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AUG 27 1954

CONF-160-1

ELECTRONIC DATA PROCESSING
AN APPLICATION TO NUCLEAR MATERIALS MANAGEMENT

by

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MASTER

This report is concerned with the application of an electronic data processing system to the unique combination of scientific and commercial data processing requirements of nuclear materials management. The organization and flow of data from the plant through the data processing equipment to the final report is the principle topic of the report. Included in the discussion, however, are topics concerned with the impact of conversion to electronic data processing on personnel, materials management costs, and on other plant organizations. Portions of the report are devoted to programming systems and decision-making abilities of data processing equipment which make these systems readily adaptable to nuclear materials management.

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The Central Data Processing facility at Oak Ridge, Tennessee, is located adjacent to the Oak Ridge Gaseous Diffusion Plant. Organizationally, it is under the direction of the Vice President of Union Carbide Corporation, Nuclear Division. The facility provides data processing and programming services to the Oak Ridge Gaseous Diffusion Plant, the Paducah Gaseous Diffusion Plant, the Y-12 Plant, the Oak Ridge National Laboratory, and Oak Ridge Operations, USAEC. Shown in Figure 1 is the building which houses Central Data Processing at Oak Ridge.

The equipment presently installed consists of two IBM 7090 computers and four IBM 1401 computers. The four IBM 1401 computers are used for all card-to-tape, tape-to-card, and tape-to-printer operations. Shown in Figure 2 is a view of the console of one of the IBM 7090 computers. Figure 3 is a view of one of the IBM 1401 computers with tape drives and printer.

Initial efforts toward utilizing electronic data processing equipment for the accountability function were begun during the summer of 1960. These initial efforts were primarily directed toward improving the diffusion cascade inventory equations by using the high capacity computing equipment to reduce large quantities of engineering test data more quickly to accurate inventory equations. The data processing equipment on which this work was done was the IBM 704 computer.

The initial benefits derived from these initial steps toward computer utilization were threefold; one, the original objective of better inventory equations was realized; two, better and wider utilization of engineering test data was achieved, since the approach to establishing an inventory equation was through areas of data analyses useful to many other functions throughout the plant; and three, probably of greatest benefit was the introduction of accountability engineering personnel to the capabilities of the computing equipment.

It might be well at this point to digress for a moment and describe the scope of the accountability data processing problem during this period in 1960.

In the separating cascade, a plant improvement program was in progress which resulted in the need for an analysis of engineering test data and the derivation of a minimum of two new cascade inventory equations each month; simultaneously, each month, the cascade inventory had to be taken and calculated. To provide an estimate of the magnitude of this problem, the cascade inventory is cited. Twenty-five thousand individual pieces of plant operating data are recorded between the hours of 8:00 and 12:00 P.M. on the last day of each month. These data must be submitted in proper order in 110 different inventory equations. To accomplish this task, five people using desk calculators required ten workdays to arrive at a finished cascade inventory, including the preparation of various summaries of the results of the calculations to be used for reporting purposes. In addition to this, the accounting group for uranium accountability numbering nine people, processed each month 8,000 transactions, including sample quantities sent to the laboratory for analyses. All monthly non-cascade physical inventories obtained throughout the ORGDP were also processed by this group. The present day problems of accountability differ little from this except for a reduction in the need for new inventory equations and a slight reduction in accountability transaction activity.

Having been made aware of the capabilities of the computer, the accountability personnel now sought the means for using the EDPM equipment for their problems. Inquiries made to programming groups revealed that it would be from three to six months before anyone could be assigned to program the problem for the IBM 704. Another alternative was offered in that accountability personnel could be trained in programming and apply the results of this training to their own problems. This latter approach was taken, and on December 3, 1960, a portion of the cascade inventory was programmed and computed on the IBM 704. (During January, 1961, the IBM 704 was placed on standby and a new IBM 7090 was placed in operation.)

During the first half of 1961, programming efforts continued, and by mid-1961 the entire separating cascade inventory, the cascade auxiliary systems inventory, and the cascade summary report programs were written and placed in operation. The programming system used for these programs was the well-known FORTRAN system. Simultaneously with the programming of the cascade inventory, it became apparent that there was a need for a faster, more efficient method of reducing the large quantity of cascade data to punched cards. During this period, the data were recorded by hand on inventory data sheets which, upon completion, became classified documents. Key punching and verifying these data took one operator approximately two workdays.

The IBM mark-sense card system was investigated and found adaptable to the recording of cascade operating data. The typical mark-sense card in use at the ORGDP is color and numerically coded to signify the particular operating variable it represents. The card is pre-punched and pre-printed by cascade location prior to being delivered to the field for marking. Spaces are provided on the card for marking instrument readings with a high graphite-content pencil. When processed through the 514 mark-sense reproducer, a hole is punched wherever a mark is recorded. This system eliminates the need for key-punching and, in the use made at the ORGDP, has reduced the time required for punched card preparation for computer application from two days to 4 hours. Shown in Figure 4 is a representative group of mark-sense cards in use for recording plant operating data. When the mark-sense card system was fully developed for the recording of inventory data, the plant operations personnel adopted the method for the recording of all plant operating data taken at the ORGDP. Such data includes motor loads, lube oil usage, cooling water usage, and the separating cascade evaporative cooling system data.

