Statewide Transportation Analysis & Research

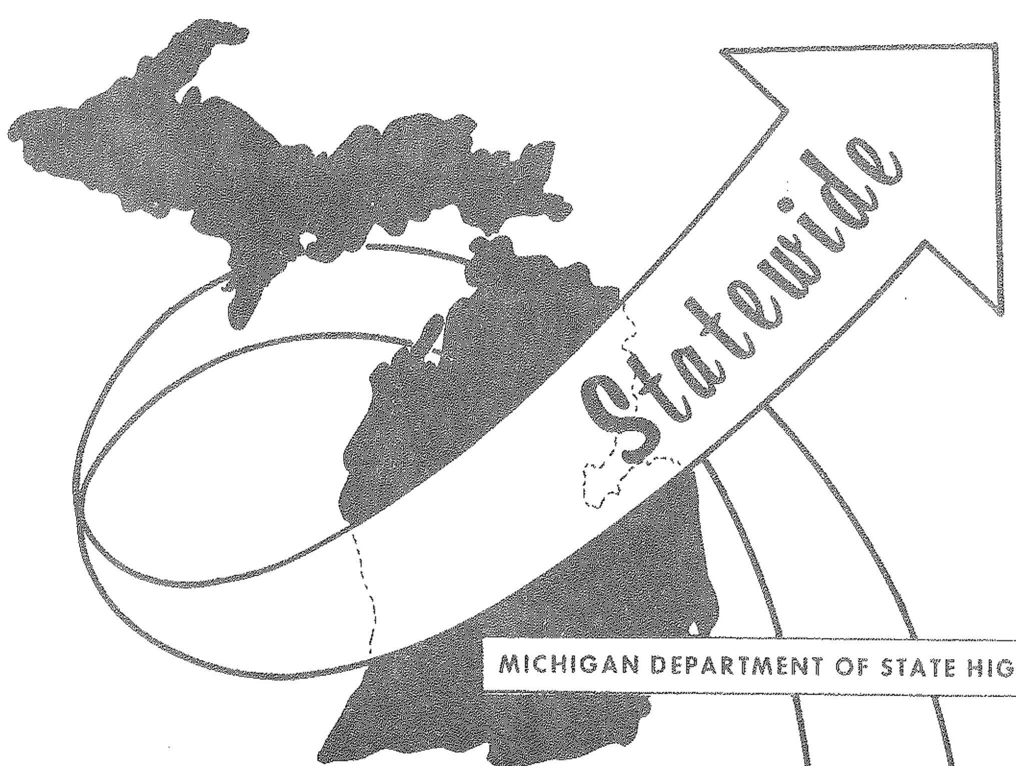
MICHIGAN'S STATEWIDE TRANSPORTATION
MODELING SYSTEM

VOLUME XIII

MICHIGAN GOES
MULTI – MODAL

STATEWIDE RESEARCH & DEVELOPMENT

JULY, 1974



MICHIGAN DEPARTMENT OF STATE HIGHWAYS AND TRANSPORTATION

MICHIGAN DEPARTMENT

OF

STATE HIGHWAYS AND TRANSPORTATION

BUREAU OF TRANSPORTATION PLANNING

MICHIGAN'S STATEWIDE TRANSPORTATION
MODELING SYSTEM

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**MICHIGAN GOES
MULTI – MODAL**

STATEWIDE RESEARCH & DEVELOPMENT

JULY, 1974

STATE OF MICHIGAN

WILLIAM G. MILLIKEN, GOVERNOR

DEPARTMENT OF STATE HIGHWAYS AND TRANSPORTATION

STATE HIGHWAYS BUILDING – POST OFFICE DRAWER K – LANSING, MICHIGAN 48904

JOHN P. WOODFORD, DIRECTOR

July 26, 1974

Mr. Sam F. Cryderman
Deputy Director
Bureau of Transportation Planning

Dear Mr. Cryderman:

The Highway Planning Division is pleased to present the opening report of Volume XIII in the Statewide Transportation Modeling System series. Entitled "Michigan Goes Multi-Modal", the report documents the preparation of an automated battery of procedures which will become the basis for the passenger travel by four modes - highway, bus, rail, and air - at the statewide or regional level.

Recent Federal legislation, the energy crisis, and financial difficulties besetting carriers in all modes make it imperative that departments of transportation be equipped to do multi-modal statewide transportation planning. A modeling system such as the one described herein seems to be an important step in achieving this capability.

The programs described in this report were implemented by Miss Joyce Newell. The report was written by Miss Newell and Mr. Terry Gotts; Mr. Thomas Franklin participated in the production of the graphics. All are members of the Statewide Interagency Procedures Research and Development Section, managed by Mr. Richard E. Esch.

Sincerely,

Richard J. Lilly, Administrator
Highway Planning Division

MICHIGAN
THE GREAT LAKE STATE

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"MICHIGAN GOES MULTI-MODAL"

by
Joyce A. Newell
and
Terry L. Gotts

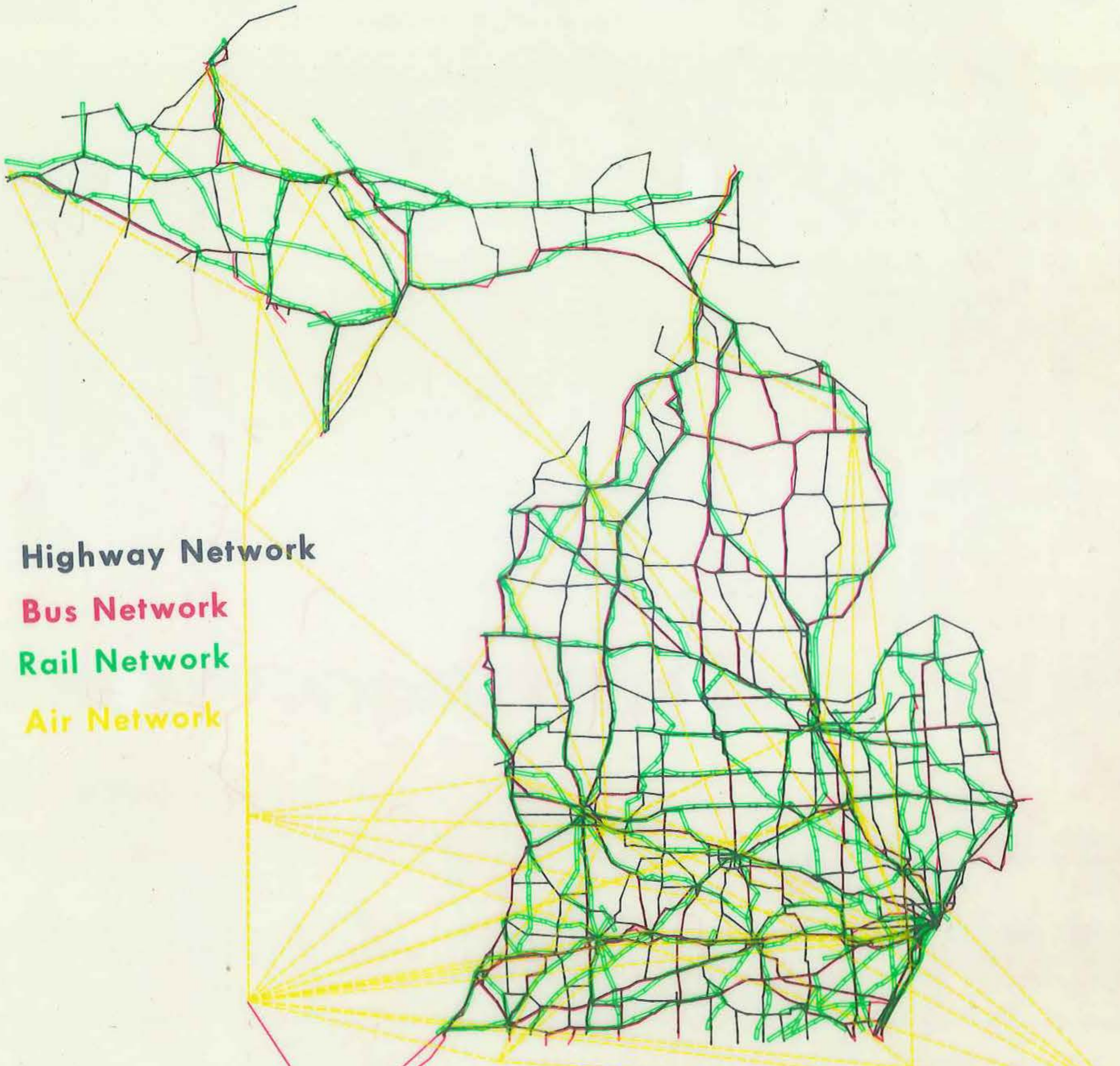


FIGURE 1

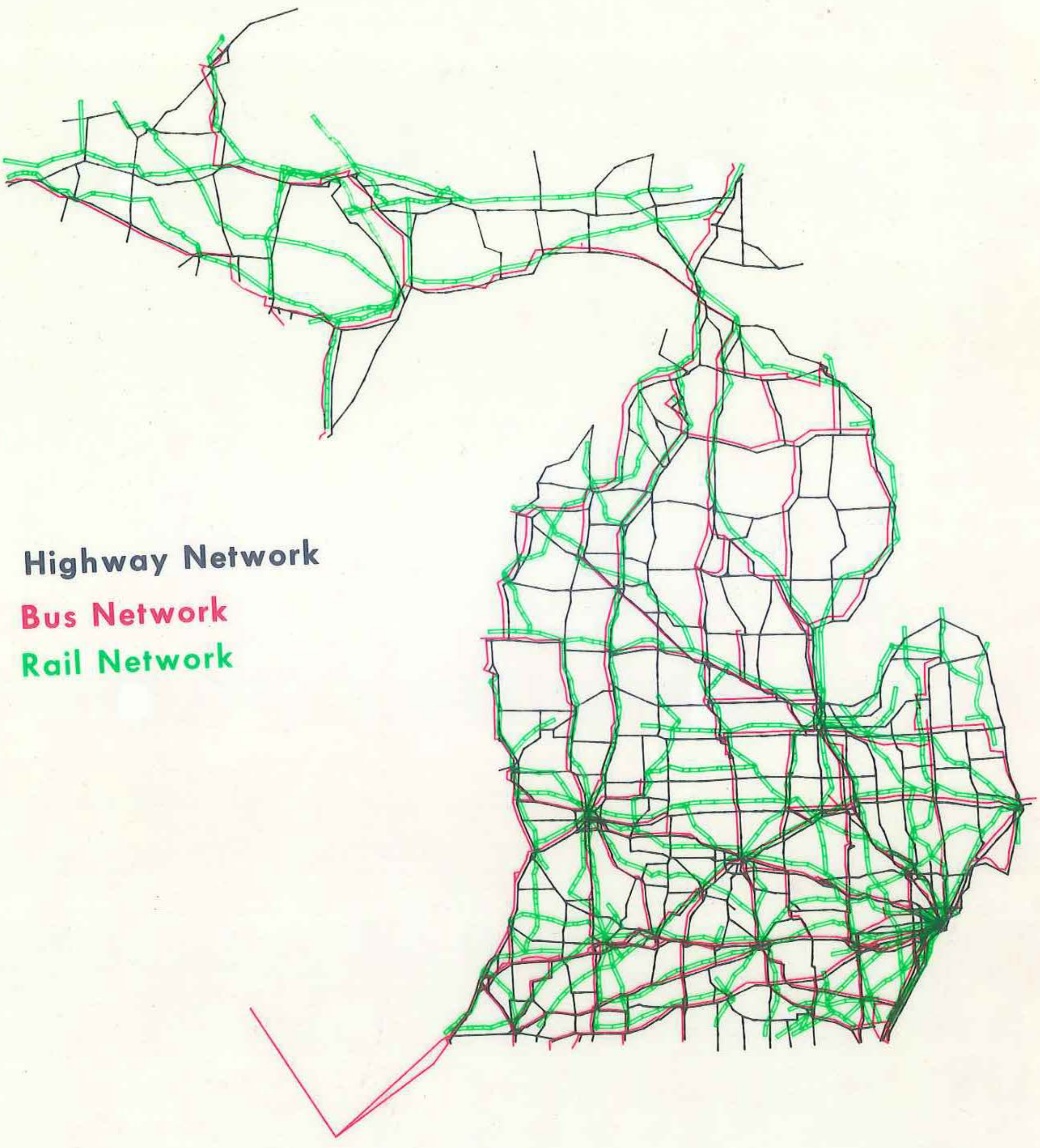


FIGURE 1

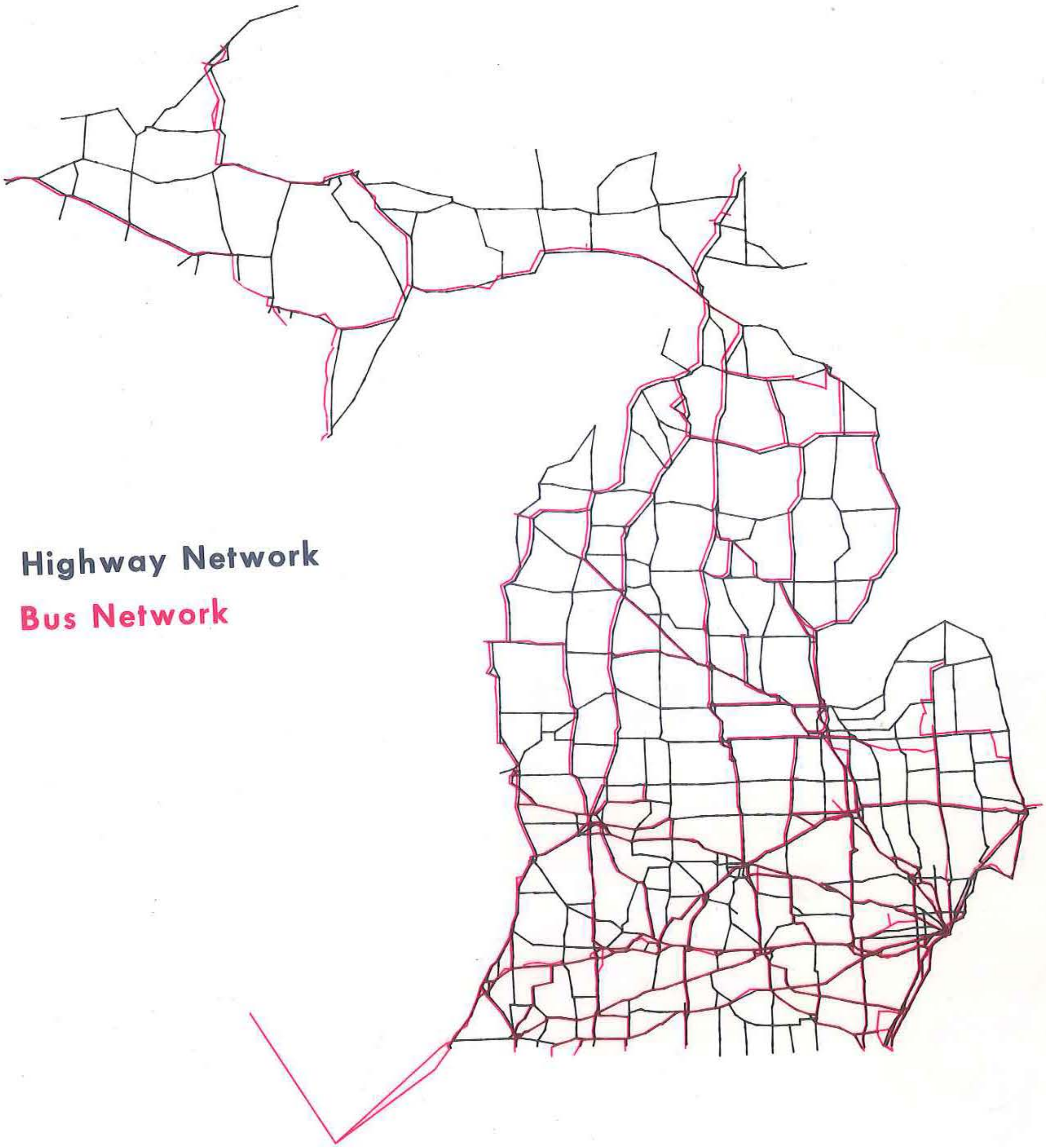


FIGURE 1

Highway Network

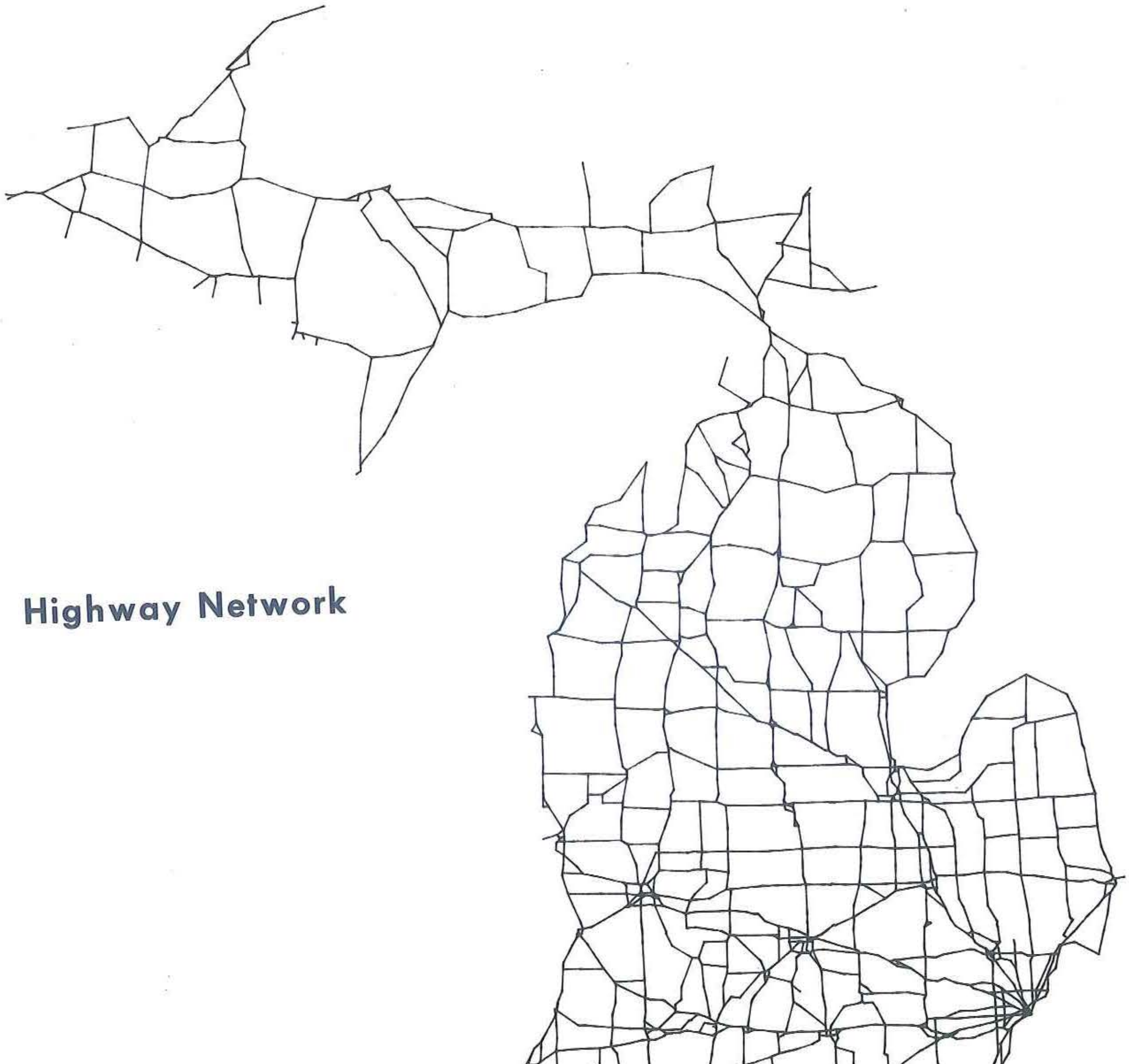
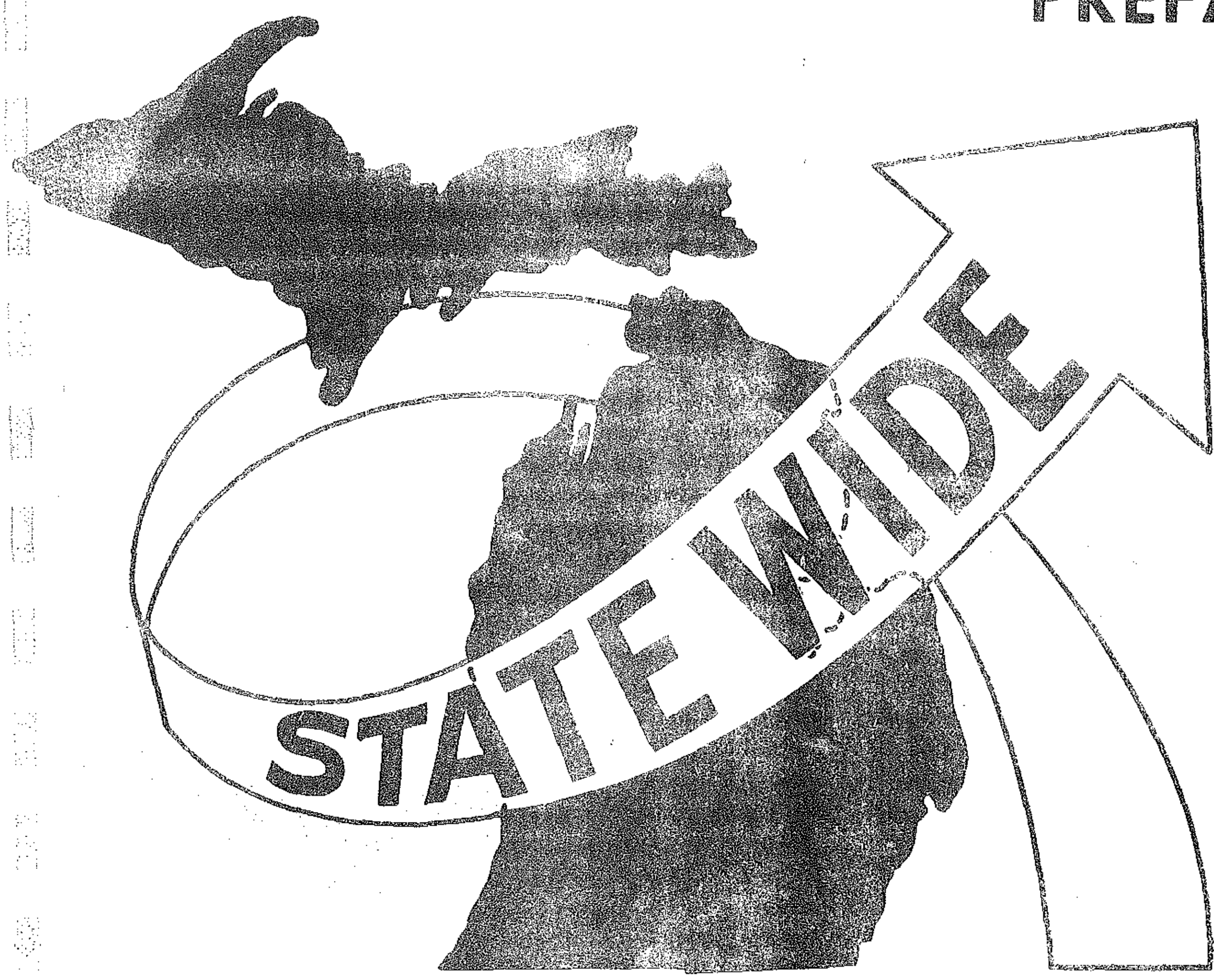


FIGURE 1

PREFACE



PREFACE

Transportation planning is rapidly becoming a sensitive and complicated task. Most transportation departments have come to realize that many issues which were once relatively unimportant have, in recent years, grown so greatly in value that now their consideration is vital to any totally successful transportation project. This is reflected in the Section 109(h) guidelines of title 23, United States Code, added to the code by Section 136(b) of the Federal-Aid Highway Act of 1970. These guidelines "call on Highway Agencies to adopt procedures and assign responsibilities to insure early identification of potential social, economic, and environmental effects, both beneficial and adverse. The Action Plan is to cover consideration of alternative courses of action, including the option of no highway improvement and, where appropriate, alternative scales of highway improvements and reliance upon other transportation modes." (Report to Congress on Section 109(h), Title 23, United States Code, Department of Transportation Federal Highway Administration, June 1972)

> "The process by which decisions are reached should be such as to merit public confidence in the Highway Agency. To achieve this objective, it is the Federal Highway Administration's policy that" (among other things)" . . . . appropriate consideration be given to reasonable alternatives, including the alternative of not building the project and alternative modes . . . . appropriate alternatives which might minimize or avoid adverse social, economic, or environmental effects should be studied and described . . . . The key trade-offs among the alternatives should be presented". (Section 109(h) guidelines).

The guidelines go on to state that the Action Plan must identify and assign responsibility and procedures to ensure that "the development of new transportation modes or the improvement of other modes are adequately considered, where appropriate." Because of these direct references requiring the consideration of other modes, it is now imperative that transportation agencies develop some systematic method of evaluating multi-modal alternatives.

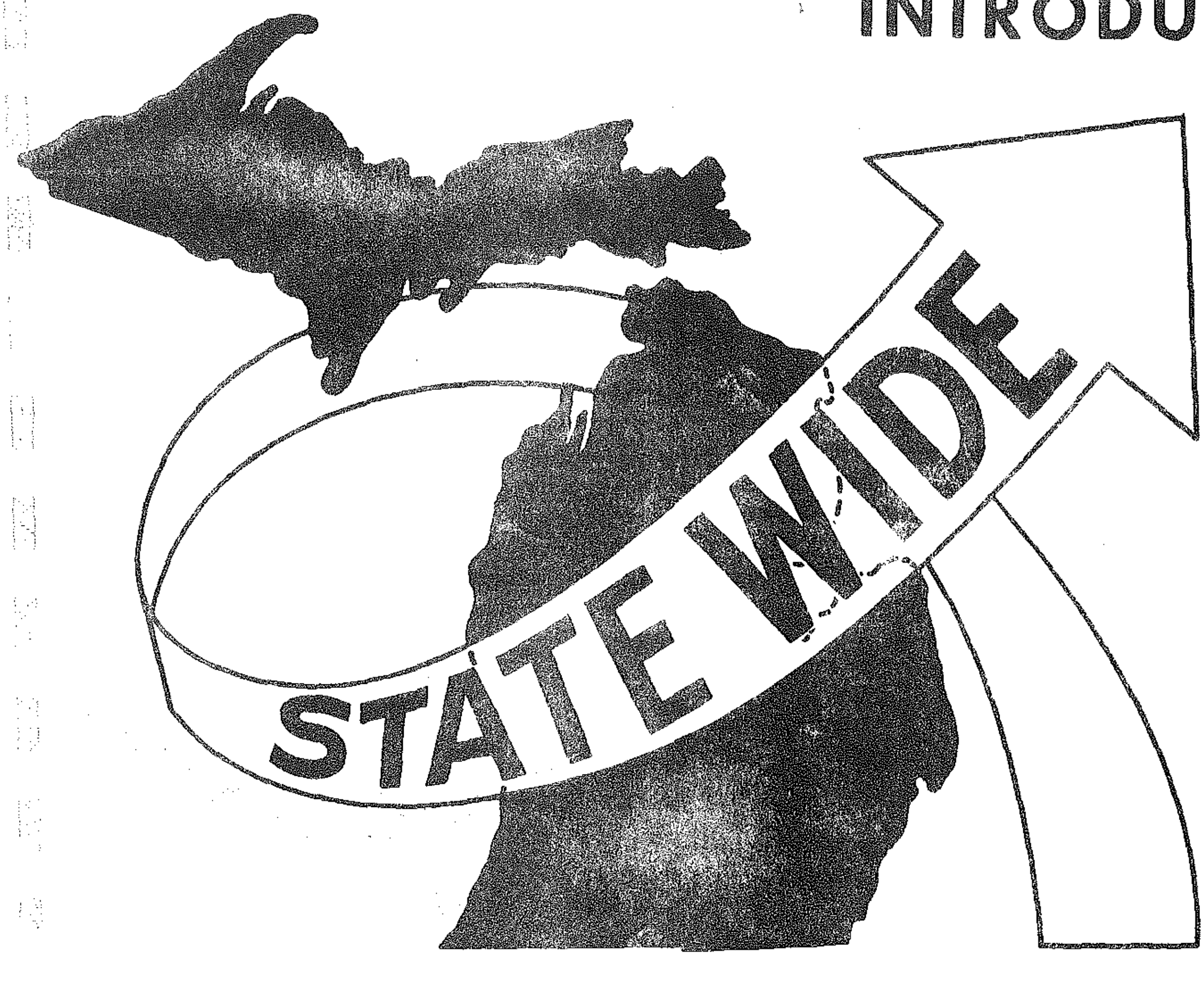
Even without such directives, present conditions make consideration of such alternatives invaluable. In the face of a potentially serious energy crisis, for example, mass transit may become an absolute necessity. For instance, it has been shown that if rail travel were utilized to its full extent, both for freight and passenger service, energy consumption would be drastically reduced. A Rand Corporation Study of 1971--"The Effect of Fuel Price Increases on Energy Intensiveness of Freight Transport"--attempted to measure modes of transportation by approximate average energy intensiveness, expressed in BTU's per ton mile. Waterways were reported at 500, railroads at 750, pipelines at 1,850, trucks at 2,400--more than three times the railroad figure--and air cargo came in at an astonishing 63,000. Other issues which alternate modes of transportation may help to address are air and noise pollution, environmental effects and land use.

Scarcities of resources are not limited to energy, moreover. In the face of increased demands on tax revenues, departments of transportation cannot afford to allocate money to projects without some degree of assurance that the money will be doing as much good as possible. A statewide multi-modal model such as the one described here could help to apportion funds to a transportation system which is "best" for the whole state.

In addition, the subject of multi-modal accessibility is becoming important. This topic actually encompasses two relevant issues. First, one might measure the accessibility of various socio-economic groups <u>to</u> various modes of travel. This is especially pertinent in the case of older or lower-income segments of the population. Second, accessibility <u>by means of</u> a particular mode could be calculated and compared between modes. This concept also is especially applicable in goods movement to choosing the optimal combination ofshipping modes.

More and more, transportation agencies will be expected to address many issues with regard to multi-modal statewide planning systematically and efficiently as some of the above examples indicate. This report deals with the development of just such a system for Michigan.

