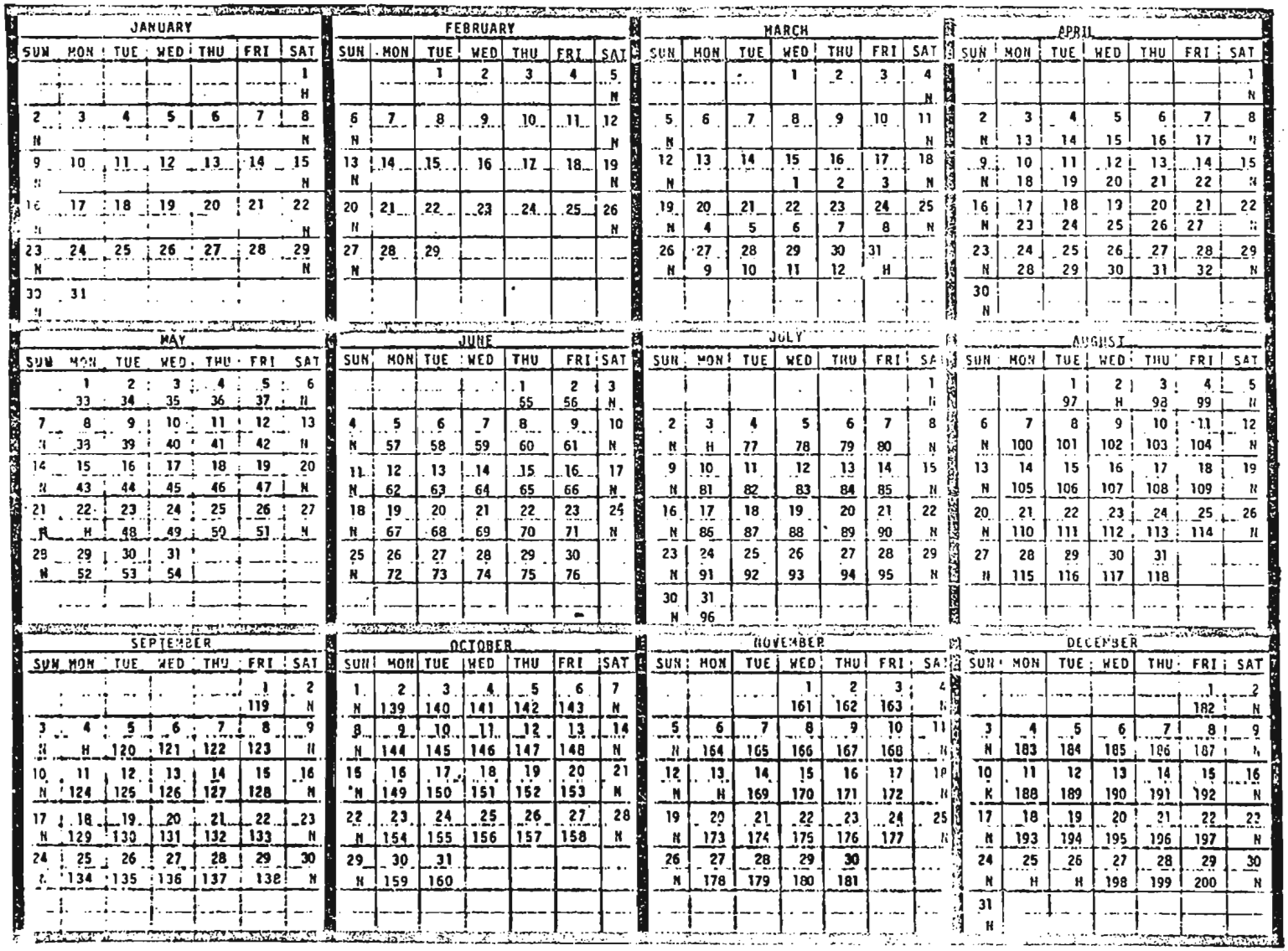
i j	ACTIVITY DESCRIPTION	E.S.	L.S.
19-20	Inst. Roof Curbs & Cants	61	61
22-28	Start Branch piping conduit ducts int. walls & D. Frames	71	73
25-28	Install Windows	73	73
25-35	Inst. Ext. Entrances & Ext. Doors	73	73
29-30	Complete Branch Piping Conduit Ducts Int. walls & D. Frames	83	83
29-37	Start Fin. Ceilings & L. Fixtures	83	83
28-33	Start. Finish Carpentry	83	83
37-40	Complete Finished Ceilings & L. Fixtures	88	104
33-42	Complete Finish Carpentry	93	104
39-40	Start. Res. Flooring	106	106
40-41	Complete Res. Flooring	109	109
40-42	Start Hang Doors	109	109
42-44	Complete Hang Doors	112	112
43-44	Start Painting	112	112
44-45	Complete Painting	117	117

FIGURE 13 (CONT'D)

TUES - DAY
2 - CALENDAR DATE
34 - PROJECT DAY NO.
H - HOLIDAY
N - NON-WORK DAY

PROJECT CALENDAR

DATE PREPARED : APRIL 4, 1972
PROJECT BASE DATE : MARCH 15, 1972
YEAR : 1972



JANUARY

SUN	MON	TUE	WED	THU	FRI	SAT
						1 H
2 N	3	4	5	6	7	8 N
9 N	10	11	12	13	14	15 N
16 N	17	18	19	20	21	22 N
23 N	24	25	26	27	28	29 N
30 N	31					

FEBRUARY

SUN	MON	TUE	WED	THU	FRI	SAT
		1	2	3	4	5 N
6 N	7	8	9	10	11	12 N
13 N	14	15	16	17	18	19 N
20 N	21	22	23	24	25	26 N
27 N	28	29				

MARCH

SUN	MON	TUE	WED	THU	FRI	SAT
			1	2	3	4 N
5 N	6	7	8	9	10	11 N
12 N	13	14	15	16	17	18 N
19 N	20 4	21 5	22 6	23 7	24 8	25 N
26 N	27 9	28 10	29 11	30 12	31 H	

APRIL

SUN	MON	TUE	WED	THU	FRI	SAT
						1 N
2 N	3 13	4 14	5 15	6 16	7 17	8 N
9 N	10 18	11 19	12 20	13 21	14 22	15 N
16 N	17 23	18 24	19 25	20 26	21 27	22 N
23 N	24 28	25 29	26 30	27 31	28 32	29 N
30 N						

MAY

SUN	MON	TUE	WED	THU	FRI	SAT
	1 33	2 34	3 35	4 36	5 37	6 N
7 N	8 39	9 40	10 41	11 42	12	13 N
14 N	15 43	16 44	17 45	18 46	19 47	20 N
21 N	22 H	23 48	24 49	25 50	26 51	27 N
28 N	29 52	30 53	31 54			

JUNE

SUN	MON	TUE	WED	THU	FRI	SAT
				1 55	2 56	3 N
4 N	5 57	6 58	7 59	8 60	9 61	10 N
11 N	12 62	13 63	14 64	15 65	16 66	17 N
18 N	19 67	20 68	21 69	22 70	23 71	24 N
25 N	26 72	27 73	28 74	29 75	30 76	

JULY

SUN	MON	TUE	WED	THU	FRI	SAT
						1 N
2 N	3 H	4 77	5 78	6 79	7 80	8 N
9 N	10 81	11 82	12 83	13 84	14 85	15 N
16 N	17 86	18 87	19 88	20 89	21 90	22 N
23 N	24 91	25 92	26 93	27 94	28 95	29 N
30 N	31 96					

AUGUST

SUN	MON	TUE	WED	THU	FRI	SAT
		1 97	2 H	3 98	4 99	5 N
6 N	7 100	8 101	9 102	10 103	11 104	12 N
13 N	14 105	15 106	16 107	17 108	18 109	19 N
20 N	21 110	22 111	23 112	24 113	25 114	26 N
27 N	28 115	29 116	30 117	31 118		

SEPTEMBER

SUN	MON	TUE	WED	THU	FRI	SAT
					1 119	2 N
3 N	4 H	5 120	6 121	7 122	8 123	9 N
10 N	11 124	12 125	13 126	14 127	15 128	16 N
17 N	18 129	19 130	20 131	21 132	22 133	23 N
24 N	25 134	26 135	27 136	28 137	29 138	30 N

OCTOBER

SUN	MON	TUE	WED	THU	FRI	SAT
1 N	2 139	3 140	4 141	5 142	6 143	7 N
8 N	9 144	10 145	11 146	12 147	13 148	14 N
15 N	16 149	17 150	18 151	19 152	20 153	21 N
22 N	23 154	24 155	25 156	26 157	27 158	28 N
29 N	30 159	31 160				

NOVEMBER

SUN	MON	TUE	WED	THU	FRI	SAT
			1 161	2 162	3 163	4 N
5 N	6 164	7 165	8 166	9 167	10 168	11 N
12 N	13 H	14 169	15 170	16 171	17 172	18 N
19 N	20 173	21 174	22 175	23 176	24 177	25 N
26 N	27 178	28 179	29 180	30 181		

DECEMBER

SUN	MON	TUE	WED	THU	FRI	SAT
					1 182	2 N
3 N	4 183	5 184	6 185	7 186	8 187	9 N
10 N	11 188	12 189	13 190	14 191	15 192	16 N
17 N	18 193	19 194	20 195	21 196	22 197	23 N
24 N	25 H	26 H	27 198	28 199	29 200	30 N
31 H						

Figure 14

FIGURE 14

MATERIALS INFORMATION SHEET

FORM 2

1 MATERIAL CODE	2 MATERIAL	3 UNIT OF MEASURE	4 ARE SHOP DRAWINGS AND/OR SAMPLES REQ'D YES/NO	5 TIME FOR PREPARATION OF SHOP DRAWINGS ETC. T1	6 TIME FOR REVIEW T2	7 TIME FOR ARCHITECT'S REVIEW AND APPROVAL T3	8 TIME FOR RESUBMISSION T4	9 TIME FOR FABRICATION T5	TIME FOR SHIPPING 10 FROM STORES T6	TIME FOR SHIPPING 11 FROM SUPPLIER T7	12 LEAD TIME
0820	WOOD DOORS	EA	YES	10	5	5	10	15	5	15	5

