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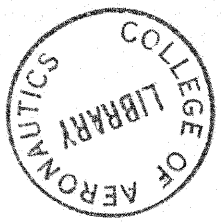
AN APPRAISAL OF A SYSTEMS PROCEDURE WITH PARTICULAR REFERENCE TO A TYRE MANUFACTURING ORGANISATION

2ND YEAR ERGONOMICS COURSE



D. BEEVIS, T. B. LEAMON, E. J. LOVESEY,
J. G. NEALE, R. H. D. STRANK.

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CoA. M and P. MEMO. 18.

AN APPRAISAL OF A SYSTEMS PROCEDURE WITH PARTICULAR REFERENCE TO A TYRE MANUFACTURING ORGANISATION

2nd Year Ergonomics Course

D. Beevis, T.B. Leamon, E.J. Lovesey

J.G. Neale, R.H.D. Strank

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1 SUMMARY

The objective of this project was to show how the procedures and techniques of system design may be used to evolve a soft system.

In this project a systems design procedure was applied to a tyre ordering and despatch method for a large manufacturing organisation.

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3 ACKNOWLEDGMENTS

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Thanks are due, also, to Mrs. M. Lesley for her help in the preparation of the report and for her forbearance throughout the duration of the project.

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5 INTRODUCTION

A need for philosophical foundations has emerged in modern systems engineering and although many concepts have been forthcoming in answer to this, there is at present a definite absence of sound techniques or methodologies which implement these ideas.

In this report there has been an attempt to evolve a technique or procedure stemming from the systems engineering approach at Cranfield. This procedure ensures a logical and systematic transition from ideal hypothetical systems based on philosophies to actual practical applications.

The subject on which this project was based was a real life manufacturing organisation. At present this Company manufactures 250 different types of tyres and tubes, or approximately 200,000 items each year at its Gravesend factory, although its sales are increasing by about 5% per annum in proportion with the number of new vehicles on the road.

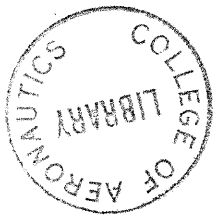
20% of its orders are received through its Maida Vale depot and the remainder by way of another 11 depots throughout the U.K. The Company's Head Office which, due to wartime strategy, is situated at Dorking, deals with the 100 or so large orders received each year.

The time between a particular depot ordering goods from the factory and despatch to the customer by van, British Railways or Road Services is within 3 or 4 days. (If the depot knows it cannot fulfil an order within 24 hours, then that order is lost). Goods are sold only to motor trade representatives and discounts are fixed according to the customer's past history.

6 A GENERAL DESCRIPTION OF SYSTEMS PROCEDURE

A noticeable trend in man's expanding environment is the growth of large and complex systems which have become necessary in modern society. They include such abstract systems as government and economics and such large scale physical systems as transportation and communication. The growth of these systems has brought about the need for a more overall view and long range development of systems. The procedures used in planning and design of complex systems are under constant review and attempts are made to evaluate their efficiency. This can best be done on a multi-disciplinary basis because of the large number of factors affecting or affected by a complex system. However, it seems at the moment that expanding needs outstrip the application of new knowledge. Systems engineering is an attempt to remedy this situation and make for a more efficient application of knowledge to design procedure. It questions the need of a piece of hardware so that development inconsistent with overall systems goals is eliminated. It directs research into the type and design of system required before development begins and makes for efficient use of resources.

Noteworthy features of the systems engineering philosophy are that it treats man as an integral part of a system. It places great emphasis on the objectives of the system and how these are achieved rather than on details of the mechanism involved in the system. It employs a synthetic approach, logically building up a system from the definition of the objectives and at the same time catering for the characteristics of the components involved whether human or hardware, and does not seek to modify an existing system.



In remedying deficiencies at the design stage, the systems approach works through an ordered routine from the specification of the objectives, dividing into sub-systems, allocating function between human and physical components, designing the communication links between sub-systems and also between man and machine (interface design), considering problems of production and maintenance and finally evaluating the design. The philosophy used is sufficiently flexible to apply to "soft" systems (office procedures) or hard systems (dominated by machinery) ranging from one man/one machine units to complex systems involving many men and machines.

It was thought possible to make a definitive statement, in the form of a procedural layout, of such a philosophy. An attempt has been made to crystalize this philosophy into sections leading up to a manageable technique with general application. It is believed that this is the first time such an attempt has been made.

7 THE PROCEDURE OF SYSTEMS DESIGN OF THE ERGONOMICS SECTION, CRANFIELD P O S D E C

Posdec is a synthetic technique which starts by gathering a nucleus of ideas and gradually expanding, at the same time assimilating known facts of the real world. In this way any awkward transitions between real and ideal situations are removed and the project develops until it is ready to fit into the external system.

By virtue of Posdec's synthetic nature unwanted redundancy is removed, since each inclusion is an attempt to satisfy a need which has arisen during the expansion process. Also useful redundancy is highlighted and should the external environment of the operating system change, then the effects on

need for such redundancy are readily reviewed. This contrasts with the analytical approach, in which it is so easy to retain functions to satisfy immediate term requirements, which are themselves highly redundant or ineffective.

