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16. Abstract

Existing manual procedures for material haul tickets when payments are by weight involve a considerable amount of manual checking, arithmetic calculations and ticket accountability. The availability of small mini-computers and appropriate input and output devices allowed for the development of a portable, automated data acquisition system which is capable of capturing the data at its source. All of the functions of ticket generation, ticket accountability, material summary reports and checking are accomplished with the system. An additional important feature is that the hardware is small enough to be transported from project to project. Due to its interactive mode of operation, a technician can be trained to use the system in approximately one hour.

While cost effectiveness of operating this system depends on the size of the hauling operation and the amount of checking required, the overall benefits of the system are derived from accurate, flexible documentation and the release of skilled technicians for other work. Since the data is captured at its source in a computer environment, remote transmission to a central material control system would minimize subsequent material accounting procedures involved in contractor payments and materials testing.

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A Portable Automated Data Acquisition System For Material Haul Documentation

By

Roger L. Merrell

Research Report 179-1F

Automation of Construction Material and Haul Quantity Documentation

Research Study 1-19-74-179

conducted by

Division of Automation
Texas Highway Department
In cooperation with the
U.S. Department of Transportation
Federal Highway Administration

February, 1975

The contents of this report reflect the views of the author who is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

Summary

The object of this research project was to develop and test a portable, prototype automated system for issuing, checking, and documenting the material haul tickets associated with highway construction projects.

The proposed automated system is based on the concept of capturing all of the required information at the weighing station through the use of a small mini-computer. In operation, all of the functions of ticket generation, ticket accountability, and associated material summary reports are accomplished with the system. In addition, the system is portable and can be easily moved from project to project since it is not interfaced with the weighing mechanisms. It is also relatively simple to operate.

In lieu of actually developing a prototype system for field testing, efforts were concentrated on developing a demonstration system to validate the concept. Through the use of available hardware (similar to that needed for a prototype), a demonstration system was developed. The hardware consisted of a 24K mini-computer, line printer (for printing tickets) and a keyboard data entry device. In addition, the hardware allowed for development of an operating program for the mini-computer which provides a minimum of operator intervention and training. Experience gained in development of the demonstration system determined the hardware requirements for the prototype system. A technician from the local district office was trained to operate the system in approximately one hour, due to the interactive mode of operation of the system. The interactive mode or control of the system is accomplished through a series of system function codes.

Static project data for the current haul operation (project I.D., material source, date, etc.) is entered once. The equipment number/tare weight table and the moisture content can be revised at will by the operator. As each load occurs

the operator enters the equipment number and gross weight. The necessary arithmetic calculations are performed by the system and the complete haul ticket is immediately printed. Ticket numbers are issued sequentially by the system. At the same time, key information from the ticket is stored in the system.

At the end of the day's operations, a ticket accountability procedure validates the tickets received on the project. Features are present to account for missing or invalid tickets.

The system will produce all the material haul summaries and ticket accountability reports (similar to those currently in use) when requested by the operator.

The demonstration system was successfully transported to a distant point and simulated operations conducted to test its portability.

The cost of a production, portable system would be approximately $10,000. Cost recovery would be through rental charges against projects utilizing the system.

Implementation

Results of simulated operation of the demonstration Portable Automated Data Acquisition System developed under this project proved the feasibility of the system.

A prototype system could be developed and placed in operation in the field within one year at a cost of $20,000. Subsequent units would cost approximately $10,000 and could be implemented within 15 months. Five to ten units, rented to projects on a need basis, would probably support most all of the Department's larger construction haul projects. The actual number of units is a function of demand. Rental fees to a project using the system would be approximately $250 per month for the duration of the haul operation.

Acknowledgements

The Portable Automated Data Acquisition System was developed by the Division of Automation of the Texas Highway Department, Hubert A. Henry, Engineer-Director, in cooperation with the Federal Highway Administration.

Special recognition is given to Messrs. Maurice Newton and Tom Harris for their enthusiastic contributions in designing and testing the system.

Recognition is also given to the personnel in Districts 3, 4, 5, 6 and 18 who encouraged the idea, and to the personnel in District 14 for their aid in its evaluation. The Department's Construction Division and Internal Audit Section also provided valuable information.

The assistance of Mrs. Margaret Walter in preparing the reports associated with this project is also appreciated.

Roger L. Merrell
Project Supervisor

Table of Contents

List of Figures

A PORTABLE AUTOMATED DATA ACQUISITION SYSTEM FOR MATERIAL HAUL DOCUMENTATION

I. Introduction

The objective of this research project was to develop, test, and demonstrate an automated system for checking and issuing material haul tickets. The system was to include facilities for producing adequate documentation and control.

The present manual procedures for the issuance of material haul tickets, when payments are by weight, are based on the need for providing adequate documentation and accurate payments to contractors. These procedures, however, involve a considerable amount of manual checking of arithmetic calculations and ticket accountability. This entire process lends itself to the applications of automated techniques.

Automated haul ticket systems are not new and such systems have been operated in conjunction with asphalt hot-mix projects within the Texas Highway Department. Attempts to adapt automation procedures for other material, such as base material, have also been made. These attempts, however, have mainly concentrated on capturing the data on punched cards by various methods (predominantly hand sized keypunch devices) and mailing the cards to a remote computer for processing. The recent technological advances and availability of small computer hardware at low cost opened the door for a different solution to the problem by providing the capability for doing all required calculations, summaries, checks and documentation at the source of the information. In addition it offered portability.

Originally, this research project was a two year study with the first year devoted to analyzing the existing system, evaluating available hardware, designing a prototype system and purchasing the hardware. The second year's work was to be devoted to testing and demonstrating a prototype system in the field in a parallel

mode to manual methods where problems of environment, procedures, reliability and feasibility could be evaluated. The proposed second year of the study was not renewed and the work plan was revised to concentrate on development of a demonstration system. This was accomplished using equipment currently available in the Department which was similar to equipment needed for a prototype.

This report contains a brief description of existing manual procedures, the concept of the proposed system, an explanation of the demonstration system hardware and software, a description of the operation of the system, a description of available hardware, and the conclusions.

II. Description of Existing Manual Procedures

The basis of the present manual system is the existing Texas Highway Department's Material and Haul Ticket (Form 124W) shown in Figure 1. This document calls for the weight inspector to record project identification data, date, source material, truck identification and tare weight, gross weight of the truck, wet weight of the material, and moisture content. On some projects the dry weight of the material is also calculated (or taken from a table) and entered on the ticket. The road inspector then records the station number and pay quarter, if applicable.

Each day's run of tickets is checked in the Resident Engineer's office. The checking process includes comparison of tickets received on the road with those issued at the loading point to validate the fact that the loads reached the project. This is referred to as "Ticket Accountability". The tickets are separated according to pay quarter (if applicable), and summary tapes of tare weights and gross weights are compiled for each quarter followed by application of a moisture correction factor. For each project, it is estimated that there are approximately 3 to 4 man hours per day spent in the checking process alone, and in some cases the process is duplicated at the district level.

Haul ticket accountability is documented on the CX-4 report (Figure 2) which is completed daily. The CX-2 report (Figure 3) summarizes the total material hauled. Where material for more than one project is being taken from a common source, the CX-4 and CX-2 reports are maintained separately.

In order to verify the general procedure outlined above and to obtain information regarding environmental conditions, field trips were made to several projects and the detailed procedures were documented. (See Appendix A.) Of particular interest in the descriptions in Appendix A is the time spent in checking the documentation at the residency and district levels, and the description of the environ-

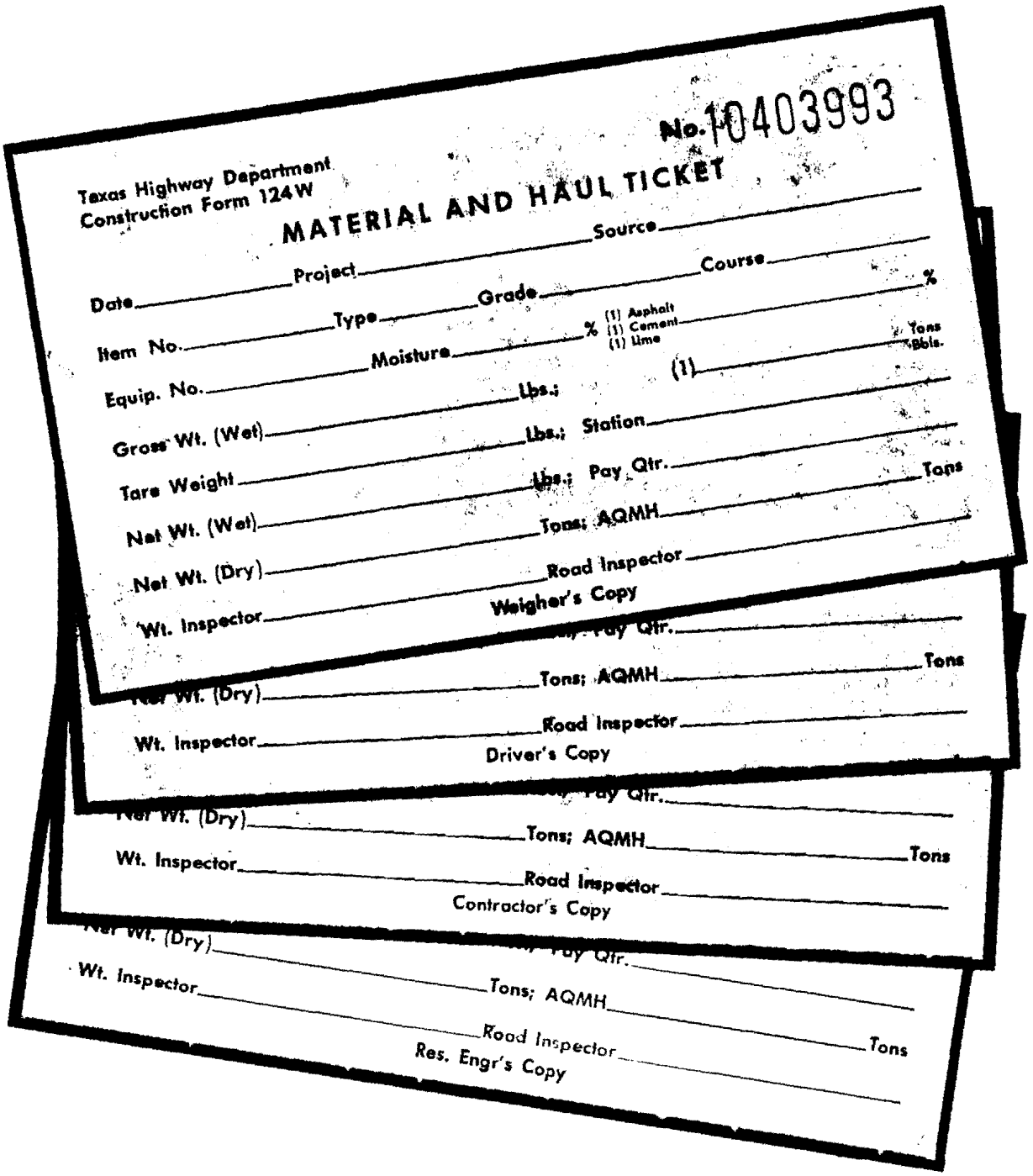

Figure 1. Material and Haul Ticket (Form 124W)

Texas Highway Department
Form CX-4

MATERIAL AND HAUL TICKET ACCOUNTABILITY RECORD

Location of Scales Wheeler Evans Grain Company, Pampa, Texas Sheet No. 1

Date 19 71	Ending Ticket Number	Voids and Exceptions	Net Pay Loads	Net Pay Loads	Project Number	Item Number	Source	Tabulated By
6-22	7914727 7914753		27	27	169-10-9	238	Williams Pit	M. L. Newton
6-23	7914786		33	33	169-10-9	238	Williams Pit	M. L. Newton
6-24	7914830		44	44	169-10-9	238	Williams Pit	M. L. Newton
6-25	7914873		43	43	169-10-9	238	Williams Pit	M. L. Newton
6-28	7914904		31	31	169-10-9	238	Williams Pit	M. L. Newton
6-29	7914962		58	58	169-10-9	238	Williams Pit	M. L. Newton
6-30	7914965		3	3	169-10-9	238	Williams Pit	M. L. Newton
7-22	7914979		14	14	169-10-9	238	Williams Pit	M. L. Newton
7-23	7915033		54	54	169-10-9	238	Williams Pit	M. L. Newton
7-26	7915078		45	45	169-10-9	238	Williams Pit	M. L. Newton
7-27	7915107		29	29	169-10-9	238	Williams Pit	M. L. Newton
7-28	7915169		62	62	169-10-9	238	Williams Pit	M. L. Newton
7-29	7915235		66	66	169-10-9	238	Williams Pit	M. L. Newton
7-30	7915236 7915562		2	2	169-10-9	238	Williams Pit	M. L. Newton

Certified Correct: _____
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Figure 2. Manually Produced CX-4 Report

Texas Highway Department
Form CX-2

TABULATION OF MATERIAL AND HAUL TICKETS ISSUED

Sheet No. 1

Item Description Flex. Base **Item No.** 238 **Type** ____ **Grade** 2 **Source** Williams Pit **Project** C 169-10-9

Date 1971	Net Pay Loads	Total Wet Weight - Lbs. Gross	Tare	Net	Conv. Factor	Item Flex.Base Unit Ton					Tabulated By
FWD.											
6-22	27	2671500	769600	1901900	2100	905.67					M. L. Newton
6-23	33	3220100	939100	2281000	2100	1086.19					M. L. Newton
6-24	44	4282900	1285600	2997300	2100	1427.29					M. L. Newton
6-25	43	4245800	1252100	2993700	2100	1425.57					M. L. Newton
6-28	31	3050400	877800	2172600	2100	1034.57					M. L. Newton
6-29	58	5700200	1640200	4060000	2100	1933.33					M. L. Newton
6-30	3	294200	85000	209200	2100	99.62					M. L. Newton
7-22	14	1333300	400800	932500	2100	444.05					M. L. Newton
7-22	54	5156500	1533300	3623200	2100	1725.33					M. L. Newton
7-26	45	4296800	1276200	3020600	2100	1438.38					M. L. Newton
7-27	29	2853800	824000	2029800	2100	966.57					M. L. Newton
7-28	62	5981800	1708900	4272900	2100	2034.71					M. L. Newton
7-29	66	6421400	1843400	4578000	2100	2180.00					M. L. Newton
7-30	2	192000	57900	134100	2100	63.86					M. L. Newton
				TOTALS TO DATE		16,765.14					CERTIFIED CORRECT: (Resident Office Use) (District Office Use)

Form 1126

Figure 3. Manually Produced CX-2 Report

mental conditions present. These visits also pointed out the problem of security, since many of the scales are located in isolated areas where security of the equipment is difficult.