FIGURE 15

GENERAL STORES MATERIALS LIST

FORM 3

MATERIAL CODE NO.	MATERIAL	MATERIAL DESCRIPTION	UNIT OF MEASURE	QUANTITY IN STOCK	WILL THIS MATERIAL BE RESTOCKED	MINIMUM QUANTITY TO BE HELD IN STOCK	MAXIMUM QUANTITY TO BE HELD IN STOCK	QUANTITY ON ORDER	DELIVERY DATE
0820	WOOD DOORS	2' - 8' x 7' x 1 3/4" WOOD SLAB	EA	6	YES	4	10	-	-
		MAH. DOORS SOLID CORE							

FIGURE 16

BILL OF MATERIALS

FORM 4

1 WORK PACKAGE NO.	2 MATERIAL CODE NO.	3 MATERIAL DESCRIPTION	4 QUANTITY	5 UNIT OF MEASURE	6 START DATE OF FIRST ACTIVITY REQUIRING THIS MATERIAL
8	0820	2' - 8" x 7' x 1 3/4" WOOD SLAB MAH. DOORS, SOLID CORE	15	EA	109
8	0820	2' x 4" x 7' x 1 3/4" WOOD SLAB MAH. DOORS, SOLID CORE	3	EA	109
8	0820	3' x 7' x 2" WOOD PLANK OAK DOORS	2	EA	109

FIGURE 17

MATERIAL STATUS SHEET FOR PROJECT

FORM 5

1 MATERIAL CODE NO.	2 MATERIAL	3 UNIT OF MEASURE	4 TOTAL JOB QUANTITY	5 TOTAL QUANTITY FROM STORES	6 TOTAL QUANTITY FROM SUPPLIER	QUANTITY PER WORK PACKAGE			10 ORDER / EXPEDITE DATE	11 RECEIVE SHOP DRAWINGS AND/OR SAMPLES	12 SUBMIT FOR APPROVAL	13 RECEIVE BACK FROM ARCHITECT	SHIPPING DATE		16 DELIVERY DATE
						7 WORK PACKAGE NO.	8 QUANTITY FROM STORES	9 QUANTITY FROM SUPPLIER					14 FROM STORES	15 FROM SUPPLIER	
0820	WOOD DOORS	EA	20	6	14	8	6	14	44	54	59	64	99	89	104

FIGURE 18

MATERIAL STATUS SHEET
FOR GENERAL STORES

FORM 6

MATERIAL CODE NO.	MATERIAL	QUANTITY	UNIT OF MEASURE	ORDER/EXPEDITE DATE	RECEIVE SHOP DRAWINGS ETC.	RETURN SHOP DRAWINGS ETC.	SHIPPING DATE	DELIVERY DATE
C820	WOOD DOORS	10	EA	99	109	114	129	144

FIGURE 19

Form 7

REQUISITION

MATERIAL CODE NO. - 0820 MATERIAL WOOD DOORS ORDER DATE 44

SOURCE OF SUPPLY: SUPPLIER

SHOP DRAWINGS REQUIRED BY: 54 SHOP DRAWINGS WILL BE RETURNED BY: 64

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	UNIT PRICE	TOTAL
2' - 8" x 7' x 1 3/4"				
WOOD				
SLAB MAH. DOORS				
SOLID CORE	10	EA		

DELIVERY SCHEDULE

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	REQUIRED SHIPPING DATE	REQUIRED DELIVERY DATE
2' - 8" x 7' x 1 3/4"				
WOOD				
SLAB MAH. DOORS				
SOLID CORE	10	EA	89	104

FIGURE 20

Form 7

REQUISITION

MATERIAL CODE NO. 4619-1-5-0820 MATERIAL WOOD DOORS ORDER DATE 44

SOURCE OF SUPPLY: GENERAL STORES

SHOP DRAWINGS REQUIRED BY: 54 SHOP DRAWINGS WILL BE RETURNED BY: 64

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	UNIT PRICE	TOTAL
2' - 8" x 7' x 1 3/4" WOOD				
SLAB MAH. DOORS				
SOLID CORE	6	EA		

DELIVERY SCHEDULE

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	REQUIRED SHIPPING DATE	REQUIRED DELIVERY DATE
2' - 8" x 7' x 1 3/4" WOOD				
SLAB MAH. DOORS				
SOLID CORE	6	EA	99	104

FIGURE 21

Form 7

REQUISITION

MATERIAL CODE NO. 4619-1-5-0820 MATERIAL WOOD DOORS ORDER DATE 44

SOURCE OF SUPPLY: SUPPLIER

SHOP DRAWINGS REQUIRED BY: 54 SHOP DRAWINGS WILL BE RETURNED BY: 64

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	UNIT PRICE	TOTAL
2' - 8" x 7' x 1 3/4" WOOD				
SLAB MAH. DOORS SOLID				
CORE	9	EA		
2' - 4" x 7' x 1 3/4" WOOD				
SLAB MAH. DOORS SOLID				
CORE	3	EA		
3' x 7' x 2" WOOD PLANK				
OAK DOORS	2	EA		

DELIVERY SCHEDULE

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	REQUIRED SHIPPING DATE	REQUIRED DELIVERY DATE
2' - 8" x 7' x 1 3/4" WOOD				
SLAB MAH. DOORS SOLID				
CORE	9	EA	89	104
2' - 4" x 7' x 1 3/4"				
WOOD SLAB MAH.				
SOLID CORE	3	EA	89	104
3' x 7' x 2" WOOD				
OAK PLANK	2	EA	89	104

FIGURE 22

CHAPTER 5

CONCLUSIONS

1. GENERAL

In Chapter I the existing situation as to the process of estimating, ordering and delivering of materials tc construction projects, with particular emphasis placed on the situation in the island of Newfoundland, was outlined. Because of the many variables and, uncertainties it was shown that there was a great need for a system or standard method to improve or streamline the procedure.

In subsequent chapters 2 and 3 in a step by step sequence, the development of the Material Expediting System was outlined and in Chapter 4 an example in the use of the system was given.

2. ADVANTAGES

The Proposed Material Expediting System provides a process for the complete listing of all materials required for a project; the lumping together in manageable quantities of like materials for delivery to the project at the approximate rate at which they are to be incorporated into the work. It is directly related to a construction or CPM Schedule. It takes into consideration the variables, procedures and approvals that are necessary; it determines the status of the materials while in the procurement process; and finally, it produces information on each material in the form of a requisition which contains pertinent information required by a supplier and a delivery schedule for the material, from which purchase orders can be made.

In order to accomplish this, very little additional work, information or input is required, over and above what is normally required for any construction or Project Management firm to procure materials economically and on a schedule. What the proposed Material Expediting System does, is merely provide a system to receive process and out put the required information in a form that is most useful.

A lot of information on each material such as: are shop drawings and/or samples required? Estimated time for Architects approval; estimated manufacturing time; estimated delivery time etc., is the same irregardless which project it is being provided for, and once inputted into the system, it is permanently stored for instant recall for the ordering of materials for project after project. It can be easily updated when necessary.

The advantages and benefits of adopting and using this system far outweigh, the modest costs involved. As every Project Manager or Construction Manager has experienced at one time or other, there are occasions during the construction of some projects when information on the project schedule, the project cost, the status of material deliveries etc. was not known. CPM/Pert/Precedence Scheduling, Cost Control; and Resource Allocation are valuable tools recently developed to aid the Project Manager manage projects more efficiently. The Material Expediting System may be added to this list of important aids and adopted for use by Progressive Construction and Project Management Organizations.

3. OBSERVATIONS & LIMITATIONS

In the requisition form 7 it is specified that the prices will be

determined by the purchasing agent and inserted by him. This is necessary because the pricing is, in almost all cases, a negotiated matter on an individual purchase basis.

The size of the delivery shipments are determined by the quantities required per work package and these are the quantities listed in the Delivery Schedule of the Requisition. The supplier after receiving the requisition and after reviewing the delivery quantities, may wish to adjust or vary the delivery quantities. This variation may be determined by the sizes of the shipments, the method of shipment and the size of shipment necessary to qualify for a more economical freight rate.

One of the purposes for breaking a project down into work packages, which in their determination have the arbitrary constraint of duration eg, 90 days, is to determine the sizes of shipments. These shipment sizes may be varied however, after review by the supplier to best suit the method of shipment and the most favourable freight rates. An area for future research might be a practical method for determining the quantities of materials for each Construction Schedule activity and accumulate the quantities for each material per activity to arrive at economical shipment sizes i.e., truck load, tractor-trailer load, railcar load etc.

A limitation of the system and another area for future research is that no consideration is given to the amount of storage space that may be available at the site and the different types of storage space that the various materials would require such as open storage space, covered storage space or covered storage requiring heat.

In the Bill of Materials form 4, Column 6 the start date of the

first Activity in the Work Package, requiring the particular material is inserted. A link is not established with the CPM Schedule. Further research may be carried out linking the CPM program to the Material Expediting System's program by using the (i, j) number of the activity and determining what benefit or flexibility is gained.

In the example in Chapter 4 an extension of the code is not used to represent each individual kind of material within a general material type, eg. 0820 represents all wood doors; where as the code could be expanded to code for each individual kind of door. eg. 0820.01 might represent - 2' - 8" x 7' - 0" x 1 3/4" solid core slab mahogany doors. *

This might be particularly useful in relating the materials required for the project (Bill of Materials - form 4) to the materials in General Stores available for use in the project (General Stores Materials List - form 3). In the example the relation is made by the material description. This is left open as a user option.

In the example the dates are project day numbers for the particular project in question. In order to convert to calendar dates it is necessary to refer to the project calendar (see figure 14).

For manual use of the system this is the easiest and most straight forward procedure. In the computer application of the system, a feature can be written into the program to output directly calendar days. In the computer example in Appendix No. IV project day numbers are out putted and the calendar date conversion has not been incorporated into the program.

4. IMPLEMENTATION

To introduce this System into an existing Construction Organization

* See Coding - Chapter 2

would not be difficult. It need not require additional personnel. Some training of the purchasing and expediting personnel naturally would be required.