1. Terms of Reference

In common with other methods the terms of reference and general policy positions must be stipulated. Because of the "blossoming" nature of Posdec, it is often of more use to define the problem and the boundaries, beyond which Posdec may not operate in the particular instance, rather than ask for a "stock-control-system" or some other "known" solution. Posdec attempts to solve the problem by satisfaction of basic needs rather than forcing a solution along preconceived lines. Thus there is no trouble, for example, in designing a working schedule to solve a problem which appeared to be a stock control problem or vice versa.

2. Allocation of Functions

The systems objectives, which are those necessary to satisfy the problem are represented in a onebloc diagram. This is a single-block diagram, with all the inputs and outputs represented on it. No attempt is made to assess or determine the function inside the block which absorbs such inputs and produces such outputs.

Once each and every peripheral connection is listed on the onebloc diagram the necessary functions are entered inside the block. No attempt is made to organise, to order or to connect these functions at this time. Each function is now defined, without regard to the present problem. This will reveal if any function has been incorrectly included, or if a function is, in fact, two related functions, a good example is STORE and DESPATCH.

Using these definitions, the functions are expanded into individual oneblocs. Any output must be a result of input of information or goods and the outputs of each onebloc must be justified in this manner. At this stage the need, the solution and the functions necessary to achieve this solution are defined in a series of oneblocs.

3. Construction of multi-block diagram

The functions specified in 2 are combined and connected together to give a multi-block definition of what goes on inside the onebloc. Note there are no geographical limitations of any kind in the question at this time. This is an iterative process.

The first connections made are between on-line functions to represent the movement of goods. This is because, in almost every conceivable case, movement of goods involves more effort than communication and control movements. Thus, the more expensive movements are defined first and any compromise necessary will affect the more easily transportable components of the system. It will now be clear that a trigger is necessary to start the goods moving (possibly with several other triggers down the line), this trigger connection is then made. Other links which determine the control are now made and the control triggers need to be considered. This is usually in the form of feedback and the necessary feedback loops should be checked. This multi-block diagram should be now compared with the onebloc diagrams with especial regard to input-outputs. If the inputs and outputs of the multi-block do not correspond with inputs and outputs of the oneblocs, then the definition of the onebloc is reviewed; if this is still valid, then the multi-block is corrected. If there are more connections the redundancy can be readily traced and its worth assessed. As was indicated previously, this is an iterative process and much labour is avoided if each iteration is drawn in a similar form.

This facilitates checking alterations by allowing the pattern recognition facilities of the Posdec operator to be used. Finally, a Dry Run Verification is carried out, starting from the "customers" end (or unsatisfied need end), to see if the synthesised system will satisfy such a need.

4. Distribution of Responsibility for Function

At this stage it cannot be stressed too strongly, functions, such as have been described so far, have no connection with geography. Thus, every geographical component of a system may perform part or all of every or any function. This is made clear in the construction of the Geofunction Matrix. Function as defined in 2 is charted along the x axis and geographical component along the vertical axis. (This is the procedure if the system is to be fitted into an existing parent system. If the parent system is also in the design stage then ideal geographical components may be formally defined as to perform the required functions most efficiently). If the geographic component should contribute to any function the position is indicated. This indicates what functions a component is limited to contributing to. This matrix enabled isofunctional lines to be superimposed on the multi-block diagram.

5. Interfaces

It is a further characteristic of Posdec that these isofunctional lines cross communication paths and in doing so, specify the information requirements for each interface. With the origin, destination and information content so neatly defined it is largely a matter of form design in construction of these interfaces.

6. Procedure

A disadvantage Posdec shares with all other procedures is the lack of dynamic representation. This is overcome by constructing a Procedure Chart. The purpose of this chart is not to provide a working handbook for the system,

indeed it would be a mistake to write procedure manuals before the system is accepted, but to link the operations and movements within the system in a chronological and dependent manner. Asme symbols are a useful technique to employ, but construction of simo characteristics is to be avoided. Instead the manner of flow diagram, namely a main process with loops and sub-routines, which has been universally accepted by systems analysts and digital computer programmers as providing the most comprehensive grasp of the system is used.

8 APPLICATION OF PROCEDURE TO THE TYRE PROJECT

a) Definition of Objectives

The project was introduced with a general statement of the problem. The objective of the project was defined thus :

To design an ordering system for the Henley Tyre Company from the time the customer's order is received until payment is made. The project was to be concerned with normal orders from the Maida Vale depot only; it would not take into account large orders which are normally handled by the Head Office.

The objectives of the system may be specified in a onebloc diagram, (see Fig.1) showing the flow of goods and information into and out of the system.

b) Allocation of Function

With the system objectives as defined, it was possible to specify the functions necessary to achieve them. These again were summarised in a block diagram (see Fig.2).

