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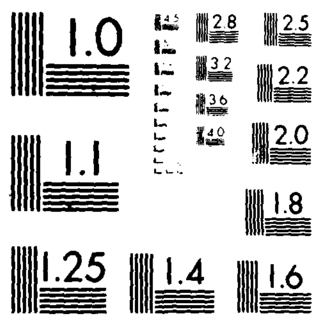

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STANDARDIZATION OF MAP SYMBOLOGY FOR LARGE SCALE MAPS.

A Thesis

Presented in Partial Fulfillment of the Requirements
for the Degree Master of Science

by

Robert P. Jacober, Jr., B.S.

The Ohio State University
1979

Approved by

Advisor
Department of Geodetic Science

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ABSTRACT

This report investigates the sub~~ject of standardization of map sym~~bology for large scale engineering maps and plans. It discusses such questions as, is there a need for standardization and what criteria should be used to design the symbols, (cont'd. p. 5)

ACKNOWLEDGMENT

My thanks first go to Dr. Dean Merchant, my academic advisor, and to the members of the Task Committee for the Preparation of a Manual on the Selection of Map Types, Scales, and Accuracies for Engineering and Planning. Dr. Merchant suggested I undertake a project for the Task Committee that eventually became the subject for this thesis. The members of the Task Committee and the Parent Committee, the Committee on Cartographic Surveying of the Surveying and Mapping Division of the American Society of Civil Engineers, accepted me as an equal and gave me much needed support as well as volumes of material.

My thanks also go to the Air Force Institute of Technology, United States Air Force, who selected me for and sponsored me during my academic stay at the Ohio State University.

I am grateful to the faculty and staff of the Department of Geodetic Science, the Ohio State University, especially Dr. Uotila, Dr. Rapp, Dr. Mueller, and Dr. Buckner for their patience, time, and the use of their material in my academic quest. Special thanks go to Dr. Joseph Loon, without whose help, interest, and support, I could not have completed my various projects at O.S.U. I wish to thank Dr. Merchant and Dr. Loon for being on my reading committee.

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To all those who donated material and time to my project, but especially to Mr. Carl Hammarstrom and Mr. Jon Leverenz of the American Congress on Surveying and Mapping, and to the Department of Energy, Mines and Resources, Ottawa, Canada, I extend a sincere thank you.

Lastly, I dedicate this thesis to my wife, Penny, without whose encouragement and support my academic achievements at O.S.U. would not have been possible. Her dedication to our home and family allowed me the nights and weekends necessary to complete my many assignments and this thesis.

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CHAPTER 1

SYMBOLOGY, A MAJOR PROBLEM IN LARGE SCALE MAPPING

This thesis is the result of the author's investigation into the subject of the standardization of map symbology for large scale engineering maps and plans. Is there a need for such standardization? What is the extent of standardization in the United States today? Should the standardization of map symbology for large scale mapping even be considered? If it is needed, what criteria should be used to design the symbols? These and related questions formed the nucleus about which the investigation revolves.

The need for a standard set of map symbols for very large scale maps has been clearly stated as early as 1938 by the United States National Resources Committee (U.S. National Resources Committee, 1938) and more recently by Joseph Steakley in a letter to the American Cartographer, in 1977. (Jacober, 1979) In his letter, Mr. Steakley states that most of the civilian mapping done by the private aerial mapping companies is for municipal planning, transportation, hydraulic engineering, construction, sewage, and drainage. The scales used are predominately those of 40 feet to the inch up to 100 feet to the inch. Mr. Steakley urges the writing of "such pragmatic pieces on: Symbology for large scale mapping (1"=40' to 1"=100'). (Do not give any consideration to color. We can't afford color in the private sector. All of our maps are drawn on mylar with black ink and reproduced in a diazo printer.)" (Steakley, 1977)

That letter describes one man's opinion on the research of symbology for large scale maps. The author conducted a phone and letter canvas of many organizations, among which are: the United States Geological Survey (USGS), National Oceanic Survey (NOS), Army Corps of Engineers, the American National Standards Institute (ANSI), Defense Mapping Agency (DMA), National Cartographic Information Center (NCIC), and the National Bureau of Standards. The results of this survey indicated a national standard for the symbology used on large scale mapping does not exist. However, none of the above organizations produced maps at scales greater than 1:5000. A second poll was taken of state and municipal mapping agencies, private mapping and consulting firms, and national professional societies. Many of the agencies and organizations use a set of symbols designed to meet their own needs. For example, the American Association of State Highway Officials developed a standard set of highway and road symbols for use by its members. But, there exists no set of map symbols for large scale engineering maps and plans used by all, or even many of the polled organizations. No national standard exists, but is there a need for one?

"The need for a greater degree of standardization of symbols used on maps and charts to show research, statistical, and survey data, as well as planning recommendations, is widely accepted. A common language, based on a common "alphabet" of symbols is obviously essential if the audience, whether general or specialized, is to interpret correctly maps and charts prepared by planning and research agencies." (New York State Executive Department, 1943) The need for standardization was recognized then, and is well demonstrated today by the number of state and local governmental agencies, professional societies, and private corporations that have developed sets of symbols for use within their organizations. Problems arise however, when people from one organization try to use a map published by another organization. If a complete, detailed legend is not on the map, symbol meaning is lost, and the map fails in its purposes. For example, if a map publishing agency uses ○ for a light pole, and a map using agency uses ⌖ for a light pole, unless a specific symbol ○ , with its meaning, was in the legend, the user agency would not know what feature the symbol represented. (Jacober, 1979) The need for nationally standardized symbology is also evident in many of the letters the author received during the course of his research.

Large scale maps perform two functions. They are extremely efficient data storage devices, and they are communication systems. (Robinson and Petchenik, 1976) But, if symbol meaning is lost, performance in both functions deteriorates. Data retrieval becomes inefficient or even erroneous. As a result, communication of incorrect information occurs. The need for a standardized set of map symbols for large scale maps is evident. But is such a set of symbols feasible?

Chapter II addresses the question of the feasibility of developing a national standard for the map symbology used on large scale maps and plans. Chapter II is also a review of the literature concerning the pros and cons of standardizing map symbology.

Chapter III describes the development of a set of symbols for large scale maps. The criteria used to develop the list of symbols, existing standards, and the selection or design procedures are additional topics discussed within this chapter.

Chapter IV provides a practical demonstration in the use of the symbol set to update a portion of a simulated urban map using computer assisted methods. Some additional applications and future uses are also presented.

Chapter V contains the author's recommendations and conclusions based on his investigation. Suggestions for additional research in this field are also offered.

During the course of the research of the problem of standardization and the development of the set of symbols, the author established three constraints on the symbols.

The first one of these is scale. For the purposes of this thesis, "large scale maps" or "engineering scale maps and plans" refer to maps produced between the scales of 20 feet to the inch (1:240) and 400 feet to the inch (1:4800). The 1:240 limit is established because most of the maps produced at scales greater than this will not use map symbols to represent specific features. Generally, the features will be drawn to scale. The second limit of 1:4800 is established becuase most maps produced at scales smaller than 1:4800 delete or generalize the features engineers and planners are interested in, i.e., power and telephone poles, highway guard rails, man holes, fire hydrants, etc. Features normally drawn to scale at 1:4800 and larger, i.e., airports, major industrial complexes, etc. begin to be represented by symbols. For maps smaller than 1:4800, the map symbols used by the USGS would be more appropriate.

The second constraint is that the symbols should be easily computer programmable. Though most maps and plans produced today are not generated on a computer driven plotter or cathode ray tube (CRT) device, many cartographers feel that technology is rapidly bringing to a close the era of hand drawn or hand scribed maps. (Robinson and Petchenic, 1976), (Robinson, 1973), (Ormeling, 1973), (Ormeling, Jr., 1978), (Keates, 1978), and (Youngman, 1978) Based on this premise, the symbols are selected or designed to be easily computer programmable.

The third constraint is color. Most maps at the scales under consideration, are not mass produced. The production method, whether by hand drafting, mechanical reproduction, or automated (computer assisted) mapping ordinarily uses only two colors. For the purposes of this thesis, black symbols on a white background is the only color arrangement considered. However, the use of these symbols may be adapted for any two color mapping system. A two color mapping system is one which uses symbols of one color contrasted against the background of another color. Examples of this type of system are blueprinting, black or colored symbols on a clear background, scribing of a clear symbol from an opaque background, etc. This constraint is imposed in order to achieve computer compatibility. Since most computer controlled graphic systems are limited to "writing" with one color onto a background of a different color. A major advantage in using computerized symbols is they may be stored in subroutine libraries. This will facilitate the editing and updating of maps.

The intent of this thesis is: a) to highlight the need for standardization in the map symbols used for large scale mapping, b) to demonstrate that such standardization if feasible, c) to illustrate the advantages and future uses of a standard symbology, and d) to spur action toward establishing a nationally accepted set of symbols for use on large scale maps and plans.

CHAPTER II

SHOULD MAP SYMBOLOGY BE STANDARDIZED ON LARGE SCALE MAPS?

The question concerning the standardization of symbology for graphic representation on maps has been debated since the mid-nineteenth century, and is still being argued today. Though most of the discussion concentrates on medium to small scale thematic mapping, the question is relevant to all mapping.

Many speciality areas of cartography have already adopted standards of format, orientation, scale, and symbology at the national and international level. Three examples of efforts toward cartographic standardization are: a) the conferences that passed and are revising the resolutions for the production of the International Map of the World at the scale of 1:1000000, b) the International Hydrographic Organization's (IHO) endeavors to standardize nautical chart symbols and abbreviations, and c) the International Civil Aviation Organization's (ICAO) success in achieving standardization of aeronautical mapping. The World Meteorological Organization's standards for synoptic weather maps, and many of the UNESCO sponsored international organizations which have standardized their map specifications and symbols, or are moving toward such standardization, show that standardization can be achieved. (Ormeling, Jr., 1978)

Though the above are examples of the efforts within the small and medium scale cartographic community, large scale mapping has also been involved in standardization. In 1938, the U.S. National Resources Committee published the book: Suggested Symbols for Plans, Maps, and Charts. (U.S. National Resources Committee, 1938) Several states had previously established standard sets of symbols, but this was the first major effort at developing a national standard. (New York State Federation of Official Planning Boards, 1943) As a result, many states adopted the symbols published by the National Resources Committee as their state standard. Although many private, state, national, and international agencies have adopted or developed sets of standard symbols, the question still remains: "Should map symbology be standardized on large scale maps?".

Most of the discussion opposing symbol standardization comes from the cartographers whose principal interest is thematic cartography. The chief arguments against standardization include:

(1) Agreement by people from many fields, i.e., cartography, geography, photogrammetry, geodesy, economics, etc, that the classification of subject matter would be very difficult to obtain.

(2) The assignment scheme would be very large and complex. It would have to remain open to include features that future scientific achievements may develop.

(3) The symbols themselves, would have to become very complex in order to maintain the uniqueness of each symbol.

(4) The symbols would have to be developed based on current and future map making and reproduction methods.

(5) Such a standardization system should include most of the "standards" adopted by convention, i.e., the use of blue for water, etc.

(6) Is standardization really a good thing? Cartographic communication may actually be reduced because a standard symbol was used rather than a symbol specifically designed for the purpose and scale of the map.

(7) Symbol "dictionaries" would stifle the creativity of the cartographer.

These arguments and others are extensively discussed in papers by Arthur Robinson and Christopher Board. (Robinson, 1973), (Board, 1973)

The proponents for standardization of map symbology are divided into two groups: those who favor standardization, but suggest that it may be too costly or too large an undertaking to make it feasible; and those who support standardization and feel that the problems are surmountable.

Among the first group is the Abbreviations and Symbols Committee of the American Congress on Surveying and Mapping (ACSM). They suggest "a fairly large, dedicated group, with proper funding" would still need several years to complete the work. And once completed, the benefits of the labors may not justify the cost. (Abbreviations and Symbols Committee, 1977)

F.J. Ormeling, Jr., is an example of the second group. In his paper, Procedures for Standardization in Cartographic Representation, presented in 1978, he outlines several case histories of successful or almost completed attempts at standardization, several of which were cited earlier in this chapter. While these cases deal with a specific map, i.e., the International Map of the World at the scale of 1:1000000, or a special class of maps such as weather maps, the examples do point out that many of the attempts are successful.

Among the opponents and proponents of standardization are those who favor standardization in some areas and oppose it to some degree in other areas. Eric Arnberger, one of this group, suggests that while standardization would be extremely difficult to accomplish in small scale thematic mapping, it would be successful in large scale topographic mapping. (Arnberger, 1974)

Opposed to those who advocate all but a minimum of standardization of symbology, is a group who favor standardizing not only cartographic symbols, but all graphic symbols. They suggest the development of an international language made up of graphic symbols that would be universally understood. (Dreyfuss, 1972)

The chief arguments proposed by those in favor of standardizing include:

(1) If a standard set of symbols exists, the cartographer could devote his time to the design of the overall map. Time and money could be saved.

(2) By having a standard set of symbols, the symbols could be distributed as templates, stick-up, or computer software.

(3) Communication could be enhanced because the map reader would become familiar with one set of symbols rather than confused by many sets of symbols.

(4) The map could be more effectively utilized as a data storage device. Data retrieval would be easier, either by manual means because of the familiar symbols, or by a scanning device which could be programmed to recognize each symbol.