III. Concept of the Proposed System

An analysis of existing procedures revealed several key objectives that must be duplicated (or equivalents substituted) or provided for in a prototype automated system. The automated system must:

+ Operate within the existing Texas Highway Department policies regarding documentation.
+ Produce this required documentation in an acceptable format.
+ Collect basic accounting data.
+ Be accurate.
+ Be simple to operate.
+ Be reliable.
+ Be economical.
+ Be portable.

The availability of small reliable mini-computers at low cost, and the availability of low cost line printers appeared to make it economically feasible to develop a small portable system capable of fulfilling all the requirements listed above.

The main concept behind the system is that all of the functions of ticket generation, ticket accountability, summary reports, and checking are accomplished at the source of the basic data, that is, at the location of the scales. Interfacing the system directly to the scales would tend to limit its portability, but could be accomplished, if warranted.

Figure 4 is a schematic of the basic hardware needed for the automated system. The mini-computer is the heart of the system and must be of sufficient size to accomplish the tasks listed above. A more detailed description of the hardware and program size requirements will be discussed later. Tied to the mini-computer

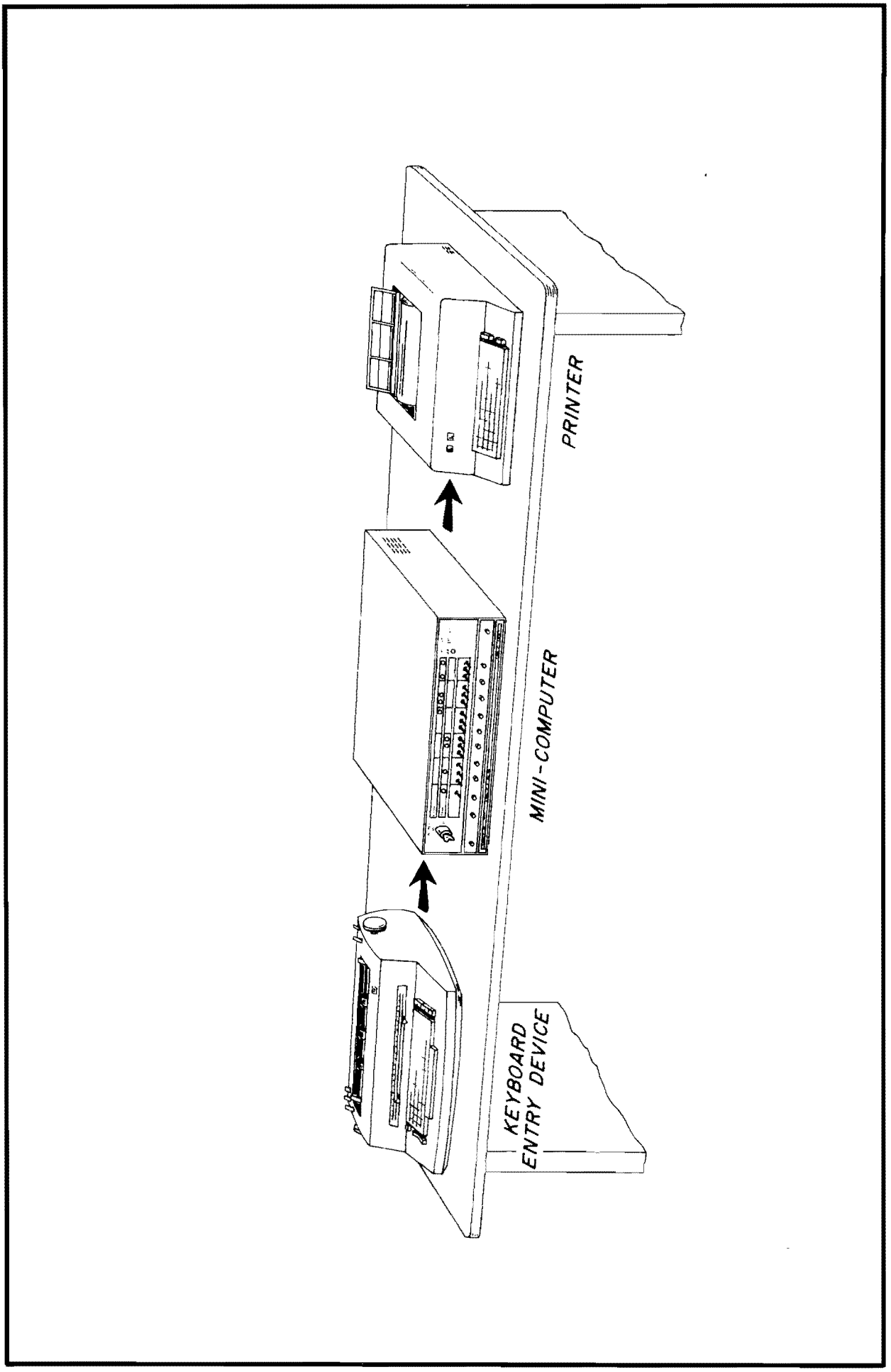

Figure 4. Schematic of the Hardware For The Automated System

is a keyboard data entry device and a small printer used to print the haul tickets and reports. The physical size of each of these devices is approximately equal to the size of a typewriter.

The basic operation of the system is shown schematically in Figure 5. The entire system is physically located at the weigh station, and the mini-computer is pre-programmed to accomplish the basic functions listed previously. After some investigation it was determined that the best method of operation would be in an interactive mode; therefore, the weight inspector concerns himself only with entering the required static data concerning the project, and the vehicle identification and gross weight for each load as they occur. The haul ticket is then printed on the mini-computer printing device and distributed in the normal manner. Key data from the ticket, however, is also stored in the mini-computer. At the end of the day's activities, a comparison is made of tickets received on the road with those issued and stored by the mini-computer system. The appropriate ticket accountability and material quantity reports are then printed out by the system on request.

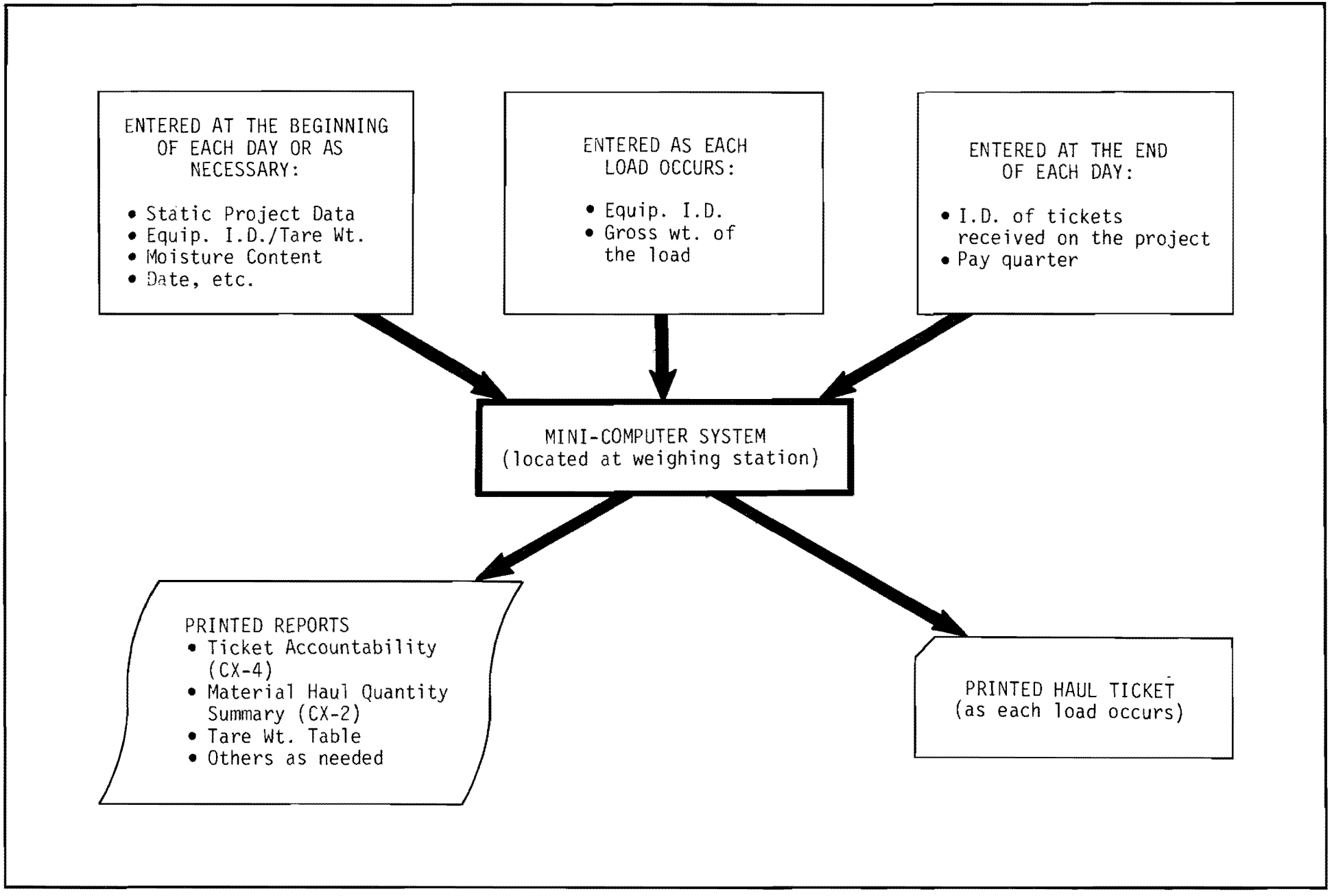

Figure 5. Operational Theory of the Automated Operation

IV. Demonstration System Hardware and Program

A demonstration system using equipment that was currently available was developed since the second half of this project was not renewed. This equipment is similar in size and capability to that which would be required in a prototype system. Figure 6 shows the various hardware components used for the demonstration system. Both the teletype and the line printer shown in this figure are larger than that anticipated for use in a prototype system. The mini-computer is also larger than needed but contains the operating characteristics and core size comparable to that needed in a prototype system.

The demonstration system was developed as a working vehicle to determine:

1. The operating characteristics of a portable automated system.
2. The extent of operator training and orientation
3. The characteristics of the hardware to be used in conjunction with a prototype.
4. Validity of the concept of a portable system.
5. The format of hard copy documentation needed for audit purposes.

The program for the mini-computer is written in FORTRAN and was designed to test the system to see if it met the requirements listed in the preceding paragraph. A flow diagram of the demonstration program is shown in Appendix B. While FORTRAN is not the most efficient program language for this mini-computer application, it was used to expedite the work and reduce program development costs. System efficiency was not a concern since the idea was to investigate the operating characteristics of the system. The program listing of the demonstration system is in Appendix B. This system operates in 12K core.

The program has facilities for storing static project data, building and maintaining a table of equipment tare weights, storing and revising material moisture

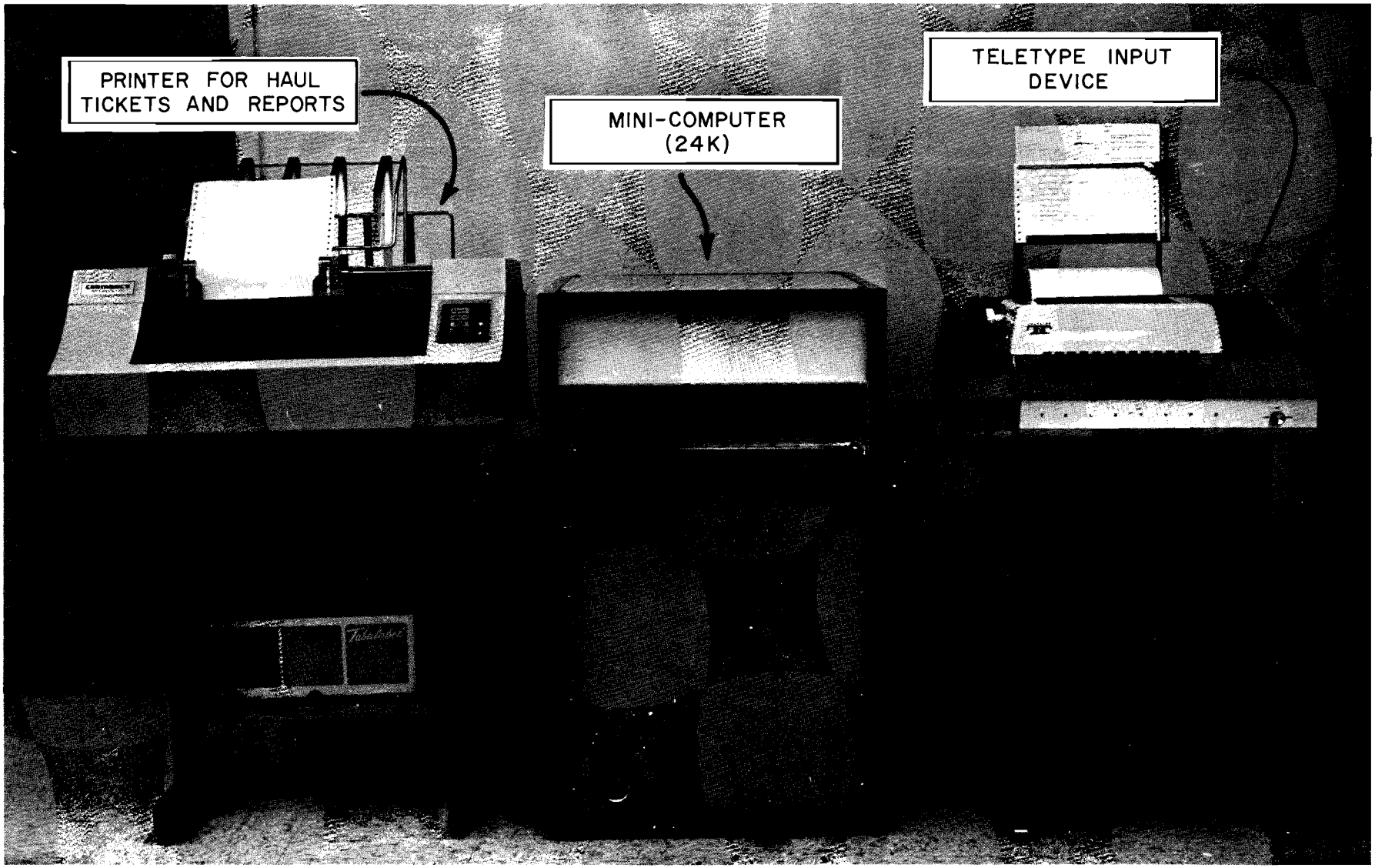

Figure 6. Hardware Used in the Demonstration System

percentages and storing the key data on each ticket issued. It also produces equivalents to the CX-2 and CX-4 reports. The program numbers tickets sequentially, starting with the beginning ticket number entered by the operator. Static project data such as project number, type of material, source and grade are also stored and entered only once. These can be revised at any time by the operator.

