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# The NBS Computerized Carpool Matching System: Users' Guide

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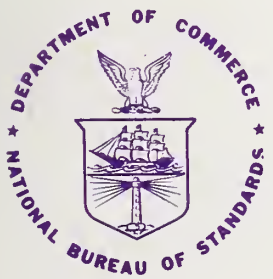
Applied Mathematics Division
Institute for Basic Standards
Operations Research Section
National Bureau of Standards
Washington, D. C. 20234

Technical Report to
The NBS Energy Taskforce

December 1974

Final




U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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# THE NBS COMPUTERIZED CARPOOL MATCHING SYSTEM: USERS' GUIDE

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Abstract: This report documents the NBS computerized carpool matching programs and the procedures used in maintaining the coordinate data base required by the matching system. The report includes flowcharts, input/output formats, and program listings for the programs, plus details of the manual process for coordinate coding. The matching program produces, for each person desiring it, a list of other NBS employees residing within a pre-specified distance of him, and is thus applicable to a single work destination having primarily one work schedule. The system is currently operational on the National Bureau of Standards' UNIVAC 1108 computer and was run in March of 1974, producing lists for about 950 employees in less than four minutes computer time. Subsequent maintenance of the system will be carried out by the NBS Management and Organization Division.

Key words: carpools; carpool matching; computer programs; transportation; urban transportation.

# 1. INTRODUCTION

Mass transit is generally held to be the most efficient way of moving large numbers of people between home and work, but this superiority depends heavily on the spatial concentration of many trips' origins and destinations to provide the assumed "mass." Where trips are more diffused geographically or in time, design of a mass transit system may require circuitous routing and result in uneconomical load factors. In addition, mass transit requires a large capital outlay for vehicles and/or guideway, a requirement which normally implies long lead times for implementation of major systems.

Carpooling, while less efficient on a cost per passenger-mile basis, avoids these difficulties and may, by eliminating unusually circuitous routing and low load factors, actually be more efficient for some trips. Also, since in most cases it calls for little or no additional capital investment for vehicles or guideway, its implementation can be relatively rapid.

Until last year (1973), the major factors encouraging citizens to carpool for work trips were economic: no need to own a second car, decreased auto operating costs per participant because of decreased mileage, and reductions (through sharing) of parking fees. Parking availability itself was probably the most compelling factor which motivated many companies and municipalities to promote carpooling. In addition, urban areas had become increasingly sensitive to the true costs of lengthened travel times and air pollution resulting from vehicle congestion, as well as the losses implicit in dedicating large areas of valuable urban land to auto-related uses. Despite special promotional programs highlighting the advantages of carpooling, few cities were able to increase average auto occupancy factors above 1.2 to 1.3 persons per car during rush hours. The onset of the "energy crisis" last winter changed the picture drastically; gasoline shortages and the resultant long queues at gas stations vividly enhanced the desirability of carpooling for many work trips.

Recognizing the desirable properties of carpooling at an early date, and anticipating an increased awareness of this desirability in the face of possible fuel shortages, in June of 1973 the Applied Mathematics Division of the National Bureau of Standards (NBS) undertook a small-scale effort to design and produce computer aids for carpooling. The effort was limited in the sense of being short term, low cost, and restricted in application to NBS itself. The supervening fuel crisis of course added urgency to this work. The primary output of this effort was a system of computer programs and an associated data base for providing NBS employees with lists of other employees who are potential carpool partners. The system saw its first operational use on March 1, 1974, producing lists for

about 950 employees who had indicated a desire for such information on a questionnaire distributed by the NBS Energy Task Force.*

The present report has been prepared to document the programs and procedures used in that process, in order to facilitate maintenance of the data base and future operation of the system. The report is divided into three sections: the first gives an overview and general description of the system and procedures, the second describes the data base and provides instructions for maintaining it, and a final section documents the computer programs. Program listings and a computer run stream for the operation of the programs are included in Appendices, as is an example of the interpolation process used in coding coordinates.

Although the system described in this report was developed for and has been applied only at NBS, it has potential for use in other situations as well. The current version is limited to one work destination and does not take differences in working hours into account. These may be handled by setting up separate files for different shifts and work addresses, and running requests for lists separately for each place of work and shift. The current version of the system handles up to 1,200 employees, but this is a function both of the size of computer and the data retained concerning each person, both of which could be modified as necessary. The philosophy and procedures have proved workable at NBS, and much of the work is general in nature and can be adapted to other settings.

* See Appendix D for a copy of the Questionnaire. No attempt has been made to evaluate whether new carpools were in fact formed as a result of the March distribution of lists, but increased carpool ridership was noted from auto occupancy factor counts which rose from 1.2 in the fall of 1973 to 1.4 in the spring of 1974.

## 2. GENERAL DESCRIPTION

Once it is decided that carpooling is to be fostered and encouraged, the main technical requirement for its implementation is the capability of matching-up compatible individuals with similar trips. Many manual aids for this function are available, such as the carpooling pin-in-map system long in use at NBS. In that system the person desiring a carpool puts a numbered pin in a centrally located map display, indicating the location of his home, and also leaves a card with his name and work address keyed to the same number in a cubbyhole below the map. One can scan the map to locate possible carpoolers near one's home, and then use the information on the number-keyed cards to get in touch with them.

While this system might in principle be adequate for an installation such as NBS, in practice it suffers from several drawbacks: 1) the scattered nature of the NBS site, necessitating a special trip to the centrally located map, 2) the frequent failure of those who have found carpools to remove their pins and cards, and 3) the inclusion of only those actively seeking carpools.

This latter drawback is particularly critical. Because of the paucity of transit service available to NBS employees, those lacking an automobile (and non-drivers) are in greatest and most immediate need of finding a carpool, and many of the map pins are placed by such people. Unfortunately the process described above is slow, and an employee often cannot afford to wait until someone happens to notice his or her need. In addition, many drivers who, if approached, would be willing to accept riders or to carpool, just do not think of using the pin map, since they do not need a carpool. As a result, in the past most carpools at NBS were formed through word of mouth. It seemed clear that real encouragement of carpooling required a more aggressive, convenient, and comprehensive matching system.

Several computerized carpool matching procedures were investigated, all relying on the basic idea that potential carpool candidates are those living near one another and traveling to approximately the same work location. (This is, of course, somewhat of an oversimplification, since some people may drive part way alone and carpool only for part of the trip. Nonetheless it has generally proved a useful approximation.)

Computer carpool matching programs are therefore primarily programs for locating neighbors with similar commutation travel characteristics, and several procedures can be used for doing this. The simplest involves matching on some piece of ordinarily available data which is correlated with residence location, such as postal ZIP code or telephone exchange. A postal ZIP matching was done on a limited basis for NBS employees using an already developed data processing system and the NBS locator file, but was dropped because over 700 employees lived in the single Gaithersburg ZIP code 20760. Thus postal ZIP code areas are too large for this process.

Telephone exchanges overlap geographically, and are thus also unsatisfactory.

The Federal Highway Administration has developed a computer carpool matching program* using grid squares (about 1 or 2 miles wide). Each employee desiring to form or join carpool locates the square in which he he lives, and this square is uniquely identified by number, which is entered into the computer. The matching program then provides lists to each person of all those potential carpool candidates within his square, supplemented with those in squares to either side if there are too few in the one square. This can result in people living near the edge of a square receiving lists of only people who live in the same square but who are not as close as some person in the next square. In addition, problems can arise if the variation in number of people per square is very great, since the program only provides for 2 square sizes, one with side twice as long as the other. Inclusion of a variety of square sizes intermixed geographically is much more difficult, since the program must locate adjacent grid squares.

The NBS carpool locator system, described herein, avoids this latter problem (particularly critical at NBS because more than 100 employees live in a single one-mile square grid near the NBS Gaithersburg site), by using actual coordinates of employee home location. The coordinates are obtained manually by locating the home address on a coordinatized map. The computer uses the coordinate information to produce for each person a list of up to 20 employees living within two miles**(and in the Gaithersburg area, within one mile) of him. It should be noted that this procedure can also result in strange matches, since straight-line distance may be very much shorter than actual road distance. For instance, one NBS employee living in McLean, Va., was perplexed that his list contained the name of another employee living in Bethesda, Md., indeed less than 2 miles away as the crow flies but in fact on the other side of the Potomac River. Such cases seem difficult to detect automatically without referring to the actual road networks, a much more cumbersome and complicated task, and in practice a list of 20 or so employees who are "neighboring" by a coordinate-based criterion should contain many legitimate carpool candidates even though some poor selections may also be present. Alternatively one might use auxiliary information, such as ZIP code, as an additional key to weed out unwanted matches.

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* Lew Pratsch, Carpool and Buspool Matching Guide, U.S. Dept. of Transportation, Federal Highway Administration, Washington, D.C. 20590 (May 1973).

** Non-metric units, miles and feet, are used in this effort because the scales of the maps available were in these units and they were thus more convenient.

To avoid searching the whole file of potential carpoolers to find those living near a particular person, the file of carpool candidates is sorted into grid squares approximately 1 mile on a side. To locate all carpool candidates within a mile of a specific person living in one square, only people living in that square and the adjacent ones need be searched (as in the Federal Highway program), but actual distance is used as the criterion upon which the chosen list is based. Thus grid squares are introduced as an intermediate step to cut down on the number of reasonable candidates for which distances to the current person have to be calculated, but the list is based on actual (Euclidean) distance.

The NBS carpool matching program uses the NBS locator file maintained by the Management and Organization Division. This file includes, for each employee:

employee name
social security number
NBS telephone extension
NBS division and section
NBS location
NBS mailing address
home address
home phone.

There has been added to the file, specifically for carpooling ,the coordinates of the employee's home address and his answers (coded) to the transportation survey. Only persons who replied "yes" to question 2 on the survey (i.e., those agreeing to be included in the carpool matching system) are considered potential carpool candidates.

All of the carpool matching methods discussed above, including those here at NBS, only provide information on prospective carpool candidates. Actual carpooling arrangements must be made by the employees themselves. since many personal preferences are involved in the choice of a carpool. These may include: the flexibility of arrival and departure hours, the driving habits of members, the size of cars used, the sex and age of carpool members, whether smoking is allowed, the topics of conversation and preferred radio programs. (In all cases, punctuality and courtesy toward other members are essential for success.) Since such diverse factors affect actual choice of carpool members, the lists produced by the NBS computerized carpool locator system contain up to 20 employees in the hope that such a number is sufficient for each person to be able to identify a compatible carpool.

## 3. DATA BASE

The data base used by the NBS carpool locator programs is the NBS locator file maintained by the Management and Organization Division on tape in COBOL-readable format. Figure 3.1 indicates the format of the data contained on this tape.

### 3.1: Transportation Survey Responses

The third and fourth coded answers* to the questionnaire sent out by the NBS Energy Task Force are the only ones relevant to the carpool matching program. The presence of a "Y" as fourth character in the coded answer set signified that the person's address had changed from the one originally in the locator file, thus requiring that new coordinates be determined. New coordinates were located for all Y-responses, unless we had no new address for the employee, because had not reported his change of address on Form NBS-390, (Directory Information). Since from now on, address changes will be dealt with as they are received, Y-responses to question 4 will no longer be relevant.

If the third character of the coded answers to the transportation survey is a Y, the person requested a carpool list and agreed to be included on others' lists. Any other character is interpreted as not desiring to be included. The carpool candidate file is made up of only those having a Y as third character. Thus any new entry to the file will be included in the carpool matching (both to receive a list and to appear on other lists) only if a Y is inserted as the third character of the coded survey responses, whether or not this person actually answered the whole questionnaire.

### 3.2: Coding Coordinates

The coordinates of the employee's home address appearing in the data base are obtained by a manual process. The original coding of coordinates for all employees was done by Applied Mathematics Division personnel, with corrections to include in the file all changes received as of February 26, 1974. It is expected that the present documentation will enable further maintenance of coordinate changes, deletions and additions by Management and Organization Division personnel.

The coordinates are numbers of up to 5 digits representing distances in hundreds of feet east (x-coordinate) and north (y-coordinate) of an origin located approximately in Manassas, Virginia. The location of the origin was arbitrary, chosen mainly because it was the lower left corner of one of the sets of maps employed. Negative coordinates indicate locations west (negative x-coordinate) or south (negative y-coordinate) of the origin.

---

* Two answers were coded for question 1 so that the third and fourth coded answers refer to questions 2 and 3 on the form in Appendix D.

Figure 3.1

Data Format for the Locator File Tape

| | characters |
|---|---|
| Social Security number | 1-9 |
| NBS telephone extension | 10-17 |
| Name | 18-43 |
| Special employee code | 44-47 |
| Division and Section | 48-53 |
| NBS office location: Building | 54-58 |
| NBS office location: Room | 59-63 |
| NBS mailing address: Building | 64-68 |
| NBS mailing address: Room | 69-73 |
| Home address (street and city) | 74-122 |
| ZIP code of home address | 123-127 |
| Home phone | 128-138 |
| x-coordinate of home address | 145-149 |
| y-coordinate of home address | 150-154 |
| coded answers to the transportation survey | 155-166 |

The actual map sets used for locating the coordinates are listed in Figure 3.2. The Alexandria Drafting Company maps were chosen because (1) they were readily available from local drug stores, (2) they covered the whole metropolitan area, (3) they contained sufficient detail showing every street, (4) they are updated every year and thus contain addresses in new subdivisions, (5) they all used the same scale, (6) they each contained a street index to facilitate look-up, and (7) block numbers were given every few streets so that house numbers could be located at least to the actual block. Unfortunately, we were unable to obtain a map of Frederick County possessing all of these properties, but the State Highway Administration map is current and does show all streets.