This, however, only involves some understanding of the system; instructions on the input to the system; and what the computer will do etc. In order to better use the system more efficiently, some rearranging of a company's organization may be necessary, depending of course on the existing arrangement.

All of the different types of construction organizations mantioned in Chapter I, which are:

Project Management

Construction Management

General Contractor

In-hours Work

Separate Contracts Controlled by the Owner

all purchase materials and expedite their delivery to the project. All of these organizations would therefore benefit from the Material Expediting system.

In the implementation of the system in a medium-size General Construction Company (see Organizational chart figure 1) input would come both from the Chief Estimator's Department and the Project Manager's Department.

The output and updating is primarily the responsibility of the Project Manager, however; as would be normally expected, from time to time information will be supplied from the Chief Estimator's Department.

5. COSTS

The costs of implementing and using this system are modest, in addition to what ever minor costs would be necessary to train the personnel. The following are representative costs for a single project of a total value of approximately $5,000,000.00:

Initial Set Up		
Purchase of Forms	-	$ 50.00
Key Punching	-	$ 100.00
Computer Time	-	$ 200.00
		$ 350.00

Cost per Month		
Key Punching	-	$ 50.00
Computer Time	-	$ 150.00
		$ 200.00

BIBLIOGRAPHY

1. Ahuja H.N. , CPM/Performance Control System - Thesis Presented to University of Waterloo, July 1969

2. Associated General Contractors of America , Cost Control and CPM in Construction: A Manual of General Contractors Washington. The Associated General Contractors of America, 1964

3. Barish Norman N., Economic Analysis For Engineering And Managerial Decision Making. McGraw Hill Book Co., Inc., New York, N.Y. 1962

4. Begley Francis D., Project Management for Construction Superintendents - Saunders of Toronto Ltd. 1970

5. Coombs William E., Construction, Accounting and Financial Management - McGraw Hill, Co. Inc., New York, 1958

6. Couger J. Daniel, Shannon Loren E., Fortran IV A Programmed Instruction Approach - Richard D. Irwin Inc., and The Dorsey Press, Illinois 1968

7. Deatherage George E. , Construction Company Organization And Management - McGraw Hill Inc., 1964

8. Deatherage George E., Construction Office Administration. McGraw Hill Inc., 1964

9. Deatherage George E., Construction Scheduling And Control. McGraw Hill Inc., 1964

10. Forsythe Alexandra I., Keenan Thomas A., Stenberg Warren., Computer Science Fortran Language - John Wiley and Sons Inc., New York, 1970

11 Hackney, John W.,Control and Management of Capital Projects, 2nd. Edition - John Wiley & Sons Inc. 1965

12. Internation Business Machines Corporation; IBM Application Program - Project Management System /360 (360A - CP - 04X) Version 2, Program Description And Operations Manual - International Business Machines Corporation, New York.

13. International Business Machines Corporation, Programmed Instruction Course - Fortran International Business Machines Corporation Education Development 1961

14. Louden Robert K. , Programming The IBM 1130 and 1800 - Prentice Hall Inc., New Jersey 1967

15. Miller Lawrence C. , Successful Management for Contractors - McGraw Hill Inc., New York 1962

16. O'Brien, James J., CPM in Construction Management McGraw Hill Book Co., N.Y. 1965

17.Peurifoy R.L. , Construction Planning, Equipment And Methods - McGraw Hill Co. Inc., New York 1956

18. Prilock Herbert M. & Hourihan, Peter M., Practical CPM in Construction - R.S. Means Co., Inc., Mass. 1968

19. Pulver H.E., Construction Estimates and Costs - McGraw Hill Book Co. Inc., New York 1947

20. Roe P.H. Soulis G.N. & Handa V.K., The Dicipline of Design, Experimental Edition, Allyn & Bacon Inc., Boston, 1967

21. Schweyer Herbert E., Analytic Modes for Managerial And Engineering Economics - Reinhold Publishing Corporation, New York, 1964

22. Thuesen H.G., Fabrycky W.J., Thuesen G.J., Engineering Economy - 4th. Edition - Pretice Hall, Inc. New Jersey 1971

23. Wiest Jerome D., Levy Ferdinand K., A Management Guide to Pert/CPM - Prentice Hall, Inc., New Jersey, 1969

APPENDIX NO. I

BUILDING CONSTRUCTION INDEX-FEBRUARY 1966 MODIFIED

SECTION 1.0		PLANNING
	.10	Correspondence with Owner
	.20	Correspondence with Consultants
	.30	Meeting Records
	.40	Budgets and
	.50	Surveys and Soils Reports
	.60	Planning Notes
	.70	Preliminary Drawings
	.80	Outline Specifications
	.90	
	to	
	.94	Permits
	.95	
	to	
	.99	Insurance
SECTION 2.0		PRE-CONTRACT FORMS
	2.10	Invitation to Bid
	2.20	Instructions to Bidders
	2.30	Bidding Form
	2.40	Contract Form
	2.50	General Conditions
	2.60	Supplementary General Conditions

2.70 Special Conditions

SECTION 3.0 SPARE

SECTION 4.0 WORKING DRAWINGS

4.10 Preliminary For Study

4.20 Issued For Tender

4.30 Issued For Construction

SECTION 5.0 SPECIFICATIONS FORMAT AND FILING INDEX (CONSTRUCTION)

Under this section the Uniform System for Construction Cost Accounting Guide will be used. See Appendix No. II.

SECTION 6.0 CONTRACT ADMINISTRATION

6.10 Site Inspection Reports

6.20 Consulting Engineer Reports

6.30 Outside Inspection and Testing Reports

6.40 Minutes of Job Meetings

6.50 Progress Reports

6.60 Photographs

6.70 Deficiency Lists

6.80 Instructions

6.90 Changes/Extra Work Orders

SECTIQN 7.0 SPECIAL CONTRACTS

7.10 Certificates & Payments

7.20 Warranties & Bonds

7.30 Maintenance Manuals

SECTION 8.0 ADMINISTRATION PROJECT OFFICE ETC.

APPENDIX NO. II

UNIFORM SYSTEM FOR CONSTRUCTION SPECIFICATIONS, DATA FILING & COST ACCOUNTING

0 CONDITIONS OF THE CONTRACT

0000-0099. unassigned

1 GENERAL REQUIREMENTS

0100. ALTERNATES OF PROJECT SCOPE
0101-0109 unassigned
0110. SCHEDULES & REPORTS
0111-0119. unassigned
0120. SAMPLES & SHOP DRAWINGS
0121-0129. unassigned
0130. TEMPORARY FACILITIES
0131-0139. unassigned
0140. CLEANING UP
0141-0149. unassigned
0150. PROJECT CLOSEOUT
0151-0159. unassigned
0160. ALLOWANCES
0161-0199. unassigned

2 SITE WORK

0200. ALTERNATES
0201-0209. unassigned
0210. CLEARING OF SITE
0211. Demolition
0212. Structures Moving
0213. Clearing & Grubbing
0214-0219. unassigned
0220. EARTHWORK
0221. Site Grading
0222. Excavating & Backfilling
0223. Dewatering
0224. Subdrainage
0225. Soil Poisoning
0226. Soil Compaction Control
0227. Soil Stabilization
0228-0229. unassigned
0230. PILING
0231-0239. unassigned
0240. SHORING & BRACING
0241. Sheeting
0242. Underpinning
0243.-0249. unassigned
0250. SITE DRAINAGE
0251.-0254. unassigned
0255. SITE UTILITIES
0256.-0259. unassigned
0260. ROADS & WALKS
0261. Paving
0262. Curbs & Gutters
0263. Walks
0264. Road & Parking Appurtenances
0265.-0269. unassigned
0270. SITE IMPROVEMENTS
0271. Fences
0272. Playing Fields
0273. Fountains
0274. Irrigation System
0275. Yard Improvements
0276.-0279. unassigned
0280. LAWNS & PLANTING
0281. Soil Preparation
0282. Lawns
0283. Ground Covers & Other Plants
0284. Trees & Shrubs
0285.-0289. unassigned
0290. RAILROAD WORK
0291.-0294. unassigned
0295. MARINE WORK
0296. Boat Facilities
0297. Protective Marine Structures
0298. Dredging
0299. unassigned

3 CONCRETE

0300. ALTERNATES
0301.-0309. unassigned
0310. CONCRETE FORMWORK
0311.-0319. unassigned
0320. CONCRETE REINFORCEMENT
0321.-0329. unassigned
0330. CAST-IN-PLACE CONCRETE
0331. Heavyweight Aggregate Concrete
0332. Lightweight Aggregate Concrete

0333. Post-Tensioned Concrete
0334. Nailable Concrete
0335. Specially Finished Concrete
0336. Specially Placed Concrete
0337.-0339. unassigned
0340. PRECAST CONCRETE
0341. Precast Concrete Panels
0342. Precast Structural Concrete
0343. Precast Prestressed Concrete
0344.-0349. unassigned
0350. CEMENTITIOUS DECKS
0351. Poured Gypsum Deck
0352. Insulating Concrete Roof Decks
0353. Cementitious Unit Decking
0354.-0399. unassigned

4 MASONRY

0400. ALTERNATES
0401.-0409. unassigned
0410. MORTAR
0411.-0419. unassigned
0420. UNIT MASONRY
0421. Brick Masonry
0422. Concrete Unit Masonry
0423. Clay Backing Tile
0424. Clay Facing Tile
0425. Ceramic Veneer
0426. Pavers
0427. Glass Unit Masonry
0428. Gypsum Unit Masonry
0429. Reinforced Masonry
0430.-0439. unassigned
0440. STONE
0441. Rough Stone
0442. Cut Stone
0443. Simulated Stone
0444. Flagstone
0445.-0449. unassigned
0450. MASONRY RESTORATION
0451.-0499. unassigned

5 METALS

0500. ALTERNATES
0501.-0509. unassigned
0510. STRUCTURAL METAL
0511.-0519. unassigned
0520. METAL DECKING
0521.-0529. unassigned
0530. METAL DECKING
0531.-0539. unassigned
0540. LIGHTGAGE FRAMING
0541.-0549. unassigned
0550. MISCELLANEOUS METAL
0551. Metal Stairs
0552. Floor Gratings
0553. Construction Castings
0554.-0569. unassigned
0570. ORNAMENTAL METAL
0571.-0579. unassigned
0580. SPECIAL FORMED METAL
0581.-0599. unassigned