These and other arguments in favor of standardization are discussed in papers and books by E.B. Wilkins, Alfred P. Frame, the Proceedings of the Eleventh National Conference on Standards, and others. (Wilkins, 1948), (Frame, 1960), (Eleventh National Conference on Standards, 1960), (Ciesielski and Podlacha, 1978), (Dreyfuss, 1972), and (Ormeling, Jr., 1978)

The author's position on the question of standardizing map symbology is similar to that of Mr. Arnberger. Standardization of symbology for large scale mapping is realistic and achievable. Standardization for small scale thematic mapping, especially choropleth mapping, may not even be possible. The purpose of this thesis is to propose supporting arguments for the standardization of map symbology for large scale mapping. Additionally, a set of symbols was derived by the author to establish a beginning from which a standard could ultimately be developed.

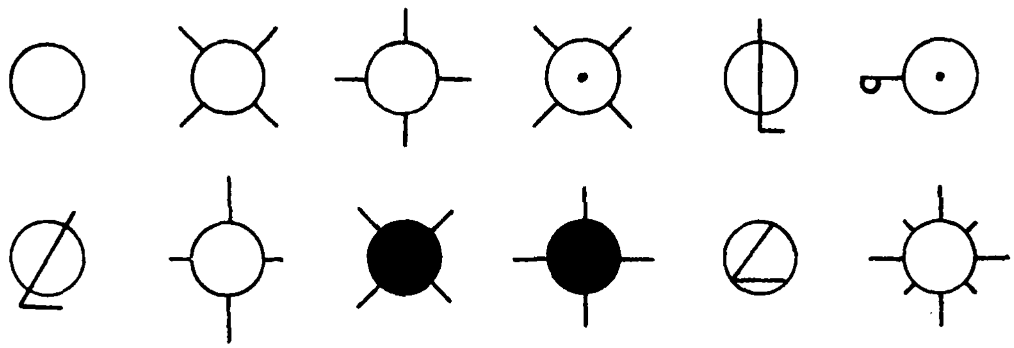
CHAPTER III

THE DEVELOPMENT OF A SET OF SYMBOLS

"Here in the United States it is almost impossible to compare drawings prepared by different draftsmen or offices, not only may they be of different scales, but because the symbols used are often as far apart as the poles." (Wilkins, 1948) This statement is as valid today as it was then. One answer lies in the adoption of a standard set of map symbols.

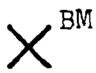
The first step in the development of the set of symbols described in this chapter was the acquisition of legends and lists of symbols for large scale maps. The author's intention was to gather as great a cross section of legends as was possible. Symbol lists were requested from private mapping firms, city, county, and state mapping agencies, U.S. Government and military mapping centers, foreign national, state, and city agencies, national and international professional organizations, and university Geography, Cartography, or Civil Engineering departments within the United States and abroad. The list of legend donors is contained in Appendix V. Of the 158 requests for information, 103 samples of symbol lists were received. Of the remaining 55 requests that were sent, 34 organizations replied that they did no mapping at the large scales being considered in this study. There was no reply to 21 of the requests.

Once the symbols were collected, the author compiled a list of features with the symbols representing the features. A count was kept for each duplication of a symbol which represented the same feature. The result is a catalog including a table of features, the symbols associated with each feature, and the number of times each symbol was used for that feature. An example from this catalog is the list of symbols used by organizations to represent free standing light poles:



(Jacober, 1979)

The author used three criteria to develop a legend. The first criterion is popularity, that is, the symbol that was used most often to represent the feature. In several cases, this alone was the deciding factor, as the most often used symbol is accepted almost by convention, for example,

Benchmark 

Horizontal Control Point 

The second criterion is a restriction that is placed on the symbol selected by the first criterion. The symbol must be easily computer programmable. This criterion is purely subjective from the author's viewpoint, and is used because, "computer assisted cartography and printer and plotter produced maps are no doubt here to stay". (Robinson, 1973) "Rapid developments in microcomputer and integrated circuit technology facilitate the creation of computers and peripherals especially suited to the needs of cartographers. Research into the applications of automated cartography is being carried out by a growing number of individuals, institutions, firms, and government agencies in the United States today." (International Cartographic Association, 1978) The symbol programs used in this study were developed for the Calcomp 1627 Plotter and the Versatec Printer 3 Plotter. The main computer is the IBM 360/370 with the Amdahl 470 Central Processing Unit, located at the Ohio State University. Though this particular system is used, the programs can be developed for any plotting system that uses move and draw commands.

The last criterion requires that there be no duplication and as little similarity as possible among the symbols in order to avoid confusing one symbol with another.

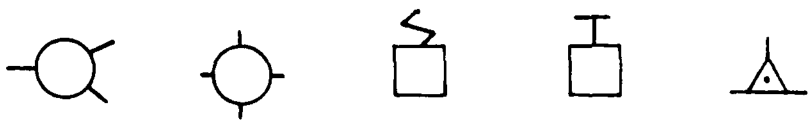
In some instances, symbols contained in the catalog failed to meet any of the criteria. This required the author to design a symbol based on the last two criteria.

At the scales between 1:240 and 1:4800, the number of features to be depicted on a map or plan is very large. This number is tripled by having to represent features as existing, proposed, or abandoned, destroyed, or intermittent. The number of features is continually growing due to advancing technology. Compounding the problem of this ever increasing number of features is how they would be represented across the range of map scales under consideration. Some minor features would be represented by a symbol on the 1:240 scale map and may not appear on the 1:4800 scale map, i.e., a water or gas meter for a private residence, street light poles, man holes, power or telephone distribution wires to a private residence, etc. Other features would be drawn to scale on the 1:240 scale map, and be represented by a symbol on the 1:4800 scale map, i.e., railroads, roads, canals, etc. A third type of feature may be too large to appear as a separate feature on the 1:240 scale map, and be drawn to scale on the 1:4800 scale map, i.e., an airport, a major industrial complex, etc. (Jacober, 1979) The symbol list developed by the author is only a start towards the eventual standardization of map symbology for large scale maps.

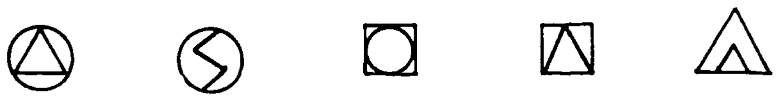
In order to accommodate the large number and variety of features, one needs to use a large number of symbols. For point symbols, one starts with three basic shapes:

Circle Rectangle Triangle

(1) The basic shapes may be modified by the addition of lines or curves:



(2) The basic shapes may be modified by including shapes, lines, or curves within the original shapes:



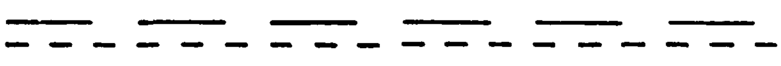
(3) The basic shapes may be modified by changing their orientation:

(4) The shapes may be modified by filling in part or all of the shape:

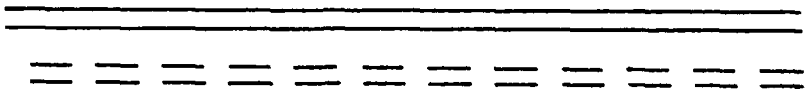
(Keates, 1973)

Though the line symbol is not as versatile as the point symbol, variation is achieved in several ways. One starts with a solid line:

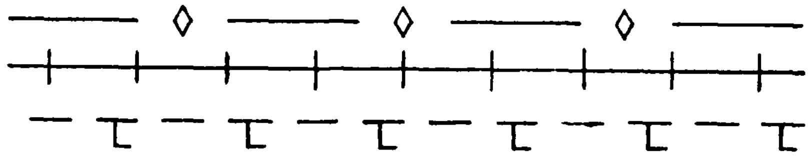
(1) The line may be interrupted in many ways:



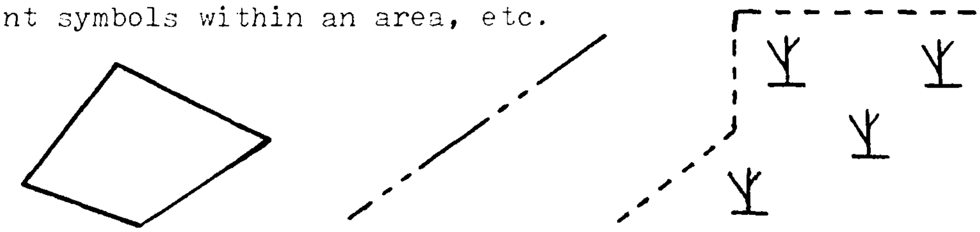
(2) More than one line may be used:



(3) The line may be combined with point symbols or hatch marks:



Areas may be differentiated by drawing a bounding line about one area, using the line to separate two areas, using point symbols within an area, etc.



To reduce the author's requirement to produce a symbol for every feature, some lists of symbols that already exist as a national standard are incorporated within this thesis. Examples of such lists are:

(1) The National Ocean Survey (NOS), of the National Oceanic and Atmospheric Administration (NOAA), a part of the Department of Commerce, together with the Defense Mapping Agency Hydrographic and Topographic Center (DMAHTC) published the pamphlet, <u>Chart No. 1, United States of America Nautical Chart Symbols and Abbreviations</u>.

(2) The NOS jointly with the Defense Mapping Agency Aerospace Center (DMAAC) has published, <u>Visual Aeronauti-</u>

cal Chart Symbols.

(3) The United States Geological Survey (USGS), a part of the Department of the Interior, has published the pamphlet, Topographic Maps.

These three pamphlets contain the lists of symbols used by the publishing agencies on all of the maps that they design and produce. The symbols contained within the first two pamphlets are also standardized internationally in accordance with the IHO and ICAO respectively. Although these symbols are generally used on maps of scales smaller than 1:12500, they already exist as national standards and should be used if they can be transferred to larger scales. The purpose of the map being drafted should be similar to that of the maps whose symbols are described in the pamphlets. For example, a large scale map of a portion of a coast line or a harbor should use the symbols for buoys, dangers to navigation, soundings, etc., found in Chart No. 1. For many of the features depicted on the large scale maps however, the symbols contained in the pamphlets may not be suitable, and some cannot be used at all, i.e., the symbols for airports, populated areas, cemeteries, etc. These features will generally be drawn to scale.

A non-governmental organization, the American National Standards Institute (ANSI), is a clearing house for most of the voluntary standards adopted by industry and professional societies such as: the American Society of Civil Engineers

(ASCE), the American Society of Mechanical Engineers (ASME), the Institute of Electrical and Electronics Engineers (IEEE), the Society of Automotive Engineers (SAE), etc. At the present time, there are fifteen standards published by ASME for ANSI which the author feels should be used by large scale mappers, if the scale and the purpose of the map permit. The appropriate volumes are listed in Table 1, page 21 , together with ANSI's address.

If no suitable symbol for a given feature exists in the aforementioned sources, the symbol for that feature from Table 2, page 32 , should be used if the scale and purpose permit. The symbols contained in Table 2 are based on the criteria explained earlier in this chapter. The most widely used symbol, if easily computer programmable, is selected. If it is not easily programmable, the next most widely used symbol is tested. If the chosen symbol too closely resembles a symbol for another feature, then an additional criterion is used. The symbol which best pictorially represents the feature is used. "For maximum effectiveness in communicating the map "message", pictorial symbols should communicate without the use of a legend..." (Robinson, Sale, and Morrison, 1978) The pictorial symbols should be constructed using the following guidelines:

(1) The contrast between the symbol and its background should be maximized.

(2) The symbol should be simple and distinctive in design.

TABLE 1 ANSI VOLUNTARY NATIONAL STANDARDS

ANSI C83.1,	1973, Electronic Industries Association Standard Colors for Color Identification and Coding.
ANSI Y1.1,	1972, Abbreviations for Use on Drawings and in Text.
ANSI Y10.2,	1968, Letter Symbols for Quantities Used in Electrical Science and Electrical Engineering.
ANSI Y10.19,	1969, Letter Symbols for Units Used in Science and Technology.
ANSI Y10.20,	1975, Mathematical Signs and Symbols for Use in the Physical Sciences and Technology.
ANSI Y14.2,	1973, Line Conventions and Lettering.
ANSI Y32.7,	1972, Graphic Symbols for Railroad Maps and Profiles.
ANSI Y32.9,	1972, Graphic Symbols for Electric Wiring and Layout Diagrams Used in Architecture and Building Construction.
ANSI Y32.10,	1967, Graphic Symbols for Fluid Power Diagrams.
ANSI Y32.11,	1961, Graphic Symbols for Process Flow Diagrams.
ANSI Y32.21,	1976, Graphic Symbols for Grid and Mapping Diagrams Used in Cable Television Systems.

TABLE 1 (Continued)

ANSI Z32.2.3, 1955, Graphical Symbols for Pipe Fittings, Valves, and Piping.

ANSI Z32.2.4, 1956, Graphical Symbols for Heating, Ventilating, and Air Conditioning.

ANSI Z32.2.6, 1956, Graphical Symbols for Heat-Power Apparatus.

The American National Standards Institute, Inc.
1430 Broadway
New York, New York 10018

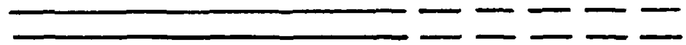
(3) The symbol should be easily recognizable, that is, have a high associative value with the feature it is representing.

(Taylor and Hopkins, 1975)

The last two guidelines are subjective in nature, and the symbol design may have to be tested with other symbol designs to determine the best symbol.