The Alexandria Drafting Company maps listed in Figure 3.2 were already overlaid with a grid of approximately 1 inch squares. The scale on all except the one depicting Frederick County is 2000 feet per inch. We chose to represent our coordinates in hundreds of feet, meaning each 1 inch equals 20 coordinate units. Coordinates of the grids were then marked in the map margins. (On some of the maps the grid marked on the map was not actually 1 inch square, but rather 1 inch by about 19/20ths of an inch. We compensated for this discrepancy by dully labeling the coordinates.)

To locate an address on the maps one must first know which map to use, which requires knowing which area the address is in. The state identifier differentiates Northern Virginia and the District of Columbia from Maryland in most instances, although a mailing address in one jurisdiction may actually be located in another. Locating addresses in the Maryland counties becomes fairly routine with practice, using the city name and in some instances the ZIP code zone (which is indicated on the map). Addresses near map boundaries often appear on two sets of maps.

Once the correct map is selected one can look up the street in the index (except for the Frederick County map, which has no index). Any street not appearing in the main index may appear in the supplemental index of new streets. The index gives the page number and grid square (for instance 23C9 for page 23 grid C9) in which the street appears, possibly listing several grid squares if the street is long. Special care must be taken when one name appears with several different qualifiers, such as street, avenue, boulevard, drive, circle, etc.

Once the street is located, the block numbers can be used to locate the actual address. Here again care must be exercised in determining the correct block, since many streets occur in several disconnected segments. Most of Montgomery County and the District of Columbia are marked off in grid systems, so that for instance house numbers in all blocks on east-west streets at the same longitude have roughly the same number. Some local jurisdictions (such as the city of Gaithersburg) may not conform to this numbering system. The county grid addresses can be a valuable aid in locating rural addresses for rural routes which include street addresses. The street addresses are also a valuable aid in locating coordinates for addresses on streets not appearing in the index, since the location can be approximated from the grid system and ZIP code information.

Figure 3.2

Maps Used in Coding Coordinates

1. General Highway Map, Frederick County, Maryland, prepared by the Department of Transportation, State Highway Administration, Roads correct to 1/1/73, scale: 1 inch = 2 miles, obtained from Frederick County Roads Board, Winchester Hall, Frederick, Md. 21701, price $.75.

2. Montgomery County Street Map,

3. Washington, D.C. and Vicinity Street Map,

4. Northern Virginia Street Map, and

5. Prince Georges County Street Map, all with scale: 1 inch = 2000 feet, published by Alexandria Drafting Company, 417 Clifford Ave., Alexandria, Va. 22305, available from Byrrd Enterprises, 1126 Cedardale Lane, Alexandria, Va. 22308, price $4.00 apiece.

Figure 3.3

Coordinates for Selected
Gaithersburg Addresses

| STREET | X | Y |
|---|---|---|
| King James Way | 1021 | 1630 |
| Lost Knife Circle | 1038 | 1777 |
| Quince Orchard Blvd. | 960 | 1652 |
| Walkers Choice | 1026 | 1732 |
| Westside Drive | 1024 | 1600 |

The final operation in this process is to associate coordinates with the map location found above. This is accomplished by estimating (or alternatively measuring) the actual x and y coordinates using the numbers listed for that grid on the map margin, interpolating between those along the top or bottom of the page for the x-coordinate, and between those along the left or right side for the y-coordinate. See Appendix C for an example.

There are some addresses which cannot be located by the above procedure. In some cases the street cannot be found either in the map index or on the map, usually because it is in a new subdivision. These cases are likely to be few enough in number that the employee can be contacted directly to obtain the location. In other cases the information in the locator file is erroneous, which again can be ascertained by querying the individual directly. Some addresses listed in the locator file are Post Office box numbers which do not actually reflect the location of the home address. Again the only source of better information is the employee himself.

Several apartment complexes in Gaithersburg have many NBS employees residing in them. To ensure that people living in the same complex receive lists containing others from that complex, each has been assigned a single pair of coordinates. Figure 3.3 lists the street addresses of those complexes and the coordinates chosen for people living on those streets.

Many addresses in upper Montgomery County and Frederick County are postal rural route addresses. Recognizing the difficulty of locating homes on rural routes, we wrote letters to several post offices requesting more detailed information about the addresses on these routes. Those routes for which the postmaster supplied box numbers on each road segment were coded using this information. Of course only approximate location was possible, but it is hoped that any location is probably not more than half a mile to a mile in error. For those places for which the information was not sufficient to locate an address with this precision, all addresses for the same ZIP code were located at a single point, chosen to be geographically representative. Figure 3.4 lists ZIP codes and the coordinates chosen. Note that whenever more accurate information is available it is used. For instance many Clarksburg addresses are listed as both rural route box numbers and street addresses. In these instances coordinates for the actual location can be given. The coordinates in Figure 3.4 for Clarksburg are used only if more precise information is not available.

The list in Figure 3.4 also contains some towns (such as Columbia) for which it would have been possible to locate addresses exactly, but which are far enough away from the NBS Gaithersburg site that employees living in the area might be willing to carpool with others living more than two miles away. To allow this, all in the town are given a single point, so that the carpool matching program will provide each with a list of the others in the same town or ZIP code.

Figure 3.4

Coordinates for Rural Routes

| ZIP | CITY | X | Y |
|---|---|---|---|
| 20704 | Beallsville | 440 | 1782 |
| 20715 | Bowie | 2361 | 1025 |
| 20734 | Clarksburg | 818 | 2020 |
| 20753 | Dickerson | 403 | 1938 |
| 20837 | Poolesville | 416 | 1660 |
| 21043 | Ellicott City | 2203 | 2110 |
| 21043 | | | |
| 21044 | Columbia | 2033 | 1927 |
| 21045 | | | |
| 21701 | Lantz | 340 | 2680 |
| 21710 | Adamstown | 258 | 2287 |
| 21713 | Boonsboro | -243 | 3004 |
| 21714 | Braddock Heights | 168 | 2793 |
| 21716 | Brunswick | -153 | 2332 |
| 21717 | Buckeystown | 358 | 2362 |
| 21740 | Hagerstown | -394 | 3506 |
| 21754 | Ijamsville | 710 | 2402 |
| 21755 | Jefferson | 108 | 2470 |
| 21758 | Knoxville | -278 | 2342 |
| 21761 | La Gore | 722 | 3164 |
| 21767 | Maugansville | -394 | 3550 |
| 21769 | Middletown | 55 | 2765 |
| 21770 | Monrovia | 835 | 2520 |
| 21771 | Mt. Airy - city & box # | 1170 | 2520 |
| | rural route 1 | — | — |
| | rural route 2 | 1190 | 2570 |
| | rural route 3 | 1150 | 2460 |
| | rural route 4 | 1100 | 2670 |
| | rural route 5 | 1110 | 2510 |

| ZIP | CITY | X | Y |
|---|---|---|---|
| 21773 | Meyersville | 0 | 3004 |
| 21776 | New Windsor | 1310 | 3130 |
| 21777 | Point of Rocks | 120 | 2181 |
| 21780 | Sabillasville | 320 | 3706 |
| 21787 | Taneytown | 1115 | 3555 |
| 21788 | Thurmont | 447 | 3425 |
| 21790 | Tuscarora | 258 | 2332 |
| 21793 | Walkersville | 609 | 2933 |
| 21797 | Woodbine | 1439 | 1589 |
| 21798 | Woodsboro | 720 | 3095 |
| 22075 | Leesburg, Va. | -14 | 1568 |
| 22080 | Lovettsville, Va. | -195 | 2150 |
| 22110 | Manassas, Va. | 223 | 337 |
| 22191 | Woodbridge, Va. | 640 | -90 |

Coordinates were established in a similar manner for those living in "fringe" commuting areas, that is, those not appearing on the maps or in the list in Figure 3.4 but still considered within commuting distance of NBS. Examples include people living in Annapolis, Baltimore, Westminster, Harpers Ferry, and Winchester. These fringe areas are divided into two segments which may be thought of as arcs of a circle. One of these arcs runs from the Potomac River south of Washington to the east and north up to Baltimore, including Annapolis. The second starts west of Baltimore and runs counter-clockwise around again to the Potomac south of Washington including Harpers Ferry and Winchester. The first fringe area receives coordinates (14000,14000) and the second (17000,17000). People living in these areas receive lists of all others living in the same are of the fringe, most of whom will however not live very close by. It is felt that even though people in fringe areas receive many incompatible names, it is better to have them included since some names may actually be compatible for carpooling.

Some people included in the locator file have addresses that are clearly outside commuting distance. In most cases these are consultants who visit NBS for short periods and whose home addresses may be anywhere. These people are not included in the carpool file. They are given coordinates (99999, 99999). Employees for whom the locator file contains no address also receive coordinates (99999, 99999).

Once coordinates for an employee's home address are determined, they are punched on a computer punch card in the format given in Figure 3.5, and are added to the locator file. Coordinate changes are made in the same way as initial coding, and are accomplished with the same type of card. The cards then become input to a file update program maintained by the Management and Organization Division.

Figure 3.5

Format of Card for Adding Coordinates to the Locator File

| cols. | contents |
|---|---|
| 1 | the letter C |
| 2-10 | employee Social Security Number |
| 12-16 | x-coordinate (right justified) |
| 18-22 | y-coordinate (right justified) |
| 24-47 | employee name (not required but useful if there is an error) |
| 80 | the number 3 |

## 4. THE CARPOOL MATCHING PROGRAMS

The data base described in the previous section is input to the carpool matching programs described below. Figure 4.1 is a flowchart of the procedures and programs involved in the NBS carpool locator system. The programs are all operational on the UNIVAC 1108 under the EXEC 8 operating system at NBS.

The file updating program was written and is maintained by Karen Burke of the Management and Organization Division. The coordinate update cards described in Figure 3.5 are input to this program, as is the locator file also maintained by Mrs. Burke. The updated locator file then becomes input to the extractor program, EXTRACT, a COBOL program written by Patricia McGuire and Alfred Redstone of the Computer Services Division to extract the data on those who have agreed to be included in the carpool file (currently those with Y for the third coded answer to the transportation survey, see section 3.1) and output them in FORTRAN readable form. This file is first input to program SELECT, which selects those to receive lists this time (usually those who have received new coordinates in the latest locator file update, but not limited to these alone). The carpool candidate file is also input to program GRID, which sorts all candidates into grid squares, computing the position in this list of the ends of the sublists corresponding to the individual grid squares. The final program, POOLIST, uses outputs from both SELECT and GRID to produce carpool lists for those desiring them. Descriptions of the programs EXTRACT, SELECT, GRID, POOLIST, and other subroutines required by them appear below. Program listings appear as an Appendix, as do sample control card streams for run setups. All programs use Social Security numbers to identify employees; alternate identification numbers could be used if privacy considerations warrant.

### 4.1: Program EXTRACT

Program EXTRACT is a COBOL program to read the locator file, extract only those who have the third coded answer to the transportation survey equal to Y (those who agreed to be in the carpool candidate file), and write them out on a FORTRAN readable file. EXTRACT calls two FORTRAN subroutines: FORWRT to write out data for each person in the carpool candidate file, and FOREND to endfile the candidate file. A flowchart of EXTRACT appears as Figure 4.2.