With the adoption of mark-sense cards to the function of recording all plant data, it became necessary to prepare an additional computer program to process these data, not only for inventory purposes, but also for reporting the data back to operations personnel.

Using IBM Commercial Translator programming system, a program was prepared that would produce listings of data, a comparison of the data to operating target levels, earmark those items exceeding specified operating limits, and also output the data punched in cards for subsequent input to cascade inventory and plant performance programs for computing on the 7090. Recently, the inventory programs were modified to read a magnetic tape containing the data which was produced by the Commercial Translator program from the 7090, and the intermediate punched card step was deleted from the data to inventory processing cycle. At the present time, all other plant performance programs are being modified to read this tape and eliminate the cards from their processing cycle.

This is essentially the system that is in use today at the ORGDP for calculation of the separating cascade inventory. Figure 5 shows a condensed schematic drawing of this data processing cycle.

During the past two years, many improvements and extensions have been made to the system. The philosophy has been that once an item of data is in the computer, every bit of useful information that can be extracted from that data will be obtained. To mention two of the most important pieces of information, there are the so-called value units, a measure of work performed by the plant and used to measure plant performance, and the dollar value of the inventoried uranium material.

In comparison to the aforementioned time that was required for hand computation, the present system will produce a finished inventory result in 48 hours. This includes delivery of data to the computer and results returned, conversion of mark-sense cards to punched cards for computer usage, program set-up time, and waiting time to get the job into the computer. Actual computer time used, however, is less than 1/10-hour.

Within the last 18 months, one additional step was made with respect to utilizing EDP equipment for accountability work and that was in the accounting area. No attempt will be made here to describe this accounting system. That has been adequately accomplished elsewhere, except to note that it is a typical double-entry accounting system consisting of sub-accounts for specific geographic locations, main accounts for functions, and cost collect accounts by programs.⁽¹⁾ It is to be noted that there is not a one-to-one correspondence between sub-accounts, main accounts, and cost-collect accounts. To illustrate, a given main accountability account may have sub-accounts of which each could be in the same or different cost-collect accounts.

Initial efforts toward programming this system were begun in January, 1962, using the IBM Commercial Translator programming system. By July, 1962, the programs which shall be described later were operational. It should be noted here that these programs are not complete with respect to the original objective which was to write the accountability report directly from the IBM 7090. The programs are complete, however, with the exception that they do not compute the final material balances, nor do they up-date the plant inventory. All other components of the material balances are produced on the computer. The final balances for report purposes are still assembled by hand with the aid of E.A.M. equipment. The reason that the accounting systems have not been completed was the decision to reprogram the entire accounting system using the COBOL programming system. This decision was based on the knowledge that the IBM Commercial Translator system would not be further implemented and, therefore, to take advantage of future improvements in compilers, it would be advantageous to program in the COBOL system. It was further assumed that the COBOL system would more likely be compatible with other organizations with whom business contacts are made and who are also using EDP equipment.

The programs as they exist today, coded in the Commercial Translator system, will now be described. It should be noted that all program concepts as described for the Commercial Translator program will, in all probability, remain the same when coded in the COBOL language. The only difference will be in the syntax and key words of the two languages. The philosophy that is used in applications of EDP systems to problems

is that the personnel will be used principally as auditors to insure correct information reaching the computer.

Necessary to an understanding of the program is a description of the record processed by the program. Figure 6 is an illustration of an 80-character card that is the input record to the accounting program. The record description is essentially self-explanatory; however, there are a few remarks that should be made concerning this record. The card is identically the same for transactions and inventory items except for the code number describing the data as a transaction or inventory item. An inventory record contains no information in the "account number from" field, whereas a transaction card does. The transaction card format is used both for internal and external plant transactions.

Observing Figures 7, 8, and 9, the flow of data through the accounting program is as follows. Initially, all transaction and/or inventory records are received by the accounting group, audited for correctness, and then key punched and verified. The typical procedure is for all of these records to be accumulated weekly. On Friday, the week's business, punched in cards, is submitted in the order received from the field to Central Data Processing for processing on the 7090. When received at Central Data Processing, the cards are put on magnetic tape.

This tape is used as data input to the 7090 SORT program and sorted internal to the 7090, by code number, account number to, account number from, transaction paper number, and material code. Output from SORT is a tape containing the sorted accountability records. This tape is then used as data input for the main accounting program.

Following the program outline, the first program step is to set an internal control switch to "off" and set all sums to be accumulated to zero. Such sums may include account receipts of uranium, uranium-235, and the dollar value, or the quantity of uranium, uranium-235, and dollar value on inventory at a specific cost collect center. The next sequence of steps is to read a record, test the switch for "on" and "off" condition. If the switch is off, which will always be the case for the first record, the paper number of that record is placed in a special storage location for use later in the program. The next operation is to test for an end-of-file condition on the input tape. When this condition is found to exist, the program skips to its final steps, otherwise record processing proceeds. The record is now interrogated through its code number whether it is a cascade inventory record, a journal entry or a transaction or non-cascade inventory item. Cascade inventory records are already in extended form, that is, contain uranium, uranium-235, and dollar values, and are channeled directly into their appropriate sums; journal entries are also extended but require an account search before being added to the correct sum; and transactions and non-cascade inventory items require extending and costing before being processed further. If the record is a transaction or non-cascade inventory item, it is again interrogated to determine the units of measure such as grams, pounds, or liters, and when determined, the extension to uranium and uranium-235 is made using the proper uranium analysis, isotopic assay, and volume measurement. The record is now ready for costing.