INTRODUCTION



INTRODUCTION

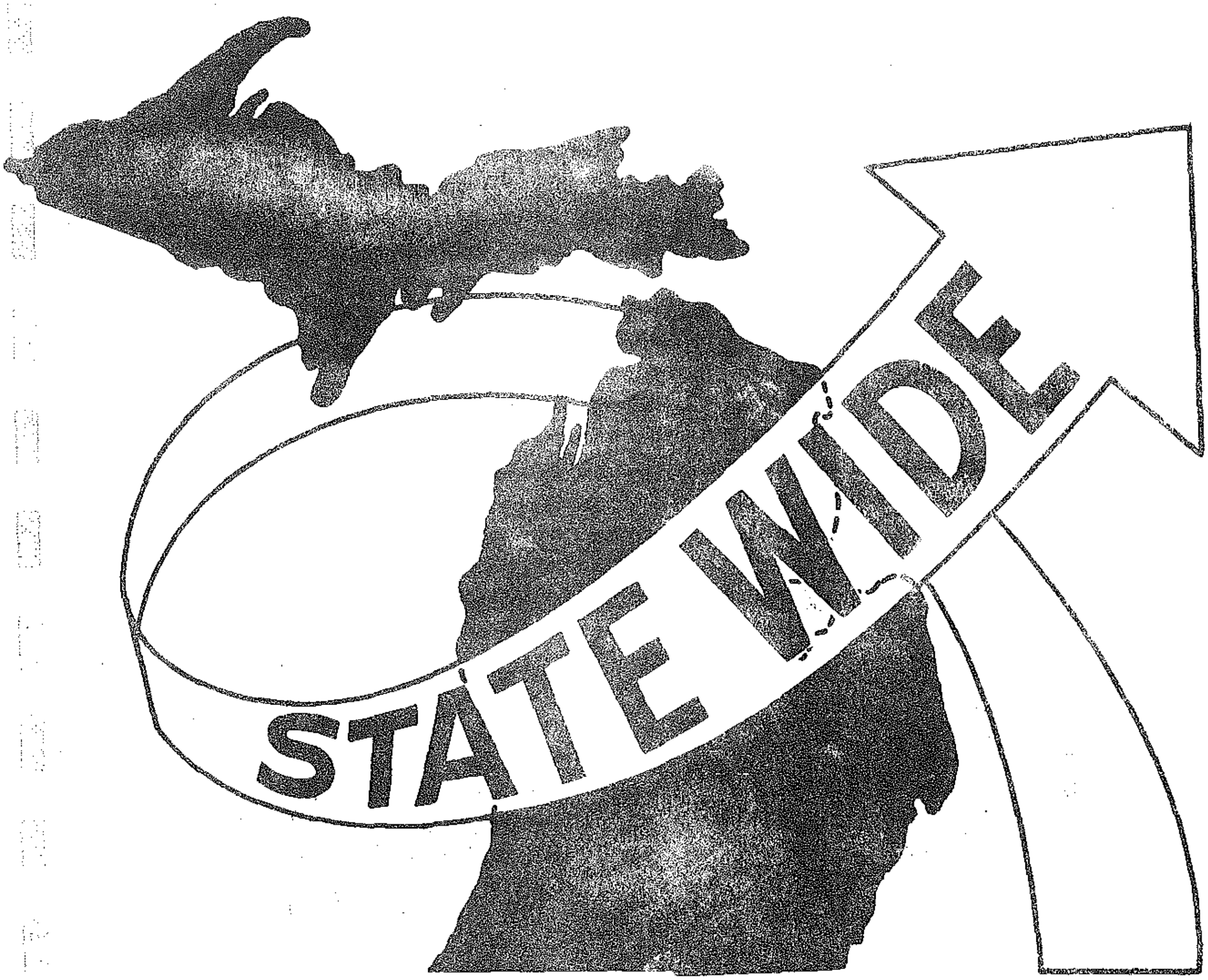
It quickly becomes obvious that the task set before transportation agencies is no small one. If the Federal guidelines are to be followed carefully, certain tools and methods must be developed to aid in a systematic, accurate evaluation of the proposed and viable alternatives. To more effectively address the task now assigned, many transportation agencies are turning to analysis at the statewide and regional system level. For this purpose, transportation models have been created which are capable of evaluating the social, economic, and environmental aspects of projected travel. Such a model of the Michigan highway system is now being used extensively to monitor these highway impacts. This computer model makes the consideration of travel, social, economic, and environmental impacts for given alternatives much simpler, for the proposed system additions or changes may be made within the base data files and the most likely results will be simulated in a very systematic manner.

Up until this report, however, Michigan's model was mainly a highway model. An invaluable addition to the system is the option of evaluating other travel modes and the interaction of those modes with daily highway travel. This multi-modal option is currently being tested at the regional level and hopefully will be available for general statewide use within the next year. To accomplish this, it has been necessary to define statewide networks for each mode, defining these transportation systems in such a way as to permit travel to be diverted from one mode to another in response to changing priorities and service levels. Figure 1 shows the four model networks as they have been developed during the implementation of the multi-modal transportation modeling system. These networks make it possible to simulate the effect removing bus service between two cities will have upon air and highway usage, for example. It may also prove invaluable to explore the effects of reinstating rail passenger service. Along certain corridors, this might alleviate some environmental and economic effects of ever-increasing automobile traffic in these cases.

In addition, once a passenger-demand model for Michigan has been calibrated at the system level, the basic networks can serve a dual purpose and be used to formulate a statewide commodity-flow model. The increasing costs of consumer goods and the current energy shortage demands that commodities be moved by the most economical and efficient means available.

An effective statewide multi-modal modeling system for Michigan must therefore be designed so as to provide a framework not only for testing the adequacy of existing facilities within present corridors, but also to facilitate long-range transportation planning. As such, it must be flexible enough to be able to reflect changing attitudes, goals, objectives, and economic conditions at a regional level. Moreover, it must have the capability of testing the probable effects of the implementation of a number of alternative multi-modal plans and to contrast the socio-economic and environmental impacts of each. Only in this way can Michigan address itself to true long-range system planning, rather than restricting its vision to stopgap measures and disjoint transportation plans which may not be advantageous to the state as a whole and, in many instances, local communities.

GOALS FOR STATEWIDE TRANSPORTATION PLANNING



GOALS FOR STATEWIDE TRANSPORTATION PLANNING

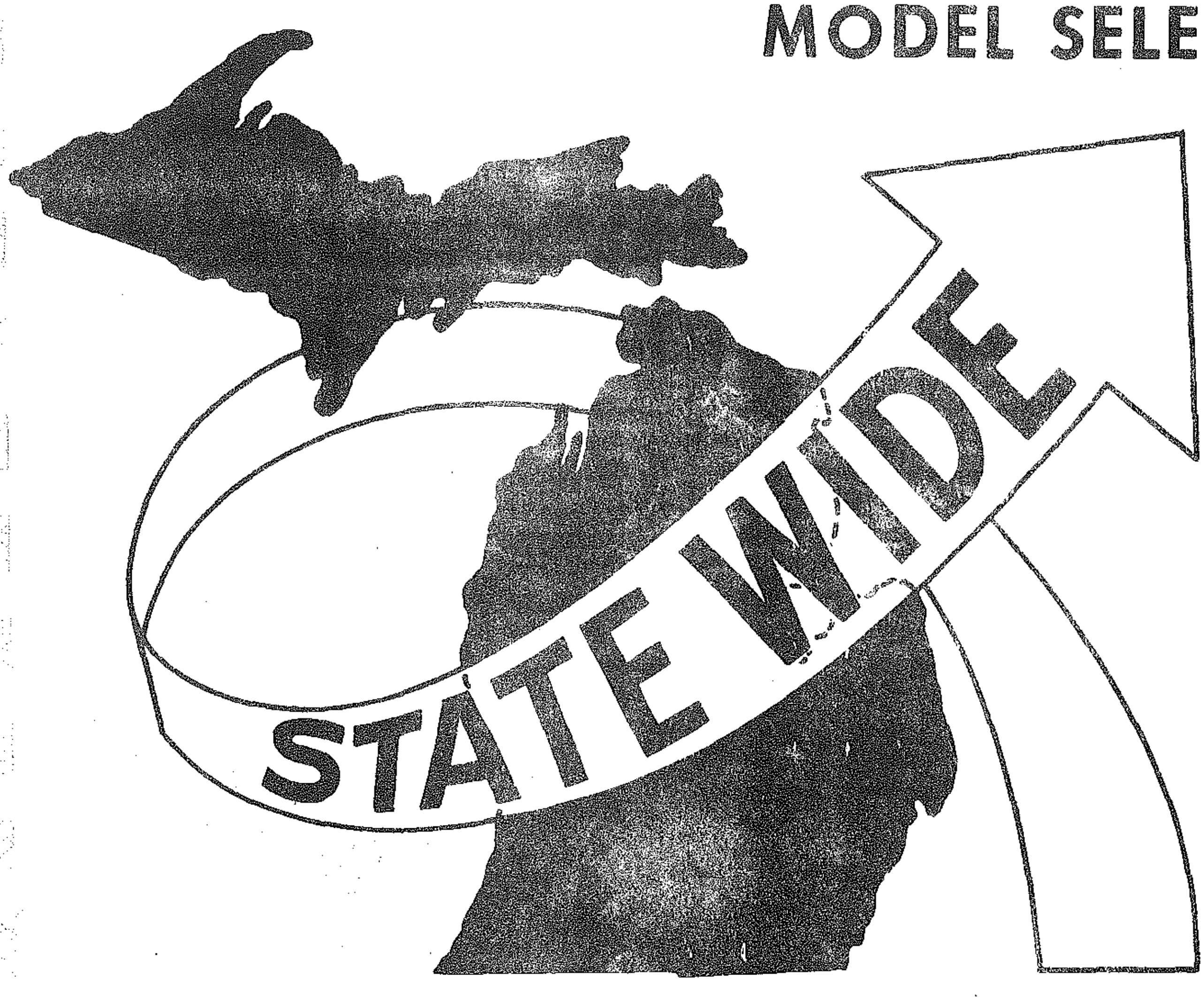
A workable multi-modal transportation modeling system is worth little if it does not address itself to system-level transportation planning goals. It is also important that the set of goals be the same for all modes. In this way, they become transportation goals rather than mode-specific goals and make possible comprehensive statewide transportation planning. In the real world, each mode competes with other modes for its share of passengers and commodities. It follows that any set of goals and objectives which treats each mode as if it existed in a vacuum cannot really reflect reality.

A partial list of possible statewide transportation planning goals may be divided into three general categories: user goals, carrier goals, and goals for the state as a whole. User goals include such things as decreasing travel time and cost, increasing safety, and increasing accessibility. This last item is especially important both to passengers and to shippers; passengers wish to be made accessible to a greater variety of opportunities for work, shopping, and recreation, and shippers would like access to wider markets and improved sources of supply. In both cases, a user should be able to choose between modes; an effective modeling system should be able to provide enough information so that a user's choice of modes is the best choice for him.

"Carrier goals" deal mainly with the carrier's ability to make a profit. The carrier would like to minimize capital costs--vehicle costs, terminal costs, and the cost of equipment for loading, unloading, and storage. He wishes to minimize his administrative, maintenance, and operating costs. He can increase profit by increasing the volume of passengers or goods he carries, and he should seek to accompany an increase in volume with an increase in efficiency. To answer a carrier's questions, a multi-modal modeling system ought to be able to show him the effects of his policy decisions on progress toward his particular set of goals.

Because any goals defined for an entire state must reflect the interests of all segments of the state's population, they tend to be less precisely drawn. However, some goals of transportation planning can be stated in general terms at the statewide level. For example, any state would like its transportation system to increase the accessibility of its citizens to opportunity, and to do this so that all segments of the population are treated equitably. In the area of land use, transportation may be used to promote desirable patterns of growth. An important goal of any state is to reduce the adverse impacts of its transportation system on the environment. Finally, a transportation system should serve as a support system for increased productivity of goods and services. In order to plan transportation that serves statewide goals such as these, decision-makers need a modeling system which can show the statewide impacts of multi-modal planning decisions.

MODEL SELECTION



MODEL SELECTION

In many situations within the state, a county-level zone system would be an acceptable level for present analysis. However, without a finer system, it might be difficult to test the future effects of adding or deleting short branches from a given mode. Therefore, Michigan's 547-zone traffic-forecasting zone system was selected as the appropriate level of detail. The instate zones, shown in Figure 2, are either cities, townships, or combinations of townships. The out-of-state zones are county-level or coarser.

Two alternatives were possible for the development of a passenger-demand model. Either an entirely new model could be formulated, or an existing modeling package could be adapted for use at the 547-zone level. Two major factors strongly influenced the decision to choose the latter course of action.

First, time is of the essence. In both the public and the private sector of the economy, attention is increasingly being turned to the problem of whether modes of travel other than highway could be more efficient in the allocation of limited resources of energy and of money. In view of the pressing nature of these questions, a method of providing answers and possible solutions as quickly as possible holds a definite advantage.

Second, it was discovered that Stanford Research Institute had developed a battery of the Stanford Network Analysis Package computer programs for predicting inter-city multi-modal passenger demand, under the auspices of the now-defunct Interagency Transportation Council. The SRI package had been calibrated to Michigan data and was already oriented to system-level analysis. The modular nature of the battery allows the use of only the specific programs which directly apply to the zone-level intercity passenger-

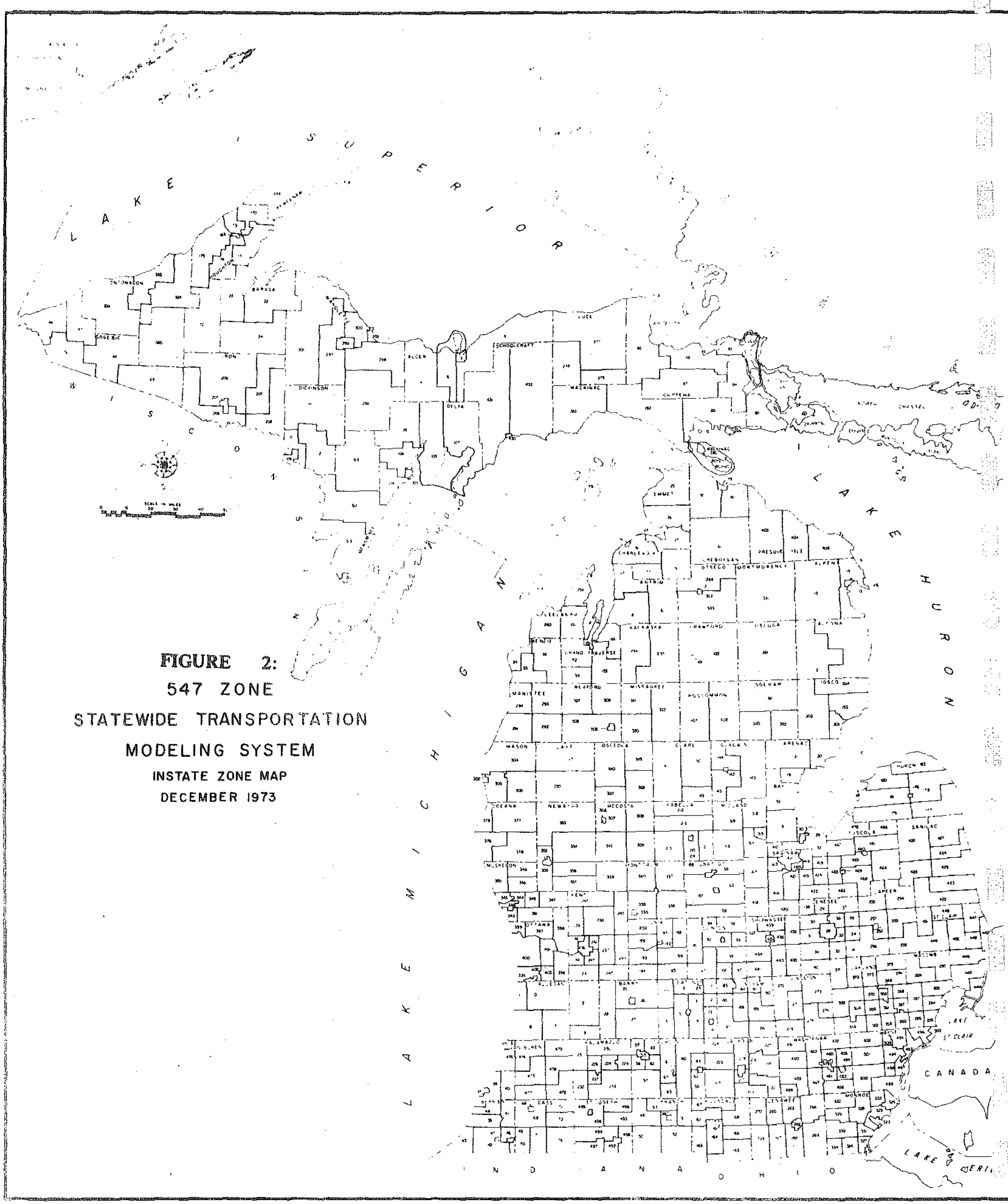


FIGURE 2:
547 ZONE
STATEWIDE TRANSPORTATION
MODELING SYSTEM
INSTATE ZONE MAP
DECEMBER 1973

demand situation. Finally, it offers the potential to answer many management questions, such as trade-offs between subsidizing alternative modes, generation of revenues through augmentation of service, and the calculation of avoidable costs through abandonment of specific routes.

Therefore, it was decided to adapt portions of the SNAP battery to the 547-zone system. In this way, a multi-modal passenger-movement model could be prepared with the least duplication of effort and expenditure of monetary and manpower resources. At a later stage, a commodity-flow model will be added, using data from the U.S. Department of Transportation Rail Waybill Surveys, trucking commodity-flow information taken by Michigan Department of State Highways and Transportation survey crews, and data on goods movement by air freight.

HIGHWAY NETWORK

HIGHWAY NETWORK

The present highway network was first developed by the Statewide Studies Unit in 1966, with the cooperation of the consultant firm of Arthur D. Little, Inc. It contains all state trunklines plus selected county roads and principal segments of highway in neighboring states. Figure 3 is a plot of this network. The zone system associated with this network contains 547 zones; 508 are in Michigan and the remainder are outstate zones. Each Michigan zone is a city, township, or a group of townships (see Figure 2). The outstate zones are county-level or coarser (Figure 4). A "centroid" or center of population has been chosen for each zone. This is a given point within the zone at which all travel is assumed to originate or terminate. The basic element of the highway network is a "link", a small segment of highway approximately 1-5 miles in length. Each link is uniquely identified by a pair of numbers, called nodes, designating its endpoints; this is referred to as an "A-node, B-node" format. A node number is found at each intersection and often at county lines. Thus a link is generally a segment of highway between two consecutive intersections. To complete the highway link file, other links, called "access" or "centroid" links are included which connect the centroids to the highway system. These are the short lines with one end unconnected which are easily spotted in Figure 3.

Many useful applications of this network would be impossible, however, without the information which is stored in a number of link specific fields called "volume words". As many as 25 pieces of data which describe the physical characteristics may be stored on each link. A list of the information

FIGURE 3: MICHIGAN STATEWIDE HIGHWAY NETWORK PLOT (547 ZONE SYSTEM)

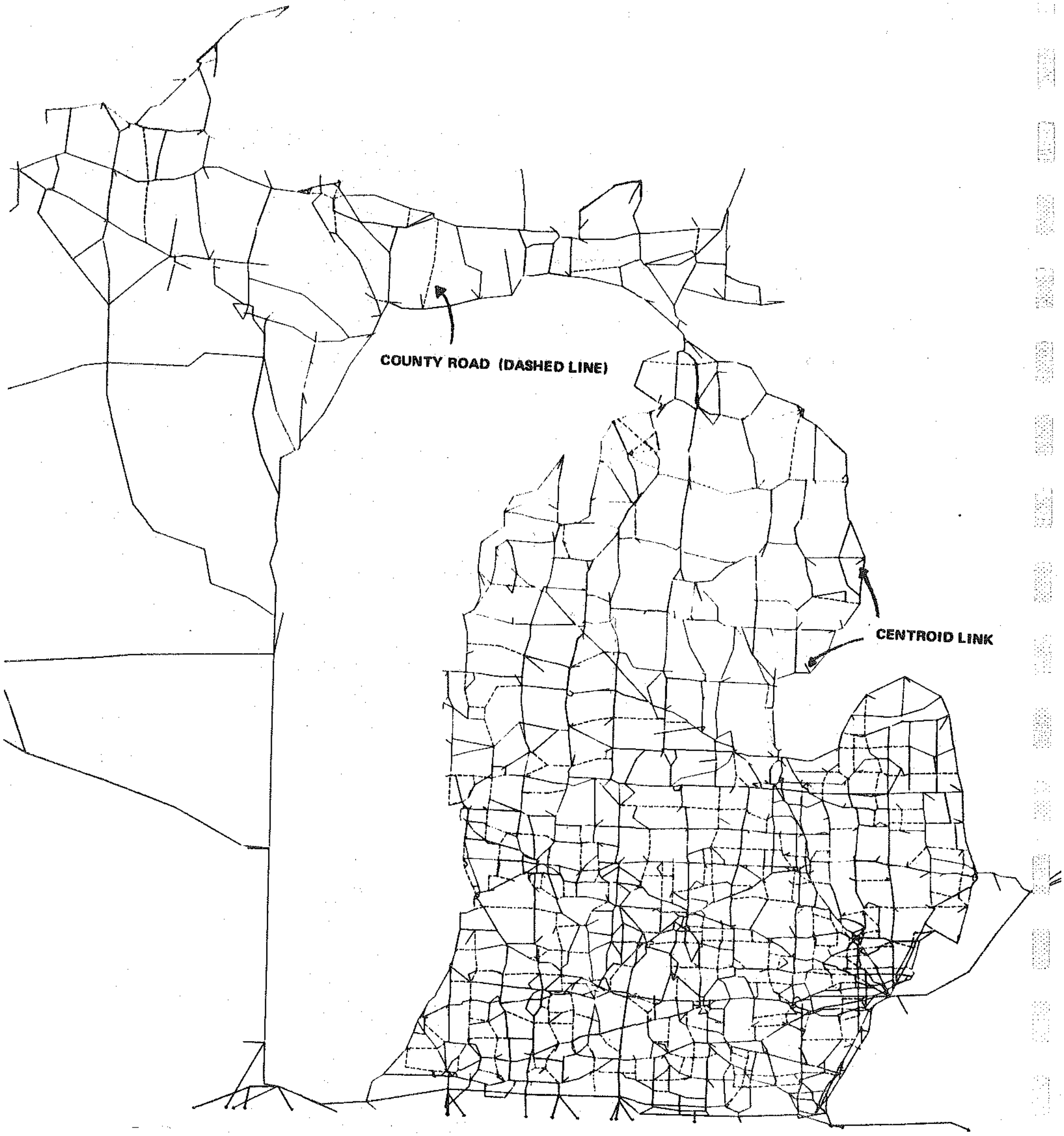
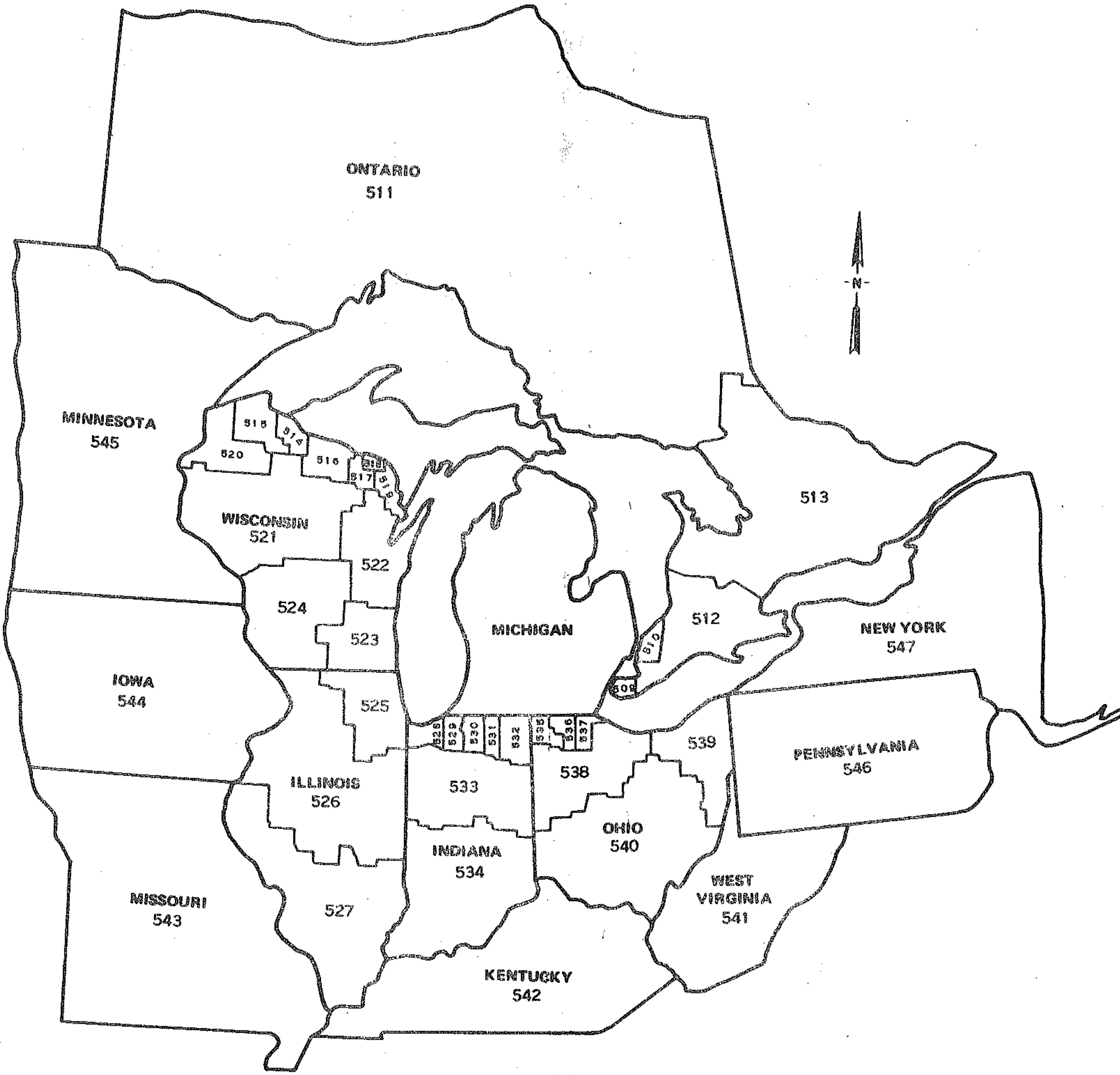


FIGURE 4:

MICHIGAN'S TRANSPORTATION MODELING SYSTEM

547 ZONE
OUTSTATE ANALYSIS ZONES



now available is given in Figure 5.

Because this network has been in use for many years and many programs have been developed in conjunction with this network description, it was obviously the only appropriate choice when selecting a highway network to use in conjunction with other modes.

STATEWIDE HIGHWAY NETWORK

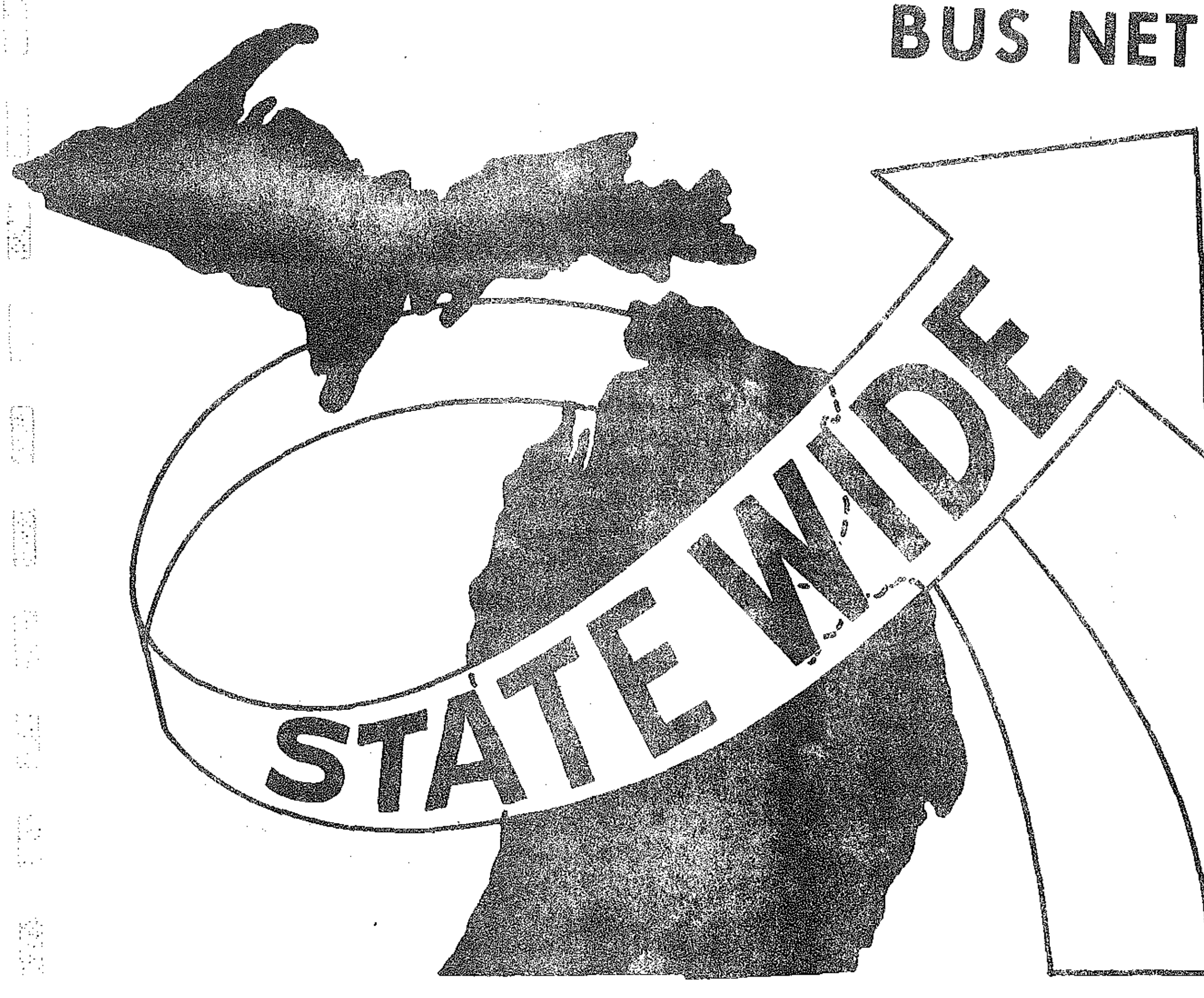
LINK FILE

CONTENTS OF EACH HIGHWAY SEGMENT OR LINK

AVERAGE SPEED
DISTANCE
URBAN-RURAL DESIGNATION
TYPE OF ROUTE
TRAFFIC VOLUME CAPACITY
AVERAGE ANNUAL DAILY TRAFFIC VOLUME
COMMERCIAL TRAFFIC VOLUME
DESIGN HOUR VOLUME
ACCIDENT FATAL RATE
ACCIDENT INJURY RATE
ACCIDENT RATE
NUMBER OF LANES
LANE WIDTH
SURFACE CONDITION
RIGHT OF WAY
SIGHT RESTRICTION

FIGURE 5

BUS NETWORK



BUS NETWORK

The bus network differs from the air and rail networks in one major respect: buses use public highways. Because of this, it seemed only logical to use the existing highway network mentioned in the previous section to create the desired bus network. With the SRI NET BUILD program in mind, the bus network was selected from "Russell's Official National Motor Coach Guide". Each Michigan route was studied and those which were unique (in terms of stops) from all others were listed for a total of 177 routes. These routes were then coded onto the highway network by successive node numbers, with negative nodes for nodes at which the bus did not stop, and positive node numbers for nodes at which the bus stopped. Using this description, the Net Build Program selects the necessary highway links to create a bus network. Since this network is subject to change whenever routes are added or deleted, this method of defining the bus network should be very convenient. Each bus link also has a volume word containing the frequency per day of buses along that link.