Input to the program is the updated locator file on tape in COBOL accessible format and assigned to unit B. The contents of this tape are described in Figure 3.1. Output from EXTRACT is the carpool candidate file, which must be assigned to unit 7, and which is described in Figure 4.3. The program also prints the number of employees in the

Figure 4.1

Flowchart of the Carpool Matching System

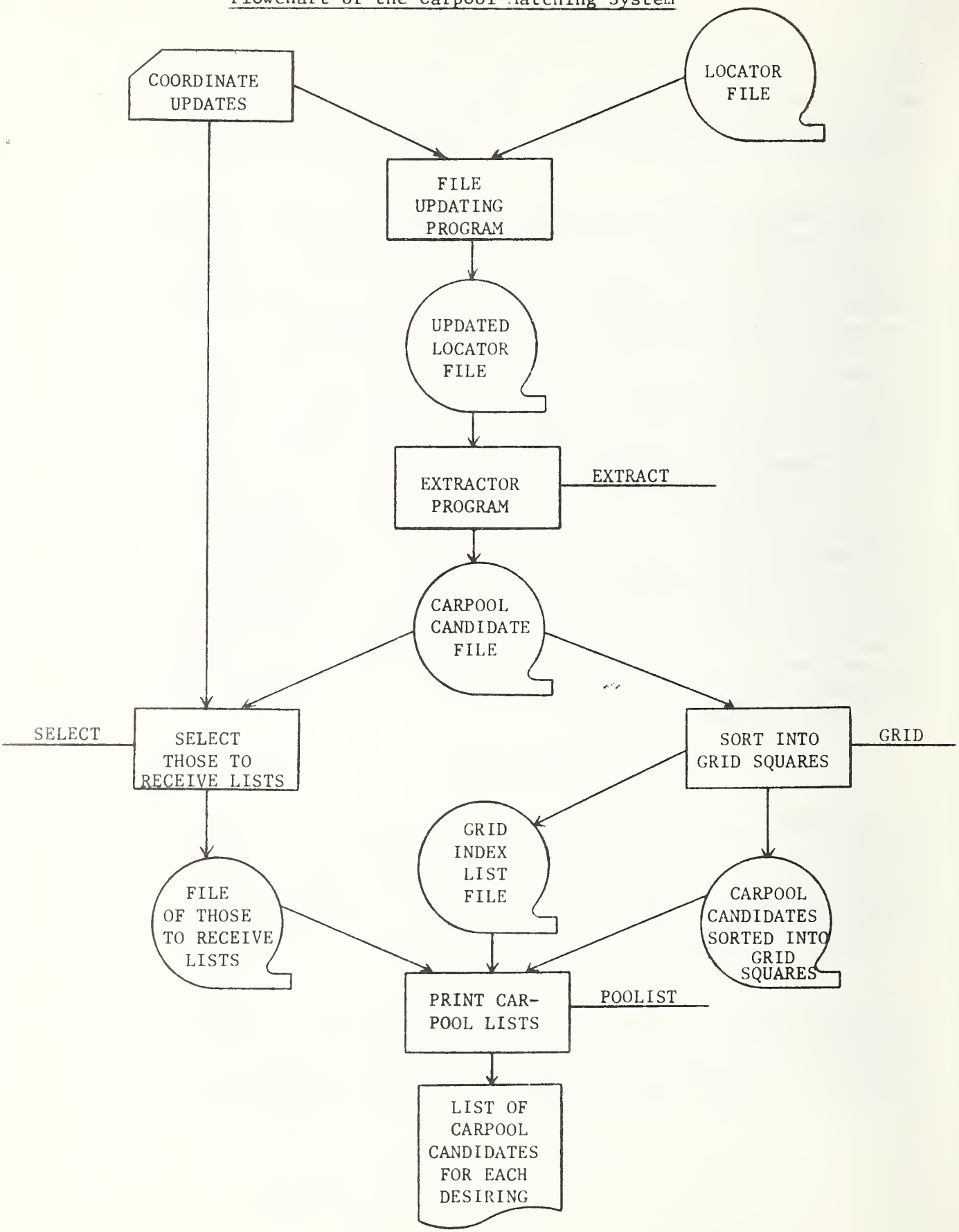


Figure 4 .2

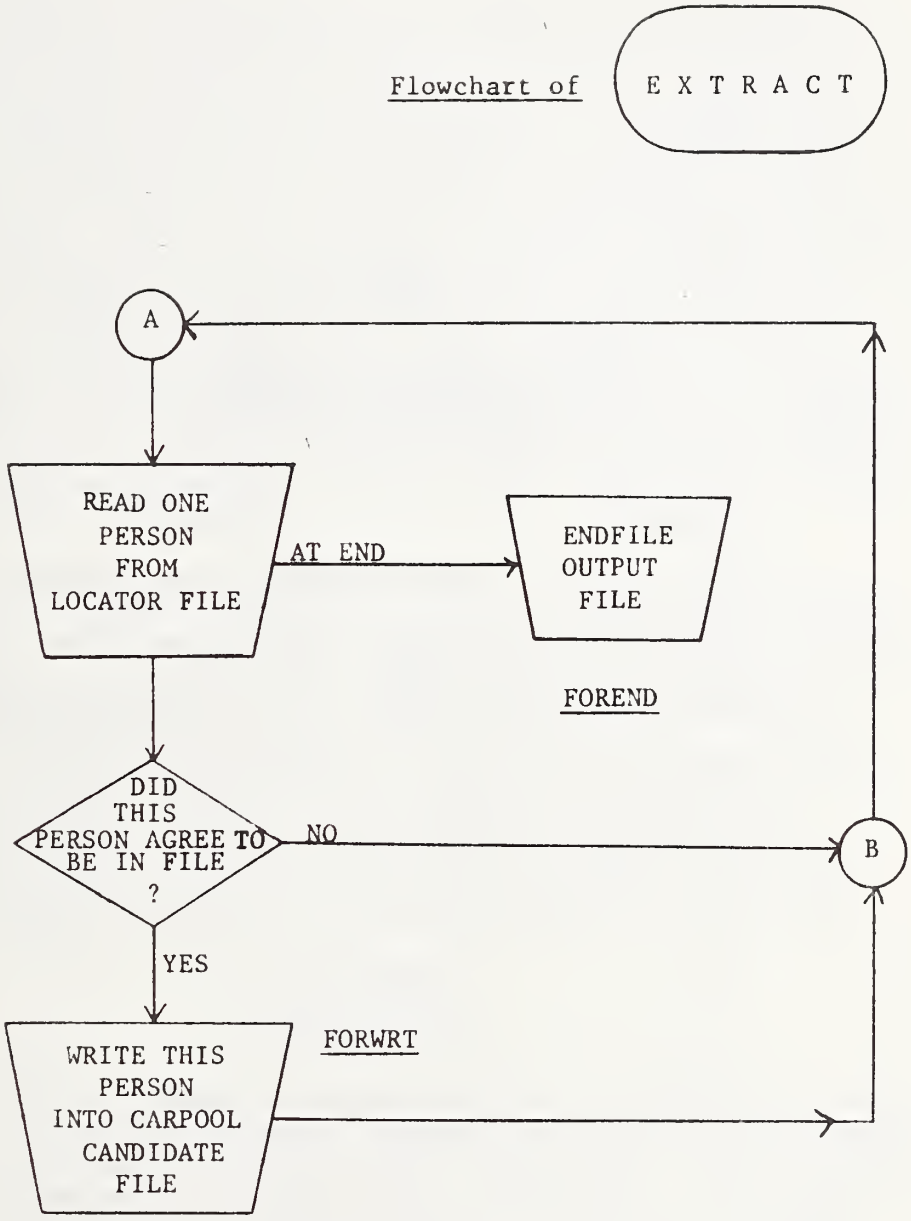

Flowchart of
E X T R A C T
A
READ ONE PERSON FROM LOCATOR FILE
AT END
ENDFILE OUTPUT FILE
FOREND
DID THIS PERSON AGREE TO BE IN FILE ?
NO
B
YES
WRITE THIS PERSON INTO CARPOOL CANDIDATE FILE
FORWRT

Figure 4.3

Format of Each Data Record of the Carpool Candidate File

| characters | contents |
|---|---|
| 1-9 | Social Security number (SS*) |
| 11-36 | employee name (NAME) |
| 38-42 | NBS mail address building (BLDG) |
| 43-47 | NBS mail address room (RM) |
| 49-52 | NBS phone extension (EXT) |
| 54-59 | NBS division and section (DIV) |
| 61-65 | x-coordinate (X) |
| 66-70 | y-coordinate (Y) |
| 72-125 | home address (ADDR) |

*Refer to Figure 4.8 for array names used in the programs.

locator file (MASTER-RECS) and the number of employees in the carpool locator file (SDF-RECS).

## 4.2: Program SELECT

SELECT is a FORTRAN program which selects those for whom lists are to be obtained. Input to the program is the Social Security numbers of those desiring carpool lists, one to a card in columns 2 through 10. Since this is compatible with the format in Figure 3.5, the locator file update cards can be used for this purpose. It is expected that people will often desire lists when an update has been made, and the same cards or duplicates can be used in the two processes. SELECT also requires as input on unit 7 the carpool candidate file described in Figure 4.3. Output from program SELECT is a file on unit 8, containing those desiring carpool lists in the same format, that is given in Figure 4.3. It should be noted that the data contained in this file are the same as those contained in the carpool candidate file for each candidate (with the exception of home address), but in a slightly different format. Output also includes a printed list of any duplicate input Social Security numbers, a list of any requested Social Security numbers not found in the carpool candidate file, and the total number of people actually selected.

Figure 4.4 is a flowchart of program SELECT. It can be seen from this flowchart that SELECT expects the carpool candidate file to appear sorted in order by Social Security number, with those "numbers" beginning with the letter A appearing first. SELECT does not call any other subroutines, but does refer to the UNIVAC 1108 FORTRAN V function FLD (i, j, k) which is used to pick j bits from the word k, starting with bit i, with bit 0 being leftmost. This function is required in the sorting procedure, because of the mixture of alphabetic (the letter A) and numeric characters in the leftmost position of the Social Security number. Figure 4.5 lists the variables and arrays appearing in SELECT. A listing of the program may be found in the Appendix.

## 4.3: Program GRID

GRID is a FORTRAN program which sorts the carpool candidate file into grid squares, so that all employees living in one square appear together in the file. GRID calls subroutine SORTP, written by Dr. James Filliben of the Applied Mathematics Division, to do the sorting. The calling parameters for SORTP are described in Figure 4.6. Input to program GRID, and assigned to unit 7, is the carpool candidate file whose format is given in Figure 4.3. Output from GRID consists of two files: on unit 8, the file of carpool candidates sorted into grid squares in the same format as the carpool candidate file (Figure 4.3), and on unit 9, the list giving the index of the last person in each grid square, 20 indices per record, six characters per index number.

Figure 4.4

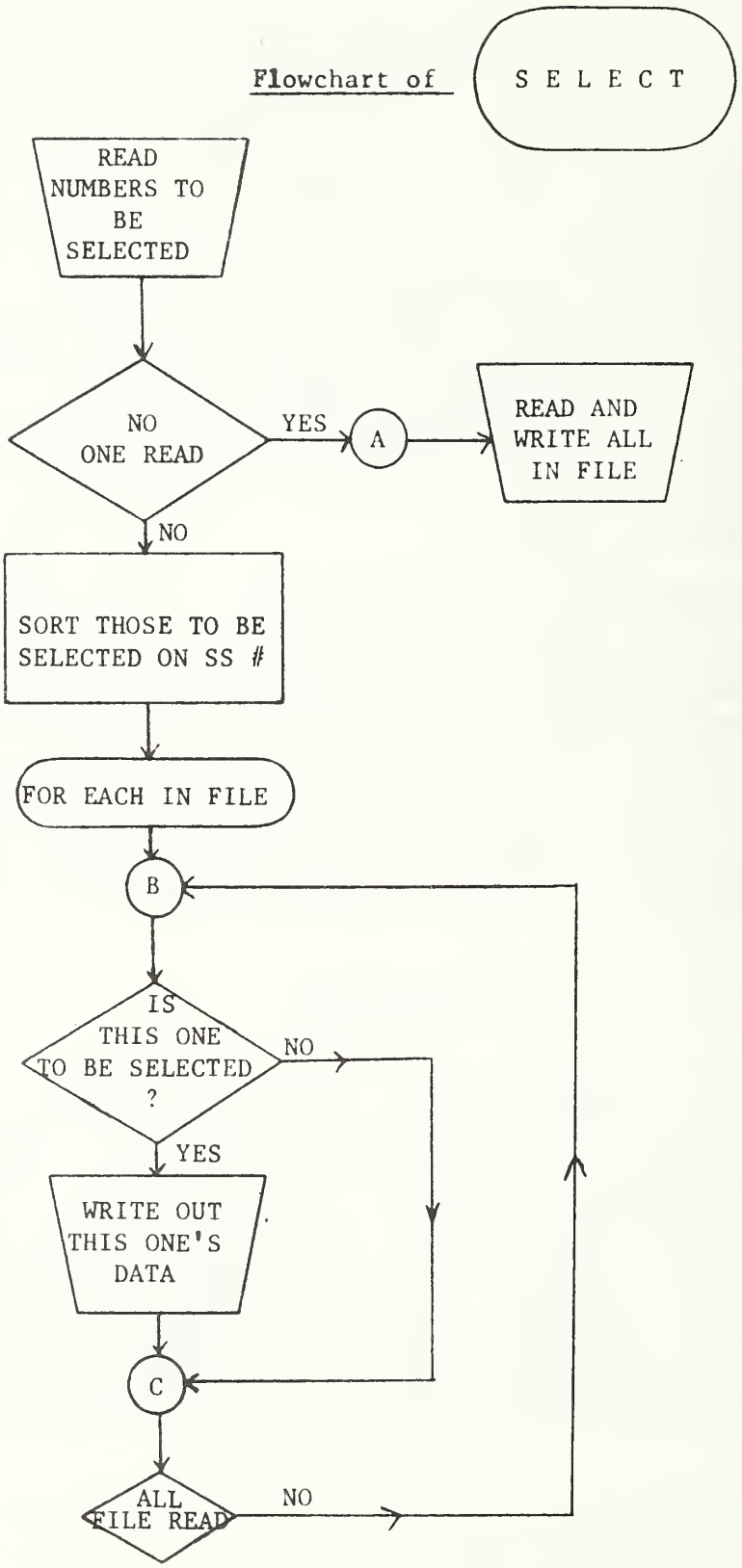

Flowchart of
S E L E C T
READ NUMBERS TO BE SELECTED
NO ONE READ
YES
A
READ AND WRITE ALL IN FILE
NO
SORT THOSE TO BE SELECTED ON SS #
FOR EACH IN FILE
B
IS THIS ONE TO BE SELECTED ?
NO
YES
WRITE OUT THIS ONE'S DATA
C
ALL FILE READ
NO

Figure 4.5

Variables and Arrays in Subroutine SELECT

| Name | Dimension or value, (if Parameter) | Description |
|---|---|---|
| CAND | 23 | array containing all information for a person in the carpool candidate file |
| INSEL | - | number of employees to be selected (note that the input list may have duplicates or erroneous Social Security numbers, so INSEL may be greater than NSEL) |
| MSEL | =1000 | maximum number to be selected |
| NEXT | MSEL | array used in sorting the Social Security numbers to be selected. NEXT (i) is the index of the next largest Social Security number after SS(i,-). Note that those beginning with "A" precede those beginning with a numeral. |
| NSEL | - | number of employees selected to have lists printed (see INSEL) |
| SS | MSEL X 3 | Social Security numbers to be selected |

Figure 4.6

Parameters in the Calling Sequence
of Subroutine SORTP

SORTP (ILIST, N, JLIST, INDX)

where:

ILIST - the list to be sorted

N - the number of entries in ILIST

JLIST - the ILIST in sorted order

INDX - INDX (i) is the position in ILIST of the $i^{th}$ entry in JLIST.