The necessary functions were derined as :-

a) Manufacturing - to be responsible for producing goods according to instructions from scheduling, at minimum cost.

b) Scheduling - to be responsible for co-ordination of goods in manufacture, goods in store, orders received and sales forecasting.

c) Stores - responsible for reducing lead time to customer and enabling economic batch production.

d) Accounts - responsible for invoicing, receipt of payment and maintaining customer records.

e) Despatch - to organise the transference of goods from stores to customers.

c) Operational Procedure

The function oneblocs of the System Diagram (see Fig.2) were expanded, each having its inputs and outputs added (see Fig.3). The Functional Diagram was synthesised from these sub-systems by joining the corresponding inputs and outputs as described. (see 7.3).

d) Distribution of Functions

With the ideal system synthesised entirely from the original Definition of Objectives, it was tailored to the constraints of the existing system. There are three geographical components to consider; Head Office at Dorking, the Factory at Gravesend, and the Depot at Maida Vale. The five Functions defined had to be distributed between these three sections in the most efficient manner. The approach to this problem was to tentatively distribute each function to each geographical component, and then to discard those considered unnecessary. The Distribution of Functions was thus finalised as :

	Manufacturing	Scheduling	Accounts	Stores	Despatch
Factory	√	√			
Office			√		
Depot		√	√	√	√

Having distributed the functions, it was possible to superimpose the geographical constraints on to the diagram of the ideal system (see Fig.4). This created the Interfaces which had to be designed.

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e) Interface Design

The interfaces implied in fig.4 were then designed. The first interface considered was the one between the customer and the accounts function at the depot - occurring when the customer originates an order. It was decided that the information transferred across this interface should consist of the customer's name and address, the type and quantity of tyres needed, and the date when the customer wanted delivery. Any extra information would be superfluous. At this point, it was noted that there was a subsidiary condition on this interface, namely that the majority of orders were placed by telephone, and the finalised procedure would have to take account of this fact.

The interface that occurred next was an internal one, where the customer's order was verified against his credit-worthiness. The information required here was a statement of the customer's current credit-worthiness, and the cash value of the present order. Subsidiary conditions on this interface were that the statement of a customer's credit-worthiness should be easily updated, and that a negative result would be acted on.

The next interface considered was also internal to the depot, between the accounts and scheduling functions, checking that the goods needed were in fact held at the depot. The information needed here was a statement of the customer's needs, and of the goods held at the depot. Subsidiary conditions on this interface were that the depot stock records should be updated rapidly, and that immediate action should be taken if the goods were not in stock.

Following the system diagram, the next interfacing that occurred was between the depot functions of scheduling and stores, to actually raise the goods. The information needed here was the quantity of goods involved, and also the date on which the goods were required.

Still following the path round the system diagram, the next logically

occurring interface was between the stores and despatch functions. Here, in addition to information, i.e. the quantity ordered, and the customer's name and address, the physical transfer of goods was required.

The despatch function had two interfaces with the customer, firstly when sending the goods to the customer, and secondly receiving confirmation that goods have been delivered. For the first of these, the transfer of goods was necessary and also verification of the goods ordered. For the second, the necessary information was a confirmation that the customer had received the goods. For the first interface, there was a subsidiary condition that it should be possible to verify that all orders received had, in fact, been sent out; for the second interface, the subsidiary condition was that it should be possible to verify that all goods sent out had been received. In this connection, it was noted that most goods were sent by van, but that an undesirable delay in returning the customer's verification could occur if goods were sent by outside carrier.

The next interface that occurred was between the despatch function at the depot and the accounts function at Head Office, where information from the depot triggered the invoice to the customer. The necessary transfer of information here was the customer's name and address, the cash value of the order, and the date of delivery. A subsidiary condition here was that the information should be pre-processed as far as possible, to reduce work at Head Office.

The final interfaces between Head Office and customer, i.e. presenting the invoice and receiving payment, were comparatively simple. The information required by the customer was the amount due, the goods to which this amount relates, and the date when payment is due. The information required by Head Office on receipt of payment was the account to which the payment related.

f) Practical Procedure

Having decided on the necessary transfers of information at the various

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interfaces, it was then a simple task to design a procedure that combined the necessary elements at each interface, the details of the system being tailored to fit any subsidiary conditions. The recommended procedure that emerged was as follows :

On receipt of the order, an order form is made out in duplicate, containing the customer's name and address, the quantity of goods ordered and their type, the required date of delivery, and the cash value of the order without discount. The customer's credit is now verified from a card file, one card being allocated to each customer. If the customer has exceeded his credit, he is informed of this and the order destroyed. If not, the value of the order is entered on the card, and cast up to give a running total of credit extended to the customer. Also entered on the card are the quantity and type of goods ordered, and the required date of delivery. The order is then checked against a record of the depot stock, to ensure that the order is available. The stock record takes the form of individual entry and difference cards, updated as each order is received. If the order is not in stock, the customer is informed of this, and a request telephoned through to factory scheduling for the necessary goods. In this case, both copies of the order are retained in a special file, to await delivery of the goods to the depot. If the goods are available in stock, both copies of the order are passed to the stores function.