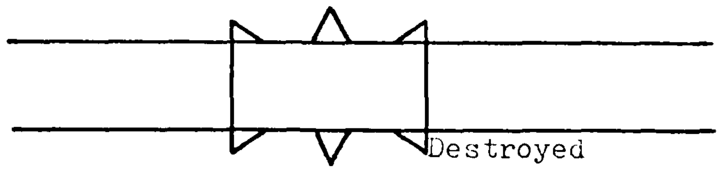
The symbols in this thesis are designed to be used with labels, where appropriate. For example, one symbol is used to represent all existing roads. The symbol should be labelled as to whether it is dirt, improved, hard surfaced, etc. The narrow gauge railroad symbol and the pipeline/cable symbol should be labelled in a similar fashion. Additionally, the pipeline/cable symbol should be labelled as to its capacity, i.e., 6" water main, 300 gallons per minute oil pipeline, 10,000 volt high power electric cable, 2400 PSI steam line, etc. The combination of the symbol and the labelling is designed to preclude having too many similar linear symbols which may become confusing.

For the transportation system, to include pipeline/cable, roads, railroads, narrow gauge common carrier systems, etc., three conditions are required to be depicted: existing, proposed, and destroyed. The category destroyed also includes abandoned and intermittent. On many maps, one symbol may change to another to depict a change in the status of the feature the symbol represents. For example, a proposed extension to an existing road is represented as a solid line becoming a dashed line. This condition is graphically portrayed as:



The symbols representing the categories existing, proposed, and destroyed were selected on the basis of what is perceived as the most prominent attribute. The solid line is perceived as the most predominant line in the visual sense, thus it represents an existing feature. A line consisting of long dashes and short spaces, graphically appears more prominant than a line with more space between the dashes. (Robinson, 1970) The more prominant dashed line was selected to represent a proposed feature, and the lesser prominant line to represent a destroyed, abandoned, or intermittent feature.

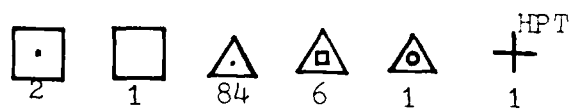
By using the symbols depicting the transportation of people, commodities, and services to identify a feature as existing, proposed, or destroyed, the need to depict all of the ancillary features, i.e., bridges, tunnels, hydrants, poles, lights, valves, meters, etc. as existing, proposed, or destroyed is eliminated. The ancillary symbols will depend on the symbol for the transportation system to show their status. The only exceptions occur when the status of the ancillary symbol does not agree with that of the transportation symbol, such as, when new fire hydrants are added to an existing water system, or a bridge is destroyed, but the road still exists. In cases such as this, the status of the feature should be labelled next to the symbol, i.e.,



THE SYMBOL SELECTION PROCESS

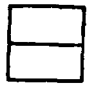
With many of the symbols, the most popular is the easiest to program. Unless there are other symbols that are too similar, this symbol is selected to represent the feature. In some cases, the symbol is accepted almost by convention. An example of the symbols chosen in this manner is the symbol for the Horizontal Control Point. This is how it appears in the catalog:

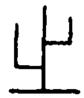
Horizontal Control Point



The numbers below the symbol reflect the number of legends that the symbol is used in. This will be used on all following symbol lists. Other symbols selected in this manner include: roads, railroads, water transportation facilities, boundaries, benchmark, spot elevation, located or landmark object, standard corner, closing corner, section corner, and spring symbols.

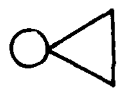
For some features only one symbol appears in the catalog. If that symbol is easily programmable and not too similar to other symbols, it is used. If it is not easily programmable, a new symbol was designed. Examples of symbols developed in this fashion are:

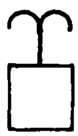
Sidewalk Elevator  Burned Tree 

Fire outlet from a Building  Cactus 

The fire outlet was the only new symbol that had to be designed. The original appeared thus: 

Two features were not symbolized in any of the legends. The author designed symbols for these using a simplified pictorial representation.

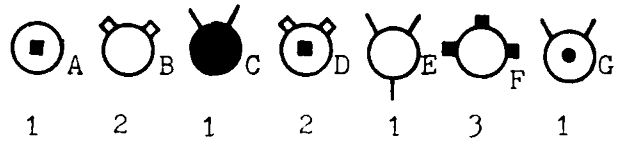
Siren (Air Raid, Hazardous Weather, Volunteer Fire Department, etc) 

Water Fountain 

Many symbols selected are not the symbols most frequently used to represent a given feature. Either the most often used symbol was not easily programmable, or it was too similar to another symbol. The principal criterion in cases such as these is either the ease of programming, or the best pictorial representation. An example of selecting a symbol based on the ease of programming is the selection of the symbol for a stump and a hydrant.

Stump

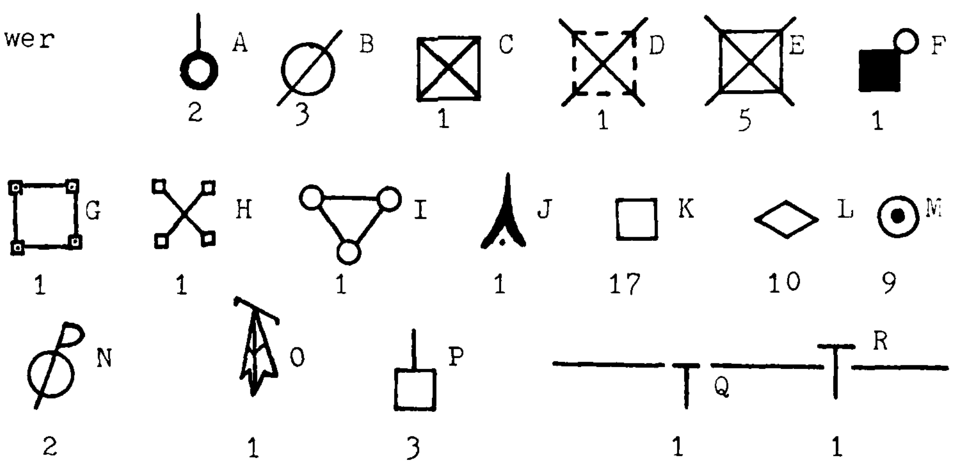
Hydrant



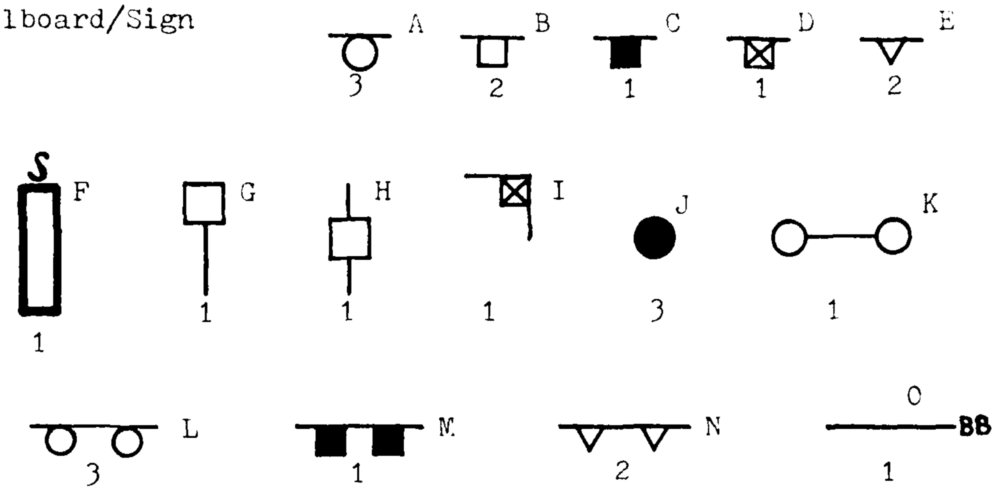
Symbol "D" was chosen to represent the stump, even though symbol "C" was the most popular. Symbol "D" was the easiest to program. Of the hydrant symbols, symbol "E" was by far, the easiest to program. Symbols selected in this manner include the symbols for a transformer, booster station, cap, valve, meter, catch basin, light, and traffic signal.

Two examples of the selection process used to choose the symbol based on pictorial representation are the tower symbol and the symbol for a sign or billboard.

Tower



Billboard/Sign

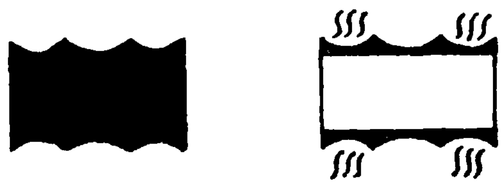


For the tower, the highest frequency of use symbols are the symbols E,K,L, and N. These were not chosen because they are too similar to symbols representing other features. For the same reason, symbols A,D, and P were rejected. Symbols C,F,G,H,I, and J are not easy to computerize on the available facilities. Symbols Q and R may be confused with the symbol for a closing corner, or thought to represent only telephone or telegraph transmission lines. Of the two remaining symbols, B and O, O represents the feature better pictorially. Since this symbol is to represent all types of towers, i.e., microwave, radio or television transmission towers, etc., The author deleted the top crossbar. The symbol is easy to program for the computer, and now appears as:  . For the billboard, the symbols A,B, and L too closely resemble the symbol for a guardrail. Symbols C,J, and M are not the easiest to program. Since the main difference between a billboard and a sign is the size and the number of supports, the author wanted the symbols to be similar. Symbols F,I,K, and O could not be easily changed into a two symbol system. Of the remaining symbols, E and N are a paired set, easily programmable, and pictorially resemble a sign or billboard. Other symbols that were selected by a similar method are the symbols for a windmill, flagpole, ski lift, scenic viewpoint, ford, picnic site, camping site, watermill, cave, and culvert.

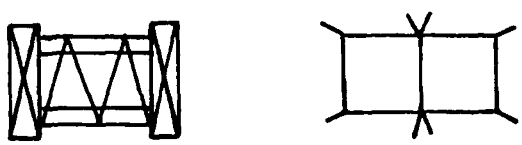
The final example of symbol development concerns those features whose symbols are, for the most part, hand drawn or too detailed for easy programming. In these cases, the author simplified the symbol design to facilitate programming. Symbols that were developed in this way are the symbols for dams, cuts, fills, rapids, waterfalls, near vertical slopes, hardwood and softwood trees, and the symbols for bridges. The symbols for bridges will provide the graphic example.

Bridges

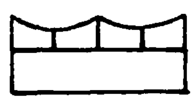
Arch



Lift

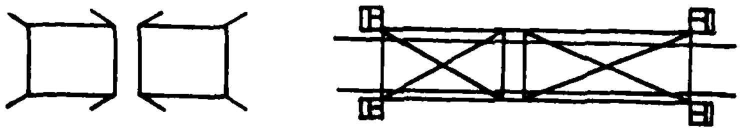


Suspension



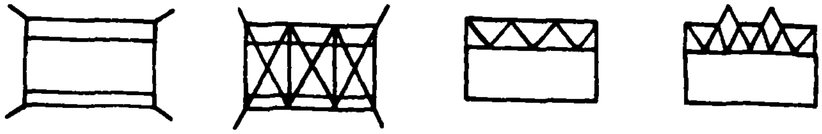
Bridges

Bascule



Truss or

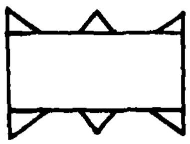
Trestle



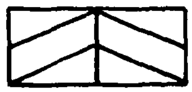
Only one legend had a symbol for a pivoting bridge. The symbol was simple in design, so it was selected to represent a pivoting bridge in the list of symbols the author developed. It appears as:

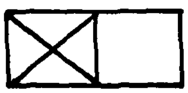
After simplification, the rest of the symbols representing different types of bridges appear as:

Arch



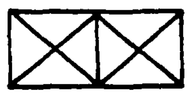
Suspension





Single and Double

Leaf Bascule or Lift



Truss or Trestle

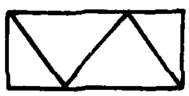


Table 2, page 32, is a listing of the symbol names in alphabetical order. The number preceding each name is the number that will be associated with the respective symbol in the appendices. Table 3, page 44, is a listing of the symbol program names and associative numbers in the same order that the symbols appear in Appendix I, page 60. This table is designed to help identify the appropriate symbol with the name in Table 1. Appendix I, page 60, is a legend of the graphic symbols arranged in the categories of point symbols and line symbols. Appendix II, page 71, is a legend of the graphic symbols arranged according to the functional categories of the features the symbols represent, i.e., utilities, transportation, boundaries, etc. Appendix III, page 83, contains the computer programs of five symbols to demonstrate how the symbols are programmed. The author selected one of the longest, one of the shortest, and three programs of average length.

As was stated earlier, this list of symbols is not an exhaustive inventory, but it does represent a beginning. These symbols, used in conjunction with the applicable ANSI symbols, and those produced by the NOS and the USGS, can satisfy many of the user requirements for symbology on large scale mapping in the United States today.

TABLE 2 ALPHABETIC LISTING OF SYMBOL PROGRAMS

(1) AERIAL - draws the symbol for a ski lift, aerial tram way, cablecar, or other cable or rail suspended means of transportation.

(2) ALARM - draws the symbol for a telephone booth, fire alarm or police telephone box, a traffic control box, or any small object for which no other symbol exists. If the symbol is not one of the specified symbols, the symbol should be labelled.

(3) ANCHOR - draws the symbol for a guy anchor.

(4) ARCHBR - draws the symbol for an arch bridge.

(5) ATTLGT - draws the symbol for a light mounted to a building or other support, other than a free standing pole, i.e., a light pole, etc.

(6) BASCBR - draws the symbol for a bascule, draw or lift bridge, with one or two leaves.

(7) BILSGN - draws the symbol for a billboard or a sign on a post, i.e., a stop sign.

(8) BNHMRK - draws the symbol for a monumented bench-mark.

(9) BORE - draws the symbol for a bore hole or other mining test hole.

(10) BURNTR - draws the symbol for a burned tree. This symbol may be used in a random or ordered

TABLE 2 (Continued)

distribution to designate a forest fire area.