Output formats of the haul tickets, and the CX-4 and CX-2 reports were patterned after the manual forms. The CX-2 report (Figure 7) was modified somewhat because of the methods used to accumulate material quantities. In the manually prepared CX-2 report (Figure 3), there are columns for Total Gross Weights and Total Tare Weights. These totals are the accumulation of figures taken from the tickets. The total wet weight and total dry weight for each moisture percentage used is then calculated. In the program, however, the net wet weight for each load is calculated and stored (along with Ticket number and moisture) at the time the ticket is issued. To produce the CX-2 report, the net wet weight values for all tickets comprising the report are added and a one-time conversion to tons is made. The total net wet weight and total tons are then printed on the CX-2. The CX-4 report (Figure 8) essentially duplicates the manually prepared version (Figure 2).

After the demonstration program was written, several sets of test data were used to refine some parts of the program, develop additional capabilities, and streamline operator functions. Additional program features could be added without increasing hardware requirements.

One of the key functions of the system is that it be portable. The demonstration system, which was physically larger than necessary, showed that the system was quite capable of fulfilling this requirement. When the entire unit was transferred to San Antonio to demonstrate its concept at a research meeting, the operating program was loaded into the mini-computer before it was transported, and the unit was set up at the new site within a few minutes. Mock operations began without incident or delay.

TABULATION OF MATERIAL AND HAUL TICKETS ISSUED

PROJECT NO. A 3126-3-1 SOURCE LOCKETT PIT

ITEM NO. 232 ITEM DESCRIPTION FLEXIBLE BASE

DATE	NET PAY LOADS	TOTAL NET WT. - LBS (NET)	TOTAL NET WT. -TONS (DRY)	PAY QUARTER	ADD L QUARTER MILE HAUL	TABULATED BY
11/7/74	1	38820.	17.77	88	1564.	
11/7/74	29	1070170.	490.00	88	43120.	
11/7/74	2	72680.	33.28	88	2928.	
11/7/74	13	482950.	221.13	88	19460.	

CX-2

Figure 7. Computer Produced CX-2 Report

MATERIAL AND HAUL TICKET ACCOUNTABILITY RECORD

PROJECT NO. A 3126-3-1 SOURCE LOCKETT PIT

ITEM NO. 232 SCALE LOCATION LOCKETT PIT

DATE	FROM TICKET NUMBER	TO TICKET NUMBER	VOIDS AND EXCEPT.	NET PAY LOADS	TABULATIONS CHECKED BY
11/7/74	8	8		1	
11/7/74	10	38		29	
11/7/74	41	42		2	
11/7/74	46	46		1	
11/7/74	47	47	47	0	
11/7/74	48	59		12	

CX-4

Figure 8. Computer Produced CX-4 Report

V. Operation of the Demonstration System

Operator Functions

One of the goals of a portable data acquisition system was to minimize operator intervention and training. This is accomplished by storing repetitive haul ticket information in the mini-computer and programming the computer to ask for the additional information needed to complete each haul ticket. In operation the operating program is loaded into the mini-computer before transportation to the site.

At the beginning of the project (or daily as required) the operator has facilities for entering static project information such as the project designator, type of material, item number and grade. The program operates with a tare weight table which can be revised at will throughout the day's operations by the operator. Also a feature is available for beginning each day's operation with a specific beginning ticket number if desired. The actual ticket numbering is accomplished by the system and is done sequentially on a daily basis.

The program is interactive in nature, that is the operator must inform the system as to what function he would like to carry out and the system responds by asking for the appropriate information. The communication is accomplished through operator codes listed in Figure 9. For instance, if the operator wants to commence the issuance of haul tickets, he types in a code 4 and the system responds by asking for the equipment number and gross weight of the load. Similar interaction occurs for each of the codes listed. Code 3 allows the operator to enter and change the per cent moisture at any time during the course of the day's activities. This moisture is used on all subsequent tickets until revised by the operator.

Once the initial project data is entered into the system, the operator only needs to revise the date on subsequent daily operations and revise the tare weight table and moisture as required. The operator is then ready for the haul operation

MATERIAL AND HAUL TICKET PROGRAM

BEGINNING TICKET NO. (ENTER 1 to 500)

CODE 1 - Prepare truck tare weight table

CODE 2 - Enter header information for Haul Tickets, (Date, Project, Source, Item No., Type, Grade and Course)

CODE 3 - Enter Percent Moisture

CODE 4 - Enter Truck No., Gross Weight and print Haul Ticket

CODE 5 - Enter information for and print Material and Haul Ticket Accountability Record (Job No., Project No., Source, Item No., Scale Location, Beginning and Ending Ticket Numbers, Void Ticket Numbers)

CODE 6 - Enter information for, and print Tabulation Of Material And Haul Tickets Issued (Job No., Project No., Source, Item No. and Item Description)

CODE 7 - Enter a new Beginning Ticket No. (not necessary at beginning of day)

CODE 8 - List the Truck Tare Weight Table

CODE 9 - List the tickets not yet accounted for, if any

CODE 10 - Enter a new date

CODE 11 - Enter Weight Inspector's Name

CODE 0 - Discontinue operation being performed and call for a new code entry

Figure 9. Operator Codes

to commence. For each load the operator enters the truck number and the gross weight of the load as they occur throughout the day. A typical operating sequence is given in Appendix C.

Ticket Generation and Data Acquisition

When the truck number and the gross weight are entered by the operator for a load, the system obtains the tare weight from the tare weight table and the previously stored moisture percentage and performs the necessary arithmetic calculation to produce the haul ticket shown in Figure 10. It should be pointed out that the printed haul ticket contains all of the static project information, the equipment number, gross and tare weights. The program then calculates the net wet weight and the net dry weight in tons (if required). The ticket is generated automatically when the operator enters the gross weight of the load. It is important to note, however, that as the ticket is printed key data is automatically stored in the mini-computer. The information stored is the ticket number, the moisture content and the net wet weight. The demonstration program will store 500 loads. Tickets are numbered by the system sequentially beginning from the ticket number entered by the operator at the beginning of the day's activities. This is done without identifying the project for the load if there was more than one project being handled. Four-part perforated paper is used to provide adequate copies of the haul tickets that can be torn off as soon as they are printed.

Ticket Accountability

Ticket accountability with the demonstration system is accomplished in much the same manner as it is in the existing manual systems. That is, the tickets received on the roadway are compared with those tickets issued at the source of the material. At the end of the day's activities, the road inspector will inform the operator of the system of the numbers of the tickets received on his project. If the system is used for multi-projects, each road inspector would

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55

MATERIAL AND HAUL TICKET

DATE 11/7/74 PROJECT A 3126-3-1 SOURCE LOCKETT PIT

ITEM NO. 232 TYPE B GRADE 2 COURSE 1 MOISTURE 9.20%

EQUIP. NO. 103 PAY QTR STATION AQMH

GROSS WT. (WET) 58890. LBS TARE WEIGHT 21790. LBS

NET WT. (WET) 37100. LBS NET WT. (DRY) 16.99 TONS

WT. INSPECTOR ROAD INSPECTOR

****

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56

MATERIAL AND HAUL TICKET

DATE 11/7/74 PROJECT A 3126-3-1 SOURCE LOCKETT PIT

ITEM NO. 232 TYPE B GRADE 2 COURSE 1 MOISTURE 9.20%

EQUIP. NO. 112 PAY QTR STATION AQMH

GROSS WT. (WET) 60280. LBS TARE WEIGHT 21480. LBS

NET WT. (WET) 38800. LBS NET WT. (DRY) 17.77 TONS

WT. INSPECTOR ROAD INSPECTOR

****

Figure 10. Computer Printed Haul Tickets

inform the operator of the tickets he received on his project. The system operator would then enter into the mini-computer the numbers of the tickets received on each project. Each ticket number can be entered singularly or a block of ticket numbers can be entered by specifying the beginning and ending ticket numbers. In addition, the operator inputs to the system those tickets that are void and any exceptions that might occur. Then, if multi-projects are being handled, the operator enters the project identification information applicable to the ticket numbers previously entered. This, in effect, assigns the proper tickets to each of the projects. Once the ticket numbers are entered, the system checks the ticket numbers against those that were issued and stored, and produces the material and haul ticket accountability record (CX-4) shown in Figure 8. In addition, the operator may request a summary of those tickets that were issued by the system and are not accounted for.

Reports

Once the operator is satisfied that all tickets are accounted for, he can then request (through code 6) the tabulation of material and haul tickets issued (CX-2) as shown in Figure 7. The operator does not have to perform any arithmetic since the total dry tons of material hauled is calculated by the system. Where multi-projects are involved, these reports are printed independently for each project.

The truck tare weight table can be printed out at any time by entering a code 8. An example of one of these is shown in Figure 11.

TARE WEIGHTS 11/7/74

TRUCK NO. 102 TARE WEIGHT=21960.
TRUCK NO. 103 TARE WEIGHT=21790.
TRUCK NO. 105 TARE WEIGHT=21720.
TRUCK NO. 106 TARE WEIGHT=21570.
TRUCK NO. 108 TARE WEIGHT=21690.
TRUCK NO. 109 TARE WEIGHT=21760.
TRUCK NO. 110 TARE WEIGHT=22070.
TRUCK NO. 112 TARE WEIGHT=21480.
TRUCK NO. 159 TARE WEIGHT=21720.
TRUCK NO. 168 TARE WEIGHT=22080.
TRUCK NO. 172 TARE WEIGHT=22120.
TRUCK NO. 173 TARE WEIGHT=21700.
TRUCK NO. 175 TARE WEIGHT=22560.
TRUCK NO. 176 TARE WEIGHT=22190.
TRUCK NO. 177 TARE WEIGHT=22750.
TRUCK NO. 178 TARE WEIGHT=22750.
TRUCK NO. 179 TARE WEIGHT=22670.
TRUCK NO. 181 TARE WEIGHT=22720.
TRUCK NO. 145 TARE WEIGHT=22000.
TRUCK NO. 146 TARE WEIGHT=22280.
TRUCK NO. 150 TARE WEIGHT=22220.
TRUCK NO. 152 TARE WEIGHT=22140.
TRUCK NO. 154 TARE WEIGHT=22740.
TRUCK NO. 157 TARE WEIGHT=21940.
TRUCK NO. 158 TARE WEIGHT=21680.
TRUCK NO. 160 TARE WEIGHT=22080.
TRUCK NO. 164 TARE WEIGHT=21980.
TRUCK NO. 166 TARE WEIGHT=22220.
TRUCK NO. 169 TARE WEIGHT=22520.
TRUCK NO. 170 TARE WEIGHT=21940.
TRUCK NO. 171 TARE WEIGHT=22240.
TRUCK NO. 174 TARE WEIGHT=22600.
TRUCK NO. 202 TARE WEIGHT=21960.
TRUCK NO. 203 TARE WEIGHT=21790.
TRUCK NO. 205 TARE WEIGHT=21720.
TRUCK NO. 206 TARE WEIGHT=21570.
TRUCK NO. 208 TARE WEIGHT=21690.
TRUCK NO. 209 TARE WEIGHT=21760.
TRUCK NO. 210 TARE WEIGHT=22070.
TRUCK NO. 212 TARE WEIGHT=21480.
TRUCK NO. 259 TARE WEIGHT=21720.
TRUCK NO. 268 TARE WEIGHT=22080.
TRUCK NO. 272 TARE WEIGHT=22120.
TRUCK NO. 273 TARE WEIGHT=21700.
TRUCK NO. 275 TARE WEIGHT=22560.
TRUCK NO. 276 TARE WEIGHT=22190.
TRUCK NO. 277 TARE WEIGHT=22750.
TRUCK NO. 278 TARE WEIGHT=22750.

Figure 11. Truck Tare Weight Table

VI. Description of Available Hardware

The concept of the prototype system is based on the fact that small, adequate computer hardware equipment is currently available at a reasonable price. A study of the hardware market, during the course of this project, indicates that hardware sufficient to develop a prototype is available. There are three main components that comprise the basic system: a keyboard entry device, a mini-computer, and a printing device. Modifications or additions to the basic system would largely have to be determined after field tests. A summary of some of the available equipment is listed in Appendix D.

Data entry devices used for this system should be small. A selectric typewriter interfaced with the mini-computer would suffice but is probably larger than necessary. There are many others that will work (even a hand held keyboard/video device). An impact printer (where the keys strike the paper) is desirable since several copies of the haul tickets are required; however, these printers are electro-mechanical by nature and may afford some maintenance difficulties in dusty conditions. Separate devices for printing the tickets and for input of system control commands are almost essential since the tickets are printed out on four-part, perforated paper making it difficult to separate the printed tickets, summary reports and the input control messages where one device is used.

There are many mini-computers that have adequate storage and computational features as shown in Appendix D. Some of these have tape cassette capabilities (such as the Data Point 2200) and acoustic telephone couplers for transmission of data over telephone lines.

The more sophisticated mini-computers have the "power fail - auto-restart" feature. This feature permits power interruptions to occur (either intentionally or unintentionally) without any effect on the information stored in the system. In other words, it is capable of starting up again without losing the sequence or the stored data.