Both copies of the order are filed in stores according to the required date of delivery, one file for each day. When required (probably as soon as the order is received), stores pass the necessary goods and both copies of the order to despatch. Despatch passes the goods and one copy of the order to the delivery van. The order form now acts as a delivery note, is signed by the customer on receipt of the goods, and is returned to the depot. Where goods are taken by outside carriers, the carrier signs the delivery note as though he were the customer. The returned

delivery notes are then checked against the copies retained in despatch, to ensure that all goods sent out have been delivered. They are then checked against the customer credit file, and the orders entered on the cards as delivered. This also acts as a check that all orders received have been sent out. The order forms are finally destroyed.

At the end of the month, the customer credit cards are removed from the file (being replaced by new ones) and sent to Head Office. When they arrive, Head Office prepares and sends an invoice. On receipt of payment, the cards are stamped "Paid" and stored for a year, then destroyed.

The above procedure can also cope with interdepot transfers, if the receiving depot is treated as a customer in the normal way. Depots receiving goods would treat them exactly as if they had come straight from the factory. (This procedure was not dealt with specifically, since it was outside the original terms of reference).

This completed the functions of the system within the terms of reference given. Some consideration was given to the interfaces arising from interactions with other parts of the complete system, chiefly those of the scheduling functions. It had already been decided that all scheduling decisions should be delegated to the central function at the factory (see "Allocation of Function" above). Therefore, the necessary information transfer between the depot and factory scheduling functions was simply a record of stock held in the depot.

9 SUMMARY OF "STANDARD WORK STUDY SOLUTION"

The usual work study techniques were employed to analyse and revise the system.

1) The present system was observed.

2) A procedure chart was drawn up from the observations.

3) The chart was systematically appraised to find redundant activities. This was done by considering the activities in groups, namely -

The CONTROL Group, which includes orders (by post and telephone), rough stock sheet, weekly stock taking sheet and the consolidated sheet.

The ORDERING Group, which includes tyre traders register, 3 part order form, and advice note.

The PRICING Group, which includes registered order book, price list, daily sales order, bad accounts, Kardex and a memo.

The INVOICING Group, which includes the invoice itself, serial number book, memo, invoice number check book, punched card, P.S. code book, and an invoice batch summary.

The objectives of each group were identified and activities were "tailored" to improve efficiency, the decisions (of what to include and what not to include) being taken on the basis of a critical examination, comparing purpose and worth with cost.

4) A revised procedure chart was produced which enabled reappraisal of the proposed method and necessary modification of proposals to be made.

5) Improvements resulting from the final proposed method were demonstrated using string diagram techniques on a Sales Order Procedure Map.

Following are some of the comments in the final report issued by the work study consultants which illustrate the above techniques employed and point to details of their solution :-

Although the charting procedure does not show inefficiencies, it was discerned that of the 137 activities involved in the present system only some 25 really contribute to the procedure.

CONTROL GROUP

1) It was noted that 80% of orders received were made by telephone and that a telephone order pad was used. It was considered inadvisable to change this procedure.

2) A simple Rotodex file was inserted instead of using a rough stock sheet to check availability of stock on receipt of an order.

3) A stock taking sheet at the Head Office was eliminated because the information contained on it was available on punch cards at the factory. A consolidated stock sheet containing information of all depots raised by punch card replaced it.

ORDERING GROUP

1) The work study consultants decided that as the details concerning the customer were constant some means of reproducing the information was desirable and so they introduced a metal plate system (ADREMA) for duplicating information at the order raising stage. This was feasible as there were only three different discount rates for all customers at any one depot and prices in the industry are reasonably stable.

2) The Advice Note was eliminated, a tear off strip on one of the order forms being used instead.

The Sales Order Procedure Map - String Diagram technique was employed to demonstrate that unnecessary duplication had been eliminated as far as possible in this ordering group.

PRICING GROUP

Pricing was considered to be a task involving a large amount of responsibility and so to lighten the burden it was decided to introduce metal plates with the Power Samas coding number on the metal plate used for each customer.

1) It was found necessary to locate bad accounts at the depot stage in order to control the distribution of tyres to unsuitable customers.

2) The Registered Order Book had two functions in the existing system:

a) To give an order number.
b) To obtain a daily sales figure.

a) is unnecessary because the order can be identified by its original order number and b) is also redundant because a daily sales order figure is obtainable via an invoice batch summary which could be circulated daily. The Registered Order Book was eliminated.

INVOICING GROUP

Attempts were made in this group to reduce goods despatch to invoice despatch lag so that discount payment terms might apply. In order to accomplish this, it was found necessary to raise the invoice at the depot.

10 APPRAISAL OF SYSTEMS PROCEDURE

The work study approach is based on the analysis of the existing system whereas the Systems approach is one of synthesis of the logically ideal system.

This dissimilarity in philosophy results in the following differences in procedure -

1) a) Work study starts with the existing system.

b) The Systems approach starts by defining the systems objectives.

The advantage of using work study lies in the fact that it ensures that nothing is omitted since the current system presumably functions. On the other hand, the Systems approach ensures that there is no bias towards a solution in terms of the present system.