6 CARPENTRY

0600. ALTERNATES
0601.-0609. unassigned
0610. ROUGH CARPENTRY
0611. Framing & Sheathing
0612. Heavy Timber Work
0613.-0619. unassigned
0620. FINISH CARPENTRY
0621. Wood Trim
0622. Millwork
0623. Wood Siding
0624.-0629. unassigned
0630. GLUE-LAMINATED WOOD
0631.-0639. unassigned
0640. CUSTOM WOODWORK
0641. Custom Cabinetwork
0642. Custom Panelwork
0643.-0699. unassigned

7 MOISTURE PROTECTION

0700. ALTERNATES
0701.-0709. unassigned
0710. WATERPROOFING
0711. Membrane Waterproofing
0712. Hydrolithic Waterproofing
0713. Liquid Waterproofing
0714. Metallic Oxide Waterproofing
0715. Dampproofing
0716. Bituminous Dampproofing
0717. Silicone Dampproofing
0718. Cementitious Dampproofing
0719. Preformed Vapor Barrier
0720. BUILDING INSULATION

0721.-0729. unassigned
0730. SHINGLES & ROOFING TILES
0731. Asphalt Shingles
0732. Asbestos-Cement Shingles
0733. Wood Shingles
0734. Slate Shingles
0735. Clay Roofing Tiles
0736. Concrete Roofing Tiles
0737. Porcelain Enamel Shingles
0738. Metal Shingles
0739. unassigned
0740. PREFORMED ROOFING & SIDING
0741. Preformed Metal Roofing
0742. Preformed Metal Siding
0743. Asbestos-Cement Panels
0744. Preformed Plastic Panels
0745. Custom Panel Roofing
0746.-0749. unassigned
0750. MEMBRANE ROOFING
0751. Builtup Bituminous Roofing
0752. Prepared Roll Roofing
0753. Elastic Sheet Roofing
0754. Elastic Liquid Roofing
0755.-0759. unassigned
0760. SHEET METAL WORK
0761. Sheet Metal Roofing
0762. Metal Roof Flashing & Trim
0763. Gutters & Downspouts
0764. Grilles & Louvers
0765. Decorative Sheet Metal Work
0766.-0769. unassigned
0770. WALL FLASHING
0771.-0779. unassigned
0780. ROOF ACCESSORIES
0781. Plastic Skylights
0782. Metal-Framed Skylights
0783. Roof Hatches
0784. Gravity Ventilators
0785.-0789. unassigned
0790. CALKING & SEALANTS
0791.-0799. unassigned

8 DOORS, WINDOWS, & GLASS

0800. ALTERNATES
0801.-0809. unassigned
0810. METAL DOORS & FRAMES
0811. Hollow Metal Doors & Frames
0812. Aluminum Doors & Frames
0813. Stainless Steel Doors & Frames
0814. Bronze Doors & Frames
0815. Metal Storm & Screen Doors
0816.-0819. unassigned
0820. WOOD DOORS
0821.-0829. unassigned
0830. SPECIAL DOORS
0831. Sliding Metal Foredoors
0832. Metal-Covered Doors
0833. Coiling Doors & Grilles
0834. Plastic-Faced Doors
0835. Folding Doors
0837. Sliding Glass Doors
0838. Tempered Glass Doors
0839. Revolving Doors
0840. Flexible Doors
0841. Hangar Doors
0842.-0849. unassigned
0850. METAL WINDOWS
0851. Steel Windows
0852. Aluminum Windows
0853. Stainless Steel Windows
0854. Bronze Windows
0855.-0859. unassigned
0860. WOOD WINDOWS
0861.-0869. unassigned
0870. FINISH HARDWARD
0871.-0874. unassigned
0875. OPERATORS
0876.-0879. unassigned
0880. WEATHERSTRIPPING
0881.-0884. unassigned
0885. GLASS & GLAZING
0886.-0889. unassigned
0890. CURTAINWALL SYSTEM
0891.-0894. unassigned
0895. STOREFRONT SYSTEM
0896.-0899. unassigned

9 FINISHES

0900. ALTERNATES
0901.-0909. unassigned
0910. LATH & PLASTER
0911. Metal Furring
0912. Metal Lath
0913. Gypsum Lath
0914. Plaster Partition Systems
0915. Plastering Accessories
0916. Plaster
0917. Stucco
0918. Acoustical Plaster
0919. Plaster Moldings & Ornaments
0920.-0924. unassigned
0925. GYPSUM DRYWALL

0926. Gypsum Drywall Systems
0927. Gypsum Drywall Finishing
0928.-0929. unassigned
0930. TILE WORK
0931. Ceramic Tile
0932. Ceramic Mosaics
0933. Quarry Tile
0934. Glass Mosaics
0935. Conductive Ceramic Tile
0936.-0939. unassigned
0940. TERRAZZO
0941. Cast-In-Place Terrazzo
0942. Precast Terrazzo
0943. Conductive Terrazzo
0944. unassigned
0945. VENEER STONE
0946.-0949. unassigned
0950. ACOUSTICAL TREATMENT
0951.-0954. unassigned
0955. WOOD FLOORING
0956. Wood Strip Flooring
0957. Wood Parquet Flooring
0958. Plywood Block Flooring
0959. Resilient Wood Floor Systems
0960. Wood Block Industrial Floor
0961.-0964. unassigned
0965. RESILIENT FLOORING
0966. Resilient Tile Flooring
0967. Resilient Sheet Flooring
0968. Conductive Resilient Floors
0969. unassigned
0970. SPECIAL FLOORING
0971. Magnesium Oxychloride Floors
0972. Epoxy-Marble-Chip Flooring
0973. Elastomeric Liquid Floors
0974. Heavy-Duty Concrete Toppings
0975.-0979. unassigned
0980. SPECIAL COATINGS
0981. Cementitious Coatings
0982. Elastomeric Coatings
0983. Fire-Resistant Coatings
0984.-0989. unassigned
0990. PAINTING
0991.-0994. unassigned
0995. WALL COVERING
0996.-0999. unassigned

10 SPECIALTIES

1000. ALTERNATES
1001.-1009. unassigned
1010. CHALKBOARD & TACKBOARD
1011. CHALKBOARD & TACKBOARD
1011.-1012. unassigned
1013. CHUTES
1014. unassigned
1015. COMPARTMENTS & CUBICLES
1016. Hospital Cubicles
1017. Office Cubicles
1018. Toilet & Shower Compartments
1019. unassigned
1020. DEMOUNTABLE PARTITIONS
1021.-1022. unassigned
1023. DISAPPEARING STAIRS
1024. unassigned
1025. FIREFIGHTING DEVICES
1026.-1029. unassigned
1030. FIREPLACE EQUIPMENT
1031. Fireplace Accessories
1032. Fireplace Dampers
1033. Prefabricated Fireplaces
1034. unassigned
1035. FLAGPOLES
1036. unassigned
1037. FOLDING GATES
1038.-1039. unassigned
1040. IDENTIFYING DEVICES
1041. Directory & Bulletin Boards
1042. Painted Signs
1043. Plaques
1044. Three-Dimensional Signs
1045.-1049. unassigned
1050. LOCKERS
1051.-1052. unassigned
1053. MESH PARTITIONS
1054. unassigned
1055. POSTAL SPECIALTIES
1056.-1059. unassigned
1060. RETRACTABLE PARTITIONS
1061. Coiling Partitions
1062. Folding Partitions
1063.-1064. unassigned
1080. TOILET & BATH ACCESSORIES
1081.-1084. unassigned
1085. VENDING MACHINES
1086.-1089. unassigned
1090. WARDROBE SPECIALTIES
1091.-1094. unassigned
1095. WASTE DISPOSAL UNITS
1096. Packaged Incinerators
1097. Waste Compactors
1098.-1099. unassigned

11 EQUIPMENT

1100. ALTERNATES
1101.-1109. unassigned
1110. BANK EQUIPMENT
1111. Depository Units
1112. Outdoor Tellers' Windows
1113. Safes
1114. Tellers' Counters
1115. COMMERCIAL EQUIPMENT
1116.-1117. unassigned
1118. DARKROOM EQUIPMENT
1119. unassigned
1120. ECCLESIASTICAL EQUIPMENT
1121. Baptismal Tanks
1122. Bells
1123. Carillons
1124. Chancel Fittings
1125. Organs
1126. Pews
1127.-1129. unassigned
1130. EDUCATIONAL EQUIPMENT
1131. Art & Draft Equipment
1132. Audio-Visual Aids
1133. Language Laboratories
1134. Prefabricated Astro-Observatories
1135. Vocational Shop Equipment
1136.-1139. unassigned
1140. FOOD SERVICE EQUIPMENT
1141. Bar Units
1142. Cooking Equipment
1143. Dishwashing Equipment
1144. Food Preparation Machines
1145. Food Preparation Tables
1146. Food Serving Units
1147. Refrigerated Cases
1148. Sinks & Drainboards
1149. Soda Fountains
1150. GYMNASIUM EQUIPMENT
1151.-1154. unassigned
1155. INDUSTRIAL EQUIPMENT
1156.-1159. unassigned
1160. Laboratory Equipment
1161.-1162. unassigned
1163. LAUNDRY EQUIPMENT
1164. unassigned
1165. LIBRARY EQUIPMENT
1166. Bookshelving
1167. Bookstacks
1168. Charging Counters
1169. unassigned
1170. MEDICAL EQUIPMENT
1171. Dental Equipment
1172. Examination Room Equipment
1173. Hospital Casework
1174. Incubators
1175. Patient Care Equipment
1176. Radiology Equipment
1177. Sterilizers
1178. Surgery Equipment
1179. Therapy Equipment
1180. MORTUARY EQUIPMENT
1181.-1184. unassigned
1188. PRISON EQUIPMENT
1189. unassigned
1190. RESIDENTIAL EQUIPMENT
1191. Central Vacuum Cleaner
1192. Kitchen & Lavotory Cabinets
1193. Residential Kitchen Equipment
1194. Residential Laundry Equipment
1195. Unit Kitchens
1196. unassigned
1197. STAGE EQUIPMENT
1198.-1199. unassigned