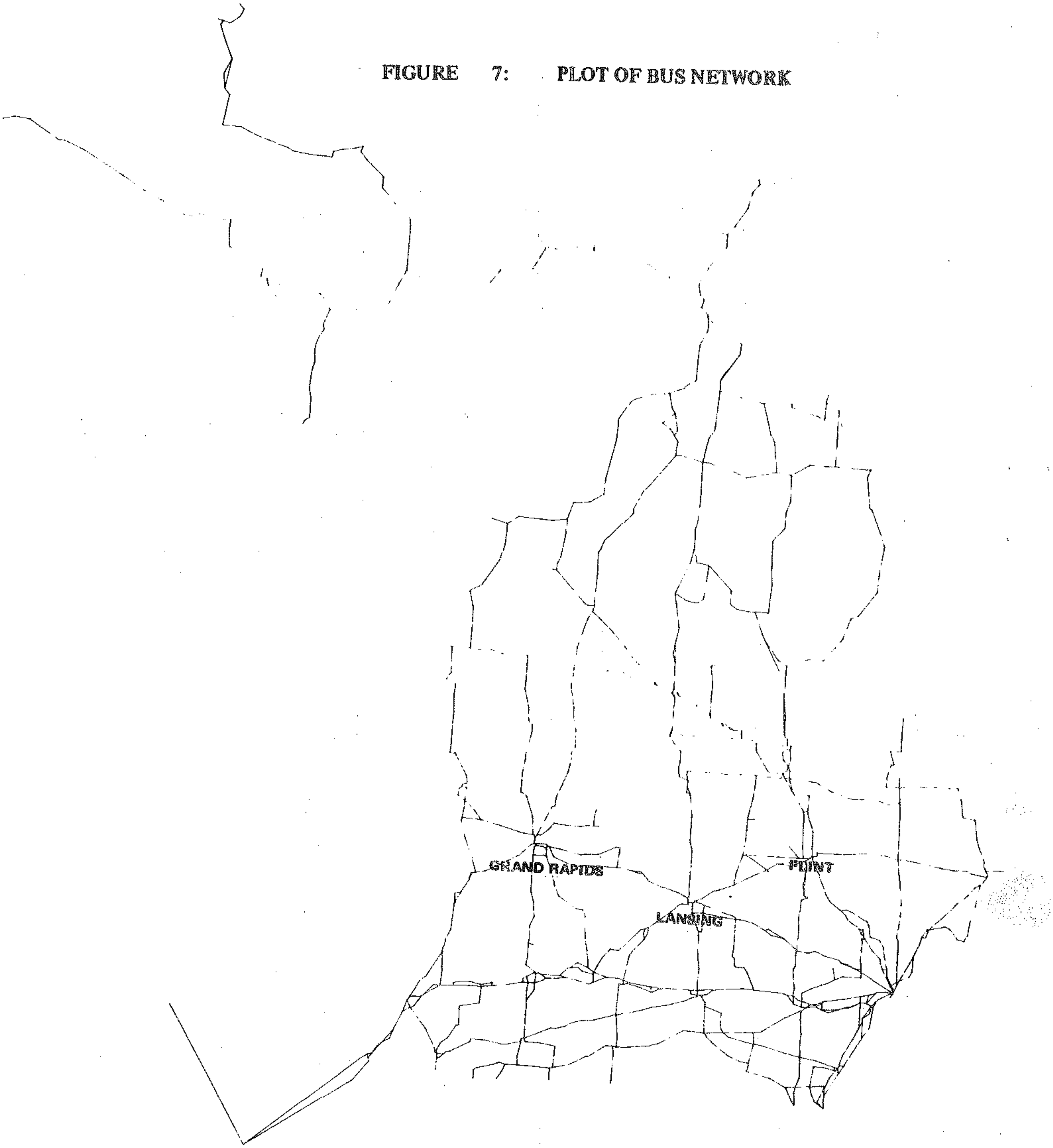
In addition, the location of each bus station appears in the Statewide Public and Private Facility File (Figure 6). This permits the calculation of the accessibility of people to bus stations with a minimum of effort and may be used in other statewide multi-modal analysis. Figure 7 is a plot of the bus network as it has been developed during the implementation of the Statewide multi-modal travel forecasting process.

STATEWIDE FACILITY FILE

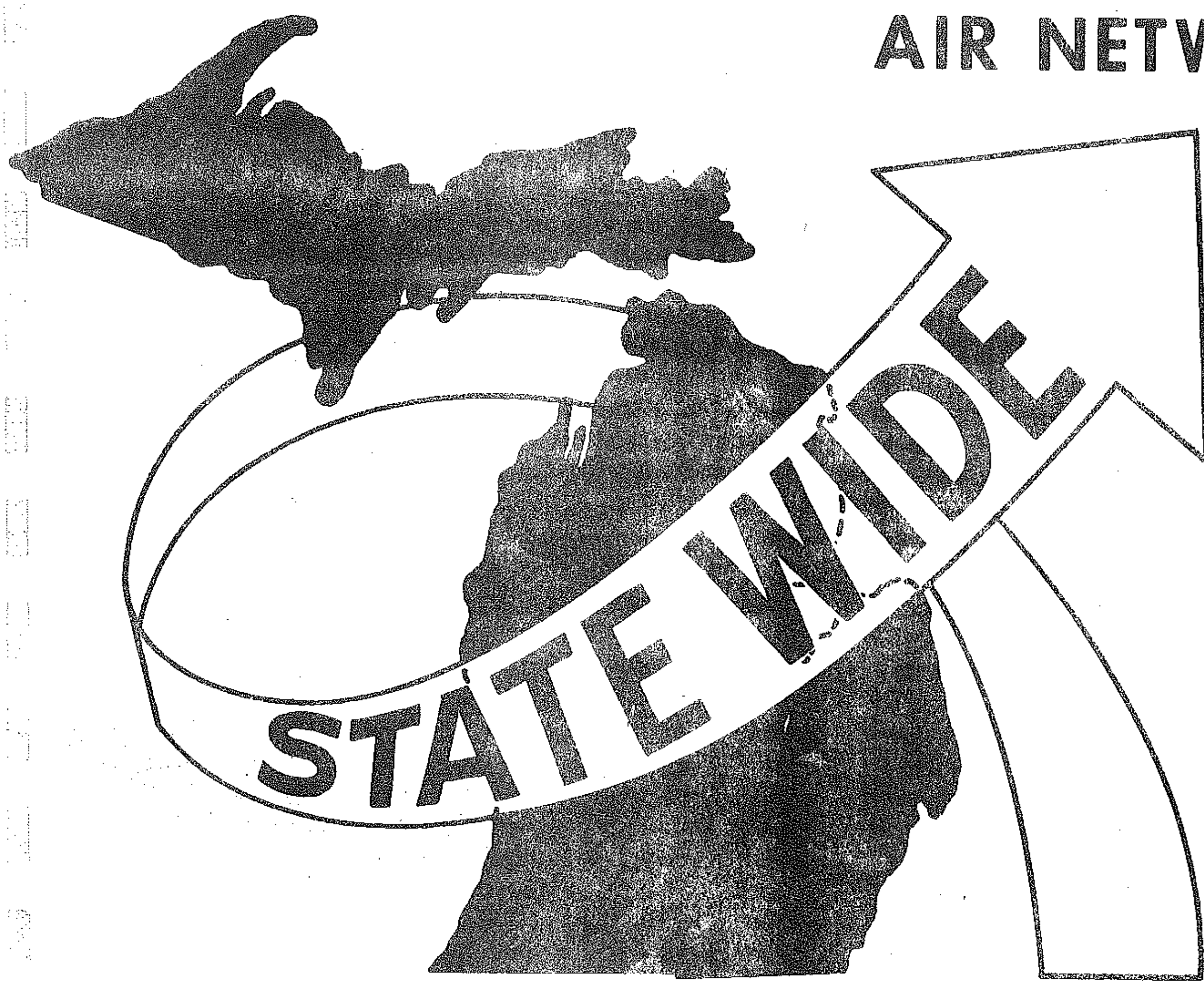
AIRPORTS
AMBULANCE SERVICE
BUS TERMINALS
CAMP GROUNDS, PUBLIC AND PRIVATE
CERTIFIED INDUSTRIAL PARKS
CITIES OVER 30,000 POPULATION
CITIES OVER 5,000 POPULATION
CIVIL DEFENSE TERMINALS
COLLEGES, NON-PUBLIC
COLLEGES, PUBLIC COMMUNITY
COLLEGES AND UNIVERSITIES, PUBLIC 4 YEAR
CONVENTION CENTERS
GAME AREAS
GOLF COURSES
HIGH SCHOOLS
HISTORIC SITES
HOMES FOR THE AGED
HOSPITALS
MAJOR COMMERCIAL CENTERS
MANUFACTURERS
MENTAL HEALTH CENTERS
NEWSPAPERS, DAILY
NEWSPAPERS, WEEKLY AND BIWEEKLY
NURSING HOMES
PORTS
RAIL TERMINALS
SECRETARY OF THE STATE OFFICES
SEWAGE TREATMENT FACILITIES
SKI RESORTS
SNOWMOBILE TRAILS
STATE PARKS
STATE POLICE POSTS
TOURIST ATTRACTIONS
TREASURY OFFICES
TRUCK TERMINALS
UNEMPLOYMENT OFFICES
WEATHER SERVICE STATIONS-NATIONAL
WHOLESALE TRADE CENTERS

FIGURE 6

FIGURE 7: PLOT OF BUS NETWORK



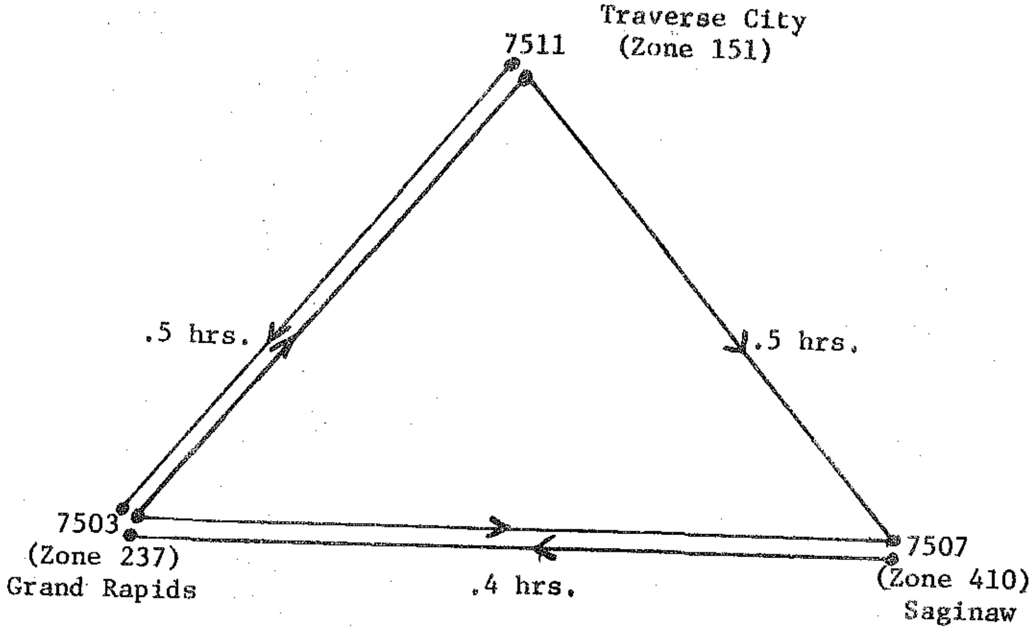
AIR NETWORK



AIR NETWORK

The air network, again similar to the highway network system, consists of all Michigan airports with regularly scheduled passenger flights and links joining those airports which are actually connected by at least one flight. To determine those airports and links which qualified, the "Official Airline Guide, North American Edition" was consulted. Node numbers are located at each airport. The links in this network are one-way links, since in some cases, flights are only scheduled in one direction between two airports. Each link contains the travel time from origin to destination and the zone of destination (see Figure 8). A few outstate airports have also been included in the network so that, at present, all direct flights from every Michigan airport has a corresponding one-way link with the exception of Detroit Metropolitan Airport. Only the closest outstate airports are currently in the network, but plans have been made to add all other airports connected to Michigan (via Detroit Metro Airport) by direct flights. Also, because of changes in scheduled flights, network changes will periodically be required. A computer plot of Michigan's air network is depicted in Figure 9.

The names and locations of all airports included in the current National Airport Systems Plan and the State Airport Systems Plan are included in the Statewide facility file together with data on the passenger travel originating and terminating at each airport. This was obtained through the cooperation of the Aeronautics Commission.



A-node	B-node	Travel Time	Destination Zone
7503	7511	.5 hrs.	151
7511	7503	.5 hrs.	237
7503	7507	.4 hrs.	410
7507	7503	.4 hrs.	237
7507	7511	.5 hrs.	151

FIGURE 8: EXAMPLE OF ONE-WAY AIR LINKS

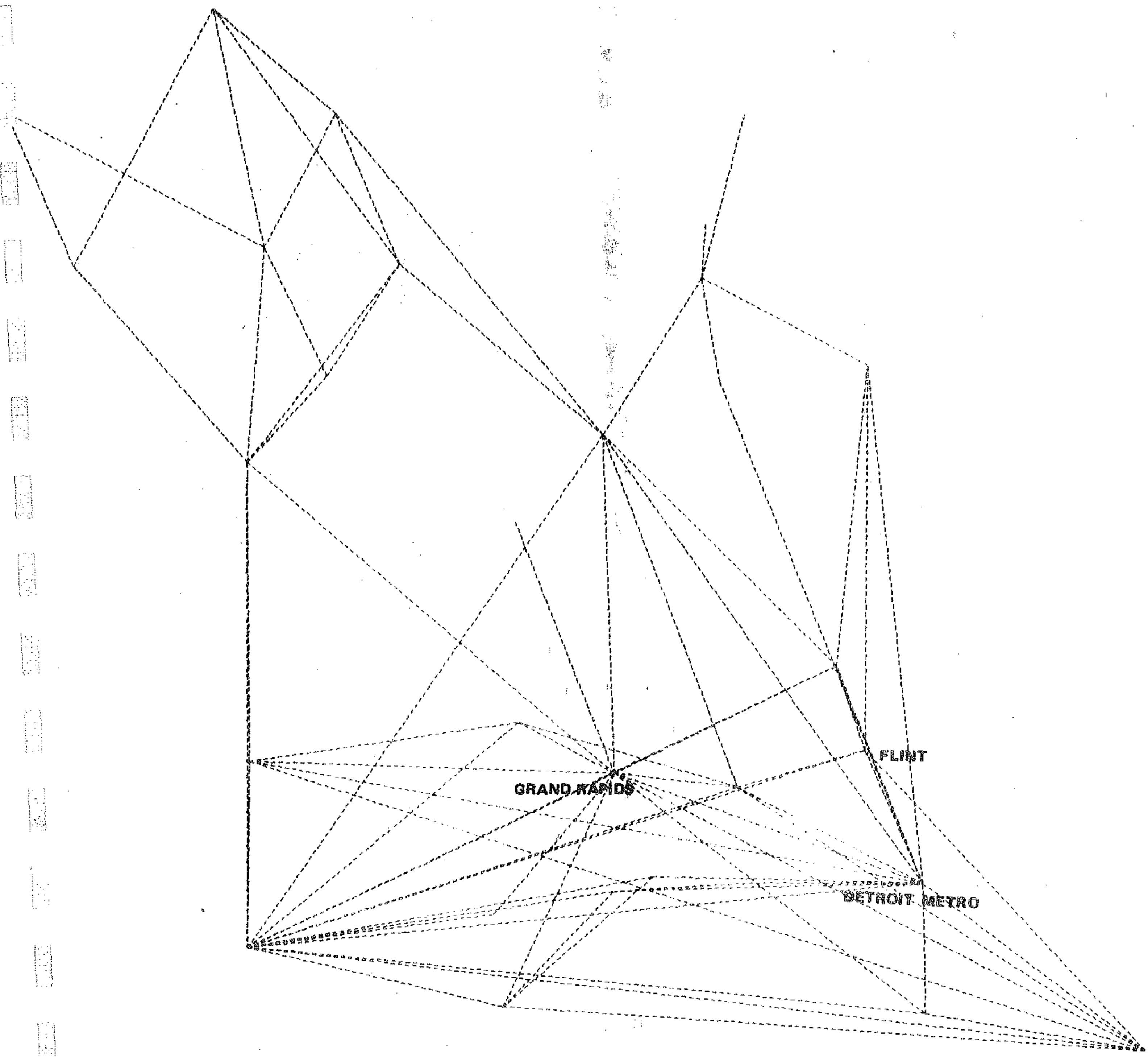
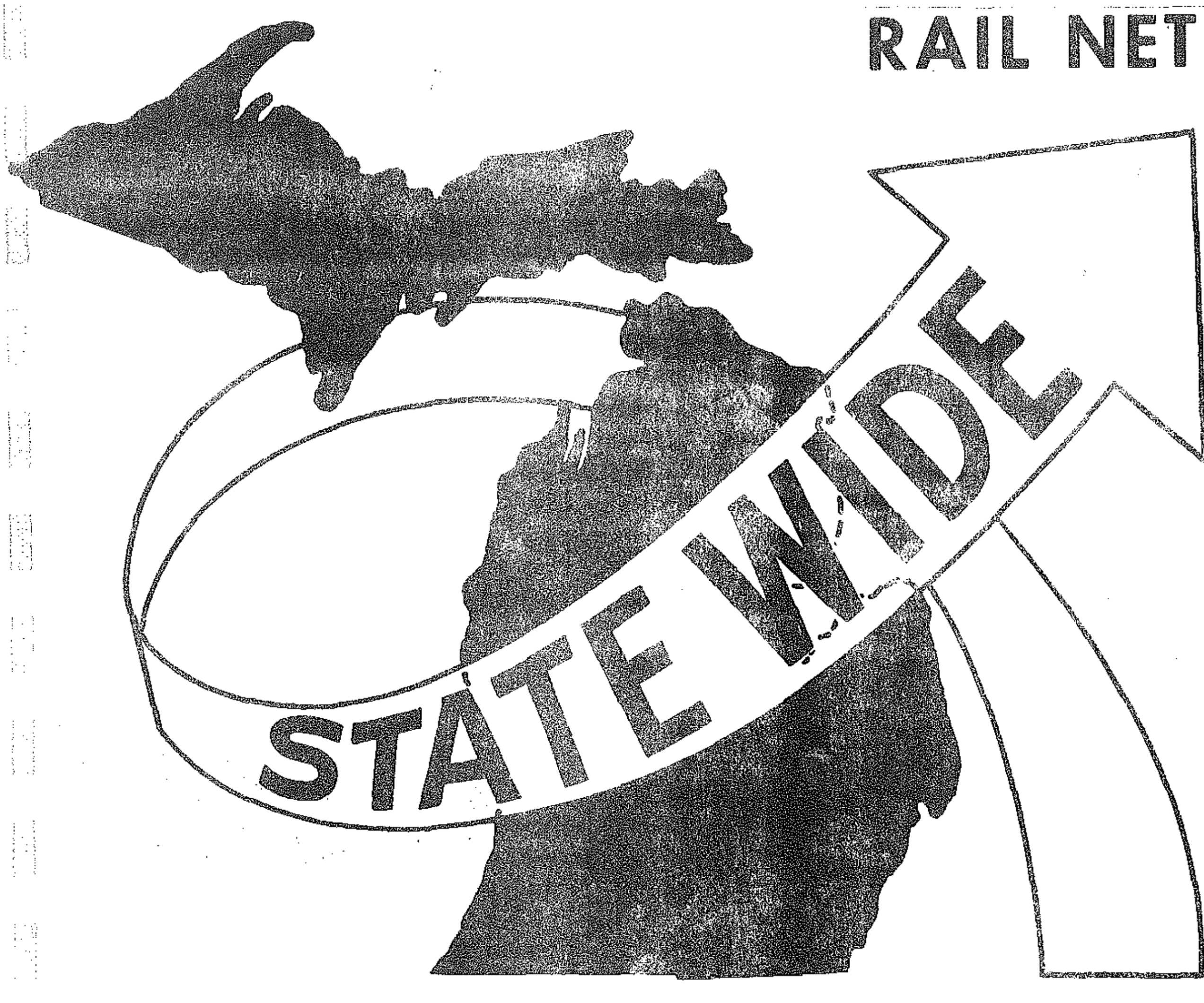


FIGURE 9: PLOT OF AIR NETWORK

RAIL NETWORK



RAIL NETWORK

This network was created in nearly the same fashion as was the highway network. The "Official Railway Map of the State of Michigan, January 1, 1965" was used as a guide. All the tracks on this map, except those known to have been removed, have become part of the coded rail network. An inventory of all stations appearing on this map resides in the facility file in Figure 6. Each segment of rail track between two consecutive stations (or intersections) was coded as one link for a total of 2300+ links. Each link as present contains six volume words. The information on these links is listed here:

1) Distance
2) Destination Zone
3) Maximum Speed
4) Control Section Numbers
5) Number of Tracks

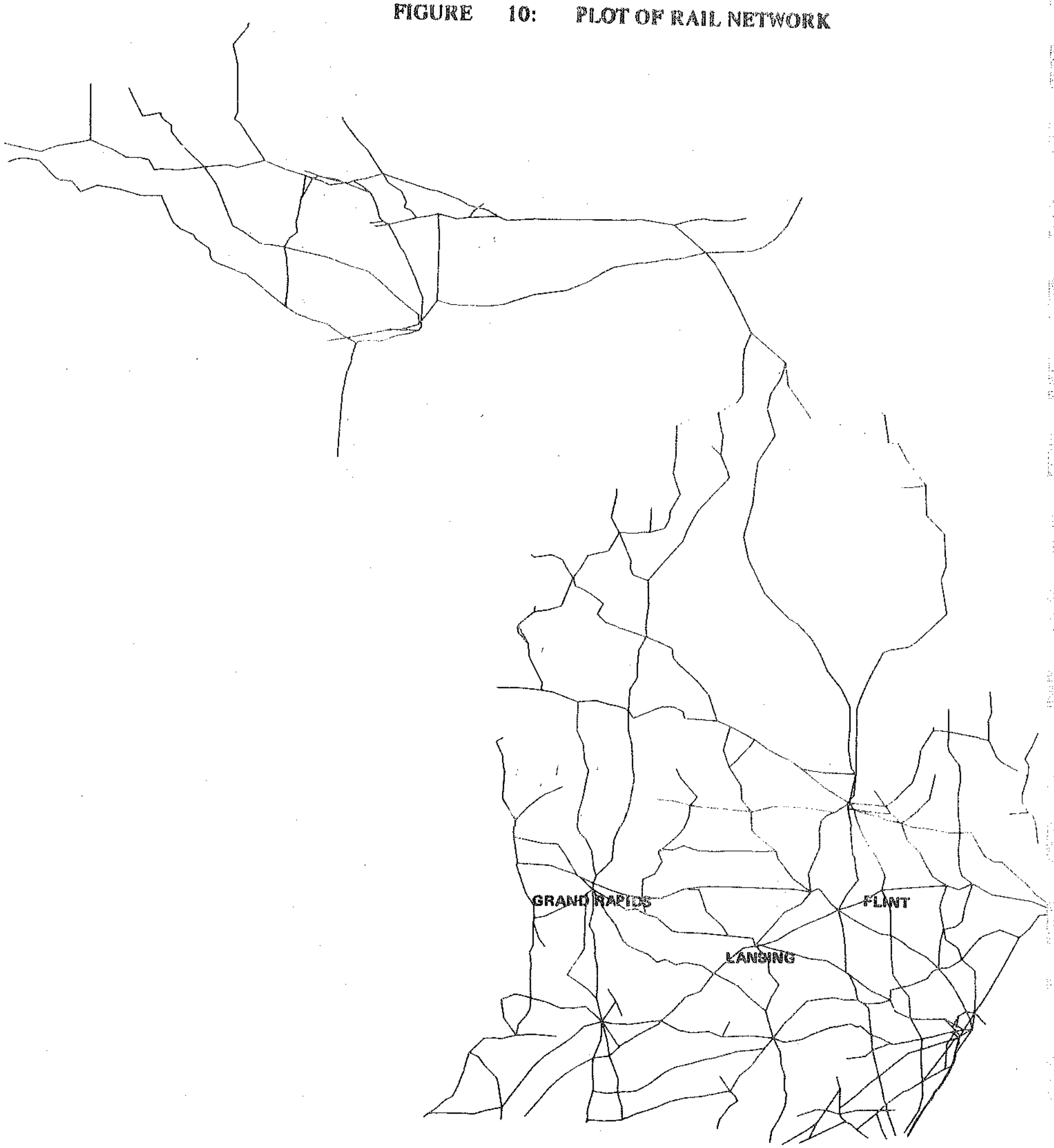
   (As defined by the Rail Planning Section of the Modal Planning Division) [items 3–5]

6) Track Company Binary Code

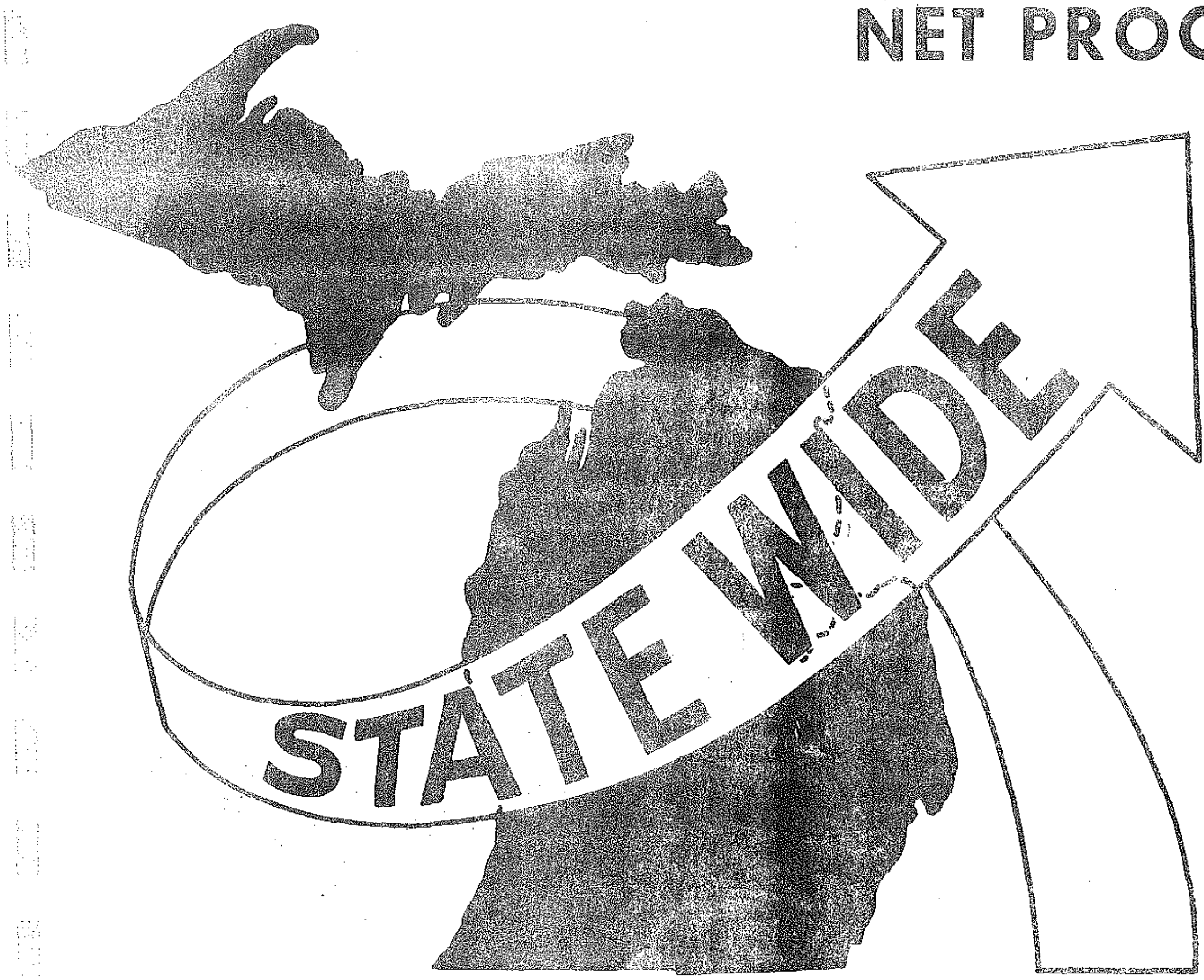
Some links also have passenger and freight times, but in most cases, this information is still being collected and edited before being placed in the rail network. Blanks may also occur in the other volume fields, indicating that this information has not yet been located for our use. In particular, speeds have not yet been coded for the entire state. Outstate rail links and car ferry links are being added to the network at this time.

The network, as it presently appears, contains some branches which are not operational. This is not an oversight. Every link need not be used in every assignment, but it is important to be able to test quickly the effects of reactivating a given branch line. This can be done most easily if the line already exists in the network and need only be "opened" internally. A plot of the Statewide rail network is shown in Figure 10.