(11) CABLE - draws the symbol for a cable or a pipeline. The symbol can be varied to represent an existing, proposed, or destroyed, abandoned, or intermittent feature. This symbol should be labelled as to what is being carried and what size the transporting feature is, i.e., 10,000 Volt Power Line, 2400 PSI Steam line, Cable TV, etc.

(12) CACTUS - draws the symbol for a cactus. Like BURNTR, this symbol may be used to designate an area.

(13) CAIRN - draws the symbol for a cairn of stones being used as a survey or boundary monument.

(14) CAMP - draws the symbol for a camping area or an individual tent site.

(15) CAP - draws the symbol for a cap or the end treatment of a pipeline.

(16) CATCHB - draws the symbol for a catch basin or drop inlet.

(17) CATTLE - draws the symbol for a cattle guard.

(18) CAVE - draws the symbol for a natural cave opening.

(19) CHIMNY - draws the symbol for a tall smokestack or chimney.

TABLE 2 (Continued)

(20) CISTRN - draws the symbol for a cistern or septic tank.

(21) CLOSCR - draws the symbol for a closing corner.

(22) CNTYBY - draws the symbol for a county or parish boundary.

(23) CULVRT - draws the symbol for a culvert.

(24) CUT - draws the symbol for a road cut or railroad cut.

(25) DAM - draws the symbol for a dam. The construction of the dam should be labelled, i.e., concrete, earthen, etc.

(26) DITCH - draws the symbol for an open linear system for transporting water. This may be a river, canal, aqueduct, ditch, flume, etc.

(27) FENCE - draws the symbol for either a barbed wire fence or other post fence.

(28) FERRY - draws the symbol for a ferry.

(29) FILL - draws the symbol for a filled area along a road or railroad bed.

(30) FIRE - draws the symbol for a fire hookup extending from a building.

(31) FISH - draws the symbol for a fish hatchery.

(32) FLAGPL - draws the symbol for a flag pole.

(33) FOOTBR - draws the symbol for a foot bridge.

TABLE 2 (Continued)

(34) FORD - draws the symbol for a ford across a stream. the symbol is the word "FORD".

(35) GATE - draws the symbol for a gate in a fence.

(36) GRDRAL - draws the symbol for a guard rail. The symbol may represent either a single or double guard rail. The type of supporting posts may also be selected. Wood or other are the two options.

(37) HARDTR - draws the symbol for a deciduous tree or bush. This symbol may be used like BURNTR to designate a wooded or brush area.

(38) HCPN - draws the symbol for a horizontal control point that is part of the national control network. The symbol should be labelled as to class and order, triangulation station, etc.

(39) HCPSL - draws the symbol for a horizontal control point that is part of a state or local network. It should be labelled as to class and order, triangulation station, etc.

(40) HEDGE - draws the symbol for a deciduous or coniferous hedge.

(41) HORZMN - draws the symbol for an underground horizontal mine shaft.

TABLE 2 (Continued)

(42) HYDRNT - draws the symbol for a fire hydrant.

(43) LGTPOL - draws the symbol for a free standing light pole.

(44) LINE - draws the symbol for a type of survey line specified by the user. The varieties of lines available are: center line, boundary line, side line, field line, property line, right of way line, or an unlabelled line.

(45) LNDOBJ - draws the symbol for a landmark or located object.

(46) LOCKS - draws the symbol for a set of locks on a river, canal, etc.

(47) LOOKOT - draws the symbol for a fire look out tower or look out station. The symbol may also be used for a forest ranger tower. The symbol should be labelled.

(48) MAILBX - draws the symbol for a mailbox, mail storage box, or letter box mounted on a pole.

(49) METER - draws the symbol for a meter. The type of meter should be labelled, i.e., gas, water, etc.

(50) MILBY - draws the symbol for the boundary around a military reservation.

TABLE 2 (Continued)

(51) MNHOLE - draws the symbol for a man hole. Like METER, the symbol should be properly labelled.

(52) MUNIBY - draws the symbol for a municipal boundary.

(53) NATLBY - draws the symbol for a national boundary or line of treaty or demarkation. The areas divided by the boundary should be properly labelled.

(54) NHCPBM - draws the symbol for a combined horizontal control point and benchmark monument belonging to the national network. The order and class of the feature should be labelled.

(55) OTHBDY - draws the symbol for boundaries other than national, state, county, municipal, or military. The boundary or the two adjoining areas should be clearly labelled.

(56) PALM - draws the symbol for a palm tree. Like BURNTR, the symbol may be used to designate an area.

(57) PBSSTN - draws the symbol for a pumping station or a power boosting station. The commodity being transported should be designated in a label.

(58) PICNIC - draws the symbol for a picnic site or a picnic area.

(59) PILLAR - draws the symbol for a pillar monument.

TABLE 2 (Continued)

(60) PIN - draws the symbol for a surveying or boundary stake or pin.

(61) PIPE - draws the symbol for a pipe monument.

(62) PITMNE - draws the symbol for an open pit mine or quarry. The substance being mined or quarried should be specified in a label. The symbol may be used to designate an operating or abandoned feature.

(63) POLE - draws the symbol for a pole other than a light pole.

(64) PUMPIS - draws the symbol for a gasoline or diesel pump or set of pumps.

(65) PVOTBR - draws the symbol for a pivoting bridge.

(66) RAILFN - draws the symbol for a rail or split rail fence.

(67) RAPIDS - draws the symbol for an area of rapids.

(68) RNGRSN - draws the symbol for a ranger station, park entrance, park headquarters, information booth, etc. The symbol should be labelled.

(69) ROAD - draws the symbol for a road. The road symbol may depict an existing, proposed, or destroyed or intermittent road. The con-

TABLE 2 (Continued)

struction and the number of lanes should be specified in a label, i.e., 2 lane, dry weather only, 4 lane limited access, etc.

(70) SCENIC - draws the symbol for a scenic view point, overlook, etc.

(71) SECTCR - draws the symbol for a section co... The numbers of the meeting sections should be labelled near the corner.

(72) SIREN - draws the symbol for a pole or building mounted siren, i.e., a volunteer fire department siren, hazardous weather siren, etc. The symbol should be labelled.

(73) SLOPE - draws the symbol for a natural or man-made near vertical slope. This symbol is used to preclude the c...our lines from becoming too close together to be indistinguishable.

(74) SOD - draws the symbol for a monument made of sod or turves of sod stacked up.

(75) SOFTTR - draws the symbol for a coniferous tree or bush. The symbol may be used like BURNTR to designate an area. The type of tree should be specified in a label.

TABLE 2 (Continued)

(76) SPOTEL - draws the symbol for a spot elevation. The symbol should be labelled with the elevation.

(77) SPRING - draws the symbol for a spring or seep. The symbol should be labelled as to fresh, hot, mineral, etc.

(78) STBNDY - draws the symbol for a state boundary. The boundary or adjoining states should be clearly labelled.

(79) STNDCR - draws the symbol for a standard corner.

(80) STNWAL - draws the symbol for a stone, brick, or concrete block wall. The wall should be labelled as to its construction.

(81) STOPLT - draws the symbol for a traffic directing or traffic warning light.

(82) STUMP - draws the symbol for a tree stump. The symbol may be used like BURNTR to designate a logged area.

(83) SUSPBR - draws the symbol for a suspension bridge.

(84) SWELEV - draws the symbol for an elevator built into the sidewalk or loading area.

(85) TANK - draws the symbol for a storage tank. The substance being stored should be specified

TABLE 2 (Continued)

in a label, i.e. water, oil, gas, etc. The function of the tank should also be stated, i.e. surge, overflow, storage, settling, etc.

(86) TNSFRM - draws the symbol for a transformer. The transformer may be pole mounted or one of several in a transformer station.

(87) TOLBTH - draws the symbol for a toll booth, or any small booth or shed. The function of the booth or shed should be labelled.

(88) TOWER - draws the symbol for a tower. The tower symbol should be labelled, i.e., radio, television, microwave, electrical transmission, etc.

(89) TRACK - draws the symbol for a railroad track. The track may be single or multiple, existing, proposed, abandoned, or destroyed. The symbol should be properly labelled.

(90) TREPIT - draws the symbol for a tree in a pit. The pit may be located in a lawn, shopping mall, sidewalk, etc.

(91) TRNTBL - draws the symbol for a railroad turntable.

(92) TROLEY - draws the symbol for any narrow gauge transportation system. The track system

may be single track or multiple track. It may be existing, proposed, destroyed, or abandoned. The symbol may represent a trolley, mine railroad, logging railroad, car line, etc. It should be properly labelled.

(93) TRUSBR - draws the symbol for a truss or trestle bridge.

(94) TUNNEL - draws the symbol for a tunnel.

(95) VALVE - draws the symbol for a valve. It may be a check valve, insulated valve, water or gas distribution valve, etc. The type of valve or commodity should be shown in a label.

(96) VERTMN - draws the symbol for a vertical mine shaft. The type of mine should be labelled.

(97) WELL - draws the symbol for a well. It should be labelled as to oil, water, salt water, etc. The flow rate may also be specified.

(98) WNDMIL - draws the symbol for a wind mill or wind motor.

(99) WTRFAL - draws the symbol for a waterfall.

(100) WTRFTN - draws the symbol for a water fountain. This

TABLE 2 (Continued)

symbol may be used to designate a drinking fountain or an outdoor splashing fountain.

(101) WTRMIL - draws the symbol for a water mill.

TABLE 3 LIST OF SYMBOLS IN APPENDIX I

PAGE 60

ALARM (2) ALARM (2) ALARM(2) ALARM (2)

ANCHOR (3) ARCHBR(4) ATTLGT (5) BASCBR (6)

BILSGN (7) BILSGN (7) BNHMRK (8) BORE (9)

BURNTR (10) CACTUS (12) CAIRN (13)

CAMP (14) CAP (15) CATCHB (16)

CATTLE (17) CAVE (18) CHIMNY (19)

PAGE 61

CISTRN (20) CLOSCR (21) CULVRT (23)

CUT (24) DAM (25)

FERRY (28) FILL (29) FIRE (30)

FISH (31) FLAGPL (32) FOOTBR (33) FORD (34)

GATE (35) HARDTR (37) HCPN (38) HCPSL (39)

PAGE 62

HORZMN (41) HYDRNT (42) LGTPOL (43) LNDOBJ (45)

LOCKS (46) LOOKOT (47) MAILBX (48) METER (49)

MNHOLE (51) NHCPBM (54) PALM (56) PBSSTN (57)

PICNIC (58) PILLAR (59) PIN (60) PIPE (61) PITLNE(62)

TABLE 3 (Continued)

POLE (63) PUMPIS (64) PVOTBR (65) RAPIDS (67) RNGRSN(68)

SCENIC (70) SECTCR (71) SIREN (72)

PAGE 63

SOD (74) SOFTTR (75) SPOTEL (76) SPRING (77)

STNDCR (79) STOPLT (81) STUMP (82) SUSPBR (83)

SWELEV (84) TANK (85) TNSFRM (86) TOLBTH (87) TOWER(88)

TREPIT (90) TRNTBL (91) TRUSBR (93) TUNNEL (94)

VALVE (95) VERTMN (96) WELL (97) WNDMIL (98)

WTRFAL (99) WTRFTN (100) WTRMIL (101)

PAGE 64

AERIAL (1)

CABLE (11)

PAGE 65 DITCH (26)

PAGE 66 FENCE (27) HEDGE (40) LINE (44)

PAGE 67 GRDRAL (36)

PAGE 68 NATLBY (53) STBNDY (78) CNTYBY (22)

MUNIBY (52) MILBY (50) OTHBDY (55)

TABLE 3 (Continued)

PAGE 69

RAILFN (66)	ROAD (69)	ROAD (69)	ROAD (69)
SLOPE (73)	STNWAL (80)		

PAGE 70

TRACK (89)	TROLEY (92)

CHAPTER IV

SYMBOL MANAGEMENT IN COMPUTER ASSISTED UPDATING AND EDITING FOR LARGE SCALE MAPS

A major advantage of having a standard set of map symbols is the ease with which they may be distributed and used across the nation. The symbols may be produced in the form of microfilm images or aperture disks for optical exposure devices, stencils, pre-printed stick-up sheets, type face "sorts" for letterpress reproduction, templates for scribing or inking devices, and as computer subroutine libraries. For this reason, one of the constraints imposed by the author on the design or selection of the map symbols for this thesis is the symbol must be easily computer programmable. This also implies the symbol is easily drawn by hand or made into templates.

The use of computers with plotters or CRT display systems is increasing. The reasons for this are the savings in money and the substantial decrease in time necessary to accomplish editing on a map and to update the data with the edited changes. The initial cost of the hardware to implement a computer assisted mapping system is high. But, the eventual savings in terms of the man-hours needed to update a map using scribing or similar techniques will defray the initial expense. Similarly, the information storage, retrieval, and restorage costs of updating just one city map using a manual filing system could be drastically reduced with an automated system further offsetting the initial costs of the system.

The flexibility of a computer assisted cartographic system is enormous. Two major areas of interest are the layering capability and the ability to specify a portion of a map and display it at a greatly increased scale. An interactive graphics system using CRT displays offers the maximum in flexibility. Using a two screen system, an operator can update a portion of a map at an enlarged scale and observe the effects of the change on the map at the production scale at the same time. Even without a two screen system, the capability of "zooming in" on a portion of a map, and displaying that portion at whatever scale the map user decides, is useful. When adding, altering, or removing a symbol from a map, the change can be made at the greatly increased scale. This provides for very accurate corrections. Map editing in the form of line over-runs, gaps in lines, etc., is also accomplished more efficiently at the magnified scale. Once the correction is made, the entire map at the original scale may be displayed. This provides for a final check before the change is approved for production. The accuracy of plotted positions is easier to achieve or check at a scale larger than the final, i.e., production scale.