12. FURNISHINGS

1200. ALTERNATES
1201.-1209. unassigned
1210. ARTWORK
1211.-1219. unassigned
1220. BLINDS & SHADES
1221.-1229. unassigned
1230. CABINETS & FIXTURES
1231. Classroom Cabinets
1232. Dormitory Units
1233.-1239. unassigned
1240. CARPETS & MATS
1241.-1249. unassigned
1250. DRAPERY & CURTAINS
1251. Drapery Tracks
1252. Fabrics
1253.-1259. unassigned
1260. FURNITURE
1261.-1269. unassigned
1270. SEATING
1271. Auditorium Seating
1272. Classroom Seating
1273. Stadium Seating
1274.-1299. unassigned

13 SPECIAL CONSTRUCTION

1300. ALTERNATES
1301.-1309. unassigned
1310. AUDIOMETRIC ROOMS
1311.-1314. unassigned
1315. BOWLING ALLEYS
1316.-1319. unassigned
1320. BROADCASTING STUDIOS
1321.-1324. unassigned
1325. CLEAN ROOMS
1326.-1324. unassigned
1325. CLEAN ROOMS
1326.-1329. unassigned
1330. CONSERVATORIES
1331.-1334. unassigned
1335. HYPERBARIC ROOMS
1336.-1339. unassigned
1340. INCINERATORS
1341.-1344. unassigned
1345. INSULATED ROOMS
1346.-1349. unassigned
1350. INTEGRATED CEILINGS
1351.-1354. unassigned
1355. OBSERVATORIES
1356.-1359. unassigned
1360. PEDESTAL FLOORS
1361.-1364. unassigned
1365. PREFABRICATED STRUCTURES
1366.-1369. unassigned
1370. RADIATION PROTECTION
1371.-1374. unassigned
1375. SPECIAL CHIMNEY CONSTRUCTION
1376.-1379. unassigned
1380. STORAGE VAULTS
1381.-1384. unassigned
1385. SWIMMING POOLS
1386.-1389. unassigned
1390. ZOO STRUCTURES
1391.-1399. unassigned

14 1400. ALTERNATES
1401.-1409. unassigned
1410. DUMBWAITERS
1411.-1419. unassigned
1420. ELEVATORS
1421.-1429. unassigned
1430. HOISTS & CRANES
1431.-1439. unassigned
1440. LIFTS
1441.-1449. unassigned

15 MECHANICAL

1500. ALTERNATES
1501.1509. unassigned
1510. BASIC MATERIALS & METHODS
1511. Pipe & Pipefittings
1512. Valves
1513. Piping Specialties
1514. Mechanical Supporting Devices
1515. Vibration Isolation
1516. Mechanical Systems Insulation
1517.-1519. unassigned
1520. WATER SUPPLY SYSTEM
1521. Water Supply Piping
1522. Domestic Hot Water System
1523. Domestic Ices Water System
1524. Water Well & Wellpump
1525. SOIL & WASTE SYSTEM
1526. Soil & Waste Piping
1527. Waste Treatment Equipment
1528. Sanitary Sewers
1529. ROOF DRAINAGE SYSTEM
1530. PLUMBING FIXTURES & TRIM
1531.-1534. unassigned
1535. GAS PIPING SYSTEM
1536.-1539. unassigned
1540. SPECIAL PIPING SYSTEMS
1541. Compressed Air System
1542. Vacuum Piping System
1543. Oxygen Piping System
1544. Nitrous Oxide Piping System
1545. Process Piping System
1546.-1549. unassigned
1550. FIRE EXTINGUISHING SYSTEM
1551. Automatic Sprinkler System
1552. Carbon Dioxide System
1553. Elevated Water Reservoir
1554. Standpipe & Firehose Stations
1555. Underground Fire Lines
1556. unassigned
1557. FUEL HANDLING SYSTEM
1558.-1559. unassigned
1560. STEAM HEATING SYSTEM
1561. Steam Boiler & Equipment
1562. Steam Circulating System
1563. Steam Terminal Units
1564. unassigned
1565. HOT WATER HEATING SYSTEM
1566. Hot Water Boiler & Equipment
1567. Hot Water Circulating System
1568. Hot Water Terminal Units
1569. Hot Water Snow-Melting System
1570.-1574. unassigned

1575. CHILLED WATER SYSTEM
1576. unassigned
1577. DUAL-TEMPERATURE SYSTEM
1578. HEAT PUMPS (see also 1684).
1579. Unassigned
1580. AIR-TEMPERING SYSTEM
1581. Warm Air Furnaces
1582. Air-Handling Equipment
1583. Air Filtration Equipment
1584. Humidity Control Equipment
1585. Packages Air-Tempering Units
1586. Air Distribution Duct System
1587. Tempered Air Terminal Units
1588. Air Curtain
1589. unassigned
1590. REFRIGERATION
1591. Water Chillers
1592. Commercial Refrigeration Units
1593. Cooling Towers
1594. unassigned
1595. HVC CONTROLS & INSTRUMENTS
1596.-1599. unassigned

16. ELECTRICAL

1600. ALTERNATES
1601.-1609. unassigned
1610. BASIC MATERIALS & METHODS
1611. Raceways & Fittings
1612. Busways
1613. Conductors
1614. Electrical Supporting Devices
1615.-1619. unassigned
1620. ELECTRICAL SERVICE SYSTEM
1621. Overhead Electrical Service
1622. Underground Electrical Service
1623. Electrical Substations
1624. Electrical Entrance Equipment
1625. Grounding System
1626. Standby Electrical System
1627.-1629. unassigned
1630. ELECTRICAL DISTRIBUTION SYSTEM
1631. Feeder Circuits
1632. Branch Circuits
1633. Panelboards
1634. Wiring Devices
1635. Underfloor Electrical System
1636.-1639. unassigned
1640. LIGHTING FIXTURES
1641. Indoor Lighting Fixtures
1642. Outdoor Lighting Fixtures
1643.-1649. unassigned
1650. COMMUNICATION SYSTEM
1651. Telephone Equipment
1652. Intercommunication System
1653. Public Address System
1654. Paging System
1655. Nurses'Call System
1656. Alarm & Detection System
1657. Clock & Program System
1658. Audio-Video Reproduces
1659. Closed-Circuit Television
1660. Radiotelephone System
1661. Commercial Projection System
1662.-1669. unassigned
1670. ELECTRICAL POWER EQUIPMENT
1671. Motors & Motor Controls
1672. Special Transformers
1673. Frequency Converters
1674. Rectifiers
1675.-1679. unassigned
1680. ELECTRICAL COMFORT SYSTEM
1681. Electrical Heating System
1682. Packaged Air-Tempering Units
1683. Electrical Snow-Melting System
1684. Heat Pumps (see also 1578)
1685.-1689. unassigned
1690. ELECTRICAL SYSTEM CONTROLS & INSTRUMENTS
1691.-1694. unassigned
1695. LIGHTNING PROTECTION SYSTEM
1696.-1699. unassigned

APPENDIX NO. III

ECONOMIC ORDER SIZES FOR GENERAL STORES

In the event that a General Contractor maintains a General Stores for the holding of some materials for use in anticipated work in the future, some criteria must be used for determining the quantities of materials to order and the minimum quantity to hold in stores, etc.

In setting up and maintaining a General Stores such questions arise, as:

What is the size of the order?

How often should an order be placed?

Should there be a certain quantity of each material held in stores at all times? (Safety Stock)

The determining of economic order quantities and inventory levels is what is referred to as a minimum cost functional relationship problem. It may be simple or complex depending on the procurement circumstances and the use requirements.

The factors which determine the most economic size of orders are:

1. The cost of placing and processing an order (C_1)
2. The unit cost of holding inventory, i.e. interest, deterioration, accounting, warehousing rental, etc. (C_2)
3. Unit purchase price (C_3)
4. Yearly usage (U)

If Q = the quantity of each order and C_T = the total annual cost of ordering, holding and purchasing:

the annual cost per order of placing orders = $C_1(U/Q)$: the annual cost of holding the item in inventory = $\frac{C_2Q}{2}$

The total annual cost of ordering, holding and purchasing is:

$$(C_T) = \frac{C_1 U}{Q} + \frac{C_2 Q}{2} + C_3 U$$

To calculate the minimum-cost order quantity, C_T is differentiated with respect to Q and the derivative set equal to zero.

Therefore, $Q = \sqrt{\frac{2\ C_1 U}{C2}}$ = the minimum cost order quantity.

To avoid the necessity of computing separately economic lot sizes for a large number of items, tables are available which present the economic order or lot sizes for various values of these factors. One such table [3] reproduced in Figure 23 on the following page is an example. This cost is calculated with U - the annual forecasted usage expressed in dollars; C_1 - the order cost expressed in dollar per unit per year; and Q - the economic order amount expressed in dollars and calculated by:

$$\frac{2C_1 U}{C_2}$$

The table is used by calculating the ratio C_1/C_2 and entering the column which has the value closest to the calculated value. In this column, opposite the annual usage, will be found the economic order quantity (Q) expressed in dollars.

In many cases materials can be purchased at quantity discounts or larger quantities may qualify for lower freight rates which will result in a lower unit delivered cost. This, of course, must be investigated when determining the sizes of orders.