FIGURE 10: PLOT OF RAIL NETWORK



NET PROGRAM



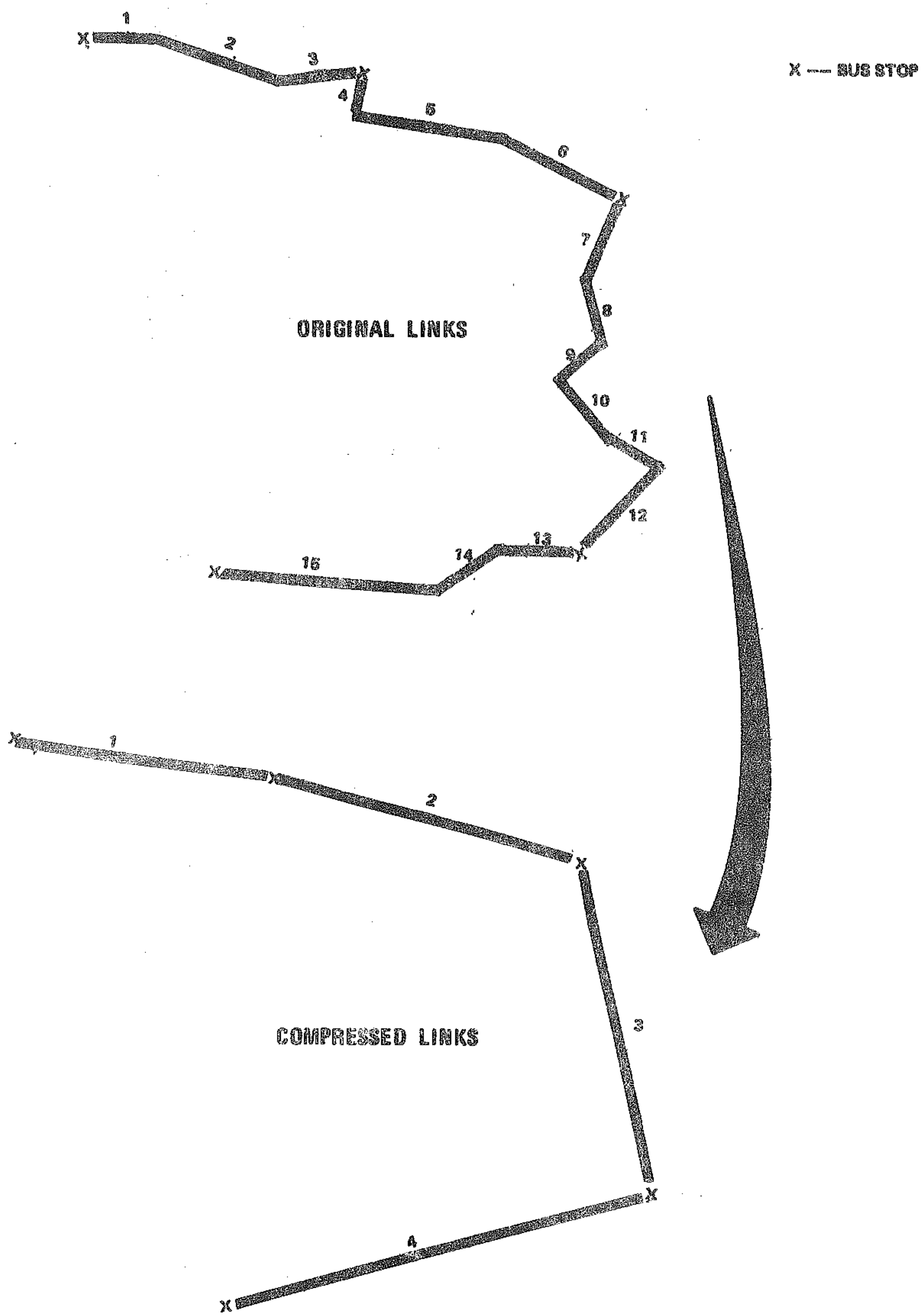
NET PROGRAM

This program produces a complete transit link deck for a specified transit system from a general transit system from a general transit network link deck and a description of the desired transit network. This description is given in terms of the consecutive nodes on each one-way transit route and the local "centroid" links connecting the zone centroids to the transit network. Since only one route is allowed to use a given link, artificial links are generated for those links used by several routes. Each one-way link in the final transit link deck is thus associated with exactly one route (with the exception of local links). The transit route on a given link has stops at both the origin and destination nodes. If in the original description of the desired transit network there were intermediate nodes, the link distances, times, etc., are combined to give the correct data from stop to stop. In this way, for example, a bus route with five stops which travels over 15 highway links can be condensed into four links (see Figure 11). The existing highway link deck is utilized to create "local links", which connect each zone centroid to the transit stops (stations) via highway. These local links are included in the final transit network.

After this program had been used a few times, and the succeeding programs examined, the program was revised slightly to create another file to aid in building the zone-to-zone frequency of service matrix needed in the MODAL SPLIT Program. This revision was very minor, but greatly simplified the task of building the necessary matrix.

Since portions of the output of the NET BUILD program are included, a few explanations should be made. In the node description of the transit ("BUS") routes, the node numbers refer to successive nodes on the general

FIGURE 11: EXPRESS LINKS



transit link deck--in this case, the existing highway link file. Negative node numbers are used if the bus does not stop at that node; positive nodes indicate bus stops (Figure 12). Routes must be numbered consecutively from one, and at present, may not exceed thirty-nine. For purposes of later convenience and time-saving, all nodes at which a bus stops are renumbered, beginning with zone centroids. The program lists the renumbering scheme, as well as listing the routes which stop at each of the bus stops (see Figure 13). The next listing from the program groups the transit links as regular, express, and local (Figure 14). Regular links are those found in the highway network at which a bus stops at both the origin node and the destination node of the link. Express links are defined as those for which several highway links were combined to form one bus transit link, and local links are links connecting zone centroids to bus stops via highway links.

The last table printed by this program is the final transit link deck (Figure 15). Artificial links were added wherever two routes coincided on a given link; these links are assigned the same data as the original link, except that a new node number was used. Dummy links are then used to connect the nodes (see Figure 16). These dummy links are given negligible distances, so that they contribute nothing to the length of a trip.

The transit network created by this program becomes a major building block for each of the succeeding programs. The program is used to create any transit network desired. A flow chart is shown in Figures 17a-e which documents the detailed operation of this program.

TRANSIT ROUTES

ROUTE NUMBER	--NODE DESCRIPTION OF ROUTE--
1	1686-1687-1891-2611-1688-1758-1764-1772-1771-1769
2	2120-2174-2117-2058-2059-1841-1834-1835-1833-1832-1831-1844-2718-1870-1853-1854-1851-1852-1849 1882-2686-1547-2789-1693-2788-1686-1687-1891-2611-1688-1758-1764-1772-1771-1769
3	2120-2122-2125-2127-2128-2123-2197-2689-2688-1838-1836-1835-1833-1832-1831-1844-2718-1870-1853-1854 1850-1851-1852-1849-1882-2686-1547-2789-1693-2788-1686-1687-1891-2611-1688-1758-1764-1772-1771-1769
4	2120-2122-2125-2123-2197-2689-2688-1838-1837-2496-1833-1832-1831-1844-2718-1870-1853-1854-1850-1851 1852-1849-1882-2686-1547-2789-1693-1692-1691-1690-1774-1661-1769
5	1686-1687-1689-1691-2608-1691-1690-1774-1661-1769
6	1769-1661-1774-1690-1691-1692-1693-2789-1547-2686-1882-1849-1852-1851-1854-1853-1870-2718-1844-1831 1832-1833-1835-1834-1841-2059-2058-2117-2174-2120
7	1769-1771-1772-1764-1758-1688-2611-1891-1687-1686-2788-1693-2789-1547-2686-1882-1849-1852-1851-1850 1854-1853-1870-2718-1844-1831-1832-1833-1835-1836-1838-1838-2688-2689-2197-2123-2128-2127-2125-2122
8	1769-1771-1772-1764-1758-1688-2611-1891-1687-1686-2788-1693-2789-1547-2686-1882-1849-1852-1851-1850 1854-1853-1870-2718-1844-1831-1832-1833-1835-1834-1841-2059-2058-2117-2174-2120
9	1769-1661-1774-1690-1691-1692-1693-2789-1547-2686-1882-1849-1852-1851-1850-1854-1853-1870-2718-1844 1831-1832-1833-2496-1847-1838-2689-2197-2123-2128
10	1686-2788-1693-2789-2547-2686-1882-1849-1852-1851-1850-1854-1870-2718-1844-1831-1832-1833-1835-1854 1834-1841-2059-2058-2117-2174-2120
11	1769-1661-1774-1690-1691-2068-1691-1689-1687-1686
12	1769-1771-1772-1764-1758-1688-2611-1891-1687-1686
13	1850-1847-1846-1845-1678-2970-1685-1684-1552-1563-1565-1674-1673-2630-2968-1679-1668-1679-2574-2708 1598-1610-1605-2438-1602
14	1602-2438-1605-1609-1612-1623-1612-1609-1610-1598-2708-2574-1670-1668-1679-2968-2630-1673-1674-1565 1563-1552-1684-1685-2970-2678-2845-2846-2847-2850-2852-2853-2852-2013-1859-1866-2807-1866-1868-1871 2562-2150-2144-2151-2162-2163
15	1602-2438-1605-1609-1612-1623-1612-1609-1610-1598-2708-2574-1670-1668-1679-2968-2630-1673-1674-1565 1563-1552-1684-1685-2970-1678-1835-1845-1846-1847-1850-1851-1852-1851-1013-1859-1866-1868-1871-2562 2144-2151-2162-2163
16	2163-2162-2151-2144-2150-2562-1871-1868-1866-2807-1866-1859-1013-1851-1852-1851-1847-1846-1845-1850 1678-2970-1685-1864-1552-1563-1675-1674-1673-1671-2575-1628-1624-1614-1610-1605-2438-1602

FIGURE 12

A. NODE RENUMBERING SCHEME

	TRANSIT NODE NO.	NETWORK NODE NO. —ROUTES ENTERING NODE—
88	1565	13 14 15 17 18 35
89	1585	21 22 23 24
90	1598	13 14 15 17 18 35
91	1602	13 14 15 16 17 18 21 22 23 24 25 26 33 34 35 36 37 38
92	1623	14 18 25 26
93	1659	19 20
94	1670	13 14 15 17 18 35
95	1680	19 20
96	1686	1 2 3 5 7 8 10 11 12
97	1693	2 3 4 6 7 8 9
98	1769	1 2 3 4 5 6 7 8 9 11 12
99	1815	25 26
100	1817	25 26
101	1832	2 3 7
102	1835	2 3 6 7 8 10
103	1841	2 6 8
104	1850	2 3 4 6 7 8 9 10 13 14 15 16 17 18 19 20 33 34 35 36 37 38 39
105	1852	2 3 4 6 7 8 9 10 14 15 16 17 19 20 33 34 35 36 37 38 39
106	1857	33 36 39
107	1871	14 16 17 20 35
108	1877	33 36 39
109	1961	25 26
110	1988	29 30
111	2038	22 24
112	2120	2 3 4 6 7 8 10 25 26 27 28 29 30 31 32
113	2128	3 7 9 25 26 28 29 30 32
114	2133	27 28 29 30 31 32
115	2163	14 15 16 17 18 27 29 30 31 32 35

FIGURE 13

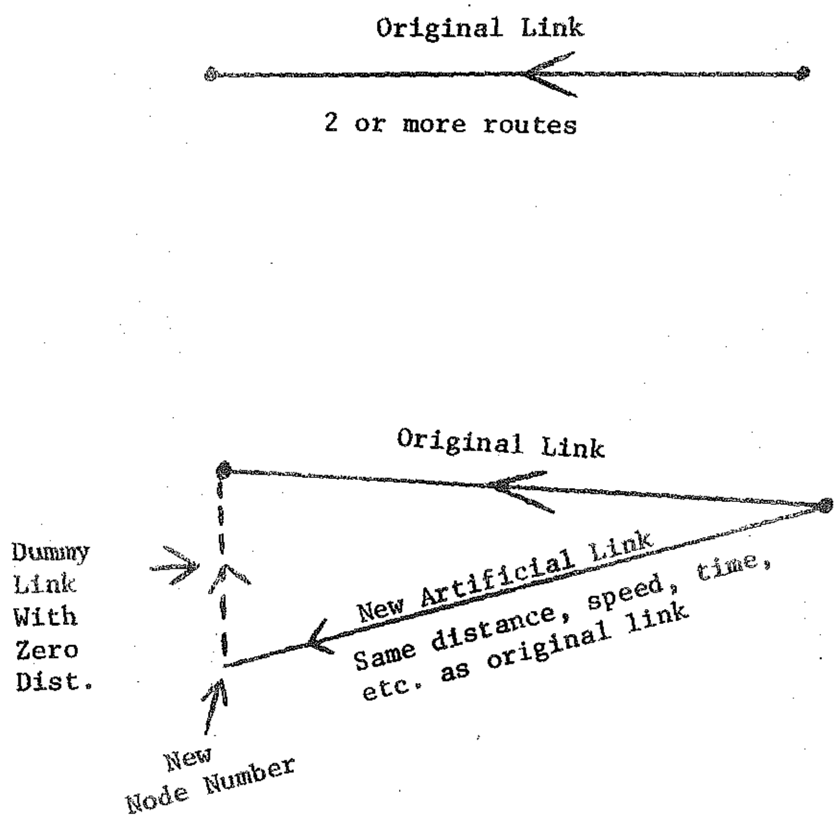
FIGURE 14

NODE FROM	NODE TO	TIME	OLD NODES		ROUTES ON LINK
REGULAR LINKS					
89	118	6.09	1585	2596	24
90	121	11.89	1598	2708	14 15 35
92	109	12.01	1623	1961	25
109	92	12.01	1961	1623	26
118	89	6.09	2596	1585	22
121	90	11.89	2708	1598	13 17 18
EXPRESS LINKS					
96	98	33.52	1686	1769	1 2 3
112	103	16.09	2120	1841	2
103	102	15.96	1841	1835	2
102	101	8.59	1835	1832	2 3
101	104	15.47	1832	1850	2 3
104	105	7.34	1850	1852	2 3 4 14 15 19 35 36 37 38 39
105	97	22.09	1852	1693	2 3 4
97	96	14.93	1693	1686	2 3
LOCAL LINKS					
1	100	2.00	25	1817	
100	1	2.00	1817	25	
2	100	11.00	26	1817	
100	2	11.00	1817	26	
3	100	21.00	27	1817	
100	3	21.00	1817	27	
4	99	17.00	28	1815	

C. TRANSIT LINK DECK

	NODE FROM	NODE TO	ZONE NO.	DIST.	TIME	SPD.	COST	CAPACITY	LINK NAME	FAC' CODE	DEGRAD TIME	DEGRAD SPD	ORIGINAL NODES	TRANSIT ROUTE
1	1	100	25	1.00	2.00	30.0	0.050	9999990.	LOCAL	1	2.000	30.00	251817	0
2	2	100	26	6.00	11.00	32.7	0.280	9999990.	LOCAL	1	11.000	32.73	261817	0
3	3	100	27	15.00	21.00	42.9	0.710	9999990.	LOCAL	1	21.000	42.86	271817	0
4	4	99	28	11.00	17.00	38.8	0.520	9999990.	LOCAL	1	17.000	38.82	281815	0
5	5	112	55	2.00	3.00	40.0	0.090	9999990.	LOCAL	1	3.000	40.00	552120	0
6	6	114	56	12.00	17.00	42.4	0.570	9999990.	LOCAL	1	17.000	42.35	562133	0
7	7	112	57	16.00	24.00	40.0	0.750	9999990.	LOCAL	1	24.000	40.00	572120	0
86	86	119	440	8.00	10.00	48.0	0.390	9999990.	LOCAL	1	10.000	48.00	4402608	0
87	87	97	441	2.00	4.00	30.0	0.090	9999990.	LOCAL	1	4.000	30.00	4411693	0
88	88	61	195	11.00	19.00	34.7	0.510	9999990.	LOCAL	1	19.000	34.74	15650195	0
89	89	64	198	15.00	22.00	40.9	0.710	9999990.	LOCAL	1	22.000	40.91	15650198	0
90	88	65	199	2.00	4.00	30.0	0.090	9999990.	LOCAL	1	4.000	30.00	15650199	0
91	88	104	183	22.13	27.39	48.5	0.000	17950.	BUS	4	27.390	48.48	15651850	14
92	88	123	192	16.15	18.95	51.1	0.000	5770.	BUS	4	18.950	51.13	15652968	13
93	88	153	0	.001	9999	0	0	10000	DUMMY	1	.001	9999	15651565	15
94	88	154	0	.001	9999	0	0	10000	DUMMY	1	.001	9999	15651565	35
95	88	155	192	16.15	18.95	51.1	0.000	5770.	BUS	4	18.950	51.13	15652968	17
96	88	156	192	16.15	18.95	51.1	0.000	5770.	BUS	4	18.950	51.13	15652968	18
97	89	91	236	20.55	20.42	60.4	0.000	28000.	BUS	2	20.419	60.38	15851602	21
98	89	111	238	8.59	8.69	59.3	0.000	19000.	BUS	1	8.689	59.31	15852038	22
99	89	118	245	5.57	6.09	54.9	0.000	3280.	BUS	1	6.087	54.90	15852596	24
100	90	68	237	2.00	4.00	30.0	0.090	9999990.	LOCAL	1	4.000	30.00	15980237	0
101	90	91	236	8.84	10.16	52.2	0.000	28000.	BUS	4	10.157	52.22	15981602	13
102	90	92	236	8.13	12.75	38.2	0.000	4410.	BUS	4	12.754	38.25	15981623	16
103	90	121	244	8.92	11.89	45.0	0.000	4760.	BUS	3	11.893	45.00	15982708	14
104	90	124	244	8.92	11.89	45.0	0.000	4760.	BUS	3	11.893	45.00	15982708	15
105	90	125	244	892	11.89	45.0	0.000	7460.	BUS	3	11.893	45.00	15982708	35
106	90	161	236	8.84	10.16	52.2	0.000	28000.	BUS	4	10.157	52.22	15981602	17
107	91	67	236	3.00	5.00	36.0	0.140	9999990.	LOCAL	1	5.000	36.00	16020236	0
108	91	72	241	14.00	15.00	56.0	0.730	9999990.	LOCAL	1	15.000	56.00	16020241	0
109	91	73	242	7.00	8.00	52.5	0.360	9999990.	LOCAL	1	8.000	52.50	16020242	0
110	91	76	246	7.00	12.00	35.0	0.330	9999990.	LOCAL	1	12.000	35.00	16020246	0
111	91	78	248	8.00	11.00	43.6	0.380	9999990.	LOCAL	1	11.000	43.64	16020248	0
112	91	89	238	20.55	20.42	60.4	0.000	3540.	BUS	3	20.419	60.38	16021585	23
113	91	90	237	16.48	24.77	39.9	0.000	2620.	BUS	3	24.768	39.92	16021598	15
114	91	92	236	8.35	12.01	41.7	0.000	4410.	BUS	4	12.014	41.70	16021623	14
115	91	104	183	64.71	67.92	57.2	0.000	17950.	BUS	4	67.917	57.17	16021850	36
116	91	111	238	11.96	11.73	61.2	0.000	20820.	BUS	1	11.730	61.18	16022038	24
117	91	161	0	.001	9999	0	0	10000	DUMMY	1	.001	9999	16021602	35
118	91	162	236	.35	12.01	41.7	0.000	4410.	BUS	4	12.014	41.70	16021623	25
119	91	168	0	.001	9999	0	0	10000	DUMMY	1	.001	9999	16021602	37
120	91	169	0	.001	9999	0	0	10000	DUMMY	1	.001	9999	16021602	38

FIGURE 15



Original Link
2 or more routes
Original Link
Dummy
Link
With
Zero
Dist.
New Artificial Link
Same distance, speed, time,
etc. as original link
New
Node Number

FIGURE 16

QTRNET

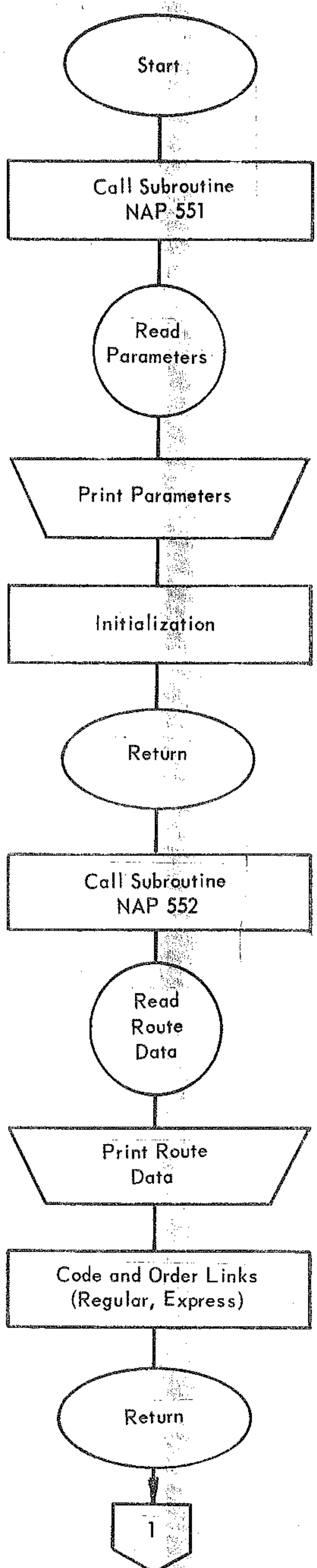


FIGURE 17a

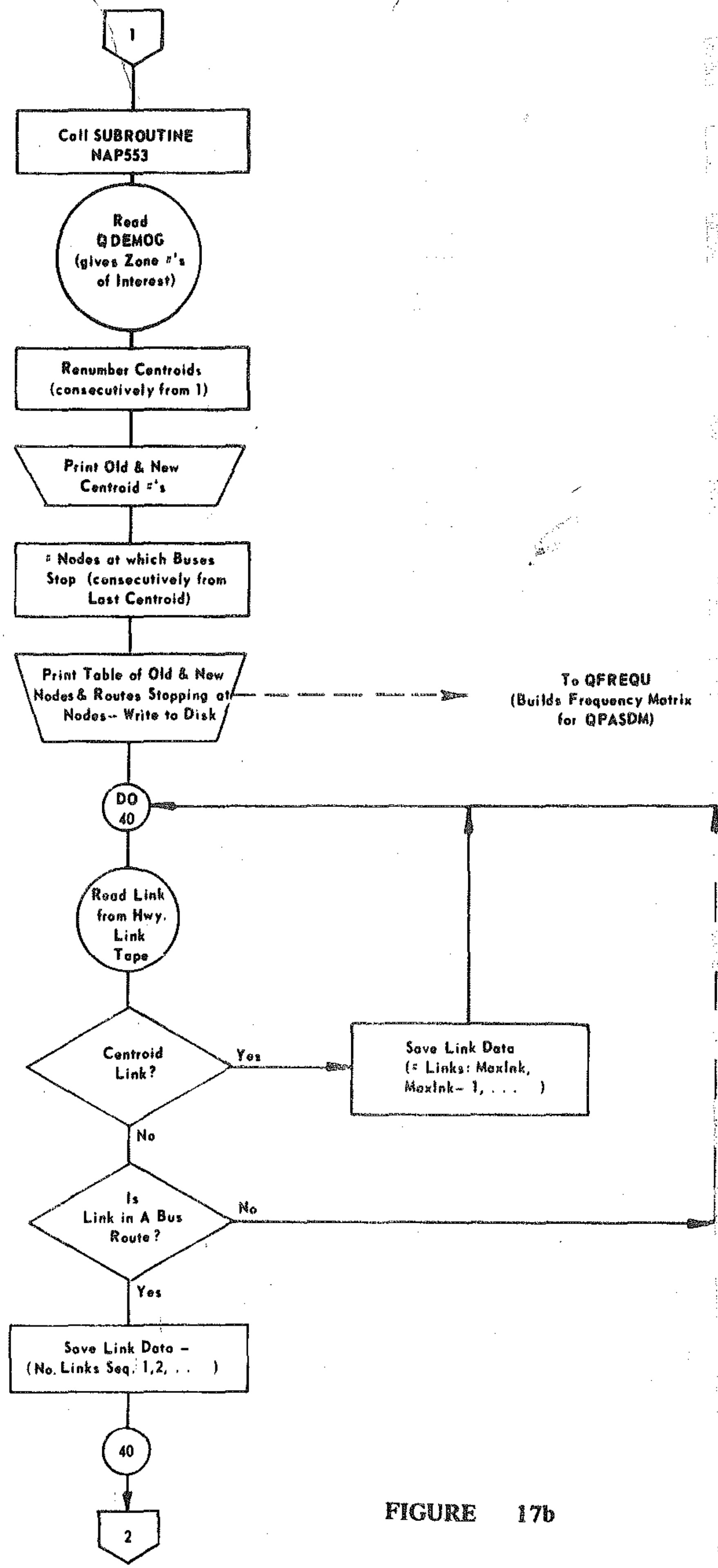

1
Call SUBROUTINE NAP553
Read QDEMOG (gives Zone #'s of Interest)
Renumber Centroids (consecutively from 1)
Print Old & New Centroid #'s
Nodes at which Buses Stop (consecutively from Last Centroid)
Print Table of Old & New Nodes & Routes Stopping at Nodes-- Write to Disk
To QFREQU (Builds Frequency Matrix for QPASDM)
DO 40
Read Link from Hwy. Link Tape
Centroid Link?
Yes
Save Link Data (# Links: Maxlnk, Maxlnk- 1, . . .)
No
Is Link in A Bus Route?
No
Yes
Save Link Data - (No. Links Seq. 1,2, . . .)
40
2

FIGURE 17b

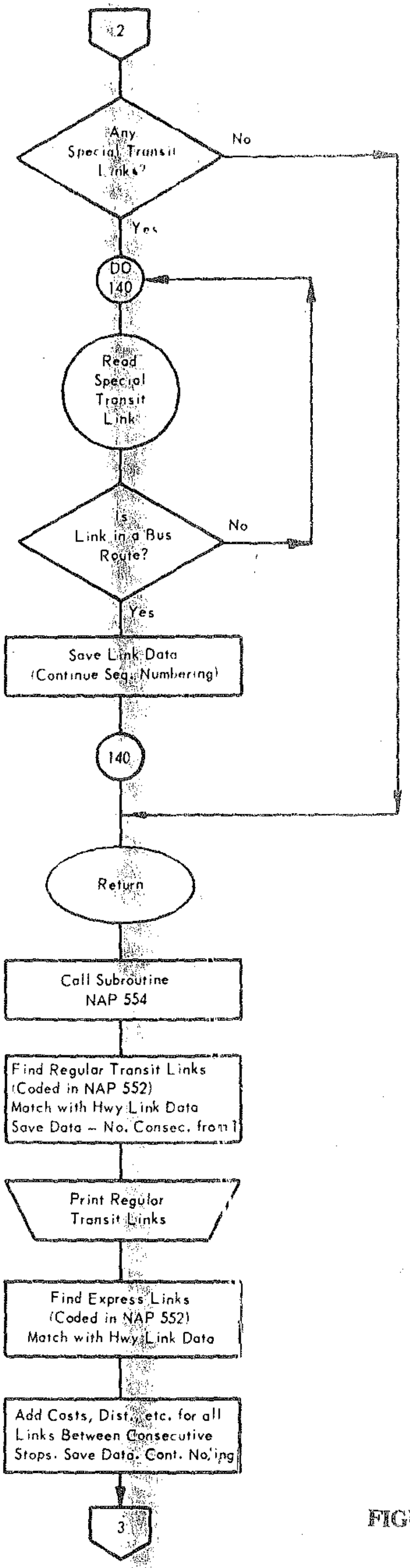

2
Any Special Transit Links?
No
Yes
DO 140
Read Special Transit Link
Is Link in a Bus Route?
No
Yes
Save Link Data (Continue Seq. Numbering)
140
Return
Call Subroutine NAP 554
Find Regular Transit Links (Coded in NAP 552) Match with Hwy Link Data Save Data – No. Consec. from 1
Print Regular Transit Links
Find Express Links (Coded in NAP 552) Match with Hwy Link Data
Add Costs, Dist., etc. for all Links Between Consecutive Stops. Save Data. Cont. No.'ing
3

FIGURE 17c

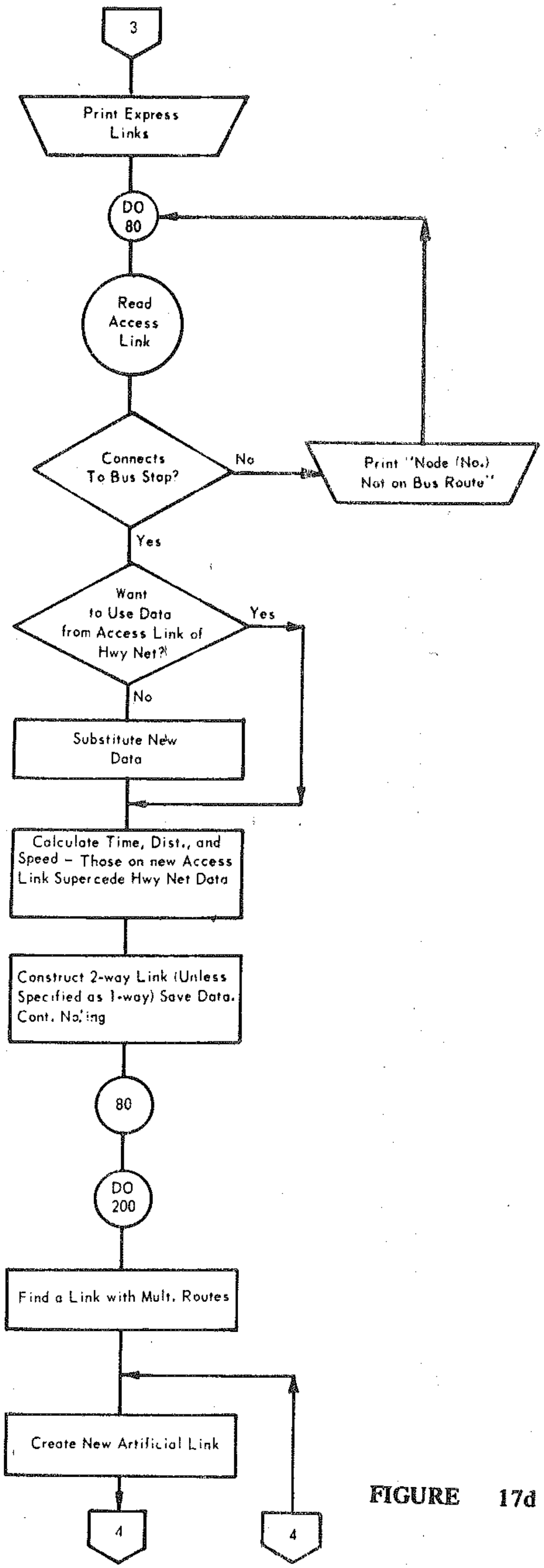

3
Print Express Links
DO 80
Read Access Link
Connects To Bus Stop?
No
Print "Node (No.) Not on Bus Route"
Yes
Want to Use Data from Access Link of Hwy Net?
Yes
No
Substitute New Data
Calculate Time, Dist., and Speed – Those on new Access Link Supercede Hwy Net Data
Construct 2-way Link (Unless Specified as 1-way) Save Data. Cont. No.'ing
80
DO 200
Find a Link with Mult. Routes
Create New Artificial Link
4
4