Figure 4.7 is a flowchart of program GRID. Variables and arrays used in the program appear in Figure 4.8. The grid system used in the carpooling effort is determined by the coordinates of the lower left corner, (MINX,MINY), which are (-400, -100), and by the width DELX and height DELY of each rectangular grid element, both 50 coordinate units here (making the grid units square). The entire main grid is 68 squares wide and 82 squares high (NY), with the two fringe area arcs placed in the two "squares" following square number 5576 (68 x 82). The squares are numbered from bottom to top and left to right, so that the grid square number for an employee with coordinates (x,y) is given by

$$[(x-MINX)/DELX] *NY + [(y-MINY)/DELY] + 1,$$

where [x] denotes the greatest integer not exceeding x (e.g. [3.9]=[3] = 3.) Coordinates for fringe areas are handled separately. The program calculates this grid number for each employee in the carpool candidate file, sorts the employees on their grid numbers, and calculates (and stores in LASRSQ) the position of the last employee of the sorted list in each grid square. If there are no employees in a square i then LASTSQ(i) = LASTSQ(i-1). Therefore employees in grid square i appear in positions LASTSQ(i-1) + 1 to LASTSQ (i), but if LASTSO (i-1) = LASTSQ(i), square i is empty.

## 4.4: Program POOLIST

POOLIST is a FORTRAN program which prints out the lists of potential carpool candidates for each person desiring such a list. POOLIST also calls subroutine SORTP, described above in Figure 4.8. Input to POOLIST consists of the file of those to receive lists on unit 5 and on unit 7 the file of carpool candidates sorted into grid squares, both in the format given in Figure 4.3, and on unit 8 the grid index list file described in the previous section. A sample output is reproduced as Figure 4.9. Home address is not given in the carpool list since some employees might consider it an invasion of privacy.

A flowchart of POOLIST appears as Figure 4.10, and variables and arrays used in the program are described in Figures 4.8 and 4.11. For each person desiring a list, POOLIST first calculates the grid square in which he lives. If he lives in an area containing many employees close to NBS (the area with x-coordinates between 950 and 1150 and y-coordinates between 1550 and 1750), then POOLIST will provide a list of those not more than one mile (actually 5000 feet) from him. If he lives outside this area, the acceptable radius is 2 miles (or 10000 feet). POOLIST actually calculates the square of the distance between the person requesting a list and others, and this is compared with 2500 coordinate units (the square of 50, which is 5000 feet expressed in coordinate units) or alternatively with 10000 coordinate units, which is the square of twice 50 units.

Figure 4.7

Flowchart of

GRID

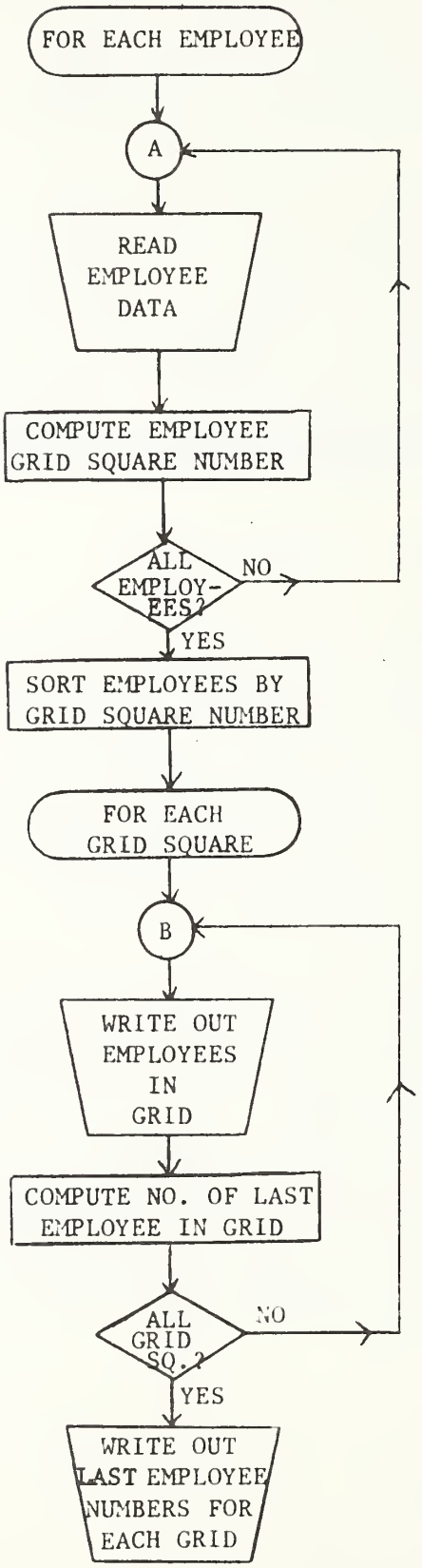


Figure 4.8

Variables and Arrays in

Subroutine GRID

| Name | Dimension (or Value, if Parameter) | Description |
|---|---|---|
| ADDR | MCAND x 9 | employee home address |
| BLDG | MCAND | NBS building (mail address) |
| DELX | =50 | width of a grid square (in coordinate units) |
| DELY | =50 | height of a grid square |
| DIV | MCAND | NBS Division and section |
| EXT | MCAND | NBS phone extension |
| FRING 1 | =14000 | fringe area 1 coordinates |
| FRING 2 | =17000 | fringe area 2 coordinates |
| GRID | MCAND | grid square number |
| GSORT | MCAND | grid square numbers in sorted order |
| INDX | MCAND | index of employees sorted by grid square number |
| LASTSQ | NXY2 | position of the last employee in each grid square |
| MCAND | =1200 | maximum number of employees in the carpool candidate file |
| MINX | =-400 | minimum allowable x-coordinate |
| MINY | =-100 | minimum allowable y-coordinate |
| NAME | MCAND x 5 | employee name |
| NCAND | - | number of employees actually in the carpool candidate file |
| NX | =68 | number of grid squares horizontally |
| NXY | =NX*NY | number of squares in the main |
| NXY2 | NXY + 2 | number of squares in the main grid plus fringe areas |
| NY | =82 | number of grid squares vertically |

| Name | Dimension (or Value, if Parameter) | Description |
|---|---|---|
| RM | MCAND | NBS room (mail address) |
| SS | MCAND x 2 | emplovee Social Security number |
| X | MCAND | x-coordinate of employee home address |
| Y | MCAND | y-coordinate of employee home address |

Figure 4.9

Sample Output

```
******************************
*                            *
* DOE JOHN                   *
*                            *
* DIV. 850.00                *
*                            *
* ADMIN A1200                *
*                            *
******************************
```

IN RESPONSE TO YOUR REQUEST FROM THE TRANSPORTATION SURVEY, BELOW IS A LIST OF NBS EMPLOYEES WHO LIVE NEAR YOU AND ARE INTERESTED IN CARPOOLING. THIS INFORMATION INCLUDES DATA FROM THE PERSONNEL LOCATOR FILE WHICH CONTAINS PERSONNEL WHO REQUESTED THAT THEIR HOME ADDRESS NOT BE PUBLICIZED. ALSO IT HAS COME TO OUR ATTENTION THAT PERSONNEL HAVE MOVED BUT HAVE NOT NOTIFIED THE MAIL SECTION OR PERSONNEL DIVISION OF THE CHANGE. CONSEQUENTLY THERE WILL BE PERSONNEL WHO REQUESTED LISTS BUT WILL NOT RECEIVE THEM OR WILL NOT BE LOCATED CORRECTLY.

| NAME | DIV. | EXT. |
|---|---|---|
| BEE ALBERT | 700.01 | 5213 |
| DEE CARL | 802.00 | 5347 |
| EFF ELLEN | 703.00 | 5222 |
| AICH GAYLE | 750.01 | 5764 |
| JAY IRA | 702.00 | 5916 |
| ELL KAREN | 801.00 | 5111 |
| ENN MARTIN | 803.00 | 5328 |
| PEA OTIS | 701.00 | 5514 |
| ARR QUENTIN | 704.00 | 5998 |
| TEA SAMUEL | 750.04 | 5769 |
| VEE URIAH | 700.01 | 5146 |
| EX WAYNE | 801.00 | 5224 |
| ZEE YOLANDA | 704.00 | 5165 |

Figure 4.10

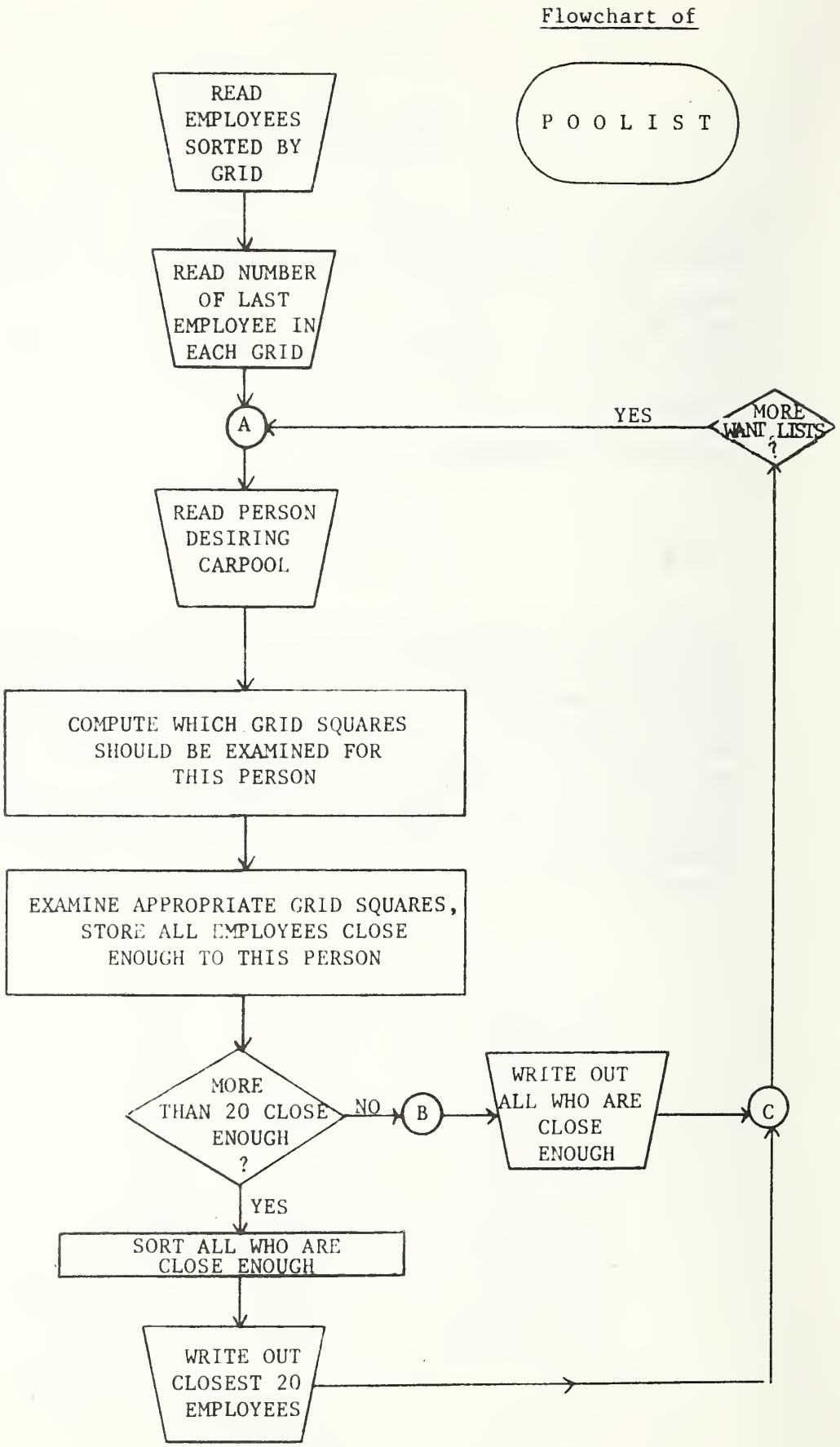

Flowchart of
POOLIST
READ EMPLOYEES SORTED BY GRID
READ NUMBER OF LAST EMPLOYEE IN EACH GRID
A
YES
MORE WANT LISTS ?
READ PERSON DESIRING CARPOOL
COMPUTE WHICH GRID SQUARES SHOULD BE EXAMINED FOR THIS PERSON
EXAMINE APPROPRIATE GRID SQUARES, STORE ALL EMPLOYEES CLOSE ENOUGH TO THIS PERSON
MORE THAN 20 CLOSE ENOUGH ?
NO
B
WRITE OUT ALL WHO ARE CLOSE ENOUGH
C
YES
SORT ALL WHO ARE CLOSE ENOUGH
WRITE OUT CLOSEST 20 EMPLOYEES