TABLE OF ECONOMIC ORDER QUANTITIES

Annual usage (U)	Order amount in dollars (Q)				
	$C_1/C_2 = 25$	$C_1/C_2 = 50$	$C_1/C_2 = 75$	$C_1/C_2 = 100$	$C_1/C_2 = 150$
$ 1,000	$ 224	$ 316	$ 387	$ 447	$ 548
1,500	274	387	474	548	671
2,000	316	447	548	632	775
3,000	387	548	671	775	949
4,000	447	632	775	894	1,095
5,000	500	707	866	1,000	1,225
7,500	612	866	1,061	1,225	1,500
10,000	707	1,000	1,225	1,414	1,732
20,000	1,000	1,414	1,732	2,000	2,449
30,000	1.225	1,732	2,121	2,449	3,000
40,000	1,414	2,000	2,449	2,828	3,464
50,000	1,581	2,236	2,739	3,162	3,873
75,000	1,936	2,739	3,354	3,873	4,743
100,000	2,236	3,162	3,873	4,472	5,477
200,000	3,162	4,472	5,477	6,325	7,746
300,000	3,873	5,477	6,708	7,746	9,487
400,000	4,472	6,325	7,746	8,944	10,954
500,000	5,000	7,071	8,660	10,000	12,247
750,000	6,124	8,660	10,607	12,247	15,000
1,000,000	7,071	10,000	12,247	14,142	17,321

FIG. 23

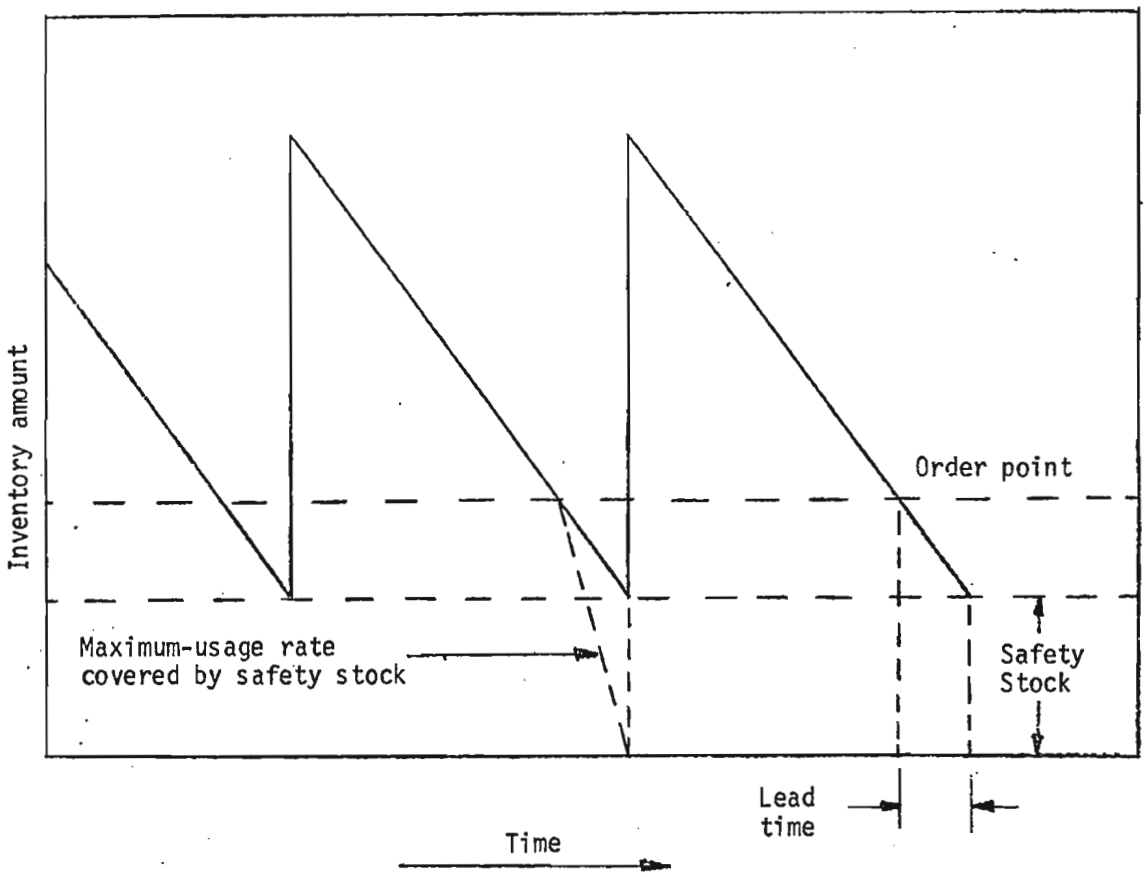
Taking this into consideration the most economic size of order will be arrived at by comparing the total annual cost C_T for the quantity (Q) calculated using the formula $Q = \sqrt{\frac{2C_1U}{C_2}}$ and for the quantity at which the price discount is obtained or at which the delivered freight applies.

The quantity which gives the lowest total annual cost (C_T) will be the order quantity.

In the proper operation of a General Stores, inventories can not be allowed to reduce to zero before placing a re-stock order. Orders must, therefore, be placed with sufficient lead time for it to arrive before the stock is reduced to zero. If the rate of usage is accurately known and is constant, the quantity could be allowed to reduce to Zero with the re-order placed sufficiently in advance for it to arrive before the store reached zero (lead time).

It is rarely the case, however, that rates of usage of materials are constant or are perdictable with any degree of accuracy. Often only the yearly consumption can be predictable with any accuracy, from previous records. Because the rate of usage is not constant it is necessary that a safety stock be maintained to provide for a higher than average rate of usage during the time that the re-stock order is placed and it arrives.

Fig. 24 graphically shows the variations in inventory levels when a safety stock is dependent upon the amount of risk that is willing to be taken of running out of stock. The larger the safety stock, the steeper will be the maximum usage rate covered by the safety



PATTERN OF VARIATIONS IN INVENTORY LEVELS WHEN SAFETY STOCK IS CARRIED

FIG. 24

stock and the smaller will be the risk of running out of stock.

An example of calculating the economic order size, etc., is as follows:

Assume that a construction company has a maintenance contract which includes replacing broken or burnt out light bulbs.

From previous records, the total required per year is 5,000 (U).

The cost to place an order is \$ 50.00 (C_1)

The unit cost per bulb is \$ 1.00 (C_3); and the unit for holding in stock, etc., is 20% of unit cost, i.e. \$ 0.20 - (C_2)

From formula $Q = \sqrt{\frac{2C_1U}{C_2}}$ the minimum cost order quantity =

$\sqrt{\frac{2 \times 50 \times 5{,}000}{.2}}$ = 1,581 or 3 orders per year = $\frac{5{,}000}{3}$ = 1,700 (approximately)

Total yearly cost C_T

$$= \frac{C_1U}{Q} + \frac{C_2Q}{2} + C_3U$$

$$= \frac{50 \times 5{,}000}{1{,}700} + \frac{.2 \times 1{,}700}{2} + 1 \times 500$$

$$= 147.00 + 170.00 + 5{,}000$$

TOTAL YEARLY COST = \$ 5,317.00

Discounts are available as follows for large quantity purchases:

For purchases of 2,000 - 2,999 bulbs - less 5% (i.e. C_3 = \$0.95)

For purchases of 3,000 - 4,999 bulbs - less 10% (i.e. C_3 = \$0.90)

Calculate new total yearly costs using discount prices for quantity of 2,000 @ \$0.95

$$C_T = \frac{50 \times 5{,}000}{2{,}000} + \frac{.2 \times 2{,}000}{2} + .95 \times 5{,}000$$

$$= 125.00 + 200.00 + 4{,}750.00$$

$$C_T = \$\ 5{,}075.00$$

For quantity of 3,000 @ $0.90

$$C_T = \frac{50 \times 5{,}000}{3{,}000} + \frac{.2 \times 3{,}000}{2} + .9 \times 5{,}000$$

$$= 83.30 + 300.00 + 4{,}500.00$$

$$C_T = \$\ 4{,}883.30$$

Therefore, the minimum cost order quantity = 3,000

From previous records, the following weekly usages are known:

Number of Bulbs per Week Replaced (N)	Number of Weeks (W)	N x W
30	1	30
50	2	100
60	5	300
75	6	450
90	8	720
100	9	900
110	10	1100
120	6	720
130	3	390
140	2	280
		5000

Average number of bulbs per week, replaced = 96.

If the lead time required for ordering and delivery is one week,

the minimum re-order level would be when the stock was at 30 bulbs and the maximum would be 140. The percentage of times that the stock would be reduced to zero as a result of orders placed at the various levels of remaining stock is as follows:

Number of bulbs per week replaced	Number of Weeks	Relative Frequency	Percentage of time, stock would run out if re-order placed at this remaining stock pt
30	1	.02	98
50	2	.04	94
60	5	.10	84
75	6	.11	73
90	8	.15	58
100	9	.17	41
110	10	.20	21
120	6	.11	10
130	3	.06	4
140	2	.04	0

From this table it can be seen that if the re-order is placed when the stock is down to 30, 98% of the time the stock will be down to zero before the order arrives. If the order is placed when the stock is at 90, the percentage of time will be .58 and so on. With this information in hand, and depending on the seriousness of running out of stock, management can arbitrarily decide the amount of the safety stock.

APPENDIX NO. IV

A COMPUTER APPLICATION OF THE MATERIAL EXPEDITING SYSTEM

1. GENERAL

The Material Expediting System has been designed to be used with the aid of a computer. In order to demostrate the feasibility of such an approach a number of computer programs have been written and tested using sample test data. These programs follow closely the concepts presented in the main body of this report and output the information required to fulfill the needs of the Material Expediting System user. Collectively these programs constitute a computer system which could be implemented with a minimum of reprogramming.

2. MACHINE REQUIREMENTS

Each program has been written in PL/I(F) programming language for the IBM 370 computer system. The minimum requirements are:

(1) 200K bytes of memory

(2) 1 tape drive

(3) 1 card reader

(4) 1 printer

(5) 1 disk drive

For more sophisticated systems pre-formated cards and printed forms could be used and, without going into the cost of such a venture, a terminal link with a large commercial computer installation would be advantageous.

A small set of test data has been compiled and operated on by the Material Expediting Computer System. This input data and the subsequent output results are discussed further under the section "System Overview" and "Sample Problem".

3. SYSTEM OVERVIEW

The Material Expediting Computer System is a set of inter-related programs or modules. These modules can be executed together or separately depending on the particular needs of the user. Continuity is maintained by the creation and subsequent updating of a permanent "General Stores Materials File" on magnetic tape which contains pertinent information on all the materials which may be required by the user.

Each of the programs which is available to the Material Expediting Computer System user is discussed below. - Note that the actual program listings and input formats are not included. This information could be separately prepared in a "Users Manual".