FIGURE 17d

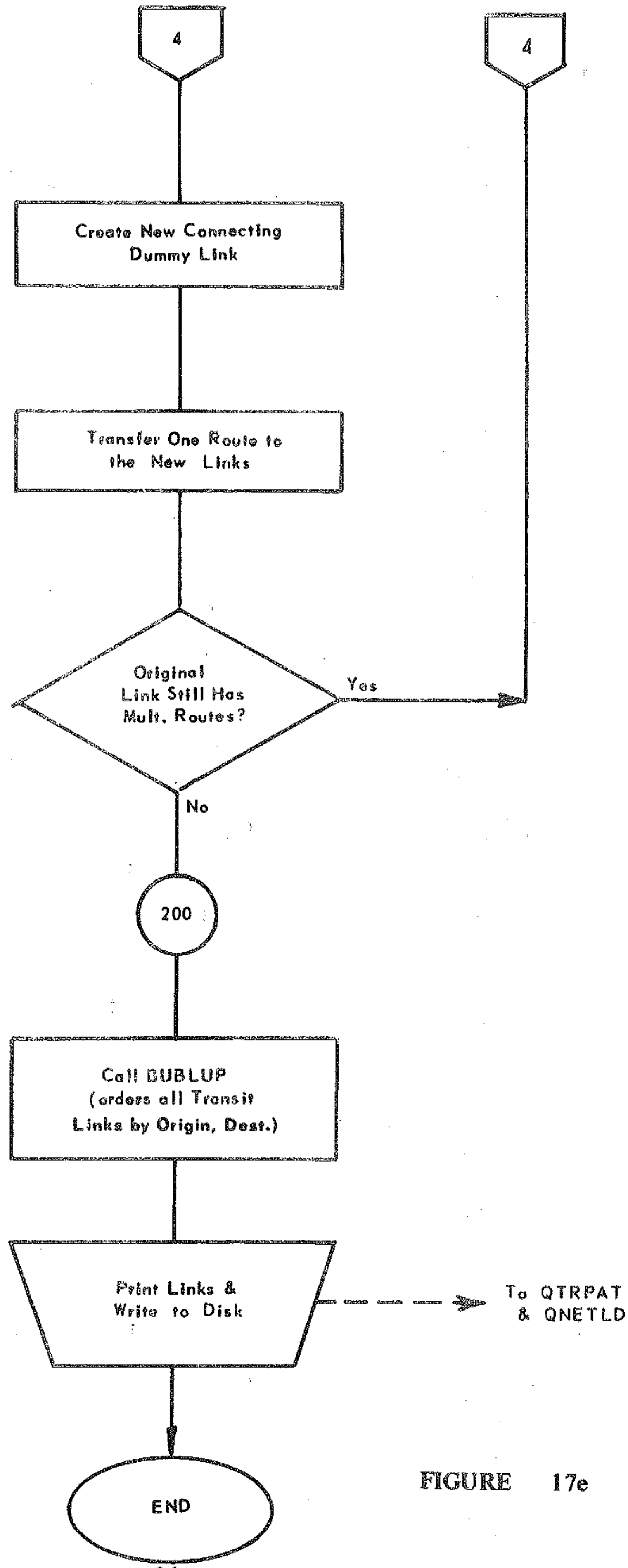
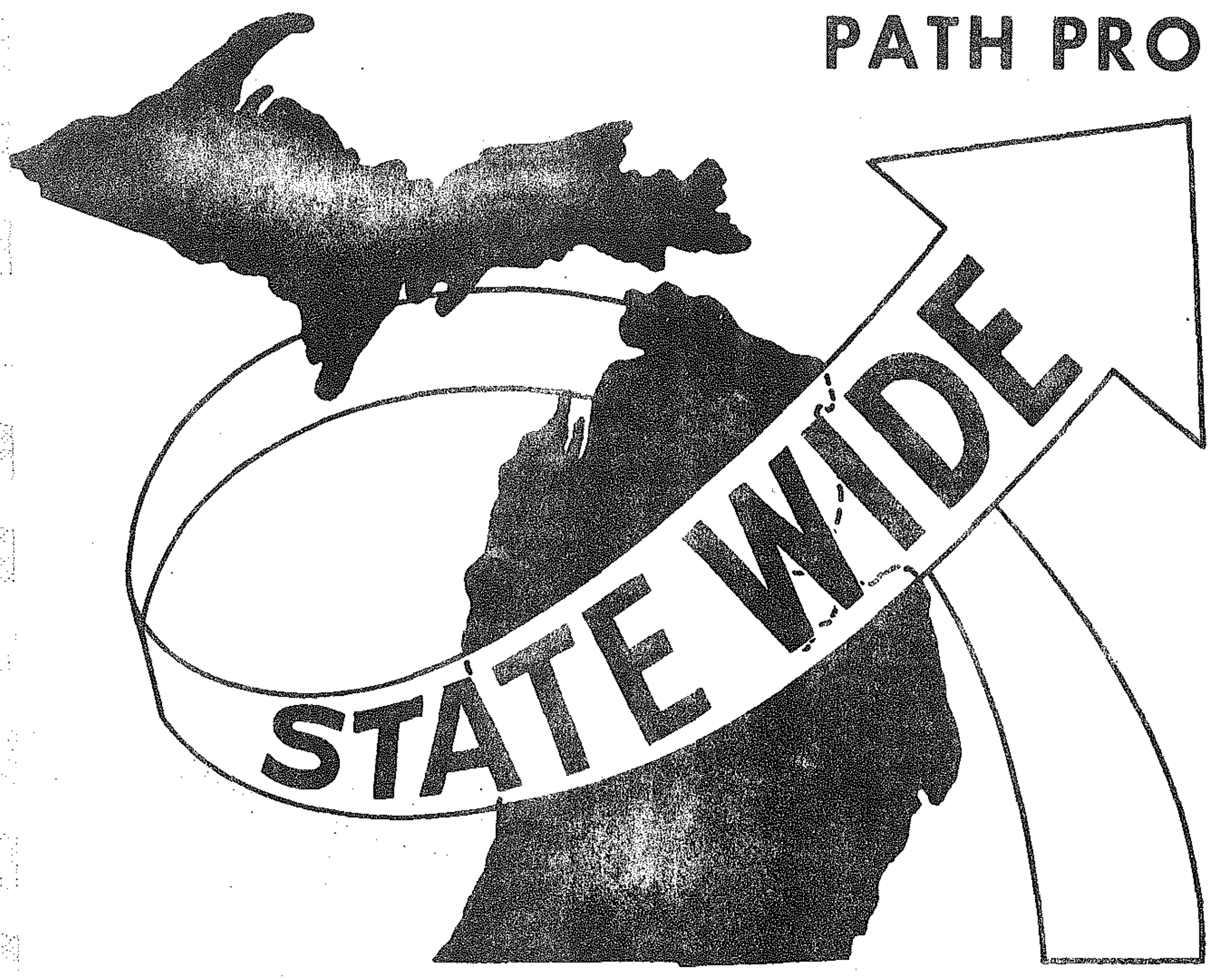

4
4
Create New Connecting Dummy Link
Transfer One Route to the New Links
Original Link Still Has Mult. Routes?
Yes
No
200
Call BUBLUP (orders all Transit Links by Origin, Dest.)
Print Links & Write to Disk
To QTRPAT & QNETLD
END

FIGURE 17e

PATH PROGRAM



PATH PROGRAM

This routine, using each selected transit network from the NET BUILD Program, determines minimum time paths for each zone centroid pair. Matrices of wait plus transfer time, access plus egress time, and total transit travel time are calculated for the minimum time paths. The paths are produced for later use in the NET LOAD Program. A headway time -- the average time between runs -- must be entered for each route. The wait time is then calculated by adding one-half the headways for all routes on the minimum path. This use of headways is not completely satisfactory and changes have been considered; but the changes would be very time-consuming, both in making them and in computer run time, so they have been postponed until more routine application of the system has been completed.

It should also be mentioned that since the flow chart was prepared for this program, three small subroutines have been added to it. These subroutines create zone-to-zone cost, fare, and frequency of service matrices for use in the succeeding programs.

Figure 18 gives a listing of the input parameters. This is followed by the minimum path table in Figure 19. The first three numbers are from the time matrices--the first is total transit time from zone 1 to zone 2, the second is access plus egress time, and the third is total wait time (all times are in minutes). Next follows the minimum time path, to be read from right to left. The numbers in parenthesis are route numbers, the others are node numbers. Thus the first path begins at node #1 (zone centroid), goes to node #100 (nearest bus stop) and then to node #2 (zone centroid). These node numbers are the newly assigned numbers from the NET BUILD program. Note that the path between these two zones does not utilize a bus route and thus the wait time is set equal to zero. When the frequency of service matrix is built, this will be noted and subsequently the frequency of bus service between Zones 1 and 2 will become zero, i.e., no routes in any given day. Also of interest is the additional wait time which is encountered when a traveler must switch buses (indicated by a change in route numbers). A flow chart of the more detailed program operation appears in Figures 20a-c.

BUS PATHS — — — TEST REGION

PARAMETERS

1. NUMBER OF ZONE CENTROIDS (NCENT) = 87
2. NUMBER OF LINKS (NLINK) = 445
   (MAXIMUM VALUE OF NLINK = 32000)
3. NUMBER OF NODES (NNODE) = 174
   (MAXIMUM VALUE OF NNODE = 2400)
4. NUMBER OF (ONE—WAY) TRANSIT ROUTES (NRTES) = 39
   (MAXIMUM VALUE OF NRTES = 40)
5. FIRST ZONE CENTROID FROM WHICH MINIMUM PATHS TO BE BUILT (NHOME) = 1
6. LAST ZONE CENTROID FROM WHICH MINIMUM PATHS TO BE BUILT NSTOP) = 87

TRANSIT ROUTE HEADWAYS — MINUTES

ROUTE NUMBER	HEADWAY
1	10.00
2	10.00
3	10.00
4	10.00
5	10.00
6	10.00
7	10.00
8	10.00
9	10.00
10	10.00

FIGURE 18

TRANSIT MINIMUM PATH PROGRAM

OUTPUT

PROJECT ID BUS PATHS——TEST REGION

TREE FROM ZONE 1

13.00	13.00	0.00	2	(0)	100	(0)	1	(				
23.00	23.00	0.00	3	(0)	100	(0)	1	(				
38.50	19.00	5.00	4	(0)	99	(26)	100	(0)	1	(		
44.60	5.00	5.00	5	(0)	112	(25)	100	(0)	1	(		
90.00	19.00	10.00	6	(0)	114	(25)	100	(0)	1	(		
65.60	26.00	5.00	7	(0)	112	(25)	100	(0)	1	(		
49.60	10.00	5.00	8	(0)	112	(25)	100	(0)	1	(		
53.60	14.00	5.00	9	(0)	112	(25)	100	(0)	1	(		
64.40	10.00	5.00	10	(0)	113	(25)	143	(25)	100	(0)	1	(
60.40	6.00	5.00	11	(0)	113	(25)	143	(25)	100	(0)	1	(
47.60	8.00	5.00	12	(0)	112	(25)	100	(0)	1	(		
49.60	10.00	5.00	13	(0)	112	(25)	100	(0)	1	(		
79.00	8.00	10.00	14	(0)	114	(31)	112	(25)	100	(0)	1	(
72.40	18.00	5.00	15	(0)	113	(25)	143	(25)	100	(0)	1	(
75.00	4.00	10.00	16	(0)	114	(31)	112	(25)	100	(0)	1	(
58.40	4.00	5.00	17	(0)	113	(25)	143	(25)	100	(0)	1	(

FIGURE 19

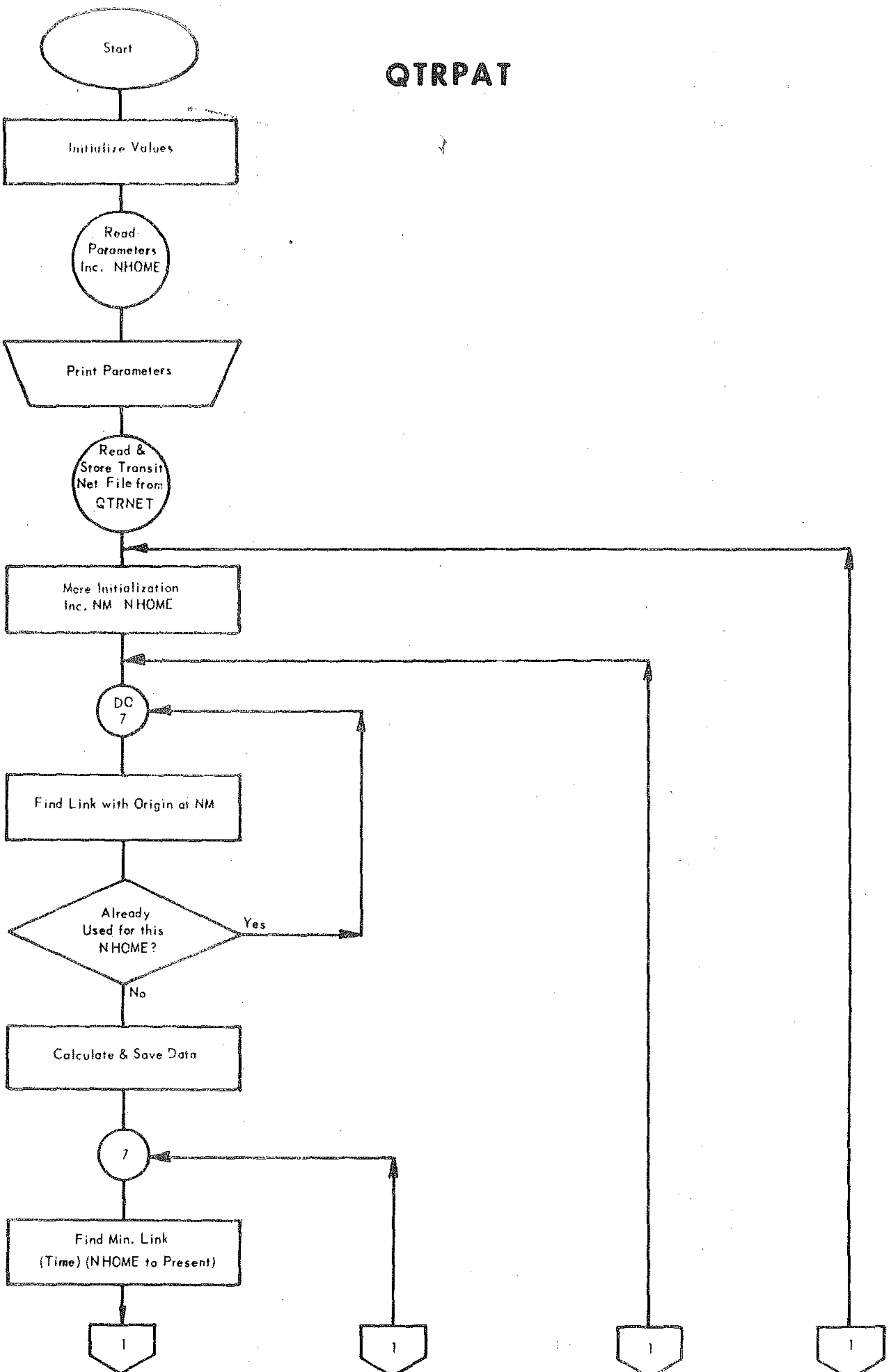

Start
QTRPAT
Initialize Values
Read Parameters Inc. NHOME
Print Parameters
Read & Store Transit Net File from QTRNET
More Initialization Inc. NM NHOME
DC 7
Find Link with Origin at NM
Already Used for this NHOME?
Yes
No
Calculate & Save Data
7
Find Min. Link (Time) (NHOME to Present)
1
1
1
1

FIGURE 20a

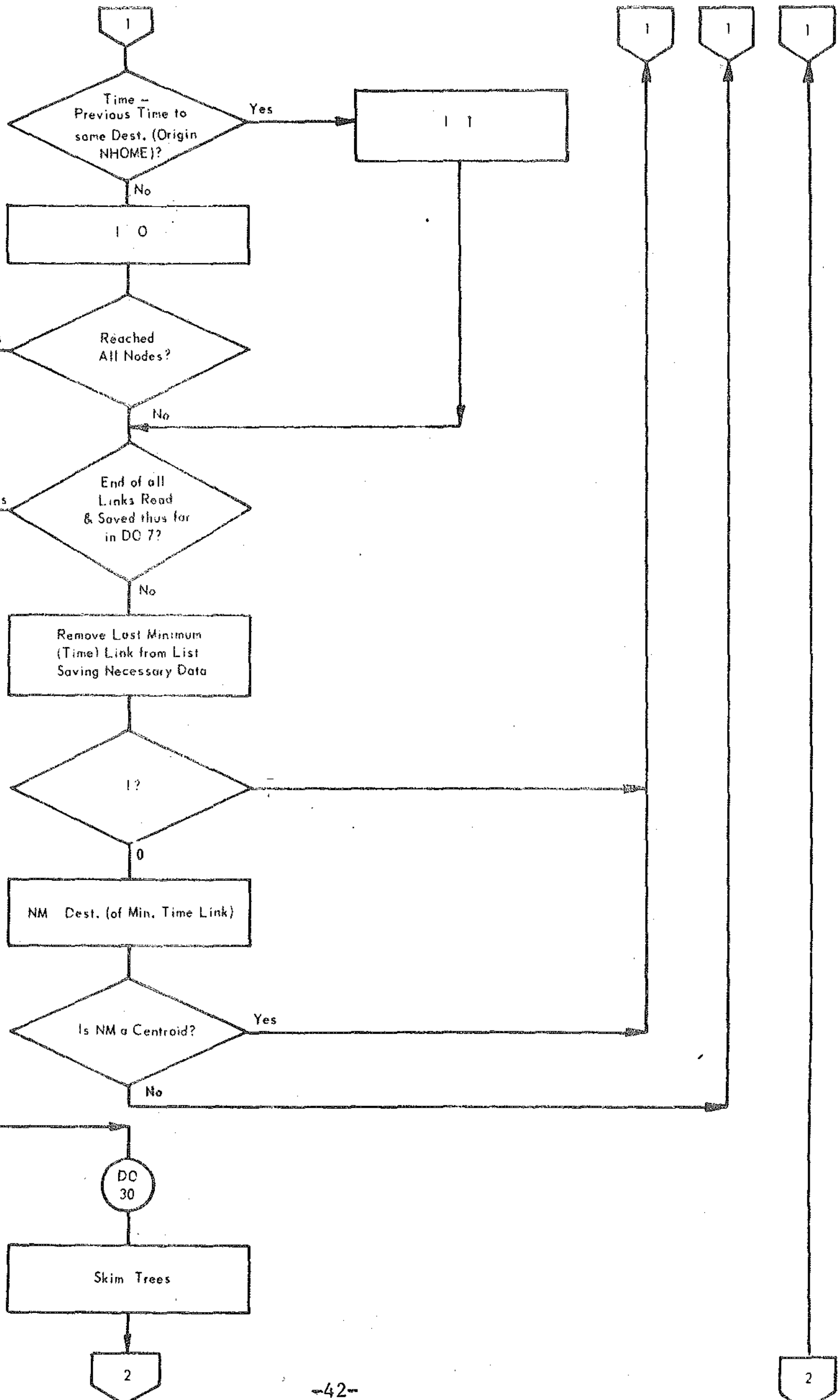

1
Time – Previous Time to same Dest. (Origin NHOME)?
Yes
I 1
No
I 0
Reached All Nodes?
Yes
No
End of all Links Read & Saved thus far in DO 7?
Yes
No
Remove Last Minimum (Time) Link from List Saving Necessary Data
I ?
0
NM Dest. (of Min. Time Link)
Is NM a Centroid?
Yes
No
DO 30
Skim Trees
2
1
1
1
2

FIGURE 20b

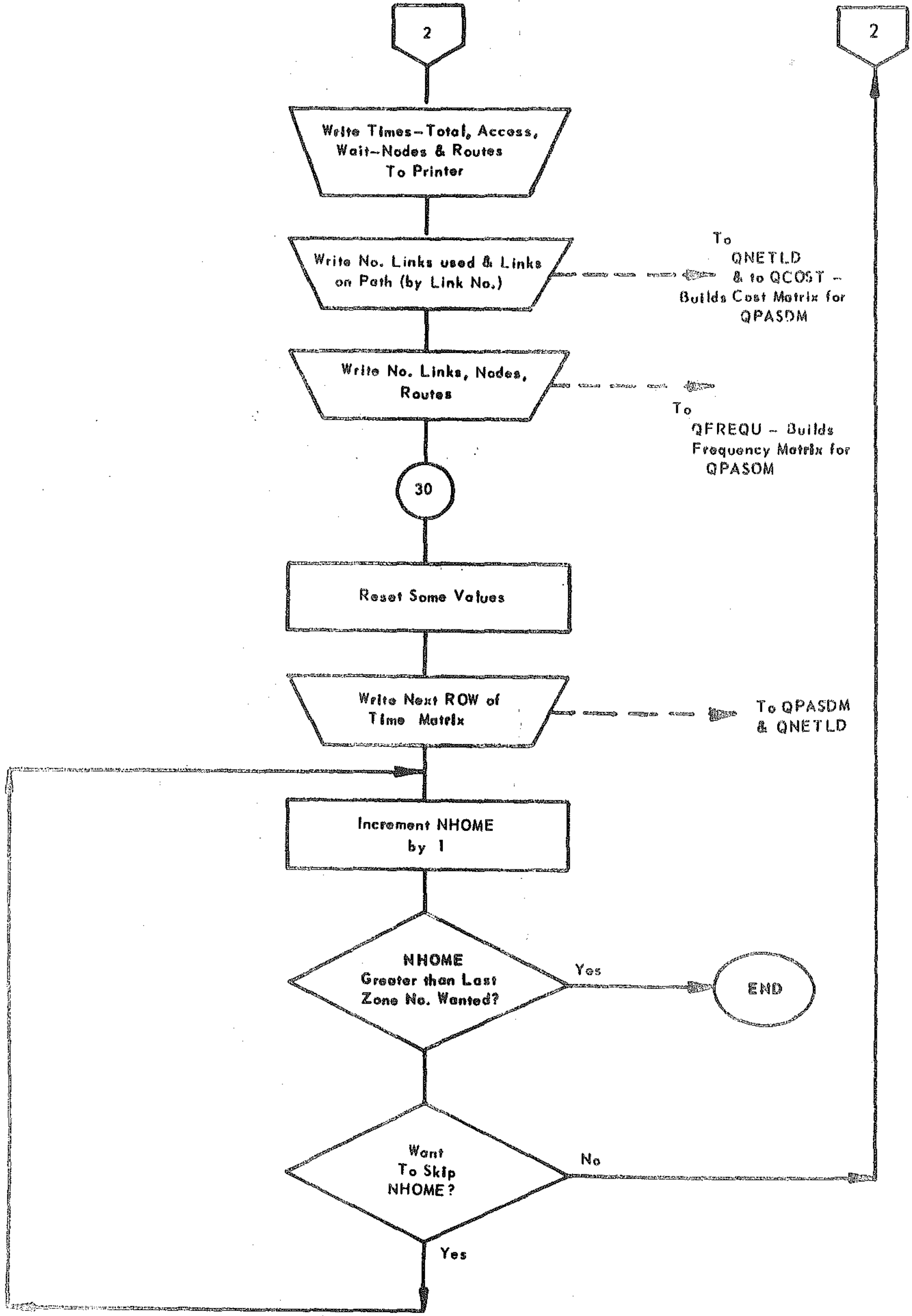
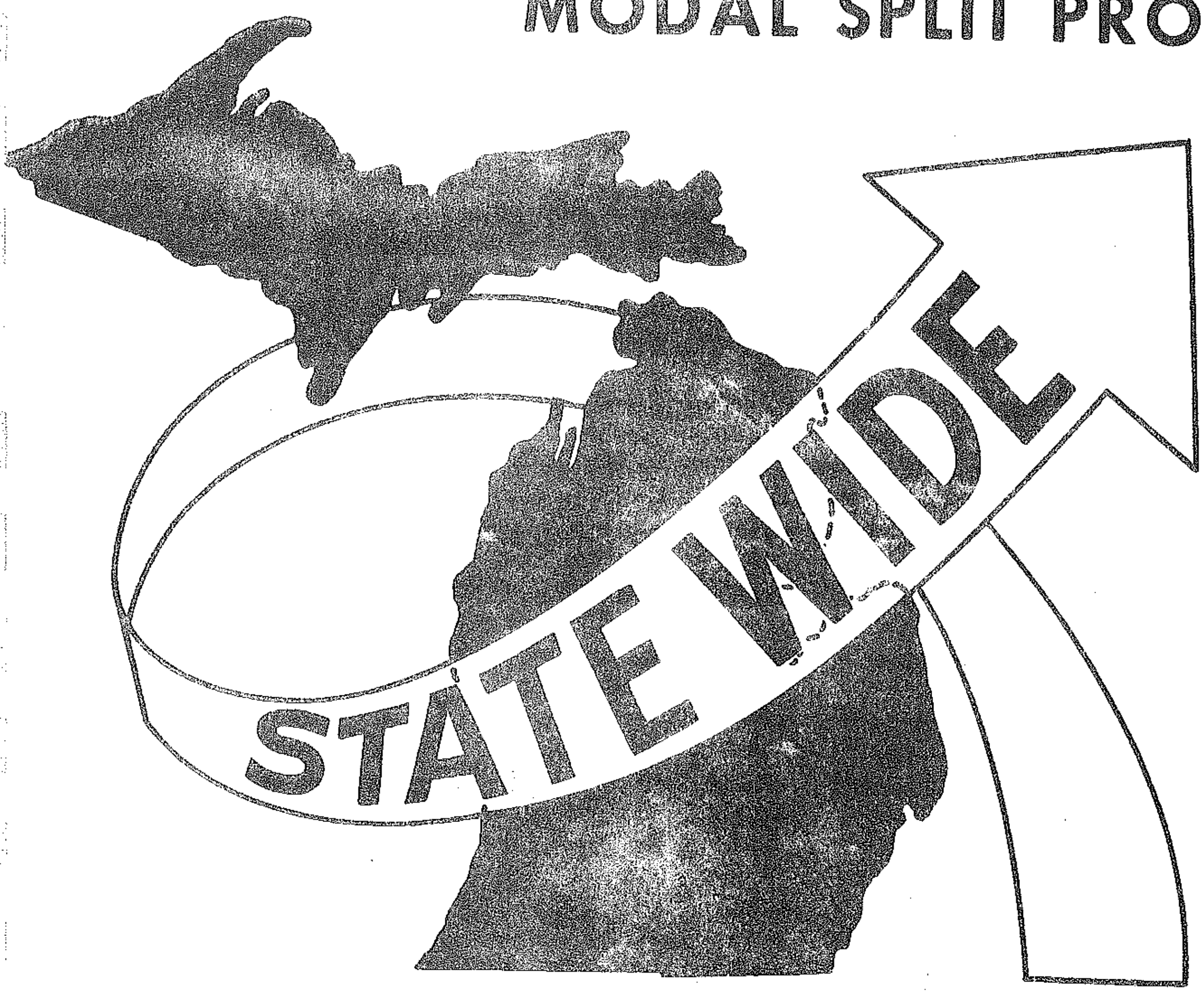

2
2
Write Times—Total, Access,
Wait—Nodes & Routes
To Printer
Write No. Links used & Links
on Path (by Link No.)
To
QNETLD
& to QCOST –
Builds Cost Matrix for
QPASDM
Write No. Links, Nodes,
Routes
To
QFREQU – Builds
Frequency Matrix for
QPASDM
30
Reset Some Values
Write Next ROW of
Time Matrix
To QPASDM
& QNETLD
Increment NHOME
by 1
NHOME
Greater than Last
Zone No. Wanted?
Yes
END
Want
To Skip
NHOME?
No
Yes

FIGURE 20c

MODAL SPLIT PROGRAM



MODAL SPLIT PROGRAM

This is the first program to consider all the desired travel modes and networks which were produced singly in the preceding two programs. The MODAL SPLIT program is an intercity passenger demand model calibrated to intercity travel within the State of Michigan. It performs trip generation, distribution, and modal split based on zone-to-zone modal time, cost, and frequency-of-service data, and upon family income levels in origin and destination zones. Any combination of auto, air, bus and rail modes may be considered.

The program, based upon the zone-to-zone data, calculates percentages of trips using each mode, and uses these percentages in combination with auto trip tables and income data to generate trips by mode for each zone pair. This procedure will permit one to compare trips between zones and "trade-offs" between modes if the relative cost of a given mode increases, or frequency of service decreases, or even if required travel wait time is reduced. The program is also sensitive to changes in the economic structure of a community, since one input is the number of families with incomes exceeding $10,000. The zone number listed by this program corresponds to the zone number of the 547 zone system. The trip tables (Figure 21) become input for the NET LOAD Program. A detailed flow chart for the program is shown in Figures 22a-d.

