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The use of microcomputers in small business applications.

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**THE USE OF MICROCOMPUTERS
IN SMALL BUSINESS APPLICATIONS**

by

Curtis Reeve

A Thesis

Presented to the Graduate Committee

of Lehigh University

in Candidacy for the Degree of

Master of Science

in

Information Science

Division of Computing and Information Science

Department of Mathematics

1982

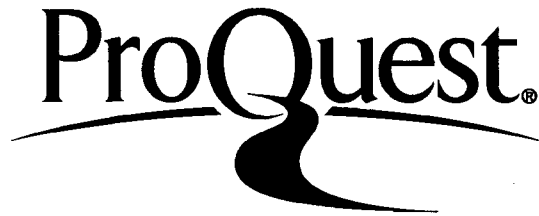
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This thesis is accepted and approved in partial fulfillment of the requirements for the degree of Master of Science.

May 10, 1982
(date)

Professor in Charge

Head of Division

To Jean

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ABSTRACT

After a study of several small businesses considering the implementation of a computer system in their operations, an inescapable conclusion is that a great deal of education of data processing consumers is in order. Preliminary systems analyses and preliminary system designs were done for six firms, final system designs were completed for four businesses and implementations were done for four. The businesses studied for this report indicated that the major source of knowledge for small business owners/operators relating to computers is vendors, and in some cases, that is the only source of their information. In one case, a hardware system was sold to a business owner for a specialized purpose when in fact it had the potential to be developed into a properly configured hardware/software system utilized in a far more effective way. The purpose of this thesis is to provide guidelines by example for the small business owner/manager considering a computer system, to aid in the educational process needed to make effective use of the microcomputer in small business.

I. Introduction

Subjects for this study of small business implementations of microcomputer systems were six firms, ranging in size from a three-employee proprietorship to a general contracting firm employing 60 persons and grossing more than \$10 million per year. The "small business" designation was based more on the number and needs of systems users than in overall numbers of employees or gross income, and in no case was a shared logic multi-user system implemented by these businesses, though in one case such a system was recommended.

Of the six businesses surveyed, two already had hardware in place; in one case, for a specialized purpose, and for which specialized software had been purchased; in the second, the hardware was in place, but no applications software had been purchased and no software configuration developed. The latter was simply a case of putting the horse before the cart, since no study or analysis of current systems had been done prior to purchasing the hardware. Two of the businesses surveyed requested anonymity, and that wish is respected throughout this thesis. Work on the project began in August, 1981, and continues at the current time.

Cost of systems implementation and length of pay-back period were major considerations in four of the six

case studies, and the only surprising thing about that statistic was that cost/payback did not appear to be of great concern to the other two firms studied. One firm concluded that complete systems implementation would be unnecessary currently, though management believed growth of the business would lead to automated data processing to effectively counter a need for additional office personnel. That firm's management also concluded that education of its office personnel in computer operations would be the most effective method of meeting any future need for EDP operations. One other management executive who concluded that cost-effectiveness was not a major consideration appeared constrained by budget considerations and apparently would not be implementing an EDP system presently.

Most of six businesses had in place systems designs which could easily be adapted to configure an EDP database for use with conventional, commercially available applications software; the major problem was sorting input, database structures and selecting appropriate applications software from the thousands of programs commercially available for microcomputers.

Approaching the study of a business

Small businesses, as the subject for systems

analysis, easily fall within established guidelines for analysis of information systems. Indeed, the eight stages of systems analysis generally acknowledged for the appraisal of need for EDP intervention held very well for the small business as well. Those divisions of study include:¹

1. Conception
2. Preliminary Analysis
3. System design
4. Programming tasks
5. Documentation
6. Installation
7. Operation
8. Cessation

The lifetime of a system configuration may be inestimable due to hardware and software advances alone, but one of the primary concerns in dealing with small businesses is the potential for growth, hence the potential for growth of EDP involvement within a given operation. One of the early solutions suggested by this study indicate that small businesses build in growth potential for larger, multi-user systems. Both hardware manufacturers and software developers are making this an

¹Class notes, CIS 422, "Analysis of Information Systems," A. Kasanda, 9/1/81.

easier option at the outset. Most microcomputer systems available outside the "home computer" market now have hard disk, time-sharing systems available as an add-on. Without dwelling on the hardware of systems configurations of small businesses, even some of the so-called "home computers" being used in business applications have that option.

Gathering of data to describe information systems currently in operation was a major task in analyzing the needs of a small business operation. Indeed, even the table of organization (though not the table of power) was difficult to discern below the owner/operator in some of the businesses studied. Below the owner, clear lines of authority did not always exist.

On the whole, however, definitions of duty and responsibility were clearly drawn, and those clearly defined roles were manifestly supportive of designing an EDP system for small businesses. Each staff member of nearly every business studied could very clearly describe the day-to-day operations for which he/she was responsible, and a larger picture of each business emerged only as the result of dealing with individual personnel assignments. While most of the employees had some notion of duties outside their own, the lower the individual in the table of organization, the less clear the concept

and structure of the table of organization. The method of querying personnel was by personal interview, using standard format in most cases -- though some exceptions were made as necessary -- and most persons willingly answered interviewer's questions.

Indeed, the general response among employees of the six firms surveyed was enthusiastic curiosity. Nearly all expressed an interest in learning operation of the computer system, some expressed an interest in learning more than mere operation of the system, and two expressed more than a passing interest in learning programming for use with their employers' systems. However, in one case, there was an express disinclination to accept the computer coming into the business, but the person who expressed that dislike was near retirement age and was not expected to participate in implementation or operation of the system, per se. Of the two who expressed interest in acquiring more than an operations-only knowledge of their systems, both were furnished tutoring in programming and rudimentary database design. It was clear in both cases that these employees would be the EDP managers for their firms, as much as the size of the firms permitted such a title and responsibility.

In both of these cases, the system implementation was only partially completed by the researcher, with the

expectation that the employee would finish installing the system for which the database configuration had already been established.

The bases for studying small business systems configurations came from a number of sources,² and were subdivided into four categories:

1. Preliminary Systems Analysis
2. Preliminary Systems Design
3. Final Systems Design and Configuration
4. Systems Implementation

As in the case of most systems analyses, the preliminary study work produced an overview of the business operation being studied; the preliminary systems design permitted innovation in and conceptualization of the database design and applications programming, and general outlines of hardware needs: the final system design affirmed the areas of database design and applications programming needs, and made possible specifications for hardware and software requests for proposals from vendors; implementation carried out the final system design and personnel assignment and training.

²Among them: Systems Analysis and Design, Leon Youssef, Prentice-Hall, 1975; A Practical Guide to Small Computers, Robert Rinder, Monarch Press, 1981.

II. Preliminary Analyses

A sample of the type of questions submitted to employees in the form of a personal interview appears on page 51.

Organizational Overview

The table of organization was greatly simplified for the smallest of the businesses surveyed, since there was one owner/manager and two persons working full-time for him. That business was T & D Automotive of Easton. The owner of the auto repair/body shop firm is Daryl Picard, who makes all management, clerical and scheduling decisions. Among his duties (besides the repair of autos), are the scheduling for repairs, vehicle inspections and resultant loggings required by the Pennsylvania Department of Transportation, choice of vendors from which to buy parts and supplies, tracking inventory, record-keeping, and collection of payment from customers. Some of the record-keeping duties have been delegated to a part-time office worker, but Picard oversees the office worker's performance. Below Picard on the table of organization is everyone else, and all report directly to him.