All materials at the ORGDP are costed, as to material value, from the standard uranium hexafluoride cost curve which is of the form

$$\$/\text{Kg. U as UF}_6 = K_1X - K_2 + K_3 (2X-1)(\ln(X/1-X))!$$

WHERE THE K'S ARE CONSTANTS WITH APPROPRIATE VALUES,

and X is the uranium-235 concentration in weight fraction. Uranium hexafluoride material is costed directly from the curve; materials that are not uranium hexafluoride are evaluated at the cost curve value less those processing costs necessary to convert the material to uranium hexafluoride.

The program accomplishes this cost procedure by first costing the material as uranium hexafluoride, regardless of its chemical form. Secondly, the program tests the material code and, from the results of this test, is directed to one of seven standard conversion costs. The curve cost less the conversion cost is now computed as the dollar value of the material represented by this record.

At this point in the program, all processing of this individual record is complete, and there remains only the problem of adding the record to the proper summations and writing out the proper results.

The next step the program accomplishes is to write this record on two magnetic tapes, one for printing off-line and one for punching a card with all of the computed extensions. A search routine is the next operation, wherein the "account number to" is matched with a table of account numbers built into the program. This table is so constructed that when a match is found for the account number, the balance area number and the cost collect number is also located. To explain this more fully, the tabular value for an account is a seven character number, the first three of which are the account number, the second two digits represent the main balance area account, and the third two digits signify the cost account. The computer, during this search routine, only interrogates the first three characters. When a match is made with the first three characters, the other two sets of numbers are then available for identifying the main account and cost-collect account.

The program now tests the record code as to whether the record is a transaction or a non-cascade inventory item. Subsequent to this test, the uranium, uranium-235, and dollar value quantities are added to the accounts receipts or inventory uranium, uranium-235, and dollar value totals. These same additions can now be made for the balance area and cost center totals since the previously mentioned search routine had also identified these locations.

The search routine is accomplished a second time, only the match now is made between the tabular values and the "account number from". When the match is completed, the appropriate sums can be accumulated for shipments from the account, balance area, and cost-collect accounts.

Entering the final phases of the program, the record is again tested by account number and uranium-235 enrichment to accumulate sums in uranium-235 enrichment ranges for reporting purposes. All transactions entering the plant site or leaving the plant site are considered

as transactions for the enrichment range balances; other materials are range balance inventory items. The ranges tested for are depleted, normal, enriched below 75%, and enriched above 75%. The results of the tests result in the quantities being entered into the proper range balance totals. The final step in processing the record is to accumulate totals by transaction paper number. This is accomplished by testing the transaction paper number in temporary storage at the beginning of processing. If the transaction paper number remains the same as record after record is processed, the transaction paper total is increased by the extended uranium, uranium-235, and dollar values. If the paper number changes, the transaction paper totals are written on magnetic tape and a summation for a new paper is initiated.

At this time, a record has been completely processed, and a new record is read and started processing, provided an end-of-file condition has not been met. The process continues until all records on the file have been processed. At the end-of-file condition, the program branches to its wind-up routine where account totals, balance area totals, cost account totals, and range balance totals are written on tape for off-line printing. The finished report is then sent to the accounting group for audit, analysis, and incorporation into material balance and cost reports to the Atomic Energy Commission and to Union Carbide fiscal accounting.

Some summarization of how the program and the accounting personnel work together to do the job may be useful. It is to be noted that two items from the input records are major controls for flow through the program. These items are the account number and the material code. If either of these data items are incorrect, the program output will be incorrect. Computer audit capabilities to guard against this type of error are only practical for isolating non-existent material codes or account numbers that may be punched into a data card. Such an audit device is incorporated into the program and will cause the offending record to be written out on an error file tape for listing. This record can then be corrected for subsequent runs of the program. From this it is seen that great responsibility rests with accountability personnel in the pre-audit phase of the operation since little can be done in the computer to compensate for incorrect weights and volumes or chemical and isotopic analyses.

It has been stated that this program is run once per week, usually on Friday, to summarize the week's business. At the end of the accounting period, all of the month's business is processed in one computer run. This feature permits an additional audit step in that the aggregate output from the weekly runs must agree with the month-end run. This is usually the case, since most errors are detected on the weekly runs and the month-end operation is used mainly for a summing up for reporting.

There remains now the question, "What has been the impact of conversion to EDP on personnel, materials management costs, and on other plant organizations?"

The first and not original impression that most of the personnel affected had was that a form of automation was taking their jobs. With respect to the accountability function this was certainly true. Personnel in the accountability organization have dropped from 17 to 10, and in the hand-computing group from 6 to 2. Those personnel who remain in the organization have, without exception, upgraded their own functions through contact with the computing facility and through more expanded responsibility within the organization. This simply means they have had to learn new techniques and assume duties, responsibilities, and functions formerly assigned to other personnel. This has been made possible since the computer has removed many hours of clerical type work from their daily schedule. To cite an example, one of the accounting clerks, in addition to his accounting work, is now accumulating and submitting for computer analysis all of the quality control data formerly requiring a full-time statistical assistant. It is gratifying to note that all personnel who have left our immediate organization have been placed in comparable or better positions. Some have gone into the Central Data Processing organization where they have gained new responsibilities and knowledge far removed from their original positions.