Micro-computers also have application advantages in this type of system. Micro-computers differ from mini-computers in that some (or all) of the basic program routines and functions are essentially "hard-wired"; that is, they are built into the electronics and become part of the basic operating system of the computer. In some applications, the results are reduced size (since core storage in the computer is reduced) and more efficient operations. Micro-computers are less expensive than mini-computers and are somewhat more adaptable to extreme environmental conditions.

Reliability is important in an automated haul ticket operation. Investigations have shown that mini-computers are being used daily for real-time control of vehicular traffic, sales inventories and other critical operations. The Texas Highway Department has participated in the development, testing and installation of several traffic systems using mini-computers in Dallas, Houston and Amarillo. Some of these systems have been in operation for several years without major difficulties with the computer hardware.

One of the major considerations in using the type of hardware suggested is the environmental conditions found in the average weigh station associated with highway projects. Dust, humidity and changes in temperature are the conditions of most concern. Printing devices operate electro-mechanically and are particularly sensitive to excessive dust. Similarly, the keyboard entry device is also affected. Almost all mini-computers have operating temperature limitations near 120°F as a maximum and 20°F as a minimum. However, generally they will operate in ambient temperatures suitable for humans.

The detrimental effect of the environmental conditions on the type of equipment can only be estimated using the experience gained from the systems mentioned above and knowledge of the average conditions in the field. The analysis indicates that proper hardware could operate satisfactorily.

VII. Conclusions

The demonstration system has been tested sufficiently to determine that the basic concept of a portable automated system is feasible and warrants additional development.

Operator training is reduced to a minimum since the interactive mode of operation eliminates having to memorize any data entry requirements. Tests with actual district field personnel show that a technician can learn to operate the system in about one hour. A system of this type has the additional advantage of reducing operator errors in the haul ticket operation since it eliminates manual copying of tare weights from a table, subtraction, and cross referencing a moisture weight table before writing the tickets.

The system is flexible. It is equally adaptable to base material and hot-mix type projects. Separate programs for each type of haul project can be loaded into the system to fit project needs. A modular program incorporating all of the variable project requirements could be written. Additional features might include computing dump spacing and printing it on the ticket, computing material yield, and expanded report generation. Also running project totals could be maintained in preparation for monthly and final construction estimates. Since the data is captured at its source in a computer environment, remote transmissions of this data to a distant computer file are feasible. Tied into a centralized material control system, the data acquired would minimize subsequent material accounting procedures involved in contractor payments and materials testing.

If a mini-computer without cassette capabilities is used, a minimum of 12K of core would be required. Use of cassette drives would reduce this to approximately 4K but this has the disadvantage of possible additional mechanical difficulties associated with the tape mechanism and possible additional operator interaction. From the work done on the demonstration system, it is believed that a 12K-16K mini-

computer without cassette drives would require less maintenance and provide all the capability needed.

The cost is reasonable. The hardware and software costs for developing a prototype system would be approximately $20,000. Production units would cost approximately $10,000 each. Amortizing $10,000 over a five year period, the rental cost for hardware on a project would be approximately $170 per month (20 hauling days). Maintenance and Administrative costs are estimated at $80 per month. This would amount to total rental costs to the projects of about $250 per month. Field reports of the accounting procedures used by resident engineers and districts indicate that a conservative estimate of time to manually check haul tickets on one day's haul operation (100-150 loads) would be approximately 3 hours. Assuming that a technician making $6.00/hour is doing the checking, then the cost to manually check one month's operation is $360. In addition the use of this system would allow the technician to pursue more productive engineering tasks.

Results from testing the demonstration system indicate that a portable data acquisition system for material haul documentation would reduce man power in checking haul tickets. The value of such a system appears to be dictated by the size and the length of the material haul operation. Not all haul projects could justify an automated system. A small project lasting for a few days and hauling less than 50 loads per day would probably not obtain sufficient benefits from the system. However, projects that involve more than 100 loads a day and lasting for several weeks could justify the use of the system and realize benefits in more efficient use of man power and more accurate results. It is important to emphasize that the essence of the system is that it is portable and could be moved from project to project as required. For instance, one unit could be made to serve several districts depending upon sequence of the hauling operations. Several of these units made available on a statewide basis and rented to the project could probably support many

haul projects. Upon completion of one project the system could be reassigned to another project.

A review of the demonstration system's operation and hard copy documentation by personnel in the Department's Construction Division and Internal Audit Section revealed no significant problems. It was generally felt that the system produced sufficient documentation and safeguards, subject to analyzing test results of parallel operations in the field.

In summary, the most significant problems revealed by this project are the effect of environmental conditions on the performance of the equipment used in the system and the determination of the operational value of such a system. These can best be determined by operating a prototype system under field conditions.

Appendix A. Summary of Field Inspections on Two Haul Jobs

Appendix A

Summary of Field Inspection on Two Haul Jobs

First Inspection

I 10-2(39)194
441-9-6
Reeves County

Date: 1-29-74
Weather: Sunny, Dusty, and Cold

1. Weigh Station

(a) The truck scales were located approximately 10 miles northwest of Balmorhea at the Roundsaville Pit, where various stockpiles were located containing the different grades of base material.
Working conditions - Windy and dusty
The scale house was heated with a butane heater and it was very drafty. Electricity and telephone service is not available. There is no security system.

(b) Procedures
In addition to the normal scale certification as required in the Standard Specifications, the truck scales are checked twice daily by the use of test weights.

The weight inspector records the tare weight of each truck twice daily and accesses this weight each time a truck is weighed. After a truck is loaded and weighed, he then records the gross (wet) weight on Form 124W and makes a subtraction to obtain the net (wet) weight. He enters the percent moisture supplied to him by others; and in the Pay Qtr. column, he enters the dump spacing from a chart produced by the D-19 computer program, "Flex. Base Spread Tables", which supply the spacing for different rates at various moisture contents. The equipment number, source, project number and date along with the pertinent specification information is also entered by the weight inspector. He then keeps the green copy (original) of Form 124W and hands the remaining 3 copies to the truck driver for delivery to the road.

A switch from one type and grade of base to another type and grade came in the middle of the day's activities. This merely called for some close coordination between the weigh station and the road inspectors.

(c) End of day
There is virtually no end of day activities other than handing the green copies (originals) to the chief inspector for delivery to the residency office.

2. Road Checker's Station

(a) Procedures
Upon receiving the copies of Form 124W, the checker read the dump spacing and supervised the measuring of the dump space.

After the truck was dumped, he validated the ticket by signing it and entered the proper station. He then returned to the driver his copy of the ticket and kept the remaining copies in his possession. This project was set up for the haul to be included in the bid price for base, so that Additional Qtr. Mi. Haul was not an item on this project.

Date: 1-30-74

3. Residency Office

(a) Procedures
The tickets for the previous day were arranged in numerical sequence and the proper entry was made on Form CX-4, "Material and Haul Record Accountability Record". (See Figure A-1.)

The carbons were then removed; and, while doing this, a check was made for incomplete information.

The Resident Engineer's copy of the tickets was systematically organized with a paper clip attached to every 25th copy. Three adding machine tapes were then run (Tare wt., Gross wt. & Net. wt.) on these tickets with a sub-total where a paper clip was encountered. If a balance was not obtained, a check of the tickets (which were organized into batches of 25) was begun and the errors located and corrected. (Most errors were subtraction errors made by the weight inspector.)

The next step was to post Form CX-2, "Tabulation of Material and Haul Tickets Issued" (Figure A-2).

From the information on Form CX-2 and Form 124WS, a "Material and Haul Ticket Summary" was prepared in duplicate. Form CX-2 and Form 124WS were checked by a second individual. Form 124WS then became the cover for the contractor's and Resident Engineer's copy of the tickets.

The adding machine tapes were then attached to the Resident Engineer's copy with the following information written on the tape for this date:

Total Gross Wt.
Total Tare Wt.
Total Net Wt.
Percent Moisture
Total Tons for date

(b) Approximately 3½ man hours were consumed in the above accounting procedures.

Texas Highway Department
Form CX-4

MATERIAL AND HAUL TICKET ACCOUNTABILITY RECORD

Location of Scales Rounsaville Pit Sheet No. 1

Date 1973	Ending Ticket Number	Voids and Exceptions	Net Pay Loads	Net Pay Loads	Project Number	Item Number	Source Pit	Tabulated By
12-6	8405128 8405152		25	25	I 10-2(39)194	249	Rounsaville	LY
12-7	8405159		7	7	"	"	"	LY
12-10	8405306		147	147	"	"	"	LY
12-11	8405382		76	76	"	"	"	LY
12-12	8405431		49	49	"	"	"	LY
12-13	8405618		187	187	"	"	"	LY
12-14	8405784		166	166	"	"	"	LY

Certified Correct: _____
(District Office Use)

Figure A-1. Material and Haul Ticket Accountability Record

Texas Highway Department
Form CX-2

TABULATION OF MATERIAL AND HAUL TICKETS ISSUED

Sheet No. 1

Item Description Flexible Base Item No. 249 Type A Grade 4 Source Roungaville Pit Project I 10-2(39)194

Date 1973	Net Pay Loads	Total Wet Weight - Lbs. Gross	Tare	Net	Conv. Factor	Item Flex Base Unit Ton					Tabulated By
FWD.											Lillie G. Talamantez
12-6	25	1,971,900	526,800	1,445,100	2174	664.72					Lillie G. Talamantez
12-7	7	545,700	147,600	398,100	2174	183.12					Lillie G. Talamantez
12-10	147	11,522,800	3,111,000	8,411,800	2128	3,952.91					Lillie G. Talamantez
12-11	76	5,926,500	1,586,100	4,340,400	2164	2,005.73					Lillie G. Talamantez
12-12	49	3,846,800	1,023,800	2,823,000	2144	1,316.70					Lillie G. Talamantez
12-13	187	14,494,800	3,897,300	10,597,500	2120	4,998.82					Lillie G. Talamantez
12-14	166	13,002,400	3,436,900	9,565,500	2118	4,516.29					Lillie G. Talamantez
				TOTALS TO DATE							CERTIFIED CORRECT:
											(Resident Office Use)
											(District Office Use)

Form 1126

Figure A-2. Tabulation of Material and Haul Tickets Issued

I 10-2(39)194
441-9-6
Reeves County

Date: 1-30-74

4. District Office

(a) A representative from the district office makes monthly visits to the residency during hauling operations for the purpose of making the following checks:

All entries on tickets
Calculations
Entries on various forms

(b) Man hours consumed on haul tickets per visit are estimated at one.

Second Inspection

I 40-1(84)115
Cont. and Sec. 275-5 thru 8
Donley & Gray Counties

Date: 5-13-74
Weather: Hot, Windy, and Dusty

1. Weigh Station

(a) The truck scales were located approximately eight miles southeast of Groom at the T.L. Roach Pit where the base material was stockpiled.
Working Conditions - Windy, hot and dusty
The scale house was better than average and electricity and telephone service could be made available. The contractor has one man to maintain security for the entire project. The gate on the haul road is locked at night. The windows and doors on the scale house are also locked.

(b) Procedures
The truck scales are checked and certified every six months as required by Item 500 of the standard specifications. The form used is shown in Figure A-3.

The weight inspector records the tare weight of each truck twice daily for a period of two weeks on Form TW(1) shown in Figure A-4. This provides the average tare weight used for each truck. This is verified once each month by checking the tare weight twice daily as it was entered on Form TW(2) shown in Figure A-5.

Each time a loaded truck is weighed, the tare weight for that truck is entered on Form 124W along with the gross weight, and a subtraction is made to secure the net (wet) weight. The equipment number, source and date are also entered by the weight inspector. He then signs the Form 124W, keeps the green copy (original) and hands the remaining three copies to the truck driver for handling on the road.

(c) End of Day
There is no special handling other than handing the green copies (originals) to the base inspector for his posting.

2. Road Checker's Station

(a) Upon receiving the copies of Form 124W, the checker makes use of the weight entered by the weight inspector and the percent moisture (supplied to him by others), secures the necessary dump spacing from a chart produced by the D-19 computer program, "Flex. Base Spread Tables", and supervises the measuring of the dump space.

After the truck is dumped, he enters the Project Designator number in the Project Column and validates the ticket by signing it. (It is necessary for the PD number to be entered on the road because of the complex situation of having so many splits on this contract.) He then returns to the driver his copy of the ticket and keeps the remaining copies in his possession.

Project:_____Control:_____Hwy:_____

ITEM_____

I certify that the scales used to weigh the above material were checked by_____

on_____and found to meet the requirements of ITEM 500.

Signed_____

Figure A-3. Truck Certification Form

TW (1)

TRUCK TARE WEIGHT

PROJECT:_____ SOURCE:_____

HIGHWAY:_____ TRUCKS USED FOR HAULING

COUNTY:_____ ITEMS:_____

DATE	TRUCK NO.	TARE WEIGHT	TIME	INITIAL	DATE	TRUCK NO.	TARE WEIGHT	TIME	INITIAL

Figure A-4. Form TW(1) - Truck Tare Weight

REMARKS:_____

TW (2)

TRUCK TARE WEIGHTS

Project_____ Control_____ Highway_____

County_____ For Hauling_____

Truck No.	Tare Weights			New Tare Wt. in Use	Ticket No.of Tare Change
	In Use	Check	Check		
		- - 73	- - 73		
		- - 73	- - 73		
		- - 73	- - 73		
		- - 73	- - 73		
		- - 73	- - 73		
		- - 73	- - 73		
		- - 73	- - 73		
		- - 73	- - 73		
		- - 73	- - 73		
		- - 73	- - 73		
		- - 73	- - 73		
		- - 73	- - 73		
		- - 73	- - 73		
		- - 73	- - 73		
		- - 73	- - 73		
		- - 73	- - 73		
		- - 73	- - 73		
		- - 73	- - 73		
		- - 73	- - 73		
		- - 73	- - 73		
		- - 73	- - 73		

Figure A-5. Form TW(2) - Truck Tare Weights

Additional Qtr. Mile Haul was not a pay item on this contract.

(b) End of Day

The base inspector works up a brief analysis of the day's activity, of loads hauled, etc. This involves about ½ man hour.

3. Residency Office

(a) Procedures

The tickets (Form 124W) for the previous day were checked visually for numerical sequence and to see that all information was complete.