If any relevant practical details are omitted during the work study recording stage, a false solution is liable to be reached. Although work study is unlikely to include unnecessary operations, there is a

tendency to accept implicitly that the existing structure has the correct general form whereas with the Systems approach there is a danger of omitting necessary operations.

2) The work study approach utilizes experience and intuition in analysing the existing sub-routines. Systems procedure uses a logical method of synthesis. In other words, the former approach is dependent on the experience of the investigator whereas the latter depends more on the operator's training.

3) A disadvantage of the Systems approach is that the synthesised ideal system must be tailored to effect a compromise with the resources of the parent system, while the work study solution does not have to pass through this design stage since it is already dealing with the existing system.

4) A measure of effectiveness can be found for both systems. The work study solution can be assessed only in relation to the original system performance. This gives no indication that this solution is, in fact, optimal. The Systems approach by definition produces the optimum solution which can be compared with both the current and the best practically realisable system.

5) Work study depends upon intimate knowledge of the practical situation, whereas the Systems approach depends only on the knowledge of objectives of the system and may be practised in isolation from the system up to the implementation stage.

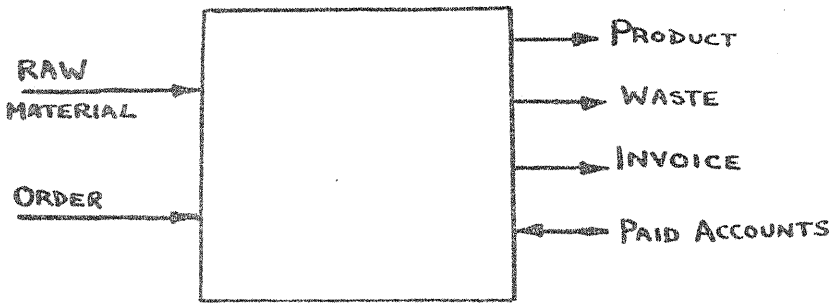
N.B. It might appear from this case study that there is a difference in the implementation level between the two methodologies. This is not, in fact, so, as the implementation stage of the systems design was omitted because of lack of time.

12 DURATION OF PROJECT

The project time consisted of nine formal sessions, each of two hours duration and additional individual work as was required.

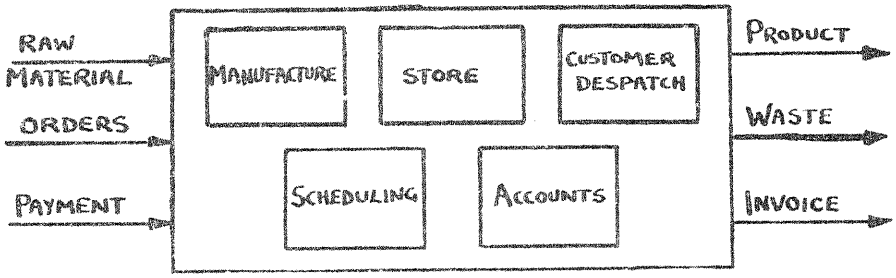
11.

ONEBLOC FIG 1.



SYSTEMS OBJECTIVES

FIG 2.