Metz Mechanical is a mechanical contracting firm in Easton, employing some 38 persons to design, install and maintain commercial and industrial mechanical systems, such as heating, cooling and ventilation, environmental controls such as air quality control within a building, and energy management for commercial and industrial installations. There are 18 service technicians, 5 "pipefitters" who are also welders, 2 persons in inventory and stockroom, 2 estimators, and 11 persons in office and managerial work, including the owner Bernard J. Metz. Beneath Metz on the table of organization are a service manager, an office manager, and an area foreman. Those managers, together with the estimators, report directly to Metz, though the implementation of the management structure at the company is informal and it is not uncommon to see the chain of command bypassed if advice or approval is needed immediately by a subordinate. The office manager is responsible for payroll, billing payables, general ledger accounting, insurance and other office and clerical functions, with a staff of four. The area foreman is responsible for supervision of pipefitters, making field estimates, vehicle maintenance schedules, and other tasks generally associated with field work. The service manager is responsible for the supervision of service technicians and inventory and stockroom control.

R. Johnson Associates, Inc., is actually two operations under one corporate umbrella: a corporate holder of a distributorship for franchises for ServiceMaster, a cleaning service based in Chicago, and the operator of several of those franchises in the Allentown-Bethlehem-Easton area, as well as areas in western and southern New Jersey. The table of organization considered for this study is that of the ServiceMaster franchise operations, not that of the corporate structure. Robert Johnson, president of the firm, directly supervises three managers; general operations, office and warehouse/vehicle. The operations manager is responsible for the day-to-day functioning of the industrial and commercial cleaning service franchises operated by Johnson. The office manager is responsible for hiring, payroll, record-keeping and other clerical and office functions. The warehouse/vehicle manager is responsible for maintaining inventory and vehicles for the Johnson operations.

The Office of Public Information at Lehigh University employs six persons permanently and three persons on a periodic, part-time basis. Of those employed permanently, two are office/secretarial personnel, three are writers and one, Sam Connor, is the director of OPI. There are two assistant directors, one for news and one for sports,

the latter also holding the title of Sports Information Director. Connor surveys incoming information, assigns story coverage, edits news releases, oversees scheduling of personnel and releases, interviews and hires permanent and part-time employees. The Sports Information Director is responsible for media arrangements at sporting events, sports news releases, various team publications, and other tasks related to sports publicity. The other assistant director at OPI is essentially a writer, with responsibility for supervision in the director's absence.

The other two firms surveyed requested anonymity, and will be referenced as Quality Metalworks and Samuel Pepys Contractors.

Quality Metalworks is a sheet metal shop and contractor, as well as a dealer for heating, cooling and ventilation systems and employs some 20 persons in the conduct of its business. The firm, below the corporate level, operates with three managers. One of the three is responsible for supervising shop operations in the sheet metal fabrication portion, as well as providing estimates for smaller custom work in that area. The second manager is responsible for heating, cooling and ventilation estimates, planning, supervision of

technicians, inventory and product update. The third manager is responsible for supervision of the office staff, liaison with design engineers on larger fabrications and estimates for larger sheet metal operations. Each of the three has field foremen in his areas reporting directly to him, or in the case of the third manager, the office manager.

Samuel Pepys Contractors is a general contracting firm, working in the industrial and commercial construction industry. It employs some 60 workers and has an office staff of five persons, including the owner. The owner employs a general manager directly responsible for all operations within the business, and the field manager and office manager report directly to the general manager. The field manager has project managers on each job reporting to him, and they in turn have field foremen working under their auspices.

Operations and Special Interest Areas

For purposes of this section, the study will focus on areas of special concern or interest to the six subject businesses. In summary, for T & D, it was the firm's accounting system and tracking work orders; for Metz, the primary concern was for an overall system

design and in particular for using their customer service reports as source documents for much of their data base; at Johnson Assoc., the areas of inventory control and applicant records were the foci of the study; at the Office of Public Information, the handling and production of news releases; at Quality Metalworks, tracking labor hours to enable closer estimates on fabrication projects; at Pepys, to handle payables in a way which would enable job cost controls to be established.

T & D Automotive - The general operation can be described as follows: A customer is scheduled according to open dates on the operation's calendar, brings his/her car in for work upon the appointed date, with parts/supplies having been ordered in advance of the appointment. The work order is completed after talking with the customer, and the work scheduled during the normal workday. Because T & D is a "cash only" business, with no receivables, payment is made upon delivery of the auto to the customer or upon pick-up of the auto by the customer. A summary of each work order is entered onto a tally sheet with customer name, total labor, total parts & supplies, inspection, subtotal, sales tax and grand total, and that information is totalled each day of business. At the end of each month, the daily totals are entered for in-

come into the P & L (profit and loss) statement.

Labor hours are calculated for each job by a "flat-rate" manual published by the automotive industry, and those figures multiplied by the hourly rate charged by T & D. Inspection work is recorded on the work order and on the inspection report required by the Commonwealth. Parts ordered for a particular work order, or parts taken from inventory are entered onto a separate worksheet of items purchased for re-sale required by the Commonwealth sales tax department. Parts invoices for items ordered for a particular job and from a vendor are kept as original entry documents for tax accounting purposes, and for inventory tracking in the case of parts or supplies taken from inventory. Other payables for the business operation are classified according to general ledger category for expenses within the P & L statement. Payroll is independent of these operations, since the wage is independent of piecework at T & D. See figure on page 52.

At Metz, service work is reported through a customer service report, which includes labor and materials used in a given maintenance operation, which may be either regularly scheduled maintenance or an emergency service call. The wage hours for technicians are kept on a separate timecard, and the two (timecards and customer

service reports) are correlated daily for billing and payroll purposes. Estimators, foremen, managers and office workers are paid a weekly salary and fall outside the purview of the timecard-service report system. Regularly scheduled maintenance activities are tracked on a large board by month and day according to maintenance contracts, which include frequency of service. Metz's primary area of concern is not incorporating the computer into its general office operations (payroll, payables, receivables, general ledger and tax accounting) at the current time, but in having a system designed for future implementation, and in the incorporation of dedicated microcomputer systems for special purposes. For example, the firm now uses a TRS-80 to run load-estimating programs to calculate heat loss and heating, cooling and ventilation requirements for commercial buildings, and the firm believes the hardware and software have been cost-effective for that use alone. Similarly dedicated use is planned for a microcomputer system to monitor and control energy use in commercial buildings to reduce peak usage of electricity, enabling customers to obtain a lower rate from the utility companies. For the most part, the study conducted for Metz concentrated on designing a data base for use with the traditional business system, particularly payroll, though some effort

was applied toward incorporating special-purpose programming into the overall schema. See figure, page 53.