TRIPS FROM	TO	AUTO	AIR	BUS	RAIL
25	25	0.00	0.00	0.00	0.00
	26	8.83	0.00	0.00	0.00
	27	8.95	0.01	0.00	0.00
	28	7.82	0.00	0.46	0.00
	29	35.68	0.03	2.10	0.00
	55	0.96	0.00	0.04	0.00
	56	4.56	0.01	0.21	0.00
	57	28.92	0.02	1.70	0.00
	58	10.52	0.00	0.54	0.00
	59	4.35	0.00	0.13	0.00
	60	5.70	0.01	0.17	0.00
	61	11.68	0.01	0.69	0.00
	62	8.90	0.01	0.51	0.00
	63	0.96	0.00	0.03	0.00
	64	0.52	0.00	0.02	0.00
	65	3.62	0.01	0.15	0.00
	66	7.32	0.01	0.24	0.00
	92	1.43	0.01	0.02	0.00
	93	1.47	0.01	0.01	0.00
	94	0.89	0.01	0.01	0.00
	95	1.39	0.01	0.01	0.00
	96	0.39	0.00	0.01	0.00
	97	3.17	0.01	0.02	0.00
	98	0.97	0.01	0.01	0.00
	99	0.34	0.00	0.01	0.00
	100	4.46	0.02	0.04	0.00
	113	7.23	0.01	0.08	0.00
	114	6.13	0.01	0.06	0.00
	115	4.52	0.01	0.04	0.00
	116	2.90	0.00	0.06	0.00
	117	18.81	0.04	0.09	0.00

TRIP TABLE

FIGURE 21

QPASDM

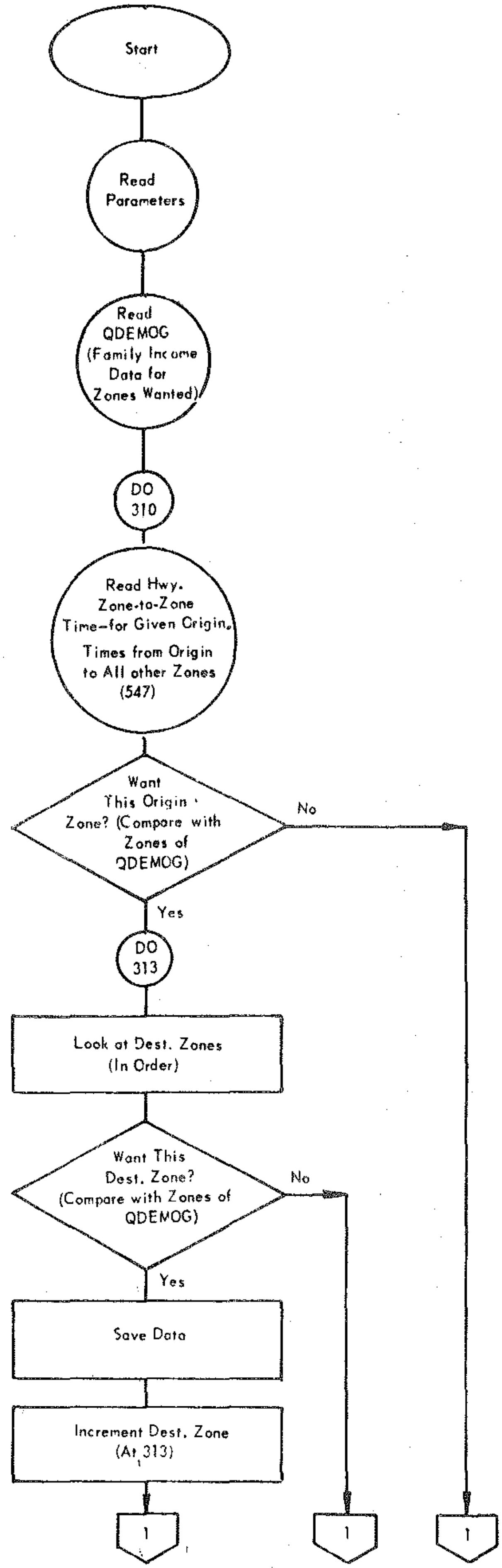


FIGURE 22a

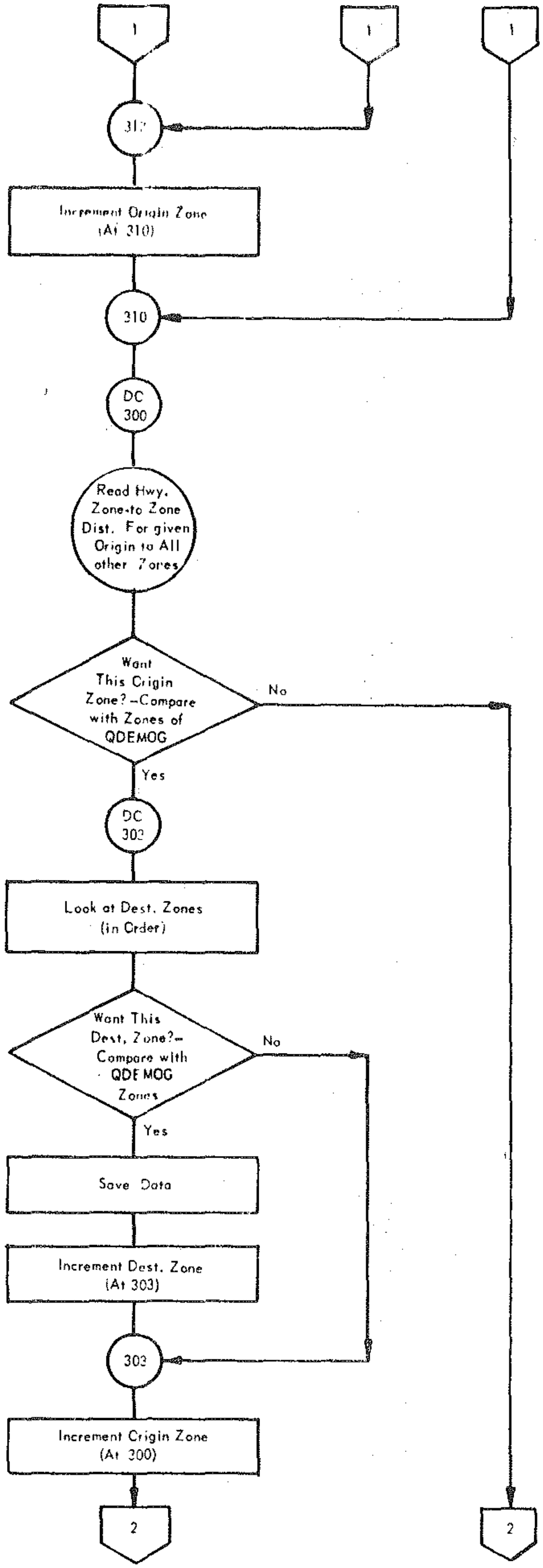

1
1
1
317
Increment Origin Zone
(At 310)
310
DC
300
Read Hwy.
Zone-to Zone
Dist. For given
Origin to All
other Zones
Want
This Origin
Zone? –Compare
with Zones of
QDEMOG
No
Yes
DC
303
Look at Dest. Zones
(in Order)
Want This
Dest. Zone?–
Compare with
QDEMOG
Zones
No
Yes
Save Data
Increment Dest. Zone
(At 303)
303
Increment Origin Zone
(At 300)
2
2

FIGURE 22b

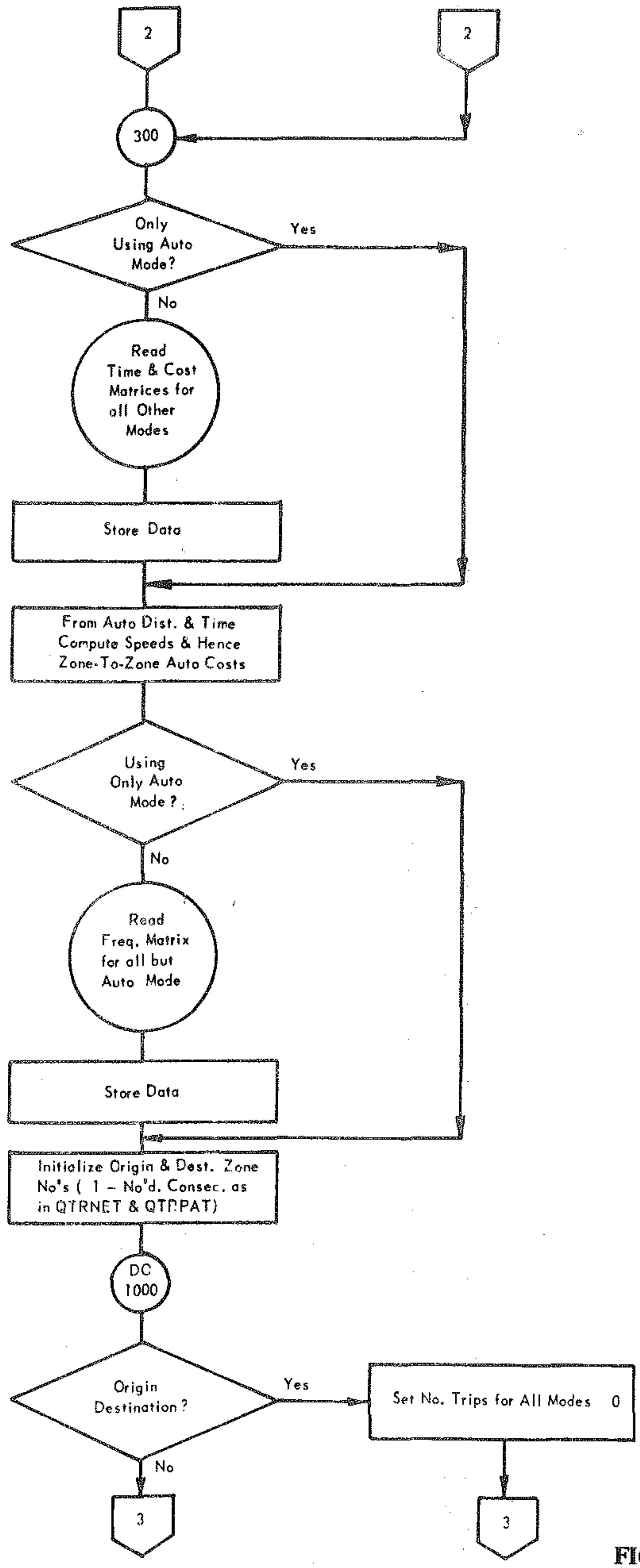

2
2
300
Only Using Auto Mode?
Yes
No
Read Time & Cost Matrices for all Other Modes
Store Data
From Auto Dist. & Time Compute Speeds & Hence Zone-To-Zone Auto Costs
Using Only Auto Mode ?
Yes
No
Read Freq. Matrix for all but Auto Mode
Store Data
Initialize Origin & Dest. Zone No's (1 – No'd. Consec. as in QTRNET & QTRPAT)
DC 1000
Origin Destination?
Yes
Set No. Trips for All Modes 0
No
3
3

FIGURE 22c

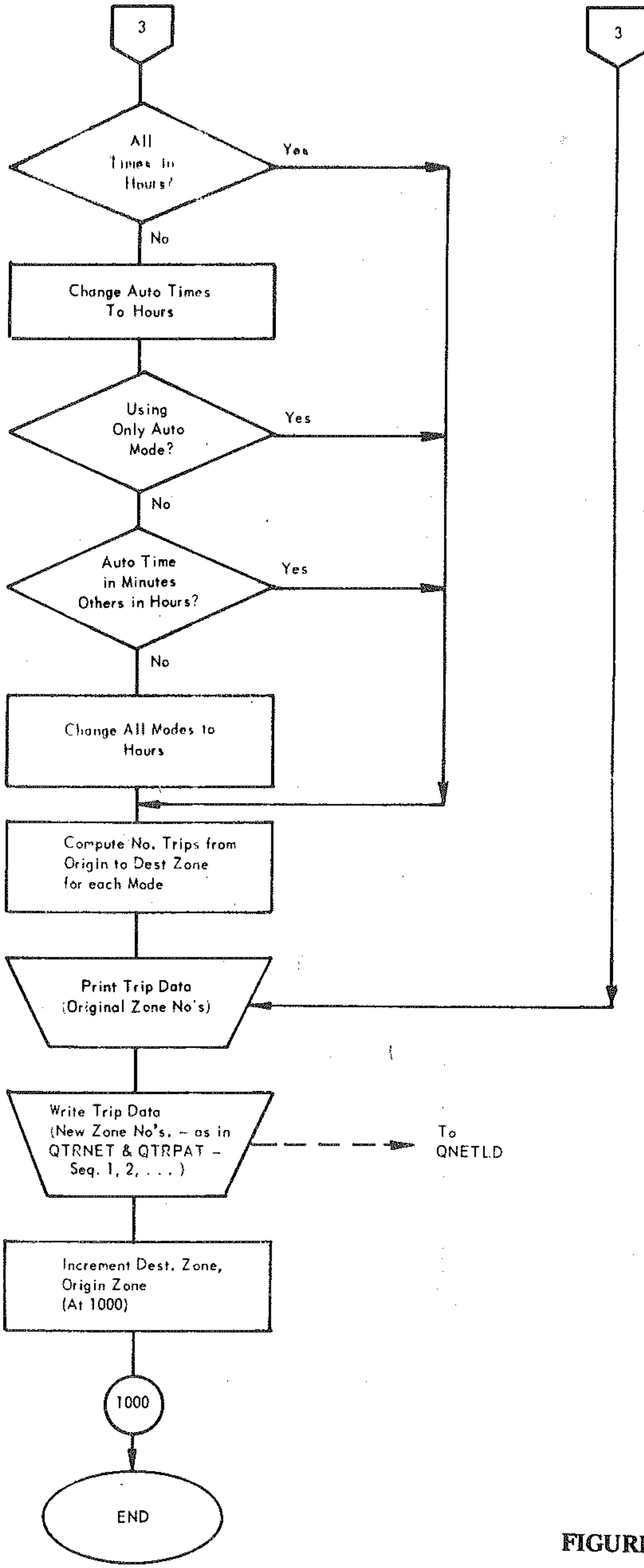
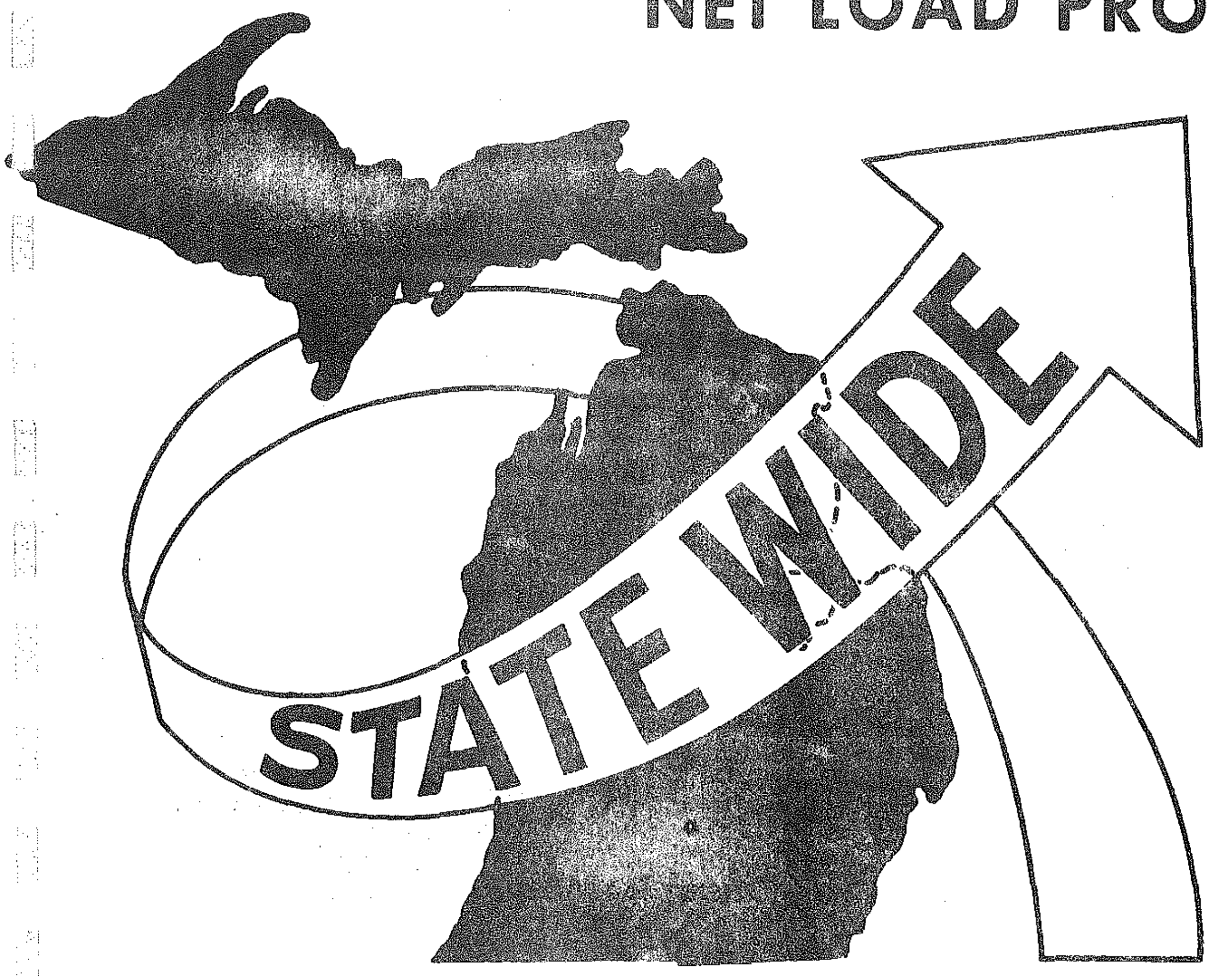

3
3
All Times in Hours?
Yes
No
Change Auto Times To Hours
Using Only Auto Mode?
Yes
No
Auto Time in Minutes Others in Hours?
Yes
No
Change All Modes to Hours
Compute No. Trips from Origin to Dest Zone for each Mode
Print Trip Data (Original Zone No's)
Write Trip Data (New Zone No's. – as in QTRNET & QTRPAT – Seq. 1, 2, . . .)
To QNETLD
Increment Dest. Zone, Origin Zone (At 1000)
1000
END

FIGURE 22d

NET LOAD PROGRAM



NET LOAD PROGRAM

This is a generalized program for loading trips on different modal networks. Accident data may be entered either (1) by link, or (2) by mode, link type, and link facility code groupings. If desired, accident data by link may be used whenever available, and, when not available, accident data for that particular group may be substituted by the program. Parking costs by zone and link toll data were also input data for the original program, but have since been omitted because they are not applicable at the present time. The original program also contained capacity restraint and multi-purpose options which are now, at least temporarily, deleted. A zone-to-zone fare matrix is required for all modes except auto; this matrix is now created by a subroutine of the PATH Program and used to determine the link loadings.

The impact analysis measurements from this program are quite extensive. The first table (Figure 23) prints the accident data entered by method two. Table B of the standard input data would list parking costs by zone (if used), followed by tolls by link in Table C. Next, a listing of parameters (Figure 24) and the transit network may appear if desired. (Tables A and B of modal input data). Table C is printed only when capacity restraint loading is performed and Table D combines the trip table generated by the MODAL SPLIT Program (for given mode) and the zone-to-zone fare matrix. Thus, most of the major results of the preceeding programs may be consolidated into the output of this program. After these tables of input data are found the output data. The first table (Figure 25) lists links and the link loadings for the first mode being considered based upon the paths and

***** STANDARD INPUT DATA *****

PROBLEM IDENTIFICATION NETLOAD ---- BUS CODE NO.

A – ACCIDENT DATA (RATES PER MILLION VEHICLE – MILES – AUTO MODE, PER MILLION PASSENGER – MILES – TRANSIT MODES)

LINK – FACILITY		-- NO. OF ACCIDENTS --			-- ACCIDENT RATIOS --		
TYPE	CODE	FATAL	INJURY	TOTAL	FATAL	INJURY	TOAL
LOCAL	13	8.800	402.200	8651.200	0.873	0.618	1.000
LOCAL	14	8.800	402.200	8651.200	0.873	0.618	1.000
HIWAY	1	1.800	70.500	-0.000	0.873	0.562	1.000
HIWAY	2	2.500	143.000	-0.000	0.873	0.591	1.000
HIWAY	3	5.700	166.700	-0.000	0.762	0.559	1.000
HIWAY	4	2.300	328.300	-0.000	0.913	0.618	1.000
HIWAY	5	7.400	164.100	-0.000	0.686	0.585	1.000
HIWAY	6	2.400	296.800	-0.000	1.000	0.590	1.000
HIWAY	7	8.800	402.400	8651.200	0.873	0.618	1.000
HIWAY	8	2.000	411.300	8651.200	0.946	0.666	1.000
HIWAY	0	4.800	81.000	-0.000	1.000	0.647	1.000
HIWAY	10	5.800	476.800	-0.000	0.750	0.627	1.000
HIWAY	11	8.800	402.200	8651.200	0.873	0.618	1.000
HIWAY	12	2.000	411.300	8651.200	0.946	0.666	1.000
HIWAY	13	8.800	402.200	8651.200	0.873	0.618	1.000
HIWAY	14	8.800	402.000	8651.200	0.873	0.618	1.000
LOCAL	1	8.800	402.200	8651.200	0.873	0.618	1.000
LOCAL	3	8.800	402.200	8651.200	0.873	0.618	1.000
AIR	3	0.630	0.000	0.251	0.398	-0.000	1.000

FIGURE 23: ACCIDENT DATA

****** INPUT DATA – BUS MODE ******

A – PARAMETERS

NO. CENT.	NO. LINKS	NO' NODES	FIRST GATEWAY	HOME NODE	STOP NODE	NODES SKIPPED	WRT FMT	MIN /HR	MPV	PERS. /VEH.	OWN COST
87	445	174	8000	1	87	0	10	MIN	T	2.00	0.050

MAX ART	NO. INTR.	MIN. TIME	TIME INCR.	MAX. TIME	CAP RES	DEST OUT	Z – Z TIMES	Z – Z FARES	NEW TIME
–0	10	0.00	5.00	50.00	0	1	0	1	1

FM = MILES
NFIN = 0
MINPAT = 2
NTPURP = 1
VEHCAP = 50.00
NRTES = 39
FIXFAR = 0.00
PEAK1 = 1.00
PEAK2 = 1.00

FIGURE 24: PARAMETER LIST

FIGURE 25: LINK LOAD

****** LINK LOADINGS FOR BUS MODE ******

LINK NUMBER	NODE FROM	NODE TO	ZONE NUMBER	CAPACITY	LINK TYPE	FACILITY CODE	ASSIGNED VOLUME	LATEST SPEED	V/C OR LOAD FACTOR	ROUTE
1	25	1817	25		LOCAL	1	9.27	30.		0
2	26	1817	26		LOCAL	1	10.60	33.		0
3	27	1817	27		LOCAL	1	7.38	43.		0
4	28	1815	28		LOCAL	1	10.37	39.		0
91	1565	1850	183	17950.	BUS	4	71.50	49.	0.00	14
92	1565	2968	192	5770.	BUS	4	44.57	51.	0.01	13
93	1565	1565	0		DUMMY	1	-0.00	0.		15
94	1565	1565	0		DUMMY	1	-0.00	0.		35
95	1565	2968	192	5770.	BUS	4	3.02	51.	0.00	17
96	1565	2968	192	5770.	BUS	4	0.46	51.	0.00	18
97	1585	1602	236	28000.	BUS	2	0.00	60.	0.00	21
98	1558	2038	233	19000.	BUS	1	0.00	59.	0.00	22
99	1585	2596	245	3280.	BUS	3	0.00	55.	0.00	24
100	1598	237	237		LOCAL	1	29.12	30.		0
101	1598	1602	236	28000.	BUS	4	113.42	52.	0.00	13
102	1598	1623	236	4410.	BUS	4	11.39	38.	0.00	18
103	1598	2708	244	4760.	BUS	3	59.35	45.	0.00	14
104	1598	2708	244	4760.	BUS	3	0.00	45.	0.00	15
105	1598	2708	244	4760.	BUS	3	0.00	45.	0.00	35
106	1602	1602	336	28000.	BUS	4	0.00	52.	0.00	17
107	1602	236	236		LOCAL	1	211.78	36.		0
181	1815	28	28	3290.	LOCAL	1	10.55	39.	0.03	0
182	1815	1817	26	3450.	BUS	3	85.99	50.	0.03	25
183	1815	1961	240		BUS	3	96.26	50.		26
184	1817	25	25		LOCAL	1	9.48	30.		0
185	1817	26	26	3390.	LOCAL	1	10.62	33.		0
186	1817	27	27	5510.	LOCAL	1	7.53	43.		0
187	1817	1815	26		BUS	3	84.35	50.	0.02	26
188	1817	2120	55		BUS	4	82.44	44.	0.01	25
189	1832	119	119		LOCAL	1	6.83	43.		0
190	1832	121	121		LOCAL	1	10.18	36.		0
191	1832	123	123		LOCAL	1	11.14	43.		0
192	1832	1835	113	7010.	BUS	4	12.70	46.	0.00	7
193	1832	1850	183	17890.	BUS	4	256.10	51.	0.01	2
194	1832	1850	183	17890.	BUS	4	20.99	51.	0.00	3

NOTE ASSIGNED VOLUME IS IN TERMS OF VEHICLES ON LOCAL LINKS AND PERSONS ON ALL OTHER LINKS AN AVERAGE OF 2.0 PERSONS PER VEHICLE WAS ASSUMED and trips generated by the PATH and MODAL SPLIT Programs, respectively. The next table (Figure 26) totals data by zone of origin. Then the trips are placed into appropriate time intervals which could help form a bar graph, again being grouped by origin zone, and then by destination zone (Figure 27). If trips are sorted by trip purpose, tables are also printed by trip purpose and zone of origin. For modes other than auto, the maximum volume is given for each route and the link listed on which this maximum volume is found (Figure 28). After all desired modes and their tables are completed, two more summary tables are created. The first table lists total passenger miles by mode (Figure 29a) and the second gives number of accidents by mode and zone of origin (Figure 29b).

Figures 30a-n show a flow chart of the program logic. It includes all options as found in the original program, even though some are not being used at this time.

Special note should be made of the data totals by zone of origin table for modes other than auto. The column headed "Fare Charges" represents revenue for the transit company, and with minor adjustments should be useful in estimating revenue by station or perhaps even by transit company.

****** DATA TOTALS BY ZONE OF ORIGIN FOR BUS MODE ******

ZONE OF ORIGIN	PERSON TRIPS	PERSON MILES	ACCESS TIME	LINE-HAUL TIME	OWNRSHP COSTS	ACCESS COSTS	FARE CHARGES	---TOTAL FATAL	ACCIDENT INJURY	COSTS--- PROP. DAM.
25	18.5	801.7	173.24	0.91	37.48	2.48	50.99	0.00	0.00	0.01
26	21.2	1042.1	390.06	1.06	46.45	5.30	59.57	0.00	0.00	0.02
27	14.8	879.0	421.52	0.76	36.65	6.90	42.85	0.00	0.00	0.01
28	20.7	978.9	509.49	0.84	40.75	7.75	47.96	0.00	0.00	0.01
55	97.2	5131.7	979.84	5.57	241.01	14.57	323.45	0.00	0.00	0.08
56	6.8	379.5	161.18	0.32	16.23	2.60	17.22	0.00	0.00	0.00
57	12.5	836.5	387.23	0.72	35.47	5.98	41.43	0.00	0.00	0.01
58	70.9	3940.0	1062.62	4.04	180.43	15.49	234.49	0.00	0.00	0.06
59	23.8	1341.8	450.79	1.35	60.95	5.78	78.23	0.00	0.00	0.02

FIGURE 26:
TOTALS BY ZONE OF ORIGIN

FIGURE 27

NETLOAD----BUS

****** TRAVEL TIME DISTRIBUTION BY ZONE OF ORIGIN FOR BUS MODE ******

– PERSON TRIPS SHOWN FOR INDICATED TRAVEL TIME INTERVALS –

TRAVEL TIME INTERVAL – MIN

ORIGIN ZONE	15.- 20.	20.- 25.	25.- 30.	30.- 35.	35.- 40.	40.- 45.	45.- 50.	+ 50.
25	0.000	0.000	0.000	0.760	2.100	4.010	0.540	11.130
26	0.000	0.000	0.000	0.000	0.000	1.210	2.650	17.430
27	0.000	0.000	0.000	0.000	0.000	0.000	0.000	14.760
28	0.000	0.000	0.000	0.850	0.000	2.380	0.000	17.510
55	3.770	3.960	2.650	4.290	6.210	4.630	4.100	67.600
56	0.000	0.000	0.000	0.270	0.200	0.190	1.920	4.190
57	0.000	0.000	0.000	0.000	0.000	1.310	0.760	10.440
58	0.000	3.060	3.220	2.150	3.480	5.010	2.960	51.080
59	0.000	0.000	1.110	1.950	0.000	1.530	1.350	17.820

****** TRAVEL TIME DISTRIBUTION BY ZONE OF DEST FOR BUS MODE ******

- PERSON TRIPS SHOWN FOR INDICATED TRAVEL TIME INTERVALS -

TRAVEL TIME INTERVAL – MIN

DEST ZONE	15.- 20.	20.- 25.	25.- 30.	30.- 35.	35.- 40.	40.- 45.	45.- 50.	+ 50.
25	0.000	0.000	0.000	0.760	2.100	4.010	0.540	11.550
26	0.000	0.000	0.000	0.000	0.000	1.200	2.650	17.870
27	0.000	0.000	0.000	0.000	0.000	0.000	0.000	15.060
28	0.000	0.000	0.000	0.850	0.000	2.380	0.000	17.860
55	3.540	3.880	2.490	4.250	6.350	4.970	4.100	75.850
56	0.000	0.000	0.000	0.290	0.220	0.200	1.920	4.360
57	0.000	0.000	0.000	0.000	0.000	1.240	0.750	11.180
58	0.000	2.870	3.150	2.020	3.440	5.140	3.530	56.110
59	0.000	0.000	1.040	1.870	0.000	1.520	1.510	19.600

FIGURE 28: MAXIMUM VOLUMES BY ROUTE

MAXIMUM VOLUMES ON ROUTES

ROUTE	LINK	--NODES--		VOLUMES
1	149	96	98	134.
2	193	101	104	256.
3	290	112	113	29.
4	158	97	98	419.
5	329	119	104	61.
6	241	105	98	451.
7	175	98	96	131.

****** TOTAL PASSENGER MILES BY MODE ******

--- AUTO MODE ---			— AIR MODE —	
LOCAL	ARTERIAL	FREEWAY	ACCESS	TRANSIT
1974474.	3451242.	2647718.	12949.	22498.

-- BUS MODE --		-- RAIL MODE ---	
ACCESS	TRANSIT	ACCESS	TRANSIT
38459.	156678.	20876.	35789.