The second capability, that of layering or the use of overlays, is equally useful in map editing and updating. With the layering capability, the user may wish to display the city boundaries and all of the systems within the city. Or, if desired, any one or a combination of overlays may be selected, i.e., property lines, parcel numbers, bus routes, railroad tracks, roads, power transmission lines, power distribution lines, cable TV distribution, telephone lines, trunk water distribution, local water distribution, trash pick-up routes for a particular day, snow emergency routes, roads under repair, roads recently repaired, sewage lines, storm drains, ad infinitum. Since much of the mapping at the engineering scales is done for planning and construction, urban development and control, or the maintenance and expansion of transporting systems for people, services, and commodities, the overlay system would greatly benefit these map users. For example, many maps of different proposed routes for a new interstate highway through a city can be plotted using computer assisted cartography in the same amount of time it takes for a hand drafted map of one of the proposed routes to be completed. Each of the computer assisted cartographic products would be as accurate as the survey data base, and as precise as every other map produced in this manner. Additionally, using the computer based overlay technique, the effect of each of the proposed routes on the city's existing power, water, road, and rail networks can be assessed.

An example of such map updating is shown in Figures 1,2, and 3 on pages 51, 52, and 53. Figure 1 represents a portion of the information from the base map of a city. Just the roads and buildings are shown. Figure 2 is the base map with street lights, stop signs, traffic lights, and electrical power distribution added. Figure 3 shows the water distribution for the same area. Water pipes, valves, hydrants, catch basins, and man holes are added.

The original "base map" was digitized from an original hand drawn manuscript. The digitized data may be displayed either on the Versatec Printer 3 or on a Tektronix 4012 CRT display. The addition of the various symbols representing the features described above, is accomplished by using a subroutine library containing a separate subroutine for each symbol. The driving program specifies the coordinates where the symbols should be plotted. In these examples, the coordinates were measured by hand on the original manuscript. In a map editing and production system, the coordinates could be input from actual survey data, photogrammetric measurements, digitizers on another base map, etc. Each symbol subroutine contains approximately eight to forty lines of code, with the average being

FIGURE 1 BASE MAP

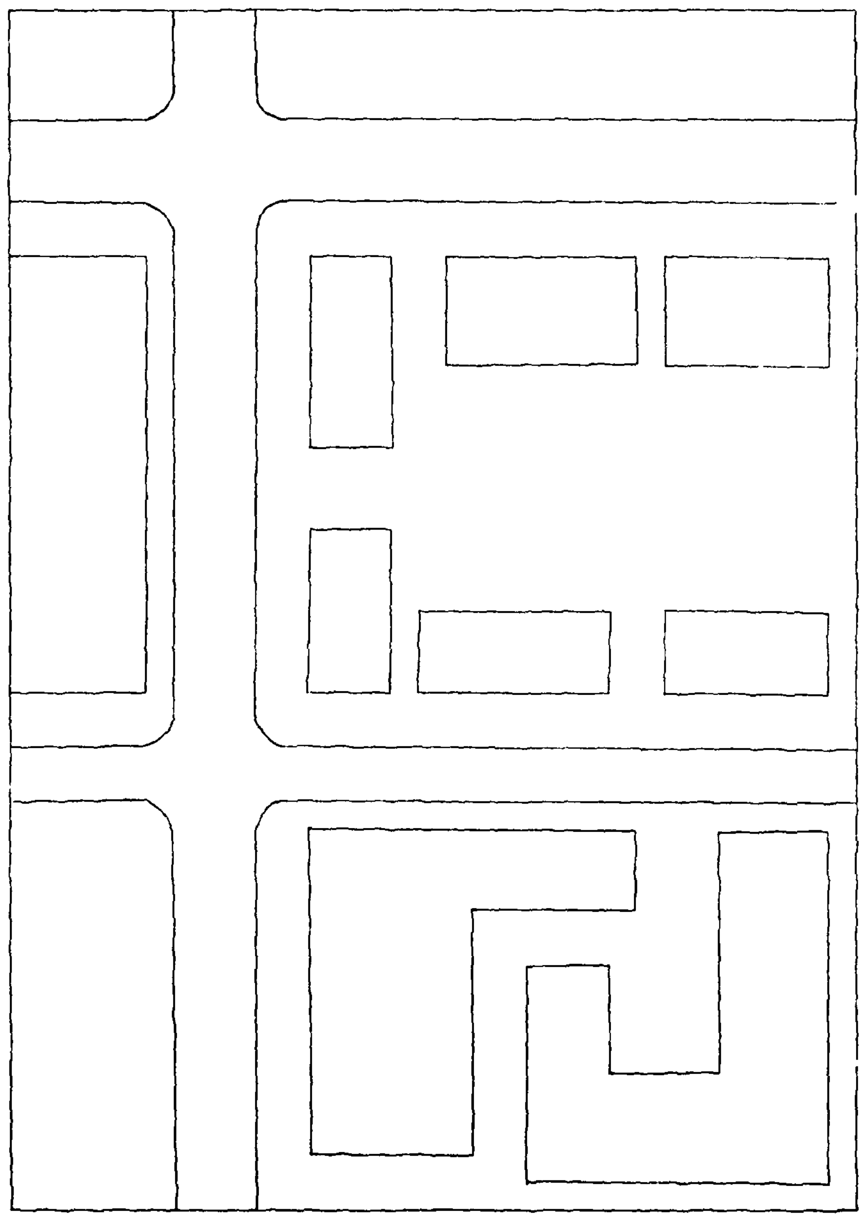


FIGURE 2 BASE MAP WITH ADDED ELECTRICAL SYMBOLS

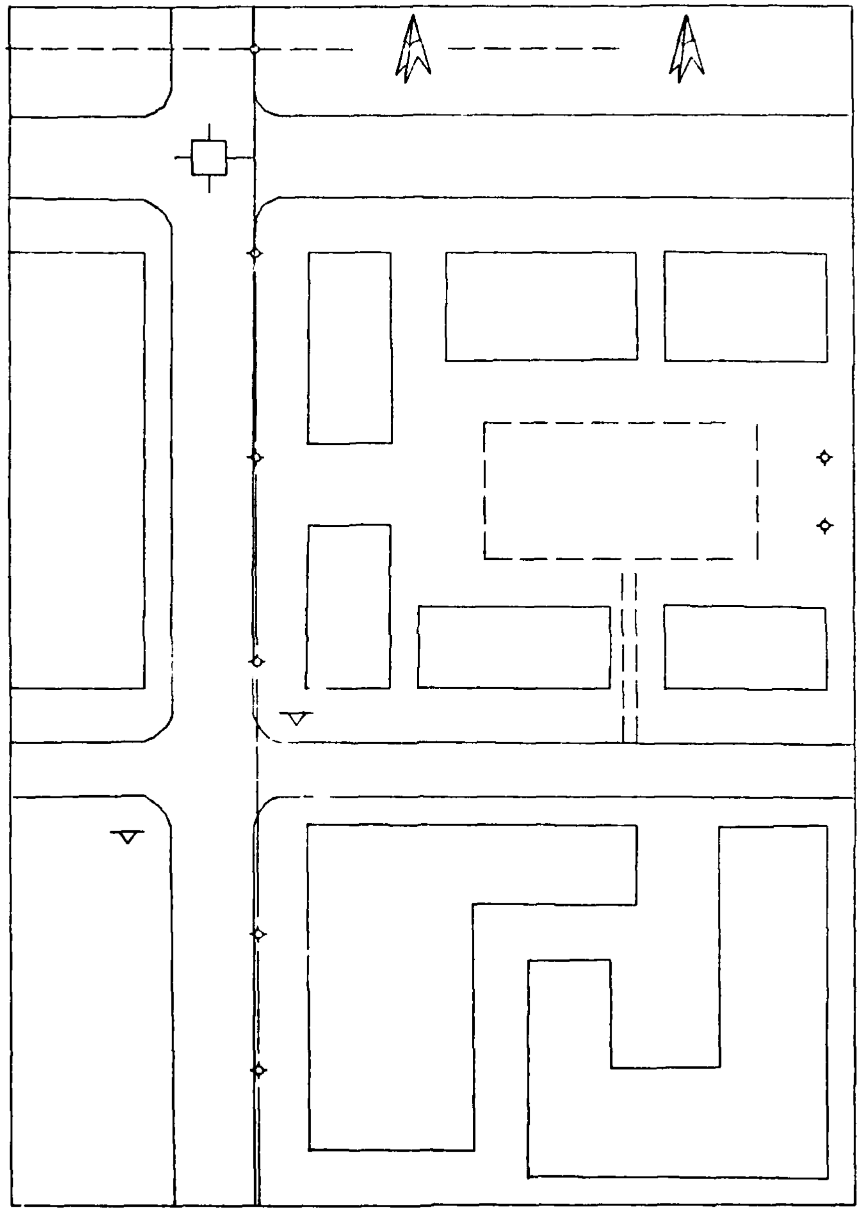
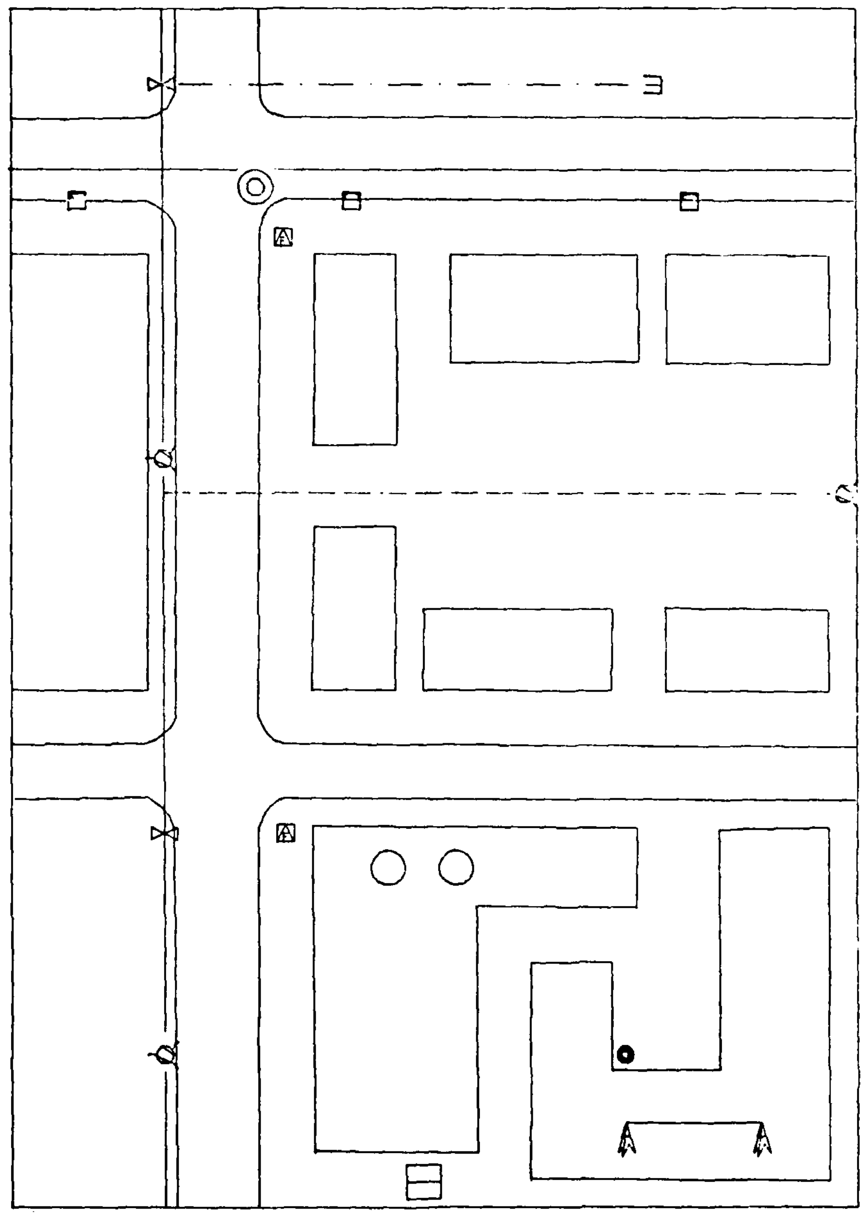


FIGURE 3 BASE MAP WITH ADDED WATER SYMBOLS



approximately eighteen. Examples of selected subroutines are listed in Appendix III, page 83.

Standardization becomes very important in computer assisted cartography. As more map producing and map using organizations adopt computer methods, the interchange of information in the form of maps and computer data between agencies within a city or county, between cities, from city to state, state to federal government, or any conceivable combination of correspondents, will require a standard list of the symbology that is used on the maps. Without such a standard, detailed legends will have to be transmitted with every map. The alternative is to maintain a copy of each legend on file for each correspondent. If this is not done, the information depicted on the maps becomes meaningless marks to the map recipient. With a national standard for the symbols, only one legend need be kept on file. Familiarity with a set of symbols reaches a point where the users recognize what the symbol represents without the need to continually refer to a legend. (Keates, 1973) This improves data retrieval by both increasing the speed and the reliability of map interpretation.