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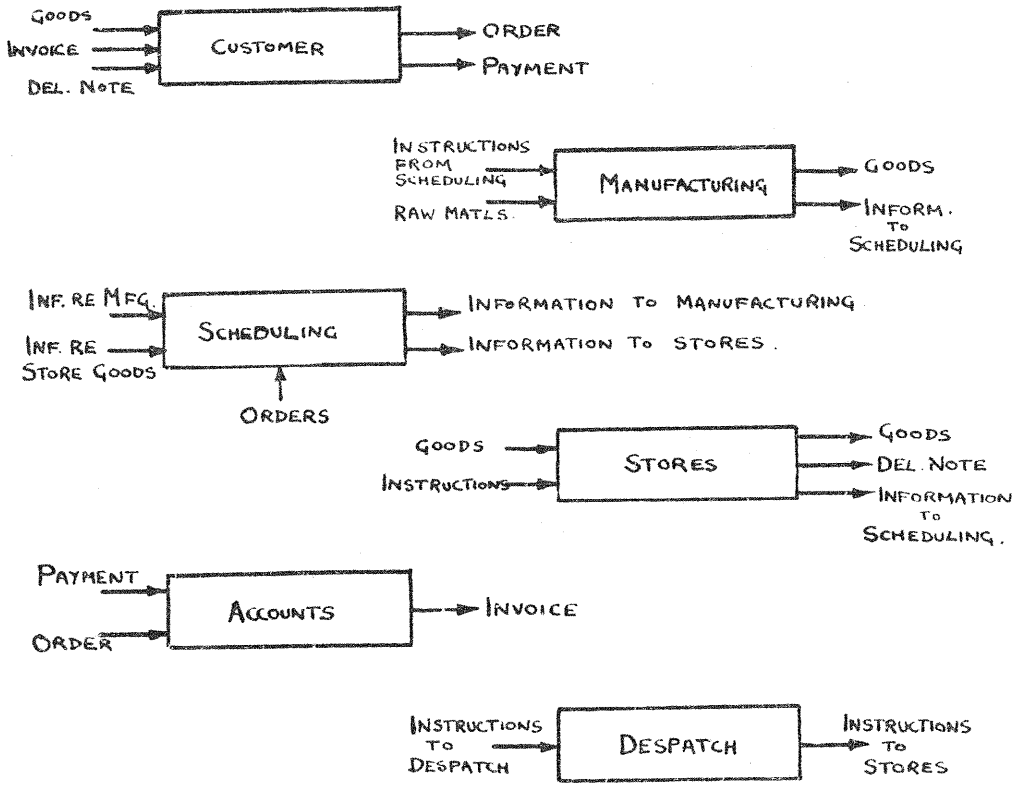
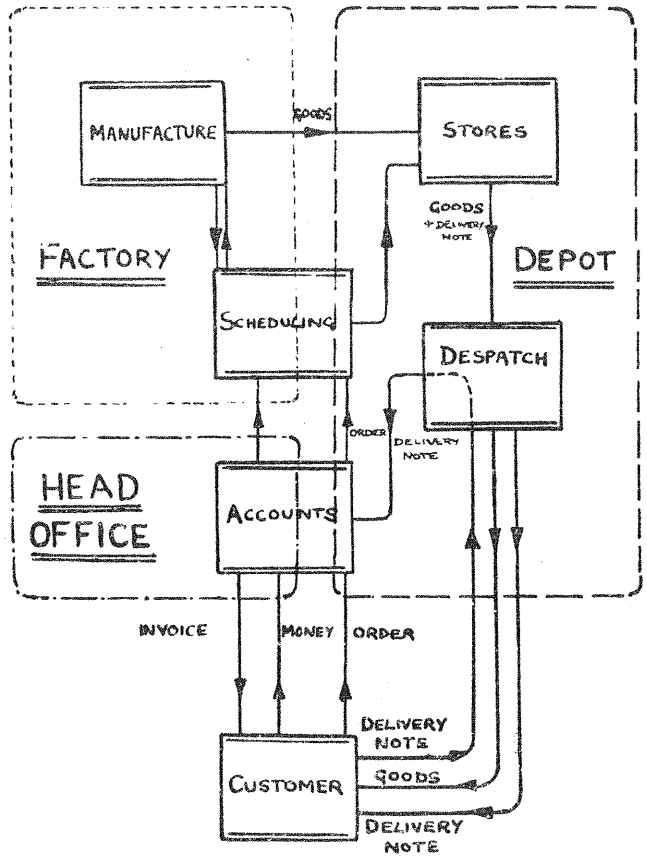
Operational Activities

Fig 3.



Multi-Bloc of Final System

Fig 4.