Figure 4.11

Variables and Arrays Appearing

Only in Subroutine POOLIST

| Name | Dimension or Value (if Parameter) | Description |
|---|---|---|
| CAND | MCAND x 9 | Carpool candidate data<br>CAND (i,1)-CAND(i,5): name<br>CAND(i,6): division and section<br>CAND(i,7): NBS phone extension<br>CAND(i,8),CAND(i,9): x and y coordinates |
| D | MNEAR | the sorted DIST array |
| DIST | MNEAR | the distance of each person in NEAR from the current person desiring a list |
| INDX | MNEAR | the index of those in NEAR sorted by DIST |
| IX | - | x-coordinate of the current person desiring a list |
| IY | - | y-coordinate of the current person desiring a list |
| LFOR | 8 | the information about the current person desiring a list<br>LFOR(1)-LFOR(5): name<br>LFOR(6)-LFOR(7): NBS mail address<br>LFOR(8): NBS phone extension |
| MAXX | =MINX + NX*DELX | Maximum x-coordinate in the main grid |
| MAXY | =MINY + NY*DELY | Maximum y-coordinate in the main grid |
| MILESQ | =2500 | a conversion factor equal to the square of 5000 feet in coordinate units |
| MNEAR | =500 | maximum number of employees within an acceptable radius of the one desiring a list |

| Name | Dimension or Value (if Parameter) | Description |
|---|---|---|
| MPRINT | =20 | maximum number of employees appearing on any list |
| NEAR | MNEAR x 7 | information about those living within an acceptable distance of the current person desiring a list (similar to CAND) |
| MNEAR | - | number of employees within an acceptable distance of the current person desiring a list |
| NPRINT | - | number of employees actually on the current list. |

One could search the whole coordinate file, computing the (squared) distance between each person and the current person desiring a list, but this would be quite time-consuming. It is to avoid this complete search that the grid system has been introduced. Note that the grid squares are only used internally to the locator system and because actual coordinates are recorded for each employee, the choice of grid system is essentially arbitrary and can be changed if desired (for instance to agree with a grid system used by another agency). In addition, the grid system does not in any way determine whether or not a person will appear on a list; it is simply an intermediate data-processing tactic which allows the program to avoid considering employees who could never be included on the current person's list because they are clearly too far away.

The list contains up to 20 potential carpool candidates. The person receiving the list will usually find his own name included, so that in most cases the number of candidates is actually 19. This also means that people who do not live sufficiently close to any other employees included in the carpool system (recall that an employee must have consented to inclusion) will receive only their own name. The limitation of inclusion to consenting staff members may, of course, result in the omission from a person's list of a neighboring employee known to him.

If a list contains fewer than 20 people, they will be listed in essentially random order, but if more than 20 were found living within an acceptable radius, POOLIST sorts them in increasing order of distance from the person whose list is being created. Only the 20 closest are printed. Since (as noted in Section 3.2 and Figure 3.3) all addresses in several apartment complexes in the Gaithersburg area are given one coordinate set, it is possible that more than 20 people will have the same coordinates. Special procedures are used to insure that these will receive different lists. In this case the next 20 names following the person receiving the list are selected. If necessary remaining candidates are selected from the top of the list.

POOLIST was put through its first application run on March 1, 1974, and printed lists for about 950 employees in about 2 minutes CPU time.

Listings of programs EXTRACT, SELECT, GRID, POOLIST and SORTP are included in Appendix A. Appendix B contains runstreams for running these programs on the NBS UNIVAC 1108 computer.

# APPENDIX A

## Program Listings

```
IDENTIFICATION DIVISION.
PROGRAM-ID.  EXTRACT AND PRODUCE FILE FOR CARPOOL.
AUTHOR.  PAT MCGUIRE.
DATE WRITTEN. FEB, 1974.
ENVIRONMENT DIVISION.
CONFIGURATION SECTION.
SOURCE-COMPUTER.  UNIVAC-1108.
INPUT-OUTPUT SECTION.
FILE-CONTROL.
    SELECT LOCATOR-FILE ASSIGN TO UNISERVO B.
DATA DIVISION.
FILE SECTION.
FD  LOCATOR-FILE
    LABEL RECORDS ARE OMITTED DATA RECORD IS LOC-REC.
01  LOC-REC PIC X(234).
COMMON-STORAGE SECTION.
01  STO-CAND-REC.
    03  CAND-SS      PIC X(9).
    03  FILLER       PIC X      VALUE SPACE.
    03  CAND-NAME    PIC X(26).
    03  FILLER       PIC X      VALUE SPACE.
    03  CAND-BLDG    PIC X(10).
    03  FILLER       PIC X      VALUE SPACE.
    03  CAND-EXT     PIC X(4).
    03  FILLER       PIC X      VALUE SPACE.
    03  CAND-DIV     PIC X(6).
    03  FILLER       PIC X      VALUE SPACE.
    03  CAND-X       PIC X(5).
    03  CAND-Y       PIC X(5).
    03  FILLER       PIC X      VALUE SPACE.
    03  CAND-ADDR    PIC X(54).
    03  FILLER       PIC X(7)   VALUE SPACE.
WORKING-STORAGE SECTION.
77  LOC-RECS     PIC 9(6).
77  CAND-RECS    PIC 9(6).
01  LOC-SWITCH          PIC 9    VALUE 0.
    88  LOC-EOF                  VALUE 1.
01  STO-LOC-REC.
    03  SS               PIC X(9).
    03  W-PHONE.
        05  FILLER     PIC X(4).
        05  W-EXT      PIC X(4).
    03  NAME             PIC X(26).
    03  TYPE             PIC XXXX.
    03  DIV-SEC          PIC X(6).
    03  LOC.
        05  I-BLDG       PIC XXXXX.
        05  I-RM         PIC XXXXX.
    03  MAIL.
        05  M-BLDG       PIC XXXXX.
        05  M-RM         PIC XXXXX.
    03  ADDR.
        05  STREET    PIC X(28).
         05  CITY-ST    PIC X(20).
         05  FILLER     PIC X.
```

```
           05  ZIP          PIC XXXXX.
       03 H-PHONE.
           05  HP-AREA      PIC XXX.
           05  HP-NUM       PIC X(8).
       03  FILLER           PIC X(6).
       03  X-COOR           PIC X(5).
       03  Y-COOR           PIC X(5).
       03  ANSWERS  PIC X  OCCURS 12 TIMES.
       03  FILLER           PIC X(68).
PROCEDURE DIVISION.
A-INITIALIZE SECTION.
A010.
       OPEN INPUT LOCATOR-FILE
       MOVE ZEROS TO LOC-RECS  CAND-RECS.
A020.
       PERFORM B-READ-INPUT.
       IF LOC-EOF
            CLOSE LOCATOR-FILE
            MONITOR LOC-RECS  CAND-RECS
            ENTER FORTRAN FOREND SUBROUTINE
            STOP RUN.
       PERFORM C-BUILD-OUTPUT.
       PERFORM D-WRITE-OUTPUT.
       GO TO A020.
B-READ-INPUT SECTION.
B010.
       READ LOCATOR-FILE INTO STD-LOC-REC
            AT END GO TO B020.
       ADD 1 TO LOC-RECS.
       IF ANSWERS (3) = 'Y'
            GO TO B-EXIT.
       GO TO B010.
B020.
       MOVE 1 TO LOC-SWITCH.
B-EXIT.
       EXIT.
C-BUILD-OUTPUT SECTION.
C010.
       MOVE SS             TO CAND-SS.
       MOVE NAME           TO CAND-NAME.
       MOVE MAIL           TO CAND-BLDG.
       MOVE W-EXT          TO CAND-EXT.
       MOVE DIV-SEC        TO CAND-DIV.
       MOVE X-COOR         TO CAND-X.
       MOVE Y-COOR         TO CAND-Y.
       MOVE ADDR           TO CAND-ADDR.
C-EXIT.
       EXIT.
D-WRITE-OUTPUT SECTION.
D010.
       ENTER FORTRAN FORWRT SUBROUTINE.
       ADD 1 TO CAND-RECS.
D-EXIT.
       EXIT.
```

```
      SUBROUTINE FORWRT
      COMMON  DUMMY,CAND(22)
      INTEGER CAND
      WRITE (7,900)  (CAND(I),I=1,22)
900   FORMAT (22A6)
      RETURN
      END



      SUBROUTINE FOREND
      ENDFILE 7
      RETURN
      END
```

```
      SUBROUTINE SORTP(X,N,Y,XPOS)
C     THIS ROUTINE SORTS THE ELEMENTS OF THE INPUT VECTOR X AND PUTS THE
C     ELEMENTS INTO THE VECTOR Y.  IT ALSO CARRIES ALONG THE INDEX NUMBE
C     OF EACH ORDERED OBSERVATION--THAT IS, IT CARRIES ALONG THE POSITIO
C     THE I-TH ORDERED OBSERVATION (FOR EACH I) AS IT WAS IN THE ORIGINA
C     UNORDERED DATA VECTOR X.  THESE POSITIONS ARE PLACED IN THE VECTOR
C     THIS ROUTINE IS USEFUL IN ATTEMPTING TO LOCATE THE MINIMUM, THE MA
C     OR SOME OTHER ORDERED OBSERVATION OF INTEREST IN THE ORIGINAL UNOR
C     INPUT VECTOR X.
C     THE INPUT TO THIS ROUTINE IS THE SINGLE PRECISION VECTOR X OF
C     (UNSORTED) OBSERVATIONS, THE INTEGER VALUE N (= SAMPLE SIZE),
C     AN EMPTY SINGLE PRECISION VECTOR Y INTO WHICH THE SORTED OBSERVATI
C     WILL BE PLACED, AND AN EMPTY SINGLE PRECISION VECTOR XPOS INTO WHI
C     POSITIONS OF THE SORTED OBSERVATIONS WILL BE PLACED.
C     THE OUTPUT FROM THIS ROUTINE IS THE SINGLE PRECISION VECTOR Y INTO
C     THE SORTED OBSERVATIONS HAVE BEEN PLACED, AND THE SINGLE PRECISION
C     XPOS INTO WHICH THE POSITIONS OF THE SORTED OBSERVATIONS HAVE BEEN
C     RESTRICTIONS ON THE MAXIMUM ALLOWABLE VALUE OF N--THE DIMENSIONS
C     OF VECTORS IU AND IL (DEFINED AND USED INTERNALLY WITHIN THIS ROUT
C     DETERMINE THE MAXIMUM ALLOWABLE VALUE OF N FOR THIS
C     ROUTINE.  IF IU AND IL EACH HAVE DIMENSION K, THEN N MAY NOT EXCEE
C     2**(K+1) - 1.  FOR THIS ROUTINE AS WRITTEN, THE DIMENSIONS OF IU A
C     HAVE BEEN SET TO 36, THUS THE MAXIMUM ALLOWABLE VALUE OF N IS
C     APPROXIMATELY 137 BILLION.  SINCE THIS EXCEEDS THE MAXIMUM ALLOWAB
C     VALUE FOR AN INTEGER VARIABLE IN MANY COMPUTERS, AND SINCE A SORT
C     BILLION ELEMENTS IS PRESENTLY IMPRACTICAL AND UNLIKELY, THEREFORE
C     TEST FOR WHETHER THE INPUT SAMPLE SIZE N EXCEEDS 137 BILLION HAS B
C     INCORPORATED INTO THIS ROUTINE.  IT IS THUS ASSUMED THAT THERE IS
C     (PRACTICAL) RESTRICTION ON THE MAXIMUM VALUE OF N FOR THIS ROUTINE
C     PRINTING--NONE UNLESS AN ERROR CONDITION EXISTS
C     THIS ROUTINE IS SINGLE PRECISION IN INTERNAL OPERATION.
C     SUBROUTINES NEEDED--NONE
C     SORTING METHOD--BINARY SORT
C     REFERENCE--CACM MARCH 1969, PAGE 186 (BINARY SORT ALGORITHM BY RIC
C                C. SINGLETON.
C               --CACM JANUARY 1970, PAGE 54.
C               --CACM OCTOBER 1970, PAGE 624.
C               --JACM JANUARY 1961, PAGE 41.
C     WRITTEN BY JAMES J. FILLIBEN, STATISTICAL ENGINEERING LABORATORY (
C     NATIONAL BUREAU OF STANDARDS, WASHINGTON, D.C. 20234        JUNE 19
C
      DIMENSION X(1),Y(1),XPOS(1)
      DIMENSION IU(36),IL(36)
      IMPLICIT INTEGER (A-Z)
```

```
C
C     CHECK THE INPUT ARGUMENTS FOR ERRORS
C
      IPR=6
      IF(N.LT.1)GOTO50
      IF(N.EQ.1)GOTO55
      HOLD=X(1)
      DO60I=2,N
      IF(X(I).NE.HOLD)GOTO90
   60 CONTINUE
      WRITE(IPR, 9)HOLD
      DO61I=1,N
      Y(I)=X(I)
      XPOS(I)=I
   61 CONTINUE
      RETURN
   50 WRITE(IPR,15)
      WRITE(IPR,47)N
      RETURN
   55 WRITE(IPR,18)
      Y(1)=X(1)
      XPOS(1)=1.0
      RETURN
   90 CONTINUE
    9 FORMAT(1H ,108H***** NON-FATAL DIAGNOSTIC--THE FIRST  INPUT ARGUME
     1NT (A VECTOR) TO THE SORTP  SUBROUTINE HAS ALL ELEMENTS = ,E15.8,6
     1H *****)
   15 FORMAT(1H , 91H***** FATAL ERROR--THE SECOND INPUT ARGUMENT TO THE
     1 SORTP  SUBROUTINE IS NON-POSITIVE *****)
   18 FORMAT(1H ,100H***** NON-FATAL DIAGNOSTIC--THE SECOND INPUT ARGUME
     1NT TO THE SORTP  SUBROUTINE HAS THE VALUE 1 *****)
   47 FORMAT(1H , 35H***** THE VALUE OF THE ARGUMENT IS ,I8    ,6H *****)
C
C     COPY THE VECTOR X INTO THE VECTOR Y
      DO100I=1,N
      Y(I)=X(I)
  100 CONTINUE
C
C     DEFINE THE XPOS (POSITION) VECTOR.  BEFORE SORTING, THIS WILL
C     BE A VECTOR WHOSE I-TH ELEMENT IS EQUAL TO I.
C
      DO150I=1,N
      XPOS(I)=I
  150 CONTINUE
C
C     CHECK TO SEE IF THE INPUT VECTOR IS ALREADY SORTED
C
      NM1=N-1
      DO200I=1,NM1
      IP1=I+1
      IF(Y(I).LE.Y(IP1))GOTO200
      GOTO250
  200 CONTINUE
      RETURN
```

```
250 M=1
    I=1
    J=N
305 IF(I.GE.J)GOTO370
310 K=I
    MID=(I+J)/2
    AMED=Y(MID)
    BMED=XPOS(MID)
    IF(Y(I).LE.AMED)GOTO320
    Y(MID)=Y(I)
    XPOS(MID)=XPOS(I)
    Y(I)=AMED
    XPOS(I)=BMED
    AMED=Y(MID)
    BMED=XPOS(MID)
320 L=J
    IF(Y(J).GE.AMED)GOTO340
    Y(MID)=Y(J)
    XPOS(MID)=XPOS(J)
    Y(J)=AMED
    XPOS(J)=BMED
    AMED=Y(MID)
    BMED=XPOS(MID)
    IF(Y(I).LE.AMED)GOTO340
    Y(MID)=Y(I)
    XPOS(MID)=XPOS(I)
    Y(I)=AMED
    XPOS(I)=BMED
    AMED=Y(MID)
    BMED=XPOS(MID)
    GOTO340
330 Y(L)=Y(K)
    XPOS(L)=XPOS(K)
    Y(K)=TT
    XPOS(K)=ITT
340 L=L-1
    IF(Y(L).GT.AMED)GOTO340
    TT=Y(L)
    ITT=XPOS(L)
350 K=K+1
    IF(Y(K).LT.AMED)GOTO350
    IF(K.LE.L)GOTO330
    LMI=L-1
    JMK=J-K
    IF(LMI.LE.JMK)GOTO360
    IL(M)=I
    IU(M)=L
    I=K
    M=M+1
    GOTO380
360 IL(M)=K
    IU(M)=J
    J=L
    M=M+1
    GOTO380
370 M=M-1
    IF(M.EQ.0)RETURN
    I=IL(M)
    J=IU(M)
```

```
380  JMI=I-1
     IF(JMI.GE.11)GOTO310
     IF(I.EQ.1)GOTO305
     I=I-1
390  I=I+1
     IF(I.EQ.J)GOTO370
     AMED=Y(I+1)
     BMED=XPOS(I+1)
     IF(Y(I).LE.AMED)GOTO390
     K=I
395  Y(K+1)=Y(K)
     XPOS(K+1)=XPOS(K)
     K=K-1
     IF(AMED.LT.Y(K))GOTO395
     Y(K+1)=AMED
     XPOS(K+1)=BMED
     GOTO390
     END
```

```
C
C  ***************************************************
C  *                                                 *
C  *  THIS PROGRAM SELECTS THOSE FOR WHOM LISTS ARE  *
C  *  TO BE MADE, USING SOCIAL SECURITY NUMBER       *
C  *                                                 *
C  ***************************************************
C
C
C*****************************************************************************
C
C  THE MAXIMUM NUMBER TO BE SELECTED IS MSEL
C
C
C  ARRAYS APPEARING IN THE PROGRAM:
C
C       SS      - SOCIAL SECURITY NUMBER OF EACH PERSON TO BE SELECTED
C       NEXT    - ARRAY USED IN SORTING SOCIAL SECURITY NUMBERS.
C                 NEXT(I) IS THE INDEX OF THE NEXT LARGEST SOCIAL SECURITY
C                 NUMBER IN SS AFTER SS(I).  (NOTE NUMBERS BEGINNING WITH
C                 THE LETTER  A  WILL APPEAR BEFORE NUMERIC ONES.)
C       CAND    - ARRAY USED IN READING THE FILE.  CAND CONTAINS ALL NEEDED
C                 INFORMATION FOR EACH PERSON.
C
C*****************************************************************************
C
      PARAMETER  MSEL=1000
      DIMENSION  SS(MSEL,3),NEXT(MSEL),CAND(23)
      IMPLICIT INTEGER (A-Z)
C
C  ***************************************************************
C  *                                                             *
C  *  READ SOCIAL SECURITY NUMBERS OF THOSE TO BE SELECTED       *
C  *                                                             *
C  ***************************************************************
C
      N=1
1     READ (5,900,END=2) STEMP,SS(N,2),SS(N,3)
900   FORMAT (1X,A1,2A4)
      SS(N,1)=FLD(0,6,STEMP)
      N=N+1
      GO TO 1
2     INSEL=N-1
C
C  ***************************************************************
C  *                                                             *
C  *  IF INSEL IS ZERO, SELECT ALL TO HAVE LISTS PRINTED         *
C  *                                                             *
C  ***************************************************************
C
C
C  NSEL COUNTS THE NUMBER OF PEOPLE ACTUALLY SELECTED
C
      NSEL=0
      IF (INSEL.GT.0) GO TO 4
3     READ (7,901,END=22) (CAND(J),J=1,23)
901   FORMAT (A1,2A4,1X,4A6,A2,1X,2A5,1X,A4,1X,A6,1X,2I5,1X,9A6)
      WRITE (8,901) (CAND(J),J=1,23)
      NSEL=NSEL+1
      GO TO 3
```