3.1 NEWTAPE - This program creates the "General Stores Materials File" on tape. Input consists of two types of cards containing data taken directly from the "General Stores Materials List" and the "Materials Information Sheet" respectively. It then prints out this information for checking purposes.

3.2 SUPDATE - This program updates the General Stores Materials File tape. Records may be added, deleted, or changed. SUPDATE is particularly useful in that it enables the user to revise "quantity in stock" and "quantity on order" at the General Stores. This should be done periodically to make sure that the Stores File is up to date.

3.3 MATLIST - This is a relatively small program which scans the General Stores Material File and outputs a "General Stores Material List". It is useful in that it enables the user to see what information he has stored on the file.

3.4 MATINFO - This program scans the General Stores Materials File and prints out a "Materials Information Sheet".

3.5 REP-GEN - This program reads two card files containing the "Work Breakdown Structure" and the "Bill of Materials" for a particular project (see example). It then calculates and prints out the "Material Status Sheet for the project, the "Material Status Sheet for stores, and all pertinent Requisitions.

3.6 FPTLIST - Since all input to the Material Expediting Computer System is to be on cards another small program has been added to the system. This procedure (FPTLIST) reads and lists card file and puts the card image records on a temporary disk file. Thus the user can get a complete list of his input data for checking purposes. It is also possible to use this disk file as input to the rest of the system, thereby eliminating the additional machine time and cost of re-submitting

the card deck.

4. SAMPLE PROBLEM

In order to test the programs a small set of test data was taken from the CPM diagram for a small building (see page 68).

The first step was the creation of a General Stores Materials File on tape. The program NEWTAPE was executed using data taken from the Materials Information Sheet (Fig. 25) and the General Stores Materials List (Fig. 26 (a & b). Next the program REP-GEN was used to generate the pertinent reports and requisitions for the project. REP-GEN required, as input, the Work Breakdown Structure for the project (Fig. 27) and the Bill of Materials (Fig. 28).

The output results are shown in Fig. 29 (a & b). They are: -

(i) Requisition (supplier) - Fig. 29 (2) to Fig. 29 (f)

(ii) Requisition (stores) - Fig. 29 (g) to Fig. 29 (k)

(iii) Requisition (supplier - stores) - Fig. 29 (l) to Fig. 29 (m)

(iv) Material Status Sheet for Project - Fig. 29 (n)

(v) Material Status Sheet for Stores - Fig. 29 (o)

MATERIALS INFORMATION SHEET

FORM 2

1 MATERIAL CODE	2 MATERIAL	3 UNIT OF MEASURE	4 ARE SHOP DRAWINGS AND/OR SAMPLES REQ'D YES/NO	5 TIME FOR PREPARATION OF SHOP DRAWINGS ETC. T1	6 TIME FOR REVIEW T2	7 TIME FOR ARCHITECT'S REVIEW AND APPROVAL T3	8 TIME FOR RESUBMISSION T4	9 TIME FOR FABRICATION T5	TIME FOR SHIPPING 10 FROM STORES T6	TIME FOR SHIPPING 11 FROM SUPPLIER T7	12 LEAD TIME
311	Concrete Formwork	PCS	NO	-	-	-	-	3	3	3	3
320	Concrete Reinforcement	LBS	YES	10	5	5	10	10	3	3	3
410	Mortar	C.Y.	NO	-	-	-	-	1	1	1	2
421	Brick Masonry	EA.	NO	-	-	-	-	5	5	10	10
611	Framing & Sheathing	FBM	NO	-	-	-	-	1	2	2	5
720	Insulation	S.F.	YES	3	3	3	5	1	5	10	5
770	Flashings	LF	YES	3	3	3	5	1	5	10	5
820	Wood Doors	EA.	YES	10	5	5	10	15	5	15	5
1521	W.S. Pipe	LF	NO	-	-	-	-	1	5	15	5
1526	S. & W Pipe	LF	NO	-	-	-	-	1	5	15	5

FIGURE 25

GENERAL STORES MATERIALS LIST

FORM 3

MATERIAL CODE NO.	MATERIAL	MATERIAL DESCRIPTION	UNIT OF MEASURE	QUANTITY IN STOCK	WILL THIS MATERIAL BE RESTOCKED	MINIMUM QUANTITY TO BE HELD IN STOCK	MAXIMUM QUANTITY TO BE HELD IN STOCK	QUANTITY ON ORDER	DELIVERY DATE
311	Concrete Formwork	2 Ft. by 8 Ft. Plywood Panels	PCS	400	NO				
311	Concrete Formwork	2 Ft. by 10 Ft. Plywood Panels	PCS	350	NO				
311	Concrete Formwork	2 Ft. by 12 Ft. Plywood Panels	PCS	200	NO				
320	Concrete Reinforcement	No 3 by RL Rebar	LBS	1000	YES	500	1500		
320	Concrete Reinforcement	No 5 by RL Rebar	LBS	1200	YES	500	1500		
320	Concrete Reinforcement	No 7 by RL Rebar	LBS	300	YES	500	1500	1200	81572
410	Mortar	Masonry Cement	C.Y.	600	YES	100	1000		
410	Mortar	Masonry Sand	C.Y.	400	YES	100	1000		
421	Brick Masonry	Modular Face Brick Buff	EA.	5000	NO				
611	Framing & Sheathing	2 by 4 by 8 Ft.	FBM	2000	YES	500	2000		
611	Framing & Sheathing	2 by 4 by 10 Ft.	FBM	600	YES	500	2000		
611	Framing & Sheathing	1 inch by 6 inch by RL T & G	FBM	1200	YES	1000	3000		
720	Insulation	1 in. Purlboard Aluminum Foil 1 Side	S.F.	6000	YES	2000	10000		
720	Insulation	1½ in. Roofmate Insulation	S.F.		NO				

FIGURE 26

GENERAL STORES MATERIALS LIST

FORM 3

MATERIAL CODE NO.	MATERIAL	MATERIAL DESCRIPTION	UNIT OF MEASURE	QUANTITY IN STOCK	WILL THIS MATERIAL BE RESTOCKED	MINIMUM QUANTITY TO BE HELD IN STOCK	MAXIMUM QUANTITY TO BE HELD IN STOCK	QUANTITY ON ORDER	DELIVERY DATE
770	Flashings	18 in. wide 2 oz. copper ffbreen	LF		NO				
820	Wood Doors	2 - 8 x 7 x 1 3/4 Slab Mah. Doors	EA	6	YES	4	10		
820	Wood Doors	3 x 7 x 2 Plank Oak Doors	EA	10	YES	4	10		
820	Wood Doors	2 - 4 x 7 x 1 3/4 Slab Mah. Doors	EA		NO				
1521	W.S. Pipe	2 in. copper pipe	LF	200	YES	100	1000		
1526	S & W Pipe	4 in. cast iron tyton joint pipe	LF		NO				

FIGURE 26 (Continued)

WORK BREAKDOWN STRUCTURE

FORM 1

1 WORK PACKAGE	2 WORK PACKAGE NO.
SITE WORK AND EXTERIOR SERVICES	1
CONCRETE FOUNDATION, CONCRETE FLOOR	
AND UNDERSLAB PIPE	2
STRUCTURAL STEEL	3
MASONRY AND EXTERIOR WALL INSULATION	4
BUILD-UP ROOF, FLASHING AND ROOF INSULATION	5
ELECTRICAL WORK	6
MECHANICAL WORK	7
CARPENTRY, WINDOWS AND ALL FINISHES	8

FIGURE 27

BILL OF MATERIALS

FORM 4

1 WORK PACKAGE NO.	2 MATERIAL CODE NO.	3 MATERIAL DESCRIPTION	4 QUANTITY	5 UNIT OF MEASURE	6 START DATE OF FIRST ACTIVITY REQUIRING THIS MATERIAL
4	0720	1 inch purlboard, aluminum foil 1 side	3000	S.F.	53
4	2421	modular face brick buff	20000	EA	53
4	0770	18" wide 2 oz. copper fibreen	330	L.F.	53
4	0410	masonry cement	200	C.Y.	53
4	0410	masonry sand	50	C.Y.	53
5	0720	1½ inch roofmate insulation	5000	S.F.	66
1	1526	4 inch cast iron tyton joint pipe	200	L.F.	10
1	1521	2 inch copper pipe	200	L.F.	10
2	1526	4 inch cast iron tyton joint pipe	70	L.F.	35
2	1521	2 inch copper pipe	70	L.F.	35
8	0820	2' - 8" x 7' x 1 3/4" slab mah. doors	15	EA	109
8	0820	2' - 4" x 7' x 1 3/4" slab mah. doors	1	EA	109
8	0820	3' x 7' x 2" plank oak doors	2	EA	109
		FIGURE 28			

REQUISITION

PROJECT: SMALL BUILDING

ORDER DATE
29

MATERIAL CODE NO. 421 MATERIAL: BRICK MASONRY

SOURCE OF SUPPLY: SUPPLIER

SHOP DRAWINGS REQUIRED BY: N/A

SHOP DRAWINGS WILL BE RETURNED BY: N/A

DELIVERY SCHEDULE

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	REQUIRED SHIPPING DATE	REQUIRED DELIVERY DATE
MODULAR FACE BRICK BUFF	15000	E.A.	3/1	4/1

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	UNIT PRICE	TOTAL
MODULAR FACE BRICK BUFF	15000	E.A.		

FIGURE 29 (a)

REQUISITION

PROJECT: SMALL BUILDING

ORDER DATE
55

MATERIAL CODE NO. 720 MATERIAL: INSULATION

SOURCE OF SUPPLY: SUPPLIER

SHOP DRAWINGS REQUIRED BY: 38

SHOP DRAWINGS WILL BE RETURNED BY: 44

DELIVERY SCHEDULE

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	REQUIRED SHIPPING DATE	REQUIRED DELIVERY DATE
1/2 IN. ROOFMATE INSULATION	5000	S.F.	52	52

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	UNIT PRICE	TOTAL
1/2 IN. ROOFMATE INSULATION	5000	S.F.		