A future application of the benefits of the standardization of map symbology, involves computerized scanning and pattern recognition. At the present time, with so many symbols representing each feature, programming a computer to accept maps from many agencies would be very time consuming and require a large storage space in the computer memory banks. Each legend would have to be programmed and kept on file. When a map from a particular agency is received, that agency's file would have to be input before pattern recognition could begin. With a standard set of map symbols, only one set would have to be programmed

Whether the activity involves scanning and pattern recognition, map editing and updating on an interactive computer graphics system, communicating between agencies with maps, or using maps in the field, standardization of the map symbols will reduce the time required and increase the efficiency of the activity.

CHAPTER V

CONCLUSION AND RECOMMENDATIONS

CONCLUSION

Map readers of engineering scale maps do not use the maps to understand theories of communication, nor do they keep the maps to appreciate the beauty of them. This type of map user relies on the maps to graphically portray a portion of the physical environment with which he is concerned. The more maps a person uses, the more important the concept of the same symbol representing the same feature becomes. The need for standardization was evident in correspondence between the author and many of the agencies and private firms which donated symbol lists.

Though standardization may not provide perfect communication between map designer and map user, it will alleviate much of the confusion caused by more than one symbol representing the same feature. (Dreyfuss, 1972)

RECOMMENDATIONS

Two recommendations by Walter R. Horner and Sanford P. Schumacher to the U.S. Army Engineering Topographic

Laboratories for symbol design and use on DMA produced maps are applicable to large scale maps as well.

(1) Standardize symbols which represent the same feature for all scales between 1:240 and 1:4800.

(2) Reduce the number of symbols required within a feature classification by using labels where appropriate. For example, instead of a specific symbol for gasoline oil, water, sewage, etc. pipes, produce a symbol to represent all pipes, then label the symbol on the map with the capacity and the product being transported.

(Horner and Schumacher, 1968)

If a symbol from one of the ANSI, USGS, or NOS lists of accepted, standard symbols is compatible with the purpose, scale, and specifications for the map being designed, that symbol should be used. If no ANSI, USGS, or NOS symbol exists for that feature, or if a symbol does exist but is unusable for the map design, the author recommends using the symbol for that feature from the set of symbols contained in Appendix I, page 60. If the feature is not represented by a symbol from Appendix I, or the symbol in Appendix I is unusable, the map designer is encouraged to design a symbol that not only meets the specifications for the map, but is also easily computer programmable. Additionally, the author recommends that the symbol pictorially represent the feature either in plan, profile, or function.

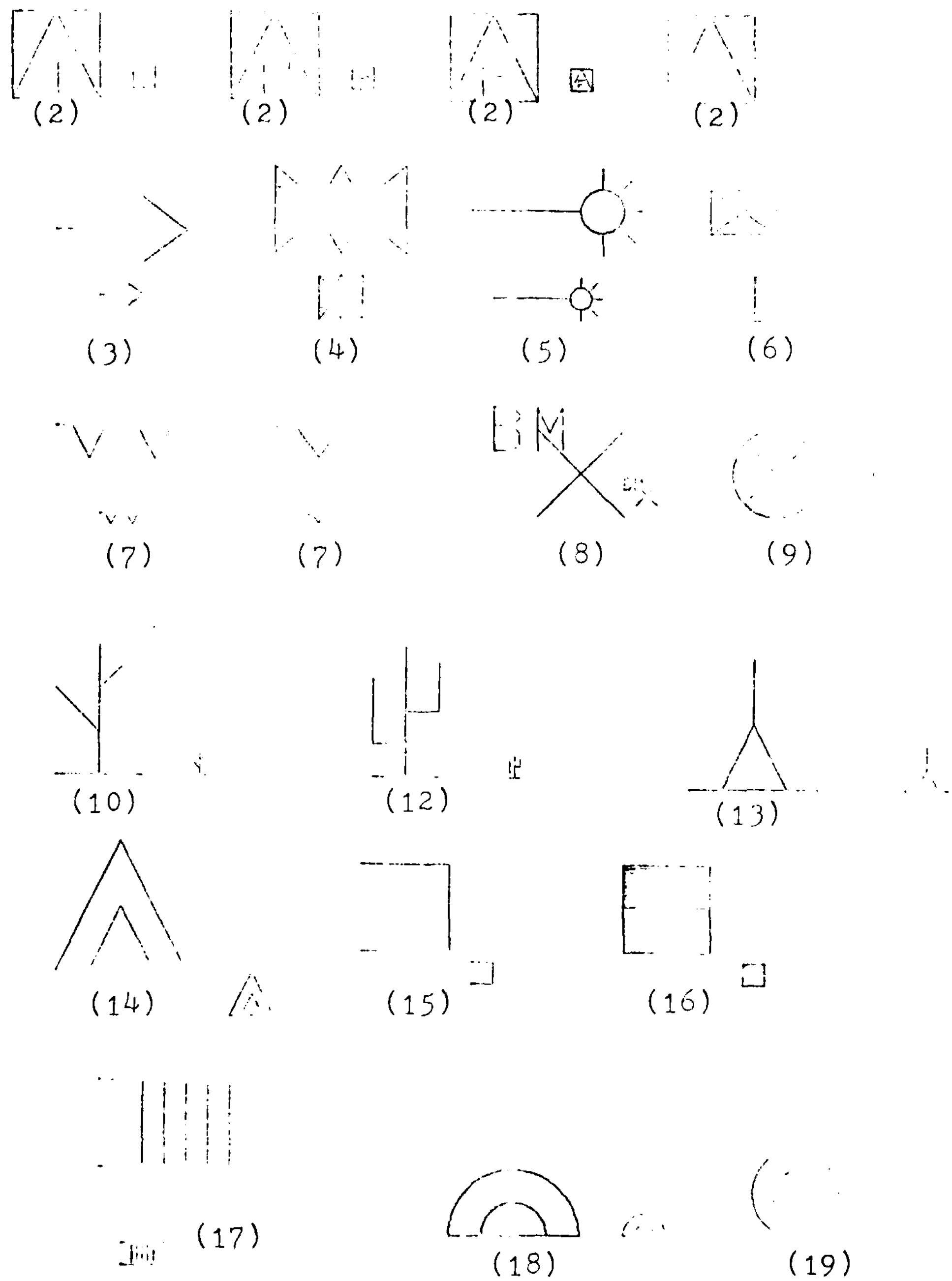
The symbol designer should then send a drawing of the symbol, the symbol specifications, and its use to the Committee on Cartographic Surveying, Surveying and Mapping Division of the American Society of Civil Engineers, to the Cartography Division of the American Congress on Surveying and Mapping, or to the Standards Committee of the American Society of Photogrammetry. If one map design requires that special symbol to represent a feature, perhaps other maps require a symbol to represent the same feature. That symbol should be incorporated into the standard symbol list.

The author has defined the need for a standard set of map symbology for engineering scale maps and developed a list of symbols he believes can be adopted as that standard. The list of symbols is not comprehensive, for the reasons stated in Chapter II of this thesis, but it is intended to serve as an initial list from which a national standard can develop. More research is needed to expand this list and improve the symbols in order to broaden their applicability as per the first recommendation adapted from Horner and Schumacher (1968). Research is also needed to test the acceptability of the symbols by mapping firms and large scale map users.

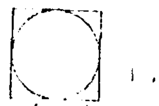
The recommendations and the symbols contained in this thesis represent a start in an area of engineering and cartography that has been neglected for far too long. The standardization of map symbology cannot take place overnight, or even in a year's time. It is a long term process. Incorporation of the symbols, once they become a standard, will require an even longer period of time. As a map is updated or redrafted, or as a new map is produced, that map should use the standard symbols. In this way, eventually, all maps at these scales will use the same symbols. The maps will be more easily interpretable, not only by engineers, but by a wider range of people. As computer technology advances, and computers become less expensive, more people will have access to the data stored in the computer banks. It is easily conceivable that a future homeowner may wish to plant a tree in his front yard. He requests a computer generated map of his front yard, which shows him the location of all of the underground utilities in his front yard and provides him with the data as to depth, size, etc. The homeowner then plants the tree and supplies the coordinates of the tree to the computer. The computer then updates the base map of the city with the information.

To satisfy the users of large scale maps today, and "everyman's" needs tomorrow, standardization of map symbology for large scale mapping is a problem that must be solved. The contribution of this study should be regarded as a step toward the solution of this problem.

APPENDIX I SYMBOLS ARRANGED BY POINT AND LINE



APPENDIX I (Continued)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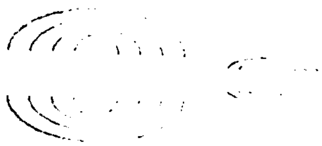
(21)


(23)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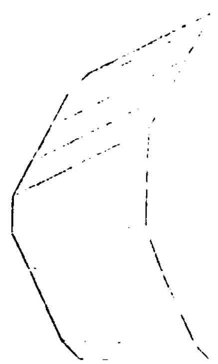
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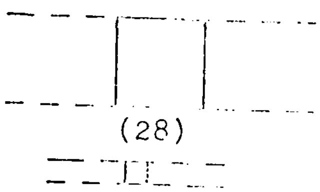
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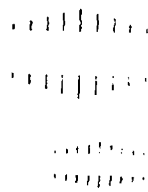
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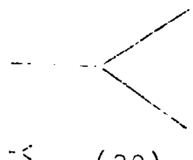
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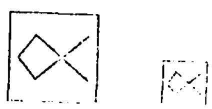
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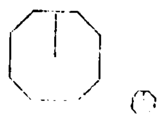
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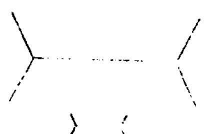
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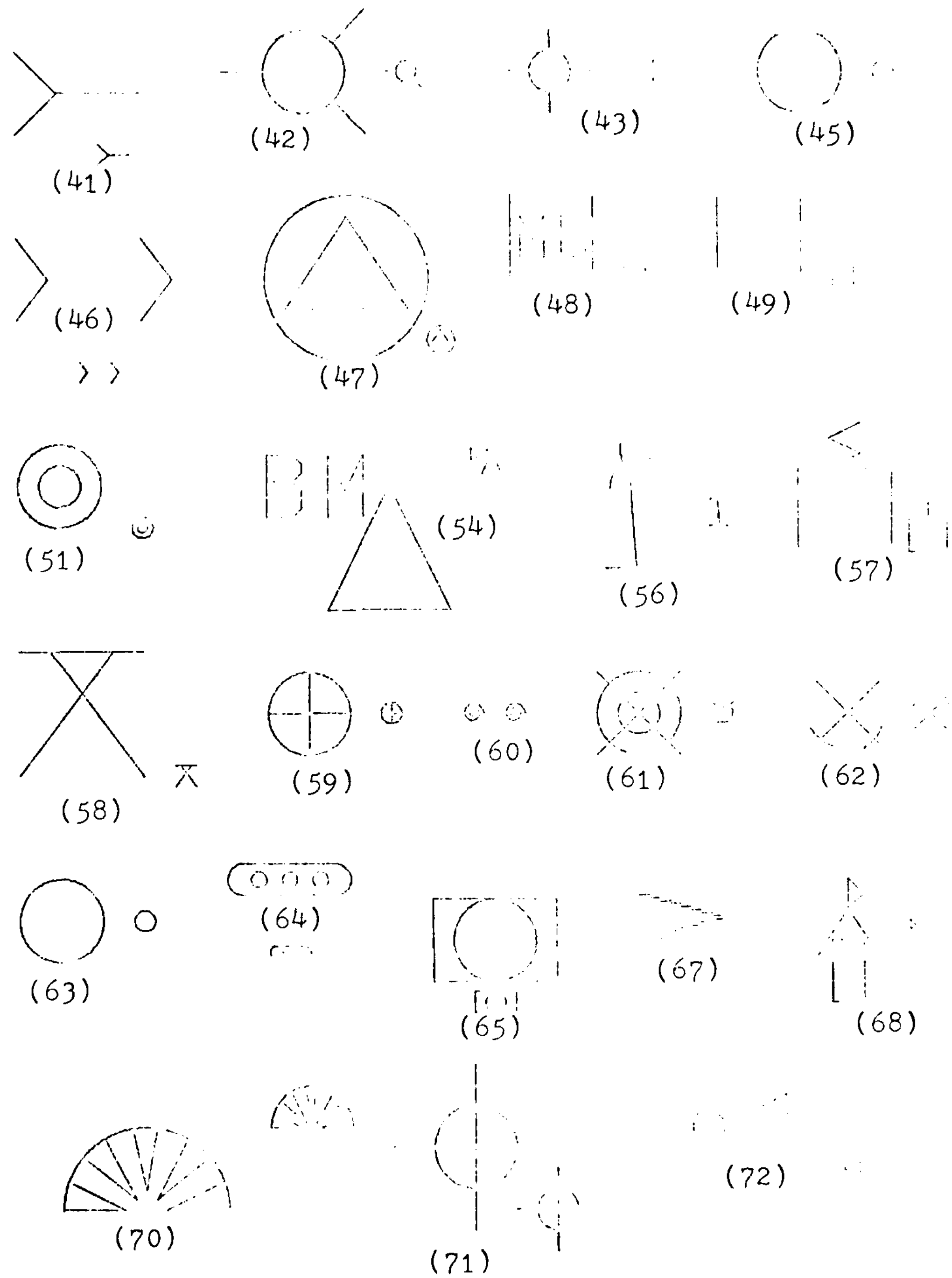
APPENDIX I (Continued)