R. Johnson Assoc. management indicated a need for automation in several areas of its operation, specifically excluding payroll from consideration, but including inventory, invoicing and re-orders to ServiceMaster, personnel record-keeping and telephone interview records, accounts listing and others. Johnson furnishes equipment and supplies to two basic groups: its own cleaning service franchise customers, and other franchises under its distributorship. Occasionally, it sells to outside customers, but that is a rare exception and handled as a sale to another franchise. The study of R. Johnson Assoc. dealt primarily with inventory, personnel records, sales records and accounts listings. The figure on page 54 shows the schema for inventory record-keeping and the subsequent data base design thereof, while the database design for personnel records was implemented using a standard database management system (DataStar) which proved sufficient for the needs of Johnson. In the past, use of cleaning supplies and equipment in the franchise operations was not monitored by the corporation simply because of a time-manpower problem with coordinating supplies and equipment used in a given building cleaning

assignment. Inventory was controlled only through a physical inventory taken by the warehouse manager once a month. However, the database did exist in the form of supply orders to be filled by the warehouse manager, and those orders could form a portion of an EDP database whose interaction would help establish an inventory control system, one of the goals of the study of the Johnson firm.³ Other goals of the Johnson study included a search-retrieval system for telephone screening of job applicants to ascertain whether they had applied for prior positions, reasons for rejection at that time and other pertinent data while the prospective applicant was still talking with the screener.

The Office of Public Information at Lehigh University requested concentration in two areas during a study of its operations: Would the use of an automated data processing system free time for writers, to be better utilized in researching and writing news releases? Would an EDP system make the production of news releases more efficient in a cost-effective manner? The general flow of information relating to news releases within OPI can be characterized as follows: the director (or assistant) originates a story idea, (though sometimes it comes from

³Report of Preliminary Analysis, R. Johnson Assoc., Inc., Curtis Reeve, October 15, 1981

the writer or an outside source) and from there the specific suggestion for a story is passed to a writer. The writer researches a story, using original contact sources, data within reference materials, OPI files, and announcements from departments and organizations within the University. After researching the information, the writer produces a news release (at times a first draft, then a second) and passes the news release to the director or assistant director. From there, the news release is edited, scheduled for production (and subsequent release to the public), and turned over to the office staff, which handles the actual production of the news releases in quantities needed for each mailing list (specified by the director). Office personnel type mimeograph stencils of the release, and submit proof copies to the original writer, who proofreads it and returns the corrected version to office personnel. The corrected mimeograph stencil is then used to print the requisite copies to be folded by machine, then hand-stuffed into envelopes for mailing. Pre-addressed envelopes are used in the stuffing process, and the envelopes are printed by another campus agency. In addition to the production of news releases the management of OPI wished to explore ways of reducing writers' time in doing routine research, of a biographical nature,

which is currently carried out by searching out OPI files, University biographical data and other sources. A study of writers' time allocations indicated that as much as 20 percent of their time is dedicated to researching more-or-less routine data to be used in news releases.⁴ Moreover, writers' time is currently being spent in proofreading, corrections and routing of copy from office to office. See figure, page 55.

Quality Metalworks derives some 80 percent of its gross income from the fabrication of sheet metal components for commercial and industrial installation, and while the firm was interested in an overall system design, the emphasis was on cost and production control for these sheet metal fabrications. Another consideration in system design for Quality was the ability to use commercial software for specialized purposes, such as heat loss estimating for the heating, ventilation and air conditioning aspect of the firm's business, which accounts for about 20 percent of its gross income. In general, the firm requires each sheet metal worker to complete a daily timecard listing hours spent on each job, and those hours are totalled for each job each day to enter into a

⁴Report of Preliminary Analysis To Office of Public Information, Lehigh University, Curtis Reeve, Feb. 26, 1982.

journal recording hours to be billed; no correlation is drawn between the number of hours spent on a job and the number of labor-hours estimated for a job unless there is a gross overage of hours spent as against hours estimated. Even so, the firm is obliged to honor its contract commitment and must simply absorb hours beyond the estimates. The timecard also is used to compute payroll, of course. The question of production control (the number of hours spent/total hours allocated vs. percentage completion) is beyond the means of the managers currently, primarily because of time constraints.⁵

Pepys management expressed interest in overall design, but placed emphasis on development of a data base design and programming for application in an accounts payable system with some special considerations. Invoices for materials and supplies arrive at the firm daily from vendors and subcontractors, and are filed according to vendor name or subcontractor. Once a month, the invoices are totalled for each vendor or subcontractor, and the totals split according to job number, of which there are about two dozen. The number of invoices per vendor or subcontractor varies from as few as

⁵ Report of Preliminary Analysis to Quality Metalworks, Curtis Reeve, March 17, 1982.

five to as many as three dozen per month. It is not uncommon for Pepys office personnel to be handling more than 300 invoices monthly, and the volume of work involved in totalling the invoices, splitting the totals according to job and entering the "split" totals indicated a need for automation of the task. Additionally, management indicated a need for job controls similar to those needed by Quality, except in Pepys's case for vendors, it was material, not labor, which needed watching. In the case of subcontractors, Pepys needs to be able to measure percentage of job completion against percentage of contract price paid, the first of which is calculated on-site, and the second of which is calculated from subcontractors' invoices.⁶

⁶Report of Preliminary Analysis to Samuel Pepys Contractors, Curtis Reeve April 10, 1982.

III. Preliminary Systems Design

In smaller business operations, even more so than in larger firms, budget constraints enter heavily into decisions involving automated data processing activities and plans; though once the decision to invest was made, most of the businesses were not primarily concerned with cost-effectiveness and length of payback period of the investment.

T & D Automative, as the smallest business surveyed, was the one most concerned with cost and payback period. Picard's goal was to displace his accountant's fees with repayment of any loans necessary to make equipment purchases (hardware and software) and to carry him through system implementation and installation costs. Those costs totalled \$65 per month, and he wanted a payback period of two years or less, which permitted a budget figure of slightly more than \$1,500 for the project. In hardware alone, that meant a restriction to a cassette system at the outset, with expansion to a diskette system possible after the system had exhausted the payback period and had proven satisfactory for the short-term needs of the firm. Initially, the data base was

established in three areas: Tracking of work orders by date and customer name; tracking parts purchased for re-sale, and keeping a general ledger record on the machine. Because the system used cassette storage, file interaction was eliminated to simplify the task for the user. The parts file and work order files were combined into one data file for ease of utilization, and the general ledger data became the second data file. Applications programs were needed for at least two areas, and maybe three: Work order history and report-generation, parts purchased for re-sale history and report generation, and general ledger accounting and report generation. It is possible to combine the first two applications programs, since both work order and parts data would be daily entry tasks, and even a small machine could accommodate a program encompassing both functions, as well as the appropriate report generation routines. Because of the restrictions of reading from, and writing to, cassette tape files, core memory size of the hardware would be the determining factor on the size the data tables contained within each program, and the subsequent size of the data files on tape. Currently, microcomputer core memory is less expensive than permanent storage; 64K of RAM can be obtained easily for less than \$500, while mini-diskette drives may cost more than \$1000 for a pair,

and still require a minimum of 48K (most systems) to operate because of space allocations needed for a disk operating system. A cassette drive, on the other hand, requires about 1K of monitor ROM, and the hardware controller.