The Resident Engineer's copies were organized into stacks of 25 tickets or less and each stack was assigned a number in ascending order. Each stack is handled as follows:

> An adding machine tape is run, totaling the Gross, Tare and Net weights. A subtraction of the Tare from the Gross to check the Net weight is performed. If an error is discovered, a search is made to locate it; and proper corrective measures are taken. Each individual stack of 25 or less is completely checked before proceeding to the next.

When all stacks have been checked individually, a summary tape for the date is made, adding the Gross, Tare and Net weights from each previously checked stack and then subtracting the Total Tare weight from the Total Gross weight to check the total Net weight hauled for the date. The moisture factor is then applied and the total pay quantity for the date is calculated and recorded on the bottom of the tape. The Form 124WS, "Material and Haul Ticket Summary", is prepared in duplicate and becomes the cover for the Contractor's and Resident Engineer's copy of the tickets.

Forms CX-2 and CX-4 are filled out from information included on the summary tape for the date.

The Resident Engineer's copy and the weigher's copy are wrapped together with the tape and a monthly submission is made to the District Office for further checking.

(b) Approximately four man hours were consumed in the above accounting procedures. Man hours vary as production varies. One and one-half man hours will check 1000 tons and this increases to approximately four man hours for 8000 tons.

(c) Comments

Also included in this contract to be paid on a weight basis is Black Base, Type B, D & F, Hot Mix. When the system is developed, it should be broad enough to handle all material paid for on a weight basis.

Date: 5-14-74

4. District Office

(a) Procedures
District Office personnel perform an audit on the monthly submission from the residency to see that all tickets are accounted for and in the proper sequence. This is accomplished by a visual check of the tape against each haul ticket. A spot check is made of Tare weights included in the monthly submission. A summary of the audit is made and a copy is returned to the residency.

(b) Man hours consumed on monthly haul ticket audit for this project were approximately 40.

C 490-4-26
S.H. 70
Roberts County
From: 15.6 miles North of Gray C/L
To: Chicken Creek

Date: 5-14-74
Weather: Hot, Windy, and Dusty

1. Weigh Station Description

   The truck scales were located at the Carter Pit, approximately 6 miles northwesterly from the Chicken Creek Bridge in Roberts County where the base material was stockpiled.
   Working Conditions - Windy, hot and dusty.
   The scale house was in very good condition and electricity and telephone service could be made available. There are contractor's employees staying at the site in small camper type mobile homes. Other than this and locked doors on the scale house, there is no security.

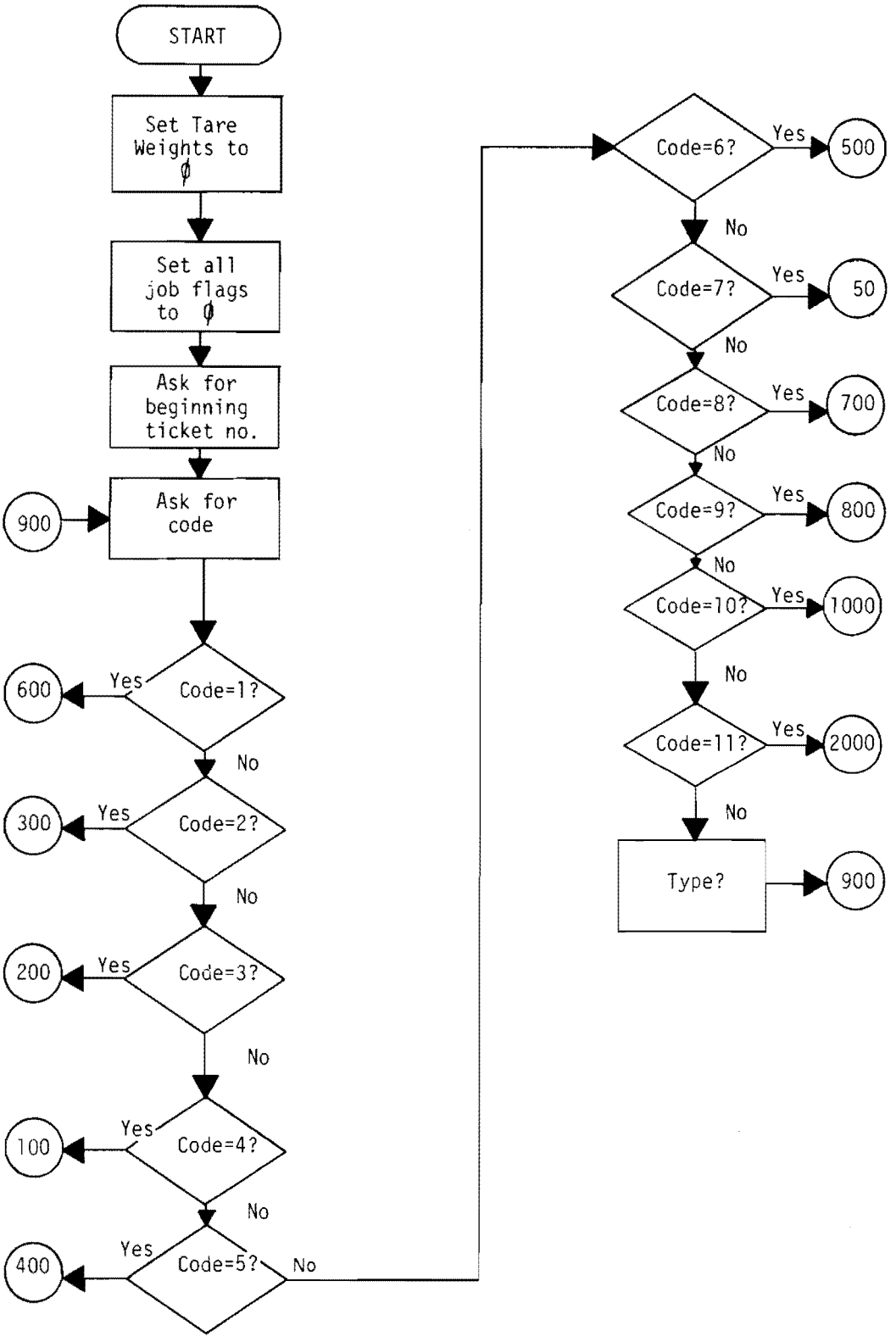
2. All other Residency and District procedures remain as described on the IH 40 portion of this report.

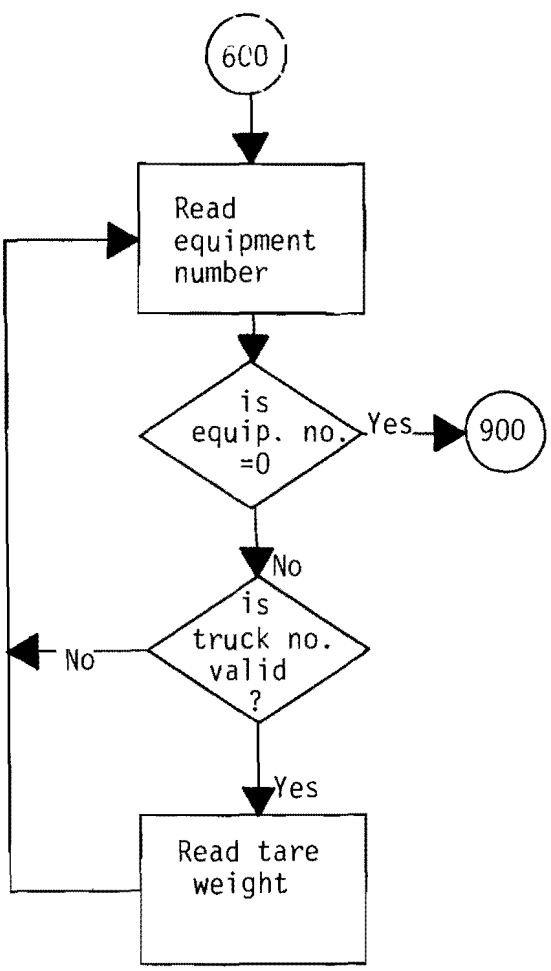
Appendix B. Program Documentation (Flow Diagram and Program Listing)

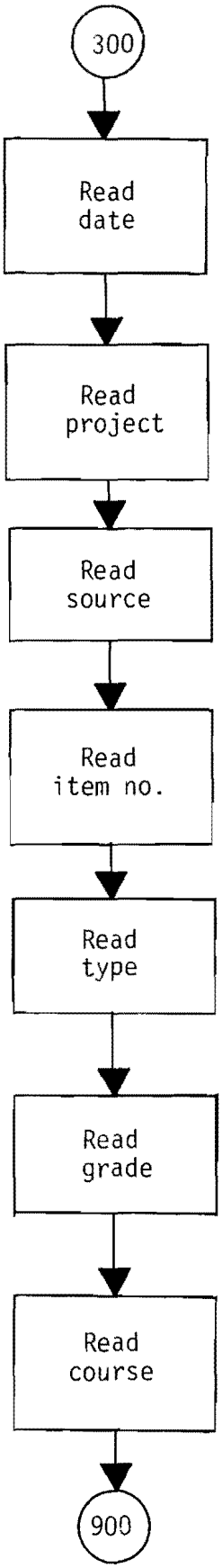
Appendix B

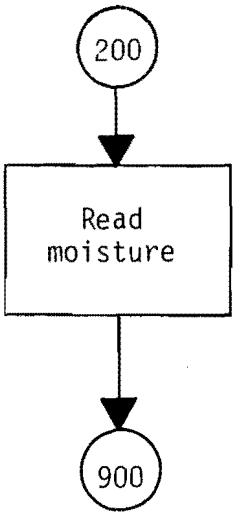
Program Documentation (Flow Diagram and Program Listing)