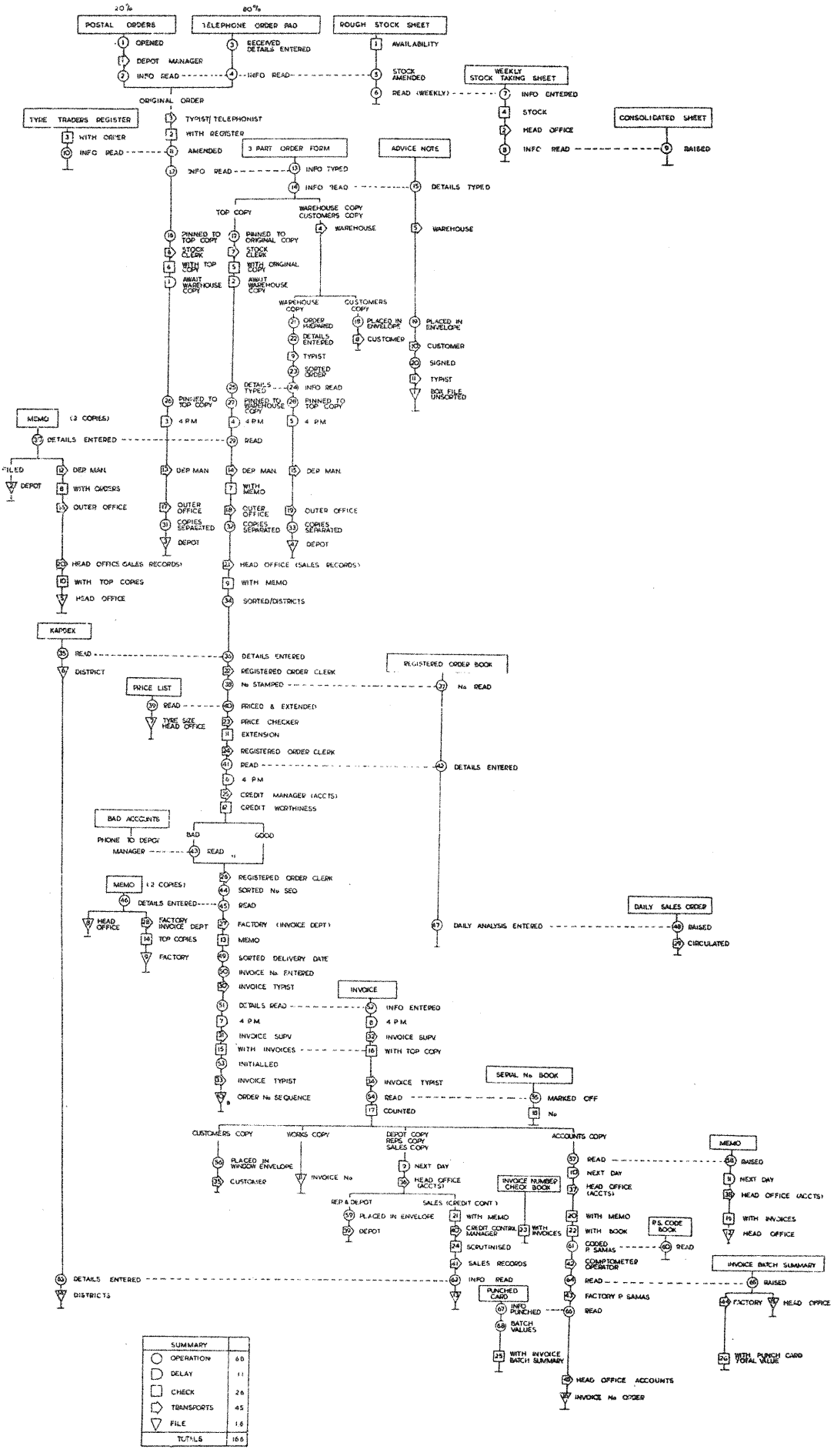
SALES ORDER PROCEDURE

EXISTING METHOD

W. S. 326

CHART BEGINS:- ORDER RECEIVED
CHART ENDS:- INVOICE FILED

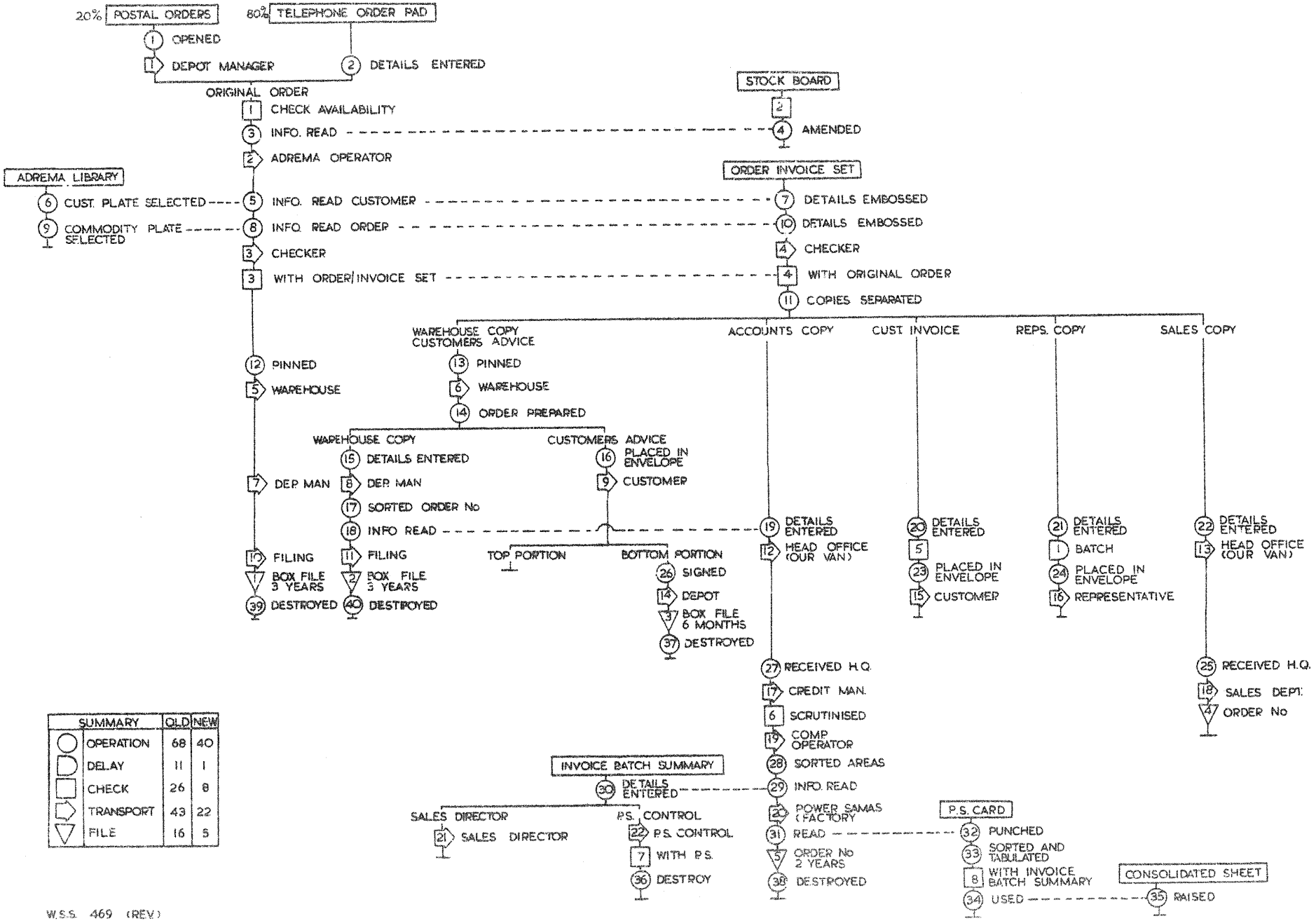
CHARTED BY: S.J.C.
21 · 6 · 59



SALES ORDER PROCEDURE
PROPOSED METHOD

CHART BEGINS: ORDERS RECEIVED