Metz Mechanical, on the other hand, was pursuing one aspect of overall system design at the time the firm was studied: Payroll, as related to its customer service reports, and overall payroll data base and programming requirements. Because each service technician manually completes one customer service report per call, including such information as customer name, hours spent, task, parts used and contract number, the report appeared to be the place to start to establish the database for payroll, and further could be used to establish a database for an inventory control system. The payroll clerk daily checks all customer service reports against time-cards (also completed by technicians) to ascertain that an eight-hour day was filled by each of the technicians, and enters the total for each technician into a journal, noting any overtime or doubletime to be paid to the technicians. On a weekly basis, totals for each technician are entered onto a journal worksheet, and onto the employee's individual work history card, along with all

deductions, employer contributions, etc. Additionally, the payroll clerk enters weekly union-associated deductions and assessments to a worksheet, and fills out a union-furnished assessments report. Three sets of data were considered as the base for the payroll system for technicians. The first was a relation called WR (Worker's Rate) and included as attributes Name, Soc. Sec. No., Hourly Rate, and deductions for a standard workweek in the record structure. The second was a data file called UP (Union Payments) and included as attributes Date, Name, Gross Wages/Week, and Union Payments in three categories. The third file would consist of a record structure much the same as the weekly payroll worksheet and was called PR (Payroll). The source file feeding the three data files was to be called CSR (Customer Service Report) and the record structure for CSR included Technician's Name, Customer Name, Date -- all key fields -- task performed, contract number (if any), parts used, and comments. Data entry into the source file would be accomplished by using a "form" generated by a Data Base Management System called Data-Star, to assure consistent record structure. Laying the groundwork now by proper design of the CSR data structure would assure that the data could later be incorporated into two other systems, inventory and

receivables, since billings are drawn almost entirely from customer service reports. Applications programming was needed for two basic areas: First to weekly read the CSR files and write to the PR file after performing the necessary calculations on the base pay and withholding rates after reading WR, the worker's rate file; and third, to write to the UP data file of all union-associated payments. Additionally, report generators were needed for weekly, monthly, quarterly and annual reports for the above three areas, customer service summaries, payroll summaries, and union payment summaries. Because Metz employees have a relatively large number of payroll deductions, the firm does not list them on the check stub, and instead encloses a listing of deductions with each check. That listing should also be generated by the payroll system being considered. Metz already had hardware in place -- a TRS 80 Model II with 64K memory, four 8-inch floppy diskette drives and a 132-column, high-speed dot matrix printer. Management was advised that while that hardware would suffice for the payroll-customer service software, it would be insufficient once a payables, receivables or inventory control system was brought into implementation.

For Johnson, the primary task was two-fold: Develop an inventory control system, and develop a method for quickly checking a telephone applicant to ascertain whether the person already had applied to the company for a position. The second task was the easier, since keyword search is a feature of most, if not all, of the database management systems offered for microcomputer users today. It appeared the most effective key for the personnel record structure was the Social Security number, since there could be no assurance of a "match" with any other attribute (an applicant calling for the second time might, for example, use a first initial in this call, where before he had used a first name). Again, the use of a commercial DBMS was needed to assure consistency in the data structure, since the database would be used by later programming to establish personnel files. The inventory control system used five data structures, each representing a different data file in the preliminary design stages. The first record structure represented a product listing and consisted of a stock number, product description, unit cost and unit price. The second record structure was to be used in the master inventory data file and consisted of everything in the product listing record, plus minimum, maximum and current stock levels. While the two data files and record structures

are somewhat redundant, the inventory structure needed the product listing subset because of discrepancies in utilization, i.e. some items carried in the product listing are never carried in inventory, only used as carry-through re-sale items to other ServiceMaster franchisees. The third and fourth record structures were to be used as supply order forms for contract services (buildings being cleaned by the Johnson franchises), in which case they employed the unit cost figures from the product listing, and order forms for other franchisees or "outside" customers, in which case the unit price figures from the product listing records were used. The fifth record structure for the inventory control system was one used for a re-order form. Much like the third and fourth structures, it included name and address (of supplier, rather than customer), shipping information, and product listings and quantities. Applications programming to implement the inventory control system would need a number of features: The ability to read data files from the master inventory, contract services orders, customer orders, and reorders; generate a master inventory activity report, re-order report of those items below minimum level; update inventory, and allow entry of new items into inventory. The original estimate by Johnson management of 300 inventory items

was inadequate, and it appeared that nearly twice that number would have to be designed into programming efforts. Additional challenges to the programming effort included recycled items, such as mops being returned for cleaning to again be dispensed to job supervisors, and cleaning chemicals which are diluted before use and therefore have an enter-exit ratio below 1:1. A look at the structure of the Johnson organization made it clear that the system would eventually be utilized by multiple users, and hardware specifications were beginning to emerge with that prospect in mind. However, the size of the operation and the data and programming files necessary to make a successful adaptation to EDP procedures also made it clear that a microcomputer application would be appropriate.

Lehigh's Office of Public Information need was essentially one of word processing, and word processing systems abound (for better or worse) on the Lehigh campus. However, it was also clear that the system would need shared logic -- a larger, multi-user system because each of the writers would need a work station, as would the director, and at least one of the office workers, and all would need to share the data base and applications programming. While commercial word-processing software would be

appropriate for OPI's use, the size of the data base and the fact of multi-user would suggest something larger than an eight-bit machine and hard-disk storage memory. Overall, preliminary system design was as much (or more) concerned with hardware as software because of these factors and one other: The large volume of printed material leaving OPI each day. In an informal survey of three weeks' output from OPI, the following results indicate the volume of printed materials produced. In week one, 25 news releases were published, totaling 34,930 characters, and 3,920 copies were printed, for an output of 137 million characters; in week two, 23 news releases, 23,620 characters and 2,100 copies; and in week three, 45,150 characters in 40 news releases and 3,955 copies. As budget considerations were the primary factor in a conversion to an automated word-processing system, clearly a solution would have to be found elsewhere than having all news releases system-printed, since printers capable of handling that volume of material are priced at about \$20,000 and up.

Quality Metalwork's need to track production costs for larger sheet metal fabrication projects led to design in two areas: Labor and materials cost control. Since each sheet metal worker filled out a daily time-

card with hours spent on each job and with materials used, the source documents for an automated system already existed in raw form. Because the system would eventually encompass payroll as well, a data file described as a relation consisting of employee's name, Social Security number, hourly wage rate and standard deductions was established as one of four data bases. The second was a record consisting of employee name, hours worked, job identification number, materials used, and date. The third was a record consisting of job identification number, description, labor (in dollars), materials and date. A fourth data file was established using a record with the following attributes: Materials type, gauge, unit price. The applications programming would access these four data files to produce reports detailing costs-to-date on any job indicated by the user. A microprocessor appeared to be a reasonable alternative for use by Quality, since the volume of entries within each data file would be limited to the number of employees times the number of jobs. However, since some specialized software use was anticipated in the off-hours at home by one of the managers, the firm would need communications capabilities and the ability to expand to a larger, multi-user system when payroll, inventory and other functions came on-line.

For Pepys, the problems in payables were much the same as those for Quality, in production control, except the reporting requirements differed somewhat, and Pepys was concerned with materials, not labor. Pepys wished to tie accounts payable to both job progress and subcontractor contract price, using their incoming invoices. For this reason, a preliminary data file was designed using job (or subcontractor) name and number, and contract price. The file would be also used to file breakdowns for specific portions of larger job, such as steelwork for a given project when appropriate. A job history summary would be kept with record attributes of date, vendor or subcontractor, and amount and one such data file would be established for each of approximately a dozen jobs in progress at any one time. A third data structure would be established for vendors and subcontractors, with attributes of name and identification number, job numbers, and date. The applications program would be a report generator using the three established data files. Though accounts payable systems are readily available commercially, the report generation features of most are sorely lacking, and for this reason, Pepys was willing to have its own data base designed and its own applications program written. As in the case of Metz, Pepys already had hardware -- a TRS 80 Model II,

with two disk drives and 132-column, high-speed dot matrix printer, and it appeared the hardware was sufficient for the task at hand.