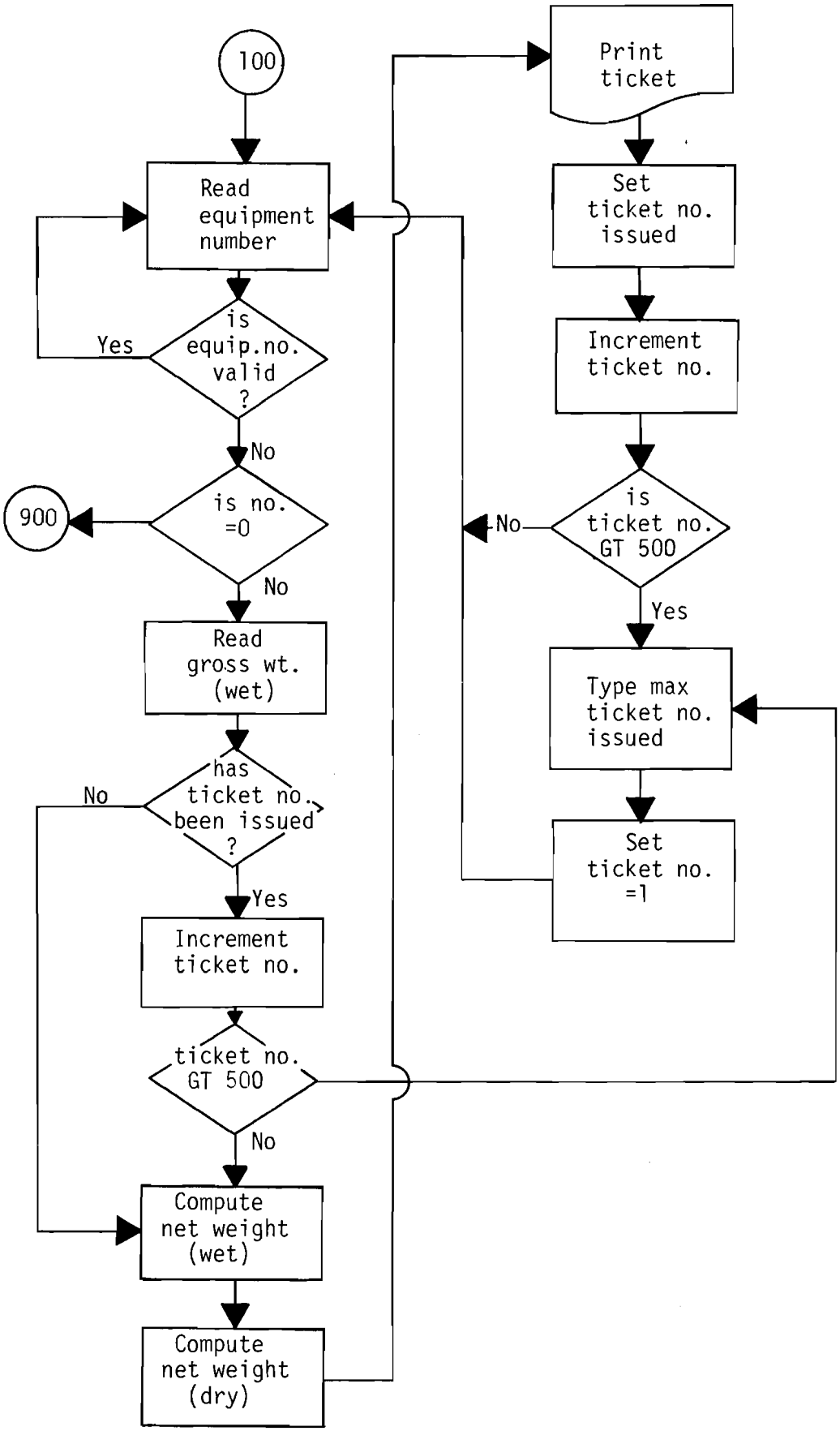
Flow Diagram

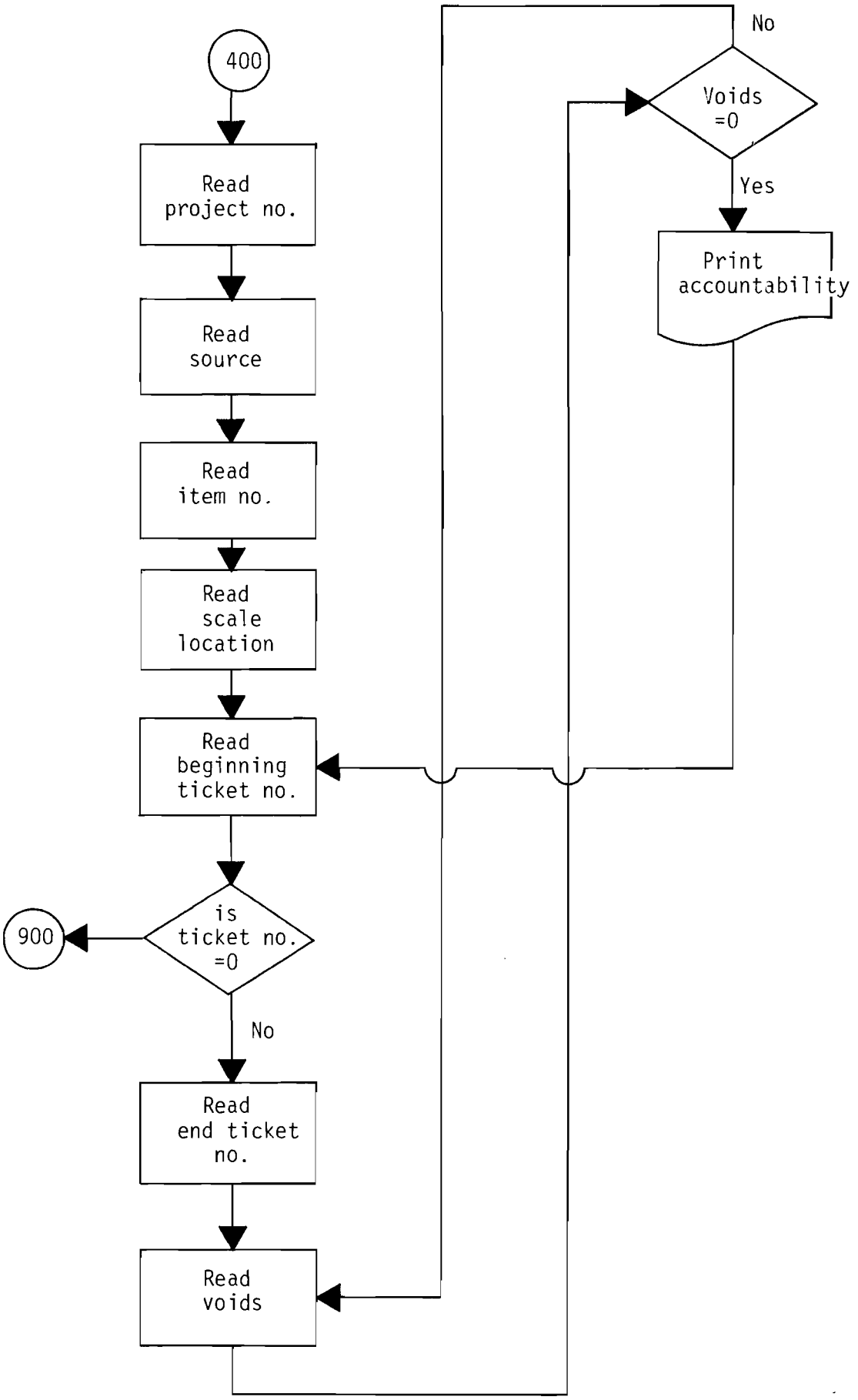


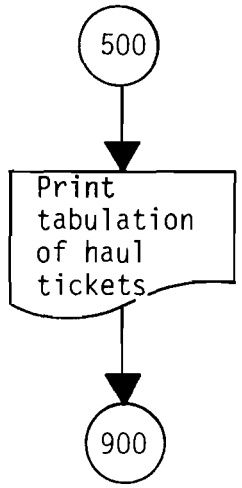

600
Read equipment number
is equip. no. =0
Yes
900
No
is truck no. valid ?
No
Yes
Read tare weight

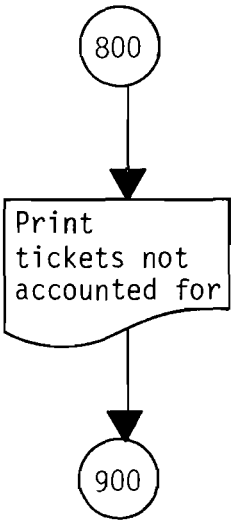

300
Read date
Read project
Read source
Read item no.
Read type
Read grade
Read course
900

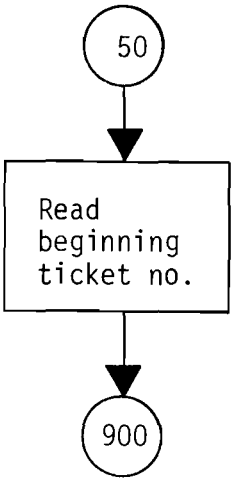

200
Read moisture
900

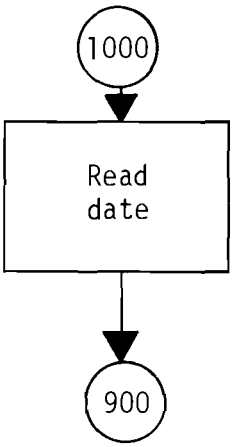

100
Read equipment number
is equip.no. valid ?
Yes
No
900
is no. =0
No
Read gross wt. (wet)
has ticket no. been issued ?
No
Yes
Increment ticket no.
ticket no. GT 500
No
Compute net weight (wet)
Compute net weight (dry)
Print ticket
Set ticket no. issued
Increment ticket no.
is ticket no. GT 500
No
Yes
Type max ticket no. issued
Set ticket no. =1

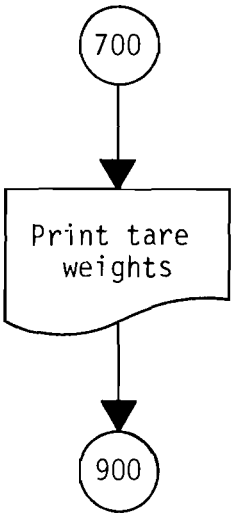

400
Read project no.
Read source
Read item no.
Read scale location
Read beginning ticket no.
is ticket no. =0
900
No
Read end ticket no.
Read voids
Voids =0
No
Yes
Print accountability

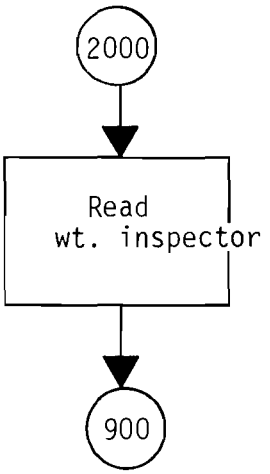

500
Print tabulation of haul tickets
900


800
Print tickets not accounted for
900


50
Read beginning ticket no.
900


1000
Read date
900


700
Print tare weights
900


2000
Read wt. inspector
900

Program Listing

This program is written in Data General's Fortran IV, ANSI, standard X3.9-1966.

```
      DIMENSION TARE(50),XNWT(500),IJOB(500),XMOST(500)
      DIMENSION DATE(3),PROJ(4),SOUR(4),WT(4)
      DIMENSION PN(4),SO(4),SLOC(4),XNO(4),XSO(4),DES(4)
      DIMENSION ITRUK(50)
      CALL FOPEN(1,'$LPT')
      INEXT=1
      DO 13 I=1,50
      ITRUK(I)=0
   13 TARE(I)=0
      DO 12 I=1,500
   12 IJOB(I)=0
   50 ACCEPT 'BEGINNING TICKET NO. ',J
  900 ACCEPT 'CODE ',IC
      IF(IC.EQ.1) GO TO 600
      IF(IC.EQ.2) GO TO 300
      IF(IC.EQ.3) GO TO 200
      IF(IC.EQ.4) GO TO 100
      IF(IC.EQ.5) GO TO 400
      IF(IC.EQ.6) GO TO 500
      IF(IC.EQ.7) GO TO 50
      IF(IC.EQ.8) GO TO 700
      IF(IC.EQ.9) GO TO 800
      IF(IC.EQ.10) GO TO 1000
      IF(IC.EQ.11) GO TO 2000
      TYPE "?"
      GO TO 900
  100 ASSIGN 102 TO ISET
      ASSIGN 609 TO ISET1
      GO TO 609
  102 IF(IJOB(J).EQ.0) GO TO 101
      J=J+1
      IF(J.GT.500) GO TO 150
      GO TO 102
  101 XNWT(J)=GWT-TARE(I)
      XMOST(J)=XMOIS
      DWT=XNWT(J)/(((XMOST(J)*.01)+2000)+2000)
      WRITE(1,9)
    9 FORMAT(1X,'**************************************************',
     1'**********',//)
      WRITE(1,6)J
    6 FORMAT(50X,I3)
      WRITE(1,7)DATE(1),PROJ(1),SOUR(1),XINO,TYP,GRDE,COUR,XMOST(J),
     1ITRUK(I),GWT,TARE(I),XNWT(J),DWT,WT(1)
    7 FORMAT(16X,'MATERIAL AND HAUL TICKET',//,
     1' DATE ',S8,6X,'PROJECT ',S14,' SOURCE ',S14,//,
     1' ITEM NO. ',S4,' TYPE ',S4,' GRADE ',S4,' COURSE ',S4,
     1 ' MOISTURE ',F5.2,'%',//,
     1' EQUIP. NO. ',I5,
     1'    PAY QTR      STATION           AQMH',//,
     1' GROSS WT. (WET) ',F7.0,' LBS        TARE WEIGHT    ',F6.0,' LBS',
     1//,
     1' NET WT. (WET)    ',F7.0,' LBS        NET WT. (DRY) ',F5.2,' TONS',
     1//,
```

```
     1' WT.  INSPECTOR ',S14,' ROAD INSPECTOR')
      WRITE(1,9)
      IJOB(J)=S
      J=J+1
      IF(J.EQ.501) GO TO 150
      GO TO 100
150   TYPE '********MAXIMUM TICKET NO.  ISSUED**********'
      J=1
      GO TO 100
200   ACCEPT 'MOISTURE ',XMOIS
      GO TO 900
300   TYPE 'DATE'
      READ(11,11)DATE(1)
 11   FORMAT(S14)
      TYPE 'PROJECT'
      READ(11,11)PROJ(1)
      TYPE 'SOURCE'
      READ(11,11)SOUR(1)
      TYPE 'ITEM NO.'
      READ(11,2)XINO
  2   FORMAT(S4)
      TYPE 'TYPE'
      READ(11,2)TYP
      TYPE 'GRADE'
      READ(11,2)GRDE
      TYPE 'COURSE'
      READ(11,2)COUR
      GO TO 900
400   ACCEPT 'JOB NO.  ',K
      TYPE 'PROJECT NO.'
      READ(11,11)PN(1)
      TYPE 'SOURCE'
      READ(11,11)SO(1)
      TYPE 'ITEM NO.'
      READ(11,2)XIN
      TYPE 'SCALE LOCATION'
      READ(11,11)SLOC(1)
      WRITE(1,404)PN(1),SO(1),XIN,SLOC(1)
404   FORMAT(1H1,15X,'MATERIAL AND HAUL TICKET ACCOUNTABILITY RECORD',
     1//,1X,'PROJECT NO.  ',S14,' SOURCE ',S14,//,
     11X,'ITEM NO.  ',S4,' SCALE LOCATION ',S14,//,
     11X,'*************************************************************',
     1'*********',
     1/,10X,1H+,9X,1H+,9X,1H+,9X,1H+,7X,1H+,/,
     110X,'*  FROM   *   TO    *  VOIDS  *  NET  * TABULATIONS',/,
     13X,'DATE   * TICKET  * TICKET  *   AND   *  PAY  * CHECKED BY',/,
     110X,'* NUMBER  * NUMBER  * EXCEPT. * LOADS *',/,
     110X,1H+,9X,1H+,9X,1H+,9X,1H+,7X,1H+,/,
     11X,'*************************************************************',
     1'*********',
     1/,10X,1H+,9X,1H+,9X,1H+,9X,1H+,7X,1H+)
405   ACCEPT 'BEGIN TICKET NO.  ',ITB
      IF(ITB.EQ.0) GO TO 410
      IF(ITB.GT.500) GO TO 405
406   ACCEPT 'END TICKET NO.  ',ITE
      IF(ITE.GT.500) GO TO 406
      IPAYL=0
420   ACCEPT 'VOID ',IVOID
```

```
      IF(IVOID.EQ.0) GO TO 421
      IJOB(IVOID)=0
      GO TO 420
421   DO 409 L=ITB,ITE
      IF(IJOB(L).NE.9) GO TO 409
      IJOB(L)=K
      IPAYL=IPAYL+1
409   CONTINUE
      WRITE(1,407)DATE(1),ITB,ITE
407   FORMAT(1X,58,' *    ',I3,'    *    ',I3,'    *          *  ',
     13X,'  *',)
      DO 121 I=ITB,ITE
121   IF(IJOB(I).NE.K) WRITE(1,122)I
122   FORMAT(10X,1H*,9X,1H*,9X,1H*,3X,I3,3X,1H*,7X,1H*)
      WRITE(1,412)IPAYL
412   FORMAT(10X,1H*,9X,1H*,9X,1H*,9X,1H*,2X,I3,2X,1H*)
      GO TO 405
410   WRITE(1,411)
411   FORMAT(10X,1H*,9X,1H*,9X,1H*,9X,1H*,7X,1H*,/,
     11X,'**********************************************************************',
     1'********************',
     1//,1X,'CX-4')
      GO TO 900
600   ASSIGN 608 TO ISET
      ASSIGN 604 TO ISET1
      GO TO 609
608   TARE(I)=GWT
609   ACCEPT 'EQUIP NO. ',ITKN
      IF(ITKN.EQ.0) GO TO 900
      DO 601 I=1,50
      IF(ITKN.EQ.ITRUK(I)) GO TO 603
601   CONTINUE
      GO TO ISET1
604   I=INEXT
      ITRUK(I)=ITKN
      INEXT=INEXT+1
      IF(INEXT.GT.50) GO TO 609
603   ACCEPT 'WEIGHT ',GWT
      GO TO ISET
500   ACCEPT 'JOB ',M
      TYPE 'PROJECT NO.'
      READ(11,11)XNO(1)
      TYPE 'SOURCE'
      READ(11,11)XSO(1)
      TYPE 'ITEM NO.'
      READ(11,2)XITM
      TYPE 'ITEM DESCRIPTION'
      READ(11,11)DES(1)
      WRITE(1,501)XNO(1),XSO(1),XITM,DES(1)
501   FORMAT(1H1,9X,'TABULATION OF MATERIAL AND HAUL TICKETS ISSUED',/,
     1,/,1X,'PROJECT NO. ',S14,14X,'SOURCE ',S14,//,
     11X,'ITEM NO. ',S4,11X,'ITEM DESCRIPTION ',S14,//,
     11X'**********************************************************************
     1**********',/,
     110X,'*',7X,'*',13X,'*',12X,'*',9X,'*',11X,'*',/,
     110X,'*  NET  *  TOTAL NET  *  TOTAL NET *',
     1'   PAY   *   ADD L   * TABULATED',/,
     13X,'DATE   *  PAY  *  WT. - LBS  *  WT. -TONS *',
     1' QUARTER *  QUARTER  *    BY',//,
```

```
     110X,'* LOADS *     (WET)     *     (DRY)    *',
     1/           * MILE HAUL *',/,
     11X'*************************************************************************
     1***************')
  505 ACCEPT 'BEGIN TICKET NO. ',ITB
      IF(ITB.GT.500) GO TO 505
      IF(ITB.EQ.0) GO TO 510
  506 ACCEPT 'END TICKET NO. ',ITE
      IF(ITE.GT.500) GO TO 506
      ACCEPT 'PAY QUARTER ',IQTR
      WET=0
      DRY=0
      NPL=0
      QTR=0
      DO 550 N=ITB,ITE
      IF(IJOB(N).NE.M) GO TO 550
      WET=WET+XNWT(N)
      NPL=NPL+1
      DWT=XNWT(N)/(((XMOST(N)*.01)+2000)+2000)
      DRY=DRY+DWT
      QTR=QTR+IQTR+DWT
      IJOB(N)=0
  550 CONTINUE
      WRITE(1,502)DATE(1),NPL,WET,DRY,IQTR,QTR
  502 FORMAT(1X,S8,' *  ',I3,'  *  ',F9.0,'  *    ',F7.2,'  *    ',I4,
     1'  *  ',F8.0,'  *')
      GO TO 505
  510 ICHK=0
      DO 551 N=1,500
      IF(IJOB(N).EQ.M) TYPE 'NO QTR HAUL FOR TICKET NO. ',N
      IF(IJOB(N).EQ.M) ICHK=1
  551 CONTINUE
      IF(ICHK.NE.0) GO TO 505
      WRITE(1,503)
  503 FORMAT(10X,'*',7X,'*',13X,'*',12X,'*',9X,'*',11X,'*',/,
     11X'*************************************************************************
     1***************',//,1X,'CX-2')
      GO TO 900
  700 WRITE(1,701)DATE(1)
  701 FORMAT(1H1,1X,'TARE WEIGHTS ',S8,//)
      DO 702 I=1,50
  702 IF(ITRUK(I).NE.0) WRITE(1,703)ITRUK(I),TARE(I)
  703 FORMAT(1X,'TRUCK NO. ',I5,' TARE WEIGHT=',F6.0)
      GO TO 900
  800 WRITE(1,801)
  801 FORMAT(1H1,'ISSUED TICKETS THAT ARE NOT ACCOUNTED FOR',//)
      DO 802 I=1,500
  802 IF(IJOB(I).EQ.9) WRITE(1,803)I
  803 FORMAT(1X,I5)
      GO TO 900
 1000 TYPE 'DATE'
      READ(11,11)DATE(1)
      GO TO 900
 2000 TYPE 'WT. INSPECTOR'
      READ(11,11)WT(1)
      GO TO 900
      STOP
      END
```