CHART ENDS: INVOICE FILED

CHARTED BY: A.B.C.
DATE: 3·8·59



SUMMARY	OLD	NEW
OPERATION	68	40
DELAY	11	1
CHECK	26	8
TRANSPORT	43	22
FILE	16	5

W.S.S. 469 (REV.)

SALES ORDER PROCEDURE PROPOSED METHOD BY SYSTEMS APPROACH

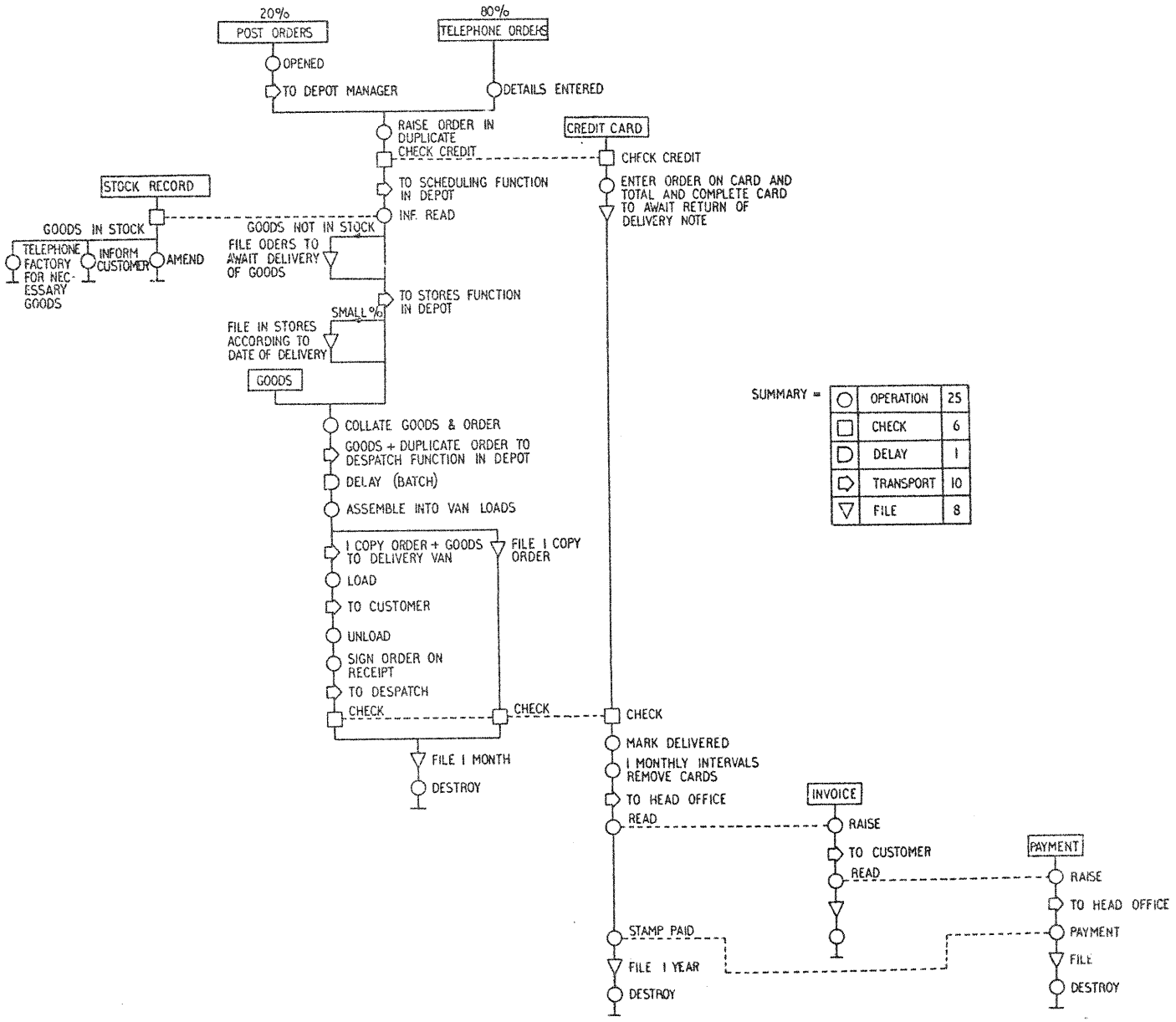



FIG. 7