IV. Final Systems Design and Implementation

With the exception of the Public Information Office, which was constrained by budget considerations, the businesses under study underwent at least partial final system design and implementation, and some were still in the process of installation as of May, 1982. The data manipulation language (DML) of choice was unfortunately BASIC, unfortunate because BASIC is not a strongly typed language, nor is it well-structured; indeed, some BASIC programmers apparently believe a structured language is one in which the For-Next loops are indented. However, the DBMS software available for microcomputers generates data files usable by BASIC. In some cases, COBOL-readable files could be generated, but the size of a COBOL compiler leaves little program space in a 64K system and both COBOL compilers and applications programs are far more costly than those in BASIC. The choice for most of the systems was Microsoft BASIC-80, a version which operates both under CP/M* and under the TRS-80 disk operating system TRSDOS. This particular type of BASIC supports two types of data files, sequential and random access. Briefly, the sequential data file record can be of any length, any field can be up to 255 characters, and

*CP/M is a trademark of Digital Research, Inc.

commas are used as data separators in both strings and numeric types. The disadvantage is that data entry to the file is sequential, i.e. new data must be written to the end of the existing data file, which means the entire file must be read into a scratch file, the new data written to the scratch file at the end of the old data, and the scratch file renamed to the old file name, if it is to be retained. Random access files, on the other hand, can be written to at any point because the record structure is rigidly defined between hardware and software. A record is defined in buffer field lengths by the number of bytes occupied by each attribute or field. Whereas a sequential file can only be opened in either a read mode or a write mode, a random access file is opened in both, and once data is located, it can be altered and written back to the same record without destroying the remainder of the file. Unlike sequential files, which are stored in ASCII representation, random access files are stored in packed binary, requiring less disk space. The primary drawback to random access files is an increased complexity in programming for them; each data record read must be unpacked and its attributes checked before either progressing to the next record or writing new data back to the same record.⁷ Another drawback is

⁷Data File Programming in BASIC, Finkel & Brown, John Wiley & Sons, Inc., 1981.

that record lengths are limited to 128 bytes in single-density format, and 256 bytes in double-density disks, the length in bytes of a sector.

As the above information related to disk BASIC, none of it was applicable to T & D Automotive because budget considerations imposed a limitation of \$1,500 for the project. Because of a concern for quality components, Picard settled on Heath equipment which did not represent state-of-the-art but which was, nonetheless, known to be reliable. The hardware included an 8080A microprocessor with 32K RAM, serial and cassette I/O board, terminal and dot matrix printer. The system was interfaced with a pair of GE cassette tape recorders, one for reading and one for writing files. The choice of hardware dictated use of Benton Harbor Extended Basic, which in a cassette system recognizes three types of BASIC files: Type 4) BASIC programs only; type 5) BASIC data only, and type 6) BASIC program and data.⁷ The preliminary design outlined in section III was followed, except that files of type 6 were used, rather than those of types 4 and 5, which simplified the loading and dumping of files to tape. Picard can obtain monthly profit-and-loss statements,

⁷ Heath Computer Systems Reference Manual, Heath Company, Benton Harbor, Mich., 1980.

one copy to be stored with the cassette containing the month's history for the general ledger; a monthly or more frequent summary report of work orders; a monthly or more frequent report of work orders by customer name; and monthly report of parts bought for stock or re-sale. While the system can hardly be described as elegant, it does appear to meet the needs of the user, provide him with necessary record-keeping and reports and greatly simplify those tasks.

For Metz, the system used a relational data base established with four relations or record types. The four relations, described in the preliminary system design and here in greater detail, were:

WR(Name, * Soc. Sec. No., Code,⁹ Hourly Rate, Deduction1, Deduction2, Deduction3, Deduction4, Deduction5, Deduction6, Deduction7, Employershare1, Employershare2, Employershare3)

UP(Date, Name, Grosswages, Unionpmt1, Unionpmt2, Unionpmt3)

PR(Date, Name, Hours, Grosswages, Deduction(1-7), Employershare(1-3), Unionpmt(1-3), Netwages)

CSR(Date, Customername, Contract No., Job or P.O. No., Name, Taskdescription, Hours, Remarks)

⁹The code specified T - technician; F - foreman; S - supervisory personnel; O - office personnel (non-union).

* Key fields are underlined throughout.

The applications program used CSR and WR as input files to calculate payroll and despite the apparent redundancy in WR and PR, the values of the attributes differed depending on the number of hours each hourly wage-earner incurred in a given pay period (one week). UP and PR were the output files for the applications program, and the following reports were generated:

1. Weekly payroll record
2. Weekly union payments
3. Monthly payroll totals
4. Quarterly individual pay histories
5. Quarterly payroll totals
6. Payroll deduction slips

The DBMS adopted for entry into the data file using the CSR records was DataStar, since it would assure record consistency and would make it easy for the non-technical user to enter data. The "form" generated by the DBMS used no external file-derived fields, and entered the data into an associated sequential data file. The remainder of the data files were of the random access type to save diskette space. The applications program was menu-driven and chained a series of smaller programs for various tasks (primarily updating files and searching to produce reports). While doing weekly payroll, a number of prompts to the user assures that all salaried workers

are covered, that hourly wage workers' hours not covered by customer service reports are included in payroll, and that other tasks are completed before calculating payroll.

For Johnson Associates, the portion of the system design encompassing inventory control was straightforward, but the record structure was complex in that the number of entries in a given record varied; i.e. there were many null entries in the records of any file consisting of orders to customers or re-orders to suppliers. For the theoretical database, two types of subschema were established:

Order1(Quantity, description, stocknumber,
unitcost, subtotal)

Order2(Quantity, description, stocknumber,
unitprice, subtotal)

Using these two relations within other record structures simplified visualizing the overall database design, and it was for that purpose they were introduced. The record structures used in the final inventory control system design included:

Productlist(Stocknumber, Description, Unitcost,
Unitprice)

Inven(Productlist), Minimum, Maximum, Currentlevel,
Lastrecorderdate)

Supplier(Order#, Date, Account, Building,
Shippingdate, (Order1), Subtotal2,
Tax, Total)

Invoice(Order#, Date, Customername, Address1,
Address2, Address3, Shippingdate,
Shipvia, (Order2), Subtotal2, Tax,
Freight, Total)

Reorder(Order#, Date, Vendorname, Address1,
Address2, Address3, Shippingdate,
Shipvia, (Order1), Subtotal2, Tax,
Freight, Total, Backorder(Order1))

The DBMS, again DataStar, was used to generate forms for all data entry into each of the records, although after initial data was entered into Productlist and Inven, applications programming was the usual method of altering data values. Stock numbers prefixed with an "R" were recycled items, such as the mops described in the preliminary systems design, and the user was queried whether they were to be deducted, and if the quantity was correct, in the case of diluted chemicals. The inventory control program was designed to be used semi-monthly, and was a single-pass program which produced the following results:

1. It updated all inventory items, using supply orders, invoices, and re-orders within the reporting period.
2. A master inventory report of all items carried, with number of transactions during the period and last re-order data.
3. A re-order list was produced for the user, but not automatically entered into the control system as another re-order.