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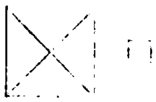
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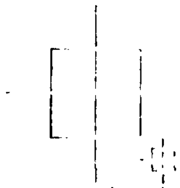
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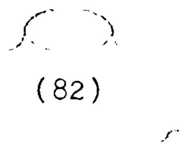
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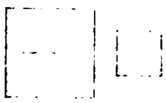
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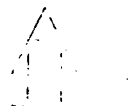
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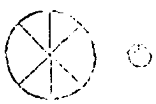
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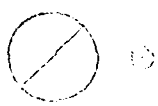
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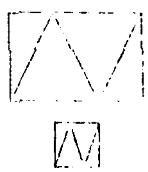
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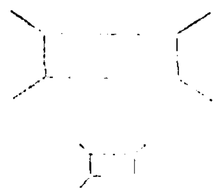
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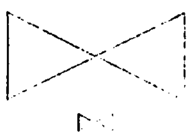
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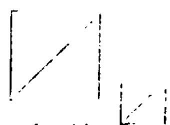
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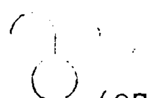
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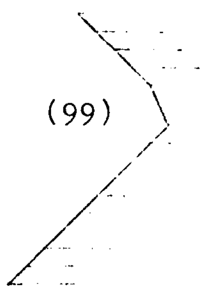
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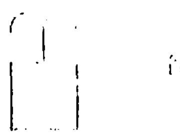
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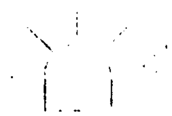
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APPENDIX I (Continued)

(1)

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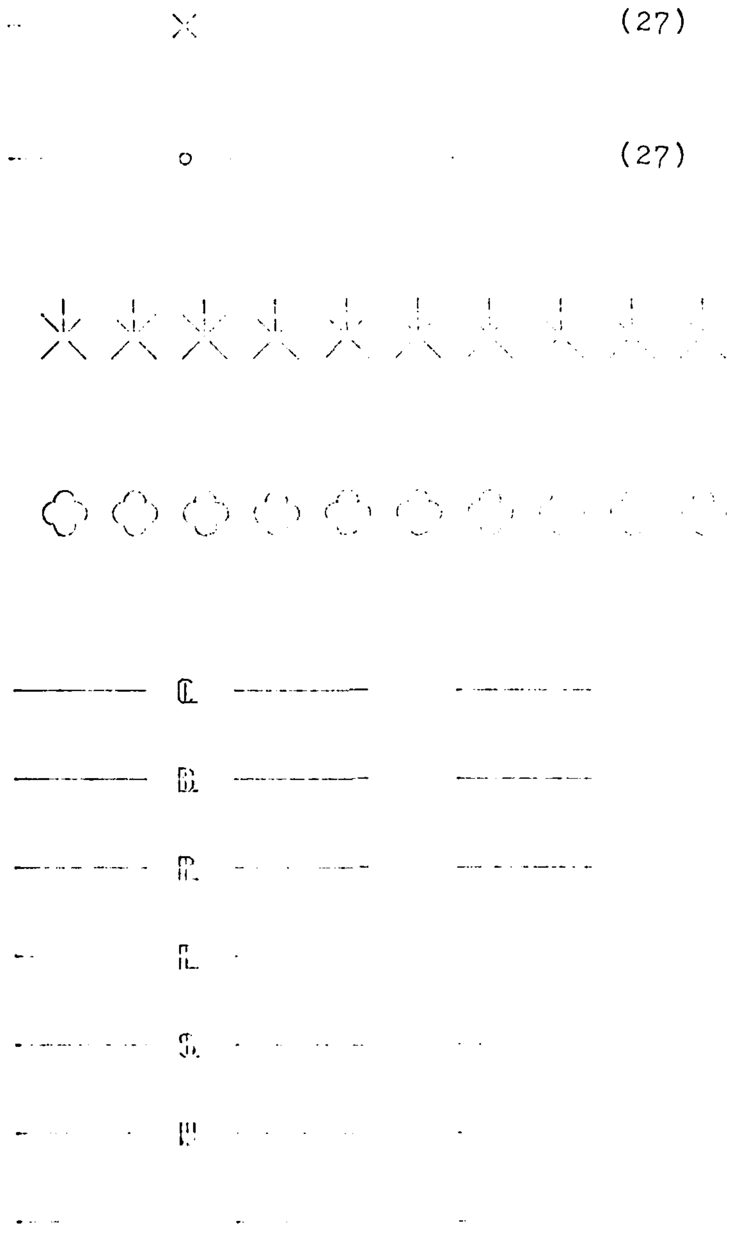
(26)

APPENDIX I (Continued)



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APPENDIX I (Continued)

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(36)

(36)

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(36)

(36)

APPENDIX I (Continued)

(53)

(78)

(22)

(52)

(50)

(55)

APPENDIX I (Continued)

APPENDIX I (Continued)

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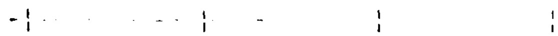
(92)

APPENDIX II SYMBOLS ARRANGED BY FUNCTIONAL CATEGORIES

TRANSPORTATION

TRACKED TRANSPORTATION SYSTEMS

 (89)

 (89)

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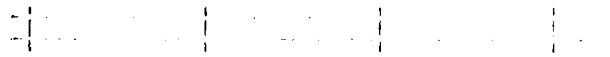 (89)

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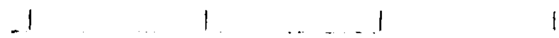 (92)

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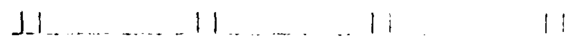
 (92)

 (92)

 (92)

APPENDIX II (Continued)

TRANSPORTATION

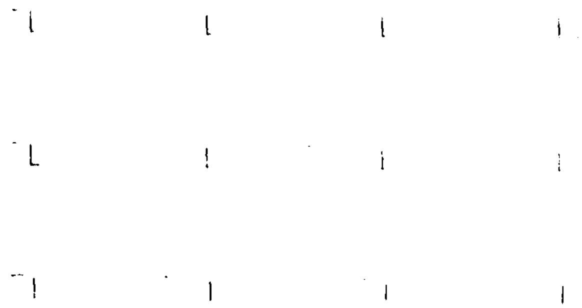
OPEN WATER TRANSPORTING SYSTEMS

CANAL	[illegible]	(26)
FLUME	[illegible]	(26)
AQUEDUCT	[illegible]	(26)
DITCH	DITCH	(26)
		(26)

APPENDIX II (Continued)

TRANSPORTATION

SKI LIFT

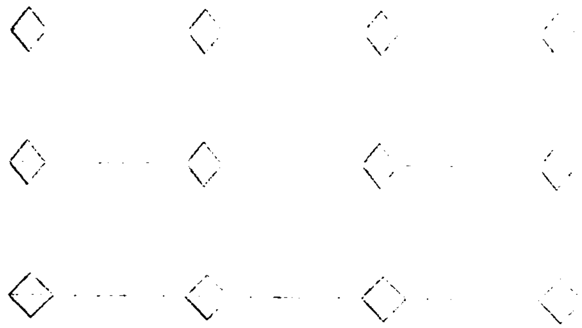


(1)

(1)

(1)

AERIAL TRAMWAY



(1)

(1)

(1)

CABLES OR PIPES

(11)

(11)

(11)

APPENDIX II (Continued)

TRANSPORTATION

ROADS

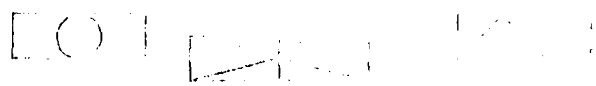
(69)

(69)

(69)

BRIDGES, TUNNEL, AND FORD

(4) (6) (6)



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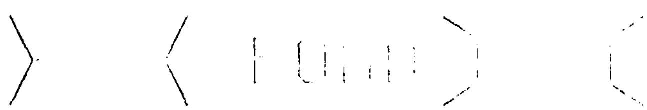

(33) (34) (94)

APPENDIX II (Continued)

TRANSPORTATION

GUARD RAILS

[illegible]	[illegible]	[illegible]	[illegible]	[illegible] (36)
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible] (36)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible] (36)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible] (36)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible] (36)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible] (36)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible] (36)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible] (36)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible] (36)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible] (36)
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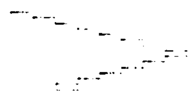
APPENDIX II (Continued)

HYDROGRAPHY



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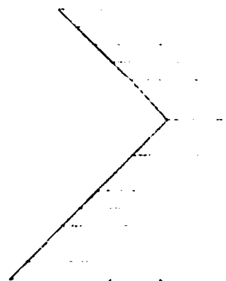

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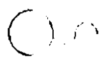

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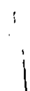

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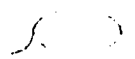

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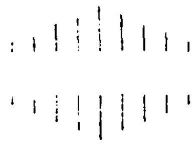
APPENDIX II (Continued)

TOPOGRAPHY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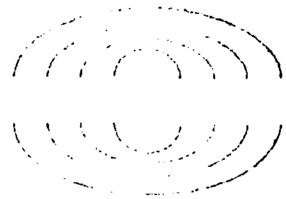
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SURVEY AND GEODETIC CONTROL


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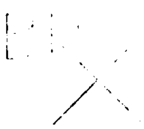
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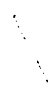
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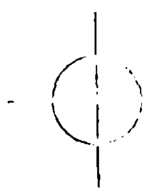
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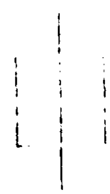
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APPENDIX II (Continued)

BOUNDARIES

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SURVEY LINES

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APPENDIX II (Continued)

FENCES, WALLS, AND HEDGES

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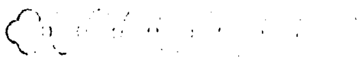 (40)

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APPENDIX II (Continued)

CULTURAL FEATURES

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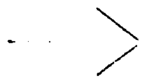
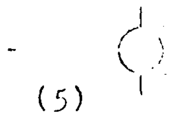
 (3)

(5) 

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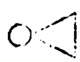 (72)

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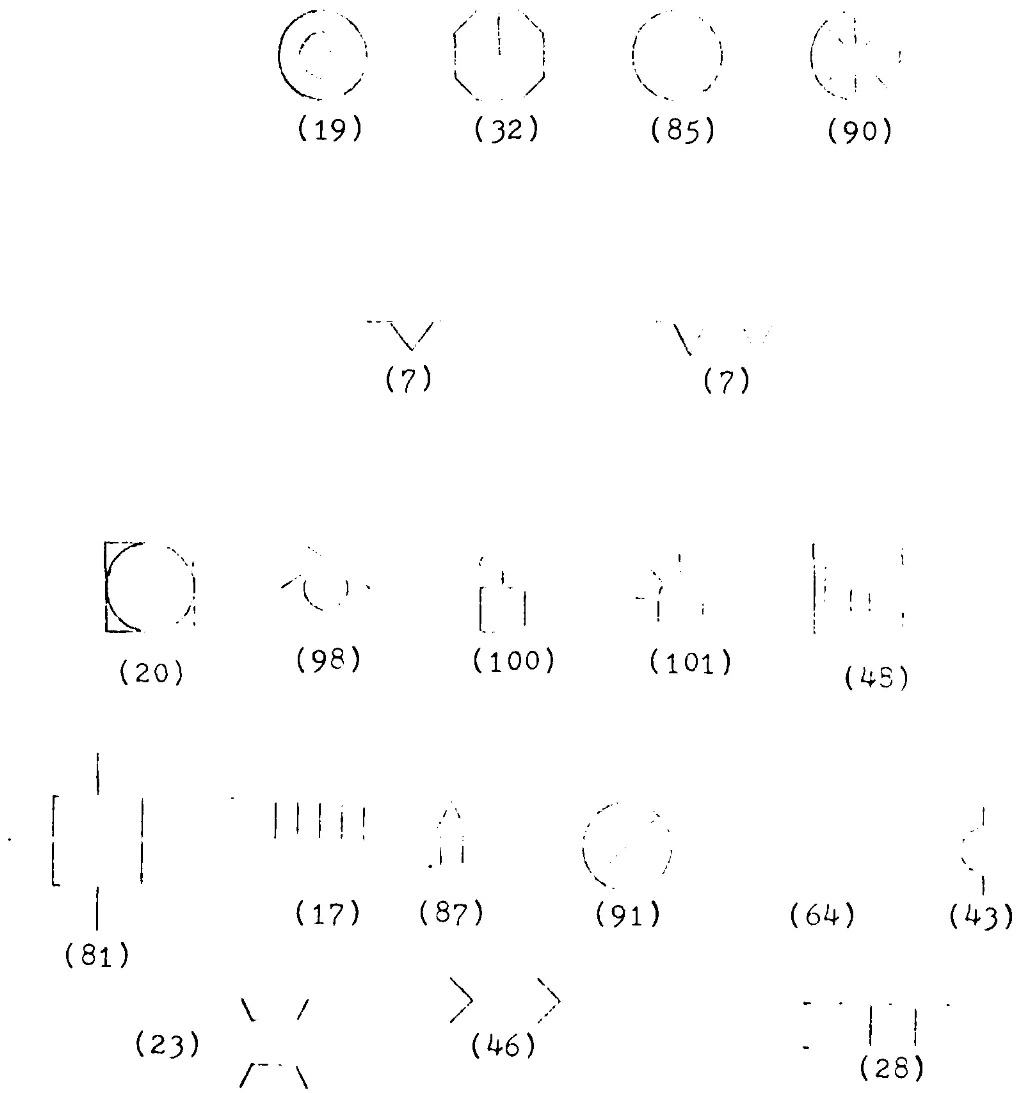
CULTURAL FEATURES



APPENDIX II (Continued)

CULTURAL FEATURES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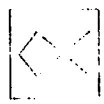
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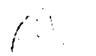
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MINING