PAGE

NO(S) 43-44

MISSING

```
C
C ***************************************************************
C *                                                             *
C * THIS PROGRAM SORTS THOSE DESIRING CARPOOLS INTO GRID SQUARES *
C *                                                             *
C ***************************************************************
C
C
C*****************************************************************
C
C THE GRID SQUARES OF WIDTH DELX AND HEIGHT DELY.  THE LOWER
C LEFT CORNER OF THE WHOLE GRID SYSTEM IS  (MINX,MINY).  THERE ARE  NX
C GRIDS ACROSS AND  NY  GRIDS UP, MAKING A TOTAL OF  NXY SQUARES IN THE
C MAIN GRID.  TWO FRINGE AREAS ARE INCLUDED, MAKING A TOTAL OF  NXY2
C SECTIONS IN ALL.  THE MAXIMUM NUMBER OF EMPLOYEES IN THE LOCATOR
C SYSTEM IS  MCAND.
C
C*****************************************************************
C
      PARAMETER  DELX=50
      PARAMETER  DELY=50
      PARAMETER  MINX=-400
      PARAMETER  MINY=-100
      PARAMETER  NX=68
      PARAMETER  NY=82
      PARAMETER  NXY=NX*NY
      PARAMETER  NXY2=NXY+2
      PARAMETER  MCAND=1200
      PARAMETER  FRING1=14000
      PARAMETER  FRING2=17000
C
C*****************************************************************
C
C ARRAYS APPEARING IN THE PROGRAM:
C
C     NAME   - THE EMPLOYEE'S NAME
C     EXT    - THE EMPLOYEE'S NBS EXTENSION
C     DIV    - THE EMPLOYEE'S NBS DIVISION AND SECTION
C     BLDG   - NBS MAILING ADDRESS BUILDING
C     RM     - NBS MAILING ADDRESS ROOM
C     ADDR   - THE EMPLOYEE'S HOME ADDRESS
C     SS     - THE EMPLOYEE'S SOCIAL SECURITY NUMBER
C     X      - X-COORDINATE OF EMPLOYEE'S HOME ADDRESS
C     Y      - Y-COORDINATE OF EMPLOYEE'S HOME ADDRESS
C     GRID   - GRID SQUARE NUMBER IN WHICH THIS EMPLOYEE LIVES
C     GSORT  - EMPLOYEE GRID SQUARE NUMBERS IN SORTED ORDER
C     INDX   - INDEX OF EMPLOYEES IN SORTED ORDER
C     LASTSQ - THE POSITION OF THE LAST EMPLOYEE IN EACH GRID SQUARE.
C              EMPLOYEES LIVING IN GRID SQUARE N APPEAR IN THE SORTED
C              LIST IN RECORDS LASTSQ(N-1)+1 THROUGH LASTSQ(N).
C
C*****************************************************************
C
      DIMENSION  NAME(MCAND,5),EXT(MCAND),DIV(MCAND),BLDG(MCAND),
     1           RM(MCAND),X(MCAND),Y(MCAND),GRID(MCAND),GSORT(MCAND),
     2           INDX(MCAND),LASTSQ(NXY2),ADDR(MCAND,9),SS(MCAND,2)
      IMPLICIT INTEGER (A-Z)
```

```
C
C  ****************************************
C*                                        *
C  * READ EMPLOYEES DESIRING CARPOOLS AND *
C  * COMPUTE GRID SQUARE FOR EACH         *
C*                                        *
C  ****************************************
C
      N=1
1     READ (7,900,END=2) (SS(N,I),I=1,2),(NAME(N,I),I=1,5),BLDG(N),RM(N)
     1  ,EXT(N),DIV(N),X(N),Y(N),(ADDR(N,I),I=1,9)
900   FORMAT (A6,A3,1X,4A6,A2,1X,2A5,1X,A4,1X,A6,1X,2I5,1X,9A6)
C
C*****************************************************************************
C
C  INPUT/OUTPUT FILE FORMAT  (1 RECORD PER EMPLOYEE)
C
C      COLS.              CONTENTS
C
C       1 -  9       SOCIAL SECURITY NUMBER
C      11 - 36       EMPLOYEE'S NAME
C      38 - 42       NBS MAILING ADDRESS BUILDING
C      43 - 47       NBS MAILING ADDRESS ROOM
C      49 - 52        NBS EXTENSION
C      54 - 59       NBS DIVISION AND SECTION
C      61 - 65       X-COORDINATE OF HOME ADDRESS
C      66 - 70       Y-COORDINATE OF HOME ADDRESS
C      72 -125       HOME ADDRESS
C
C*****************************************************************************
C
      GRID(N)=((X(N)-MINX)/DELX)*NY+(Y(N)-MINY)/DELY+1
      IF (X(N).EQ.FRING1) GRID(N)=NXY+1
      IF (X(N).EQ.FRING2) GRID(N)=NXY2
C
C*****************************************************************************
C
C  IF THE CALCULATED GRID NUMBER IS TOO LARGE PRINT OUT THE EMPLOYEE DATA
C
C*****************************************************************************
C
      IF (GRID(N).LE.NXY2) GO TO 5
      WRITE (6,990) (SS(N,K),K=1,2),(NAME(N,K),K=1,5),BLDG(N),RM(N),
     1  EXT(N),DIV(N),X(N),Y(N),(ADDR(N,K),K=1,9),GRID(N)
990   FORMAT (1X,A6,A3,1X,4A6,A2,1X,2A5,1X,A4,1X,A6,1X,2I5,1X,9A6,
     1  I4)
5     N=N+1
      GO TO 1
2     NCAND=N-1
      WRITE (6,991)
991   FORMAT ('1')
```

```
C
C  ****************************************
C*                                        *
C  * SORT EMPLOYEES BY GRID SQUARE NUMBER *
C*                                        *
C  ****************************************
C
      CALL SORTP(GRID,NCAND,GSORT,INDX)
C
C  ***************************************************************************
C  *                                                                         *
C  * COMPUTE GRID INDEX NUMBERS AND WRITE OUT EMPLOYEES IN SORTED ORDER      *
C  *                                                                         *
C  ***************************************************************************
C
      J=1
      BACK=0
      DO 4 I=1,NXY2
      LASTSQ(I)=BACK
3     IF (GSORT(J).GT.I) GO TO 4
      LASTSQ(I)=LASTSQ(I)+1
      L=INDX(J)
      WRITE (8,900) (SS(L,K),K=1,2),(NAME(L,K),K=1,5),BLDG(L),RM(L),
     1  EXT(L),DIV(L),X(L),Y(L),(ADDR(L,K),K=1,9)
C
      WRITE (6,990) (SS(L,K),K=1,2),(NAME(L,K),K=1,5),BLDG(L),RM(L),
     1  EXT(L),DIV(L),X(L),Y(L),(ADDR(L,K),K=1,9),GSORT(J)
      J=J+1
      IF (J.LE.N) GO TO 3
      J=J-1
      GSORT(J)=999999
4     BACK=LASTSQ(I)
C
C  ************************************************************
C  *                                                          *
C  * WRITE OUT POSITION OF LAST PERSON IN EACH GRID SQUARE    *
C  *                                                          *
C  ************************************************************
C
      WRITE (9,902) (LASTSQ(I),I=1,NXY2)
902   FORMAT (2016)
      WRITE (6,903) NCAND,LASTSQ(NXY2)
903   FORMAT (' GRID SORT COMPLETE',I6,' EMPLOYEES IN',I6,' EMPLOYEES OU
     1T')
      STOP
      END
```

```
C
C  ********************************************************
C  *                                                      *
C  *  THIS PROGRAM PRINTS LISTS OF CARPOOL CANDIDATES     *
C  *                                                      *
C  ********************************************************
C
      PARAMETER  DELX=50
      PARAMETER  DELY=50
      PARAMETER  NX=68
      PARAMETER  NY=82
      PARAMETER  NXY=NX*NY
      PARAMETER  NXY2=NXY+2
      PARAMETER  MINX=-400
      PARAMETER  MINY=-100
      PARAMETER  MAXX=MINX+NX*DELX
      PARAMETER  MAXY=MINY+NY*DELY
      PARAMETER  MCAND=1200
      PARAMETER  MILESQ=2500
      PARAMETER  MNEAR=500
      PARAMETER  MPRINT=20
      PARAMETER  FRING1=14000
      PARAMETER  FRING2=17000
C
C*************************************************************************
C
C THOSE DESIRING CARPOOLS ARE SORTED INTO GRID SQUARES OF WIDTH AND
C HEIGHT  DELX  AND  DELY  RESPECTIVELY.  THERE ARE NX  SQUARES ACROSS
C AND NY  SQUARES UP.  THE LOWER LEFT CORNER IS (MINX,MINY).  THE
C TOTAL NUMBER OF GRID SQUARES IS  NXY2,  2 MORE THAN NXY TO INCLUDE THE
C TWO FRINGE AREAS WITH COORDINATES (FRING1,FRING1) AND (FRING2,FRING2).
C MILESQ IS A CONVERSION FACTOR EQUAL TO
C THE SQUARE OF THE SMALLER RADIUS FOR THE ALLOWABLE DISTANCE IN THE
C UNITS OF THE COORDINATE SYSTEM.  (HERE 1 UNIT IS 100 FEET, AND THE
C SMALLER RADIUS IS 5000 FEET, OR ABOUT 1 MILE.)  THE NUMBER OF PEOPLE
C IN THE FILE IS AT MOST  MCAND.  THE MAXIMUM EXPECTED TO BE CLOSE ENOUGH
C TO ONE PERSON IS  MNEAR, AND THE NUMBER IN THE LIST PROVIDED IS MPRINT
C
C*************************************************************************
C
      DIMENSION  LASTSQ(NXY2),CAND(MCAND,9),NEAR(MNEAR,7),D(MNEAR),
     1  DIST(MNEAR),INDX(MNEAR),LFOR(8)
      IMPLICIT INTEGER (A-Z)
```

```
C
C*****************************************************************
C
C ARRAYS APPEARING IN THE PROGRAM:
C      LASTSQ - ENTRY POINTS IN THE LIST OF CARPOOL CANDIDATES FOR EACH
C               GRID SQUARE. LASTSQ(N) IS THE LAST ENTRY FOR GRID SQUARE
C               N.  THEREFORE ENTRIES FOR GRID SQUARE N GO FROM
C               LASTSQ(N-1)+1  TO AND INCLUDING  LASTSQ(N).
C      CAND   - THE LIST OF ALL THOSE WISHING CARPOOLS, SORTED INTO GRIDS
C               CAND(I,1) - CAND(I,5)  IS THE PERSON'S NAME
C               CAND(I,6) IS THE DIVISION AND SECTION
C               CAND(I,7) IS THE NBS PHONE EXTENSION
C               CAND(I,8) AND CAND(I,9) ARE THE X AND Y COORDINATES
C      NEAR   - THE PEOPLE LIVING CLOSE ENOUGH TO THE CURRENT PERSON