All three items were optional and were independent, so that reports could be issued without updating inventory and vice versa. The most time-consuming task on the part

of the firm was establishing maximum and minimum values for each of the items carried in stock, and it continues to be an ongoing task to assign efficient levels of inventory. Because the inventory carries fewer than 600 items and because all files used in the data structure were sequential, the entire inventory file is read into memory, where all searching and updating is done, and after updating, is written back to disk. The hardware choices for Johnson were limited by two factors:

Management intended to continue to incorporate EDP into its operations, meaning system functions and data base size would continue to grow; and, the system would eventually be multi-user. At the time of the installation, (December, 1981) few micros had hard-disk multi-user system expansion capabilities, but among those who did were Altos, Cromemco and IMS. After getting bids on all three systems, Johnson chose an IMS 5000, a 5-inch minifloppy system for which a 10-megabyte hard-disk Winchester system was available. The system included 64K RAM, two drives, terminal, printer, CP/M operating system, DataStar DBMS, and a BASIC interpreter, and cost about \$5,200. Johnson personnel designed data entry forms and did initial data entry.

OPI chose not to complete system design work after getting preliminary cost estimates of system installation, and for that reason, no final system design was made. The report of preliminary analysis to OPI indicated that direct system output of all news releases would not be cost-effective and as a compromise between cost and efficiency, it appeared that direct system output of smaller, low-volume news releases could be achieved. For the larger, high-volume news releases, system output would be restricted to a mimeo master, or some other device which could be used on available printing equipment. Of the number of news releases each week, about half fell into the small, low-volume category and thus could be directly produced by an EDP system printer of the type originally planned for OPI.

Quality's production control data base would eventually serve a four-fold purpose: production control, payroll, receivables, and inventory control. But the need which Quality proposed to serve first was production control, so emphasis was placed upon the design of that data base, bearing in mind the ultimate utilization of it in other applications as well. Again, a record was structured for employee payroll information and was called "Wage-rate." Originally, the second and third record types

showed some redundancy of data items and as a result, the schemata for those two relations were re-designed to produce more clearly defined concepts, namely that projects be more clearly separated into a labor aspect and a materials aspect. Hence, the second relation was entitled "Joblabor" and the third, "Jobmaterials." The fourth record type was "Materials." The record layout was thus:

Wagerate(Name, Soc. Sec. No., Hourlyrate, Deduction1, Deduction2, Deduction3, Deduction4, Deduction5, Deduction6, Deduction8, Code)⁹

Joblabor(Name, Jobnumber, Date, Taskdescription, Hours)

Jobmaterials(Jobnumber, Date, Code, Weight)

Materials(Type, Gauge, Unitprice, Code)

To the four original data relations was added a fifth, "Job," because it would ease report-generation requirements, and that schema was:

Job(Jobnumber, Customer name, Hours, Material)

The Job recordtype data would use the estimates originally utilized in the bid for the job, to allow the tracking desired by Quality. For hardware selection, the choices available to Quality were wider than those for Johnson, three months earlier, because many popular microcomputers on the market had brought out hard disk systems and multi-

¹⁰The code would indicate the type of worker, sheet-metal or HVAC, and would be used to relate to a later record type for payroll.

user operating systems in the interval. Finally chosen was a Zenith Z-89, a Z-80-based system, with two double-sided, double-density 5-inch disk drives, and a Centronics 737 printer. To be added to the hardware was a Z-19 terminal and Hayes Smartmodem for use by one of the managers at home evenings when doing job estimates.

The Pepys firm's accounts payable system, while incorporating some aspects of commercially available applications programming, suggested a somewhat different approach -- using separate files for each of the jobs, subcontractors, and vendors -- to reduce file size, hence reducing any search time associated with file I/O. Because a major portion of the programming and operating effort would be spent writing to files, the decision was made to use files of the random access type rather than the sequential type. Data records for the files would be quite limited in length, with no more than four fields, so disk space could easily be conserved. The use of random access files ruled out commercial DBMS software, since those programs create, read and write to sequential files and will write to only one data file at a time. The first relation established in the data base was a table functioning as a "directory" of all job, subcontractor and vendor files and used:

List(Name, number, Code)¹⁰

The remainder of the record structures were quite similar in nature and included general attributes of date, description, amount. The first record in each file is the budgeted amount for a job or subcontractor. Because the keys in the "directory" became filenames, the only other key which could be needed inside the relations is the date. The values assigned the attribute "description" would vary according to the file function; for example, in a job file it might take on as the value the name of either a vendor or a subcontractor, while inside a subcontractor file, it would be the name of a vendor and/or job. The applications program queries the user at the outset for the code, V, S, J or U; then queries for the identification number and responds from the "directory" with the name as a check. Because a single invoice grouping may be distributed among up to six accounts, the user is queried for number and amount and when input is complete for distribution of one invoice, the names associated with the accounts are displayed for verification. Again, the program is menu-driven, and upon report generation, delivers totals-to-date and percentage of budget to date for subcontractors and jobs.

¹⁰ Codes included P - project; S - subcontractor; V - vendor, U - unassigned.

IV. Observations and Conclusions

In the course of study for this thesis, the author conducted a day-long seminar, on the use of microcomputers in small businesses, sponsored jointly by the Lehigh University Center for Information and Computer Science and the Small Business Center. A record-high number of attendees, 70, turned out for the seminar, and a follow-up evaluation tended to confirm an observation the author made during the study of the six subject businesses: The major pressing need of small systems users and potential small systems users is one of education. Though 100 percent of those surveyed found the seminar helpful, a mean of 75 percent said they needed outside help in developing, buying and installing a system.¹¹ For the small business owner/operator, there is almost nowhere to turn for expert advice without a built-in bias; nearly everyone in the field is selling hardware or software and few of those interested in sales are interested in educating this new, large consumer group. Indeed, the plight of the Pepys firms is not atypical in the community of small business owners; buying the hardware first is backing into a solution (or a larger problem) and vendors rather en-

¹¹"Computer Seminar Evaluation," Lehigh University Small Business Center, April, 1982.

courage that approach. With the ever-broadening advances in hardware technology difficult for the knowledgeable to absorb, the problem of keeping pace becomes nearly insurmountable for the neophyte who also has time constraints on his/her education in the field. One partial solution to the education problem is user groups, of which there are many; but that solution begs the question -- the user groups are organized primarily by hardware ownership, hence membership presumes a hardware selection already has been made. For the short term, the potential small system user has essentially two choices: 1) self-education through seminars, texts and demonstrations, or; 2) paying an "expert" to provide the information needed to make a sound decision. Unfortunately, many persons billing themselves as experts in the field have direct ties to vendors or are, in fact, vendors.

If sources of good information are lacking in the field, existing documentation for commercial software merely adds to the problem of the new user. Users' manuals are filled with jargon, are unclear, incomplete and sometimes inaccurate, and an attempt to fully evaluate software by a careful reading of the user's manual will in most cases be a futile effort. A clear statement of what a given software package can do and

what it cannot do would contribute immeasurably to the education of new and experienced users alike.

With continuing advances in hardware, software and firmware, the notion of piecemeal microcomputer applications is evolving toward the concept of a total system design. Nearly all of the businesses studied for this thesis began their experiences with microcomputers based on a perceived need for applications in one area; as user knowledge became enhanced, so did the awareness that the computer is part of a larger system, the information system of an organization. Only as that awareness spreads can the small business make the most effective use of this most powerful tool.