FIGURE 29a

TOTAL NUMBERS OF ACCIDENTS BY ZONE OF ORIGIN

ZONE OF ORIGIN	LOCAL	ARTRL	---- FATAL FREEWAY	ACCIDENTS ---- AIR	BUS	RAIL
25	.010	.015	.005	.000	.000	.000
26	.015	.020	.007	.001	.001	.000
27	.009	.007	.003	.000	.000	.000

ZONE OF ORIGIN	LOCAL	ARTRL	---- INJURY FREEWAY	ACCIDENTS ---- AIR	BUS	RAIL
25	.020	.017	.010	.000	.001	.000
26	.035	.025	.012	.002	.001	.001
27	.022	.017	.009	.000	.000	.001

ZONE OF ORIGIN	LOCAL	ARTRL	---- TOTAL NUMBER OF ACCIDENTS---- FREEWAY	AIR	BUS	RAIL
25	.039	.045	.025	.001	.001	.000
26	.075	.061	.034	.003	.003	.002
27	.042	.032	.021	.000	.001	.001

FIGURE 29b

QNETLD

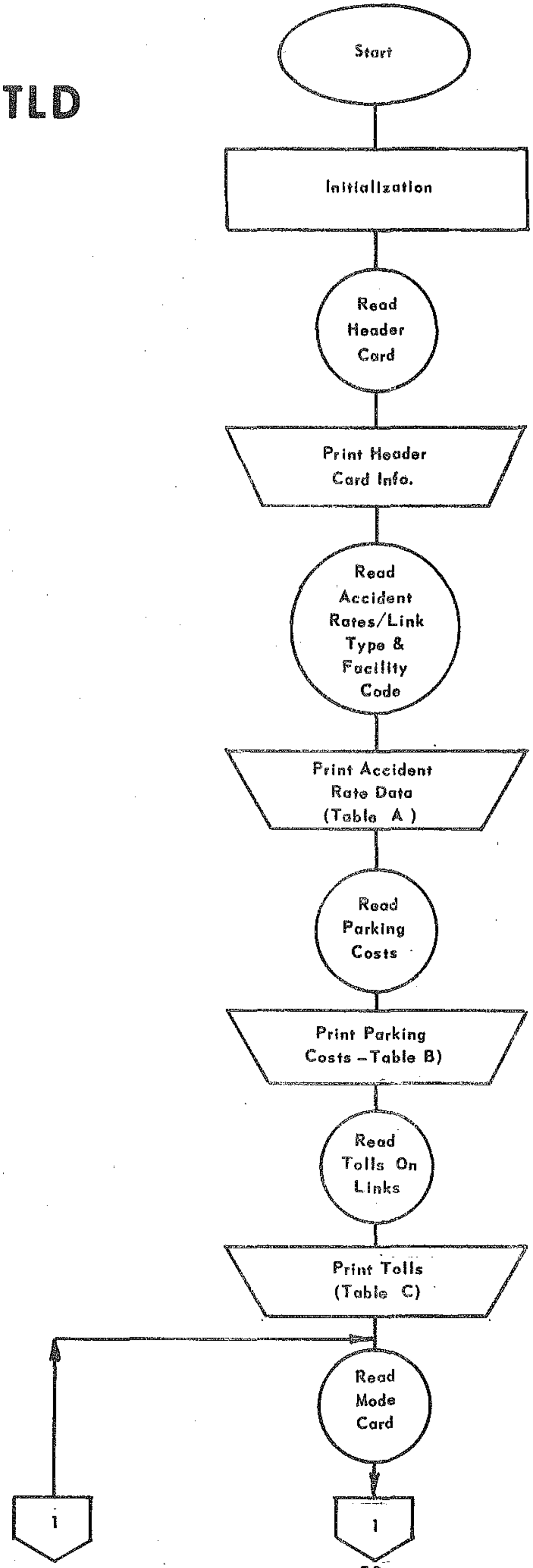


FIGURE 30a

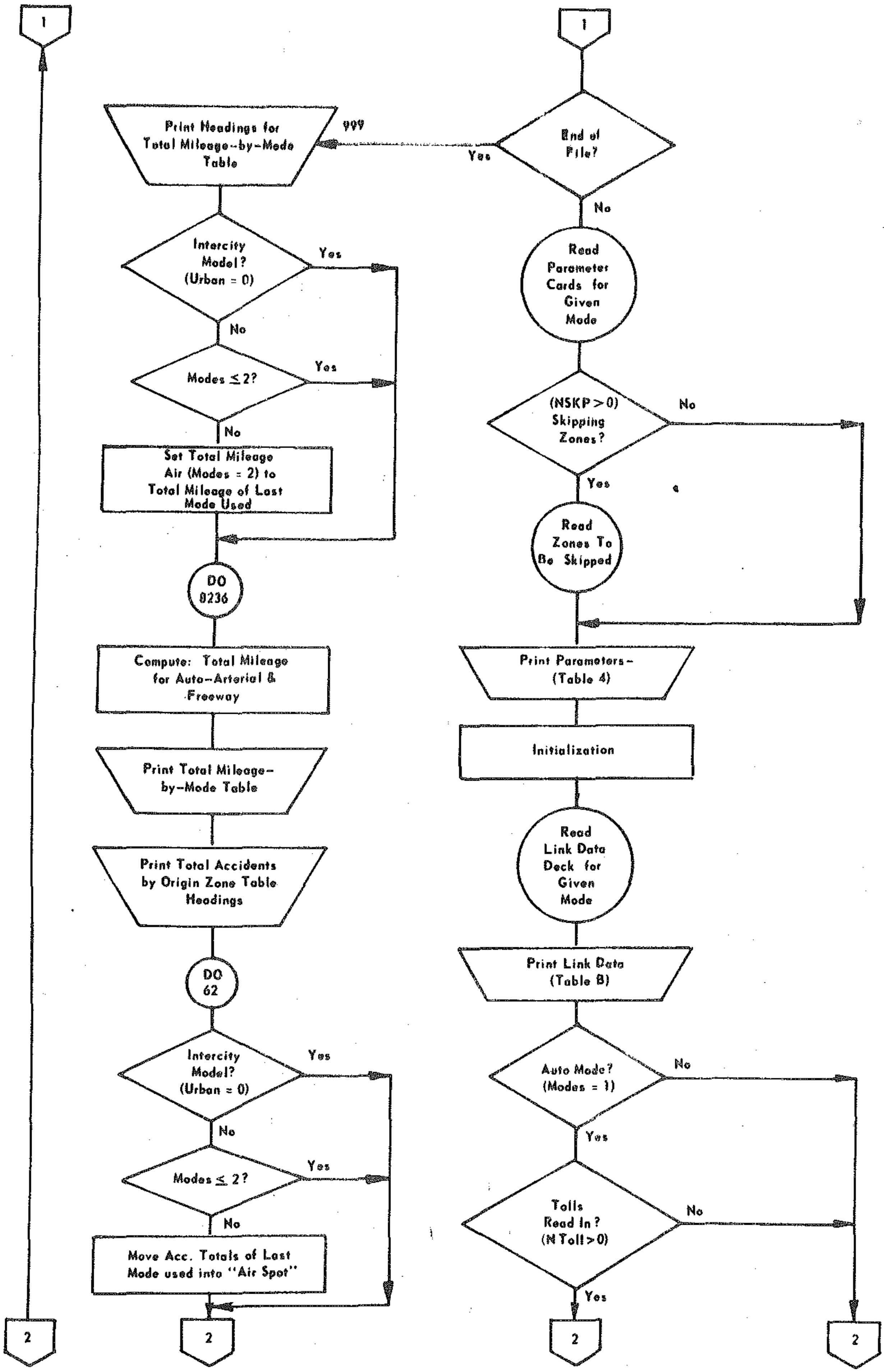

1
Print Headings for Total Mileage-by-Mode Table
999
Intercity Model? (Urban = 0)
Yes
No
Modes ≤ 2?
Yes
No
Set Total Mileage Air (Modes = 2) to Total Mileage of Last Mode Used
DO 8236
Compute: Total Mileage for Auto-Arterial & Freeway
Print Total Mileage-by-Mode Table
Print Total Accidents by Origin Zone Table Headings
DO 62
Intercity Model? (Urban = 0)
Yes
No
Modes ≤ 2?
Yes
No
Move Acc. Totals of Last Mode used into "Air Spot"
2
2
1
End of File?
Yes
No
Read Parameter Cards for Given Mode
(NSKP > 0) Skipping Zones?
No
Yes
Read Zones To Be Skipped
Print Parameters - (Table 4)
Initialization
Read Link Data Deck for Given Mode
Print Link Data (Table 8)
Auto Mode? (Modes = 1)
No
Yes
Tolls Read In? (N Toll > 0)
No
Yes
2
2

FIGURE 30b

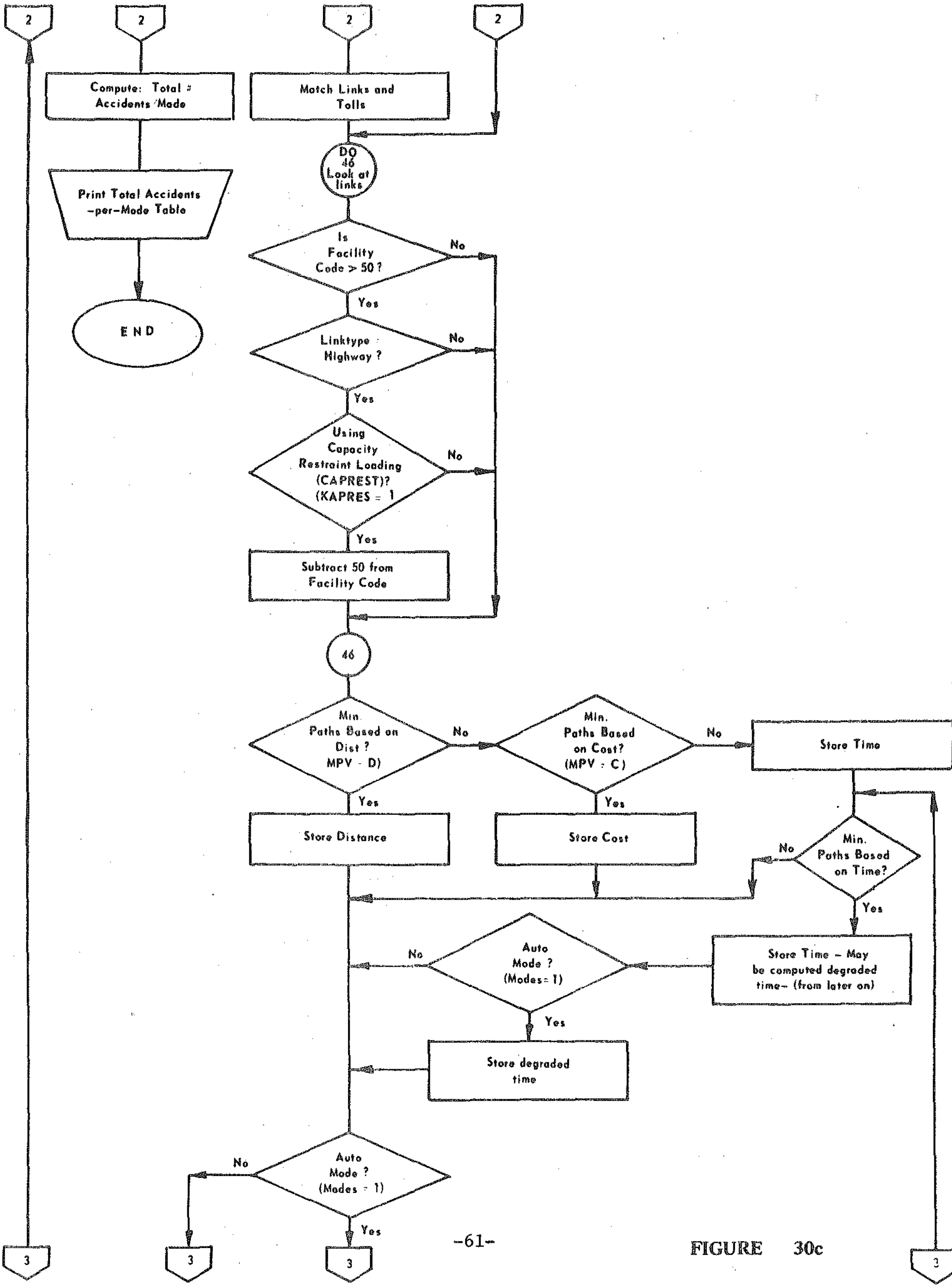

2
2
2
2
Compute: Total # Accidents/Mode
Match Links and Tolls
Print Total Accidents -per-Mode Table
DO 46 Look at links
END
Is Facility Code > 50 ?
No
Yes
Linktype : Highway ?
No
Yes
Using Capacity Restraint Loading (CAPREST)? (KAPRES = 1
No
Yes
Subtract 50 from Facility Code
46
Min. Paths Based on Dist ? MPV - D)
No
Min. Paths Based on Cost? (MPV : C)
No
Store Time
Yes
Store Distance
Yes
Store Cost
No
Min. Paths Based on Time?
Yes
Store Time – May be computed degraded time– (from later on)
No
Auto Mode ? (Modes= 1)
Yes
Store degraded time
No
Auto Mode ? (Modes = 1)
Yes
3
3
3
3

FIGURE 30c

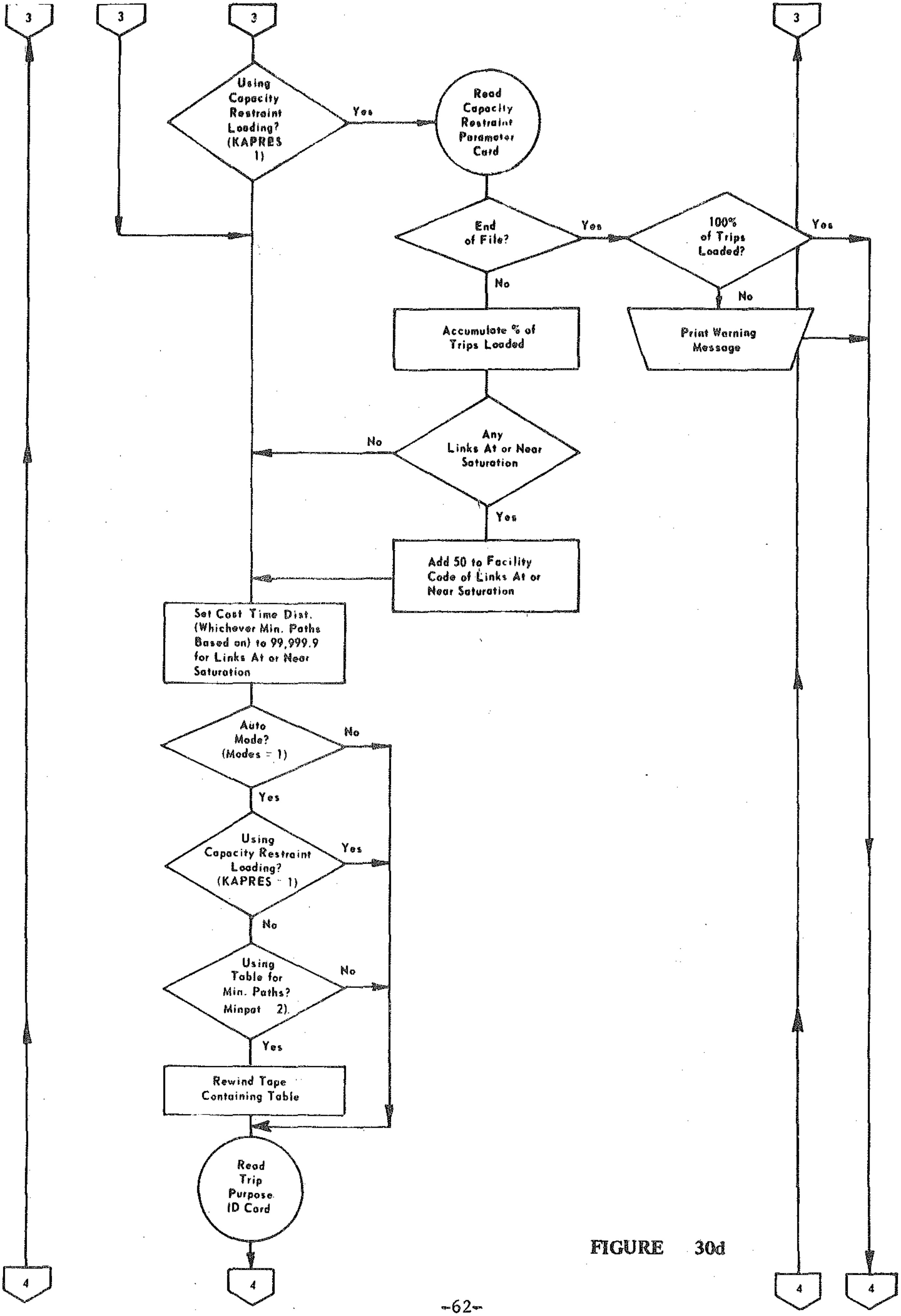

3
3
3
3
Using Capacity Restraint Loading? (KAPRES 1)
Yes
Read Capacity Restraint Parameter Card
End of File?
Yes
100% of Trips Loaded?
Yes
No
No
Accumulate % of Trips Loaded
Print Warning Message
Any Links At or Near Saturation
No
Yes
Add 50 to Facility Code of Links At or Near Saturation
Set Cost Time Dist. (Whichever Min. Paths Based on) to 99,999.9 for Links At or Near Saturation
Auto Mode? (Modes = 1)
No
Yes
Using Capacity Restraint Loading? (KAPRES 1)
Yes
No
Using Table for Min. Paths? Minpat 2).
No
Yes
Rewind Tape Containing Table
Read Trip Purpose ID Card
4
4
4
4

FIGURE 30d

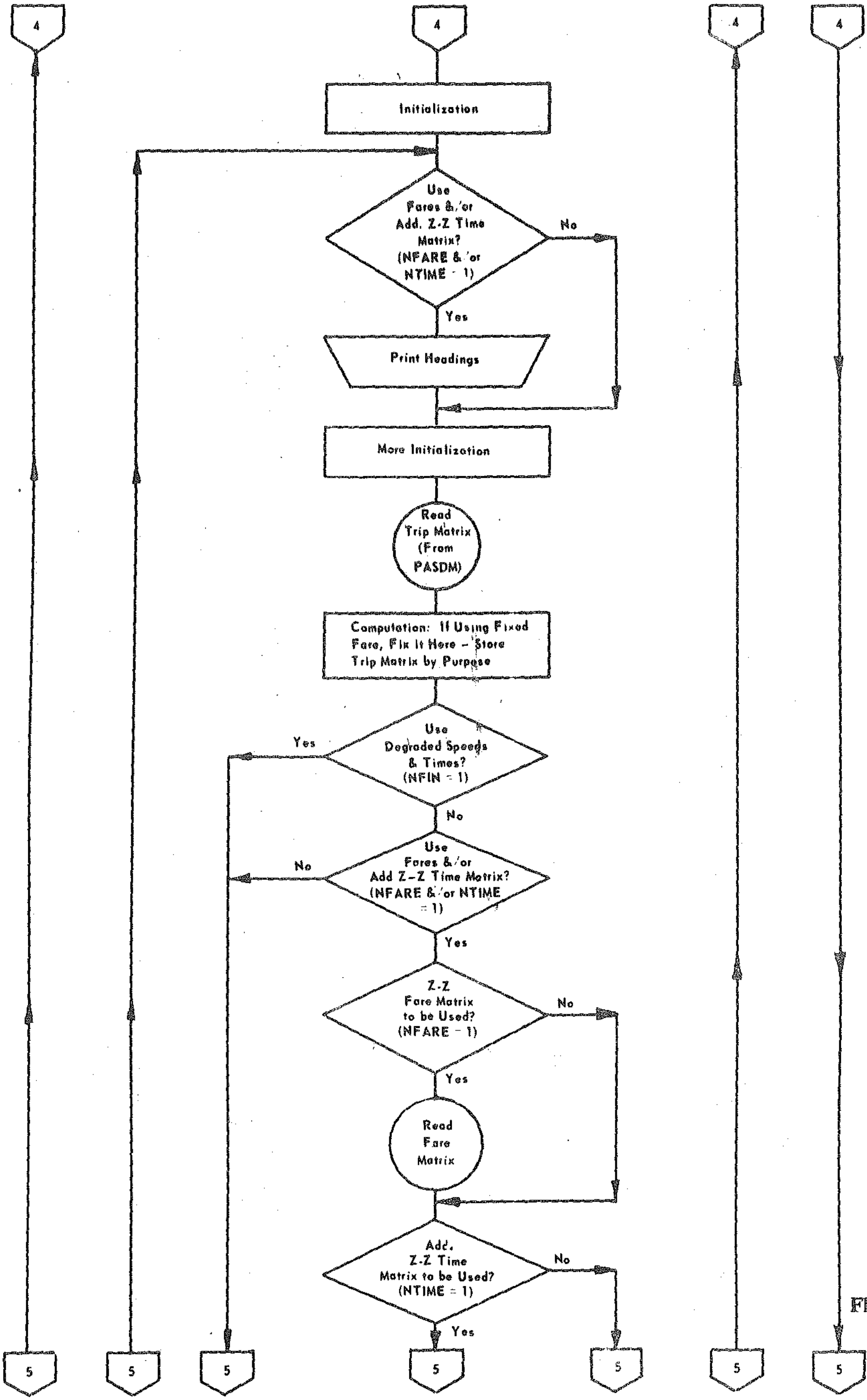

4
4
4
4
Initialization
Use Fares &/or Add. Z-Z Time Matrix? (NFARE &/or NTIME = 1)
No
Yes
Print Headings
More Initialization
Read Trip Matrix (From PASDM)
Computation: If Using Fixed Fare, Fix It Here – Store Trip Matrix by Purpose
Use Degraded Speeds & Times? (NFIN = 1)
Yes
No
Use Fares &/or Add Z-Z Time Matrix? (NFARE &/or NTIME = 1)
No
Yes
Z-Z Fare Matrix to be Used? (NFARE = 1)
No
Yes
Read Fare Matrix
Add. Z-Z Time Matrix to be Used? (NTIME = 1)
No
Yes
5
5
5
5
5
5
5

FIGURE 30e

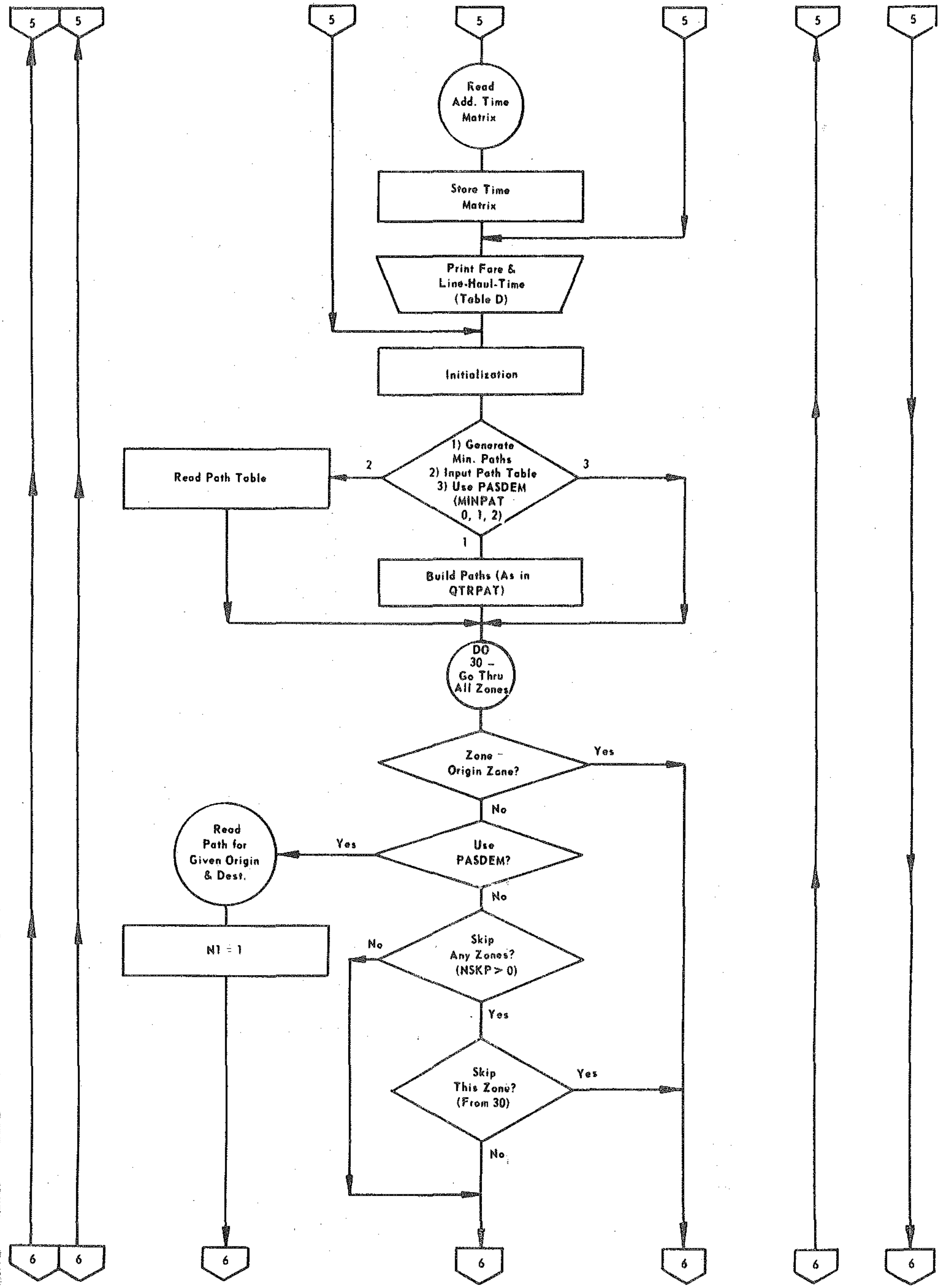

5
Read
Add. Time
Matrix
Store Time
Matrix
Print Fare &
Line-Haul-Time
(Table D)
Initialization
1) Generate
Min. Paths
2) Input Path Table
3) Use PASDEM
(MINPAT
0, 1, 2)
2
3
1
Read Path Table
Build Paths (As in
QTRPAT)
DO
30 –
Go Thru
All Zones
Zone –
Origin Zone?
Yes
No
Use
PASDEM?
Yes
No
Read
Path for
Given Origin
& Dest.
N1 = 1
Skip
Any Zones?
(NSKP > 0)
No
Yes
Skip
This Zone?
(From 30)
Yes
No
6

FIGURE 30f

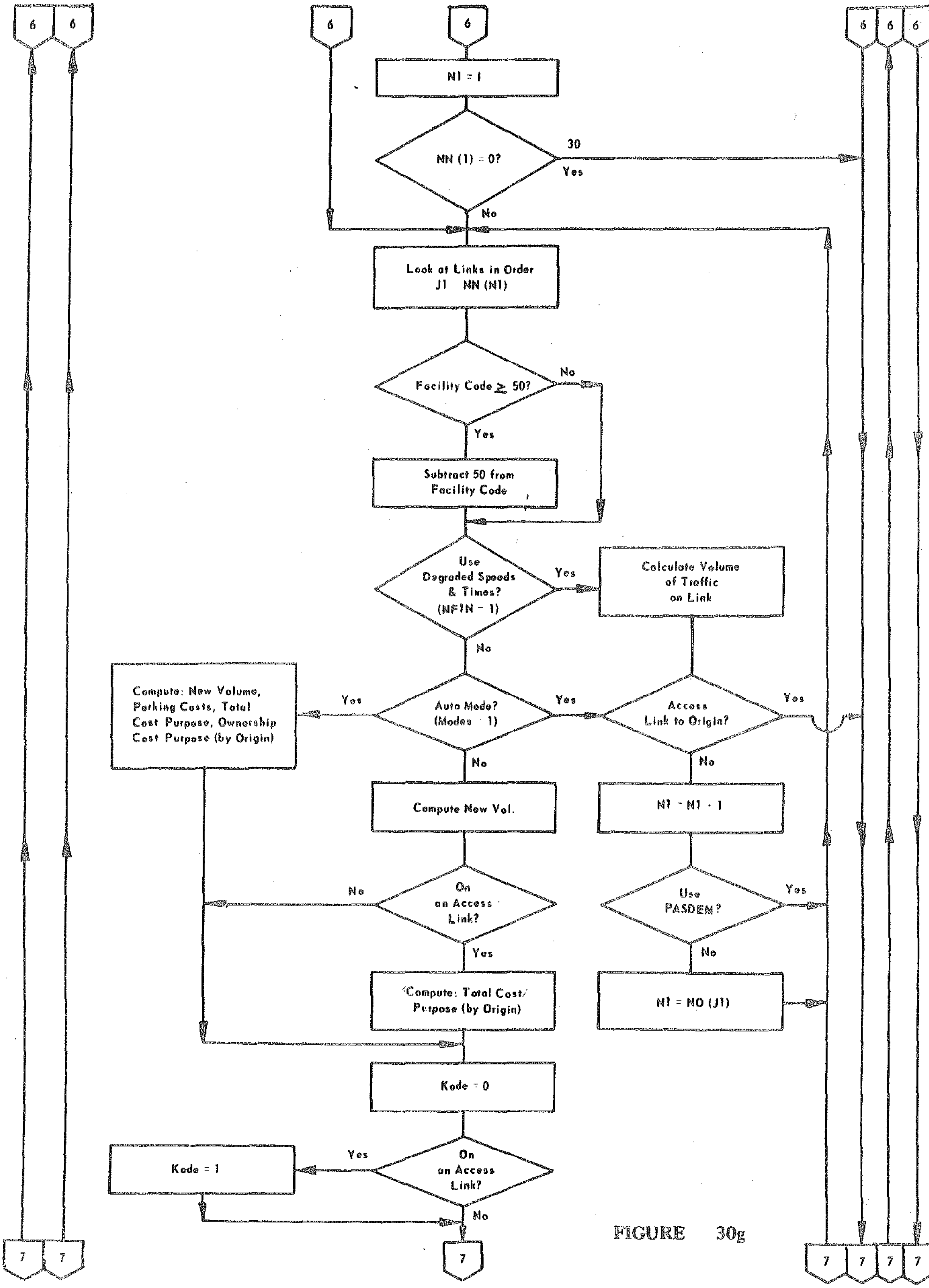

6
NI = 1
NN (1) = 0?
30
Yes
No
Look at Links in Order
J1 NN (N1)
Facility Code ≥ 50?
No
Yes
Subtract 50 from
Facility Code
Use
Degraded Speeds
& Times?
(NFIN = 1)
Yes
Calculate Volume
of Traffic
on Link
No
Compute: New Volume,
Parking Costs, Total
Cost Purpose, Ownership
Cost Purpose (by Origin)
Auto Mode?
(Modes = 1)
Access
Link to Origin?
Compute New Vol.
On
on Access
Link?
Compute: Total Cost/
Purpose (by Origin)
Use
PASDEM?
N1 = NO (J1)
Kode = 0
Kode = 1
7