The materials management function costs have, during the period of conversion to EDP, decreased. The reduction in personnel costs have more than paid for all computer usage, including routine production runs, programming, and program de-bugging time.

The accountability function at the ORGDP was one of the first to utilize the EDP facilities for a large-scale data processing problem and, in this regard, it is of interest to note the impact of this usage on other plant organizations. During the period in which the conversion to EDP was being made, it became obvious as each new program was developed that given one more piece of data or one more cost number, these programs could produce information that was being developed in other departments or through other channels. Further, the additional programming work or computer time used to obtain this additional information was nil. In the interest of economy of operation and computer usage, these data were often made available to the accountability group and were incorporated into the programs.

In summary, it may be stated that many benefits, both of a personal and organizational nature, have been gained from our use of the 7090 computer. From a personnel viewpoint, much has been learned about this new instrument, the large-scale computer, and how it can be used. From an organizational viewpoint, doing more work with equal or less effort, doing more accurate work, and in observing the interrelationship between our organizational functions and other plant organizations are lasting benefits which, in our opinion, could not have been accomplished in any other way.

- (1) Frazier, R. R., Diversified Application of Basic Accounting Data, Paper presented at AEC and Contractor Source and Special Materials Management Representatives Meeting, Washington, D. C., June 17-19, 1957, TID-7541 (Pt. 1).