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APPENDIX III SELECTED SYMBOL SUBROUTINES

```
SUBROUTINE LINE(X1,Y1,X2,Y2,S,IN)
C     THIS SYMBOL DRAWS THE SYMBOL FOR A TYPE OF SURVEY LINE.
C     THE ROUTINE LEAVES A SPACE FOR THE APPROPRIATE LETTERS.
C     THE SYMBOL IS DRAWN FROM X1,Y1 TO X2,Y2.
C     THE USER MAY SELECT FROM ONE OF THE SUPPLIED LABELS
C     OR LEAVE THE SPACE BLANK.
C     S IS THE HEIGHT OF THE LETTERS IN INCHES.
C     L IS THE LENGTH OF THE LINE IN INCHES.
C     IN = 1  FOR A CENTER LINE.
C     IN = 2  FOR A BOUNDARY LINE.
C     IN = 3  FOR A PROPERTY LINE.
C     IN = 4  FOR A FIELD LINE.
C     IN = 5  FOR A SIDE LINE.
C     IN = 6  FOR A RIGHT OF WAY LINE.
C     IN = 7  FOR AN UNLABELLED LINE.
DIMENSION R(2)
S2 = S * .5
S4 = s * .25
H = 0
N = 2
NS = 1
R(1) = .75
R(2) = .5
```

APPENDIX III (Continued)

```
CALL BROKEN(X1,Y1,X2,Y2,H,R,N,NS)
X3 = (X1 + 1.) - S2
Y3 = Y1 - S2
L = ABS(X2 - X1)
IF (IN .EQ. 1)  GO TO 20
IF (IN .EQ. 2)  GO TO 30
IF (IN .EQ. 3)  GO TO 40
IF (IN .EQ. 4)  GO TO 50
IF (IN .EQ. 5)  GO TO 60
IF (IN .EQ. 6)  GO TO 70
GO TO 80
20  CALL SYMBOL(X3,Y3,S,'C',0.,1)
X4 = X3 + S4
CALL SYMBOL(X4,Y3,S,'L',0.,1)
X3 = X3 + 1.25
IF (X3 .LT. L)  GO TO 20
GO TO 80
30  CALL SYMBOL(X3,Y3,S,'B',0.,1)
X4 = X3 + S4
CALL SYMBOL(X4,Y3,S,'L',0.,1)
X3 = X3 + 1.25
IF (X3 .LT. L)  GO TO 30
GO TO 80
```

APPENDIX III (Continued)

```
40  CALL SYMBOL(X3,Y3,S,'P',0.,1)
X4 = X3 + S4
CALL SYMBOL(X4,Y3,S,'L',0.,1)
X3 = X3 + 1.25
IF (X3 .LT. L)  GO TO 40
GO TO 80
50  CALL SYMBOL(X3,Y3,S,'F',0.,1)
X4 = X3 + S4
CALL SYMBOL(X4,Y3,S,'L',0.,1)
X3 = X3 + 1.25
IF (X3 .LT. L)  GO TO 50
GO TO 80
60  CALL SYMBOL(X3,Y3,S,'S',0.,1)
X4 = X3 + S4
CALL SYMBOL(X4,Y3,S,'L',0.,1)
X3 = X3 + 1.25
IF (X3 .LT. L)  GO TO 60
GO TO 80
70  CALL SYMBOL(X3,Y3,S,'W',0.,1)
X4 = X3 + S4
CALL SYMBOL(X4,Y3,S,'L',0.,1)
X3 = X3 + 1.25
IF (X3 .GT. L)  GO TO 80
GO TO 70
```

```
80  CALL PLOT(X2,Y2,1)
RETURN
END


SUBROUTINE PIN(X,Y)
C     THIS SUBROUTINE DRAWS THE SYMBOL FOR A STAKE OR PIN.
C     THE SYMBOL IS CENTERED ON THE POINT X,Y.
X1 = X + .0625
CALL CIRCLE(X1,Y,0.,720.,.0625,.0125,-2)
CALL PLOT(X,Y,2)
CALL PLOT(X,Y,1)
RETURN
END

SUBROUTINE PVOTBR(X1,Y1,X2,Y2,S)
C     THIS SUBROUTINE DRAWS THE SYMBOL FOR A PIVOTING
C     BRIDGE.
C     THE SYMBOL IS DRAWN FROM A LINE CENTERED ON THE POINT
C     X1,Y1 TO A LINE CENTERED ON THE POINT X2,Y2.
C     S IS THE SYMBOL HEIGHT IN INCHES.
S2 = S * .5
W = ABS(X2 - X1)
```

APPENDIX III (Continued)

```
W2 = W * .5
WS2 = W2 + S2
CALL CIRCLE(X1 + WS2, Y1, 0., 360., S2, S2, -2)
CALL RECT(X1, Y1 - S2, S, W, 0., 1)
CALL PLOT(X,Y,1)
RETURN
END

SUBROUTINE PUMPIS(X,Y,S)
C     THIS SUBROUTINE DRAWS THE SYMBOL FOR A PUMP ISLAND.
C     THE SYMBOL IS CENTERED ON THE POINT X,Y.
C     S IS THE SYMBOL IN INCHES.
S2 = S * .5
S4 = S * .25
S8 = S * .125
S16 = S * .0625
S416 = S4 + S16
S415 = S4 - S16
S12 = S4 + S8
CALL CIRCLE(X + S16, Y, 0., 360., S16, S16, -2)
CALL CIRCLE(X - S416, Y, 0., 360., S16, S16, -2)
CALL CIRCLE(X - S415, Y, 0., 360., S16, S16, -2)
CALL CIRCLE(X - S12, Y + S8, 90., 270., S8, S8, -2)
```

APPENDIX III (Continued)

```
CALL CIRCLE(X + S12, Y - S8, 270., 360., S8, S8, -2)
CALL CIRCLE(X + S2, Y, 0., 90., S8, S8, -2)
CALL PLOT(X - S12, Y + S8, 1)
CALL PLOT(X + S12, Y + S8, 2)
CALL PLOT(X - S12, Y - S8, 1)
CALL PLOT(X + S12, Y - S8, 2)
CALL PLOT(X,Y,1)
RETURN
END

SUBROUTINE ANCHOR(X,Y,S)
C     THIS SUBROUTINE DRAWS THE SYMBOL FOR A GUY ANCHOR.
C     THE STRAIGHT LINE IS ORIENTED IN THE DIRECTION OF
C     THE GUY WIRE.
C     X,Y IS THE POINT AT THE END OF THE LINE AWAY FROM THE
C     ARROW.
C     S IS THE SYMBOL WIDTH IN INCHES.
S3 = S * .3333
S4 = S * .25
S23 = S3 * 2.
CALL PLOT(X + S23, Y + S4, 1)
CALL PLOT(X + S, Y, 2)
CALL PLOT(X + S23, Y - S4, 2)
```

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STANDARDIZATION OF MAP SYMBOLOGY FOR LARGE SCALE MAPS.(U)
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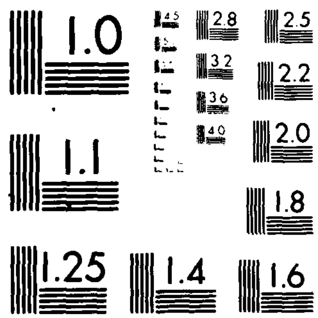

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NATIONAL BUREAU OF STANDARDS 1963 A

APPENDIX III (Continued)

```
CALL PLOT(X + S, Y, 1)
CALL PLOT(X,Y,2)
CALL PLOT(X,Y,1)
RETURN
END
```

APPENDIX IV LIST OF SYMBOL SOURCES

Abbreviations and Symbols Subcommittee, ACSM, Falls Church, Virginia, U.S.A.

Alster-Ayers and Associates, Inc., Madison, Wisconsin, U.S.A.

American Association of State Highway and Transportation Officials, Washington, D.C., U.S.A.

American National Standards Institute, New York, New York, U.S.A.

American Railway Engineering Association

Army Map Service, Washington, D.C., U.S.A.

Berger Associates, Columbus, Ohio, U.S.A.

Berol Corporation, Danbury, Connecticut, U.S.A.

British Tourist Authority, Great Britain

Calcomp, California Computer Products, Anaheim, California, U.S.A.

Carl Feldscher, Palm Harbor, Florida, U.S.A.

Carl Hammarstrom, Atlanta, Georgia, U.S.A.

City of Hayward Engineering Division, Haywood, California, U.S.A.

Colorado Highway Department, Denver, Colorado, U.S.A.

Consulting Engineers Council of New York State, New York, New York, U.S.A.

Defense Mapping Agency, Product Specifications, Washington, D.C., U.S.A.

APPENDIX IV (Continued)

Department of Lands and Surveys, New Zealand

Deutsches Hydrographisches Institut, Hamburg, West Germany

East Bay Council on Surveying and Mapping, Los Angeles, California, U.S.A.

Federal Highway Administration, Washington, D.C., U.S.A.

Geological Survey, (Book, Topographic Maps)

Hunting Surveys Limited, New York, New York, U.S.A.

Hydrographic Office, Royal New Zealand Navy, Aukland, New Zealand

Illinois Department of Transportation, Chicago, Illinois, U.S.A.

Institut fur Geodasie und Photogrammetrie, ETH Honggerberg, Zurich, Switzerland

Institut fur Kartographic, ETH Honggerberg, Zurich, Switzerland

International Hydrographic Organization, Monte Carlo, Monaco

International Standards Organization, ANSI, New York, New York, U.S.A.

Interstate Commerce Commission, Washington, D.C., U.S.A.

James W. Sewall Company, Oldtown, Maine, U.S.A.

Kentucky Department of Highways, Frankfort, Kentucky, U.S.A.

Koh-I-Noor, Bloomsburg, New Jersey, U.S.A.

APPENDIX IV (Continued)

L.M. Sebert, Mapping Program Section, Topographical Survey Department, Department of Energy, Mines and Resources, Ottawa, Canada

Lockwood, Kessler, and Barnett, Inc., Syosset, New York, U.S.A.

Los Angeles County Mapping Symbols, Los Angeles, California, U.S.A.

L. Robert Kimball and Associates, Ebensburg, Pennsylvania, U.S.A.

Map Service of the National Board of Survey, Helsinki, Finland

Mark Hurd Aerial Surveys Inc., Minneapolis, Minnisota, U.S.A.

Metropolitan Toronto, Public Utilities Co-ordinating Committee, Toronto, Canada

Ministry of Construction and Housing, Department of Surveys, State of Israel

Ministry of Overseas Development, Directorate of Overseas Surveys, United Kingdom

National Forest Outdoor Recreation Resource Review

National Land Survey, Sweden

National Ocean Survey and the Defense Mapping Agency Aerospace Center, Washington, D.C., U.S.A.

National Ocean Survey and the Department of Defense Hydrographic and Topographic Center, Washington, D.C., U.S.A.

New York City Housing Authority, New York, New York, U.S.A.

New York State Department of Transportation, New York, New York, U.S.A.

Norges Sjokartverk, Norway

Office of the Base Civil Engineer, Rickenbacker AFB, Ohio, U.S.A.

Ohio Department of Transportation, Columbus, Ohio, U.S.A.

Ohio State University, Department of Geodetic Science, Columbus, Ohio, U.S.A.

Oregon State Highway Department, Oregon, U.S.A.

Pacific Gas and Electric Company, California, U.S.A.

Pan American Institute of Geography and History, Mexico City, Mexico

Photogrammetric Services, Inc., Columbus, Ohio, U.S.A.

State of Florida Department of Trnasportation, Tallahassie, Florida, U.S.A.

Survey Department of the Rijkswaterstaat, Delft, The Netherlands

Survey of India, India

Symbol Sourcebook, Henry Dreyfuss (Book)

APPENDIX IV (Continued)

Systemhouse LTD, Graphics Division, Ottawa, Ontario, Canada

Tennessee Valley Authority, Chattanooga, Tennessee, U.S.A.

Topographic Survey of Switzerland, Bern, Switzerland

Topographical Survey, Surveys and Mapping Branch,
Department of Energy, Mines, and Resources

APPENDIX V ADDRESSES OF ORGANIZATIONS TO CONTACT FOR STANDARD SYMBOLS

American Congress on Surveying and Mapping:

Cartography Division
American Congress on Surveying and Mapping
210 Little Falls Street
Falls Church, Virginia 22046

American National Standards Institute:

American National Standards Institute
1430 Broadway
New York, New York 10018

American Society of Civil Engineering:

Committee on Cartographic Surveying
Surveying and Mapping Division
American Society of Civil Engineers
United Engineering Center
345 East 47th Street
New York, New York 10017

American Society of Photogrammetry:

Standards Committee
American Society of Photogrammetry

APPENDIX V (Continued)

105 North Virginia Avenue

Falls Church, Virginia 22046

Defense Mapping Agency Aerospace Center:

DMAAC

Second and Arsenal Streets

St. Louis, Missouri 63118

Defense Mapping Agency Hydrographic and Topographic Center:

DMAHTC

6500 Brooks Lane

Washington, D.C. 20315

International Hydrographic Organization:

Directing Committee

International Hydrographic Organization

Avenue President John F. Kennedy

MC - Monte Carlo

Monaco

National Ocean Survey:

National Ocean Survey

National Oceanic and Atmospheric Administration

APPENDIX V (Continued)

Department of Commerce
439 W. York Street
Norfolk, Virginia 23510

United States Geological Survey:

U.S. Geological Survey
Department of the Interior
12201 Sunrise Valley Drive
Reston, Virginia 22092

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al Conference on Standards, New York, New York, 1960.

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Meeting of the American Congress on Surveying and Mapping, held at Washington, D.C.

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