C      DIST   - THE DISTANCE FROM THE CURRENT PERSON OF EACH OF THOSE
C               OTHERS STORED IN NEAR
C      D      - THE SORTED DIST ARRAY
C      INDX   - THE INDICES OF ENTRIES IN NEAR SORTED BY DISTANCE
C      LFOR   - THE INFORMATION ABOUT THE CURRENT PERSON DESIRING A LIST
C               LFOR(1) - LFOR(5)  IS THE PERSON'S NAME
C               LFOR(6) - LFOR(7)  IS THE NBS MAILING ADDRESS
C               LFOR(8)  IS THE NBS PHONE EXTENSION
C
C*****************************************************************
C
C
C
C  ***************************************************
C  *                                                 *
C  * READ THOSE DESIRING CARPOOLS, SORTED INTO GRIDS *
C  *                                                 *
C  ***************************************************
C
      N=1
200   READ (7,903,END=201) (CAND(N,I),I=1,5),CAND(N,7),CAND(N,6),
     1  CAND(N,8),CAND(N,9)
903   FORMAT (10X,4A6,A2,12X,A4,1X,A6,1X,2I5)
C
C*****************************************************************
C
C CARPOOL CANDIDATE FILE FORMAT FOR EACH EMPLOYEE
C
C      COLS.            CONTENTS
C
C       1 -  9      SOCIAL SECURITY NUMBER
C      11 - 36      EMPLOYEE NAME
C      38 - 42      NBS BUILDING FOR MAILING ADDRESS
C      43 - 47      NBS ROOM FOR MAILING ADDRESS
C      49 - 52      NBS PHONE EXTENSION
C      54 - 59      NBS DIVISION AND SECTION
C      62 - 65      X-COORDINATE OF HOME ADDRESS
C      66 - 70      Y-COORDINATE OF HOME ADDRESS
C      72 -125      HOME ADDRESS
C
C*****************************************************************
C
      N=N+1
      GO TO 200
201   NCAND=N-1
```

```
C
C ***********************************************************
C *                                                         *
C * READ POSITION OF LAST PERSON IN EACH GRID SQUARE        *
C *                                                         *
C ***********************************************************
C
203   READ (8,900) (LASTSQ(I),I=1,NXY2)
900   FORMAT(2016)
C
C ***************************************
C *                                     *
C * READ PERSON DESIRING A CARPOOL LIST *
C *                                     *
C ***************************************
C
1     READ (5,901,END=100) (LFOR(I),I=1,8),IX,IY
901   FORMAT (10X,4A6,A2,1X,2A5,6X,A4,1X,2I5)
C
C*****************************************************************************
C
C INPUT FOR THOSE DESIRING LISTS IS SIMILAR TO THE CARPOOL CANDIDATES
C ONLY EMPLOYEE NAME, NBS MAILING ADDRESS, NBS DIVISION AND SECTION, AND
C X AND Y COORDINATES ARE ACTUALLY READ AND USED.
C
C*****************************************************************************
C
      IF ((IX.GE.MINX.AND.IX.LE.MAXX).OR.IX.EQ.FRING1.OR.IX.EQ.FRING2)
     1  GO TO 30
      GO TO 1
30    IF ((IY.GE.MINY.AND.IY.LE.MAXX).OR.IY.EQ.FRING1.OR.IY.EQ.FRING2)
     1GO TO 31
      GO TO 1
```

```
C  ***********************************************
C  *                                             *
C  * COMPUTE LOWER LEFT GRID AND NUMBER OF       *
C  * GRIDS TO BE USED FOR THIS PERSON'S LIST     *
C  *                                             *
C  ***********************************************
C
C
C*****************************************************************************
C
C KL IS THE LOWER LEFT GRID TO BE INCLUDED FOR THIS PERSON
C ENDX AND ENDY ARE THE NUMBER OF GRIDS TO BE INCLUDED ACROSS AND UP
C FOR THIS PERSON.  MAXR IS THE  RADIUS FOR THIS PERSON'S CARPOOL.
C SEVERAL FLAG VARIABLES ARE USED IN CALULATING THESE - FLAGL, FLAGR,
C FLAGB, FLAGT ARE SET IF THE PERSON DESIRING A LIST LIVES IN A GRID
C SQUARE AT THE LEFT SIDE, RIGHT SIDE, BOTTOM, OR TOP OF THE WHOLE
C GRID.  FLAGN  IS SET IF THE PERSON LIVES IN A PRE-SET HIGH DENSITY
C AREA  (FOR THIS CASE AN AREA IN GAITHERSBURG NEAR NBS).
C
C*****************************************************************************
C
31      J=1
        IF (IX.LT.FRING1) GO TO 4
        ENDX=1
        ENDY=1
        KL=NXY+1
        IF (IX.EQ.FRING2) KL=NXY2
        KLTEMP=KL
        GO TO 7
4        FLAGL=1
         FLAGB=1
         FLAGR=0
         FLAGT=0
        FLAGN=0
        KL=NY*((IX-MINX)/DELX)+((IY-MINY)/DELY+1
        KLTEMP=KL
        IF (MOD(KLTEMP,NY).EQ.1) GO TO 5
        FLAGB=0
        KL=KL-1
5       IF (MOD(KLTEMP,NY).EQ.0) FLAGT=1
        IF (KLTEMP.LE.NY) GO TO 6
        FLAGL=0
        KL=KL-NY
6       IF (KLTEMP.GE.(NXY-NY)) FLAGR=1
        IF (ABS(IX-1050).LE.100.AND.ABS(IY-1650).LE.100) GO TO 61
        ENDX=5
        IF (NXY-KL.LT.4*NY) ENDX=(NXY-KL)/NY+1
        ENDY=5
        IF (NY-MOD(KL,NY).LT.4) ENDY=NY-MOD(KL,NY)+1
        FLAGN=1
        GO TO 7
61      ENDX=3
        IF (KLTEMP.GT.NXY-NY) ENDX=2
        ENDY=3
        IF (MOD(KLTEMP,NY).EQ.0) ENDY=2
        FLAGN=0
7       MAXR=MILES0*(FLAGN+1)**2
```

```
C
C ***************************************************
C *                                                 *
C * EXAMINE APPROPRIATE GRID SQUARES -              *
C * STORE ALL WITHIN MAXR OF THIS PERSON IN NEAR    *
C *                                                 *
C ***************************************************
C
      DO 10 I=1,ENDX
      IBEG=LASTSQ(KL-1)+1
      IF (KL.EQ.1) IBEG=1
      IEND=LASTSQ(KL+ENDY-1)
      IF (IEND.LT.IBEG) GO TO 10
      DO 9 II=IBEG,IEND
93    DTEM=(CAND(II,8)-IX)**2+(CAND(II,9)-IY)**2
      IF (DTEM.GT.MAXR) GO TO 9
      DO 94 W=1,7
94    NEAR(J,W)=CAND(II,W)
      DIST(J)=DTEM
      J=J+1
9     CONTINUE
10    KL=KL+NY
      NNEAR=J-1
      NPRINT=NNEAR
C
C *******************************
C *                             *
C * WRITE LIST FOR THIS PERSON  *
C *                             *
C *******************************
C
      WRITE (6,904) (LFOR(I),I=1,5),LFOR(9),LFOR(10),LFOR(6),LFOR(7)
904   FORMAT ('1*****************************' /' *',28X,'*'/' * ',4A6,
     E  A2,' *'/' *',28X,'*'/' *  DIV. ',2A3,15X,'*'/' *',28X,'*'/' *  '
     F ,A5,1X,A5,15X,'*'/' *',28X,'*'/' *****************************'
     G  ///////
     2' IN RESPONSE TO YOUR REQUEST FROM THE TRANSPORTATION SURVEY,'/
     3' BELOW IS A LIST OF NBS EMPLOYEES WHO LIVE NEAR YOU AND ARE'/
     4' INTERESTED IN CARPOOLING.  THIS INFORMATION INCLUDES DATA'/
     5' FROM THE PERSONNEL LOCATOR FILE WHICH CONTAINS PERSONNEL WHO'/
     6' REQUESTED THAT THEIR HOME ADDRESS NOT BE PUBLICIZED.  ALSO IT'/
     7' HAS COME TO OUR ATTENTION THAT PERSONNEL HAVE MOVED BUT HAVE'/
     8' NOT NOTIFIED THE MAIL SECTION OR PERSONNEL DIVISION OF THE'/
     9' CHANGE.  CONSEQUENTLY THERE WILL BE PERSONNEL WHO REQUESTED'/
     A' LISTS BUT WILL NOT RECEIVE THEM OR WILL NOT BE LOCATED'/
     B' CORRECTLY.'////
     C11X,'NAME',19X,'DIV.',3X,'EXT.'//)
      IF (NNEAR.LE.MPRINT.OR.IX.GE.FRING1) GO TO 18
```

```
C*****************************************************************
C
C SORT THOSE WITHIN THE ACCEPTABLE RADIUS, IF THERE ARE MORE THAN MPRINT
C OF THEM
C
C*****************************************************************
C
      CALL SORTP(DIST,NNEAR,D,INDX)
      J=0
      IF (D(1).NE.D(MPRINT+1)) GO TO 15
C
C*****************************************************************
C
C IF MORE THAN MPRINT OF THOSE WITHIN AN ACCEPTABLE RADIUS ARE AT THE
C SAME PLACE, PICK A SUBSET OF SIZE MPRINT IN SUCH A WAY TO ENSURE THAT
C DIFFERENT PEOPLE GET DIFFERENT LISTS
C
C*****************************************************************
C
      DO 12 II=1,NNEAR
      I=INDX(II)
      DO 11 JJ=1,5
      IF (NEAR(I,JJ).NE.LFOR(JJ)) GO TO 12
11    CONTINUE
      GO TO 14
12    CONTINUE
      WRITE (6,990) (LFOR(JJ),JJ=1,5)
990   FORMAT('0*** ERROR *** ',4A6,2X,'NOT FOUND IN FILE')
      NPRINT=MPRINT
      GO TO 18
14    IF(D(II+1).NE.D(II)) GO TO 15
      J=J+1
      II=II+1
      I=INDX(II)
      WRITE (6,920)(NEAR(I,LL),LL=1,7)
920   FORMAT (5X,4A6,A2,2X,A6,2X,A4)
      IF (J.LT.MPRINT) GO TO 14
15    NPRINT=MPRINT-J
      IF (NPRINT-1) 1,20,16
16    DO 17 I=1,NPRINT
      II=INDX(I)
17    WRITE (6,920) (NEAR(II,LL),LL=1,7)
      GO TO 1
C
C*****************************************************************
C
C IF FEWER THAN MPRINT ARE WITHIN AN ACCEPTABLE RADIUS OR IF THE PERSON
C LIVES IN A FRINGE AREA, INCLUDE ALL IN LIST
C
C*****************************************************************
C
18    DO 19 I=1,NPRINT
19    WRITE (6,920) (NEAR(I,LL),LL=1,7)
      GO TO 1
20    WRITE (6,921)
921   FORMAT (' NO EMPLOYEE DESIRING A CARPOOL LIVES WITHIN 2 MILES OF Y
     1OU.')
      GO TO 1
100   STOP
      END
```