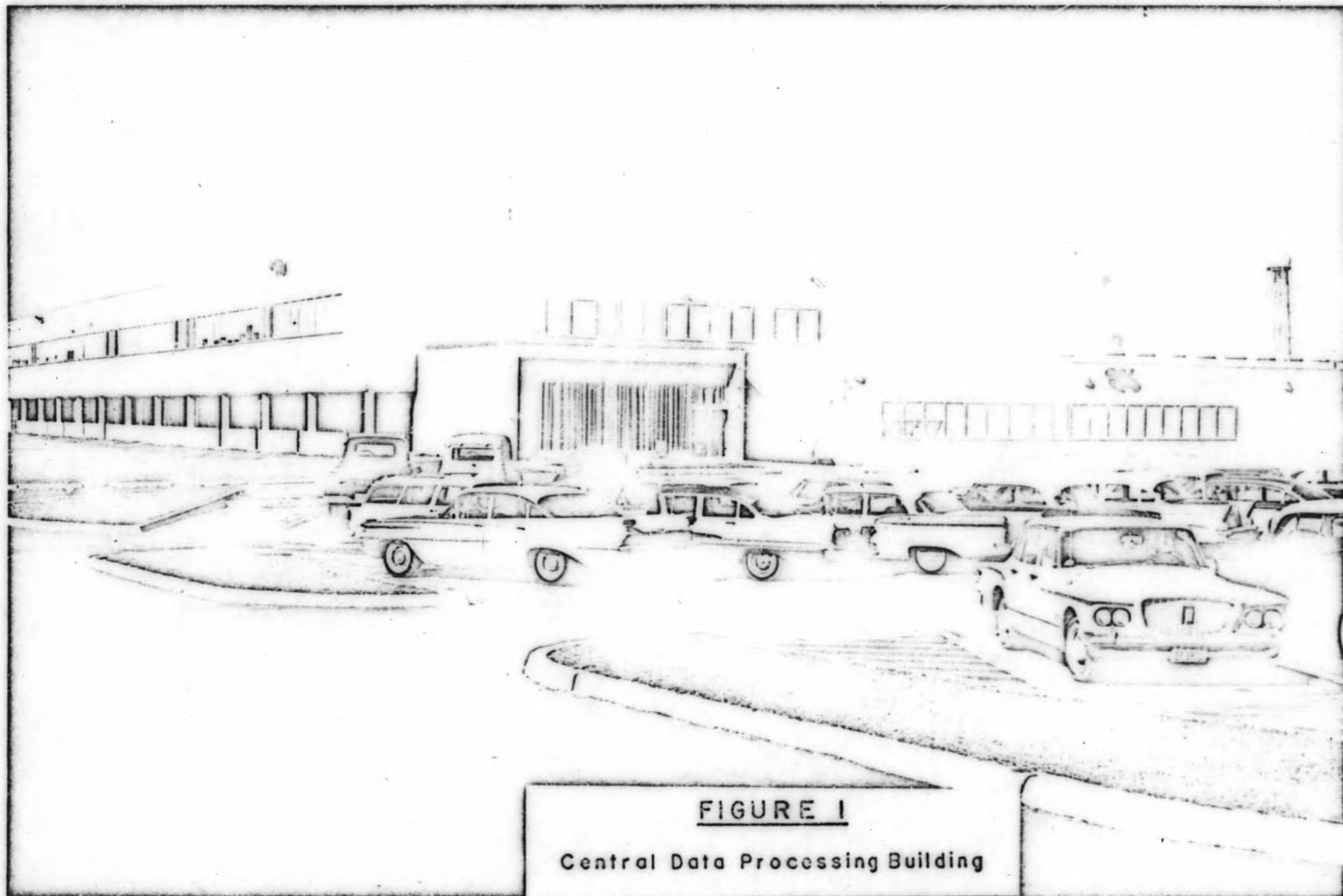


FIGURE 1

Central Data Processing Building

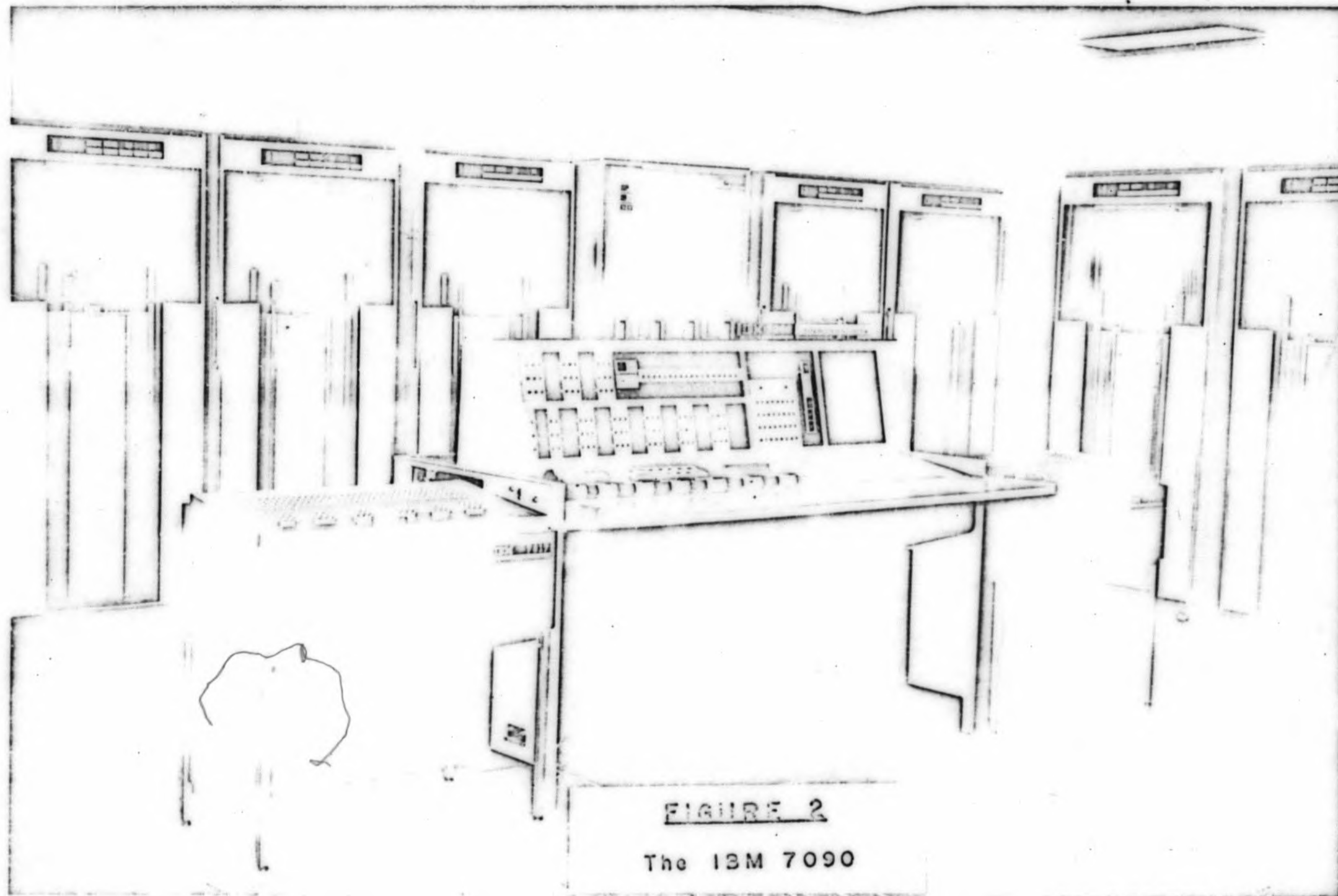


FIGURE 2
The IBM 7090