FIGURE 30g

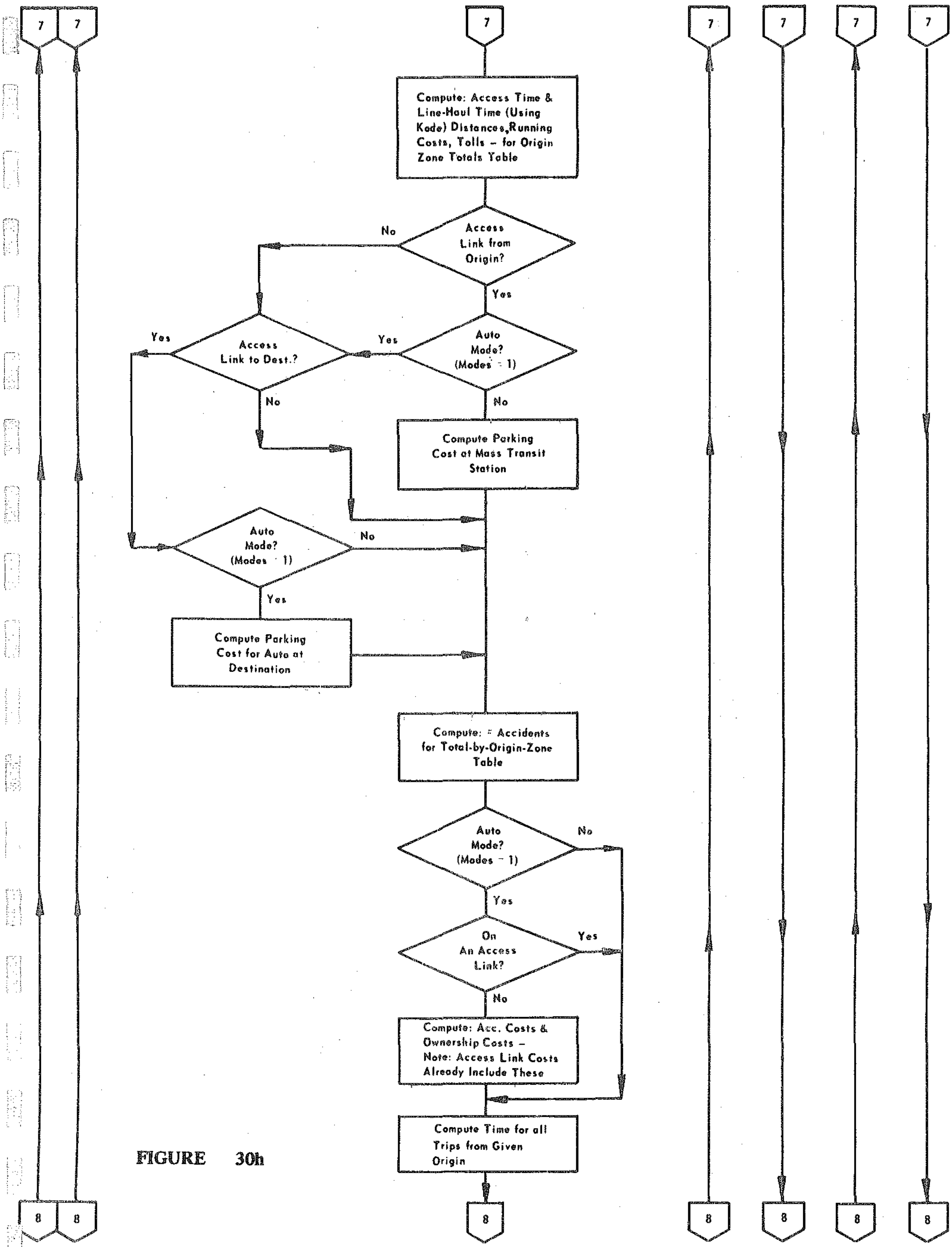
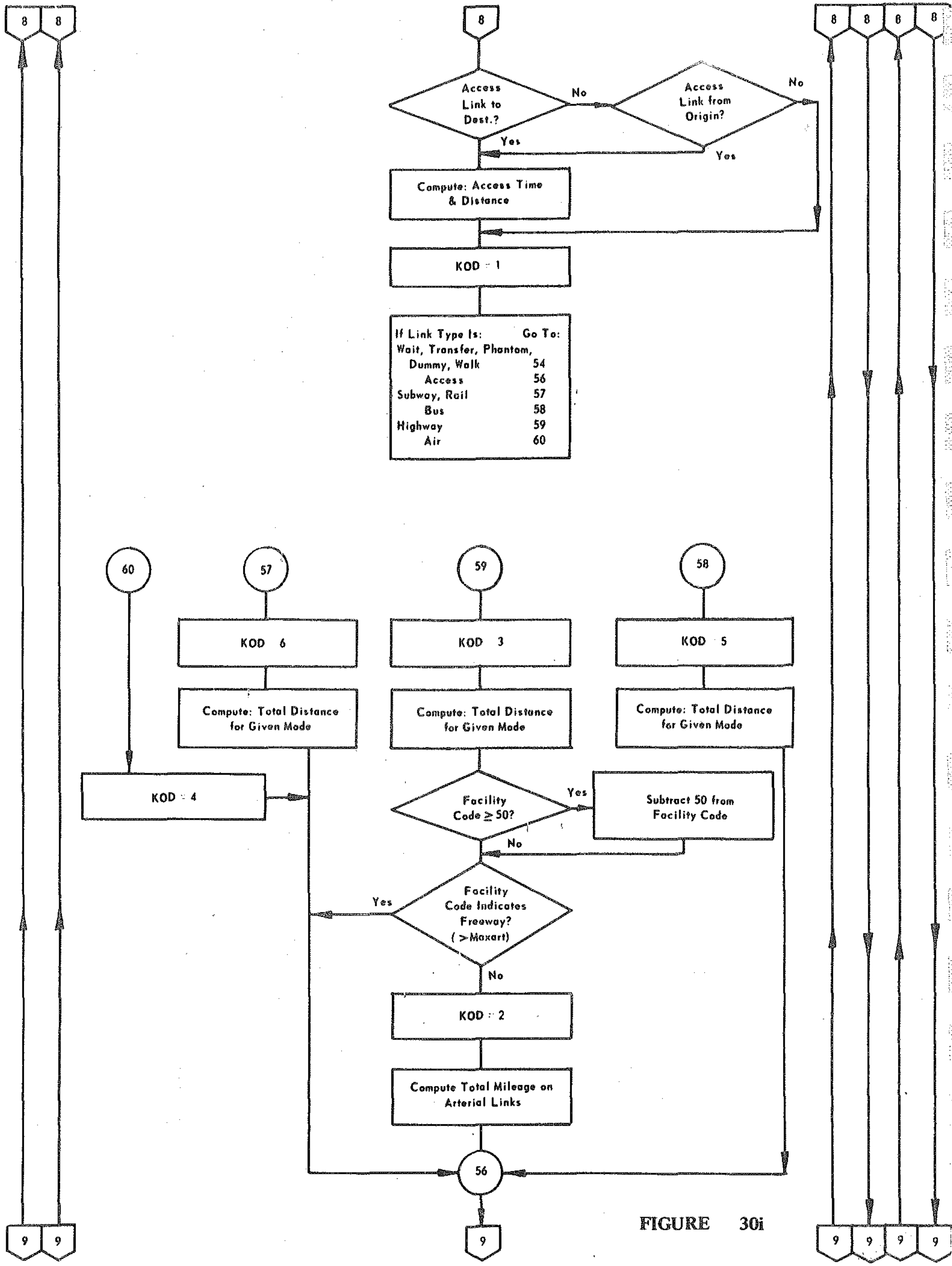
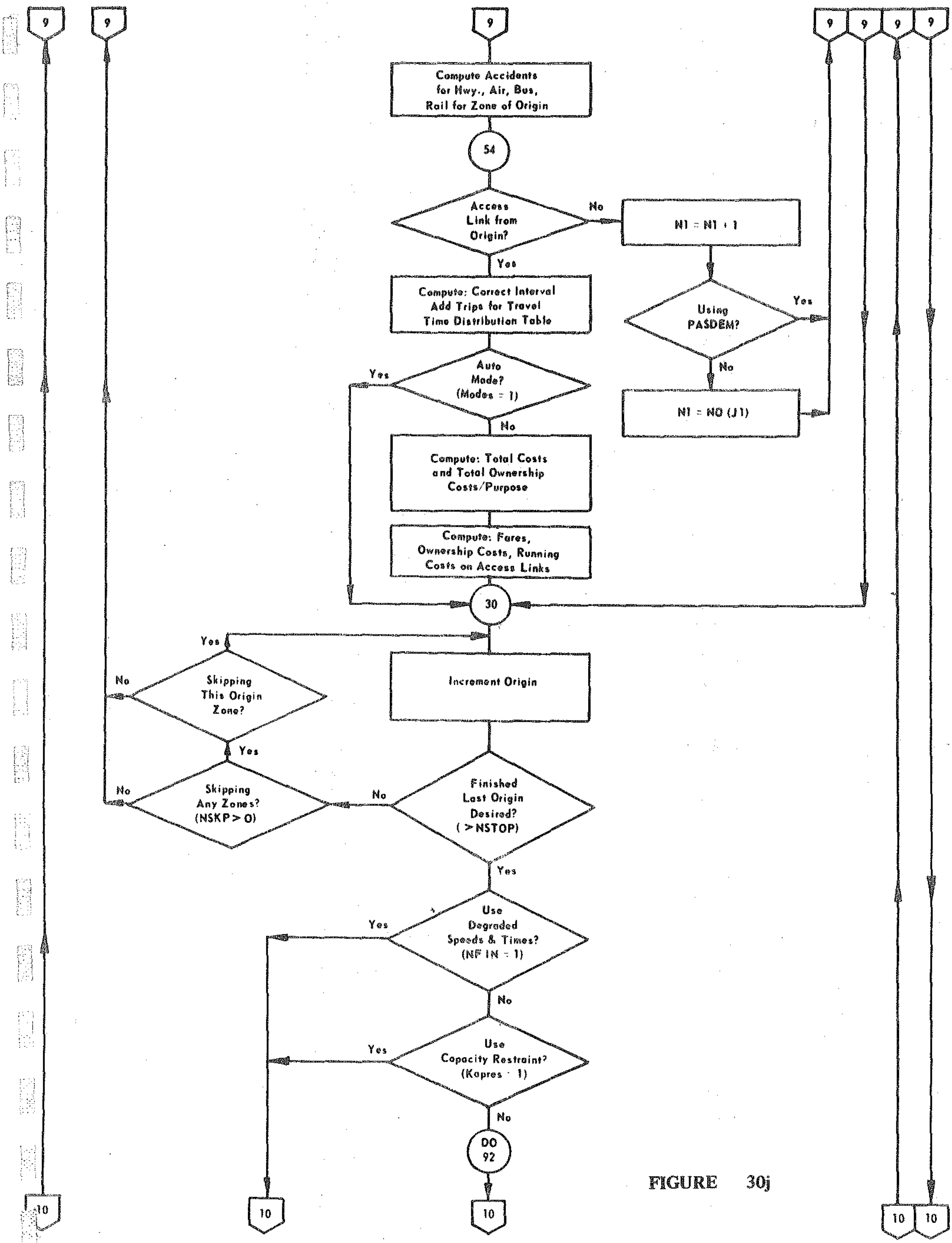

7
Compute: Access Time & Line-Haul Time (Using Kode) Distances, Running Costs, Tolls – for Origin Zone Totals Table
Access Link from Origin?
No
Yes
Auto Mode? (Modes = 1)
Yes
No
Access Link to Dest.?
Yes
No
Compute Parking Cost at Mass Transit Station
Auto Mode? (Modes = 1)
No
Yes
Compute Parking Cost for Auto at Destination
Compute: # Accidents for Total-by-Origin-Zone Table
Auto Mode? (Modes = 1)
No
Yes
On An Access Link?
Yes
No
Compute: Acc. Costs & Ownership Costs – Note: Access Link Costs Already Include These
Compute Time for all Trips from Given Origin
8

FIGURE 30h



8
Access Link to Dest.?
No
Access Link from Origin?
No
Yes
Yes
Compute: Access Time & Distance
KOD = 1
If Link Type Is: Go To:
Wait, Transfer, Phantom, Dummy, Walk 54
Access 56
Subway, Rail 57
Bus 58
Highway 59
Air 60
60
57
59
58
KOD 6
KOD 3
KOD 5
Compute: Total Distance for Given Mode
Compute: Total Distance for Given Mode
Compute: Total Distance for Given Mode
KOD = 4
Facility Code ≥ 50?
Yes
Subtract 50 from Facility Code
No
Facility Code Indicates Freeway? (>Maxart)
Yes
No
KOD = 2
Compute Total Mileage on Arterial Links
56
9

FIGURE 30i



9
Compute Accidents for Hwy., Air, Bus, Rail for Zone of Origin
54
Access Link from Origin?
No
N1 = N1 + 1
Using PASDEM?
Yes
No
N1 = NO (J1)
Yes
Compute: Correct Interval Add Trips for Travel Time Distribution Table
Auto Mode? (Modes = 1)
Yes
No
Compute: Total Costs and Total Ownership Costs/Purpose
Compute: Fares, Ownership Costs, Running Costs on Access Links
30
Increment Origin
Skipping This Origin Zone?
Skipping Any Zones? (NSKP > 0)
Finished Last Origin Desired? (> NSTOP)
Use Degraded Speeds & Times? (NF IN = 1)
Use Capacity Restraint?
DO 92
10

FIGURE 30j

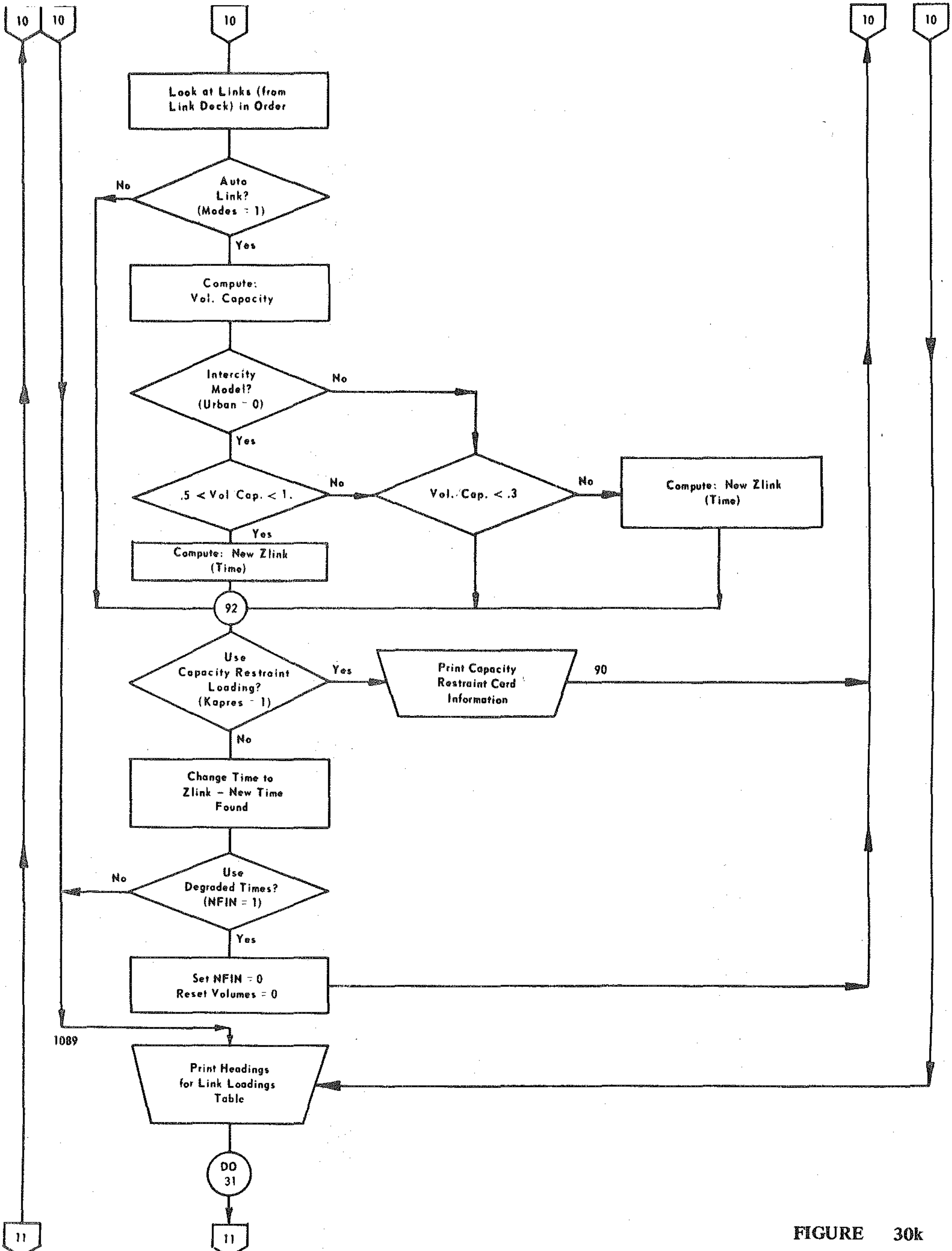

10
10
10
10
10
Look at Links (from Link Deck) in Order
Auto Link? (Modes = 1)
No
Yes
Compute: Vol. Capacity
Intercity Model? (Urban = 0)
No
Yes
.5 < Vol Cap. < 1.
No
Yes
Vol. Cap. < .3
No
Compute: New Zlink (Time)
Compute: New Zlink (Time)
92
Use Capacity Restraint Loading? (Kapres = 1)
Yes
Print Capacity Restraint Card Information
90
No
Change Time to Zlink – New Time Found
Use Degraded Times? (NFIN = 1)
No
Yes
Set NFIN = 0
Reset Volumes = 0
1089
Print Headings for Link Loadings Table
DO 31
11
11

FIGURE 30k

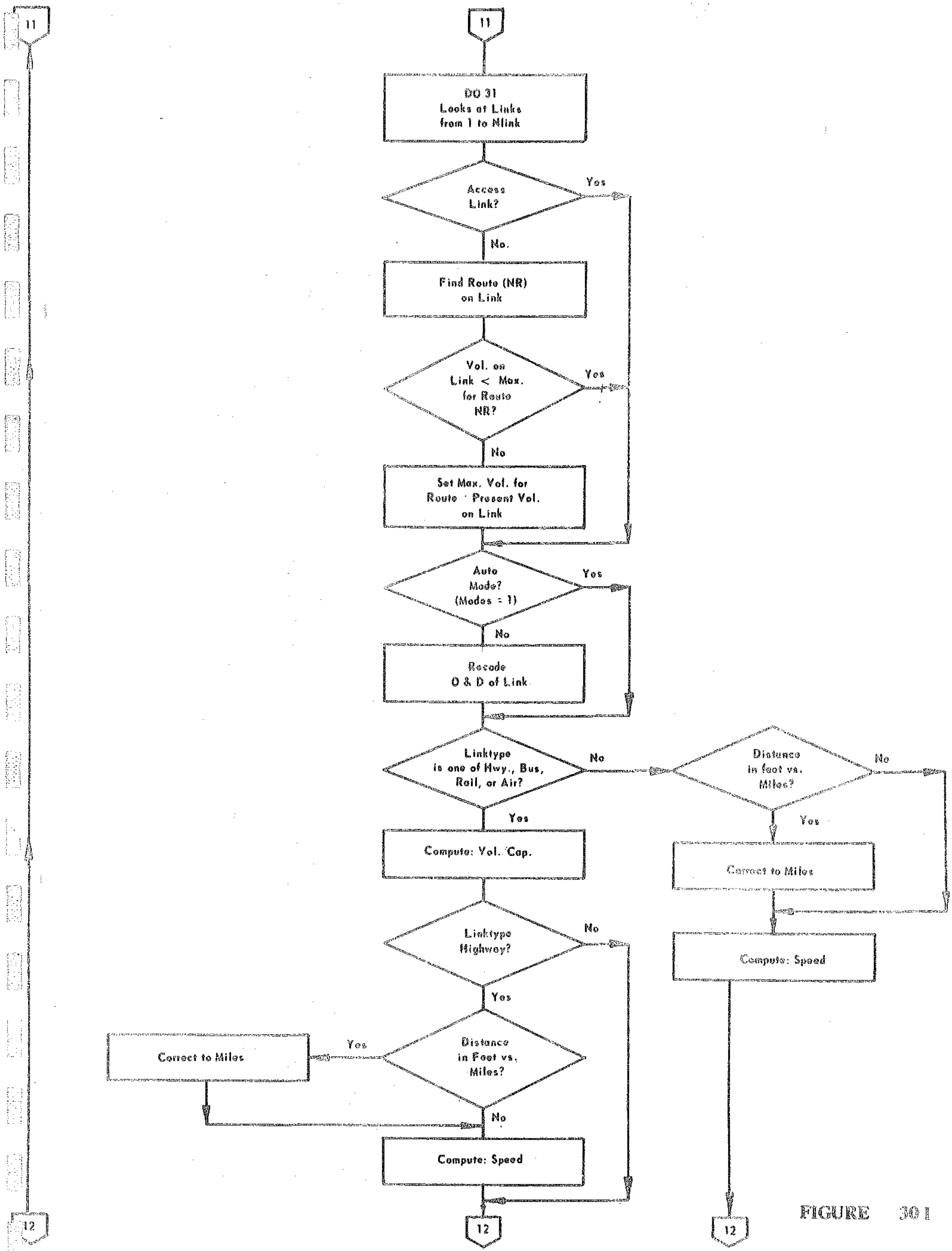
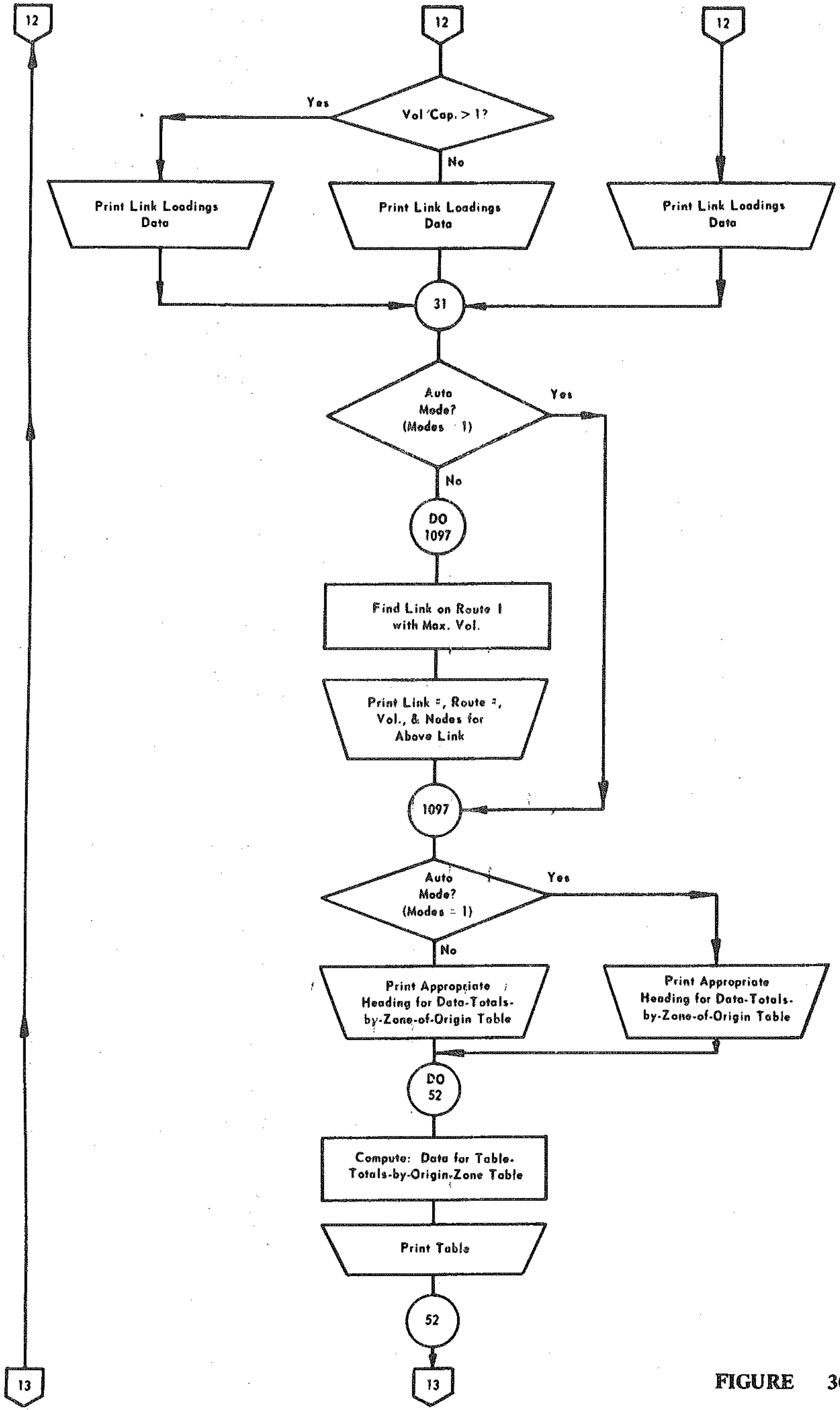

11
DO 31
Looks at Links
from 1 to Nlink
Access
Link?
Yes
No.
Find Route (NR)
on Link
Vol. on
Link < Max.
for Route
NR?
Yes
No
Set Max. Vol. for
Route · Present Vol.
on Link
Auto
Mode?
(Modes = 1)
Yes
No
Recode
O & D of Link
Linktype
is one of Hwy., Bus,
Rail, or Air?
No
Distance
in feet vs.
Miles?
No
Yes
Correct to Miles
Compute: Speed
Yes
Compute: Vol. Cap.
Linktype
Highway?
No
Yes
Correct to Miles
Yes
Distance
in Feet vs.
Miles?
No
Compute: Speed
12
12
12

FIGURE 301



12
12
12
Vol/Cap. > 1?
Yes
No
Print Link Loadings Data
Print Link Loadings Data
Print Link Loadings Data
31
Auto Mode? (Modes = 1)
Yes
No
DO 1097
Find Link on Route I with Max. Vol.
Print Link #, Route #, Vol., & Nodes for Above Link
1097
Auto Mode? (Modes = 1)
Yes
No
Print Appropriate Heading for Data-Totals-by-Zone-of-Origin Table
Print Appropriate Heading for Data-Totals-by-Zone-of-Origin Table
DO 52
Compute: Data for Table-Totals-by-Origin-Zone Table
Print Table
52
13
13

FIGURE 30m

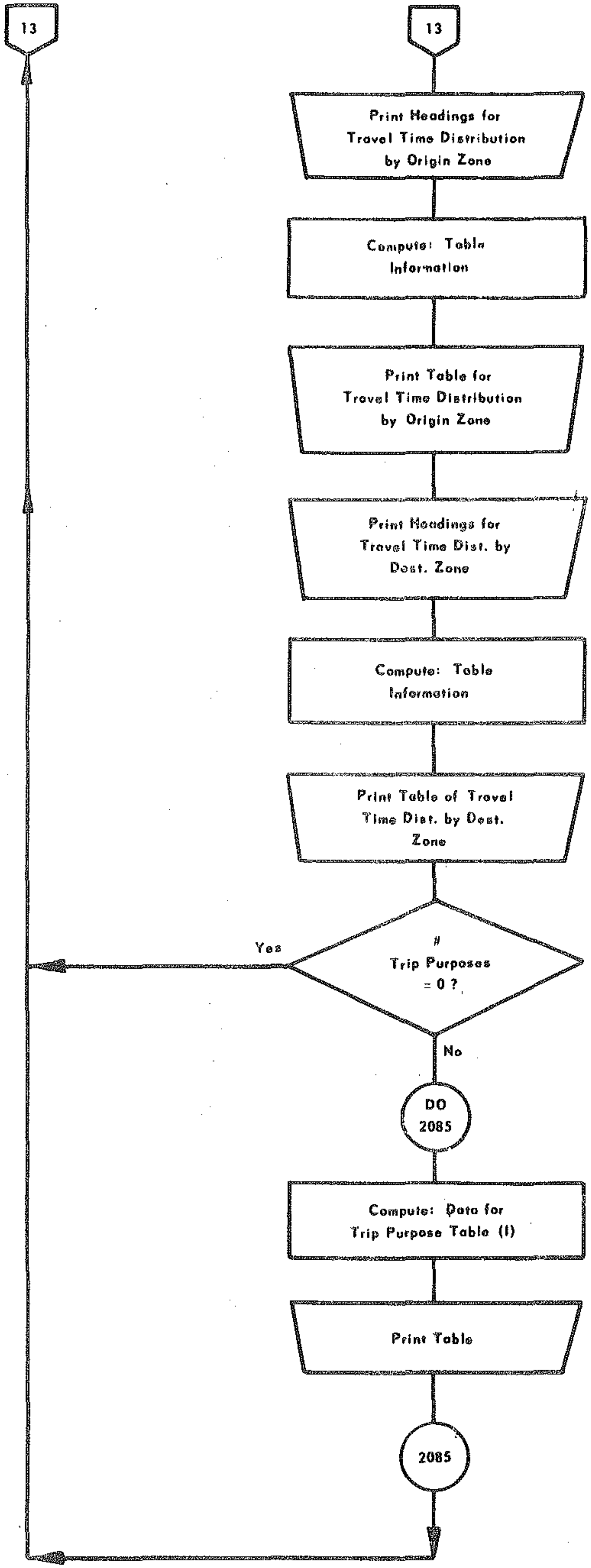
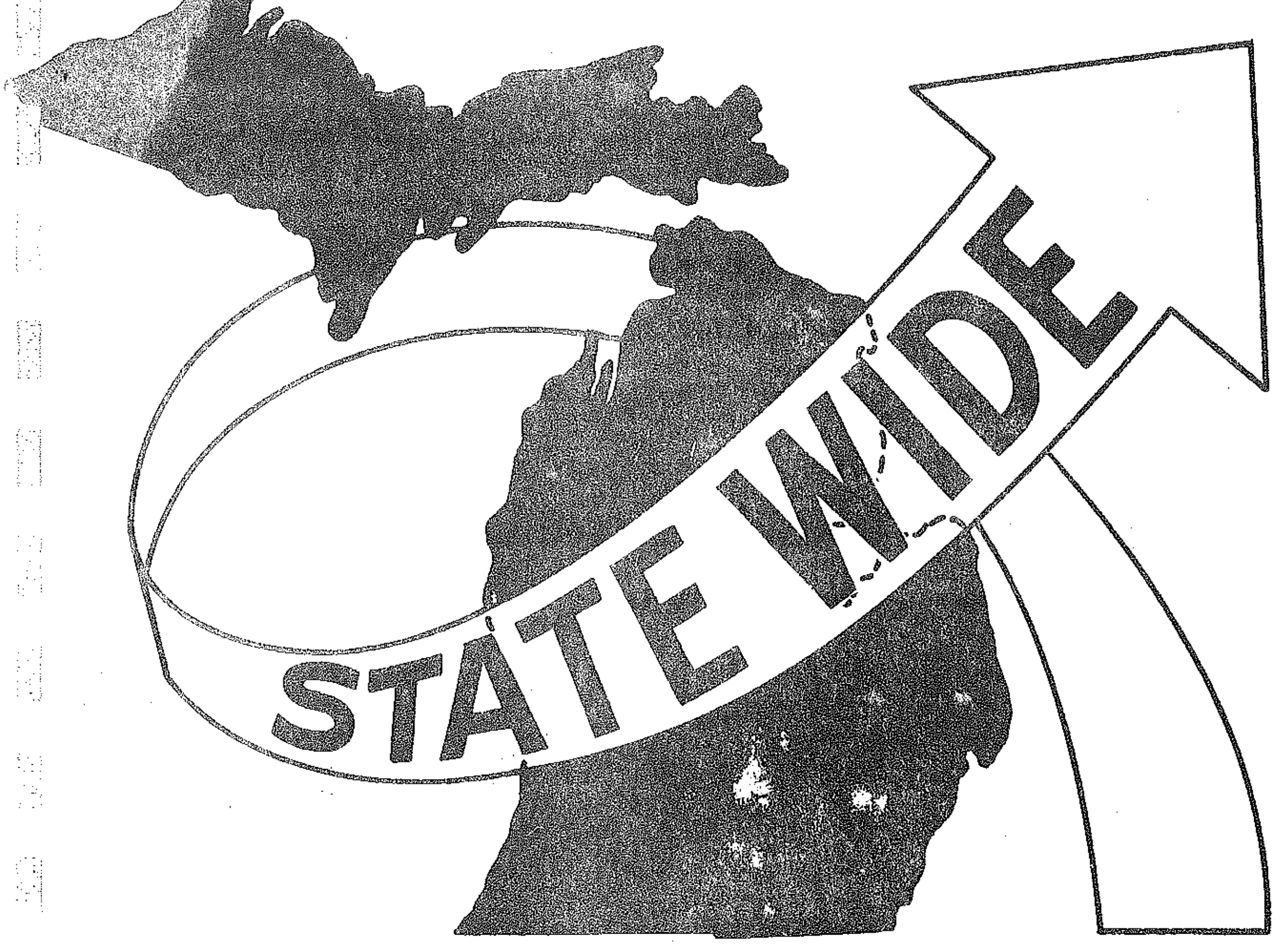

13
13
Print Headings for
Travel Time Distribution
by Origin Zone
Compute: Table
Information
Print Table for
Travel Time Distribution
by Origin Zone
Print Headings for
Travel Time Dist. by
Dest. Zone
Compute: Table
Information
Print Table of Travel
Time Dist. by Dest.
Zone
Yes
#
Trip Purposes
= 0 ?
No
DO
2085
Compute: Data for
Trip Purpose Table (I)
Print Table
2085

FIGURE 30n

CONCLUSION



CONCLUSION

New Federal legislation has demanded that regional transportation systems planning must include the consideration of modal options and the adequacy of existing facilities within present corridors. In order for the results of such considerations to influence the actual selection of a transportation plan, there must exist a multi-modal transportation modeling system which enables decision-makers to monitor the trade-offs between alternative plans and to do this quickly and efficiently. Further, such a modeling system must be flexible enough to reflect changing goals, attitudes, and socio-economic conditions.

Michigan is currently testing such a planning-oriented modeling system. The basic programs in Michigan's package modifications of routines were developed specifically for Michigan by the Stanford Research Institute. At this writing, networks for air, rail, bus, and highway have been defined, the four basic programs have been converted to the Burroughs B-5500 computer used at the Michigan Department of State Highways and Transportation, and passenger traffic assignments for all four modes have been accomplished in a test region. A report soon to follow will document the use of the system in regional multi-modal planning, in which trade-offs between modes will be examined in the test region.

This modeling system holds the potential for addressing many questions which are currently at issue, such as branch line abandonments, avoidable costs, subsidy trade-offs between modes, and induced revenues generated by improvements in frequencies of service. It allows management to compute needed capital expenditures by route or to begin to do cost-benefit or cost-effectiveness analysis on proposed improvements. Its by-products include the ability to monitor increased or decreased social interaction, farm-to-market or factory-to-outlet costs and times, and regional economic stimulation or depression as a result of adding or deleting service in one or more modes of travel. In short, such a modeling framework is necessary if effective long-range multi-modal transportation system planning is to become feasible in Michigan.