FIGURE 29 (b)

REQUISITION

PROJECT: SMALL BUILDING ORDER DATE 29

MATERIAL CODE NO. 770 MATERIAL: FLASHINGS

SOURCE OF SUPPLY: SUPPLIER

SHOP DRAWINGS REQUIRED BY: 32

SHOP DRAWINGS WILL BE RETURNED BY: 58

DELIVERY SCHEDULE

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	REQUIRED SHIPPING DATE	REQUIRED DELIVERY DATE
18 IN. WIDE 2 OZ. COPPER FIBREEN	330	LF	39	39

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	UNIT PRICE	TOTAL
18 IN. WIDE 2 OZ. COPPER FIBREEN	330	LF		

FIGURE 29 (c)

REQUISITION

PROJECT: SMALL BUILDING

ORDER DATE
55

MATERIAL CODE NO. 820 MATERIAL: WOOD DOORS

SOURCE OF SUPPLY: SUPPLIER

SHOP DRAWINGS REQUIRED BY: 65

SHOP DRAWINGS WILL BE RETURNED BY: 75

DELIVERY SCHEDULE

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	REQUIRED SHIPPING DATE	REQUIRED DELIVERY DATE
2-8 X 7 X 1 3/4 SLAB MAH. DOORS	9	EA.	90	105
2-4 X 7 X 1 3/4 SLAB MAH. DOORS	3	EA.	90	105

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	UNIT PRICE	TOTAL
2-8 X 7 X 1 3/4 SLAB MAH. DOORS	9	EA.		
2-4 X 7 X 1 3/4 SLAB MAH. DOORS	3	EA.		

FIGURE 29 (d)

REQUISITION

PROJECT: SMALL BUILDING ORDER DATE 1

MATERIAL CODE NO. 1521 MATERIAL: W.S. PIPE

SOURCE OF SUPPLY: SUPPLIER

SHOP DRAWINGS REQUIRED BY: N/A

SHOP DRAWINGS WILL BE RETURNED BY: N/A

DELIVERY SCHEDULE

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	REQUIRED SHIPPING DATE	REQUIRED DELIVERY DATE
2 IN. COPPER PIPE	70	LF	16	31

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	UNIT PRICE	TOTAL
2 IN. COPPER PIPE	70	LF		

FIGURE 29 (e)

REQUISITION

PROJECT: SMALL BUILDING

ORDER DATE -1W

MATERIAL CODE NO. 1526 MATERIAL: S & W PIPE

SOURCE OF SUPPLY: SUPPLIER

SHOP DRAWINGS REQUIRED BY: N/A

SHOP DRAWINGS WILL BE RETURNED BY: N/A

DELIVERY SCHEDULE

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	REQUIRED SHIPPING DATE	REQUIRED DELIVERY DATE
4 IN. CAST IRON TYTON JOINT PIPE	200	LF	-9	6
4 IN. CAST IRON TYTON JOINT PIPE	70	LF	16	31

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	UNIT PRICE	TOTAL
4 IN. CAST IRON TYTON JOINT PIPE	270	LF		

FIGURE 29 (f)

REQUISITION

PROJECT: SMALL BUILDING

ORDER DATE
51

MATERIAL CODE NO. 410 MATERIAL: MORTAR

SOURCE OF SUPPLY: STORES

SHOP DRAWINGS REQUIRED BY: N/A

SHOP DRAWINGS WILL BE RETURNED BY: N/A

DELIVERY SCHEDULE

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	REQUIRED SHIPPING DATE	REQUIRED DELIVERY DATE
MASONRY CEMENT	200	C.Y.	51	52
MASONRY SAND	50	C.Y.	51	52

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	UNIT PRICE	TOTAL
MASONRY CEMENT	200	C.Y.		
MASONRY SAND	50	C.Y.		

FIGURE 29 (g)

REQUISITION

PROJECT: SMALL BUILDING

ORDER DATE
29

MATERIAL CODE NO. 421 MATERIAL: BRICK MASONRY

SOURCE OF SUPPLY: SIOUX

SHOP DRAWINGS REQUIRED BY: N/A

SHOP DRAWINGS WILL BE RETURNED BY: N/A

DELIVERY SCHEDULE

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	REQUIRED SHIPPING DATE	REQUIRED DELIVERY DATE
MODULAR FACE BRICK BUFF	5000	EA.	39	44

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	UNIT PRICE	TOTAL
MODULAR FACE BRICK BUFF	5000	EA.		

FIGURE 29(h)

REQUISITION

PROJECT: SMALL BUILDING ORDER DATE 35

MATERIAL CODE NO. 720 MATERIAL: INSULATION

SOURCE OF SUPPLY: SIMES

SHOP DRAWINGS REQUIRED BY: 38

SHOP DRAWINGS WILL BE RETURNED BY: 44

DELIVERY SCHEDULE

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	REQUIRED SHIPPING DATE	REQUIRED DELIVERY DATE
1 IN. PURLBOARD ALUMINUM FOIL 1 SIDE	3000	S.F.	44	49

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	UNIT PRICE	TOTAL
1 IN. PURLBOARD ALUMINUM FOIL 1 SIDE	3000	S.F.		

FIGURE 29 (i)

REQUISITION

PROJECT: SMALL BUILDING ORDER DATE 55

MATERIAL CODE NO. 824 MATERIAL: WOOD DOORS

SOURCE OF SUPPLY: STORES

SHOP DRAWINGS REQUIRED BY: 65

SHOP DRAWINGS WILL BE RETURNED BY: 75

DELIVERY SCHEDULE

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	REQUIRED SHIPPING DATE	REQUIRED DELIVERY DATE
2-8 X 7 X 1 3/4 SLAB MAH. DOORS	6	EA.	100	105
3 X 7 X 2 PLANK OAK DOORS	2	EA.	140	105

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	UNIT PRICE	TOTAL
2-8 X 7 X 1 3/4 SLAB MAH. DOORS	6	EA.		
3 X 7 X 2 PLANK OAK DOORS	2	EA.		

FIGURE 29 (j)

REQUISITION

PROJECT: SMALL BUILDING ORDER DATE 1

MATERIAL CODE NO. 1521 MATERIAL: W.S. PIPE

SOURCE OF SUPPLY: STORES

SHOP DRAWINGS REQUIRED BY: N/A

SHOP DRAWINGS WILL BE RETURNED BY: N/A

DELIVERY SCHEDULE

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	REQUIRED SHIPPING DATE	REQUIRED DELIVERY DATE
2 IN. COPPER PIPE	200	LF	1	6

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	UNIT PRICE	TOTAL
2 IN. COPPER PIPE	200	LF		

FIGURE 29 (k)

REQUISITION

PROJECT: SMALL BUILDING

ORDER DATE
100

MATERIAL CODE NO. 82M MATERIAL: WOOD DOORS

SOURCE OF SUPPLY: SUPPLIER OF DOORS

SHOP DRAWINGS REQUIRED BY: 11M

SHOP DRAWINGS WILL BE RETURNED BY: 12M

DELIVERY SCHEDULE

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	REQUIRED SHIPPING DATE	REQUIRED DELIVERY DATE
2-8 X 7 x 1 3/4 SLAB MAH. DOORS	10	EA.	13S	15M

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	UNIT PRICE	TOTAL
2-8 X 7 X 1 3/4 SLAB MAH. DOORS	1M	EA.		

FIGURE 29 (1)

REQUISITION

PROJECT: SMALL BUILDING ORDER DATE 1

MATERIAL CODE NO. 1521 MATERIAL W.S. PIPE

SOURCE OF SUPPLY: SUPPLIER'S NAME

SHOP DRAWINGS REQUIRED BY: 1

SHOP DRAWINGS WILL BE RETURNED BY: 1

DELIVERY SCHEDULE

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	REQUIRED SHIPPING DATE	REQUIRED DELIVERY DATE
2 IN. COPPER PIPE	1000	LF	2	17

MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	UNIT PRICE	TOTAL
2 IN. COPPER PIPE	1000	LF		

FIGURE 29 (m)

MATERIAL STATUS SHEET
FOR PROJECT

PROJECT: SMALL BUILDING CODE: 4619-1-5

MATERIAL CODE NO.	UNIT OF MEASURE	TOTAL QUANTITY FOR JOB	FROM STORES	FROM SUPPLIER	QUANTITY PER WORK PACKAGE PACKAGE NO.	FROM STORES	FROM SUPPLIER	ORDER EXPEDITE DATE	RECEIVE SHOP DRAWINGS	SUBMIT FOR APPROVAL	RECEIVE FROM ARCHITECT	SHIPPING DATE FROM STORES	FROM SUPPLIER	DELIVERY DATE
410	C.Y.				4	200	0					51	0	52
410	C.Y.				4	50	0					51	0	52
410	C.Y.	250	250	0				51	N/A	N/A	N/A			
421	EA.				4	5000	15000					39	34	44
421	EA.	20000	5000	15000				29	N/A	N/A	N/A			
720	S.F.				5	0	5000					0	52	62
720	S.F.				4	3000	0					44	0	49
720	S.F.	8000	3000	5000				35	38	41	44			
770	LF				4	0	330					4	39	49
770	LF	330	0	330				29	32	35	38			
820	EA.				8	6	9					100	90	105
820	EA.				8	0	3					0	90	105
820	EA.				8	2	0					100	0	105
820	EA.	20	8	12				55	65	70	75			
1521	LF				1	200	0					1	0	6
1521	LF				2	0	70					0	16	31
1521	LF	270	200	70				1	N/A	N/A	N/A			
1526	LF				1	0	200					0	-9	6
1526	LF				2	0	70					0	16	31
1526	LF	270	0	270				-10	N/A	N/A	N/A			

FIGURE 29 (n)

MATERIAL STATUS SHEET
FOR GENERAL STORES

PROJECT: SMALL BUILDING CODE: 4619-1-5

MATERIAL CODE NO.	MATERIAL DESCRIPTION	QUANTITY	UNIT OF MEASURE	ORDER EXPEDITE DATE	RECEIVE SHOP DRAWINGS	RETURN SHOP DRAWINGS	SHIPPING DATE	DELIVERY DATE
820	2-0 X 7 X 1 3/4 SLAB MAH. DOORS	10	EA.	100	110	120	135	150
1521	2 IN. COPPER PIPE	1000	LF	1	N/A	N/A	2	17

FIGURE 29 (o)