Appendix C. [illegible] Operating Assurance

Appendix C

Typical Operating Sequence

I. Beginning a New Job

1. Turn on the equipment.
2. Enter beginning ticket number.
3. Enter Code No. 1 for preparation of the tare weight table.
   a. Prepare the tare weight table by entering the Truck No. and the Tare Weight as they are requested by the system.
   b. When all the trucks have been entered, enter Truck No. 0 and the system will request a new code entry.
4. Enter Code No. 8 for listing of the Truck Tare Weights, and then check it.*
5. Enter Code No. 2 for the static project information which is to appear on each Haul Ticket. The system will request the following information:

   Date
   Project
   Source
   Item No.
   Type
   Grade
   Course

6. Enter Code No. 3, and then follow with the percent of moisture, e.g., 9.22.**

---

* To modify the tare weight table at any time during the operation, enter a Truck No. 0, and the system will ask for a new CODE number. Enter Code No. 1, and proceed as in Steps 2 and 3 under "Beginning A New Job".

** To change the percent moisture content at any time during the operation, enter a Truck No. 0, and the system will ask for a new CODE number. Enter Code No. 3, and follow with the new moisture content. The system will ask for a new CODE number. To resume printing Haul Tickets, enter Code No. 4, and proceed to enter Truck No. and Gross Weight as they are requested by the system.

7. Enter Code No. 4 to print the Haul Tickets.

   a. Print the haul tickets by entering the truck no. and the gross weight as they are requested by the system.

   b. To stop printing tickets, enter Truck No. 0, and the system will request a new CODE number.

8. Enter Code No. 5 to start ticket accountability for the CX-4 Report.

   a. The system will request the following information:

      Job No.
      Project
      Source
      Item No.
      Scale Location
      Beginning Ticket No.
      Ending Ticket No.
      Void Ticket Numbers

   b. Enter the Beginning Ticket No. 0 to print the CX-4 report. After the report is printed, the system will request a new CODE number.

9. Enter Code No. 6 to start the tabulation of Material for the CX-2 report.

   a. The system will request the following information:

      Job No.
      Project
      Source
      Item No.
      Item Description
      Beginning Ticket No.
      Ending Ticket No.
      Pay Quarter

   b. Enter beginning Ticket No. 0 to print the CX-2 report.

10. At the conclusion of the first day's activities, turn off the equipment.

II. Each Succeeding Day

1. Turn on the equipment.
2. Enter Code 10, and then enter the new date.
3. Enter Code 1 and modify the tare weight table as needed.
4. Enter Code 3, and modify the moisture content which is stored if it is different from the previous day.
5. Enter Code 4, and print haul tickets as previously outlined.
6. Enter Code 5 and repeat Step 7 for CX-4 report.
7. Enter Code 6 and repeat Step 8 for CX-2 report.
8. At the conclusion of the day's activities, turn off the equipment.

Appendix D. Summary of Available Equipment

Appendix D

Summary of Available Hardware

Minicomputers

MANUFACTURER & MODEL	Hewlett-Packard 2105A (21-M/10)	Computer Automation Alpha LSI-1	Data General Nova 2/4	Digital Computer Controls D-116S	Digital Equipment PDP-11/05
DATA FORMATS					
Word length, bits	16	16	16	16	16
Fixed-point operand length, bits	16	16/32	16	16	16
Instruction length, bits	16	16/32	16	16	16/32/48
MAIN STORAGE					
Storage type	Semiconductor	Core/semicond.	Core	Core	Core
Cycle time, microseconds/word	0.650	1.6/1.2/0.98	1.0/0.8	1.2	0.9
Minimum capacity, words	4,096	1,024	4,096	4,096	4,096
Maximum capacity, words	32,768	262,144	32,768	131,072	28,672
Parity checking	Standard	Optional	No	No	No
Storage protection	No	Optional	No	Optional	No
CENTRAL PROCESSOR					
No. of accumulators	2	2	4	4	8
No. of index registers	2	1	2	2	8 min.
No. of directly addressable words	2,048	1,024	1,024	1,024	32,768*
Indirect addressing	Multi-level	Multi-level	Multi-level	Multi-level	One-level
Add time, microseconds (full word)	1.94	9.2	0.8/1.0	1.35	3.7
Hardware multiply/divide	Standard	Standard	Optional	Optional	Optional
Hardware floating point	Standard	No	No	No	No
Hardware byte manipulation	Standard	Standard	Standard	Standard	Standard
Immediate (literal) instructions	Standard	Standard	No	No	Standard
Power failure protection	Optional	Optional	Optional	Optional	Standard
Real-time clock or timer	Optional	Optional	Optional	Optional	Standard
INPUT/OUTPUT CONTROL					
I/O word size, bits	16	8/16	16	16	16
Direct memory access channel	Optional	Standard	Standard	Standard	Standard
Maximum I/O rate, words/sec	617,000	1,666,000	1.25/.833M	833,000	2,000,000
No. of external interrupt levels	60	3-unlimited	16	16	Variable
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	Yes	Yes	Yes	Yes
Non-interchangeable disk storage	Yes	Yes	Yes	Yes	Yes
Drum storage	No	No	No	No	Special order
Magnetic tape speed, cps	72K max.	20K	60K max.	30K	36K max.
Punched card input speed, cpm	600	300	225/1,000	300/600	300
Punched card output speed, cpm	45	—	—	100	75 max.
High-speed paper tape input, cps	500	300	400	300	300
High-speed paper tape output, cps	75	75	63.3	75	50
Other standard peripheral units	Line printers, communications interfaces, plotters	Line printer, CRT, cassette, communications	Line printer, A/D converters, communications, plotter, etc.	Line printer, communications interfaces, A/D converters, etc.	Communications interface, CRT displays, printers, etc.
SOFTWARE					
Assembler	2-pass	2-pass	2-pass	2-pass	1 & 2-pass
Macro assembler	No	Yes	Yes (3)	Yes	Yes
FORTRAN compiler	Yes	Yes	Yes	Yes	Yes
Other compilers	ALGOL, BASIC	BASIC	ALGOL, BASIC	BASIC, IRIS	BASIC
Operating system	Yes	Yes	Yes	Yes	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words	$5,950	$2,390	$3,500	$2,975	$4,795
Price of basic system with 8K words	$6,800	$2,760	$4,000	$3,365	$6,495
Date of first delivery	Aug. 1974	NA	Oct. 1973	Nov. 1971	Feb. 1972
Number installed to date	NA	NA	NA	2,600	See Comments on next page.
COMMENTS	Controlled by semiconductor read-only memory. User-microprogrammable; supports writable control store.	LSI-1 has 168 instructions including hardware multiple/divide and memory scan.	Nova 2 uses a 1-microsec., 16K-word memory or an 800-nanosec., 4K- or 8K-word memory; 2/4 has 4 slots.	Designed to be fully compatible with the Data General Nova 1200 series computers. Offers 16K memory on single board.	*28K is main memory; 4K is I/O device addresses implemented in IC's.

Minicomputers (Cont.)

MANUFACTURER & MODEL	Interdata 7/32	General Automation SPC-16	Lockheed Electronics SUE	Prime 100	Texas Instruments Model 960A
DATA FORMATS					
...ngth, bits	8/16/32	16	16	16	16
Fixed-... operand length, bits	8/16/32	16	16	16/32	16
In...uction length, bits	16/32/48	16	16/32	16/32	32
MAIN STORAGE					
Storage type	Core	Core	Core/ROM/RAM	Semicond...	Semiconductor
Cycle time, microseconds/word	0.75/1.0	0.80/0.96/1.44	0.85/0.20/0.25	1.0	0.75
Minimum capacity, words	4,096 (32-bit)	4,096	4K/1K/1K	4,096	4,096
Maximum capacity, words	262,144 (32-bit)	65,536	32K/30K/30K	65,536	65,536
Parity checking	Optional	No	Optional	No	Standard
Storage protection	Optional	No	Optional	No	Standard
CENTRAL PROCESSOR					
No. of accumulators	32	16	7	1	Up to 16
No. of index registers	30	6	7	1	Up to 16
No. of directly addressable words	262,144	32,768	32,768	32,768	65,536
Indirect addressing	No	One-level	Multi-level	Multi-level	One-level
Add time, microseconds (full word)	1.0	0.80/0.96/1.44	2.79	2.44	3.2
Hardware multiply/divide	Standard	Optional	Optional	Optional	Optional
Hardware floating point	Optional	Optional	No	No	No
Hardware byte manipulation	Standard	Standard	Standard	Standard	Standard
Immediate (literal) instructions	Standard	Standard	Standard	No	Standard
Power failure protection	Optional	Standard	Optional	Optional	Standard
Real-time clock or timer	Optional	Standard	Optional	Optional	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	8/16	16	8/16	16	1 to 16
Direct memory access channel	Optional	Standard	Standard	Standard	Standard
Maximum I/O rate, words/sec	350,000	1,040,000	5,000,000	694,444	1,300,000
No. of external interrupt levels	1,024	64-unlimited	4-64	64	2
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	Yes	Yes	Yes	Yes
Non-interchangeable disk storage	Yes	Yes	Yes	Yes	Yes
Drum storage	Yes	Yes	No	No	No
Magnetic tape speed, cps	72K	60K max.	36K	36K	300K max.
Punched card input speed, cpm	1,000	400/1000	600	400	300
Punched card output speed, cpm	–	100	35	285	100
High-speed paper tape input, cps	300	400	300	200	300
High-speed paper tape output, cps	60	75	75	75	60
Other standard peripheral units	Cassette tape, line printer, A/D, CRT display	A/D converters, communications interfaces, CRT, printer, plotter	Line printer, cassette tape, communications, displays	Printer, CRT display, comm. and A/D interfaces	Line printers, communications interfaces, A/D converters, etc.
SOFTWARE					
Assembler	1 & 2-pass	2-pass	1-pass	2-pass	2-pass
Macro assembler	No	Yes	Yes	Yes	Yes
FORTRAN compiler	Yes	Yes	Yes	Yes	Yes
Other compilers	No	BASIC	RPG-II	BASIC	No
Operating system	Yes	Yes	Yes	Yes	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words	Not available	$3,950 to $8,550	$4,270	$4,600	$2,850
Price of basic system with 8K words	Not available	$5,350 to $10,150	$5,870	$5,500	$4,350
Date of first delivery	July 1974	May 1970	Sept. 1972	Feb. 1973	Nov. 1971
Number installed to date	NA	1,900	400	See Comments	450
COMMENTS	Hardware and software compatible with S/7/16. Price of 7/32 with 32KB memory is $9,950.	Available in six models, offering choice of core size, speeds, and I/O packaging. Read-only memory is interchangeable with core. Replaced by LSI-16.	Highly modular packaging; core and semiconductor memory can be intermixed. Up to 4 processors can be used in a system.	Microprogrammed logic uses 64-bit microinstruction word format. Has flexible memory addressing facilities. Approximately 250 100, 200, and 300 systems have been sold to date.	Has 2 processor modes, each with 8 general registers. Real-time monitor system handles multiprogramming.