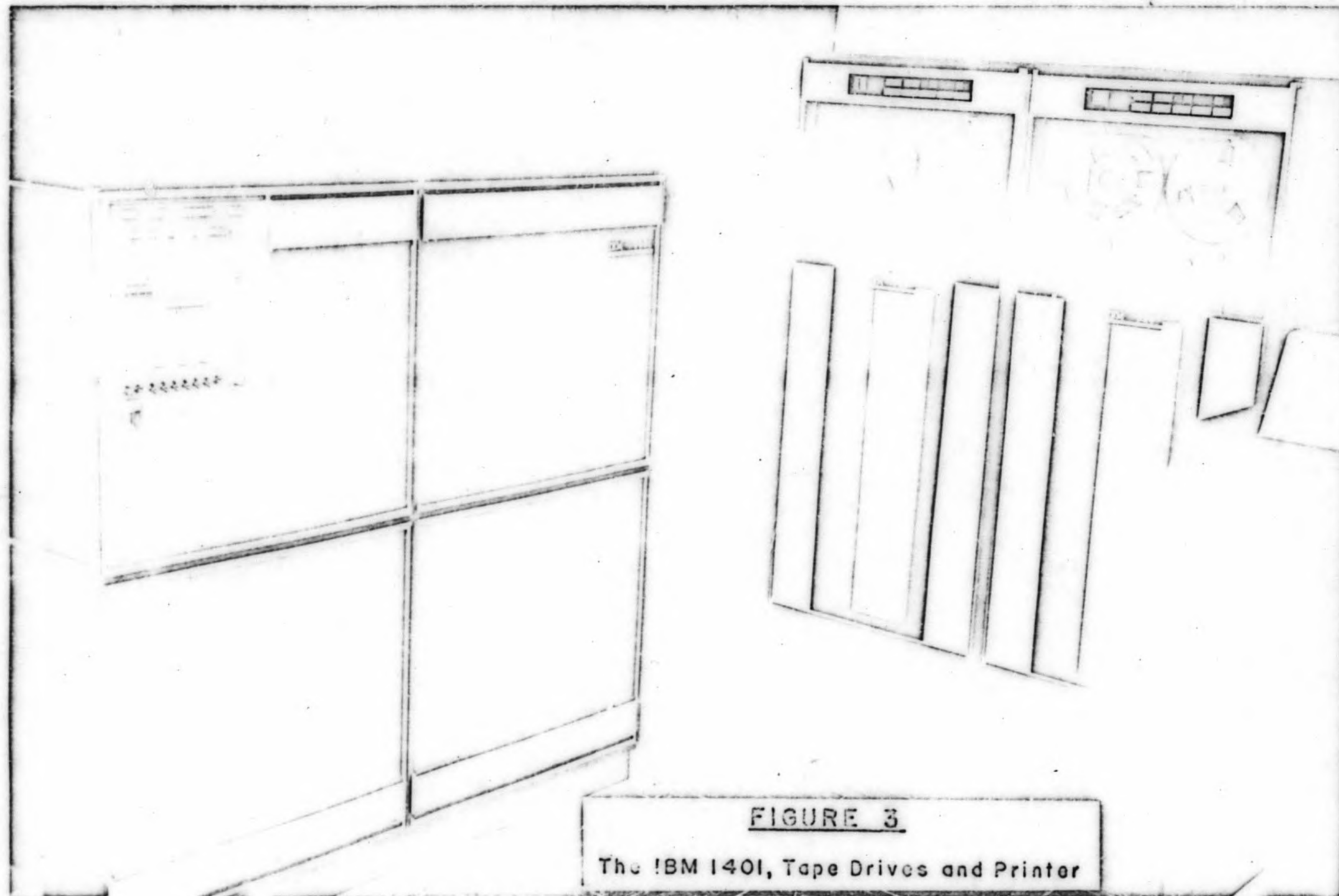


FIGURE 3

The IBM 1401, Tape Drives and Printer

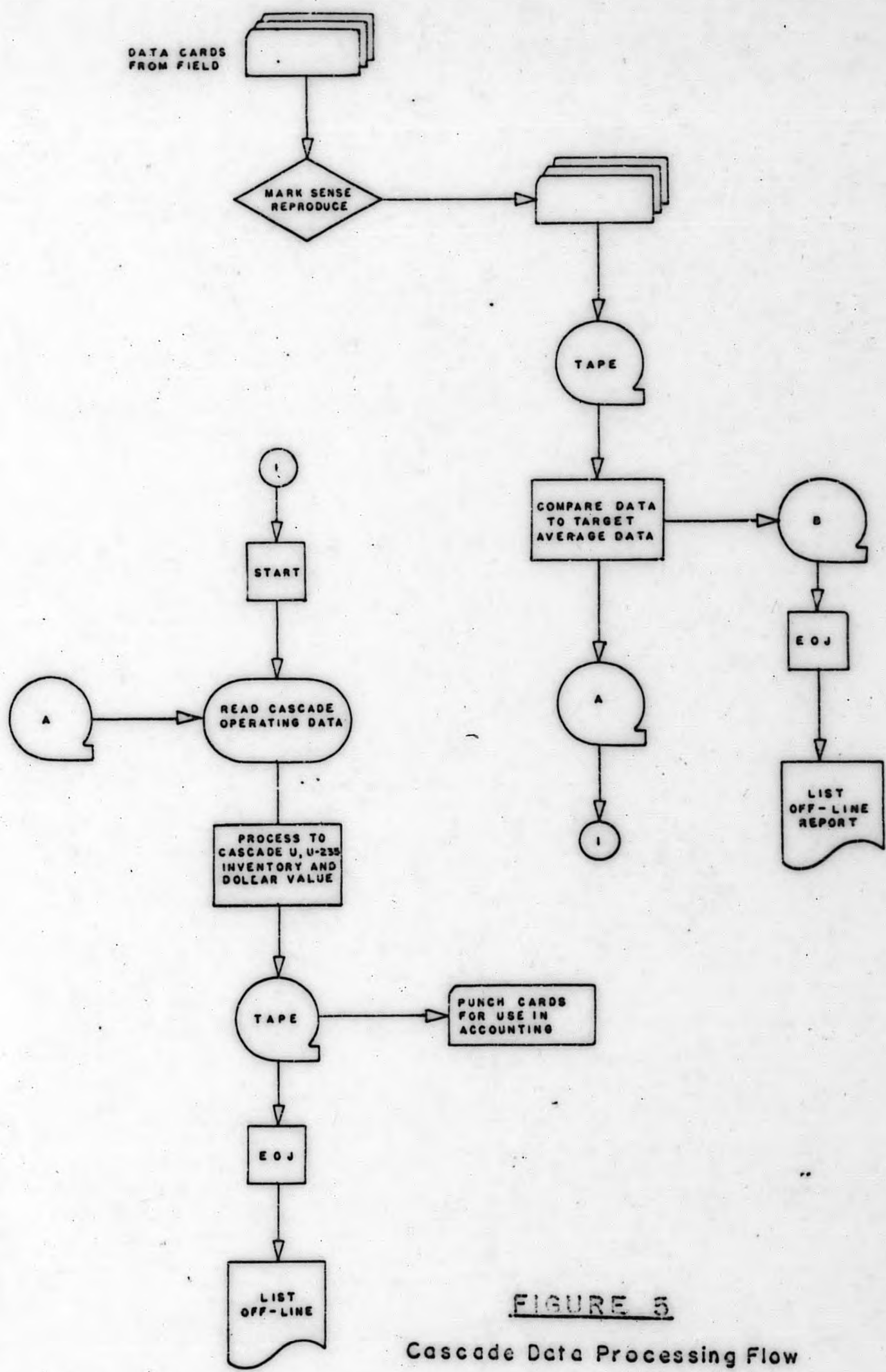


FIGURE 5

Cascade Data Processing Flow

CARD LAYOUT