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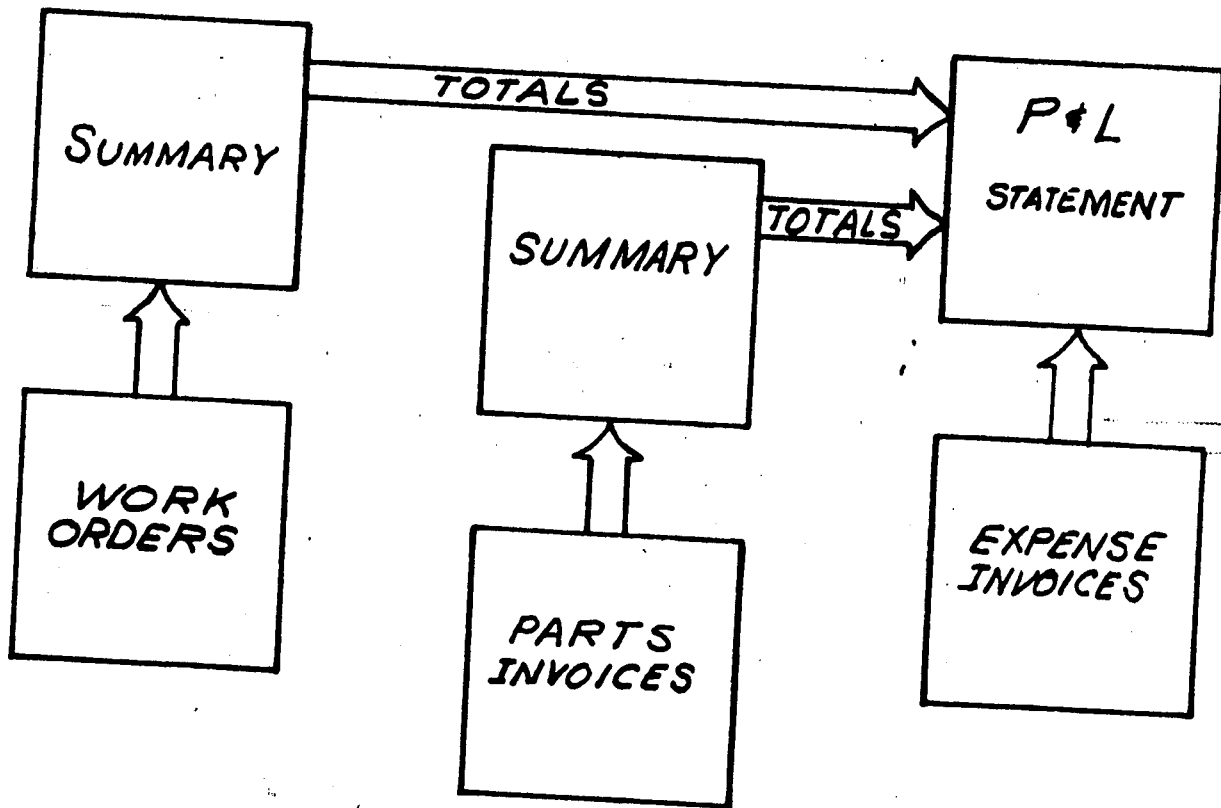
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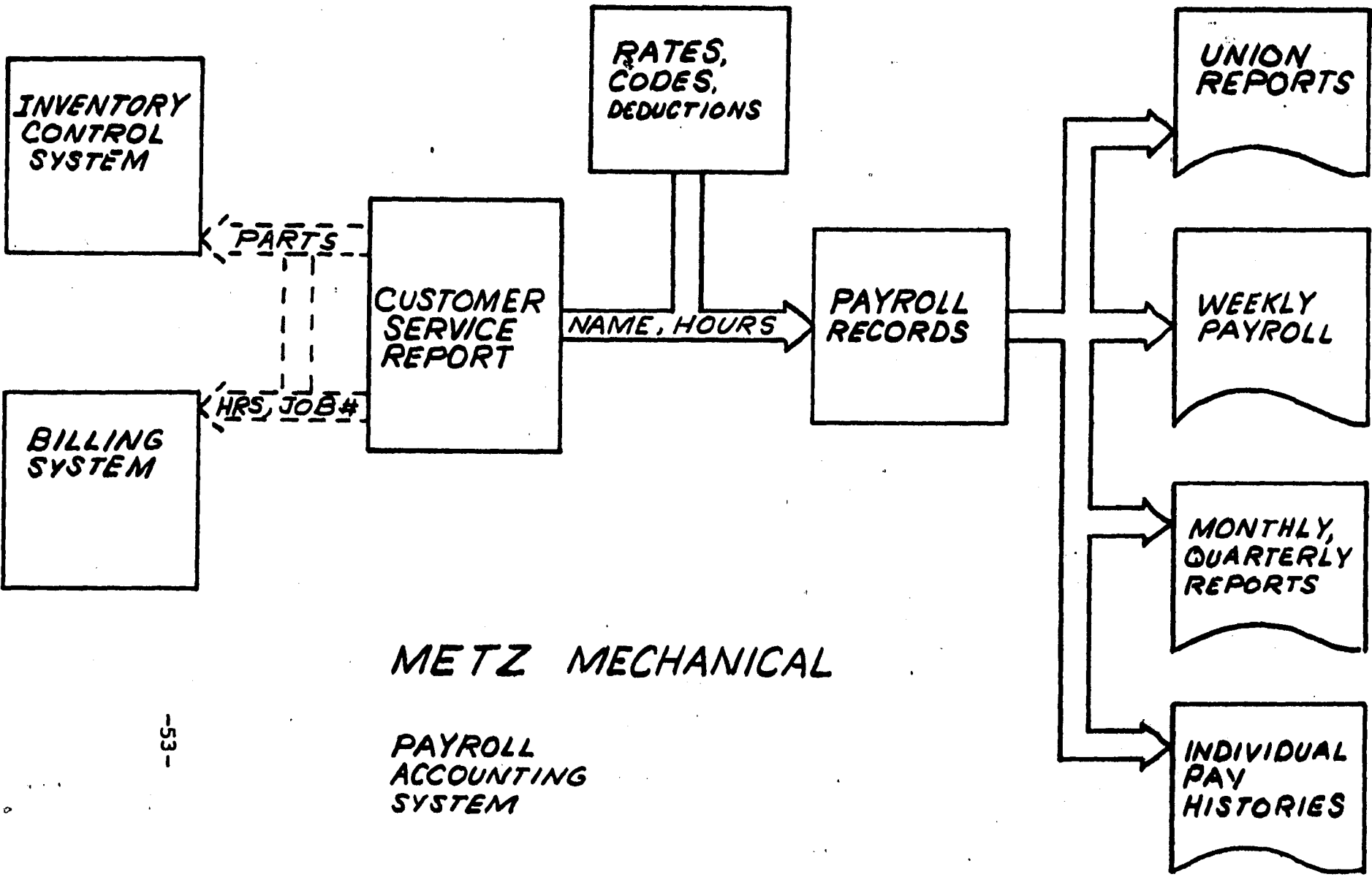
Questionnaire Used in Study (Typical)*

1. What is your position/title?
2. Who is your immediate superior/boss?
3. Describe the work/tasks you perform and estimate the time each takes:
 - a) Daily
 - b) Weekly
 - c) Monthly
 - d) Less often than monthly
4. What forms do you use in each of these tasks?
5. Do you issue reports or summaries in the course of your job:
 - a) Daily
 - b) Weekly
 - c) Monthly
 - d) Less often
6. Which files do you use in your work?
 - a) As sources of information
 - b) For storage of your forms and reports
7. How do you feel about the use of the computer in your job? Do you feel it would be helpful, or that you would need more time to finish your work each day?
8. Have you ever worked on a computer terminal before?