APPENDIX B

## Sample Runstreams

The programs described in Section IV are in file CARPOOL*PROGRAMFILE in symbolic, relocatable and absolute forms, so that they may be executed directly from the absolute elements in this file. Six data files are referenced in the runstreams in Figure B.1:

LOCATOR - the updated locator file on tape

CANDIDATE - the carpool candidate file

GETLISTS - the file of those to receive lists

SORTEDCAND - the file of carpool candidates sorted into grid squares

GRIDINDEX - the grid index list file

LISTS - the breakpointed output tape containing lists to be printed off-line.

The programs would normally be run in the sequence shown, so that each time a file is first referenced it is assigned as a new file to be catalogued as publicly accessible (option UP on the ASG card). In subsequent runs, it must be referenced as already catalogued (option A on the ASG card). All programs for these runs are stored in the file PROGRAMFILE with qualifier CARPOOL.

Figure B.1

Example Runstreams for Obtaining Carpool Lists

To Run Program EXTRACT:

```
@RUN,N/R   POOL01,99999-POOLEX,CARPOOL,5,50
@ASG,TJ    LOCATOR.,8C,9999
@ASG,UP    CANDIDATE.
@USE    B.,LOCATOR.
@USE    7.,CANDIDATE.
@ASG,A    PROGRAMFILE.
@XQT    PROGRAMFILE.EXTRACT
@FIN
```

To run program SELECT:

```
@RUN,N/R   POOL02,99999-POOLEX, CARPOOL,5,50
@ASG,A    CANDIDATE.
@ASG,UP    GETLISTS.
@USE    7.,CANDIDATE.
@USE    8.,GETLISTS.
@ASG,A    PROGRAMFILE.
@XQT    PROGRAMFILE.SELECT
[Data cards containing Social Security numbers to be selected]
@EOF
@FIN
```

To run program GRID:

```
@RUN,N/R   POOL03,99999-POOLEX,CARPOOL,5,50
@ASG,A    CANDIDATE.
@AGG,UP    GRIDINDEX.
@ASG,UP    SORTEDCAND.
@USE    7.,CANDIDATE.
@USE    8.,SORTEDCAND.
@USE    9.,GRIDINDEX.
@ASG,A    PROGRAMFILE.
@XQT    PROGRAMFILE.GRID
@FIN
```

To run program POOLIST:

```
@RUN,N/R    POOL04,99999-POOLEX,CARPOOL,5,2000
@ASG,TJ     LISTS.,8C,0000W
@ASG,A    GETLISTS.
@ASG,A    SORTEDCAND.
@ASG,A    GRIDINDEX.
@USE    7.,SORTEDCAND.
@USE    8.,GRIDINDEX.
@ASG,A    PROGRAMFILE.
@BRKPT    PRINTS/LISTS
@XQT    PROGRAMFILE.POOLIST
@ADD    GETLISTS.
@EOF
@BRKPT    PRINTS
@FIN
```

Ask to have Breakpointed reel number 0000 printed on 8 1/2 X 11 white paper.

APPENDIX C

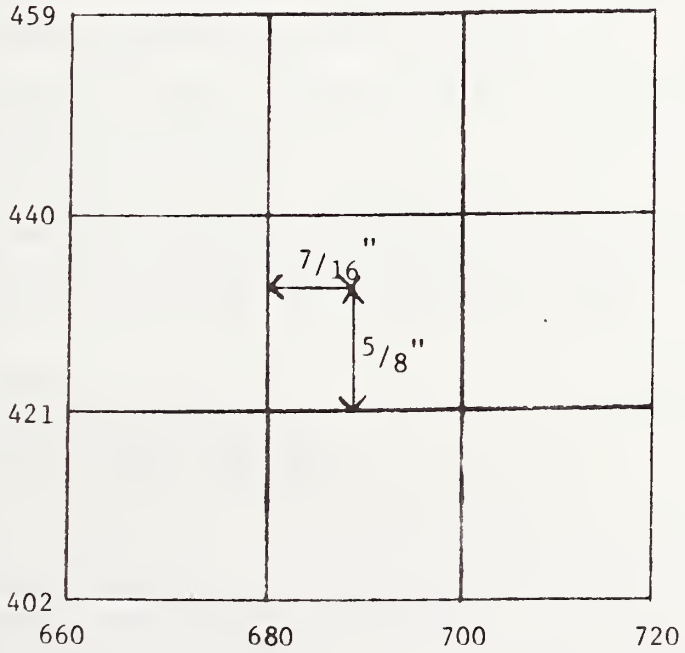
## Locating Coordinates by Interpolation: An Example

We wish to obtain coordinates for the point shown below in a section of the maps having the displayed coordinates in the margin. (It should be noted that the vertical lines are one inch apart which equals 20 coordinate units, and the horizontal lines are only 19/20 of an inch apart or 19 coordinate units.) The position of the point is 5/8 inch from the bottom of its square and 7/16 inch from the left edge. Interpolating using 20 units per inch yields an x-coordinate of

$$[5/8 \text{ inch} \cdot 20 \text{ units per inch}] + 680 \text{ units} = 693$$

and a y-coordinate of

$$[7/16 \text{ inch} \cdot 20 \text{ units per inch}] + 421 \text{ units} = 430.$$



APPENDIX D

Staff Transportation Survey Questionnaire

STAFF TRANSPORTATION SURVEY

The NBS Energy Task Force is seeking to assist employees with transportation problems and to reduce fuel consumption in travel to and from work. Carpooling is being encouraged; improved bus and train service are being sought. The accompanying questionnaire was designed to obtain the information that is needed to enable the Transportation Task Group to determine the feasibility of public transportation and to plan possible routes of travel. Your cooperation is requested in filling out this questionnaire and returning it to your Division Administrative Office by January 9, 1974.

Thank you,

J. D. Hoffman, Chairman
NBS Energy Task Force

Enter Social Security No. (will be used as a key field identifier for survey control purposes; will not be printed in conjunction with name for distribution)

1. How do you get to work now? (circle appropriate letter at right) A C W M O

   A = drive alone; C = carpool; W = walk; M = metrobus; O = other
   If Other, describe_____

CARPOOLING (circle Y = Yes; N = No on right)

2. Please send me a list of up to 20 NBS employees who live nearest me. I understand that my name, address and work phone number will be sent to NBS employees who live near me. . . . . Y N

3. Has your home address changed in the past 10 months? . . . . . Y N

4. Are you willing to take turns in carpool driving? . . . . . Y N

5. Are you interested in riding only? . . . . . Y N

6. Would you consider driving only and picking up riders? . . . . . Y N

BUS SERVICE Buses may be chartered to provide express service between NBS and central pick-up points in the metropolitan area (up to 40 miles away)

7. Circle the appropriate letter: . . . . . A B C

   A = am not interested in bus service
   B = may use bus if it becomes available
   C = will definitely use bus if it is at all convenient

8. Maximum distance I would travel to a bus pick-up point is: . . . . . A B C D

   A = walking distance only
   B = longer distance, if safe parking is provided
   C = longer distance, need no parking
   D = can't answer now

9. Maximum daily round trip bus fare I would pay is: . . . . . 1 2 3 4 5 X

   1 = $1.00 3 = $3.00 5 = $5.00
   2 = $2.00 4 = $4.00 X = can't answer now

TRAIN SERVICE There is a commuter line from Martinsburg, West Virginia, to Washington D.C. This line has stops at Brunswick, Point of Rocks, Dickerson, Barnesville, Buck Lodge, Boyds, Germantown and Gaithersburg, Maryland. The monthly fare from Brunswick to Gaithersburg is $37.50. Assuming adequate transportation between Gaithersburg and NBS (for example, shuttle service), answer the following: (Y = Yes; N = No)

10. If service were improved (for example, better schedules), would you use the existing commuter line? . . . . . Y N

11. If service becomes available from the other direction, that is, from D.C. to Gaithersburg with stops in-between -- would you be interested in using it? . . . . . Y N

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OTHER Answers, comments, or suggestions in the appropriate sections below, will be welcomed

12. Please suggest convenient bus pick-up points in your area with adequate parking, for example, a large shopping center. Name each point (shopping center), nearest town, and road intersection, sufficient to fully identify its location.

13. What are the principal reasons you have, or would have, to join a car pool?

14. What obstacles keep you, or would keep you, from joining a car pool?

15. Please write in any suggestions or comments you may have on staff transportation to and from work. (Attach additional sheets if necessary)

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6. Performing Organization Code

7. AUTHOR(S)

Judith F. Gilsinn and Susan Landau

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15. SUPPLEMENTARY NOTES

16. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)

This report documents the NBS computerized carpool matching programs and the procedures used in maintaining the coordinate data base required by the matching system. The report includes flowcharts, input/output formats, and program listings for the programs, plus details of the manual process for coordinate coding. The matching program produces, for each person desiring it, a list of others residing within a pre-specified distance of him, and is thus applicable to a single work destination having primarily one work schedule. The system is currently operational on the National Bureau of Standards' UNIVAC 1108 computer and was run in March of 1974, producing lists for about 950 employees in less than four minutes computer time. Subsequent maintenance of the system will be carried out by the NBS Management and Organization Division.

17. KEY WORDS (six to twelve entries; alphabetical order, capitalize only the first letter of the first key word unless a proper name; separated by semicolons)

Carpools; carpool matching; computer programs; transportation; urban transportation.

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