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FIGURE 3

SS Material Data Card

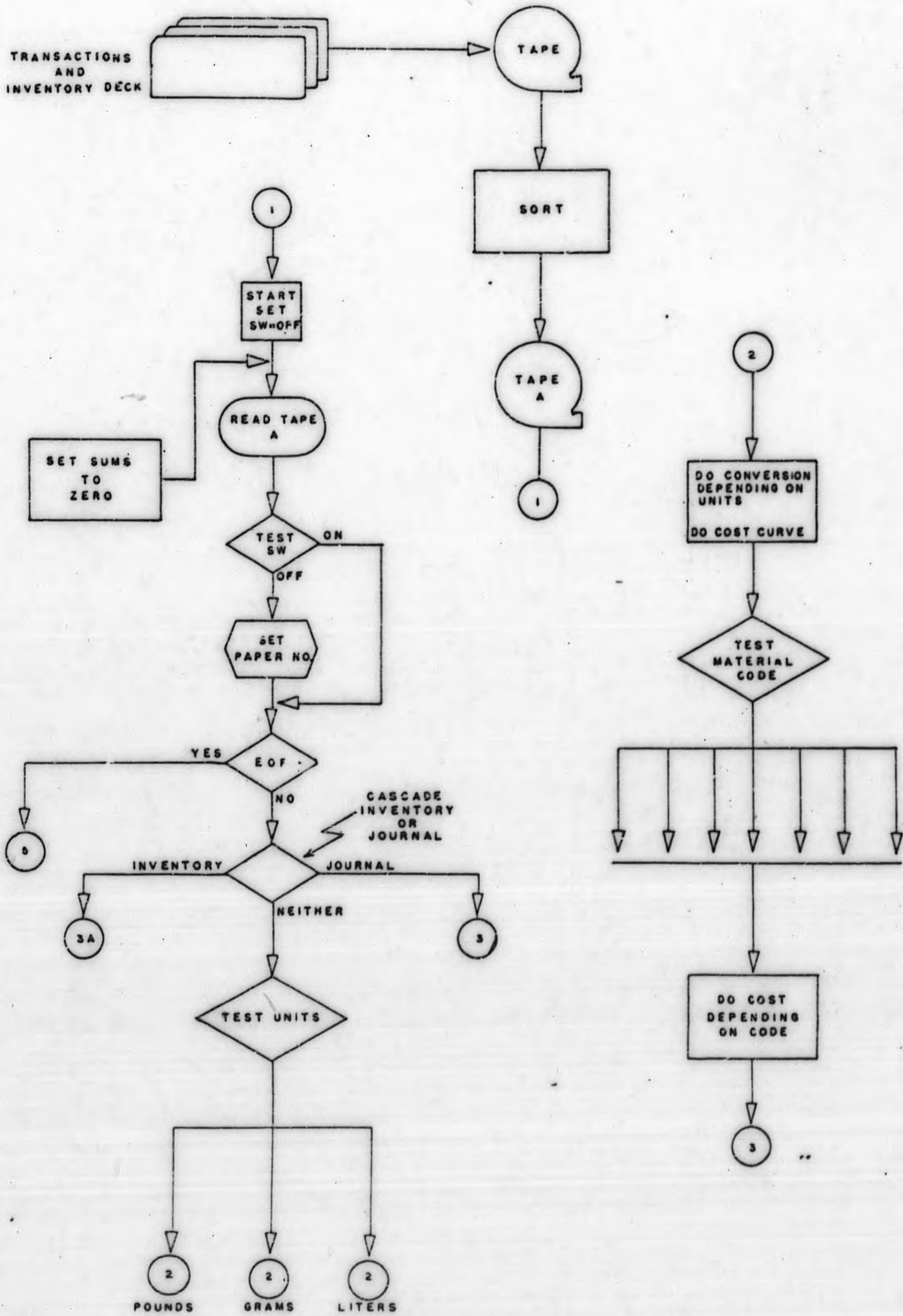


FIGURE 7

SS Material Accounting Program 1