*This is of the type used in face-to-face oral interviews, and in no case was a written questionnaire filled out by an employee.

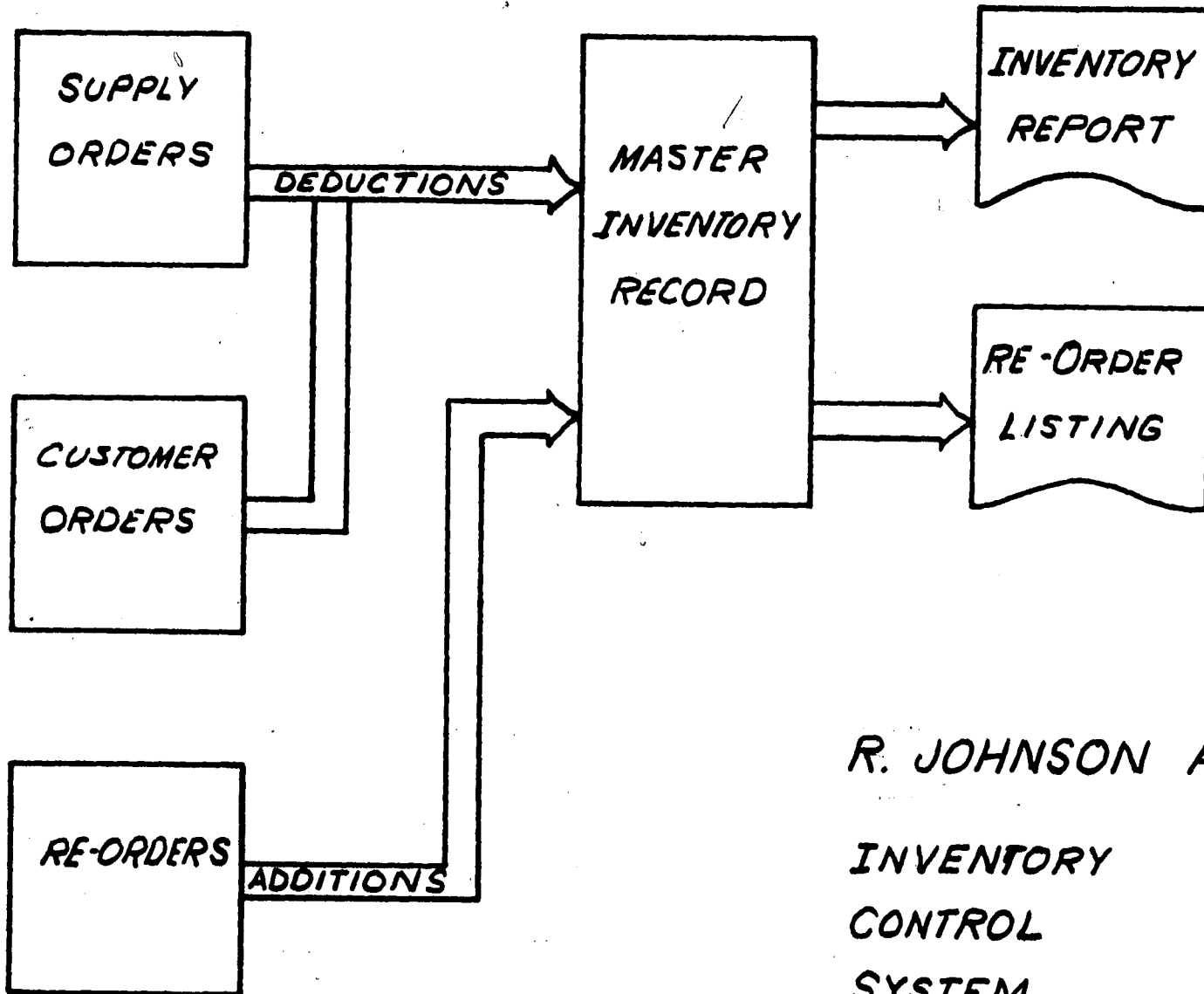


T&D AUTOMOTIVE
INFORMATION FLOW



METZ MECHANICAL

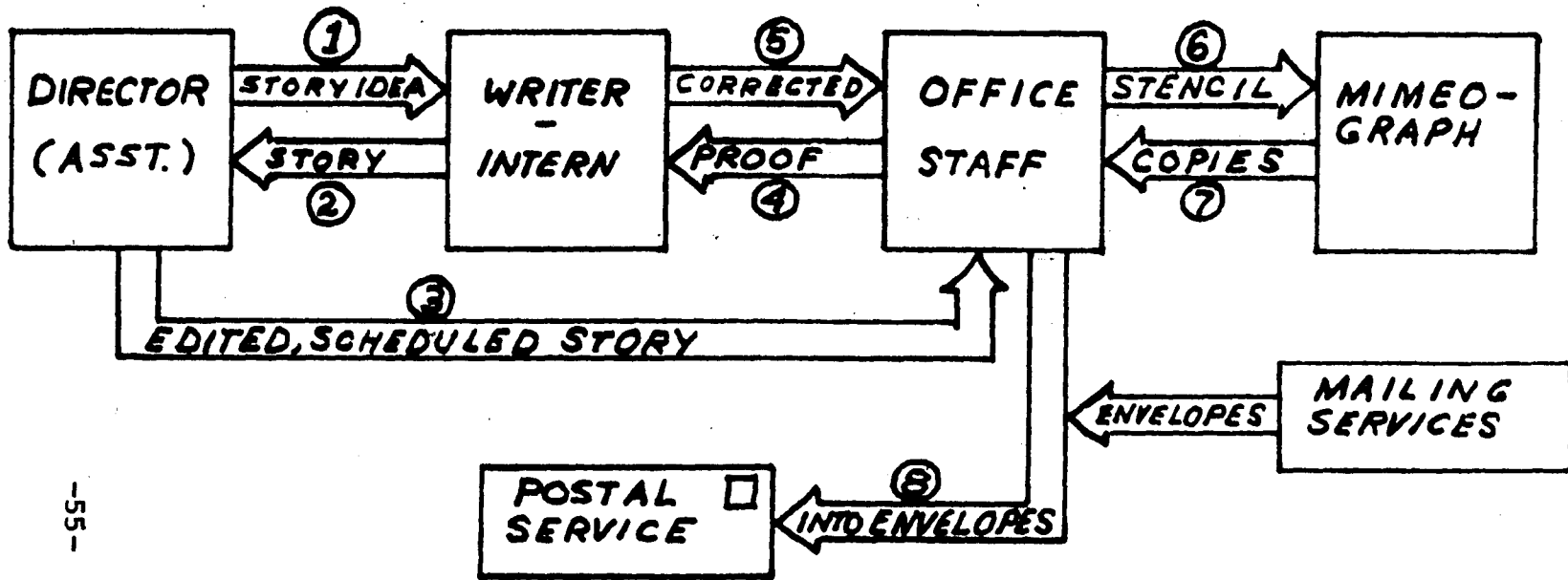
**PAYROLL
ACCOUNTING
SYSTEM**



-54-

R. JOHNSON ASSOC.

INVENTORY
CONTROL
SYSTEM



-55-

PRODUCTION
OF NEWS RELEASES

(CURRENT)

OFFICE OF
PUBLIC INFORMATION
LEHIGH UNIVERSITY

VITA

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