Printers

MANUFACTURER & MODEL	Computer Transceiver Systems Execuport 1200	Centronics 306	Diablo Hy-Type I Printer	Kleinschmidt Model 7300	Potter LP6150
MINICOMPUTERS INTERFACED	Serial or parallel logic	RS-232C, most popular minicomputers; ASCII	Data General Nova 1200	Serial or parallel	PDP-8, 11; Nova
PRIMARY MARKET	OEM and end user	OEM	OEM	OEM and end user	OEM
TYPE	Impact, character	Impact, character	Character	Impact, character	Line
MECHANISM					
Arrangement	Wire matrix	Wire matrix	Daisy wheel	Drum	Bar hammers with rotating helical scanner
Buffer	Full line optional	Full line	None	No	Full line
CONFIGURATION					
Controller model number	None	None	1207	None	–
PHYSICAL DESCRIPTION					
Character formation	5x7 dot matrix	9x7 dot matrix	Full	Full	5x7, 9x7, 9x9
Special paper required	No	No	No	No	No
Forms feed	Tractors	Pin	Friction, pin and traction	Friction/pin	Dual tractors
Vertical forms control	Optional	Tab	Program control	Solid state	Single & 4/12 VFU
Vertical spacing, lines/inch	6	6	Variable	6	6
Character set	120	64	96	64	to 128
Forms width, inches	14.875	11	15	8.5 or 9	4½ to 14-7/8
Characters per line	132	80	132	80	–
Dimensions (h x w x d), inches	–	–	–	–	40x28x26
Weight,pounds	–	–	–	–	250
PERFORMANCE					
Peak speed	120 char/sec	120 char/sec	30 cps	40 cps	180 lpm
Paper advance speed, inches/sec.	6.5	NA	4	NA	8½
PRICING AND AVAILABILITY					
Controller purchase, $	–	–	600	–	Under 1,000
Printer purchase, $	2,800 to 5,300	2,055	1,825	1,975	3,500
First delivery	Sept. 1972	Fall 1972	Summer 1972	1965	July 1973
Availability, days ARO	90	45 to 60	Stock	30	60-90
Number installed to date	–	–	Over 6000	About 3000	See Comments
Serviced by	Honeywell	Syntonics	Diablo	Kleinschmidt	Potter
COMMENTS			Horizontal spacing variable at 60 positions per inch; all functions independently controlled by servos	Acoustical enclosure available	1,000 of the same mechanism installed in earlier systems; can be used for plotting

Printers (Cont.)

MANUFACTURER & MODEL	Printer Technology Printec Series 1100	Printer Technology Printec Series 1200	Singer-ITC Model 30 Automatic S/R	Tally 2100	Typagraph DP-30 Mark V
MINICOMPUTERS INTERFACED	PDP-11	Data General Nova	RS-232	PDP-11, PDP-8; HP 2100; Npva 800/1200, H 316/516	Any with RS-232 or TTY
PRIMARY MARKET	End user	End user	OEM	OEM and end user	OEM and end user
TYPE	Line	Line	Character	Line	Character
MECHANISM					
Arrangement	Multiple unit helix type wheel	Multiple split helix type wheel	Impact, matrix	Comb. matrix	Wheel
Buffer	Standard	Standard	40-character	Full line	128 character
CONFIGURATION					
Controller model number	–	–	–	21XX	Integral
PHYSICAL DESCRIPTION					
Character formation	Full	Full	5x7 dot matrix	7x8 dot matrix	Full
Special paper required	No	No	No	No	No
Forms feed	Tractors	Tractors	Friction/pin	Pin	Pin
Vertical forms control	2-channel VFU standard	2-channel VFU standard	Top of form	8-channel VFU	Tab
Vertical spacing, lines/inch	6 or 8	6 or 8	6	6	6
Character set	64/96	64/96	64 or 96	64	94
Forms width, inches	4 to 14-7/8	4 to 14-7/8	7 to 15¼	4 to 14-7/8	4 to 15
Characters per line	–	–	80 or 132	132	Up to 135
Dimensions (h x w x d), inches	12-3/8x28½ x22-1/8	12-3/8x28½ x22-1/8	8x23x17¾	11x28x23	10x20x15
Weight, pounds	111	111	85-105	150	70
PERFORMANCE					
Peak speed	70/100 cps	70/100 cps	30 cps	125 lpm	30 cps
Paper advance speed, inches/sec.	51	51	5.5	4	7
PRICING AND AVAILABILITY					
Controller purchase, $	–	–	–	–	3,500
Printer purchase, $	3,850-4,150	3,850-4,150	3,200/3,325	5,200	Included in contr. price
First delivery	–	–	Aug. 1974	Sept. 1972	Jan. 1972
Availability, days ARO	30	30	60	30	30-45
Number installed to date	–	–	–	400	–
Serviced by	Litton Sweda	Litton Sweda	–	Tally	Leasco
COMMENTS	Bit-serial, RS-232 interface available optionally; stand and paper stacker available optionally		Mfr'd. by International Teleprinter Corp. (subsidiary of Singer)		Price includes keyboard

Keyboard Entry Devices

SUPPLIER AND MODEL	Carterfone 300 Data Terminal	Carterfone 33 ASR/1200 Data Terminal	ComData Model 33 Series	Compro Corp. Model 1030	Data Products PortaCom
COMPATIBILITY					
Teletype 33/35	Yes	Yes	Yes	Yes	Yes
IBM 2740-1/2740-2	No	No	No	Yes	No
IBM 2741	No	No	No	Yes	No
MODEL CONFIGURATIONS					
Printer only (RO)	No	No	No	Yes	No
Keyboard and printer (KSR)	Yes	Yes	Yes	Yes	Yes
Keyboard, printer, and punched tape reader/punch (ASR)	No	Yes; 8-level	Yes; 8-level	Opt.	No
Keyboard, printer, and magnetic tape recorder (ASR)	No	No	No	Yes; cassette	Yes; cassette recorder
Other devices	None	None	None	None	None
Portable	No	Opt.; 70 lbs.	Opt.	Yes; 25 lbs.	Yes; 30 lbs.
TERMINAL FEATURES					
Programmable	No	Yes	No	Yes	No
Internal buffer	No	Yes	No	Opt.	No
Internal buffer capacity, chars.	–	8K or 16K bytes	–	–	–
Editing, line and/or character	No	Line and char.	No	Opt.	No
Parity checking/generation	Gen. std.; chk. opt.	Both opt.	Gen. std.	Yes	Both
Polling/Addressing capability	Opt.	Std.	No	Opt.	No
Automatic answer	Opt.	Std.	Opt.	Opt.	No
PRINTER CHARACTERISTICS					
Type	Impact	Impact	Impact	Impact	Impact
Technique	Full char. printing via type belt and hammers	Full cher. printing via type cylinder	Full char. printing via type cylinder	Full char. printing via type belt	Full char. printing
Character positions per line	118	72	74	80	80
Print rate, char/second	10, 15, or 30	10	10	30	10
Character set	94 ASCII	64 ASCII	64 ASCII	64 ASCII	64 ASCII
Lower case alphabetic	Std.	No	No	Opt.	No
Horizontal pitch, char/inch	10	10 std.; 12 opt.	10	10/12	10.8
Vertical spacing, lines/inch	6	3 or 6	6	6	6
Forms feed	Friction; pin opt.	Pin feed	Pin	Friction	Pin
Horizontal tabulation	Opt.	Opt.	No	Opt.	No
Vertical formatting	Vertical tab	Opt.	No	Opt.	No
Other features	None	None	None	None	–
KEYBOARD CHARACTERISTICS					
Keyboard arrangement	Typewriter	53-key teleprinter	53-key teleprinter	53-key typewriter	58-key typewriter
Character set	128 ASCII	64 ASCII	128 ASCII	128 ASCII	128 ASCII
Features	Character repeat; numeric pad opt.	Character repeat std.; numeric pad opt.	Character repeat; numeric pad opt.	Character repeat	Numeric pad std.
TRANSMISSION					
Mode	Half/full duplex	Half duplex	Half/full duplex	Half/full duplex	Half/full duplex
Technique	Asynchronous	Asynchronous	Asynchronous	Asynchronous	Asynchronous
Speed, bits/second	110/150/300	110 to 1200	110	110/150/300	300
Code	8-level ASCII	8-level ASCII	8-level ASCII	8-level ASCII	8-level ASCII
Unit code structure	10/11 bits/char.	11 bits/char.	11 bits/char.	10/11 bits/char.	11 bits/char.
Operator selectable speeds	Std.	No	No	Yes	No
Block size	Char. by char.	Char.; block opt.	Char. by char.	Char.; block opt.	Char. by char.
Communications interface	RS-232C	20 ma dc current or RS-232C	20/60 ma. dc current; RS-232C opt.	RS-232C; 60 ma dc opt.	Acoustic
Integral modem	No	No	Opt. some models	Opt.	No
Telephone coupler	No	No	Opt. some models	Std.	Std.
PRICING AND AVAILABILITY					
Lease price:					
One year lease, $	See Comments	See Comments	73-137	240	–
Two year lease, $	See Commants	See Comments	40-74	180	–
Purchase price, $	1,675	1,885-2,485	817-1,535	2,950-3,600	1,695-3,145
Date of first production delivery	1970	June 1973	–	September 1973	March 1970
Terminals installed to date	About 200	100	–	–	Over 2,000
Serviced by	Carterfone	Carterfone	Not specified	Compro	Sorbus
COMMENTS	Made by GE as TermiNet 300; 30-day rental only, at approx. $150 per month	Teletype 33 ASR with Fairchild core buffer; month-to-month rental ranges from $105 to $192 per month	Teletype 33 KSR or ASR with ComData acoustic coupler or modem		Uses Mite printer mechanism; see Report 70D-31B-01 for details

Keyboard Entry Devices (Cont.)

SUPPLIER AND MODEL	Digital Equipment LA30 DECwriter	General Electric TermiNet 300	SCM-Kleinschmidt 7300 Series Teleprinters	Singer International Teleprinter Model 30	Teletype Model 33
COMPATIBILITY					
Teletype 33/35	Yes	Yes	Yes	Yes	Yes
IBM 2740-1/2740-2	No	No	No	No	No
IBM 2741	No	No	No	No	No
MODEL CONFIGURATIONS					
Printer only (RO)	Yes	Yes	Yes	Yes	Yes
Keyboard and printer (KSR)	Yes	Yes	Yes	Yes	Yes
Keyboard, printer, and punched tape reader/punch (ASR)	No	Yes; 8-level	Yes, 5-8 level	Yes	Yes, 8-level
Keyboard, printer, and magnetic tape recorder (ASR)	No	Yes; cassette recorder	Yes	No	Yes, cartridge
Other devices	None	None	None	None	None
Portable	No	No	No	No	No
TERMINAL FEATURES					
Programmable	No	No	No	No	No
Internal buffer	No	No	No	No	No
Internal buffer capacity, chars.	—	—	—	—	—
Editing, line and/or character	No	No	Char. only	No	Char. only
Parity checking/generation	No	Gen. Std.; chk. opt.	Yes	Both std.	Gen. std.; chk. opt.
Polling/Addressing capability	No	Opt.			
Automatic answer	No	Opt.	Yes Opt.	Opt. Opt.	Opt. Std.
PRINTER CHARACTERISTICS					
Type	Impact	Impact	Impact	Impact	Impact
Technique	5 x 7 dot matrix	Full character printing via type belt	Full char. printing via rotating type cylinder	5 x 7 dot matrix	Full char. printing via rotating type cylinder
Character positions per line	80	75 std.; 80/118 opt.	72	80/132	72
Print rate, char/second	10/15/30	10/15/30; 20 opt.	30	10/15/30	10
Character set			64 ASCII	64; 128 opt.	64 ASCII
Lower case alphabetic	64 ASCII	94 ASCII	No	Opt.	No
Horizontal pitch, char/inch	No	Std.	10	10	10
Vertical spacing, lines/inch	10	10	6	6	6/3
Forms feed	6	6/3	Frict.; pin opt.	Frict.; pin opt.	Friction or pin
Horizontal tabulation	Pin	Frict.; pin opt.	Opt.	Opt.	No
Vertical formatting	Yes	Opt.	Opt.	Opt.	No
Other features	— Tractor feed	Opt. Tractor feed	—	—	Prints lower case alphabetics as upper case equivalents
KEYBOARD CHARACTERISTICS					
Keyboard arrangement	57-key typewriter	Typewriter			
Character set	96/128 ASCII	128 ASCII	53-key typewriter 128 ASCII	Typewriter 128 ASCII	53-key teleprinter 64 ASCII
Features	—	Character repeat, numeric pad std.	Character repeat std.	—	—
TRANSMISSION					
Mode	Half duplex	Half/full duplex	Half/full duplex	Half/full duplex	Half/full duplex
Technique	Asynchronous	Asynchronous	Asynchronous	Asynchronous	Asynchronous
Speed, bits/second	110/150/300	110/150/300	50 to 300	110/150/300	110
Code			8-level ASCII	8-level/ASCII	8-level ASCII
Unit code structure	8-level ASCII	8-level ASCII	10/11 bits/char.	10/11 bits/char.	11 bits/char.
Operator selectable speeds	10/11 bits/char.	10/11 bits/char.	Std.; 7 speeds	Std.	No
Block size			Char. by char.	Char. by char.	Char. by char.
Communications interface	Std. Char. by char. RS-232C; 20 ma dc current, or CCITT	Std. Char. by char. RS-232C or 20 ma dc current	RS-232C, CCITT, 20/60 ma dc current, or TTL	RS-232C, 20/60 ma dc current, or TTL	RS-232C or 20/60 ma dc current
Integral modem	No	Opt.	No	No	Opt.
Telephone coupler	No	Opt.	No	No	No
PRICING AND AVAILABILITY					
Lease price:					
One year lease, $	—	103-322	—	—	—
Two year lease, $	—	—	—	—	—
Purchase price, $	3,195	2,080-6,990	See Comments	1,200-3,200	595-1,061
Date of first production delivery	July, 1971	July 19691	—	1973	1962
Terminals installed to date	Over 2,000	—	—	200	—
Serviced by	DEC	General Electric	SCM-Kleinschmidt	Singer ITC	Teletype
COMMENTS			Purchase prices are: RO, $1,1975; KSR, $2,275; ASR, $3,950		Standard-duty unit; also available from third-party lessors; see Report 70D-830-01 for details