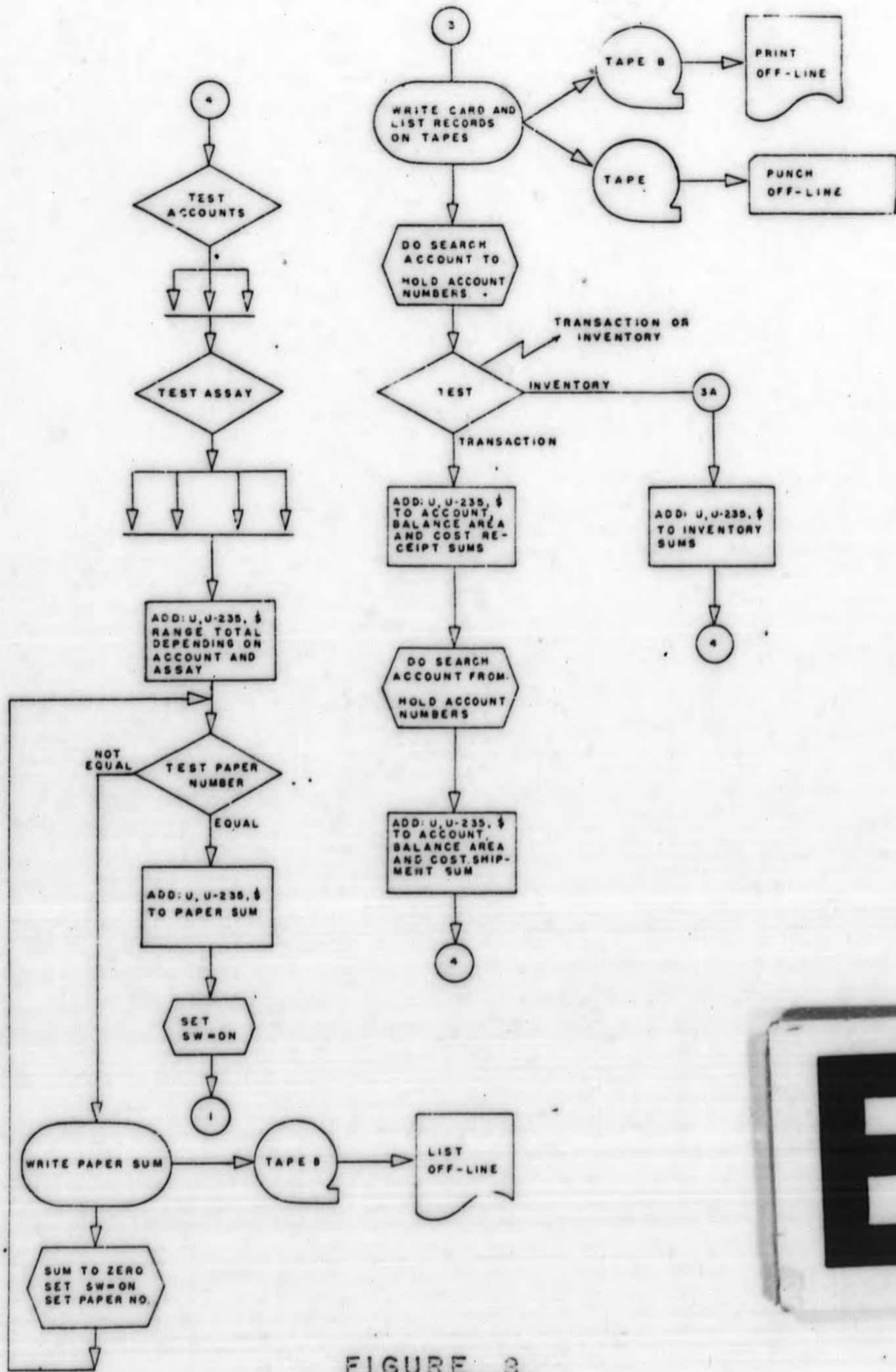


FIGURE 3

SS Material Accounting Program II

EN

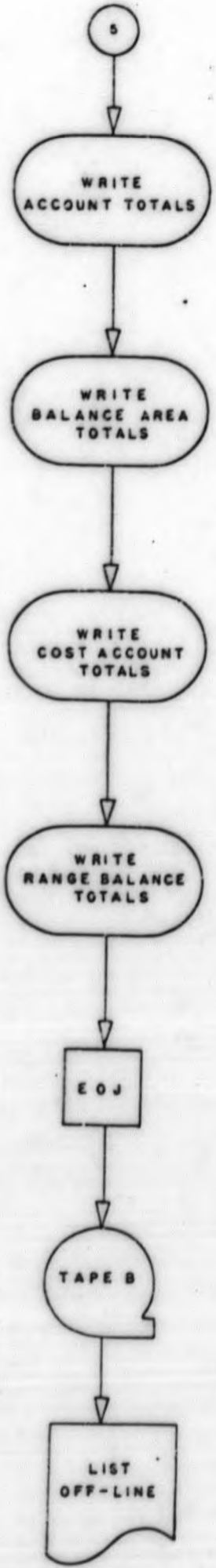


FIGURE 9

SS Material Accounting Program III

ND